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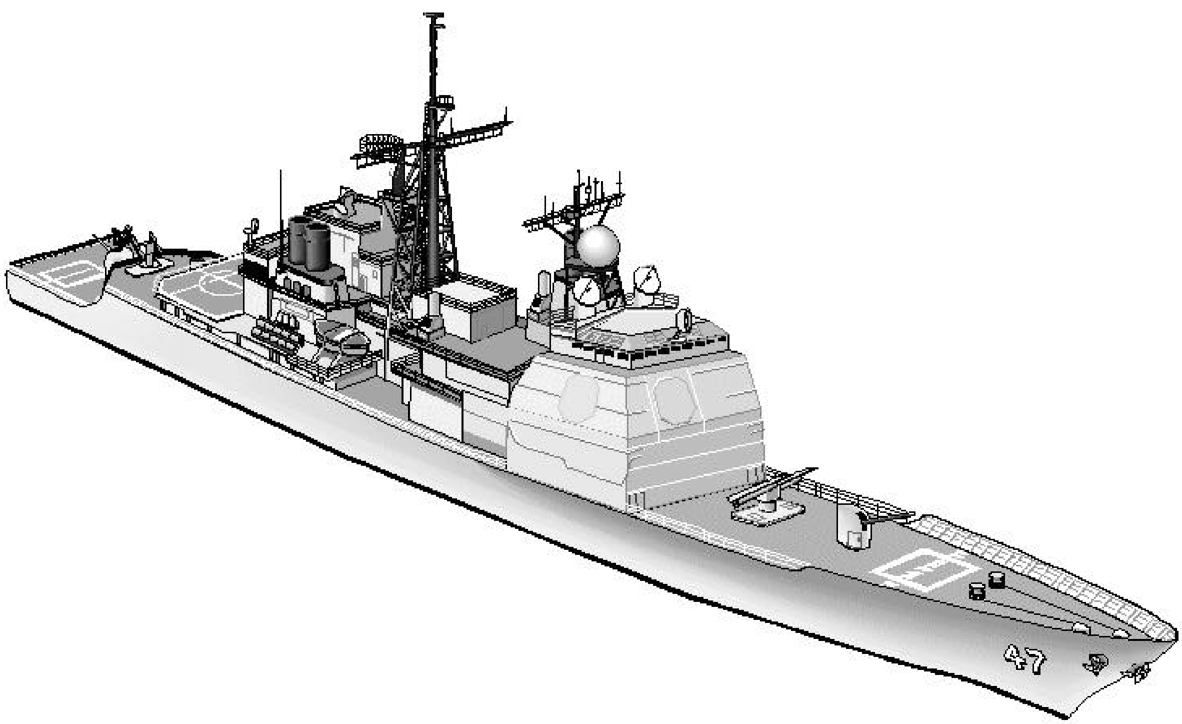
PHASE I UNIFORM NATIONAL DISCHARGE STANDARDS FOR VESSELS OF THE ARMED FORCES

TECHNICAL DEVELOPMENT DOCUMENT



Technical Development Document

for

Phase I Uniform National Discharge Standards

for

Vessels of the Armed Forces

Naval Sea Systems Command
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and

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FOREWORD

This Technical Development Document was produced jointly by the Naval Sea Systems Command of the United States Navy and the Office of Water of the United States Environmental Protection Agency. The purpose of this document is to provide, in part, the technical background that was used to develop the Phase I regulation that is issued under authority of the Uniform National Discharge Standards provisions of the Clean Water Act, 33 U.S.C., 1322(n).

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EXECUTIVE SUMMARY

This Technical Development Document provides the technical background for the Phase I regulation that is issued under authority of the Uniform National Discharge Standards (UNDS) provisions of the Clean Water Act (CWA). The purpose of Phase I of UNDS is to determine those discharges that are incidental to the normal operation of Armed Forces vessels for which it is reasonable and practicable to require the use of a marine pollution control device (MPCD) on at least one vessel class, type, age, or size. An extensive data collection effort was conducted to identify vessels of the Armed Forces producing discharges incidental to normal operations and to characterize those discharges. Initial requests for information were made to each branch of the Armed Forces to obtain discharge information and to help compile a list of vessels that could be subject to UNDS requirements. EPA and DoD identified a list of 39 types of discharges incidental to the normal operations of vessels of the Armed Forces and evaluated them during Phase I of UNDS. Consultations with personnel having equipment expertise were held on each discharge to identify available data and data gaps. Sampling data were collected from various vessels, where needed, to supplement existing data. Concurrently, existing laws and regulations were reviewed, including applicable international, Federal, State, and local standards. In addition, consultation meetings were held with interested Federal agencies, States, and environmental organizations.

The information collected from surveys, consultations, and discharge sampling and analysis was used collectively to evaluate the 39 types of discharges. Phase I decisions were made on these discharges according to the seven factors required to be considered by § 312(n)(2)(B) of the CWA:

- the nature of the discharge;
- the environmental effects of the discharge;
- the practicability of using a MPCD;
- the effect that installing or using the MPCD has on the operation or the operational capability of the vessel;
- applicable United States law;
- applicable international standards; and
- the economic costs of installing and using the MPCD.

The Administrator of the Environmental Protection Agency ("Administrator") and the Secretary of Defense ("Secretary") have determined that it is reasonable and practicable to require MPCDs on at least one vessel class, type, age, or size for 25 of the 39 discharges to mitigate adverse impacts or the potential for adverse impacts on the marine environment. These discharges are listed in Table ES-1 along with a brief description of each. For these 25 discharges, assessments of the practicability, operational impact, cost, and environmental effectiveness of potentially available MPCDs were conducted. The Administrator and the Secretary also have determined that it is not reasonable and practicable to require MPCDs for the remaining 14 discharges because these discharges exhibit a low potential to cause adverse impacts to the marine environment. These discharges are listed and briefly described in Table ES-2.

Table ES-1. Discharges Determined To Require MPCDs

Discharge	Description
Aqueous Film-Forming Foam	The primary fire-fighting agent used for flammable liquid fires on vessels of the Armed Forces. It is a concentrated liquid that is mixed with seawater to form a 3% to 6% solution which is discharged during planned maintenance, testing, system inspections, and flight deck certifications.
Catapult Water Brake Tank and Post-Launch Retraction Exhaust	Discharge from the water brake and from retracting catapults on aircraft carriers during aircraft launching operations and testing. Lubricating oil that is applied to the catapult cylinder collects in the water brake tank during these operations and is eventually discharged overboard. Also, expended steam and residual oil are released overboard when the catapult is retracted between launchings and testings.
Chain Locker Effluent	Seawater and debris that collects in the anchor chain storage locker as a result of anchor chain washdowns, retrievals, and heavy weather. The liquid collects in a sump and is removed by a drainage eductor powered by the shipboard firemain.
Clean Ballast	Either seawater or freshwater that is transferred into and out of dedicated tanks to adjust a surface ship's draft and to improve stability under various operating conditions. On submarines, seawater taken aboard into the main ballast system to control buoyancy and into the variable ballast system to control trim, list, and to adjust buoyancy. The discharge is generated when the ballast is no longer required and the tanks are partially or completely emptied.
Compensated Fuel Ballast	Seawater that is introduced into fuel tanks to maintain the stability of a vessel by compensating for the weight of the expended fuel that is consumed. During refueling, this seawater is displaced overboard.
Controllable Pitch Propeller Hydraulic Fluid	Hydraulic oil that is released from controllable pitch propeller (CPP) systems under three conditions: leakage through CPP seals, releases during underwater CPP repair and maintenance, or releases from equipment used for CPP blade replacement.
Deck Runoff	Water runoff from precipitation, freshwater washdowns, and seawater that falls on the exposed decks of a vessel such as a weather deck or flight deck. This water washes off residues from the deck and topside equipment, can be contaminated with materials from other deck activities, and is discharged overboard to receiving waters.
Dirty Ballast	Seawater that is occasionally pumped into empty fuel tanks for the specific purpose of improving ship stability. Before taking on seawater, fuel in the tank to be ballasted is transferred to another fuel tank or holding tank. Dirty ballast is comprised of residual fuel mixed with seawater. The discharge is generated when the ballast is no longer required and the tanks are partially or completely emptied.
Distillation and Reverse Osmosis Brine	Seawater concentrate or "brine" that is left over by water purification systems that generate freshwater from seawater for a variety of shipboard applications including potable water for drinking. This "brine" is discharged overboard.
Elevator Pit Effluent	Liquid from deck runoff and elevator equipment maintenance activities that collects in the bottom of elevator shafts. The liquid waste is either directed overboard, collected for shore-side disposal, or processed along with bilgewater.
Firemain Systems	Seawater distributed for fire fighting and other services aboard ships. Discharges of firemain water from normal operations occur during firemain testing, maintenance and training activities, anchor chain washdown, and cooling of auxiliary machinery.
Gas Turbine Water Wash	Wash water discharge from cleaning internal and external propulsion and auxiliary gas turbine components.

Table ES-1. Discharges Determined To Require MPCDs (contd.)

Discharge	Description
Graywater	Wastewater from showers, galleys, laundries, deck drains, lavatories, interior deck drains, water fountains, miscellaneous shop sinks, and similar sources.
Hull Coating Leachate	Antifouling agents that leach into surrounding waters from hull coatings designed to prevent corrosion and to inhibit biological growth on the hull surface.
Motor Gasoline Compensating Discharge	Seawater used to compensate for expended motor gasoline (MOGAS) used to operate equipment stored on some Navy vessels. MOGAS is stored in a compensating tank system to which seawater is added to fuel tanks as fuel is consumed. The discharge occurs as a result of refueling when the displaced water is discharged overboard.
Non-Oily Machinery Wastewater	Generated from the operation of distilling plants, water chillers, low- and high-pressure air compressors, and propulsion engine jacket coolers. The discharge is captured in a dedicated system of drip pans, funnels, and deck drains to segregate the water from bilgewater, and is either drained directly overboard or into dedicated collection tanks before being discharged overboard.
Photographic Laboratory Drains	Shipboard photographic lab wastes from processing color and black-and-white film. Typical wastes include spent film processing chemical developers, fixer-bath solutions, and film rinse water.
Seawater Cooling Overboard Discharge	Seawater used to cool heat exchangers, propulsion plants, and mechanical auxiliary systems.
Seawater Piping Biofouling Prevention	Anti-fouling compounds such as sodium hypochlorite introduced in seawater cooling systems to inhibit the growth of fouling organisms on interior piping and component surfaces.
Small Boat Engine Wet Exhaust	Seawater injected into the exhaust of small boat engines for cooling and to quiet operation. Exhaust gas constituents are entrained in the injected seawater and discharged overboard as wet exhaust.
Sonar Dome Discharge	Some domes that house detection, navigation, and ranging equipment are filled with freshwater and/or seawater to maintain their shape and pressure. The discharge occurs when water from inside the dome is pumped overboard before performing maintenance or repair on the dome and when materials leach from the dome exterior.
Submarine Bilgewater	Sources of bilgewater include seawater accumulation, normal leakage from machinery, and fresh water washdowns that collect in the bilge. On some submarines, oily wastewater is separated from non-oily wastewater. The oily wastewater is held for shore-side disposal and the non-oily wastewater is discharged overboard.
Surface Vessel Bilgewater/Oil-Water Separator Discharge	Sources include condensate from steam systems, boiler blowdowns, water fountains, and machinery space sinks that drain to the bilge. Bilgewater is either held for shore-side disposal or treated in an oil-water separator before being discharged overboard.
Underwater Ship Husbandry	Discharge from the grooming, maintenance, and repair of hulls and hull appendages performed while a vessel is waterborne. Underwater ship husbandry includes hull cleaning, fiberglass repair, welding, sonar dome repair, non-destructive testing, masker belt repairs, and painting operations.
Welldeck Discharges	Water and residuals from precipitation, equipment and vehicle washdowns, washing gas turbine engines, graywater from stored landing craft, and general washdowns of welldecks and vehicle storage areas.

Table ES-2. Discharges Determined To Not Require MPCDs

Discharge	Description
Boiler Blowdown	Water removed from the boiler system to prevent particulates, sludge, and treatment chemical concentrations from accumulating.
Catapult Wet Accumulator Discharge	Steam and water discharged from the wet accumulator tank to keep the water level in the accumulator within operating limits. The catapult wet accumulator provides steam to operate the catapult during aircraft launching.
Cathodic Protection	Zinc, aluminum, and chlorine-produced oxidants released during the consumption of sacrificial anodes and the operation of impressed current cathodic protection systems. The purpose of cathodic protection is to prevent hull corrosion.
Freshwater Lay-Up	Freshwater used to fill condensers when submarine seawater cooling systems are placed in stand-by mode, or “lay-up.” While the condenser is in lay-up mode, the water is discharged and refilled approximately every 30 days.
Mine Countermeasures Equipment Lubrication	Lubricating grease and oil released from mine countermeasures equipment that is towed behind vessels to locate and destroy mines.
Portable Damage Control Drain Pump Discharge	Seawater and harbor water that is discharged by the portable damage control drain pumps during pump maintenance, testing, and training.
Portable Damage Control Drain Pump Wet Exhaust	Water used to quiet and cool the exhaust from gasoline- and kerosene-fueled portable damage control drain pumps. Portable damage control drain pump wet exhaust discharge occurs during training and monthly planned maintenance activities.
Refrigeration /Air Conditioning Condensate	Condensate from air conditioning, refrigerated spaces, and stand-alone refrigeration units. The condensate is collected in drains and is either discharged directly overboard or held in dedicated tanks before discharge.
Rudder Bearing Lubrication	Grease and oil used to lubricate rudder bearings. The grease and oil can be released while the vessel is moving, when the rudder is used, or when pierside because the oil lubricant is slightly pressurized.
Steam Condensate	Condensate from steam used to operate auxiliary systems, such as laundry facilities, heating systems, and other shipboard systems, that drains into collection tanks and is discharged overboard.
Stern Tube Seals and Underwater Bearing Lubrication	Lubricants used in propeller support struts and bearings that can be released to the environment.
Submarine Acoustic Countermeasures Launcher Discharge	Water contained in the acoustic countermeasures Mk 2 launch tube after the countermeasures device is expelled.
Submarine Emergency Diesel Engine Wet Exhaust	Water used to quiet and cool the exhaust of submarine emergency diesel engines. These emergency diesel engines are operated for equipment checks that occur before submarine deployment, during monthly testing, and during periodic trend analyses.
Submarine Outboard Equipment Grease and External Hydraulics	Grease applied to a submarine’s outboard equipment. The grease is released to the environment by erosion from mechanical action of seawater while the submarine is underway and by slow dissolution of the grease into the seawater.

1. BACKGROUND OF THE UNIFORM NATIONAL DISCHARGE STANDARDS

This chapter provides background on and summarizes the requirements of the Uniform National Discharge Standards (UNDS) legislation. Section 1.1 describes the evolution of the UNDS legislation; section 1.2 cites the legal authority for the UNDS regulations and gives an overview of the scope of UNDS, including key definitions; section 1.3 describes the multi-phase UNDS development process; and section 1.4 lists the references cited in chapter 1.

1.1 Background

Armed Forces vessels produce liquid discharges that vary greatly in composition, amount, and potential for causing adverse environmental effects. Many are common to nearly all vessels while others are unique to specific vessel types. The composition and volume of a specific discharge may also vary with vessel type and age, installed hardware, operating mode, external environmental conditions, and other factors. Many discharges are discrete waste streams such as graywater (which includes effluent from sources such as sinks, showers, and galleys) and seawater cooling overboard discharge, while others, such as leachate from hull protective coatings, lubricants from various external bearings and joints, and contaminants from other external surfaces are released by direct contact with the marine environment or runoff from precipitation.

In support of national defense and other missions assigned by the President, Armed Forces vessels are required to operate in and visit coastal waters and ports throughout the United States. The potential for different ship discharge requirements between local and State jurisdictions makes it difficult for Armed Forces vessels to simultaneously ensure environmental regulatory compliance and operational readiness. Clear, achievable, and uniform discharge standards would enable the Armed Forces to design, build, and train their crews to operate environmentally sound vessels and simultaneously maintain their ability to meet national defense and other mission requirements. In addition, uniform national standards would result in enhanced environmental protection because standards would be established for certain discharges that presently are not comprehensively regulated. Establishing national standards for discharges from the vessels of the Armed Forces is the purpose of the UNDS program.

In 1990, the Navy began preliminary discussions with various Federal agencies concerning the need for uniform national standards to maintain operational flexibility while promoting environmentally responsible ships. The U.S. Environmental Protection Agency (EPA), the Coast Guard, the National Oceanic and Atmospheric Administration, and other agencies were contacted. The Navy also actively solicited input from the States, recognizing that coastal States, in particular, have a great interest in the quality of the water in and around their ports. State briefings and discussions held before UNDS legislation was passed began in October 1993 and continued through the winter of 1995.[1] During the same period, the Navy hosted several information sessions on UNDS with Federal and State environmental officials, environmental interest groups, and congressional staff. As a result, legislation was drafted and sent to Congress.

Ultimately, Congress enacted UNDS legislation as part of the 1996 Defense Authorization Bill and the President signed the bill into law as part of the National Defense Authorization Act of 1996.

The National Defense Authorization Act established that the purposes of UNDS are to:

- enhance the operational flexibility of vessels of the Armed Forces domestically and internationally;
- stimulate the development of innovative vessel pollution control technology; and
- advance the development by the United States Navy of environmentally sound ships.

1.2 Legal Authority and Statutory Requirements for the UNDS Regulations

Section 325 of the National Defense Authorization Act of 1996, entitled "Discharges from Vessels of the Armed Forces" (Pub. L. 104-106, 110 Stat. 254), amended § 312 and § 502(6) of the Federal Water Pollution Control Act (also known as the Clean Water Act or the CWA) to require the Administrator of the EPA ("Administrator") and the Secretary of Defense ("Secretary") to develop uniform national standards to control certain discharges from vessels of the Armed Forces.

1.2.1 Discharges

The UNDS legislation specifies that standards would apply to discharges (other than sewage) incidental to the normal operation of vessels of the Armed Forces unless the Secretary finds that complying with UNDS would not be in the national security interests of the United States (CWA § 312(n)(1)). The standards would apply anytime the vessel is waterborne in inland U.S. waters or within 12 nautical miles (n.m.) from the United States or its territories, regardless of whether the vessel is underway or pierside (see section 1.2.3). Discharges subject to UNDS include discharges from the operation, maintenance, repair, or testing of vessel propulsion systems, maneuvering systems, habitability systems, or installed major systems such as elevators or catapults, and discharges from protective, preservative, or adsorptive hull coatings. UNDS does not apply to discharges overboard of rubbish, trash, garbage, or other such materials; air emissions resulting from a vessel propulsion system, motor driven equipment or incinerator; or discharges that require permitting under the National Pollutant Discharge Elimination System (NPDES) program, Title 40 Part 122 of the Code of Federal Regulations (CFR) (see CWA § 312(a)(12)). UNDS does not apply to discharges containing source, special nuclear, or byproduct materials. These materials are regulated under the Atomic Energy Act of 1954, as amended (42 United States Code (USC) 2011). See Train v. CIPR, Inc., 426 U.S. 1 (1976).

1.2.2 Vessels

Armed Forces vessels subject to the UNDS regulations include most watercraft or other artificial contrivances used, or capable of being used, as a means of water transportation by the Armed Forces. Examples of such vessels are ships, submarines, barges, tugs, floating drydocks, and landing craft, as well as boats of all sizes. Armed Forces vessels are any vessel owned or operated by the Department of Defense other than time- or voyage-chartered vessels. This includes vessels of the Navy, Army, Marine Corps, Air Force, and Military Sealift Command (MSC). In addition, a vessel of the Armed Forces is defined as any vessel owned or operated by the Department of Transportation (DOT) that is designated by the Secretary of the Department in which the Coast Guard is operating as a vessel equivalent to a vessel of the DoD. The Secretary of the DOT has determined that Coast Guard vessels are equivalent to DoD vessels and are therefore included as vessels of the Armed Forces for the purposes of UNDS.

A vessel becomes a vessel of the Armed Forces when the government assumes overall operational control of the vessel. Vessel discharges that occur before the government assumes control of the vessel (e.g., vessels under construction) and those that occur during maintenance and repair while the vessel is in drydock are addressed by the NPDES permits issued to the shore facility or the drydock. Discharges related to a floating drydock's function as a vessel are covered by UNDS and do not require authorization by NPDES permits.

While the majority of Armed Forces vessels are subject to UNDS, there are several classes of vessels that are not subject to UNDS. The Armed Forces vessels that are subject to UNDS and those vessels not subject to UNDS are discussed in detail in chapter 2.

1.2.3 Waters

UNDS is applicable to discharges from Armed Forces vessels when they operate in the navigable waters of the United States and the contiguous zone. As defined in § 502 of the CWA, the term "navigable waters" means all inland waters of the United States, including the Great Lakes, and all waters seaward from the coastline to a distance of three n.m. from the shore of the States, District of Columbia, Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Canal Zone, and the Trust Territories of the Pacific Islands. The contiguous zone extends from three n.m. to 12 n.m. from the coastline. Therefore, UNDS applies to Armed Forces vessel discharges into inland waters and into waters from the shoreline out to 12 n.m. of shore. UNDS is not enforceable beyond the contiguous zone.

1.3 UNDS Development Requirements

Section 312(n) of the CWA requires that UNDS be developed in three phases:

Phase I. The first phase of UNDS requires the Administrator and the Secretary to determine for which Armed Forces vessel discharges it is reasonable and practicable to require control with a marine pollution control device (MPCD) on at least one vessel class, type, age, or size to mitigate potential adverse impacts on the marine environment (CWA § 312(n)(2)). The UNDS legislation states that a MPCD may be a piece of equipment or a management practice designed to control a particular discharge (CWA § 312(a)(13)). The Administrator and the Secretary are required to consider the following seven factors when determining if a discharge requires a MPCD:

- the nature of the discharge;
- the environmental effects of the discharge;
- the practicability of using the MPCD;
- the effect that installing or using the MPCD has on the operation or the operational capability of the vessel;
- applicable United States laws;
- applicable international standards; and
- the economic costs of installing and using the MPCD.

The Administrator and the Secretary are required to consult with the Secretary of the department in which the Coast Guard is operating (i.e., DOT), the Secretary of Commerce, and interested States during Phase I rule development. The statute provides that after promulgation of the Phase I rule, neither States nor political subdivisions of States may adopt or enforce any State or local statutes or regulations with respect to discharges identified as not requiring control with a MPCD, except to establish no-discharge zones (CWA § 312(n)(6)). A no-discharge zone is an area of water determined by a State or the Administrator to need greater environmental protection than that provided by UNDS. It can encompass one or more discharges that will be prohibited from being released, either treated or untreated, into the waters of the no-discharge zone. In addition, States and their political subdivisions will be similarly prohibited from adopting or enforcing any statutes or regulations affecting discharges that require control with MPCDs once "Phase III" regulations (see below) that govern the design, construction, installation, and use of the MPCDs for those discharges are promulgated.

When there is new, significant information not considered during the Phase I rulemaking that could result in a change to the Phase I discharge determination, § 312(n)(5)(D) of the CWA authorizes the Governor of any State to submit a petition to the Administrator and the Secretary requesting them to re-evaluate whether a discharge requires control. In addition, § 312(n)(5) of the CWA requires the Administrator and the Secretary to review the Phase I determinations every five years and, if necessary, revise the determinations based on significant new information.

Phase II. The second phase of UNDS requires the Secretary and the Administrator to promulgate Federal performance standards for each MPCD determined to be required in Phase I (CWA § 312(n)(3)). Phase II requires that the Secretary of the department in which the Coast Guard is operating, the Secretary of State, the Secretary of Commerce, other interested Federal agencies, and interested States be consulted. When developing performance standards for the MPCDs during Phase II, the Secretary and Administrator must consider the same seven factors that were considered during Phase I (see above), and may establish standards that:

- distinguish between vessel class, type and size;
- distinguish between new and existing vessels; and
- provide a waiver from UNDS requirements as necessary or appropriate for particular classes, types, sizes, or ages of vessels.

The performance standards developed during Phase II are to be issued two years after the Phase I regulation is issued, and reviewed every five years in accordance with § 312(n)(5) of the CWA.

Phase III. The third phase of UNDS requires the Secretary, after consulting with the Administrator and the Secretary of the department in which the Coast Guard is operating, to establish requirements for designing, constructing, installing, and using the MPCDs identified in Phase II (CWA § 312(n)(4)). These requirements will be codified under the authority of the Secretary. Phase III is to be completed within one year after Phase II is promulgated. Following completion of Phase III, neither States nor political subdivisions of States may adopt or enforce any State or local statutes or regulations with respect to discharges identified as requiring control with a MPCD, except to establish no-discharge zones (CWA §312(n)(6)).

1.4 References

1. Quinn, John P., Captain U.S. Navy. "Uniform National Discharge Standards for Armed Forces Vessels: Enhancing Operational Flexibility and Environmental Protection." Presented at the 22nd Environmental Symposium and Exhibition of the American Defense Preparedness Association. Orlando, Florida. 21 March 1996.

2. VESSELS OF THE ARMED FORCES

This chapter describes Armed Forces vessels, to which UNDS is applicable, and clarifies which vessels do not qualify as such. Section 2.1 gives a brief overview of the vessels subject to UNDS; section 2.2 provides a more detailed description of the different vessel types and lists the vessel classes covered by UNDS in each branch of the Armed Forces and those not covered by UNDS; section 2.3 discusses where these vessels operate; and references are listed in section 2.4.

2.1 Introduction

The UNDS legislation defines vessels of the Armed Forces as any vessel owned or operated by the DoD, other than a time or voyage chartered vessel, or any vessel owned or operated by the Department of Transportation (DOT) that is designated by the Secretary of the department in which the Coast Guard is operating as being equivalent to a vessel of the Armed Forces (CWA § 312(a)(14)). The branches of the Armed Forces that own or operate vessels that are subject to UNDS are listed in Table 2-1 along with the number of vessels as of August 1997.

Table 2-1. Armed Forces Vessels Subject to UNDS Regulations

Branch of Armed Forces	Branch Abbreviation	Number of Vessels
United States Navy	USN	4,760
United States Coast Guard	USCG	1,445
United States Marine Corps	USMC	538
United States Army	USA	334
Military Sealift Command	MSC	57
United States Air Force	USAF	36
	TOTAL =	7,170

Categories of vessels that are not covered by UNDS include: commercial vessels; privately owned vessels; vessels owned or operated by State, local, or tribal governments; vessels under the jurisdiction of the Army Corps of Engineers; vessels, other than those of the Coast Guard, under the jurisdiction of the Department of Transportation; vessels owned or operated by other Federal agencies that are not part of the Armed Forces (i.e., Maritime Administration (MARAD) vessels); vessels preserved as memorials and museums; time- and voyage-chartered vessels; vessels under construction; vessels in drydock; and amphibious vehicles. Several categories of these vessels are described in section 2.2.7.

The five largest Navy ports are Norfolk, VA; San Diego, CA; Pearl Harbor, HI; Puget Sound (Bremerton), WA; and Mayport, FL. Numerous other naval ports are located around the country. The largest Coast Guard base is located in Portsmouth, VA; with other major bases in California, Florida, Hawaii, Massachusetts, South Carolina, Texas, and Washington. Fort Eustis, VA, is the primary site for the Army vessels, but the Army also ports vessels in California, Florida, Hawaii, Maryland, North Carolina, and Washington. Military Sealift Command vessels make use of Navy ports, as available, and commercial ports at all other times. Neither the Marine Corps nor the Air Force has a major port. Marine Corps craft are typically stowed aboard larger Navy vessels and maintained and stationed ashore. Air Force vessels are located in Florida, North Carolina, Virginia, New Mexico, and Nevada. Operating locations for Armed Forces vessels are discussed in more detail in Section 2.3.

2.2 Description of Vessel Classes and Types

The number of specific vessel types within each branch of the Armed Forces constantly changes due to vessel commissionings, decommissionings, and transfers within branches of the Armed Forces. In order to maintain consistency, the Armed Forces vessel population as of August 1997 was used in analyses supporting this rule.

2.2.1 Vessels of the U.S. Navy[1-4]

2.2.1.1 Navy Mission

The role of the U.S. Navy is to maintain an effective naval fighting force to defend the U.S. during war, and to use this force to prevent conflicts and control crises around the world. The Navy is responsible for organizing, training, and equipping its forces to conduct prompt and sustained combat operations at sea. For combat, as well as humanitarian missions, the Fleet must be capable of quick deployment, while being optimized for carrying personnel, weapons, and supplies whenever and wherever needed.

2.2.1.2 Navy Vessel Description

There are approximately 4,800 Navy vessels (active and inactive), the majority of which are small boats and service craft. Navy vessels can be categorized into eight groups according to mission: aircraft carriers, surface combatants, amphibious ships, submarines, auxiliaries, mine warfare ships, small boats and service craft, and inactive assets. Differences in vessel size, mission, and mode of operation are explained below. Table 2-2 summarizes Navy vessel characteristics including length, displacement, and mission for each vessel classification. A summary of vessel-related abbreviations may be found in the Glossary and Abbreviations section.

Aircraft Carriers. Aircraft carriers are the largest vessels in Navy service, averaging approximately 1,100 feet long. They provide combat air support to the fleet. To accomplish this, aircraft carriers have landing and launch platforms for fixed-wing aircraft and helicopters. Carriers are classified as having either conventional propulsion (CV) or non-conventional propulsion (CVN). The USS Nimitz (CVN 68) Class, is the largest class of carriers, composed of ships that are intended to provide fleet support well into the next century. Aircraft carriers are ocean-going vessels that typically operate within 12 n.m. only during transit in and out of port. However, testing and maintenance activities may be conducted in port and during transits.

Surface Combatants. Surface combatants provide air defense, ballistic missile defense, antisubmarine warfare support, antisurface warfare support, merchant and carrier group protection, independent patrol operations, and tactical support of land-based forces. They include cruisers (CG and CGN), destroyers (DD and DDG), frigates (FFG), and coastal patrol craft (PC). The Navy's surface combatants range from 171 feet long (for PCs) to 596 feet long (for CGNs), and may have either conventional or non-conventional propulsion. Surface combatants are ocean-going vessels that, for the most part, operate inside 12 n.m. only during transit in and out of port and for short periods of time to meet mission requirements, such as training. Testing and other systems maintenance activities may be done in port and during transits.

Amphibious Ships. Amphibious ships provide a platform for vertical landing and take-off of aircraft, primarily helicopters, and conduct launch and recovery operations of smaller landing craft. They include command ships (LCC and AGF), assault ships (LHD, LHA, and LPH), transport docks (LPD), and dock landing ships (LSD). Amphibious ships range from 522 to 844 feet long and use landing craft and helicopters to move Marine Corps equipment and vehicles ashore. Amphibious ships are ocean-going vessels that operate inside 12 n.m. not only during transit in and out of port, but also to train for and perform their designed mission as an interface between water- and land-based operations. Testing and maintenance activities may be performed in port and during transits.

Submarines. Submarines provide strategic missile, battlefield support, stealth strike, special forces, littoral warfare, and other miscellaneous capabilities. They are categorized as attack (SSN), ballistic missile (SSBN), and research and survey (AGSS) types. Navy submarines range from 165 feet long for the research submarine to 560 feet long for ballistic missile submarines. Nearly all submarines in active service have non-conventional propulsion, with the exception of search and rescue types. Submarines are ocean-going vessels that operate inside 12 n.m. for transit in and out of port and to meet mission requirements, such as training. Testing and maintenance activities may be performed in port and during transits.

Auxiliaries. Auxiliary ships provide logistical support, such as underway replenishment of ordnance, fuel, and consumable products (AO and AOE); and rescue and salvage operations (ARS). Submarine tenders (AS) provide maintenance facilities, weapon stores, hospital facilities, and additional berthing space for submarines. Auxiliary vessels range in length from 255 feet to 795 feet. Auxiliaries are ocean-going vessels that typically operate inside 12 n.m. for transit in and out of port or to meet mission requirements. Testing and maintenance activities may be performed in port and during transits.

Mine Warfare Ships. Mine warfare ships (mine countermeasures ships (MCM) and minehunter, coastal (MHC)) conduct minesweeping missions to find, classify, and destroy moored and bottom mines. These vessels range in length from 188 to 224 feet long. Mine warfare vessels primarily operate in coastal waters.

Small Boats and Service Craft. Due to their large numbers and diverse duties, small boats and service craft have been summarized collectively in Table 2-2. The Navy owns and operates approximately 4,200 small boats and service craft. Small boats are used as harbor patrol boats, transport boats, work boats (WB), and utility boats (UB). Many of the service craft are non-self-propelled "lighters," or barges (YC, YFN, YON, and YRBM), used for berthing, office, messing, or repair functions or to carry fuel or equipment. Other small boats and service craft include: tugboats of various sizes (YTB, YTM, and YTL), training patrol craft (YP), landing craft (LCU, LCM, CM, and PL), torpedo retrievers (TWR, TRB, and TR), floating drydocks (AFDB, AFDL, AFDM, ARD, and ARDM), and rigid inflatable boats (designated RB or RIB). Small boats are often kept out of the water when not in use to increase the vessels' longevity or for storage while transiting to operational areas. Small boats and service craft operate within the waters of the homeport area and other coastal locations within 12 n.m. from shore.

Inactive Assets. The Navy owns and maintains additional surface ships in various states of readiness. These inactive assets are comprised of numerous vessel types with varying missions and capabilities. The Navy also owns and maintains inactive submarines. The significant majority of these inactive assets are scheduled for scrapping or other permanent disposal. Some surface ships might be transferred to MARAD to be made part of the National Defense Reserve Fleet, or might be destined for sale to foreign nations. However, due to the Navy's retained ownership of these assets, pending final disposal, these vessels are covered under UNDS. These inactive vessels are prepared for long-term storage with their systems and equipment secured or removed and are not operated. They are moored in designated port locations and typically not moved until final disposal.

Table 2-2. Navy Vessel Classification

Vessel Type	Ship Class	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Aircraft Carriers	CV 59	1	1,056	82,360	Provide air combat support to the fleet with landing and launch platform for airplanes and helicopters
	CV 63	3	1,046	81,985	
	CVN 65	1	1,102	93,970	
	CVN 68	7	1,092	95,413	
Surface Combatants	CG 47	27	567	9,589	Provide air defense, missile defense, antisubmarine and antisurface warfare support, merchant and carrier group protection, independent patrol operations, and tactical support of land-based forces
	CGN 36	2	596	10,530	
	CGN 38	1	585	11,400	
	DD 963	31	563	8,280	
	DDG 993	4	563	9,574	
	DDG 51	18	504	8,373	
	FFG 7	43	445	3,658	
	PC 1	13	171	329	
Amphibious Ships	LCC 19	2	636	16,790	Provide a landing and take-off platform for aircraft, primarily helicopters, and a means for launching and recovering smaller landing craft
	AGF 3	1	522	13,900	
	AGF 11	1	569	16,912	
	LHD 1	4	844	40,530	
	LHA 1	5	834	39,967	

Table 2-2. Navy Vessel Classification (contd.)

Vessel Type	Ship Class	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Amphibious Ships (contd.)	LPD 4	3	569	17,595	
	LPD 7	3	569	17,595	
	LPD 14	2	569	17,595	
	LPH 2	2	602	18,300	
	LSD 36	5	553	13,680	
	LSD 41	8	609	16,165	
	LSD 49	3	609	16,695	
Submarines	SSN 671	1	315	5,284	Provide strategic missile defense, search and rescue, and research and survey capability
	SSN 637	13	302	4,250	
	SSN 688	56	360	6,300	
	AGSS 555	1	165	860	
	SSBN 726	17	560	16,754	
Auxiliaries	AOE 1	4	795	53,600	Provide logistical support, such as underway replenishment, material support, and rescue and salvage operations
	AOE 6	3	755	48,800	
	AO 177	5	708	37,866	
	AS 33	1	644	19,934	
	AS 39	3	646	22,650	
	ARS 50	4	255	3,193	
Mine Warfare Ships	MCM 1	14	224	1,312	Conduct minesweeping missions to find and destroy mines
	MHC 51	12	188	918	
Small Boats and Service Craft	YTB 760	68	109	356	Provide a variety of services. Includes: patrol training craft (YP), tug boats (YTB), torpedo trials craft (YTT), landing craft, barges, transport boats, personnel boats, harbor patrol boats, work boats, utility boats, floating drydocks, and rigid inflatable boats
	YTB 756	3	109	409	
	YTB 752	1	101	375	
	YTT 9	3	187	1,200	
	YP 654	1	--	--	
	YP 676	27	--	--	
	Various others	4,089	12-192	--	
Inactive Assets	Various surface ships	228	--	--	Vessels in various states of readiness, the majority of which are scheduled for scrapping, transfer to MARAD, or sale to foreign nations.
	Various sub-marines	16	--	--	
TOTAL	Vessels =	4,760			

2.2.2 Vessels of the Military Sealift Command[1,5,6]

2.2.2.1 Military Sealift Command Mission

The Military Sealift Command (MSC) transports DoD materials and supplies, provides towing and salvage services, and conducts specialized missions for Federal agencies. To accomplish this mission, the MSC maintains and operates a fleet of vessels classified within four major maritime programs: the Special Mission Support Force (SMSF), the Naval Fleet Auxiliary Force (NFAF), Strategic Sealift, and the Afloat Prepositioning Force (APF, which is sometimes categorized under Strategic Sealift). Consistent with the definition of vessel of the Armed Forces in CWA § 312(a)(14), UNDS does not apply to chartered Strategic Sealift and APF vessels.

Table 2-3 summarizes MSC vessel characteristics including length, displacement, and mission for each vessel classification. MSC owned vessels are differentiated from Navy vessels by the prefix, "T-" (e.g., T-AGOS and T-AGS). Although MARAD's Ready Reserve Force (RRF) ships come under the direction of the MSC and its Strategic Sealift program when activated, they are normally maintained and crewed by MARAD. RRF ships are discussed in section 2.2.7.2 in conjunction with other MARAD vessels.

2.2.2.2 Special Mission Support Force

The MSC's Special Mission Support Force (SMSF) includes ships designed to support the Navy, Air Force, and the Army in specialized military missions. SMSF vessels often operate in remote areas to conduct undersea surveillance, missile range tracking, oceanographic and hydrographic surveys, acoustic research, and submarine escort. SMSF vessels range from 234 feet to 595 feet long. They include the following vessel types: ocean surveillance (AGOS), surveying (AGS), miscellaneous (AG) navigation test support and acoustic research; missile range instrumentation (AGM), and cable repairing (ARC) vessels. The vessels are operated by civil service mariners or mariners under contract to the MSC. SMSF vessels are ocean-going ships that operate inside 12 n.m. during transit in and out of port or to meet mission requirements. Additionally, cable repairing vessels may operate frequently inside 12 n.m. for mission purposes. Testing and maintenance activities may be conducted in port and during transits.

2.2.2.3 Naval Fleet Auxiliary Force

The MSC's Naval Fleet Auxiliary Force (NFAF) is comprised of auxiliary ships that provide underway replenishment services to Navy surface combatants, in addition to ocean towing and salvage services. By transporting and delivering fuel, food, spare parts and equipment, and ammunition, NFAF ships enable surface combatants to remain at sea for extended periods. NFAF vessels are between 240 feet and 677 feet in length. The NFAF vessels are ocean-going, and typically operate inside 12 n.m. only to transit in and out of port or to meet certain mission requirements. Testing and maintenance activities may be conducted in port and during transits.

Table 2-3. Military Sealift Command Vessel Classification[6]

MSC Maritime Program Classification	Class/Ship	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
SMSF	T-AGOS	5	234	3,438	Support the Armed Forces in specialized missions such as undersea surveillance, missile range tracking, oceanographic and hydrographic surveys, acoustic research, and submarine escort
	T-AGOS	4	285	2,558	
	T-AGS	9	442	12,208	
	T-AG	2	455	11,860	
	T-AGM	1	595	21,478	
	T-ARC	1	502	14,225	
NFAF	T-AE	8	563	19,937	Provide underway replenishment services (i.e., deliver fuel, food, spare parts, equipment, and ammunition) to Navy surface combatants, as well as ocean towing and salvage services
	T-AFS	8	523	16,792	
	T-AO	12	677	40,700	
	T-ATF	7	240	2,260	
TOTAL	Vessels =	57			

2.2.3 Vessels of the U.S. Coast Guard[1,7,8]

2.2.3.1 Coast Guard Mission

The Coast Guard is part of DOT and is responsible for enforcing laws on the waters of the U.S., including coastal waters, oceans, lakes, and rivers that are subject to the jurisdiction of the U.S. During war, the Coast Guard may become part of the Navy. The principal peacetime missions of the Coast Guard are enforcing recreational boating safety, conducting search and rescue operations, maintaining aids to navigation (e.g., lighthouses and navigational lights), ensuring merchant marine safety (e.g., via vessel inspection and operator certification), providing drug interdiction, and participating in environmental protection efforts. The Coast Guard also carries out port safety responsibilities (e.g., icebreaking), enforces laws and treaties (e.g., customs, immigration, and fisheries law enforcement), and, ultimately, defends U.S. harbors and coasts during war. Table 2-4 summarizes Coast Guard vessel characteristics including length, displacement, and mission for each vessel classification.

2.2.3.2 Coast Guard Vessel Description

Cutters. Coast Guard cutters are vessels 65 feet or longer that are capable of accommodating crew living on board. Cutters are used for patrol, air defense, search and rescue, and drug interdiction. High endurance cutters (WHEC), medium endurance cutters (WMEC),

Table 2-4. Coast Guard Vessel Classification

Vessel Classification	Ship Class	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Cutters	Hamilton WHEC 715	12	378	3,050	Provide multi-mission capability, including patrol, air defense, search and rescue, and drug interdiction
	Bear WMEC 901	13	270	1,820	
	Reliance WMEC 615	16	210	1,007	
	Storis WMEC 38	1	230	1,925	
	Escape WMEC 6	1	213	1,745	
	Island WPB 1301	49	110	155	
	Point WPB 82301	36	82	69	
Tenders	Juniper WLB 201	2	225	2,000	Used to maintain inland, river, coastal, and offshore buoys and navigational aids, or to serve as a construction platform
	Balsam WLB 62	23	180	1,038	
	Ida Lewis WLM	2	175	916	
	Red WLM	5	157	525	
	White WLM	4	133	600	
	Buckthorn WLI	1	100	200	
	Cosmos WLI 293	1	100	178	
	Berry WLI	4	65	71	
	Pamlico WLIC	4	160	416	
	Cosmos WLIC	3	100	178	
	Anvil WLIC	7	75	145	
	Sumac WLR	1	115	478	
	Kankakee WLR	3	75	172	

Table 2-4. Coast Guard Vessel Classification (contd.)

Vessel Classification	Ship Class	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Tenders (contd.)	Gasconade WLR	10	75	141	
	Ouachita WLR	6	65	143	
Icebreakers	Polar WAGB 10	2	399	13,190	Support the winter icebreaking efforts in order to maintain open waterways in the Arctic, Antarctic, and the northern regions of the U.S. including the Great Lakes, Northwest, and Northeast
	Mackinaw WAGB 83	1	290	5,320	
Tugboats	Bay WTGB	9	140	662	Provide towing and support services (icebreaking, search and rescue, and law enforcement) to other vessels
	Capstan WYTL	11	65	72	
Small Boats and Craft	Various	1,217	22-58	2-32	Used in harbors (drug interdiction, port security, cable repair, harbors and inland waters, navigation aids, illegal dumping, search and rescue, etc.), in rough surf for rescue, for inland river and lake patrol, as transports, and for firefighting
Other Vessels	Eagle WIX 327	1	295	1,784	A sailing cutter used for training
TOTAL	Vessels =	1,445			

and patrol boats (WPB) have multi-mission capabilities due to features such as anti-ship missiles, gun systems, and other weapon systems. Because of these capabilities, the cutters are strategically stationed along the Atlantic and Pacific coasts of the U.S. The Coast Guard no longer maintains anti-submarine warfare capability. WHECs perform patrol, air defense, and search-and rescue operations, and can remain at sea for 30-45 days without support. This compares to 10-30 days at sea for WMECs and 1-7 days for WPBs. The cutters range in length from 82 feet to 378 feet. Cutters are ocean-going vessels. However, they operate inside 12 n.m. during transit in and out of port, and during certain patrol or search and rescue missions. Testing and maintenance activities may be performed in port and during transits.

Tenders. Tenders are a specific type of cutter used to maintain inland, river, inshore, coastal, and offshore buoys and navigational aids, or to serve as a construction platform in inland waters. Coast Guard tenders range in size from 65 to 225 feet in length to accommodate numerous and diverse tasks. Tenders are operated frequently inside 12 n.m.

Icebreakers. Icebreakers have multi-mission capabilities and are often equipped with hangar decks, flight decks, gun systems, and arctic or oceanographic laboratories. They primarily support winter icebreaking efforts in order to maintain open waterways in the Arctic and Antarctic, and the northern regions of the U.S. including the Great Lakes, Northwest (e.g., Alaska and Washington), and Northeast (e.g., Maine and Massachusetts). The Coast Guard icebreakers range in length from 290 to 399 feet. Icebreakers are frequently operated inside 12 n.m.

Tugboats. Tugboats operate in various capacities, providing towing and support services to other vessels. Icebreaking tugs (WTGB) are 140 feet long and specially designed to break through thick ice. By joining this tug with a work barge, it can also be used to maintain aids to navigation. Small harbor tugs (WYTL) are 65 feet long and, in addition to towing, can perform law enforcement and search and rescue operations. They have also been used for small-scale icebreaking, firefighting, delivering humanitarian aid, and assisting in spill containment. Tugboats usually operate within 12 n.m. of shore; however, specific missions may require them to operate beyond 12 n.m.

Small Boats and Craft. Small boats and craft are used for various harbor duties, rough surf rescues, inland river and lake patrols, transporting equipment, and firefighting. Some of these vessels can be transported by trailer and used on any inland waterway in the U.S. Due to their numbers and diversity, small boats and craft of the Coast Guard have been summarized collectively in Table 2-4.

Other Vessels. Coast Guard Academy cadets use the Coast Guard's training cutter (WIX), a multi-masted sailing vessel, as a summer training vessel.

2.2.4 Vessels of the U.S. Army[1,9,10]

2.2.4.1 Army Mission

The role of the Army is to preserve the peace and security, and provide for the defense of the U.S., territories, commonwealths, possessions, and any areas occupied by the U.S. The Army has land and aviation combat forces, augmented, in part, by waterborne transport vessels. Army vessels are used primarily for ship to shore transfer of equipment, cargo, and personnel.

2.2.4.2 Army Vessel Description

The Army's fleet is divided into three sections: the Transportation Corps, the Intelligence and Security (I&S) Command, and the Corps of Engineers (COE). The COE operates survey and construction craft, tugs, barges, and other utility craft. COE boats and craft are not covered by UNDS as described in section 2.2.7.1.

The Army Transportation Corps operates lighterage and floating utility vessels. Lighterage are craft used to transport equipment, cargo, and personnel between ships, from ship-to-shore, and for operational mission support, and include logistics support vessels, landing craft, and modular powered causeway ferries. Floating utility craft are used to perform port terminal operations and include ocean and harbor tugs, floating cranes, barges, and floating causeways. Army Transportation Corps vessels operate primarily within 12 n.m., with the exception of the LSV, LCU-2000, and the LT-28, which are ocean-going.

Army I&S vessels are aerostat radar-equipped patrol ships operated in the Caribbean Sea to counter illegal drug flights. The patrol ships operate within 12 n.m. during transit in and out of port, but most often operate outside of 12 n.m. Table 2-5 summarizes Army vessel characteristics including length, displacement, and mission for each vessel classification.

Table 2-5. Army Vessel Classification[4, 8]

Vessel Type	Vessel Classification	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Lighterage	LSV	6	273	4,199	Transport equipment, cargo, and personnel between ships, from ship to shore, or for operational mission support
	LCU-2000	35	174	1,087	
	LCU -1600	13	135	390	
	LCM-8	104	74	111	
	CF	1	--	--	
Floating Utility	BC	37	120	760	Perform port terminal operations
	BD	10	140	1630	
	BG	8	120	763	
	BK	7	45	33	
	CHI	1	25	--	
	FB	2	75	64	
	HF	1	65	--	
	J-Boat	4	46	12	
	LT-128	6	128	1,057	
	LT-100	16	107	390	
	PB	10	25	--	
	Q-Boat	1	65	37	
	SLWT	4	--	--	
	ST-65	11	71	122	
	ST-45	2	45	29	
	T-Boat	1	65	--	
	Workboats	47	--	--	
Patrol Ships	ABT	7	190-194	1500-1,900	Perform drug interdiction in the Caribbean Sea
TOTAL	Vessels =	334			

2.2.5 Vessels of the U.S. Marine Corps[1,11]

2.2.5.1 Marine Corps Mission

As part of the Department of the Navy and in conjunction with the other Armed Forces, the Marine Corps develops the tactics, techniques, and equipment necessary to employ forces onto land from the sea.

2.2.5.2 Marine Corps Vessel Description

The Marine Corps operates a large number of watercraft and amphibious craft used during special operations. Assets that are primarily land-operated vehicles, such as the amphibious assault vehicles (AAVs), are not included under UNDS. The watercraft consist of inflatable combat rubber raiding craft (CRRC) and fiberglass rigid raiding craft (RRC). The CRRCs are used for in-port, river, lake, and coastal operations, and can be transported to the combat area by nearly all of the Navy's vessels. The RRCs are normally deployed aboard Navy transport dock ships (i.e., LPDs) for transport to the combat area. The CRRCs and RRCs operate exclusively in coastal waters. Table 2-6 summarizes Marine Corps vessel characteristics including length, weight, and mission for each vessel classification.

Table 2-6. Marine Corps Vessel Classification

Vessel Type	Description	Number Active	Class Length (ft)	Weight (lbs)	Mission
RRC	Rigid Raiding Craft	120	18	--	Perform offensive amphibious operations
CRRC	Zodiak (replacing RRCs)	418	15	265 (without the engine)	
TOTAL	Vessels =	538			

2.2.6 Vessels of the U.S. Air Force[1]

2.2.6.1 Air Force Mission

The U.S. Air Force defends the U.S. through control and exploitation of air and space. The Air Force provides land and space-based air forces needed to establish air support for ground forces in combat and the primary airlift capability for use by all of the nation's military services. The Air Force operates vessels to support this mission.

2.2.6.2 Air Force Vessel Description

Missile retrievers (MRs) are aluminum vessels used for the location and recovery of practice missiles. MRs range in length from 65 to 120 feet. These vessels primarily operate within 12 n.m.

Floating utility vessels provide logistics support for Air Force operations and include utility boats (U), training and recovery boats (TR), and personnel boats (P) ranging in length from 17 to 40 feet. These vessels operate almost entirely within 12 n.m. Table 2-7 summarizes Air Force vessel characteristics including length, displacement, and mission for each vessel classification.

Table 2-7. Air Force Vessel Classification

Vessel Type	Vessel Classification	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
Missile Retrievers	MR	5	65-120	90-133	Locate and recover practice missiles
Floating Utility	U	27	17-33	--	Used for personnel and utility transport, training, and repair operations
	TR	2	21-25	--	
	P	2	22-40	--	
TOTAL	Vessels =	36			

2.2.7 Vessels Not Covered by UNDS

UNDS applies only to Armed Forces vessels. UNDS does not apply to commercial vessels; privately owned vessels; vessels owned or operated by State, local, or tribal governments; or vessels owned or operated by Federal agencies that are not part of the Armed Forces. In addition, several other categories of vessels are not covered by UNDS, including: 1) vessels under the jurisdiction of the Army COE; 2) vessels, other than those of the Coast Guard, under the jurisdiction of the DOT (e.g., MARAD vessels); 3) vessels preserved as memorials and museums; 4) time- and voyage- chartered vessels; 5) vessels under construction; 6) vessels in drydock; and 7) amphibious vehicles. These vessels are discussed below.

2.2.7.1 Army Corps of Engineers Vessels

Army Corps of Engineers vessels are typically used for civil works purposes. Congress has consistently addressed the Army Corps of Engineers separately from other parts of the DoD in both authorization and appropriations bills.[12] The DoD and EPA do not consider that Congress intended to apply UNDS to Army Corps of Engineers vessels. Therefore, vessels of the Army Corps of Engineers are not covered by UNDS.

2.2.7.2 Maritime Administration Vessels

A number of vessels are operated or maintained by the Maritime Administration (MARAD), which is a part of the DOT. As established in § 312(a)(14) of the CWA, the definition of “vessel of the Armed Forces” includes those DOT vessels that are designated by the Secretary of the department in which the U.S. Coast Guard is operating (currently the DOT) as operating as a vessel equivalent to a DoD vessel. The Secretary of Transportation has determined that MARAD vessels, including the National Defense Reserve Fleet, do not operate equivalently to DoD vessels, and therefore, MARAD vessels are not covered by UNDS.[13]

2.2.7.3 Vessels Preserved as Memorials and Museums

Ships and submarines preserved as memorials and museums once served a military mission. However, with the exception of one submarine, these vessels are no longer owned or operated by the Armed Forces, and therefore, they are not vessels of the Armed Forces, and UNDS does not apply to them. The Navy owns and operates the submarine Nautilus as a museum; however, the vessel is stationary and its systems are not routinely operated. Therefore, the EPA and DoD have excluded this vessel from the scope of UNDS.

2.2.7.4 Time- and Voyage-Chartered Vessels

Section 312(a)(14) of the CWA specifically excludes time- and voyage-chartered vessels from the definition of "vessels of the Armed Forces." Time- and voyage-chartered vessels are vessels operating under a contract between the vessel owner and a charterer (in this case, the Armed Forces) whereby the charterer hires the vessel for a specified time period or voyage, respectively. Such vessels at all times remain manned and navigated by the owner, and they are not owned and operated by the Armed Forces. Examples of chartered vessels are those operated by the MSC in the APF and the Strategic Sealift Program.

2.2.7.5 Vessels Under Construction

EPA and DoD do not consider a vessel under construction for the DoD or Coast Guard, and for which the Federal government has not taken custody, to be a "vessel of the Armed Forces." Therefore, UNDS does not apply to these vessels until the Federal government gains custody.

2.2.7.6 Vessels in Drydock

The statutory definition of "discharge incidental to the normal operation of a vessel" includes incidental discharges whenever the vessel is waterborne. See CWA § 312(a)(12). UNDS does not apply to discharges from vessels while they are in drydock (either land-based or floating) because they are not waterborne, even if the discharges would otherwise meet the definition of a "discharge incidental to the normal operation of a vessel."

2.2.7.7 Amphibious Vehicles

EPA and DoD do not consider amphibious vehicles as vessels for the purposes of UNDS because they are operated primarily as vehicles on land. Water use of these vehicles is of short duration for near-shore transit to and from vessels.

2.3 Locations of Armed Forces Vessels

2.3.1 Homeports

Homeports are the bases from which vessels perform the majority of their operations that occur within 12 n.m. of shore, and thus give an indication of the zones where most vessel discharges occur. The sizes and locations of Armed Forces homeports vary with the mission of the vessels they service. Homeports provide pierside services (e.g., potable water, sewage and trash disposal, and electrical power), supplies (e.g., repair parts, cleaning materials, and food); and maintenance and repair functions (e.g., drydock, afloat, and shoreside services).

2.3.1.1 Navy Ports

Norfolk, VA; San Diego, CA; Mayport, FL; Puget Sound, WA; and Pearl Harbor, HI are the five largest Navy ports based on the number of ships serviced. In addition to these five ports, the Navy has many comparably sized and smaller ports throughout the U.S. UNDS evaluations pertain to all U.S. ports, and are not limited to those mentioned above. Figure 2-1 shows the location of homeports for Navy surface ships and submarines only, and the approximate vessel distribution. Inactive vessels and vessels ported outside of the U.S. (e.g., in Japan or Bahrain) are not shown, nor is the distribution of small boats and craft. Small boats and craft are widely distributed with heavy concentrations near San Diego and Norfolk.

2.3.1.2 Coast Guard Ports

Coast Guard duty stations are found on coastal waters, as well as on rivers, lakes, and other inland waterways throughout the U.S. Figure 2-2 shows the Coast Guard homeport locations having three or more vessels that are 65 feet or greater in length. Using the number of large vessels as an indication of base size, the largest Coast Guard bases are located in Portsmouth, VA; Honolulu, HI; Boston, MA; Charleston, SC; Alameda, CA; Galveston, TX; Seattle, WA; and St. Petersburg, FL. Some of the mid-sized bases are located in Corpus Christi, TX; Key West, FL; Roosevelt Roads, PR; and Miami Beach, FL. There is a ship repair and overhaul facility in Baltimore, MD. Ship repair and overhaul is usually done at a commercial facility near the homeport of the vessel.

2.3.1.3 Army Ports

The Army has one major active-component port facility at Fort Eustis near Newport News, VA. In addition, smaller active and reserve-component port facilities are located in Accotink, VA; Baltimore, MD; Cieba, PR; Edgewood, MD; Ford Island, HI; Morehead City, NC; Oakland, CA; Palakta, FL; St. Petersburg, FL; Stockton, CA; Tacoma, WA; and Virginia Beach, VA. Repair, overhaul, and planned maintenance is performed at commercial shipyards located near the homeport of the vessel.

2.3.1.4 Military Sealift Command, Marine Corps, and Air Force Port Usage

The Military Sealift Command makes use of Navy ports, as available, and commercial ports at all other times. The Marine Corps and Air Force make use of local port facilities, since they operate no major port facilities of their own. Air Force floating utility vessel locations include Alamogordo, NM; Cape Canaveral, FL; Fayetteville, NC; Goldsboro, NC; Langley, VA; Las Vegas, NV; Melbourne, FL; and Pensacola, FL. Air Force missile retrievers are located at Panama City, FL; Key West, FL; and Carrabelle, FL.

2.3.2 Operation within Navigable Waters of the U.S. and the Contiguous Zone

UNDS applies to discharges from Armed Forces vessels in the navigable waters of the U.S. and the contiguous zone. As defined in the CWA (§ 502(7)), the term “navigable waters” means waters of the U.S., including the Great Lakes, and includes waters seaward from the coastline to a distance of 3 nautical miles from the shore of the States, District of Columbia, Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Canal Zone, and the Trust Territories of the Pacific Islands. The contiguous zone extends from 3 nautical miles to 12 nautical miles from the coastline. Discharges that occur within this zone that extends 12 n.m. from shore are addressed in following chapters. UNDS is not enforceable beyond the contiguous zone.

The amount of time each vessel spends in its homeport varies based on factors such as vessel class, command, assignment/demand, and budget. For the purposes of UNDS, the DoD estimated the amount of time spent each year in waters subject to UNDS requirements for each vessel type, as discussed below.

Ocean-going vessels operate inside 12 n.m. while transiting in and out of port. Periodically, they may also be used for mission or training exercises within this zone. Service craft and small boats operate far more frequently near the homeport and within 12 n.m. These vessels may be stowed aboard ships while in transit to operational areas. When in port, small boats and craft are often removed from the water until the next required use.

The DoD and EPA used five years of Navy, Coast Guard, and MSC vessel movement data to support the estimation of time spent within 12 n.m..[14] From this operational data, the average number of port entries, port exits, and days spent in port was determined for most vessel classes.

The DoD data on ship movement was originally organized as a series of trips from one point to another for each ship. Each record contained a succeeding trip leg. For example, if a ship went from Norfolk to Mayport, it may have been reported as a single trip with the date and time of departure from Norfolk recorded as the departure, and the date and time it arrived in Mayport as the arrival. It may also have been reported as a series of trips from Norfolk to some latitude/longitude pair in the Atlantic, from that latitude/longitude to another, from the second latitude/longitude to a third, etc., with the last entry being a trip from the last latitude/longitude to

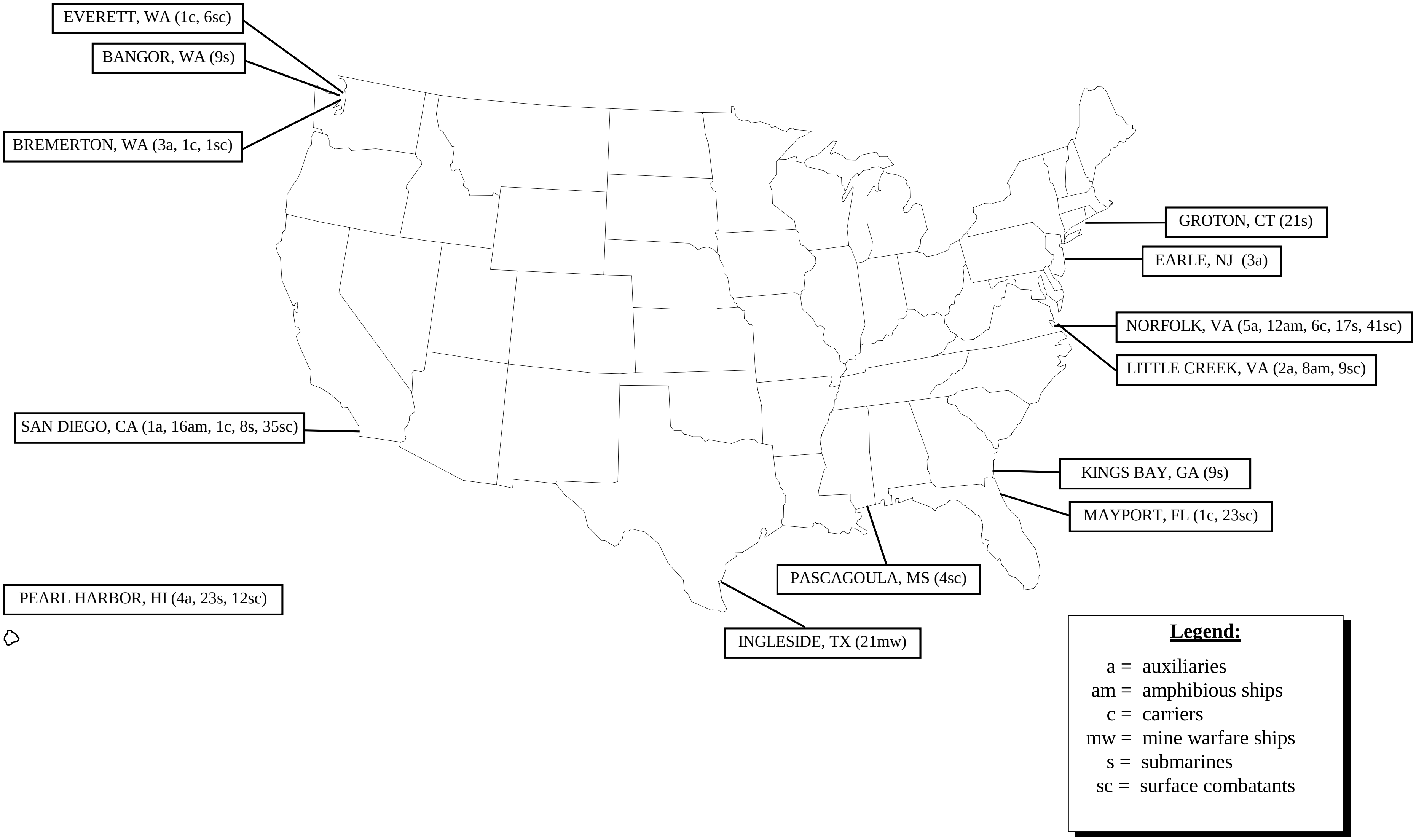

Figure 2-1. Largest Navy Surface Ship and Submarine Homeports

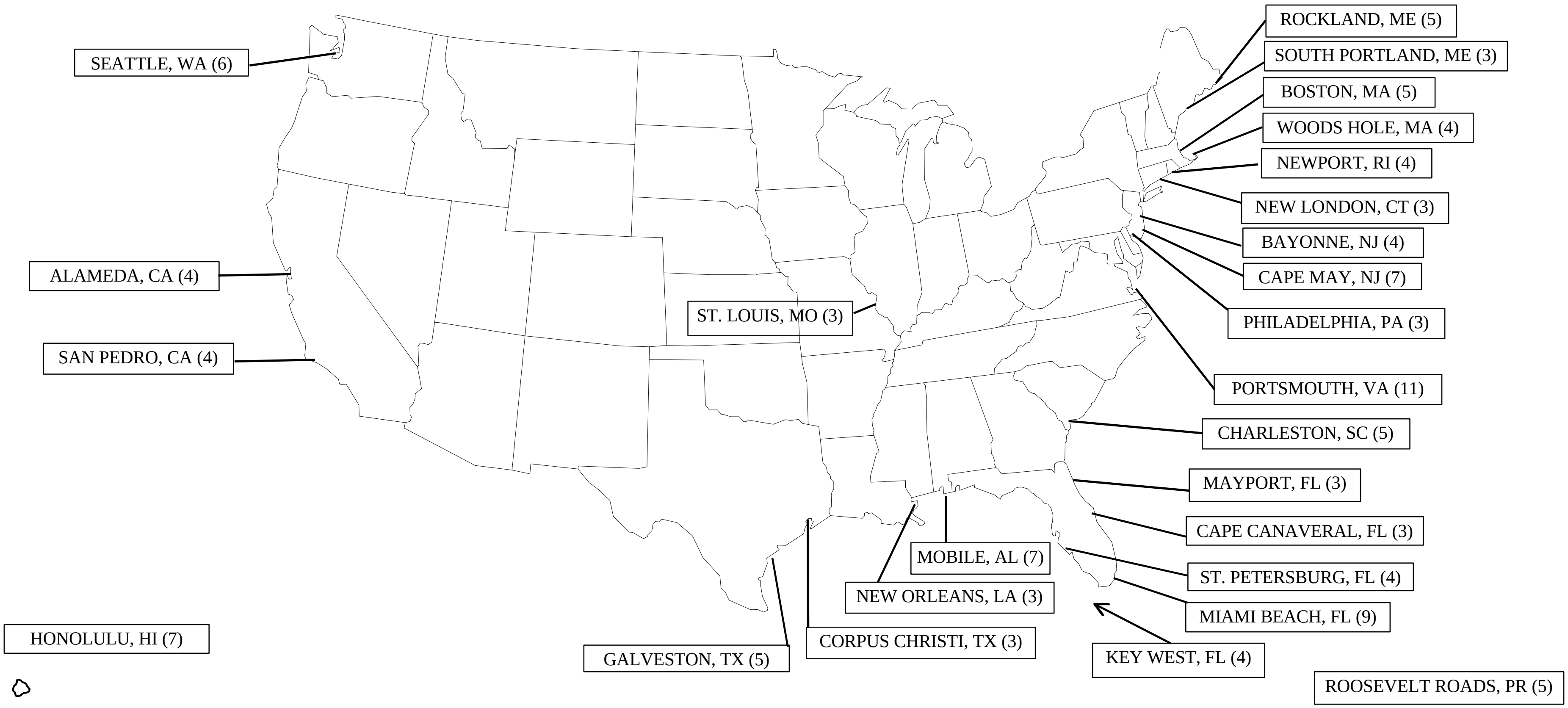

Figure 2-2. Coast Guard Ports with Three or More Vessels Equal to or Longer than 65 Feet

Mayport. Each of the legs of the journey was recorded as a separate record. All of one ship's trips for the given year (1991, 1992, 1993, 1994, or 1995) were recorded in succession, before going on to the next ship. Since the records were in order, it was obvious if there were missing entries in the data. A missing entry consisted of a ship arriving at a location in one record, and then departing from a different location in the next record.

The first step was to translate the data from the format received into a format that was usable for the purposes of UNDS. For the purposes of UNDS, it was more useful to know when the ship arrived at and departed from a specific location (i.e., a U.S. port), as opposed to looking at individual trip legs. Therefore, the DoD created a simplified database that was obtained by taking the arrival location and time from one record, and the departure time and location from the next. At this point, the data was filtered to exclude data where the location began with a latitude/longitude pair, and where the arrival location and departure location were not the same (i.e., a missing entry).

The UNDS program only used the ship/year data from ships where complete data was available for the entire year. If there was a complete record of where that ship was for the entire year, the number of days that that ship spent in U.S. ports that year, and the number of times it transited into and out of any U.S. port that year were recorded. The number of transits and days in port were totaled for every ship in the class, and that total was divided by the number of ship-years compiled in order to derive averages for that ship class. These final numbers can be interpreted as the number of transits into and out of U.S. ports and the number of days spent in U.S. ports for a typical ship of that class.

These numbers vary widely between ship classes due to differing missions, operational schedules, maintenance, etc.. For instance, a typical DDG 51 Class destroyer averages 101 days per year in port with 11 transits in and out, compared to a typical ARS 50 Class salvage ship which may spend an average of 208 days per year in port with 22 transits. The number of days spent in port and the number of transits per year can vary significantly for the same vessel in different years due to varying operational and maintenance schedules. For example, the aircraft carrier CVN 68 spent 10 days in port with two transits in 1995, compared to 237 days in port and nine transits in 1992. For non-self-propelled vessels (e.g., barges, cranes, and dry dock companion craft) or harbor-oriented vessels (e.g., harbor utility craft, dredges, and harbor tugs), it was assumed that the vessels operate within 12 n.m. from shore for the entire year.

By multiplying these typical numbers of days in port and number of transits by the number of ships in that ship class in service in any given year, a reasonable approximation of the total number of days spent in U.S. ports and the total number of transits into and out of U.S. ports for all ships in that class during the year in question was calculated. These values were then used in combination with pollutant concentration data to calculate mass loadings for vessel discharges.

Based on Navy and Coast Guard operational experience, four hours are typically required for each one-way transit between port and 12 n.m. (The estimated vessel transit time from shore to 3 n.m. is approximately 2-3 hours for most locations. A vessel typically requires one additional hour in order to traverse to 12 n.m. from 3 n.m.) Significantly longer transits, such as

11 hours to travel 12 n.m. offshore from Puget Sound can occur, but are atypical. Ten hours may be required in Puget Sound to travel 3 n.m. from the overall shoreline because the port is located in an inlet at the southern end of the Sound, requiring travel through both the Sound and the Straits of Juan de Fuca. This creates a transit distance that is actually greater than 3 n.m. when measured from the port itself.

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3. DATA COLLECTION

This chapter describes the efforts that were made to obtain information on the UNDS discharges. An overview of the information collection effort is presented in section 3.1; the surveys issued to gather discharge information are described in section 3.2 along with the list of incidental discharges from Armed Forces vessels that resulted; the consultations with personnel having discharge expertise to review information and identify data gaps are described in section 3.3; section 3.4 describes the consultation and outreach efforts with organizations outside DoD; section 3.5 discusses the approach to discharge sampling and analysis; and section 3.6 lists the references cited in Chapter 3.

3.1 Introduction

Section 312(n)(2)(B) of the CWA lists seven factors to consider when determining if a vessel discharge should be controlled by a MPCD (see section 1.3). One of these factors is the "nature of the discharge." To comprehensively consider this factor as well as the other six factors, EPA and DoD jointly established an UNDS Technical Working Group (TWG) composed of representatives from EPA and the Armed Forces. The TWG gathered and analyzed technical data to identify: 1) the universe of Armed Forces vessels subject to UNDS requirements (described in chapter 2); 2) the characteristics of the vessel discharges, including sources, frequencies, amounts, and specific constituents; 3) relevant U.S. laws, regulations, and international standards that limit or otherwise set standards on the amount of contamination allowed in the discharges; and 4) any controls that are currently in place.

Initial requests were made to each branch of the Armed Forces for discharge information and for information that would allow a list of vessels subject to UNDS requirements to be compiled. Personnel within and outside DoD with specific discharge expertise were consulted to help identify additional available data and data gaps. Where needed, sampling data were collected from various Armed Forces vessels to supplement existing data. The methods that were used to collect discharge information are discussed in the following sections.

3.2 Surveys

Survey questionnaires were issued in 1996 by the Navy to obtain information about vessel discharges and to provide a broad basis for subsequent technical efforts. As part of these surveys, a memorandum was distributed to the Navy's technical community, including Navy fleet commands, subcommands, shore installations, and shipboard operators; other branches of the Armed Forces; and to all other organizations that are represented on the TWG.[1] The memorandum provided background on the UNDS development effort, an explanation of the UNDS scope and approach, and two enclosures. The first enclosure was a report entitled *U.S. Navy Ship Wastewater Discharges*,[2] which provided those surveyed with findings from previous Navy-sponsored efforts on vessel wastewater identification, characterization, and quantification. The second enclosure was a survey entitled *Equipment/System Discharge Stream Questionnaire*.[3] This questionnaire sought information about vessel discharges such as: system description, how the discharge is generated and released (if applicable), time and location of the discharge, discharge volume, discharge constituents and their concentrations, contributing vessel classes and number of vessels, applicable regulations, currently employed control devices and/or management practices, and any reports or documentation available that were pertinent to the system or the discharge. Survey recipients were requested to review the report, provide comments on its contents, and respond to the questionnaire.

In addition to information from the surveys, information was also obtained during pre-sampling "ship checks" (i.e., vessel inspections) and during other scheduled visits to vessels. During these checks and visits, additional information was often obtained by directly observing discharges and by talking with the ship's crew.

3.3 Consultations with Department of Defense Personnel Having Equipment Expertise

The survey responses helped identify incidental vessel discharges and their characteristics. However, the survey responses did not, in all cases, provide sufficient understanding of the discharges to make well-supported Phase I decisions. Therefore, the Navy and EPA met with vessel discharge experts from the government and the private sector (as consultants to the Navy), including engineers, field-activity representatives, and Navy laboratory personnel. The objective of these consultations was to obtain information that was not obtained from the survey responses, such as:

- system equipment design, operation, and maintenance practices;
- discharge volume and composition;
- the numbers and types of vessels producing the discharge; and
- existing engineering and environmental analysis reports for the discharge including available sampling data.

In addition, these meetings provided information beyond the scope of the surveys, such as:

- potential MPCD options for controlling the discharge;
- ongoing research and development efforts; and
- information useful for assessing the practicability of implementing various MPCD options.

The information that was gathered during the numerous consultations on large-vessel systems (i.e., ships and submarines) was supplemented with information on discharges from small Navy watercraft during a meeting with the Navy's small boat group in Norfolk, Virginia. Meetings were also held with Army representatives from the U.S. Army Tank-Automotive and Armaments Command (TACOM) in Warren, Michigan and from the 7^{th} Transportation Group at Fort Eustis, VA to review Army watercraft systems, operations, and discharges.

After the survey responses and information obtained during ship checks were analyzed, DoD and EPA developed a list of 39 types of discharges incidental to the normal operation of Armed Forces vessels. These discharges are listed in Table 3-1.

Table 3-1. Incidental Discharges from Vessels of the Armed Forces

- Aqueous Film-Forming Foam
- Boiler Blowdown
- Catapult Water Brake Tank and Post-Launch Retraction Exhaust
- Catapult Wet Accumulator Discharge
- Cathodic Protection
- Chain Locker Effluent
- Clean Ballast
- Compensated Fuel Ballast
- Controllable Pitch Propeller Hydraulic Fluid
- Deck Runoff
- Dirty Ballast
- Distillation and Reverse Osmosis Brine
- Elevator Pit Effluent
- Gas Turbine Water Wash
- Graywater
- Hull Coating Leachate
- Firemain Systems
- Freshwater Lay-Up
- Mine Countermeasures Equipment Lubrication
- Motor Gasoline Compensating Discharge
- Non-Oily Machinery Wastewater
- Photographic Laboratory Drains
- Portable Damage Control Drain Pump Discharge
- Portable Damage Control Drain Pump Wet Exhaust
- Refrigeration/Air Conditioning Condensate
- Rudder Bearing Lubrication
- Seawater Cooling Overboard Discharge
- Seawater Piping Biofouling Prevention
- Small Boat Engine Wet Exhaust
- Sonar Dome Discharge
- Steam Condensate
- Stern Tube Seals and Underwater Bearing Lubrication
- Submarine Acoustic Countermeasures Launcher Discharge
- Submarine Bilgewater
- Submarine Emergency Diesel Engine Wet Exhaust
- Submarine Outboard Equipment Grease and External Hydraulics
- Surface Vessel Bilgewater/Oil-Water Separator Discharge
- Underwater Ship Husbandry
- Welldeck Discharges

3.4 Consultation and Outreach Outside the Department of Defense

During Phase I of UNDS, DoD and EPA consulted with other interested Federal agencies, States, and environmental organizations. Other Federal agencies that have been involved in UNDS development include the Coast Guard for DOT; the Department of State; and the National Oceanic and Atmospheric Administration for the Department of Commerce. The Coast Guard has been involved in all aspects of UNDS development. The other agencies have participated with DoD, EPA, and the Coast Guard as members of the UNDS Executive Steering Committee

(ESC), which is responsible for UNDS policy development and is composed of senior-level managers. Separately, DoD and EPA provided an overview of the Phase I process and results to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Two mechanisms were used to consult with States. First, a representative from the Environmental Council of the States (ECOS) participates in UNDS ESC meetings. ECOS is the national association of State and territorial environmental commissioners and was established, in part, to provide State positions on environmental issues to EPA. Second, representatives from the Navy (as the lead for DoD), EPA, and the Coast Guard met at least once, and in most cases twice, with each State interested in UNDS development. The states agreeing to these meetings were predominantly those with significant numbers of Navy or Coast Guard vessels.

3.4.1 Initial State Consultation Meetings

In early 1996, the Navy and EPA invited States with a DoD or Coast Guard vessel presence to participate in an initial round of consultation meetings. Of the approximately 40 States invited, 21 requested a meeting. These initial State consultation meetings were held between August and December 1996. State environmental regulatory authorities hosted each meeting, which consisted of a Navy/EPA briefing on UNDS activities and an opportunity to discuss State-specific issues. A Coast Guard representative was present at each meeting to address discharges from Coast Guard vessels. The Navy/EPA briefing summarized the UNDS legislative history and requirements, considerations for evaluating discharges, the technical approach for determining which discharges require control, an overview of the vessels to which UNDS is applicable, and the roles of DoD and EPA in the rulemaking process. The States that participated in the first round of State meetings are listed in Table 3-2. The minutes from these meetings are compiled in the *Uniform National Discharge Standards State Consultation Meetings (Round #1) Compendium of Minutes*.[4]

Table 3-2. States Involved in Initial Consultation Meetings

• Alaska	• Illinois	• Nevada
• California	• Indiana	• New York
• Connecticut	• Kentucky	• North Carolina
• Delaware	• Louisiana	• Rhode Island
• Florida	• Maryland	• South Carolina
• Georgia	• Michigan	• Virginia
• Hawaii	• Mississippi	• Washington

3.4.2 Second Round of State Consultation Meetings

The Navy and EPA held a second round of State consultation meetings from October 1997 through January 1998. Of the 22 States consulted during the second round of meetings, five had not been briefed initially. The second round of consultation meetings provided Navy and EPA an opportunity to summarize the activities that had taken place since the initial round of consultation meetings. This included discussing the 39 types of vessel discharges that were identified and the preliminary decisions regarding which of the discharges would be proposed to require control. States were given information on the equipment or process generating the discharges, the locations where the discharges occur, vessels producing the discharges, the preliminary results of environmental effects screenings, and the preliminary conclusions of whether MPCDs would be required. States were generally supportive of the UNDS effort. States most commonly expressed interest in matters related to the implementation of UNDS regulations, including enforcement and procedures for establishing no-discharge zones; the relationship between UNDS and other State programs; which vessels are subject to UNDS; and potential MPCD options. States that participated in the second round of consultation meetings are identified in Table 3-3. The minutes from these meetings are compiled in the *Uniform National Discharge Standards State Consultation Meetings (Round #2) Compendium of Minutes*.[5]

Table 3-3. States Involved in the Second Round of Consultation Meetings

• Alaska	• Louisiana	• North Carolina
• California	• Maryland	• Oregon
• Connecticut	• Massachusetts	• Rhode Island
• Florida	• Michigan	• Texas
• Georgia	• Mississippi	• Virginia
• Hawaii	• New Hampshire	• Washington
• Indiana	• New Jersey	
• Kentucky	• New York	

Separately, city representatives from Portland, OR requested a briefing on UNDS activities. In February 1998, the Navy, EPA, and Coast Guard provided an overview of UNDS to city representatives. This meeting is summarized in the *Uniform National Discharge Standards State Consultation Meetings (Round #2) Compendium of Minutes*.[5]

3.4.3 Consultation with Environmental Organizations

In addition to State meetings, the Navy, EPA, and Coast Guard met with environmental organizations to provide an overview of UNDS and the preliminary results of the first phase of the UNDS regulatory development process. These meetings were held in December 1997 and May 1998 and are summarized in the *Uniform National Discharge Standards State Consultation Meetings (Round #2) Compendium of Minutes*.[5]

3.4.4 UNDS Newsletter and Homepage

To provide a continuous source of information on UNDS and as a way to receive information relative to UNDS, the Navy and EPA publish a newsletter and an Internet web site.

The newsletter contains feature articles on UNDS-related subjects (e.g., nonindigenous species, Navy research and development programs, etc.), provides answers to frequently asked questions, and provides an update on recent progress and upcoming events. The newsletter is mailed to State and environmental group representatives, Armed Forces and EPA contacts, and interested members of the general public. Approximately 360 newsletters are distributed, approximately 200 of which are distributed outside the EPA, DoD, and their contractor's organizations. Electronic copies of the newsletter are available for downloading from the UNDS Internet site (http://206.5.146.100/n45/doc/unds/unds.html). In addition to providing an electronic version of the newsletter, the Internet site provides UNDS legislative information, a summary of the technical and management approach to used to develop the rule, and a description of the benefits expected to result from UNDS. Both the newsletter and the Internet site provide points of contact for obtaining information on UNDS.

3.5 Sampling and Analysis

3.5.1 Approach to Identifying Discharges Requiring Sampling

The available information for each discharge was evaluated to determine if additional data were necessary to adequately evaluate potential environmental effects. Sampling was not required for discharges where existing information was sufficient to characterize the nature of the discharge and to assess potential environmental impacts, if any. Nine of the 39 types of discharges required additional information and were sampled.[6,7] Table 3-4 lists these discharges.

Table 3-4. Discharges Sampled During Phase 1 of UNDS

- Boiler Blowdown
- Compensating Fuel Ballast
- Distillation and Reverse Osmosis Brine
- Firemain Systems
- Freshwater Lay-Up
- Non-Oily Machinery Wastewater
- Seawater Cooling Overboard Discharge
- Steam Condensate
- Surface Vessel Bilgewater/Oil-Water Separator Discharge

3.5.2 Approach to Determining Analytes

To determine which constituents to analyze for in the nine sampled discharges, a comprehensive list of approximately 450 candidate analytes was considered, including the "priority pollutants" referenced in § 307(a) of the CWA. Analyses for constituents or analytical groups were not performed if it was evident that these constituents or groups could not be present based on process knowledge. A sampling rationale document was prepared to describe the reasons for excluding analytes from analysis on a discharge-by-discharge basis.[6,7] Table 3-5 shows the categories of analytes that were analyzed in each of the nine sampled discharges.

Table 3-5. Type of Analysis According to Discharge

Discharge	Classicals	VOCs	SVOCs	Metals	Pesticides	PCBs	Mercury	Hydrazine
Boiler Blowdown	x		x	x		x		x
Compensated Fuel Ballast	x	x	x	x			x	x
Distillation and Reverse Osmosis Brine	x		x	x				
Firemain Systems	x		x	x		x		
Freshwater Lay-Up	x		x	x		x		
Non-Oily Machinery Wastewater	x	x	x	x		x	x	
Seawater Cooling Overboard Discharge	x		x	x		x		
Steam Condensate	x		x	x				
Surface Vessel Bilgewater/ Oil Water Separator Discharge	x	x	x	x	x	x	x	x

Notes:
x = constituents analyzed for, but not necessarily detected.
Classicals: Includes analytes such as total dissolved solids (TDS) and total suspended solids (TSS), as well as other classical analytes listed in Table 3-8.
PCBs: polychlorinated biphenyls
VOCs: volatile organic compounds
SVOCs: semi-volatile organic compounds

3.5.3 Shipboard Sampling

For the purpose of UNDS Phase I, samples were collected from ten vessels representing a total of six Navy, Coast Guard, and MSC vessel types. The Navy vessels that were sampled included an aircraft carrier, three surface combatants, two amphibious ships, and a submarine. A Coast Guard cutter and two MSC oilers, which are Naval Fleet Auxiliary Support Force vessels used for fuel transport, were also sampled. The discharges that were sampled on each vessel are presented in Table 3-6. The reasoning for sampling specific discharges on certain vessel classes is contained in the sampling rationale document.[6,7] In addition, the sampling procedures for eight of the ten vessels are presented in sampling and analysis plans (SSAP) prepared for each vessel.[8-15] SSAPs were not prepared for the *USS Mitscher* or the *USNS Big Horne* because they are the same class of vessel as the *USS Arleigh Burke* and the *USNS Laramie*, respectively. Therefore, the SSAPs for the *USS Arleigh Burke* and the *USNS Laramie* were used when sampling the *USS Mitscher* and the *USNS Big Horne*, respectively. The details of each sampling event are documented in a separate volume of the *UNDS Phase I Sampling Episode Report*, which contains the sampling analytical results and discusses any deviations from the SSAPs.[16] The laboratory methods used to analyze the samples are listed in Tables 3-7 and 3-8.

3.5.4 Quality Assurance/Quality Control and Data Validation Procedures

EPA-approved quality assurance/quality control (QA/QC) and data validation procedures were used throughout the sample collection and sample analysis activities during Phase I of UNDS. The field and analytical QA/QC procedures are described in detail in SSAPs[8-15] and the *UNDS Phase I Sampling Episode Report*.[16] During sample collection in the field, trip and equipment blanks were collected as well as field duplicate samples. Analytical QA/QC included analysis of blanks, matrix spikes, and samples. The analyses followed the QA/QC requirements specified in the analytical methods listed in Tables 3-7 and 3-8.

In addition, the analytical results were validated according to standard EPA procedures. The purpose of the data validation was to detect and then verify any data values that may not reflect actual sample constituents and concentrations. The data validation step was conducted to identify data errors, biases, and outlying data so that such values would not be used when making Phase I decisions.

Table 3-6. Discharges Sampled by Ship

Discharge	***USS John C.***		**Amphibious Assault Ship (LHD)** ***USS Wasp***	**Cruiser (CG)** ***USS Anzio***	**Cutter (WHEC)** ***USCG Dallas***	**Dock Landing Ship (LSD)** ***USS Oak Hill***	**Attack Submarine (SSN)** ***USS Scranton***	**Oilers (T-AO)** ***USNS Laramie*** ***USNS Big Horne***
Boiler Blowdown			x	x	x	x		x
Compensated Fuel Ballast		x						
Distillation and Reverse Osmosis Brine	x		x			x		
Firemain Discharge	x		x			x		
Freshwater Lay-Up							x	
Non-Oily Machinery Wastewater	x	x	x			x		
Seawater Cooling Overboard Discharge	x	x	x		x	x		x
Steam Condensate			x	x		x		x
Surface Vessel Bilgewater / Oil-Water Separator Discharge	x							

Table 3-7. Analytes and Analytical Methods

Target Analytes	Analytical Method
Classicals	see Table 3-8
Volatile Organic Compounds (VOC)	EPA Method 1624
Semi-Volatile Organic Compounds (SVOC)	EPA Method 1625
Metals	EPA Method 1620
Pesticides, Polychlorinated Biphenyls (PCBs)	EPA Method 1656, 1657, 1658, 1660
Mercury	EPA Method 1631
Hydrazine	American Society for Testing and Materials (ASTM) D1385-88

Table 3-8. Classical Analytes and Methods

Target Chemical/Analyte	Analytical Method
Ammonia as Nitrogen (NH_3 - N)	EPA 350
Total Kjeldahl Nitrogen (TKN)	EPA 351
Nitrate/Nitrite (NO_2/NO_3)	EPA 353
Total Phosphorus	EPA 365
Total Suspended Solids (TSS)	EPA 160.2
Biochemical Oxygen Demand (BOD_5)	EPA 405.1
Total Organic Carbon (TOC)	EPA 415.1
Chemical Oxygen Demand (COD)	EPA 410.4
Total Dissolved Solids (TDS)	EPA 160.1
Total Volatile Solids (TVS)	EPA 160.4
Total Petroleum Hydrocarbons (TPH)	EPA 1664
Oil and Grease	EPA 1664/ modified EPA 418.2
Cyanide	EPA 335
Chlorine	DPD* [17]
Alkalinity	EPA 310
Sulfate	EPA 375
Sulfide	EPA 376
Chloride	EPA 325.1

Notes:
* DPD: N,N-diethyl-p-phenylene diamine

3.6 References

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4. DISCHARGE EVALUATION METHODOLOGY

4.1 Introduction

The information collected during Phase I from surveys, consultations, and from discharge sampling and analysis was used collectively to evaluate the discharges and to make Phase I decisions according to the seven factors listed in section 1.3. This chapter explains how Phase I decisions were made for the 39 discharge types listed in Table 3-1 (i.e., which discharges need to be controlled by MPCDs and which do not). Section 4.2 describes how the environmental effects screening of the discharges was conducted. Section 4.3 describes the Nature of Discharge (NOD) analysis and the contents of the NOD reports contained in Appendix A. Section 4.4 describes the MPCD practicability, operational feasibility, and cost analysis and the contents of the MPCD reports - also contained in Appendix A. Section 4.5 lists the chapter 4 references.

4.2 Environmental Effects Determination

EPA and DoD assessed the potential environmental effects of the discharges using a screening approach characterized by the following questions concerning their chemical, physical, and biological characteristics:

- **Chemical Constituents**. Does the discharge contain constituents in concentrations that exceed State aquatic water quality criteria or Federal aquatic water quality criteria (as promulgated by EPA in the National Toxics Rule (NTR)[1]) and have the potential to be released into the environment in significant amounts, resulting in a potential adverse impact on the environment?
- **Thermal Pollution**. Does the discharge pose the potential to exceed State thermal water quality criteria in the receiving waters beyond a mixing zone, and to a degree sufficient to have an adverse impact on the environment?
- **Bioaccumulative Chemicals of Concern**. Does the discharge have the potential to contain bioaccumulative chemicals of concern in amounts sufficient to have an adverse impact on the environment?
- **Nonindigenous Species**. Does the discharge have the potential to introduce viable nonindigenous aquatic species to new locations?

If the answer to any of the above questions was "yes," EPA and DoD determined that the discharge had a potential for adverse environmental effect. Each of these factors is discussed below.

4.2.1 Chemical Constituents

EPA and DoD used sampling results or process knowledge to identify the potential presence and concentrations of constituents in the discharge. Constituent concentrations in the discharge were compared to Federal aquatic water quality criteria promulgated by EPA in the National Toxic Rule (NTR)[1] and State aquatic water quality numeric criteria for the ten States with the most significant presence of Armed Forces vessels.[2-11] These ten States are California, Connecticut, Florida, Georgia, Hawaii, Mississippi, New Jersey, Texas, Virginia, and Washington. Constituent concentrations in the discharge were compared against the most stringent of the Federal and ten States' criteria for that constituent. For almost all constituents, the State aquatic water quality criteria are more stringent than the Federal NTR aquatic water quality criteria. EPA and DoD used aquatic water quality criteria in this assessment because they are a measure of the level of water quality that provides for the protection and propagation of aquatic life.

EPA and DoD used saltwater aquatic life criteria for screening the discharges because most Armed Forces vessels operate in the brackish water of estuaries or bays, or in the marine environment off the coast or in open ocean, where the biology of the waterbody is dominated by saltwater aquatic life. In addition, aquatic life criteria were used instead of human health criteria, which are related to consumption of fish and shellfish, because recreational activities such as fishing and swimming generally do not occur in the immediate vicinity of Armed Forces vessels.

Depending on the nature of the discharge, EPA and DoD compared discharge concentrations to either the acute or chronic aquatic water quality criteria values. Where discharges are intermittent or occasional in nature, of relatively short duration (a few seconds to a few hours), and dissipate rapidly in the environment, constituent concentrations were compared to acute aquatic water quality criteria. Where discharges are of a longer duration or continuous and likely to result in concentrations in the environment that approach a steady-state condition, the constituent concentrations were compared to chronic aquatic water quality criteria. Table 4-1 is a list of the most stringent saltwater-based aquatic water quality criteria for the constituents that were either detected in UNDS discharge samples or thought to be present based on engineering knowledge. It contains aquatic water quality criteria for both short-term (acute) and long-term (chronic) exposure published in Federal and State regulations.

Because metals may be present in the discharges in both dissolved and solid forms, the Federal criteria and many States' criteria distinguish between dissolved and "total recoverable" forms. As issued by EPA or a particular State, an aquatic water quality criterion for the dissolved form of a metal is always less than or equal to the criterion for the "total recoverable" form. However, not all States issue criteria for both forms of metal. For metal constituents, the following method was used to compare concentrations in the discharge to aquatic water quality criteria:

- When the form of the metal was known (i.e., either "total recoverable" or "dissolved") as in the nine discharges that were sampled, as well as some of the non-sampled discharges, the measurement of "total recoverable" metal in the discharge was compared to "total recoverable" criteria, and the measurement of "dissolved" metal in the discharge was compared to "dissolved" criteria.

- When the form of the metal was unknown, the metal concentration was compared to the most stringent criteria, whether for "total recoverable" or "dissolved."

Table 4-1. Aquatic Life Water Quality Criteria

Constituent Name	Most Stringent Acute Aquatic Life Water Quality Criterion		Source of Most Stringent Acute Criterion	Most Stringent Chronic Aquatic Life Water Quality Criterion		Source of Most Stringent Chronic Criterion
PRIORITY POLLUTANTS*	**(µg/L)**			**(µg/L)**		
Acenaphthene	320		HI	--------		
Acenaphthylene	0.031	a	FL	0.031	a	FL
Acrolein, 2-Propenal	18		HI	780		GA
Anthracene	110,000		GA	110,000		GA
Antimony	4,300		FL	4,300		FL
Arsenic (Dissolved)	69		EPA, CA, HI, CT	36		EPA, CA, HI, CT
Arsenic (Total)	36		GA, FL	36		GA, FL, WA, MS
Benzene	71.28		FL, GA	71.28		FL, GA
Benzidine	0.000535		GA	0.000535		GA
Benzo(a)anthracene	0.031	a	FL	0.031	a	FL
Benzo(a)pyrene	0.031	a	FL	0.031	a	FL
Benzo(b)fluoranthene	0.031	a	FL	0.031	a	FL
Benzo(g,h,i)perylene	0.031	a	FL	0.031	a	FL
Benzo(k)fluoranthene	0.031	a	FL	0.031	a	FL
Beryllium	0.13		FL	0.13		FL
BHC, alpha- **	0.0131		GA	0.0131		GA
BHC, beta- **	0.046		GA, FL	0.046		GA, FL
BHC, gamma- \ Lindane **	0.0625		GA	0.01		VA
Bis(2-ethylhexyl) phthalate	5.92		GA	5.92		GA
Cadmium (Dissolved)	42		EPA, CA, CT	9.3		EPA, CA, HI, VA, CT, MS
Cadmium (Total)	9.3		GA, FL	8		WA
Chromium (Dissolved)	1,100		EPA & 6 STATES	50		EPA & 6 STATES
Chromium (Total)	50		GA, FL	50		WA, GA, FL
Chrysene	0.031	a	FL	0.031	a	FL
Copper (Dissolved)	2.4		EPA, CT, MS	2.4		EPA, CT, MS
Copper (Total)	2.9		WA	2.9		GA. FL
Cyanide	1		EPA & 9 STATES	1		EPA & 9 STATES
Dibenzo(a,h)anthracene	0.031		FL	0.031		FL
Diethyl phthalate	120,000		GA	120,000		GA
Dimethyl phthalate	2,900,000		GA	2,900,000		GA
Ethylbenzene	140		HI	28,718		GA
Fluoranthene	13		HI	370		GA
Fluorene	14,000		GA	14,000		GA
Heptachlor	0.00021		FL	0.00021		FL
Heptachlor epoxide	0.00011		GA	0.00011		GA
Indeno(1,2,3-cd)pyrene	0.031	a	FL	0.031	a	FL
Lead (Dissolved)	140		HI, TX	5.6		TX
Lead (Total)	5.6		GA, FL	5.6		GA, FL
Mercury ** (Dissolved)	1.8		EPA, CA, CT, MS	0.025		VA
Mercury ** (Total)	0.025		GA, FL	0.025		EPA, WA, GA, CT, MS, FL

Table 4-1. Aquatic Water Quality Criteria (contd.)

Constituent Name	Most Stringent Acute Aquatic Life Water Quality Criterion	Source of Most Stringent Acute Criterion	Most Stringent Chronic Aquatic Life Water Quality Criterion	Source of Most Stringent Chronic Criterion
Naphthalene	780	HI	--------	
Nickel (Dissolved)	74	EPA, CA, CT	8.2	EPA, CA, CT
Nickel (Total)	8.3	GA, FL	7.9	WA
Nitrophenol, 4-	1,600	HI	--------	
Phenanthrene	0.031 a	FL	0.031 a	FL
Phenol	170	HI	58	MS
Pyrene	11,000	GA	11,000	GA
Selenium (Dissolved)	290	EPA, CA, CT	71	EPA, CA, HI, VA, CT, MS
Selenium (Total)	71	GA, FL	71	WA, GA, FL
Silver (Dissolved)	1.9	EPA, CA, MS	--------	
Silver (Total)	1.2	WA	1.2	WA
Thallium	6.3	FL	6.3	FL
Toluene	2,100	HI	200,000	GA
Trichloroethane, 1,1,1-	10,400	HI	--------	
Zinc (Dissolved)	90	EPA, CA, CT, MS	81	EPA, CA, MS
Zinc (Total)	84.6	WA	76.6	WA
NON-PRIORITY POLLUTANTS				
Chlorine (Chlorine Produced Oxidants)	10	FL	7.5	HI, WA, VA, CT, MS, NJ
Oil & Grease	5,000	FL	5,000	FL
Aluminum	1,500	FL	1,500	FL
Ammonia as NH3***	6	HI	6	HI
Bromine	100	FL	100	FL
Chloride	10% > ambient	FL	10% > ambient	FL
Iron	300	FL	300	FL
Nitrate/Nitrite***	8	HI	8	HI
Phosphorus***	25	HI	25	HI
Total Nitrogen***	200	HI	200	HI,
Tributyltin	0.001	VA	0.001	VA

Notes:
* from 40 CFR 136.36
** Denotes bioaccumulative chemicals of concern (40 FR 15366, Table 6A)
*** Nutrient criteria are not specified as either acute or chronic and are, therefore, listed in both columns.
a: Total of acenaphthylene benzo(a)anthrancene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and phenanthrene.

The initial screening process involved comparing the constituent concentrations in the undiluted discharge to the aquatic water quality criteria. For those discharges, such as cathodic protection, where the constituents diffuse from the exterior of a vessel or vessel component, EPA and DoD generally computed a concentration within a small mixing zone (a few inches to a few feet).

EPA and DoD further assessed those discharges that had constituents exceeding aquatic water quality criteria. EPA and DoD considered mass loadings, flow rates, the geographic location of the discharge, the manner in which the discharge occurs (e.g., continuous or intermittent), and in some cases, the effect of the dilution within a small mixing zone. The purpose of this further assessment was to determine whether the constituents are discharged with such a low frequency or in such small amounts that the resulting constituent mass loading has the potential to produce only minor or undetectable environmental effects, or whether the constituents are released in such a manner that dilution in a small mixing zone quickly results in concentrations below aquatic water quality criteria. If so, EPA and DoD considered the chemical constituents of the discharge not to have the potential to adversely affect the environment.

4.2.2 Thermal Pollution

In addition to chemical constituents, EPA and DoD assessed whether the discharges exceeded State thermal water quality criteria for the five States with the most significant presence of Armed Forces vessels (California, Florida, Hawaii, Virginia, and Washington). A screening study was performed on these discharges to quantify these potential effects.[12] Many discharges did not need a detailed assessment because they are discharged at ambient or only slightly elevated temperatures, or the volume or discharge rate is very low. EPA and DoD determined that six discharges are released at sufficiently high temperatures and volumes that further assessment was warranted to determine whether the discharge had the potential to cause an adverse thermal effect. These discharges are:

- Boiler Blowdown;
- Catapult Water Brake Tank and Post-Launch Retraction Exhaust;
- Catapult Wet Accumulator Discharge;
- Distillation And Reverse Osmosis Brine;
- Seawater Cooling Overboard Discharge; and
- Steam Condensate.

EPA and DoD modeled these discharges to determine the size of the mixing zone that would be needed for receiving waters to meet State thermal water quality criteria and compared this zone to State thermal mixing zone allowances. Small boat engine wet exhaust, firemain systems, portable damage control drain pump wet exhaust, and submarine emergency diesel engine wet exhaust discharges also have elevated temperatures above ambient when released. These discharges generally have minimal temperature differences between the influent and effluent streams, are released in small volumes, and generally occur only while the vessel is moving, which distributes the heat load over a wide area. Submarine emergency diesel engine wet exhaust is released into the air as a mist and cools before contacting the water. The overall thermal impact from these discharges is minimal; thus, they were not included in the thermal effects study.

Two screening protocols were used to evaluate thermal discharges. For discharges that can be continuous such as steam condensate, seawater cooling overboard discharge, and distillation and reverse osmosis brine, the Cornell Mixing Zone Expert System (CORMIX, Version 3.2) was used to estimate the plume size and temperature gradients in the receiving waterbody for comparison to mixing zone requirements for States with major naval ports. CORMIX is a software model used to analyze and predict aqueous pollutant discharges into water bodies. The output from CORMIX provides the shape and size of the thermal plume along with temperature contours that can then be compared to various thermal criteria. However, CORMIX has several limitations when modeling this discharge, including modeling the effect of tidal action and turbulent mixing beyond the plunge zone (i.e., area of initial mixing from a discharge above the waterline) on the discharge plume. Therefore, additional modeling was performed using a hydrodynamic transport model, CH3D, to evaluate steam condensate because CH3D simulates the mixing of the buoyant plume with ambient and tidal flows by advection and turbulent mixing both horizontally and vertically in the water column.[13]

For discharges that can be intermittent, short-duration, or batch (boiler blowdown, catapult water brake tank and post-launch retraction exhaust, and catapult wet accumulator blowdown), thermodynamic equations were used to estimate the temperature effects because CORMIX and CH3D were designed primarily for continuous, steady-state discharges. Batch discharges of high-temperature water require a different screening approach than continuous discharges because these discharges are not steady-state and are generally small. The steps used to estimate the maximum size of the impact zone for a given acceptable plume temperature included:

- calculating the total heat and water mass released;
- calculating the volume of water needed to dilute this mass of water such that the acceptable mixed temperature is obtained; and
- determining the region around the release point assuming complete vertical mixing that will provide the required volume.

4.2.3 Bioaccumulative Chemicals of Concern

EPA and DoD reviewed each discharge to determine whether it contained bioaccumulative chemicals of concern, as identified in the Final Water Quality Guidance for the Great Lakes System.[14] This guidance contains a list of bioaccumulative chemicals of concern identified after scientific study, in a process subjected to public notice and comment, designed to support a regionally uniform set of standards applicable to the waters of the Great Lakes. Table 4-2 lists these bioaccumulative chemicals of concern. In every case where the presence of a bioaccumulative chemical of concern was confirmed in a discharge, EPA and DoD had already determined based on other information that it was reasonable and practicable to require control of that discharge.

4.2.4 Nonindigenous Species

EPA and DoD also assessed each discharge for its potential to transport viable living aquatic organisms between naturally isolated water bodies. Preventing the introduction of invasive nonindigenous aquatic species has been recognized as important in maintaining

Table 4-2. List of Bioaccumulative Chemicals of Concern[14]

- BHC, alpha-
- BHC, beta-
- BHC, delta-
- BHC, gamma- \Lindane
- Chlordane
- DDD
- DDE
- DDT
- Dieldrin
- Hexachlorobenzene
- Hexachlorobutadiene
- Mercury
- Mirex/Dechlorane
- PCB-1016
- PCB-1221
- PCB-1232
- PCB-1242
- PCB-1248
- PCB-1254
- PCB-1260
- Pentachlorobenzene
- 1,2,4,5-Tetrachlorobenzene
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin
- Toxaphene

Notes:
BHCs are chlorinated cyclohexanes
DDT is dichlorodiphenyl trichloroethane
DDD and DDE are metabolites of DDT
PCBs are polychlorinated biphenyls

biodiversity, water quality, and the designated uses of water bodies. If the available data indicate that a discharge has a potential for transporting and then subsequently discharging viable aquatic organisms into waters of the U.S., then EPA and DoD considered the discharge to present a potential for causing adverse environmental effects from nonindigenous species.

4.2.5 Discharge Evaluation

In some cases, EPA and DoD determined it was reasonable and practicable to require MPCDs to control a discharge even though available information indicates that the discharge has a low potential for adversely affecting the environment. For the Chain Locker Effluent and Sonar Dome discharges, at least one class of Armed Forces vessel has a management practice or control technology already in place to control the environmental effects of the discharge. EPA and DoD considered the existence of a currently applied management practice or control technology to be sufficient indication that it was reasonable and practicable to require a MPCD. In other cases (Non-Oily Machinery Wastewater and Photographic Laboratory Drains), analysis of whether the discharge had a potential to adversely affect the environment was inconclusive. However, EPA and DoD determined that it was reasonable and practicable to require a MPCD to mitigate possible adverse environmental effects from the discharge.

For each discharge that was determined to have the potential to adversely affect the environment, EPA and DoD conducted an initial evaluation of the practicability, operational impact, and economic cost of using a MPCD to control each discharge. EPA and DoD first determined whether a control technology or management practice is currently in place to control the discharge for environmental protection on any vessel type. The use of existing controls on a vessel was considered sufficient demonstration that at least one reasonable and practicable control is available for at least one vessel type. The Phase I UNDS rule does not address whether existing control technologies or management practices are adequate to mitigate potential adverse impacts. In Phase II of UNDS, EPA and DoD will promulgate MPCD performance standards for the discharges requiring control. For discharges without any existing pollution controls, EPA and DoD analyzed potential pollution control options to determine whether it is reasonable and practicable to require the use of MPCDs. For every discharge that was found to have a potential to cause adverse environmental effects, EPA and DoD determined that it is reasonable and practicable to require a MPCD for at least one vessel type. The results of the MPCD assessments are presented in Appendix A.

4.3 Nature of Discharge Analysis

The nature of the discharge was analyzed for each of the 39 discharges incidental to the operations of Armed Forces vessels (Table 3-1), and based on this analysis, a NOD report was prepared that describes the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. The NOD report summarizes the results of additional sampling or other data gathered on the discharge. Based on this information, the NOD report describes how the estimated constituent concentrations and mass loadings in the environment were determined. The constituent concentrations are compared to applicable Federal and State water quality criteria. In addition to comparing discharge concentrations to Federal and State water quality criteria, other U.S. laws and international standards were also evaluated, including the standards for oil established by the International Convention for the Prevention of Pollution from Ships (MARPOL) (73/78) as implemented by the Act to Prevent Pollution from Ships, and the oil spill regulations at 40 CFR Part 110. Where Federal law and international standards were relevant to a discharge, the law and standards are discussed in the NOD reports contained in Appendix A.

In addition, known bioaccumulative chemicals of concern are identified, possible thermal effects are discussed (if applicable) and the potential for introducing nonindigenous aquatic species is assessed. The NOD report also discusses the potential for the discharge to cause adverse environmental effects.

4.3.1 Nature of Discharge Report Contents

NOD reports are divided into six sections, the outline of which is presented below:

<u>Section 1.0 -- Introduction</u>
Provides a brief description of the basic objectives of the NOD analysis. This section is identical for each of the reports.

<u>Section 2.0 – Discharge Description</u>

2.1 <u>Equipment Description and Operation</u> – *this section describes the equipment and ship operations that generate the discharge. It includes any pertinent figures and schematics that assist in explaining the origin of the discharge.*

2.2 <u>Releases to the Environment</u> *– this section describes the actual discharge released to the environment. The section also describes how the discharge is released, such as whether the flow is a stream, a mist, or results from direct contact with surrounding waters.*

2.3 <u>Vessels Producing the Discharge</u> *– this section describes which Armed Forces vessels produce the discharge.*

<u>Section 3.0 -- Discharge Characteristics</u>

3.1 <u>Locality</u> *– this section describes whether the discharge occurs within 12 n.m. from shore.*

3.2 <u>Rate</u> *– this section presents the estimated flow rate of the discharge. This rate can be a distinct flow in the case of liquid discharges, or a release rate in the case of constituents that corrode, erode, or dissolve into the environment.*

3.3 <u>Constituents</u> *– this section identifies the constituents in the discharge, including thermal pollution, when applicable. Included in this section is an identification of those pollutants known to be particularly detrimental to environmental quality. Section 3.3 includes the following:*

- *a list of all constituents identified in the discharge;*
- *identification of priority pollutants; and*
- *identification of bioaccumulative chemicals of concern.*

3.4 <u>Concentrations</u> *– this section presents the concentrations of the constituents in the discharge. When possible, this is estimated from an analysis of the existing data or alternatively, from process knowledge of the system that produces the discharge. When sampling was conducted, results of the sample analyses are presented.*

<u>Section 4.0 - Nature of Discharge Analysis</u>

4.1 <u>Mass Loadings</u> *-- in this section, the flow rate and the concentrations presented in section 3.0 are used to calculate an estimated annual mass loading on a fleet-wide basis.*

4.2 <u>Environmental Concentrations</u> *– this section varies with each analysis, but includes a comparison of the concentrations (from section 3.4) with the Federal aquatic water quality criteria and aquatic water quality criteria for selected States. Where appropriate, this section presents estimates of the concentrations after dilution in the environment. Any mixing zone calculations are clearly explained and assumptions are* *listed. Pertinent figures from any analysis are included to support statements regarding the results of the analysis.*

4.3 <u>Potential for Introducing Nonindigenous Species</u> *– this section describes an evaluation of the potential for the discharge to transport and introduce nonindigenous aquatic species.*

<u>Section 5.0 -- Conclusion</u>
Provides a summary of the assessment of the potential for the discharge to cause an adverse environmental effect based on information presented in the report.

<u>Section 6.0 -- Data Sources and References</u>
This section contains a table that indicates the type and source of information presented in each section of the analysis. The section also lists the references cited in the report.

4.3.2 Peer Review

Peer review is a documented critical review of a scientific and technical work product. It is an in-depth assessment that is used to ensure that the final work product is technically sound. Peer reviews are conducted by qualified individuals who are independent of those who prepared the work product. For the Phase I rule, reviewers were selected because of their technical expertise in assessing pollutant behavior in coastal and estuarine ecosystems, modeling pollutant concentrations, and predicting the effects of pollutant loadings on ambient water quality, sediments, and biota.

NOD reports for five discharges were selected for peer review. For each of these discharges, EPA and DoD determined that it is not reasonable and practicable to require the use of MPCDs because they exhibit a low potential for causing adverse impacts on the marine environment. Peer reviewers were asked whether the data and process information presented in the NOD reports are sufficient to characterize the discharges; whether the analyses are appropriate for the discharges; and whether the conclusions regarding the discharges' potential for causing adverse environmental impacts are supported by the information presented in the NOD reports. Peer review comments are compiled in a separate report.[15]

EPA and DoD reviewed the peer review comments and determined that the comments did not indicate any fundamental flaws in the methodology used to assess a discharge's potential to cause adverse impacts on the marine environment. EPA and DoD resolution of peer review comments are compiled in *Uniform National Discharge Standards For Vessels Of The Armed Forces Peer Review Comment Response.* [16]

4.4 MPCD Practicability, Operational Feasibility, and Cost Analysis

If a discharge was determined to have a potential to cause an adverse environmental impact in the absence of pollution controls, EPA and DoD evaluated the practicability, operational impact, and economic cost of using a MPCD to control the discharge. First, EPA and DoD determined whether a control technology or management practice is currently in place to control the discharge for environmental protection on any vessel type. The use of existing controls was considered sufficient demonstration that at least one practicable control is available. The Phase I UNDS rule does not address whether existing control technologies or management practices are adequate to mitigate potential adverse impacts. In Phase II of UNDS, EPA and DoD will promulgate MPCD performance standards for the discharges requiring control. For discharges without any existing pollution controls but having the potential to cause an adverse environmental impact, EPA and DoD analyzed potential pollution control options to determine whether it is reasonable and practicable to require the use of MPCDs. Practicability analyses were prepared for the following four discharges (these analyses are contained in Appendix A):

- Distillation and Reverse Osmosis Brine;
- Hull Coating Leachate;
- Small Boat Engine Wet Exhaust; and
- Underwater Ship Husbandry.

For every discharge that showed a potential to cause adverse environmental effects, EPA and DoD determined that it is reasonable and practicable to require a MPCD.

4.4.1 MPCD Practicability, Operational Feasibility, and Cost Report Contents

Each MPCD report gives a brief description of the discharge, lists and describes the MPCD options, and reports the results of analyzing each MPCD option according to practicability, operational impact, cost, and environmental effectiveness. The contents of the MPCD reports are briefly described below:

<u>Analysis of Practicability, Operational Impact, and Cost of Selected MPCD Options</u>
This section describes the purpose of the MPCD analysis and discusses the factors that are considered when determining which discharges should be controlled by MPCDs.

<u>1.0 MPCD Options</u>
This section describes the discharge and how it is generated and lists each of the MPCD options considered.

<u>2.0 MPCD Analysis Results</u>
This section presents the results of the MPCD analysis including discussions on practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a determination for each MPCD option. It recommends one or more MPCD options for further consideration under Phase II of UNDS.

4.5 References

1. USEPA. "Water Quality Standards." 40 CFR Part 131.36. The following Federal Register notices addressed the National Toxic Rule that is promulgated at 40 CFR Part 131.36: "Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants," 57 FR 60848, 22 December 1992, and "Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria," 60 FR 22230, 4 May 1995.
2. State of Florida. "Florida Department of Environmental Protection. Surface Water Quality Standards," Chapter 62-302. Effective 26 December 1996.
3. State of Georgia. Georgia Final Regulations. "Water Quality Control," Chapter 391-3-6 as provided by The Bureau of National Affairs, Inc. 1996.
4. State of Connecticut. Connecticut Department of Environmental Protection. "Surface Water Quality Standards," Effective 8 April 1997.
5. State of Mississippi. Mississippi Department of Environmental Quality, Office of Pollution Control. "Water Quality Criteria for Intrastate, Interstate and Coastal Waters." Adopted 16 November 1995.
6. State of Texas. Texas Natural Resource Conservation Commission. "Texas Surface Water Quality Standards." 307.2 - 307.10. Effective 13 July 1995.
7. State of New Jersey. New Jersey Final Regulations. "Surface Water Quality Standards." Section 7:9B-1, as provided by The Bureau of National Affairs, Inc. 1996.
8. USEPA. "Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California," Proposed Rule under 40 CFR Part 131, Federal Register, Vol. .62, Number 150. 5 August 1997.
9. State of Hawaii. "Water Quality Standards." Chapter 54, Section 11-54.
10. State of Washington. "Water Quality Standards for Surface Waters of the State of Washington." Chapter 173-201A. Washington Administrative Code.
11. State of Virginia. "Water Quality Standards." Chapter 260. Virginia Administrative Code VA 9; VAC 25-260.
12. NAVSEA. "Thermal Effects Screening of Discharges From Vessels of the Armed Forces." July 1997.
13. USNavy/USEPA. "Supplement to Thermal Effects Screening of Discharges from Vessels of the Armed Forces."
14. USEPA. Table 6A of the "Water Quality Guidance for the Great Lakes System." 60 FR 15365. 23 March 1995.
15. USEPA. "Peer Review Comments Document, Nature of Discharge Reports for Uniform National Discharge Standards." Contract No. 68-C7-0002, Work Assignment No. 1-50. 1 July 1998.
16. USNavy/USEPA. "Uniform National Discharge Standards For Vessels Of The Armed Forces Peer Review Comment Response." 1 March 1999.

5. PHASE I DISCHARGE DETERMINATIONS

This chapter summarizes the 39 discharge types listed in Table 3-1 and the UNDS Phase I decisions made regarding whether MPCDs are required. Section 5.1 provides this information for the discharges that EPA and DoD determined to require MPCDs; section 5.2 provides information for the discharges determined not to require MPCDs; and section 5.3 lists the chapter 5 references.

5.1 Discharges Determined To Require MPCDs

For the reasons discussed below, EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD to control 25 types of discharges from vessels of the Armed Forces. Except where noted, the pollutant characteristics of these discharges indicate a potential to cause adverse environmental impacts. Table 5-1 lists those discharges for which EPA and DoD determined it was reasonable and practicable to require the use of an MCPD, and identifies the characteristics of each discharge that formed the basis of the determination.

For the Phase I rule, EPA and DoD identified at least one potential MPCD control option for each discharge that could mitigate the environmental impacts of the discharge from at least one class of Armed Forces vessel. In Phase II of the UNDS rulemaking, EPA and DoD will perform a more detailed assessment of MPCD control options. EPA and DoD will consider options that are being evaluated as part of research and development programs in addition to those that are currently available. EPA and DoD will evaluate MPCDs for all classes of vessels and promulgate the specific performance standards for each MPCD that are reasonable and practicable for that class of vessel. In developing specific MPCD performance standards, EPA and DoD will consider the same factors considered in Phase I. The Phase II rule may distinguish among vessel types and sizes, between new and existing vessels, and may waive the applicability of Phase II standards as necessary or appropriate to a particular type or age of vessel (see CWA section 312(n)(3)(B)).

A MPCD is a control technology or a management practice that can reasonably and practicably be installed or otherwise used on a vessel of the Armed Forces to receive, retain, treat, control or discharge a discharge incidental to the normal operation of the vessel.

The discussions below provide a brief description of the discharges and the systems that produce the discharges EPA and DoD propose to control. The discussions highlight the most significant constituents released to the environment, and describes the current practice, if any, to prevent or minimize environmental effects. Because of the diversity of vessel types and designs, these control practices are usually not uniformly applied to all vessels generating the discharge. In addition, these controls do not necessarily represent the only control options available. A more detailed discussion of the discharges is presented in the NOD reports in Appendix A.

Table 5-1. Discharges Requiring the Use of a MPCD and the Basis for the Determination[a]

	Chemical Constituents						
Discharge	**Oil**	**Metals**	**Organic Chemicals**	**Thermal Pollution**	**Bioaccum-ulative Chemicals of Concern**	**Nonindigenous Species**	**Other**
Aqueous Film-Forming Foam							(b)
Catapult Water Brake Tank Discharge and Post-Launch Retraction Exhaust	X						
Chain Locker Effluent							(c)
Clean Ballast						X	
Compensated Fuel Ballast	X						
Controllable Pitch Propeller Hydraulic Fluid	X						
Deck Runoff	X						
Dirty Ballast	X						
Distillation and Reverse Osmosis Brine		X					
Elevator Pit Overboard Discharge	X						
Firemain Systems		X					
Gas Turbine Washdown Discharge	X		X				
Graywater			X				
Hull Coating Leachate		X					
Motor Gasoline Compensating Overboard Discharge	X					X	
Non-Oily Machinery Wastewater							(d)
Photographic Laboratory Drains							(d)
Seawater Cooling Overboard Discharge		X		X			
Seawater Piping Biofouling Prevention							(e)
Small Boat Engine Wet Exhaust			X				
Sonar Dome Discharge							(c)
Submarine Bilge Water	X						
Surface Vessel Bilge Water/Oil-Water Separator Discharge	X						
Underwater Ship Husbandry		X				X	
Welldeck Discharges	X						

Notes:

(a) This table provides a simplified overview of the basis for requiring the use of MPCDs for particular discharges. It is not intended to fully characterize the discharges or describe the analyses leading to the decision. More complete characterizations of the discharges and the analyses leading to the decisions are presented in this section and in Appendix A.
(b) Discharge may produce floating foam in violation of some State water quality standards.
(c) Discharge was determined to have a low potential to adversely affect the environment, but an existing MPCD is in place on at least one type of vessel to reduce this low potential even further.
(d) No conclusion was drawn on the potential of the discharge to adversely affect the environment, but EPA and DoD determined a MPCD is reasonable and practicable to mitigate any possible adverse effects.
(e) Chlorine and chlorination byproducts.

5.1.1 Aqueous Film-Forming Foam (AFFF)

This discharge consists of a mixture of seawater and firefighting foam discharged during training, testing, and maintenance operations. Aqueous film forming foam (AFFF) is the primary firefighting agent used to extinguish flammable liquid fires on surface ships of the Armed Forces. AFFF is stored on vessels as a concentrated liquid that is mixed with seawater to create the diluted solution (3-6% AFFF) that is sprayed as a foam on the fire. The solution is applied with both fire hoses and fixed sprinkler devices. During planned maintenance of firefighting systems, system testing and inspections, and flight deck certifications, the seawater/foam solution is discharged either directly overboard from hoses, or onto flight decks and then subsequently washed overboard. These discharges are considered incidental to the normal operation of Armed Forces vessels. Discharges of AFFF that occur during firefighting or other shipboard emergency situations are not incidental to normal operations and are not subject to the requirements of the rule.

AFFF is discharged from all Navy ships, those MSC ships capable of supporting helicopter operations, and Coast Guard cutters, icebreakers, and tugs. AFFF discharges generally occur at distances greater than 12 n.m. from shore, and in all cases more than 3 n.m. from shore due to existing Armed Forces operating instructions. The constituents of AFFF include water, 2-(2-butoxyethoxy)-ethanol, urea, alkyl sulfate salts, amphoteric fluoroalkylamide derivative, perfluoroalkyl sulfonate salts, triethanolamine, and methyl-1H-benzotriazole. Because the water used to mix with the AFFF concentrate comes from the vessel's firemain, the discharge will also include bis(2-ethylhexyl)phthalate, nitrogen (measured as total Kjeldahl nitrogen), copper, nickel, and iron from the firemain piping.

The AFFF discharge produces an aqueous foam intended to cool and smother fires. Water quality criteria for some States include narrative requirements for waters to be free of floating materials attributable to domestic, industrial, or other controllable sources, or include narrative criteria prohibiting discharges of foam. AFFF discharges in State waters would be expected to result in violating such narrative criteria for foam or floating materials. At present, the Navy uses certain management practices to control these discharges, including a self-imposed prohibition on AFFF discharges in coastal waters by most Armed Forces vessels. These management practices to control discharges of AFFF demonstrate the availability of a MPCD to mitigate the potential adverse impacts that could result from the discharge of AFFF. Therefore, EPA and DoD have determined that it is reasonable and practicable to require use of a MPCD for this discharge.

AFFF discharges occur beyond 3 n.m. but within 12 n.m. from shore infrequently and in relatively small volumes, and preliminary investigation indicates that the diluted (3-6%) AFFF solution does not exhibit significant toxic effects. Further, any discharges that do occur take place while the vessel is underway and will be dispersed in the turbulence of the vessel wake.

5.1.2 Catapult Water Brake Tank and Post-Launch Retraction Exhaust

This intermittent discharge is the oily water skimmed from the catapult water brake tank, and the condensed steam discharged when the catapult is retracted. Catapult water brakes are used to stop the forward movement of the steam-propelled catapults used to launch aircraft from Navy aircraft carriers. The catapult water brake system includes water brake cylinders and a water brake tank that contains freshwater. During flight operations, water from the catapult water brake tank is continuously injected into the catapult water brake cylinders. At the end of a launch stroke, spears located on the front of the catapult pistons enter the water brake cylinders. The water in the cylinders builds pressure ahead of the spears, cushioning the catapult pistons to a stop. The catapult brake water is continuously circulated between the catapult water brake tank and the catapult water brake cylinders.

Prior to the launch stroke, lubricating oil is applied to the catapult cylinder through which the catapult piston and piston spear are driven. As the catapult piston is driven forward during the launch stroke, the catapult piston and spear carries lubricating oil from the catapult cylinder into the water brake cylinder at the end of the stroke. Over the course of multiple launchings, the oil and water circulating through the water brake cylinder and tank leads to the formation of an oil layer in the water brake tank. The oil layer can adversely affect water brake operation by interfering with the cooling of water in the water brake tank. To prevent excessive heat buildup in the tank, the oil is periodically skimmed off and discharged overboard. Additionally, as the catapult piston is retracted following the launch, expended steam from the catapult launch stroke and some residual lubricating oil from the catapult cylinder walls are discharged below the waterline through a separate exhaust pipe.

Only aircraft carriers generate this discharge. Catapult operations during normal flight operations generate both the water brake tank discharge and the post-launch retraction exhaust; however, flight operations take place beyond 12 n.m. from shore. Catapult testing which occurs within 12 n.m. always discharges the post-launch retraction exhaust, but usually does not add sufficient quantities of oil to the water brake tank to require skimming.

The water brake tank is used within 12 n.m. for dead-load catapult shots when testing catapults on new aircraft carriers, and following major drydock overhauls or major catapult modifications. This testing requires a minimum of 60 dead-load shots each and may occur over a period of several days within 12 n.m. from shore. New carrier testing occurs only once, and major overhauls generally occur on 5- to 7-year cycles in conjunction with drydocking. Major modifications to catapults may occur during an overhaul or pierside and are also infrequent events. Carriers also routinely perform no-load shots when leaving port. The number of no-load shots conducted when leaving port, however, usually do not add enough lubricating oil to the water brake tank to require skimming the oil while the ship is within 12 n.m. from shore.

The Water Brake Tank and Post-Launch Retraction exhaust discharge includes lubricating oil, a limited thermal load associated with the heated oil and water (or condensed steam, in the case of the post-launch retraction exhaust), nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), and metals such as copper and nickel from the piping systems. EPA and DoD analyzed the thermal effects of this discharge and concluded they were unlikely to exceed thermal mixing zone criteria in the States where aircraft carriers most frequently operate. The post-launch retraction exhaust discharge can contain oil, copper, nickel, ammonia, bis(2-ethylhexyl)phthalate, phosphorus, and benzidine in concentrations exceeding State acute water quality criteria. The post-launch retraction exhaust discharge can also contain nitrogen in concentrations exceeding the most stringent State water quality criteria.

The Navy has imposed operational controls limiting the amount of oil applied to the catapult cylinder during the launch stroke, which directly affects the amount of oil that is subsequently discharged from the water brake tank or during the post-launch retraction exhaust. The Navy has also established requirements prescribing when catapult testing is required within 12 n.m. from shore. These operational constraints minimize discharges of oil from the water brake tank and post-launch retraction exhaust in coastal waters. These existing management practices demonstrate the availability of controls for this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require use of a MPCD to mitigate potential adverse environmental impacts from this discharge.

5.1.3 Chain Locker Effluent

This discharge consists of accumulated precipitation and seawater that is occasionally emptied from the compartment used to store the vessel’s anchor chain.

The chain locker is a compartment used to store anchor chain aboard vessels. Navy policy requires that the anchor chain, appendages, and anchor on Navy surface vessels be washed down with seawater during retrieval to prevent onboard accumulation of sediment. During washdown, some water adheres to the chain and is brought into the chain locker as the chain is stored. The chain locker sump accumulates the residual water and debris that drains from the chain following anchor chain washdown and retrieval, or washes into the chain locker during heavy weather. Water accumulating in the chain locker sump is removed by a drainage eductor powered by the shipboard firemain system.

All Armed Forces vessels housing their anchor chains in lockers, except submarines, can generate this discharge. Since submarine chain lockers are always open to the sea, water is always present in the chain locker and there is no “collected” water to be discharged as effluent. Navy policy prohibits discharging chain locker effluent within 12 n.m. Other vessels of the Armed Forces are currently authorized to discharge chain locker effluent within 12 n.m.;

however, most Armed Forces vessels also observe the 12 n.m. discharge prohibition. A recent review of practices on several Navy ships found no water accumulation in the chain locker sump, and the ships' crew confirmed that discharges of chain locker effluent occur outside 12 n.m.

In addition to water, materials collecting in the chain locker sump can include paint chips, rust, grease, and other debris. Chain locker effluent may contain organic and inorganic compounds associated with this debris, as well as metals from the sump and from sacrificial anodes installed in the chain locker to provide cathodic protection. If the anchor chain washdown is not performed and the chain locker effluent is subsequently discharged in a different port, the discharge could potentially transport nonindigenous species. Discharge volume will vary depending upon the frequency of anchoring operations, the number of anchors used, and the depth of water (which determines the amount of chain that will be lowered into the water).

Given the manner in which water collects in the chain locker sump and remains there for extended periods of time, it is possible that the discharge could contain elevated levels of metals at concentrations exceeding State water quality criteria. However, given the small volume of the discharge and the infrequency of anchoring operations, it is unlikely that discharges of chain locker effluent would adversely impact the environment. Nevertheless, the Navy and other Armed Forces already have management practices in place for most vessels requiring anchors and anchor chains to be washed down with seawater during retrieval, and prohibiting the discharge of chain locker effluent until beyond 12 n.m. from shore. DoD has chosen as a matter of policy to continue prohibiting the discharge of chain locker effluent within 12 n.m. from shore. This prohibition, while not considered necessary to mitigate an existing or potential adverse impact, will eliminate the possibility of discharging into coastal waters any metals, other contaminants, or nonindigenous aquatic species that may have accumulated in the chain locker sump. EPA and DoD have determined that the existing management practices demonstrate that it is reasonable and practicable to require use of a MPCD for chain locker effluent.

5.1.4 Clean Ballast

This discharge is composed of the seawater taken into, and discharged from, dedicated ballast tanks used to maintain the stability of the vessel and to adjust the buoyancy of submarines.

Many types of Armed Forces vessels store clean ballast in dedicated tanks in order to adjust a vessel's draft, buoyancy, trim, and list. Clean ballast may consist of seawater taken directly onboard into the ballast tanks or seawater received from the vessel's firemain system. Clean ballast differs from "dirty ballast" and "compensated ballast" discharges (described below) in that clean ballast is not stored in tanks that are also used to hold fuel. Many surface vessels introduce clean ballast into tanks to replace the weight of off-loaded cargo or expended fuel to improve vessel stability while navigating on the high seas. Amphibious ships also flood clean ballast tanks during landing craft operations to lower the ship's stern, allowing the well deck to be accessed. Submarines introduce clean ballast into their main ballast tanks when submerging, and introduce clean ballast into their variable ballast tanks to make minor adjustments to buoyancy, trim, and list while operating submerged or surfaced. The discharge occurs when fuel or cargo is taken on and the ballast is no longer needed, when amphibious operations are concluded and the vessel is returned to its normal operating draft, when submarines surface, or when submarines make some operational adjustments in trim or list while submerged or surfaced.

Clean ballast discharges are intermittent and can occur at any distance from shore, including within 12 n.m. Constituents of clean ballast can include materials from tank coatings (e.g., epoxy), chemical additives (e.g., flocculant chemicals or rust inhibitors), and metals from piping systems and sacrificial anodes used to control corrosion. Based on analytical data for firemain system discharges, metals expected to be present in the discharge include copper, nickel, and zinc. These data indicate that the pollutant concentrations in the discharge may exceed State water quality criteria.

Previous studies have documented the potential of ballasting operations to transfer nonindigenous aquatic species into receiving waters. Ballast water potentially contains living microorganisms, plants, and animals that are native to the location where the water was pumped aboard. When the ballast water is transported to another port or coastal area and discharged, the surviving organisms are released and have the potential to invade and impact the local ecosystem.

The Navy, MSC, and Coast Guard either currently implement or are in the process of approving a ballast water management policy requiring open-ocean ballast water exchange, based on guidelines established by the International Maritime Organization.[1] These management practices demonstrate the availability of controls to mitigate the potential adverse environmental impacts from this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require a MPCD for discharges of clean ballast.

5.1.5 Compensated Fuel Ballast

This intermittent discharge is composed of the seawater taken into, and discharged from, tanks designed to hold both fuel and ballast water to maintain the stability of the vessel.

Compensated fuel ballast systems are configured as a series of fuel tanks that automatically draw in seawater to replace fuel as it is consumed. Keeping the fuel tanks full in this manner enhances the stability of a vessel by using the weight of the seawater to compensate for the mass of ballast lost through fuel consumption. During refueling, fuel displaces the seawater, and the displaced seawater is discharged overboard.

Compensated fuel ballast is discharged by approximately 165 Navy surface vessels and submarines. In most cases, surface ships with compensated fuel ballast systems discharge directly to surface waters each time they refuel. However, in some situations that discharge is collected for processing on shore. Surface vessels are refueled both in port and at sea. All at-sea refueling is accomplished beyond 12 n.m. from shore. For submarines, refueling occurs only in port and the compensated ballast is transferred to shore facilities for processing.

The compensated fuel ballast discharge can contain 2-propenal, phosphorus, thallium, oil (and its constituents, such as benzene, phenol, and toluene), copper, mercury (a bioaccumulative chemical of concern), nickel, silver, and zinc. Concentrations of 2-propenal, benzene, copper, nickel, phosphorus, silver, thallium, and zinc can exceed acute Federal criteria or State acute water quality criteria. The compensated fuel ballast discharge can also contain nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) in concentrations exceeding the most stringent State water quality criteria.

To reduce the discharge of fuel in compensated fuel ballast discharge, the Navy has instituted operational guidelines intended to reduce the potential for overfilling tanks or discharging excessive amounts of fuel entrained in the displaced compensating water while refueling surface vessels. These guidelines limit the amount of fuel that can be taken on in port (i.e., to prevent "topping off" the fuel tanks) and establish maximum allowable rates for in port refueling. Additionally, submarines transfer all compensated fuel ballast water to shore facilities when refueling diesel fuel oil tanks. These operational controls for surface vessel refueling and the practice of transferring the discharge to shore for submarines demonstrates the availability of MPCDs to mitigate potential adverse environmental impacts; therefore, EPA and DoD have determined it is reasonable and practicable to require the use of a MPCD for compensated fuel ballast.

5.1.6 Controllable Pitch Propeller Hydraulic Fluid

This discharge is the hydraulic fluid that is discharged into the surrounding seawater from propeller seals as part of normal operation, and the hydraulic fluid released during routine maintenance of the propellers.

Controllable pitch propellers (CPP) are used to control a vessel's speed or direction while maintaining constant propulsion plant output (i.e., varying the pitch, or "bite," of the propeller blades allows the propulsion shaft to remain turning at a constant speed). CPP blade pitch is controlled hydraulically through a system of pumps, pistons, and gears. Hydraulic oil may be released from CPP assemblies under three conditions: leakage through CPP seals, releases during underwater CPP repair and maintenance activities, or releases from equipment used for CPP blade replacement.

Over 200 Armed Forces vessels have CPP systems. Leakage through CPP seals can occur within 12 n.m., but seal leakage is more likely to occur while the vessel is underway than while pierside or at anchor because the CPP system operates under higher pressure when a vessel is underway. Blade replacement occurs in port on an as-needed basis when dry-docking is unavailable or impractical, resulting in some discharge of hydraulic oil. Approximately 30 blade replacements and blade port cover removals (for maintenance) are conducted annually, fleetwide.

CPP assemblies are designed to operate at 400 psi without leaking. Typical pressures while pierside range from 6 to 8 psi. CPP seals are designed to last five to seven years, which is the longest period between dry-dock cycles, and are inspected quarterly to check for damage or excessive wear. Because of the hub design and the frequent CPP seal inspections, leaks of hydraulic oil from CPP hubs are found to be negligible. During the procedure for CPP blade replacement, however, hydraulic oil is released to the environment from tools and other equipment. In addition, hydraulic oil could also leak from the CPP hub during a CPP blade port cover removal.

The Navy's repair procedures impose certain requirements during blade replacement and blade port cover removal to minimize the amount of hydraulic oil released to the extent possible. In addition, booms are placed around the aft end of the vessel to contain possible oil release during these procedures. Nevertheless, EPA and DoD have determined that the amount of hydraulic oil released during underwater CPP maintenance could create an oil sheen and exceed State water quality criteria. Constituents of the discharge could include paraffins, olefins, and metals such as copper, aluminum, tin, nickel, and lead. Metal concentrations are expected to be low because hydraulic oil is not corrosive, and the hydraulic oil is continually filtered to protect against system failures.

EPA and DoD have determined that pollution controls are necessary to mitigate the potential adverse environmental impacts that could result from releases of hydraulic oil during underwater maintenance on controllable pitch propellers. The existing repair procedures and the staging of containment booms and oil skimming equipment to capture released oil demonstrate the availability of MPCDs (i.e., best management practices) for this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require MPCDs to control discharges of CPP hydraulic fluid.

5.1.7 Deck Runoff

Deck runoff is an intermittent discharge generated when water from precipitation, freshwater washdowns, wave action, or spray falls on the exposed portion of a vessel such as a weather deck or flight deck. This water is discharged overboard through deck openings and washes overboard any residues that may be present on the deck surface. The runoff drains overboard to receiving waters through numerous deck openings. All vessels of the Armed Forces produce deck runoff, and this discharge occurs whenever the deck surface is exposed to water, both within and beyond 12 n.m.

Contaminants present on the deck originate from topside equipment components and the many varied activities that take place on the deck. This discharge can include residues of gasoline, diesel fuel, Naval distillate fuel, grease, hydraulic fluid, soot, dirt, paint, glycol, cleaners such as sodium metasilicates, and solvents. A number of metal and organic pollutants may be present in the discharge, including silver, cadmium, chromium, copper, nickel, lead, benzene, ethylbenzene, toluene, xylene, polycyclic aromatic hydrocarbons, and phenol. Mass loadings and concentrations of these constituents will vary with a number of factors including ship operations, deck washdown frequency, and the frequency, duration, and intensity of precipitation events.

Based on the results from limited sampling from catapult troughs (a component of runoff from aircraft carrier flight decks), oil and grease, phenols, chromium, cadmium, nickel, and lead could be present in this discharge at levels exceeding acute Federal criteria and State acute water quality criteria. If not properly controlled, oil collecting in catapult troughs can cause deck runoff from aircraft carrier flight decks to create an oil sheen on the surface of the receiving water, which would violate State water quality criteria. Armed Forces vessels already institute certain management practices intended to reduce the amount of pollutants discharged in deck runoff, including keeping weather decks cleared of debris, immediately mopping up and cleaning spills and residues, and engaging in spill and pollution prevention practices. These practices demonstrate the availability of controls to mitigate adverse impacts from deck runoff. Therefore, EPA and DoD have determined it is reasonable and practicable to require a MPCD for deck runoff.

5.1.8 Dirty Ballast

This intermittent discharge is composed of the seawater taken into, and discharged from, empty fuel tanks to maintain the stability of the vessel. The seawater is brought into these tanks for the purpose of improving the stability of a vessel during rough sea conditions. Prior to taking on the seawater as ballast, fuel in the tank to be ballasted is transferred to another fuel tank or holding tank to prevent contaminating the fuel with seawater. Some residual fuel remains in the tank and mixes with the seawater to form dirty ballast. Dirty ballast systems are configured differently from compensated ballast and clean ballast systems. Compensated ballast systems continuously replace fuel with seawater in a system of tanks as the fuel is consumed. Clean ballast systems have tanks that carry only ballast water and are never in contact with fuel. In a dirty ballast system, water is added to a fuel tank after most of the fuel is removed.

Thirty Coast Guard vessels generate dirty ballast as a discharge incidental to normal vessel operations. These Coast Guard vessels do so because their size and design do not allow for a sufficient volume of clean ballast tanks. The larger of these vessels discharge the dirty ballast at distances beyond 12 n.m. from shore, while the smaller vessels discharge the dirty ballast between 3 and 12 n.m. from shore. Coast Guard vessels monitor the dirty ballast discharge with an oil content monitor. If the dirty ballast exceeds 15 parts per million (ppm) oil, it is treated in an oil-water separator prior to discharge.

Expected constituents of dirty ballast are Naval distillate fuel or aviation fuel. Based on sampling results for compensated fuel ballast, which is expected to have similar constituents to dirty ballast, this discharge can contain oil (and its constituents such as benzene and toluene); biocidal fuel additives; metals such as copper, mercury (a bioaccumulative chemical of concern), nickel, silver, thallium, and zinc; and the constituents 2-propenal, nitrogen (in the form of ammonia and total Kjeldahl nitrogen), and phosphorus.

Uncontrolled discharges of dirty ballast would be expected to exceed acute Federal criteria or State acute water quality criteria for oil, benzene, , copper, nickel, phosphorus, 2-propenal, silver, thallium, and zinc. Concentrations of nitrogen would be expected to exceed the most stringent State water quality criteria. The use of oil content monitors and oil-water separators to reduce the concentration of oil (and associated constituents) demonstrates the availability of MPCDs to control this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require the use of MPCDs to control discharges of dirty ballast.

5.1.9 Distillation and Reverse Osmosis Brine

This intermittent discharge is the concentrated seawater (brine) produced as a byproduct of the processes used to generate freshwater from seawater.

Distillation and reverse osmosis plants are two types of water purification systems that generate freshwater from seawater for a variety of shipboard applications, including potable water for drinking and hotel services, and high-purity feedwater for boilers. Distillation plants boil seawater, and the resulting steam is condensed into high-purity distilled water. The remaining seawater concentrate, or "brine," that is not evaporated is discharged overboard. Reverse osmosis systems separate freshwater from seawater using semi-permeable membranes as a physical barrier, allowing a portion of the seawater to pass through the membrane as freshwater and concentrating the suspended and dissolved constituents in a saltwater brine that is subsequently discharged overboard.

Distillation or reverse osmosis systems are installed on approximately 540 Armed Forces vessels. This discharge can occur in port, while transiting to or from port, or while operating anywhere at sea (including within 12 n.m.). Distillation plants on steam-powered vessels may be operated to produce boiler feedwater any time a vessel's boilers are operating; however, operational policy limits its use in port for producing potable water because of the increased risk of biofouling from the water in harbors and the reduced demand for potable water. MSC steam-powered vessels typically operate one evaporator while in port to produce boiler feedwater; most diesel and gas-turbine powered MSC vessels do not operate water purification systems within 12 n.m.

Pollutants detected in distillation and reverse osmosis brine include copper, iron, lead, nickel, , and zinc. The sampling data indicate that copper, lead, nickel, iron, and zinc can exceed acute Federal criteria or State acute water quality criteria. The distillation and reverse osmosis brine discharge can also contain nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) and phosphorus in concentrations exceeding the most stringent State water quality criteria. The mass loadings of copper and iron are estimated to be significant. Thermal effects modeling of distillation plant discharges indicates that the thermal plume does not exceed State water quality criteria.

Review of existing practices indicate that certain operational controls limiting the use of distillation plants and reverse osmosis units can reduce the potential for this discharge to cause adverse environmental impacts in some instances. Additionally, it appears that, for some vessels, reverse osmosis units may present an acceptable alternative to the use of distillation plants. Reverse osmosis units discharge brines are expected to contain lower concentrations of metals because these systems have non-metallic membranes and ambient operating temperatures, resulting in less system corrosion. Further analysis is necessary before determining whether distillation plants should be replaced by reverse osmosis units. Nevertheless, existing operational practices for distillation and reverse osmosis plants and the availability of reverse osmosis units to replace distillation units on some vessels demonstrates the availability of MPCDs to reduce the effects of this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require the use of MPCDs to control discharges from distillation and reverse osmosis plants.

5.1.10 Elevator Pit Effluent

This discharge is the liquid that accumulates in, and is occasionally discharged from, the sumps of elevator wells on vessels. Most large surface ships have at least one type of elevator used to transport supplies, equipment, and personnel between different decks of the vessel. These elevators generally can be classified as either a closed design in which the elevator operates in a shaft, or an open design used to move aircraft between decks. Elevators operating in a shaft are similar to the conventional design seen in many buildings. For these elevators, a sump is located in the elevator pit to collect liquids entering the elevator and shaft areas. Deck runoff and elevator equipment maintenance activities are the primary sources of liquids entering the sump. On some vessels, the elevator sump is equipped with a drain to direct liquid wastes overboard. On others, piping is installed that allows an eductor to pump the pit effluent overboard. However, most vessels collect and containerize the pit effluent for disposal onshore or process it along with their bilgewater.

The elevators used on aircraft carriers to move aircraft and helicopters from one deck to another are an open design (i.e., there is no elevator shaft). The elevator platform is supported by cables and pulleys, and it operates on either the port or starboard side of the ship away from the hull. Unlike elevators with pits, the aircraft elevators are exposed to the water below and there are no systems in place for collecting liquid wastes.

Coast Guard, Army and Air Force vessels do not have elevators and therefore do not produce this discharge. The discharge of elevator pit effluent may occur at any location, within or beyond 12 n.m. from shore. Constituents in elevator pit effluent are likely to include grease, lubricating oil, fuel, hydraulic fluid, cleaning solvents, dirt, paint chips, aqueous film-forming foam, glycol, and sodium metasilicate. The discharge can also contain nitrogen (measured as total Kjeldahl nitrogen) and metals from firemain water used to operate eductors draining the elevator pit.

The concentrations of copper, iron, nickel, and bis(2-ethylhexyl)phthalate in firemain water (discussed in section 5.1.11) may exceed acute Federal criteria or State acute water quality criteria. The elevator pit effluent discharge can also contain nitrogen in concentrations exceeding the most stringent State water quality criteria. Constituent concentrations and mass loadings vary among ship classes depending on the frequency of elevator use, the size of the elevator openings, the amount and concentration of deck runoff, and the frequency of elevator equipment maintenance activities. Material accumulated in elevator pits is either collected for disposal onshore or directed to the bilgewater system for treatment through an oil-water separator prior to discharge. These existing practices demonstrate the availability of controls to reduce the potential for this discharge to cause adverse impacts on the environment. Therefore, EPA and DoD have determined that it is reasonable and practicable to require MPCDs for elevator pit effluent.

5.1.11 Firemain Systems

This discharge is the seawater pumped through the firemain system for firemain testing, maintenance, and training, and to supply water for the operation of certain vessel systems.

Firemain systems distribute seawater for firefighting and other services aboard ship. Firemain water is provided for firefighting through fire hose stations, sprinkler systems, and foam proportioners, which inject aqueous film-forming foam (AFFF) into firemain water for distribution over flammable liquid spills or fire. Firemain water is also directed to other services including ballast systems, machinery cooling, lubrication, and anchor chain washdown. Discharges of firemain water incidental to normal vessel operations include anchor chain washdown, firemain testing, various maintenance and training activities, bypass flow from the firemain pumps to prevent overheating, and cooling of auxiliary machinery equipment (e.g., refrigeration plants). UNDS does not apply to discharges of firemain water that occur during firefighting or other shipboard emergency situations, because they are not incidental to the normal operation of a vessel.

Firemain systems aboard Armed Forces vessels are classified as either wet or dry. Wet firemain systems are continuously charged with water and pressurized so that the system is available to provide water upon demand. Dry firemains are not continuously charged with water, and consequently do not supply water upon demand. Dry firemain systems are periodically tested and are pressurized during maintenance or training exercises, or during emergencies.

With the exception of small boats and craft, all Armed Forces vessels use firemain systems. All Navy surface ships and some MSC vessels use wet firemain systems. Submarines and all Army and Coast Guard vessels use dry firemains. Firemain system discharges occur both within and beyond 12 n.m. from shore. Flow rates depend upon the type, number, and operating time of the equipment and systems using water from the firemain system.

Samples were collected from three vessels with wet firemain systems and analyzed to determine the constituents present. Because of longer contact times between seawater and the piping in wet firemains, and the use of zinc anodes in some seachests and heat exchangers to control corrosion, pollutant concentrations in wet firemains are expected to be higher than those in dry firemain systems. Pollutants detected in the firemain discharge include nitrogen (measured as total Kjeldahl nitrogen), copper, nickel, iron, and bis(2-ethylhexyl)phthalate. The concentrations of iron exceeded the most stringent State chronic water quality criteria. The concentrations of nitrogen exceeded the most stringent State water quality criteria. Copper, nickel, and bis(2-ethylhexyl)phthalate concentrations exceeded the relevant chronic Federal criteria and State chronic water quality criteria. These concentrations contribute to a significant total mass loading in the discharge due to the large volume of water discharged from wet firemain systems. Circulation through heat exchangers to cool auxiliary machinery increases the temperature of the firemain water, but the resulting thermal effects do not exceed State mixing zone criteria.

Firemain systems have a low potential for transporting nonindigenous aquatic species, primarily because the systems do not transport large volumes of water over great distances. In addition, stagnant portions of the firemain tend to develop anaerobic conditions that are inhospitable to most marine organisms.

EPA and DoD believe that dry firemain systems may offer one means for reducing the total mass of pollutants discharged from firemain systems. The use of dry firemains for Coast Guard vessels demonstrates that, for at least some types of vessels, this option may be an available control mechanism. Another possible MPCD option for achieving pollutant reductions is the use of alternative piping systems (i.e., different metallurgy) that provide lower rates of pipe wall corrosion and erosion. The use of dry firemains and the potential offered by alternative piping systems demonstrates the availability of controls to mitigate potential adverse impacts on the environment. Therefore, EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD for firemain systems.

5.1.12 Gas Turbine Water Wash

Gas turbine water wash consists of water periodically discharged while cleaning internal and external components of propulsion and auxiliary gas turbines. Approximately 155 Armed Forces vessels use gas turbines for either propulsion or auxiliary power generation. Gas turbine water wash is generated within 12 n.m. and varies by the type of gas turbine and the amount of time it is operated. Because the drain collecting system is limited in size, discharges may occur within 12 n.m. On most Navy and MSC gas turbine ships, gas turbine water wash is collected in a dedicated collection tank and is not discharged overboard within 12 n.m. On ships without a dedicated collection tank, this discharge is released as a component of deck runoff, welldeck discharges, or bilgewater.

Expected constituents of gas turbine water wash are synthetic lubricating oil, grease, solvent-based cleaning products, hydrocarbon combustion by-products, salts from the marine environment, and metals leached from metallic turbine surfaces. The concentration of naphthalene (from solvents) in the discharge is expected to exceed State acute water quality criteria. To limit the impacts of gas turbine water wash discharge while operating in coastal areas, most vessels direct the discharge to a dedicated holding tank for shore disposal. This containment procedure demonstrates the availability of controls for this discharge. Therefore, EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD for gas turbine water wash.

5.1.13 Graywater

Section 312(a)(11) of the CWA defines graywater as “galley, bath, and shower water.” Recognizing the physical constraints of Armed Forces vessels and the manner in which wastewater is handled on these vessels, graywater is more broadly defined for the purposes of

UNDS. For the purposes of this regulation, the graywater discharge consists of graywater as defined in CWA section 312(a)(11), as well as drainage from laundries, interior deck drains, water fountains and miscellaneous shop sinks. All ships, and some small boats, of the Armed Forces generate graywater on an intermittent basis. Graywater discharges occur both within and beyond 12 n.m. from shore. Most Armed Forces vessels collect graywater and transfer it to shore treatment facilities while pierside. Some vessel types, however, have minimal or no graywater collection or holding capability and discharge the graywater directly overboard while in transit. Graywater is discharged pierside when collection facilities are not available.

Less than half of all graywater discharged within 12 n.m. occurs pierside from vessels lacking graywater collection holding capability. The remainder of the discharge in coastal waters occurs during transit within 12 n.m. from shore. Copper, lead, mercury (a bioaccumulative chemical of concern), nickel, silver, and zinc were detected in concentrations that exceed acute Federal criteria and State acute water quality criteria. Graywater also contains conventional and nonconventional pollutants, such as total suspended solids, biochemical oxygen demand, chemical oxygen demand, oil, grease, ammonia, nitrogen, and phosphates. Due to the large volume of graywater generated each year, the mass loadings of these constituents may be significant. The use of containment systems to transfer graywater to shore treatment facilities demonstrates the availability of controls to mitigate adverse impacts on the environment. Therefore, EPA and DoD have determined that it is reasonable and practicable to require a MPCD to control graywater discharges.

5.1.14 Hull Coating Leachate

This discharge consists of constituents that leach, dissolve, ablate, or erode from hull paints into the surrounding seawater.

Vessel hulls that are continuously exposed to seawater are typically coated with a base anti-corrosive coating covered by an anti-fouling coating. This coating system prevents corrosion of the underwater hull structure and, through leaching action releases antifouling compounds. Ablative coatings allow the paint surface to erode or dissolve to release antifouling compounds. These compounds inhibit the adhesion of biological growth to the hull surface.

The coatings on most vessels of the Armed Forces are either copper- or tributyl tin (TBT)-based, with copper-based ablative paints being the most predominant coating system. The Armed Forces have been phasing out the use of TBT paints, and currently it is found only on approximately 10-20 percent of small boats and craft with aluminum hulls. Small boats and craft that spend most of their time out of water typically do not receive an anti-corrosive or anti-fouling coating.

Hull coating leachate is generated continuously whenever a vessel hull is exposed to water, within and beyond 12 n.m. from shore. Priority pollutants expected to be present in this discharge include copper and zinc. TBT is also expected to be present in this discharge for those vessels with TBT paint. The release rate of the constituents in hull coating leachate varies with the type of paint used, water temperature, vessel speed, and the age of the coating. Using average release rates derived from laboratory tests, the wetted surface area of each vessel, and the number of days the vessel is located within 12 n.m., EPA and DoD estimated the mass of copper, zinc, and TBT released in the leachate and concluded that the discharge has the potential to cause an adverse environmental effect.

Annual releases of TBT are expected to decrease since TBT coatings are being phased out by DoD and the Coast Guard. Both DoD and the commercial industry have conducted research on the use of advanced antifouling coatings such as easy release coatings (e.g., silicone) that resist biofouling when the vessel is in motion and a critical speed is reached. The combination of phasing out TBT paints, the potential to establish limits on copper release rates for copper-based coating systems, and the potential for alternative coating systems to reduce copper discharges demonstrates the availability of controls to mitigate potential environmental impacts from hull coating leachate. Thus, EPA and DoD determined that it is reasonable and practicable to require use of a MPCD for hull coating leachate.

5.1.15 Motor Gasoline Compensating Discharge

This intermittent discharge consists of seawater taken into, and discharged from, motor gasoline tanks. Motor gasoline (MOGAS) is used to operate vehicles and equipment stored or transported on some Navy amphibious vessels. MOGAS is stored in a compensating fuel tank system in which seawater is automatically added to fuel tanks as the gasoline is consumed in order to eliminate free space where vapors could accumulate. The compensating system is used for MOGAS to provide supply pressure for the gasoline and to keep the tank full to prevent potentially explosive gasoline vapors from forming. During refueling, gasoline displaces seawater from the tanks, and the displaced seawater is discharged directly overboard.

The Navy has two classes of vessels with MOGAS storage tanks. Eleven of these vessels are homeported in the U.S. Based on operational practices, vessels with MOGAS storage tanks typically refuel once per year, and the refuelings are always conducted in port. Therefore, all discharges from the MOGAS compensating system occur in port.

Seawater in the MOGAS compensating system is in contact with the gasoline for long periods of time. MOGAS discharges are expected to contain components of gasoline, including benzene, ethylbenzene, toluene, phenols, and naphthalenes at concentrations that exceed acute water quality criteria.

Specific operating procedures are followed when refueling MOGAS tanks to reduce the potential for discharging gasoline. These procedures require MOGAS tanks to be filled slowly and prohibit filling the tanks beyond 80 percent of the total tank capacity. Containment is placed around hose connections to contain any releases of gasoline, and containment booms are placed in the water around the vessel being refueled. Diffusers are used within the tanks to prevent entraining fuel into the discharged compensating water. These management practices demonstrate the availability of controls to mitigate potential adverse impacts to the environment. Therefore, EPA and DoD have determined that it is reasonable and practicable to require MPCDs for the MOGAS compensating discharge.

5.1.16 Non-Oily Machinery Wastewater

This intermittent discharge is composed of water leakage from the operation of equipment such as distillation plants, water chillers, valve packings, water piping, low- and high-pressure air compressors, and propulsion engine jacket coolers. Only wastewater that is not expected to contain oil is collected in this system. The discharge is captured in a dedicated system of drip pans, funnels, and deck drains to prevent mixing with oily bilgewater. Non-oily machinery wastewater from systems and equipment located above the waterline is drained directly overboard. Non-oily machinery wastewater from systems and equipment below the waterline is directed to collection tanks prior to overboard discharge. In limited cases, steam condensate generated when a vessel is in port is directed to the non-oily machinery wastewater collection tank. See section 5.2.10 for additional information on steam condensate discharges.

Nuclear-powered Navy surface vessels and some conventionally powered vessels have dedicated non-oily machinery wastewater systems. Most other Armed Forces vessels have no dedicated non-oily machinery wastewater system, so this type of wastewater drains directly to the bilge and is part of the bilgewater discharge.

Non-oily machinery wastewater is discharged in port, during transit, and at sea. This discharge is generated whenever systems or equipment are in use, and varies in volume according to ship size and the level of machinery use.

Pollutants, including copper, nickel, silver, bis(2-ethylhexyl)phthalate, and zinc were present in concentrations that exceed acute Federal criteria or State acute water quality criteria. Nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) and total phosphorus were present in concentrations exceeding the most stringent State water quality criteria. Mercury (a bioaccumulative chemical of concern) was also detected, but at concentrations that did not exceed Federal or State water quality criteria. There was significant variability in sampling data, and flow rate data were insufficient for reliably estimating mass loadings for this discharge. System design changes to control the types and numbers of contributing systems and equipment, and implementation of management practices to reduce the generation of non-oily machinery wastewater are potential options for reducing the potential impact of this discharge on the environment. For this rule, EPA and DoD have determined that it is reasonable and practicable to require MPCDs for non-oily machinery wastewater.

5.1.17 Photographic Laboratory Drains

This intermittent discharge is laboratory wastewater resulting from processing photographic film. Typical liquid wastes from these activities include spent film processing chemical developers, fixer-bath solutions and film rinse water.

Navy ship classes such as aircraft carriers, amphibious assault ships, and submarine tenders have photographic laboratory facilities, including color, black-and-white and x-ray photographic processors. The Coast Guard has two icebreakers with photographic and x-ray processing capabilities. The MSC has two vessels that have photographic processing equipment onboard, but the equipment normally is not operated in U.S. waters. Army, Air Force, and Marine Corps vessels do not use photographic equipment aboard their vessels and therefore do not produce this discharge.

Photographic laboratory wastes may be generated within and beyond 12 n.m. from shore, although current practice is to collect and hold the waste onboard within 12 n.m. The volume and frequency of the waste generation varies with a vessel's photographic processing capabilities, equipment, and operational objectives.

Expected constituents in photographic laboratory wastes include acetic acid, aluminum sulfate, ammonia, boric acid, ethylene glycol, sulfuric acid, sodium acetate, sodium chloride, ammonium bromide, aluminum sulfate, and silver. Concentrations of silver can exceed acute Federal criteria and State acute water quality criteria; however, the existing data are insufficient to determine whether drainage from shipboard photographic laboratories has the potential to cause adverse environmental effects.

The Navy has adopted guidance to control photographic laboratory drains, including containerizing for onshore disposal all photographic processing wastes generated within 12 n.m., and is transitioning to digital photographic systems. The current handling practices and the availability of digital photographic systems demonstrates that MPCDs are available to mitigate potential adverse effects, if any, from photographic laboratory drains. Therefore, EPA and DoD have determined that it is reasonable and practicable to require use of a MPCD for this discharge.

5.1.18 Seawater Cooling Overboard Discharge

This discharge consists of seawater from a dedicated system that provides noncontact cooling water for other vessel systems. The seawater cooling system continuously provides cooling water to heat exchangers, removing heat from main propulsion machinery, electrical generating plants, and other auxiliary equipment. The heated seawater is discharged directly overboard. With the exception of some small, non-self-propelled vessels and service craft, all Armed Forces vessels discharge seawater from cooling systems. Typically, the demand for seawater cooling is continuous and occurs both within and beyond 12 n.m. from shore.

Seawater cooling overboard discharge contains trace materials from seawater cooling system pipes, valves, seachests, pumps, and heat exchangers. Pollutants detected in seawater cooling overboard discharge include copper, zinc, nickel, arsenic, chromium, lead, and nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen). Copper, nickel, and silver were detected in concentrations exceeding both the chronic Federal criteria and State chronic water quality criteria. Nitrogen was detected in concentrations exceeding State chronic water quality criteria. These concentrations contribute to a significant total mass released by this discharge due to the large volume of cooling water. In addition, thermal effects modeling indicates that some vessels may exceed State thermal mixing zone requirements. The seawater cooling water system has a low potential for transporting nonindigenous species, because the residence time for most portions of the system are short. However, a strainer plate is used to minimize the inflow of larger biota during system operation. The strainer plate is periodically cleaned using low pressure air or steam to dislodge any accumulated material. This procedure may result in releasing biota that have attached to the plate.

A potential MPCD option for achieving pollutant reductions is the use of alternative piping systems (i.e., different metallurgy) that provide lower rates of pipe wall corrosion and erosion. The potential substitution of materials demonstrates the availability of controls to mitigate potential adverse impacts on the environment. Based on this information, EPA and DoD have determined that it is reasonable and practicable to require use of a MPCD for this discharge.

5.1.19 Seawater Piping Biofouling Prevention

This discharge consists of the additives used to prevent the growth and attachment of biofouling organisms in seawater cooling systems on selected vessels, as well as the reaction byproducts resulting from the use of these additives. Fouling reduces seawater flow and heat transfer efficiency. Aboard some vessels, active biofouling control systems are used to control biological fouling of surfaces within the seawater cooling systems. Generally, these active biofouling control systems are used when the cooling system piping does not have inherent antifouling properties (e.g., titanium piping). The most common seawater piping biofouling prevention systems include chlorination, chemical dosing, and anodic biofouling control systems. All three systems act to prevent fouling organisms from adhering to and growing on interior piping and components. Chlorinators use electric current to generate chlorine and chlorine-produced oxidants from seawater. Anodic biofouling control systems use electric current to accelerate the dissolving of an anode to release metal ions into the piping system. Chemical dosing uses an alcohol-based chemical dispersant that is intermittently injected into the seawater system.

Twenty-nine Armed Forces vessels use active seawater piping biofouling control systems. Nine vessels use onboard chlorinators, 19 vessels use anodic biofouling control systems, and one vessel employs chemical dosing. Chlorinators operate on a preset schedule of intermittent operation, a few hours daily. Chemical dispersant dosing is performed for one hour every three days. Anodic systems normally operate continuously.

Seawater discharged from systems with active biofouling control systems is likely to contain residuals from the fouling control agent (chlorine, alcohol-based chemical additives, or copper), in addition to constituents normally found in cooling water. Based on modeling of the discharge plume, EPA and DoD estimate that receiving water concentrations of residual chlorine could exceed chronic Federal criteria and State chronic water quality criteria. Because of the large volume of seawater discharged from these systems, the resulting mass loading of chlorine released to the environment is considered significant.

Existing operational controls that limit the residual chlorine discharged to the environment demonstrate the availability of a MPCD to mitigate the potential for adverse impacts from this discharge. EPA and DoD have determined that it is reasonable and practicable to require a MPCD for seawater piping biofouling prevention systems.

5.1.20 Small Boat Engine Wet Exhaust

This discharge is the seawater that is mixed and discharged with small boat propulsion engine exhaust gases to cool the exhaust and quiet the engine. Small boats are powered by either inboard or outboard engines. Seawater is injected into the exhaust of these engines for cooling and to quiet engine operation. Constituents from the engine exhaust are transferred to the injected seawater and discharged overboard as wet exhaust.

Most small boats with engines generate this discharge. The majority of inboard engines used on small boats are two-stroke engines that use diesel fuel. The majority of outboard engines are two-stroke engines that use a gasoline-oil mixture for fuel. This discharge is generated when operating small boats. Due to their limited range and mission, small boats spend the majority of their operating time within 12 n.m. from shore.

Wet exhaust from outboard engines contains several constituents that can exceed acute Federal criteria or State acute water quality criteria including benzene, toluene, ethylbenzene, and naphthalene. Wet exhaust from inboard engines can contain benzene, ethylbenzene, and total polycyclic aromatic hydrocarbons (PAHs) that can exceed State water quality criteria. Mass loadings of these wet exhaust constituents are considered large. Potential MPCD options include replacing existing outboard engines with new reduced-emission outboard engines, and ensuring all new boats and craft have inboard engines with dry exhaust systems. Therefore, EPA and DoD have determined that it is reasonable and practicable to require use of a MPCD for small boat engine wet exhaust.

5.1.21 Sonar Dome Discharge

This discharge is generated by the leaching of antifoulant materials from the sonar dome material into the surrounding seawater and the discharge of seawater or freshwater from within the sonar dome during maintenance activities. Hull-mounted sonar domes house the electronic equipment used to navigate, detect, and determine the range to objects. Sonar domes are composed of either rubber impregnated with tributyltin (TBT) anti-foulant, rubber without TBT, steel, or glass-reinforced plastic, and are filled with freshwater and/or seawater to maintain their shape and internal pressure. The discharge is generated when materials leach from the exterior surface of the dome, or when water containing leach materials from inside the dome is pumped overboard to allow for periodic maintenance or repairs on the sonar dome or equipment housed inside the dome.

Only Navy and MSC operate vessels with sonar domes. Sonar domes are currently installed on approximately 225 vessels, including eight classes of Navy vessels and one class of MSC vessels. Sonar domes on MSC vessels are fiberglass and do not contain TBT.

The leaching of materials from the exterior surface of the dome is a continuous discharge and occurs both within and beyond 12 n.m. from shore. Discharges from the interior of the dome are intermittent and occur while the vessel is pierside as water inside the dome is removed to allow for periodic maintenance or repairs (approximately twice per year per dome).

Expected constituents of sonar dome water discharge are TBT, dibutyl tin, monobutyl tin, and metals such as copper, nickel, zinc, and tin. Based on sampling data in the record, concentrations of TBT, copper, nickel, and zinc can exceed acute Federal criteria or State acute water quality criteria, although fleetwide mass loadings of these constituents are not considered large (15 pounds/year of TBT, 23 pounds/year of copper, 11 pounds/year of nickel, and 122 pounds/year of zinc). Nevertheless, the Navy has instituted a program to install new sonar domes that do not have TBT-impregnated internal surfaces as existing domes require replacement. This practice demonstrates the availability of a control to mitigate potential adverse environmental impacts, if any, from sonar dome discharges. Therefore EPA and DoD have determined that it is reasonable and practicable to require a MPCD for sonar dome discharges.

5.1.22 Submarine Bilgewater

The submarine bilgewater discharge contains a mixture of wastewater and leakage from a variety of sources that are allowed to drain to the lowest inner part of the hull, known as the bilge. These sources can include condensed steam from steam systems, spillage from drinking fountains, valve and piping leaks, and evaporator dumps (i.e., evaporator water that fails to meet specifications for use). From the various collection points in the bilge, this bilgewater is transferred via an auxiliary drain system to a series of holding tanks. Most submarines have the capability to segregate oily wastewater from non-oily wastewater. The non-oily waste is discharged directly overboard and the oily wastewater is collected in a tank that allows gravity separation of the oil and water. The separated water phase is then discharged overboard, as needed, and the oil phase held onboard until it can be transferred to shore facilities for disposal.

This discharge is generated by all submarines, all of which are operated by the Navy. Approximately 60 of the submarines (the SSN 688 class) discharge the separated water phase from the bilgewater collection tanks within and beyond 12 n.m. from shore. The remaining submarines generally hold all bilgewater onboard until they are beyond 50 n.m. from shore. The frequency and volume of the discharge is highly variable, depending upon crew size, operating depth, and equipment conditions.

Sampling conducted onboard submarines showed concentrations of cadmium, chlorine, copper, cyanide, heptachlor, heptachlor epoxide, mercury (a bioaccumulative chemical of concern), nickel, oil, phenol, silver, and zinc that exceeded acute Federal criteria or State acute water quality criteria. Submarines use gravity separation to reduce the concentration of oil in bilgewater prior to discharge; however, this method apparently does not consistently produce a discharge that meets water quality criteria. The adequacy of existing gravity separation treatment to provide effective environmental protection will be addressed by the Phase II rulemaking. The nature of this discharge is such that submarine bilgewater, if untreated, could potentially impact the environment. Because of this potential to cause adverse environmental impacts, coupled with the demonstration that pollution controls are available to reduce the oil content of the discharge, EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD for submarine bilgewater.

5.1.23 Surface Vessel Bilgewater/OWS Discharge

The Surface Vessel Bilgewater/OWS Discharge consists of a mixture of wastewater and leakage from a variety of sources that are allowed to drain to the lowest inner part of the hull, known as the bilge. The sources of surface vessel bilgewater are generally similar to those discussed above for submarines. An additional source of bilgewater for surface vessels is water from the continual blowdown of boilers (i.e., boiler blowdown). On surface vessels, bilgewater is usually transferred to an oily waste holding tank, where it is stored for shore disposal or treated in an oil-water separator (OWS) to remove oil before being discharged overboard. Some vessels also have an oil content monitor (OCM) installed downstream from the OWS to monitor bilgewater oil content prior to discharge. Vessels with OCMs have the capability to return bilgewater not meeting a preset oil concentration limit to the OWS for reprocessing until the limit is met. Oil collected from the OWS separation process is held in a waste oil tank until transferred to shore facilities for disposal.

All vessels of the Armed Forces produce bilgewater and most of the larger vessels have OWS systems. Small craft bilgewater is collected and transferred to shore facilities while pierside.

Bilgewater accumulates continuously; however, vessels of the Armed Forces do not discharge untreated bilgewater. Under current policy, bilgewater treated by an OWS can be discharged as needed within 12 n.m., while untreated bilgewater is held for transfer to a shore facility for treatment. For vessels with an OWS and OCM, oil concentrations in the treated bilgewater must be less than 15 ppm prior to overboard discharge.

Sampling data for OWS effluent show oil, copper, iron, mercury (a bioaccumulative chemical of concern), nickel, and zinc exceed acute Federal criteria or State acute water quality criteria. Sampling data also show concentrations of nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) and phosphorus exceed the most stringent State water quality criteria. The estimated mass loading for oil is considered to be large.

The existing policies prohibiting the discharge of untreated bilgewater, and the extensive use of oil-water separators and oil content monitors demonstrate the availability of pollution controls for bilgewater. The data in the record indicate that untreated bilgewater would likely cause adverse environmental impacts. Therefore, EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD for this discharge.

5.1.24 Underwater Ship Husbandry

The underwater ship husbandry discharge is composed of materials discharged during the inspection, maintenance, cleaning, and repair of hulls and hull appendages performed while the vessel is waterborne. Underwater ship husbandry includes activities such as hull cleaning, fiberglass repair, welding, sonar dome repair, propulsor lay-up, non-destructive testing, masker belt repairs, and painting operations.

Underwater ship husbandry discharge is created occasionally by all Navy surface ships and submarines, and some Coast Guard vessels. These ship husbandry operations are normally conducted pierside. With the exception of underwater hull cleaning and propulsor (i.e., propeller) lay-up, other ship husbandry discharges have a low potential for causing an adverse environmental effect. Underwater hull cleaning is conducted by divers using a mechanical brush system. Copper and zinc are released during cleaning in concentrations that exceed acute Federal criteria and State acute water quality criteria and produce a significant mass loading of constituents. The copper and zinc in this discharge originate from the anti-fouling and anticorrosive hull coatings applied to vessels. Data from commercial vessels indicate that underwater hull cleaning also has the potential to transfer nonindigenous aquatic species. Propulsor lay-up requires the placement of a vinyl cover over the propulsor to reduce fouling of the propulsor when the vessel is in port for extended periods. Chlorine-produced oxidants are generated from impressed current cathodic protection systems and can build up within the cover to levels exceeding State water quality criteria. However, discharges from this operation, as well as other ship husbandry operations (excluding hull cleaning) are infrequent and small in terms of volume or mass loading.

The Navy has established policies to minimize the number of hull cleanings, based on the degree to which biological fouling has occurred. In addition, the Navy has established procedures to use the least abrasive cleaning equipment necessary as a means for reducing the mass of copper and zinc in the discharge. These practices represent available controls to mitigate adverse impacts from underwater ship husbandry operations, and EPA and DoD have determined that it is reasonable and practicable to require the use of a MPCD to control this discharge.

5.1.25 Welldeck Discharges

This discharge is the water that accumulates from the seawater flooding of the docking well (welldeck) of a vessel used to transport, load, and unload amphibious vessels, and from the maintenance and freshwater washings of the welldeck and equipment and vessels stored in the welldeck.

Amphibious operations by the Armed Forces require transport of vehicles, equipment, and personnel between ship and shore on landing craft. The landing craft are stored in a docking well, or welldeck, of some classes of amphibious warfare ships. To load or unload landing craft, amphibious warfare ships may need to flood the welldeck by taking on ballast water and sinking the aft (rear) end of the ship. Water that washes out of the welldeck contains residual materials that were on the welldeck prior to flooding. Other welldeck discharges are created by routine operations such as washing equipment and vehicles with potable water, washing the gas turbine engines of air-cushion landing craft (LCACs) in the welldeck with mild detergents, and graywater from stored utility landing craft (LCUs). Additionally, the U.S. Department of Agriculture (USDA) requires washing welldecks, vehicle storage areas, and equipment upon return from overseas locations. The washing is required to ensure that there is no inadvertent transport of nonindigenous species to land. USDA-required washes of welldecks and vehicle storage areas occur pierside, while vehicles and equipment are washed onshore in a USDA-designated area. Effluent from such shipboard activities drain to unflooded welldecks and are discharged directly overboard.

The Navy is the only branch of the Armed Forces with ships having welldecks. Thirty-three amphibious warfare ships produce this discharge, which is released both within and beyond 12 n.m. from shore.

Depending upon the specific activities conducted, welldeck discharges contain a variety of residual constituents, including oil and grease, ethylene glycol (antifreeze), chlorine, detergents/cleaners, metals, solvents, and sea-salt residues. The volume of welldeck washout varies depending upon the type of landing craft to be loaded or unloaded. The greatest volume of welldeck discharge occurs when LCUs are being loaded into, or unloaded from the welldeck. Loading and unloading of LCACs does not require the welldeck to be flooded. Instead, a small "surge" of water enters the ship during these operations. Constituent concentrations in welldeck washout are expected to be low due to dilution in the large volume of water discharged, and because of general housekeeping procedures that require containment and cleanup of materials spilled on the welldeck.

Other discharges from the welldeck include vehicle and craft washwater, gas turbine engine washes, and USDA washes. Constituents of these discharges are expected to be identical to those in welldeck washout. Of the various welldeck discharges, gas turbine water washes and USDA washes may result in hydrocarbon, or metal concentrations that exceed acute water quality criteria. In addition, there is a potential for nonindigenous species to be introduced from USDA-required welldeck washes, although it should be noted that the viability of any species introduced is questionable since they generally would have been exposed to air for extended periods of time prior to their introduction into U.S. coastal waters (i.e., for the most part, these species would have been removed from vehicles and deck surfaces and thus it would not be a water-to-water transfer, in contrast to species transfers from ballast water systems).

Existing practices for containment and cleanup of welldeck spills demonstrate the availability of controls to reduce contamination of welldeck discharges and the potential for causing adverse environmental impacts (e.g., oil sheens). EPA and DoD have determined that it is reasonable and practicable to require a MPCD for welldeck discharges.

5.2 Discharges Determined To Not Require MPCDs

For the reasons discussed below, EPA and DoD have determined that it is not reasonable and practicable to require the use of a MPCD to control 14 discharges incidental to the normal operation of Armed Forces vessels. These discharges have a low potential to adversely affect the environment by introduction of chemical constituents, thermal pollution, bioaccumulative chemicals of concern, or nonindigenous species.

As discussed below, in some cases, the concentration of one or more constituents in the undiluted discharge exceed water quality criteria at the point of discharge. However, such discharges occur in low volumes or infrequently. In all of these instances, either the pollutant concentration in the discharge plume quickly falls below water quality criteria once the dilution effect of mixing zones is taken into account, or the low mass loading of the discharge is unlikely to adversely affect the environment.

These 14 discharge types do not require control, and no control standards will be set for them, in Phase II of UNDS development. Upon promulgation of this Phase I rule, States and their political subdivisions are prohibited from adopting or enforcing any statute or regulation to control these discharges, except by establishing no-discharge zones. States can petition EPA and DoD to review the determination not to require MPCDs for these discharges.

The discussion below provides a brief description of the discharges and the systems that produce the discharge and highlights the most significant constituents released to the environment and other characteristics of the discharge. A more detailed discussion of these discharges is presented in Appendix A.

5.2.1 Boiler Blowdown

This discharge is the water and steam discharged during the blowdown of a boiler or steam generator, or when a safety valve is tested. Boilers are used to produce steam for propulsion and a variety of auxiliary and hotel services. Water supplied to the boiler system (feedwater) is treated with chemicals to inhibit corrosion and the formation of scale in the boiler and boiler system piping. Periodically, water must be removed from the boiler to control the buildup of particulates, sludge, and treatment chemical concentrations. The term "blowdown" refers to the minimum discharge of boiler water required to prevent the buildup of these materials in the boiler to levels that would adversely affect boiler operation and maintenance. There are four types of boiler blowdown procedures employed on Armed Forces vessels: 1) surface blowdowns for removing materials dissolved in the boiler water and for controlling boiler water chemistry; 2) scum blowdowns for removing surface scum; 3) bottom blowdowns for removing sludge that settles at the bottom of boilers; and 4) continuous blowdowns for removing dissolved metal chelates and other suspended matter. The type of blowdown used is a function of the boiler water chemistry and thus varies among vessel classes. With the exception of continuous blowdowns, boiler blowdowns are discharged below the vessel waterline. Continuous blowdowns are discharged inside the vessel and are directed to the bilge. These are addressed as part of the surface vessel bilgewater/OWS discharge (see section 5.1.23). Another discharge occurs during periodic testing of steam generator safety valves on nuclear-powered vessels. The safety valve discharge is a short-duration release of steam below the vessel waterline.

Approximately 360 surface vessels and submarines discharge boiler blowdowns directly to receiving waters. These blowdowns occur both within and beyond 12 n.m. from shore. Nuclear-powered ships perform steam generator safety valve testing only in port once every five years.

Boiler blowdown is discharged intermittently in small volumes (approximately 300 gallons per discharge), at high velocities (over 400 feet/second), and at elevated temperatures (over 325 degrees Fahrenheit). Boiler water treatment chemicals used by Armed Forces vessels include ethylenediamine-tetraacetic acid (EDTA), hydrazine, sodium hydroxide, and disodium phosphate. Sampling data for boiler blowdowns indicate the presence of nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), phosphorus, hydrazine, iron, bis(2-ethylhexyl)phthalate, copper, lead, nickel, and zinc. Boiler blowdown discharges from conventionally powered boilers can exceed Federal criteria or State water quality criteria for copper, iron, lead, nickel, zinc, bis(2-ethylhexyl)phthalate, nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) and phosphorus. Blowdown discharges from nuclear-powered steam generators exceed acute Federal criteria and State acute water quality criteria for copper, and the most stringent State acute water quality criteria for lead and nickel. For nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen) and phosphorus, the most stringent State water quality criteria was exceeded. However, the turbulent mixing resulting from the high velocity discharge, and the relatively small volume of the boiler blowdown causes pollutant concentrations to rapidly dissipate to background levels or below acute Federal criteria and State acute water quality criteria within a short distance from the point of discharge.

Based on thermal modeling of the discharge plume, boiler blowdowns are not expected to exceed State standards for thermal effects. Thermal effects from safety valve testing are substantially less than those from blowdowns, thus safety valve testing also will not exceed State standards for thermal effects.

While the pollutant concentrations in the boiler blowdown discharges exceed acute Federal criteria and State acute water quality criteria, they are discharged intermittently and in small volumes. Further, these discharges are distributed throughout the U.S. at Armed Forces ports, and each individual port receives only a fraction of the total fleetwide mass loading. Based on the information in the record regarding the low mass of pollutants discharged during boiler blowdowns and safety valve discharges, and the manner in which the discharges take place, there is a low potential for causing adverse environmental impacts. Therefore, EPA and DoD have concluded that it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.2 Catapult Wet Accumulator Discharge

This discharge is the water discharged from a catapult wet accumulator, which stores a steam/water mixture for launching aircraft from an aircraft carrier.

The steam used as the motive force for operating the catapults for launching aircraft is provided to the catapult from a steam reservoir, referred to as the catapult wet accumulator. The catapult wet accumulator is a pressure vessel containing a steam/water mixture at a high temperature and pressure. The accumulator is fed an initial charge of boiler feedwater and provided steam from boilers. As steam is released from the accumulator for the catapult launch, the pressure reduction in the accumulator allows some of the water to flash to steam, providing additional steam to operate the catapult. During operation of the system, steam condenses in the accumulator and causes the water level in the accumulator to gradually rise. Periodic blowdowns of the accumulator are required to maintain the water level within operating limits. This steam/water mixture released during the blowdown is discharged below the vessel waterline. In addition to blowdowns required during catapult operation and testing, wet accumulators are emptied prior to major maintenance of the accumulator or when a carrier will be in port for more than 72 hours. When emptying the accumulator, multiple blowdowns are performed over an extended period (up to 12 hours) to reduce pressure prior to draining the tank.

The Navy is the only branch of the Armed Forces with vessels generating this discharge. Eleven of the aircraft carriers are homeported in the United States.

Wet accumulator blowdowns are performed during flight operations, which occur beyond 12 n.m., and during catapult testing, which occurs within 12 n.m. from shore. Wet accumulators are emptied outside 12 n.m. when returning to port for accumulator maintenance or when the carrier will be in port for more than 72 hours. If catapult testing is conducted in port, and the carrier will remain in port for more than 72 hours following the testing, the accumulator will be emptied in port.

Catapult wet accumulator blowdowns have little potential for causing adverse environmental impacts because of the low pollutant loadings and thermal effects of this discharge. Because boiler feedwater is used for the initial charge of water to an empty accumulator, the constituents of the discharge include water treatment chemicals present in boiler feedwater. These chemicals include EDTA, disodium phosphate, and hydrazine. During normal operation, the boiler feedwater chemicals are diluted by the supplied steam. Additional constituents present in the blowdowns originate from the steam provided to the accumulator. Based on sampling data for steam condensate (a similar discharge discussed below in section 5.2.10) and the volume of wet accumulator blowdowns performed within 12 n.m., the combined mass loading for all metals is estimated at less than 0.01 pounds/year. Constituents found in steam condensate include benzidine, bis(2-ethylhexyl)phthalate, copper, nickel, nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), and phosphorus. The concentrations of benzidine, copper, and nickel in steam condensate were found to exceed acute Federal criteria and State acute water quality criteria. The concentration of bis(2-ethylhexyl)phthalate was found to exceed State acute water quality criteria. The concentrations of nitrogen and phosphorus were found to exceed the most stringent State water quality criteria. However, using steam condensate data may overestimate wet accumulator pollutant concentrations because of the shorter contact time between catapult steam and its associated piping system (resulting in less opportunity to entrain corrosion products from the piping). Based on thermal modeling of the discharge plume, catapult wet accumulator blowdowns are not expected to exceed State standards for thermal effects.

Catapult wet accumulator blowdowns have little potential for causing adverse environmental impacts because of the very low pollutant mass loadings in this discharge and because of the low thermal effects from this discharge. Therefore, EPA and DoD determined that it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.3 Cathodic Protection

This discharge consists of the constituents released into the surrounding water from sacrificial anodes or impressed current cathodic protection systems used to prevent hull corrosion.

Steel-hulled vessels require corrosion protection. In addition to anti-corrosion hull paints, these vessels employ cathodic protection which is provided by either sacrificial anodes or Impressed Current Cathodic Protection (ICCP) systems. The most common cathodic protection system for vessels of the Armed Forces is the zinc sacrificial anode, although a few submarines use aluminum anodes. With the sacrificial anode system, zinc or aluminum anodes attached to the hull will preferentially corrode from exposure to the seawater and thereby minimize corrosion of the vessel's hull.

In ICCP systems, the vessel's electrical system passes a current through inert platinum-coated anodes. This current protects the hull in a manner similar to sacrificial anodes by generating current as the anodes corrode. Depending on the type of cathodic protection used, the discharge will include either zinc or aluminum from sacrificial anodes, or chlorine-produced oxidants (CPO) from ICCP systems. Zinc anodes are approximately 99.3% zinc and contain small amounts of zinc, silicon, and indium (for activation). Aluminum anodes can contain 0.001% mercury as an impurity; mercury is a known bioaccumulator.

Approximately 2,170 large Armed Forces vessels use cathodic protection. Of these, nearly 270 have ICCP systems, fewer than five use aluminum sacrificial anodes, and the remaining use zinc sacrificial anodes. The discharge is continuous while the vessel is waterborne and occurs both within and beyond 12 n.m. from shore.

EPA and DoD modeled the discharge from cathodic protection systems to determine the range of constituent concentrations that could be expected in the water surrounding a vessel. This discharge is best described as a mass flux of reaction byproducts emanating from the electro-chemical reaction that occurs at the anodes. Two separate modeling techniques were used for both sacrificial anodes and ICCP systems. The first technique was a dilution model for harbors that takes into account the number of homeported vessels and harbor-specific volume and tidal flow information. Three Navy ports were modeled, representing a range of port sizes. The resulting constituent concentrations calculated for the three ports in this dilution model were below chronic Federal criteria and State chronic water quality criteria.

The second technique modeled mixing zones around a vessel using calculations for a hull size typical of vessels using cathodic protection systems. The mixing model results indicate that a mixing zone of five feet for CPO and 0.5 feet for zinc results in concentrations below the chronic Federal criteria or State chronic water quality criteria. For vessels with aluminum anodes, a mixing zone of less than 0.1 feet achieves concentrations below chronic Federal criteria and State chronic water quality criteria. Concentrations of mercury will be 1,000 times lower than the acute State water quality criteria and 35 times lower than the chronic criteria. The total amount of mercury discharged from aluminum anodes on all Armed Forces vessels is estimated to be less than 0.001 pounds annually.

For ICCP calculations, the modeling is based on an assumption that 100 percent of the supplied electrical current results in CPO generation. Less CPO is actually expected to be generated because the efficiency of the chlorine generation process is known to be less than 100 percent. In addition, using the generation rate alone does not account for the rapid decay of CPO in water through chemical reactions involving CPO, which occur within minutes.

The dilution and mixing zone modeling performed for this discharge indicates that cathodic protection has a low potential for causing adverse impacts on the marine environment. Therefore, EPA and DoD determined that it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.4 Freshwater Lay-Up

This discharge is the potable water that is periodically discharged from the seawater cooling system while the vessel is in port, and the cooling system is in a lay-up mode.

Seawater cooling systems are used onboard some Armed Forces vessels to remove heat from main propulsion machinery, electrical generating plants and other auxiliary equipment. These are single-pass, non-contact cooling systems whereby the seawater enters the hull, is pumped through a piping network and circulated through one or more heat exchangers, then exits the vessel. On certain vessels, the seawater cooling systems are placed in a stand-by mode, or lay-up, when the machinery is not in use. The lay-up is accomplished by blowing the seawater from the condenser with low-pressure air. The condenser is then filled with potable water and drained again to remove residual seawater as protection against corrosion. Then, the condenser is refilled with potable water for the actual lay-up. After 21 days, the lay-up water is discharged overboard and the condenser refilled. The condenser is discharged and refilled on a 30-day cycle thereafter. The volume of each condenser batch discharge is approximately 6,000 gallons.

The Navy is the only branch of the Armed Forces with vessels discharging freshwater lay-up. All submarines generate this discharge, which only occurs while in port. Eight aircraft carriers also lay-up their condensers; however, these condensers are drained to the bilge and the water is handled as bilgewater. Generally, the cooling system is only placed in a lay-up condition if the vessel remains in port for more than three days and the main steam plant is shut down.

Sampling data for submarine freshwater lay-up indicate the presence of chlorine, nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), and the priority pollutants chromium, copper, lead, nickel, and zinc. The concentrations of chlorine, copper, nickel, and zinc can exceed acute Federal criteria or State acute water quality criteria. For nitrogen and phosphorus, the most stringent State water quality criteria was exceeded. Chlorine was detected in the initial flush discharge, but was not found in the extended lay-up discharge. Mass loadings for the priority pollutants (copper, nickel, and zinc) were estimated using total annual discharge volumes and average pollutant concentrations. The total mass loading from all discharges of freshwater lay-up from submarines is estimated at 7 pounds/year of copper, 36 pounds/year of nickel, 29 pounds/year of zinc, 55 pounds/year of nitrogen, 0.58 pounds of total chlorine, 8.3 pounds/year total phosphorus. The mass discharge from any individual freshwater lay-up discharge event would be a fraction of that total. Because of the low total annual mass loading, the low frequency at which the discharge occurs, and the volume of an individual discharge event, discharges of freshwater lay-up have a low potential for causing adverse environmental impacts. Therefore, EPA and DoD determined that it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.5 Mine Countermeasures Equipment Lubrication

This discharge consists of the constituents released into the surrounding seawater by erosion or dissolution from lubricated mine countermeasures equipment when the equipment is deployed or towed. Various types of mine countermeasures equipment are deployed and towed behind vessels to locate and destroy mines. Lubricating grease and oil applied to this equipment can be released into surrounding seawater during its deployment and use, including during training exercises.

The Navy is the only branch of the Armed Forces with a mine countermeasures mission. The Navy uses two classes of vessels, totaling 23 ships, to locate, classify, and destroy mines. The discharge is generated during training exercises, which are normally conducted between 5 and 12 n.m. from shore. Depending on the class of vessel and the type of mine countermeasures equipment being used, the number of training exercises conducted by each vessel ranges from 6 to 240 per year.

Using estimates of the amount of lubricant released during each training exercise, EPA and DoD calculated the annual mass loading of lubricant discharges to be approximately 770 pounds of grease and oil. Using the estimates of the pollutant mass loading released during an exercise, and the volume of water through which the countermeasures equipment is towed or operated during an exercise, EPA and DoD estimated the oil and grease concentrations resulting from mine countermeasures training exercises. These estimated concentrations of oil and grease in the receiving water range from 0.688 to 7.3 µg/l and do not exceed acute water quality criteria.

An additional calculation was performed for the lift cable for the SLQ-48 mine neutralization vehicle (MNV). This lift cable is lubricated with grease; however, the cable is not towed through the water and is only used to deploy or recover the MNV while a vessel is stationary. Using the maximum predicted release of 0.15 ounces of grease per deployment, modeling results indicate that the grease released from the lift cable would disperse in the surrounding receiving waters and be at concentrations below the most stringent State acute water quality criteria within 3 to 5 feet from the cable.

Most discharges from mine countermeasures equipment occur while vessels are underway and the pollutants are quickly dispersed in the environment due to the turbulent mixing conditions caused by the wake of the vessel and towed equipment. Further, these discharges take place beyond 5 n.m. from shore in waters with significant wave energy, allowing for rapid and wide dispersion of the releases. The manner in which these releases occur, coupled with the relatively small amounts of lubricants released, results in this discharge having a low potential for causing adverse impacts on the marine environment. Therefore, EPA and DoD determined that it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for the mine countermeasures equipment lubrication discharge.

5.2.6 Portable Damage Control Drain Pump Discharge

This discharge consists of seawater pumped through the portable damage control drain pump and discharged overboard during periodic testing, maintenance, and training activities.

Portable damage control (DC) drain pumps are used to remove water from vessel compartments during emergencies or to provide seawater for shipboard firefighting in the event water is unavailable from the firemain system. The types of pumps used are described in section 5.2.7, Portable Damage Control Drain Pump Wet Exhaust. Discharges from drain pumps being used during onboard emergencies are not incidental to normal vessel operations, and therefore are not within the scope of this rule. These pumps are, however, periodically operated during maintenance, testing, and training, and pump discharges during these activities are within the scope of this rule. To demonstrate that the pumps are functioning properly, the suction hose is hung over the side of the vessel and the pump operated to verify that the pump effectively transfers the seawater or harbor water. This pump effluent is discharged directly overboard during this testing.

All large ships and selected boats and craft of the Armed Forces generate this discharge. As part of equipment maintenance, testing, and training, the pumps are operated both within and beyond 12 n.m. from shore. Navy, Army, and MSC vessels operate portable DC drain pumps for approximately 10 minutes per month and an additional 15 minutes/year to demonstrate working order and condition. Coast Guard vessels operate their portable DC drain pumps for approximately 30 minutes/month for maintenance and testing.

This discharge consists of seawater/harbor water that only briefly passes through a pumping process. The drain pump discharge is unlikely to cause adverse impacts because the water has a residence time of less than five seconds in the pump and associated suction and discharge hoses, and no measurable constituents are expected to be added to the seawater/harbor water. Therefore, EPA and DoD determined it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.7 Portable Damage Control Drain Pump Wet Exhaust

This periodic discharge is seawater that has mixed and been discharged with portable damage control drain pump exhaust gases to cool the exhaust and quiet the engine.

Portable, engine-driven pumps provide seawater for shipboard firefighting in the event water is unavailable from the firemain. Two models of these portable damage control (DC) drain pumps are used: P-250 and P-100. The P-250 pumps operate on gasoline, injected with oil-based lubricants. Part of the seawater output from these pumps is used to cool the engine and quiet the exhaust. This discharge, termed wet exhaust, is typically routed overboard through a separate exhaust hose and does not include the main discharge of the pump which is classified separately as Portable Damage Control Drain Pump Discharge and discussed in section 5.2.6.

Fuel residuals, lubricants, or their combustion byproducts are present in P-250 engine exhaust gases, condense in the cooling water stream, and are discharged as wet exhaust. The P-100 model operates on diesel fuel. Although the engine that drives the P-100 pump is air-cooled and no water is injected into the exhaust of the pump, a small amount of water contacts the engine during pump priming. Up to one-seventh of a gallon of water may be discharged during each priming event. This water discharged during P-100 priming is considered part of the portable DC drain pump wet exhaust.

The Navy operates approximately 910 drain pumps, the MSC approximately 140 drain pumps, and the Coast Guard approximately 370 drain pumps.

Portable DC drain pump wet exhaust discharges occur during training and monthly planned maintenance activities both within and beyond 12 n.m. from shore. During monthly maintenance activities, the pumps are run for approximately 10 to 30 minutes. The use of portable DC drain pumps during onboard emergencies is not incidental to normal operations, and therefore not within the scope of this rule.

Based on data in the record, the wet exhaust discharge is likely to include metals, oil and grease, and volatile and semi-volatile organic compounds. The concentrations of copper, lead, nickel, silver, and zinc in portable DC drain pump wet exhaust can exceed acute Federal criteria and State acute water quality criteria. Concentrations of oil and grease, benzene, toluene, ethylbenzene, and naphthalene can exceed State acute water quality criteria. Concentrations of these constituents in receiving waters are not expected to exceed water quality criteria because they will dissipate quickly since the mass loadings per discharge event are small and the discharge locations are dispersed fleetwide. The discharge from each of the 500 P-250 pumps occurs separately at different discharge locations. On average, each P-250 pump discharges less than 0.3 pounds of pollutants per discharge event. The duration of each discharge is short, averaging less than 30 minutes. These factors allow the pollutants to dissipate rapidly. Based on this information, the portable DC drain pump wet exhaust is expected to have a low potential for exhibiting adverse environmental impacts on the marine environment. Therefore, EPA and DoD determined it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.8 Refrigeration and Air Conditioning Condensate

This discharge is the drainage of condensed moisture from air conditioning units, refrigerators, freezers, and refrigerated spaces. Refrigerators, refrigerated spaces, freezers, and air conditioning units produce condensate when moist air contacts the cold evaporator coils. This condensate drips from the coils and collects in drains. Condensate collected in drains above the vessel waterline is continuously discharged directly overboard. Below the waterline, condensate is directed to the bilge, non-oily machinery wastewater system, or is retained in dedicated holding tanks prior to periodic overboard discharge.

Approximately 650 Navy, MSC, Coast Guard, Army, and Air Force vessels produce this discharge. The condensate may be discharged at any time, both within and beyond 12 n.m. from shore.

Condensate flow rates depend on air temperature, humidity, and the number and size of cooling units per vessel. The discharge can contain cleaning detergent residuals, seawater from cleaning refrigerated spaces, food residues, and trace metals leached from contact with cooling coils and drain piping. Because evaporator coils are made from corrosion-resistant materials and condensation is non-corrosive, condensate is not expected to contain metals in significant concentrations. Discharges of refrigeration and air conditioning condensate are expected to have a low potential for causing adverse environmental impacts, therefore EPA and DoD determined it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for condensate discharges.

5.2.9 Rudder Bearing Lubrication

This discharge is the oil or grease released by the erosion or dissolution from lubricated bearings that support the rudder and allow it to turn freely. Armed Forces vessels generally use two types of rudder bearings, and two lubricating methods for each type of rudder bearing: 1) grease-lubricated roller bearings; 2) oil-lubricated roller bearings; 3) grease-lubricated stave bearings; and 4) water-lubricated stave bearings. Only oil-lubricated roller bearings and grease-lubricated stave bearings generate a discharge.

Approximately 220 Navy vessels, 50 Coast Guard vessels, and eight MSC vessels use a type of rudder bearing that generates this discharge. The discharge occurs intermittently, primarily when a vessel is underway or its rudder is in use, although some discharges from oil-lubricated roller bearings could potentially occur pierside even when the rudder is not being used because the oil lubricant is slightly pressurized.

This discharge consists of oil leakage and the washout of grease from rudder bearings. EPA and DoD developed an upper bound estimate of the fleetwide release of oil and grease based on allowable leakage/washout rates and the amount of time each vessel spends within 12 n.m. from shore. The maximum allowable oil leak rate for oil-lubricated roller bearings is one gallon/day when the vessel is underway and one pint/day while in port. In practice, these leakage rates are not reached under normal conditions. The grease washout rate for grease-lubricated stave bearings is based on Navy specifications limiting grease washout to 5 percent. Grease washout estimates for this rule are based on releasing 5 percent of the grease over a two-week period, which corresponds to the time between grease applications.

EPA and DoD calculated the expected receiving water concentrations of oil and grease from this discharge to evaluate the potential for the discharge to cause adverse impacts. The underway receiving water volume was determined using an average size vessel and estimating the volume of water displaced by the vessel while transiting from port to a distance of 12 n.m. from shore. In port, discharges are not expected since the lower bearing seals are designed to prevent leakage and, as noted above, the oil to the bearings is kept at a low pressure while in port. The resulting estimated pollutant concentrations do not exceed acute Federal criteria or State acute water quality criteria. The rudder bearing lubrication discharge has a low potential for causing adverse environmental impacts. EPA and DoD determined that it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.10 Steam Condensate

This discharge is the condensed steam discharged from a vessel in port, where the steam originates from shore-based port facilities. Navy and MSC surface ships often use steam from shore facilities during extended port visits to operate auxiliary systems such as laundry facilities, heating systems, and other shipboard systems. In the process of providing heat to ship systems, the steam cools and condenses. This condensate collects in drain collection tanks and is periodically discharged by pumping it overboard. The steam condensate is discharged above the vessel waterline and a portion of the condensate can vaporize as it contacts ambient air.

This discharge is generated only in port because vessels only discharge the condensed steam if it was generated by a shore facility. Ships producing their own steam will recycle their condensate back to the boiler. Vessels take on shore steam when their own boilers are shut down, and thus they have no means for reusing the condensate. There are no systems in place that would allow vessels to return steam condensate to shore for reuse.

Depending on the steam needs of individual vessels, the discharge can be intermittent or continuous whenever shore steam is supplied. Approximately 180 Navy and MSC vessels discharge steam condensate. Coast Guard vessels do not generate this discharge because they operate their auxiliary boilers to produce their own steam even while in port. Army and Air Force vessels do not have steam systems and therefore do not discharge steam condensate.

The constituents of steam condensate include metals from onshore steam piping, ship piping, and heat exchangers, and may have some residual water treatment chemicals. Constituents found in the discharge include nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), phosphorus, bis(2-ethylhexyl)phthalate, benzidine, copper, and nickel. Sampling of steam condensate from four vessels found copper concentrations that exceed both chronic Federal criteria and State chronic water quality criteria. Nickel concentrations exceeded the most stringent State chronic water quality criteria, but not the chronic Federal criteria. Benzidine, bis(2-ethylhexyl)phthalate, nitrogen (in the form of ammonia, nitrates and nitrites, and total Kjeldahl nitrogen), and phosphorus concentrations exceeded the most stringent State water quality criteria.

The potential for steam condensate to cause thermal environmental effects was evaluated by modeling the thermal plume generated by the discharge and then comparing the model results to State thermal discharge water quality criteria. Results of the modeling indicate that only the largest generator of steam condensate (an aircraft carrier) may exceed state thermal mixing zone criteria, and then, only in the State of Washington. The models predict that the thermal plume from an aircraft carrier moored at the pier in Bremerton, Washington would extend a distance of 80 m from the discharge port along the vessel hull, not extending past the end of the hull. The plume would also extend outward no more than a distance of 30 m from the vessel hull at any point along the hull. Results of the modeling indicate that the aircraft carrier may exceed Washington criteria in an area that only covers 5% of the width, 2% of the length, and 0.07% of the total surface area of Sinclair Inlet.

The EPA and DoD do not consider that the plume results in a significant environmental impact. Such a localized plume would have a low potential for interfering with the passage of aquatic organisms in the water body and would have a limited impact on the organisms that reside in the upper water layer (sea surface boundary layer). In addition, because the discharge is freshwater (no salinity) and warmer than the receiving water, the plume floats in the surficial layer of the water body and has no impact on bottom-dwelling organisms.

The low mass loadings in the discharge and the thermal effects modeling results indicate that steam condensate has a low potential for causing adverse environmental impacts. Therefore, EPA and DoD determined that it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.11 Stern Tube Seals and Underwater Bearing Lubrication

This discharge is the seawater pumped through stern tube seals and underwater bearings to lubricate and cool them during normal operation.

Propeller shafts are supported by stern tube bearings at the point where the shaft exits the hull (for surface ships and submarines), and by strut bearings outboard of the ship (for surface ships only). A stern tube seal is used to prevent seawater from entering the vessel where the shaft penetrates the hull. The stern tube seals and bearings are cooled and lubricated by forcing seawater from the firemain or auxiliary cooling water system through the seals and over the bearings. On submarines, potable water (freshwater) may be supplied from pierside connections for stern tube seal lubrication during extended periods in port.

Strut bearings are not provided with forced cooling or lubrication. Instead, strut bearings use the surrounding seawater flow for lubrication and cooling when the vessel is underway. Submarines do not have strut bearings and instead use a self-aligning bearing aft of the stern tube that supports the weight of the propeller and shafting outboard of the vessel.

Almost all classes of surface vessels and submarines have stern tube seals and bearings that require lubrication, and these discharges are continuous. The discharge can contain synthetic (Buna-N) rubber used in the construction of the bearings. Metals such as copper and nickel, the materials of construction of the stern tube, can also be present in the discharge. When freshwater is used for lubricating submarine seals, the freshwater may contain residual chlorine. Based on estimates of chlorine concentrations in potable water, fleetwide approximately 0.8 pounds/year of chlorine exit through the stern tube seals and bearings.

Total annual mass loadings for the metal constituents of seawater lubrication were calculated based on materials of construction in the stern tube, corrosion rates for those materials, and the surface area of the material exposed to seawater for a DDG 51 Class ship. While the copper concentrations can exceed chronic Federal criteria and State chronic water quality criteria, the rate at which the water is discharged through a vessel's stern tube seal and bearings is relatively small - 20 gal/min each shaft, 2 shafts per ship -- resulting in a low pollutant mass loading exiting through the seals and bearings. Further, these discharges are distributed throughout the U.S. at Armed Forces ports, and each individual port receives only a fraction of the total fleetwide mass loading. Given the low rate of the discharge and the low mass loadings, this discharge has a low potential for causing adverse environmental impacts. Therefore, EPA and DoD determined it is not reasonable and practicable to require the use of a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.12 Submarine Acoustic Countermeasures Launcher Discharge

This intermittent discharge is composed of seawater that mixes with acoustic countermeasure device propulsion gas after launching an acoustic countermeasure device, and subsequently discharged either through exchange with the surrounding seawater or while draining from an expended device being removed from the submarine.

Navy submarines have the capability to launch acoustic countermeasures devices to improve the survivability of a submarine by generating sufficient noise to be observed by hostile torpedoes, sonars, or other monitoring devices. The only countermeasures systems that generate a discharge within 12 n.m. are the countermeasures set acoustic (CSA) Mk 2 systems, which launch the countermeasure devices by gas propulsion through a launch tube. Following the launch, a metal plate closes the launch tube forming a watertight endcap. To equalize pressure, a one-way check valve allows water to flow into the tube after launch, but does not allow any of the water to be released through the opening. The launch tube cap contains three, 3/8 inch, bleed hole plugs that dissolve approximately three days after the launch. This allows exchange between the launch tube and the surrounding seawater while the submarine is moving. The bleed holes also allow some launch tube water to drain into the surrounding water when the assembly is removed from the submarine for replacement. The CSA Mk2 system is installed on 24 Navy submarines.

Constituents found in the CSA Mk2 launch tubes after launching countermeasures devices include copper, cadmium, lead, and silver. The discharge may also contain constituents from the propulsion gas including hydrochloric acid, carbon dioxide, carbon monoxide, nitrogen, alumina, iron (II) chloride, titanium dioxide, hydrogen, and iron (II) oxide. Sampling indicates that copper, cadmium, and silver concentrations are above both Federal acute water criteria and the most stringent State acute water quality criteria; lead concentrations are above the most stringent State water quality criteria. The total annual mass loadings from all discharges from submarine CSA Mk2 countermeasure launcher systems are estimated at 0.0005 pounds/year cadmium, 0.0009 pounds/year lead, 0.0007 pounds/year copper, and 0.00009 pounds/year silver.

Because of the low annual mass loading, the low frequency at which the discharge occurs, and the volume of the individual discharge event (17 gallons), discharges from submarine CSA launcher systems have a low potential for causing adverse environmental impacts. Therefore EPA and DoD determined it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.2.13 Submarine Emergency Diesel Engine Wet Exhaust

This discharge is seawater that is mixed and discharged with exhaust gases from the submarine emergency diesel engine for the purpose of cooling the exhaust and quieting the engine.

Submarines are equipped with an emergency diesel engine that is also used in a variety of non-emergency situations, including electrical power generation to supplement or replace shore-supplied electricity, routine maintenance, and readiness checks. This wet exhaust discharge is generated by injecting seawater (or harbor water) as a cooling stream into the diesel engine exhaust system. The cooling water mixes with and cools the hot exhaust gases, and is discharged primarily as a mist that disperses in the air before depositing on the surface of the water body.

All submarines generate this discharge. Diesel engines must be operated for equipment checks that occur prior to submarine deployment, monthly availability assurance, and periodic trend analyses. On average, each submarine will operate the diesel engine for approximately 60 hours/year while within 12 n.m. from shore. Most of the operating time (54 hours/year) occurs while the submarine is pierside.

Typical constituents of diesel engine exhaust include various hydrocarbon combustion by-products, measured as volatile and semi-volatile organic compounds. The priority pollutants expected to be present in the discharge include polycyclic aromatic hydrocarbons (PAHs), toluene, and possibly metals. Although no individual pollutant exceeds water quality criteria, the total concentration of PAHs in the discharge is predicted to exceed State acute water quality criteria. Nevertheless, the discharge of PAHs is unlikely to cause adverse impacts on the marine environment because the total fleetwide annual mass loading of PAHs is calculated to be less than 0.06 pounds/year. Therefore, EPA and DoD determined that it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for submarine diesel engine wet exhaust.

5.2.14 Submarine Outboard Equipment Grease and External Hydraulics

This discharge occurs when grease applied to a submarine's outboard equipment is released to the environment through the mechanical action of seawater eroding the grease layer while the submarine is underway, and by the slow dissolution of the grease into the seawater. This discharge also includes any hydraulic oil that may leak past the seals of hydraulically operated external components of a submarine (e.g., bow planes).

Outboard equipment grease is discharged by all submarines, but the discharge of oil from external hydraulic equipment is limited to 22 submarines. This discharge occurs continuously both within and beyond 12 n.m. from shore, although the rate of discharge depends upon the degree of contact between seawater and the greased outboard components, and how fast the submarine is traveling. Most hydraulically-operated outboard equipment, for example, does not contact seawater within 12 n.m. from shore because submarines generally operate on the surface in this region, and the hydraulically-operated equipment producing this discharge is located mostly above the waterline.

This discharge consists of grease (Termalene #2) and hydraulic oil. Termalene #2 consists of mineral oil, a calcium-based rust inhibitor, thickening agents, an antioxidant, and dye. Using an assumption that 100 percent of all grease applied to outboard equipment is washed away at a constant rate during submarine operations, the amount of grease released fleetwide within 12 n.m. is approximately 520 pounds/year. This value is believed to overstate the actual mass of grease discharged within 12 n.m. because submarines operate at lower rates of speed in coastal waters (thus leading to less erosion of the grease) and a surfaced submarine exposes a lesser amount of grease to the water than is exposed by a submerged submarine.

Hydraulic oil consists of paraffinic distillates and additives. Using a calculation that assumes all hydraulic system seals leak oil at the maximum allowable leak rate, approximately 0.4 pounds/year of hydraulic oil is released fleetwide within 12 n.m. from shore. (Based on discussions with Navy hydraulic system experts, such oil leakage rates are not common and thus this calculation overestimates the amount of oil actually leaked.) The submarine will displace approximately 120 million cubic feet of water as it travels within 12 n.m. from shore. Assuming that hydraulic oil and outboard grease are leaked at a constant rate, this will result in concentrations below the levels established in acute Federal criteria and State acute water quality criteria.

In addition, the turbulence created by the vessel wake is expected to result in rapid dispersion of the constituents released. As a result, the submarine outboard equipment grease and external hydraulics discharge has low potential for causing adverse environmental effects. EPA and DoD determined it is not reasonable and practicable to require a MPCD to mitigate adverse impacts on the marine environment for this discharge.

5.3 References

1. International Maritime Organization. "Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Water and Sediment Discharge." 10 May 1995.

GLOSSARY AND ABBREVIATIONS

AAV	amphibious assault vehicle
ABT	aerostat balloon tender
AC	area command cutter
AC	anti-corrosive – as related to vessel hull coatings
ACE	armored combat earthmover
Administrator	the Administrator of the U.S. Environmental Protection Agency
AE	ammunition ship
AF	anti-fouling
AFB	air force base
AFDB	large auxiliary floating drydock
AFDL	small auxiliary floating drydock
AFDM	medium auxiliary floating drydock
AFFF	aqueous film-forming foam
AFS	combat store ship
AG	miscellaneous auxiliary
AGER	environmental research ship
AGF	miscellaneous command ship
AGM	missile range instrumentation ship
AGOR	oceanographic research ship
AGOS	ocean surveillance ship
AGS	surveying ship
AGSS	auxiliary research submarine
AH	hospital ship
AKR	vehicle cargo ship
Amps	amperes
Anode	the site at which oxidation occurs in an electrochemical cell
ANB	aids to navigation boat
AO	oiler
AOE	fast combat support ship
AP	area point system search craft
APF	afloat pre-positioning force
APL	barracks craft

GLOSSARY AND ABBREVIATIONS (contd.)

APU	auxiliary power unit
AR	repair ship
ARC	cable repairing ship
ARD	auxiliary repair dock
ARDM	medium auxiliary repair dock
ARS	salvage ship
AS	submarine tender
ASR	annual sedimentation rate
ASTM	American Society for Testing and Materials
ASW	anti-submarine warfare
AT	armored troop carrier
ATC	mini-armored troop carrier
ATF	fleet ocean tug
avg.	average
AWR	army war reserve
B	barge
BC	dry cargo barge
BCDK	decked, enclosed conversion kit barge
BD	floating crane
BDL	below detection limit
BG	liquid cargo barge
BH	boom handling boat
BK	deck cargo barge
BMP	best management practice
BOD	biochemical oxygen demand
BPL	delong mobile piers
BRM	refrigerated stores barge
BT	bomb target
BU	buoy utility boat
BUSL	stern loading buoy utility boat
BW	boston whaler
CA	catamaran (also a gun cruiser, surface combatant)
Cathode	the site at which reduction occurs in an electrochemical cell
CC	cabin cruiser

GLOSSARY AND ABBREVIATIONS (contd.)

CDNSWC	(see NSWCCD)
CFR	Code of Federal Regulations
CG	guided missile cruiser
CGN	guided missile cruiser (non-conventional propulsion)
CHT	collection, holding and transfer (tank)
CID	commercial item description
CM	landing craft, mechanized
Cm	centimeter
CNO	Chief of Naval Operations
COD	chemical oxygen demand
COE	Corps of Engineers
COMNAVAIRLANT	Commander Naval Air Force, Atlantic Fleet
COMNAVAIRPAC	Commander Naval Air Force, Pacific Fleet
COMNAVSURFLANT	Commander Naval Surface Force, Atlantic Fleet
COMNAVSURFPAC	Commander Naval Surface Force, Pacific Fleet
COPHOS	coordinated phosphate treatment
CORMIX	Cornell mixing zone expert system
CPO	chlorine produced oxidants
CPP	controllable pitch propeller
CRRC	combat rubber raiding craft
CT	craft of opportunity coop trainer
CU	landing craft, utility
CV	multi-purpose aircraft carrier
CVN	multi-purpose aircraft carrier, non-conventional
CWA	Clean Water Act
DB	distribution box boat
DBT	dibutyltin
DC	direct current
DC	damage control
DD	destroyer
DDG	guided missile destroyer
DFT	dry film thickness
DoD	Department of Defense
DOT	Department of Transportation

GLOSSARY AND ABBREVIATIONS (contd.)

DSRV	deep submergence rescue vehicle
DSV	deep submergence vehicle
DT	diving tender
DW	dive workboat
EDTA	ethylenediaminetetraacetic acid, a chelating agent
EE	equipment expert
EGT	emergency gas turbine
EOSS	engineering operating sequencing systems
EPA	the U.S. Environmental Protection Agency
ESC	the UNDS Executive Steering Committee
FAS	fueling at sea
FB	catamaran ferry
FFG	guided missile frigate
FLO/FLO	float-on/float-off vessel
FMS	floating machine shop
FR	Federal Register
FR	fouling rating
FSS	fast sealift ship
G	grams
Gal	gallons
Gpm	gallons per minute
GRP	glass reinforced plastic
HC	hydrocarbon
HEM	hexane extractable materials
HOPM	hydraulic oil pressure module
HP	horsepower
I&S	intelligence and security
ICCP	impressed current cathodic protection
ILS	integrated logistics services
IMO	International Maritime Organization
INSURV	board of inspection and survey
IX	unclassified miscellaneous unit
J-Boat	work and inspection boat
Kw	kilowatt

GLOSSARY AND ABBREVIATIONS (contd.)

L	liter
LA	landing craft, assault
LARC	four-wheeled amphibious cargo vehicle
LASH	lighter-aboard-ship
Lb	pound
LC	landing craft
LCAC	landing craft, air cushion
LCC	amphibious command ship
LCM	landing craft, mechanized
LCPL	landing craft, personnel, large
LCU	landing craft, utility
LCVP	landing craft, vehicle, personnel
LH	line handling boat
LHA	amphibious assault ship (general-purpose)
LHD	amphibious assault ship (multi-purpose)
LPD	amphibious transport dock
LPH	amphibious assault ship (helicopter)
LSD	dock landing ship
LST	tank landing ship
LSV	logistics support vessel
LT	large harbor tug
MARAD	Maritime Administration
MARPOL	international convention for the prevention of pollution from ships
MBT	monobutyltin
MBT	main ballast tank
MC	mine countermeasures support craft
MCB	motor cargo boat
MCM	mine countermeasures ship
MDL	minimum detection limit
MDZ	maritime defense zone
MEB	marine expeditionary brigade
MERR	metal element repair and restoration machine
μg	micrograms (one millionth of a gram)

GLOSSARY AND ABBREVIATIONS (contd.)

Mg	milligrams (one thousandth of a gram)
Mgal	million gallons
Mgy	million gallons per year
MHC	minehunter, coastal
Min	minute
ML	motor launch
ML	milliliter (one thousandth of a liter)
MLB	motor life boat
MM	marine mammal support craft
MNV	mine neutralization vehicle
MOGAS	motor gasoline
MPC	maintenance procedure card
MPCD	marine pollution control device
MPS	maritime pre-positioning ship
MR	missile retriever
MRC	major regional conflict
MSB	motor surf boat
MSC	Military Sealift Command
MSD	marine sanitation device
MSDS	material safety data sheet
MV	motor vessel
MW	motor whaleboat
MWT	magnetic water treatment
n.m.	nautical miles
NAVSEA (or SEA)	Naval Sea Systems Command
NAVSTA	naval station
NDRF	National Defense Reserve Fleet
NDZ	no-discharge zone
NFAF	Naval Fleet Auxiliary Force
NFESC	Naval Facilities Engineering Services Command
NFME	naval fleet marine expeditionary (see MEB)
NFO	normal fuel oil
NL	no limit
NM	noise measuring boat

GLOSSARY AND ABBREVIATIONS (contd.)

NOAA	National Oceanic and Atmospheric Administration
NOD	nature of discharge
NPDES	national pollutant discharge elimination system
NraD	Naval Research and Development Command
NRF	Naval Reserve Fleet
NS	non-standard (commercial) boat
NSTM	naval ships' technical manual
NSWCCD	Naval Surface Warfare Center, Carderock Division
OCM	oil content monitor
OPNAVINST	naval operations instruction manual
OWHT	oily waste holding tank
OWS	oil-water separator
P	personnel boats
PAH	polynuclear aromatic hydrocarbon
PB	patrol boat
PB-HS	patrol boat, harbor security
PBR	river patrol craft
PC	patrol, coastal
PCB	polychlorinated biphenyl
PE	personnel boat
PF	patrol craft, fast
PG	patrol gunboat
PK	picket boat
PL	landing craft, personnel light
PMS	preventative maintenance system
PMS	planned maintenance system
Ppb	parts per billion
Ppm	parts per million
PR	plane personnel and rescue
PREPO	pre-positioning ships
Priority pollutants	toxic pollutants designated in section 307(a) of the Clean Water Act
PSB	port security boat
Psi	pounds per square inch

GLOSSARY AND ABBREVIATIONS (contd.)

PT	punt
PWB	ports and waterways boat
RB or RIB	rigid inflatable boat
RHIB	rigid hull inflatable boat
RHIL	large rigid hull inflatable boat
RHIM	medium rigid hull inflatable boat
RIMSS	redundant independent mechanical starting systems
RO	reverse osmosis
RO/RO	roll-on/roll-off type vessel
ROS	reduced operating status
RRC	rubber raiding craft
RRDF	roll-on/roll-off discharge facilities
RRF	Ready Reserve Fleet
RX	rigid inflatable boat (non-standard)
SB	sound/sail
SC	support craft
SCAMP	submerged cleaning and maintenance platform
SCC	sample control center
Secretary	the Secretary of the U.S. Department of Defense
SER	sampling episode report
SERC	Smithsonian Environmental Research Center
SES	surface effects ship
SESO	Ships Environmental Support Office
SGT	silicone gel treated
SLO	synthetic lubricating oil
SLWT	side-loading warping tug
SMSF	special mission support force
SRB	surf rescue boat
SRFO	standard refueling, fuel oil
SS	steamship
SS	submarine, (also swimmer support)
SSAP	specific sampling and analysis plan
SSBN	ballistic missile submarine, non-conventional
SSN	submarine, non-conventional

GLOSSARY AND ABBREVIATIONS (contd.)

ST	sail training craft also small harbor tug
SVOC	semi-volatile organic compound
T-Boat	small freight and supply vessel
TACOM	U.S. Army Tank-Automotive and Armaments Command
TANB	trailerable aids to navigation boat
TBT	tributyltin
TC	training craft
TCLP	toxicity characteristic leaching procedure
TD	target drone
TDD	technical development document
TDS	total dissolved solids
TG	tugboat
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TR	torpedo retriever
TRC	total residual chlorine
TRO	total residual oxidants
TS	training ship, State Maritime Academies
TSS	total suspended solids
TWG	technical working group
U	utility boat
UB	utility boat
UMI	underway material inspections
UNDS	uniform national discharge standards
UNREP	underway replenishment
UTB	utility boat
UTL	large utility boat
VOC	volatile organic compound
VP	landing craft, vehicle personnel
VSTOL	vertical/short take-off and landing
WAGB	icebreaker
WB	work boat
Welldeck	the docking well onboard amphibious warfare ships used to store landing craft

GLOSSARY AND ABBREVIATIONS (contd.)

WH	wherry
WHEC	high endurance cutter
WIX	training cutter/sailing bark
WLB	offshore buoy tender
WLI	inshore buoy tender
WLIC	inland construction tender
WLM	coastal buoy tender
WLR	river buoy tender
WMEC	medium endurance cutter
WOCT	waste oil collection tank
WOT	waste oil tank
WPB	patrol boat
WQC	water quality criteria
WT	warping tug
WTGB	icebreaking tug
WYTL	harbor tug, small
WYTM	harbor tug, medium
YC	open lighter
YCF	car float
YCV	aircraft transportation lighter
YD	floating crane
YDT	diving tender
YFB	ferryboat or launch
YFN	covered lighter
YFNB	large covered lighter
YFND	drydock companion craft
YFNX	lighter - special purpose
YFP	floating power barge
YFRN	refrigerated/covered lighter
YFRT	covered lighter, range tender
YFU	harbor utility craft
YGN	garbage lighter
YL	yawl
YLC	salvage lift craft

GLOSSARY AND ABBREVIATIONS (contd.)

YM	dredge
YMN	dredge
YNG	gate craft
YO	fuel oil barge
YOG	gasoline barge
YOGN	gasoline barge
YON	fuel oil barge
YOS	oil storage barge
YP	patrol craft, training
YPD	floating pile driver
YR	floating workshop
Yr	year
YRB	repair and berthing barge
YRBM	repair, berthing and messing barge
YRDH	floating drydock workshop, hull
YRR	radiological repair barge
YRST	salvage craft tender
YSD	seaplane wrecking derrick
YSR	sludge removal barge
YTB	large harbor tug
YTL	small harbor tug
YTM	medium harbor tug
YTT	torpedo trials craft
YWN	water barge

Appendix A
Nature of Discharge (NOD) and Marine Pollution Control Device (MPCD) Reports

Appendix A

Appendix A contains each of the 39 NOD reports, the contents of which are described in section 4.3 of the main document. Reports are arranged alphabetically, in order of appearance. The title of each report may be found on the bottom center of each page. The following four MPCD practicability analyses are also included in this appendix, after the respective NOD reports:

- Distillation and Reverse Osmosis Brine;
- Hull Coating Leachate;
- Small Boat Engine Wet Exhaust; and
- Underwater Ship Husbandry

Refer to section 4.4 for a more detailed discussion of the process used to determine MPCD practicability.

Appendix A
List of NOD and MPCD Reports (in order of appearance)

Aqueous Film-Forming Foam NOD Report
Boiler Blowdown NOD Report
Catapult Water Brake Tank and Post-Launch Retraction Exhaust NOD Report
Catapult Wet Accumulator Discharge NOD Report
Cathodic Protection NOD Report
Chain Locker Effluent NOD Report
Clean Ballast NOD Report
Compensated Fuel Ballast NOD Report
Controllable Pitch Propeller Hydraulic Fluid NOD Report
Deck Runoff NOD Report
Dirty Ballast NOD Report
Distillation and Reverse Osmosis Brine NOD Report
Distillation and Reverse Osmosis Brine MPCD Report
Elevator Pit Effluent NOD Report
Firemain Systems NOD Report
Freshwater Lay-Up NOD Report
Gas Turbine Water Wash NOD Report
Graywater NOD Report
Hull Coating Leachate NOD Report
Hull Coating Leachate MPCD Report
Mine Countermeasures Equipment Lubrication NOD Report
Motor Gasoline Compensating Discharge NOD Report
Non-Oily Machinery Wastewater NOD Report
Photographic Laboratory Drains NOD Report
Portable Damage Control Drain Pump Discharge NOD Report
Portable Damage Control Drain Pump Wet Exhaust NOD Report
Refrigeration /Air Conditioning Condensate NOD Report
Rudder Bearing Lubrication NOD Report
Seawater Cooling Overboard Discharge NOD Report
Seawater Piping Biofouling Prevention NOD Report
Small Boat Engine Wet Exhaust NOD Report
Small Boat Engine Wet Exhaust MPCD Report
Sonar Dome Discharge NOD Report
Steam Condensate NOD Report
Stern Tube Seals and Underwater Bearing Lubrication NOD Report
Submarine Acoustic Countermeasures Launcher Discharge NOD Report
Submarine Bilgewater NOD Report
Submarine Emergency Diesel Engine Wet Exhaust NOD Report
Submarine Outboard Equipment Grease and External Hydraulics NOD Report
Surface Vessel Bilgewater/Oil-Water Separator Discharge NOD Report
Underwater Ship Husbandry NOD Report
Underwater Ship Husbandry MPCD Report
Welldeck Discharges NOD Report

NATURE OF DISCHARGE REPORT

Aqueous Film Forming Foam (AFFF)

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "..discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the AFFF and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

AFFF is the primary firefighting agent used aboard U.S. Coast Guard (USCG) and Navy vessels for flammable liquid fires. A different class of agents, Fluoroprotein foams, are used for the same purpose on vessels in the Military Sealift Command (MSC). Aqueous Film Forming Foam (AFFF) is a particular type of synthetic firefighting foam whose performance is governed by military specification. Fluoroprotein foam is a protein-based material to which fluorinated surfactants have been added to improve fluidity and surface tension properties, while reducing the tendency of the protein base to absorb liquids.

These foams control and extinguish flammable liquid fires and help prevent such fires after spills by spreading a vapor-sealing film over the flammable liquid. The foam layer effectively excludes oxygen from the surface of the fuel, while the high water content cools the surface. The foam layer also provides a reservoir that will reseal a disturbed fuel surface and inhibit reignition. Both foams have excellent “wetting” or penetrating characteristics can be used against fires involving densely packed wood, wood products, cloth, textile and fibrous materials, paper, and paper products. Both types of foam concentrates can be stored for indefinite periods in approved equipment and systems with no degradation in chemical properties or capabilities.

In use, foam concentrate is mixed with seawater to form a dilute seawater foam solution. Seawater foam solution is generated in foam proportioning stations or by portable proportioners.[1] Each type involves metering foam concentrate into pressurized, firefighting seawater. The metering accuracy of the proportioning stations is verified by periodic tests.

Foam is applied both manually, with conventional foam or water/fog equipment such as fire hoses equipped with foam nozzles, and from fixed sprinkler devices. Fixed systems provide seawater foam solution to sprinklers on flight decks, and to overhead sprinklers in hangars, tank decks, well decks, weapon elevator pits, fueled vehicle decks or holds, refueling stations, and fuel pump rooms. If a protected area requires a greater flow rate than can be supplied by a single proportioning station, the area is subdivided into zones or groups, each independently supplied from a single proportioning station. Bilge sprinkler systems are installed in machinery spaces and pump rooms. Firefighting hose reel stations are supplied through a system of proportioners, pumps, and permanently installed piping.

Foam concentrate is stored in tanks, 55-gallon drums, and 5-gallon cans. Aircraft carriers, large amphibious ships, and other large ships can carry more than 20,000 gallons of AFFF or fluoroprotein foam concentrate.

Neither AFFF nor fluoroprotein foam is ever discharged from vessels in concentrated form. Only the dilute seawater foam solution is discharged. Incidental discharge of seawater foam solution occurs during maintenance that is part of the Planned Maintenance System (PMS), Board of Inspection and Survey (INSURV) underway material inspections (UMI), flight deck certifications, or biennial tests on MSC vessels by the USCG Office of Marine Inspection.

Regular preventive maintenance of firefighting systems and equipment requiring the discharge of seawater foam solution aboard ship occurs annually during PMS activities, although some maintenance is performed at 18 month intervals. Table 1 indicates the frequency of foam solution discharges on Navy, MSC, and USCG vessels. For Navy vessels, an INSURV UMI occurs every 3 years and involves the same system checks and resulting seawater foam discharges as the annual PMS activities. An MSC damage control instruction requires that foam solution be present at flight deck nozzles before every flight operation (approximately twice per month per vessel), which is verified by operating the nozzles until foam is sighted.[2] For aircraft carriers, Navy requirements call for a flight deck certification during the first deployment to sea after a shipyard or repair period (approximately every 1.5 years). Other than aircraft carriers, ships with flight decks, whether Navy or MSC, receive flight deck certification inspections every 3 years that test for foam solution at all flight deck nozzles and hoses.

2.2 Releases to the Environment

The seawater foam solutions that are discharged onto flight and weather decks as a result of maintenance, inspection, and certification activities are washed overboard with pressurized seawater from fire hoses, or by activating the seawater washdown system. Foam that is discharged into internal ship compartment bilges during system testing and flushing evolutions is pumped overboard by eductors.

Seawater foam discharge will contain all the constituents from the firemain, in addition to constituents unique to the foam concentrate. As discussed more fully in the Firemain Systems NOD Report, the principal constituent of the firemain discharge that could have an adverse water quality effect is copper, derived from the copper nickel firemain piping. Therefore, copper will be an expected component of the AFFF solution discharge.

2.3 Vessels Producing the Discharge

All Navy surface ships, all classes of USCG cutters, icebreakers and icebreaking tugs, and MSC ship classes with the ability to support helicopter operations produce the discharge. Table 2 shows the vessel classes that produce the discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

The Navy provides instruction on where seawater AFFF solutions can be discharged during maintenance that tests the proportioning accuracy of AFFF proportioning stations. This test is commonly conducted by discharging an AFFF hose over the side, when beyond the 12 nautical mile (n.m.) limit. The PMS instructions state:

> "Accomplish maintenance requirements only when ship is beyond 12 nautical miles of shore and preferably while underway. When within 3 nautical miles of shore or in port, discharge to a tank, barge or to an authorized truck. In other cases, when between 3 and 12 nautical miles, overboard discharge is permitted with a minimum (ship) speed of 10 knots."[3-9]

Discharges that are part of inspections and certifications are not governed by the maintenance instruction, and can be discharged anywhere, except that seawater foam solution in a machinery space bilge is governed by bilge pumping rules, and cannot be discharged within 12 n.m.[10] In practice, the maintenance policy applies because a single discharge event will be scheduled to satisfy simultaneously the requirements for maintenance, inspection, and certification.

3.2 Rate

When testing the proportioning accuracy of proportioning stations, ships typically test one station at a time by discharging a foam hose over the side. This discharge rate is 125 gallons per minute (gpm) or 250 gpm, depending on the flow rate of the hose selected for the test. When testing or demonstrating flight deck sprinkling, the most common practice is to operate one or two zones at a time, continuing until all the zones have been tested. The nominal flow rate for each zone on Navy ships is 1,000 gpm, so the typical discharge rate is 2,000 gpm.

AFFF concentrate is mixed with seawater from the firemain to form a 6% dilute solution, that is, 100 gallons of solution contains 6 gallons of AFFF concentrate and 94 gallons of seawater.[1] The WTGB 140 Class of icebreaking tugs operated by the USCG use more concentrated base stock which is diluted to a 3% solution. Fluoroprotein foams are mixed on MSC ships in both 3% and 6% solutions, depending on the design of the installed proportioning equipment.[11] These mixing ratios are used in Table 2 to derive discharge quantities of foam concentrate and seawater.

After tests or demonstrations of flight deck sprinkling, the foam blanket is washed off using fire hoses, or by operating the fixed seawater washdown system. Both techniques result in a seawater discharge supplied from the firemain. The flow rate is variable, but a typical range is 250 gpm (two fire hoses on a ship with a helicopter landing platform) to 2,000 gpm (two flight deck zones on an aircraft carrier).

Tests or demonstrations of bilge sprinkling do not result in environmental discharges until bilges are pumped overboard. Bilges can be pumped within 12 n.m. of shore if the discharge is passed through oil water separators. However, the surfactants in AFFF and fluoroprotein foam render the oil water separators ineffective, so crews do not discharge seawater foam solution through their oil water separators. Accordingly, bilges containing seawater foam solution are pumped only beyond 12 n.m. from shore[10]. Therefore, this NOD report does not account for foam discharges attributable to bilge sprinkling, discharge of machinery space bilge hoses, nor the seawater used to wash and pump bilges.

By ship class, Table 2 shows the discharges of seawater foam solution, foam concentrate in the solution, seawater in the solution, and seawater used to wash the solution off the ship. All discharges are assumed to occur within 12 n.m. of shore. The fleetwide estimates are summarized in Table 3.

3.3 Constituents

The ingredients in foam concentrate are listed on material safety data sheets (MSDSs) prepared by the manufacturer. The AFFF concentrate produced by the principal Armed Forces supplier contains water, 2-(2-butoxyethoxy)-ethanol, urea, alkyl sulfate salts (2 in number), amphoteric fluoroalkylamide derivative, perfluoroalkyl sulfonate salts (5), triethanolamine, and methyl-1H-benzotriazole, with fresh water accounting for approximately 80% of the ingredients by weight (see Table 3).[12] Freshwater is the principal ingredient of all the foam concentrates used by the Armed Forces, comprising approximately 80% - 90% of the product by weight.[12-16] The protein base in fluoroprotein foam is nontoxic and biodegradable. The chemical identities and corresponding weight percents of the surfactants in AFFF and fluoroprotein concentrates are proprietary, but are stated by the manufacturers to be nontoxic in the quantities present in the manufactured product, and more benign when diluted with seawater to a 3% or 6% solution. Fluoroprotein foam and 3% AFFF used on MSC and USCG vessels contribute only 4% of the total volume of foam discharged annually from vessels.

No priority pollutants nor bioaccumulators are known to be present in the AFFF product or fluoroprotein foam concentrates used aboard vessels of the Armed Forces.

The firemain provides the seawater in the seawater foam solution. Metals and other materials from the firemain system can be dissolved by the seawater, and particles can be eroded and physically entrained in the seawater flow. Any wetted material in the firemain system can become a constituent of the firemain discharge. None of the potential constituents are known bioaccumulators. The priority pollutants in the discharge are bis(2-ethylhexyl) phthalate, copper, nickel, and iron, which are found in the piping of wet firemain systems.

The piping in Navy AFFF systems is made of copper nickel alloy, the same as used in the firemain system. Total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron from this source will be constituents of the discharge.

3.4 Concentrations

Table 3 shows the concentrations of the chemical constituents in AFFF concentrate. The data are based on the type of concentrate that is most widely used. Table 3 also shows the concentrations in the seawater foam solution.

Seawater foam discharges have not been part of the sampling program. The concentrations of total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron contributed from the AFFF system are not known. AFFF concentrate includes corrosion inhibitors.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of constituents in the discharge are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Discharge quantities in Table 2 and constituent concentrations in Table 3 are combined to estimate mass loadings.

Based on the approximate mass of 366,000 pounds of AFFF concentrate discharged annually from Navy and USCG vessels, and the weight percentages of AFFF constituents, upper bound estimates of the annual mass loadings for the constituents range from a maximum of approximately 38,500 pounds for 2-(2-butoxyethoxy)-ethanol to a minimum of 370 pounds for methyl-1H-benzotriazole. The mass loadings resulting from 3% AFFF and fluoroprotein foam discharges aboard MSC vessels do not significantly change the calculated loadings because the total volume of these concentrates represents 4.0% of the foam discharged annually.

The annual mass loadings of copper, nickel, and iron from the firemain system are shown in Table 3, based on a total of 4,924,000 gallons of seawater used to produce foam and wash it off the ship after the test.

4.2 Environmental Concentrations

As listed in Table 2, individual constituent concentrations in foam range from 6,400 mg/L for 2-(2-butoxyethoxy)-ethanol down to about 61 mg/L for methyl-1H-benzotriazole. The concentrations presented represent AFFF seawater foam constituent concentrations in the product as discharged from hose nozzles and sprinkler heads aboard ship. These concentrations do not take into account the additional diluting effect of any seawater used to wash the AFFF seawater solution overboard. Thus, the concentration of the constituents in AFFF seawater solutions is reduced when this additional dilution factor is considered. Further, the ship's motion through the sea causes the discharge to be distributed along the ship's track, instead of being discharged in a single spot. Upon discharge to the environment, AFFF concentrate has been diluted 94:6 (about

16:1) by the proportioning process, with further dilution during the wash-off procedure, followed by rapid dispersion in the wake of a moving ship.

AFFF could potentially be discharged from vessels in amounts that cause visible foam floating on the water surface. Floating foam detracts from the appearance of surface waters and can violate aesthetic water quality criteria. Several states have standards to prevent "floating

The bis(2-ethylhexyl) phthalate, copper, nickel, and iron constituents are the only priority pollutants sampled which exceed acute water quality criteria. Table 4 shows the concentration of the constituents of firemain water, total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron, that exceed acute water quality criteria. The copper concentration exceeds both the Federal and most stringent state criteria while the total nitrogen, bis(2-ethylhexyl) phthalate, nickel, and iron concentrations exceed only the most stringent state criterion.

4.3 Potential for Introducing Non-Indigenous Species

AFFF and fluoroprotein concentrates do not include biota. Seawater foam discharge can include microbial and invertebrate marine organisms, since biofouling accumulates in firemain systems, wet and dry types. See the Firemain Systems NOD Report for a discussion of the potential for introducing non-indigenous species in the firemain discharge.

5.0 CONCLUSION

AFFF discharges from vessels of the Armed Forces have the potential to cause an adverse environmental impact. There is currently an operational policy and procedure that prohibits any overboard discharge of AFFF from Navy vessels within 3 n.m. of shore, and stipulates that discharge could only occur at a minimum speed of 10 knots between 3 and 12 n.m. from shore. If this policy were not in place, the discharge could deposit significant amounts of foam on surface water. This foam would diminish the visual quality of the water.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information was used to estimate the volume of discharge. Based on this estimate and on the reported constituent percentages by weight, the concentrations of the AFFF constituents in this discharge were then estimated. Table 5 shows the sources of the data used to develop this NOD report.

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The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Frequency of AFFF Discharge Events

Months	12	18	24	30	36	42	48	54	60	66	72
USCG Ships											
PMS - annual	X		X		X		X		X		X
FD Cert - triennial					X						X
Hose: 3 times in 3 years											
Flt dk: 1 time in 3 years											
MSC Ships											
PMS - annual	X		X		X		X		X		X
USCG - biennial	X				X				X		
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 9 times in 6 years											
Flt dk: 7 times in 6 years											
T-AKR Class											
Foam maker: 7 times in 6 years											
Hose: 9 times in 6 years											
Flt Dk: 7 times in 6 years											
LPH Class											
PMS - 18 months		X			X			X			X
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 3 times in 3 years											
Flt Dk: 2 times in 3 years											
CV/CVN Classes											
PMS - 18 months		X			X			X			X
FD Cert - 18 months		X			X			X			X
INSURV - triennial					X						X
Hose: 3 times in 3 years											
Flt Dk: 3 times in 3 years											
Other Navy Classes											
PMS - annual	X		X		X		X		X		X
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 4 times in 3 years											
Flt Dk: 2 times in 3 years											

Notes for Table 1:

1. PMS discharges are scheduled by the ship. The ships are assumed to schedule their PMS maintenance tests to coincide with a demonstration required by an off-ship inspection team, when possible. The tests that satisfy off-ship inspection teams are assumed to be separate, not combined.

2. PMS tests are required annually, although, for some ships the periodicity is 18 months. Flight deck certification is required on all air capable ships every 3 years, except for aircraft carriers additional certifications are required after industrial work on the flight deck; the assumed average periodicity for aircraft carriers is every 18 months. INSURV underway material inspections are required every 3 years, only on Navy and MSC ships. For MSC ships, the USCG Office of Marine Inspection requires demonstration of foam making capability every 2 years.

3. Data are derived from references 2, and 3-9.

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
WAGB	1	USCG	1	Hose	1	125	125	8	118	0
WAGB	2	USCG	1	Hose	1	125	250	15	235	0
WHEC	12	USCG	2	Hose	1	125	3000	180	2820	0
WMEC	31	USCG	1	Hose	1	125	3875	233	3643	0
WTGB	9	USCG	1	Hose	1	125	1125	34	1058	0
T-AE 26	8	MSC	2	Hose	1.5	125	3000	180	2910	0
	8	MSC	2	Fl. Dk	1.167	353	6599	396	6203	54989
T-AFS 1	8	MSC	2	Hose	1.5	311	7459	448	7012	0
	8	MSC	2	Fl. Dk	1.167	350	6529	392	6137	54410
T-AGOS 1	5	MSC	1	Hose	1.5	125	938	56	881	0
19	4	MSC	1	Hose	1.5	125	750	45	705	0
T-AGS 26	2	MSC	1	Hose	1.5	125	375	23	353	0
T-AGS 45	1	MSC	1	Hose	1.5	125	188	11	176	0
T-AGS 51	2	MSC	1	Hose	1.5	125	375	23	353	0
T-AGS 60	4	MSC	1	Hose	1.5	125	750	45	705	0
T-AH 19	2	MSC	1	Hose	1.5	384	1152	69	1083	0
	2	MSC	1	Monitor	1.167	500	1167	70	1097	9725
T-AKR	11	MSC	2	Foam Mkr.	1.167	107	2747	82	2665	22893
	11	MSC	2	Hose	1.5	125	4125	124	4001	0
	11	MSC	2	Fl. Dk.	1.167	1707	43826	1315	42511	365213
T-AO 187	12	MSC	2	Hose	1.5	125	4500	270	4230	0
	12	MSC	2	Fl. Dk.	1.167	360	10083	605	9478	84024
T-ARC 7	1	MSC	1	Hose	1.5	125	188	11	176	0
	1	MSC	1	Fl. Dk.	1.167	360	420	25	395	3501
T-ATF 166	7	MSC	1	Hose	1.5	125	1313	79	1234	0
	7	MSC	1	Fl. Dk.	1.167	125	1021	61	960	8509
AGF 11	2	NAVY	4	Hose	1.33	125	1330	80	1250	0
	2	NAVY	4	Fl. Dk.	0.67	1021	5470	328	5142	45587
AGOR 21	1	NAVY	1	Hose	1.33	125	166	10	156	0
	1	NAVY	1	Fl. Dk.	0.67	0	0	0	0	0

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
AGOR 23	2	NAVY	1	Hose	1.33	125	333	20	313	0
	2	NAVY	1	Fl. Dk.	0.67	0	0	0	0	0
AO 177	5	NAVY	2	Hose	1.33	125	1663	100	1563	0
	5	NAVY	2	Fl. Dk.	0.67	273	1829	110	1719	15243
AOE 1	4	NAVY	2	Hose	1.33	125	1330	80	1250	0
	4	NAVY	2	Fl. Dk.	0.67	464	2489	149	2339	20738
AOE 6	3	NAVY	3	Hose	1.33	125	1496	90	1406	0
	3	NAVY	3	Fl. Dk.	0.67	374	2258	135	2123	18817
ARS 50	4	NAVY	1	Monitor	1	1000	4000	240	3760	0
	4	NAVY	1	Hose	1	250	1000	108	892	0
AS 33	1	NAVY	2	Hose	1.33	125	333	20	313	0
	1	NAVY	2	Fl. Dk.	0.67	270	362	22	340	3015
AS 39	3	NAVY	2	Hose	1.33	125	998	60	938	0
	3	NAVY	2	Fl. Dk.	0.67	314	1261	76	1185	630
CG 47	27	NAVY	3	Hose	1.33	125	13466	808	12658	0
	27	NAVY	3	Fl. Dk.	0.67	170	9212	553	8659	76765
CGN 36	2	NAVY	2	Hose	1.33	125	665	40	625	0
	2	NAVY	2	Fl. Dk.	0.67	144	386	23	363	3216
CGN 38	1	NAVY	2	Hose	1.33	125	333	20	313	0
59/63/65	4	NAVY	17	Hose	1	250	17000	1836	15164	0
	4	NAVY	17	Fl. Dk.	1	1000	68000	4080	63920	566667
CVN 65/68	8	NAVY	16	Hose	1	250	32000	1920	30080	0
CVN 65/68	8	NAVY	20	Fl. Dk.	1	1000	160000	9600	150400	1333333
DDG 963	31	NAVY	2	Hose	1.33	125	10308	618	9689	0
	31	NAVY	2	Fl. Dk.	0.67	130	5416	325	5091	45133
DDG 51	18	NAVY	2	Hose	1.33	125	5985	359	5626	0
	18	NAVY	2	Fl. Dk.	0.67	210	5065	304	4761	2533
DDG 993	4	NAVY	2	Hose	1.33	125	1330	80	1250	11083
	4	NAVY	2	Fl. Dk.	0.67	130	699	42	657	349

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
FFG 7	43	NAVY	2	Hose	1.33	125	14298	858	13440	0
	43	NAVY	2	Fl. Dk.	0.67	182	10510	631	9879	87582
IX 308	2	NAVY	1	Hose	1.33	125	333	20	313	0
IX 35	2	NAVY	1	Hose	1.33	125	333	20	313	0
IX 501	1	NAVY	1	Hose	1.33	125	166	10	156	0
LCC 19	2	NAVY	2	Hose	1.33	125	665	40	625	0
	2	NAVY	2	Fl. Dk.	0.67	320	857	51	805	7140
LHA 1	5	NAVY	12	Hose	1.33	250	19950	1197	18753	0
	5	NAVY	12	Fl. Dk.	0.67	1000	40200	2412	37788	335000
LHD 1	4	NAVY	12	Hose	1.33	250	15960	958	15002	0
	4	NAVY	12	Fl. Dk.	0.67	1000	32160	1930	30230	268000
LPD 4	8	NAVY	4	Hose	1.33	125	5320	319	5001	0
	8	NAVY	4	Fl. Dk.	0.67	1021	21882	1313	20569	182347
LPH 2	2	NAVY	10	Hose	1	250	5000	540	4700	0
	2	NAVY	10	Fl. Dk.	0.67	1000	13400	804	12596	111667
LSD 36	5	NAVY	4	Hose	1.33	125	3325	200	3126	0
	5	NAVY	4	Fl. Dk.	0.67	365	4888	293	4595	40736
LSD 41	8	NAVY	4	Hose	1.33	125	5320	319	5001	0
	8	NAVY	4	Fl. Dk.	0.67	936	20068	1204	18864	167232
LSD 49	3	NAVY	4	Hose	1.33	125	1995	120	1875	0
	3	NAVY	4	Fl. Dk.	0.67	936	7525	452	7074	62712
LST 1179	3	NAVY	1	Hose	1.33	125	499	30	469	0
	3	NAVY	1	Fl. Dk.	0.67	216	434	26	408	3618
MCM 1	14	NAVY	1	Hose	1.33	125	2328	140	2188	0
MHC 51	12	NAVY	1	Hose	1.33	125	1995	120	1875	0
PC 1	13	NAVY	1	Hose	1.33	125	2161	130	2032	0
	13	NAVY	1	Fl. Dk.	0.67	162	1408	85	1324	11737
Misc. (See Note 6)	30	MSC	N/A	N/A	N/A	N/A	27500	1650	25850	220000
TOTAL							**722537**	**42902**	**679931**	**4244144**

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

Notes for Table 2:

1. Values in this table are upper bound estimates, because all discharge is assumed to occur within 12 n. m. of shore.

2. Discharges are due to maintenance tests of the proportioning accuracy of the foam proportioners, to demonstrations of foam making capability for flight deck certification teams, and to demonstrations of foam making capability for the Board of Inspection and Survey. Discharges to bilges, by hose nozzles or fixed sprinklers, are not tabulated because the foam solution is not pumped overboard within 12 n.m. of shore.

3. The discharge flow through hoses is 125 gpm or 250 gpm, depending on the ship's installed equipment. The discharge rate through fixed flight deck sprinklers is .06 gpm/ft2 X Flight Deck area. For aircraft carriers, and the big deck amphibious ships, LHD, LHA, and LPH, flight deck discharge is calculated at 1000 gpm per zone.

4. Total hose flow is No. of ships X No. of stations per ship X Hose nozzle flow rate X 1 minute. Foam is 6% of total flow, and seawater is 94% of total flow rate. For ships with fixed speed foam injection pumps, foam flow is 27 gpm and seawater flow = total flow - 27 gpm. Total flight deck flow is No. of ships X flight deck area X .06 gpm/ft2 X 1 minute. For aircraft carriers and the big deck amphibious ships, LHD, LHA, and LPH, the total flow is No. of ships X No. of zones per ship X 1000 gpm per zone X 1 minute. For both cases, foam is 6% of total flow, and seawater is 94% of total flow. For WTGB and T-AKR Class ships foam is 3% of total flow and seawater is 97% of total flow; these ships use a more concentrated foam concentrate than other ships.

5. The flow from demonstrations and tests of flight deck hoses is directed over the side. No seawater is needed for clean up. The flow through fixed flight deck sprinklers is cleaned off the ship by seawater from the firemain, either through hose nozzles or the fixed flight deck sprinklers. As an average figure to account for both options, the cleanup flow is assumed to be .05 gpm/ft2, or 833 gpm per zone, flowing for 10 minutes.

6. Aboard MSC ships with helicopter landing capabilities, the presence of foam must be demonstrated at flight deck nozzles and hoses before each flight operation. Assuming two such operations per month per ship, the total annual discharge of fluoroprotein foam concentrate for the 30 ships involved is 30 ships X 55 gallons foam concentrate per ship per year, which equals 1650 gallons/year. The concentrate is assumed to be 6% of the total flow, so the total flow of solution is 1650/.06 or 27,500 gallons of seawater foam solution per year. The water portion is assumed to be 94% of the total flow. Cleanup seawater flow is assumed to be eight times the total solution flow, or 220,000 gallons.

7. To perform a maintenance test of the proportioning accuracy of a proportioning station, foam solution will be directed over the side via a hose nozzle rated at 125 gpm or 250 gpm, depending on the ship's installed equipment. Test is assumed to require 1 minute of flow.

8. To demonstrate foam-making ability for an off-ship inspection team, foam will be discharged over the side through hose nozzles and onto the flight deck through the fixed sprinklers. Demonstration is assumed to require 1 minute of flow.

9. Data are derived from Table 1 , specific references 1, 2, 11, and general references.

Table 3. Upper Bound Estimates of Annual Mass Loading and Constituent Concentrations Due to AFFF Discharge

Annual discharge of AFFF/seawater solution, gals	722,500	
Annual discharge of AFFF concentrate, gals	42,900	
Annual discharge of AFFF concentrate, lbs	366,366	8.54/lb/gal density
Annual discharge of seawater in the solution, gals	680,000	
Annual discharge of cleanup seawater, gals	4,244,000	
Annual discharge of seawater, including cleanup, gals	4,924,000	

			Mass Loading		Concentration	
Constituent	**Wt % Low**	**Wt % High**	**Low (lb)**	**High (lb)**	**Low mg/L**	**High mg/L**
Fresh water	78.0%	81.0%	286,000	297,000	47,400	49,200
2-(2-butoxyenthoxy)-ethanol	9.5%	10.4%	34,800	38,500	5,800	6,400
urea	3.0%	7.0%	11,000	25,600	1,800	4,300
alkyl sulfate salts (2)	1.0%	5.0%	3,700	18,300	610	3,040
amphoteric fluoroalkylamide derivative	1.0%	2.0%	3,700	7,300	610	1,220
perfluoroalkyl sulfonate salts (5)	0.1%	1.0%	370	3,700	61	610
triethanolamine	0.1%	1.0%	370	3,700	61	610
methyl-1H-benzotriazole	0.0%	0.1%	0	370	0	61
Constituent	**Concentration**		**Mass Loading**			
Total nitrogen	500 μg/L		16.8 lb			
Bis(2-ethylhexyl) phthalate in seawater	22 μg/L		0.74 lb			
Copper in seawater	45.59 μg/L		1.87 lb			
Nickel in seawater	15.24 μg/L		0.62 lb			
Iron in seawater	21.28 μg/L		0.87 lb			

Notes:

1. Conversion: 1 μg/L = 8.345 X 10^{-9} lb/gal
2. Concentrations in mg/L are for the diluted AFFF/seawater solution. The concentrations are accurate for hoses discharged over the side, but overstated by about 30% for flight deck discharges which are washed over the side with additional seawater. Calculation is pounds of constituent, divided by gallons of discharged solution, and converted to mg/L.
3. Data derived from Table 2, and References 12, 17.

Table 4. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (µg/L)					
Total nitrogen	500			None	200 (HI)[A]
Organics (µg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (µg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.5 (WA)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Total	15.2	BDL	52.1	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 5. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	NSTM Ch 555			X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	PMS Cards			X
3.2 Rate			X	X
3.3 Constituents	X			
3.4 Concentrations	MSDS Sheets			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	X

NATURE OF DISCHARGE REPORT

Boiler Blowdown

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes boiler blowdown and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

There are two ways to produce steam for use on ships: conventionally powered boilers and nuclear powered ship steam generators. Conventionally powered boilers and nuclear powered ship steam generators are discussed separately in this report.

2.1.1 Conventionally Powered Ship Boiler Blowdown

Boilers are used to produce steam for the majority of surface vessels that have steam systems. Aboard conventionally powered steam ships, the main propulsion boilers supply steam at high pressure and temperature to the main propulsion turbines, ship service turbogenerators, and a host of auxiliary and hotel services. Many gas turbine and diesel-powered ships have auxiliary or waste heat boilers that produce steam at relatively low pressure for hotel services.

The water supplied to the boiler system (feedwater) is treated to minimize the formation of scale and to inhibit corrosion in the boiler and boiler system piping. All main propulsion boilers in the Navy now use the chelant treatment system, which replaced the coordinated phosphate (COPHOS) treatment system used in main propulsion boilers.[1] Main and auxiliary boilers of the Military Sealift Command (MSC) ships use boiler feedwater chemistry prescribed by the original equipment manufacturer.[2] Auxiliary boilers aboard U.S. Coast Guard (USCG) vessels are treated in accordance with USCG instructions.[3]

The process of boiling water to make steam creates higher concentrations of particulates (the result of corrosion products and sludge forming minerals in the boiler water) and chemicals in the boiler water. The feedwater that is added to maintain the water level in the boiler (boiler water) has a lower concentration of chemicals and dilutes the chemical concentrations that develop during steam generation. Even with careful boiler water treatment management, water or a water/steam mixture must be periodically released from the boiler to remove particulates and sludge and to control boiler water chemical treatment concentrations. This process is referred to as a "boiler blowdown." Blowdowns are accomplished by releasing controlled amounts of boiler water through sea connections that exit the ship below the waterline.

There are four types of boiler blowdown procedures: surface blowdown, scum blowdown, bottom blowdown, and continuous blowdown. Surface blowdowns are used to remove particulates and dissolved materials in the boiler water and to control boiler water chemistry. If contamination or boiler water treatment chemical over-addition exist, both are reduced by a surface blowdown. Scum blowdowns are used to remove surface scum. Bottom blowdowns are used to control the amount of sludge in the boiler water. Continuous blowdowns are used in all chelant treatment systems to rid the boiler of dissolved metal chelates and suspended matter.[1] All boiler blowdowns are performed in accordance with published guidance.

In all cases, except bottom blowdown, blowdowns can be conducted while the boiler is operating. Bottom blowdowns for propulsion and auxiliary boilers are conducted only when the boiler is secured.[1] Waste heat boiler bottom blowdowns can be conducted while the boiler is operating. The four boiler blowdown procedures are conducted in the following ways:

- **Surface blowdowns** discharge approximately five percent of the total volume of water in the boiler.[4,5] During a surface blowdown, the water level in the boiler is increased three to four inches, the surface blowdown valve is opened and then closed when the boiler empties to the normal water level.

- **Scum blowdowns** discharge approximately one percent of the total volume of water in the boiler.[4,5] During a scum blowdown, the water level in the boiler is increased by one inch and the surface blowdown valve is opened and then closed when the boiler empties to the normal water level.[1]

- **Bottom blowdowns** discharge approximately ten percent of the total volume of water in the boiler.[4,5] For a bottom blowdown, the water level in the boiler is increased six inches, the bottom blowdown valve is opened and then closed when the boiler empties to the normal water level.[1]

- **Continuous blowdowns** discharge approximately four percent of the total volume of water in the boiler per day.[5,6] This discharge flows to the bilge of the vessel. Thus, continuous blowdowns are not considered in the total blowdown volume in this report and are covered by the Surface Vessel Bilgewater/OWS Discharge NOD Report.

Ships normally receive steam and electrical power from the pier while they are in port during extended upkeep periods. However, there are occasions when a steam powered ship can have a main propulsion boiler operating in port or at anchor for the operation of a turbogenerator set and to provide hotel service steam. Auxiliary boilers can also be operated in port to provide hotel service steam. When a boiler is secured in port (laid-up), one of six different methods is used. Only one of these methods, placing the boiler under a steam blanket, results in boiler blowdowns. A secured boiler is placed under a steam blanket by keeping steam continuously applied to the boiler. This steam can be from shore or from an operating boiler on the ship. The steam blanket excludes oxygen, thereby minimizing the potential for corrosion in the boiler. Boilers under a steam blanket require a blowdown because the steam applied to the boiler condenses and increases the boiler's water level. A blowdown returns the water to its proper level.

2.1.1.1 Chelant Feedwater Treatment

The chelant system adds ethylenediaminetetraacetic acid (EDTA) to the boiler feedwater in powder form. Only distilled water is used as feedwater in the system. EDTA reacts with metal ions and forms soluble metal chelates (that do not precipitate) that are removed during blowdowns.[7] This helps reduce boiler scaling by removing calcium and magnesium. Hydrazine is used to eliminate residual dissolved oxygen in the feedwater, thus inhibiting the corrosive effects of oxygen in the boiler.

2.1.1.2 Coordinated Phosphate Chemistry

COPHOS systems treat the feedwater to the boiler to reduce boiler scale and corrosion, thus ensuring boiler system reliability. COPHOS systems also use only distilled water as feedwater. Chemicals such as trisodium phosphate, disodium phosphate, and sodium hydroxide are used to precipitate scale forming magnesium and calcium.[1]

Auxiliary and waste heat boilers on Navy ships use a feedwater chemical treatment system similar to COPHOS. This system uses disodium phosphate to reduce boiler corrosion and scale.[1]

2.1.1.3 Drew Ameroid Chemistry

Drew Ameroid systems treat the feedwater to the boiler with disodium phosphate, sodium hydroxide, and morpholine to control scale and corrosion in the boiler. Main propulsion boilers aboard MSC ships, operating at pressures greater than 850 pounds per square inch (psi), use the Drew Ameroid “Ultra Marine” system of treatment. Main propulsion boilers aboard MSC ships, operating at pressures less than 850 psi, use the Drew Standard system. Auxiliary and waste heat boilers on MSC ships use the Drew AKG-100 chemical treatment system.[2] Three different treatment systems are used due to the different operating temperatures of each type of boiler. The treatment chemicals are the same for all three systems but the proportions of the chemicals are different depending on the operating temperature of the boiler.

2.1.1.4 USCG Boiler Water Chemistry

There are no steam-powered ships in the USCG; however, many USCG ships have auxiliary boilers. The preferred method of water treatment in the USCG is a magnetic water treatment (MWT) system, which does not utilize any chemicals. The MWT system uses a device that generates a magnetic field in the water stream to help prevent scale formation. Although the preferred method of treatment is MWT, some USCG ships treat their boiler water with COPHOS, as defined by Navy guidance.[3,8]

2.1.2 Nuclear Powered Ship Steam Generator Blowdown

All nuclear-powered ships have steam generators which require periodic blowdowns (typically about once per week) to maintain safe operation of the system.[4] Section 3 and 4 contain discussions of constituents, concentrations, and mass loadings from nuclear powered ships steam generators, but further information on the process description is classified.

2.1.3 Safety Valve Testing

Testing is necessary to ensure the proper operation of all main and auxiliary boiler safety valves. Safety valves are installed on each boiler to prevent a boiler rupture in the event of excessive pressure buildup. They are installed on the upper portion of the boiler and only discharge steam. Unlike surface and bottom blowdowns, liquid and particulate matter are not discharged from safety valves. Main propulsion boilers usually have three or four safety valves, and auxiliary or waste heat boilers have two valves. Periodic testing results in a very short discharge of steam at full boiler pressure to the atmosphere through an escape pipe on the ship's smokestack. This testing must be performed annually for each boiler. Safety valves must also be tested after each boiler hydrostatic test and whenever a boiler is placed back in service after a repair.[9] For MSC ships, safety valve tests are performed annually during each USCG inspection. These tests are typically performed in port.

Safety valves are tested to measure the exact pressure at which the safety valves fully lift and reset. These pressures are defined by the boiler specifications. If the valves do not lift or reseat at the specified pressure, the test must be repeated after making adjustments to the safety valves until the exact pressures are met.[8] Although steam is discharged at full boiler pressure, the release is to the atmosphere through an escape pipe on the back of the smokestack and only small amounts of condensate reach the water. The discharge is in the form of water vapor released to the atmosphere.

Safety valve testing is also performed on each nuclear powered ship steam generator. This discharge is identical to safety valve testing on conventionally-powered ship boilers; however, the discharge exits below the waterline instead of being released to the atmosphere through an escape pipe. Safety valve testing is performed once every five years on each nuclear steam generator.

2.2 Releases to the Environment

Boiler and steam generator blowdown discharges are infrequent, of short duration (seconds), in small volumes (approximately 310 gallons maximum), and at high pressures (up to 1200 psi). The discharge consists of water and steam or sludge-bearing water at elevated temperatures (above 325° F) and pressures. The discharge can contain metals or boiler water treatment chemicals. The frequency of the discharge is based on boiler and steam generator water chemistry and operation and is therefore not predictable. Boiler and steam generator blowdown discharges are released through hull fittings located below the ship's waterline (underwater discharge).

2.3 Vessels Producing the Discharge

Table 1 list the various Navy, MSC, and USCG vessels which generate boiler blowdown discharge. Ships that use steam for propulsion purposes produce the largest volume of discharge. These ships use high pressure steam (1200 and 600 psi steam systems) to drive propulsion and auxiliary equipment. Diesel and gas turbine powered ships can use fuel fired or waste heat boilers, which operate at pressures up to 150 psi, to generate steam for auxiliary systems. Vessels that use auxiliary and waste heat boilers are also identified in Table 1. All nuclear powered ships have steam generators. There are 89 submarines, 3 nuclear powered cruisers, and 8 nuclear powered aircraft carriers that blow down steam generator water.[4] Army, Marine Corps, and Air Force vessels do not utilize steam systems and do not generate this discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Boiler blowdowns can occur when a boiler is operating, after it has been secured, or when under a steam blanket. Thus, these discharges occur within and beyond 12 nautical miles (n.m.) from shore. Safety valve testing on nuclear powered ship steam generators only occurs in port.

3.2 Rate

The volume of water in the boiler while steaming (steaming volume) is used to determine the amount of water/sludge discharged during surface, scum, and bottom blowdowns. These volumes are listed in Table 1 for each ship class and a sample calculation is provided below.[1] Surface blowdowns discharge five percent of the steaming water volume, scum blowdowns discharge one percent of the steaming water volume, and bottom blowdowns discharge ten percent of the steaming water volume.[1] The number of blowdowns per year within 12 n.m. were estimated based on a Naval Ship Systems Engineering Station report on boiler blowdown discharges and revised based on vessel operation within 12 n.m.[5,10] These estimates for each ship category are listed in Table 2. USCG ships with MWT do not use chemical boiler water treatments, but are included in the blowdown table to include their thermal effect and because their blowdown contains metal constituents.[3] USCG ships with COPHOS treated feedwater are also included in the table. The majority of USCG vessel operations are typically performed within 12 n.m. of shore; therefore, the total number of bottom and surface blowdowns is higher than for Navy vessels.[10,11]

Boiler Blowdown Volume, gal per year = (discharge)(number of blowdowns) Where: discharge (gal) = (Boiler steaming volume, gal)(percent volume discharged per blowdown) number of blowdowns = number of blowdowns with 12 n.m. per year

The total blowdown discharge volume within 12 n.m. of shore is 570,860 gallons for Navy main propulsion boilers and 190,348 gallons for Navy auxiliary and waste heat boilers. Total blowdown discharge volume within 12 n.m. is 205,800 gallons for MSC main propulsion boilers and 58,500 gallons for MSC auxiliary and waste heat boilers. The total blowdown discharge volume from USCG auxiliary boilers is 93,600 gallons. The total boiler blowdown discharge volume within 12 n.m. for all Navy, MSC, and USCG ships is 1,119,108 gallons.

Blowdowns for nuclear powered ships steam generators results in a total volume of 3,615,000 gallons per year.[12]

The volume discharged from safety valve testing on nuclear powered ships steam generators is not available. The safety valves are tested once every five years. The available information is in the form of mass loadings and is discussed in Section 4.1.

3.3 Constituents

Boiler blowdown for conventionally powered ships (e.g., steam, diesel, and gas turbine) was sampled under the UNDS sampling program. Samples were taken from five ship classes: the LHD 1 class, the CG 47 class, the LSD 49 class, the T-AO 187 class, and WHEC 378 class. LHD 1 class uses chelant water treatment; CG 47 and LSD 49 classes use COPHOS water treatment; T-AO 187 class uses the Drew Ameroid water treatment; and WHEC 378 uses magnetic water treatment. Boiler samples were analyzed for metals, organics, and classicals based on the boiler blowdown process, system designs, and analytical data available. In addition, hydrazine, a boiler treatment chemical, was specifically tested for since it was not in the aforementioned analyte classes and it was most likely to be present in boiler blowdown. The results of the sampling are provided in Table 3.

The surface blowdown sample for T-AO-187 class was contaminated at the sampling station, which is also used by the ship to sample diesel jacket water (a closed loop cooling system) through common sampling piping.[13] The bottom blowdown sample was taken from the same sampling system, but was completed after the surface blowdown sample was taken and after additional flushing of the piping system had occurred. The constituent concentrations for the bottom blowdown sample appear to be similar to other systems sampled. Even though the surface blowdown constituent concentrations are suspect, they have been used to calculate mass loadings since no other data is available at this time.

The sampling of nuclear powered ships steam generators was conducted separate from the sampling performed on conventionally-powered boilers. Constituent data for nuclear powered ships steam generators is listed in Table 4.[12]

Of the constituents detected in boiler and steam generator blowdown and safety valve testing discharges, antimony, arsenic, cadmium, copper, chromium, lead, nickel, selenium, thallium, zinc, and bis(2-ethylhexyl) phthalate are priority pollutants as defined by the EPA. There are no constituents in boiler or steam generator blowdown that have been identified as bioaccumulators.

3.4 Concentrations

A summary of the analytical results are presented in Table 3.[14] This table shows the constituents, the log-normal mean or concentration value for single sample data, the frequency of detection for each constituent, the minimum and maximum concentrations for multiple sample data, and the mass loadings of each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for non-detected results. The concentrations of constituents in nuclear powered ships steam generator blowdowns are provided in Table 4.[15] No constituent concentration data are available for safety valve testing discharges.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on the discharge volume estimates developed in Tables 1 and 2 and the log-normal mean discharge concentrations, mass loadings are presented in Table 3. Table 5 is present in order to highlight constituents with log-normal mean concentrations that exceed ambient water quality criteria. A sample calculation of the estimated annual mass loading for copper is shown here:

Mass Loading for Copper (Total)

Mass Loading = (Net Positive Log-normal Mean Concentration)(Flow Rate)

(203 μg/L)(3.785 L/gal)(590,343 gal/yr)(g/1,000,000 μg)(lb/453.593 g) ≅ 1 lb/yr

The annual mass loadings are reported for the entire fleet. The total annual discharge of copper is only 7.2 pounds per year for conventionally powered ships which is discharged over a large geographical area. The largest metal mass loading discharged is iron at 37.5 pounds per year for conventionally powered boilers which is discharged over a large geographical area. These loadings include the constituent concentration data from the T-AO 203 surface blowdown sample even though this sample has been determined to be contaminated.

The annual mass loadings per ship class are reported for the ship classes that the samples were taken. The total loading of copper for the LHD 1 class (Chelant) is 0.063 pounds, for the CG 47 and LSD 49 classes (COPHOS) is 1.6 pounds, for the WHEC 378 class (MWT) is 0.008 pounds, and for the T-AO 187 class (Drew) is 0.194 pounds. A sample calculation of the estimated annual mass loading for copper on the LHD 1 is shown here:

Mass Loading on the LHD 1 for Copper (Total)
= (Surface Blowdown Log-normal Mean Concentration)(Surface Blowdown Flow Rate) + (Bottom Blowdown Log-normal Mean Concentration)(Bottom Blowdown Flow Rate)
= (203 μg/L)(3.785 L/gal)(32,240 gal/yr)(g/1,000,000 μg)(lb/453.593 g) + (40.6 μg/L)(3.785 L/gal)(24,800 gal/yr)(g/1,000,000 μg)(lb/453.593 g) ≅ 0.063 lb/yr

Nuclear powered ships steam generator blowdown mass loadings are listed in Table 6. The annual mass loading of copper from nuclear powered ships steam generators is approximately 3.2 pounds per year.

The total annual discharge of copper is only 11.62 pounds for the entire fleet or 0.03 pound per ship per year, which is discharged over a large geographical area. The largest metal discharge is iron at approximately 38.5 pounds annually for the entire fleet or 0.11 pound per ship per year.

Since safety valve testing releases only steam, and not liquid nor particulate matter as in surface and bottom blowdowns, the mass of constituents discharged is expected to be much smaller than that discharged from boiler blowdown. Table 7 lists the discharges from safety valve testing from nuclear powered ships steam generators.[15] The total mass loadings of all constituents for all nuclear powered ships for safety valve testing is approximately 4.38 pounds per year.

4.2 Environmental Concentrations

The constituent concentrations and their corresponding Federal and most stringent state water quality criteria (WQC) are listed in Tables 8 and 9. These tables include the constituent concentrations from the T-AO 203. Federal and most stringent state WQC for metals are based on the dissolved fraction of the metal.

For conventionally powered boilers, copper concentrations for all feedwater treatment systems exceeded Federal and most stringent state WQC. Iron concentrations for all feedwater treatment systems exceeded Florida's WQC. Lead concentrations for all feedwater treatment systems, except chelant, exceeded Florida's and Georgia's WQC but did not exceed the Federal WQC except for Drew Chemicals feedwater treatment. Nickel concentrations for the chelant, Drew Chemicals and COPHOS feedwater treatment systems exceeded Federal and most stringent state WQC. Nickel concentrations for the magnetic water treatment system exceeded the most stringent state (Florida and Georgia) WQC but did not exceed the Federal WQC. Zinc concentrations for the chelant, Drew Chemicals and COPHOS feedwater treatment systems exceeded Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) concentrations for all feedwater treatment systems exceeded most stringent state WQC. Phosphorous concentrations for all feedwater treatment systems other than Drew

Chemicals for Bottom Blowdown exceeded most stringent state WQC. Bis(2-Ethylhexyl) phthalate for Drew Chemicals feedwater treatment systems and COPHOS Bottom Blowdown feedwater treatment system exceeded most stringent state WQC.

For nuclear powered ships steam generators, copper concentrations exceed Federal and most stringent state WQC. Lead concentrations exceed Florida's WQC. Nickel concentrations for the CVN 65 carrier exceed both Federal and most stringent state water quality criteria; all other ships are below the Federal WQC for nickel, but are above the most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) and phosphorous exceed the most stringent state WQC.

Although the concentrations of copper from boiler blowdowns are greater than water quality criteria at the point of discharge, the turbulent mixing, pressure of the blowdown discharge, and small volumes of the blowdown will cause concentrations to decrease rapidly. The estimated discharge velocity at boiler pressure (1200 psi) is 422 ft/sec. This translates to discharge rates of 68 gal/sec for a 2.0 inch diameter discharge fitting and 38.74 gal/sec for a 1.5 inch discharge fitting. As a comparison, at 100 psi (auxiliary boiler pressure) the discharge velocity is 121 ft/sec, which translates to a discharge rate of 11.22 gal/sec from a 1.5 inch diameter discharge fitting. The LHA1 class ships have the boilers that produce the largest volume blowdown of 310 gallons. A bottom blowdown from a boiler on an LHA 1 class ship will only discharge 0.09 grams of copper. Therefore, it is expected concentrations of copper, lead, and nickel will fall below WQC briefly after discharge.

4.3 Thermal Effects

The potential for boiler blowdown to cause thermal environmental effects was evaluated by modeling the thermal plume for boiler blowdown generated under conservative conditions and then comparing the calculated thermal plume to the state thermal plume size requirements. The thermal effects were modeled by using a batch discharge approach which uses thermodynamic equations and geometry to estimate the plume size. The steps to estimate the maximum size of the thermal plume for a given acceptable mixed temperature are given below:[16]

- calculate the total heat and mass injected in a blowdown;
- calculate the volume of water needed to dilute this mass of water such that the acceptable mixed temperature is obtained; and
- use geometry to find the region centered on the release point (and assuming a totally vertically mixed column) that will provide the volume required to reduce the temperature to the desired temperature criteria.

The discharge is directed downward at a high flow rate and at high velocities. Therefore, the plume is assumed to expand outward and equally in all directions, thus forming a vertically cylindrical shape. The velocity of the discharge at the discharge fitting would be 422 ft/sec, which would put the discharge rate at 68 gal/sec from a 2.0 inch diameter discharge fitting and 38.74 gal/sec from a 1.5 inch diameter discharge fitting. As a comparison, at 100 psig (auxiliary boiler pressure), the velocity of the discharge would be 121 ft/sec, which would put the discharge rate at 11.22 gal/sec from a 1.5 inch diameter discharge fitting.

The bottom blowdown discharges from an LHA 1 Class vessel and an AFS 1 Class vessel were modeled. The LHA 1 uses the chelant treatment system and has main propulsion boilers (the largest size) and the AFS 1 uses Drew chemistry with average size boilers. They represent a large boiler blowdown volume and an average boiler blowdown volume. The LHA was modeled with a batch discharge of 310 gallons at roughly 504 °F (262 °C) through a 2-inch diameter pipe at the bottom of the ship. The AFS 1 was modeled with a batch discharge of 150 gallons at 495 °F (257 °C) through a 1.5-inch diameter pipe at the bottom of the ship. A sample calculation is provided at the end of this report. The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington State, which are the only two states with established thermal plume mixing zone criteria. The Washington State thermal regulations require that when natural conditions exceed 16 °C, no temperature increases will be allowed that will raise the receiving water temperature by greater than 0.3 °C. The mixing zone requirements state that mixing zones shall not extend for a distance greater than 200 feet plus the depth of the water over the discharge point, or shall not occupy greater than 25% of the width of the water body. The Virginia thermal regulations state that any rise above natural temperature shall not exceed 3 °C. Virginia's mixing zone requirements state that the plume shall not constitute more than one-half of the receiving watercourse. They shall not extend downstream at any time a distance more than five times the width of the receiving watercourse at the point of discharge.

The assumptions for all the thermal modeling conducted under the UNDS program are listed below and the results of the thermal modeling for this discharge are summarized in Table 11.[16]

- The discharge will occur during a simulated slack tide event, using a minimum water body velocity (0.03 m/s);
- The discharge would occur during the winter months (largest difference in temperature between the discharge and receiving water temperatures), which results in the largest thermal plume; and
- The average depth of water at the pier is 40 feet.

Using these assumptions, boiler blowdown discharges from all Navy ships meet Virginia and Washington State thermal mixing zone criteria, Table 10.[16]

Safety valve testing from nuclear powered ships steam generators is discharged in small, intermittent bursts of steam that condenses when reaching the water. The volume of water discharged is too small to be effectively modeled and the thermal effects are negligible due to the immediate mixing with surrounding waters.

4.4 Potential for Introducing Non-Indigenous Species

The potential for introducing non-indigenous species is not significant, since the source of the water is treated freshwater that is heated to high temperatures (over 325 °F) and high pressures (up to 1200 psi).

5.0 CONCLUSIONS

5.1 Boiler and Nuclear Powered Ship Steam Generators Blowdowns

Boiler and nuclear powered ships steam generator blowdowns have a low potential to cause an adverse environmental effect because:

- Mass loadings of copper, lead, nickel, bis(2-ethylhexyl) phthalate, ammonia, nitrogen, and phosphorous are small.

- This discharge rapidly dissipates because it occurs at high flow rates (up to 68 gal/sec) and it is a small volume (310 gallons or less). Modeling the discharge plume shows the constituent concentrations and temperature will be below water criteria within a short distance from the ship for all ship classes that discharge boiler blowdown.

- Boiler blowdown is discharged intermittently throughout the U.S. at Armed Forces ports, and each individual port receives only a fraction of the total fleetwide mass loading.

5.2 Safety Valve Testing

Safety valve testing discharge from nuclear powered ships steam generators is released to the water. However, the total mass discharged is small, only 4.38 pounds of all constituents per year for all nuclear powered ships combined. The small volumes of the discharge cause the thermal loading to dissipate in the receiving waters almost immediately after entry. Therefore, safety valve testing has a low potential to cause an adverse environmental effect.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Sampling data from four surface ships provided concentrations, and mass loadings were calculated from the rate and the concentrations. Table 13 shows the source of data used to develop this NOD report.

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Calculation Sheet # 1
Thermal Batch Discharge Screening Calculations

A. Assumptions and Given Conditions:

1. Saturated liquid heat loss(specific heat, c_p) from 262 °C down to 100 °C emits 0.9 cal/g-°C
2. Water heat loss (specific heat, c_p) from 100 down to regulation temperature (7.44°C Virginia regulation) emits 1 cal/g-°C
3. Heat transfer will occur under conditions of constant pressure
4. Maximum rise in water temperature will be assumed to equal the Virginia regulation of 3°C
5. Ambient temperature is assumed to be 4.44 °C
6. Assume plume will disperse in the shape of a vertical cylinder 4 m in depth
7. Calculations will be based on an LHA 1 blowdown event, therefore:
   - Blowdown discharge temperature is assumed to be 262 °C
   - Blowdown discharge volume is assumed to be 310 gallons

The heat required to change temperature without a phase change is given by the following equation:

$$Q = (m)(c_p)(\Delta T)$$

where: Q = heat (calories)
m = mass of water (grams)
c_p = constant pressure specific heat (cal/g-°C)
ΔT = change in temperature (°C)

B. Determine Mass of Water in Discharge:

Initial volume of water in steam form is 310 gallons of water (LHA 1 Blowdown):

Conversion from gallons of water to mass of water:

$$(8.343 \text{ lbs/gallons})(454 \text{ grams/lbs})(310 \text{ gallons}) = 1.17 \times 10^6 \text{ grams}$$

C) High Temperature Water Heat Loss

$$Q = (m)(c_p)(\Delta T)$$
$$Q = (1.17 \times 10^6 \text{ grams})(0.9 \text{ cal/gram/°C})(262 - 100 \text{ °C})$$
$$Q = 170{,}586{,}000 \text{ calories}$$

D) Water Heat Loss

$$Q = (m)(c_p)(\Delta T)$$
$$Q = (1.17 \times 10^6 \text{ grams})(1 \text{ cal/g-°C})(100 - 7.44 \text{ °C(Virginia regulation)})$$
$$Q = 108{,}295{,}200 \text{ calories}$$

E). Determine Volume of Surrounding Water to Absorb Heat

Calculate the volume of surrounding water required to absorb heat in order to obtain completely mixed water at the regulatory limit (gallons). Assume that the heat lost by the steam and water in the discharge is the same as the heat gained by the surrounding water.

i) Mass of Water Required
Let X= the mass of water required to obtain the mixture, then

$$\Sigma Q = (m)(c_p)(\Delta T)$$
$$(108{,}295{,}200) + (170{,}586{,}000) = (X \text{ grams of water})(1 \text{ cal/g-°C})(3 \text{ °C})$$
$$92{,}960{,}400 \text{ grams} = X$$

Converting to gallons:
(92,960,400 grams)(1 lb/454 grams) (1 gall/8.343lbs) = 24,542 gallons

ii) Total Volume of Water Required to Meet Virginia Regulations = 24,542 gallons + 310 gallons

= **24,850 gallons**

F). Determine Dimensions of Cylinder

The cylinder of water (estimated plume shape) over the water depth to bottom of 4 m (estimated value based on process knowledge):

Volume = 24,850 gallons x 0.0037854 m^3/gallon = 94 m^3

Volume = $(\pi)(d^2/4)(h)$ where d = cylinder diameter and h = cylinder height

Rearranging:

$d^2 = (vol)(4)/(\pi)(h)$

h=4 m (water depth to bottom)
vol=94 m^3

d = **5.5 m (diameter of plume cylinder)**

Table 1. Annual Surface, Scum, and Bottom Blowdown Volumes for each Ship Class of the Navy, MSC, and USCG

Armed Force Owner	Ship Classes with Main Propulsion Boilers	Number of Ships per Class	Number of Boilers per Ship	Boiler Volume During Steaming (gallons per boiler)	Surface Blowdown Volume per year (5% of boiler steaming volume in gallons)	Scum Blowdown Volume per year (1% of boiler steaming volume in gallons)	Bottom Blowdown Volume per year (10% of boiler steaming volume in gallons)	Total Blowdown Volume per year within 12 n.m. (gallons)
Navy	CV 63	3	8	2,200	58,080	10,560	52,800	121,440
	CV 59	1	8	2,000	17,600	3,200	16,000	36,800
	LPH 2	2	2	1,600	7,040	1,280	6,400	14,720
	LPD 7	3	2	1,300	8,580	1,560	7,800	17,940
	LPD 4	3	2	1,200	7,920	1,440	7,200	16,560
	LPD 14	2	2	1,200	5,280	960	4,800	11,040
	LSD 36	5	2	1,600	17,600	3,200	16,000	36,800
	AGF 3	1	2	1,200	2,640	480	2,400	5,520
	AGF 11	1	2	1,300	2,860	520	2,600	5,980
	AO 177	5	2	2,900	31,900	5,800	29,000	66,700
	AOE 1	4	4	1,900	33,440	6,080	30,400	69,920
	AS 33	1	2	1,500	3,300	600	3,000	6,900
	AS 39	3	2	1,400	9,240	1,680	8,400	19,320
	LCC 19	2	2	1,400	6,160	1,120	5,600	12,880
	LHD 1	4	2	3,100	27,280	4,960	24,800	57,040
	LHA 1	5	2	3,100	34,100	6,200	31,000	71,300
Total Boiler Blowdown for Navy Main Propulsion Boilers =570,860								
MSC	T-AE 26	8	3	1,500	39,600	NA	36,000	75,600
	T-AFS 1	8	3	1,500	39,600	NA	36,000	75,600
	T-AGM 22	1	2	1,000	2,200	NA	2,000	4,200
	T-AG 194	2	2	1,000	4,400	NA	4,000	8,400
	T-AH 19	2	2	1,000	4,400	NA	4,000	8,400
	T-AKR 287	8	2	1,000	17,600	NA	16,000	33,600
Total Boiler Blowdown for MSC Main Propulsion Boilers =205,800								

Note: Information obtained from NAVSSES Memo of 23 August, 1991,[5] and M. Rosenblatt & Son, Inc.

Table 1. Annual Surface, Scum, and Bottom Blowdown Volumes for each Ship Class of the Navy, MSC, and USCG

Armed Force Owner	Ship Classes with Auxiliary or Waste Heat Boilers	Number of Ships per Class	Number of Boilers per Ship	Boiler Volume During Steaming (gallons per boiler)	Surface Blowdown Volume per year (5% of boiler steaming volume in gallons)	Scum Blowdown Volume per year (1% of boiler steaming volume in gallons)	Bottom Blowdown Volume per year (10% of boiler steaming volume in gallons)	Total Blowdown Volume per year within 12 n.m. (gallons)
NAVY	DDG 993	4	3	200	6,000	240	4,800	11,040
	CG 47	27	3	100	20,250	810	16,200	37,260
	DD 963	31	3	200	46,500	1,860	37,200	85,560
	AOE 6	3	2	310	4,650	186	3,720	8,556
	LSD 41	8	2	310	12,400	496	9,920	22,816
	LSD 49	3	2	310	4,650	186	3,720	8,556
	ARS 50	4	3	300	9,000	360	7,200	16,560
Total Boiler Blowdown for Navy auxiliary and waste heat boilers =190,348								
MSC	T-AFS 1	8	2	300	6,000	NA	9,600	15,600
	T-ARC 7	1	2	300	750	NA	1,200	1,950
	T-AGS 26	2	2	300	1,500	NA	2,400	3,900
	T-AGS 45	1	2	300	750	NA	1,200	1,950
	T-AGS 51	2	2	300	1,500	NA	2,400	3,900
	T-AGS 60	4	2	300	3,000	NA	4,800	7,800
	T-AO 187	12	2	300	9,000	NA	14,400	23,400
Total Boiler Blowdown for MSC Auxiliary and Waste Heat Boilers =58,500								
USCG	WLIC 160	4	2	100	2,400	NA	2,400	4,800
	WLR 115	1	2	100	600	NA	600	1,200
	WIX 295	1	2	100	600	NA	600	1,200
	WAGB 399*	2	2	100	1,200	NA	1,200	2,400
	WAGB 290*	1	2	100	600	NA	600	1,200
	WHEC 378*	12	2	100	7,200	NA	7,200	14,400
	WMEC 210A	5	2	100	3,000	NA	3,000	6,000
	WMEC 210B	11	2	100	6,600	NA	6,600	13,200
	WLB 180A*	8	2	100	4,800	NA	4,800	9,600
	WLB 180B*	2	2	100	1,200	NA	1,200	2,400
	WLB 180C*	13	2	100	7,800	NA	7,800	15,600
	WLM 157*	9	2	100	5,400	NA	5,400	10,800
	WTGB 140*	9	2	100	5,400	NA	5,400	10,800
Total Boiler Blowdown for Coast Guard Auxiliary Boilers =93,600								
Total Boiler Blowdown for all Ships =1,119,108								

Notes:
Information obtained from NAVSSES Memo of 23 August, 1991,[5] and M. Rosenblatt & Son, Inc.
*=These boilers use magnetic water treatment and do not discharge any chemicals. Their volumes are included because they contribute a thermal load.
NA=USCG Auxiliary boilers do not have surface or scum blow connections and the MSC does not perform scum blowdowns.

Table 2. Estimated Blowdown Frequencies for Calculation of Total Boiler Blowdown Volume within 12 n.m.

Armed Force Owner and Boiler Type	Number of Surface Blowdowns per year per boiler within 12 n.m.	Number of Scum Blowdowns per year per boiler within 12 n.m.	Number of Bottom Blowdowns per year per boiler within 12 n.m.
Navy			
Main Propulsion	22	20	10
Auxiliary and Waste Heat	25	10	20
MSC			
Main Propulsion	22	20	10
Auxiliary and Waste Heat	25	10	20
USCG*			
Auxiliary	60	none	30

Notes:
Information taken from a NAVSSES Memo of 23 August 1991,5 detailing boiler blowdowns per year and revised based ship operation, time in port, and operation within 12 n.m.
* = The USCG auxiliary boilers conduct surface blowdowns once per day.
Most of their activity is performed within 12 n.m. and therefore the number of bottom blowdowns are elevated to control boiler water chemistry.

Table 3. Summary of Detected Analytes

Constituent Chelant Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	38	1 of 1	102
Ammonia As Nitrogen	0.44	1 of 1	1
Biochemical Oxygen Demand	8	1 of 1	21
Chloride	24	1 of 1	64
Nitrate/Nitrite	0.23	1 of 1	1
Sulfate	12	1 of 1	32
Total Dissolved Solids	290	1 of 1	779
Total Kjeldahl Nitrogen	2.5	1 of 1	7
Total Organic Carbon (Toc)	13	1 of 1	35
Total Phosphorous	0.97	1 of 1	3
Total Sulfide (Iodometric)	7	1 of 1	19
Volatile Residue	184	1 of 1	494
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.009	1 of 1	0.03
METALS	(μg/L)		(lbs/yr)
Aluminum			
Dissolved	630	1 of 1	2
Total	494	1 of 1	1
Antimony			
Dissolved	8.3	1 of 1	0.022
Total	9.7	1 of 1	0.026
Arsenic			
Dissolved	1	1 of 1	0.003
Total	2.5	1 of 1	0.007
Barium			
Dissolved	1.7	1 of 1	0.005
Total	2.2	1 of 1	0.006
Boron			
Total	29.6	1 of 1	0.080
Calcium			
Dissolved	51.6	1 of 1	0.1
Total	114	1 of 1	0.3
Cobalt			
Total	10.7	1 of 1	0.03
Copper			
Dissolved	207	1 of 1	1
Total	203	1 of 1	1

Constituent Chelant Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Iron			
Dissolved	626	1 of 1	2
Total	884	1 of 1	2
Magnesium			
Dissolved	179	1 of 1	0.5
Total	195	1 of 1	1
Manganese			
Dissolved	93.5	1 of 1	0.3
Total	95.5	1 of 1	0.3
Molybdenum			
Dissolved	17.6	1 of 1	0.05
Total	18.1	1 of 1	0.05
Nickel			
Dissolved	1,860	1 of 1	5
Total	1,810	1 of 1	5
Sodium			
Dissolved	40,100	1 of 1	108
Total	39,300	1 of 1	106
Zinc			
Dissolved	594	1 of 1	2
Total	601	1 of 1	2
ORGANICS	(µg/L)		(lbs/yr)
Benzoic Acid	1,230	1 of 1	3

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Chelant Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	30	1 of 1	62
Ammonia As Nitrogen	0.11	1 of 1	0.2
Biochemical Oxygen Demand	9	1 of 1	19
Chloride	13	1 of 1	27
Nitrate/Nitrite	0.39	1 of 1	1
Sulfate	7,830	1 of 1	16,183
Total Dissolved Solids	102	1 of 1	211
Total Kjeldahl Nitrogen	0.47	1 of 1	1
Total Organic Carbon (TOC)	12	1 of 1	25
Total Phosphorous	8.4	1 of 1	17
Total Recoverable Oil And Grease	2.45	1 of 1	5
Total Sulfide (Iodometric)	4	1 of 1	8
Volatile Residue	50	1 of 1	103
METALS	(µg/L)		(lbs/yr)
Aluminum			
Dissolved	430	1 of 1	1
Total	477	1 of 1	1
Antimony			
Dissolved	4.5	1 of 1	0.009
Total	5.55	1 of 1	0.011
Arsenic			
Total	1.3	1 of 1	0.003
Barium			
Dissolved	0.75	1 of 1	0.002
Total	0.85	1 of 1	0.002
Calcium			
Total	94.5	1 of 1	0.2
Copper			
Dissolved	75.9	1 of 1	0.2
Total	40.6	1 of 1	0
Iron			
Dissolved	222	1 of 1	0.5
Total	344	1 of 1	1
Manganese			
Dissolved	59.9	1 of 1	0.1
Total	61.3	1 of 1	0.1
Molybdenum			
Dissolved	16	1 of 1	0.03
Total	18.2	1 of 1	0.04

Constituents of Chelant Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Nickel			
Dissolved	1,740	1 of 1	4
Total	1,835	1 of 1	4
Selenium			
Total	6	1 of 1	0.01
Sodium			
Dissolved	37,700	1 of 1	78
Total	38,750	1 of 1	80
Thallium			
Dissolved	1	1 of 1	0.002
Zinc			
Dissolved	377	1 of 1	1
Total	382	1 of 1	1
ORGANICS	(µg/L)		(lbs/yr)
Benzoic Acid	1,385	1 of 1	3

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	30	1 of 1	8
Ammonia As Nitrogen	0.22	1 of 1	0.1
Biochemical Oxygen Demand	5	1 of 1	1
Chemical Oxygen Demand (COD)	13	1 of 1	4
Chloride	17	1 of 1	5
Nitrate/Nitrite	0.78	1 of 1	0.2
Sulfate	36	1 of 1	10
Total Dissolved Solids	132	1 of 1	37
Total Kjeldahl Nitrogen	1	1 of 1	0.3
Total Organic Carbon (TOC)	6	1 of 1	2
Total Phosphorous	0.05	1 of 1	0.01
Total Recoverable Oil And Grease	1.1	1 of 1	0.3
Total Sulfide (Iodometric)	16	1 of 1	4
Total Suspended Solids	7	1 of 1	2
Volatile Residue	49	1 of 1	14
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.007	1 of 1	0.003
METALS	(µg/L)		(lbs/yr)
Arsenic			
Total	1.3	1 of 1	0.0004
Barium			
Dissolved	41.9	1 of 1	0.01
Total	42.8	1 of 1	0.01
Boron			
Dissolved	38.3	1 of 1	0.01
Total	39.9	1 of 1	0.01
Calcium			
Dissolved	28,900	1 of 1	8
Total	31,300	1 of 1	9
Copper			
Dissolved	15.8	1 of 1	0.004
Total	64.9	1 of 1	0.02
Iron			
Total	4,170	1 of 1	1
Lead			
Dissolved	22.8	1 of 1	0.006
Total	193	1 of 1	0.054

Constituents of Magnetic Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Magnesium			
Dissolved	1,270	1 of 1	0.4
Total	2,220	1 of 1	1
Manganese			
Total	83	1 of 1	0.02
Nickel			
Total	27.6	1 of 1	0.01
Selenium			
Total	32.4	1 of 1	0.01
Sodium			
Dissolved	8,080	1 of 1	2
Total	5,380	1 of 1	2
Zinc			
Total	53.1	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Magnetic Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	34	1 of 1	10
Ammonia As Nitrogen	1.4	1 of 1	0.4
Chloride	13	1 of 1	4
Nitrate/Nitrite	0.93	1 of 1	0.3
Sulfate	108	1 of 1	30
Total Dissolved Solids	207	1 of 1	58
Total Organic Carbon (TOC)	3.2	1 of 1	1
Total Phosphorous	0.14	1 of 1	0.04
Total Sulfide (Iodometric)	11	1 of 1	3
Total Suspended Solids	40	1 of 1	11
Volatile Residue	174	1 of 1	49
METALS	(µg/L)		(lbs/yr)
Aluminum			
Total	100	1 of 1	0.03
Arsenic			
Dissolved	1.15	1 of 1	0.0003
Barium			
Dissolved	18.4	1 of 1	0.005
Total	20.2	1 of 1	0.006
Boron			
Total	26.7	1 of 1	0.007
Calcium			
Dissolved	25,750	1 of 1	7
Total	27,400	1 of 1	8
Copper			
Total	63.1	1 of 1	0.02
Iron			
Dissolved	116	1 of 1	0.03
Total	1855	1 of 1	1
Lead			
Dissolved	2.2	1 of 1	0.001
Total	41.7	1 of 1	0.012
Magnesium			
Dissolved	2,455	1 of 1	1
Total	3,000	1 of 1	1
Manganese			
Dissolved	15.3	1 of 1	0.004
Total	40.6	1 of 1	0.01
Nickel			
Total	14.7	1 of 1	0.004
Sodium			
Dissolved	6,385	1 of 1	2
Total	5,140	1 of 1	1
Zinc			
Total	49.9	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	945	1 of 1	1,030
Ammonia As Nitrogen	1.8	1 of 1	2
Chemical Oxygen Demand (COD)	2,030	1 of 1	2,213
Chloride	148	1 of 1	161
Nitrate/Nitrite	115	1 of 1	125
Sulfate	66	1 of 1	72
Total Dissolved Solids	2,540	1 of 1	2,769
Total Kjeldahl Nitrogen	10	1 of 1	11
Total Organic Carbon (TOC)	100	1 of 1	109
Total Phosphorous	0.26	1 of 1	0.3
Total Recoverable Oil And Grease	3.5	1 of 1	4
Total Sulfide (Iodometric)	10	1 of 1	11
Total Suspended Solids	45	1 of 1	49
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.1	1 of 1	0.11
METALS	(µg/L)		(lbs/yr)
Aluminum			
Total	1,140	1 of 1	1
Arsenic			
Dissolved	24.7	1 of 1	0.03
Total	23.5	1 of 1	0.03
Barium			
Dissolved	13.6	1 of 1	0.01
Total	60	1 of 1	0.07
Boron			
Dissolved	177,000	1 of 1	193
Total	175,000	1 of 1	191
Cadmium			
Total	5	1 of 1	0.01
Calcium			
Dissolved	25,400	1 of 1	28
Total	29,900	1 of 1	33
Copper			
Dissolved	14.8	1 of 1	0
Total	2,340	1 of 1	3
Iron			
Dissolved	70.9	1 of 1	0.1
Total	24,800	1 of 1	27

Constituents of Drew Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Lead			
Dissolved	2.9	1 of 1	0.003
Total	463	1 of 1	1
Magnesium			
Dissolved	178	1 of 1	0.2
Total	9,140	1 of 1	10
Manganese			
Total	261	1 of 1	0.3
Molybdenum			
Dissolved	10.6	1 of 1	0.01
Total	10.7	1 of 1	0.01
Nickel			
Total	125	1 of 1	0.1
Sodium			
Dissolved	697,000	1 of 1	760
Total	660,000	1 of 1	720
Tin			
Total	62.4	1 of 1	0.1
Titanium			
Total	28.3	1 of 1	0.03
Zinc			
Dissolved	47.3	1 of 1	0.1
Total	7,850	1 of 1	9
ORGANICS	(µg/L)		(lbs/yr)
2-(Methylthio) Benzothiazole	213	1 of 1	0.2
Bis(2-Ethylhexyl) Phthalate	16	1 of 1	0.02

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Drew Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	45	1 of 1	50
Ammonia As Nitrogen	1.5	1 of 1	2
Biochemical Oxygen Demand	8	1 of 1	9
Chloride	49	1 of 1	55
Nitrate/Nitrite	0.32	1 of 1	0.4
Sulfate	4.8	1 of 1	5
Total Dissolved Solids	112	1 of 1	125
Total Kjeldahl Nitrogen	11	1 of 1	12
Total Organic Carbon (TOC)	24	1 of 1	27
Total Recoverable Oil And Grease	2.85	1 of 1	3
Total Sulfide (Iodometric)	10	1 of 1	11
Volatile Residue	81	1 of 1	90
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.007	1 of 1	0.01
METALS	(µg/L)		(lbs/yr)
Aluminum			
Dissolved	63.4	1 of 1	0.07
Arsenic			
Dissolved	8.3	1 of 1	0.01
Barium			
Dissolved	15.3	1 of 1	0.02
Total	19.8	1 of 1	0.02
Calcium			
Dissolved	74.3	1 of 1	0.1
Total	83.6	1 of 1	0.1
Copper			
Dissolved	127	1 of 1	0.1
Total	153	1 of 1	0.2
Iron			
Dissolved	44.8	1 of 1	0.05
Total	1,001	1 of 1	1
Lead			
Total	7.35	1 of 1	0.01
Magnesium			
Dissolved	80	1 of 1	0.09
Total	82	1 of 1	0.09

Constituents of Drew Bottom Blowdown	**Concentration**	**Frequency of Detection**	**Mass Loading**
METALS (Cont'd)	(µg/L)		(lbs/yr)
Manganese			
Dissolved	2.95	1 of 1	0.00
Total	21	1 of 1	0.02
Nickel			
Total	12.6	1 of 1	0.01
Selenium			
Total	12.7	1 of 1	0.01
Sodium			
Dissolved	1,590	1 of 1	2
Total	1,425	1 of 1	2
Zinc			
Dissolved	97.8	1 of 1	0.1
Total	277	1 of 1	0.3
ORGANICS	(µg/L)		(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	13	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	97.3	2 of 2	91	104	75
Ammonia As Nitrogen	0.21	2 of 2	0.11	0.39	0.2
Chloride	1.22	1 of 2	BDL	3	1
Hexane Extractable Material	3.87	1 of 2	BDL	6	3
Nitrate/Nitrite	0.45	2 of 2	0.24	0.85	0.3
Sulfate	3.16	1 of 2	BDL	4	2
Total Dissolved Solids	81.0	2 of 2	17	386	62
Total Kjeldahl Nitrogen	0.45	2 of 2	0.28	0.71	0.3
Total Organic Carbon (TOC)	0.87	1 of 2	BDL	1.5	1
Total Phosphorous	11.5	2 of 2	2.6	51	9
Total Recoverable Oil And Grease	8.14	2 of 2	3.4	19.5	6
Total Sulfide (Iodometric)	4.30	1 of 2	BDL	37	3
Total Suspended Solids	11.5	2 of 2	6	22	9
Volatile Residue	67.7	2 of 2	23	199	52
HYDRAZINE	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Hydrazine	0.01	1 of 2	BDL	0.0019	0.01
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Aluminum					
Dissolved	53.7	1 of 2	BDL	103	0.04
Barium					
Total	2.01	1 of 2	BDL	8.1	0.002
Calcium					
Total	36.9	1 of 2	BDL	64.9	0.03
Copper					
Dissolved	103	2 of 2	56.7	187	0.08
Total	3,390	2 of 2	1,310	8,780	3
Iron					
Dissolved	440	2 of 2	334	579	0.3
Total	4,327	2 of 2	2,480	7,550	3
Lead					
Dissolved	2.49	1 of 2	BDL	6.2	0.002
Total	22.4	2 of 2	8.2	61.4	0.017
Magnesium					
Total	91.2	1 of 2	BDL	260	0.070
Manganese					
Dissolved	3.00	2 of 2	1.7	5.3	0.002
Total	85.7	2 of 2	57.8	127	0.066

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS (Cont'd)	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Molybdenum					
Dissolved	3.46	1 of 2	BDL	8	0.003
Total	2.68	1 of 2	BDL	4.8	0.002
Nickel					
Dissolved	12.3	1 of 2	BDL	19	0.009
Total	473	2 of 2	253	883	0.4
Sodium					
Dissolved	22,520	2 of 2	6,170	82,200	17
Total	22,505	2 of 2	6,460	78,400	17
Thallium					
Dissolved	0.77	1 of 2	BDL	1.2	0.001
Tin					
Dissolved	3.49	1 of 2	BDL	6.1	0.003
Total	3.69	1 of 2	BDL	6.8	0.003
Titanium					
Total	4.15	1 of 2	BDL	6.9	0.003
Zinc					
Dissolved	26.0	2 of 2	23.4	28.8	0.02
Total	143	2 of 2	67.2	304	0.11

BDL = Below Detection Limit

Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., “non-detect” samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a “non-detect” sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	44.5	2 of 2	30	66	36
Ammonia As Nitrogen	0.13	2 of 2	0.12	0.14	0.1
Chloride	1.22	1 of 2	BDL	3	1
Hexane Extractable Material	3.26	1 of 2	BDL	6	3
Nitrate/Nitrite	0.44	2 of 2	0.24	0.81	0.4
Sulfate	4.47	1 of 2	BDL	8	4
Total Dissolved Solids	110	2 of 2	80	150	88
Total Kjeldahl Nitrogen	0.20	1 of 2	BDL	0.8	0.2
Total Organic Carbon (TOC)	1.26	1 of 2	BDL	3.2	1
Total Phosphorous	21.8	2 of 2	15.3	31	17
Total Recoverable Oil And Grease	1.34	2 of 2	0.8	2.25	1
Total Sulfide (Iodometric)	3.08	1 of 2	BDL	19	2
Total Suspended Solids	3.46	1 of 2	BDL	6	3
Volatile Residue	42.0	2 of 2	22	80	34
HYDRAZINE	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Hydrazine	0.01	1 of 2	BDL	0.021	0.01
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Aluminum					
Dissolved	58.2	2 of 2	56.6	91.7	0.05
Total	51.8	1 of 2	BDL	95.8	0.04
Antimony					
Dissolved	3.69	1 of 2	BDL	2.3	0.003
Barium					
Total	1.37	2 of 2	0.85	2.2	0.001
Calcium					
Total	73.5	2 of 2	48.9	200	0.06
Copper					
Dissolved	80.0	2 of 2	47.55	135	0.06
Total	1,724	2 of 2	662	4,490	1
Iron					
Total	1430	2 of 2	1210	1690	1
Lead					
Dissolved	2.12	2 of 2	1.5	3	0.002
Total	8.63	2 of 2	4.7	15.9	0.007
Magnesium					
Dissolved	40.4	1 of 2	BDL	70	0.032
Total	57.1	1 of 2	BDL	102	0.046

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS (Cont'd)	(μg/L)		(μg/L)	(μg/L)	(lbs/yr)
Manganese					
Dissolved	2.24	2 of 2	1.7	5.4	0.002
Total	36.1	2 of 2	30.7	42.5	0.029
Molybdenum					
Dissolved	2.81	1 of 2	BDL	5.25	0.002
Total	2.79	1 of 2	BDL	5.2	0.002
Nickel					
Dissolved	15.8	2 of 2	12.95	19.4	0.013
Total	183	2 of 2	119	280	0.1
Sodium					
Dissolved	32,390	2 of 2	19,250	54,500	26
Total	38,737	2 of 2	28,500	52,650	31
Thallium					
Dissolved	0.65	1 of 2	BDL	1.2	0.001
Tin					
Dissolved	2.85	1 of 2	BDL	6.1	0.002
Titanium					
Total	3.61	1 of 2	BDL	7.9	0.003
Zinc					
Dissolved	8.02	1 of 2	BDL	14.3	0.01
Total	58.5	2 of 2	46.9	73	0.05
ORGANICS	(μg/L)		(μg/L)	(μg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	10.8	1 of 2	BDL	42	0.01

BDL = Below Detection Limit

Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 4. Maximum Concentration of Constituents Detected in Nuclear Powered Ship Steam Generator Blowdown

Analyte	SSN & SSBN Submarines	CVN 68 Class Carriers	CVN 65 Only
Metals	µg/L	µg/L	µg/L
Aluminum	40	20	20
Antimony	5	U	U
Arsenic	3	20	U
Barium	1	10	U
Cadmium	2	10	10
Calcium	4	70	150
Chromium	2	5	50
Copper	40	150	50
Iron	50	20	80
Lead	10	15	50
Magnesium	1	15	200
Manganese	1	20	20
Molybdenum	20	20	U
Nickel	25	30	90
Silver	1	20	U
Sodium	160,000	160,000	360,000
Tin	2	20	U
Titanium	3	10	U
Zinc	4	10	50
Classicals	mg/L	mg/L	mg/L
Ammonia	0.30	0.30	0.30
Chemical Oxygen Demand	30.00	30.00	30.00
Chloride	0.05	0.05	0.05
Nitrate + Nitrite (as N)	70.00	70.00	70.00
Sulfate	300.00	300.00	300.00
Sulfide	2.00	2.00	2.00
Total Dissolved Solids	1000.00	1000.00	1000.00
Total Kjeldahl Nitrogen	16.00	16.00	16.00
Total Organic Carbon	3.00	3.00	3.00
Total Phosphorous	100.00	100.00	100.00
Total Suspended Solids	2.00	2.00	2.00
Organics	mg/L	mg/L	mg/L
Hydrazine	0.10	0.10	0.10

Note:
U = Analyte analyzed for but not detected

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers

Constituents of Chelant Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.44	1
Nitrate/Nitrite	0.23	1
Total Kjeldahl Nitrogen	2.5	7
Total Nitrogen[A]	2.8	8
Total Phosphorous	0.97	3
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	207	1
Total	203	1
Iron		
Dissolved	626	2
Total	884	2
Nickel		
Dissolved	1,860	5
Total	1,810	5
Zinc		
Dissolved	594	2
Total	601	2

Constituents of Chelant Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.11	0.2
Nitrate/Nitrite	0.39	1
Total Kjeldahl Nitrogen	0.47	1
Total Nitrogen[A]	0.86	2
Total Phosphorous	8.4	17
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	75.9	0.2
Total	40.6	0
Iron		
Total	344	1
Nickel		
Dissolved	1,740	4
Total	1,835	4
Zinc		
Dissolved	377	1
Total	382	1

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.22	0.1
Nitrate/Nitrite	0.78	0.2
Total Kjeldahl Nitrogen	1	0.3
Total Nitrogen[A]	1.8	0.5
Total Phosphorous	0.05	0.01
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	15.8	0.004
Total	64.9	0.02
Iron		
Total	4170	1
Lead		
Dissolved	22.8	0.006
Total	193	0.054
Nickel		
Total	27.6	0.01

Constituents of Magnetic Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.4	0.4
Nitrate/Nitrite	0.93	0.3
Total Nitrogen[A]	0.93	0.3
Total Phosphorous	0.14	0.04
METALS	(µg/L)	(lbs/yr)
Copper		
Total	63.1	0.02
Iron		
Total	1855	1
Lead		
Total	41.7	0.012
Nickel		
Total	14.7	0.004

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.8	2
Nitrate/Nitrite	115	125
Total Kjeldahl Nitrogen	10	11
Total Nitrogen[A]	125	136
Total Phosphorous	0.26	0.3
METALS		(lbs/yr)
Copper		
Dissolved	14.8	0
Total	2,340	3
Iron		
Total	24,800	27
Lead		
Total	463	1
Nickel		
Total	125	0.1
Zinc		
Total	7,850	9
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	16	0.02

Constituents of Drew Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.5	2
Nitrate/Nitrite	0.32	0.4
Total Kjeldahl Nitrogen	11	12
Total Nitrogen[A]	11	12
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	127	0.1
Total	153	0.2
Iron		
Total	1,001	1
Lead		
Total	7.35	0.01
Nickel		
Total	12.6	0.01
Zinc		
Dissolved	97.8	0.1
Total	277	0.3
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	13	0.01

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.21	0.2
Nitrate/Nitrite	0.45	0.3
Total Kjeldahl Nitrogen	0.45	0.3
Total Nitrogen[A]	0.9	0.6
Total Phosphorous	11.5	9
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	103	0.08
Total	3,390	2.60
Iron		
Dissolved	440	0.34
Total	4,327	3.32
Lead		
Total	22.4	0.02
Nickel		
Dissolved	12.3	0.01
Total	472.7	0.36
Zinc		
Total	143	0.11

Constituents of COPHOS Bottom Blowdown	Log Normal Mean Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.13	0.1
Nitrate/Nitrite	0.44	0.4
Total Kjeldahl Nitrogen	0.2	0.2
Total Nitrogen[A]	0.64	0.6
Total Phosphorous	21.8	17
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	80.0	0.06
Total	1,724	1.38
Iron		
Total	1430	1.14
Lead		
Total	8.63	0.01
Nickel		
Dissolved	15.8	0.01
Total	183	0.15
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	10.8	0.01

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 6. Mass Loadings for Nuclear Powered Ship Steam Generators

Analyte	Discharge Concentration from CVN 65 (µg/L)	Discharge Concentration from CVN 68 (µg/L)	Discharge Concentration from Submarines (µg/L)	Total Loading for 1 CVN 65 per year* (pounds/year)	Total Loading for 7 CVN 68s per year* (pounds/year)	Total Loading for 72 SSNs and 17 SSBNs per year* (pounds/year)	Total Loading From All Steam Generator ships and subs within 12 n.m. (pounds/year)
Copper	50	150	40	0.09	2.72	0.41	3.22
Lead	50	15	10	0.09	0.27	0.10	0.47
Nickel	90	30	25	0.17	0.54	0.25	0.97
Ammonia	30	30	30	0.06	0.54	0.30	0.90
Nitrate/Nitrite	70,000	70,000	70,000	126	1270	710	2106
Total Kjeldahl Nitrogen	16,000	16,000	16,000	28.8	290	162	481
Total Nitrogen[A]	86,000	86,000	86,000	155	1560	872	2587
Total Phosphorous	100,000	100,000	100,000	190	1800	1000	2990

Notes:
* = Loadings are based on total volumes within 12 n.m. including 225,000 gallons per year for CVN 65, 310,000 gallons per year for CVN 68 Class, 16,000 gallons per year each SSN Class vessel, and 4,000 gallons per year for each SSBN Class vessel.
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 7. Naval Nuclear Propulsion Summary of Steam Generator Safety Valve Testing Loadings Per Year (maximum values)

Material Discharged	Loading for Submarines and Cruisers (pounds per vessel, per year)	Total Loading for all Submarines and Cruisers (pounds per year)	Total Loading for Carriers (pounds per vessel, per year)	Total Loading for all Carriers (pounds per year)
Phosphorous (as phosphate)	0.003	0.3	0.006 (CVN 65 only)	0.006
Sulfur (as sulfite and sulfate)	0.000	0	0.008 (CVN 65 only)	0.008
Nitrogen (as nitrite or nitrate)	0.001	0.1	0.000	0
Nitrogen (as amines)	0.03	3	0.08	0.64
Hydrazine	0.000	0	0.001	0.008
Organic Acids	0.001	0.1	0.001	0.008
Sodium	0.002	0.2	0.007 (CVN 65 only)	0.007
Total		**3.7**		**0.68**

Note:
Information taken from NAVSEA 08 summary information, May 1997.[15]

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents of Chelant Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	440	None	6 (HI)[A]
Nitrate/Nitrite	230	None	8 (HI)[A]
Total Kjeldahl Nitrogen	2500	None	-
Total Nitrogen[B]	2800	None	200 (HI)[A]
Total Phosphorous	970	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	207	2.4	2.4 (CT, MS)
Total	203	2.9	2.5 (WA)
Iron			
Dissolved	626	None	300 (FL)
Total	884	None	300 (FL)
Nickel			
Dissolved	1,860	74	74 (CA, CT)
Total	1,810	74.6	8.3 (FL, GA)
Zinc			
Dissolved	594	90	90 (CA, CT, MS)
Total	601	95.1	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Chelant Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	110	None	6 (HI) [A]
Nitrate/Nitrite	390	None	8 (HI)[A]
Total Kjeldahl Nitrogen	470	None	-
Total Nitrogen[B]	860	None	200 (HI)[A]
Total Phosphorous	8400	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	75.9	2.4	2.4 (CT, MS)
Total	40.6	2.9	2.5 (WA)
Iron			
Total	344	None	300 (FL)
Nickel			
Dissolved	1,740	74	74 (CA, CT)
Total	1,835	74.6	8.3 (FL, GA)
Zinc			
Dissolved	377	90	90 (CA, CT, MS)
Total	382	95.1	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	220	None	6 (HI) [A]
Nitrate/Nitrite	780	None	8 (HI)[A]
Total Kjeldahl Nitrogen	1000	None	-
Total Nitrogen[B]	1800	None	200 (HI)[A]
Total Phosphorous	50	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	15.8	2.4	2.4 (CT, MS)
Total	64.9	2.9	2.5 (WA)
Iron			
Total	4,170	None	300 (FL)
Lead			
Total	193	217.2	5.6 (FL, GA)
Nickel			
Total	27.6	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Magnetic Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1400	None	6 (HI) [A]
Nitrate/Nitrite	780	None	8 (HI)[A]
Total Nitrogen[B]	780	None	200 (HI)[A]
Total Phosphorous	140	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Total	63.1	2.9	2.5 (WA)
Iron			
Total	1855	None	300 (FL)
Lead			
Total	41.7	217.2	5.6 (FL, GA)
Nickel			
Total	14.7	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

FL = Florida
GA = Georgia
HI = Hawaii
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1800	None	6 (HI) [A]
Nitrate/Nitrite	115,000	None	8 (HI)[A]
Total Kjeldahl Nitrogen	10,000	None	-
Total Nitrogen[B]	125,000	None	200 (HI)[A]
Total Phosphorous	260	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	14.8	2.4	2.4 (CT, MS)
Total	2,340	2.9	2.5 (WA)
Iron			
Total	24,800	None	300 (FL)
Lead			
Total	463	217.2	5.6 (FL, GA)
Nickel			
Total	125	74.6	8.3 (FL, GA)
Zinc			
Total	7,850	95.1	84.6 (WA)
ORGANICS	(µg/L)		(µg/L)
Bis(2-Ethylhexyl) Phthalate	16	None	5.92 (GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Drew Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1500	None	6 (HI) [A]
Nitrate/Nitrite	320	None	8 (HI)[A]
Total Kjeldahl Nitrogen	11,000	None	-
Total Nitrogen[B]	11,000	None	200 (HI)[A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	127	2.4	2.4 (CT, MS)
Total	153	2.9	2.5 (WA)
Iron			
Total	1,001	None	300 (FL)
Lead			
Total	7.35	217.2	5.6 (FL, GA)
Nickel			
Total	12.6	74.6	8.3 (FL, GA)
Zinc			
Dissolved	97.8	90	90 (CA, CT, MS)
Total	277	95.1	84.6 (WA)
ORGANICS	(µg/L)		(µg/L)
Bis(2-Ethylhexyl) Phthalate	13	None	5.92 (GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Ammonia as Nitrogen	210	110	390	None	6 (HI) [A]
Nitrate/Nitrite	450	240	850	None	8 (HI)[A]
Total Kjeldahl Nitrogen	450	280	710	None	-
Total Nitrogen[B]	900			None	200 (HI)[A]
Total Phosphorous	11,500	2600	51,000	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Copper					
Dissolved	103	56.7	187	2.4	2.4 (CT, MS)
Total	3,390	1,310	8,780	2.9	2.5 (WA)
Iron					
Dissolved	440	334	579	None	300 (FL)
Total	4,327	2,480	7,550	None	300 (FL)
Lead					
Total	22.4	8.2	61.4	217.2	5.6 (FL, GA)
Nickel					
Dissolved	12.3	BDL	19	74	74 (CA, CT)
Total	473	253	883	74	8.3 (FL, GA)
Zinc					
Total	143	67.2	304	95.1	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington
BDL = Below Detection Limit

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Ammonia as Nitrogen	130	120	140	None	6 (HI) [A]
Nitrate/Nitrite	440	240	810	None	8 (HI)[A]
Total Kjeldahl Nitrogen	200	BDL	800	None	-
Total Nitrogen[B]	640			None	200 (HI)[A]
Total Phosphorous	21,800	15,300	31,000	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Copper					
Dissolved	80.0	47.6	135	2.4	2.4 (CT, MS)
Total	1,724	662	4490	2.9	2.5 (WA)
Iron					
Total	1,430	1,210	1,690	None	300 (FL)
Lead					
Total	8.63	4.7	15.9	217.2	5.6 (FL, GA)
Nickel					
Dissolved	15.8	12.95	19.4	74	74 (CA, CT)
Total	183	119	280	74.6	8.3 (FL, GA)
ORGANICS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Bis(2-Ethylhexyl) Phthalate	10.8	BDL	42	None	5.92 (GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington
BDL = Below Detection Limit

Table 9. Concentrations of Constituents that Exceed Water Quality Criteria for Nuclear Powered Steam Generators (maximum values) (μg/L)

Analyte	Discharge Concentration from Submarines	Discharge Concentration from CVN 68 Class carriers	Discharge Concentration from CVN 65 Class carrier	Federal Acute WQC	Most Stringent State Acute WQC
Copper	40	150	50	2.4	2.4 (CT, MS)
Lead	10	15	50	210	5.6 (FL, GA)
Nickel	25	30	90	74	8.3 (FL, GA)
Ammonia	30	30	90	None	6 (HI)[A]
Nitrate/Nitrite	70,000	70,000	70,000	None	8 (HI)[A]
Total Kjeldahl Nitrogen	16,000	16,000	16,000	None	-
Total Nitrogen[B]	86,000	86,000	86,000	None	200 (HI)[A]
Phosphorous	100,000	100,000	100,000	None	25 (HI)[A]

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi

Table 10. Summary of Thermal Effects of Boiler Blowdown Discharge

Ship Modeled	Discharge Temp (°F)	Discharge Volume (gals)	Ambient Water Temp (°F)	Predicted Plume Width and Length (m)*	Allowable Plume Width (m)	Allowable Plume Length (m)	Predicted Plume Depth (m)
Washington State (0.3°C Δ T)							
LHA 1	503	310	50	19.7	400	73	4
AFS 1	495	150	50	13.4	400	73	4
Virginia (3.0°C Δ T)							
LHA 1	503	310	40	5.5	3,200	32,000	4
AFS 1	495	150	40	3.7	3,200	32,000	4

Note: The discharge was modeled such that the resultant plume is cylindrical shaped, therefore the plume width and length are equal.

Table 11. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment		X		X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents		X		
3.4 Concentrations		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	
4.4 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Catapult Water Brake Tank and Post Launch Retraction Exhaust

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the catapult water brake tank and post launch retraction exhaust and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Every Navy aircraft carrier is equipped with four steam catapults for launching aircraft. High pressure steam from the catapult wet steam accumulator is used to operate each catapult. Each catapult has a dedicated water brake tank and catapult steam exhaust piping. During each catapult cycle, lubricating oil is applied to the catapult power cylinder. Different amounts of lubricating oil are applied depending on catapult model. Mod 2 catapults use more lubricating oil per catapult cycle than Mod 1 catapults (see Section 3.2.1).

Catapults are operated every time an aircraft is launched and for testing purposes. Catapults are normally tested after an aircraft carrier is built, before an aircraft carrier is sent out on deployment, and after major repairs and overhauls. Catapult testing before deployments is called “no-load” testing because there is no load applied to the catapult. Catapult testing after building and after major repairs and overhauls is called “dead-load” testing because a weight is applied to the catapult to simulate the weight of an aircraft. During catapult testing, lubricating oil is supplied to the catapult’s power cylinder in the same fashion as during aircraft launching operations.

The forward motion of the catapult piston is stopped by means of a water brake that is supplied by high pressure water from the water brake tank. As the catapult operates, the lubricating oil is carried into the water brake and subsequently into the water brake tank. During the retraction of the catapult piston, the steam left in the power cylinder and a small amount of residual oil are discharged overboard through the catapult exhaust piping. A smaller fraction of the residual oil also leaks by the catapult cylinder sealing strips and into the catapult trough. Catapult trough discharge is addressed in a separate NOD report on deck runoff.

2.1.1 Catapult Water Brake Tank

The catapult water brake tank supplies freshwater to the catapult water brake, which is used to stop the forward motion of the catapult piston. Water from the catapult water brake tank is injected into the water brake during each catapult cycle at approximately 1,300 gallons per minute (gpm) using two 650-gpm pumps.[1] When the catapult piston enters the water brake, it forces water from the water brake into the upper portion of the water brake tank. Figure 1 provides an illustration.

The oil used to lubricate the catapult power cylinder conforms to both SAE J1966, Grade 60 and Military Specification MIL-L-6082E grade 1100 standards.[2] During each catapult cycle, oil is sprayed onto the internal surface of the catapult power cylinder. As the catapult piston travels down the catapult power cylinder, lubricating oil is carried with the catapult piston into the water brake.[1] Over the course of multiple launches, and because water is recirculated through the catapult water brake and the water brake tank, oil builds up in the water brake tank. The oil accumulates on the surface of the water in the water brake tank in the form of an oil-water emulsion. Heat is added to the water from heat accumulated in the oil, the action of the pistons, and by conduction from the steam-heated catapult piston. The accumulated oil also inhibits cooling at the surface of the water brake tank. Consequently, the water temperature rises. Excessive water temperature adversely affects the catapult water brake performance.

To prevent excessive water temperatures in the water brake tank, the accumulated oil is periodically skimmed. The water brake tank is equipped with an oil-skimming funnel and a 2.5-inch pipe for draining the oil from the tank. Fresh cool water is added to the water brake tank via a freshwater fill line to raise the water level in the tank, thus causing the floating oil and oil/water mixture to flow into the skimming funnel. The funnel drain piping discharges the oil and oil/water mixture overboard above the waterline. The contents of the water brake tank drain overboard until the liquid level falls below the top of the drain funnel. Oil accumulation in the water brake tank is directly related to the number of catapult cycles. During aircraft launch operations, the water brake tank is skimmed on an as-needed basis.[3]

As mentioned previously, aircraft carriers perform no-load catapult tests before leaving port on deployment and dead-load tests after building, major repairs and overhauls. The number of no-load and dead-load tests, however, do not generate enough lubricating oil in the water brake tank to require that the tank to be skimmed within 12 nautical miles (n.m.).

2.1.2 Post-Launch Retraction Exhaust

During the post-launch retraction of the catapult piston, the expended steam and residual oil from the catapult power cylinder walls are discharged overboard below the water line through copper/nickel piping. The exhaust steam exits the catapult power cylinder at approximately 350 ^{o}F (i.e., the operating temperature of the catapults) and cools and condenses as it flows through the exhaust piping overboard. The temperature of the final discharge is estimated to be 200 ^{o}F.

2.2 Releases to the Environment

2.2.1 Water Brake Tank

Discharge from the water brake tank is released overboard above the water line and consists of freshwater, lubricating oil, and small amounts of metals introduced by the catapult systems.

2.2.2 Post-Launch Retraction Exhaust

Discharge from the post-launch retraction exhaust is released overboard below the water line and consists of condensed steam with lubricating oil and small amounts of metals from the catapult.

2.3 Vessels Producing the Discharge

The Navy's aircraft carriers are the only armed forces vessels that generate this discharge. Of the 11 aircraft carriers that are homeported in the United States, eight are equipped with Mod 1 catapults, and the three newest aircraft carriers are equipped with Mod 2 catapults. There are a total of 12 aircraft carriers

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

3.1.1 Catapult Water Brake Tank

The catapult water brake tank discharge is generated on an as-needed basis during aircraft carrier flight operations, which occur beyond 12 n.m. from shore.[1,4,5] Catapult testing, which occurs within 12 n.m. does not generate a sufficient quantity of oil in the water brake tank to require discharge. In addition, OPNAVINST 5090.1B prohibits oil from being discharged within 12 n.m. of shore, including the oil contained in this discharge.

Because this discharge does not occur within 12 n.m. of shore, it is not discussed further in this report.

3.1.2 Post-Launch Retraction Exhaust

The post-launch retraction exhaust discharge is generated during all catapult operations including aircraft launching and catapult testing. Because catapults are operated within 12 n.m. of shore during no-load/dead-load testing, the post-launch retraction exhaust discharge occurs on a limited basis within 12 n.m.

3.2 Rate

The discharge for the post-launch retraction exhaust discharge consists of condensed steam and the residual oil from lubricating the catapult power cylinders. During each catapult cycle, approximately 1,000 pounds of water from the wet accumulator are flashed to steam to drive the catapult piston down the flight deck, and 0.415 gallon of oil is injected onto the catapult power cylinder wall for Mod 1 catapults, and 0.83 gallon of oil for Mod 2 catapults.[6] Based on operating experience, approximately 890 pounds of water and 0.10 gallon of oil from Mod 1 catapults, or 0.42 gallon of oil from Mod 2 catapults, are discharged overboard during each catapult cycle.[6]

An aircraft carrier performs approximately 50 no-load catapult tests per year.[3] Therefore, all 11 aircraft carriers homeported in the United States perform approximately 550 no-load test shots per year. At a fleet-wide average rate of 0.19 gallon of oil (weighted average discharge of 0.10 gallon for Mod 1 catapults and 0.42 gallon for Mod 2 catapults) and 890 pounds of steam condensate per each catapult test, the annual fleet-wide discharge of oil and condensed steam from no-load catapult tests within 12 n.m. is approximately 105 gallons of oil and 490,000 pounds of condensed steam.

Major catapult overhauls and modifications are not normal occurrences for aircraft carriers. In general, one to two aircraft carriers annually undergo a major overhaul or modification that requires 60 dead-load catapult test shots to recertify the catapult. Assuming that on average, the catapults on 1.5 carriers are overhauled each year (i.e., six catapults), an estimated 360 dead-load catapult test shots are performed annually fleet-wide within 12 n.m. Thus, an estimated 69 gallons of oil (at a rate of 0.19 gallon per test) and 320,000 pounds of steam condensate (at a rate of 890 pounds per test) are discharged annually from dead-load catapult testing.

Thus, 174 gallons of oil and 810,000 pounds of condensed steam (~97,000 gallons) are discharged annually, fleetwide, from post-launch retraction exhaust during no-load and dead-load catapult testing.

3.3 Constituents

The post-launch retraction exhaust discharge consists of steam and condensed steam with associated non-organic metal constituents and lubricating oil. The lubricating oils are comprised primarily of higher chain (C_{17} and higher) paraffins and olefins.[7,8] Another UNDS discharge, Steam Condensate Discharge, is similar to the condensed steam discharge from the catapult retraction stroke, with the exception of the oil content. The Steam Condensate NOD Report analyzes steam condensate originating from shore-based facilities. The steam condensate from ship heating supplied from shore facilities consists primarily of condensed steam that is generally collected and pumped or drained overboard. The discharge from the catapult retraction exhaust is steam, condensed steam, and oil that is vented overboard under pressure. The condensed steam portion of both discharges will, however, be somewhat similar. Based on the data presented in that report, nitrogen (as ammonia, nitrate/nitrite, and total nitrogen), phosphorous, and the priority pollutants antimony, arsenic, benzidine, bis(2-ethylhexyl) phthalate, cadmium, copper, lead, nickel, selenium, thallium, and zinc can be present in the condensed steam in post-launch retraction exhaust. There are no known bioaccumulators in this discharge.

3.4 Concentrations

Approximately 890 pounds of catapult condensed steam and 0.19 gallon of oil is discharged during each catapult cycle. The density of water at 70 ^{o}F (i.e., ambient temperature) is 8.32 pounds per gallon (lbs/gal) or 0.998 kilograms per liter (kg/l) and the oil density is of 7.32

lbs/gal or 0.878 kg/l. Therefore, the concentration of oil in the exhaust discharge is approximately 1,560 mg/L. The calculation is presented below:

$$[(0.19\ gal_o)\ (7.32\ lbs_o\ /gal_o)(453{,}590\ mg/lb)]\ /[(890\ lbs_w)(gal/8.32\ lbs_w)(3.785\ l/gal)] = \cong 1560\ mg/l$$

Where the subscripts *o* refer to oil and *w* refer to water.

Table 1 shows the concentrations of the priority pollutants identified in the Steam Condensate NOD Report. It is assumed that the same constituents would be found in the condensed steam from the catapult retraction exhaust in similar concentrations to those found in steam condensate originating from facilities.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

As estimated in Section 3.2, approximately 174 gallons of oil are discharged annually from no-load and dead-load testing in post-launch retraction exhaust. This results in an annual fleet-wide mass loading of 1,275 pounds (based on a conversion factor of 7.33 pounds of oil/gallon).

Of the non-oil constituents in the 810,000 pounds of catapult condensed steam generated annually fleet wide from post-launch retraction exhaust (see Section 3.2) less than one pound of pollutants are estimated to be discharged from no-load and dead-load testing. The mass loadings were estimated using the following equation:

$$(\text{log-normal mean conc. } \mu g/l)(g/1{,}000{,}000\ \mu g)\ (lbs/453.593\ g)\ (\text{annual volume } l/yr) \cong \text{mass loading } (lbs/yr)$$

4.2 Environmental Concentrations

The condensed steam and oil from the post-launch retraction exhaust exits the ship via the exhaust piping. The estimated concentration of oil in the discharge is approximately 1,560 mg/L. This value exceeds the most stringent state water quality criteria (WQC), which is Florida’s 5 mg/L criterion (Table 2). Concentrations this high are likely to cause a sheen in the receiving waters.

Assuming the concentrations of the priority pollutants shown in Table 1 are representative of condensed steam discharged in post-launch retraction exhaust discharge, there would be four priority pollutants - benzidine, bis(2-ethylhexyl) phthalate, copper, and nickel - discharged in excess of Federal and/or the most stringent state WQC. Two other constituents, nitrogen (as ammonia, nitrate/nitrite, and total nitrogen) and phosphorous, exceed the most stringent state WQC. Table 2 shows the concentrations of these constituents and the applicable WQC.

4.3 Thermal Effects

The thermal effects of the post-launch retraction exhaust were screened for potential adverse effects to determine if the resulting thermal plume exceeded water quality criteria for temperature.[9] Based upon the evaluation of the exhaust discharge, the thermal effects rapidly dissipate within a short distance of the point of discharge.[9] Under the most stringent criteria (e.g., Washington State), the resulting plume from the post-launch retraction exhaust is estimated to be approximately 20 feet in diameter and extends to approximately 12 feet in depth.[9] These dimensions are within limits established for Washington.[9]

4.4 Potential for Introducing Non-Indigenous Species

During catapult launch operations, seawater is not transported. Therefore, there is no potential for transporting non-indigenous species.

5.0 CONCLUSIONS

The catapult water brake tank discharge does not occur within 12 n.m. because flight operations are not conducted within this zone. Therefore, this discharge has no potential to cause an adverse environmental effect within 12 n.m.

The post-launch retraction exhaust has a potential for adverse environmental effect because significant amounts of oil are discharged at high concentrations during the short duration of the discharge event. The high concentrations exceed water quality criteria and discharge standards. The high concentrations of oil are likely to cause an oil sheen.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. process information and assumption were used to estimate the rate of discharge. Based on this estimate and on the reported concentration of oil constituents, the concentration of the oil constituents in the environment resulting from this discharge were then estimated. Table 3 shows the source of the data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Catapult Discharges. July 26, 1996.

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3. Commander Naval Air Forces, U.S. Atlantic Fleet. Responses to TYCOM Questionnaire. M. Rosenblatt & Son, Inc. May 20, 1997.

4. UNDS Equipment Expert Meeting Minutes - Catapult Trough, Water Brake Tank, Jet Blast Deflector and Arresting Cables. August 22, 1996.

5. UNDS Equipment Expert Meeting Minutes - Catapult Wet Accumulator Steam Blowdown Discharge. August 20, 1997.

6. Steve Opet, NAWCADLKE. Information on Volume of Water and Temperature for Catapult Shots. April 11, 1997. Clarkson Meredith, Versar, Inc.

7. Perry and Chilton. Chemical Engineers' Handbook. Fifth Ed. McGraw Hill. 1953

8. Patty's Industrial Hygiene and Toxicology, 3rd Ed., Volume IIB. G.D. and F.E. Clayton, Editors. New York: 1981.

9. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 1997.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

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The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, pg 15366. March 23, 1995.

Committee Print Number 95-30 of the Committee of Public Works and Transportation of the House of Representatives, Table 1.

Jane's Information Group, Jane's Fighting Ships. Capt. Richard Sharpe, Ed. Sentinel House: Surrey, United Kingdom, 1996.

UNDS Phase I Sampling Data Report, Volumes 1-13. October 1997.

Table 1. Estimated Post-Launch Retraction Exhaust Discharge Constituents, Concentrations, and Mass Loadings Based Upon Steam Condensate Sampling Data

Constituents From Steam Condensate[1]	Concentrations (μg/L) Log Normal Mean[2]	Range	Rate of Wet Accumulator Discharge (l/yr)[3]	Fleet-Wide Mass Loading (pounds/yr)
Antimony				
Total	7.13	BDL - 26.8	367,000	5.8×10^{-3}
Arsenic				
Total	0.74	BDL - 2.3	367,000	6.0×10^{-4}
Cadmium				
Total	2.86	BDL - 6.1	367,000	2.3×10^{-3}
Copper				
Dissolved	13.4	BDL - 49.0	367,000	1.1×10^{-2}
Total	20.1	BDL - 91.0	367,000	1.6×10^{-2}
Lead				
Dissolved	3.58	BDL - 12.7	367,000	2.9×10^{-3}
Total	4.38	BDL - 18.9	367,000	3.5×10^{-3}
Nickel				
Dissolved	10.3	BDL - 22	367,000	8.3×10^{-3}
Total	11.6	BDL - 34.7	367,000	9.4×10^{-3}
Selenium				
Total	2.87	BDL - 3.5	367,000	2.3×10^{-3}
Thallium				
Dissolved	1.18	BDL - 13.3	367,000	9.5×10^{-4}
Zinc				
Dissolved	13.94	7.15 - 21.9	367,000	1.1×10^{-2}
Total	11.35	BDL - 23.0	367,000	9.2×10^{-3}
Ammonia as Nitrogen	180	120 - 370	367,000	1.4×10^{-1}
Nitrate/Nitrite	440	300 - 810	367,000	3.4×10^{-1}
Total Kjeldahl Nitrogen	1240	NA	367,000	9.6×10^{-1}
Total Phosphorous	90	BDL - 270	367,000	7.1×10^{-2}
Benzidine	32.8	BDL - 73.5	367,000	2.7×10^{-2}
Bis(2-ethylhexyl) phthalate	19.4	BDL - 112	367,000	1.6×10^{-2}

The constituents listed above are those expected to be found in the wet accumulator discharge. BDL denotes below detection limit.

1. Constituents listed are the priority pollutants detected in steam condensate samples.
2. Highest of the dissolved and total log average values.
3. This value is the product of the annual condensed steam released from no-load and dead-load testing (810,000 pounds combined) cited in Section 3.2.1 and the conversion factors 0.0175 cubic foot/pound (inverse density of water at 200 ^{o}F), 7.4805 gallons/cubic foot, and 3.785 liters/gallon.

Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 2. Mean Concentrations of Constituents that Exceed Water Quality Criteria Post-Launch Retraction Exhaust Condensed Steam Discharge

Constituent	Log-Normal Mean Concentration (μg/L)	Federal Acute WQC (μg/L)	Most Stringent State Acute WQC (μg/L)
Oil	1,560,000	visible sheen [1] /15,000[2]	5,000 (FL)
Ammonia as Nitrogen	180	None	6 (HI)[A]
Nitrate/Nitrite	440	None	8 (HI)[A]
Total Nitrogen	1240	None	200 (HI)[A]
Total Phosphorous	90	None	25 (HI)[A]
Benzidine	32.8	None	0.000535 (GA)
Bis(2-Ethylhexyl) Phthalate	19.4	None	5.92 (GA)
Copper [3]			
Dissolved	13.4	2.4	2.4 (CT, MS)
Total	20.1	2.9	2.5 (WA)
Nickel [3]			
Dissolved	10.3	74	74 (CA, CT)
Total	11.6	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.

[1] Discharge of Oil. 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
[2] International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). MARPOL 73/78 as implemented by the Act to Prevent Pollution from Ships (APPS).
[3] Assumes the constituents and their concentrations in this discharge are similar in concentration to the constituents found in steam condensate that originates from shore facilities.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI= Hawaii
MS = Mississippi
WA = Washington

Table 3. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	X			X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	X		X	
3.3 Constituents			X	X
3.4 Concentrations			X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Thermal Effects			X	
4.4 Potential for Introducing Non-Indigenous Species				X

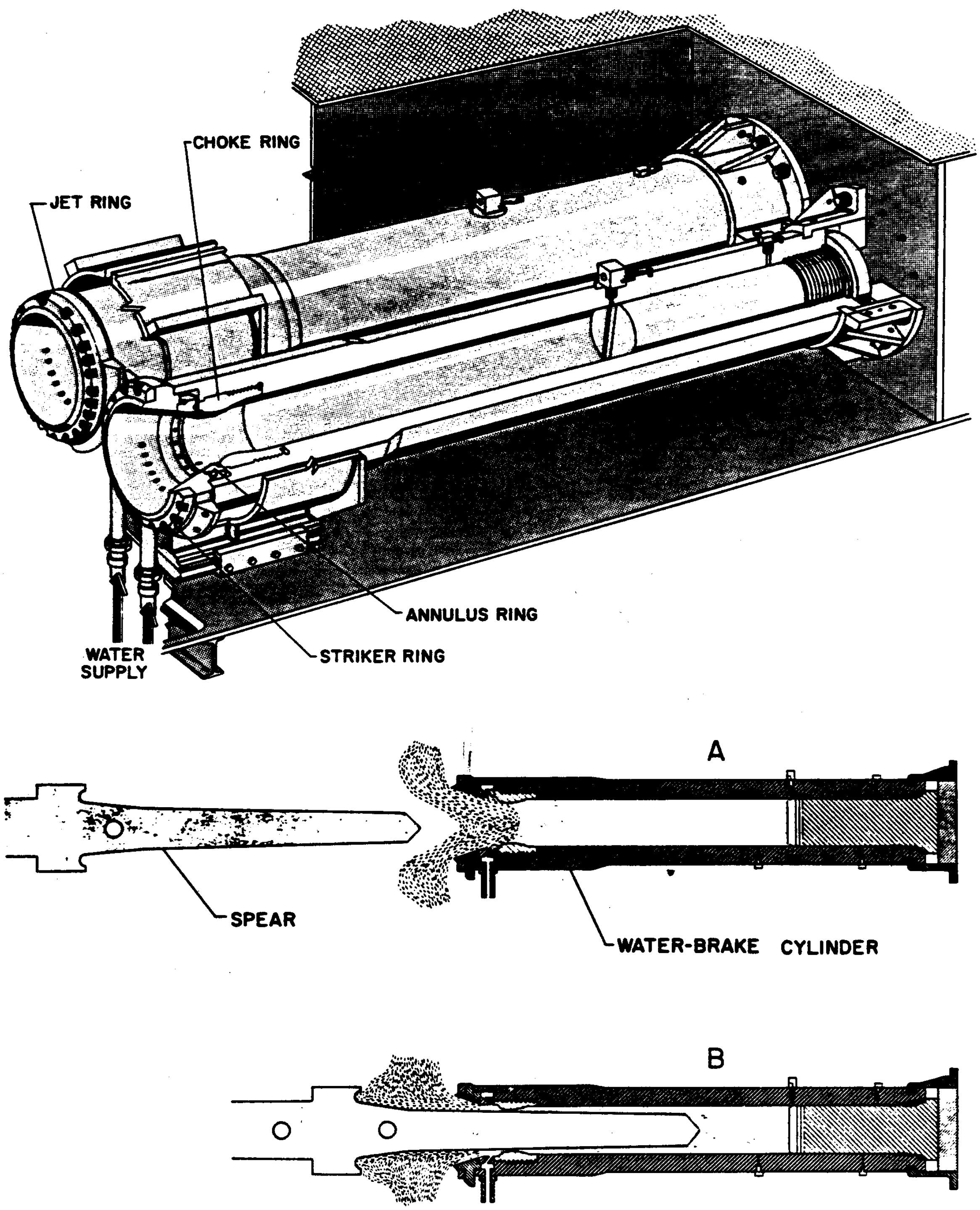

Fig. 1 Water Brakes

NATURE OF DISCHARGE REPORT

Catapult Wet Accumulator Discharges

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the catapult wet accumulator discharges and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Aircraft are launched from aircraft carriers using a steam driven catapult piston. Steam is supplied to a catapult from a 16,000-gallon pressure vessel known as a catapult wet accumulator. The wet accumulator contains a mixture of steam and saturated water at a high temperature and pressure. As steam is released from the accumulator for a launch, the pressure drops in the accumulator and water flashes to steam producing additional steam. The pressure from the steam against the catapult piston forces the piston to accelerate rapidly, providing sufficient force and velocity to launch the aircraft.[1] Each aircraft carrier has four catapults.

Approximately 8,000 gallons of boiler feedwater are used when initially filling an accumulator on conventionally-powered aircraft carriers. Similarly, 8,000 gallons of steam generator feedwater are used when initially filling an accumulator on nuclear-powered aircraft carriers. Feedwater from boilers and steam generators contain similar constituents. Feedwater is distilled fresh water from the ship's water generating plant. Steam from the ship's main steam plant is used to maintain the water level and to pressurize the accumulator to between 450 and 520 pounds per square inch (psi).[2] The steam is provided to the accumulator through a manifold that distributes the steam below the water level in the accumulator. Figures 1 and 2 show a schematic of a wet accumulator and its associated external and internal piping.

The continuous addition and condensation of steam during flight operations, while standing by for flight operations, or during catapult testing causes the water level in an accumulator to rise. Blowdowns are required to keep water level within operating limits, normally 40 to 50 inches of water.[2] Blowdowns to control water levels release up to 5 inches (750 gallons) of water from the accumulator.[3] The water is blown down through a pipe that is connected to the bottom of the accumulator and discharged overboard approximately 18 to 24 inches below the waterline through a seachest.[1]

Blowdowns also can be performed using a steam blowdown valve that is connected at the top of the accumulator. This valve can also be used to control the water level in the accumulator; however, its primary function is to reduce the pressure in the accumulator to atmospheric pressure prior to emptying the accumulator. Wet accumulators are emptied before major maintenance or if an aircraft carrier will be in port for 72 hours or longer.[2,4] To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to slowly reduce pressure and to minimize noise.

2.2 Releases to the Environment

Aircraft carrier catapult wet accumulators are initially charged with boiler or steam generator feedwater and fed with steam from the steam plant as the catapult is operated. The feedwater is treated with chemicals at specified rates to prevent scaling and corrosion, including oxygen scavengers and chelating agents. Unlike boilers, wet accumulators are unfired pressure vessels and scale and corrosion are not significant problems. Therefore, the treatment chemicals in the initial charge of boiler feedwater are expected to be unreacted and discharged from the wet accumulator during flight operations and blowdowns.[5,6,7,8] With each blowdown, the concentration of feed chemicals is reduced in the accumulator, and the concentration in the accumulator tank approaches that of steam condensate.

Some of the steam supplied to the accumulator is used directly to drive the catapult, while some condenses to distilled water, diluting the initial charge of boiler feedwater in the wet accumulator. The steam supplied to the wet accumulator is pure water with very minor amounts of constituents derived from the materials of construction of the steam generating and handling systems (e.g., copper nickel piping). In addition, there may be small amounts of water treatment chemicals. The constituents are expected to be similar to those found in steam condensate based on process knowledge of similarities in the materials of construction. The amounts of these constituents in steam directed to the wet accumulator are expected to be less than the amounts contained in steam condensate discharge because steam condensate discharge is produced from steam that has longer contact times with piping and equipment of the shore steam system. For the purposes of this NOD report, condensed wet accumulator steam was considered similar to steam condensate. Steam condensate is a separate UNDS discharge and is described in detail in the Steam Condensate NOD report.

2.3 Vessels Producing the Discharge

Only the Navy's aircraft carriers produce this discharge. There are 12 aircraft carriers in the Navy, one of which is homeported in Japan. All of the remaining 11 aircraft carriers are homeported in the United States.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Wet accumulator blowdowns occur as a result of flight operations and catapult testing. Blowdowns resulting from flight operations occur outside 12 nautical miles (n.m.). Blowdowns resulting from catapult tests occur within 12 n.m.

Wet accumulators are emptied before major maintenance or when a ship will be in port for greater than 72 hours. In both cases, aircraft carriers empty the accumulator outside 12 n.m. when returning to port. However, after major maintenance has been performed on a wet accumulator or catapult, the wet accumulator is refilled and the entire catapult system tested in port. If the aircraft carrier will be in port for more than 72 hours after testing is complete, the accumulator will be emptied in port.[4]

3.2 Rate

Before each test, the wet accumulator is filled with approximately 8,000 gallons of boiler or steam generator feedwater. Based on process knowledge, approximately 50 catapult shots are performed during each test. Wet accumulators are emptied before major maintenance of the catapult system or if an aircraft carrier will be in port for 72 hours or longer. After catapult testing, the wet accumulator is blown down or drained of the original 8,000 gallons of feedwater and approximately 1,100 gallons of condensed steam accumulated from the catapult shots. To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to reduce pressure slowly and minimize noise. A blowdown of 5 inches of water, which is equivalent to approximately 750 gallons of water, typically takes about 5 minutes to complete.

Each of the 11 aircraft carriers in the fleet has four wet accumulators, which are tested as described above approximately once every 1.5 years. Thus, fleetwide, approximately 235,000 gallons of water are discharged within 12 n.m. each year from wet accumulators:

Wet Accumulator Annual Blowdown Volume (gallons per year) = (Wet accumulator feedwater capacity) (4 accumulators per carrier) (11 carriers) / (Frequency of test) = (8,000 gallons/accumulator)(4 accumulators/carrier)(11 carriers) / (1.5 years) = 235,000 gallons per year

Similarly, approximately 33,000 gallons of condensed steam are discharged annually:

33,000 gallons/year = (1,125 gallons/accumulator)(4 accumulators/carrier)(11 carriers) / (1.5 years)

3.3 Constituents

The constituents in the feedwater that is used to fill a wet accumulator include disodium phosphate, ethylenediaminetetraacetic acid (EDTA), and hydrazine. None of these constituents are priority pollutants. Based on the analysis of steam condensate samples, the priority pollutants antimony, arsenic, benzidine, bis(2-ethylhexyl) phthalate, cadmium, copper, lead, nickel, selenium, thallium, and zinc can be present in the condensed steam in the wet accumulator. There are no known bioaccumulators in this discharge.

3.4 Concentrations

Table 1 shows the concentrations of the constituents identified in Section 3.3. The table is divided into two sections. The first section shows the concentrations of the pollutants detected in steam condensate. As explained in Section 2.2, the steam supplied to the wet accumulator is expected to contain lower concentrations of these constituents than measured in steam condensate samples. Nevertheless, to be conservative, the concentrations of these constituents in steam condensate were used to estimate the mass loadings from the condensed steam portion of wet accumulator discharge.

The second section of Table 1 shows specified concentrations of boiler feedwater treatment chemicals. As stated in section 2.2 and to be conservative, these chemicals were assumed to be discharged at these concentrations in the boiler feedwater portion of wet accumulator discharge.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the thermal effect of this discharge is discussed. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loading

Table 1 shows the estimated mass loadings of the constituents in wet accumulator discharge that were identified in Section 3.3. Fleet-wide annual mass loadings (in pounds/year) were estimated by multiplying the concentration of the constituents (in micrograms per liter (μg/L)) by the discharge rates from Section 3.2 (converted to liters per year) and the appropriate conversion factors using the following equation:

$$\text{(log-normal mean conc. } \mu\text{g/l)(g/1,000,000 } \mu\text{g) (lbs/453.593 g) (annual volume l/yr)} \cong \text{mass loading (lbs/yr)}$$

The annual volume for this discharge is a combination of the volume of steam condensed per year (33,000 gallons) and the volume of feedwater (235,000 gallons) charged into the wet accumulator.

As shown in Table 1, the amounts of priority pollutants discharged annually from the condensed steam portion of wet accumulator discharge are significantly less than one pound. Because the constituent concentrations used to calculate the mass loadings are actually from steam condensate discharge -- thought to overestimate pollutant concentrations in wet accumulator steam -- the actual mass loadings in the condensed steam portion of wet accumulator discharge are probably lower. The annual, fleet-wide mass loadings of the boiler feedwater chemicals in wet accumulator discharge are estimated to be 195, 49, and 49 pounds for disodium phosphate, EDTA, and hydrazine, respectively.

4.2 Environmental Concentrations

Wet accumulator discharge is released directly to the environment. The estimated concentrations of the constituents in the discharge are shown in Table 1. The constituent concentrations for the condensed steam portion of the discharge shown in Table 1 are considered to be maximums for the reasons previously cited.

Based upon a comparison of the concentrations of all constituents in Table 1 to Federal and most stringent state water quality criteria (WQC), the concentrations of nitrogen (as ammonia, nitrate/nitrite, and total nitrogen), phosphorous, benzidine, bis(2-ethylhexyl) phthalate, copper, and nickel shown in Table 1 are discharged in excess of Federal and/or the most stringent state WQC. Table 2 shows the comparison of concentrations of those constituents that exceed WQC to their WQC.

The discharge will not significantly increase concentrations of pollutants near the ship. To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to reduce pressure slowly and minimize noise, so concentrations near the ship will be lower because the incremental discharges allow concentrations to dissipate.

4.3 Thermal Effects

The potential for catapult wet accumulator discharge to cause thermal environmental effects was evaluated by modeling the thermal plume using mixing conditions that would produce the largest plume and then comparing the thermal plume to state thermal discharge requirements. Thermal effects of catapult wet accumulator discharge were modeled using thermodynamic equations to estimate the plume size and temperature gradients in the receiving water body.[9] The model was run under conditions that would estimate the maximum plume size (e.g., minimal wind, slack water) for a wet accumulator on an aircraft carrier. The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington State.[9] Of the five states that have a substantial presence of Armed Forces vessels, only Virginia and Washington have established thermal mixing zone dimensions. Other coastal states require that thermal mixing zones be established on a case-by-case basis. Based upon this analysis, the discharge of a wet accumulator pierside does not cause thermal effects that exceed any known state criteria.[9]

4.4 Potential for Introducing Non-Indigenous Species

Given that the water in wet accumulators is condensed steam at a temperature of 460^{o}F, and the charging feedwater to the wet accumulators is distilled fresh water from the ship's water generating plant, there is no potential for the transport of non-indigenous species.

5.0 CONCLUSION

Catapult wet accumulator discharge has a low potential to cause an adverse environmental effect because:

- Mass loadings of benzidine, bis(2-ethylhexyl) phthalate, nitrogen, phosphorous, copper, and nickel within 12 n.m. are small, less than a pound per year combined fleetwide, discharged at concentrations near WQC;
- The discharge contains small quantities of water treatment chemicals;
- Resulting contributions to environmental concentrations from the discharge are expected to be insignificant because the discharge event is spread out over multiple blowdowns that allow concentrations to dissipate; and
- The discharge of a wet accumulator pierside does not cause thermal effects that exceed known state thermal mixing zone criteria.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources were obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on concentration requirements of boiler feedwater chemistry, the concentrations of feedwater chemistry constituents resulting from this discharge were then estimated. Table 3 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Catapult Wet Accumulator Discharges, Round Two Meeting. March 14, 1997.

2. UNDS Equipment Expert Meeting Minutes - Catapult Wet Accumulator Steam Blowdown. August 20, 1996.

3. Joe Hungerbuhler, NSWCCD-SSES 9223. Information on Catapult Wet Accumulator Blowdown. November 1, 1996. Clarkson Meredith, Versar, Inc.

4. Commander, Naval Air Force, U.S. Atlantic Fleet. Responses to TYCOM Questionnaire. M. Rosenblatt and Son, Inc. May 20, 1997.

5. Naval Ship Systems Engineering Station, Memorandum - Boiler Blowdown Discharges. August 23, 1991.

6. UNDS Equipment Expert Meeting Structured Questions - Nuclear Steam Generator Blowdown/Safety Valve Testing Effluents. NAVSEA 08U, August 16, 1996.

7. NSWC, Carderock Division, Memorandum - Chelant Boiler Feedwater Treatment Implementation. March 18, 1995.

8. Naval Ships' Technical Manual (NSTM), Chapter 220, Volume 2, Revision 7, Sections 21 and 22. Boiler Water/Feed Water Test & Treatment. December 1995.

9. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 1997.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

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USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, Proposed Rule under 40 CFR Part 131, Federal Register, Vol. 62, Number 150. August 5, 1997.

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The Bureau of National Affairs, Inc., 1996.

Texas. Texas Surface Water Quality Standards, Sections 307.2 - 307.10. Texas Natural Resource Conservation Commission. Effective July 13, 1995.

Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

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UNDS Equipment Expert Meeting Minutes - Aircraft Launch Equipment and Recovery Equipment Discharge Meeting. August 22, 1996.

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Patty's Industrial Hygiene and Toxicology, 3rd Edition, George D. and Florence E. Clayton, Ed. John Wiley & Sons: New York, 1981.

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

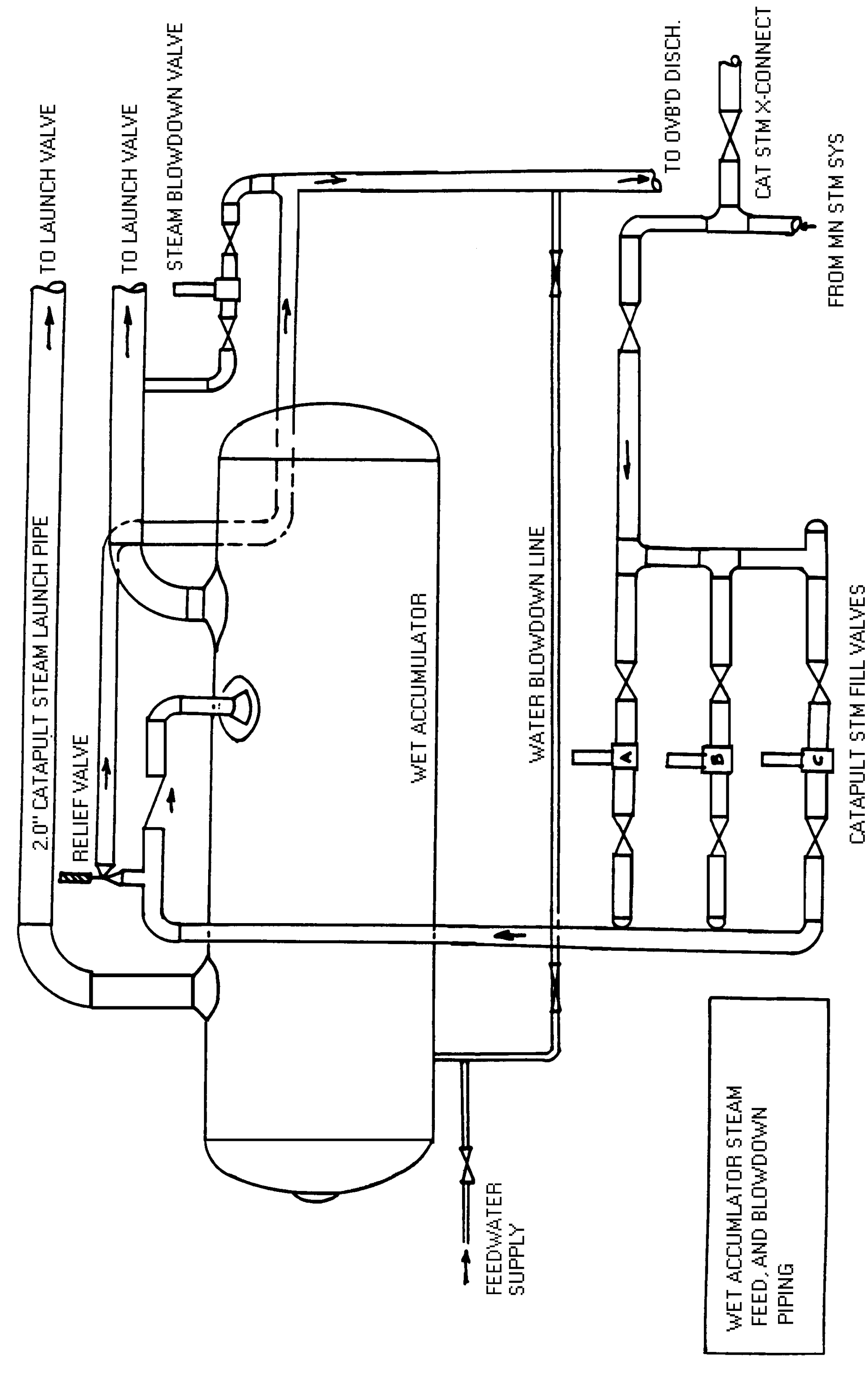

Figure 1. Wet Accumulator Steam, Feed, and Blowdown Piping

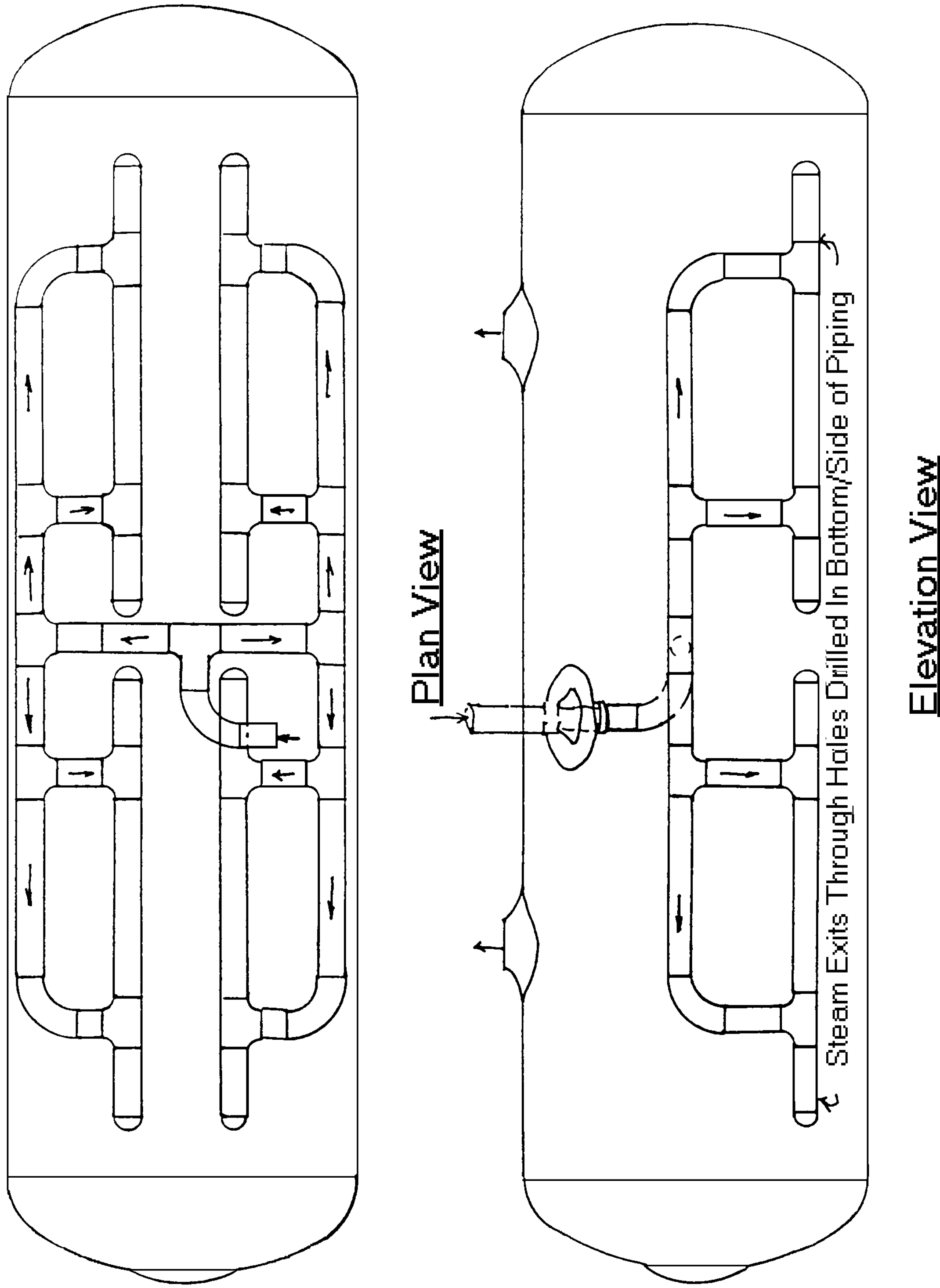

Figure 2. Wet Accumulator Internal Steam Charging Manifold

Table 1. Estimated Catapult Wet Accumulator Discharge Constituents, Concentrations, and Mass Loadings Based Upon Steam Condensate Sampling Data

Constituents From Steam Condensate[1]	Concentrations (μg/l) Log Normal Mean[2]	Concentration Range	Rate of Wet Accumulator Discharge (l/yr)[3]	Fleet-Wide Mass Loading (pounds/yr)
Antimony				
Total	7.13	BDL - 26.8	125,000	2.0×10^{-3}
Arsenic				
Total	0.74	BDL - 2.3	125,000	2.0×10^{-4}
Cadmium				
Total	2.86	BDL - 6.1	125,000	7.9×10^{-4}
Copper				
Dissolved	13.4	BDL - 49.0	125,000	3.7×10^{-3}
Total	20.1	BDL - 91.0	125,000	5.5×10^{-3}
Lead				
Dissolved	3.58	BDL - 12.7	125,000	9.9×10^{-4}
Total	4.38	BDL - 18.9	125,000	1.2×10^{-3}
Nickel				
Dissolved	10.3	BDL - 22	125,000	2.8×10^{-3}
Total	11.6	BDL - 34.7	125,000	3.2×10^{-3}
Selenium				
Total	2.87	BDL - 3.5	125,000	7.9×10^{-4}
Thallium				
Dissolved	1.18	BDL - 13.3	125,000	3.3×10^{-4}
Zinc				
Dissolved	13.94	7.15 - 21.9	125,000	3.8×10^{-3}
Total	11.35	BDL - 23.0	125,000	3.1×10^{-3}
Ammonia as Nitrogen	180	120 - 370	125,000	4.9×10^{-2}
Nitrate/Nitrite	440	300 - 810	125,000	1.2×10^{-1}
Total Nitrogen	1240	NA	125,000	3.4×10^{-1}
Total Phosphorous	90	BDL - 270	125,000	2.5×10^{-2}
Benzidine	32.8	BDL - 73.5	125,000	9.0×10^{-3}
Bis(2-ethylhexyl) phthalate	19.4	BDL - 112	125,000	5.3×10^{-3}
From Boiler Feedwater Treatment Chemicals[4]				
Disodium phosphate	100,000	NA	888,000	196
Ethylenediaminetetraacetic acid (EDTA)	25,000	NA	888,000	49
Hydrazine	25,000	NA	888,000	49

The constituents listed above are those expected to be found in the wet accumulator discharge. BDL denotes below detection limit.

1. Constituents listed are the priority pollutants detected in steam condensate samples.
2. Highest of the dissolved and total log average values.
3. This value is the product of the annual wet accumulator discharge cited in section 3.2 and the conversion factor of 3.785 liters per gallon.
4. These concentrations are based on the specified rates of application of these constituents to boiler feedwater to inhibit scaling and corrosion.

Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 2. Mean Concentrations of Constituents that Exceed Water Quality Criteria Catapult Wet Accumulator Discharge

Constituent	Log-Normal Mean Concentration (μg/L)	Federal Acute WQC (μg/L)	Most Stringent State Acute WQC (μg/L)
Ammonia as Nitrogen	180	None	6 (HI)[A]
Nitrate/Nitrite	440	None	8 (HI)[A]
Total Nitrogen	1240	None	200 (HI)[A]
Total Phosphorous	90	None	25 (HI)[A]
Benzidine	32.8	None	0.000535 (GA)
Bis(2-Ethylhexyl) Phthalate	19.4	None	5.92 (GA)
Copper [1]			
Dissolved	13.4	2.4	2.4 (CT, MS)
Total	20.1	2.9	2.5 (WA)
Nickel [1]			
Total	11.6	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.

[1] Assumes the constituents and their concentrations in this discharge are similar in concentration to the constituents found in steam condensate that originates from shore facilities.

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WA = Washington

Table 3. Data Sources

	Data Sources			
NOD Section	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	X			X
3.2 Rate	X			
3.3 Constituents				X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations				X
4.3 Thermal Effects	X			
4.4 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Cathodic Protection

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the discharge associated with cathodic protection and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Nearly all vessels use some form of cathodic protection to prevent metal hulls and underwater structures from corroding. The Armed Forces (Navy, Air Force, Army, Military Sealift Command (MSC)) and the U.S. Coast Guard (USCG) use cathodic protection, in conjunction with corrosion-resistant coatings, to protect their vessels. This combination provides an optimal corrosion control system which utilizes the advantages of each individual system. While coatings are the primary means of controlling corrosion, nearly all coatings have some defects (whether from wear or damage) and some components are uncoated by design (e.g., propellers). Cathodic protection could, in theory, be used alone to protect a hull and other external underwater structures, but the number of anodes for sacrificial-anode-based systems or power requirements for Impressed Current Cathodic Protection (ICCP)-based systems would increase greatly. When used in conjunction with coatings, cathodic protection reduces the effects of wear and failure of the paint systems and reduces the associated required repairs and maintenance. Without cathodic protection systems, vessels would be subject to severe corrosion (i.e., dissolution and discharge of hull material) of the underwater hull and appendages resulting in either increased underwater repairs and maintenance or more frequent dry-docking of the vessels for renewal of underwater hull paint systems.

The two types of cathodic protection used by the Armed Forces -- sacrificial anodes and ICCP systems -- are illustrated schematically in Figure 1. Small boats and craft which have wood, aluminum, fiberglass or rubber (inflatable) hulls do not require cathodic protection to protect these materials from corrosion (but may have small anodes located near the propellers for their protection). Also, many of the small boats and craft with steel hulls that utilize sacrificial anodes are stored out of the water on trailers or blocks.

2.1.1 Sacrificial Anodes

When sacrificial anodes are used, the anodes are physically connected (e.g., by bolts or welding) to ship components and structures. As shown in Figure 2, an electrochemical cell is formed between the anode and the cathode (the structure to which the anode is connected) through the surrounding electrolyte (usually seawater). The anode is preferentially corroded or “sacrificed”, producing a flow of electrons to the cathode which results in a reduction or elimination of corrosion at the cathode. Large ships with mandatory dry-dock inspection and overhaul intervals of less than three years, as well as the most boats and small craft, use sacrificial anodes to protect the underwater hull. The numbers and sizes of the anodes are determined by the wetted surface area of the hull, the planned replacement cycle of the anodes, and the corrosion history of the vessel.

Sacrificial anodes continually corrode when immersed and require routine replacement to maintain sufficient mass and surface area for adequate cathodic protection. On average, zinc anodes are estimated to be completely consumed every six years.[1,2,3,4] The consumption rate depends on the service environment, the condition of the hull coating, and the location of the anode on the hull.

Zinc anodes are used almost exclusively by DoD and USCG vessels for sacrificial cathodic protection of hulls,[5] with aluminum anode usage limited to a few (less than 5) Navy submarines. Naval Sea Systems Command (NAVSEA) continues to evaluate aluminum anodes for use on other Navy ships and their use requires prior NAVSEA authorization and design review.[5]

Aluminum anodes have 3.4 times the current capacity[i] of zinc anodes due primarily to differences in valence (3 for aluminum vice 2 for zinc) and density.[5] The lower density of aluminum anodes also results in aluminum anodes occupying more volume than zinc anodes of the same weight. Development of the military specification[6] for aluminum anodes has only recently been completed although commercial aluminum anodes have been available for many years. Aluminum anodes are not as readily available as zinc anodes and are more prone to passivate (become inactive) than zinc anodes, but may be considered for use where the benefits of increased current capacity and reduced weight offset the disadvantages of increased volume.

Sacrificial anodes used to prevent corrosion of heat exchangers, condensers, evaporators, sewage collection, holding and transfer tanks, ballast tanks, bilges, sea chests, sonar domes, or other non-hull areas or components are not addressed in this NOD report, but in NOD reports describing these discharges (e.g. Seawater Cooling Discharge and Clean Ballast).

2.1.2 ICCP Systems

The Armed Forces also use ICCP systems (see Figure 3) to protect hulls in lieu of sacrificial anodes. ICCP systems are employed when the wetted surface of the hull and other underwater components requiring cathodic protection is large or a controllable system is required.[5] ICCP systems protect against corrosion using direct current (DC) from a source within the ship in lieu of current provided by a sacrificial anode. Except for the source of current, the mechanism of protection is identical for sacrificial anode cathodic protection and ICCP (see Figure 1). The current is passed through platinum-plated tantalum anodes designed for a 20-year service life. A silver/silver chloride (Ag/AgCl) reference electrode (control reference cell) measures the electrical potential of the hull and is used to determine how much current is required from the ICCP system to provide adequate cathodic protection.

[i] *Current capacity*, a sacrificial anode material property, is the total current available per unit mass over the life of the anode, commonly expressed as (amp-hr/kg) or (amp-yr/lb). The current capacity for zinc and aluminum anodes is 812 amp-hr/kg and 2759 amp-hr/kg, respectively. Current capacity should not be confused with the *maximum output current* of an anode, which is a function of the anode material, anode surface area, system resistance, and driving potential. For most common types of zinc anodes used on underwater hulls, the maximum output current is approximately 0.4 amps per anode.[5]

2.2 Releases to the Environment

2.2.1 Sacrificial Anodes

As the zinc or aluminum anode is consumed (oxidized), ionized zinc or aluminum is released into the receiving waters. Water at the cathode (such as the steel hull) is reduced forming hydroxyl (OH^-) ions which combine with the zinc or aluminum ions to form zinc or aluminum hydroxide if excess oxygen is present. Another possible reaction produces hydrogen at the cathode, especially in deaerated seawater.

In addition, oxidants (primarily chlorine and bromine) could also be produced in secondary reactions because of the electrical potential of the anode. Precise reactions and probabilities will vary with conditions in the seawater environment. However, the relatively low electrical potential of the sacrificial anode (-1.05 volts average) compared with ICCP systems (-15volts Ag/AgCl reference electrode) will result in less oxidant being formed. Those oxidants which are formed will rapidly react with the surface of the sacrificial anode to form zinc or aluminum chloride, or react with oxidant-demanding substances in the water. Due to the relatively low electrical potential of sacrificial anodes and the rapid reactive nature of the anode surface, the possible generation of oxidants by sacrificial anodes will not be considered further.

2.2.2 ICCP Systems

ICCP systems operate at higher electrical potentials than sacrificial anodes and consequently can generate more oxidants. Precise primary and secondary reactions of oxidants will vary with seawater conditions such as salinity, temperature, ammonia content, pH, etc., but will primarily consist of various chlorinated and brominated substances. These substances include: hypochlorous and hypobromous acids, hypochlorite and hypobromite, chloro- and bromo-organics, chloride, bromide, chloramines, and bromamines. These substances are commonly called Chlorine-Produced Oxidants (CPO) when associated with brackish or seawater.[7]

The general reactions related to CPO are initiated when chlorine (Cl_2) is generated by the reduction of chloride ions (Cl^-) in seawater. The chlorine reacts to form hypochlorous acid (HOCl) and the hypochlorite ion (OCl^-) in the water. These two compounds, along with the chlorine, are referred to as free chlorine. Free chlorine, the standard disinfection agent used in water treatment facilities, undergoes four important types of reactions in natural waters: (1) oxidation of reduced substances and subsequent conversion to chloride; (2) reaction with ammonia and organic amines to form chloramines, collectively called combined chlorine; (3) reaction with bromide to form hypobromous acid (HOBr) and hypobromite (OBr^-), called free bromine; and (4) reaction with organics to form chloro-organics. Free bromine reacts in a manner similar to free chlorine, oxidizing reduced substances or forming bromamines (combined bromine) or bromo-organics. Most common analytical methods for quantifying CPO measure the sum of all free and combined chlorine and bromine in solution, but do not measure the chloro- and bromo-organics.

Human health issues are a concern for some of these chlorinated hydrocarbons, which are suspected carcinogens and pose a concern when found in significant quantities in drinking water. However, these small quantities of chloro- and bromo-organics are produced only in brackish or seawater. These materials are not generated by ICCP systems in freshwater ports due to the low concentrations of chlorides and bromides. Most drinking water is drawn from groundwater or freshwater sources. Armed Forces vessels that are homeported in seawater or brackish water ports are not docked near drinking water intakes. Given the limited quantity and the location of discharge, exposure to drinking water intakes is unlikely. These chlorinated hydrocarbons are not separately addressed further in this NOD report.

2.3 Vessels Producing the Discharge

Table 1 shows the vessels that produce this discharge.[1,8,9,10] The table identifies whether vessels use sacrificial anodes or ICCP systems. Boats and craft of the Navy, Naval Auxiliary, USCG, MSC, Army, and Air Force use sacrificial anodes for cathodic protection. Of the approximately 5000 miscellaneous small boats and craft, approximately 30% are expected to have steel hulls and therefore cathodic protection. The remaining 70% are assumed to have hulls constructed of fiberglass, wood, aluminum, or other non-ferrous materials which do not require cathodic protection.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Discharge from cathodic protection systems associated with a vessel's hull occurs continuously whenever the vessel is waterborne. This discharge occurs both within and beyond 12 nautical miles (n.m.).

3.2 Rate

3.2.1 Sacrificial Anodes

The discharge from sacrificial anodes is characterized by a mass flux instead of a volumetric flow rate because the "constituents" enter the receiving water directly (via corrosion and dissolution). The following factors were used to calculate the average mass flux (also called corrosion/dissolution) of sacrificial anodes while pierside and underway:

1. Based on underwater hull inspections and maintenance records one-half of an

anode is consumed after three years.[4]

2. The corrosion/dissolution rate while underway is approximately three- to five-times the pierside rate based on field studies.[3,11] A factor of four is used for calculations. Probable explanations for this phenomenon are: (1) the fully aerated seawater produced by a moving hull increases reaction rates; and (2) more corrosion products and other deposits and surface films are removed due to the erosion forces of the seawater.

3. Based on the actual vessel movement data available, the average Navy vessel spends approximately 176 days in port (pierside) and transits to or from port (underway) approximately 11 times each year.[12] The average MSC vessel spends approximately 94 days in port and performs approximately six transits. Vessel movement estimates for the Air Force, Army, and USCG vessels were made based on operational knowledge (see Table 2). The vessel movement data for the Navy was used in dissolution calculations since it results in the highest period of time that vessels are in port.

Using the above factors, the corrosion/dissolution rates were calculated for zinc anodes as shown in Calculation Sheet 1. At pierside, the rate was calculated to be 7.4×10^{-6} (lb zinc/lb anode)/hr, and underway, it was 3.0×10^{-5} (lb zinc/lb anode)/hr. These rates can also be expressed as a function of wetted hull area using a conversion factor based on information presented in Table 2 which lists the vessels incorporating sacrificial anode cathodic protection. This relationship is stated as follows:

Average density of zinc anodes = (total amount of anodes) / (total wetted surface area)

= (1,860,000 lb) / (10,826,000 ft^2) = 0.17 lb/ft^2

This results in average pierside and underway zinc generation rates of 1.3×10^{-6} and 5.1×10^{-6} (lb zinc/square foot of underwater surface area)/hr.

Shipboard experience with aluminum anodes is limited, but as with zinc anodes the corrosion/dissolution rate of the anode is primarily determined by factors such as the area of bare metal requiring protection. Rates for aluminum anodes can therefore be calculated based on process knowledge and the previously calculated generation rates for zinc anodes. Using the ratio of current capacity of aluminum to zinc anodes, generation rates for aluminum anodes are 2.2×10^{-6} (lb aluminum/lb anode)/hr pierside, and 8.8×10^{-6} (lb aluminum/lb anode)/hr underway.

Current capacity ratio = (aluminum anode current capacity) / (zinc anode current capacity)

= (2759 amp-hr/kg) / (812 amp-hr/kg) = 3.4

3.2.2 ICCP Systems

Oxidant discharges from operating ICCP systems are also characterized by mass flux instead of flow rate because the constituents are created from the surrounding water due to electrolysis. Precise reactions and probabilities depend on a variety of conditions as described in Section 2.2.2.

In order to estimate the rate that CPOs are formed from ICCP systems, a sample of ICCP system logs was reviewed and the average current output for Navy vessels in port was found to be approximately 35 amperes (amps).[13] Using the assumption that 100% of ICCP system current goes into producing chlorine, an hourly pierside chlorine generation rate of 46.3 grams (g) per vessel was calculated using Faraday's Law:

(35 amps) (1 coulomb/amp-sec) (3,600 sec/hr) (35.45 g chlorine/mole) (mole/96,484 coulomb)

= 46.3 g chlorine/hr

Since ICCP systems are designed (i.e., anode design and system operating voltage) to maximize cathodic protection provided to the hull, and generation of chlorine or CPO is a secondary reaction, actual CPO generation rates are expected to be significantly lower.

ICCP anode deterioration rates have been measured at 4.4 to 6.1 milligrams/ampere per year by the manufacturer.[14] For a vessel operating an ICCP system at 35 amps in port for 176 days per year, the resulting dissolution rate of platinum using 6.1 milligrams/ampere per year is:

(6.1 mg/amp-year) (35 amps/ship) = 214 mg/(ship-year)

3.3 Constituents

3.3.1 Sacrificial Anodes

Zinc anodes are approximately 99.3% zinc and contain small amounts of cadmium and aluminum (for activation).[15] Table 3a lists the chemical composition of zinc anodes according to military specifications.[15] Zinc and cadmium are priority pollutants. None of the materials in zinc anodes are bioaccumulators.

Aluminum anodes are approximately 95% aluminum, 5% zinc, and contain small amounts of silicon and indium (for activation).[6] Table 3b lists the chemical composition of aluminum anodes according to military specifications.[6] Zinc is a priority pollutant in aluminum anodes. Aluminum anodes could possibly contain up to 0.001% mercury as an impurity; mercury is a known bioaccumulator.

3.3.2 ICCP Systems

The deterioration of ICCP anodes (see Section 3.2.2) produces 214 mg/yr per ship of platinum. ICCP systems also produce by-products (oxidants) when they operate. In addition to the reduction reactions at the hull, ICCP systems can also produce chlorine, bromine and other oxidants (CPO) through secondary reactions at the anode because of the electrical potential (voltage) of the anode (see Section 2.2). These constituents are the primary concern for the ICCP portion of this discharge. Chlorine or CPOs are neither priority pollutants nor bioaccumulators, though EPA has developed water quality criteria for chlorine/CPO.

3.4 Concentrations

The discharge due to cathodic protection is a mass flux rather than a flow. The resultant concentration of constituents in the environment are discussed in Section 4.2.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

4.1.1 Sacrificial Anodes

The number of sacrificial anodes installed on a vessel is related to the area of wetted surface needing protection and the area that is available for placing the anodes. The discharge from sacrificial anodes is therefore proportional to vessel size (except for submarines because the anodes only protect the propeller and stern appendages and not the hull). The amount of anodes installed is based on:

1. One 23-pound zinc anode per 115 ft^2 of total wetted area for large vessels (with more than 3,000 ft^2 of wetted area).[3,5]

2. One 23-pound anode per 400 ft^2 of total wetted area for smaller vessels, boats, and craft.[3]

3. 2,024 pounds (88 anodes) of zinc anodes per submarine.[3]

Using the large vessel criteria for all vessels with over 3,000 ft^2 of wetted surface is a conservative assumption because this criteria was written for large, high value vessels that have long periods between drydockings (and thus, less opportunity for anode replacement). Vessels with wetted surface areas between 3,000 ft^2 and 10,000 ft^2 are drydocked more frequently, increasing the opportunity for repainting and anode replacement, and therefore could use fewer zinc anodes than the large vessel criteria. If the actual wetted surface area of a vessel was unavailable, it was approximated using a formula in the Naval Ships' Technical Manual (NSTM), Chapter 633:[5]

$$S = 1.7\,(l)\,(d) + (V) / (d)$$

where S = wetted surface area of the hull and appendages, in square feet
l = length between perpendiculars, in feet
d = molded mean draft at full displacement, in feet
V = molded volume of displacement in cubic feet

Where available, data on actual vessel movements were used to determine the number of days in port, number of transits, and days underway operating within 12 n.m. for Navy, MSC, USCG, and Army vessels. Where actual vessel movement data were not available, movement data for vessels with similar missions were used. This information is shown in Table 2 and Table 4. Using these data, the numbers of anodes installed on vessels, and anode corrosion/dissolution rates, the mass flow rate of this discharge was calculated.[ii] When vessels are in port, the pierside dissolution rate is used to calculate the constituent mass flow rate. When vessels are operating within 12 n.m. of shore, the applicable dissolution rate is derived by summing 66.7% of the pierside dissolution rate and 33.3% of the underway dissolution rate. This applicable dissolution rate is then used to calculate the constituent mass flow rate. Total constituent-specific mass flow rates are calculated by summing the pierside constituent mass flow rate and the constituent mass flow rate when the vessel is operating within 12 n.m. An example of the calculation for determining total constituent-specific mass loading is provided below.

(305 days in port/yr) (24 hrs/day) (417 lb anode/class) (7.4×10^{-6} lb zinc/lb anode/hr) +
(60 days operating within 12 n.m./yr) (24 hrs/day) (417 lb anode/class) [(0.667) (7.4×10^{-6} lb zinc/lb anode/hr) + (0.333) (3.0×10^{-5} lb zinc/lb anode/hr)] =
(22.59 lb zinc/yr/class) + (8.96 lb zinc/yr/class) = 31.55 lb zinc/yr/class

For the 89 submarines in the Navy fleet that use sacrificial anodes, the total estimated annual loading of zinc within 12 n.m. is 6,360 pounds. Zinc anodes on submarines are required to protect propellers and stern appendages, which are similar in surface area for all submarine classes. Fifty-six of the Fleet's 89 submarines are Los Angeles Class submarines. A Los Angeles Class submarine has eighty-eight 23-pound zinc anodes (2,024 pounds total) to protect propellers and stern appendages.[3] The number of anodes on a Los Angeles Class submarine (88) was used for all submarine classes because the surface areas of the propellers and stern appendages are similar among submarine classes.

[ii] Most DOD vessels will be at anchor or otherwise stationary 2/3 of the time and conducting transits or otherwise moving 1/3 of the the time when operating within 12 n.m. of shore. For mass loading calculation purposes, a combination of the pierside and underway dissolution rates was used, weighted 66.7% and 33.3% respectively. These percentages are based on fleet provided information.

For surface vessels, an estimated 113,201 pounds of zinc is discharged annually within 12 n.m. The wetted surface areas and total amount of anodes used to calculate the zinc discharged by vessels within 12 n.m. are presented in Table 2. The estimated mass loading was based on 1,805 surface vessels with a total wetted surface area of approximately 11 million square feet.

Mass loading for the approximately 5,000 small boats and craft of the Armed Forces was estimated using the following information:

1. 30% have steel hulls, and therefore sacrificial anodes (the remaining have wood, fiberglass, or aluminum hulls which do not require cathodic protection);

2. The average wetted surface area is 1,000 ft^2 (the approximate wetted surface area of a 65 ft tug boat), which is protected by approximately 58 pounds of zinc anodes (23 pounds per 400 square feet);[iii]

3. Each vessel spends 100% of the time in the water (a conservative estimate since many spend considerable time out of the water on trailers or blocks);

The resulting zinc discharged was then calculated using the static dissolution rate.

(5,000 vessels) (30%) (58 lb anodes/vessel) (100%) (7.4 x 10^{-6} lb zinc/lb anode/hr) (365 days/yr) (24 hr/day) = 5,640 lb zinc/yr

Based on conservative assumptions, this calculation presents the maximum magnitude of the discharge from small boats and craft, which represents approximately only 5% of the previously estimated total annual discharge of 119,561 pounds of zinc (surface ships and submarines combined) for a maximum combined total of 125,201 pounds of zinc per year. This discharge could contain up to 626 pounds per year of aluminum and up to 88 pounds per year of cadmium, based on the potential concentration of minor constituents in zinc anodes.

Aluminum anodes are currently used on no more than 5 submarines.[16] Using the information in Table 4, each submarine with zinc anodes discharges approximately 71.5 pounds zinc/year within 12 n.m. This zinc loading was scaled for aluminum anodes using the current capacity ratio derived in Section 3.2.1 and the maximum number of vessels with aluminum anodes, resulting in a total fleetwide annual consumption (discharge) of 105 pounds of aluminum anodes as shown below.

[iii] Small boats and craft are non-standard vessels with wetted surface areas ranging from under one hundred square feet to one thousand square feet. Because adequate information is not available to characterize the surface area of specific small boats and craft, the upper bound of this range, one thousand square feet, is used as a conservative estimate of the average wetted surface area.

(71.5 lb zinc anode/submarine) / (3.4) = 21.0 lb aluminum anode/submarine
(21.0 lb aluminum anode/submarine) (5 submarines) = 105 lb aluminum anodes consumed, fleetwide

Based on the composition of aluminum anodes, this discharge is comprised of 100 pounds aluminum, 5 pounds zinc, and could contain up to 0.21 pound per year of silicon and 0.02 pound per year of indium. The maximum potential loading of mercury from aluminum anodes was estimated to be 0.001 pound fleetwide, assuming that all aluminum anodes contain the highest allowable amount of mercury.

4.1.2 ICCP Systems

The mass loading due to deterioration of ICCP anodes was calculated using the previously discussed anode deterioration rate and the number of vessels with ICCP systems. For the 267 vessels with ICCP systems, this results in a total fleet-wide platinum loading of:

(214 mg/yr) (273 vessels) = 57,138 mg/yr = 57 g/yr ≅ 2 ounces/yr

Annual CPO loadings were calculated using the estimated CPO generation rate of 46.3 g/hr per vessel (see Section 3.2). This rate was applied to the 273 vessels with ICCP systems (see Table 1) and time spent in port for each class to calculate the mass loadings presented in Table 5. The estimated annual loading of CPO based on the 273 vessels with ICCP systems is 98,000 pounds.

4.2 Environmental Concentrations

Two approaches were used to estimate the concentration of zinc and CPO in receiving waters from cathodic protection systems. The first uses a simplified dilution model, based on tidal flow in three major Armed Forces ports and is hereafter referred to as the “tidal prism” approach. The second approach was based on a mixing zone proximate to the hull of a typical Navy vessel. Each approach used the hourly zinc corrosion/dissolution rates and CPO production rate developed in Section 3.2 (i.e., for zinc: a pierside rate of 1.3×10^{-6} (lb zinc/ft^2)/hr and an underway rate of 5.1×10^{-6} (lb zinc/ft^2)/hr, and for CPO: 46.3 (g/vessel)/hr).

Tidal Prism. The tidal prism approach uses the mass of the constituent generated by vessels and mixes this mass with a volume of water. The mass is calculated by determining the number of vessels in a particular homeport, the type of cathodic protection system utilized, and the number of hours each vessel spends in port (both pierside and in transit) along with the aforementioned zinc and CPO generation rates. Together, these factors are used to calculate an annual loading to the harbor. The water volume used is the sum of all outgoing tides over a year times the surface area of the harbor. The sum of outgoing tides is called the “annual tidal excursion” which is defined as the difference between mean high water and mean low water over the course of a year. Annual tidal excursion data is readily available from the National Oceanographic and Atmospheric Agency (NOAA), and the 1996 data[17] was used for these calculations.

The tidal prism model assumes steady-state conditions, where zinc and CPO are completely mixed with the harbor water and are removed solely by discharge from the port during ebb tides. The outgoing tidal volumes are assumed to be carried away by long-shore currents (i.e., those moving parallel to shore) and do not re-enter the harbor. The tidal prism model also does not assume removal or concentration by other factors such as river flow, precipitation, evaporation, sediment exchange, or natural decay. By not accounting for removal or dilution due to river flow, precipitation, sediment exchange, and natural decay, the calculations result in a higher constituent concentration. The effect of evaporation could be to increase concentration due to water loss, or the effect could be neutral since water loss by evaporation is replaced by (additional) water inflow from the sea. While the model assumes complete mixing, there will be areas in the harbors with higher concentrations, primarily near the source vessels, along with areas of lower concentration.

The three ports that are used for the tidal prism model shown in Tables 6a, 6b, and 6c include Mayport, FL, San Diego, CA, and Pearl Harbor, HI. These ports were selected because they have minimal river inflow, small but well-defined harbor areas, and a high number of vessels of the armed forces. Each of these factors will tend to overestimate concentrations of zinc and CPO, either due to less volume of water or high numbers of potential sources. Other major ports, such as Norfolk (VA) and Bremerton (WA), were considered, but not included because of large river effects and very large harbor areas. The 1996 annual tidal volumes (annual tidal excursion times the harbor surface area) for the three ports (calculations provided in Calculation Sheet 2) are shown below:

- San Diego, CA: 3.77×10^{13} liters;
- Mayport, FL: 6.67×10^{11} liters; and
- Pearl Harbor HI: 3.41×10^{12} liters.

Mixing Zone: For the mixing zone approach, the previously calculated zinc and CPO generation rates were used for each discharge, but the resultant environmental concentrations were calculated based on various volumes of water around a typical Armed Forces vessel (i.e., a "mixing zone") instead of the entire port, as above. A vessel with 19,850 ft^2 of wetted surface area (i.e., a FFG 7 Class frigate size vessel) was selected for modeling the environmental concentration from sacrificial anodes since precise information was available for the number of zinc anodes installed on that ship class. A vessel with 37,840 ft^2 of wetted surface area (i.e., a CG 47 Class cruiser size vessel) was selected for modeling ICCP system discharges because of the large number of vessels in this ship class and it's hull size is typical of most vessels with ICCP systems.

The model assumes the hull to be a half immersed cylinder (see Calculation Sheets 3 and 4). The zinc and CPO generation rates were then applied to various sizes of mixing zones (volumes of water surrounding the vessel), ranging from 0.1 to 100 feet from the hull, and mixing rates (the time required for the mixing zone contents to be exchanged with a new volume of clean seawater), ranging from 0.1 to 1 hour, to calculate resultant incremental zinc and CPO concentration increases shown in Table 7. The maximum time of exchange of 1 hour corresponds to a realistic duration of slack tide, and is also the time required for a volume of water flowing at 0.1 knots to flow past a 600 foot long vessel longitudinally. Actual exchange times will usually be much less. For example, water flowing at 2 knots (typical for tidal flow) past the same 600 foot long vessel results in a time of exchange of 3 minutes.

4.2.1 Sacrificial Anodes

The in-port (static) and transient (dynamic) zinc corrosion/dissolution rates of 7.4×10^{-6} and 3.0×10^{-5} pounds of zinc per pound of anode per hour, respectively, (see Calculation Sheet 1) were used for the tidal prism model. Only the static rate was used for the mixing zone model since the highest potential concentrations would occur while the vessel is pierside.

Tidal prism. Based on the number and types of ships located in each of the three harbors[18] and the type of cathodic protection, the numbers of sacrificial anodes installed on each of the vessels in each ship class were estimated, based on the information in Section 3.2.1. The number and types of vessels using zinc sacrificial anodes at each port are listed in Table 6a. Using the annual zinc loadings and annual tidal excursion volumes, the average zinc concentrations caused by these vessels were calculated for each port (also shown in Table 6a). The average zinc concentration estimated by the tidal prism model and the ambient zinc concentrations[19] are summarized below.

Port	Ambient	Zinc from Anodes
• San Diego, CA:	11.3 µg/L	0.09 µg/L
• Mayport, FL:	5.0 µg/L	1.35 µg/L
• Pearl Harbor, HI:	12.8 µg/L	0.31 µg/L

As shown above, the contribution of zinc from sacrificial anodes makes up only a small portion of the ambient concentration, except for Mayport, where almost 30 percent of the ambient concentration can be attributed to the dissolution of zinc anodes. In each case, the ambient concentrations are well below the Federal and most stringent state water quality criteria (between 76 and 85 µg/L) as shown in Table 8. Resultant incremental concentration increases of minor constituents (aluminum and cadmium) are shown in Table 6a and are at least 40,000 times lower than the most stringent Federal or state WQC.

A similar tidal prism analysis can be performed for aluminum anode usage on submarines. Assuming that Pearl Harbor and San Diego each have the maximum five submarines with aluminum anodes, Table 6b shows the concentrations resulting from aluminum sacrificial anodes to be 0.02 µg/L of aluminum and 2×10^{-7} µg/L of mercury for Pearl Harbor, and much less for San Diego. These concentrations are significantly less than the most stringent state WQC of 1,500 µg/L of aluminum (FL) and 0.025 µg/L of mercury (CT, FL, WA, and VA). Incremental concentration increases for other minor constituents (zinc, silicon, and indium) are also shown in Table 6b and are nearly 1,000,000 times lower than the most stringent Federal or state WQC.

Mixing zone. The mixing zone model calculated zinc concentrations within "envelopes" or mixing zones of uniform size and shape around a vessel's hull, assuming various exchange rates. For calculation purposes, the mixing zones ranged from 0.1 foot to 100 feet from the hull, and the exchange rates ranged from 0.1 hour to 1 hour. Actual exchange rates are rarely more than one hour as discussed previously. Tabulated mixing zone calculations are presented in Table 7 and do not include ambient concentrations of zinc in the water. Ambient zinc concentrations for each port were then added to the mixing zone concentrations and compared to ambient WQC.

Federal and state WQC exist for zinc (see Table 8). The Federal WQC is 81 µg/L for chronic exposure. Washington state's WQC of 76.6 µg/L for chronic exposure is the most stringent state criteria.[19] For exchange rates of one hour or less, any mixing zone of six inches or more results in zinc concentrations (including the contribution of zinc from ambient water in each port) less than the most stringent state WQC of 76.6 µg/L for chronic exposure. Ambient zinc concentrations for Mayport, FL and Pearl Harbor, HI were obtained from EPA's STORET system. The Navy had more recent data on San Diego Bay and used this data rather than the data from the STORET system.[9,19] These concentrations are assumed to include any contributions of zinc from sacrificial anodes.

The results of the mixing zone analysis developed for sacrificial zinc anodes (Table 7) can be scaled to provide similar results for aluminum anodes using the current capacity ratio (3.4) developed in Section 3.2.1 and the maximum allowable concentration of mercury (0.001%). The sample calculation below was performed for the scenario from Table 7 that would produce the highest estimated concentrations of aluminum and mercury (a time of exchange of one hour, and a mixing zone of 0.1 foot):

Zinc concentration at radius of 0.1 ft = 236 µg/L

Aluminum concentration at same radius: = (236 µg/L)/(3.4) = 69.4 µg/L

Maximum potential mercury concentration at same radius = (69.4 µg/L)/(100,000)

The estimated concentration for aluminum (69.4 µg/L) is twenty times less than the most stringent state chronic WQC of 1,500 µg/L (Fl), and there are no federal WQC for aluminum. The estimated concentration for mercury (0.0007 µg/L) is 35 times less than Federal and most stringent state chronic WQC (0.025 µg/L). Similar calculations can be performed for other minor constituents of sacrificial anodes. In all cases, the resultant concentration increase is at least 50 times less than the most stringent Federal and state WQC at a distance 0.1 feet from the hull.

4.2.2 ICCP Systems

This discharge consists of various chlorinated and brominated substances (CPOs). As discussed in Section 3.2.2, these generation rates assume that 100% of the current passed by the

ICCP system creates CPOs, while in actuality, the current also produces metal complexes, oxygen, hydrogen, and other compounds in addition to CPOs with each collateral reaction consuming a portion of the total current. Seawater conditions have a strong influence on the type and magnitude of secondary reactions at the hull and sacrificial anodes. Because seawater conditions vary with geographic location, the extent of secondary chemical reactions cannot be accurately predicted. Therefore, a conservative assumption that 100% of the current produces CPOs is used.

In order to estimate the amount of CPOs generated by ICCP systems, ships' logs for a variety of vessels were reviewed to determine the average current produced by ICCP systems in port (35 amps).[13] From this information and Faraday's Law, an hourly, pierside CPO generation rate of 46.3 g/hr was calculated (see Section 3.2.2). This rate was used for both the tidal prism and the mixing zone models.

Tidal prism. Using the same approach as described in Section 4.2.1 and CPO generation rates, annual CPO loading due to the Armed Forces vessels in each of the three ports were calculated as shown in Table 6c. The chronic criteria and concentrations estimated from the tidal prism model are summarized below:

Port	Criteria	CPO from ICCP
• San Diego, CA:	N/A*	0.17 μg/L
• Mayport, FL:	10.0 μg/L	3.43 μg/L
• Pearl Harbor, HI:	7.5 μg/L	0.75 μg/L

* San Diego discharge limits are set on a case-by-case basis

This model assumes complete mixing and does not consider any decay or secondary reactions. However, CPO is known to rapidly decay in seawater. In the first stage of CPO decay, a portion of the CPO disappears within one minute, consumed by the instantaneous oxidant demand. The rate of this first-stage reaction is related to temperature. One study, for example, found that the percentage of CPO that disappeared within one minute varied from 4% at 0 °C to [20] Other factors that influence the initial rate of decay include ammonia concentration and the nature of the oxidant demand. In the second stage of CPO decay, the CPO remaining after the first stage is reduced more slowly. Second stage decay half-lives of between 1 and 100 minutes have been observed.[20] In most cases, however, the majority of CPO will disappear within an hour of being added to seawater.[20,21]

If these decay rates were incorporated into the tidal prism model, the average CPO concentrations shown above for the three ports would be lower. For example, the average CPO concentration of 3.43 μg/L in Mayport, FL was calculated assuming zero CPO decay for the duration of a tidal excursion. Using average decay estimates (i.e., 25% first stage decay after one minute, 50% second stage decay per hour) provides a 98.8% reduction in CPO for the 12 hour duration of a tidal excursion, resulting in CPO concentrations orders of magnitude below WQC.

Mixing zone. Using the mixing zone approach described for sacrificial anodes, CPO concentrations within "envelopes" or mixing zones around a vessel's hull were calculated. For calculation purposes the mixing zones ranged from 0.1 foot to 100 feet from the hull, and the mixing rates ranged from 0.1 hour to 1 hour. As stated previously, actual exchange rates are rarely more than 1 hour, and may be as low as a few minutes.

Tabulated calculations of CPO mixing zone calculations are included in Table 7. For exchange rates of 1 hour or less, any mixing zone of 5.5 feet or more results in CPO concentrations below the most stringent state chronic WQC of 7.5 μg/L. EPA's STORET system does not contain monitoring data for chlorine; therefore, ambient conditions can not be determined.

As for the tidal prism model calculations, these figures assume no decay of CPO. Using the CPO decay rates discussed above, a 47.0% reduction in the CPO concentrations listed in Table 6b for a 1 hour mixing zone exchange rate would be expected. Applying this decay rate to the mixing zone model and assuming a time of exchange of one hour, any mixing zone with a radius of 3 feet or more results in CPO concentrations caused by ICCP systems less than the most stringent state chronic WQC of 7.5 μg/L.

4.3 Potential for Introducing Non-Indigenous Species

There is insignificant potential for transport of non-indigenous species by this discharge because no water is retained nor transported.

5.0 CONCLUSIONS

5.1 Sacrificial Anodes

Cathodic protection discharges from sacrificial anodes have a low potential for causing adverse environmental effects for the following reasons:

- the loadings from sacrificial zinc and aluminum anodes do not result in zinc or aluminum concentrations, or concentrations of minor constituents, above ambient water quality criteria in any of the harbors based on the results of the tidal prism model;

- zinc, aluminum, and mercury concentrations are below WQC within a distance of 0.5, 0.1, and 0.1 feet, respectively, during periods of slack water (little water movement in the harbor); and

- loadings of mercury are small (less than 0.001 pound per year fleetwide).

This conclusion is based on corrosion/dissolution rates estimated from the average anode replacement intervals for Navy vessels. The number of anodes per vessel class was based on actual numbers or, in lieu of such data, estimated using the vessel's wetted surface area. This approach was also applied to other Armed Forces vessels.

5.2 ICCP Systems

Cathodic protection discharges from Impressed Current Cathodic Protection (ICCP) systems have a low potential for causing adverse environmental effects for the following reasons:

- the loadings from ICCP systems do not result in CPO concentrations above ambient water quality criteria in any of the harbors based on the results of the tidal prism model; and

- CPO concentrations drop below WQC within a distance of 5.5 feet during periods of slack water without considering CPO decay (which would reduce concentrations even lower).

This conclusion is based on a review of ICCP system logs and the assumption that 100% of the current passed from the ICCP system anodes generates CPO.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 9 shows the sources of data used to develop this NOD report.

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Table 1. Listing of Vessels,
Navy, MSC, Army, and USCG using Cathodic Protection

Class	Description	Quantity of Vessels	Cathodic Protection System
	Navy Combatants		
ATC	River Raider Class Mini Armored Troop Carriers	20	Sacrificial Anodes
AT	Armored Troop Carriers	21	Sacrificial Anodes
CM	Landing Craft, Mechanized	151	Sacrificial Anodes
CU	Landing Craft, Utility	40	Sacrificial Anodes
CV 59	Forrestal Class Aircraft Carrier	1	ICCP
CVN 65	Enterprise Class Aircraft Carrier	1	ICCP
CV 63	Kitty Hawk Class Aircraft Carrier	3	ICCP
CVN 68	Nimitz Class Aircraft Carrier	7	ICCP
CG 47	Ticonderoga Class Guided Missile Cruisers	27	ICCP
CGN 38	Virginia Class Guided Missile Cruiser	1	ICCP
CGN 36	California Class Guided Missile Cruiser	2	ICCP
DDG 993	Kidd Class Guided Missile Destroyers	4	ICCP
DDG 51	Arleigh Burke Class Guided Missile Destroyers	18	ICCP
DD 963	Spruance Class Destroyers	31	ICCP
FFG 7	Oliver Hazard Perry Guided Missile Frigates	1	ICCP
FFG 7	Oliver Hazard Perry Guided Missile Frigates	42	Sacrificial Anodes
LCC 19	Blue Ridge Class Amphibious Command Ships	2	ICCP
LCM 3	Mechanized Landing Craft	2	Sacrificial Anodes
LCM 6	Mechanized Landing Craft	60	Sacrificial Anodes
LCM 8	Mechanized Landing Craft	100	Sacrificial Anodes
LCU 1610	Utility Landing Craft (LCU 1600)	40	Sacrificial Anodes
LHD 1	Wasp Class Amphibious Transport Docks	4	ICCP
LHA 1	Tarawa Class Amphibious Assault Ships	5	ICCP
LPD 4	Austin Class Amphibious Transport Docks	3	ICCP
LPD 7	Amphibious Transport Docks	3	ICCP
LPD 14	Amphibious Transport Docks	2	ICCP
LPH 2	Iwo Jima Class Assault Ships	2	Sacrificial Anodes
LSD 36	Anchorage Class Dock Landing Ships	5	Sacrificial Anodes
LSD 41	Whidbey Island Class Dock Landing Ships	8	ICCP
LSD 49	Harpers Ferry Dock Landing Ships	3	ICCP
MCM 1	Avenger Class Mine Countermeasure Vessels	14	Sacrificial Anodes
MHC 51	Osprey Class Coastal Minehunter Vessels	12	Sacrificial Anodes
PB	Mk III and Mk IV Patrol Boats	31	Sacrificial Anodes
PBR	Mk II River Patrol Boats	25	Sacrificial Anodes
PC 1	Cyclone Class Coastal Defense Ships	13	ICCP
SSBN 726	Ohio Class Ballistic Missle Submarine	17	Sacrificial Anodes
SSN 637	Sturgeon Class Attack Submarine	13	Sacrificial Anodes
SSN 688	Los Angeles Class Attack Submarine	56	Sacrificial Anodes
SSN 671	Narwhal Class Submarines	1	Sacrificial Anodes
SSN 640	Benjamin Franklin Class Submarines	2	Sacrificial Anodes
	Navy Auxiliary		
AFDB 4	Large Auxiliary Floating Dry Dock	1	ICCP
AFDB 8	Large Auxiliary Floating Dry Dock	1	ICCP
AFDL 1	Small Auxiliary Floating Dry Docks	2	ICCP
AFDM 14	Medium Auxiliary Floating Dry Dock	1	ICCP
AFDM 3	Medium Auxiliary Floating Dry Docks	4	ICCP
AGF 3	Raleigh Class Miscellaneous Flagship	1	Sacrificial Anodes

Table 1. Listing of Vessels,
Navy, MSC, Army, and USCG using Cathodic Protection

Class	Description	Quantity of Vessels	Cathodic Protection System
AGF 11	Austin Class Miscellaneous Flagship	1	Sacrificial Anodes
AGOR 21	Gyre Class Oceanographic Research Ships	1	Sacrificial Anodes
AGOR 23	T.G. Thompson Class Oceanographic Research Ships	2	Sacrificial Anodes
AO 177	Jumboised Cimarron Class Oilers	5	ICCP
AOE 6	Supply Class Fast Combat Support Ships	3	ICCP
AOE 1	Sacramento Class Fast Combat Support Ship	4	ICCP
ARD 2	Auxiliary Repair Dry Docks	1	Sacrificial Anodes
ARDM	Medium Auxiliary Repair Dry Docks	3	ICCP
ARS 50	Safeguard Class Savage Ships	4	ICCP
AS 39	Emory S Land Class Submarine Tenders	3	Sacrificial Anodes
AS 33	Simon Lake Class Submarine Tenders	1	Sacrificial Anodes
TR	Torpedo Retrievers	22	Sacrificial Anodes
YC	Open Lighters (nsp)	254	Sacrificial Anodes
YD	Floating Cranes (nsp)	63	Sacrificial Anodes
YDT	Diving Tenders	3	Sacrificial Anodes
YFN	Covered Lighters (nsp)	157	Sacrificial Anodes
YFNB	Large Covered Lighters (nsp)	11	Sacrificial Anodes
YFNX	Lighter - Special Purpose (nsp)	8	Sacrificial Anodes
YFP	Floating Power Barges (nsp)	2	Sacrificial Anodes
YFRT	Covered Lighters - Range Tender (self propelled)	2	Sacrificial Anodes
YFU	Harbor Utility Craft (YFU 83 & 91)	2	Sacrificial Anodes
YO 65	Fuel Oil Barges	3	Sacrificial Anodes
YOG 5	Gasoline Barges	2	Sacrificial Anodes
YOGN	Gasoline Barges (nsp)	12	Sacrificial Anodes
YON	Fuel Oil Barges (nsp)	48	Sacrificial Anodes
YOS	Oil Storage Barges (nsp)	14	Sacrificial Anodes
YP	Patrol Craft (YP 654 & 676)	28	Sacrificial Anodes
YR	Floating Workshops (nsp)	25	Sacrificial Anodes
YRB	Repair and Berthing Barges (nsp)	4	Sacrificial Anodes
YRBM	Repair, Berthing and Messing Barges (nsp)	39	Sacrificial Anodes
YRR	Radiological Repair Barges (nsp)	9	Sacrificial Anodes
YRST	Salvage Craft Tenders (nsp)	3	Sacrificial Anodes
YSD 11	Seaplane Wrecking Derrick (self propelled)	1	Sacrificial Anodes
YTB 752	Large Harbor Tug (self propelled)	1	Sacrificial Anodes
YTB 756	Large Harbor Tugs (self propelled)	3	Sacrificial Anodes
YTB 760	Large Harbor Tugs (self propelled)	68	Sacrificial Anodes
YTL 422	Small Harbor Tug (self propelled)	1	Sacrificial Anodes
YTT	Torpedo Trials Craft	3	Sacrificial Anodes
	Miscellaneous Boats and Craft	~5,000	Sacrificial Anodes
	Military Sealift Command (MSC)		
T-AE 26	Kilauea Class Ammunition Ships	5	ICCP
T-AE 26	Kilauea Class Ammunition Ships	3	Sacrificial Anodes
T-AFS 1	Mars Class Combat Stores Ships	6	ICCP
T-AFS 1	Mars Class Combat Stores Ships	2	Sacrificial Anodes
T-AG 194	Mission Class Navigation Research Ship	1	ICCP
T-AG 194	Mission Class Navigation Research Ship	1	Sacrificial Anodes
T-AGM 22	Compass Island Class Missle Instrumentation Ship	1	ICCP
T-AGOS 1	Stalwart Class Ocean Surviellance Ship	5	Sacrificial Anodes

Table 1. Listing of Vessels,
Navy, MSC, Army, and USCG using Cathodic Protection

Class	Description	Quantity of Vessels	Cathodic Protection System
T-AGOS 19	Victorius Class Ocean Surviellance Ship	4	Sacrificial Anodes
T-AGS 26	Silas Bent and Wilkes Classes Surveying Ships	2	Sacrificial Anodes
T-AGS 45	Waters Class Surveying Ships	1	ICCP
T-AGS 51	John McDonnel Class Surveying Ships	2	ICCP
T-AGS 60	Pathfinder Class Surveying Ships	4	ICCP
T-AH 19	Mercy Class Hospital Ships	2	ICCP
T-AKR 295	Maesrk Class Fast Sealift Ships	2	ICCP
T-AKR 295	Maesrk Class Fast Sealift Ships	1	Sacrificial Anodes
T-AKR 287	Algol Class Vehicle Cargo Ships	6	ICCP
T-AKR 287	Algol Class Vehicle Cargo Ships	2	Sacrificial Anodes
T-AO 187	Henry J Kaiser Class Oilers	13	ICCP
T-ARC 7	Zeus Class Cable Repairing Ship	1	ICCP
T-ATF 166	Powhatan Class Fleet Ocean Tugs	5	ICCP
T-ATF 166	Powhatan Class Fleet Ocean Tugs	2	Sacrificial Anodes
	U.S. Coast Guard		
WHEC 378	Hamilton and Hero Class High Endurance Cutters	12	Sacrificial Anodes
WMEC 230	Storis Class Medium Endurance Cutters	1	Sacrificial Anodes
WMEC 213	Diver Class Medium Endurance Cutters	1	Sacrificial Anodes
WMEC 270 A	Famous Class Medium Endurance Cutters	4	Sacrificial Anodes
WMEC 270 B	Famous Class Medium Endurance Cutters	9	Sacrificial Anodes
WMEC 210 A	Reliance Class Medium Endurance Cutters	5	Sacrificial Anodes
WMEC 210 B	Reliance Class Medium Endurance Cutters	11	Sacrificial Anodes
WAGB 290	Mackinaw Class Icebreakers	1	Sacrificial Anodes
WAGB 399	Polar Class Icebreakers	2	ICCP
WTGB 140	Bay Class Icebreaking Tugs	9	Sacrificial Anodes
WPB 110 A	Island Class Patrol Craft	16	ICCP
WPB 110 B	Island Class Patrol Craft	21	ICCP
WPB 110 C	Island Class Patrol Craft	12	ICCP
WPB 82 C	Point Class Patrol Craft	28	Sacrificial Anodes
WPB 82 D	Point Class Patrol Craft	8	Sacrificial Anodes
WLB 225	Juniper Class Seagoing Buoy Tenders	2	Sacrificial Anodes
WLB 180 A	Balsam Class Seagoing Buoy Tenders	8	Sacrificial Anodes
WLB 180 B	Balsam Class Seagoing Buoy Tenders	2	Sacrificial Anodes
WLB 180 C	Balsam Class Seagoing Buoy Tenders	13	Sacrificial Anodes
WLM 551	Keeper Class Coastal Buoy Tenders	2	Sacrificial Anodes
WLM 157	White Sumac Class Coastal Buoy Tenders	9	Sacrificial Anodes
WLR 115	River Buoy Tenders	1	Sacrificial Anodes
WLR 65	River Buoy Tenders	6	Sacrificial Anodes
WLR75	River Buoy Tenders	13	Sacrificial Anodes
WIX	Eagle Class Sail Training Cutter	1	Sacrificial Anodes
WLIC 160	Pamlico Class Inland Construction Tenders	4	Sacrificial Anodes
WLIC 100	Cosmos Class Inland Construction Tenders	3	Sacrificial Anodes
WLIC 115	Inland Construction Tender	1	Sacrificial Anodes
WLIC 75 A	Anvil Class Inland Construction Tenders	2	Sacrificial Anodes
WLIC 75 B	Inland Construction Tenders	3	Sacrificial Anodes
WLIC 75 D	Clamp Class Inland Construction Tenders	2	Sacrificial Anodes
WLI 100 A	Inland Buoy Tender	1	Sacrificial Anodes
WLI 100 C	Inland Buoy Tender	1	Sacrificial Anodes

Table 1. Listing of Vessels,
Navy, MSC, Army, and USCG using Cathodic Protection

Class	Description	Quantity of Vessels	Cathodic Protection System
WLI 65303	Inland Buoy Tender	2	Sacrificial Anodes
WLI 65400	Inland Buoy Tender	2	Sacrificial Anodes
WYTL 65 A	65 ft. Class Harbor Tugs	3	Sacrificial Anodes
WYTL 65 B	65 ft. Class Harbor Tugs	3	Sacrificial Anodes
WYTL 65C	65 ft. Class Harbor Tugs	3	Sacrificial Anodes
WYTL 65 D	65 ft. Class Harbor Tugs	2	Sacrificial Anodes
	Army		
BCDK	Coversion Kit, Barge, Deck Cargo, Deck Enclosure	3	Sacrificial Anodes
BD	Barges, Derrick	12	Sacrificial Anodes
BK	Barges, Deck Cargo (nsp)	2	Sacrificial Anodes
BPL	Pier, Barge Type, Self-Evaluating (nsp)	1	Sacrificial Anodes
FMS	Floating Machine Shops	3	Sacrificial Anodes
J-Boat	Picket Boats	6	Sacrificial Anodes
LARC-LX	Lighter Amphibious Resupply Cargo (formerly BARC)	23	Sacrificial Anodes
LCM-8	Landing Craft Mechanized	104	Sacrificial Anodes
LCU	Landing Craft Utility	48	Sacrificial Anodes
LSV	Frank S. Besson Class Logistic Support Vessels	6	Sacrificial Anodes
LT	Inland and Coastal Tugs	19	Sacrificial Anodes
LT	Inland and Coastal Tugs	6	ICCP
Q-Boat	Picket Boat	1	Sacrificial Anodes
ST	Small Tugs	13	Sacrificial Anodes
T-Boat	Boat, Passenger and Cargo	1	Sacrificial Anodes
	Total	**2167**	

Table 2. Vessels Estimated Annual Sacrificial Anode Cathodic Protection Discharges

Class	Description	Quantity of Vessels w/ Zincs	Wetted Surface Area per Vessel (sq ft)	Wetted Surface Area of Class (sq ft)	Total Amount of Anodes by Class (lbs)		Days in Port per Vessel		Number of Transits per Vessel (e)	Days Operating within 12 n.m.	Zinc Discharged within 12 n.m. (lbs)
	Navy Combatants										
ATC	River Raider Class Mini Armored Troop Carriers	20	362	7,244	417	a	305	b	0	60	32
AT	Armored Troop Carriers	21	362	7,606	437	a	305	b	0	60	33
CM	Landing Craft, Mechanized	151	4,275	645,525	129,105	a	305	b	0	60	9,798
CU	Landing Craft, Utility	40	3,860	154,400	30,880	a	305	b	0	60	2,344
FFG 7	Oliver Hazard Perry Guided Missile Frigates	42	19,850	833,700	166,152	c	167		13	0	5,477
LCM 3	Mechanized Landing Craft	2	990	1,980	114	a	305		0	60	9
LCM 6	Mechanized Landing Craft	60	990	59,400	3,416	a	305		0	60	259
LCM 8	Mechanized Landing Craft	100	1,603	160,300	9,217	a	305		0	60	700
LCU 1610	Utility Landing Craft (LCU 1600)	40	3,915	156,600	31,320	d	200		6	0	1,165
LPH 2	Iwo Jima Class Assault Ships	2	49,945	99,890	19,964	c	186		11	0	716
LSD 36	Anchorage Class Dock Landing Ships	5	45,405	227,025	51,060	c	215		13	0	2,121
MCM 1	Avenger Class Mine Countermeasure Vessels	14	8,410	117,740	9,982	c	232		28	0	481
MHC 51	Osprey Class Coastal Minehunter Vessels	12	6,418	77,016	9,936	c	232		28	0	479
PB	Mk III and Mk IV Patrol Boats	31	897	27,796	1,598	a	305	b	0	60	121
PBR	Mk II River Patrol Boats	25	261	6,531	376	a	305	b	0	60	29
	Navy Auxiliary										
AGF 3	Raleigh Class Miscellaneous Flagship	1	41,595	41,595	8,326	c	183		12	0	296
AGF 11	Austin Class Miscellaneous Flagship	1	51,830	51,830	8,326	c	183		12	0	296
AGOR 21	Gyre Class Research Ships	1	8,834	8,834	1,767	a	113		11	0	40
AGOR 23	Thom. G. Thompson Class Research Ships	2	13,960	27,920	5,584	a	113		11	0	127
ARD 2	Auxiliary Repair Dry Docks	1	46,994	46,994	5,405	c	305	b	60	0	372
AS 39	Emory S Land Class Submarine Tenders	3	59,630	178,890	41,400	c	293		6	0	2,228
AS 33	Simon Lake Class Submarine Tenders	1	59,630	59,630	13,800	c	229		6	0	585
TR	Torpedo Retrievers	22	1,125	24,750	1,423	a	305	b	0	60	108
YC	Open Lighters (nsp)	254	6,475	1,644,650	94,567	d	305	b	0	60	7,177
YD	Floating Cranes (nsp)	63	12,875	811,125	162,225	d	305	b	0	60	12,312
YDT	Diving Tenders	3	8,885	26,655	5,331	d	305	b	0	60	405
YFN	Covered Lighters (nsp)	157	6,680	1,048,760	209,752	d	305	b	0	60	15,919
YFNB	Large Covered Lighters (nsp)	11	15,955	175,505	35,101	d	305	b	0	60	2,664
YFNX	Lighter - Special Purpose (nsp)	8	4,760	38,080	7,616	d	305	b	0	60	578
YFP	Floating Power Barges (nsp)	2	15,590	31,180	6,236	d	305	b	0	60	473
YFRT	Covered Lighters - Range Tender (self propelled)	2	5,490	10,980	2,196	d	305	b	0	60	167
YFU	Harbor Utility Craft (YFU 83 & 91)	2	3,915	7,830	1,566	d	305	b	0	60	119

Table 2. Vessels Estimated Annual Sacrificial Anode Cathodic Protection Discharges

Class	Description	Quantity of Vessels w/ Zincs	Wetted Surface Area per Vessel (sq ft)	Wetted Surface Area of Class (sq ft)	Total Amount of Anodes by Class (lbs)		Days in Port per Vessel		Number of Transits per Vessel (e)	Days Operating within 12 n.m.	Zinc Discharged within 12 n.m. (lbs)
YO 65	Fuel Oil Barges	3	10,205	30,615	6,123	d	305	b	0	60	465
YOG 5	Gasoline Barges	2	10,205	20,410	4,082	d	305	b	0	60	310
YOGN	Gasoline Barges (nsp)	12	8,512	102,144	20,429	a	305	b	0	60	1,550
YON	Fuel Oil Barges (nsp)	48	8,512	408,576	81,715	a	305	b	0	60	6,202
YOS	Oil Storage Barges (nsp)	14	8,512	119,168	23,834	a	305	b	0	60	1,809
YP	Patrol Craft (YP 654 & 676)	28	2,074	58,070	3,339	d	305	b	0	60	253
YR	Floating Workshops (nsp)	25	7,350	183,750	36,750	d	305	b	0	60	2,789
YRB	Repair and Berthing Barges (nsp)	4	4,320	17,280	3,456	d	305	b	0	60	262
YRBM	Repair, Berthing and Messing Barges (nsp)	39	10,180	397,020	79,404	d	305	b	0	60	6,026
YRR	Radiological Repair Barges (nsp)	9	6,405	57,645	11,529	d	305	b	0	60	875
YRST	Salvage Craft Tenders (nsp)	3	10,965	32,895	6,579	d	305	b	0	60	499
YSD 11	Seaplane Wrecking Derrick (self propelled)	1	3,845	3,845	769	d	305	b	0	60	58
YTB 752	Large Harbor Tug (self propelled)	1	3,170	3,170	634	d	305	b	0	60	48
YTB 756	Large Harbor Tugs (self propelled)	3	3,265	9,795	1,959	d	305	b	0	60	149
YTB 760	Large Harbor Tugs (self propelled)	68	3,265	222,020	44,404	d	305	b	0	60	3,370
YTL 422	Small Harbor Tug (self propelled)	1	1,015	1,015	58	d	305	b	0	60	4
YTT 9	Torpedo Trials Craft	3	7,205	21,614	4,323	a	305	b	0	60	328
	Miscellaneous Boats and Craft	~5,000	Unknown		Unknown						Unknown
	Military Sealift Command										
T-AE 26	Kilauea Class Ammunition Ships	3	54,240	162,720	32,544	d	26		4	0	182
T-AFS 1	Mars Class Combat Stores Ships	2	46,930	93,860	23,000	c	148		7	0	647
T-AG 194	Mission Class Navigation Research Ship	1	59,126	59,126	11,825	a	151		10	0	348
T-AGOS 1	Stalwart Class Ocean Surviellance Ship	5	10,987	54,935	10,987	a	70		4	0	148
T-AGOS 19	Victorius Class Ocean Surviellance Ship	4	14,679	58,716	11,743	a	107		5	0	239
T-AGS 26	Silas Bent and Wilkes Surveying Ships	2	13,913	27,826	5,565	a	44		6	0	52
T-AKR 295	Maesrk Class Fast Sealift Ships	1	107,028	107,028	21,406	a	59		9	0	272
T-AKR 287	Algol Class Vehicle Cargo Ships	2	111,650	223,300	44,660	a	109		3	0	902
T-ATF 166	Powhatan Class Fleet Ocean Tugs	2	11,398	22,796	4,559	a	127		16	0	121
	U.S. Coast Guard										
WHEC 378	Hamilton and Hero Class High Endurance Cutters	12	17,339	208,068	41,614	a	151		13	0	1,253
WMEC 230	Storis Class Medium Endurance Cutters	1	9,498	9,498	1,900	a	167		11	0	62
WMEC 213	Diver Class Medium Endurance Cutters	1	8,954	8,954	1,791	a	98		9	0	35
WMEC 270 A	Famous Class Medium Endurance Cutters	4	10,976	43,904	8,781	a	137		6	0	228

Table 2. Vessels Estimated Annual Sacrificial Anode Cathodic Protection Discharges

Class	Description	Quantity of Vessels w/ Zincs	Wetted Surface Area per Vessel (sq ft)	Wetted Surface Area of Class (sq ft)	Total Amount of Anodes by Class (lbs)		Days in Port per Vessel		Number of Transits per Vessel (e)	Days Operating within 12 n.m.	Zinc Discharged within 12 n.m. (lbs)
WMEC 270 B	Famous Class Medium Endurance Cutters	9	10,976	98,784	19,757	a	164		7	0	612
WMEC 210 A	Reliance Class Medium Endurance Cutters	5	7,478	37,390	7,478	a	235		13	0	337
WMEC 210 B	Reliance Class Medium Endurance Cutters	11	7,157	78,727	15,745	a	149		9	0	453
WAGB 290	Mackinaw Class Icebreakers	1	19,167	19,167	3,833	a	215	b	4	150	356
WTGB 140	Bay Class Icebreaking Tugs	9	4,869	43,821	8,764	a	215	b	1	150	807
WPB 82 C	Point Class Patrol Craft	28	1,243	34,804	2,001	a	135	b	6	200	194
WPB 82 D	Point Class Patrol Craft	8	1,243	9,944	572	a	135	b	6	200	55
WLB 225	Juniper Class Seagoing Buoy Tenders	2	10,357	20,714	4,143	a	190		18	100	306
WLB 180 A	Balsam Class Seagoing Buoy Tenders	8	6,751	54,008	10,802	a	190		18	100	798
WLB 180 B	Balsam Class Seagoing Buoy Tenders	2	6,751	13,502	2,700	a	120		5	100	157
WLB 180 C	Balsam Class Seagoing Buoy Tenders	13	6,751	87,763	17,553	a	123		16	100	1,078
WLM 551	Keeper Class Coastal Buoy Tenders	2	6,408	12,816	2,563	a	123	b	16	200	249
WLM 157	White Sumac Class Coastal Buoy Tenders	9	4,648	41,832	8,366	a	123	b	16	200	811
WLR 115	River Buoy Tenders	1	3,415	3,415	196	a	160	b	0	205	20
WLR 65	River Buoy Tenders	6	1,583	9,498	546	a	160	b	0	205	55
WLR75	River Buoy Tenders	13	1,823	23,699	1,363	a	160	b	0	205	138
WIX	Eagle Class Sail Training Cutter	1	12,264	12,264	2,453	a	188		7	150	217
WLIC 160	Pamlico Class Inland Construction Tenders	4	5,113	20,452	4,090	a	160	b	0	205	415
WLIC 100	Cosmos Class Inland Construction Tenders	3	2,432	7,296	420	a	160	b	0	205	43
WLIC 115	Inland Construction Tender	1	2,796	2,796	161	a	160	b	0	205	16
WLIC 75 A	Anvil Class Inland Construction Tenders	2	1,735	3,470	200	a	160	b	0	205	20
WLIC 75 B	Inland Construction Tenders	3	1,735	5,205	299	a	160	b	0	205	30
WLIC 75 D	Clamp Class Inland Construction Tenders	2	1,735	3,470	200	a	160	b	0	205	20
WLI 100 A	Inland Buoy Tender WLI	1	2,432	2,432	140	a	160	b	0	205	14
WLI 100 C	Inland Buoy Tender WLI	1	2,068	2,068	119	a	160	b	0	205	12
WLI 65303	Inland Buoy Tender WLI	2	1,037	2,074	119	a	160	b	0	205	12
WLI 65400	Inland Buoy Tender WLI	2	1,142	2,284	131	a	160	b	0	205	13
WYTL 65 A	65 ft. Class Harbor Tugs	3	1,083	3,249	187	a	50	b	6	300	22
WYTL 65 B	65 ft. Class Harbor Tugs	3	1,083	3,249	187	a	50	b	6	300	22
WYTL 65 C	65 ft. Class Harbor Tugs	3	1,083	3,249	187	a	50	b	6	300	22
WYTL 65 D	65 ft. Class Harbor Tugs	2	1,083	2,166	125	a	50	b	6	300	15
	Army										
BCDK	Coversion Kit, Barge, Deck Cargo, Deck Enclosure	3	1,202	3,606	721	a	305	b	0	60	55
BD	Barges, Derrick	12	1,627	19,524	6,072	c	305	b	0	60	461

Table 2. Vessels Estimated Annual Sacrificial Anode Cathodic Protection Discharges

Class	Description	Quantity of Vessels w/ Zincs	Wetted Surface Area per Vessel (sq ft)	Wetted Surface Area of Class (sq ft)	Total Amount of Anodes by Class (lbs)		Days in Port per Vessel		Number of Transits per Vessel (e)	Days Operating within 12 n.m.	Zinc Discharged within 12 n.m. (lbs)
BK	Barges, Deck Cargo (nsp)	2	1,155	2,310	736	c	305	b	0	60	56
BPL	Pier, Barge Type, Self-Evaluating (nsp)	1	4,955	4,955	991	a	305	b	0	60	75
FMS	Floating Machine Shops	3	7,951	23,853	4,771	a	305	b	0	60	362
J-Boat	Picket Boats	6	366	2,196	126	a	305	b	0	60	10
LARC-LX	Lighter Amphibious Resupply Cargo(formerly BARC)	23	1,214	27,922	6,348	c	305	b	0	60	482
LCM-8	Landing Craft Mechanized	104	1,440	149,760	26,312	c	305	b	0	60	1,997
LCU	Landing Craft Utility	48	2,095	100,560	45,264	c	305	b	0	60	3,435
LSV	Frank S. Besson Class Logistic Support Vessels	6	17,816	106,896	17,802	c	183	b	6	60	988
LT	Inland and Coastal Tugs	19	5,875	111,625	7,866	c	305	b	0	60	597
Q-Boat	Picket Boat	1	806	806	161	a	305	b	0	60	12
ST	Small Tugs	13	1,318	17,134	2,990	c	305	b	0	60	227
T-Boat	Boat, Passenger and Cargo	1	1,335	1,335	77	a	305	b	0	60	6
	TOTALS	**1,805**		**10,825,814**	**1,859,992**						**113,201**

Notes:

(a) Denotes an estimate of amount of anodes on ship class based on a calculated wetted surface area.
(b) Denotes an estimate of days in port and number of transits.
(c) Denotes actual amount of anodes installed on ship class.
(d) Denotes an estimate of amount of anodes on ship class based on a known wetted surface area.
(e) Denotes round-trip transits

Vessels with a wetted surface area greater than 3,000 sq ft are assumed to have 23 pound of zinc anodes for each 115 sq ft of wetted surface area.
Vessels with a wetted surface area less than 3,000 sq ft are assumed to have 23 pounds of zinc anodes for each 400 sq ft of wetted surface area.

Table 3a. Chemical Composition, Zinc Anodes (Galvanic Protectors)

Cadmium (range)	Aluminum (range)	Zinc
Percent	Percent	Percent
0.025-0.07	0.1-0.5	approx. 99.3

Table 3b. Chemical Composition, Aluminum Anodes (Galvanic Protectors)

Indium (range)	Zinc (range)	Silicon (range)	Aluminum
Percent	Percent	Percent	Percent
0.014 - 0.020	4.0 - 6.5	0.08-0.20	approx. 95.2

Table 4. Submarines Estimated Annual Sacrificial Anode Cathodic Protection Discharge

Class	Description	Quantity of Submarines	Total Amount of Anodes by Class (lbs) (a)	Days in Port per Vessel	Number of Transits per Vessel (b)	Zinc Discharged within 12nm (lbs)
SSBN 726	Ohio Class Ballistic Missle Submarine	17	34,408	183	6	1,175
SSN 637	Sturgeon Class Attack Submarine	13	26,312	183	6	899
SSN 688	Los Angeles Class Attack Submarine	56	119,416	183	6	4,079
SSN 671	Narwhal Class Submarines	1	2,024	183	6	69
SSN 640	Benjamin Franklin Class Submarines	2	4,048	183	6	138
	Totals	**89**	**186,208**			**6,360**

Notes:

(a) Each submarine is assumed to have 88 anodes @ 23 pounds each to protect the prop and stern appendages only.

(b) Denotes round-trip transits

Table 5. Vessels Estimated Annual ICCP Discharges

Class	Description	Quantity of Vessels w/ICCPs	Days within 12 n.m. per Vessel		CPO Discharged within 12 n.m. (lbs)
	Navy Combatant				
CV 59	Forrestal Class Aircraft Carrier	1	143		350
CVN 65	Enterprise Class Aircraft Carrier	1	76		186
CV 63	Kitty Hawk Class Aircraft Carrier	3	137		1,007
CVN 68	Nimitz Class Aircraft Carrier	7	147		2,520
CG 47	Ticonderoga Class Guided Missile Cruisers	27	166		10,978
CGN 38	Virginia Class Guided Missile Cruiser	1	161		394
CGN 36	California Class Guided Missile Cruiser	2	143		701
DDG 993	Kidd Class Guided Missile Destroyers	4	175		1,715
DDG 51	Arleigh Burke Class Guided Missile Destroyers	18	101		4,453
DD 963	Spruance Class Destroyers	31	178		13,516
FFG 7	Oliver Hazard Perry Guided Missile Frigates	1	167		409
LCC 19	Blue Ridge Class Amphibious Command Ships	2	179		877
LHD 1	Wasp Class Amphibious Transport Docks	4	185		1,813
LHA 1	Tarawa Class Amphibious Assault Ships	5	173		2,119
LPD 4	Austin Class Amphibious Transport Docks	3	178		1,308
LPD 7	Amphibious Transport Docks	3	188		1,381
LPD 14	Amphibious Transport Docks	2	192		941
LSD 41	Whidbey Island Class Dock Landing Ships	8	170		3,331
LSD 49	Harpers Ferry Dock Landing Ships	3	215		1,580
PC 1	Cyclone Class Coastal Defense Ships	13	105		3,344
	Navy Auxiliary				
AFDB 4	Large Auxiliary Floating Dry Dock	1	365	e	894
AFDB 8	Large Auxiliary Floating Dry Dock	1	365	e	894
AFDL 1	Small Auxiliary Floating Dry Docks	2	365	e	1,788
AFDM 14	Medium Auxiliary Floating Dry Dock	1	365	e	894
AFDM 3	Medium Auxiliary Floating Dry Docks	4	365	e	3,576
AO 177	Jumboised Cimarron Class Oilers	5	188		2,302
AOE 6	Supply Class Fast Combat Support Ships	3	114		838
AOE 1	Sacramento Class Fast Combat Support Ship	4	183		1,793
ARDM	Medium Auxiliary Repair Dry Docks	3	365	e	2,682
ARS 50	Safeguard Class Savage Ships	4	208		2,038
	Military Sealift Command				
T-AE 26	Kilauea Class Ammunition Ships	5	26		318
T-AFS 1	Mars Class Combat Stores Ships	6	148		2,175
T-AG 194	Mission Class Navigation Research Ship	1	151		370
T-AGM 22	Compass Island Class Missle Instrumentation Ship	1	133		326
T-AGS 45	Waters Class Surveying Ships	1	7		17
T-AGS 51	John McDonnel Class Surveying Ships	2	96		470
T-AGS 60	Pathfinder Class Surveying Ships	4	96		941
T-AH 19	Mercy Class Hospital Ships	2	184		901
T-AKR 295	Maesrk Class Fast Sealift Ships	2	59		289
T-AKR 287	Algol Class Vehicle Cargo Ships	6	109		1,602
T-AO 187	Henry J Kaiser Class Oilers	13	78		2,484
T-ARC 7	Zeus Class Cable Repairing Ship	1	8		20
T-ATF 166	Powhatan Class Fleet Ocean Tugs	5	127		1,555
	U.S. Coast Guard				
WAGB 399	Polar Class Icebreakers	2	148		725
WPB 110 A	Island Class Patrol Craft	16	72		2,822
WPB 110 B	Island Class Patrol Craft	21	137		7,047
WPB 110 C	Island Class Patrol Craft	12	157		4,615
	U.S. ARMY				
LT	Inland and Coastal Tugs	6	60		882
	TOTALS	**267**			**98,182**

Estimates based on 100 % ICCP anode efficiency at a cuurent of 35 Amps producing 46.3 g/hr. of Chlorine.
(e) Denotes an estimate of days in port

Table 6a. Tidal Prism Model - Zinc From Sacrificial Cathodic Protection Anodes

Class	Description	Quantity of Vessels w/ Zincs	Total Amount of Anodes by Class (kg)	Days in Port per Vessel	Number of Transits per Vessel (a)	Zinc Discharged in Port (kg) (b)	Zinc Conc. in Port (µg/L)
	San Diego						
FFG	Oliver Hazard Perry Guided Missile Frigates	11	16,243	167	13	989	
SSN	Los Angeles Class Attack Submarines	9	8,261	183	6	389	
SSN	Sturgeon Class Attack Submarine	1	918	183	6	43	
LSD	Anchorage Class Dock Landing Ships	3	13,894	215	13	965	
AGF	Raleigh Class Miscellaneous Flagship	1	3,776	183	12	232	
AS	Emory S Land Class Submarine Tender	1	6,259	293	6	417	
LPH	Iwo Jima Class Assault Ship	1	4,527	186	11	269	
					Total	3,304	0.0876
	Mayport						
FFG	Oliver Hazard Perry Guided Missile Frigates	10	14,766	167	13	899	1.35
	Pearl Harbor						
FFG	Oliver Hazard Perry Guided Missile Frigates	2	2,953	167	13	180	
SSN	Los Angeles Class Attack Submarine	15	13,769	183	6	648	
SSN	Sturgeon Class Attack Submarine	4	3,672	183	6	173	
SSN	Benjamin Franklin Class Submarines	1	918	183	6	43	
					Total	1,043	0.306

(a) Denotes round-tip transits

(b) Based on a hourly zinc dissolution rates of 7.4E-6 lbs. of zinc/lb.anode (static) and 3.0E-5 lbs. of zinc/lb. anode (dynamic)

Table 6b. Tidal Prism Model - Aluminum and Mercury From Sacrificial Cathodic Protection Anodes

Class	Description	Quantity of Vessels w/ Al Anodes (a)	Total Amount of Anodes by Class (kg)	Days in Port per Vessel	Number of Transits per Vessel (b)	Aluminum/ Mercury Discharged in Port (kg) (c)	Aluminum/ Mercury Conc. in Port (ng/L)	
	San Diego							
SSN	Los Angeles Class Attack Submarines	5	4,590	183	6	170	4.50	Al
						0.0017	0.000045	Hg
	Mayport							
SSN	Los Angeles Class Attack Submarines	0				0	0	Al
						0	0	Hg
	Pearl Harbor							
SSN	Los Angeles Class Attack Submarine	5	4,590	183	6	170	49.7	Al
						0.0017	0.000497	Hg
	(a) Assuming the maximum of 5 submarines with aluminum anodes are located Pearl Harbor and/or San Diego; there are no submarines homeported in Mayport.							
	(b) Denotes round-tip transits							
	(c) Aluminum anode dissolution rates equals zinc anode dissolution dates divided by 3.4 (current capacity ratio)							

Table 6c. Tidal Prism Model - CPO From Impressed Current Cathodic Protection Systems

Class	Description	Quantity of Vessels w/ ICCP	Days in Port per Vessel	CPO Discharged in Port (kg/yr)	CPO Conc. in Port (µg/L)
	San Diego				
CG 47	Ticonderoga Class Guided Missile Cruisers	8	166	1,476	
CV 63	Kitty Hawk Class Aircraft Carrier	2	137	304	
DD 963	Spruance Class Destroyers	6	178	1,187	
DDG 51	Arleigh Burke Class Guided Missile Destroyers	5	101	561	
LHA 1	Tarawa Class Amphibious Assault Ships	2	173	384	
LHD 1	Wasp Class Amphibious Transport Docks	2	185	411	
LPD 4	Austin Class Amphibious Transport Docks	5	178	989	
LSD 41	Whidbey Island Class Dock Landing Ships	2	170	378	
LSD 49	Harpers Ferry Dock Landing Ships	1	215	239	
PC	Cyclone Class Coastal Defense Ships	4	105	467	
			Total	6,395	0.1697
	Mayport				
CG 47	Ticonderoga Class Guided Missile Cruisers	5	166	922	
CV 63	Kitty Hawk Class Aircraft Carrier	1	137	152	
DD 963	Spruance Class Destroyers	5	178	989	
DDG 51	Arleigh Burke Class Guided Missile Destroyers	2	101	224	
			Total	2,288	3.43
	Pearl Harbor				
AO 177	Jumboised Cimarron Class Oilers	2	188	418	
ARS 50	Safeguard Class Savage Ships	2	208	462	
CG 47	Ticonderoga Class Guided Missile Cruisers	3	166	553	
DD 963	Spruance Class Destroyers	4	178	791	
DDG 51	Arleigh Burke Class Guided Missile Destroyers	3	101	337	
			Total	2,561	0.751
	Based on CPO generation rate of 46.3 g/hr. @ 35 amps				

Table 7 - Mixing Zone Models

Sacrificial Anode - Zinc Concentration (ug/L)											ICCP - CPO Concentration (ug/L)									
Time of Exchange (hrs)											Time of Exchange (hrs)									
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	Distance From Hull(ft)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
24	47	71	94	118	142	165	189	213	236	**0.1**	43	86	129	172	216	259	302	345	388	431
4.7	9.3	14	19	23	28	33	37	42	47	**0.5**	8.5	17	26	34	43	51	60	68	77	85
2.3	4.6	6.9	9.2	11	14	16	18	21	23	**1**	4.2	8.5	13	17	21	25	30	34	38	42
1.1	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10	11	**2**	2.1	4.1	6.2	8.3	10	12	14	17	19	21
0.72	1.4	2.2	2.9	3.6	4.3	5.0	5.8	6.5	7.2	**3**	1.4	2.7	4.1	5.4	6.8	8.1	9.5	11	12	14
0.52	1.0	1.6	2.1	2.6	3.1	3.7	4.2	4.7	5.2	**4**	1.0	2.0	3.0	4.0	5.0	6.0	6.9	7.9	8.9	10
0.41	0.81	1.2	1.6	2.0	2.4	2.8	3.3	3.7	4.1	**5**	0.78	1.6	2.3	3.1	3.9	4.7	5.4	6.2	7.0	7.8
0.33	0.66	0.99	1.3	1.6	2.0	2.3	2.6	3.0	3.3	**6**	0.64	1.3	1.9	2.5	3.2	3.8	4.5	5.1	5.7	6.4
0.28	0.55	0.83	1.1	1.4	1.7	1.9	2.2	2.5	2.8	**7**	0.53	1.1	1.6	2.1	2.7	3.2	3.7	4.3	4.8	5.3
0.23	0.47	0.70	0.94	1.2	1.4	1.6	1.9	2.1	2.3	**8**	0.46	0.92	1.4	1.8	2.3	2.8	3.2	3.7	4.1	4.6
0.20	0.41	0.61	0.81	1.0	1.2	1.4	1.6	1.8	2.0	**9**	0.40	0.80	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
0.18	0.36	0.54	0.71	0.89	1.1	1.2	1.4	1.6	1.8	**10**	0.35	0.71	1.1	1.4	1.8	2.1	2.5	2.8	3.2	3.5
0.11	0.21	0.32	0.42	0.53	0.63	0.74	0.85	0.95	1.1	**15**	0.22	0.43	0.65	0.87	1.1	1.3	1.5	1.7	1.9	2.2
0.071	0.14	0.21	0.29	0.36	0.43	0.50	0.57	0.64	0.71	**20**	0.15	0.30	0.45	0.60	0.75	0.90	1.0	1.2	1.3	1.5
0.052	0.10	0.16	0.21	0.26	0.31	0.36	0.42	0.47	0.52	**25**	0.11	0.22	0.33	0.45	0.56	0.67	0.78	0.89	1.0	1.1
0.040	0.080	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40	**30**	0.087	0.17	0.26	0.35	0.43	0.52	0.61	0.69	0.78	0.87
0.031	0.063	0.094	0.13	0.16	0.19	0.22	0.25	0.28	0.31	**35**	0.070	0.14	0.21	0.28	0.35	0.42	0.49	0.56	0.63	0.70
0.026	0.051	0.077	0.10	0.13	0.15	0.18	0.20	0.23	0.26	**40**	0.057	0.11	0.17	0.23	0.29	0.34	0.40	0.46	0.52	0.57
0.021	0.042	0.064	0.085	0.11	0.13	0.15	0.17	0.19	0.21	**45**	0.048	0.10	0.14	0.19	0.24	0.29	0.34	0.39	0.43	0.48
0.018	0.036	0.054	0.072	0.090	0.11	0.13	0.14	0.16	0.18	**50**	0.041	0.082	0.12	0.16	0.21	0.25	0.29	0.33	0.37	0.41
0.009	0.018	0.027	0.036	0.046	0.055	0.064	0.073	0.082	0.091	**75**	0.022	0.043	0.065	0.087	0.11	0.13	0.15	0.17	0.20	0.22
0.006	0.011	0.017	0.022	0.028	0.033	0.039	0.044	0.050	0.055	**100**	0.013	0.027	0.040	0.054	0.067	0.081	0.094	0.11	0.12	0.13

Input For Calculations	
Ship Class	FFG 7
Wetted Hull Area (sqft)	19,850
Zinc Generation Rate (lb/lb-hr)	7.4E-06

Input For Calculations	
Ship Class	CG 47
Wetted Hull Area (sqft)	37,840
CPO Generation Rate (g/hr)	46.3
CPO Generation Efficiency	100%

Table 8. Comparison of Constituent Environmental Concentrations and Water Quality Criteria (μg/L)

Constituent	Tidal Prism Concentrations: San Diego; Mayport; Pearl Harbor	Federal Chronic WQC	Most Stringent State Chronic WQC
CPO	0.17; 3.43; 0.75	-	7.5 (CT, HI, MS, NJ, VA, WA)
Zinc	0.09; 1.35; 0.31	81	76.6 (WA)
Aluminum	0.000005; 0; 0.049	None	1,500 (FL)
Mercury*	0.00000004; 0; 0005	0.025	0.025 (CT, FL, GA, MS, VA, WA)
CT = Connecticut			
FL = Florida			
GA = Georgia			
HI = Hawaii			
NJ = New Jersey			
MS = Mississippi			
VA = Virginia			
WA = Washington			
Notes:			

Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

* Bioaccumulator

Table 9. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	X			X
2.2 Releases to the Environment	X		X	X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	X		X	X
3.2 Rate			X	X
3.3 Constituents	X			X
3.4 Concentrations			X	X
4.1 Mass Loadings			X	X
4.2 Environmental Concentrations	X	X	X	
4.3 Potential for Introducing Non-Indigenous Species				X

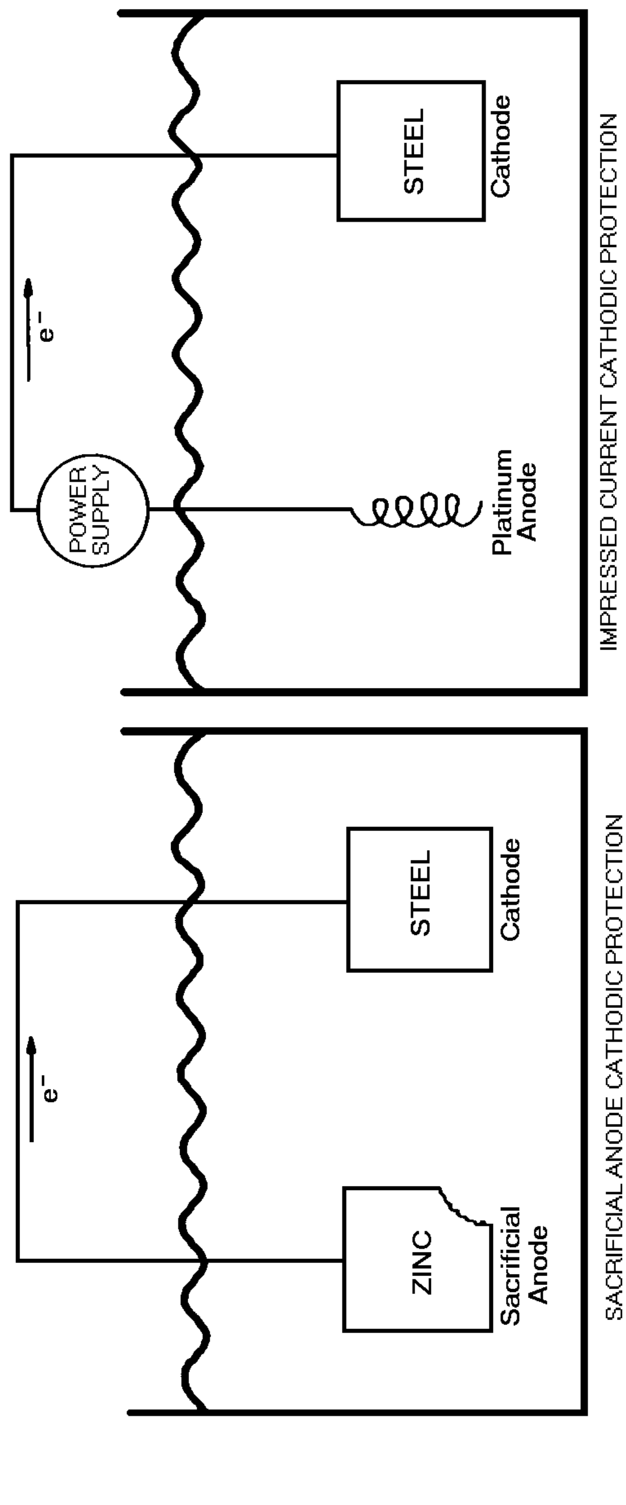


Figure 1. Sacrificial Anode and Impressed Current Cathodic Protection

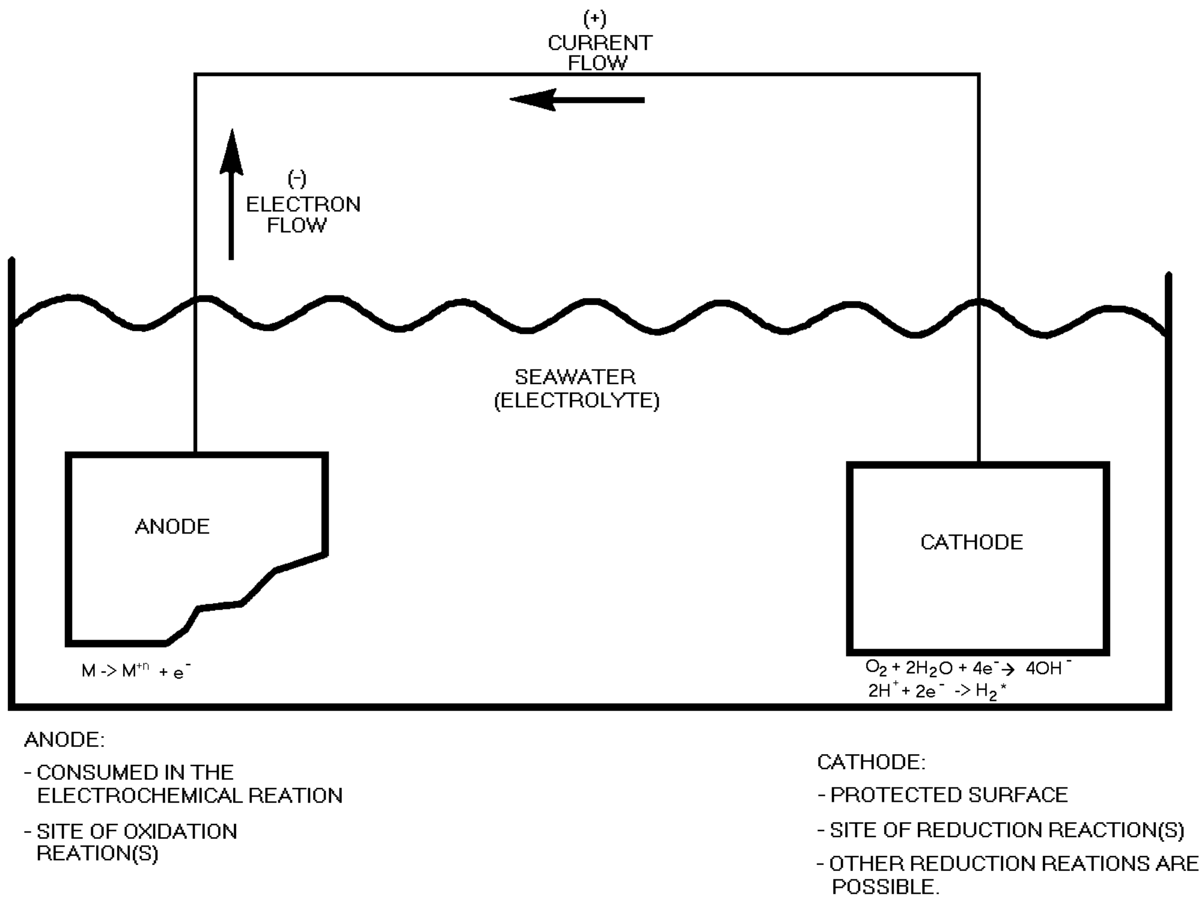


Figure 2. Electrochemical Cell

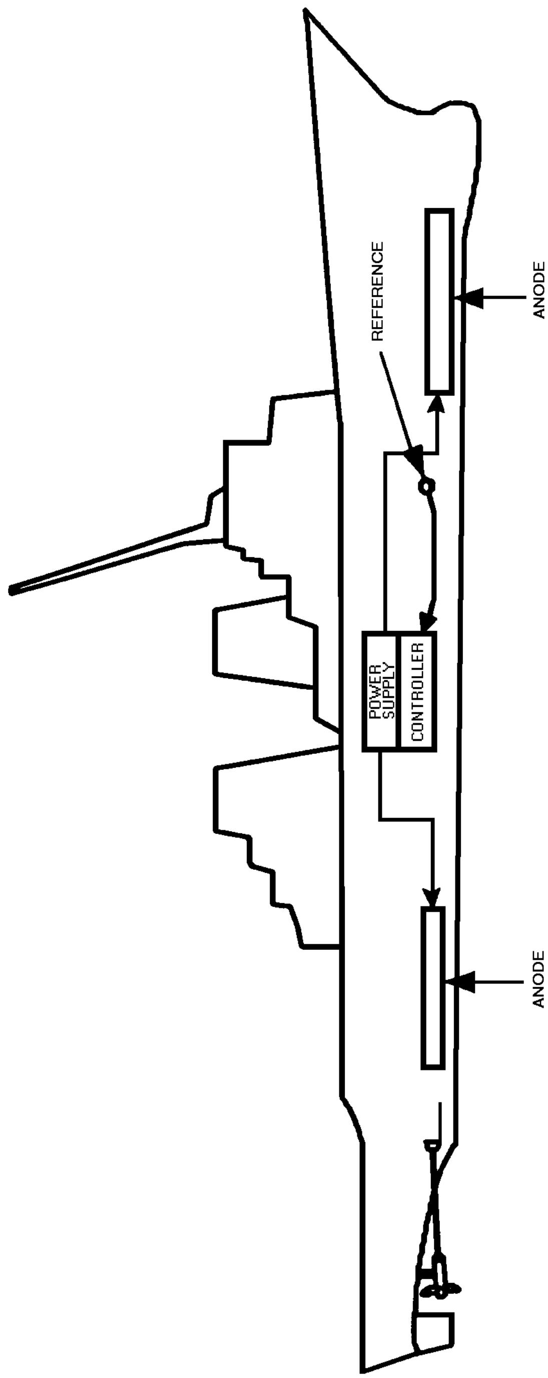


Figure 3. Impressed Current Cathodic Protection System

1. Observed Zinc Consumption Rate: (aggregate of in-port and underway)	Per 23-lb Anode	Per Pound of Anode
	50% of 23 lb/3 years	3.83 (lb zinc/yr)/ 23 lb anode
	= 3.83 lb zinc/yr	= 0.167 lb zinc/yr/lb of anode
2. Fraction of Year Vessel is:	In Port	Underway
	$\frac{176 \text{ days/yr}}{365 \text{ days/yr}}$	$\frac{189 \text{ days/yr}}{365 \text{ days/yr}}$
	= 0.48	= 0.52

3. Annual Zinc Corrosion/Dissolution Rate:
let x = in port corrosion/dissolution rate,
and 4x = underway corrosion/dissolution rate

$$0.48\ (x) + 0.52\ (4)\ (x) = 0.167 \text{ (lb zinc/yr)/lb of anode}$$
$$x = 0.065 \text{ (lb zinc/yr)/lb of anode}$$
$$4x = 0.261 \text{ (lb zinc/yr)/lb of anode}$$

note: the underway corrosion/dissolution rate is 4 times the in port rate as discussed in section 3.2.1 and reference 3 and 10.

4. Hourly zinc corrosion/dissolution rate: (per lb anode)	In-Port	Underway
	$\frac{0.065 \text{ (lb zinc/lb anode)/yr}}{8760 \text{ hr/yr}}$	$\frac{0.261 \text{ (lb zinc/lb anode)/yr}}{8760 \text{ hr/yr}}$
	$= 7.4 \times 10^{-6}$ (lb zinc/lb anode)/hr	$= 3.0 \times 10^{-5}$ (lb zinc/lb anode)/hr

5. Unit conversion:

Average density of zinc anodes (Table 2) = (1,862,000 lb) / (10,861,000 ft^2) = 0.17 lb/ft^2

In-Port: (7.4×10^{-6} (lb zinc/lb anode)/hr) (0.17 lb/ft^2) = 1.3×10^{-6} (lb zinc/ft^2)/hr

Underway (3.0×10^{-5} (lb zinc/lb anode)/hr) (0.17 lb/ft^2) = 5.1×10^{-6} (lb zinc/ft^2)/hr

Calculation Sheet 1. Calculation of Corrosion/Dissolution Rates from Sacrificial Anodes

Vertical tidal excursions for 1996 is based on the summation of the daily outgoing tides (i.e., high-high water to low-low water and high water to low water).

San Diego

- Surface Area = (10,532 acres) (4046.2 m^2/acre) = 4.26 x 10^7 m^2
- Total annual vertical tidal excursion for 1996 = 884.5 m
  Average tidal excursion = (884.5 m/yr)/((365 days/yr)(2 tides/day) = 1.2 m
- Tidal prism volume for 1996 = (4.26 x 10^7 m^2) (884.5 m) = 3.77 x 10^{10} m^3
  = 3.77 x 10^{13} L

Mayport

- Surface Area = (169.8 acres) (4046.2 m^2 /acre) = 6.87 x 10^5 m^2
- Total annual vertical tidal excursion for 1996 = 970.3 m
  Average tidal excursion = (970.3 m/yr)/((365 days/yr)(2 tides/day) = 1.3 m
- Tidal prism volume for 1996 = (6.87 x 10^5 m^2) (970.3 m) = 6.67 x 10^8 m^3
  = 6.67 x 10^{11} L

Pearl Harbor

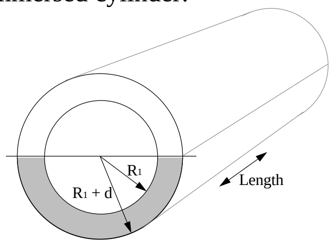
- Surface Area = (3,031 acres) (4046.2 m^2 /acre) =1.23 x 10^7 m^2
- Total annual vertical tidal excursion for 1996 = 278.2 m
  Average tidal excursion = (278.2 m/yr)/((365 days/yr)(2 tides/day) = 0.38 m
- Tidal prism volume for 1996 = (1.23 x 10^7 m^2) (278.2 m) = 3.41 x 10^9 m^3
  = 3.41 x 10^{12} L

Calculation Sheet 2. Calculation of Tidal Prism Volumes for San Diego, CA; Mayport, FL; and Pearl Harbor, HI

1. Concentration = (Mass of Zinc) / (Volume)

---

2. Volume modeled as a half-immersed cylinder:



Ship Class: FFG 7

Length = 415 ft

Underwater Wetted Area = 19,850 ft^2 = ½(2)(π)(R_1)(length)

==> R_1 = 15.225 ft$^{(1)}$

Volume$_{(model)}$ = V_2 - V_1

V_1 = ½π(R_1)^2(length) = 151,110 ft^3

V_2 = ½π(R_1 + d)^2(length)

d = variable (1 ft for this sample calculation)

Volume = V_2 - V_1 = [½π(15.225 ft + 1 ft)^2(415 ft)] - (151,110 ft^3)

= 20,500 ft^3

---

3. Mass of zinc:

Mass = (generation rate)(mass of anode installed)(time between water exchanges)

Generation rate = 7.4 x 10^{-6} (lb zinc/lb anode-hr)

Mass of installed anodes = (172 anodes)(23 lb/anode) = 3,956 lb

Time between water exchanges = variable (1 hr for this sample calculation)

Mass of zinc generated = (7.4 x 10^{-6} (lb zinc/lb anode-hr))(3,956 lb)(1 hr)

= 0.029 lb zinc

---

4. Concentration:

Concentration = (Mass of Zinc)/(Volume)*(required conversion factors)*

= (0.029 lb zinc)*(454 g/lb)(10^6mg/g)*/[(20,500 ft^3)*(28.32 L/ft^3)*]

= 22.7 µg/L ≅ 23 µg/L

---

notes:

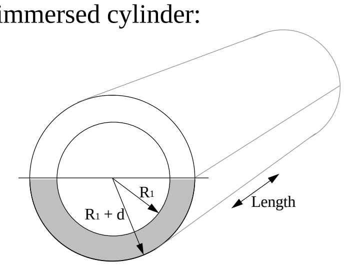
(1) Additional significant figures recommended in this step due to subsequent squaring operation.

Calculation Sheet 3. Zinc Concentration (Mixing Zone Model) Sample Calculations

1. Concentration = (Mass of CPO) / (Volume)

---

2. Volume modeled as a half-immersed cylinder:



Ship Class: CG 47
Length = 533 ft
Underwater Wetted Area = 37,840 ft^2 = $\frac{1}{2}(2)(\pi)(R_1)$(length)
==> R_1 = 22.598 ft[(1)]
$Volume_{(model)} = V_2 - V_1$
$V_1 = \frac{1}{2}\pi(R_1)^2$(length) = 427,558 ft^3
$V_2 = \frac{1}{2}\pi(R_1 + d)^2$(length)
d = variable (1 ft for this sample calculation)

Volume = $V_2 - V_1$ = [$\frac{1}{2}\pi$(22.598 ft + 1 ft)^2(533 ft)] - (427,558 ft^3)
= 38,677 ft^3

---

3. Mass of CPO:
Mass = (generation rate)(efficiency)(time between water exchanges)
Generation rate = 46.g/hr
Efficiency = 100%
Time between water exchanges = variable (1 hr for this sample calculation)

Mass of CPO generated = (46.3 g/hr)(100%)(1 hr)
= 46.3 g

---

4. Concentration:
Concentration = (Mass of CPO)/(Volume)*(required conversion factors)*
= (46.3 g CPO)$(10^6 mg/g)$/[(38,677 ft^3)$(28.32\ L/ft^3)$]
= 42.3 μg/L ≅ 42 μg/L

---

notes:
(1) Additional significant figures recommended in this step due to subsequent squaring operation.

Calculation Sheet 4. CPO Concentration (Mixing Zone Model) Sample Calculations

NATURE OF DISCHARGE REPORT

Chain Locker Effluent

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the chain locker effluent and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Surface vessels of the Armed Forces have one to three anchors, depending on vessel class.[1] Each surface vessel's anchor is attached to at least 810 feet (135 fathoms) of steel chain that is stored below decks in the chain locker when not in use. The chain is constructed in 90-foot (15-fathom) lengths, called "shots," which are connected together by detachable links. A diagram of a typical detachable link is provided in Figure 1. The inside of each detachable link is greased to prevent binding and corrosion, and to permit easy disassembly of the detachable parts. The chain locker is an enclosed compartment used only to store the anchor chain.[2] The bottom of the locker has a grating on which the chain is stowed. Below the grating is a sump. The chain locker sump contains multiple zinc sacrificial anodes to prevent corrosion. The anodes are physically connected (e.g. by bolts or welding) to the steel surface of the chain locker sump. The zinc anode is preferentially corroded or "sacrificed" instead of the chain locker sump's steel surface.

The chain moves through the chain pipe and the hawse pipe as the anchor is raised or lowered. The chain pipe connects the chain locker to the deck and the hawse pipe runs from the deck through the hull of the ship. When recovering the anchor, the anchor and chain are washed off with a fire hose to remove mud, marine organisms, and other debris picked up during anchoring. Seawater from the fire hose is directed either through the hawse pipe or directly over the side onto the chain while recovering the anchor.

The top of the chain pipe has a canvas sleeve to keep water from entering the chain locker through the chain pipe. Under rare circumstances, like heavy weather, rain or green water (seawater that comes over the bow during heavy weather) gets under the chain pipe canvas cover and into the chain locker. A diagram of a typical chain locker is provided in Figure 2.

Any fluid that accumulates in the chain locker sump is removed by either a drainage eductor for discharge directly overboard or by draining the chain locker effluent into the bilge. As the fluid in the chain locker sump is being drained for overboard discharge, the locker is sprayed with firemain water to flush out sediment, mud, or silt. An eductor is a pumping device that uses a high velocity jet of seawater from the firemain system to create a suction to remove the accumulated liquids and solids. The seawater supply from the firemain system is referred to as motive water for the eductor. OPNAVINST 5090.1B, Section 19-10 requires chain lockers of Navy vessels to be washed down outside of 12 n.m. to prevent the transfer of non-indigenous species and to flush out any sediment, mud, or silt.[2] Chain locker effluent which is drained into the bilge becomes bilgewater and is covered by the Surface Vessel Bilgewater/OWS Discharge NOD report.

2.2 Releases to the Environment

Chain locker effluent has the potential to contain living plants and animals, including microorganisms and pathogens, that are native to the location where the water was brought aboard during anchor retrieval. Chain locker effluent can also contain paint, rust, grease, and zinc. The chain locker and eductor operations are performed using water from the firemain. Therefore, the chain locker effluent can contain any constituents present in firemain water (see Firemain NOD report).

2.3 Vessels Producing the Discharge

Chain locker discharges occur in surface ships equipped with a wet firemain, including vessels belonging to the Navy, U.S. Coast Guard, Military Sealift Command, Army, and Air Force.[3] Submarine chain lockers are always submerged, open to the sea, and do not collect effluent to produce this discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

The Navy has an instruction for chain locker effluent discharge.[2] This instruction states that following anchor retrieval, chain lockers shall be washed down outside 12 miles from land to flush out any sediment, mud, and silt. This guideline also helps prevent the transfer of unwanted pathogens and marine organisms present in chain locker effluent.

3.2 Discharge Rate

Rated capacities of the eductors used to pump out chain locker sumps range between 50 and 150 gallons per minute. The chain locker effluent is mixed directly with the motive water from the firemain system before going overboard. The eductor uses 1/2 to 1 gallon of motive water for every gallon of effluent. Therefore, the total discharge ranges between 75 and 300 gallons per minute, of which 25 to 150 gallons per minute is motive water. The amount of effluent discharged yearly cannot be measured because the discharge is infrequent and little effluent is discharged.

3.3 Constituents

The small amount of water that is washed into the chain locker drains through the bottom grating and into the sump where it contacts paint chips, rust, grease, and sacrificial zinc anodes. This water has the potential to contain marine organisms.

The chain locker is painted using epoxy polyamide, epoxy, and zinc primer.[1,4,5,6]

The detachable links and other anchor chain components are periodically lubricated with Termalene #2, a water-resistant grease (Commercial Item Description (CID) A-A-50433). Termalene #2 is a compound that includes mineral oil, an aluminum complex, a calcium-based rust inhibitor, an antioxidant, and dye.[7] The grease was tested for resistance to washout.[8,9] This test measures the water washout characteristics of lubricating greases under elevated temperatures and mechanical operating conditions. Termalene #2 experienced “nil” washout when tested.[9] Because the grease is not exposed outside the link and due to the wash-resistant nature of the grease, it is unlikely grease would be released to the environment.

The zinc anodes in the chain locker can be in contact with seawater for extended periods of time. Zinc can leach continuously into the chain locker sump. The water that collects in the chain locker is a combination of seawater and water from the firemain. Also, firemain water is used as motive water when chain locker effluent is discharged. Therefore, the water could contain the constituents present in the firemain water. A more complete discussion of these constituents is found in the Firemain Systems NOD report.

The chain locker effluent might contain the priority pollutants bis(2-ethylhexyl) phthalate, copper, iron, nickel, and zinc. This effluent does not contain any bioaccumulators.

3.4 Concentrations

The concentrations of constituents present in the chain locker cannot be easily measured. Chain lockers are kept dry on most vessels to reduce maintenance. Zinc anodes are present in the bottom of the chain locker. Because the chain locker is often dry, it is unlikely that these anodes significantly affect the concentration of zinc in the effluent. The average measured concentrations of firemain water constituents that exceed the Federal and/or most stringent water quality criteria are presented in Table 1.[10] Firemain is used as the motive water for drainage eductors.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. Mass loadings are discussed in Section 4.1 and the concentrations of discharge constituents after release to the environment are discussed in Section 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Mass loadings were not calculated because constituent concentrations were not estimated. Chain locker effluent is not anticipated to result in significant loads within 12 n.m. because of the infrequency of discharge and because of the management practices in place which pump this discharge overboard when the vessel is beyond 12 n.m. of shore. Chain locker effluent is discharged infrequently because only small volumes of water accumulate in the chain locker sump over time. This determination was made after inspections of chain lockers aboard several ships.[10,11]

4.2 Environmental Concentrations

Chain locker effluent is expected to contain zinc, rust, paint, grease, and any constituents from the firemain water. Because of the intermittent nature of this discharge, acute toxicities are the primary concern. There is no concentration data available for chain locker effluent. Table 1 shows the concentration of constituents of firemain water that total nitrogen, bis(2-ethylhexyl) phthalate, copper, iron, and nickel, exceed the Federal and/or the most stringent state acute water quality criteria.

4.3 Potential for Introduction of Non-Indigenous Species

Inspections of chain lockers aboard several ships revealed that only small amounts of water actually accumulate within the chain locker. Therefore, there is little potential for introducing non-indigenous species into the chain locker. The process of washing down the anchor as it is taken aboard and discharging the effluent beyond 12 n.m. further reduces the possibility of transferring species via the chain locker.[2]

5.0 CONCLUSIONS

The small volume of chain locker effluent results in small mass loadings and provides little opportunity for the transfer of non-indigenous species. The discharge volume is expected to be small even if the discharge was not controlled. Therefore, this discharge has a low potential for causing adverse environmental effects.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 2 shows the source of the data used to develop this NOD report.

<u>Specific References</u>

1. UNDS Equipment Expert Meeting Minutes - Anchor Chain Washdown and Chain Locker Effluent. July 30, 1996.

2. OPNAVINST 5090.1B, Environmental and Natural Resources Program Manual, November 1 1994.

3. UNDS Round 2 Equipment Expert Meeting Minutes. March 11, 1997.

4. Military Specification MIL-P-24441, Epoxy polyamide. July 1991.

5. Performance Specification MIL-PRF-23236, Epoxy. April 1990.

6. Naval Ships' Technical Manual (NSTM). Chapter 631, Paragraph 8.23.2.1. Preservation of Ships in Service. December 1996.

7. Bel Ray Company, Inc., Material Safety Data Sheet for Termalene #2. 1996.

8. The American Society for Testing and Materials (ASTM) test method D-1264. June 1996.

9. Bel Ray Company, Inc., Product Data Sheet for Termalene #2. 1993.

10. UNDS Phase 1 Sampling Data Report. Volumes 1-13, October 1997.

11. Navy Fleet Technical Support Center Pacific (FTSCPAC) Inspection Report Regarding Elevator Pit and Anchor Chain Locker Inspection Findings on Six Navy Ships, March 3, 1997.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Van der Leeden, et al. The Water Encyclopedia, 2nd Ed. Lewis Publishers: Chelsea, Michigan, 1990.

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

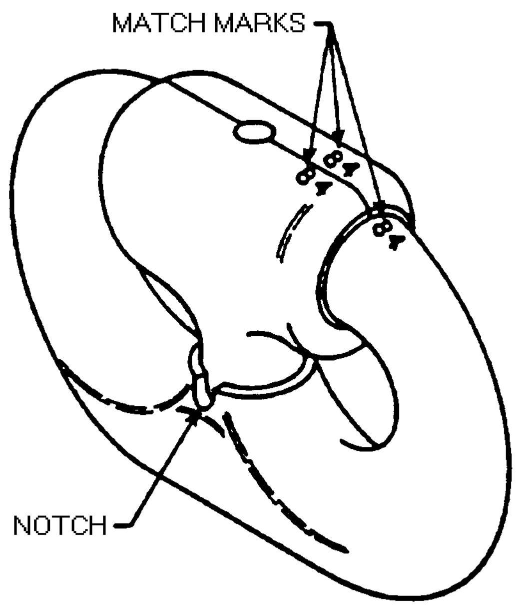

Figure 1. Schematic Diagram of a Typical Detachable Chain Link

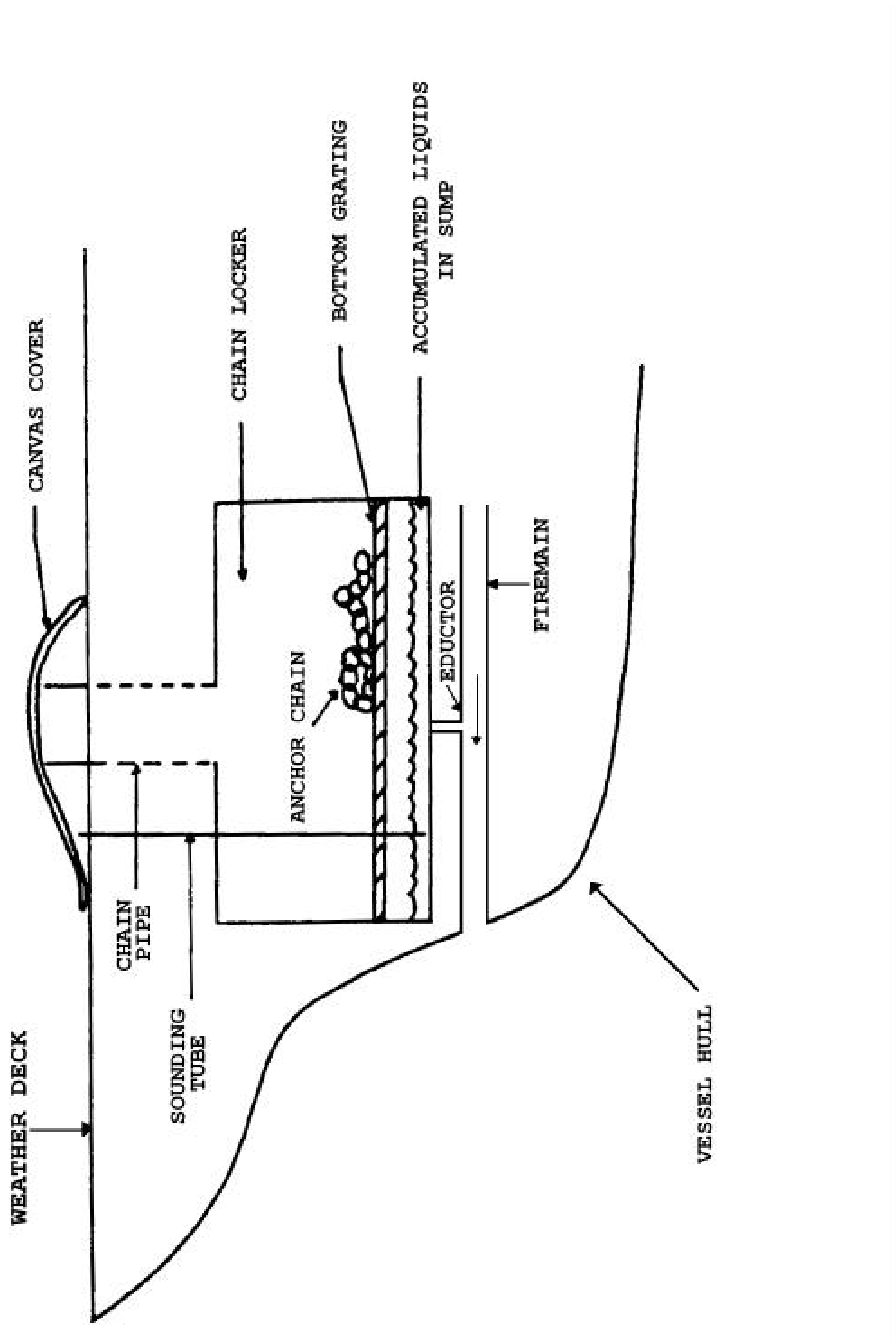

Figure 2. Schematic Diagram of a Typical Chain Locker

Table 1. Concentrations of Constituents of Wet Firemain Discharge that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (µg/L)					
Total Nitrogen	500			None	200 (HI)[A]
Organics (µg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (µg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.5 (WA)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Dissolved	13.8	BDL	38.9	74	74 (CA, CT)
Total	15.2	BDL	52.1	74.6	8.3 (FL, GA)

Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 2. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents	PMS Cards (a)			X
3.4 Concentrations			unknown	
4.1 Mass Loadings			unknown	
4.2 Environmental Concentrations			unknown	
4.3 Potential for Introducing Non-Indigenous Species				X

(a) PMS - Navy planned maintenance system

NATURE OF DISCHARGE REPORT

Clean Ballast

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the clean ballast discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Ballast water is carried by many types of vessels and is held in a variety of tanks. The relative complexity of ballast operations depends on the size, configuration, and requirements of the vessel and on the complexity of its pumping and piping systems.

Clean ballast water is seawater which is introduced into dedicated ballast tanks to adjust a vessel's draft, buoyancy, trim and list, and to improve stability under various operating conditions. For example, ballast water is used on various vessel classes to replace the weight of off-loaded cargo or expended fuel oil. Generally, seawater is directed to the ballast tanks from the firemain, by flooding, and/or from dedicated ballast pumps. Ballast intake systems are usually covered with a grate; suction strainers can be used to protect the pumping system from debris. Ballast water is discharged through valves by gravity or pressurized air, or is pumped out by eductors. Clean ballast tanks are dedicated to ballasting operations and their contents are not mixed with fuel or oil.

Amphibious assault ships also flood clean ballast compartments during landing craft operations to lower the ship's stern, allowing the well deck to be accessed. This ballast water is subsequently discharged at the end of the operation. Figure 1 depicts a typical amphibious ship ballast and deballast tank system.

U.S. Navy submarines have main and variable ballast systems. The main ballast system controls the submarine's overall buoyancy while the variable ballast system controls the submarine's trim and list, and adjusts for variations in the submarine's buoyancy while operating submerged.

2.2 Releases to the Environment

Ballast water has the potential to contain plants and animals, including microorganisms and pathogens, that are native to the location where the water was brought aboard. When the ballast water is transported and discharged into another port or coastal area, the surviving organisms have the potential to impact the local ecosystem. Ballast water also has the potential to contain metals and chemical constituents from contact with piping systems and ballast tank coatings. Releases to the environment occur when ballast water is discharged.

2.3 Vessels Producing the Discharge

Ballast water collection and discharge practices depend on vessel class and mission characteristics. Most surface vessels in the Navy have clean ballast systems, including the following vessel classes: amphibious assault ships (LHD, LHA, LPH), aircraft carriers (CV/CVN), amphibious transport docks (LPD), frigates (FFG), dock landing ships (LSD), oilers (AOE), and amphibious command ships (LCC). All U.S. Navy submarines (SSNs and SSBNs) have main and variable ballast systems.

U.S. Coast Guard (USCG) vessels that have designated seawater ballast tanks include the following classes: medium endurance cutters (WMEC), sea going buoy tenders (WLB), and ice breakers (WAGB).

Most Military Sealift Command (MSC) have clean ballast systems, including the following vessel classes: fleet-support auxiliary ships (T-AFS, T-AE, and T-AO), point-to-point supply ships (T-AKR) and other ships (T-AH, T-AGS, T-AGOS, T-AGOR, T-AG, T-AGM, and T-ATF).[1]

Army ships designed for intra-theater cargo transport (LCU-2000 and LSV) take on and discharge clean ballast when loading and unloading cargo and equipment. Vessels of the Air Force also discharge ballast water within 12 nautical miles (n.m.) of shore.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

The mode and location of ballast water discharge differs for Navy, USCG, MSC, Army, and Air Force vessels, and also varies among individual ship classes depending on the mission or design of the vessel. Discharge of ballast water is intermittent for vessels of each service. Discharges can occur in port or at sea depending upon service policies and the individual vessel's operational requirements. Ballast water is normally released at sea (outside of 12 n.m.) or in the same general vicinity from which it was taken aboard.

In order to adopt the intent of guidelines established by the International Maritime Organization (IMO), the Navy has instituted a "double-exchange" policy for surface vessels.[2] All Navy surface vessels completely offload ballast water originating in a foreign port outside of 12 n.m. from shore and take on and discharge 'clean sea water' two times prior to entry within 12 n.m. of shore. The seawater then can be discharged within 12 n.m. of shore whenever ballast is no longer needed.

All submarines submerge by filling externally mounted main ballast tanks (MBTs) and surface by emptying them. Discharges from MBTs happen mainly during surfacing when seawater in MBTs is displaced overboard by air forced into the tanks. The majority of submarines submerge and surface outside of 12 n.m. of shore, however, submarines on occasion do surface and submerge within 12 n.m. of shore at selected ports where ocean depth and vessel traffic permit this practice. While transiting on the surface from port, variable ballast water can be discharged to make small adjustments to the ship's trim. Once the submarine submerges, the variable ballast system is used as necessary to maintain trim and stability. In port, both main and variable ballast can occasionally be taken on or discharged to support maintenance activities or to compensate for weight changes. Any ballast water taken on by the MBTs in port is discharged prior to leaving port. While visiting foreign ports, submarines avoid taking water into the variable ballast system. If additional variable ballast water is required, submarines take on freshwater to prevent fouling of systems and equipment.

Amphibious ships take on ballast water in coastal waters (within 12 n.m.) during landing craft operations and discharge it at the conclusion of those operations in the same general location.

USCG vessels do not discharge ballast water collected near one coastal area into another coastal area. Coast Guard vessels are required to exchange their ballast water twice beyond 12 n.m. of shore, if the water originated from within 12 n.m.[3, 4]

MSC vessels may discharge clean ballast both at sea and in port. The location of the discharge varies by vessel category. Fleet-support auxiliary ships typically load ballast at sea when discharging cargo and unload ballast near shore when taking on cargo. Point-to-point supply ships typically ballast to replace the weight of consumed fuel, not to compensate for off loaded cargo, and deballast occurs after a voyage, usually in port. The remaining ships of the MSC fleet typically ballast to bring the ship to an appropriate draft and trim for mission requirements. Some of these ships may hold ballast for long periods and others may use freshwater ballast only.[1] Although an official MSC policy has not yet been approved, many MSC vessels currently abide by IMO guidelines, which recommend exchanging ballast water in waters 2,000 meters or more in depth before entering coastal zones.[5]

Navy, USCG, and IMO policies for surface vessels are summarized in Table 1.

3.2 Rate

The volume of seawater discharged during deballasting operations varies by vessel class and activity. Typical ballasting operations on surface ships only use a portion of the total ballast capacity. For example, the average maximum ballast carried by a T-AO 187 Class ship has been reported to be around 50% of capacity, although the actual quantity of ballast varies significantly depending on the quantity of cargo carried.[1]

Total capacity of individual ballast systems varies significantly by vessel class. The LSD 41 Class and T-AO 187 Class ships have ballast tanks with a capacity of three million gallons. T-AKR 287 Class ships have a total ballast capacity of approximately 1.2 million gallons, while the MSC oceanographic research ship, USNS Vanguard (T-AG 194), carries approximately 1.7 million gallons of freshwater ballast that is only emptied in dry dock during tank inspections.[1,6]

Other ship capacities for Navy and USCG vessels are as shown in Table 2.

Deballasting flow rates also vary significantly by vessel class. Deballasting methods include gravity fed systems, eductor systems, or compressed air pumps with associated drain valves. Typical air compressors that pressurize and empty ballast tanks on board amphibious ships are rated for 2,000 standard cubic feet per minute (scfm) air flow which is sufficient to displace an equivalent of 14,960 gallons per minute (gpm) of ballast water. Main ballast tanks on submarines are typically evacuated within 30 minutes using pressurized air.[7]

3.3 Constituents

Constituents of clean ballast may include material from piping and piping components, coatings, and additives.

Rust inhibitors containing aliphatic petroleum distillates are commonly applied to some MSC ballast tanks. Additional constituents may include flocculant chemicals, composed of 95% water and 5% salts and polymers.[8] Flocculant chemicals are introduced in ballast tanks of some MSC vessels to facilitate the discharge of suspended silts during deballasting operations. Sediments frequently accumulate on the bottom and on many horizontal surfaces of ballast tanks and may be discharged during deballasting operations. Lead-block ballast are also present in the ballast tanks on some MSC vessels.

Metals and chemical constituents can be introduced to ballast water through contact with piping systems and ballast tank coatings. Constituent loadings are expected to increase with increased residence time of water in the clean ballast systems. The composition of piping and components that contact ballast water includes iron, copper, nickel, bronze, titanium, chromium, and composites. These composites are a linen reinforced graphite phenolic compound and reinforced epoxy matrix. Fitting and valve materials include aluminum, copper, nickel, and silver-brazed materials. Synthetic and cloth-rubber gaskets, nitrile seals, and ethylene propylene rubber O-ring seals may also be wetted parts of the ballast system.[9,10]

The interiors of tanks of Navy vessels are typically coated with epoxy coatings, and the tanks can contain zinc or aluminum anodes for cathodic protection.[11,12] Ballast tank coating specifications list the following constituents: polyamide, magnesium silicate, titanium dioxide, a solvent, naphtha, and epoxy resin. Specifications also dictate the maximum allowable concentrations of solvents in epoxy coatings.

Firemain systems are used to fill many clean ballast tanks. Although concentrations in firemain discharge cannot be directly correlated with constituent concentrations in clean ballast water, analytical data obtained from sampling of shipboard firemain systems could serve as an indicator of potential constituents introduced to clean ballast water. Based on the make up of clean ballast systems and the analytical results of firemain discharge sampling, the following priority pollutants could be present within the discharge: copper, nickel, and zinc. No bioaccumulators are known or suspected to be present in clean ballast discharge.

3.4 Concentrations

Although suspected constituents in clean ballast discharge have been identified, constituent concentrations were not estimated.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. Mass loadings are discussed in Section 4.1 and the concentrations of discharge constituents after release to the environment are discussed in Section 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Using known tank volumes and numbers of vessels in specific classes, an estimate of the total ballast capacity is presented in Table 2. Most surface vessels are required to conduct double exchanges outside of 12 n.m. of shore unless the discharge of the clean ballast is located in the same geographical region as the intake, or operational conditions prevent the double flush from being performed. Additional ballast exchanges occur within 12 n.m. Although total ballast capacity estimates have been made, mass loading of chemical constituents were not estimated due to the uncertainty in the frequency of ballasting operations and the lack of chemical constituent data.

4.2 Environmental Concentrations

Although water quality criteria are available for suspected constituents, no analyses have been completed and constituent concentrations are not available. A comparison of concentrations with water quality criteria was not made.

4.3 Potential for Introducing Non-indigenous Species

Discharged clean ballast water from vessels of the Armed Forces has potential for introducing non-indigenous species into receiving waters. This can be inferred from studies of commercial vessels.

Studies of foreign ballast water commonly introduced into the Chesapeake Bay found that more than 90% of the commercial vessels carried live organisms. Forty percent of the sampled vessels had organisms within their ballast tanks including dinoflagellates and diatoms. Such organisms are suspended in both water and sediments within ballast tanks. Organisms also may attach to tank walls and be dislodged during deballasting.[13] One study characterized a variety of non-indigenous species in 159 cargo vessels arriving in Coos Bay, Oregon, from 25 different Japanese ports. The study found 367 distinctly identifiable taxa, representing 16 animal phyla, 3 protist phyla, and 3 plant divisions. Organisms present in most vessels included copepods (99%

of vessels), polycheate worms (89%), barnacles (83%), clams and mussels (71%), flatworms (65%), crabs and shrimp (48%), and chaetognaths (47%).[13]

The preliminary conclusion of a Smithsonian Environmental Research Center (SERC) study of three Navy surface ships' ballast water during transit of the Atlantic is that the double-exchange of ballast water can be a "very effective" method of preventing the introduction of non-indigenous species. The SERC study performed a double-exchange of clean ballast water containing a known number/concentration of microbials and found that 95% to 100% of the microbials were removed.[14] The SERC study noted that a "large number" of the microbials would not have survived the transit even if the double exchange of ballast water had not been performed. Therefore, the percentage reduction of the number or type of non-indigenous species transported in the ballast water of Navy surface vessels achieved by double-exchange has not been determined.

Although the presence of non-indigenous species has been verified by previous studies of commercial vessels, exact densities of individual species introduced through deballasting operations of vessels of the Armed Forces have not been evaluated.

5.0 CONCLUSION

Clean ballast discharges have a potential to cause an adverse environmental effect because clean ballast water has the potential for transferring non-indigenous species between ports.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information, equipment specifications, and research concerning non-indigenous species was used. Table 3 shows the sources of data used to develop this NOD report.

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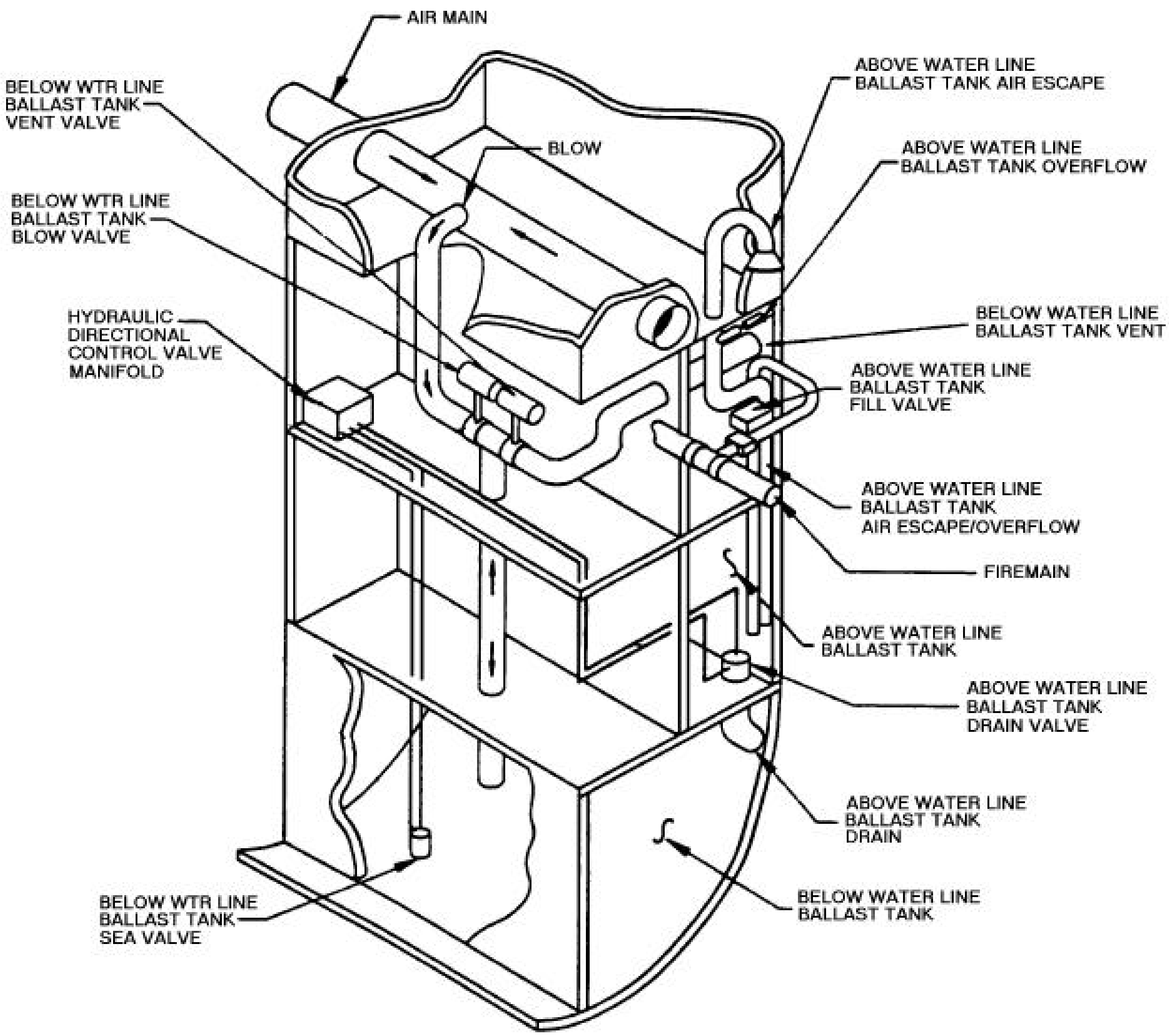

Figure 1. Typical Amphibious Ship Ballast and Deballast Tank Piping Composite

Table 1. Summary of IMO, USCG, and Navy Exchange Policies for Clean Ballast Water From Surface Vessels

NAVY[2]	USCG[3,4]	IMO[15]
Requires potentially polluted ballast water to be offloaded outside of 12 n.m. from shore and clean sea water taken on and discharged twice prior to entry within 12 n.m. from shore. Requires entering records of ballast water exchanges and their geographical location in ship's engineering log.	Requires potentially polluted ballast water to be offloaded outside of 12 n.m. from shore and clean sea water taken on and discharged twice prior to entry within 12 n.m. form shore. Requires entering records of ballast water exchanges and their geographical location in ship's engineering log.	Recommends ballast water exchange to take place in areas with a depth of 2000 meters or more to minimize the introduction of non-indigenous invasive species. Recommends record keeping of ballast water exchange, sediment removal, procedures used, and appointment of responsible officer on board ships to ensure procedures are followed and records maintained.

Table 2. Estimate of Total Ballast Capacity*

Vessel Class	Service	Ballast Capacity (Gallons)	# Vessels	Total Capacity (Gallons)
T-AO 187	MSC	3,000,000	12	36,000,000
T-AKR 287	MSC	1,200,000	8	9,600,000
T-AG 194	MSC	1,700,000	1	1,700,000
WMEC 270 A&B	USCG	42,250	13	549,250
WLB 225	USCG	92,300	2	184,600
WAGB 399	USCG	115,300	2	230,600
LHA 1	Navy	3,445,867	5	17,229,335
CVN 68	Navy	278,533	7	1,949,731
LCC 19	Navy	593,383	2	1,186,766
LPD 4	Navy	3,700,000	8	29,600,000
LSD 41	Navy	3,090,000	8	24,720,000
LHD 1	Navy	4,000,000	4	16,000,000
AOE 6	Navy	209,941	3	629,823
SSBN 726	Navy	668,904	17	11,371,368
SSN 688	Navy	229,225	56	12,836,600
LSV	Army	403,000	6	2,418,000
LCU-2000	Army	111,369	35	3,897,915
			Total:	170,103,988

Estimate is based upon the largest vessels of the Navy, USCG, MSC, and Army that use clean ballast. Ballast volumes of vessels of the Air Force are not included.

Table 3. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation	X			X
2.2 Releases to the Environment	X			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate				X
3.3 Constituents				X
3.4 Concentrations			N/A	
4.1 Mass Loadings			N/A	
4.2 Environmental Concentrations			N/A	
4.3 Potential for Introducing Non-Indigenous Species	X			X

NATURE OF DISCHARGE REPORT

Compensated Fuel Ballast

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes compensated fuel ballast discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Compensated ballast tanks are used for fuel storage and to maintain stability on some classes of Navy vessels. As fuel is consumed while underway, water is taken in by the vessel to maintain a nearly constant total fluid weight in the vessel. Compensated fuel ballast tanks are maintained full of either fuel, seawater, or a combination of both. When both fuel and seawater are present in the same tank, the fuel floats on top of the seawater because the fuel is less dense. These tanks are only completely emptied of all fluid (seawater and fuel) during in-tank maintenance or modification work that is not part of the ships' normal operation.

In vessels that use compensated fuel ballast systems, several compensated fuel ballast tanks are connected in series to form a tank group. The first tank of the group is called the "receiving tank." Fuel enters and exits the tank group via the receiving tank. The last tank of the group is called the "overflow/expansion tank." Seawater enters and exits the tank group via the overflow/expansion tank from the ship's firemain. Compensating water is introduced into the overboard discharge pipe of the overflow/expansion tank through a level control valve. This valve maintains a constant pressure within the compensated fuel tanks. The compensated ballast/fuel storage tanks are in between the receiving and the overflow/expansion tanks. All the tanks in the group are connected by sluice pipes. Each tank in the group has an upper and lower sluice pipe. The lower sluice pipe in the first tank of the group is connected to the upper sluice pipe of the next tank in the series. The upper sluice pipe in the receiving tank connects to the ship's fill and transfer fuel piping and allows fuel to enter and leave the tank group. The lower sluice pipe of the overflow/expansion tank allows seawater to enter and leave the tank group. Figure 1 shows a schematic diagram of the tank group interconnection pipes.

Each Navy surface vessel using a compensated fuel ballast system has six tank groups in adjacent tank group pairs; two tank groups forward, two tank groups midship, and two tank groups aft. Figure 2 shows the general layout of the six tank groups. For each adjacent tank group pair, there is one port tank group and one starboard tank group. Each tank group consists of three to six tanks connected in a series: a receiving tank, one to four storage tanks, and an overflow/expansion tank. The overboard discharge from each adjacent port and starboard tank group are cross-connected resulting in a port-starboard pair of overboard discharges forward, midship, and aft. Figure 3 illustrates a typical fuel oil tank layout for pair of port and starboard tank groups with cross-connected overflow piping on a surface vessel.

During a fueling operation, fuel enters the receiving tank via the inlet sluice pipe and pushes seawater through the rest of the tanks in the group via the sluice pipes. By simple displacement, an equal amount of seawater is discharged overboard from the overflow/expansion tank. Each tank in the group fills in sequence since fuel cannot get into the next tank in the series until the fuel level reaches the lower sluice pipe of the tank being filled. When the fuel level reaches the lower sluice pipe in a tank the fuel starts to flow into the next tank in the series via the sluice pipe. Operating procedures dictate that the fueling process be stopped prior to fuel entering the overflow/expansion tank.[1] The overflow/expansion tank is intended to hold only seawater, acting as a buffer between the fuel storage tanks and the overboard discharge. This tank is used to prevent the accidental discharge of fuel overboard due to overfilling of the tank group, or due to the thermal expansion of the fuel when ambient temperatures increase.

Fuel is transferred via purifiers to uncompensated fuel service tanks prior to use by ship's propulsion and electrical generating plants. Only fuel from the service tanks is used to power the ship's propulsion and electrical generating plants, fuel is not taken directly from the compensated fuel ballast tanks to the engines. Therefore, compensating water is not taken on when the ship's engines are operating in port.

Non-conventional submarines have a compensated fuel ballast system to provide fuel for the emergency diesel generator. This compensated fuel ballast system consists of a Normal Fuel Oil (NFO) tank and a seawater expansion tank. Compensating water is not discharged to the surrounding water under any normal operating condition. When fueling, the displaced seawater is removed from the NFO tank via the seawater compensating line and is transferred via a hose connection to a port collection facility for treatment and disposal.[2] While operating at sea, compensating seawater is not discharged from the NFO tank because an air charge in the expansion tank compresses to account for volumetric changes due to hull compression during changes in ship depth or as a result of tank liquid temperature changes.

Mixing of the fuel into seawater discharged from the overflow/expansion tank is believed to occur via the following mechanisms:

- Fuel and water can be mixed by turbulence in the tank during rapid introduction of fuel or water, or the rolling motion of the ship. The turbulence is caused by fluid flow around internal tank structure and by interfacial shear between the fuel and the water layers.

- Internal tank structure can cause incorrect fuel level readings and inadvertent discharge of fuel with the compensated ballast water by trapping pockets of fuel and seawater.

- Soluble fuel constituents can be dissolved in seawater.

Some of the design and operational practices used by the Navy to mitigate fuel discharges from compensating ballast systems include:

- Engineering Operating Sequencing Systems (EOSS) fuel filling procedure "Standard Refueling, Fuel Oil" (SRFO) and the Class Advisories (temporary operating instructions and notices) for destroyers and conventional cruisers recommend that fuel storage tanks be refueled to no greater than 85 percent of capacity in port.[1-4] This prevents the fuel/seawater interface from entering the overflow/expansion tank and overboard discharge pipe.

- EOSS fuel filling procedure SRFO and the Class Advisories for the same vessels direct that the in-port flow limiting valves in the supply to each tank group be closed during in-port refueling only (open while refueling at sea). The flow limiting valves restrict the fill rate to each tank group to approximately 400 gallons per minute (gpm) versus 1000 gpm while at sea. This reduces fuel/seawater mixing in the tank.[1-4]

- EOSS fuel filling procedure SRFO requires individuals to stand watch to halt refueling in the event of overboard spills, while others are required to monitor fuel levels in each tank during the refueling operation.[1]

2.2 Releases to the Environment

As discussed in Section 2.1 compensated ballast discharge occurs through the overflow/expansion tank during refueling operations. Compensated ballast discharge consists primarily of seawater containing some fuel constituents. Leaching and corrosion of fuel containment systems are expected to result in the presence of metals.

2.3 Vessels Producing the Discharge

The Navy is the only branch of the Armed Forces whose vessels utilize compensated fuel ballast systems. Compensated fuel ballast systems are used only on CG 47 Class cruisers; DD 963 Class, DDG 993 Class, and DDG 51 Class destroyers; and all non-conventional submarine classes.[2] A total of 75 U.S. based surface vessels generate this discharge. Submarine compensated fuel ballast systems do not discharge to the surrounding water whether in port or at sea. USCG, MSC, Army, Air Force, and Marine Corps vessels do not utilize compensated fuel ballast systems and do not generate this discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

In-port refueling of surface ships is the only circumstance during which compensated ballast discharge occurs within 12 nautical miles (n.m.). At-sea refueling operations take place outside of 12 n.m. based on standard operating practice.

3.2 Rate

During in-port refuelings of surface vessels, compensated ballast is discharged at a rate of up to 400 gpm per tank group (2,400 gpm maximum per ship). Based on actual refueling data obtained from Navy personnel, each ship takes on about 200,000 gallons per refueling in port and the refuelings occur on average two times per year per ship.[5]

3.3 Constituents

The Navy has conducted several studies of compensated ballast in the past. These included:

- in-port refueling test of the USS Nicholson (DD 982);[6]
- at-sea refueling testing of the USS Spruance (DD 963);[7]
- in-port and at-sea testing of the USS John Hancock (DD 981);[8] and
- in-port testing of the USS Arleigh Burke (DDG 51).[9,10]

These previous studies have typically measured the oil concentration of the discharge. On the DDG 51, in-line oil content monitors were used in conjunction with standard laboratory analyses to determine the oil concentration in the discharged ballast water. Table 1 summarizes the data for oil concentration in compensated ballast water from the previous Navy studies. The concentration of oil in water varied from below detection levels to 370 milligrams per liter (mg/L).

To further support this NOD report, a sampling effort was conducted. Five samples of compensated ballast discharge, and an additional quality assurance/quality control sample, were taken through the course of an in-port refueling operation from the discharge of a single midship tank group of the USS Arleigh Burke, (DDG 51) on January 27, 1997.[11] Based on previous Navy operational and design experience, midship tank groups on DDG 51 Class vessels are expected to contain the greatest concentration of fuel oil constituents in the ballast water. The samples were analyzed for volatile and semivolatile organics, selected classical pollutants, metals, and mercury using EPA series 1600 protocols. Table 2 presents a summary of the validated analytical data for all detected analytes from the sampling effort that occurred on January 27, 1997. The following priority pollutants were present in measurable amounts: copper, nickel, silver, thallium, zinc, benzene, phenol, and toluene;[12] the only bioaccumulator found was mercury.[13] Also, during the UNDS sampling effort, 8 additional samples were taken and analyzed for TPH by the modified 418-2 method, with results ranging from 11.9 to 108.2 mg/L.[14]

3.4 Concentrations

As mentioned in Section 3.3, Table 2 presents the validated analytical data from the UNDS sampling effort. The table includes metals, volatile organics, semivolatile organics, classicals, and mercury. The table shows the constituents, the log-normal mean, the frequency of detection for each constituent, the minimum and maximum concentrations, and the mass loadings of each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for non-detected results.

In addition to the oil concentration data collected in previous sampling as described in Table 1, two separate sets of analyses were developed from the UNDS sampling effort to support this NOD report. The samples were analyzed for Hexane Extractable Materials (HEM) and Silica Gel Treated (SGT) -HEM. The HEM values correspond to oil and grease and the SGT-HEM values correspond to total petroleum hydrocarbon (TPH) which is a subset of oil and grease. The results varied from 8 to 36.5 mg/L for HEM and from 6 to 12.5 mg/L for SGT-HEM.[11]

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on ship transit data, Navy surface ships with compensated ballast systems are at their homeport (within 12 n.m.) between 101 and 178 days per year, and at sea for the balance of the year.[15] A per-ship total annual discharge of 400,000 gallons per year was calculated based upon the following averages obtained from Navy refueling data:[5]

- 200,000 gallons median discharge per in port refueling; and
- 2 refuelings in port per year.

As mentioned in Section 2.3, 75 surface vessels are homeported in the U.S. and generate compensated ballast within 12 n.m. of the U.S.[16] The majority of these ships' in-port refuelings occur at their homeport. Flow per ship class can be roughly approximated as the product of the number of vessels in a class and 400,000 gallons discharged per ship per year as presented in Table 3. The 75 U.S. based surface vessels discharge 30.0 million gallons within the 12 n.m. zone.

Total mass loading, for in-port discharges, was estimated by multiplying the log-normal mean concentration by the total compensated ballast discharge volume of 30.0 million gallons per year. The generalized equation is shown below:

$$\text{Mass Loading (lbs/yr)} = (\text{Concentration } (\mu g/L))(\text{Volume (gal/yr)})(3.785 \text{ L/gal})(2.2 \text{ lbs/kg})(10^{-9} \text{ kg}/\mu g)$$

Based on the SGT-HEM log-normal mean concentration of 4.65 mg/L the TPH loading could be 1,160 pounds per year (lbs/yr). Based on the HEM log-normal mean concentration of 12.73 mg/L, the total estimated oil & grease loading from in-port discharges could be expected to be 3,180 lbs/yr.

Using the metal log-normal mean concentrations as listed in Table 2; the mass loadings are estimated to be 13.3 lbs/yr for copper; 47.4 lbs/yr for nickel; 2 lbs/yr for thallium; 1,063 lbs/yr for zinc; 0.77 lbs/yr for silver; and 0.00015 lbs/yr for mercury. Using the organic log-normal concentration in Table 2, the mass loading was estimated to be 10.3 lbs/yr for 2-Propenal; and 22 lbs/yr for benzene. Using the log-normal concentration in Table 2, the mass loading was estimated to be 65 lbs/yr for ammonia, 97 lbs/yr for nitrogen, and 15 lbs/yr for phosphorous. These mass loadings are summarized in Table 4. The ratio of the number of vessels in each U.S. homeport to the total of 75 compensated ballast vessels allows the loadings to be proportioned as shown in Table 5.

4.2 Environmental Concentrations

Screening for acute toxicity was accomplished by comparing the log-normal mean resulting from the UNDS sampling to Federal or the most stringent state water quality criteria for these constituents. These data are provided in Table 6. Individual sample concentrations exceed Florida criteria for oil, as indicated by SGT-HEM, but the log-normal mean does not; however, this discharge has demonstrated that potential for causing a sheen when procedural controls are not used.[6,8] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters. The Federal discharge standard is 15 mg/L based on *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 as implemented by the *Act to Prevent Pollution from Ships* (APPS).

The log-normal mean concentrations for copper, nickel, silver, and zinc samples exceed both Federal and most stringent state water quality criteria (WQC). The most stringent state criteria are exceeded by the log-normal mean concentration for 2-Propenal, ammonia, benzene, HEM, total nitrogen, phosphorous, and thallium. Mercury, a persistent bioaccumulator, was present in three of the four samples, although it did not exceed WQC.

4.3 Potential for Introducing Non-Indigenous Species

Water taken into the fuel tanks during refueling could contain non-indigenous species, but it is unlikely that the organisms will be transferred between ports for the following reasons:

1) Water is not taken into the compensated fuel ballast tanks during refueling operations – water is only discharged during this operation. Water is only taken into the compensated fuel ballast tanks during fuel transfer operations (either between compensated fuel ballast tank groups or from a compensated fuel ballast tank to a fuel service tank). Water could be taken into the compensated fuel ballast tanks prior to a refueling operation because ship’s personnel are trying to maximize the fuel storage on board by transferring fuel from the compensated ballast tanks to top off the fuel service tanks. This process is normally done at-sea prior to entering to a port facility. This process also prevents silt and debris from shallow harbors from being introduced into the tanks.

2) If the ship has been generating its own electrical power for an extended period while in-port then the fuel transfer may take place in the harbor prior to the refueling in order to maximize the fuel stored on-board the vessel. However, the refueling that takes place immediately after the fuel transfer will discharge the compensating water back into the same harbor.

3) Compensating water from the fuel storage tanks is frequently flushed while the ship is at sea due to frequent refuelings. Navy surface ships with compensated ballast systems normally refuel every three to four days while out at sea to prevent fuel levels from dropping below 70% capacity. Based on ship transit data, these ships are at sea between 187 and 264 days per year.[11] Using the minimum number of days at sea (187), and assuming that the ship is refueled at-sea every 4 days, results in an estimate of approximately 46 at-sea refuelings per year compared to two in-port refuelings per year. Therefore, there is little chance for compensating water that may have been taken on in one port to be discharged in another port.

5.0 CONCLUSIONS

Uncontrolled, compensated ballast discharge has the potential to cause an adverse environmental effect because significant amounts of oil are discharged during a short duration at concentrations that exceed discharge standards and water quality criteria. This discharge has been reported to cause an oil sheen when procedural controls are not applied.[6,8]

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on the reported concentrations of the constituents, the concentrations of the constituents in the environment resulting from this discharge were compared with relevant water quality criteria. Table 7 shows the sources of data used to develop this NOD report.

Specific References

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2. UNDS Equipment Expert Meeting Minutes - Compensated Fuel Ballast. July 24, 1996.

3. Naval Sea Systems Command, DD 963 - DDG 993 Class Advisory NR 04-94, Inport Refueling / Operational Procedures, 2 May 1994.

4. Naval Sea Systems Command, DDG 51 Class Advisory NR 22-95, Fuel Tank Level Indicator Alignment Procedures, 21 December 1995.

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6. Oil Concentrations in Ballast Water During In-Port Refueling of USS Nicholson (DD 982). DTNSRDC Report TM-28-81-145 (December 1981).

7. Oil Concentrations in Ballast Water During At-Sea Refueling of USS Nicholson (DD 982). DTNSRDC Report TM-28-82-158 (December 1982).

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9. SEA 05Y32 Preliminary Trip Report/Test Brief. DDG 51 In-Port Refueling Test, August 12-14, 1992.

10. SEA 05Y32 DDG 51 Post-PSA In-Port Fueling Test. August 4, 1992.

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14. Compensated Ballast Sample Analysis Results from DDG 51 In-port Refueling, 27 January 97, Commanding Officer, Naval Surface Warfare Center, Carderock Division, Philadelphia Site, Philadelphia, PA, letter 9593, Ser 631/63 of 14 February 1997.

15. UNDS Ship Database, August 1, 1997.

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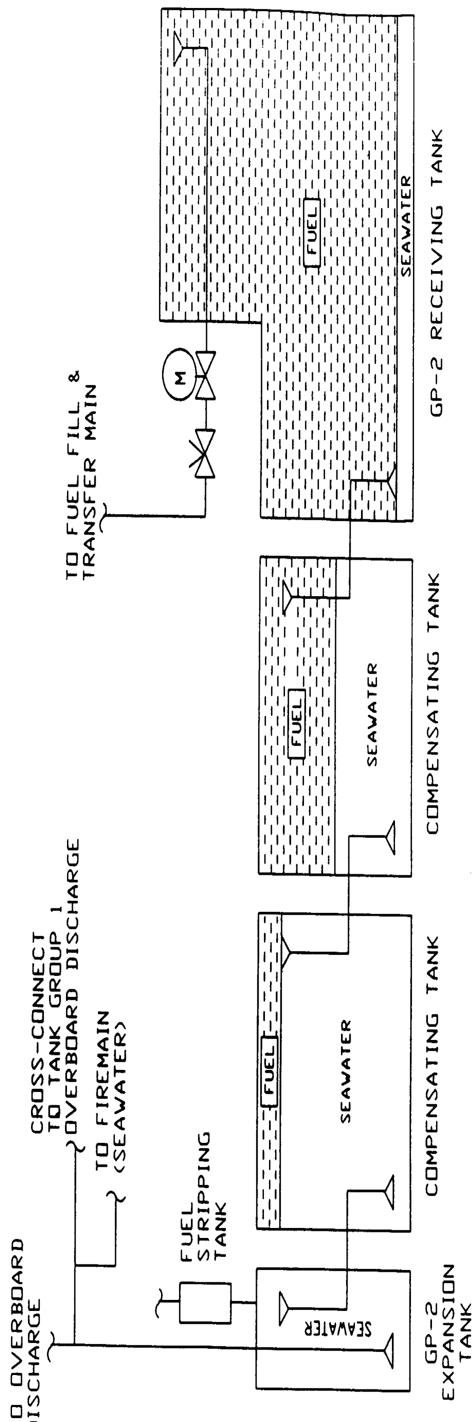

Figure 1. Fuel Tank Group 3 and 4 (Typical) Compensated Seawater Ballast

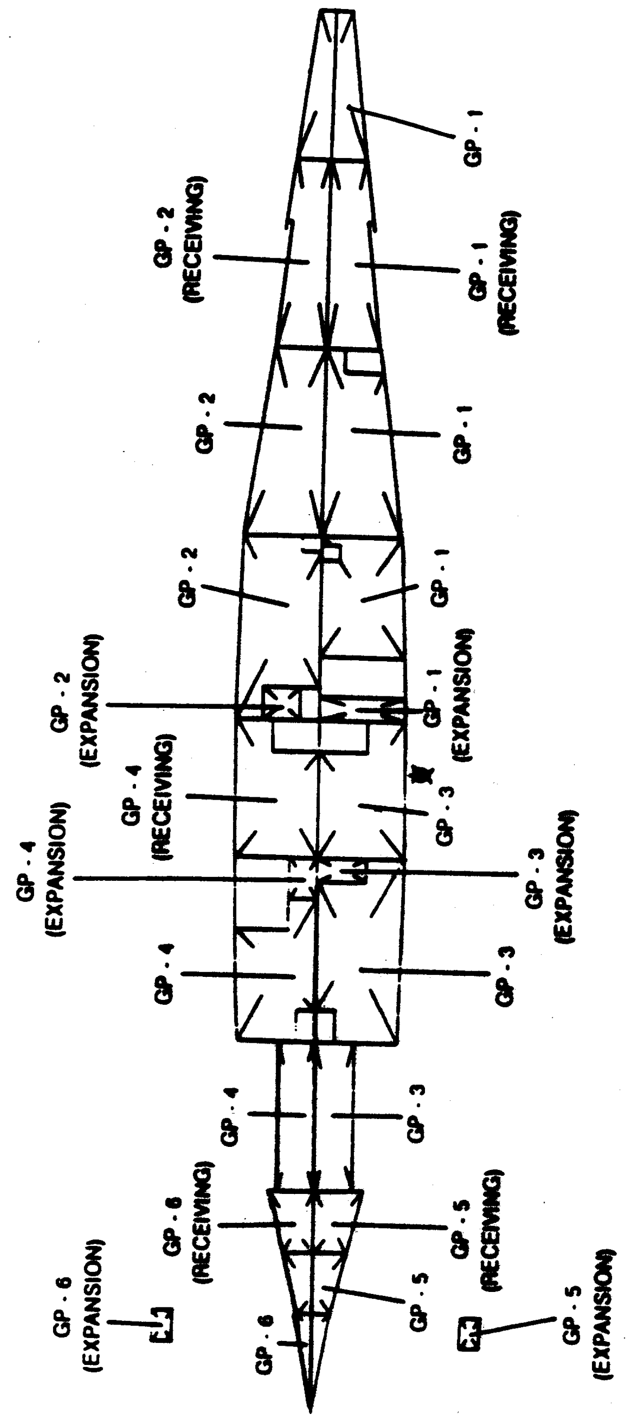

Figure 2. Compensated Fuel Ballast Tank Layout

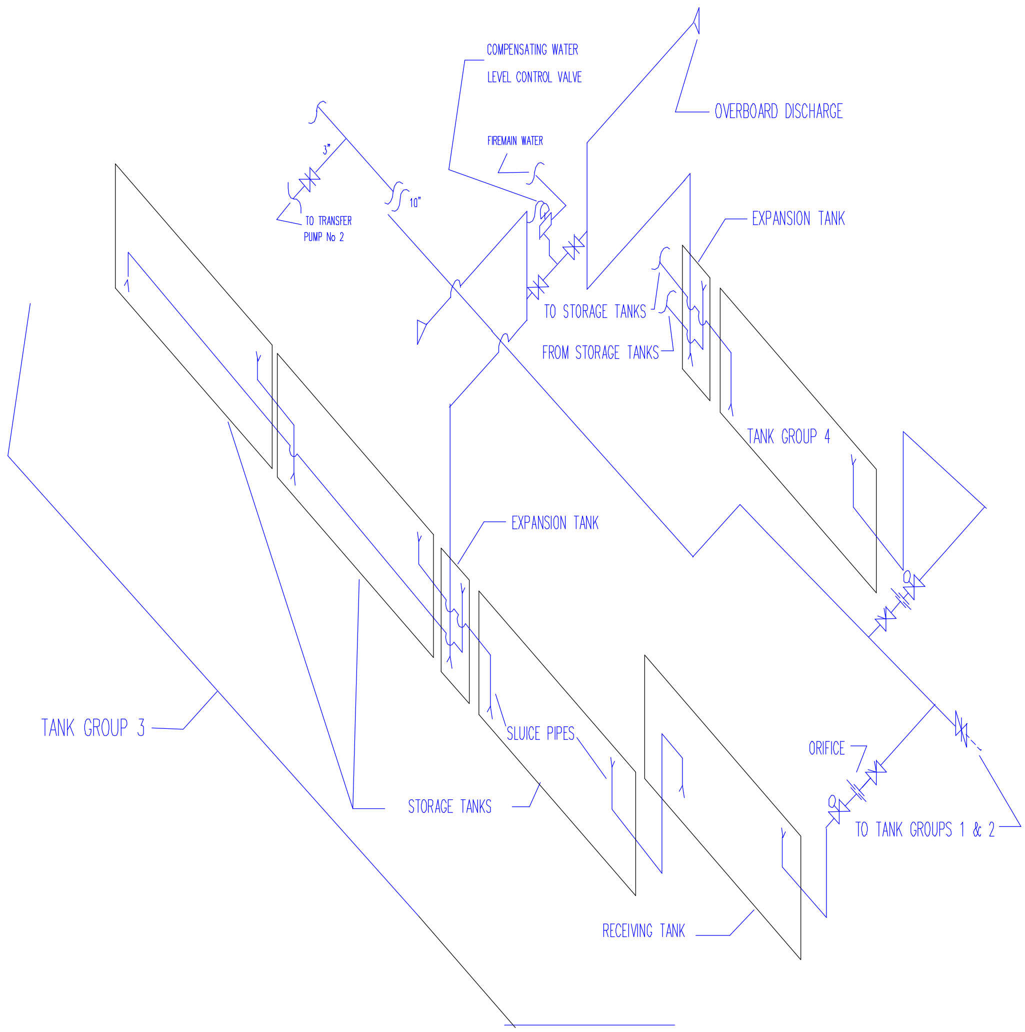

Figure 3. Typical Port and Starboard Tank Groups with Cross-connected Overflow

Table 1. Oil Concentrations in Compensated Ballast Waters (mg/L)

Previous Navy Studies			
USS Nicholson DD 982[6] (in-port)	USS Spruance DD 963[7] (at-sea)	USS John Hancock DD 981[8] (in-port)	USS Arleigh Burke DDG 51[10,11] (in-port)
2 to 149	< 60	<1 to 370	0.0 to 10.35 (lab)

mg/L - milligrams of oil per liter of fluid
(lab) - laboratory analysis results for physical samples taken during testing

Table 2. Summary of Detected Analytes for Compensated Ballast Discharge

Constituent		Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading (lbs/yr)
Classicals (mg/L)						
ALKALINITY		46.72	4 of 4	45	49	11,671
AMMONIA AS NITROGEN		0.26	4 of 4	0.19	0.3	65
BIOCHEMICAL OXYGEN DEMAND		6.82	1 of 4	BDL	12	1,704
CHEMICAL OXYGEN DEMAND (COD)		429.25	4 of 4	380	490	107,231
CHLORIDE		16042.18	4 of 4	15400	16800	4,007,497
HEXANE EXTRACTABLE MATERIAL		12.73	4 of 4	8	36.5	3,180
SGT-HEM		4.65	2 of 4	BDL	12.5	1,162
SULFATE		2005.74	4 of 4	1900	2120	501,054
TOTAL DISSOLVED SOLIDS		27760.50	4 of 4	27000	29300	6,934,851
TOTAL KJELDAHL NITROGEN		0.39	4 of 4	0.28	0.58	97
TOTAL ORGANIC CARBON (TOC)		28.98	4 of 4	21	40	7,239
TOTAL PHOSPHOROUS		0.06	3 of 4	BDL	0.34	15
TOTAL SULFIDE (IODOMETRIC)		3.94	4 of 4	3	5	984
TOTAL SUSPENDED SOLIDS		9.62	4 of 4	4	18	2,403
VOLATILE RESIDUE		2506.27	4 of 4	1910	3160	626,091
Hydrazine (mg/L)						
HYDRAZINE		0.08	4 of 4	0.0705	0.089	20
Mercury (ng/L)						
MERCURY		0.60	3 of 4	BDL	0.835	0.0001
Metals (μg/L)						
ALUMINUM	Dissolved	52.03	2 of 4	BDL	120	13
	Total	37.00	1 of 4	BDL	135.5	9
BARIUM	Dissolved	11.44	4 of 4	10.35	12	3
	Total	11.24	4 of 4	10.25	11.8	3
BORON	Dissolved	3098.77	4 of 4	2990	3220	774
	Total	3060.48	4 of 4	2990	3175	765
CALCIUM	Dissolved	256841.05	4 of 4	203000	292000	64,161
	Total	291451.71	4 of 4	286000	299000	72,808
COPPER	Total	53.37	4 of 4	43.7	86	13
IRON	Dissolved	99.76	4 of 4	37.45	159	25
	Total	130.50	4 of 4	74.95	202	33
MAGNESIUM	Dissolved	907229.15	4 of 4	881000	923500	226,635
	Total	938389.79	4 of 4	907000	1024500	234,419
MANGANESE	Dissolved	12.13	4 of 4	11.15	13.7	3
	Total	12.13	4 of 4	10.7	13.7	3
NICKEL	Dissolved	184.65	4 of 4	137	263.5	46
	Total	189.72	4 of 4	144	267.5	47
SILVER	Dissolved	3.07	1 of 4	BDL	5.68	1
SODIUM	Dissolved	8225693.86	4 of 4	8040000	8450000	2,054,861
	Total	8039337.04	4 of 4	7740000	8550000	2,008,307

THALLIUM	Dissolved	5.61	1 of 4	BDL	10.8	1
	Total	7.40	1 of 4	BDL	24	2
ZINC	Dissolved	1220.18	4 of 4	173	4330	305
	Total	4256.14	4 of 4	3840	4845	1,063
Organics (µg/L)						
2,3-DICHLOROANILINE		6.09	1 of 4	BDL	11	2
2,4-DIMETHYLPHENOL		312.10	4 of 4	180	430	78
2-METHYLBENZOTHIOAZOLE		8.07	1 of 4	BDL	34	2
2-METHYLNAPHTHALENE		61.34	4 of 4	58	63	15
2-PROPANONE		41.18	2 of 4	BDL	73	10
2-PROPENAL		42.20	1 of 4	BDL	203	11
4-CHLORO-2-NITROANILINE		12.04	1 of 4	BDL	21	3
ACETOPHENONE		21.99	4 of 4	21	23	5
ANILINE		6.58	1 of 4	BDL	15	2
BENZENE		89.99	4 of 4	31	153	22
BENZOIC ACID		75.62	3 of 4	BDL	146	19
BENZYL ALCOHOL		12.16	3 of 4	BDL	24	3
BIPHENYL		9.76	4 of 4	7.5	11	2
ETHYLBENZENE		38.59	4 of 4	20.5	59	10
HEXANOIC ACID		16.93	4 of 4	7.5	28	4
ISOSAFROLE		6.69	1 of 4	BDL	16	2
LONGIFOLENE		54.02	1 of 4	BDL	545	13
M-XYLENE		58.13	4 of 4	41.5	73	15
N-DECANE		7.28	1 of 4	BDL	22.5	2
N-DOCOSANE		7.11	1 of 4	BDL	20.5	2
N-DODECANE		10.01	2 of 4	BDL	36.5	3
N-EICOSANE		20.35	4 of 4	14	51	5
N-HEXADECANE		39.36	4 of 4	26	99.5	10
N-OCTADECANE		24.98	4 of 4	16	64	6
N-TETRADECANE		21.19	4 of 4	14	60	5
NAPHTHALENE		19.54	3 of 4	BDL	47	5
O+P XYLENE		100.66	4 of 4	71	127	25
O-CRESOL		181.10	4 of 4	84.5	296	45
O-TOLUIDINE		40.24	4 of 4	8	95	10
P-CRESOL		110.73	4 of 4	46.5	192	28
P-CYMENE		5.53	1 of 4	BDL	10	1
PHENOL		69.70	4 of 4	59	83	17
THIOACETAMIDE		19.75	1 of 4	BDL	152	5
TOLUENE		164.46	4 of 4	63.5	269	41
TOLUENE,2,4,-DIAMINO-		72.44	1 of 4	BDL	227	18

Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 3. Estimated Total U.S. In-port Discharge of Compensated Ballast (millions of gallons/year Fleetwide)

Ship Class	Number of Ships	Total In-port Discharge
CG 47	25	10.0
DD 963	28	11.2
DD 993	4	1.6
DDG 51	18	7.2

Table 4. Estimated Annual Mass Loadings of Constituents

Constituent		Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading (lbs/yr)
Classicals (mg/L)						
Ammonia As Nitrogen		0.26	4 of 4	0.19	0.3	65
Hexane Extractable Material		12.73	4 of 4	8	36.5	3,180
Nitrate/ Nitrite		-	-	-	-	-
Total Kjeldahl Nitrogen		0.39	4 of 4	0.28	0.58	97
Total Nitrogen[a]		0.39	4 of 4	0.28	0.58	97
Total Phosphorous		0.06	3 of 4	BDL	0.34	15
Mercury (ng/L)						
Mercury*		0.6	3 of 4	BDL	0.835	0.00015
Metals (μg/L)						
Copper	Total	53.37	4 of 4	43.7	86	13
Nickel	Dissolved	184.65	4 of 4	137	263.5	46
	Total	189.72	4 of 4	144	267.5	47
Silver	Dissolved	3.07	1 of 4	BDL	5.68	0.77
Thallium	Total	7.40	1 of 4	BDL	24	2
Zinc	Dissolved	1220.18	4 of 4	173	4330	305
	Total	4256.14	4 of 4	3840	4845	1,063
Organics (μg/L)						
2-Propenal		42.2	1 of 4	BDL	203	10
Benzene		89.99	4 of 4	31	153	22

* - Mercury was not found in excess of WQC; mass loading is shown only because it is a bioaccumulator.
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Mass Loadings by Homeport (lbs/yr)

	Total	Everett	Mayport	Norfolk	Pascagoula	Pearl Harbor	San Diego
Ships	75	4	13	27	2	10	19
	Loading Ranges						
HEM	3180	170	551	1145	85	424	805
SGT-HEM	1160	62	201	417	31	155	294
Copper	13.3	0.7	2.3	4.75	0.35	1.8	3.4
Nickel	47.4	2.5	8.25	17.1	1.25	6.3	12
Zinc	1063	56.7	184.25	382.7	28.35	141.7	269.3
Thallium	2	0.11	0.35	0.72	0.05	0.27	0.51
Silver	0.77	0.04	0.135	0.285	0.02	0.1	0.19
2-Propenal	10.3	0.55	1.8	3.7	0.28	1.4	2.6
Ammonia	65	3.5	11.3	23.4	1.75	8.7	16.5
Benzene	22	1.2	3.8	7.9	0.6	2.9	5.6
Nitrogen	97	1.7	17	35	0.84	13	25
Phosphorous	15	0.8	2.6	5.4	0.4	2.0	3.8

Table 6. Mean Concentrations of Constituents Exceeding Water Quality Criteria

Constituent		Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (mg/L)						
Ammonia As Nitrogen		0.26	0.19	0.3	None	0.006 (HI)[A]
Nitrate/Nitrite		-	-	-		
Total Kjeldahl Nitrogen		0.39	0.28	0.58	None	-
Total Nitrogen[B]		0.39	0.28	0.58	None	0.2 (HI)[A]
Hexane Extractable Material		12.73	8	36.5	visible sheen[a]/ 15[b]	5 (FL)
Total Phosphorous		0.06	BDL	0.34	None	0.025 (HI)[A]
Mercury (ng/L)						
Mercury*		0.6	BDL	0.835	1800	25 (FL, GA)
Metals (µg/L)						
Copper	Total	53.37	43.7	86	2.9	2.5 (WA)
Nickel	Dissolved	184.65	137	263.5	74	74 (CA, CT)
	Total	189.72	144	267.5	74.6	8.3 (FL, GA)
Silver	Dissolved	3.07	BDL	5.68	1.9	1.9 (CA, MS)
Thallium	Total	7.40	BDL	24	None	6.3 (FL)
Zinc	Dissolved	1220	173	4330	90	90 (CA, CT, MS)
	Total	4256	3840	4845	95.1	84.6 (WA)
Organics (µg/L)						
2-Propenal		42.2	BDL	203	None	18 (HI)
Benzene		89.99	31	153	None	71.28 (FL)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.
* - Mercury was not found in excess of WQC; concentration is shown only because it is a bioaccumulator.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

[a] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
[b] *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 as implemented by the *Act to Prevent Pollution from Ships* (APPS)

Table 7. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	Data call responses			X
2.2 Releases to the Environment	Data call responses			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	Data call responses			X
3.2 Rate	Data call responses		X	
3.3 Constituents	Data call responses	X		X
3.4 Concentrations	Data call responses	X		X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X	X		
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Controllable Pitch Propeller Hydraulic Oil

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as candidates for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the controllable pitch propeller (CPP) hydraulic oil discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

CPPs are used to control vessel speed and direction without changing the speed or direction of the vessel's main propulsion plant shafting. With CPPs, the angle of the propeller blades (pitch) is variable, which affects the "bite" that the blade has on the water. This allows the amount of water displaced in the forward or reverse directions to be varied, which changes the forward and reverse speed of the vessel.

The pitch of the CPP blades is controlled hydraulically through a system consisting of a pump, piston, crosshead, and blade crank rings. The piston, crosshead, and crank rings are located in the propeller hub. High pressure hydraulic oil, acting on either side of the piston, moves the piston axially within the propeller hub. The piston is attached to a piston rod that connects to the crosshead that moves axially with the piston. Sliding blocks fit in machined slots on the crosshead and these sliding blocks fit over eccentrically-located pins mounted on the crank pin rings. As the crosshead moves forward and backwards within the hub, the sliding blocks move in an arc that also moves the eccentric pin and rotates the crank pin rings to which the CPP blades are bolted.[1]

High-pressure hydraulic control oil is provided to each propeller by a hydraulic oil pressure module (HOPM). While operating, the HOPM supplies oil pressure at 400 pounds per square inch (psi) to control the CPP. While a vessel is pierside, the HOPM is idle and the pressure to the CPP consists of approximately 6 to 8 psi provided by 16 to 21 feet of hydraulic head, depending on the vessel class, from a 40- to 65-gallon reservoir that supplies head to a larger sump tank (600 to 800 gallons) for the CPP system. Several rubber O-ring seals, along with the finely machined surfaces of the blade port cover, the bearing ring, and the crank pin ring, keep the hydraulic oil inside the CPP hub and away from the water.

Figures 1 through 3 show cross sections and a top view of a CPP. Figure 4 is a block diagram of a CPP system.

2.2 Releases to the Environment

The hydraulic oil can be released under three conditions from a CPP and CPP maintenance tools: leaks past CPP seals; releases during underwater CPP repair and maintenance activities; and release of power head tool hydraulic oil during CPP blade replacement. Small quantities of oil can leak past the CPP seals if they are old, worn, or defective.

Oil can also be released to the environment during the underwater maintenance of CPP propeller blades or seals.[2] Underwater maintenance is performed to: 1) replace seals or center blade post sleeves; or 2) replace one or more propeller blades. The procedures for performing underwater replacements are detailed in reference (2). The detailed information in the following subsections applies to Navy vessels. Data on Military Sealift Command (MSC) underwater replacements are unavailable, and the U.S. Coast Guard (USCG) performs replacements only in dry dock.[3,4]

Blade Port Cover Removal. Approximately five to seven of the estimated thirty underwater replacements per year fleetwide are to remove blade port covers for maintenance and can cause some hydraulic oil to be released from the CPP hub.[5] The CPP hub seals or center post sleeve are replaced when observations or inspections indicate failure or cracking.[6] To change hub seals or the center post sleeve, the CPP blade is removed to access the blade port cover, which, in turn, must be removed to access the seals and center post sleeve. The underwater husbandry manual for the underwater change outs also references "NAVSEA Best Management Practices (BMPs) to Prevent/Mitigate Oil Spills Related to Waterborne Removal(s) of Blades on Variable Pitch Propellers for Naval Vessels." This BMP is described in Section 3.2.2.

CPP Blade Replacement. CPP blade replacement normally occurs after a casualty that causes blade damage (e.g., running aground, hitting a submerged object). During blade replacements, a CPP blade is unbolted from the blade port cover and replaced (see Figure 1). Removing a CPP blade does not, in itself, cause hydraulic oil to be released from the CPP hub assembly (other than that released by the bleeding procedure described above). Seals, bearings, and sleeves are still in place to prevent any oil from being released.

During CPP blade replacement, the blade is rotated to the 12 o'clock position to remove the Morgrip bolts that secure the blade to the CPP hub.[6] The Morgrip bolts are removed with a hydraulic power head tool. Before the power head tool is used, it is bled of air underwater while attached to the Morgrip bolt by allowing oil to flow from a port until a "steady stream of hydraulic fluid (no air) bleeds from the loosened port opposite the HP tube in the power head."[6]

2.3 Vessels Producing the Discharge

The Navy, MSC and USCG operate vessels equipped with CPPs. The Army and Air Force do not operate any vessels equipped with CPPs. Table 1 lists the vessels that have CPPs and the number of shafts (i.e., number of CPPs, per vessel).

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 provides concentrations of the constituents in the discharge.

3.1 Locality

Leaks of hydraulic oil past seals can occur at sea or within 12 n.m. of shore. Discharge underway is more likely than while pierside or at anchor because the CPP system is operating under a higher pressure.

Hydraulic oil can be discharged within 12 n.m. of shore during CPP repairs. The replacements are performed in port and are conducted on an as-needed basis when dry-docking is not scheduled for a vessel or is impractical.

3.2 Rate

The rate of oil release from CPPs will vary with the activity performed on the CPP. The leakage rate from CPP seals is expected to be negligible while the release of oil from CPP blade replacement will be larger. The release of oil from the underwater replacement of CPP seals will generate more oil than the underwater replacement of CPP blades only. The following paragraphs provide further information related to the anticipated release rates from CPPs.

3.2.1 Leaks From CPP Seals

The systems that monitor hydraulic oil loss can detect catastrophic failures on the order of 5 to 250 gallons over 12 hours, but not small leaks. The internal pressure in the CPP hub is approximately 6 to 8 psi, depending on the vessel class, when the HOPM is not operating (e.g., while a vessel is pierside). The external pressure from the seawater is approximately 5.8 to 8 psi provided by 13 to 18 feet of seawater, depending on the vessel class. Therefore, the pressure differential between the hydraulic oil in the CPP and the seawater is low (e.g., 1 psi or less) and provides little driving force to force oil from the CPP hub. Leakage rates under these conditions constitute seal failures requiring repairs/replacement considering that CPP hubs are designed to operate at 400 psi without leakage. CPPs are pressure tested at 400 psi prior to ship delivery and during dry dock maintenance. The CPPs are inspected quarterly for damage and signs of failure or excessive wear.[7] CPP seals are designed to last five to seven years and are reported to last their projected life.[7,8] Most Navy vessels equipped with CPPs have dry-dock cycles of approximately five years and MSC vessels have dry-dock cycles of two to three years.[3,9,10] During the dry dock cycle, the CPP is removed and shipped back to the manufacturer for inspection and maintenance, which includes replacement of the CPP seals. Based on the above information, the release rate of hydraulic oil from CPPs under normal operating conditions is expected to be negligible.

3.2.2 Underwater Replacements

Approximately thirty underwater CPP blade replacements occur per year, and five to seven of these include blade port cover removal to access the seal or center post sleeve for replacement.[5]

CPP Blade Port Cover Removal. According to Reference No. 2, as much as five gallons of oil could be present in CPP hub cavities.[2] It is unlikely that all of this oil is released during a seal replacement because the hub cavity opening is required to be oriented to the 6 o'clock position; the hydraulic oil is buoyant and floats within the hub cavity, effectively trapping the oil.[6]

Oil (0 to 5 gallons) could be released when oil is supplied to the assembly to displace water before replacing the blade port cover.[6] After the seals or the center post sleeve are replaced, head pressure is applied from the head tank to force out any water that entered the hub. The husbandry manual does not specify if oil is discharged when displacing water in the hub, but it appears to be a reasonable probability. The blade port cover is then replaced, and the hub is pressure tested at 20 psi. Leaks can appear if the seals are not properly seated, the mylar shims (i.e., spacers) are not the proper thickness, or the bearing ring is worn.[6] If the bearing ring requires replacement the vessel must be put in a dry dock.

Small amounts of oil can be discharged when removing and replacing the seal, bearing ring, blade seal base ring, and center post sleeve. Assuming the worst-case condition, five gallons of oil are discharged from the CPP hub during each replacement. At most a total of 35 gallons of hydraulic oil could be discharged annually fleetwide based on an average of seven replacements per year.

The BMP also requires the following precautionary measures:

a. Establish/install a floating oil boom in the vicinity of the work. Position this boom to enclose the aft one-third of the vessel, with approximately 20 feet beyond the stern to ensure that escaping oil is contained.[11]

b. Ensure that the oil recovery kit and personnel, who are trained in oil spill recovery, are at the work site at all times during the propeller blade removal/ installation to respond to any oil spill. The spill kit shall include a boom, absorbent pads, and other materials that remove oil from water.[11]

c. Any released oil will be captured within the oil boom and subsequently removed by the oil recovery team on the surface. A vacuum truck, equipped with a noncollapsible hose, will be at the site to remove any visible oil on the surface.[11]

CPP Blade Replacement. For the replacement of a CPP blade, the only source of oil release is from bleeding the Morgrip bolt power head tool. Each blade replacement results in approximately twenty ounces of hydraulic oil bled from the power tool (e.g., 10 ounces for the blade removal and 10 ounces for the blade replacement).[12] For the estimated 30 replacements that occur each year, this translates to approximately 600 ounces (4.7 gallons) of hydraulic oil bled from power head tools.

3.3 Constituents

The expected constituents of the discharge are 2190 TEP hydraulic oil from the CPP and the hydraulic oil (e.g., Tellus #10) that is bled from the power head tool. Constituents of the oil vary by manufacturer and are noted in Table 2. Hydraulic oils contain C_{17} (heptadecane, heptadecene) and large paraffins and olefins.[13] The 2190 TEP oil can also contain up to 1% tricresylphosphate (TCP) as an antiwear additive.[14] Shell Oil Tellus Oil #10 (Code 65203) hydraulic oil contains solvent-refined, hydrotreated middle distillates and light hydrotreated naphthenic distillates.[15] CPP hydraulic oil can contain copper, tin, aluminum, nickel, and lead that are leached from the piping, hub, and propeller.

Copper, nickel, and lead are priority pollutants that could be present in the hydraulic oil. There are no known bioaccumulators in this discharge.

3.4 Concentrations

The released material is expected to be hydraulic oil with metals such as copper, tin, aluminum, nickel, and lead from the piping, hub, and propeller. These metal constituents are expected to be in low concentrations because metals have low corrosion rates when in contact with oil. In addition, the hydraulic oil is continually processed through a filtration system to prevent particulate matter and water from entering the CPP system and potentially causing system failures.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

4.1.1 Leaks From CPP Seals

As discussed in Section 3.2.1, the release rate of oil from CPP seals due to normal operations is expected to be negligible. CPPs are designed not to leak and are tested prior to delivery at 400 psi. In addition, the CPPs are inspected quarterly.[7] The majority of those vessels equipped with CPPs have dry-dock cycles of five years or less and CPPs are returned to the manufacturer for inspection and overhaul during the dry dock period.[3,7,9,10] Therefore, the mass loading for oil leakage from CPPs is expected to be negligible.

4.1.2 Underwater Replacements

As estimated in Section 3.2.2, Armed Forces vessels could release up to 4.7 gallons of hydraulic oil from the Morgrip tool and 35 gallons of hydraulic oil from blade port cover removals each year. This quantity of oil has a mass of approximately 290 pounds based on a specific gravity of 0.88 for the hydraulic oil.

4.2 Environmental Concentrations

The quantities of hydraulic oil released can cause a sheen on receiving waters that violate federal and state “no sheen” standards. The metal constituents (e.g., copper, tin, nickel, and lead) in the oil can also be toxic, but it is anticipated that the concentrations, when dissolved in water, will be below toxicity thresholds. Florida has a water quality criterion for oil and grease of 5 milligrams per liter (mg/L) that the estimated environmental concentration for underwater replacement exceeds.

4.2.1 Leaks From CPP Seals

Because the release of oil from a CPP under routine operations is negligible, the resulting environmental concentration is negligible.

4.2.2 Underwater Replacements

The underwater replacements are expected to result in periodic, batch releases of hydraulic oil. Based upon the estimated release rates given in Section 3.2.2, the estimated discharge volume during each replacement is five gallons. During a typical underwater replacement requiring the removal of the port blade cover, the aft third of a vessel plus an additional 20 feet are enclosed with an oil boom. The Navy vessels having CPPs are between 445 and 567 feet in length and between 45 and 67 feet in beam (i.e., width). The average boomed length is approximately 190 feet and width of approximately 65 feet (e.g., average beam of 55 feet plus an estimated 10 feet for proper deployment). The quantity of oil released from CPPs during underwater replacements will result in free-phase oil that will result in localized visible oil sheens on the surface of the water. The resulting visible oil sheens are prohibited releases of oil under the Discharge of Oil (40CFR110) regulations of the Federal Water Pollution Control Act.

4.3 Potential for Introducing Non-Indigenous Species

CPPs do not transport seawater; there is no potential for transporting non-indigenous species.

5.0 CONCLUSIONS

5.1 Leaks From CPP Seals

The release of oil from CPPs during normal operation due to seal leakage is expected to be negligible. This is due to the following:

1) CPPs are designed not to leak at 400 pounds per square inch (psi) when new or

overhauled and are tested at 400 psi for leaks prior to delivery. There is a zero-leakage tolerance under the 400 psi test.

2) CPP seals are designed with service lives of 5 to 7 years and leakage that can occur due to wear or age occurs late within this operational life. The majority of vessels equipped with CPPs have dry-docking cycles for overhauls of approximately 5 years such that the releases occurring toward the end of the operational life of a CPP seal are avoided.

3) CPPs are inspected quarterly for damage and evidence of system failure (e.g., leaking seals).

The amount of oil leakage of CPPs under routine operating conditions has a low potential to cause an adverse environmental effect.

5.2 Underwater Replacements

CPP hydraulic oil discharge has the potential for causing adverse environmental effects during underwater replacements because:

1) oil is released to receiving waters by the equipment used to perform the underwater replacements, and

2) oil is released from the CPP hub assembly during underwater removals of the CPP blade port covers.

Releases due to underwater replacements are periodic and occur approximately thirty times per year. Those replacements that require the removal of the blade port cover release sufficient oil to cause a visible oil sheen on receiving waters and also exceed state WQC. These releases from waterborne CPP repairs are controlled using NAVSEA BMPs that reduce the adverse effects of the oil releases to receiving waters.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. The resulting

environmental oil and grease concentrations were then estimated. Table 3 shows the sources of data used to develop this NOD report.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

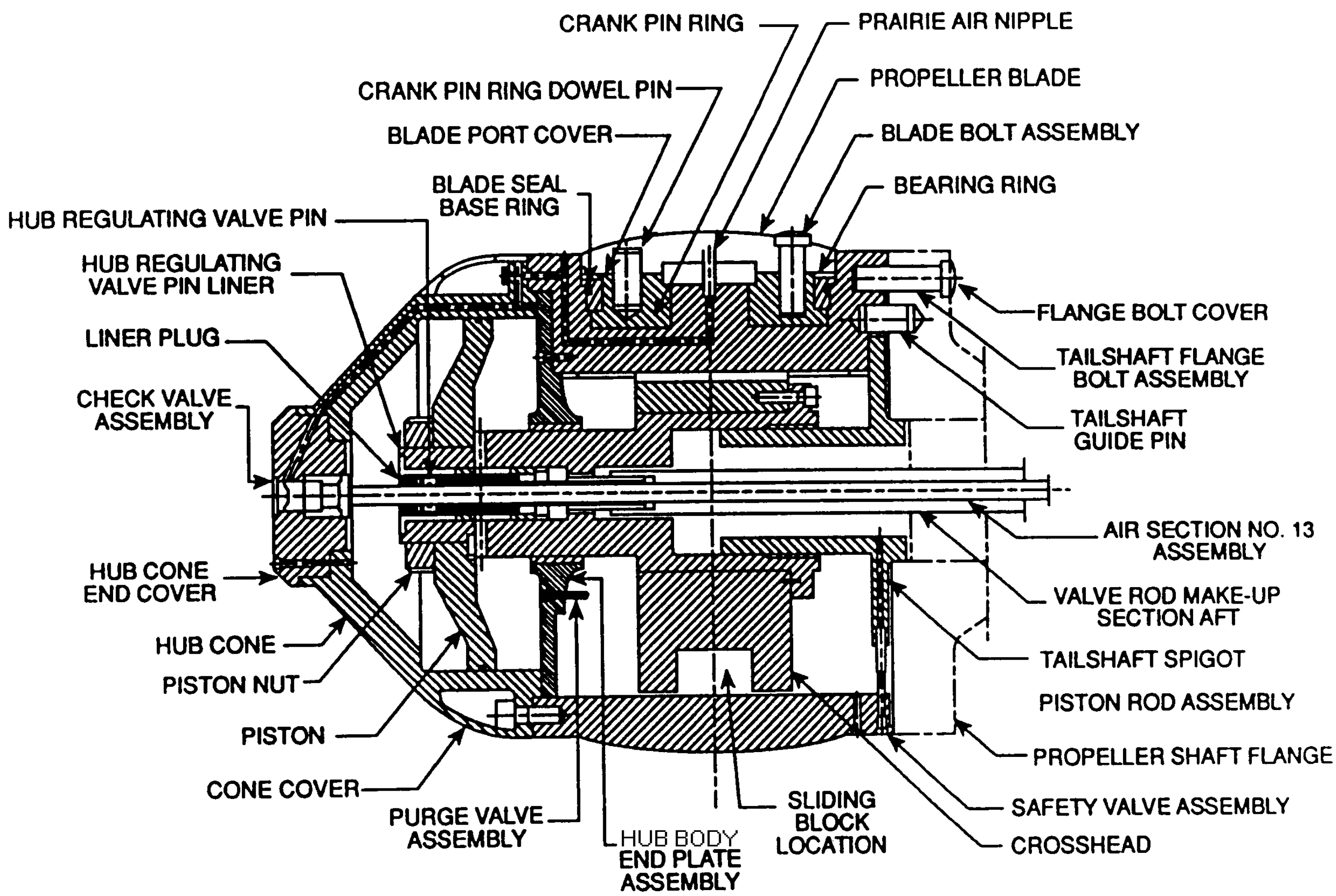


Figure 1. Cross Section of a CPP

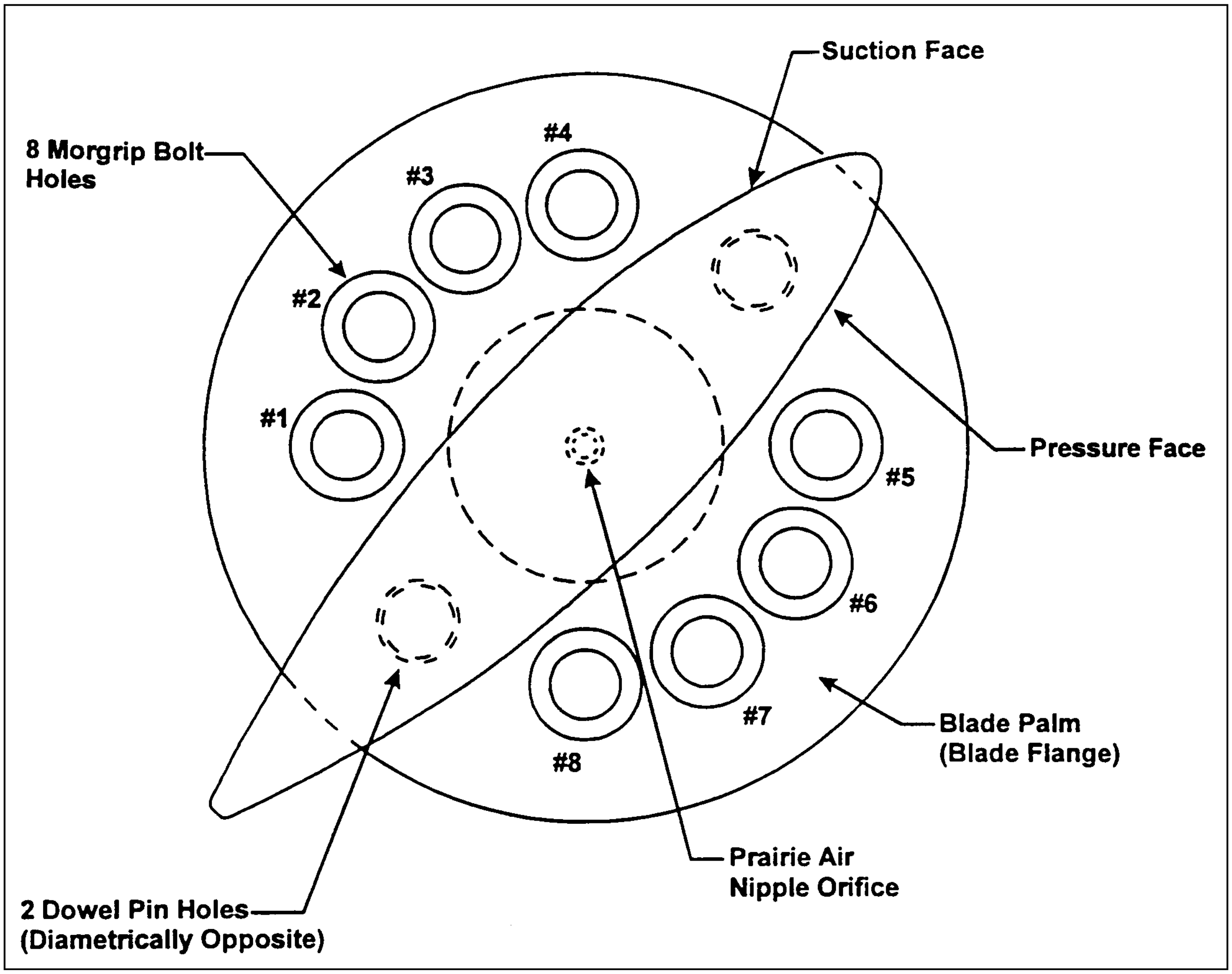
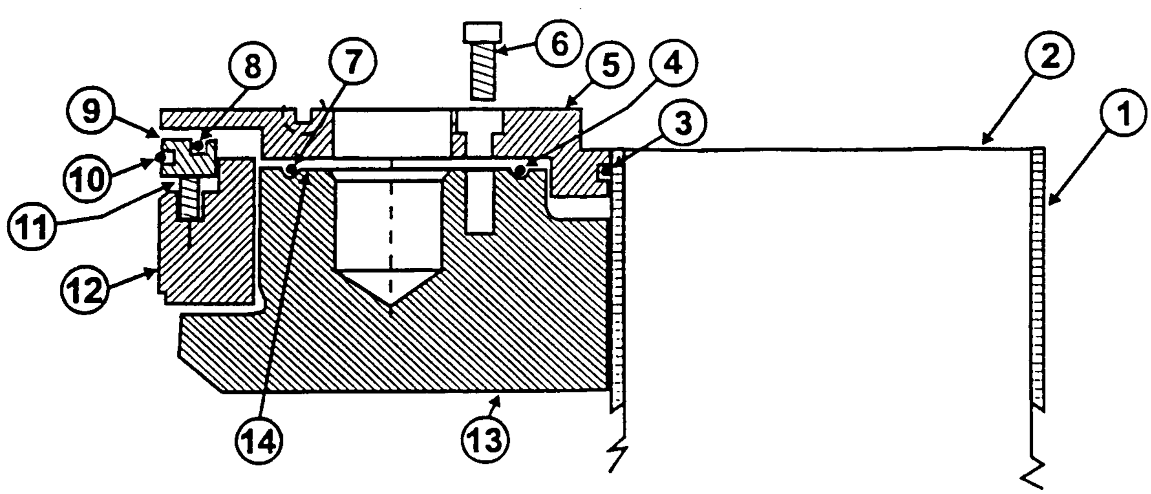


Figure 2. Top View of a CPP Blade



Item	Name
1	Center Post Sleeve
2	Center Post
3	O-ring (dynamic)
4	O-ring (static)
5	Blade Port Cover
6	Capscrew
7	O-ring (static)
8	O-ring (dynamic)
9	Blade Seal Base Ring
10	O-ring (static)
11	Spring
12	Bearing Ring
13	Crank Pin Ring
14	Mylar Shim

Figure 3. Cross Section of a CPP Blade Port Assembly

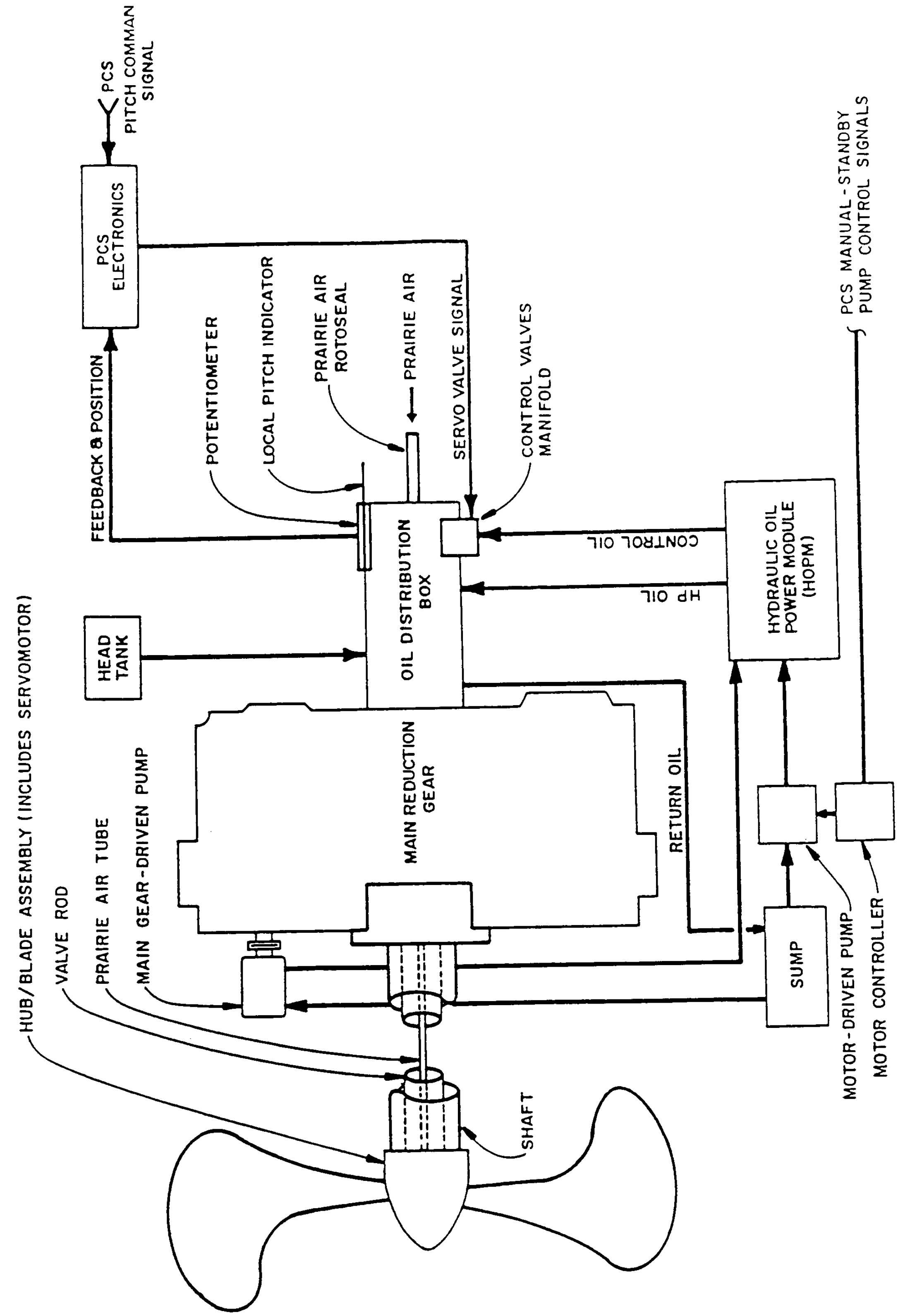


Figure 4. Block Diagram of a CPP System

Table 1. Armed Forces Vessels with CPP Systems

Vessel Class	Description	Vessel	Shafts
Navy:			
CG 47	Ticonderoga Class Guided Missile Cruiser	27	2
DD 963	Spruance Class Destroyers	31	2
DDG 51	Arleigh Burke Class Guided Missile Destroyers	19	2
DDG 993	Kidd Class Guided Missile Destroyers	4	2
FFG 7	Oliver Hazard Perry Guided Missile Destroyers	43	1
LSD 41	Whidbey Island Class Dock Landing Ships	8	2
LSD 49	Harpers Ferry Class Dock Landing Ships	3	2
MCM 1	Avenger Class Mine Counter Measures Ship	14	2
	Total:	149	
MSC:			
T-AO 187	Henry J. Kaiser Class Oilers	13	2
T-ATF 166	Powhatan Class Fleet Ocean Tugs	7	2
	Total:	20	
USCG:			
WHEC 715	Hamilton and Hero Class High Endurance Cutters	12	2
WMEC 901	Famous Class Medium Endurance Cutters	13	2
WMEC 615	Reliance Class Medium Endurance Cutters	16	2
WAGB 10	Polar Class Icebreakers	2	3
	Total:	43	
	Total Armed Forces Vessels with CPP:	212	

Table 2. Percentages of Constituents, TEP 2190 Oil and Tellus Hydraulic Oil

Constituent	MIL-L-17331H Turbine Oil 2190	Chevron Oil MSDS Turbine Oil 2190	Mobil Oil MSDS Turbine Oil 2190	Shell Oil MSDS Tellus Oil #10
Virgin Petroleum Lubricating Oil (a)	Balance			
Tricresyl Phosphate (TCP)	≤ 1%			
Additives	≤ 0.5%		Unknown Formaldehyde	< 1%
Hydrotreated Heavy Paraffinic Distillates		> 99%	> 95%	
Solvent-Dewaxed Heavy Petroleum Distillates		< 1%		
Hydrotreated Middle Distillate				0 - 100%
Hydrotreated Light Naphthenic Distillate				0 - 100%

(a) Virgin Petroleum Lubricating Oil is all classes of lubricating oil including heavy and middle Paraffinic distillates, solvent-dewaxed heavy distillates, light naphthenic distillates, etc.

Table 3. Data Sources

	Data Sources			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database, Jane's, Navy Home Page, USCG Cutters List			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents	MSDSs, Mil Specs			X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	Federal and State Regs		X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Deck Runoff

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the deck runoff discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

Decks are addressed in this NOD report under three categories: weather decks, aircraft flight decks, and oiler weather decks. The runoff from each deck type reflects the materials and treatment to which it is exposed during normal operations. All decks are exposed to a similar and harsh environment; however, there is a core group of activities, weapons, and machinery common to all ships. These common elements are addressed under the general category of weather deck runoff. Runoff from flight decks from which aircraft are launched and recovered and from oiler weather decks are addressed separately since the unique nature of the operations conducted on these decks distinguishes them from other weather deck surfaces.

2.1 Equipment Description and Operation

2.1.1 Weather Deck Runoff

Weather deck runoff consists of rain and other precipitation, seawater which washes over the decks (green water), and freshwater washdowns. Precipitation is usually the primary source within 12 nautical miles (n.m.) of shore. Except for small craft, green water or salt spray over the deck occurs primarily at sea and does not contribute to deck runoff while a ship is in port or in protected coastal waters. Freshwater washdowns also occur, but contribute less to weather deck runoff than precipitation.

The following paragraphs summarize each source that can contribute components to weather deck runoff.[1]

Deck Machinery - Ships have many pieces of deck machinery, such as windlasses, mooring winches, boat winches, underway replenishment gear, cranes, towing winches, and stern gates. This equipment is maintained with a variety of materials, including lubricating oils and greases that may be present in the deck runoff.

Topside Debris - Debris is trash (e.g., cigarette butts, dirt, paper) that can be washed overboard. The amount of debris is almost entirely a function of housekeeping practices, and crew discipline determines how much is collected for disposal instead of being washed overboard.

Wire Rope - Wire rope is used extensively in topside rigging, deck machinery, replenishment gear, and other equipment. It must be lubricated to prevent premature failure caused by friction between strands as the rope is worked. The lubricating oil or grease must be thin enough to flow or be worked between individual strands, but sufficiently wash-resistant to withstand rain and washdowns.

Fueling Operations - Fueling operations, either at sea or in port, may contaminate the deck with petroleum hydrocarbons (e.g., diesel, JP-5, fuel oil).

Weapons Systems - Gun mounts, missile launchers, weapons directors, and other weapons-related equipment can contribute constituents similar to those of deck machinery; however, they are less likely to contribute to deck runoff because most are contained in a turret or other water-tight or water-resistant enclosure.

Ship's Boats - Surface ships have small boats (e.g., punts, landing craft, rigid inflatable boats [RIBs]) that are stored topside. They have bilge plugs that are removed while stored, to drain rainwater, washdown water, or green water through their bilge and onto the deck if the boats are not properly covered. Constituents in the bilge (primarily diesel fuel) are discharged with the water.

Soot Particles - Burned fuels can leave fine soot particles on the deck. Except for MSC ships that are powered in equal numbers by steam and diesel propulsion equipment, the majority of the Armed Forces' surface ships and craft have diesel or gas turbine propulsion and use clean-burning distillates to minimize soot. However, significant amounts of soot can be produced during boiler light-off or after prolonged shutdowns of turbines and diesels.

Firefighting Agents - Aqueous Film Forming Foam (AFFF) firefighting systems are tested periodically in accordance with the planned maintenance system (PMS). These tests are conducted beyond 12 n.m. or while making 12 knots or more when transiting between 3 and 12 n.m.. The AFFF must be collected if the exercise occurs within 3 n.m. As discussed in the AFFF NOD report, AFFF is not discharged overboard within 3 n.m. of shore except in the rare instance of an actual shipboard fire.

Cleaning Solvents and Detergents - Miscellaneous solvents are used to clean and maintain topside equipment. These solvents may contain chlorinated compounds. However, they are also volatile and evaporate quickly. As such, their presence in deck runoff is expected to be minimal to nonexistent. During freshwater washdowns, crew members may use detergents that become part of the runoff.

Some or all of the above-listed sources that contribute to the contamination in deck runoff are common to all vessels.

Various Navy ports treat weather deck runoff differently. To date, no port is known to require the containment of rainwater runoff; however, a containment requirement may exist for some freshwater washdowns in certain Navy ports. For instance, at the Naval Submarine Base, Bangor, WA, freshwater washdowns containing cleaning agents, detergents, or other additives are considered to be industrial discharges; and, as such are not permitted to be discharged into the Hood Canal, rated a class AA "extraordinary" water body.[2] On the other hand, low-pressure freshwater washdowns completely free of cleaning agents or other chemicals need not be contained, and may be discharged into the Hood Canal.[2]

The U.S. Coast Guard (USCG) performs washdowns of its ships after returning to port and weekly while in port.[3] Initially, the decks are cleared of debris by hand and/or vacuum and then scrubbed with fresh water and detergent using brushes and screening pads. Fresh water is used to rinse the washdown overboard.[3]

Deck runoff occurs on boats and craft although some, such as RIBs, are stored on land. Because these vessels are small, green water becomes a significant contributor to deck runoff, and freshwater washdowns occur more frequently to remove the effects of green water on these vessels compared to larger ships. Craft, such as mechanized landing craft (LCMs), and smaller boats, such as RIBs and river patrol boats (PBRs), are washed down frequently to remove saltwater spray and residues left by heavy equipment and troops. However, many of these craft have large wells and very little deck area, which reduces the amount of deck runoff. Instead, precipitation, washwater, and green water collect in the bilge, rather than contributing to deck runoff. The USCG washes down its smaller vessels (i.e., those less than 65 feet long) nearly every day.[3]

2.1.2 Flight Deck Runoff

The same three sources of water contribute to this discharge as to that of weather deck runoff: precipitation, greenwater over the deck from heavy seas, and deck washdowns, in this case flight deck washdowns. As with weather deck runoff, flight deck runoff can be contaminated with a variety of chemicals.

Aircraft carrier launch and recovery equipment, e.g., catapult troughs and jet blast deflectors, are unique to aircraft carriers and are a major contributor of contaminants to flight deck runoff. Lubricating oil is applied to the catapult before each launch, and a fraction of this oil, along with the fuel mist emitted from aircraft during launch and hydraulic fluid and grease from the catapult, are deposited in the four catapult troughs of each carrier. [4-6] Most of these deposits drain overboard during flight operations, i.e., beyond 12 n.m., but a considerable amount of residual deposits can remain where precipitation can wash it overboard, either during transit or in port.[4-6] Oil sheens have been observed in port around aircraft carriers. This usually occurs following rainstorms due to runoff from the catapult troughs. In addition, the jet blast deflectors accumulate soot from jet exhaust, and have hydraulic system leakage that could contribute to flight deck runoff.

Most commissioned Navy vessels have flight decks for helicopter landing and takeoff. Many of these ships also have hangar facilities for helicopter storage and maintenance. The LHA, LHD, and LPH Classes of amphibious assault vessels have between 30 and 36 helicopters embarked, and some have about a dozen Vertical/Short Take-Off and Landing (VSTOL) aircraft as well. Flight exercises are conducted routinely with these aircraft.

Several other classes of vessels also have helicopter landing areas and hangars which accommodate one to three helicopters. These ships carry helicopters as part of their normal complement, but conduct flight operations less frequently than carriers or amphibious assault ships. Exceptions are the large service force ships, such as fast support ships (AOEs), ammunition ships (T-AEs), and combat stores ships (T-AFSs), which carry two or three UH-46 Sea Knight helicopters for underway replenishment (UNREP). These ships use the helicopters to transfer large volumes of provisions and ammunition rapidly during UNREP operations.

Vessels with ancillary helicopter flight decks and do not have their own helicopters, are not included in this analysis because they contribute very little helicopter-specific flight deck runoff compared to an amphibious assault vessel, which can carry up to 36 helicopters.

Flight deck washdowns to eliminate fire and slip hazards and to wash salt spray off flight decks are performed while ships are underway.[7,8] Both Commander Naval Air Force, U.S. Atlantic Fleet (COMNAVAIRLANT) and Commander Naval Air Force, U.S. Pacific Fleet (COMNAVAIRPAC) have promulgated policies that carrier flight decks are not to be washed down within 12 n.m. of shore except in cases of emergency.[7,8] Further, both Commander Naval Surface Force, U.S. Atlantic Fleet (COMNAVSURFLANT) and Commander Naval Surface Force, U.S. Pacific Fleet (COMNAVSURFPAC) have policies in force that state that decks shall not be washed within 12 n.m. of shore.[9,10]

Aircraft and helicopter freshwater washdowns are performed to remove dirt, hydrocarbons, salt deposits, and other materials resulting from flight operations or from salt spray. Unless the ship’s engineering officer is short of fresh water, the aircraft are washed before they disembark upon the ship’s return to port. Since current policies require that flight deck washing be completed prior to the ship arriving within 12 n.m. of shore, and since aircraft are disembarked prior to washing the flight deck, aircraft are not usually aboard either aircraft carriers or amphibious assault ships within 12 n.m. of shore. Therefore, aircraft freshwater washdowns do not contribute to deck runoff with 12 n.m. of shore.[11]

MSC has not promulgated protocols for the washing of helicopter flight decks on its vessels. The cleaning agent/solvent used and the washdown frequency are at the discretion of the officer in charge of the deck. Except in unusual circumstances, flight decks are not washed in port.[12]

2.1.3 Oiler Weather Deck Runoff

Oilers carry various petroleum products as cargo. This report examines the discharge from Navy and MSC oilers and UNREP ships which perform fueling-at-sea (FAS) operations. It also examines the discharge from the fuel barge service craft, which are used to fuel and defuel surface vessels while in port.

During the receiving and off-loading of bulk fuel, oilers have the potential to discharge oil. To prevent this, the weather deck is sealed by plugging or blocking the weather deck openings as required by Federal Regulations.[13] If the liquid contains oil from inadvertent spills or releases, the liquid is processed through the ship’s oily waste treatment system. These ships are also provided with oil spill containment and cleanup kits.

The newer oilers, such as the T-AO 187 Class, incorporate engineering design features and follow fueling practices that minimize oil releases. Excess oil and other uncontained liquids drain to a sludge collection tank, which is routed to an oily waste collection system. Any other liquid that collects in these sumps, such as rainwater or seawater, is also routed through the oily waste collection system.[14] The 7-inch fueling hoses contain check valves to prevent spills when disconnected. Additional protection against spills is provided by "blowing down" the hose with compressed air and/or taking a "back suction" with the cargo or stripping pumps and pumping the contents of the hose back to the oiler's cargo reclamation system before disconnecting the hose. FAS stations are also provided with spill response equipment to contain one to six barrels of oil (42 to 252 gallons), and with sorbents to contain any drips or small spills.

The newer designs also include the required catchment basin around fuel tank vent stations to contain oil and other liquids released because of overfilling during fueling operations.[13] If the liquids contain oily residues, these basins are pumped to the oily waste collection system. If the catchment basin contains only rainwater, the rainwater is discharged overboard. The catchments are routinely cleaned to remove oily residue. The disposition of these wash waters is to the oily waste collection system.[14] The treatment and disposition of oily waste is covered in the Surface Vessel Bilgewater/OWS Discharge NOD report.

All fuel barges have fire and flooding alarms, and are equipped with high tank level alarms. Ship alterations have been prepared to install oil retaining coamings and plugs for all fuel barges. Most barges currently in use were built or retrofitted with the coamings.[15] Fuel oil barges refuel ships within 12 n.m. of shore, whereas the oilers/UNREP vessels refuel ships beyond 12 n.m.

2.2 Releases to the Environment

Deck runoff is produced when water falls on or is applied to the exposed surfaces, such as weather and flight decks, superstructure, bulkheads, and the hull above the waterline, of a ship. Frequently runoff is contaminated by residues from the activities described in Section 2.1. The probable contaminants include: oil and grease; petroleum hydrocarbons; surfactants; cleaners; glycols; solvents; and particulates, such as soot, dirt, or metallic particles.

2.3 Vessels Producing the Discharge

Deck runoff is produced on all ships, submarines, boats, and craft of the Armed Forces (Table 1). Table 1 lists ship class, number of ships homeported in the U.S., dimensions (length and beam), flight deck dimensions (where applicable), and the number of days annually that each class of ship averages within 12 n.m.[16-25] The several thousand small boats and craft of the Armed Forces are not individually categorized.

Water, other than green water, that falls on the decks of submarines while they are in port or transiting inside of 12 n.m. is deck runoff. For submarines, green water is not considered deck runoff because of their design. All operating equipment on a submarine, with some minor exceptions, is contained within the double hull of the ship. Some outboard equipment, such as the hydroplanes, rudder, shaft seals, periscope, and antennae, are greased on a submarine; however, discharges from these sources are described in a separate NOD report. When operating, submarines spend virtually all of their time submerged beyond 12 n.m., and no activities are performed topside on a routine basis that could contribute to the contamination of deck runoff. Similarly, while submarines are in port, the majority of work occurs on the inside of the ship, not topside. Based on this information, the deck runoff from submarines is not a significant discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge consists of runoff from rainfall and other precipitation, from freshwater washdowns, and from green water; therefore, it can occur while in port or at sea. Table 1 contains a tabulation of the number of days the various vessel types spend within 12 n.m. of shore.[16]

3.2 Rate

The gallons of precipitation runoff per year estimated for each home port of a ship class is the product of the deck area of a ship in the class, the number of ships in the class in a given homeport, the average fraction of the year spent within 12 n.m. of shore, the average annual rainfall in the homeport, and the appropriate conversion factors. The total gallons of runoff from a ship class is the sum of the estimates thus developed for all the homeports of the class.

3.2.1 Weather Deck Runoff

Precipitation is expected to be the largest contributor to deck runoff in all types of vessels. Annual average precipitation data were obtained for the largest ports used by the Armed Forces as homeports: Norfolk and Little Creek, VA; San Diego, CA; Pearl Harbor, HI; Groton, CT; Mayport, FL; Ingleside, TX; and Bremerton, WA.[26] The average number of transits and days in port were developed for the years 1991 through 1995 for Navy and USCG ships.[16]

The various deck areas were estimated by multiplying the product of a vessel's length and beam by a factor intended to account for the departure of the deck's shape from a rectangle. In Table 1, those ship classes which are asterisked have a helicopter platform, but do not have a helicopter routinely embarked. The deck areas listed for these vessel classes include the area of the flight deck. For vessel classes whose helicopter platform dimensions are without an asterisk, such as the Spruance Class destroyers (DD 963), the deck area listed in Table 1 does not include the area of the helicopter platform.

The gallons per year precipitation runoff values listed in Tables 2 through 7 and in Tables 9a and 9b were all estimated using the same formula:

$$(N)\,(D/365)(A)(P)(PF)(FG) = \text{Annual Runoff (gallons per year)}$$

where N = the number of ships with the same deck area contributing to the annual runoff
D = the number of days per year each ship is within 12 n.m. of shore
A = the area in square feet of the deck or flight deck under consideration
P = the annual rainfall in inches
PF = 1/12, the conversion factor - one foot per 12 inches
FG = 7.48 gallons per cubic foot

Based upon this information and average deck area, an estimate of weather deck runoff from precipitation was developed for Navy ships by home port, and is presented in Table 2. Approximately 37.6 million gallons of weather deck runoff occurs annually from Navy surface ships in U.S. homeports due to rainfall.

To derive estimates of the precipitation-induced weather deck runoff from MSC, USCG, and Army vessels, a 40-inches-per-year rainfall was assumed, the annual average for the Navy homeports. The estimates are provided in Table 3. Approximately 54.6 million gallons of weather deck runoff occur annually within 12 n.m. of the U.S. coast from MSC, USCG, and Army vessels due to precipitation.

The Armed Forces operate literally thousands of boats and craft of a multitude of sizes throughout the offshore waters, harbors, and rivers of the U.S. Because neither the precise location of all of the boats and craft nor the mode of operation and storage at each location has been determined, it is impractical to estimate rates for these vessels.

3.2.2 Flight Deck Runoff

An estimate for aircraft carrier flight deck precipitation runoff is based upon reported average annual precipitation, the number of ships in each homeport, the flight deck area, and the number of days in port. Approximately 23.3 million gallons of weather deck runoff from aircraft carrier flight decks occur annually within 12 n.m. of the U.S. coast due to precipitation.

These results show that the quantity of aircraft carrier flight deck runoff varies significantly with geographical location. San Diego, CA, has the lowest average annual rainfall resulting in the least runoff. Although Norfolk, VA does not have the highest precipitation rate, it produces the highest amount of flight deck runoff because it is homeport to the most carriers. The data and results are presented in Table 4. Because it is not unusual for three carriers to be in Norfolk at the same time, and for summer storms to produce an inch of rain in a few hours, the three carriers, with a combined flight deck area of 690,000 ft^2, will generate approximately 430,000 gallons of flight deck runoff for each inch of rain.

Of the 11 amphibious assault vessels in service, 10 are stationed in U.S. ports, and are homeported either in Norfolk, VA, or San Diego, CA. The ships, by class, are divided evenly between these two ports. The mine countermeasures support ship USS Inchon (MCS 12) is a converted Iwo Jima Class LPH, and is homeported in Ingleside, TX. The estimated total annual helicopter flight deck runoff for these vessels due to precipitation is approximately 8.3 million gallons. Table 5 is a compilation of the data used to estimate the average annual deck runoff from these ships due to precipitation.

Table 6 lists flight deck runoff from Navy surface vessels, other than aircraft carriers and amphibious assault vessels, by U.S. homeport, number and location of vessels by class, and the average annual rainfall for each port. Based on this information, these ships generate an annual deck runoff of approximately 2.6 million gallons due to precipitation.

The estimate for precipitation runoff from helicopter flight decks of MSC and USCG surface ships is presented in Table 7. The estimate was derived from the areas of the flight decks, the average annual rainfall, and the number of days in port for each ship class. Based on this information, MSC and USCG surface ships generate an estimated annual deck runoff of 860 thousand gallons due to precipitation.

A volume of helicopter flight deck wash water generated by USCG vessels is estimated in Table 8. The volume used to wash and rinse a given flight deck area is considered to be the same as would be used on a Navy ship, that is, 30-gallons of a cleaning solution mix of MIL-C-85570, type II detergent, sodium metasilicate (anhydrous or pentahydrate), and freshwater will treat approximately 3,000 ft^2 of deck. The amount of water used to rinse the cleaning solution off of the deck is on the order of three to five times the volume of the cleaning solution used. Further, because the USCG washes weekly, the number of washes annually is estimated by dividing the number of days a vessel is within 12 n.m. of shore by seven.[3] Based upon these assumptions, USCG surface ships generate approximately 70 thousand gallons of helicopter flight deck wash water as compiled in Table 8.

3.2.3 Oiler Weather Deck Runoff

Estimates have been prepared, using the same methodology, for the deck runoff from Navy and MSC oilers due to precipitation. They are presented in Table 9a. Similar estimates were prepared for the various service craft, such as fuel barges, and are presented in Table 9b. As indicated in the tables, the estimated annual runoff from the oilers is approximately 8 million gallons, and from the various service craft approximately 8.9 million gallons.

3.2.4 Runoff Summary

Table 10 is a compilation of the runoff volumes associated with the various runoff sources and vessel types. As indicated in the table, the estimated annual runoff from vessels of the Armed Forces due to precipitation and the limited number of in-port washdowns is approximately 143.9 million gallons.

3.3 Constituents

The runoff from flight and other weather decks can contain a number of different constituents, including: JP-5, found in the runoff from aircraft carrier flight decks, helicopter flight decks, and the weather decks of support ships carrying JP-5 as cargo; diesel fuel marine, distillate fuel, or gasoline, from vessel fueling and refueling operations; various solids, such as soot, paint chips, dirt, and trash; glycol from the windshield washing system; hydraulic fluid leakage; metals from scrapes, gouges and corrosion; rubber from aircraft tires; and the residue from cleaners and solvents, particularly sodium metasilicate.

These materials contain short- and medium-length aliphatics, light and heavy aromatics, paraffins, olefins, surfactants, glycols, and metals. Some cleaning solvents can contain chlorinated compounds, such as tetrachloroethylene. These solvents quickly evaporate.

Analytical data are available for one element of aircraft carrier flight deck runoff: the runoff that flows through a catapult trough and is discharged overboard. This runoff was sampled in a study on the feasibility of using an oil/water separator to treat trough runoff.[27] The resulting data are not representative of the runoff from the entire flight deck of a carrier, only of runoff that is discharged from one of the catapult troughs. The aqueous phase of the catapult trough runoff was analyzed for:

- oil and grease,
- phenols, and
- metals (silver, cadmium, chromium, copper, nickel, and lead).

The four catapult troughs are located in close proximity to the aircraft fueling spots, and collect spilled JP-5. Lubricating oil is applied to a catapult before each shot. A fraction of this oil, along with fuel mist emitted from aircraft during launch, and hydraulic fluid and grease from the catapult is deposited in each of the four catapult troughs.[4-6] The concentrations originating in the catapult troughs can, therefore, be expected to exceed those for the flight deck runoff in general.

None of the constituents analyzed for are bioaccumulators, and no bioaccumulators are anticipated in this discharge. The materials used on the decks of vessels do not contain the pesticides, herbicides, PCBs, or other chlorinated aromatic compounds that constitute bioaccumulators.

Of the constituents listed above, silver, cadmium, chromium, copper, nickel, lead, and phenols are priority pollutants.

3.4 Concentrations

The laboratory data from an aircraft carrier catapult trough drain system are presented in Table 11. The data are the concentrations before processing the runoff through an oil/water separator, and are not representative of the runoff from the entire flight deck of an aircraft carrier.[27]

Constituent concentrations resulting from precipitation are expected to vary significantly with a number of factors. These include: time since the last rain or deck washing; the intensity and duration of the last rainfall; the season (which will effect glycol loading from deicing fluids); the ship's adherence to good housekeeping practices; and the type, intensity, and duration of weather (high sea state and green water) and ship's operations. For example, higher seas which result in more frequent green water runoffs and more frequent freshwater washdowns, both of which generally occur outside 12 n.m., will minimize the concentrations of accumulated residues that contribute to runoff contamination in port. Further, it should be noted that deck runoff from precipitation may mimic the constituent concentration patterns observed in storm water runoff from highways and parking lots: contaminant concentrations will be higher in first portions of the runoff, and then will taper off to low or nondetectable levels as the precipitation continues.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. A discussion of mass loadings is presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents are compared with the water quality standards. In Section 4.3, the potential for transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Currently, no basis exists for estimating the mass loadings of deck runoff accurately. The factors discussed in Section 3.4, that combine to produce the great variance in deck runoff, prohibit the development of engineering assumptions from which to estimate deck contaminant concentrations. The use of the data from any analysis of the untreated runoff that had flowed through an aircraft carrier catapult trough could result in mass loadings that are overestimated by orders of magnitude.

4.2 Environmental Concentrations

As with mass loadings, because the constituent concentrations vary with a number of factors, most of which vary over time since the last rainfall or washdown; the environmental concentrations will vary accordingly. For any given set of factors discussed in Section 3.4, the discharge concentrations for the catapult trough portion of deck runoff can be used as a worst case for a specific contributor.

The catapult trough discharges as a component of the flight deck runoff are diluted as they enter the receiving waters, but to what extent is unknown. Therefore, the raw concentration values are used for comparison to the Federal and most stringent state water quality criteria listed in Table 12. The comparisons show that a number of the constituent concentrations in catapult trough runoff exceed Federal and state acute water quality criteria, in addition to discharging oil exceeding the Federal discharge limits.[28] Chromium concentrations exceed the most stringent state's water quality criteria. The detected metals that exceed the Federal and most stringent state water quality criteria are: cadmium, nickel, and lead. In addition, two metals, silver and copper, which were not detected, have reported limits that are more than an order of magnitude higher than their corresponding Federal and state water quality criteria. The reported phenols concentration exceeded the most stringent state criteria. The oil and grease concentration exceeds the Federal criterion and the concentrations reported are also likely to cause a visible sheen on receiving waters. Discharges of oil that cause a visible sheen on receiving waters must be reported.[28]

4.3 Potential For Introducing Non-Indigenous Species

The potential for non-indigenous species transport is insignificant. The runoff due to rainfall and washdown has a low potential to contain non-indigenous species, and the runoff from green water is discharged in the same location from which it came aboard.

5.0 CONCLUSION

Oil in the deck runoff discharge has the potential to cause an adverse environmental effect. This conclusion is based upon observations of oil sheens on the water surface surrounding certain vessels during and after rainfalls.

6.0 DATA SOURCES AND REFERENCES

Table 13 shows the sources of data used to develop this NOD report.

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Table 1. Listing of Ships and Vessels for Deck Runoff
Navy, MSC, USCG and Army

Vessel Category	Homeported In U.S.*	Additional Projected	Ship Dimensions Length (ft)	Ship Dimensions Beam (ft)	Helo Pad Dimensions Length (ft)	Helo Pad Dimensions Width (ft)	Weather Deck Area (sq ft)	Days within 12 n.m.
* Where ships of this class are homeported in foreign ports, their number appears in parentheses, e.g., 8 (2) indicates 8 ships in the class, 2 homeported overseas, therefore only six are considered in calculating the deck runoff in that class.								
** Denotes ships which do not embark helicopters as part of their normal complement, so helocopter flight deck area is included in weather deck area								
*** DDG 51-78 do not have helos embarked; DDG 79 and Follow will have two embarked helos.								
Navy Ships								
Aircraft Carriers								
Forrestal Class Carrier (CV 59)	1 (1)	0	1052	130			220,000	0
Kitty Hawk Class Carriers (CV 63)	3	0	1063	130			220,000	139
Enterprise Class Carriers (CVN 65)	1	0	1123	133			230,000	78
Nimitz Class Carriers (CVN 68)	7	2	1092	134			230,000	149
Amphibious Assault Ships								
Wasp Class Assault Ship (LHD 1)	4	3	819	106			86,814	188
Tarawa Class Assault Ship (LHA 1)	5 (1)	0	820	118			92,800	175
Iwo Jima Class Assault Ship (LPH 2)	2	0	602	104			62,608	189
Submarines								
Ohio Class Ballistic Missile Submarines (SSBN 726)	17	0	560	42			15,288	185
Sturgeon Class Attack Submarine (SSN 637)	13	0	302.2	31.8			6,246	185
Los Angeles Class Attack Submarine (SSN 688)	56	0	362	33			7,765	185
Narwhal Class Submarine (SSN 671)	1	0	314.6	37.7			7,709	185
Benjamin Franklin Class Submarines (SSN 640)	2	0	425	33			9,116	185
Surface Ships								
Virginia Class Cruisers (CGN 38)	1	0	585	63	20**	27	28,747	164
California Class Cruisers (CGN 36)	2	0	596	61	43**	38	28,358	146
Ticonderoga Class Cruisers (CG 47)	27 (2)	0	567	55	54	40	22,164	169
Kidd Class Destroyers (DDG 993)	4	0	563.3	55	52**	41	24,166	104
Arleigh Burke Class Destroyers (DDG 51)***	18 (2)	30	504.5	66.9	49**	42	26,326	178
Spruance Class Destroyers (DD 963)	31 (3)	0	563.2	55.1	52	42	22,021	181
Oliver Hazard Perry Class Frigates (FFG 7)	43 (2)	0	445	45	54	36	13,676	170
Blue Ridge Class Command Ships (LCC 19)	2 (1)	0	636.5	107.9	72**	74	53,569	181
Austin Class Amphibious Transport Dock (LPD 4)	3	0	570	100	209**	61	44,460	181
Austin Class Amphibious Transport Dock (LPD 7)	3 (1)	0	570	100	199**	61	44,460	191
Austin Class Amphibious Transport Dock (LPD 14)	2	0	570	100	203**	75	44,460	195
Whidbey Class Dock Landing Ships (LSD 41)	8 (2)	0	609.5	84	189**	71	39,934	171
Harpers Ferry Class Dock Landing Ships (LSD 49)	3	1	609.5	84	188**	72	39,934	216
Anchorage Class Dock Landing Ships (LSD 36)	5	0	553.3	84	78**	78	36,252	218
Newport Class Tank Landing Ships (LST 1179)	3	0	522.3	69.5	49**	54	28,314	183
Avenger Class Mine Countermeasures Ship (MCM 1)	14 (2)	0	224	39			6,814	239
Osprey Class Coastal Minehunters (MHC 51)	12	6	188	35.9			5,264	239
Cyclone Class Patrol Ships (PC 1)	13	1	170.3	24.9			3,308	110

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** Denotes ships which do not embark helicopters as part of their normal complement, so helocopter flight deck area is included in weather deck area

*** DDG 51-78 do not have helos embarked; DDG 79 and Follow will have two embarked helos.

Vessel Category	Homeported In U.S.*	Additional Projected	Ship Dimensions Length (ft)	Ship Dimensions Beam (ft)	Helo Pad Dimensions Length (ft)	Helo Pad Dimensions Width (ft)	Weather Deck Area (sq ft)	Days within 12 n.m.
Patrol and Landing Craft								
Pegasus Class Mk V Patrol Boats (SOC/PBF)	7	14	82	17.5			1,119	320
Mk III Patrol Boats (PB)	14		68	18			955	320
Stinger Class Patrol Boats (PB)	10		65	18			955	320
Mk II River Patrol Boats (PBR)	25		35	9.3			246	320
Landing Craft Air Cushion (LCAC)	91 (3)		81	43			3,483	320
LCU 1600 Class Utility Landing Craft (LCU)	40		134.9	29			3,912	320
LCM 8 Class Mechanized Landing Craft (LCM)	100		73.7	21			575	320
LCM 6 Class Mechanized Landing Craft (LCM)	60		56.2	14			300	320
Landing Craft Personnel (LCPL)	130		36	12.1			160	320
Armored Troop Carriers (AT)	21		36	12.7			365	365
Auxiliaries								
Jumboised Cimmaron Class Oilers (AO 177)	5	0	709	88	59**	76	48,666	191
Sacramento Class Fast Combat Support (AOE 1)	4	0	793	107	83	71	60,291	186
Supply Class Fast Combat Support (AOE 6)	3	1	754	107	70	95	56,279	116
Raleigh Class Command ship (AGF 3)	1 (1)		522	90**	90**	76	34,201	0
Austin Class Command Ship (AGF 11)	1	0	570	100	195	78	29,250	186
Safeguard Class Salvage Ships (ARS 50)	4	0	255	51	20**	20	10,144	214
Simon Lake Class Submarine Tender (AS 33)	1 (1)		644	85	39**	65	42,697	0
Emory S Land Class Submarine Tenders (AS 39)	3	0	643.8	85	31**	34	42,684	295
Iwo Jima Class MCM Support Ship (MCS 12)	1	0	602	104			62,608	189
Diving Tenders (YDT)	3		50	12			600	320
Harbor Utility Craft (YFU)	2		134.9	29			3,912	365
Patrol Craft (YP)	28		108	24			2,022	365
Torpedo Trials Craft (YTT)	3		186.5	40			5,819	320
Torpedo Retrievers, 65 ft (TR)	3		65	14			710	320
Torpedo Retrievers, 72 ft (TR)	5		72	15			842	320
Torpedo Retrievers, 85 ft (TR)	5		85	18			1,193	320
Torpedo Retrievers, 100 ft (TR)	3		100	21			1,638	320
Torpedo Retrievers, 120 ft (TR)	6		120	25			2,340	320
Large Harbor Tugs (YTB)	72		109	30			2,551	320
Ashville Class Research Ships (YAG)	3		164.5	23.8			3,054	320
Fuel Oil Barge, Nonselfpropelled (YON)	40		165	40			6,600	365
Fuel Gasoline Barge, Nonselfpropelled (YOGN)	9		165	40			6,600	365
Fuel Oil Storage Barge (YOS)	5		165	40			6,600	365
Miscellaneous Boats and Craft	3000+		Various dimensions				-	365
Military Sealift Command								
Kilauea Class Ammunition Ships (T-AE)	8	0	564	81	69	60	31,494	45

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*** DDG 51-78 do not have helos embarked; DDG 79 and Follow will have two embarked helos.								
Mars Class Combat Stores Ship (T-AFS)	5	0	581	79	70	62	31,461	45
Sirius Class Combat Stores Ship (T-AFS)	3	0	524	72	64	67	25,140	45
Henry J. Kaiser Oilers (T-AO)	12	0	677	97	67**	73	51,222	50
Hayes Class Acoustic Research Ship (T-AG)	1	0	256.5	75			15,005	45
Mission Class Navigation Research Ship (T-AG)	1	0	595	75			34,808	45
Observation Is. Class (T-AGM)	1	0	563	76			33,375	45
Stalwart Class Ocean Surveillance Ship (T-AGOS)	5	0	224	43			7,513	60
Victorious Class Ocean Surveillance Ships (T-AGOS)	4	0	234.5	93.6	20**	20	21,949	120
Silas Bent Class Surveying Ships (T-AGS)	2	0	285.3	48			10,682	45
Waters Class Surveying Ship (T-AGS)	1	0	455	68.9			24,453	45
McDonnell Class Surveying Ships (T-AGS)	2	0	208	45			7,301	45
Pathfinder Surveying Ships (T-AGS)	4	1	328.5	58			14,861	45
Mercy Class Hospital Ships (T-AH)	2	0	894	105.6	80**	80	73,637	365
Maersk Class Strategic Sealift Ships (T-AKR)	3	0	946	106	80**	80	78,215	320
Gordon Class Strategic Sealift Ships (T-AKR)	2	1	956	106	80**	80	79,042	320
Algol Class Fast Sealift Ships (T-AKR)	8	0	946.2	106	81**	84	78,232	320
Zeus Class Cable Repairing Ship (T-ARC)	1	0	502.5	73			28,612	45
Powhatan Class Fleet Ocean Tugs (T-ATF)	7	0	240.2	42	25**	20	7,869	120
USCG								
Hamilton Class High Endurance Cutters (WHEC)	12	0	378	42	50	35	10,633	154
Famous Class Medium Endurance Cutters (WMEC)	4	0	270	38	40	30	6,803	139
Famous Class Medium Endurance Cutters (WMEC)	9	0	270	38	40	30	6,803	166
Reliance Class Medium Endurance Cutters (WMEC)	5	0	210.5	34	48**	30	5,582	238
Reliance Class Medium Endurance Cutters (WMEC)	11	0	210.5	34	48**	30	5,582	151
Polar Class Icebreaker (WAGB)	2	0	399	86	65	82	21,435	365
Bay Class Tugs (WTGB)	9	0	140	37.6			4,106	365
Point Class Patrol Craft (WPB)	36	0	83	17.2			1,114	320
Island Class Patrol Boats (WPB)	49	0	110	21			1,802	320
Juniper Class Seagoing Buoy Tender (WLB)	2	1	225	46			8,073	287
Balsam Class Buoy Tenders (WLB)	23	0	180	37			5,195	295
Keeper Class Buoy Tenders (WLM)	2	12	175	36			4,914	227
Red Class Buoy Tenders (WLM)	9		157	33			4,041	227
White Sumac Class Buoy Tenders (WLM)	4		133	31			3,216	227
Inland Buoy Tenders (WLI)	2		100	24			1,872	365
Inland Buoy Tenders (WLI)	4		65	17			862	365
River Buoy Tenders, 65 ft (WLR)	6		65	22			1,115	365
River Buoy Tenders, 75 ft (WLR)	13		75	22			1,287	365

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River Buoy Tenders, 115 ft (WLR)	1		115	30			2,691	365
Pamlico Class Construction Tenders (WLIC)	4		160.9	30			3,765	365
Cosmos Class Construction Tenders (WLIC)	3		100	24			1,872	365
Anvil/Clamp Class Construction Tenders (WLIC)	9		75	22			1,287	365
Harbor Tugs (WYTL)	11		65	19			963	365
Motor Lifeboats	26	94	47.9	14			523	365
Misc. Rescue and Utility Craft	1400+		Various Sizes					365
Army Vessels								
Frank Besson Class Logistic Support Ship (LSV)	6		272.8	60			6,547	183
Mechanized Landing Craft (LCM 8)	104		73.7	21			511	320
Utility Landing Craft (LCU 2000)	34		174	42			2,412	320
Utility Landing Craft (LCU 1600)	14		135	29			1,292	320
Lighter Amphibious Resupply, Cargo (LARC)	23		35	8			92	365
Large Tug (LT 128)	10		128	36			3,594	320
Large Tug (LT 100)	15		107	26.5			2,212	320
Barge Derrick, 115T (BD)	5		175	75			13,125	365
Barge Derrick, 89T (BD)	7		140	70			9,800	365
Barge Cargo (BC)	3		110	32			3,520	365

Table 2. Estimate of Annual Weather Deck Runoff From Precipitation
Navy Surface Ships, By Port

Ship Class		Home Port:	Bremerton, WA	Everett, WA	Ingleside, TX	Little Creek, VA	Mayport, FL
	Average Annual Rainfall (in):		50	31	30	45	52
	Weather Deck Area (sq ft)	Days within 12 n.m.	No. Ships	No. Ships	No. Ships	No. Ships	No. Ships
Virginia Class Cruisers (CGN 38)	28,747	164	1				
California Class Cruisers (CGN 36)	28,358	146	1				
Ticonderoga Class Cruisers (CG 47)	22,164	169					5
Kidd Class Destroyers (DDG 993)	24,166	104		2			
Arleigh Burke Class Destroyers (DDG 51)	26,326	178					2
Spruance Class Destroyers (DD 963)	22,021	181		2			6
Oliver Hazard Perry Class Frigates (FFG 7)	13,676	170		3			10
Blue Ridge Class Command Ships (LCC 19)	53,569	181					
Austin Class Transport Docks (LPD 4)	44,460	181					
Austin Class Transport Docks (LPD 7)	44,460	191					
Austin Class Transport Docks (LPD 14)	44,460	195					
Whidbey Class Dock Landing Ships (LSD 41)	39,934	171				4	
Harpers Ferry Class Dock Landing Ships (LSD 49)	39,934	216				2	
Anchorage Class Dock Landing Ships (LSD 36)	36,252	218				2	
Newport Class Tank Landing Ships (LST 1179)	28,314	183				1	
Avenger Class Mine Countermeasures Ship (MCM 1)	6,814	239			12		
Osprey Class Coastal Minehunters (MHC 51)	5,264	239			9		
Cyclone Class Patrol Ships (PC 1)	3,308	110				9	
Austin Class Command Ship (AGF 11)	29,250	186					
Safeguard Class Salvage Ships (ARS 50)	10,144	214				2	
Emory S Land Class Submarine Tenders (AS 39)	42,684	295					
Estimated Surface Runoff, (gal/yr):			756,138	1,057,434	1,581,483	5,623,465	6,684,183

Table 2. Estimate of Annual Weather Deck Runoff From Precipitation
Navy Surface Ships, By Port

Ship Class		Home Port:	Norfolk, VA	Pearl Hr, HI	Pascagoula, MS	San Diego, CA
	Average Annual Rainfall (in):		45	25	72	10
	Weather Deck Area (sq ft)	Days within 12 n.m.	No. Ships	No. Ships	No. Ships	No. Ships
Virginia Class Cruisers (CGN 38)	28,747	164				
California Class Cruisers (CGN 36)	28,358	146	1			
Ticonderoga Class Cruisers (CG 47)	22,164	169	7	3	2	8
Kidd Class Destroyers (DDG 993)	24,166	104	2			
Arleigh Burke Class Destroyers (DDG 51)	26,326	178	7	2		5
Spruance Class Destroyers (DD 963)	22,021	181	9	4		6
Oliver Hazard Perry Class Frigates (FFG 7)	13,676	170	12	2	2	12
Blue Ridge Class Command Ships (LCC 19)	53,569	181	1			
Austin Class Transport Docks (LPD 4)	44,460	181	1			2
Austin Class Transport Docks (LPD 7)	44,460	191	1			1
Austin Class Transport Docks (LPD 14)	44,460	195	2			
Whidbey Class Dock Landing Ships (LSD 41)	39,934	171				3
Harpers Ferry Class Dock Landing Ships (LSD 49)	39,934	216				1
Anchorage Class Dock Landing Ships (LSD 36)	36,252	218				3
Newport Class Tank Landing Ships (LST 1179)	28,314	183		1		
Avenger Class Mine Countermeasures Ship (MCM 1)	6,814	239				
Osprey Class Coastal Minehunters (MHC 51)	5,264	239				
Cyclone Class Patrol Ships (PC 1)	3,308	110				4
Austin Class Command Ship (AGF 11)	29,250	186				1
Safeguard Class Salvage Ships (ARS 50)	10,144	214		2		
Emory S Land Class Submarine Tenders (AS 39)	42,684	295	1			1
Estimated Surface Runoff, (gal/yr):			14,458,310	2,165,816	1,492,969	3,451,692
					Estimated Total, All Ports (gal/yr):	**37,271,490**

Table 3. Estimate of Annual Weather Deck Runoff From Precipitation
MSC, Army and USCG Surface Ships

Average Annual Rainfall (in): 40 Vessel Category	Weather Deck Area (sq ft)	Days within 12 n.m.	Number of Vessels	Estimated Runoff, (gal):
Military Sealift Command				
Kilauea Class Ammunition Ships (T-AE)	31,494	45	8	774,534
Mars Class Combat Stores Ship (T-AFS)	31,461	45	5	483,587
Sirius Class Combat Stores Ship (T-AFS)	25,140	45	3	231,853
Henry J. Kaiser Oilers (T-AO)	51,222	50	12	2,099,533
Hayes Class Acoustic Research Ship (T-AG)	15,005	45	1	46,129
Mission Class Navigation Research Ship (T-AG)	34,808	45	1	107,004
Observation Is. Class (T-AGM)	33,375	45	1	102,600
Stalwart Class Ocean Surveillance Ship (T-AGOS)	7,513	60	5	153,975
Victorious Class Ocean Surveillance Ships (T-AGOS)	21,949	120	4	719,741
Silas Bent Class Surveying Ships (T-AGS)	10,682	45	2	65,674
Waters Class Surveying Ship (T-AGS)	24,453	45	1	75,172
McDonnell Class Surveying Ships (T-AGS)	7,301	45	2	44,888
Pathfinder Surveying Ships (T-AGS)	14,861	45	4	182,746
Mercy Class Hospital Ships (T-AH)	73,637	365	2	3,672,277
Maersk Class Strategic Sealift Ships (T-AKR)	78,215	320	3	5,129,551
Gordon Class Strategic Sealift Ships (T-AKR)	79,042	320	2	3,455,850
Algol Class Fast Sealift Ships (T-AKR)	78,232	320	8	13,681,694
Zeus Class Cable Repairing Ship (T-ARC)	28,612	45	1	87,959
Powhatan Class Fleet Ocean Tugs (T-ATF)	7,869	120	7	451,557
USCG				
Hamilton Class High Endurance Cutters (WHEC)	10,633	154	12	1,342,412
Famous Class Medium Endurance Cutters (WMEC)	6,803	139	4	258,392
Famous Class Medium Endurance Cutters (WMEC)	6,803	166	9	694,312
Reliance Class Medium Endurance Cutters (WMEC)	5,582	238	5	453,826
Reliance Class Medium Endurance Cutters (WMEC)	5,582	151	11	633,449
Polar Class Icebreaker (WAGB)	21,435	365	2	1,068,959
Bay Class Tugs (WTGB)	4,106	365	9	921,430
Point Class Patrol Craft (WPB)	1,114	320	36	876,335
Island Class Patrol Boats (WPB)	1,802	320	49	1,930,053
Juniper Class Seagoing Buoy Tender (WLB)	8,073	287	2	316,565
Balsam Class Buoy Tenders (WLB)	5,195	295	23	2,407,882
Keeper Class Buoy Tenders (WLM)	4,914	227	2	152,408
Red Class Buoy Tenders (WLM)	4,041	227	9	564,018
White Sumac Class Buoy Tenders (WLM)	3,216	227	4	199,485
Inland Buoy Tenders (WLI)	1,872	365	2	93,357
Inland Buoy Tenders (WLI)	862	365	4	85,966
River Buoy Tenders, 65 ft (WLR)	1,115	365	6	166,875
River Buoy Tenders, 75 ft (WLR)	1,287	365	13	417,187
River Buoy Tenders, 115 ft (WLR)	2,691	365	1	67,100
Pamlico Class Construction Tenders (WLIC)	3,765	365	4	375,527
Cosmos Class Construction Tenders (WLIC)	1,872	365	3	140,035
Anvil/Clamp Class Construction Tenders (WLIC)	1,287	365	9	288,822
Harbor Tugs (WYTL)	963	365	11	264,219
Motor Lifeboats	523	365	26	339,110
Army				
Frank Besson Class Logistic Support Ship (LSV)	6,547	183	6	491,105
Mechanized Landing Craft (LCM 8)	511	320	104	1,161,183
Utility Landing Craft (LCU 2000)	2,412	320	34	1,792,495
Utility Landing Craft (LCU 1600)	1,292	320	14	395,403
Lighter Amphibious Resupply, Cargo (LARC)	92	365	23	52,992
Large Tug (LT 128)	3,594	320	10	785,730
Large Tug (LT 100)	2,212	320	15	725,240
Barge Derrick, 115T (BC)	13,125	365	5	1,636,359
Barge Derrick, 89T (BD)	9,800	365	7	1,710,541
Barge Cargo (BC)	3,520	365	3	263,314
	Estimated Total Annual Runoff (gals):			**54,638,410**

Table 4. Estimate of Annual CV/CVN Flight Deck Runoff From Precipitation

Homeport	CV/CVN Flt Deck Area (sq.ft.)	Estimated Days within 12 n.m.	Avg. Annual Precip. (in)			Estimated Annual Runoff (gal)
Bremerton, WA:						
USS Carl Vinson (CVN 70)	230,000	149	50			2,926,455
USS Nimitz (CVN 68)	230,000	149	50			2,926,455
Everett, WA:						
USS Abraham Lincoln (CVN 72)	230,000	149	31			1,814,402
Mayport, FL:						
USS John F. Kennedy (CV 67)	220,000	139	52			2,715,804
Norfolk, VA:						
USS Dwight D. Eisenhower (CVN 69)	230,000	149	45			2,633,809
USS Enterprise (CVN 65)	230,000	78	45			1,378,773
USS George Washington (CVN 73)	230,000	149	45			2,633,809
USS John C. Stennis (CVN 74)	230,000	149	45			2,633,809
USS Theodore Roosevelt (CVN 71)	230,000	149	45			2,633,809
San Diego, CA:						
USS Constellation (CV 64)	220,000	139	10			522,270
USS Kitty Hawk (CV 63)	220,000	139	10			522,270
			Total Annual Gallons:			**23,341,665**

Table 5. Estimate of Annual Helicopter Flight Deck Runoff from Precipitation Navy Amphibious Assault and MCM Support Ships

Ship Class		Home Port:	Norfolk, VA		San Diego, CA		Ingleside, TX	
	Flt Deck Area (sq ft)	Days within 12 n.m.	No. Ships	Avg. Ann. Rain (in)	No. Ships	Avg. Ann. Rain (in)	No. Ships	Avg. Ann. Rain (in)
Wasp Class (LHD)	86,814	188	2	45	2	10	0	0
Tarawa Class (LHA)	92,800	175	2	45	2	10	0	0
Iwo Jima Class (LPH)	62,608	189	1	45	1	10	0	0
Iwo Jima Class (MCS)	62,608	320	0	45	0	10	1	30
Estimated Runoff, gal:				5,914,333		1,314,296		1,026,497
Total Amphibious Assault Ship Runoff:								**7,228,629**
Total Mine Countermeasure Runoff:								**1,026,497**
							Total Runoff, gallons:	**8,255,126**

Table 6. Estimate of Annual Helicopter Flight Deck Runoff from Precipitation
Navy Surface Ships

Ship Class		Home Port:	Bremerton WA	Earle, NJ	Everett, WA	Mayport, FL	Norfolk, VA	Pascagoula MS	Pearl, HI	San Diego, CA
	Avg.Annual Rainfall (in):		50	42	31	52	45	72	25	10
Navy Surface Ships:	**Flt Deck Area (sq ft)**	**Days within 12 n.m.**	**No. Ships**	**No. Ships**	**No. Ships**	**No. Ships**	**No. Ships**	**No. Ships**	**No. Ships**	**No. Ships**
Ticonderoga Class Cruisers (CG)	2,160	169				5	7	2	3	8
Spruance Class Destroyers (DD)	2,184	181			2	6	9		4	6
Oliver Hazard Perry Class Frigates (FFG)	1,944	170			3	10	12	2	2	12
Austin Class Command Ships (AGF)	15,210	186								1
Sacramento Class Fst Combat Spt (AOE1)	5,893	186	2	2						
Supply Class Fst Combat Spt (AOE6)	6,650	116	1				2			
Annual Flight Deck Runoff (gals):			253,073	157,248	94,349	666,234	893,170	171,052	142,492	206,430
									Total Annual Flight Deck Runoff (gals):	**2,584,049**

Table 7. Estimate of Annual Flight Deck Runoff From Precipitation
MSC and USCG Surface Ships

	No. Ships	Flight Deck Area (sq ft)	Avg Days within 12 n.m.	U.S. Avg. An. Prec.(in)	Estimated Annual Runoff (gal)
Military Sealift Command					
Kilauea Class Ammunition Ships (T-AE)	8	4,140	45	40	101,817
Mars Class Combat Stores Ship (T-AFS)	5	4,340	45	40	66,710
Sirius Class Combat Stores Ship (T-AFS)	3	4,288	45	40	39,546
Henry J. Kaiser Oilers (T-AO)*	12	0	50	40	0
				Estimated Subtotal (gals/yr):	**208,073**
USCG					
Hamilton Class High Endurance Cutters (WHEC)	12	1,750	154	40	220,931
Famous Class Medium Endurance Cutters (WMEC)	4	1,200	139	40	45,580
Famous Class Medium Endurance Cutters (WMEC)	9	1,200	166	40	122,475
Polar Class Icebreaker (WAGB)	2	5,330	365	40	265,807
				Estimated Subtotal (gals/yr):	**654,793**
				Estimated Total (gal/yr):	**862,866**

* Denotes ships having helicopter flight decks but do not embark helicopters as part of their normal complement. Flight deck area included in deck area listed in Table 1.

Table 8. Estimate of Annual Helicopter Flight Deck Runoff From Washdowns
USCG Surface Ships

Ship Class	Flt Deck Area (sq ft)	Volume (gals/wash)			No. Ships U.S. Ports	In Port Washdowns	Totals
		Cleaner	Rinseate	Total			
Hamilton Class High Endurance Cutters (WHEC)	1,750	18	72	90	12	22	23,760
Famous Class Medium Endurance Cutters (WMEC)	1,200	12	48	60	4	20	4,800
Famous Class Medium Endurance Cutters (WMEC)	1,200	12	48	60	9	24	12,960
Polar Class Icebreaker (WAGB)	5,330	54	216	270	2	52	28,080
						Estimated Total (gals/yr):	**69,600**

* Assumes flight deck washed as a result of visiting helicopter operations.

Table 9a. Estimate of Annual Weather Deck Runoff From Precipitation
Oiler Weather Decks

Ship Class		U.S. Home Port:	Bremerton WA	Earle NJ	Norfolk VA	Pearl Harbor HI
	Average Annual Rainfall (in):		50	42	45	25
	Deck Area	Days within 12 n.m.	No. Ships	No. Ships	No. Ships	No. Ships
Jumboised Cimarron Class Oilers (AO)	48,666	191			3	2
Sacramento Class Fast Combat Support Ships (AOE 1)	60,291	186	2	2		
Supply Class Fast Combat Support Ships (AOE 6)	56,279	116	1	1	1	
Henry J Kaiser Class Oilers (TAO187)*	0	50				
Estimated Runoff, (gal):			2,472,708	2,077,075	2,644,856	793,749
* See Tables 1 and 3					**Estimated Annual Total, All Ports (gal):**	**7,988,388**

Table 9b. Estimate of Annual Weather Deck Runoff From Precipitation
Navy Auxiliary Service Craft Oilers

Service Craft Category	Deck Area (sq ft)	Days within 12 n.m.	No. Ships	U.S. Avg. An. Rainfall (in)	Estimated Annual Runoff (gal)
Fuel Oil Barge, Nonself Propelled (YON)	6,600	365	40	40	6,582,840
Fuel Gasoline Barge, Nonself Propelled (YOGN)	6,600	365	9	40	1,481,139
Fuel Oil Storage Barge (YOS)	6,600	365	5	40	822,855
				Estimated Annual Total (gal):	**8,886,834**

Table 10. Summary of Annual Runoff Estimates

		Totals (gal/yr)
Weather Deck Runoff from Precipitation		
	Navy Surface Ships	37,271,490
	MSC, Army, and USCG Surface Ships	54,638,410
	Navy Oilers	7,988,388
	Navy Service Craft, Oilers	8,886,834
Flight Deck Runoff from Precipitation		
	Navy Aircraft Carriers	23,341,665
	Navy Amphibious Assault Ships	7,228,629
	Navy Mine Countermeasure Support Ship	1,026,497
	Navy Surface Ships	2,584,049
	MSC and USCG Surface Ships	862,866
Flight Deck Runoff from Freshwater Washdowns		
	USCG Surface Ships	69,600
	Estimated Annual Total (gal/yr)	143,898,427

Table 11. Laboratory Results, Catapult Trough Drains Aqueous Phase Discharge*

Constituent	Sample Results (mg/L)	
Date:	**4/13/94**	**4/14/94**
Phenols	4.6	5.3
Oil and grease	9,683	13,919
Silver	<0.050	<0.050
Cadmium	0.155	0.141
Chromium	0.l03	0.088
Copper	<0.050	<0.050
Nickel	1.90	1.81
Lead	26.1	76.3
Zinc	<0.050	<0.050

Source: NNS Laboratory Services, 1994[28]

* Data represent concentrations prior to processing through an oil water separator.

Table 12. Comparison of Catapult Trough Drains Discharge to Water Quality Criteria[27]

Constituent	Sample Results (mg/L)		Federal Acute WQC (mg/L)	Most Stringent State Acute WQC (mg/L)
Date:	4/13/94	4/14/94		
Phenols	4.6	5.3	none	0.17 (HI)
Oil and grease	9,683	13,919	Visible sheen [1]/15[2]	5 (FL)
Silver	<0.050	<0.050	0.0019	0.0012 (WA)
Cadmium	0.155	0.141	0.042	0.0093 (FL, GA)
Chromium	0.103	0.088	1.1	0.05 (FL, GA)
Copper	<0.050	<0.050	0.0024	0.0025 (WA)
Lead	26.1	76.3	0.210	0.0056 (FL, GA)
Nickel	1.90	1.81	0.074	0.0083 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

FL = Florida
GA = Georgia
HI = Hawaii
WA = Washington

1. *The Federal Pollution Control Act*, 40CFR110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on the receiving waters.
2. *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 is implemented by the *Act to Prevent Pollution From Ships* (APPS).

Table 13. Data Sources

	Data Source			
NOD Section	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents				X
3.4 Concentrations		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Dirty Ballast

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the dirty ballast discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Dirty ballast is created when seawater is pumped into fuel tanks for the purpose of improving ship stability. Ballast is weight added to a vessel to move the center of gravity to a position that increases the vessel's stability. Ballast is normally placed low within a vessel's hull to lower the center of gravity. Permanent ballast is usually heavy solid material, such as lead. Temporary ballast is normally seawater, which is pumped in and out of tanks in the vessel.

Dirty ballast systems are different from compensated ballast and clean ballast systems. Compensated ballast systems continuously replace fuel with water in a system of tanks as fuel is consumed. Clean (or segregated) ballast systems have tanks that only carry ballast water; therefore, the ballast water does not mix with fuel. These systems are covered in other NOD reports. In a dirty ballast system, water is added to a fuel tank after most of the fuel is used. Some fuel remaining in the tank mixes with the ballast water, producing "dirty" ballast.

Most classes of Armed Forces vessels use segregated tanks as the primary ballast system and use dirty ballast systems only in extraordinary or emergency situations. Some vessel classes, however, are not provided with clean ballast systems. These vessels regularly use dirty ballast systems and discharge overboard, using oil content monitors (OCM) and oil water separators (OWS) to avoid discharging oil at concentrations greater than regulatory limits.[1] Using fuel tanks for ballast water degrades fuel quality and is therefore avoided whenever possible.

As a vessel consumes fuel, air displaces the fuel in its fuel tanks, thus reducing the vessel’s stability. There is an added detrimental effect to stability when a tank is partially full and the liquid inside can slosh around. The degree to which these factors affect ship stability are dependent on ship design and the sea state. Some classes of ships are more susceptible to stability problems than others and certain locations have historically high wave action. When ship stability is threatened, ballast water can be pumped into a fuel tank to replace the consumed fuel and to regain stability. Ballast water is discharged when it is no longer needed for operational reasons or when preparing for fuel reintroduction.

To maintain safe stability, vessels without clean ballast systems may begin ballasting fuel tanks when remaining ship’s fuel drops to approximately 70-80% of total capacity. These vessels may continue to ballast fuel tanks until approximately 20% of ship’s fuel capacity remains (the minimum percentage allowed by U.S. Coast Guard (USCG) ships).[1] Therefore, by the end of a voyage, as much as 80% of the fuel tanks’ contents could be seawater.

Procedures have been established for both ballasting and deballasting to minimize the concentration of fuel in the dirty ballast. To prepare a fuel tank for ballast, most of the remaining fuel is pumped to another fuel tank. The small quantities of fuel not removed in this first step is transferred to a waste oil tank. When deballasting, most of the dirty ballast is pumped overboard, while being monitored by an OCM, which measures the concentration of oil (fuel) in the water. If the OCM detects oil concentrations in excess of the 15 parts per million (ppm), an alarm sounds and the overboard discharge is stopped. The remaining dirty ballast is then processed through an OWS to reduce the oil concentration to 15 ppm or below, as measured by another OCM. The processed seawater is discharged overboard and the separated oil (fuel) is retained in a waste oil tank for pierside disposal.

2.2 Releases to the Environment

Dirty ballast is water which may contain residual fuel and other constituents as a result of sea water being stored in fuel tanks. Dirty ballast is discharged to the environment after being processed through OCMs and/or OWS systems that ensure the ballast water fuel/oil concentrations are below Federal standards. The discharge is infrequent and occurs just above the waterline of the ship. The possible sources of the constituents of dirty ballast are seawater, fuel remaining in the tank, fuel additives, materials used in the ballast system, and the zinc anodes in the fuel tanks.

2.3 Vessels Producing the Discharge

Three USCG vessel classes use dirty ballast systems. Ships of the WHEC 378 Class (12 ships), WMEC 210 (16 ships), and the WAGB 399 Class icebreakers (2 ships) use their fuel tanks for ballasting in accordance with published Coast Guard directives and as conditions dictate.

In an emergency, all vessels of the Armed Forces with fuel tanks have the capability to generate emergency dirty ballast. Generation of emergency dirty ballast on Navy, MSC, Army, Air Force, Marine Corps, and the remainder of the USCG vessels occurs only when the vessels' clean or compensated ballast systems are insufficient to maintain proper stability during extraordinary or emergency circumstances. Emergency dirty ballast is not considered a discharge under UNDS, and is not addressed in this report.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Two of the three USCG ship classes (WHEC 378 and WAGB 399) that use dirty ballast systems operate beyond 12 nautical miles (n.m.) of land and only transit through 12 n.m. of land entering and leaving port. These ships may deballast within 12 n.m. of land using their OCM and OWS systems however this is rarely done. The third class of ship that uses a dirty ballast system is the USCG's WMEC 210. These ships are located in several ports on the East, Gulf and West Coasts. They may conduct normal operations within 12 n.m. of land on these Coasts, and therefore may ballast and deballast within 12 n.m. of land. These vessels also deballast using their OCM and OWS systems.

The policy for MSC and Navy vessels, and the practice of USCG vessels, is to discharge dirty ballast beyond 12 n.m. of shore, or to hold the dirty ballast until it can be transferred to a shore facility or containment barge.[2,3]

3.2 Rate

A survey found that few cutters routinely use dirty ballast within 12 n.m. even though USCG policy permits discharge within this area if using an OWS and OCM.[4] The limited number of ballasting operations were insufficient to estimate the annual volume of dirty ballast discharged. Therefore, for cutter class vessels, fuel capacities, and the maximum percentage of these fuel tank capacities that are allowed by USCG policy for dirty ballasting, were used to estimate the annual volume of dirty ballast discharged. This resulted in an overestimate of dirty ballast discharge volumes for USCG vessels. Table 1 lists USCG vessel fuel capacities.

Using 80% of fuel capacities listed in Table 1 to estimate the deballasting discharge for each deballasting event, WMEC 210 Class vessels could discharge approximately 41,800 gallons of dirty ballast [(0.8)(52,236 gallons)]. The WAGB 399 Class ships could generate up to 1,080,000 gallons of dirty ballast and WHEC 378 Class ships could generate up to 166,400 gallons per deballasting event. The estimated maximum total annual discharge of dirty ballast for the three classes of USCG ships is 21.6 million gallons, using the number of deballast events per year from Table 2 and the following calculations. All of this discharge is assumed to occur within 12 n.m. of shore and the results are believed by the USCG to be a gross overestimate of the actual discharge. Of this 21.6 million gallons, two-thirds is from one class (WHEC 378) which operates principally beyond 12 n.m.

Total (gal/yr) = sum of [(0.8)(capacity)(# vessels)(# deballasting events)]

where,

Total = estimated maximum dirty ballast total annual discharge
0.8 = maximum percentage of fuel tank capacity allowed by USCG policy for dirty ballast
capacity = fuel capacity in gallons
# vessels = number of vessels per class
# deballasting events = number of deballasting events per year

The estimated maximum dirty ballast total annual discharge for WHEC 378 Class ships is:

(0.80) (208,000 gallons of fuel) (12 vessels in the class) (7 deballasting events per year)
= approximately 14 million gallons per year.

The duration of USCG vessels' dirty ballast discharge is estimated by considering deballasting procedures and equipment characteristics. Based on operational experience, approximately 75% of the dirty ballast can be discharged directly overboard while being monitored through an OCM at an estimated flow rate of 250 gallons per minute (gpm).[2] The remaining 25% of ballast is required to be processed through an OWS, at a flow rate of 25 gpm. Using a dirty ballast volume of 80% of vessel fuel capacity, an estimated flow rate of 250 gpm for direct ballast overboard discharge, and 25 gpm through the OWS, the discharge duration is summarized in Table 3. For example, the maximum time to deballast for WHEC 378 Class ships is approximately 36 hours.

These values result in the maximum expected time to deballast since the calculations assume the largest dirty ballast volume (the maximum allowed is 80% of the ship's fuel capacity) and ignore any processing of ballast through the OWS performed concurrently with the ballast being discharged directly overboard. Also, it is unlikely that the entire duration of deballasting is within 12 n.m. of shore, so the calculations overestimate the amount of dirty ballast discharged within 12 n.m.

3.3 Constituents

Because process information and data on compensated fuel ballast, a similar discharge, were sufficient to characterize this discharge, no sampling was performed on dirty ballast. The constituent sources of dirty ballast are almost identical to the constituent sources in compensated fuel ballast systems. Therefore, sampling performed for compensated fuel ballast discharge can be used to predict the constituents in dirty ballast.

Soluble components of the fuel remaining in the tank mix with the seawater ballast during extended contact while in the compensated fuel or dirty ballast tanks. The fuels will normally be either Naval Distillate Fuel (NATO F-76) or Aviation Turbine Fuel (JP-5). In addition, the USCG uses biocide fuel additives in their fuel tanks to control bacterial growth in the fuel-water interface.[5,6] All these sources can contribute to the concentrations reported as total petroleum hydrocarbons and oil and grease. Specific fuel-based constituents can include benzene, toluene, ethylbenzene, xylene, cresols, phenols, and polycyclic aromatic hydrocarbons.[7]

Materials used in fuel and ballast systems on the ships, which include copper, nickel, iron and zinc, and the fuel or additives in the fuel such as biocides, can contribute to metal concentrations in the discharge. Based on compensated ballast sampling, the metals in the discharge can include copper, nickel, silver and zinc. The biocides used can contain naphtha and dioxaborinane compounds.

The potential priority pollutants in dirty ballast discharge are 2-propenal, benzene, toluene, ethylbenzene, phenol, copper, nickel, silver, thallium, and zinc. The only bioaccumulator found in compensated ballast screening was mercury.

3.4 Concentrations

Knowledge of dirty ballasting systems and practices and use of compensated fuel ballast screening enables the characterization of dirty ballast discharge concentrations.

In support of the Compensated Ballast NOD report, a sampling effort was conducted during a refueling evolution. The results of the sampling effort are applicable to this NOD report because the same fuels are used in both compensated ballast and dirty ballast. Constituent concentrations are based on compensated ballast with the exception of oil concentrations, which are limited to 15 ppm by USCG practices and the use of OCMs and OWSs. The concentrations of detected priority pollutants, oil and grease, and a bioaccumulator are shown in Table 4.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

An estimate of the maximum oil loading from dirty ballast for the three USCG vessel classes was calculated by first estimating the greatest potential discharge volume and assuming that the discharge contains the maximum allowable concentration of oil (15 ppm). In reality, the concentration is expected to be somewhat lower than this, due to the preballasting and deballasting procedures used by the USCG vessels, as described in Section 2.1. Using these values with existing information on vessel operating profiles, an annual oil mass loading value for each of the three USCG vessel classes was calculated.

The estimated maximum oil mass loading generated for each deballast event was calculated using the equation:

Estimated Maximum Oil Loading Generated by Deballasting Event in Pounds (lbs) =
[80% fuel capacity (gal)] (3.785 L/gal)(15 mg/L)(10^{-6} kg/mg)(2.205 lb/kg)

Using this equation, the estimated maximum oil loading generated in each deballasting event for WHEC 378 Class ships is:

(0.80)(208,000 gal)(3.785 L/gal)(15 mg/L)(10^{-6} kg/mg)(2.205 lb/kg) = approximately 21 lbs

Similarly, the WMEC 210 Class and the WAGB 399 Class would generate approximately

5 and 135 pounds of fuel for each deballasting event, respectively.

The annual maximum oil mass loading per class was calculated using the equation:

Estimated Maximum Oil Loading Generated by Deballasting (lbs/yr) = (discharge amt. per event (lbs))(# vessels)(# deballasts/year)
where,
discharge amt. = pounds of oil per deballasting event
vessels = number of vessels in class
deballasts/year = number of deballasting events per year

Using this equation, the estimated maximum oil loading generated by deballasting per year for WHEC 378 Class ships is:

(21 lbs per deballast) (12 vessels in class) (7 deballasting events per year) = 1,764 lbs/yr

Given the assumed maximum concentration of 15 ppm, the maximum total mass loading for oil for all Coast Guard vessels is 2,704 pounds per year as shown in Table 2.

In a similar manner, the concentrations of each of the constituents shown in Table 4 (which are based on compensated ballast data for constituent concentrations) were used to calculate the mass loadings shown in Table 5.

4.2 Environmental Concentrations

Dirty ballast water discharged from armed forces vessels is expected to be similar to the compensated ballast discharge. In compensated ballast samples, copper, nickel, silver, and zinc exceeded Federal and the most stringent state WQC, and ammonia, benzene, phosphorous, thallium, total nitrogen, O&G, and 2-propenal concentrations exceeded the most stringent state WQC.[7] Table 4 is a summary of compensated ballast sample concentrations and applicable WQC.

4.3 Potential for Introducing Non-Indigenous Species

There is no significant potential for introducing, transporting, or releasing non-indigenous species with dirty ballast discharge. Navy and MSC policy requires that all dirty ballast be discharged beyond 50 n.m., and those USCG vessels with a combination of clean and dirty ballast systems also follow that practice.[2,3] The potential is mitigated by the fact that the three classes of USCG vessels with exclusively dirty ballast systems do not take on ballast while in port and normally ballast and deballast beyond 12 n.m., where they are less likely to take on non-indigenous species. In addition, the USCG has a policy that states if a cutter does ballast within 12 n.m. of land, a full-tank ballast exchange should be conducted twice while in open waters beyond 12 n.m., otherwise, hold the ballast and discharge it on the next voyage beyond 12 n.m.

Dirty ballast could also be discharged to a shore facility for processing. Most USCG vessels deballast prior to returning to port, at greater than 12 n.m. from shore.

5.0 CONCLUSIONS

Uncontrolled, dirty ballast has the potential to cause an adverse environmental effect because:

1) oil can be discharged in significant amounts above water quality criteria, and

2) oil in the discharge can also create a sheen that diminishes the appearance on surface waters.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 6 lists data sources for this NOD report.

Specific References

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Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. USCG Vessel Fuel Capacity and Consumption Data [8]

Vessel Class	WMEC 210	WHEC 378	WAGB 399
Fuel Capacity (100%) (gal):			
F-76 (diesel)	52,236	208,000	1,349,920

Table 2. Maximum Annual Oil Mass Loading Estimate for USCG Vessels

Vessel Class	No. of Vessels	Oil per Deballast Event (lb)	Deballast Events per Year	Maximum Oil Discharged (lbs/yr)[A]
WMEC 210	16	5	5	400
WHEC 378	12	21	7	1764
WAGB 399	2	135	2	540
				Total: 2,704 lbs/yr

Notes:

A - based on maximum allowable OWS system discharge concentration limit (15 ppm),

Table 3. USCG Vessel Dirty Ballast Discharge Duration

Vessel Class	WMEC 210	WHEC 378	WAGB 399
Amount to Deballast (gal)[A]	41,800	166,400	1,080,000
Direct Discharge (gal)	31,400	124,800	810,000
Direct Discharge (gpm)	250	250	250
Direct Discharge (hours)	2.1	8.3	54
OWS Processing (gal)	10,500	41,600	270,000
OWS Processing (gpm)	25	25	25
OWS Processing (hours)	7.0	27.7	180
Total Ballast Discharge Time (hours)[B]	9.1	36	234

Notes:

A - Amount to deballast is 80% of F-76 fuel capacity.

B - Time estimates are maximum values per deballast event, based on maximum ballast volumes and moderate direct discharge flow rates.

Table 4. Estimated Dirty Ballast Constituent Concentrations that Exceed Federal and/or Most Stringent State Water Quality Criteria Based on Compensated Ballast Sampling Measurements

Constituent	Maximum Dirty Ballast Concentration (μg/L)	Federal Acute WQC (μg/L)	Most Stringent State Acute WQC (μg/L)
Ammonia as Nitrogen	300	none	6 (HI)[A]
Benzene	153	none	71.28 (FL)
2-Propenal	203	none	18 (HI)
Total Nitrogen	580	none	200 (HI)[A]
Total Phosphorous	340	none	25 (HI)[A]
Copper	86	2.4	2.4 (CT, MS)
Mercury[B]	0.00083	1.8	0.025 (FL, GA)
Nickel	267	74	8.3 (FL, GA)
Silver	5.7	1.9	1.9 (CA, MS)
Thallium	10.8	none	6.3 (FL)
Zinc	4845	90	84.6 (WA)
Oil & Grease	15000	visible sheen[C] /15,000[D]	5000 (FL)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

A - Nutrient criteria are not specified as acute or chronic values.
B - Mercury was not found in excess of WQC; concentration is shown only because it is a bioaccumulator.
C - Discharge of Oil. 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
D - International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). MARPOL 73/78 as implemented by the Act to Prevent Pollution from Ships (APPS).

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 5. Estimated Maximum Annual Mass Loadings for Dirty Ballast Constituents that Exceed Water Quality Criteria

Constituent	Annual Mass Loading (lb/yr)
Ammonia[A]	54.2
Benzene[A]	27.6
Phosphorous[A]	61.4
Total Nitrogen	105
2-Propenal	36.6
Copper[A]	15.5
Nickel[A]	48.1
Silver[A]	1.0
Thallium	1.95
Zinc[A]	872.1
Mercury[A,B]	0.00015
Oil & Grease[C]	2704

Notes:
A - Based on constituent concentrations found in compensated ballast water
B - Mercury was not found in excess of WQC; mass loading is shown only because it is a bioaccumulator.
C - Oil and Grease mass loading based on maximum allowable OWS system discharge concentration limit (15 ppm), not on compensated ballast sampling results.
80% of the ship's fuel capacity is always used for ballast anytime a ship takes on ballast water.

Table 6. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	Data Call Responses			X
2.2 Releases to the Environment	Data Call Responses			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	Data Call Responses			X
3.2 Rate	Data Call Responses		X	
3.3 Constituents	Data Call Responses		X	X
3.4 Concentrations	Data Call Responses		X	X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Distillation and Reverse Osmosis Brine

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the distillation and reverse osmosis (RO) brine discharge and it includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Distilling and RO plants, known as “water purification plants,” generate freshwater from seawater for a variety of shipboard applications. These include potable water for drinking and hotel services (e.g., sanitary, laundry, and food preparation) and high-purity feedwater for boilers. Vessels with steam turbine propulsion plants are equipped with large boiler systems that require significant amounts of high-purity feedwater for generating high-pressure steam to operate the ship's engines. Vessels also need low-pressure steam for producing hot water and for heating.

2.1.1 Distilling Plants

Distilling plants, also known as evaporators, are used to distill freshwater from seawater. Non-volatile seawater components, such as inorganic and organic solids (dissolved and suspended), remain in the plant and become concentrated. The mixture of concentrated seawater components that remain and the constituents leached from material in the plant is known as brine and is discharged overboard.

There are two types of distilling plants used on Armed Forces vessels. One type uses low-pressure steam as the heat source and generally operates under vacuum. Figure 1 is a diagram of a two-stage flash-type distilling plant. The other type, vapor compression, uses a compressor to "drive" the evaporation process. Both types produce similar brine discharges.

The heat that is essential to the distilling process is transmitted to the influent seawater through one or more heat exchangers. The heat exchangers consist of a series of metal tubes or plates enclosed in a metal casing. They are designed to segregate the heat source fluid (steam in the case of distilling plants) from the fluid to which the heat is transmitted (influent seawater) while providing as much thermal contact through the metal surfaces as possible. This is accomplished by having a high density of tubes or plates.

Condensate, which is segregated from distillate and brine, is produced from the generating steam when it is cooled by distilling plant heat transfer surfaces. The condensate can be directed to a collection tank along with condensate from other heating devices (e.g., ventilation heaters) for reuse in the ship's boilers. The condensate that is not reused in the boilers is a source of non-oily machinery wastewater, as discussed in the NOD report for that discharge.

During the distilling process, inorganic seawater constituents form a scale on the distilling plant heat transfer surfaces. Anti-scaling compounds are continuously injected into the influent seawater to control the scaling. Nevertheless, the surfaces will gradually foul from scaling over extended periods and periodic cleaning is required to restore flow and heat transfer efficiency.

Citric acid cleaning can be done at sea or in port. At-sea acid cleaning is done during distillation by injecting the citric acid solution into the influent seawater. The citric acid reacts with the distilling plant scale to form soluble byproducts that are discharged with the distilling plant brine. Carbon dioxide is also given off by this reaction and is removed by the distilling plant air ejector.

In-port citric acid cleaning is done every 5 to 7 years on Navy distilling plants. The cleaning solution is recirculated between the distilling plant and a tank truck on the pier. The spent cleaning solution is disposed at an off-site shore facility.[1]

2.1.2 RO Plants

RO plants separate freshwater from seawater by using semi-permeable membranes as a physical barrier. The RO membrane retains a large percentage of suspended and dissolved constituents, allowing freshwater to pass through. The retained substances become concentrated into brine. Shipboard RO plants produce lower-purity freshwater than distilling plants, with total dissolved solids (TDS) concentrations two orders of magnitude greater than distilling plant distillate.[2]

Because RO plants operate at ambient temperatures, scaling is not a concern. Therefore, chemicals are not used in RO plants for either scaling suppression or cleaning.

2.2 Releases to the Environment

The overboard discharge from water purification plants on vessels is RO and distilling plant brine. The brine primarily consists of seawater, but can also contain materials from the purification plants and anti-scaling treatment chemicals. RO and distilling processes separate a relatively small proportion of freshwater from the influent seawater, returning the slightly more concentrated brine effluent to the sea. The discharged brine from distilling plants is at elevated temperatures, typically 100 to 120 °F.

The citric acid cleaning solutions that are used to periodically clean the distilling plants are either collected on-site after shoreside cleaning or discharged overboard beyond 12 n.m. after at sea cleaning.

2.3 Vessels Producing the Discharge

There are currently 541 vessels of the Armed Forces equipped with water purification plants. Four hundred fifty-seven vessels have distilling plants and the remainder have RO plants. Table 1 provides a list of Navy, MSC, USCG, and Army vessels that produce this discharge.[3]

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

The distilling plant on a steam-propelled vessel can be operated any time the vessel's boilers are operating. MSC steam-propelled ships typically operate one distiller while in port, except for ships on reduced operating status. As a result, discharge of brine from steam-propelled vessels can occur in port, at sea, and while transiting to and from port. However, diesel- and gas-turbine-propelled vessels with distilling plants, and all vessels with RO plants seldom operate their water purification plants in port or while transiting coastal waters less than 12 nautical miles (n.m.) from shore.

For Navy vessels, brine discharge within 12 n.m. is from the production of boiler feedwater. Navy vessels do not produce potable water within 12 n.m., except during extended operations.

3.2 Rate

While the existing Navy fleet has water purification plants of many sizes and capacities, current naval ship design practice is to use standardized water purification plants of two capacities: 12,000-gallons per day (gpd) distilling and RO plants and 100,000-gpd distilling plants. Multiple water purification plants will be used to achieve capacities of up to 450,000-gpd. For example, a destroyer's RO system may include two 12,000-gpd plants, while the new LPD 17 Class amphibious transport dock vessels require five 12,000-gpd plants to meet freshwater demand. Aircraft carriers have multiple 100,000-gpd distilling plants.

The volume of brine discharged from water purification plants depends on the type of plant. When operating, distilling plants are typically run at full capacity, even when the demand for potable water is low. Excess distillate is discharged directly overboard. Based on operating experience, distilling plants generate 17 gallons of brine for every gallon of fresh water. RO plants generate 4 gallons of brine for every gallon of fresh water.[3] These brine production factors can be used to calculate the water purification plant brine flow rate in gallons per day:

Water Purification Plant Brine Flow Rate in gallons per day (gpd) = (total freshwater flow in gpd) (brine production factor)

A single distilling plant on a typical Navy DD 963 Class destroyer produces 8,000 gpd of freshwater.[4] Therefore:

(8,000 gpd freshwater) (17) = 136,000 gpd brine discharge

A single RO plant on a typical Navy MHC 51 coastal minehunter produces 1,600 gpd of freshwater.[3] Therefore:

(1,600 gpd freshwater) (4) = 6,400 gpd brine discharge

Current Navy vessel water purification plant operating practice is for steam-propelled ships to operate one distilling plant in port for one to five days before departure (to fill boiler feed water tanks) and while transiting through coastal waters less than (<) 12 n.m.). Submarines are normally supplied boiler feed water by shore or a tender while in port. The distilling plants on all these vessels can be operated at full capacity while at sea (greater than (>) 12 n.m.)).

Table 1 shows estimated distilling and RO plant brine discharge quantities for various vessel classes. The estimates are based on available information regarding the number of vessels in each class, type and capacity of water purification plant(s), vessel operating schedules (number of transits and days in port per year), and water purification plant operating practices while in port, in transit (<12 n.m.) and at sea (>12 n.m.). The assumptions and formulas used to calculate the brine discharge estimates are summarized in the notes section of Table 1, and include four hours per vessel transit in coastal waters. The assumptions also include operation of one distilling plant to produce boiler feedwater for four hours prior to departure from port in the case of submarines.[3] Surface steam-powered vessels may operate a distilling plant for as much as three days prior to departure from port (i.e., every second transit).[3,5] The calculation of the total annual brine discharge within 12 n.m. of shore consists of an in-port component and a transit component, which are added together. The formula for a Navy vessel class is:

Annual Flow within 12 n.m. (gals/yr) =
(number of vessels in class) (single distiller brine flow in gal/day/vessel) (number of distillers/vessel) (number of transits/yr) ((3 days before each transit/2 transits) +
(4 hours/transit X 1 day/24 hours))

A sample calculation for the LSD 36 Class dock landing ship is as follows:

(5 ships) (510,000 gal/day/ship) (26 transits/yr) ((3 days before each transit /2) +
(4/24 day per transit)) = 111 million gals/yr

Table 1 lists the results of the above calculation for all vessels of the Armed Forces. A total of approximately 2.47 billion gallons of distilling and RO plant brine discharges occur annually within 12 n.m. from shore. Of this, approximately 1.84 billion gallons is discharged in port and 620 million gallons is discharged in transit within 12 n.m. These calculations overestimate the actual discharge rate because steam-powered surface ships can operate a distilling plant for less than three days prior to leaving port.

The volume of influent seawater to a distilling plant can be estimated using the ratio of brine produced to gallons of freshwater produced, or 17:1. This ratio indicates that for every 18 gallons of seawater introduced into a distilling plant, 17 gallons of brine is produced. Knowing that a total of approximately 2.47 billion gallons of distilling and RO plant brine discharges occur annually within 12 n.m. of shore, the following calculation can be made to approximate the total annual volume of seawater influent:

(18 gallons of seawater/17 gallons of brine) (2.47 billion gallons of brine) = 2.62 billion gallons seawater

Therefore, the influent flow rate is approximately 2.62 billion gallons, and the effluent flow rate is approximately 2.47 billion gallons

3.3 Constituents

The three sources of the constituents of water purification plant discharge are: 1) influent seawater; 2) anti-scaling treatment chemicals; and 3) the purification plant components, including heat exchangers, casings, pumps, piping and fittings. The primary constituents of the brine discharge are identical to those in seawater. These include non-volatile dissolved and suspended solids, and metals.

Distilling plants are made primarily of metal alloys that are corroded by seawater, particularly at the elevated temperatures at which these plants operate. The metal alloys used for heat transfer surfaces and other components include copper-nickel alloys, nickel/chromium alloys, stainless steel, titanium, brass, and bronze. Based on the metallurgical composition of these alloys, the corrosion process could be expected to introduce copper, chromium, nickel, and zinc into the brine. The corrosion effect on the brine discharge metal loadings is less of a concern for the RO plants, with non-metallic membranes and ambient seawater operating temperatures.

The distilling plant anti-scaling compound used in Navy surface ships is Distiller Scale Preventive Treatment Formulation. The military specification requires anti-scaling compound products to contain organic polyelectrolytes such as polyacrylates, and an antifoaming agent in aqueous solution.[6] The polyelectrolyte chelates (ties-up) inorganic constituents (calcium, magnesium, metals) to prevent them from depositing on equipment surfaces. Equipment supplier material safety data sheets (MSDSs) indicate that the products contain about 10% to 20% polyacrylate and low levels of antifoaming chemicals (e.g., one product contains 1% polyethylene glycol). Ethylene oxide was identified on two of the MSDSs as potentially present in trace amounts. One of the MSDSs also indicated that acrylic acid, acetaldehyde, and 1,4-dioxane can also be present at trace levels.[7]

Distilling plant influent and effluent were sampled for materials that had a potential for being in the discharge. An aircraft carrier, an amphibious assault ship, and a landing ship dock were sampled.[8] Based on the brine generation process, system designs, and analytical data available, analytes in the metals, organics, and classicals classes were tested. In addition, Bis(2-ethylhexyl) phthalate, a semi-volatile organic compound, was specifically tested for, since it is not covered in the three aforementioned analyte classes, but is a standard parameter in sampling for semi-volatile constituents. The results of the sampling are provided in reference 8. Table 2 provides a list of all constituents and their concentrations that were detected in the discharge. In terms of thermal effects, this discharge is expected to be warmer than ambient water temperatures with a maximum overboard discharge temperature of 120 ^{o}F.

Priority pollutants that were detected included copper, iron, lead, nickel, and zinc; and the semi-volatile organic compound bis(2-ethylhexyl) phthalate. No bioaccumulators were detected.

3.4 Concentrations

The concentrations of detected constituents are listed in Tables 2 and 3.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The water purification plant brine annual discharge flow rate (Section 3.2) and constituent concentration data (Tables 2 and 3) were used to develop brine constituent effluent mass loading estimates. Similarly, constituent influent mass loadings were found by using the seawater annual flow rate (Section 3.2) and constituent concentration data (Tables 2 and 3).

The following general formula was used to determine influent mass loading and effluent mass loading:

Mass Loading (lbs/yr) =
(concentration in µg/L) (flow rate in gal/yr) (3.7854 L/gal) (2.2 lb/kg) (10^{-9} kg/µg)

For instance, the estimated effluent mass loading for copper generated by distilling plant brine discharge is:

(217.38 µg/L) (2.47 billion gal/yr) (3.7854 L/gal)) (2.2 lb/kg) (10^{-9} kg/µg) = 4471.48 lbs/yr

The estimated influent mass loading calculation for copper is:

(83.51 µg/L) (2.62 billion gal/yr) (3.7854 L/gal) (2.2 lb/kg) (10^{-9} kg/µg) = 1822.11 lbs/yr

The mass loading of the discharge was then determined by subtracting the influent mass loading from the effluent mass loading for each constituent. Concentration values and mass loadings are provided in Table 2. Log-normal average concentrations were used because the sample data were assumed to approximate a log-normal distribution.

The mass loadings were calculated based upon flow from all distilling and RO plants and assuming constituent concentrations in distiller and RO effluent are equal. Calculations using this assumption are expected to overestimate mass loadings because constituent concentrations will be lower in RO effluent because the operating temperature is lower, resulting in less corrosion. Table 3 provides a water purification plant brine discharge mass loading summary.

4.2 Environmental Concentrations

Table 4 identifies distilling plant brine constituents that were detected at or above their respective Federal or most stringent state water quality criteria (WQC). Copper and zinc exceeded both Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen), phosphorous, iron, lead, nickel, and zinc exceed the most stringent state WQC.

4.3 Thermal Effects

The potential for distilling plant brine discharge to cause thermal environmental effects was evaluated by modeling the thermal plume generated and then comparing it to plumes representing state thermal discharge requirements. Thermal effects of distilling plant brine were modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in the receiving water body. The model was run under conditions that would overestimate the size of the thermal plume (minimal wind, slack tide) for the largest generator of distilling plant brine (aircraft carrier) and for a typical distillation brine generator (cruiser). The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington. Other coastal states require that thermal mixing zones be established on a case-by-case basis.

The Washington thermal regulations state that when natural conditions exceed 16 °C, no temperature increases will be allowed that will raise the receiving water temperature by greater than 0.3 °C. The mixing zone requirements state that mixing zones shall not extend for a distance greater than 200 feet plus the depth of the water over the discharge point, or shall not occupy greater than 25% of the width of the water body. The Virginia thermal regulations state that any rise above natural temperature shall not exceed 3 °C. Virginia requires that the plume shall not constitute more than one-half of the receiving watercourse, and shall not extend downstream at any time a distance more than five times the width of the receiving of water body at the point of discharge.

The aircraft carrier distilling plant brine flow rate was determined to be 24,083 gallons per hour at a temperature of 104 °F while the cruiser flow parameters were 120 °F and 6,375 gallons per hour for temperature and flow rate, respectively. The ambient water temperature was dependent upon location and varied between 40 and 60 °F. Both modeled discharges were continuous and were assumed to emanate from a 6-inch diameter pipe located at the bottom of the hulls. The results of this modeling are provided in Table 5.[9]

Some of the model parameter assumptions lead to a reduced amount of mixing within the harbor. The assumptions are:

- wind velocity is at a minimum (1 m/s);
- the discharge will occur during a simulated slack tide event, using a minimum water body velocity (0.03 m/s);
- the average depth of water at the pier is 40 feet.

Using the above parameters and assumptions, distilling plant brine discharges from Armed Forces vessels do not exceed state thermal mixing zone criteria.

4.4 Potential for Introducing Non-Indigenous Species

The potential for introducing, transporting, or releasing non-indigenous species with this discharge is low because the maximum retention time of water in these plants is short; therefore the effluent is discharged in the same area from which the influent seawater is taken.

5.0 CONCLUSIONS

The discharge from vessel water purification plants has the potential to cause adverse environmental effects because significant amounts of metals are discharged at concentrations above WQC.

6.0 DATA SOURCES AND REFERENCES

Table 6 lists the data source of the information presented in each section of this NOD report.

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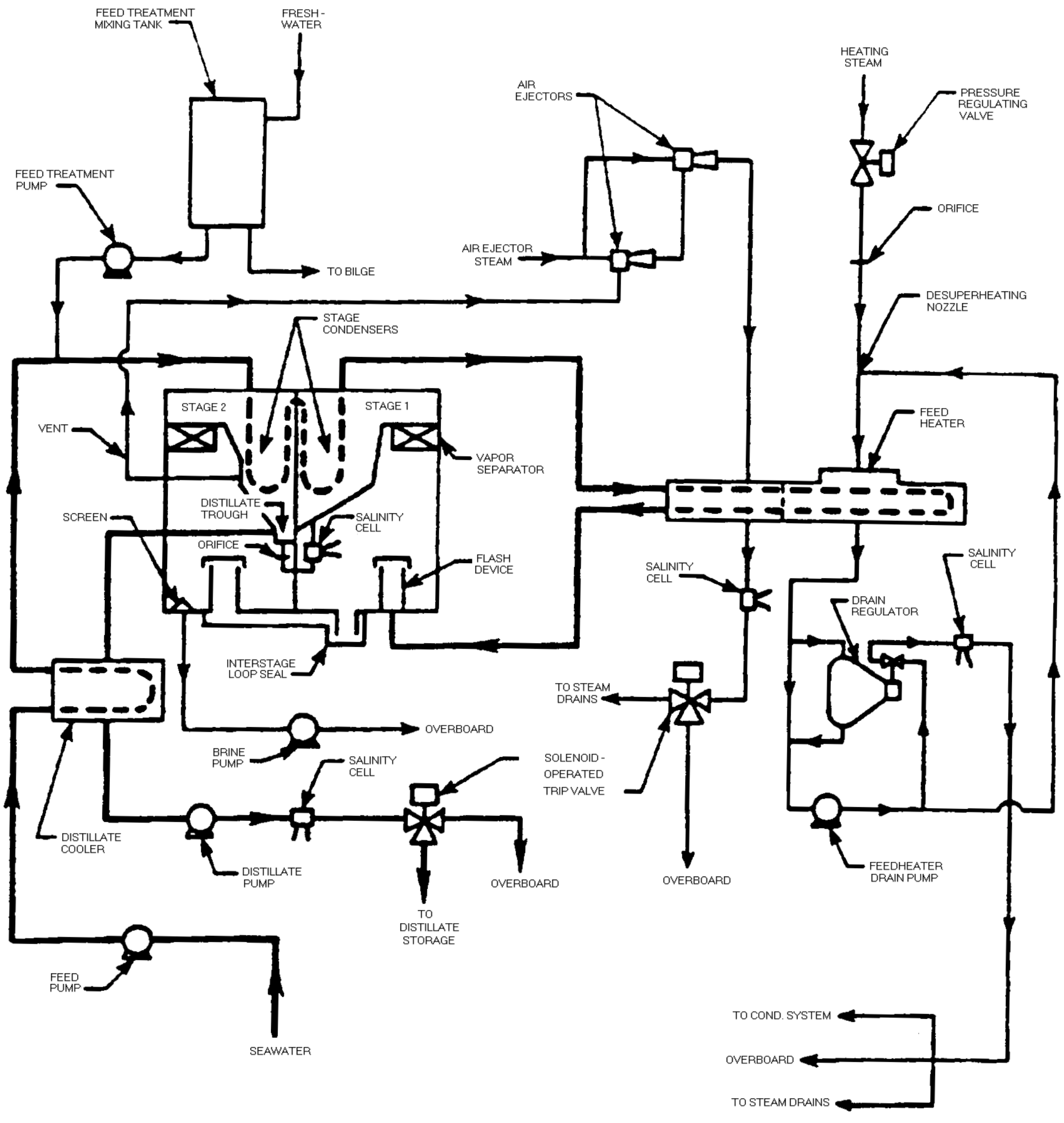

Figure 1. Diagram of a Two Stage Flash-Type Distilling Plant

Table 1. Water Purification Plant Discharge Summary

VESSEL CLASSIFICATION INFORMATION						WATER PURIFICATION SYSTEM			TRANSIT INFORMATION		ANNUAL BRINE WASTEWATER DISCHARGE (million gals/year)			
CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PRO-PULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
AE 26	MSC	Kilauea	Ammunition Ship	5	Steam	Distill / 2	32,000	544,000	8	26	35.4	1.8	918.5	955.6
AE 26	MSC	Kilauea	Ammunition Ship (ROS)	3	Steam	Distill / 2	32,000	544,000	8	26	9.8	1.1	551.1	562.0
AFS 1 (1)	MSC	Mars	Combat Store Ship (ROS)	1	Steam	Distill / 2	24,000	408,000	14	148	4.3	0.5	87.6	92.3
AFS 1 (3,5,6,7)	MSC	Mars	Combat Store Ship	4	Steam	Distill / 2	32,000	544,000	14	148	161.0	2.5	467.1	630.7
AFS 8	MSC	N/A	Combat Store Ship	3	Steam	Distill / 2	32,000	544,000	14	148	120.8	1.9	350.3	473.0
AG 194	MSC	Vanguard	Navigation Research Ship	1	Steam	Distill / 1	16,000	272,000	20	151	41.1	0.9	57.3	99.3
AG 195	MSC	Hayes	Sound Trials Ship	1	Diesel	RO 2	10,000	40,000	20	151	0	0	8.4	8.4
AGM 22	MSC	Converted Haskell	Missile Range Instrumentation Ship	1	Steam	Distill / 2	24,000	408,000	8	133	27.1	0.3	94.1	121.5
AGOS 1	MSC	Stalwart	Ocean Surveillance Ship	5	Diesel	Distill / 2	6,000	102,000	8	70	0	0	149.8	149.8
AGOS 19	MSC	Victorious	Ocean Surveillance Ship	4	Diesel	Distill / 2	6,000	102,000	10	107	0	0	104.6	104.6
AGS 26	MSC	Silas Bent and Wilkes	Surveying Ship	2	Diesel	Distill / 2	6,000	102,000	12	44	0	0	65.1	65.1
AGS 45	MSC	Waters	Surveying Ship	1	Diesel	Distill/ 2	15,324	260,508	2	7	0	0	93.2	93.2
AGS 51	MSC	John McDonnell	Surveying Ship	1	Diesel	RO/ 2	4,000	16,000	12	96	0	0	4.3	4.3
AGS 52	MSC	John McDonnell	Surveying Ship	1	Diesel	RO/ 3	6,000	24,000	12	96	0	0	6.4	6.4
AGS 60	MSC	Pathfinder	Surveying Ship	4	Diesel	RO/ 2	8,000	32,000	NA	NA	0	0	0	NA
AH 19	MSC	Mercy	Hospital Ship (ROS)	2	Steam	Distill/ 4	300,000	5,100,000	4	184	15.3	1.7	1839.4	1856.4
AKR 287	MSC	Algol	Vehicle Cargo Ship (ROS)	8	Steam	NA	NA	NA	6	109	NA	NA	NA	NA
AKR 295	MSC	NA	Vehicle Cargo Ship (ROS)	2	Diesel	Distill/ 1	9,511	161,687	NA	NA	0	0	NA	NA
AKR 296	MSC	NA	Vehicle Cargo Ship (ROS)	1	Diesel	Distill/ 4	8,200	139,400	NA	NA	0	0	NA	NA
ARC 7	MSC	Zeus	Cable Ship	1	Diesel	Distill/ 2	18,000	306,000	4	8	0	0	109.0	109.0
AO 187	MSC	Henry J. Kaiser	Oiler	12	Diesel	Distill 2	20,000	340,000	12	78	0	0	1162.8	1162.8
ATF 166	MSC	Powhatan	Fleet Ocean Tug	7	Diesel	RO/ 1	2,000	8,000	32	127	0	0	13.0	13.0
AO 177	NAVY	Jumboised Cimarron	Oiler	5	Steam	Distill/ 2	12,000	204,000	20	188	15.3	1.7	177.1	194.1
AOE 1	NAVY	Sacramento	Fast Combat Support Ship	1	Steam	Distill/ 2	100,000	1,700,000	22	183	28.1	3.1	303.2	334.3
AOE 1 (2-4)	NAVY	Sacramento	Fast Combat Support Ship	3	Steam	Distill/ 2	80,000	1,360,000	22	183	67.3	7.5	727.6	802.4
AOE 6	NAVY	Supply	Fast Combat Support Ship	3	Gas	Distill/ 2	60,000	1,020,000	12	114	0	0	761.9	761.9
ARS 50	NAVY	Safeguard	Salvage Ships	3	Diesel	Distill/ 2	8,000	136,000	44	208	0	0	61.1	61.1
ARS 50 (ARS 52)	NAVY	Safeguard	Salvage Ships	1	Diesel	Distill/ 3	12,000	204,000	44	208	0	0	30.5	30.5
AS 33	NAVY	Simon Lake	Submarine Tender	1	Steam	Distill/ 2	100,000	1,700,000	12	229	15.3	1.7	227.8	244.8

VESSEL CLASSIFICATION INFORMATION						WATER PURIFICATION SYSTEM			TRANSIT INFORMATION		ANNUAL BRINE WASTEWATER DISCHARGE (million gals/year)			
CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PRO-PULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
AS 39	NAVY	Emory S Land	Submarine Tender	3	Steam	Distill/ 2	100,000	1,700,000	12	293	45.9	5.1	357.0	408.0
CG 47	NAVY	Ticonderoga	Guided Missile Cruiser	27	Gas	Distill/ 2	24,000	408,000	24	166	0	0	2126.1	2126.1
CGN 36	NAVY	California	Guided Missile Cruiser	2	Nuclear	Distill/ 2	36,000	612,000	22	143	20.2	2.2	265.0	287.4
CGN 38	NAVY	Virginia	Guided Missile Cruiser	1	Nuclear	Distill/ 2	36,000	612,000	22	143	10.1	1.1	132.5	143.7
CV 59 (CV 62)	NAVY	Forrestal	Aircraft Carrier	1	Steam	Distill/ 5	380,000	6,460,000	14	137	27.1	3.0	1450.3	1480.4
CV 63	NAVY	Kitty Hawk	Aircraft Carrier	1	Steam	Distill/ 5	380,000	6,460,000	14	137	27.1	3.0	1450.3	1480.4
CV 63 (CV 64)	NAVY	Kitty Hawk	Aircraft Carrier	1	Steam	Distill/ 6	400,000	6,800,000	14	137	23.8	2.6	1526.6	1553.0
CVN 65	NAVY	Enterprise	Aircraft Carrier	1	Nuclear	Distill/ 5	350,000	5,950,000	12	76	21.4	2.4	1701.7	1725.5
CV 67	NAVY	Kennedy	Aircraft Carrier	1	Steam	Distill/ 5	450,000	7,650,000	14	137	32.1	3.6	1717.4	1753.1
CVN 68	NAVY	Nimitz	Aircraft Carrier	7	Nuclear	Distill/ 4	400,000	6,800,000	14	147	249.9	27.8	10210.2	10487.9
DD 963	NAVY	Spruance	Destroyer (Typical)	27	Gas	Distill/ 2	16,000	272,000	24	178	0	0	1329.3	1329.3
DD 963	NAVY	Spruance	Destroyer (DD 963 & DD 964)	2	Gas	RO/ 2	24,000	96,000	24	178	0	0	34.8	34.8
DD 963	NAVY	Spruance	Destroyer (DD 992)	1	Gas	Distill/RO 3	25,000	308,000	24	178	0	0	55.7	55.7
DD 997	NAVY	Spruance	Destroyer	1	Gas	Distill/ 2	24,000	408,000	24	178	0	0	73.8	73.8
DDG 51	NAVY	Arleigh Burke	Guided Missile Destroyer	18	Gas	RO/ 2	24,000	96,000	22	101	0	0	446.7	446.7
DDG 993	NAVY	Kidd	Guided Missile Destroyer	4	Gas	Distill/ 2	20,000	340,000	24	175	0	0	250.2	250.2
FFG 7	NAVY	Oliver Hazard Perry	Guided Missile Frigate	43	Gas	Distill/ 2	8,000	136,000	26	167	0	0	1119.9	1119.9
LCC 19	NAVY	Blue Ridge	Amphibious Command Ship	2	Steam	Distill/ 2	100,000	1,700,000	16	179	40.8	4.5	618.8	664.1
LHA 1	NAVY	Tarawa	Amphibious Assault Ship	5	Steam	Distill/ 2	140,000	2,380,000	18	173	160.7	17.9	2231.3	2409.8
LHD 1	NAVY	Wasp	Amphibious Assault Ship	4	Steam	Distill/ 2	200,000	3,400,000	26	185	265.2	29.5	2359.6	2654.3
LPD 4	NAVY	Austin	Amphibious Transport Dock	3	Steam	Distill/ 2	60,000	1,020,000	22	178	50.5	5.6	555.4	611.5
LPD 7	NAVY	Austin	Amphibious Transport Dock	3	Steam	Distill/ 2	60,000	1,020,000	24	188	55.1	6.1	523.3	584.5
LPD 14	NAVY	Austin	Amphibious Transport Dock	2	Steam	Distill/ 2	60,000	1,020,000	22	192	33.7	3.7	341.7	379.1
LPH 2	NAVY	Iwo Jima	Amphibious Assault Helicopter Carrier	2	Steam	Distill/ 2	100,000	1,700,000	22	186	56.1	6.2	589.9	652.2
LSD 36	NAVY	Anchorage	Dock Landing Ship	5	Steam	Distill/ 2	60,000	1,020,000	26	215	99.5	11.1	731.9	835.4
LSD 41	NAVY	Whidbey Island	Dock Landing Ship	8	Diesel	Distill/ 2	60,000	1,020,000	26	170	0	0	1538.2	1538.2
LSD 49	NAVY	Harpers Ferry	Dock Landing Ship	3	Diesel	Distill/ 2	60,000	1,020,000	NA	NA	0	0	NA	NA
MCM 1 (1-10)	NAVY	Avenger	Mine Countermeasure Vessel	10	Diesel	Distill/ 2	4,000	68,000	56	232	0	0	80.9	80.9
MCM 1 (11-14)	NAVY	Avenger	Mine Countermeasure Vessel	4	Diesel	Distill/RO 2	6,000	76,000	56	232	0	0	36.2	36.2

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CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PROP-ULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
MHC 51	NAVY	Osprey	Coastal Minehunter Vessel	12	Diesel	RO/ 1	1,600	6,400	56	232	0	0	9.1	9.1
MCS 12	NAVY	Converted Iwo Jima	MCM Support Ship	2	Steam	Distill / 2	100,000	1,700,000	22	186	56.1	6.2	589.9	652.2
PC 1	NAVY	Cyclone	Coastal Defense Ship	13	Diesel	RO/ 3	1,200	4,800	36	105	0	0	15.7	15.7
SSN 637	NAVY	Sturgeon	Submarine	13	Nuclear	Distill / 1	8,000	136,000	14	NA	2.1	4.1	NA	NA
SSN 640	NAVY	Ben Franklin	Submarine	2	Nuclear	Distill / 1	8,000	136,000	14	NA	0.3	0.6	NA	NA
SSN 671	NAVY	Narwhal	Submarine	1	Nuclear	Distill / 1	8,000	136,000	14	NA	0.2	0.3	NA	NA
SSN 688	NAVY	Los Angeles	Submarine	56	Nuclear	Distill / 1	10,000	170,000	14	NA	11.1	22.2	NA	NA
SSBN 726	NAVY	Ohio	Submarine	17	Nuclear	Distill / 1	12,000	204,000	22	NA	6.4	12.7	NA	NA
WAGB 399	USCG	Polar	Icebreaker	2	Diesel	Distill / 2	16,000	272,000	NA	NA	0	0	NA	NA
WHEC 378	USCG	Hamilton/Hero Class	High Endurance Cutter	12	Diesel	Distill / 1	10,000	170,000	26	151	0	100.0	329.9	429.9
WIX 295	USCG	Eagle	Sailing Ship (Barque, Training)	1	Diesel	RO/ 2	7,600	30,400	24	265	0	0	2.9	2.9
WLB 180B	USCG	Balsam	Seagoing Tenders	2	Diesel	RO/ 1	500	2,000	10	120	0	0.0	0	0.0
WLB 225	USCG	Juniper	Seagoing Tenders	2	Diesel	Distill / 1	1,000	17,000	NA	NA	0	0	NA	NA
WMEC 210A	USCG	Reliance	Medium Endurance Class	5	Diesel	Distill / 1	3,000	51,000	18	149	0	59.9	60.0	119.9
WMEC 210B	USCG	Reliance	Medium Endurance Class	11	Diesel	Distill / 1	3,000	51,000	18	149	0	59.9	60.0	119.9
WMEC 213	USCG	Diver	Medium Endurance Class	1	Diesel	Distill / 1	3,000	51,000	18	98	0	7.0	20.0	27.0
WMEC 230	USCG	Storis	Medium Endurance Class	1	Diesel	Distill / 1	3,000	51,000	22	167	0	2.0	8.0	10.0
WMEC 270A	USCG	Bear	Medium Endurance Class	4	Diesel	Distill / 1	6,000	102,000	14	164	0	83.0	100.0	183.0
WMEC 270B	USCG	Bear	Medium Endurance Class	9	Diesel	Distill / 1	6,000	102,000	14	164	0	83.0	100.0	183.0
WPB 110A	USCG	Island	Patrol Craft	16	Diesel	RO/ 1	300	1,200	4	72	0	6.0	0	6.0
WPB 110B	USCG	Island	Patrol Craft	21	Diesel	RO/ 1	300	1,200	14	137	0	6.0	0	6.0
WPB 110C	USCG	Island	Patrol Craft	12	Diesel	RO/ 1	300	1,200	10	157	0	3.0	0	3.0
LSV	ARMY	NA	Logistics Support Vessel	6	Diesel	Distill/ 2	2,000	34,000	40	150	0	0.0	41.8	41.8
LCU-2000	ARMY	NA	2000 Class Landing Craft Utility	35	Diesel	RO/ 2	800	32,000	6	275	0	0.0	9.9	9.9
LT-128	ARMY	NA	128 ft Large Tug	6	Diesel	RO/ 2	600	2,400	10	245	0	0.0	1.7	1.7
			TOTALS:	541					1,480	10,957	1,836	616	43,575	46,027

Notes:

1. NA = Information not available; distilling plant assumed.
2. One transit = travel from sea to port, or from port to sea.
3. General Assumptions (typical or average per fleet):
   a. Vessel and submarine travel time in coastal waters (<12 n.m.) is 4 hours per transit.
   b. Steam propelled ships operate one distilling plant unit in port for an average of 3 days (4 hours for submarines) prior to departure (to fill boiler feed water tanks) and while transiting outbound through coastal waters. Ship distilling plants are operated at full capacity while at sea (>12 n.m.).
   c. Diesel and gas turbine propelled ships do not operate water purification systems in port or while transiting coastal waters.
   d. Daily Brine Flow = H20 Design Capacity times 17 for evaporation systems and 4 for RO systems..
4. MSC Water Purification Operating Criteria
   a. Steam propelled MSC ships operate at least one distilling plant unit at all times while in port, except for ships in reduced operating status (ROS).
5. Annual Brine Discharge Formulas:
   a. IN-PORT (steam propelled)
      1.) Navy and MSC ROS
      2.) MSC NON-ROS
   b. IN-TRANSIT (steam propelled)
   c. >12 n.m. (all ships)
6. Out of the 18 DDG51 Class ships currently in commission, DDG 52 through 63 do not have RO units. They have vapor compression distillers. There are plans to replace them with ROs in the future.

Table 2. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Influent Mass Loading	Effluent Mass Loading	Mass Loading (Effluent - Influent)
	Evaporator Brine Influent				Evaporator Brine Effluent						
Metals	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)	(lbs/yr)	(lbs/yr)
Aluminum											
Dissolved	34.54	1 of 3	BDL	61.3	41.65	1 of 3	BDL	187	753.63	856.73	103.1
Total	370.83	2 of 3	BDL	2390	938.56	3 of 3	493.5	1380	8091.16	19306.05	11214.89
Arsenic											
Dissolved	~	~	~	~	2.93	2 of 3	BDL	10.9	~	60.27	60.27
Total	1.71	1 of 3	BDL	2	2.18	1 of 3	BDL	1	37.31	44.84	7.53
Barium											
Dissolved	12.51	3 of 3	7.1	17.8	21.21	3 of 3	17.5	23.8	272.96	436.29	163.33
Total	22.18	3 of 3	16.6	27.5	30.15	3 of 3	27	34.35	483.95	620.18	136.23
Boron											
Dissolved	2368.67	3 of 3	2140	2810	2472.67	3 of 3	2270	2775	51682.12	57033.44	5351.32
Total	2466.79	3 of 3	2030	3160	2588.76	3 of 3	2350	3115	53823	53250.44	(a)
Calcium											
Dissolved	227789.51	3 of 3	204000	267000	234484.79	3 of 3	210500	264000	4970149.71	4823320.15	(a)
Total	234025.72	3 of 3	193000	290000	243238.76	3 of 3	221000	287500	5106217.86	5003388.16	(a)
Copper											
Dissolved	29.97	2 of 3	BDL	404	59.21	3 of 3	49.7	71.15	653.92	1217.94	564.02
Total	83.51	3 of 3	12.7	1560	217.38	3 of 3	127	325.5	1822.11	4471.48	2649.37
Iron											
Total	594.59	3 of 3	107	2090	1081.50	3 of 3	576.5	1590	12973.39	22246.31	9272.92
Lead											
Dissolved	~	~	BDL	BDL	10.94	2 of 3	BDL	12.95	~	225.03	225.03
Total	6.77	1 of 3	BDL	2.7	23.84	2 of 3	BDL	24.4	147.71	490.39	342.68
Magnesium											
Dissolved	765931.19	3 of 3	699000	883000	783038.72	3 of 3	712500	904500	16711887.56	16106999.66	(a)
Total	781032.79	3 of 3	661000	978000	793166.24	3 of 3	693500	945500	17041390.06	16315321.37	(a)
Manganese											
Dissolved	11.10	3 of 3	3.5	24	9.83	3 of 3	6.6	12.5	242.19	202.20	(a)
Total	39.86	3 of 3	25.1	51.3	35.27	3 of 3	23.65	51.75	869.71	725.50	(a)
Molybdenum											
Dissolved	6.83	1 of 3	BDL	8.5	5.97	2 of 3	BDL	7.05	149.02	122.80	(a)
Total	8.57	2 of 3	BDL	14	6.72	2 of 3	BDL	15.4	186.99	138.23	(a)
Nickel											
Dissolved	32.40	1 of 3	BDL	500	9.71	1 of 3	BDL	20.1	706.94	199.73	(a)
Total	44.43	1 of 3	BDL	1290	13.17	2 of 3	BDL	32	969.42	270.91	(a)
Selenium											
Dissolved	~	~	BDL	BDL	13.83	1 of 3	BDL	42.9	~	284.48	284.48
Total	~	~	BDL	BDL	13.72	1 of 3	BDL	41.6	~	282.22	282.22
Sodium											
Dissolved	6733418.84	3 of 3	5840000	8500000	7096448.89	3 of 3	6190000	8585000	146916772.7	145972985.71	(a)

Total	6756605.00	3 of 3	5540000	8310000	7047726.17	3 of 3	6390000	8110000	147422672.6	144970766.01	(a)
Tin											
Dissolved	~	~	BDL	BDL	7.20	1 of 3	BDL	6.9	~	148.10	148.1
Total	~	~	BDL	BDL	14.68	3 of 3	8.2	42.1	~	301.97	301.97
Titanium											
Total	13.12	2 of 3	BDL	55.8	25.49	3 of 3	8.85	51.15	286.27	524.33	238.06
Zinc											
Dissolved	14.78	2 of 3	BDL	26.8	70.33	3 of 3	54.15	116.5	322.49	1446.68	1124.19
Total	18.49	2 of 3	BDL	43.9	122.26	3 of 3	92.95	174	403.43	2514.87	2111.44
Classicals	(mg/L)		(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(lb/yr)	(lb/yr)	(lbs/yr)
Alkalinity	82.44	3 of 3	70	92	91.50	3 of 3	76	105	1798762.12	1882142.52	83380.4
Ammonia as Nitrogen	0.07	1 of 3	BDL	0.11	0.17	2 of 3	BDL	0.33	1527.33	2262.68	735.35
Chemical Oxygen Demand	139.58	2 of 3	BDL	412	244.93	3 of 3	137	429	3045502.39	5038176.69	1992674.3
Chloride	12288.42	3 of 3	10900	15200	13260.50	3 of 3	11500	14800	268121596.3	272766676.27	4645080
HEM	3.83	1 of 3	BDL	9	2.86	1 of 3	BDL	5	83566.94	58829.81	(a)
Nitrate/Nitrite	0.02	1 of 3	BDL	0.2	0.02	1 of 3	BDL	0.22	436.38	411.39	(a)
Sulfate	1626.17	3 of 3	1360	1860	1629.17	3 of 3	1370	1890	35481477.38	33511804.68	(a)
Total Dissolved Solids	20202.53	3 of 3	18200	22100	20659.78	3 of 3	17700	26500	440799923.3	424968856.61	(a)
Total Kjeldahl Nitrogen	0.54	3 of 3	0.31	0.75	0.47	2 of 2	0.46	0.49	11782.28	9667.84	(a)
Total Organic Carbon	1.59	2 of 3	BDL	3.5	3.01	3 of 3	2.6	3.5	34692.28	61915.29	27223.01
Total Phosphorous	0.17	3 of 3	0.13	0.25	0.23	3 of 3	0.16	0.27	3709.24	4731.07	1021.83
Total Recoverable Oil & Grease	1.38	2 of 3	BDL	3.4	1.95	3 of 3	0.6	4.2	30110.28	40111.23	10000.95
Total Sulfide	5.77	3 of 3	4	8	5.52	3 of 3	4	7	125895.89	113545.65	(a)
Total Suspended Solids	48.34	3 of 3	32	107	85.04	3 of 3	27	386	1054732.66	1749261.20	694528.54
Volatile Residue	620.87	2 of 3	BDL	18200	594.19	2 of 3	BDL	18900	13546790.84	12222407.25	(a)
Organics	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(lb/yr)	(lb/yr)	(lbs/yr)
4-Chloro-3-Methylphenol	~	~	BDL	BDL	20.94	2 of 3	BDL	75	~	430.73	430.73

BDL = Below Detection Limit
~ = Value could not be calculated because samples are BDL
(a) = Mass loading estimates were not determined for parameters for which the influent mass loading exceeded the effluent mass loading.

Table 3. Estimated Mass Loadings of Constituents

Constituent	Log-normal Mean Influent (μg/L)	Log-normal Mean Effluent (μg/L)	Influent Mass Loading (lbs/yr)	Effluent Mass Loading (lbs/yr)	Estimated Annual Mass Loading (Effluent - Influent) (lbs/yr)
Ammonia as Nitrogen	0.07	0.17	1527.33	2262.68	735.35
Nitrate/Nitrite	20	20	436.38	411.39	-24.99
Total Kjeldahl Nitrogen	540	470	11782.28	9667.84	-2114.44
Total Phosphorous	0.17	0.23	3709.24	4731.07	1021.83
Copper					
Dissolved	29.97	59.21	653.92	1217.94	564.02
Total	83.51	217.38	1822.11	4471.48	2649.37
Iron					
Total	594.59	1081.50	12973.39	22246.31	9272.92
Lead					
Total	6.77	23.84	147.71	490.39	342.68
Nickel					
Total	44.43	13.17	969.42	270.91	-698.51
Zinc					
Total	18.49	122.26	403.43	2514.87	2111.14

Notes:

1. The table lists all constituents whose effluent log-normal mean concentration exceeds the Federal or most stringent state water quality criteria. 2. The average total concentration is the log-normal mean for a constituent, determined from Table 2, by subtracting the influent total average (background) concentration from the effluent total average concentration.
3. Mass loadings are based on average total concentrations and a total fleet brine discharge flow estimate of 2.47 billion gallons per year to navigable waters less than 12 n.m. from shore (1.84 billion gallons per year in port and 0.62 billion gallons per year in transit, from Table 1). Mass loading was not determined for nickel, for which the influent concentration exceeded the effluent concentration.

Table 4. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (μg/L)					
Ammonia as Nitrogen	170	BDL	330	None	6 (HI)[A]
Nitrate/Nitrite	20	BDL	220	None	8 (HI)[A]
Total Kjeldahl Nitrogen	470	460	490	None	-
Total Nitrogen[B]	490			None	200 (HI)[A]
Total Phosphorous	230	160	270	None	25 (HI)[A]
Metals (μg/L)					
Copper					
Dissolved	59.21	49.7	71.15	2.4	2.4 (CT, MS)
Total	217.38	127	325.5	2.9	2.5 (WA)
Iron					
Total	1081.5	576.5	1590	None	300 (FL)
Lead					
Total	23.84	BDL	24.4	217.2	5.6(FL, GA)
Nickel					
Total	13.17	BDL	32	74.6	8.3 (FL, GA)
Zinc					
Total	122.3	93.0	174	95.1	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 5. Summary of Thermal Effects of Distilling Plant Brine Discharge[9]

CASE	Discharge Temp (°F)	Discharge Flow (gallons per hour)	Ambient Water Temp (°F)	Predicted Plume Length (m)	Allowable Plume Length (m)	Predicted Plume Width (m)	Allowable Plume Width (m)	Predicted Plume Depth (m)
Virginia State (3.0°C ΔT)								
4a (CV 63)	104	24,083	40	3.8	32,000	0.43	3,200	0.43
4b (CGN 36)	120	6,375	40	2.57	32,000	0.35	3,200	0.35
Washington State (0.3°C ΔT)								
4a (CV 63)	104	24,083	50	16.42	73	1.83	400	1.83
4b (CGN 36)	120	6,375	50	7.72	73	19.28	400	0.96

Table 6. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation	NSTM[a]			X
2.2 Releases to the Environment	NSTM and MSDSs[a,b]			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	Design Documentation		X	X
3.3 Constituents		X		X
3.4 Concentrations	MSDS[b]	X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Thermal Effects	X			
4.4 Potential for Introducing Non-Indigenous Species				X

[a] NSTM - Naval Ships' Technical Manual
[b] MSDS - Material Safety Data Sheet

DISTILLATION AND REVERSE OSMOSIS BRINE MARINE POLLUTION CONTROL DEVICE (MPCD) ANALYSIS

Several alternatives were investigated to determine if any reasonable and practicable MPCDs exist or could be developed for controlling distillation and reverse osmosis (RO) brine discharges. An MPCD is defined as any equipment or management practice, for installation or use onboard a vessel, designed to receive, retain, treat, control, or eliminate a discharge incidental to the normal operation of a vessel. Phase I of UNDS requires several factors to be considered when determining which discharges should be controlled by MPCDs. These include the practicability, operational impact, and cost of an MPCD. During Phase I of UNDS, an MPCD option was deemed reasonable and practicable even if the analysis showed it was reasonable and practicable only for a limited number of vessels or vessel classes, or only on new construction vessels. Therefore, every possible MPCD alternative was not evaluated. A more detailed evaluation of MPCD alternatives will be conducted during Phase II of UNDS when determining the performance requirements for MPCDs. This Phase II analysis will not be limited to the MPCDs described below and may consider additional MPCD options.

MPCD Options

Distilling and RO plants generate freshwater from seawater for a variety of shipboard applications, including potable water for drinking, hotel services, aircraft and vehicle washdowns, boiler feedwater on steam-powered vessels, and auxiliary boiler feedwater on most vessels. Discharges from distilling and RO plants contain influent seawater, contaminants from system components, and anti-scaling treatment chemicals. Distilling plants boil seawater, and the resulting steam is condensed into distilled water. During the distilling process, seawater constituents form a scale on the heat transfer surfaces. Therefore, anti-scaling compounds are continuously injected into the influent seawater to control the scaling. The remaining seawater concentrate or “brine” that does not boil away is discharged overboard. RO systems separate freshwater from seawater using semi-permeable membranes as a physical barrier, allowing a portion of the influent seawater to pass through the membrane as freshwater, while capturing suspended and dissolved constituents. These captured substances become concentrated in a seawater brine that is subsequently discharged overboard.

Five potential MPCD options were investigated for controlling this discharge within 12 n.m. of shore. The MPCD options were selected based on screenings of alternate materials and equipment, pollution prevention options, and management practices. They are listed below with brief descriptions of each:

Option 1: Restrict operation of water purification plants in port - Eliminate or minimize distilling and RO plant use in port. This would require alternate sources of distilled/demineralized water for boiler feedwater for steam powered vessels.

Option 2: Layup non-essential water purification plants with freshwater when in port - Require the use of shore-supplied freshwater to layup all water purification plants on non-steam powered vessels and the non-essential plants onboard steam powered vessels, to reduce corrosion.

Option 3: Require RO systems on new ships - Specify RO plants instead of distilling plants to meet freshwater requirements (except boiler feedwater production) for new construction ships. RO plant discharges are expected to contain fewer heavy metals.

Option 4: Substitute freshwater for seawater to operate distilling plants onboard steam-powered vessels while in port - Require freshwater from a shore connection, instead of seawater, to provide feedwater for distilling plants on steam-powered vessels. This option would reduce metal mass loadings in the brine discharge by reducing seawater induced corrosion.

Option 5: Change distilling and RO plant construction materials - Specify water purification plants that are constructed of materials that minimize or eliminate discharge of harmful constituents.

MPCD Analysis Results

Table 1 shows the results of the MPCD analysis. It contains information on the elements of practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a final determination for each option. Based on these findings, Option 3 -- requiring RO systems on new construction ships – offers the best combination of these elements and is considered to represent a reasonable and practicable MPCD.

Table 1. MPCD Option Analysis and Determination

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 1. Restrict operation of water purification plants in port	This option primarily affects steam-powered surface ships, which run their distillers in port to produce feedwater for their propulsion boilers. Distilled water would alternatively have to be provided by shore facilities and it is unlikely that the shore facilities could meet the full feedwater requirements of the ships in a port.	The impact of this option on operational capabilities depends on the amount of distilled water that can be obtained from shore for boiler feedwater. Inadequate feedwater supply will adversely affect the ability to get a steam-powered ship underway, and whether or not sufficient reserves are available to quickly go to full power and to sustain that power for as long as needed.	This option would impose additional costs to meet distilled water requirements from an alternate, shoreside source. [1] Costs include shore infrastructure and possible additional shoreside manning. Similar costs would be incurred if shore-supplied steam were used in place of steam from in-port boiler operation. This option would reduce shipboard water purification plant operating and maintenance costs.	This option would be effective in reducing in-port distilling plant brine discharge constituents and any accompanying thermal effects. The effectiveness of this option is proportional to how much the distilling plant operation could be restricted, which would depend on the availability of alternate sources of boiler feedwater and/or steam.	Although this option would reduce the discharge, there is currently no alternate source of boiler feedwater, the option has the possibility to cause an adverse effect on operational capabilities, and this option would impose additional costs to provide an alternate source of boiler feedwater for the operation of propulsion boilers. However, on vessels that are not steam powered, this option warrants further consideration.
Option 2. Layup non-essential water purification plants with fresh-water when in port	Steam powered vessels normally operate just one plant in port to produce the required high purity feedwater for boilers. Therefore, this option addresses all plants on non-steam powered vessels and the non-essential plants onboard steam powered vessels. Freshwater is predicted to be less corrosive than seawater, leading to improved maintenance and reliability. NSTM procedure already allows for freshwater	Freshwater layup of non-essential water purification plants in port is a minor change in management practice, which will not affect the operational availability of the vessel.	The additional cost for the freshwater layup procedure would include shore supplied freshwater for the layup, at approximately $1.00/1000 gallons,[1] and engineering and installation costs for pipings and fittings to provide a pierside freshwater supply. The beneficial effects of reduced corrosion may decrease maintenance costs.	This option would reduce the magnitude of metal mass loadings, however, purification plants still operated in port, may continue to exceed water quality standards.	Implementing a freshwater layup of water purification plants on is: 1) feasible, 2) would not affect ship capabilities, 3) should not impose significant costs, and 4) could reduce metal mass loading. Despite this reduction, metal concentrations could continue to exceed water quality standards.

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
	layups. A freshwater source and the means to feed it to the plant are required for this option.				
Option 3. Require RO systems on new ships	Steam-powered-vessel propulsion boilers require quantities of high purity feedwater not currently achievable by shipboard RO systems, so these vessels would require a combination of RO and distilling plants. RO units are smaller, requiring less space and equipment interface than distilling plants.	RO membranes are damaged by oil and other contaminants prevalent in littoral waters.[2,3] This option would reduce acoustic and thermal signatures since RO plants have fewer motors and pumps, and do not require or produce heat.	Overall, RO systems cost significantly less than distilling plants with respect to life cycle costs, including acquisition, engineering and installation, logistics support, operation, and maintenance. RO units do not require chemical feed and cleaning agents, so chemical and cleaning costs would not incur.	This option would reduce the brine discharge volume and is predicted to reduce the concentrations of constituents in the discharge. Compared to distillers, RO plants contain fewer heavy metal sources, do not use heat in the water purification process-eliminating thermal effects, and do not use anti-scaling chemical additives.	Requiring the installation of RO plants on all new ships would: 1) be feasible if installed along with distilling plants on steam-powered vessels, 2) have minimal operational impacts, 3) cost significantly less than distilling plants, and 4) reduce brine discharge constituent concentrations.
Option 4. Substitute freshwater for seawater to operate distilling plants onboard steam-powered vessels while in port	Influent water for the distillers would require a pierside freshwater supply, however, shore facilities may not be equipped to provide a sufficient volume of freshwater. Considerable shore infrastructure upgrades would be required to implement this option.	Since this option is confined to in-port operation of distilling plants, it will not impact operational and warfighting capabilities.	This option would impose cost increases due to: 1) shore supplied freshwater at $1.00/1000 gallons[1] and 2) engineering and installation costs for shore infrastructure upgrades. The beneficial effects of reduced corrosion could reduce maintenance costs, therefore compensating for and increase from cleaning and de-scaling.	This option would reduce, but not eliminate the discharge of heavy metals, such as copper and nickel, originating from distilling plant components.	Implementing the use of freshwater for water purification plant operation on steam powered vessels in port is: 1) feasible with shore infrastructure upgrades, 2) would not affect ship capabilities, and 3) would reduce metal mass loading. Despite this reduction, metal concentrations could continue to exceed water quality standards.
Option 5. Change distilling and RO plant construction materials	This option would primarily apply to distilling plants because RO plants do not employ heating coils which introduce metals into the	This option would not impact ship operations, provided that system reliability is maintainted. Thermal signature is not	This option would impose research, development, and material costs. The alternative materials (i.e. stainless steel, titanium, or	Alternate materials would reduce the concentration and volume of brine discharge constituents. The level of constituent	Changing plant piping and fitting materials will reduce heavy metal and scaling treatment constituent concentrations and loadings

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
	discharge stream. In order for this option to be practicable, the new materials could not increase the maintenance requirements, size, or weight of the water purification plant. If materials are simply substituted, space requirements would remain the same and weight would be expected to decrease, making this a practicable option.	expected to change.	nickel alloys) would range in cost from $0.10/lb to $100/lb.[4,5,6] Shore infrastructure and manning costs would increase if material changes required special maintenance and repair capabilities.	reduction would be proportional to the extent to which materials contributing to heavy metals in the discharge are replaced or removed from the system.	from brine discharge. Using alternate materials for the actual water purification equipment is less practicable, may entail higher life cycle cost, and Navy grade water purification plants made of alternate materials are not readily available.

REFERENCES

[1] Memorandum from Mr. R. Bernstein (M. Rosenblatt & Son, Inc.), Subj: Estimate for Freshwater Supply to Vessels While Inport, November 13, 1997.

[2] Naval Ship's Technical Manual, Chapter 531 - Desalination, Volume 1 - Low-Pressure Distilling Plants, S9086-SC-STM-010/CH-531V1, First Revision, March 21, 1996.

[3] Naval Ship's Technical Manual, Chapter 533 - Potable Water Systems, S9086-SC-STM-010/CH-533, Third Revision, March 15, 1995.

[4] Titanium Prices, e-mail from Mr. Sam Fisher, Principal Metals, Inc., November 13, 1997.

[5] Titanium Prices, personal communication with Mr. Bob Marsh, Titanium Industries, Inc., November 24, 1997.

[6] Metals Prices, MetalWorld, Inc., http://www.metalworld.com, August 29, 1997.

NATURE OF DISCHARGE REPORT

Elevator Pit Effluent

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..."[Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the discharge from elevator pits and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Most large surface vessels have at least one type of elevator; however, elevator configurations vary between ship classes. On each ship, several different types and sizes of elevators may be used to transport small packages, large cargo items, ordnance, food supplies, and personnel.[1] Elevators can service several decks depending on their purpose. Elevator doors open at each deck for loading and unloading. The elevator operates using either cables, rails, or hydraulic pistons. The elevators that raise and lower aircraft on aircraft carriers cannot produce this discharge because they are open to the sea and do not have elevator pits. Elevators that operate in shafts have a sump in the pit to collect liquids that may enter the elevator and shaft area.[1] If the elevator pit is located above the waterline, the sump is fitted with a drain that directs the waste overboard. This drain is normally higher than the sump floor to prevent clogging from solids. If the elevator pit is located below the waterline, the pit is educted dry using the firemain water supply.

2.2 Releases to the Environment

For elevators with pits, deck runoff and elevator equipment maintenance activities are the major sources of liquid that accumulate in the pit. Deck runoff occurs during heavy rains, rough seas, and deck washdowns. During these events, water from the deck can enter the elevators and elevator shafts when the elevator doors are open, or through worn seals when the doors are closed (non-watertight). When water enters the elevator pit, it can contain materials that were on the deck, including aviation fuel, hydraulic fluid, lubricating oil, residual water, and aqueous film forming foam (AFFF).[2] The runoff may also include lubricant applied to the elevator doors, door tracks, and other moving elevator parts. Residue in the elevator car from the transport of materials may also be washed into the elevator pit. The cleaning solvent used during maintenance cleaning operations as well as liquid wastes generated by the cleaning process drain into the elevator pit sump. This mixture of materials and liquid collects in the sump at the bottom of the elevator pit.

Waste accumulated in the elevator pits is removed by gravity draining, by educting overboard using firemain powered eductors, by using a vacuum or sponges to transfer the waste to the ship's bilge system for treatment as bilgewater, or by containerizing it for shore disposal.[3] Since elevator pit eductors use the firemain water supply, the elevator pit effluent can contain any constituents present in the firemain water. The ratio of elevator pit waste to firemain supply can vary from 1:1 to 3:1, depending on the type of eductor used to evacuate the elevator pit.

2.3 Vessels Producing the Discharge

All of the ships listed in Tables 1, 2, and 3 have the potential to produce an elevator pit discharge. Table 1 lists the MSC ships that have elevators. Tables 2 and 3 list the number and types of major elevator systems on Navy surface combatants and support ships, respectively.[4] U.S. Coast Guard (USCG), Air Force, and Army vessels do not produce this discharge because they do not have elevator pits.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge has the potential to occur within and beyond 12 nautical miles (n.m.) from shore. Inspections of elevator pits on Navy ships in port revealed that elevator pits are generally dry and that elevator pit effluent is not expected to be discharged in significant amounts within 12 n.m. because of current practices which educt the waste overboard prior to the ship coming within 12 n.m. of shore.[3] Without these practices, this effluent could be discharged while pierside or underway.

3.2 Rate

The rate of this discharge is subject to frequency and amount of deck runoff (e.g., washdown water and rainfall), as well as the frequency of use of the elevators and the size of the elevator opening. These factors vary greatly between vessel classes. Inspections were performed on nine vessels to investigate the presence of accumulated waste in elevator pits. The inspections revealed that elevator pits in each vessel were often dry when the vessel came into port, because the accumulated waste had either been drained or educted overboard prior to the vessel coming within 50 n.m. of land, containerized for shore disposal, or the waste had been transferred to the bilge for treatment by the oil water separator (OWS) as bilgewater.[3] Based on this information, it is estimated that the discharge flow rates of elevator pit effluent within the 12 n.m. zone are minimal.

3.3 Constituents

The constituents of elevator pit effluent are affected by the amount and type of materials on deck, the agents used during cleaning and maintenance of the elevators, and to some degree the material transported in the elevators. At any given time elevator pit effluent may contain the following constituents:

- grease;
- lubricating oil;

- solvent;
- soot;
- dirt;
- paint chips;

Additional constituents that may be carried into the elevator pit by deck runoff can include fuel, AFFF, glycol, and sodium metasilicate. Material safety data sheet (MSDS) information on these materials indicate that the constituents can include polymers, heavy hydrocarbons, paraffinic distillates, silicone compounds, various organic acids, hydroxyl compounds, naphtha compounds, various oils, and some metals such as lead and zinc.

When eductors are used to remove the waste accumulated in elevator pits, the effluent is a combination of the pit waste and the firemain water that is used for eduction. It is not possible to determine the percentages of each of these sources, because they would vary from ship to ship depending upon a number of factors. Furthermore, effluent sampling would not help to determine these percentages, as it would be impossible to isolate and analyze the three sources of the discharge. The Firemain Systems NOD report contains a more complete discussion of those constituents found in firemain water. The only constituents present in the firemain water that were found to exceed water quality criteria were copper, iron, and nickel.

Of the constituents listed above, the expected priority pollutants in this discharge are bis(2-ethylhexyl) phthalate, silver, chromium, copper, iron, nickel, lead, zinc, and phenols. Deck runoff is the source of these pollutants, with the exception of bis(2-ethylhexyl) phthalate, copper, iron, and nickel, which are also present in firemain water. Additional information concerning these pollutants can be found in the Deck Runoff NOD report.

No bioaccumulators are anticipated in this discharge.

3.4 Concentrations

Constituent concentrations of deck runoff resulting from precipitation will vary with a number of factors. The following factors affecting deck runoff constituent concentrations are dependent on time since the last rainfall or deck washdown:

- intensity and duration of rainfall;
- type, intensity, and duration of weather (high sea state and green water);
- season (which will affect glycol loading from deicing fluids);
- ship's adherence to good housekeeping practices; and
- ship's operations.

The periodicity of cleaning and lubrication of the mechanical components in the elevator pit will also affect constituent concentrations. For example, if the guide rollers, bearings, etc., located in the bottom of the elevator shaft are cleaned and greased more often, the concentrations of solvent and grease in the effluent could increase.

The Firemain Systems NOD report contains a more detailed analysis of firemain water constituent concentrations. As shown in Table 4, the firemain water constituents that exceeded the most stringent water quality criteria were total nitrogen, bis(2-ethylhexyl) phthalate, copper, iron, and nickel, where the total measured effluent log-normal mean concentrations were 500 micrograms per liter (µg/L), 22 µg/L, 62.4 µg/L, 370 µg/L, and 15.2 µg/L, respectively.[5]

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. A discussion of mass loadings is presented in Section 4.1. In Section 4.2, the concentrations of discharge are discussed, and in Section 4.3, the potential for the transfer of non-indigenous species is evaluated.

4.1 Mass Loading

Mass loadings cannot be calculated because the quantity of constituents released from elevator pits cannot be estimated, and because the concentration of these constituents will vary as discussed in Section 3.4. Inspections of elevator pits on Navy ships in port revealed that elevator pits are generally dry and that elevator pit effluent is not expected to be discharged in significant amounts within 12 n.m. because of current practices which educt the waste overboard prior to the ship coming within 12 n.m. of shore.[3]

4.2 Environmental Concentrations

Concentrations of grease, oil, cleaning solvent, and other pollutants that might be present in elevator pit effluent have not been estimated. The concentrations of total nitrogen, bis(2-ethylhexyl) phthalate, copper, iron, and nickel in the firemain water used for eduction have been found to exceed water quality criteria.

4.3 Potential for Introducing Non-Indigenous Species

The major sources of elevator pit effluent, deck runoff and maintenance activities, do not have a significant potential to introduce non-indigenous species; therefore, this discharge does not have a significant potential for transporting non-indigenous species.

5.0 CONCLUSION

Uncontrolled, elevator pit effluent could possibly have the potential to cause an adverse environmental effect because oil could be discharged in amounts and concentrations high enough to cause an oil sheen, especially when the vessel is pierside. There are currently no formalized management practices in place regulating this discharge. However, surveys and inspections of nine Navy ships indicated that the current practice is to containerize the waste for shore disposal, to transfer the waste to the ship's bilges for processing by the OWS, or to refrain from discharging the waste overboard.[3]

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained, reviewed, and analyzed. Table 5 indicates the data source of the information presented in each section of this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Elevator Pit Effluents. October 1, 1996.

2. Round 2 Equipment Expert Meeting Minutes - Elevator Pit Effluent. April 3, 1997.

3. Navy Fleet Technical Support Center Pacific (FTSCPAC) Inspection Report Regarding Elevator Pit and Anchor Chain Locker Inspection Findings on Six Navy Ships, March 3, 1997.

4. Naval Surface Warfare Center, Carderock Division, Philadelphia Site (NSWCCD-SSES) Report Regarding Number and Type of Elevators on Various Navy Vessels, Paul Hermann, October 17, 1997.

5. UNDS Phase I Sampling Data Report, Volumes 1-13, October 1997.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Type of Elevators and Conveyors on MSC Ships

Vessel	Passenger Elevators	Cargo Elevator	Stores Lift (British)
Mars AFS 1		(1) 16,000 lb CARGO (2) 4,000 lb (HYD) HELO	
Niagara Falls AFS 3		(1) 16,000 lb CARGO (2) 10,000 lb HELO (2) 12,000 lb CARGO	
Concord AFS 5		(1) 16,000 lb CARGO (2) 10,000 lb HELO (2) 12,000 lb CARGO	
San Diego AFS 6		(1) 16,000 lb CARGO (2) 10,000 HELO	
San Jose AFS 7		(1) 16,000 lb CARGO (2) 10,000 lb HELO (2) 12,000 CARGO (3) 4,000 lb CARGO	
T-AFS 8 Class 3 Vessels		8 per vessel	1 per vessel
T-AH 19 Class 2 Vessels	10 per vessel		
T-AO 187 Class 10 Vessels	1 per vessel		
LKA-113 Class 2 Vessels		6 per vessel	
T-AE 28 Class 4 Vessels		6 per vessel	
T-AE 32 Class 4 Vessels		6 per vessel[1]	

1. Number 6 elevator divides into two elevators.

Table 2. Number and Type of Major Elevator Systems (Navy Surface Combatants)

Ship Class	Number of Vessels	Number of Elevators Per Vessel	Type of Elevator
CG 47	27	2	Ammunition
DD 963/ DDG 993	35	2	Ammunition
FFG 7	48	1	Pallet
CVN 65	1	14	Weapons
CVN 68	7	9 (CVN 72 - 74) 10 (CVN 68, 70, 71) 11 (CVN 69)	Weapons
CV 67	1	9	Weapons
CV 63	2	11 (CV 63) 12 (CV 64)	Weapons

Table 3. Number and Type of Major Elevator Systems (Navy Auxiliary and Amphibious ships)

Ship Class	Hull	Number of Elevators	Type of Elevator
Underway Replenishment Ships	AE 27	6	Cargo/Weapons
	AE 28	6	Cargo/Weapons
	AE 29	6	Cargo/Weapons
	AE 32	7	Cargo/Weapons
	AE 33	7	Cargo/Weapons
	AE 34	7	Cargo/Weapons
	AE 35	7	Cargo/Weapons
	AOE 1	9	Cargo/Weapons
	AOE 2	9	Cargo/Weapons
	AOE 3	9	Cargo/Weapons
	AOE 4	9	Cargo/Weapons
	AOE 6	6	Cargo/Weapons
		1	Cargo
	AOE 7	6	Cargo/Weapons
		1	Cargo
	AOE 8	7	Cargo/Weapons
	AO 177	1	Weapons
	AO 178	1	Weapons
	AO 179	1	Weapons
	AO 180	1	Weapons
	AO 186	1	Weapons
Material Support Ships	AS 36	8	Cargo
		2	Component
		2	Weapons
	AS 39	8	Cargo
		2	Component
		1	Weapons
	AS 41	8	Cargo
		2	Component
		1	Weapons
Amphibious Warfare Ships	LCC 19	1	Vehicle
	LCC 20	1	Vehicle
	LHA 1	5	Cargo/Weapons
		1	Medevac
	LHA 2	5	Cargo/Weapons
		1	Medevac
	LHA 3	5	Cargo/Weapons
		1	Medevac
	LHA 4	5	Cargo/Weapons
		1	Medevac
	LHA 5	5	Cargo/Weapons
		1	Medevac
	LHD 1	6	Cargo/Weapons
		1	Medevac
	LHD 2	6	Cargo/Weapons
		1	Medevac

Ship Class	**Hull**	**Number of Elevators**	**Type of Elevator**
Amphibious Warfare Ships (continued)	LHD 3	6	Cargo/Weapons
		1	Medevac
	LHD 4	6	Cargo/Weapons
		1	Medevac
	LHD 5	6	Cargo/Weapons
		1	Medevac
	LPD 1	Decommissioned	
	LPD 2	Decommissioned	
	LPD 4	1	Cargo/Weapons
	LPD 5	1	Cargo/Weapons
	LPD 6	1	Cargo/Weapons
	LPD 7	1	Cargo/Weapons
	LPD 8	1	Cargo/Weapons
	LPD 9	1	Cargo/Weapons
	LPD 10	1	Cargo/Weapons
	MCS 12	1	Cargo/Weapons
	LPD 13	1	Cargo/Weapons
	LPD 14	1	Cargo/Weapons
	LPD 15	1	Cargo/Weapons
	LPH 3	2	Weapons
	LPH 11	2	Weapons
	LPH 12	2	Weapons
	LSD 41	1	Cargo
		1	Weapons
	LSD 42	1	Cargo
		1	Weapons
	LSD 43	1	Cargo
		1	Weapons
	LSD 44	1	Cargo
		1	Weapons
	LSD 45	1	Cargo
		1	Weapons
	LSD 46	1	Cargo
		1	Weapons
	LSD 47	1	Cargo
		1	Weapons
	LSD 48	1	Cargo
		1	Weapons
	LSD 49	2	Cargo
		1	Ammunition
		3	Lift Platform
	LSD 50	2	Cargo
		1	Ammunition
		3	Lift Platform
	LSD 51	2	Cargo
		1	Ammunition
		3	Lift Platform
Other Auxiliary Ships	AGF 3	1	Cargo/Weapons/Stores
	AGF 11	1	Cargo/Weapons

Table 4. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (μg/L)					
Total Nitrogen	500			None	200 (HI)[A]
Organics (μg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (μg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.5 (WA)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Total	15.2	BDL	52.1	74.6	8.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.

CT = Connecticut
FL = Florida
GA = Georgia
MS = Mississippi
WA = Washington

Table 5. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment	X			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	X			X
3.2 Rate	X			
3.3 Constituents	MSDS			X
3.4 Concentrations			unknown	
4.1 Mass Loadings			unknown	
4.2 Environmental Concentrations			unknown	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Firemain Systems

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the firemain discharges and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Firemain systems distribute seawater for fire fighting and secondary services. The firefighting services are fire hose stations, seawater sprinkling systems, and foam proportioning stations. Fire hose stations are distributed throughout the ship. Seawater sprinkling systems are provided for spaces such as ammunition magazines, missile magazines, aviation tire storerooms, lubricating oil storerooms, dry cargo storerooms, living spaces, solid waste processing rooms, and incinerator rooms. Foam proportioning stations are located in rough proximity to the areas they protect, but are separated from each other for survivability reasons. Foam proportioners inject fire fighting foam into the seawater, and the solution is then distributed to areas where there is a risk of flammable liquid spills or fire. Foam discharge is covered in the aqueous film forming foam (AFFF) NOD report. The secondary services provided by wet firemain systems are washdown countermeasures, cooling water for auxiliary machinery, eductors, ship stabilization and ballast tank filling, and flushing for urinals, commodes and pulpers. The washdown countermeasure system includes an extensive network of pipes and nozzles, to produce a running water film on exterior ship surfaces. Not all these services are provided on all vessels.

Firemain systems fall under two major categories: wet and dry firemains. Wet firemains are continuously pressurized so that the system will provide water immediately upon demand. Dry firemains are not charged with water and, as a result, do not supply water upon demand. Most vessels in the Navy's surface fleet operate wet firemains.[1] Most vessels in the Military Sealift Command (MSC) use dry firemains.[1] All U.S. Coast Guard (USCG), and U.S. Army vessels use dry firemains.

For the purposes of the Firemain Systems NOD report, the firemain system includes all components between the fire pump suction sea chest and the cutout valves to the various services. If the discharge from the service is not covered by its own NOD report, it is included in this Firemain Systems NOD report. The components of the firemain system are the sea chests, fire pumps, valves, piping, fire hose, and heat exchangers.

Seawater from the firemain is discharged over the side from fire hoses, or directly to the sea through submerged pipe outlets. Seawater discharges from secondary services supplied from the firemain are described in the pertinent NOD reports; see Section 2.2 below.

The sea chest is a chamber inset into the hull, from which seawater flows to a fire pump. The fire pump sea chests are constructed of the hull material - steel - and are coated with durable epoxy paints. They also contain steel waster pieces or zinc sacrificial anodes for corrosion protection. The fire pumps are constructed of titanium, stainless steel, copper alloyed with tin or nickel, or non-metallic composites. The pipes in wet firemain systems are primarily copper-nickel alloys and fittings are bronze that are connected by welding or by silver-brazed joints. Dry firemain systems can be constructed of these same materials but are normally constructed of steel.

Fire pumps are centrifugal style pumps driven by steam turbines, electric motors, and/or diesel engines. The pumps are located in the lower levels of vessels and are sized to deliver required flow and pressure to equipment or systems on the upper decks. Pump sizes range from 50 to 250 gallons per minute (gpm) on small vessels to 2,000 gpm on large vessels.[1] To prevent overheating when firemain load demands are low, Navy fire pumps are designed to pass 3 to 5% of the nominal flow rate back to the sea suction or overboard.[2] This also provides flow to the pump's seals.

The firemain piping layout (architecture) is governed by the mission or combatant status of the ship. The simplest architecture consists of a single main run fore and aft in the ship, with single branches to the various services supplied from the firemain. More complex architectures incorporate multiple, widely separated mains with cross connects, and feature multiple pipe paths to vital services. Regardless of the architecture, all firemain systems include pipe sections which may contain stagnant water. For example, except during fire fighting, the valves at the fire plugs are closed and sprinkling systems do not flow.

Navy firemain system capacity is designed to meet peak demand during emergency conditions, after sustaining damage. This capacity is determined by adding the largest fire fighting demand, the vital continuous flow demands, and a percentage of the intermittent cooling demands. The number of fire pumps required to meet this capacity is increased by a 33% margin to account for battle damage or equipment failure.[2] As a result, Navy firemain systems have excess capacity during routine operations.

Firemain capacity on most MSC, U.S. Coast Guard (USCG), and Army ships is designed to commercial standards as prescribed by regulations pertinent to each ship type.[3,4] Ships acquired from naval or other sources satisfy other design criteria, but the firemain capacity requirements meet or exceed commercial standards. A minimum of two pumps is required. The required firemain capacity is less than would be required on Navy ships of similar type and size.

Dry firemains are not charged and do not provide instantaneous water pressure. These systems are periodically tested as part of the planned maintenance system (PMS) and are pressurized during training exercises.

2.2 Releases to the Environment

Seawater discharged overboard from the firemain contains entrained or dissolved materials, principally metals, from the components of the firemain system. Some traces of oil or other lubricants may enter the seawater from valves or pumps.

Fire fighting, space dewatering using eductors, counterflooding, and countermeasure washdown constitute emergency discharges from the firemain, and are not incidental to the vessel's operation. Some auxiliary machinery is provided with backup emergency cooling from the firemain. Use of the firemain for backup emergency cooling is not an incidental discharge. Seawater from the firemain is released to the environment as an incidental discharge for the following services:

- Test and maintenance;
- Training;
- Cooling water for auxiliary machinery and equipment, for which the firemain is the normal cooling supply. Examples are central refrigeration plants, steering gear coolers, and the Close In Weapon System;
- Bypass flow overboard from the pump outlet, to prevent overheating of fire pumps when system demands are low; and
- Anchor chain washdown.

The following are incidental services provided from the firemain, but the release to the environment is discussed separately as shown:

- Ballast tank filling (Clean Ballast NOD report);
- Flushing water for commodes (Black Water[sewage]; not part of the UNDS study);
- Flushing water for food garbage grinders (Graywater NOD report);
- Stern tube seals lubrication (Stern Tube Seals & Underwater Bearing Lubrication NOD report); and
- AFFF (AFFF NOD report).

2.3 Vessels Producing the Discharge

All Navy surface ships use wet firemain systems with the exception of two classes of oceanographic research ships. Submarines use dry systems. Boats and craft are not equipped with firemain systems and generally use portable fire pumps or fire extinguishers for fire fighting. Most ships operated by the MSC use dry firemain systems, so they do not continuously discharge water overboard as part of normal operations; however, two classes of ships use wet firemains. These classes are ammunition ships (T-AE) and combat stores ships (T-AFS). The USCG and Army use dry firemain systems, so they do not continuously discharge water overboard as part of normal operations. Table 1 lists the ships and submarines in the Navy, MSC, USCG, and Army, and notes whether their firemain systems are the wet or dry type.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Firemain discharge occurs both within and beyond 12 nautical miles (n.m.) of shore.

3.2 Rate

The flow rates for wet firemain discharge depend on the type, number, and operating time of equipment and systems that use water from the firemain. Operating times of many systems are highly variable. Some connected services, such as refrigeration plants, are operated continuously; others, such as hydraulics cooling or aircraft carrier jet blast deflectors, are operated only during specific ship evolutions. Ships with auxiliary seawater cooling systems tend to have relatively few services that draw continuous flow from the firemain. For these ships, the firemain discharge will be small compared to the discharge from the seawater cooling system. Table 2 shows the theoretical upper bound estimate of discharge from wet firemain systems, with an estimated total annual volume of approximately 18.6 billion gallons. The estimate is considered an upper bound because, for most ships, all flow from the fire pumps is assumed to be an environmental release attributable to the firemain system.

Sample calculation for Table 2:

(Qty of ships)(Flow rate (gpm))(1440 min/day)(Days within 12 n.m./yr) = gal/yr

The discharge from dry firemains is approximately 0.1% of the discharge from wet firemains because none of the discharge is continuous. A theoretical upper bound estimate for discharges from dry systems within 12 n.m. is given in Table 3.

Sample calculation for Table 3:

(Qty of ships)(Flow rate (gpm))(10 minutes/wk)(Days within 12 n.m./yr)(1 wk/7 days) = gal/yr

The 10 minutes/week is based on a minimum of 2 pumps required by USCG regulations, in addition to a run time of 5 minutes/week per pump based upon equipment expert knowledge.[5,6,7]

3.3 Constituents

The water for firemain services is drawn from the sea and returned to the sea. Metals and other materials from the firemain and its components can be dissolved by the seawater. Table 4 lists such metals and other materials. Where seawater flow is turbulent, particles of metal will be eroded from pump impellers, valve bodies, and pipe sections, and carried in the firemain as entrained particles.[8] Electrochemical corrosion attacks at the junctions of dissimilar metals to produce both dissolved and particulate metals. Any wetted material in the system can contribute dissolved or particulate constituents to the firemain discharge. These constituents can include copper, nickel, aluminum, tin, silver, iron, titanium, chromium, and zinc. Based on knowledge of the system, the principal expected constituents that are priority pollutants would be copper, nickel, and zinc. Copper and nickel are found in the piping of wet firemain systems, and sacrificial zinc anodes are placed in some sea chests and heat exchangers. None of these expected constituents are bioaccumulators.

Most dry type firemain systems are constructed of steel pipe, without zinc anodes. Therefore, copper, nickel and zinc are not expected constituents of dry type firemain systems.

3.4 Concentrations

The firemain systems of three ships were sampled for 26 metals (total and dissolved), semi-volatile organic compounds, polychlorinated biphenyls (PCBs), and classical constituents. Only wet firemains were sampled because the volumes discharged by wet firemains comprise the vast majority of the total volume of the discharge. The firemains were sampled both at the inlet and at the discharge to determine what constituents were contributed by the firemain system. The three ships sampled were a dock landing ship, an aircraft carrier, and an amphibious assault ship. Details of the sampling effort and the sampled data are described in the Sampling Episodes Report for seawater cooling. Table 4 summarizes the results.

Variability is expected within this discharge as a result of several factors including material erosion and corrosion, residence times, passive films, and influent water variability. Pipe erosion is caused by high fluid velocity, or by abrasive particles entrained in the seawater flowing at any velocity. In most cases of pipe erosion, the problematic high fluid velocity is a local phenomenon, such as would be caused by eddy turbulence at joints, bends, reducers, attached mollusks, or tortuous flow paths in valves. Passive films inhibit metal loss due to erosion. Corrosion is influenced by the residence time of seawater in the system, temperature, biofouling, constituents in the influent, and the presence or absence of certain films on the pipe surface. All of these influences on metallic concentrations are variable within a given ship over time, and between ships.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Mass loadings are shown in Table 5. The concentrations of constituents contributed by the firemain system were combined with the estimated annual firemain discharge from Table 2 for wet firemains to determine mass loadings by the equation:

$$\text{Mass Loading (lbs/yr)} = (\text{Table 4 net log normal mean concentration } (\mu g/L))\\ (\text{Table 2 discharge volume (18.6 billion gal/yr)})(3.785 \text{ L/gal})(2.205 \text{ lbs/kg})(10^{-9} \text{ kg}/\mu g)$$

Dry firemains were not sampled. Most dry firemain systems are constructed of steel, so the principal expected metallic constituent will be iron. The discharge rate from dry firemain systems is about 0.1% of the rate from wet firemain systems, so the mass loadings should also be much less. Accordingly, the mass loadings from dry firemain systems were not included in the mass loading estimates.

4.2 Environmental Concentrations

Table 6 compares measured constituent concentrations with Federal and the most stringent state chronic water quality criteria (WQC). The comparison in Table 6 shows that the effluent concentrations of bis(2-ethylhexyl) phthalate, nitrogen (as nitrate/nitrite and total nitrogen), copper, iron, and nickel exceed WQC. The copper and nickel contributions each exceed both the Federal and most stringent state criteria. The ambient copper concentration in most ports exceeds the chronic WQC. As mentioned previously, copper and nickel constitute the major construction materials for wet firemains in the Navy. Bis(2-ethylhexyl) phthalate, nitrogen, and iron concentration exceeds the most stringent state chronic criterion.

4.3 Thermal Effects

As mentioned previously, portions of the firemain are used for seawater cooling purposes and will discharge excess thermal energy to receiving waters. The thermal plume from firemains was not modeled directly; however, firemain discharge can be compared to a discharge that was modeled, such as seawater cooling water from an Arleigh Burke Class (DDG 51) guided missile destroyer. The use of DDG51 flow parameters for seawater cooling will overestimate the size of the thermal plume because all vessels have firemain discharge rates less than the estimated pierside seawater cooling rate of 1,680 gpm for a DDG 51 class ship. Additionally, the temperature difference (delta T) between the effluent and influent for firemain is lower (measured at 5°F) than the delta T for seawater cooling from a DDG 51 class ship (measured at 10°F).

The seawater cooling water discharge was modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in a receiving water body using conditions tending to produce the largest thermal plume. Thermal modeling was performed for the DDG 51 in two harbors (Norfolk, Virginia; and Bremerton, Washington). Of the five states that have the largest presence of Armed Forces vessels, only Virginia, and Washington have established thermal mixing zone criteria.[9] The discharge was also assumed to occur in winter when the discharge would produce the largest thermal plume. Based on modeling for a DDG 51 class ship, the resulting plume did not exceed the thermal mixing zone requirements for Virginia or Washington.[9]

All vessels have firemain discharge rates less than the seawater cooling discharge rate, and delta T's less than the measured temperature difference associated with a DDG 51.

Therefore, the heat rejection rate from any firemain system will be lower than that of a DDG 51 class ship for seawater cooling water. Accordingly, the resulting thermal plume for the firemain discharge is not expected to exceed the thermal criteria for , Virginia or Washington and adverse thermal effects are not anticipated.

4.4 Potential for Introducing Non-Indigenous Species

Wet and dry firemain systems have a minimal potential for transporting non-indigenous species, because the residence times for most portions of the system are short. Some portions of the system lie stagnant where marine organisms may reside. However, these areas tend to develop anaerobic conditions quickly, except at the junctions with the active portions of the system, where oxygenated water continuously flows by and through the ship. Anaerobic conditions are not hospitable to most marine organisms. Additionally, firemain systems do not transport large volumes of water over large distances.

5.0 CONCLUSIONS

Firemain discharge has the potential to cause an adverse environmental effect because the concentrations of Bis(2-ethylhexyl) phthalate, nitrogen, copper, nickel, and iron exceed federal or most stringent state water quality criteria and the estimated annual mass loadings for these metals are significant. The thermal effects of this discharge were reviewed and are not significant. The potential for introducing non-indigenous species is minimal.

6.0 REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge and sampling was performed to gather results related to the constituents and concentrations of the discharge. Table 7 shows the sources of data used to develop this NOD report.

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Malcolm Pirnie, Inc. UNDS Phase 1 Sampling Data Report, Volumes 1 through 13, October 1997.

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

UNDS Ship Database, August 1, 1997.

Table 1. Wet and Dry Firemains of the Navy, MSC, USCG, and Army

Class	Description	Quantity of Vessels	Wet/Dry
	Navy Ships		
SSBN	Ohio Class Ballistic Missile Submarines	17	Dry
SSN	Sturgeon Class Attack Submarines	13	Dry
SSN	Los Angeles Class Attack Submarines	56	Dry
SSN	Narwhal Class Submarine	1	Dry
SSN	Benjamin Franklin Class Submarines	2	Dry
CV	Forrestal Class Aircraft Carrier	1	Wet
CVN	Enterprise Class Aircraft Carrier	1	Wet
CV	Kitty Hawk Class Aircraft Carriers	3	Wet
CVN	Nimitz Class Aircraft Carriers	7	Wet
CGN	Virginia Class Guided Missile Cruiser	1	Wet
CG	Ticonderoga Class Guided Missile Cruisers	27	Wet
CGN	California Class Guided Missile Cruisers	2	Wet
DDG	Kidd Class Guided Missile Destroyers	4	Wet
DDG	Arleigh Burke Class Guided Missile Destroyers	18	Wet
DD	Spruance Class Destroyers	31	Wet
FFG	Oliver Hazard Perry Guided Missile Frigates	43	Wet
LCC	Blue Ridge Class Amphibious Command Ships	2	Wet
LHD	Wasp Class Amphibious Assault Ships	4	Wet
LHA	Tarawa Class Amphibious Assault Ships	5	Wet
LPH	Iwo Jima Class Assault Ships	2	Wet
LPD	Austin Class Amphibious Transport Docks	3	Wet
LPD	Amphibious Transport Docks	2	Wet
LPD	Amphibious Transport Docks	3	Wet
LSD	Whidbey Island Class Dock Landing Ships	8	Wet
LSD	Harpers Ferry Dock Landing Ships	3	Wet
LSD	Anchorage Class Dock Landing Ships	5	Wet
MCM	Avenger Class Mine Countermeasure Vessels	14	Wet
MHC	Osprey Class Minehunter Coastal Vessels	12	Wet
PC	Cyclone Class Coastal Defense Ships	13	Wet
	Navy Auxiliary Ships		
AGF	Raleigh Class Miscellaneous Command Ship	1	Wet
AGF	Austin Class Miscellaneous Command Ship	1	Wet
AO	Jumboised Cimarron Class Oilers	5	Wet
AOE	Supply Class Fast Combat Support Ships	3	Wet
AOE	Sacramento Class Fast Combat Support Ships	4	Wet
ARS	Safeguard Class Salvage Ships	4	Wet
AS	Emory S Land Class Submarine Tenders	3	Wet
AS	Simon Lake Class Submarine Tender	1	Wet
AGOR	Gyre Class Oceanographic Research Ship	1	Dry
AGOR	Thompson Class Oceanographic Research Ships	2	Dry
	Military Sealift Command		
T-AE	Kilauea Class Ammunition Ships	8	Wet
T-AFS	Mars Class Combat Stores Ships	8	Wet
T-ATF	Powhatan Class Fleet Ocean Tugs	7	Dry
T-AO	Henry J Kaiser Class Oilers	13	Dry

Class	Description	Quantity of Vessels	Wet/Dry
T-AGM	Compass Island Class Missile Instrumentation Ships	1	Dry
T-ARC	Zeus Class Cable Repairing Ship	1	Dry
T-AKR	Maersk Class Fast Sealift Ships	3	Dry
T-AKR	Algol Class Vehicle Cargo Ships	8	Dry
T-AGOS	Stalwart Class Ocean Surveillance Ships	5	Dry
T-AGOS	Victorious Class Ocean Surveillance Ships	4	Dry
T-AG	Mission Class Navigation Research Ships	2	Dry
T-AGS	Silas Bent Class Surveying Ships	2	Dry
T-AGS	Waters Class Surveying Ship	1	Dry
T-AGS	McDonnell Class Surveying Ships	2	Dry
T-AGS	Pathfinder Class Surveying Ships	4	Dry
	Coast Guard		
WHEC	Hamilton and Hero Class High Endurance Cutters	12	Dry
WMEC	Storis Class Medium Endurance Cutter	1	Dry
WMEC	Diver Class Medium Endurance Cutter	1	Dry
WMEC	Famous Class Medium Endurance Cutters, Flight A	4	Dry
WMEC	Famous Class Medium Endurance Cutters, Flight B	9	Dry
WMEC	Reliance Class Medium Endurance Cutters, Flight A	5	Dry
WMEC	Reliance Class Medium Endurance Cutters, Flight B	11	Dry
WAGB	Mackinaw Class Icebreaker	1	Dry
WAGB	Polar Class Icebreakers	2	Dry
WTGB	Bay Class Icebreaking Tugs	9	Dry
WPB	Point Class Patrol Craft	36	Dry
WPB	Island Class Patrol Craft	49	Dry
WLB	Juniper Class Seagoing Buoy Tenders	2	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight A	8	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight B	2	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight C	13	Dry
WLM	Keeper Class Coastal Buoy Tenders	2	Dry
WLM	White Sumac Class Coastal Buoy Tenders	9	Dry
WLI	Inland Buoy Tenders	6	Dry
WLR	River Buoy Tenders, 115-foot	1	Dry
WLR	River Buoy Tenders, 75-foot	13	Dry
WLR	River Buoy Tenders, 65-foot	6	Dry
WIX	Eagle Class Sail Training Cutter	1	Dry
WLIC	Inland Construction Tender, 115-foot	1	Dry
WLIC	Pamlico Class Inland Construction Tenders	4	Dry
WLIC	Cosmos Class Inland Construction Tenders	3	Dry
WLIC	Anvil and Clamp Classes Inland Construction Tenders	7	Dry
WYTL	65 ft. Class Harbor Tugs	11	Dry
	Army		
FMS	Floating Machine Shops	3	Dry
LSV	Frank S. Besson Class Logistic Support Vessels	6	Dry
LCU	2000 Class Utility Landing Craft	48	Dry
LT	Inland and Coastal Tugs	25	Dry

Table 2. Theoretical Upper Bound-Estimate of Annual Wet Firemain Discharge

Class	Description	Quantity of Vessels	Flow Rate per Vessel (GPM)	Days w/in 12 n.m.	Estimated Annual Volume for Class, Gal
	Navy				
CV	Forrestal Class Aircraft Carrier	1	1,000	143	205,920,000
CVN	Enterprise Class Aircraft Carrier	1	1,000	76	109,440,000
CV	Kitty Hawk Class Aircraft Carriers	3	1,000	137	591,840,000
CVN	Nimitz Class Aircraft Carriers	7	1,000	147	1,481,760,000
CGN	Virginia Class Guided Missile Cruiser	1	250	166	59,760,000
CG	Ticonderoga Class Guided Missile Cruisers	27	250	161	1,564,920,000
CGN	California Class Guided Missile Cruisers	2	250	143	102,960,000
DDG	Kidd Class Guided Missile Destroyers	4	250	175	252,000,000
DDG	Arleigh Burke Class Guided Missile Destroyers	18	500	101	1,308,960,000
DD	Spruance Class Destroyers	31	250	178	1,986,480,000
FFG	Oliver Hazard Perry Guided Missile Frigates	43	250	167	2,585,160,000
LCC	Blue Ridge Class Amphibious Command Ships	2	400	179	206,208,000
LHD	Wasp Class Amphibious Assault Ships	4	800	185	852,480,000
LHA	Tarawa Class Amphibious Assault Ships	5	800	173	996,480,000
LPH	Iwo Jima Class Assault Ships	2	600	186	321,408,000
LPD	Austin Class Amphibious Transport Docks	3	300	178	230,688,000
LPD	Amphibious Transport Docks	2	300	178	153,792,000
LPD	Amphibious Transport Docks	3	300	178	230,688,000
LSD	Whidbey Island Class Dock Landing Ships	8	300	170	587,520,000
LSD	Harpers Ferry Dock Landing Ships	3	300	215	278,640,000
LSD	Anchorage Class Dock Landing Ships	5	300	215	464,400,000
MCM	Avenger Class Mine Countermeasure Vessels	14	150	232	701,568,000
MHC	Osprey Class Minehunter Coastal Vessels	12	100	232	400,896,000
PC	Cyclone Class Coastal Defense Ships	13	50	50	46,800,000
	Navy Auxiliary				
AGF	Raleigh Class Miscellaneous Command Ship	1	400	183	105,408,000
AGF	Austin Class Miscellaneous Command Ship	1	400	183	105,408,000
AO	Jumboised Cimarron Class Oilers	5	200	188	270,720,000
AOE	Supply Class Fast Combat Support Ships	3	500	114	246,240,000
AOE	Sacramento Class Fast Combat Support Ships	4	600	183	632,448,000
ARS	Safeguard Class Salvage Ships	4	100	202	116,352,000
AS	Emory S Land Class Submarine Tenders	3	400	293	506,304,000
AS	Simon Lake Class Submarine Tender	1	400	229	131,904,000
	Military Sealift Command				
T-AE	Kilauea Class Ammunition Ships	8	300	183	632,448,000
T-AFS	Mars Class Combat Stores Ships	8	300	45	155,520,000
				Total Estimated Annual Volume, (gal):	**18,623,520,000**

Table 3. Theoretical Upper-Bound Estimate of Annual Dry Firemain Discharge

Class	Description	Flow (GPM)	Quantity of Vessels	Days within 12 n.m.	Estimated Annual Volume (gal)
	Navy				
SSBN	Ohio Class Ballistic Missile Submarines	250	17	183	1,111,071
SSN	Sturgeon Class Attack Submarines	250	13	183	849,643
SSN	Los Angeles Class Attack Submarines	250	56	183	3,660,000
SSN	Narwhal Class Submarine	250	1	183	65,357
SSN	Benjamin Franklin Class Submarines	250	2	183	130,714
	Navy Auxiliary				
AGOR	Gyre Class Oceanographic Research Ship	50	1	113	8,071
AGOR	Thompson Class Oceanographic Research Ships	100	2	113	32,286
	Military Sealift Command				
T-ATF	Powhatan Class Fleet Ocean Tugs	100	7	127	127,000
T-AO	Henry J Kaiser Class Oilers	200	13	78	289,714
T-AGM	Compass Island Class Missile Instrumentation Ships	100	2	133	38,000
T-AH	Mercy Class Hospital Ships	400	2	184	210,286
T-ARC	Zeus Class Cable Repairing Ship	100	1	8	1,143
T-AKR	Maesrk Class Fast Sealift Ships	400	3	59	101,143
T-AKR	Algol Class Vehicle Cargo Ships	400	8	350	1,600,000
T-AGOS	Stalwart Class Ocean Surveillance Ships	200	5	70	100,000
T-AGOS	Victorious Class Ocean Surveillance Ship	200	4	107	122,286
T-AG	Mission Class Navigation Research Ships	200	2	151	86,286
T-AGS	Silas Bent Class Surveying Ships	200	2	44	25,143
T-AGS	Waters Class Surveying Ship	200	1	7	2,000
T-AGS	McDonnel Class Surveying Ships	200	2	96	54,857
T-AGS	Pathfinder Class Surveying Ships	200	4	96	109,714
	Coast Guard				
WHEC	Hamilton and Hero Class High Endurance Cutters	250	12	151	647,143
WMEC	Storis Class Medium Endurance Cutter	250	1	167	59,643
WMEC	Diver Class Medium Endurance Cutters	250	1	98	35,000
WMEC	Famous Class Medium Endurance Cutters, Flight A	250	4	137	195,714
WMEC	Famous Class Medium Endurance Cutters, Flight B	250	9	164	527,143
WMEC	Reliance Class Medium Endurance Cutters, Flight A	250	5	235	419,643
WMEC	Reliance Class Medium Endurance Cutters, Flight B	250	11	149	585,357
WAGB	Mackinaw Class Icebreaker	250	1	365	130,357
WAGB	Polar Class Icebreaker	250	2	365	260,714
WTGB	Bay Class Icebreaking Tugs	250	9	365	1,173,214
WPB	Point Class Patrol Craft	50	36	157	403,714
WPB	Island Class Patrol Craft	50	49	157	549,500
WLB	Juniper Class Seagoing Buoy Tenders	200	16	290	1,325,714

Class	Description	Flow (GPM)	Quantity of Vessels	Days within 12 n.m.	Estimated Annual Volume (gal)
WLB	Balsam Class Seagoing Buoy Tenders, Flight A	200	8	290	662,857
WLB	Balsam Class Seagoing Buoy Tenders, Flight B	200	2	220	125,714
WLB	Balsam Class Seagoing Buoy Tenders, Flight C	200	13	223	828,286
WLM	Keeper Class Coastal Buoy Tenders	100	2	323	92,286
WLM	White Sumac Class Coastal Buoy Tenders	100	9	223	286,714
WLI	Inland Buoy Tenders	100	6	365	312,857
WLR	River Buoy Tenders, 115-foot	100	1	365	52,143
WLR	River Buoy Tenders, 75-foot	100	13	365	677,857
WLR	River Buoy Tenders, 65-foot	100	6	365	312,857
WIX	Eagle Class Sail Training Cutter	50	1	188	13,429
WLIC	Inland Construction Tenders, 115 foot	50	1	365	26,071
WLIC	Pamlico Class Inland Construction Tenders	50	4	365	104,286
WLIC	Cosmos Class Inland Construction Tenders	50	3	365	78,214
WLIC	Anvil and Clamp Classes Inland Construction Tenders	50	27	365	703,929
WYTL	65 ft. Class Harbor Tugs	50	14	350	350,000
	Army				
FMS	Floating Machine Shops	400	3	350	600,000
LSV	Frank S. Besson Class Logistic Support Vessel	564	6	180	870,171
LCU	2000 Class Utility Landing Craft	500	48	335	11,485,714
LT	Inland and Coastal Tugs	640	25	295	3,371,429
				Total Estimated Annual Volume, (gal):	**35,992,385**

Note:
1. Estimates assume that all discharge is due to maintenance or testing. All fire fighting exercises are assumed to occur at sea beyond 12 n.m. Maintenance is assumed to occur weekly while vessels are in port, with seawater flowing at the design rate of the pumps for 5 minutes each week.

Table 4: Summary of Detected Analytes Firemain Systems

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Effluent-Influent Log Normal mean	Mass loading (lbs/yr)
	Seawater Cooling Firemain Influent				Seawater Cooling Firemain Effluent					
Classicals (mg/L)										
ALKALINITY	77.24	3 of 3	72	80	79.12	3 of 3	72	86	1.88	291,179
AMMONIA AS NITROGEN	0.10	2 of 3	BDL	0.18	0.07	1 of 3	BDL	0.11	-0.03	(b)
CHEMICAL OXYGEN DEMAND	132.28	3 of 3	106	179	105.96	2 of 3	BDL	195	-26.32	(b)
CHLORIDE	10497.14	3 of 3	10200	10800	10750.73	3 of 3	9780	12100	253.59	39,276,577
NITRATE/ NITRITE	0.06	2 of 3	BDL	0.34	0.02	1 of 3	BDL	0.4	-0.04	(b)
SULFATE	1273.43	3 of 3	1160	1380	1245.96	3 of 3	1190	1290	-27.47	(b)
TOTAL DISSOLVED SOLIDS-	19705.66	3 of 3	18300	20700	18261.70	3 of 3	16900	19800	-1443.96	(b)
TOTAL KJELDAHL NITROGEN	0.31	2 of 3	BDL	0.95	0.48	3 of 3	0.23	0.84	0.17	26,330
TOTAL ORGANIC CARBON	1.72	2 of 3	BDL	3.2	1.72	2 of 3	BDL	3.2	0	0
TOTAL PHOSPHOROUS	0.15	3 of 3	0.13	0.19	0.15	3 of 3	0.13	0.2	0	0
TOTAL RECOVERABLE OIL AND GREASE	2.79	3 of 3	0.9	5.6	2.16	2 of 3	BDL	10.9	-0.63	(b)
TOTAL SULFIDE (IODOMETRIC)	7.00	2 of 2	BDL	7	6.54	3 of 3	5	8	-0.46	(b)
TOTAL SUSPENDED SOLIDS	21.09	3 of 3	19	26	20.05	3 of 3	12	28	-1.04	(b)
VOLATILE RESIDUE	9016.50	3 of 3	1920	20200	8755.30	3 of 3	2230	19800	-261.2	(b)
Metals (μg/L)										
ALUMINUM										
Dissolved	37.44	1 of 3	BDL	78.1	-	-	-	-	-	-
Total	197.35	2 of 3	BDL	732	85.79	1 of 3	BDL	805.5	-111.56	(b)
ANTIMONY										
Dissolved	7.08	1 of 3	BDL	23.7	-	-	-	-	-	-
ARSENIC										
Dissolved	1.79	1 of 3	BDL	5	2.64	2 of 3	BDL	5	0.85	132
Total	1.27	2 of 3	BDL	3.4	2.71	1 of 3	BDL	5	1.44	223
BARIUM										
Dissolved	20.43	3 of 3	16.5	25.6	18.0	3 of 3	13.4	26.5	-2.39	(b)
Total	21.65	3 of 3	16.1	25.3	23.7	3 of 3	17.7	29.7	2.09	324
BORON										
Dissolved	2109.70	3 of 3	2010	2290	2110	3 of 3	1930	2340	-3.1	(b)
Total	2076.31	3 of 3	2040	2130	2160	3 of 3	2080	2320	80.8	12,514
CALCIUM										
Dissolved	198376.19	3 of 3	190000	214000	195800	3 of 3	179500	219000	-2560.58	(b)
Total	196332.23	3 of 3	187000	213000	198600	3 of 3	186000	217000	2242.88	347,382
COPPER										
Dissolved	8.43	2 of 3	BDL	13.3	24.9	2 of 3	BDL	150	16.46	2,549
Total	16.82	3 of 3	13.1	21.9	62.4	3 of 3	34.2	143	45.59	7,061

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Effluent-Influent Log Normal mean	Mass loading (lbs/yr)
	Seawater Cooling Firemain Influent				Seawater Cooling Firemain Effluent					
IRON										
Dissolved	-	-	-	-	20.3	1 of 3	BDL	189	20.3 (a)	3,138 (a)
Total	348.48	3 of 3	161	824	370	3 of 3	95.4	910.5	21.28	3,296
MAGNESIUM										
Dissolved	673065.05	3 of 3	634000	697000	657000	3 of 3	590000	698000	-15948.78	(b)
Total	674584.89	3 of 3	664000	689000	672000	3 of 3	663000	678000	-2782.22	(b)
MANGANESE										
Dissolved	11.12	3 of 3	9.4	12.5	10.77	3 of 3	7.4	13.3	-0.35	(b)
Total	17.32	3 of 3	11.4	24.5	19.00	3 of 3	12.2	27.2	1.68	260
MOLYBDENUM										
Dissolved	7.21	2 of 3	BDL	25.5	-	-	-	-	-	-
Total	4.51	1 of 3	BDL	6.1	3.29	1 of 3	BDL	10.8	-1.22	(b)
NICKEL										
Dissolved	-	-	-	-	13.8	1 of 3	BDL	38.9	13.83 (a)	2,142 (a)
Total	-	-	-	-	15.2	1 of 3	BDL	52.1	15.24 (a)	2,360 (a)
SELENIUM										
Dissolved	16.90	1 of 3	BDL	48.3	14.9	1 of 3	BDL	56.7	-1.96	(b)
SODIUM										
Dissolved	5743515.23	3 of 3	5540000	6140000	5710000	3 of 3	5190000	6160000	-37826.6	(b)
Total	5782507.24	3 of 3	5500000	6030000	5780000	3 of 3	5585000	6160000	-37.06	(b)
THALLIUM										
Dissolved	6.80	1 of 3	BDL	12.6	6.52	1 of 3	BDL	11.1	-0.28	(b)
Total	7.15	1 of 3	BDL	14.6	7.27	1 of 3	BDL	15.4	0.12	19
TIN										
Dissolved	7.03	1 of 3	BDL	6.2	-	-	-	-	-	-
TITANIUM										
Total	7.60	2 of 3	BDL	23.7	7.67	2 of 3	BDL	25.8	0.07	11
ZINC										
Dissolved	15.67	2 of 3	BDL	40.5	24.2	3 of 3	21.2	29.5	8.54	1,323
Total	22.76	3 of 3	20	25.1	31.3	3 of 3	21.3	44.9	8.55	1,324
Organics (µg/L)										
BIS(2-ETHYLHEXYL) PHTHALATE	-	-	-	-	22.0	1 of 3	BDL	428	22.04 (a)	3,414 (a)

BDL= Below Detection Level

note (a) - No background concentration is given for the parameter - therefore an influent concentration of zero was used to determine a conservative mass loading

note (b) - Mass loading was not determined for parameters for which the influent concentration exceeded the effluent

Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 5. Estimated Annual Mass Loadings of Constituents

Constituent*	**Log-normal Mean Influent (μg/L)**	**Log-normal Mean Effluent (μg/L)**	**Log-normal Mean Concentration (μg/L)**	**Estimated Annual Mass Loading (lbs/yr)**
Bis(2-ethylhexyl) phthalate	-	22	22.04	3,414
Nitrate/Nitrite	60	20	-40	(a)
Total Kjeldahl Nitrogen	310	480	170	26,330
*Total Nitrogen**				26,330
Copper				
Dissolved	8.43	24.9	16.46	3,111
Total	16.82	62.4	45.59	8,618
Iron				
Total	348.48	370	21.28	4,022
Nickel				
Dissolved	-	13.8	13.8 (b)	2,142 (b)
Total	-	15.2	15.2 (b)	2,360 (b)

* Mass loadings are presented for constituents that exceed WQC only. See Table 4 for a complete listing of mass loadings.

Notes:
* Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.
(a) - Mass loading was not determined for parameters for which the influent concentration exceeded the effluent
(b) - No background concentration is given for the parameter

Table 6. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Chronic WQC	Most Stringent State Chronic WQC
Classicals (μg/L)					
Nitrate/Nitrite	20	BDL	400	None	8 (HI)[A]
Total Kjeldahl Nitrogen	480	230	840	None	-
Total Nitrogen[B]	500			None	200 (HI)[A]
Organics (μg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (μg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.9 (GA, FL)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Dissolved	13.8	BDL	38.9	8.2	8.2 (CA, CT)
Total	15.2	BDL	52.1	8.3	7.9 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.
BDL-Below Detection Level

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 7. Data Sources

	Data Sources			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X	X		
4.3 Thermal Effects		X	X	
4.4 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Freshwater Layup

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..."[Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the freshwater layup discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Seawater cooling systems on vessels provide cooling water for propulsion plant and auxiliary system heat exchangers. Heat exchangers remove heat directly from the main propulsion machinery and the electrical generating plants, and directly or indirectly from all other equipment requiring cooling. The primary purpose of the main seawater system is to provide the coolant to condense low pressure steam from the main turbines and the generator turbines.[1]

When nuclear-powered submarines and aircraft carriers remain for an extended period and the seawater cooling systems are not circulated, the main condensers are placed in a freshwater layup.[1] The purpose of placing the condensers in a freshwater layup is to prevent the accumulation of biological growth and the resultant loss of condenser efficiency while the seawater cooling system is not in use. The propulsion plants of nuclear-powered vessels generally require a 2- to 3-day cooling down period prior to being laid up.[1]

The layup is accomplished by blowing the seawater from the main condensers with low pressure air and isolating the condensers.[1] The condensers are then filled with potable water from port facilities, a process that takes 1 to 2 hours, or more, to complete.[2] The potable water remains in the condensers, uncirculated, for approximately 2 hours. After this period of time, the potable water fill is blown overboard with low pressure air, which takes approximately an hour to accomplish.[1,2] The condensers are then considered flushed of any residual seawater (seawater or potable water). The condensers are then refilled with potable water for the actual layup. This process can be referred to as a double fill and flush cycle.

After 21 days, the initial fill water is discharged overboard and replaced.[1] The layup is discharged and refilled on a 30-day cycle thereafter.[1] This process can be referred to as a refill cycle. The freshwater layup may be terminated at any point during these cycles to support equipment maintenance or ship's movement.[1]

During a ship check and sampling episode aboard USS Scranton (SSN 756), it was observed that the main seawater condensers were filled indirectly with freshwater from port facilities.[3] The crew filled the forward potable water tank from the pier connection and then transferred the freshwater to the aft potable water tank.[3] The main condensers were then put in freshwater layup from the aft potable water tank.[3] The initial freshwater layup process lasted greater than 5 hours (e.g., from the beginning of initial fill to initiating the low pressure air blow to remove the initial freshwater flush).[3]

The main steam condensers on submarines are constructed either of titanium or 70/30 copper/nickel alloy.[4] Aircraft carrier main seawater condensers are constructed of 90/10 copper/nickel alloy. The condenser boxes for the 70/30 copper/nickel alloy condensers are constructed of a nickel/copper alloy and can be lined with a tin/lead solder and have zinc anodes installed for corrosion control.[4] The seawater piping that carries cooling water from the condensers to overboard discharge is constructed of 70/30 copper/nickel piping.[4]

2.2 Releases to the Environment

These discharges occur in port at pierside when the submarines' nuclear power plant has cooled and the main seawater cooling system is unable to be circulated for more than 3 days. Also, this discharge can occur if the ship will be in port for greater than 7 days (i.e., It takes 72 hours to cool down a reactor and 72 hours to ramp up a reactor which translates to six days, or roughly one week.) and the seawater cooling system can not be circulated. The freshwater is discharged from the seawater cooling piping openings located below the waterline of the ship. The discharge occurs when the fresh water is pushed out by low pressure air applied to the seawater cooling piping system. It is expected that this discharge will contain many of the constituents found in the fresh water (typically supplied by port facilities) used for the layup, as well as metals leached from the ship's piping system while the water is held during the layup, and any residual seawater remaining in the system after the double fill and flush.

2.3 Vessels Producing the Discharge

All attack submarines (SSNs), ballistic missile submarines (SSBNs), and nuclear-powered carriers (CVNs) generate this discharge. A total of 89 SSNs and SSBNs, and eight CVNs are currently in service in the Navy. While the three existing nuclear guided missile cruisers (CGNs) also produce this discharge, these are scheduled to be removed from service by 2003/2004, and therefore, will not be considered further. The Navy is the only member of the Armed Forces that operates nuclear-powered vessels.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge only occurs when vessels are in port.

3.2 Rate

The volume of the initial fill and flush of a nuclear-powered submarine is approximately 6,000 gallons of freshwater. This 6,000 gallons of freshwater is discharged overboard after a 1- to 2-hour layup in the main seawater condensers and refilled with an additional 6,000 gallons of freshwater as described in Section 2.1.[5] The total volume of freshwater required for the fill, flush, and refill of the condenser for freshwater layup on nuclear submarines is approximately 12,000 gallons, of which 6,000 gallons is discharged overboard.[5] The volume of this discharge will vary with the volumes of the main steam condensers for each submarine class.[5]

The amount of time that a submarine is in port, and hence, the number of layup cycles required, is dependent upon many factors, the most critical being the submarine's current mission. Each mission requires varying times in port for preparation, repairs, or modifications to support the mission specifics. In addition, many submarines undergo overhauls or other maintenance and/or repair activities that extend their time in port (e.g., must put their seawater systems into a dry layup condition).

Attack submarines (SSNs) average about 10 layup cycles per year, including five double fill and flush cycles and five refill cycles.[5] Each double fill and flush cycles and each refill cycle discharges approximately 6,000 gallons of freshwater per evolution. This results in 60,000 gallons of freshwater for each of the Navy's 72 SSNs per year. Therefore, fleet-wide discharge for the SSNs is 4,320,000 gallons of freshwater layup discharge per year, of which half is from the initial fill and half is from the refill cycles, or 2,160,000 gallons for each.

Ballistic missile submarines (SSBNs) have extended layovers of 1 to 1 1/2 months approximately three or four times per year. The volume of seawater systems in ballistic missile submarines are comparable to those of attack submarines. These submarines have an estimated three initial flush and fill cycles per year and approximately six refill cycles per year.[5] For an SSBN, this totals 54,000 gallons per submarine per year. The Navy operates 17 SSBNs. Therefore, the total freshwater layup discharged for all SSBNs is estimated to be 918,000 gallons per year, of which 306,000 gallons is from the initial fill and flush and 612,000 gallons is from refill cycles.

A total estimated volume of 5,238,000 gallons of freshwater layup is discharged in U.S. ports from the 89 SSN and SSBN hulls. The initial fill cycle accounts for 2,466,000 gallons and the refill cycles account for 2,772,000 gallons.

Nuclear powered aircraft carriers do establish freshwater layups in their various condensers, but the effluent is dumped into the bilges of the ship rather than being discharged directly overboard. Hence, the residual water from the aircraft carriers' layup is covered under the Surface Vessel Bilgewater/OWS Nature of Discharge report.

3.3 Constituents

The freshwater used in the freshwater layup can contain disinfectants from potable water treatment. The most common disinfectant is chlorine. Some municipalities, however, are switching over to chloramine disinfection to reduce the amount of disinfectant by-products formed. This switch could be permanent or seasonal, with the chloramines added during the warmer months when formation of disinfectant by-products are more prevalent. It is noted that the constituent make-up of the freshwater used to conduct the layup will have a significant effect on the discharge.

The constituents that can be present in freshwater layup from nuclear-powered submarines include: copper, lead, nickel, chlorine, ammonia, nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), phosphorous and related disinfectants, chromium, tin, titanium and zinc. Chromium, copper, lead, nickel, and zinc are priority pollutants. None of these constituents are bioaccumulators. The freshwater layup of a single submarine was sampled to determine the constituents that are present in the discharge.

3.4 Concentrations

The water used to fill the main condensers, the initial layup discharge, and an extended, 21-day discharge were sampled from USS Scranton (SSN 756).[3] A total of 17 metals were measurable in the initial and extended layup discharges from the sampling event. The vast majority of the metals detected have sources from either the materials within the main steam condenser or from the domestic water treatment/distribution system. The metals and classical parameters detected in the discharge are compiled in Table 1. In addition, the mass loadings are estimated for those constituents that were detected in either the 2-hour or 21-day layup discharges. Three priority pollutant metals, copper, nickel and zinc, were detected in the discharge at elevated concentrations. Total chlorine was also detected in the initial layup discharge (28 μg/L), but not in the discharge after 21 days. The domestic water from the pier connection was also sampled for total and free residual chlorine levels and contained 1,200 μg/L and 1,000 μg/L, respectively.[3] Nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), ammonia, and phosphorous were detected in both the 2-hour layup and the 21-day layup discharges.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based upon the concentrations of the metals reported for the layup effluents in Table 1 and the estimated discharge volumes in Section 3.2, the mass loadings were calculated using the estimated volumes of freshwater layup discharge in Table 2 for those constituents that exceeded either Federal or most stringent state water quality criteria (WQC). Table 3 highlights the constituents that exceed WQC. The estimated mass loadings, provided in Table 2, are derived by adding together contributions from both the initial fill volumes and the refill cycle volumes, because the two portions of the effluent have different concentrations.

(conc. μg/L)(g/1,000,000 μg) (lbs/453.593 g) (annual volume gal/yr) (3.785 l/gal) = mass loading (lbs/yr)

Based on the sampling data, the total fleet-wide loadings of ammonia, nitrogen, chlorine, copper, nickel, phosphorous, and zinc from this discharge are approximately 41, 55, 1, 7, 36, 8, and 29 pounds per year, respectively.

4.2 Environmental Concentrations

The discharge concentrations presented in Table 3 are compared to Federal and most stringent state WQC.

Copper was present in the fill water from the aft potable water tank, but it is unknown if copper was present in domestic water from the pier connection. The fill water copper concentrations exceeded Federal and the most stringent state. Copper is normally present in the domestic water supply in concentrations that exceed WQC because of the presence of copper-constructed components in drinking water distribution systems. The levels of copper can be partially attributable to the construction of the potable water systems on board the submarine through which the domestic water was routed prior to filling the main seawater condensers. These systems have copper piping and brass valves that can contribute copper to the water.

Table 3 shows the concentrations of the three priority pollutant metals (copper, nickel, and zinc) that exceed Federal and most stringent state WQC. The chlorine concentration from the initial 2-hour layup exceeds the most stringent state criterion. Ammonia, total nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), and total phosphorous concentrations in the two layup discharges exceed the most stringent state criterion. The presence of phosphorous in the effluent appears to be from the domestic water as the effluent concentrations for total phosphorous shows no increase over the fill water concentrations.

4.3 Potential for Introducing Non-Indigenous Species

There is no movement of the vessel during the layup process and the water used for the layup is chlorinated domestic water from shore facilities. As such, there is no potential for transporting non-indigenous species.

5.0 CONCLUSION

Freshwater layup of seawater cooling systems has a low potential of adverse environmental effects for the following reasons.

1. The mass loadings of chlorine, copper, nickel, and zinc are small although the concentrations exceed Federal and most stringent state WQC. The mass loadings of ammonia, nitrogen, and phosphorous are also small, but concentrations exceed the most stringent state WQC. The total annual mass loadings for ammonia,

nitrogen, chlorine, copper, nickel, phosphorous, and zinc contribute approximately 41, 55, 1, 7, 36, 8, and 29 pounds, respectively. The 89 submarines producing this discharge are geographically dispersed over seven ports.

2. There is no potential for the transfer of non-indigenous species.

6.0 DATA SOURCES AND REFERENCES

Process knowledge and sampling of this discharge were used in preparing this NOD report. Table 4 shows the sources of data used to develop this NOD report. The specific references cited in the report are shown below.

Specific References

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3. UNDS Phase I Sampling Data Report, Volumes 1 - 13. October 1997.

4. Bredehorst, Kurt, NAVSEA 03L. Materials Within the Seawater Side of Main Condenser. September 1996. Miller, Robert B, M. Rosenblatt & Son, Inc.

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The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, pg. 15366. March 23, 1995.

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Table 1. Summary of Detected Analytes

Constituent	Freshwater Influent	2-Hour Freshwater Effluent	21-Day Freshwater Effluent	Frequency of Detection	Mass Loading
Classicals	(mg/L)	(mg/L)	(mg/L)		(lbs/yr)
Alkalinity	26	27	46	1 of 1	1,616
Ammonia as Nitrogen	0.17	1.3	0.6	1 of 1	41
Chemical Oxygen Demand (COD)	12	BDL	48	1 of 1	1,108
Chloride	20	63	34	1 of 1	2,078
Nitrate/Nitrite	0.62	0.68	0.4	1 of 1	23
Sulfate	21	22.8	17	1 of 1	861
Total Chlorine	1.2	0.028	BDL	1 of 1	0.58
Total Dissolved Solids	140	232	82	1 of 1	6,657
Total Kjeldahl Nitrogen	0.70	0.63	0.81	1 of 1	32
Total Organic Carbon (TOC)	2.70	2.7	25	1 of 1	633
Total Phosphorous	0.22	0.19	0.19	1 of 1	8.3
Total Recoverable Oil and Grease	1.0	BDL	1.0	1 of 1	23
Total Sulfide (Iodometric)	6	3.0	BDL	1 of 1	62
Volatile Residue	76	165	BDL	1 of 1	3,388
Metals	(µg/L)	(µg/L)	(µg/L)		(lbs/yr)
Aluminum					
Dissolved	BDL	57.7	BDL	1 of 1	1.19
Total	109	43.9	BDL	1 of 1	0.90
Arsenic					
Dissolved	BDL	0.8	BDL	1 of 1	0.016
Barium					
Dissolved	35.5	27.5	25.6	1 of 1	1.16
Total	36.2	28.10	26.3	1 of 1	1.19
Beryllium					
Dissolved	BDL	BDL	0.75	1 of 1	0.017
Boron					
Dissolved	BDL	36.8	BDL	1 of 1	0.76
Total	BDL	37.5	BDL	1 of 1	0.77
Calcium					
Dissolved	15700	17050	19800	1 of 1	807
Total	16000	16750	20400	1 of 1	815
Copper					
Dissolved	135	137	107	1 of 1	5.3
Total	136	150	148	1 of 1	6.5
Lead					
Dissolved	BDL	BDL	3.45	1 of 1	0.08
Total	2.3	2.0	4.75	1 of 1	0.15
Magnesium					
Dissolved	2720	6880	5185	1 of 1	261
Total	2860	6890	5495	1 of 1	268
Manganese					
Dissolved	BDL	19.7	276	1 of 1	6.8
Total	6.3	21.8	310	1 of 1	7.6
Nickel					
Dissolved	BDL	409	1175	1 of 1	35.6

Total	BDL	433	1175	1 of 1	36.1
Selenium					
Dissolved	BDL	BDL	2.45	1 of 1	0.057
Total	BDL	BDL	1.60	1 of 1	0.037
Sodium					
Dissolved	10500	39200	17800	1 of 1	1,216
Total	10500	37550	21400	1 of 1	1,265
Thallium					
Dissolved	BDL	0.75	BDL	1 of 1	0.015
Total	1.3	BDL	BDL	1 of 1	(a)
Tin					
Dissolved	5.1	BDL	BDL	1 of 1	(a)
Total	4.2	BDL	2.75	1 of 1	0.06
Zinc					
Dissolved	137	463	784	1 of 1	27.7
Total	127	451	851	1 of 1	29
Organics	(μg/L)	(μg/L)	(μg/L)		(lbs/yr)
Bis(2-ethylhexyl) phthalate	137	BDL	BDL	1 of 1	(a)

BDL - Denotes the below the detection for the method and instrument.
(a) No mass loadings are calculated for constituents that were not detected in either the 2-hour or 21-day freshwater layup discharge.

Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 2: Estimated Annual Mass Loadings for Freshwater Layup Discharge

Analyte	2-hr Layup Conc. (μg/L)	Estimated Mass Loadings (lbs/yr)	21-day Layup Conc. (μg/L)	Frequency of Detection	Estimated Mass Loadings (lbs/yr)	Total Estimated Loadings, Freshwater Layup (lbs/yr) Fleetwide
Annual Volume (gal/yr):		2,466,000			2,772,000	
Copper						
Dissolved	137	2.8	107	1 of 1	2.5	5.3
Total	150	3.1	148	1 of 1	3.4	6.5
Nickel						
Dissolved	409	8.4	1175	1 of 1	27.2	35
Total	433	8.9	1175	1 of 1	27.2	36
Zinc						
Dissolved	463	9.5	784	1 of 1	18.7	27
Total	451	9.3	851	1 of 1	19.7	29
Ammonia as Nitrogen	1300	27	600	1 of 1	14	41
Nitrate/Nitrite	680	14	400	1 of 1	9	23
Total Kjeldahl Nitrogen	630	14	810	1 of 1	18	32
Total Nitrogen[A]	1310	28	1210		27	55
Total Chlorine	28	0.58	-	1 of 1	-	0.58
Total Phosphorous	190	3.9	190	1 of 1	4.4	8.3

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 3: Mean Concentrations of Constituents Exceeding Water Quality Criteria

Constituent	2-Hour Layup Concentration	21-Day Layup Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Metals (μg/L)				
Copper				
Dissolved	137	107	2.4	2.4 (CT, MS)
Total	150	148	2.9	2.5 (WA)
Nickel				
Dissolved	409	1175	74	74 (CA, CT)
Total	433	1175	74.6	8.3 (FL, GA)
Zinc				
Dissolved	463	784	90	90 (CA, CT, MS)
Total	451	851	95.1	84.6 (WA)
Classicals (mg/L)				
Ammonia as Nitrogen	1.3	0.6	None	0.006 (HI)[A]
Nitrate/Nitrite	0.68	0.4	None	0.008 (HI)[A]
Total Kjeldahl Nitrogen	0.63	0.81	None	-
Total Nitrogen[B]	1.31	1.21	None	0.2 (HI)[A]
Total Chlorine	0.028	-	None	0.010 (FL)
Total Phosphorous	0.19	0.19	None	0.025 (HI)[A]

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 4. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and 3Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate				X
3.3 Constituents		X		X
3.4 Concentrations		X		
4.1 Mass Loadings		X		
4.2 Environmental Concentrations	X			
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Gas Turbine Water Wash

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the gas turbine water wash and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Shipboard gas turbine systems are used on certain vessels to provide propulsion power, provide initial mechanical starting power for large gas turbine propulsion systems, and to generate electricity. Power is generated by combusting fuel in a "gas generator" (commonly referred to as a "combustor"). The combustor exhaust gas rotates the "power turbine," providing the mechanical energy to either drive a propulsion shaft, start a larger turbine, or generate electricity.[1]

Over extended periods of operation, residual lubrication oil and hydrocarbon combustion by-product deposits can form on gas turbine internals. Since naval vessels operate in a marine environment, salt water introduced with intake air can also lead to salt deposits on the gas turbine internals. Washing the gas turbine internals periodically with a solution of freshwater and cleaning compound maintains operating efficiency and prevents corrosion of the metallic components. The cleaning compound that is currently used for this purpose is a petroleum-based solvent referred to as "gas path cleaner."[1]

Two types of water wash systems exist on vessels with gas turbines. One is a dedicated "hard-piped" system; the other type requires manual attachment of a hose to a hot water source and placement of the other hose end into the turbine plenum. Both of these systems are designed to introduce water wash into the turbine housing while the turbine starter motor is slowly rotated, (i.e., cranked without combustion). The hard-piped system includes a rinse tank where distilled/demineralized water and cleaning compound are mixed. The contents of the tank are sprayed into the gas turbine under pressure, either by using a pump or by pressurizing the tank with compressed air.[1] Immediately following the wash, the engine is sprayed with water.

Gas turbine engines are enclosed in a "module" with floor drains designed to remove minor leakage of fuel and synthetic lube oil that may occur during normal turbine operation. The floor drains also remove any water wash introduced into the turbine that is not discharged to the atmosphere. Water wash from external scrubbing of the gas turbine also flows to these floor drains. Inadvertent spills of synthetic lube oil that occasionally occur during turbine maintenance activities are potentially capable of entering the drains; however, standard procedure is for ship personnel to immediately contain and wipe up any spillage that occurs.[1]

On most Navy ships, gas turbine water wash effluent and any drainage of residual material from leaks and spills are collected and held in a dedicated tank system for shore disposal. The Navy refers to this system as the "Gas Turbine Waste Drain Collecting System." The dedicated system includes a centrifugal pump and piping to transfer the water wash to a hose connection topside. A hose is used to transfer the water wash to a pierside collection facility. On vessels without this system, the drainage is discharged to the environment as a component of other UNDS discharges (i.e., Surface Vessel Bilgewater/OWS, Welldeck, and Deck Runoff).[1]

The wash water effluent discharge from U.S. Coast Guard (USCG) vessel gas turbine washing operations is to the bilge, from where it is processed as bilgewater (along with other bilgewater contributors) through the shipboard OWS prior to overboard discharge. The gas turbine water wash effluent for USCG vessels is addressed as a component of the Surface Vessel Bilgewater/OWS Discharge NOD Report.

Gas turbine propulsion engines are also used aboard Navy landing craft air cushion (LCAC) amphibious landing crafts. Two gas turbine auxiliary power units (APUs) are also installed on LCACs to provide starter air. The LCAC gas turbine washwater discharge is addressed as a component of the Welldeck Discharges NOD Report.

Water wash cleaning of aircraft gas turbine engines aboard an aircraft carrier is addressed as a component of the Deck Runoff NOD Report.

2.2 Releases to the Environment

The water wash introduced into Navy propulsion turbines contains water and solvent-based gas path cleaner. The discharge could be expected to contain components of the cleaner, oil and grease (O&G), petroleum-derived fuel and lubricant constituents, synthetic lubricating oil, constituents introduced into the turbine system with the incoming sea air, hydrocarbon combustion by-products, and metals leached from gas turbine components. On most gas turbine Navy and MSC ships, gas turbine washwater is collected in a dedicated tank and not discharged overboard within 12 n.m. On ships without a dedicated collecting tank, this discharge is a component of deck Runoff, welldeck runoff, or bilgewater as described in the previous section.

2.3 Vessels Producing the Discharge

Table 1 lists the vessel classes that have shipboard gas turbine systems. Vessel classes equipped with a Gas Turbine Waste Drain Collecting System are denoted in Table 1. For the other vessel classes listed in Table 1, the gas turbine water wash is discharged as a component of another UNDS discharge. The maximum number of vessels with Gas Turbine Waste Drain Collecting System is 127. Army and Air Force vessels do not have gas turbine engines and do not generate this discharge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Vessels with Gas Turbine Waste Drain Collecting Systems collect and store drainage from normal turbine operations and water wash effluent for pierside disposal. On most gas turbine Navy and MSC ships, gas turbine washwater is collected in a dedicated collecting tank and not discharged overboard within 12 n.m. On ships without a dedicated collecting tank, this discharge is a component of deck Runoff, welldeck runoff, or bilgewater as described in the previous section.

3.2 Rate

Available information on gas turbine water wash usage rates is contained in gas turbine design and operations and maintenance documentation.[2,3,4] The frequency of water wash cleanings and the quantity of water wash consumed per washing event is different between USCG, Navy, and Military Sealift Command (MSC) vessels.

Navy and MSC vessel gas turbines used for propulsion are washed after each 48 hours of operation or at least once per month.[5] Two gallons of the gas path cleaner are initially mixed with 38 gallons of distilled/demineralized water. Immediately following the wash, the turbine is spray rinsed with 80 gallons of water. An additional 2 gallons of detergent/water mixture is used to clean external turbine surfaces, as necessary. Each cleaning of the propulsion turbines produces 122 gallons of water wash. Therefore a vessel with four propulsion gas turbines each cleaned once every 48 hours of operation would generate an average of 244 gallons of water wash per day.

3.3 Constituents

The chemicals used in gas turbine operation and maintenance that could potentially contribute to contamination of turbine water wash are gas path cleaner, Naval distillate fuel F-76, gas turbine fuel, JP-5, synthetic lube oil, copper, cadmium, and nickel.[6-10]

The gas path cleaners used by the Navy include petroleum distillates (aromatic and aliphatic hydrocarbons), assorted glycols, detergents, soaps, and water.[6,7] The composition of one such cleaner used by the Navy can be found in its material safety data sheet (MSDS).[6] According to the MSDS sheet, the cleaner can contain the aromatic hydrocarbon naphthalene at concentrations of up to 3.9%. Other petroleum distillate hydrocarbon constituents that could be present include aliphatic volatile organic compounds and other semivolatile compounds that are priority pollutants. The priority pollutants that are potential constituents of gas turbine water wash are cadmium, copper, nickel, and naphthalene. None of the constituents is a bioaccumulator.

3.4 Concentrations

The addition of gas path cleaner containing 3.9% naphthalene to the wash water at a 2% gas path cleaner concentration yields an estimated water wash naphthalene concentration of 800 milligrams per liter (mg/L). The following shows this calculation.

Naphthalene Concentration (mg/L) =
(% of cleaner in water)(% of naphthalene in cleaner)(density of naphthalene)

where,

% of cleaner in water = 2

% of naphthalene in cleaner = 3.9

density of naphthalene = $(1.0253\ g/cm^3)(1000\ mg/g)(1000\ cm^3/L) = 1.025 * 10^6\ mg/L$

Naphthalene Concentration = $(0.02)(0.039)(1.025 * 10^6) = 800\ mg/L$

Because naphthalene is a semivolatile organic compound that is not expected to volatilize while the water wash is sprayed into the turbine, the maximum water wash effluent naphthalene concentration is also estimated at 800 mg/L. Other constituents are variable and were not estimated.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The water wash volume estimate for a Navy ship propulsion turbine cleaning operation and naphthalene concentration estimate of 800 mg/L were used to estimate the maximum annual mass loading. The estimate is based on the assumption that one turbine cleaning for each vessel is performed each day within 12 n.m.

Mass Loading of Naphthalene (lbs/yr) =
(naphthalene conc.)(discharge vol.)(365 days/yr)(# vessels) (3.7854 L/gal) (2.2 lb/kg) (10^{-6} kg/mg)

(800 mg/L)(244 gal/day)(365 days/yr)(127)(3.7854 L/gal)(2.2 lb/kg)(10^{-6} kg/mg) = 75,400 lbs/yr

The mass loading of O&G that can be introduced into the water wash effluent from within the gas turbine depends on (a) the amount of residue present; and (b) the degree to which the water wash spray removes the residue as it passes through the turbine.

4.2 Environmental Concentrations

Table 2 shows that the estimated naphthalene concentration exceeds the most stringent state water quality criteria (WQC) for naphthalene. Concentrations of oil and grease are expected to exceed WQC because the source of this discharge (gas turbine cleaning) is designed to dissolve fuel, lubricant, and other hydrocarbon deposits.

4.3 Potential for Introducing Non-Indigenous Species

There is no potential of introduction, transport, or release of non-indigenous species between different geographical areas, because the water wash system does not use seawater and therefore does not involve the discharge of seawater originating in another geographical region.

5.0 CONCLUSIONS

If discharged, gas turbine water wash has the potential to cause an adverse environmental effect within 12 n.m. because:

1) Estimated concentrations of naphthalene exceed and the most stringent state WQC and the mass loading of this priority pollutant would be significant; and

2) Concentrations of oil and grease are expected to be significant because the source of this discharge (gas turbine cleaning) is designed to dissolve fuel, lubricants and other deposits.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from the following sources was obtained to develop this NOD report. Table 3 shows the sources of data used to develop this NOD report.

<u>**Specific References**</u>

1. UNDS Equipment Expert Meeting Minutes. June, 20, 1997.

2. Uniform Maintenance Procedure Card (MPC), WAGB 400 Main Gas Turbine, MPC M-C-062, Amendment 3.

3. Uniform Maintenance Procedure Card (MPC), WHEC 378 Main Gas Turbine, MPC M-C-017, Amendment 0.

4. Uniform Maintenance Procedure Card (MPC), WHEC 378 Emergency Generator, MPC A-W-001, Amendment 0.

5. Maintenance Requirement Card (MRC), OPNAV 4790 (Rev. 2-82).

6. Gas Path Cleaner Material Safety Data Sheet, supplied by M. Galecki of DDG 51 Flight Upgrade Office via facsimile to Malcolm Pirnie (C. Geiling) on June 12, 1997.

7. Military Specification MIL-C-85704, "Cleaning Compound, Turbine Engine Gas Path".

8 Military Specification MIL-F-16884, "Fuel, Naval Distillate".

9. Military Specification MIL-F-5624, "Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-

10. Military Specification MIL-L-23699, "Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156".

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USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Vessels With Gas Turbine Systems

Branch	Class	No.	Vessel Type	Comment
Navy	AOE 6	3	Fast Combat Support Ship	Dedicated collection system
	CG 47	27	Guided Missile Cruiser	Dedicated collection system
	DD 963	31	Destroyer	Dedicated collection system
	DDG 51	18	Guided Missile Destroyer	Dedicated collection system
	DDG 993	4	Guided Missile Destroyer	Dedicated collection system
	FFG 7	43	Guided Missile Frigate	Dedicated collection system
	MCM 1	14	Mine Countermeasure Vessel	Unknown configuration
MSC	T-AKR 310	1	Fast Sealift Ship	Dedicated collection system
USCG	WAGB 399	2	Icebreaker	Discharged to bilge
	WHEC 378	12	High Endurance Cutter	Discharged to bilge

No. = number of vessels in class

Table 2. Comparison of Gas Turbine Water Wash Estimated Concentration and Water Quality Criteria (μg/L)

Constituent	Maximum Estimated Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Naphthalene	800,000	None	780 (HI)

Notes:
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

HI = Hawaii

Table 3. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation	Equipment Literature			X
2.2 Releases to the Environment	OPNAVINST 5090.1B			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	Standard Operating Procedures		X	X
3.3 Constituents	MSDS		X	X
3.4 Concentrations	MSDS		X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Graywater

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the graywater discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Graywater is defined in section 312(a) of the Clean Water Act as wastewater from showers, baths and galleys. On vessels of the Armed Forces, drainage from laundry, interior deck drains, lavatory sinks, water fountains, and miscellaneous shop sinks is often collected together with graywater. Therefore, this discharge covers graywater as well as mixtures of graywater with wastewater from these additional sources.[1] In this report, the term “graywater” will be used to describe all of these related discharges. Graywater is distinct from “blackwater”, the sewage generated by toilets and urinals.

While pierside, most classes of Navy vessels direct graywater to the vessel’s blackwater Collection, Holding, and Transfer (CHT) tanks, via segregated graywater plumbing drains. Some recently built ships (such as CVN 73 and CVN 74) do not have segregated blackwater/graywater drains. These ships collect the blackwater/graywater mixture while inside 3 nautical miles (n.m.). The blackwater and graywater mixture is then pumped to pierside connections for treatment ashore. A typical CHT system is shown in Figure 1. Most navy surface vessels without CHT systems have dedicated graywater tanks and pumps to collect and transfer this discharge to shore facilities. Some vessels lack the means to collect all the graywater that is generated while pierside. On these vessels a portion of the graywater plumbing drains run directly overboard.[1-4]

While operating away from the pier, most Navy surface vessels that collect graywater in CHT tanks divert graywater drains overboard to preserve holding capacity for blackwater in the tanks. Vessels equipped with separate graywater collection and transfer systems are not designed to hold graywater for extended periods of time and therefore drain or pump their graywater overboard while operating away from the pier.

Submarines collect their graywater in the ship’s sanitary tank while pierside and within 3 n.m. of land. Pierside, graywater mixed with blackwater is discharged to a shore facility for treatment; when outside 3 n.m., graywater is discharged directly overboard. Unlike surface vessels, holding capacity in the submarines’ sanitary tanks is generally sufficient to allow collection of graywater and blackwater up to 12 n.m. from shore.[1]

All Military Sealift Command (MSC) vessels are equipped with U.S. Coast Guard (USCG) certified Marine Sanitation Devices (MSDs) designed to treat sewage to EPA and USCG standards. On some MSC vessels, graywater can be collected and sent to the MSD for processing, or diverted overboard. On other MSC vessels, graywater is neither collected nor treated, but is discharged directly overboard.

Most USCG vessels are similar to Navy vessels since they can collect graywater while pierside. However, some USCG vessels currently cannot collect graywater, but continually discharge it overboard.

The majority of Army vessels collect graywater together with blackwater (sewage)[*] for treatment by a USCG certified MSD. The MSD effluent is either sent overboard, held in an effluent holding tank, or discharged to a shore facility.

2.2 Releases to the Environment

Contributions to graywater are described below. Three sources comprise the majority of graywater flow: Galley and scullery (18% in port, 22% at sea); laundry (22% in port, 33% at sea); and showers and sinks (60% in port and 45% at sea).[5] In addition, other minor sources include: filter cleaning discharges, deck drains, and medical/dental waste discharges.[1]

2.2.1 Galley

Food preparation occurs in a vessel's galley. Large Navy vessels have several galley compartments. In smaller vessels, the galley can be a shared space with related functions (e.g., the scullery), and have a single sink through which wastewater is discharged. Galley discharges specifically exclude food/garbage grinder wastes. Garbage grinders are required to be secured inside 3 n.m.[6]

Wastewater from the galley is generated through food preparation, disposal of cooking liquids, and cleaning of surfaces (bulkheads, appliances, sinks, and working surfaces). The generation and discharge are periodic, with the majority of the flow occurring during the hours preceding meal times. Galley graywater can contain highly biodegradable organics, oil and grease, and detergent residuals.

2.2.2 Scullery

The scullery can be separate from or integral with the galley and is used for the cleaning of dishes and cookware. Scullery wastewater also specifically excludes garbage grinder wastes, as garbage grinders are required to be secured inside 3 n.m.[6] Scullery graywater can contain food residuals and detergents.

2.2.3 Showers and Lavatory Sinks

Lavatory sinks and showers drain to the vessel's graywater system and can contain soap residues, shampoos, shaving cream, and other products resulting from personal hygiene. Detergent residuals similar to those used in the galley can also be present.

2.2.4 Laundry

[*] The Army usually refers to bilgewater as "blackwater" and sewage as "sewage".

Graywater derived from laundering crew uniforms, linens, and other articles of clothing can contain laundry detergents, bleaches, oils and greases, and traces of other constituents. Detergent residuals similar to those used in the galley, lavatory sinks, and showers can also be present.

2.2.5 Other Discharges

Other minor discharges which are collected with graywater include filter cleaning discharges, deck drains, and medical/dental waste discharges. These discharges combined represent less than 1% of the total shipboard generated graywater.[5] Filter cleaning discharges consist of detergents and small amounts of oil from commercial dishwashing machines or sinks used to wash ship ventilation system air filters. Deck drains contribute small and intermittent flows which can include detergents used for floor cleaning and other general space cleaning. Small amounts of medical/dental wastes are collected with graywater on only a few Navy ships with extensive medical and dental facilities such as aircraft carriers (CV/CVNs) and amphibious assault ships (LHD/LHA/LPHs). This would include wastes from dental spit sinks and small blood samples less than 7.5 milliliters (mL).[7]

2.3 Vessels Producing the Discharge

Vessels in the Navy, MSC, Army, Air Force, and USCG generate graywater. However, there are some vessels that do not produce a separate and distinct graywater discharge. These are the vessels not equipped with segregated graywater collection systems. Instead, they collect graywater together with blackwater for combined treatment with a MSD.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Discharges of graywater incidental to normal operations occur under three circumstances: (1) at the pier, for the ship classes lacking the means to collect graywater for shore treatment; (2) between 0 and 3 n.m. for most Navy and USCG vessels and for some MSC vessels; and (3) outside 3 n.m., where most graywater is discharged overboard.

3.2 Rate

The Navy uses a design figure of 30 gallons per capita-day (gal/cap/day) when designing graywater collections systems.[8]

Table 1 presents estimates of discharge rates by vessel class for Navy, MSC, USCG, and Army ships. The following assumptions are inherent in the table:

- With the few exceptions noted in Section 2.1 and 2.3, vessels discharge graywater overboard at all times when not pierside. It is assumed, for purposes of calculation, that USCG, MSC, and Army vessels also discharge graywater overboard at all times when not pierside.

- A typical vessel is estimated to require about four hours to transit 12 n.m. from shore, with a per capita average rate of 1.25 gallons/hour (30 gal/cap/day). If this vessel undergoes 20 transits a year and has a crew size of 400, the annual graywater discharge rate while in transit would be:

(20 transits/year) (4 hours/transit) (1.25 gal/capita-hour) (400 personnel) = 40,000 gallons/year

Some vessels of the USCG and Army operate on a routine basis within 12 n.m. of shore. Annual graywater discharge rate calculations for these vessels are based, in part, on the number of days each ship operates within 12 n.m. A vessel's graywater discharge that results from operating within 12 n.m. is calculated by using the following general formula:

(personnel) (hours in operation/year) (1.25 gal/capita-hour) = gallons/year

USCG vessels that operate within 12 n.m. include: Mackinaw Class Icebreakers (approx. 150 days/year, 24 hours/day), Bay Class Icebreaking Tugs (approx. 150 days/year, 24 hours/day), and Balsam Class Seagoing Buoy Tenders (approx. 100 days/year, 24/hours/day). Army vessels that operate within 12 n.m. include: Logistic Support Vessels (approx. 30 days/year, 10 hours/day) and Landing Craft Utility (approx. 60 days/year, 10 hours/day). Due to the fact that the majority of Army vessels collect most of their graywater with blackwater, approximately only 10% of the graywater generated is discharged separately.[9]

As shown in Table 1, the total estimated amount of graywater discharged overboard annually inside 12 n.m. is 39 million gallons. Of that volume, 15.3 million gallons are discharged pierside.

3.3 Constituents

In graywater, soaps, shampoos, detergents, and cleaners contribute organics as well as inorganic compounds such as nitrogen and phosphorous. Food waste will contribute oxygen demand (as measured by Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)), nutrients, and oil and grease. Metals, pesticides, and organics from adhesives, sealants, lubricants, and cleaners can also be present in graywater. The constituents that have been measured in previous graywater studies are shown in Tables 2 and 3. The priority pollutants cadmium, chromium, copper, lead, nickel, silver, and zinc were identified. Mercury, a bioaccumulator, was also identified. It is possible that certain parameters not tested for, and thus not listed in Tables 2 and 3, could also be present in graywater.

3.4 Concentrations

Table 2 shows the average values measured for classical water quality parameters in various shipboard streams that contribute to graywater based on samples collected from three classes of vessels. Data are shown for the following graywater discharge components: wash basins and showers, food preparation, laundry, and dishwasher and deep sink. The ranges of the average measured values are: pH (6.74 - 10), total suspended solids (TSS)(94 - 4,695 milligrams per liter (mg/L)), total dissolved solids (TDS)(225 - 8,064 mg/L), BOD (144 - 2618 mg/L), COD (304 - 7,839 mg/L), total organic carbon (TOC)(59 - 1,133 mg/L), oil and grease (5 - 1,210 mg/L), methylene blue active substances (MBAS) (0.1 - 4.1 mg/L), ammonia nitrogen (0.17 - 669 mg/L), phosphate (1.03 - 28.2 mg/L), and coliform bacteria (178 - >2,000,000 per 100 mL). Flow-weighted average concentrations of these constituents are calculated in Table 2, based upon the data presented therein and the relative contribution of the three major sources of graywater.

Table 3 shows the mean concentrations of metals in various graywater components based on samples collected from three classes of vessels. Data are shown for the following graywater components: potable water sink, galley drains, sink, and scullery. The ranges of the average measured values are: silver (.007 - 0.012 mg/L), cadmium (0.004 - 0.017 mg/L), chromium (0.002 - 0.03 mg/L), copper (0.25 - 3.4 mg/L), lead (0.042 - 1.56 mg/L), mercury (.0002 - .0095 mg/L), nickel (0.025 - 0.113 mg/L), and zinc (0.19 - 2.36 mg/L). Flow-weighted average concentrations of these metals are calculated in Table 3, based upon the data presented therein and the relative contribution of graywater sources involved.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Total flow, and therefore mass loadings, are influenced by the number of personnel aboard, time spent in transit, and time spent operating within 12 n.m. Total loadings can be estimated by multiplying concentration data by the total annual flow of graywater. Based on typical constituent concentrations and the estimated total flow calculated in Table 1, annual loadings of constituents are presented in Table 4.

4.2 Environmental Concentrations

Screening for constituents was accomplished by comparing measured levels of constituents to the lowest applicable water quality criteria. For graywater, the only constituents for which both data and water quality criteria are available are metals. Parameters such as BOD and nutrients are at levels that would be expected to cause localized adverse environmental effects.

As shown in Table 5, concentrations of the priority pollutants copper, lead, nickel, silver, and zinc (measured as total metals), in one or more graywater components, exceed the most stringent water quality criteria. The bioaccumulator, mercury, exceeds the most stringent water quality criteria. Ammonia also exceeds the most stringent water quality criteria.

4.3 Potential for Introducing Non-Indigenous Species

Graywater originates from potable water rather than seawater. Therefore, the potential for introduction of non-indigenous species is not significant.

5.0 CONCLUSIONS

Graywater has the potential to cause adverse environmental effects because measured concentrations and estimated loadings of nutrients and oxygen-demanding substances are significant.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on the reported concentrations of constituents, the mass loadings to the environment resulting from this discharge were then estimated. Table 6 shows the source of the data used to develop this NOD report.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Ships of the Navy, MSC, USCG, and Army; Annual Graywater Discharge

Class	Description	Vessels[10]	Crew Size	Transits per Year[11]	Estimated Total Time in Transit (hr)	Graywater Discharge, in Transit (gal/yr)	Vessels Discharging Overboard at Pier	Days in Port, per year[11]	Graywater Discharged Pierside (gal/yr)	Total Graywater Generation, 0 to 12 n.m. (gal/year)	Total Discharge, 0 to 12 n.m. (gal/yr)
	Navy Ships										
CG 47	Ticonderoga Class Cruiser	27	409	24	96	1,325,160				1,325,160	1,325,160
CGN 36	California Class Guided Missile Cruiser	2	603	22	88	132,660				132,660	132,660
CV 62	Forrestal Class Aircraft Carrier	1	5,624	6	24	168,720				168,720	168,720
CVN 65	Enterprise Class Aircraft Carrier	1	5,815	12	48	348,900				348,900	348,900
CV 63	Kitty Hawk Class Aircraft Carrier	3	5,624	14	56	1,181,040				1,181,040	1,181,040
CVN 68	Nimitz Class Aircraft Carrier	7	6,286	14	56	3,080,140				3,080,140	3,080,140
CGN 40	Virginia Class Guided Missile Cruiser	1	600	22	88	66,000				66,000	66,000
DDG 993	Kidd Class Guided Missile Destroyers	4	386	24	96	185,280				185,280	185,280
DDG 51	Arleigh Burke Class Guided Missile Destroyers	18	303	22	88	599,940				599,940	599,940
DD 963	Spruance Class Destroyers	31	396	24	96	1,473,120	4	175	1,663,200	3,136,320	3,136,320
FFG 7	Oliver Hazard Perry Guided Missile Frigates	43	220	26	104	1,229,800				1,229,800	1,229,800
LCC 19	Blue Ridge Class Amphibious Command Ships	2	1,516	16	64	242,560				242,560	242,560
LHD 1	Wasp Class Amphibious Transport Docks	4	3,151	26	104	1,638,520				1,638,520	1,638,520
LHA 1	Tarawa Class Amphibious Assault Ships	5	2,292	18	72	1,031,400	4	173	9,516,384	10,547,784	10,547,784
MCS 12	Iwo Jima Class Assault Ships	2	1,746	*18*	72	314,280				314,280	314,280
LPD 4	Austin Class Amphibious Transport Docks	3	1,487	22	88	490,710				490,710	490,710
LSD 41	Whidbey Island Class Dock Landing Ships	8	852	26	104	886,080				886,080	886,080
LSD 36	Anchorage Class Dock Landing Ships	5	794	26	104	516,100				516,100	516,100
MCM 1	Mine Countermeasures Ship Avenger Class	14	72	56	224	282,240				282,240	282,240
MHC 51	Mine Countermeasures Ship Osprey Class	12	50	*50*	200	150,000				150,000	150,000
PC 1	Cyclone Class Coastal Defense Ships	13	4	36	144	9,360				9,360	9,360
SSN 640	Benjamin Franklin Class Attack Submarines	2	120	*16*	64	0				19,200	0
SSN 671	Narwhal Class Attack Submarine	1	129	*16*	64	0				10,320	0
SSN 688	Los Angeles Class Attack Submarines	56	120	*16*	64	0				537,600	0
SSN 637	Sturgeon Class Attack Submarines	13	107	*16*	64	0				111,280	0
SSBN 726	Ohio-Class Ballistic Missile Submarines	17	136	*16*	64	0				184,960	0
	Navy Auxiliary Ships										
AE 28	Kilauea Class Ammunition Ships	8	383	8	32	122,560		26	477,984	600,544	600,544
AO 177	Cimarron Class Oilers	12	135	20	80	162,000		188	1,827,360	1,989,360	1,989,360
AOE 6	Supply Class Fast Combat Support Ships	3	667	12	48	120,060				120,060	120,060
AOE 1	Sacramento Class Fast Combat Support Ship	4	601	22	88	264,440				264,440	264,440
ARS 50	Safeguard Class Savage Ships	4	90	44	176	79,200				79,200	79,200
AS 36	LY Spear and Emory S Land Class Submarine Tenders	3	604	10	40	90,600				90,600	90,600
AS 33	Simon Lake Class Submarine Tenders	1	915	12	48	54,900				54,900	54,900
	Military Sealift Command										
T-AE	Kilauea Class Ammunition Ships	8	187	*40*	160	299,200		45	403,920	703,120	703,120
T-AFS	Mars Class Combat Stores Ships	5	135	*40*	160	135,000				135,000	135,000
T-AFS	Sirius Class Combat Stores Ships	3	165	*40*	160	99,000				99,000	99,000

T-ATF	Powhatan Class Fleet Ocean Tugs	7	23	*40*	160	32,200				32,200	32,200
T-AO	Henry J Kaiser Class Oilers	12	137	*40*	160	328,800		45	443,880	772,680	772,680
T-AGM	Haskell Class Missile Instrumentation Ship	1	124	*40*	160	24,800				24,800	24,800
T-AGM	Compass Island Class Missile Instrumentation Ship	1	143	*40*	160	28,600				28,600	28,600
T-AH	Mercy Class Hospital Ships	2	1,275	*4*	16	51,000				51,000	51,000
T-ARC	Zeus Class Cable Repairing Ship	1	126	*40*	160	25,200				25,200	25,200
T-AKR	Selandia Class Fast Sealift Ships	3	90	*40*	160	54,000				54,000	54,000
T-AKR	Bob Hope Class Fast Sealift Ships	8	90	*40*	160	144,000				144,000	144,000
T-AGOS	Stalwart Class Ocean Surveillance Ship	4	33	*40*	160	26,400				26,400	26,400
T-AGOS	Victorious Class Ocean Surveillance Ship	4	34	*40*	160	27,200				27,200	27,200
T-AG	Navigation Research Ship	2	204	*40*	160	81,600				81,600	81,600
T-AGS	Silas Bent Class Surveying Ships	2	65	*40*	160	26,000				26,000	26,000
T-AGS	Waters Class Surveying Ships	1	95	*40*	160	19,000				19,000	19,000
T-AGS	McDonnel Class Surveying Ships	2	33	*40*	160	13,200				13,200	13,200
T-AGS	Pathfinder Class Surveying Ships	4	52	*40*	160	41,600				41,600	41,600
T-AGOR	Gyre Class Oceanographic Research Ships	1	32	*40*	160	6,400				6,400	6,400
T-AGOR	Thompson Class Oceanographic Research Ships	2	59	*40*	160	23,600				23,600	23,600
	U.S. Coast Guard										
WHEC	Hamilton and Hero Class High Endurance Cutters	12	176	26	104	274,560				274,560	274,560
WMEC	Storis Class Medium Endurance Cutters	1	92	18	72	8,280		167	92,184	100,464	100,464
WMEC	Diver Class Medium Endurance Cutters	1	136	18	72	12,240		98	79,968	92,208	92,208
WMEC	Famous Class Medium Endurance Cutters	13	98	18	72	114,660				114,660	114,660
WMEC	Reliance Class Medium Endurance Cutters	16	71	18	72	102,240				102,240	102,240
WAGB	Mackinaw Class Icebreakers* (150 d, 24 hr/d)	1	85		(3600)	(382,500)		*150*	76,500	459,000	459,000
WAGB	Polar Class Icebreakers	2	140	8	32	11,200				11,200	11,200
WTGB	Bay Class Icebreaking Tugs* (150 d, 24 hr/d)	9	17		(3600)	(688,500)		8	7,344	695,844	695,844
WPB 110	110' Class Patrol Craft	49	10	14	56	34,300		*140*	411,600	445,900	445,900
WLB	Juniper Class Seagoing Buoy Tenders	1	40	36	144	7,200				7,200	7,200
WLB	Balsam Class Seagoing Buoy Tenders* (100 d, 24 hr/d)	24	53		(2400)	(3,816,000)				3,816,000	3,816,000
WIX	Eagle Class Sail Training Cutter	1	245	*12*	48	14,700		188	276,360	291,060	291,060
	U.S. Army **										
LSV	Logistic Support Vessel* (30 d, 10 hr/d)	6	32	*40*	160 (300)	3,840 (+7,200)				110,400	11,040
LCU	Landing Craft Utility* (60 d, 10 hr/d)	48	13	*6*	24 (600)	1,872 (+46,800)				486,720	48,672
	Total Volume (Gallons):					18,311,950			15,276,684	39,936,114	38,535,346

Notes:

Values in italics are estimated.

At-pier discharge presented only for classes without or with inadequate capability to capture graywater for shore treatment

At-pier discharge based on 20% occupancy by crew.

* Vessel classes that operate within 12 n.m. of U.S. shore on a routine basis (days of operation within 12 n.m. per year and hours per day)

** The majority of Army vessels collect graywater with blackwater. Approximately 10% of the graywater generated is discharged separately.[9]

Table 2. Classicals Concentration in Graywater (mg/L)[12-14] (Arithmetic Average)

Parameter	DD 889 Wash Basins and Showers[14]	DD 889 Comb. Food Prep[14]	DD 889 Laundry[14]	AOE 3 Wash Basins and Showers[13]	AOE 3 Dishwasher and Deep Sink[13]	AOE 3 Laundry[13]	AD 18 Wash Basins and Showers[12]	Galley Weighted Average	Sink and Shower Weighted Average	Laundry Weighted Average	Flow Weighted Average**
No. Samples	*114*	*134*	*28*	*7*	*60*	*20*	*91*				
pH	7.3	6.88	9.99	7.12	6.74	8.33	6.86				
TSS	404	4,695	221	94	194	176	119	3303	271.4	202.3	802
TDS	1,445	8,064	1,006	237	752	583	225	5803	881.4	829.8	1756
BOD	230	2,618	419	226	503	190	144	1964	193	323.6	540
COD	348	7,839	721	509	2,380	469	304	6150	334.4	616	1443
TOC	70	1,133	165	82	251	59	-	860	70.7	120.8	224
Oil & grease	12.06	1,210	8.11	20.65	82.46	4.56	-	861.3	12.6	6.6	164
MBAS *	0.96	0.09	0.84	0.12	0.14	4.12	-	0.11	0.9	2.2	1.1
N-ammonia	15.4	669	80.48	0.58	0.64	0.17	-	462.3	14.5	47	102.3
N-nitrate	2.73	10.85	1.16	0.89	2.08	0.29	-	8.1	2.6	0.8	3.2
N-nitrite	-	-	-	0.09	0.11	-	-	-	-	-	-
N-Kjeldahl	187	99.84	164	4.31	4.84	0.43	-	70.5	176.4	95.8	140
P (phosphate)	1.36	20.78	1.3	1.03	6.34	28.25	-	16.3	1.3	12.5	6.5
Total coliforms (microorg/100mL)	707,000	257,000	178	8,300	2,360,000	3,890	60,600	907,412	406,466	1725	407,593
Fecal coliforms (microorg/100mL)	178,000	103,000	-	200	1,250,000	21,000	7,900	457,742	99,115	-	141,862

(-) no data reported for this parameter
(*) MBAS - Methylene Blue Active Substances
(**) Weighted averages for galley, showers/sinks, and laundry based on data presented herein. Flow-weighted average for graywater based on in-port contribution of major graywater sources (galley 18%, showers/sinks 60%, and laundry 22% of total)[5]

Table 3. Metals Concentrations in Graywater (mg/L)[15] (Mean Values)

Metal (total)	CVN 73 Potable Water Sink[15]	CVN 73 Galley Drains[15]	AS 39 Sink[15]	AD 38 Scullery[15]	Galley Weighted Average	Sink & Shower Weighted Average	Flow-Weighted Average
No. Samples	*12*	*13*	*8*	*11*			
Cadmium	0.004	0.017	0.005	0.004	0.011	0.004	0.006
Chromium*	0.002	0.03	0.007	0.01	0.01	0.004	0.005
Copper	0.754	3.404	0.443	0.250	1.96	0.630	0.936
Lead	0.042	1.560	0.047	0.182	0.928	0.044	0.247
Mercury	0.0003	0.0004	0.0002	0.0095	0.0046	0.0003	.0013
Nickel	0.037	0.113	0.025	0.031	0.075	0.032	0.042
Silver	0.007	0.012	0.008	0.011	0.012	0.007	0.008
Zinc	0.194	2.363	0.305	0.216	1.38	0.238	0.501

Note:

(*) Sample readings below the lower detection limit for chromium were treated as zero. For all the other metals listed above, when samples were measured at < LDL, the LDL was used in calculating the average.

(**) Weighted averages for galley and showers/sinks based on data presented herein. Flow-weighted average for graywater based on in-port contribution of graywater sources (galley 23%, showers/sinks 77% of total)

Table 4. Mass Loadings of Constituents*

Parameter	Flow-Weighted Average Concentration (mg/L)	Loading (lb/yr.)
Copper	0.936	304
Lead	0.247	80.3
Mercury	0.0013	.423
Nickel	0.042	13.7
Silver	0.008	2.60
Zinc	0.501	163
TSS	802	260,900
BOD	540	175,600
COD	1443	469,400
Oil and Grease	164	53,340
MBAS	1.1	358
N-Ammonia	102	33,180
N-NO_3	3.2	1,040
N- Kjeldahl	140	45,540
P- Phosphate	6.5	2110

* Based on flow-weighted average constituent concentrations. See Tables 2 and 3.

Table 5. Comparison of Graywater Concentration Data Versus Acute Water Quality Criteria (μg/L)

Parameter	Concentration*	Federal Acute WQC	Most Stringent State Acute WQC (State)
Ammonia	102	None	6 (HI)[A]
Copper	3,404	2.4	2.4 (CT, MS)
Lead	1,559	210	5.6 (FL, GA)
Mercury**	9.5	1.8	0.025 (FL, GA)
Nickel	113	74	8.3 (FL, GA)
Silver	12	1.9	1.2 (WA)
Zinc	2,363	90	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.
A - Nutrient criteria are not specified as acute or chronic values.

CT = Connecticut
FL = Florida
GA = Georgia
MS = Mississippi
WA = Washington
(*) Highest concentration for any individual component from Table 3.
(**) Bioaccumulator

Table 6. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	Data call responses		X	
3.3 Constituents	X			
3.4 Concentrations	X			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

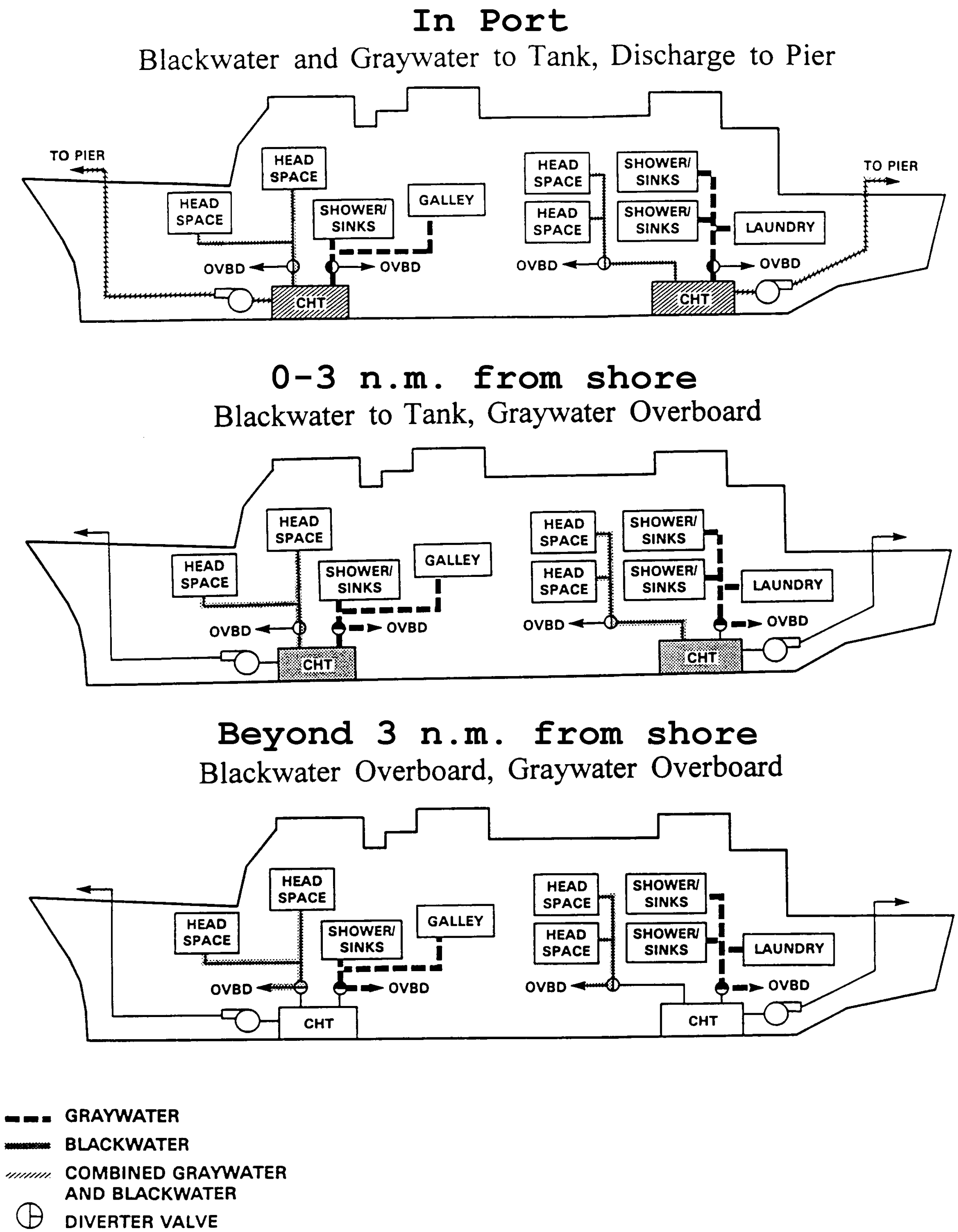

Figure 1. A Typical Collection, Holding, and Transfer System

NATURE OF DISCHARGE REPORT

Hull Coating Leachate

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the hull coating leachate discharge and includes information on the coating systems used and how they function (Section 2.1), a general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 System Description and Operation

Underwater hull coating systems typically include a base anticorrosive (AC) coating covered by an antifouling (AF) coating. The function of the AC coat, in conjunction with cathodic protection (described in the Cathodic Protection NOD report), is to prevent hull corrosion. The AC coat also provides bonding between the hull and the AF topcoats. Since the AC coating is not exposed directly to the seawater, unless the AF coating has been damaged, the AC coatings do not leach. The AF topcoat inhibits the development of marine growth on the hull. Marine fouling is undesirable because it increases drag and fuel consumption, while decreasing vessel speed.[1]

2.1.1 Types of AF Topcoats

Several different types of AF topcoats, qualified to MIL-PRF-24647 or MIL-P-15931, are used on the hulls of the Armed Forces vessels.[2,3] Within MIL-PRF-24647, they are categorized by:

- action;
- type of substrate;
- volatile organic compound (VOC) content of the coating; and
- service life requirement and color.

Action - The coating may work through ablative (Type I) or nonablative (Type II) action. An ablative coating thins as it erodes or dissolves. Through this action, a fresh layer of antifouling agent (e.g., copper) is exposed, maintaining the antifouling properties of the paint. Type II nonablative AF coatings do not thin during service. Some of these coatings function by leaching metals that prevent marine fouling.[1]

Type of Substrate - Most hulls of major vessels in the Armed Forces are steel. Hulls of smaller vessels and some specialty vessels (e.g., minesweepers and minehunters) are often constructed of alternate materials such as aluminum, fiberglass sheathing, glass reinforced plastic (GRP), rubber, or wood. The coating system applied will vary with the hull material. For instance, steel, fiberglass, GRP, and wood hulls are typically coated with copper-based coatings, and aluminum hulls with tributyltin (TBT) or biocide-free silicone-based coatings.[1,4] Rubber craft are left unpainted and, therefore, do not contribute to this discharge.

VOC Content - Coatings are classified into four grades based on their maximum VOC content. The upper limits for each grade are 3.4 pounds per gallon (lbs/gal), 2.8 lbs/gal, 2.3 lbs/gal, and zero lbs/gal.[2]

Service Life Requirement and Color - Coatings are also classified based on the desired service life of the coating system and their color. A vessel's coating system may have a five-, seven-, or ten-year service life. Vessels also may use either red, black, or gray coatings (and white on some smaller craft). Therefore, there are a number of different coating combinations, based on service life and color.[1]

2.2 Releases to the Environment

AF topcoats control biological growth by ablating and/or releasing antifouling agents into the surrounding water. This release is gradual and continuous. The release rate depends on the type of paint, water temperature, vessel speed, frequency of vessel movement in and out of port, and coating age. The type of material released is dependent on the type of topcoat employed. Most hulls use copper-based coatings; therefore, copper and zinc (another biocide commonly found in antifouling paints) are the most common releases. Those aluminum-hulled vessels with TBT-containing coatings will release TBT and small amounts of zinc, and may release copper, depending on the TBT coating formulation.[1]

2.3 Vessels Producing the Discharge

Most vessels of the Armed Forces use AC paints or AC/AF coating systems. Selected boats and craft may not be coated with AF paint if they spend most of their time out of the water. The Navy, Military Sealift Command (MSC) and United States Coast Guard (USCG) use paint systems qualified to MIL-PRF-24647. The Army uses paint systems with AF topcoats qualified to MIL-P-15931. Additional guidance for Navy vessels is contained in Naval Ships' Technical Manual (NSTM) Chapter 631.[5,6] It should be noted that paint types and applications vary for each vessel, depending on where the vessels are docked and the port in which they are painted, which influences paint availability.

2.3.1 Copper-Based Coatings

Most Navy, MSC, USCG, and Army ships have steel hulls with copper-based AF coatings. The Navy ships that do not have steel hulls are the mine countermeasure vessels (MCM 1 and MHC 51 Classes), consisting of 26 ships. MCM 1 Class vessels have wood hulls sheathed with fiberglass and MHC 51 Class vessels have GRP hulls.[7] However, these vessels are still protected with AC coats and copper ablative AF paints similar to those applied to steel vessels.[1]

MSC vessels use two types of Navy-approved copper-based AF paints, ablative and nonablative. Approved MSC underwater hull coatings are listed in MSC Instruction 4750.2C.[8] The USCG utilizes Navy-approved hull coating systems qualified to MIL-PRF-24647, as listed in the USCG Coatings and Color Manual.[9] The Air Force uses copper ablative paints similar to those used by the Navy.[10] AF topcoats used on Army watercraft are qualified to MIL-P-15931, as listed in Department of the Army Technical Bulletin TB 43-0144.[3]

2.3.2 TBT-Based Coatings

The predominant use of TBT-based coatings in the Armed Forces has been on aluminum-hulled vessels. Copper-based AF paints can accelerate the rate at which aluminum hulls corrode, especially if defects or damage to the AC coating are present. Currently, all Navy ships with aluminum hulls (i.e., hydrofoils) have been decommissioned.[1] However, the Navy does have approximately 280 small boats and craft with aluminum hulls. Approximately 10-20% of the aluminum-hulled small boats and craft in the Navy (28-56 vessels; e.g., special warfare patrol craft) could still have TBT-based hull coatings.[11] The USCG estimates that 50 aluminum-hulled small boats and craft are coated with AF paint containing TBT.[12] The MSC has no vessels with aluminum hulls.[13] The Air Force has six large vessels with aluminum hulls, the MR Class missile retrievers. These vessels are coated with TBT-free, copper-based coatings.[7,10] The Air Force also has approximately 50 small craft that may have TBT-containing coatings. The Army has approximately 11 small boats and craft that may have TBT coatings.[13] The numbers of vessels from the respective Armed Forces branches estimated to have TBT coatings are listed below.

- Navy - 56
- USCG - 50
- MSC - 0
- Air Force - 50
- Army - 11

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge occurs within harbors, rivers, and coastal waters from every surface vessel and submarine, as well as most boats and craft. This discharge is continuous and will occur any time a painted vessel is waterborne.

3.2 Rate

This discharge is not a flow; rather, it is the release of AF agents from hull coatings into the surrounding water. This rate of release, which is the combined effect of ablation and leaching, has been the subject of previous Navy studies.[14] In these studies, painted panels were submerged in San Diego Bay and copper and zinc release rates were calculated for two of the most frequently used ablative copper AF paint systems.

Dynamic exposure tests included intervals of simulated vessel movement (cruising) at 17 knots followed by periods of no movement, in order to simulate actual vessel operations. The calculated long-term average release rates (from both test coatings) for simulated vessel operation exposures were 17.0 micrograms per square centimeter-day (($\mu g/cm^2$)/day) for copper and 6.7 ($\mu g/cm^2$)/day for zinc. Release rates were highest at the initial stages of the exposures, when the coatings were new.[14]

Long-term average release rates for panels remaining in a static position (no simulated movement) for the entire test were 8.9 ($\mu g/cm^2$)/day for copper and 3.6 ($\mu g/cm^2$)/day for zinc.[14] It is assumed that the static tests underestimate the actual average release rate from vessels because they do not account for vessel movement and the resulting ablation effects.

A comparison of the above dynamic and static release rates shows that dynamic conditions resulted in increased release of copper and zinc. The higher release rates are presumably caused by continuous re-exposure of fresh copper and zinc. The dynamic tests may, however, overestimate actual conditions for some vessels, as the dynamic intervals used in the test may have been more aggressive than in actual practice.

In-situ release rates of TBT from vessels in Pearl Harbor were collected by the Navy in 1987 and 1988.[15] These studies reported an average steady-state TBT release rate of 0.38 ($\mu g/cm^2$)/day.

3.3 Constituents

The primary antifouling agent in most AF topcoats is copper. Because copper is toxic to marine organisms, it inhibits their accumulation and growth on the hull. Other than copper compounds, the constituents that can be released from approved, underwater hull paint systems include acrylate (in ablative coatings), vinyls (in non-ablative coatings), rosin, zinc compounds, and anticorrosive compounds.[16,17] The discharge from aluminum-hulled vessels may also contain TBT. Of the known constituents in AF coatings; copper, zinc, TBT, and ethyl benzene are priority pollutants, and there are no known bioaccumulators.

3.4 Concentrations

Most copper-based AF coatings contain 40 to 50 weight percent (wt%) cuprous oxide.[16] Some ablative AF paints also contain as much as 20 wt% zinc, which may act as a mild co-biocide.[16] Concentrations within TBT-based AF coatings range from less than 5 wt% to 25 wt% for TBT compounds and 25-50 wt% for copper. Some TBT-based coating formulations contain 1-10 wt% ethyl benzene.[18]

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

4.1.1 Copper and Zinc Loadings

The mass loadings for copper and zinc were calculated for Navy, MSC, USCG, Army, and Air Force vessels based on the reported release rates.[14] Loading for a single vessel was calculated by the following equation:

Copper Loading = (release rate)(surface area)(time)

where: release rate = dynamic release of copper and zinc (Section 3.2)
surface area = wetted surface area of vessel
time = number of days vessel is within 12 nautical miles (n.m.)

The wetted surface area of the vessels were either taken directly from a naval manual or were estimated by the following formula presented in the same source:[19]

$$S = 1.7(L)(d) + (V/d)$$

where: S = wetted surface area (ft^2)
L = length between perpendiculars (ft)
d = molded mean draft at full displacement (ft)
V = molded volume of displacement (for seawater, 35 ft^3 per ton displacement)

Calculations were performed for each vessel class. A sample calculation of the mass loading of copper from a destroyer is provided in Calculation Sheet 1 at the end of the report. From actual vessel movement data compiled for 1991 through 1995, the sum of the average number of days in port, the average number of transits, and time of operation within 12 n.m. was determined for each vessel class.[20] The number of vessels in each class are listed in conjunction with the total calculated loadings per vessel class in Table 1. A total annual copper loading of 216,657 lbs (98,257 kilograms (kg)) and a total annual zinc loading of 85,389 lbs (38,725 kg) were calculated. The mass loadings calculated represent the worst-case conditions.

The approach used overestimates the mass loading for the following reasons:

- Calculations were based on the dynamic release rate, and vessels are not in motion while pierside.
- All vessels were assumed to be deployed at ports within the jurisdiction of the United States, while many are actually deployed overseas.
- All vessels are assumed to be fully operational; that is, no reduction was made to account for the number of vessels which may be in dry dock during the year.
- All small workboats and utility craft were assumed to be in the water at all times, when they may actually be stored on land.
- Amphibious assault craft of both the Army and Navy, which are capable of being transported or otherwise held within larger amphibious ships, were assumed to be in the open water at all times.

4.1.2 TBT Loadings

Table 2 presents mass loadings of TBT from Navy, USCG, Army, and Air Force vessels, based on the study of TBT concentration measurements from five vessels in Pearl Harbor.[15] The average release rate measured during this study was 0.38 ($\mu g/cm^2$)/day. The mass loading value was estimated to be 24 lbs/yr (11 kg/yr) based on the following assumptions:

- Small boats and craft were estimated to be within 12 n.m. at all times and to spend 10% of the year out of the water. This assumption leads to an overestimate of the mass loadings for TBT because many small boats and craft spend much more than 10% of their time out of the water.
- Twenty percent of the Navy's aluminum-hulled small boats and craft were assumed to still have TBT-based AF coatings, although the actual number may be as low as 10%.
- All of the 50 Air Force and 11 Army small craft were assumed to be painted with TBT coatings.

Use of these assumptions also overestimates the potential TBT loading since the use of TBT coatings is being phased out, and the number of TBT coated craft in the Armed Forces is continually declining.

4.2 Environmental Concentrations

The estimated quantities of constituents released to the environment are shown in Tables 1 and 2. Using the mass loadings and a tidal prism model for analyzing mixing within specific harbors, the resulting concentration of constituents in the environment were estimated in the manner described below.

4.2.1 Copper and Zinc Concentrations

Table 3 lists the Federal and most stringent state water quality criteria for the constituents of the hull coating leachate discharge. Using the annual copper and zinc loadings and annual tidal excursion volumes, the average copper and zinc concentrations caused by these vessels were calculated for each port. The approach used to estimate concentrations uses a simplified dilution model based on tidal flow in three major Armed Forces ports and hereafter referred to as the "tidal prism" approach. The tidal prism approach uses the mass of the constituent generated by vessels and mixes this mass with a volume of water. The mass is calculated by determining the number of vessels in a particular homeport, the wetted surface area of each vessel's hull, and the number of hours each vessel spends in port (both pierside and in transit). Together, these factors are used to calculate an annual loading to the harbor. The water volume used is the sum of all outgoing tides over a year times the surface area of the harbor. The sum of outgoing tides is called the "annual tidal excursion." This can be calculated by subtracting the annual mean low tide from the annual mean high tide and multiplying the difference by the number of days in the year. Annual tidal excursion data is readily available from the National Oceanographic and Atmospheric Agency (NOAA) and the 1996 data [21] was used for these calculations. The following is the equation used to estimate concentrations of copper and zinc contributed to harbors by hull coating leachate:

Concentration increase = Annual load / Annual tidal prism volume
where: annual load = $(\text{kg/yr})/(10^9\ \mu\text{g/kg}) = (\mu\text{g/yr})$
annual tidal prism volume = $(\text{m}^3/\text{yr})\ (10^3\ \text{L/m}^3) = (\text{L/yr})$
Concentration increase = μg/L

The three ports used for the tidal prism model are Mayport, FL, San Diego, CA, and Pearl Harbor, HI. These ports were selected because they have minimal river inflow, small but well-defined harbor areas, and a high number of vessels of the Armed Forces. Each of these factors will tend to provide higher concentrations of copper and zinc, either due to less volume of water or higher numbers of potential sources. Other major ports, such as Norfolk (VA) and Bremerton (WA), were considered, but not included because of large river effects and very large harbor areas. The 1996 annual tidal volumes (annual tidal excursion times the harbor surface area) for the three ports are shown below:

- San Diego, CA, 3.78×10^{10} m^3 per year;
- Mayport, FL, 6.7×10^8 m^3 per year; and
- Pearl Harbor, HI, 3.42×10^9 m^3 per year.

The tidal prism model assumes steady-state conditions, where copper and zinc are completely mixed with the harbor water and are removed solely by discharge from the port during ebb tides. The outgoing tidal volumes are assumed to be carried away by long-shore currents (i.e., those moving parallel to shore) and do not re-enter the harbor. The tidal prism model also does not assume removal or concentration by other factors such as river flow, precipitation, evaporation, or sediment exchange. By not accounting for removal or dilution due to river flow, precipitation, and sediment exchange, the results depict a higher water column concentration than expected. The effect of evaporation could be to increase concentration due to water loss, or the effect could be neutral since water loss by evaporation is replaced by (additional) water inflow from the sea. While the model assumes complete mixing, there will be areas in the harbors with higher concentrations, primarily near the source vessels, along with areas of lower concentration.

To estimate the annual load for the same three ports, the number and types of vessels in each of these locations were obtained.[22] The ratios of Navy vessels at each of these ports to the total number of vessels per respective ship class were multiplied by the copper and zinc mass loadings of Table 1 and summed. The estimated contribution of Armed Forces' AF paint to the existing copper and zinc concentrations in each port is provided in Table 4. The actual annual load attributable to hull coating leachate for each of these ports should be smaller than estimated for two reasons. First, the calculated mass loadings are based upon dynamic release rates, yet the vessels in port are primarily static. Also, the mass loadings of copper and zinc were determined using the total amount of time that the vessels are within 12 n.m., not just in port. Therefore, the actual concentrations in port will be lower than stated.

The calculated copper concentration increases are shown in Table 5 and range from 0.19 μg/L at San Diego to 3.0 μg/L at Mayport, the latter of which exceeds Federal and state water quality criteria. Copper from AF paint adds to the ambient copper concentrations from other sources. In other words, these concentrations represent the ambient copper concentration if hull coating leachate were the only source of copper in each harbor. Ambient copper concentrations in San Diego Harbor have been reported to average near 3.7 μg/L, with locally impacted areas near vessels at twice the average.[23]

As demonstrated by Table 5, the estimated copper contributions from hull coating releases are a significant contributor to total copper levels within the Navy ports analyzed. In addition, some of these ports are already near or above ambient water quality criteria levels for copper. Therefore, dilution of copper to levels below the water quality criteria cannot be expected. By contrast, the three ports analyzed were all well below the water quality criteria for zinc, and estimated zinc concentration increases were not large enough to cause the zinc levels in these ports to approach the zinc water quality criteria.[24]

4.2.2 TBT Concentrations

As discussed in Section 2.3.2, only small boats and craft of the Armed Forces still use TBT-containing coatings. A tidal prism approach can also be used to estimate TBT concentrations, assuming that the TBT loading in each harbor is proportional to the copper loading, as might be the case if the locations of small boats and craft parallel that of larger vessels. As shown in Calculation Sheet 2, TBT is estimated to range from 0.02 nanograms per liter (ng/L) to 0.30 ng/L in the harbors analyzed. TBT does not have specific Federal water quality criteria at the present; however, criteria have been proposed.[25] Table 3 lists the proposed Federal and most stringent state water quality criteria for TBT.

4.3 Potential for Introducing Non-Indigenous Species

Although it is possible for non-indigenous species to be transported on vessel hulls, AF coatings reduce the amount of marine growth on vessel hulls. The discharge itself (released components of AF coatings) does not provide the opportunity for transport of non-indigenous species.

5.0 CONCLUSIONS

Hull coating leachate has the potential to cause an adverse environmental effect because estimated mass loadings of copper from hull coatings are significant and could cause environmental copper concentrations to exceed water quality criteria in some ports.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained, reviewed, and analyzed. Process information and assumptions were used to estimate the rates of discharge. Table 6 shows the sources of data used to develop this NOD report.

Specific References

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12. Aivalotis, J., USCG, TBT on USCG Ships, 28 May 1997, L. Panek, Versar, Inc.

13. UNDS Ship Database, 1 August 1997.

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16. Material Safety Data Sheets for the following products:

Product/Trade Name:	BRA 640 Interviron, Red Antifouling Paint
Manufacturer:	Courtaulds Coatings
Product/Trade Name:	283S5772 ABC #3 - Red Ablative Antifouling Paint Product Number 406940
Manufacturer:	Ameron Protective Coatings Group
Product/Trade Name:	283S5773 ABC #3 - Black Ablative Antifouling Paint Product Number 407150
Manufacturer:	Ameron Protective Coatings Group
Product/Trade Name:	Epoxy Adhesives 2216 B/A Gray, 2216 B/A Tan NS, and 2216 B/A Translucent
Manufacturer:	3M Scotch-Weld™, March 1995
Product/Trade Name:	Epoxy Adhesives
Manufacturer:	3M Innovation, March 1996

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Table 1. Navy, MSC, and USCG, Army, and Air Force Mass Loadings for Ships, and Small Boats and Craft

Ship Class	Ship Class Description	Quantity of Ships per Class	Days in Port per Year	Number of Transits per year (each is a transit in and out)[T]	Days of Operation within 12 n.m.	Ship's Wetted Surface Area (sq ft)	*Copper Loading per ship class (kg/yr)	**Zinc Loading per ship class (kg/yr)
	NAVY							
AC	Area Command Cutter	2	305	0	60	539	6	2
AP	Area Point System Search Craft	6	305	0	60	343	12	5
AR	Aircraft Rescue	6	305	0	60	2,127	74	29
AT	Armored Troop Carrier	21	305	0	60	362	44	17
BH	Boom Handling	8	305	0	60	189	9	3
BT	Bomb Target	4	305	0	60	94	2	1
BW	Boston Whaler	4	305	0	60	94	2	1
CA	Catamaran	1	305	0	60	207	1	0
CC	Cabin Cruiser (Commercial)	4	305	0	60	411	9	4
CM	Landing Craft, Mechanized	151	305	0	60	4,275	3,721	1,467
CRRC	Combat Rubber Raiding Craft (USMC)	418	305	0	60	57	137	54
CT	Craft of Opportunity Coop Trainers	14	305	0	60	411	33	13
CU	Landing Craft, Utility	40	305	0	60	3,860	890	351
DB	Distribution Box	4	305	0	60	704	16	6
DT	Diving Tender	1	305	0	60	813	5	2
DW	Dive Workboat	7	305	0	60	539	22	9
HH	Hawser Handling	7	305	0	60	400	16	6
HL	Hydrographic Survey Launch	3	305	0	60	342	6	2
LA	Landing Craft, Assault	1	305	0	60	2,745	16	6
LCM(3)	Mechanized Landing Craft	2	305	0	60	not available	--	--
LCM(6)	Mechanized Landing Craft	60	305	0	60	990	342	135
LCM(8)	Mechanized Landing Craft	100	305	0	60	1,603	924	364
LCPL	Landing Craft Personnel	130	305	0	60	332	249	98
LCVP		10	305	0	60	not available	--	--
LH	Line Handling	3	305	0	60	400	7	3
MC	Mine Countermeasure Support Craft	2	305	0	60	343	4	2
ML	Motor Launch	3	305	0	60	256	4	2
MM	Marine Mammal Support Craft	5	305	0	60	331	10	4
MW	Motor Whaleboat	121	305	0	60	256	179	70
NM	Noise Measuring	1	305	0	60	800	5	2
NS	Non-Standard (commercial)	120	305	0	60	540	374	147
PE	Personnel	211	305	0	60	352	428	169
PF	Patrol Craft, Fast	3	305	0	60	539	9	4
PK	Picket Boat	1	305	0	60	366	2	1
PL	Landing Craft, Personnel Light	147	305	0	60	332	281	111
PR	Plane Personnel and Rescue	8	305	0	60	392	18	7
PT	Punt	266	305	0	60	83	127	50
SB	Sound/Sail	1	305	0	60	350	2	1
SC	Support Craft	6	305	0	60	400	14	5
SS	Swimmer Support	12	305	0	60	400	28	11
ST	Sail Training Craft	21	305	0	60	350	42	17
TC	Training Craft	19	305	0	60	580	64	25
TD	Target Drone	2	305	0	60	580	7	3
UB	Utility Boat	793	305	0	60	398	1,819	717
VP	Landing Craft, Vehicle Personnel	12	305	0	60	332	23	9
WB	Workboat	263	305	0	60	620	940	370
WH	Wherry	12	305	0	60	400	28	11

[T]Zero entered for number of transits per year when no further information was available.
nsp = not self-propelled
N/A = Not enough information available to calculate a wetted surface area.

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WT	Warping Tug	1	305	0	60	2,662	15	6
YFRN	Refrigerated/Covered Lighter	3	305	0	60	not available	--	--
YL	Yawl	7	305	0	60	400	16	6
YTM	Medium Harbor Tug (self-propelled)	11	305	0	60	3,170	201	79
AFDB 4	Large Auxiliary Floating Dry Dock	1	305	0	60	not available	--	--
AFDB 8	Large Auxiliary Floating Dry Dock	1	305	0	60	not available	--	--
AFDL 1	Small Auxiliary Floating Dry Docks	2	305	0	60	47,645	549	216
AFDM 14	Medium Auxiliary Floating Dry Dock	1	305	0	60	not available	--	--
AFDM 3	Medium Auxiliary Floating Dry Docks	4	305	0	60	47,645	1,099	433
AGER 2		1	305	0	60	not available	--	--
AGF 11	Raleigh Class Miscellaneous Command Ships	1	183	12	0	41,595	123	48
AGF 3	Austin Class Miscellaneous Command Ship	1	183	12	0	51,830	153	60
AGOR 21	Gyre Class Oceanographic Research Ships	1	113	11	0	8,834	16	6
AGOR 23	Thompson Class Oceanographic Research Ships	2	113	11	0	13,960	51	20
AGSS 555	Dolphin Class Submarine	1	305	0	60	9,130	53	21
AO 177	Jumboised Cimarron Class Oilers	5	188	10	0	63,185	955	376
AOE 1	Supply Class Fast Combat Support Ships	4	114	6	0	93,821	688	271
AOE 6	Sacramento Class Fast Combat Support Ship	3	183	11	0	103,520	916	361
APL	Barricks Craft (nsp)	16	305	0	60	13,775	1,270	501
ARD 2	Auxiliary Repair Dry Docks	1	305	0	60	40,750	235	93
ARDM	Medium Auxiliary Repair Dry Docks	3	305	0	60	47,645	824	325
ARS 50	Safeguard Class Savage Ships	4	208	22	0	13,299	181	71
AS 33	Emory S Land Class Submarine Tenders	1	293	6	0	59,630	278	109
AS 39	Simon Lake Class Submarine Tenders	3	229	6	0	59,630	653	257
ASDV		2	305	0	60	not available	--	--
CG 47	Ticonderoga Class Guided Missile Cruisers	27	166	12	0	37,840	2,743	1,081
CGN 36	California Class Guided Missile Cruiser	2	143	11	0	40,260	187	74
CGN 38	Virginia Class Guided Missile Cruiser	1	161	11	0	42,390	110	43
CV 59	Forrestal Class Aircraft Carrier	1	143	6	0	141,470	324	128
CV 63	Kitty Hawk Class Aircraft Carrier	3	137	7	0	141,470	934	368
CVN 65	Enterprise Class Aircraft Carrier	1	76	6	0	156,990	193	76
CVN 68	Nimitz Class Aircraft Carrier	7	147	7	0	159,500	2,633	1,038
DD 963	Spruance Class Destroyers	31	178	12	0	35,745	3,185	1,255
DDG 51	Arleigh Burke Class Guided Missile Destroyers	18	101	11	0	31,769	945	373
DDG 993	Kidd Class Guided Missile Destroyers	4	101	11	0	31,769	210	83
DSRV-1	Deep Submergence Rescue Vehicles	2	305	0	60	not available	--	--
DSV 1	Deep Submergence Vehicles	3	305	0	60	not available	--	--
FFG 7	Oliver Hazard Perry Guided Missile Frigates	43	167	13	0	19,850	2,310	910
IX 308	Unclassified Miscellaneous	2	305	0	60	5,180	60	24
IX 501	Unclassified Miscellaneous	1	305	0	60	8,365	48	19
IX 35	Barrick Ships	2	305	0	60	not available	--	--
EX YFU	Harbor Utility Craft	1	305	0	60	4,160	24	9
SES 200	High Performance Test Platform (ex- USCG Dorado)	1	305	0	60	not available	--	--
LCC 19	Blue Ridge Class Amphibious Command Ships	2	179	8	0	51,250	294	116
LCU 1610	1600 Class Landing Craft Utility	40	200	6	0	3,915	500	197
LHA 1	Tarawa Class Amphibious Assault Ships	5	173	9	0	94,325	1,311	517
LHD 1	Wasp Class Amphibious Transport Docks	4	185	13	0	88,965	1,064	419
LPD 14	Amphibious Transport Docks	2	178	11	0	51,830	297	117

[T]Zero entered for number of transits per year when no further information was available.
nsp = not self-propelled
N/A = Not enough information available to calculate a wetted surface area.

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Ship Class	Ship Class Description	Quantity of Ships per Class	Days in Port per Year	Number of Transits per year (each is a transit in and out)[T]	Days of Operation within 12 n.m.	Ship's Wetted Surface Area (sq ft)	*Copper Loading per ship class (kg/yr)	**Zinc Loading per ship class (kg/yr)
LPD 4	Austin Class Amphibious Transport Docks	3	178	11	0	51,830	446	176
LPD 7	Amphibious Transport Docks	3	178	11	0	51,830	446	176
LPH 2	Iwo Jima Class Amphibious Assault Ships	2	186	11	0	49,945	299	118
LSD 36	Anchorage Class Dock Landing Ships	5	215	13	0	45,405	786	310
LSD 41	Whidbey Island Class Dock Landing Ships	8	170	13	0	51,020	1,124	443
LSD 49	Harpers Ferry Dock Landing Ships	3	215	13	0	41,595	432	170
LST 1179	Tank Landing Ships	3	178	11	0	34,650	298	118
MCM 1	Avenger Class Mine Countermeasures Vessels	14	232	28	0	8,410	449	177
MHC 51	Osprey Class Coastal Minehunters	12	232	28	0	6,418	294	116
PC	Cyclone Class Coastal Defense Ships	13	105	18	0	3,704	84	33
SLWT	Side Loadable Warping Tugs	24	305	0	0	not available	--	--
SSBN 726	Ohio Class Ballistic Missile Submarine	17	183	6	0	74,575	3,704	1,460
SSN 640	Sturgeon Class Attack Submarine	13	183	6	0	27,075	1,028	405
SSN 688	Los Angeles Class Attack Submarine	56	183	6	0	34,765	5,688	2,242
SSN 671	Narwhal Class Submarines	1	183	6	0	29,135	85	34
SSN 637	Benjamin Franklin Class Submarines	2	183	6	0	44,061	257	101
YC	Open Lighters (nsp)	254	305	0	60	6,475	9,480	3,736
YCF	Car Float (nsp)	1	305	0	60	not available	--	--
YCV	Aircraft Transportation Lighters (nsp)	9	305	0	60	not available	--	--
YD	Floating Cranes (nsp)	63	305	0	60	12,875	4,676	1,843
YDT	Diving Tenders	3	305	0	60	8,885	154	61
YFB	Ferryboat or Launch (nsp)	2	305	0	60	3,895	45	18
YFN	Covered Lighters (nsp)	157	305	0	60	6,680	6,046	2,383
YFNB	Large Covered Lighters (nsp)	11	305	0	60	15,955	1,012	399
YFND	Dry Dock Companion Craft (nsp)	2	305	0	60	not available	--	--
YFNX	Lighter - Special Purpose (nsp)	8	305	0	60	4,760	220	87
YFP	Floating Power Barges (nsp)	2	305	0	60	15,590	180	71
YFRT	Covered Lighters - Range Tender (self propelled)	2	305	0	60	5,490	63	25
YFU 83	Harbor Utility Craft (self propelled)	1	305	0	60	3,915	23	9
YFU 91	Harbor Utility Craft (self propelled)	1	305	0	60	3,915	23	9
YGN 80	Garbage Lighters (nsp)	3	305	0	60	not available	--	--
YLC	Salvage Lift Crane (nsp)	1	305	0	60	not available	--	--
YM	Dredges (self propelled)	2	305	0	60	not available	--	--
YMN	Dredge (nsp)	1	305	0	60	not available	--	--
YNG	Gate Craft (nsp)	2	305	0	60	4,760	55	22
YO 65	Fuel Oil Barges (self propelled)	3	305	0	60	10,205	176	70
YOG 5	Gasoline Barges (self propelled)	2	305	0	60	10,205	118	46
YOGN	Gasoline Barges (nsp)	12	305	0	60	8,512	589	232
YON	Fuel Oil Barges (nsp)	48	305	0	60	8,512	2,355	928
YOS	Oil Storage Barges (nsp)	14	305	0	60	8,512	687	271
YPD	Floating Pile Drivers (nsp)	4	305	0	60	not available	--	--
YR	Floating Workshops (nsp)	25	305	0	60	7,350	1,059	417
YRB	Repair and Berthing Barges (nsp)	4	305	0	60	4,320	100	39
YRBM	Repair, Berthing and Messing Barges (nsp)	39	305	0	60	10,180	2,289	902
YRDH	Floating Dry Dock Workshop (Hull) (nsp)	1	305	0	60	not available	--	--
YRR	Radiological Repair Barges (nsp)	9	305	0	60	6,405	332	131
YRST	Salvage Craft Tenders (nsp)	3	305	0	60	10,965	190	75
YSD 11	Seaplane Wrecking Derrick (self propelled)	1	305	0	60	3,845	22	9

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Ship Class	Ship Class Description	Quantity of Ships per Class	Days in Port per Year	Number of Transits per year (each is a transit in and out)[T]	Days of Operation within 12 n.m.	Ship's Wetted Surface Area (sq ft)	*Copper Loading per ship class (kg/yr)	**Zinc Loading per ship class (kg/yr)
YSR	Sludge Removal Barges (nsp)	14	305	0	60	not available	--	--
YTB 752	Large Harbor Tug (self propelled)	1	305	0	60	3,170	18	7
YTB 756	Large Harbor Tugs (self propelled)	3	305	0	60	3,265	56	22
YTB 760	Large Harbor Tugs (self propelled)	68	305	0	60	3,265	1,280	504
YTL 422	Small Harbor Tug (self propelled)	1	305	0	60	1,015	6	2
YTT 9	Torpedo Trails Craft (self propelled)	3	305	0	60	not available	--	--
YWN	Water Barges (nsp)	6	305	0	60	not available	--	--
	MILITARY SEALIFT COMMAND							
T-AE	Kilauea Class Ammunition Ships	8	26	4	0	54,240	187	74
T-AFS	Mars Class Combat Stores Ships	8	148	7	0	46,930	891	351
T-AG	Mission Class Navigation Research Ship	2	151	10	0	59,126	288	114
T-AGM	Compass Island Class Missile Instrumentation Ship	1	133	4	0	47,791	101	40
T-AGOS	Stalwart Class Ocean Surveillance Ship	5	70	4	0	10,987	62	24
T-AGOS	Victorious Class Ocean Surveillance Ship	4	107	5	0	14,679	101	40
T-AGS	Silas Bent Class Surveying Ships	2	44	6	0	13,913	20	8
T-AGS	Waters Class Surveying Ships	1	7	1	0	36,590	4	2
T-AGS	John McDonnell Class Surveying Ships	2	96	6	0	10,085	31	12
T-AGS	Pathfinder Class Surveying Ships	4	96	6	0	19,383	120	47
T-AH	Mercy Class Hospital Ships	2	184	2	0	123,862	722	285
T-AKR	Algol Class Vehicle Cargo Ships	8	109	3	0	111,650	1,552	612
T-AKR	Maersk Class Fast Sealift Ships	3	59	9	0	107,028	314	124
T-AO	Henry J Kaiser Class Oilers	13	78	6	0	44,511	731	288
T-ARC	Zeus Class Cable Repairing Ship	1	8	2	0	41,176	6	2
T-ATF	Powhatan Class Fleet Ocean Tugs	7	127	16	0	11,398	167	66
	COAST GUARD							
WAGB	Polar Class Icebreakers	2	148	4	100	36,132	285	112
WAGB	Mackinaw Class Icebreakers	1	215	4	150	19,167	111	44
WHEC	Hamilton and Hero Class High Endurance Cutters	12	151	13	0	17,339	510	201
WIX	Eagle Class Sail Training Cutter	1	188	7	150	12,264	66	26
WLB	Juniper Class Seagoing Buoy Tenders	16	190	18	100	10,357	775	305
WLB	Balsam Class Buoy Tender WLB 180A	8	190	18	100	6,751	252	100
WLB	Balsam Class Buoy Tender WLB 180B	2	120	5	100	6,751	47	19
WLB	Balsam Class Buoy Tender WLB 180C	13	123	16	100	6,751	316	125
WLI	Inland Buoy Tender WLI 100A	1	160	0	205	2,432	14	6
WLI	Inland Buoy Tender WLI 100C	1	160	0	205	2,068	12	5
WLI	Inland Buoy Tender WLI 65303	2	160	0	205	1,037	12	5
WLI	Inland Buoy Tender WLI 65400	2	160	0	205	1,142	13	5
WLIC	Inland Construction Tender 115	1	160	0	205	2,796	16	6
WLIC 100	Cosmos Class Inland Construction Tenders	3	160	0	205	2,432	42	17
WLIC 75A	Anvil Class Construction Tenders	2	160	0	205	1,753	20	8
WLIC 75B	Inland Construction Tenders	3	160	0	205	1,753	30	12
WLIC 75D	Clamp Class Inland Construction Tenders	2	160	0	205	1,753	20	8
WLIC 115	Inland Construction Tenders	1	160	0	205	2,796	16	6
WLIC 160	Pamlico Class Inland Construction Tenders	4	160	0	205	5,113	118	46
WLM	White Sumac Class Coastal Buoy Tenders	9	123	16	200	4,648	217	85
WLM	Keeper Class Coastal Buoy Tenders	14	123	16	200	6,408	465	183

[T]Zero entered for number of transits per year when no further information was available.
nsp = not self-propelled
N/A = Not enough information available to calculate a wetted surface area.

Table 1. Navy, MSC, and USCG, Army, and Air Force Mass Loadings for Ships, and Small Boats and Craft

Ship Class	Ship Class Description	Quantity of Ships per Class	Days in Port per Year	Number of Transits per year (each is a transit in and out)[T]	Days of Operation within 12 n.m.	Ship's Wetted Surface Area (sq ft)	*Copper Loading per ship class (kg/yr)	**Zinc Loading per ship class (kg/yr)
WMEC	Diver Class Medium Endurance Cutters	1	98	9	0	8,954	14	6
WMEC	Storis Class Medium Endurance Cutters	1	167	11	0	9,498	26	10
WMEC	Reliance Class Medium Endurance Cutters	5	235	13	0	10,976	207	82
WMEC	Reliance Class Medium Endurance Cutters	11	149	9	0	10,976	290	114
WMEC	Famous Class Medium Endurance Cutters	4	137	6	0	10,976	96	38
WMEC	Famous Class Medium Endurance Cutters	9	164	7	0	10,976	259	102
WPB	Island Class Patrol Craft A	16	135	6	200	2,171	185	73
WPB	Island Class Patrol Craft B	21	135	6	200	2,171	243	96
WPB	Island Class Patrol Craft C	12	135	6	200	2,171	139	55
WPB	Point Class Patrol Craft B	1	135	6	200	1,243	7	3
WPB	Point Class Patrol Craft C	28	135	6	200	1,243	185	73
WPB	Point Class Patrol Craft D	8	135	6	200	1,243	53	21
WTGB	Bay Class Icebreaking Tugs	9	215	1	150	4,869	253	100
WYTL	65 ft. Class Harbor Tugs A	3	50	6	300	1,083	18	7
WYTL	65 ft. Class Harbor Tugs B	3	50	6	300	1,083	18	7
WYTL	65 ft. Class Harbor Tugs C	3	50	6	300	1,083	18	7
WYTL	65 ft. Class Harbor Tugs D	2	50	6	300	1,083	12	5
	ARMY							
BCDK	Barge, conversion deck enclosure kit	3	305	0	60	3,376	58	23
BD	89 Ton Derrick Barge (nsp)	12	335	0	30	10,442	722	285
BK	Cargo Barge (nsp)	2	335	0	30	1,947	22	9
BPL	Barge, pier, self-elevating	1	305	0	60	N/A	--	--
FB		3	305	0	60	N/A	--	--
FMS	Floating Machine Shop	3	305	0	60	3,775	65	26
J-BOAT	Workboat, Picket Boat	6	305	0	60	771	27	11
LARC-LX	Lighter, Amphibious, Resupply, Cargo	23	305	0	60	1,209	160	63
LCM-8	Landing Craft, Mechanized	104	305	0	60	1,603	961	379
LCU-1600	1600 Class Landing Craft Utility	13	305	0	60	3,557	267	105
LCU-2000	2000 Class Landing Craft Utility	35	275	3	60	6,646	1,234	486
LSV	Landing Ship, Vehicle	6	150	20	30	17,470	309	122
LT	Large Tug (100'-128')	16	305	0	60	3,026	279	110
Q-BOAT	Workboat (over 50')	1	305	0	60		--	--
ST-65	65 ft Small Tug	11	305	0	60	1,381	88	35
	AIR FORCE							
B	*Barge*	4	305	0	60	N/A	--	--
DT		2	305	0	60	N/A	--	--
MR	Missile Retrievers	6	305	0	60	1,954	68	27
TG	Small Tug	2	305	0	60	721	8	3
TR	*Torpedo Retriever*	3	305	0	60	2,127	37	14
						Total Loading	**98,257**	**38,725**
* = Based on a dynamic copper leaching rate of 17 ug/cm^2/day.								
** = Based on a dynamic zinc leaching rate of 6.7 ug/cm^2/day.								
NOTES:								
1)	A transit includes inbound and outbound legs of 4 hours between the 12 n.m. limit and port.							
2)	Small boats and craft of the Navy were assumed to spend 365 days per year within 12 n.m. and 60 of those days underway within 12 n.m.							

[T]Zero entered for number of transits per year when no further information was available.

nsp = not self-propelled

N/A = Not enough information available to calculate a wetted surface area.

Table 1. Navy, MSC, and USCG, Army, and Air Force Mass Loadings for Ships, and Small Boats and Craft

Ship Class	Ship Class Description	Quantity of Ships per Class	Days in Port per Year	Number of Transits per year (each is a transit in and out)[T]	Days of Operation within 12 n.m.	Ship's Wetted Surface Area (sq ft)	*Copper Loading per ship class (kg/yr)	**Zinc Loading per ship class (kg/yr)
3)	Number of workboats estimated							
4)	Tank Landing Ships (LST) assumed to have similar operations to other amphibious assault ships							
5)	All vessels of the Army and Air Force assumed to have movement characteristics							
	similar to coastal vessels of the Navy							
6)	Italicized ship class descriptions are assumed, since only the ship class (letter) designation and quantity were provided.							

[T]Zero entered for number of transits per year when no further information was available.
nsp = not self-propelled
N/A = Not enough information available to calculate a wetted surface area.

Table 2. Estimated TBT Mass Loadings within 12 n.m. from Small Boats and Craft

Class	Description	Quantity		Total Wetted Surface Area per Class (sq ft)
	Navy Small Boats and Craft			
PB	Mark III Patrol Boats	11	1,835	20,185
PB	Mark IV Patrol Boat	3	2,368	7,104
PBR	Stinger Class River Patrol Boat	25	410	10,250
ATC	Mini Armored Troop Carrier[b]	20	810	16,197
TR	Torpedo Retrievers	22	2,127	46,794
HS	Harbor Security Boat	70	189	13,230
LARC-LX	Lighter Amphibious Resupply Cargo	23	1,214	27,922
WB	Boom Handling Workboat	25	340	8,499
WB	35ft Workboat[b.c]	50	620	30,990
YP 654	Patrol Craft, Training	1	1,302	1,302
YP 676	Patrol Craft, Training	27	2,302	62,154
	Total Number of Small Boats and Craft	277	Net Surface Area	244,627
	Small Boats and Craft w/TBT Coatings	55	TBT Coated Area	48,572
	Coast Guard Small Boats and Craft			
	Motor Lifeboats	6	535	3,213
	Small Boats	44	513	22,576
			TBT Coated Area	25,789
	Army Small Boats and Craft			
PB-HS	Patrol Boat, High Speed	10	189	1,890
T-BOAT	Small Freight (under 100')	1	not available	
			TBT Coated Area	1,890

Table 2. Estimated TBT Mass Loadings within 12 n.m. from Small Boats and Craft

Class	Description	Quantity	Vessel Wetted Surface Area (sq ft)[a]	Total Wetted Surface Area per Class (sq ft)
	Air Force Small Boats and Craft			
U[h]	*Utility Craft* [j]	47	398	18,706
P[i]	*Patrol Boat* [j]	3	1,235	3,704
			TBT Coated Area	22,410
	Total Surface Area of all Vessels with TBT Coatings (sq. ft)			98,661
	Total Surface Area of all Vessels with TBT Coatings (sq. cm)			91,656,090
	Loading (kg/yr) with 20% of Navy small boats and craft having TBT paint =			12.7
	Final total (kg/yr) after adjusting for time spent out of water			**11.4**
	Sample Calculation for TBT Loading per Vessel Class (kg/yr):			
	Quantity of Vessels x Vessel Wetted Surface Area (ft^2) x TBT Leaching Rate ($\mu g/cm^2$)/day...			
	...x (0.90 x 365 days/yr) x (6.452 cm^2/in^2) x (144 in^2/ft^2) x (10^{-9} kg/mg)			

Notes:

a) Where available, beam measurements are at the waterline.

b) This craft or boat is rectangular.

c) No information was available regarding quantities of workboats by class. The quantities listed are not reliable.

d) TBT Loadings based on all operations per ship occurring within 12 n.m. and applying a 10% factor to subtract the time that some small boats and craft spend completely out of water.

e) The steady state TBT leaching rate was taken from a Naval Command, Control & Ocean Surveillance Center RDT&E Division Hull Coatings Discharge Evaluation on Butyltin Concentrations Measurements in Pearl Harbor, Hawaii from April 1986 to January 1988.

f) Steady-state TBT release rate assumed to be (0.38 $\mu g/cm^2$)/day.

g) 20% of all Navy small boats and craft are assumed to have TBT coated hulls.

h) Air Force "P" designators are assumed to have similar size as the Coast Guard Point Class Patrol Craft.

i) Air Force "U" designator is assumed to have a similar size to the Navy utility boat.

j) Italicized ship class descriptions are assumed, since only the ship class (letter) designation and quantity were provided.

Table 3. A Comparison of Estimated Concentrations Versus Water Quality Criteria

Constituent	Estimated Environmental Concentration (μg/L)[a]	Federal Chronic Water Quality Criteria (μg/L)	Most Stringent State Chronic Water Quality Criteria (μg/L)
Copper (dissolved)	0.19-3.0	2.4	2.4 (CT, MS)
Zinc (dissolved)	5.0-12.8	81	76.6 (WA)
TBT	0.00002 - 0.0003	0.01[b]	0.001 (VA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

CT - Connecticut
MS - Mississippi
VA= Virginia
WA- Washington
[a] Range is for three high use Navy ports: San Diego, CA; Mayport, FL; and Pearl Harbor, HI.
[b] Proposed water quality criteria, August 7, 1997

Table 4. Copper and Zinc Loading into San Diego, Pearl Harbor, and Mayport for Use in Concentration Estimate

Ship Class	Ship Class Description	Quantity of Ships per Class	*Copper Loading per year (kg/yr)	*Zinc Loading per year (kg/yr)
	SAN DIEGO HARBOR			
CG 47	Ticonderoga Class Guided Missile Cruisers	8	813	320
CV 63	Kitty Hawk Class Aircraft Carrier	2	623	245
DD 963	Spruance Class Destroyers	6	616	243
DDG 51	Arleigh Burke Class Guided Missile Destroyers	5	263	104
LHA 1	Tarawa Class Amphibious Assault Ships	2	524	207
LHD 1	Wasp Class Amphibious Transport Docks	2	532	210
LPD 4	Austin Class Amphibious Transport Docks	5	743	293
LSD 41	Whidbey Island Class Dock Landing Ships	2	281	111
LSD 49	Harpers Ferry Dock Landing Ships	1	144	57
PC	Cyclone Class Coastal Defense Ships	4	26	10
FFG 7	Oliver Hazard Perry Guided Missile Frigates	11	590	233
SSN	Los Angeles Class Attack Submarines	9	914	360
SSN	Sturgeon Class Attack Submarine	1	79	31
LSD	Anchorage Class Dock Landing Ships	3	472	186
AGF	Raleigh Class Miscellaneous Flagship	1	123	48
AS	Emory S Land Class Submarine Tender	1	278	109
LPH	Iwo Jima Class Assault Ship	1	150	59
		Total Loading =	**7,171**	**2,826**
	PEARL HARBOR			
AO 177	Jumboised Cimarron Class Oilers	2	382	150
ARS 50	Safeguard Class Savage Ships	2	91	36
CG 47	Ticonderoga Class Guided Missile Cruisers	3	305	120
DD 963	Spruance Class Destroyers	4	411	162
DDG 51	Arleigh Burke Class Guided Missile Destroyers	3	158	63
FFG	Oliver Hazard Perry Guided Missile Frigates	2	107	42
SSN	Los Angeles Class Attack Submarine	15	1,524	601
SSN	Sturgeon Class Attack Submarine	4	316	125
SSN	Benjamin Franklin Class Submarines	1	129	51
		Total Loading =	**3,423**	**1,350**
	MAYPORT HARBOR			
CG 47	Ticonderoga Class Guided Missile Cruisers	5	508	200
CV 63	Kitty Hawk Class Aircraft Carrier	1	311	123
DD 963	Spruance Class Destroyers	5	514	202
DDG 51	Arleigh Burke Class Guided Missile Destroyers	2	105	41
FFG	Oliver Hazard Perry Guided Missile Frigates	10	537	212
		Total Loading =	**1,975**	**778**

Table 5. Estimated Copper and Zinc Contributions to Some Ports of the Armed Forces

Port	Ambient Cu Concentration (μg/L)	Cu from Hull Coating Leachate (μg/L)	Ambient Zn Concentration (μg/L)[a]	Zn from Hull Coating Leachate (μg/L)
San Diego	3.7[b]	0.19	11.3	0.074
Mayport	Unknown[c]	3.0	5.0	1.16
Pearl Harbor	1.76[a]	1.0	12.8	0.39

[a] Information from STORET database.
[b] For San Diego Bay, information from prior Navy Studies.
[c] Available STORET information was insufficient to make estimate.

Table 6. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment	X			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	X			
3.3 Constituents	MSDS			X
3.4 Concentrations	X			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

Copper Loading = (release rate)(surface area)(Number of ships)(time), where:

release rate = daily dynamic release rate of copper kg/cm^2
surface area = wetted surface area of a DD 963 Class ship (cm^2)
Number of ships = total number of ships in DD 963 Class
time = {Σ (time in port + time in transit + time in operation within 12 n.m.)}(number of DD 963 Class ships)(number of days within 12 n.m. each year per ship)

1) Daily dynamic release rate of copper (From NRaD study)
= 17 ($\mu g/cm^2$)/day = (17 ($\mu g/cm^2$)/day) (1 kg / 1,000,000,000 μg) = 17×10^{-9} (kg/cm^2)/day

2) Wetted surface area of a DD 963 Class ship in cm^2 (From NSTM Chapter 633)
= (35,745 ft^2) (929 cm^2/ft^2) = 33,207,105 cm^2/ship

3) Number of DD 963 Class ships = 31 ships (From ship inventory database)

4) Number of days within 12 n.m. each year per ship (From ship movement database)
= days in port/year + [(transits/year) (2 legs/transit) (4 hrs/leg) (1 day/24 hours)] + days operation within 12 n.m./yr
= 178 days/yr + [(12 transits/yr) (2 legs/transit) (4 hrs/leg) (1 day/24 hrs)] + 0 days/yr = 182 days/yr

Thus:
Copper Loading = (17×10^{-9} (kg/cm^2)/day)(33,207,105 cm^2/ship)(31 ships)(182 days/yr)
= 3,185 kg/yr = **7,007 lbs/yr**

Calculation Sheet 1. Mass Loading of Copper from DD 963 Class Vessels

Copper loading in San Diego = 7,171 kg/yr (See Table 4)
Copper loading in Pearl Harbor = 3,423 kg/yr (See Table 4)
Copper loading in Mayport = 1,975 kg (See Table 4)

Total copper loading = 98,257 kg/yr (See Table 1)

Proportion of copper loading in each harbor to the total copper loading:
San Diego = (7,171 kg/yr) / (98,257 kg/yr) = 0.073 (or 7.3%)
Pearl Harbor = 0.035 (or 3.5%)
Mayport = 0.020 (or 2%)

Total estimated TBT loading = 11.4 kg/yr (See Table 2)

Estimated TBT loading in each harbor = (copper proportion) (total TBT loading):
San Diego = (0.073) (11.4 kg/yr) = 0.8 kg/yr
Pearl Harbor = (0.035) (11.4 kg/yr) = 0.4 kg/yr
Mayport = (0.020) (11.4 kg/yr) = 0.2 kg/yr

Proportion of copper concentration in each harbor (Table 5) to annual copper loading in the respective harbor:
San Diego = (0.19×10^{-6} g/L Cu) / ($7{,}171 \times 10^{3}$ g Cu) = 2.7×10^{-14}
Pearl Harbor = (1×10^{-6} g/L Cu) / ($3{,}423 \times 10^{3}$ g Cu) = 2.9×10^{-13}
Mayport = (3×10^{-6} g/L Cu) / ($1{,}975 \times 10^{3}$ g Cu) = 1.5×10^{-12}

Estimated TBT concentration in each harbor is proportional to copper ratio:
San Diego: (0.19 μg/L Cu) / (7,171 kg Cu) = (X μg/L TBT) / (0.8 kg TBT)
X = (2.7×10^{-14}) (0.8×10^{3} g TBT) = **2.2×10^{-5} μg/L TBT**
Pearl Harbor: X = (2.9×10^{-13}) (0.4×10^{3} g TBT) = **1.2×10^{-4} μg/L TBT**
Mayport: X = (1.5×10^{-12}) (0.2×10^{3} g TBT) = **3.0×10^{-4} μg/L TBT**

Calculation Sheet 2. Estimates of Contributed TBT Concentrations by Harbor

HULL COATING LEACHATE
MARINE POLLUTION CONTROL DEVICE (MPCD) ANALYSIS

Several alternatives were investigated to determine if any reasonable and practicable MPCDs exist or could be developed for controlling discharges from hull coatings. An MPCD is defined as any equipment or management practice, for installation or use onboard a vessel, designed to receive, retain, treat, control, or eliminate a discharge incidental to the normal operation of a vessel. Phase I of UNDS requires several factors to be considered when determining which discharges should be controlled by MPCDs. These include the practicability, operational impact, and cost of an MPCD. During Phase I of UNDS, an MPCD option was deemed reasonable and practicable even if the analysis showed it was reasonable and practicable only for a limited number of vessels or vessel classes, or only on new construction vessels. Therefore, every possible MPCD alternative was not evaluated. A more detailed evaluation of MPCD alternatives will be conducted during Phase II of UNDS when determining the performance requirements for MPCDs. This Phase II analysis will not be limited to the MPCDs described below and may consider additional MPCD options.

MPCD Options

Hull coating leachate refers to the transfer by diffusion or ablation of coating constituents from the underwater portion of a vessel's hull into the water. The anticorrosive (AC) and antifouling (AF) coating system minimizes adhesion and propagation of marine fouling organisms on the hull surface which increase drag, and prevents costly structural damage to the hull (metal or material loss) which would otherwise result from long-term exposure to seawater. Without effective antifouling coatings, ships' hulls would have to be cleaned or dry docked and repainted much more frequently; thereby expending time, money, and manpower, while compromising operational readiness.

To determine the practicability of mitigating the potentially adverse environmental effects of hull coating leachate, three potential MPCD options were investigated. The purpose of these MPCDs would be to reduce or eliminate the release of antifouling agents, specifically copper and tributyltin, from antifouling hull coatings. The MPCD options were selected based on initial screenings of alternate materials, equipment, pollution prevention options, and management practices. They are listed below with brief descriptions of each:

Option 1: Use Less Toxic Fouling Release Coatings - This option would require that hulls be coated with less toxic paints that may initially foul, but readily release fouling organisms when the vessel reaches a target speed.

Option 2: Control the Maximum Allowable AF Release Rate - This option would set limits on the maximum allowable release rate of copper from fouling resistant coatings to a level known to effectively control fouling but not cause an excess of copper to be released.

Option 3: Limit or Eliminate Use of Tributyltin (TBT) Paints - The goal of this option is to further reduce or eliminate the use of TBT paints on Armed Forces vessels.

MPCD Analysis Results

Table 1 shows the results of the MPCD analysis. It contains information on the elements of practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a final determination for each option. Based on these findings, Option 2 – establishing the maximum release rate of copper in AF coatings, and Option 3 – further restricting the application of TBT paints on vessels of the Armed Forces, offer the best combination of these elements and are each considered to represent a reasonable and practicable MPCD.

Table 1. MPCD Option Analysis and Determination

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 1. Use Less Toxic Fouling Release Coatings	Since 1993, the Navy has been investigating non-polluting antifouling hull coatings and, as part of this program, silicone-based coatings are being tested on Navy ships. When the tests are completed, the coating must demonstrate a five to twelve year service life, ease of self and mechanical cleaning, good adhesion to various hull substrates, and overall durability. The coating may not be suitable for low speed ships.	If the new coating does not perform on Navy ships as well as the current coatings, marine fouling will increase, detrimentally affecting the ship's acoustic signature, vessel speed, endurance, maneuverability, and fuel consumption.	Costs for this option include research and development costs and an estimated four-fold increase in paint costs. If the self-cleaning coating is not as effective at bio-fouling prevention as current hull coating technologies, maintenance costs will increase and fuel costs could increase by 15%.[1] If the self-cleaning coating is effective, maintenance costs will decrease. Disposal costs will decrease because hazardous waste is no longer generated.	Use of less toxic coatings would significantly reduce the amount of copper and zinc discharged from antifouling hull paints.	Using less toxic fouling release coatings would reduce toxic discharge levels, but may not effectively prevent hull fouling which would adversely affect ship capabilities and increase fuel and maintenance costs. The technology has not yet been proven aboard vessels of the armed forces.
Option 2. Control the Maximum Allowable AF Release Rate	This option could be implemented by establishing a maximum copper release rate that is near the release rate of the lowest acceptable release rate. The Navy has tested ablative copper paints containing 28-32% cuprous oxide, as opposed to the standard 40-50%.[2] These trial formulations of AF coatings did not prevent fouling. Setting the release rate below what is determined to be effective	Ship capabilities will not be affected if limits are set near current copper release rates. If the maximum copper release rate is set below what is effective in preventing hull fouling then noise emissions will increase, affecting acoustic signature; maximum speed will decrease; and the frequency of hull cleanings will increase, affecting ship mobility and availability.	In order to accurately define minimum copper release rates, it would cost an estimated \$300K to \$500K. If hull fouling is not adequately prevented, there will be an increase in fuel and maintenance costs.	This option would prevent future increases in ambient water concentrations of copper from hull coatings, and would potentially reduce copper discharge quantities.	Establishing a maximum copper release rate: 1) can be implemented, 2) would be inexpensive to institute, and 3) would prevent future increases in copper loadings. This MPCD warrants further consideration in Phase II.

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 2 (continued)	would be impractical because of the potential for excess fouling and increased rates of hull cleaning.				
Option 3. Limit or Eliminate Use of TBT Paints	The Armed Forces have been phasing out the use of TBT paints since 1988, and replacing them with copper- or silicone-based coatings. Copper-based AF paints accelerate corrosion of aluminum substrates. Newer silicone-based coatings are only effective when the vessel reaches a minimum effective speed, which some Navy and USGS vessels are unable to attain. Exceptions could be provided for critical use vessels.	No AF alternative as effective as TBT self-polishing copolymer paint has been found so, without the use of TBT, underwater hull fouling is expected to increase causing a negative impact on acoustic signature, maximum ship speed, hull cleaning frequency, and ship readiness.	Assuming TBT paint is replaced by silicone-based easy release coatings, material costs could increase by $91K for all remaining small boats, fuel costs will increase, and maintenance costs may increase if ships have to be recoated more frequently, yet disposal costs will decrease since TBT is a hazardous waste.	Prohibiting the use of TBT as an antifouling hull coating for non-critical Navy and USCG small boats will be effective in reducing TBT loadings. Approximately 80% of the estimated 11 kg (24 lbs) of TBT released annually by the Armed Forces could be eliminated. If replaced by copper-based AF coatings, total copper loading from hull coatings will increase slightly.	Further restricting the use of TBT paints is: 1) reasonable to implement, 2) not cost prohibitive, and 3) will significantly reduce TBT loadings in the environment. Therefore, this MPCD option warrants further consideration.

REFERENCES

[1] Naval Ships' Technical Manual S9086-CQ-STM-010 R3 Chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships. 4 August 1997. Page 1-1.

[2] EPA and the Secretary of the Navy. "Congressional Report on Alternatives to Organotin Antifoulants and Alternative Antifoulant Research." December 1996. Pages 8, 29.

NATURE OF DISCHARGE REPORT

Mine Countermeasures Equipment Lubrication

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the mine countermeasures discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

The Navy is the only branch of the Armed Forces with a mine countermeasures mission. To accomplish this mission, mine countermeasures vessels use towed sonar and video arrays, cable cutters, and mine detonation equipment. During training exercises, the mine countermeasures equipment is deployed and towed behind the ship as it practices sweeping the area for mines.

Specific types of mine countermeasures equipment are:

- devices to detonate acoustic mines, such as acoustic hammers and vibrating diaphragms;
- robotic devices (mine neutralization vehicles) which locate and destroy mines;
- devices which generate magnetic fields to explode magnetic mines;
- minehunting sonar; and
- cables fitted with mechanical or explosive cutters to cut the cables of moored mines.

Mine countermeasures equipment is normally located at the stern or fantail portion of mine countermeasures vessels. Most equipment is non-magnetic, and winches and cranes are hydraulically powered. Brief descriptions of the specific mine countermeasures equipment used by the Navy are presented below:[1]

A-MK4-V and A-MK6-B mine detonators use vibrating diaphragms and acoustic hammers, respectively, to generate noise and detonate acoustic mines. When deployed, both types of acoustic detonators are towed astern on buoyant 1,600-foot-long cables. Both types of detonators are not deployed simultaneously but rather, one detonator type is selected for a given minesweeping event, depending on the type of mine targeted.

Magnetic minesweeping cables float, are trailed astern of the ship, and generate large electric currents through the water. This creates a magnetic field around the cable which detonates magnetic mines. Several cable configurations are used and all are carried on a common cable reel drum with three sections. Cable lengths range from 450 to 1,800 feet for the various configurations.

AN/SLQ-48 mine neutralization vehicles (MNVs) are cable-controlled, unmanned robotic devices used to locate and destroy mines. They contain closed-circuit television cameras and close-range sonar for locating mines, that are then destroyed using cable cutters or small explosive charges. A crane with a lifting cable is used to deploy and recover the AN/SLQ-48 MNV on some vessels. A 5,000-foot-long cable is used to supply power.

AN/SQQ-32 sonar tow cables and reels are used to tow and supply power to AN/SQQ-32 variable-depth, mine-hunting sonars.

AN/SQQ-30 sonar tow cable and reels are used to tow and supply power to older, less-capable mine hunting sonars used on some ships. These systems will eventually be replaced with AN/SQQ-32 sonars.

O-type mechanical gear is used to sweep moored mines. It consists of wire cables towed through the water at depths where it can strike the mine's mooring. The mooring slides along the cable until it contacts mechanical or explosive cutters, which sever the mooring. The mines then bob to the surface where they are detonated by gunfire.

A typical layout of mine countermeasures equipment on the fantail of a mine countermeasures ship is provided in Figure 1. Figure 2 shows a schematic of an O-type setup used to sweep moored mines.[1]

2.2 Releases to the Environment

This discharge consists of the lubricating grease and oil removed by the mechanical action of seawater as the equipment is towed. Greases and oils are used externally on wetted equipment (e.g., blocks, swivels, and cutters) to minimize wear and to prevent the mine countermeasures equipment from binding as it is deployed.[2] Tow cables are made of stainless steel and are not lubricated, with the exception of the lifting cable on the crane of MHC 51 Class vessels, which is grease-lubricated.[3,4] Grease and oil application procedures are discussed in Section 3.

Lubricants used on mechanical components inside the water-tight compartments of towed acoustic and electromagnetic devices are not released from the devices to the sea. Neither are leaks and spills of lubricants to the deck from non-wetted, on-board mine countermeasures equipment; these are cleaned-up and contained using rags or other sorbents.[5]

2.3 Vessels Producing the Discharge

Mine countermeasures equipment is found on only two classes of Armed Forces vessels: the Navy's Osprey (MHC 51) Class, and the Navy's Avenger (MCM 1) Class.[1] The nine MHC 51 Class coastal minehunters perform harbor clearing, channel clearing, and deep-water coastal mine countermeasures. The MCM 1 Class has 14 vessels designed to locate and destroy mines that cannot be countered by conventional minesweeping techniques. Table 1 shows the vessels producing the mine countermeasures equipment lubrication discharge.[1]

Both the MCM and the MHC classes are equipped with a hull-mounted, variable-depth sonar (VDS) (either a SQQ-30 or a newer SQQ-32) as their primary means of mine detection, and a cable-controlled and powered SLQ-48 Mine Neutralization Vehicle (MNV) for the examination and clearing of mines.

MHC 51 Class vessels are equipped only with the SLQ-48 MNV and the SQQ-32 sonar. The SQQ-32 is retained in its hull-mounted position unless the vessel is actually engaged in minehunting, when it may be towed. An MHC conducts minehunting operations at speeds of five to seven knots. At these speeds, depending upon its deployed depth, the 7,846-pound towed body of the SQQ-32 tows directly beneath or sometimes slightly astern of the MHC.[6] To sweep or neutralize mines, the SLQ-48 is deployed. It is a self-propelled vehicle, controlled and powered through a 5,000-ft cable, and is remotely ‘piloted’ by an operator on the MHC.

In addition to a SQQ sonar and a SLQ-48 MNV, MCM 1 class vessels are equipped with the O-type mechanical gear, magnetic minesweeping cables, and A-MK4-V and A-MK6-B mine detonators described in Section 2.1.[7] Like the MHCs, MCMs retain their SQQ sonar in the hull-mounted position unless the vessel is engaged in minehunting. MCMs generally deploy their gear based on the type of mine being targeted: the SLQ-48 MNV for deep bottom mines, O-type mechanical sweep gear for shallow moored mines, and acoustic and magnetic detonators for acoustic and magnetic mines.

The SQQ sonar is mostly operated in the hull-mounted position. It is not towed while any of the sweeping gear is deployed. The MNV is usually deployed by itself. However, because it is controlled and can remain clear of streamed gear whenever it must be deployed, it can be deployed with any of the other gear.[6] Although they may be streamed together, the O-type and magnetic-acoustic gear are usually streamed individually. The O-type gear fans out when streamed (see Figure 2), while the magnetic-acoustic gear streams directly astern in the absence of current. The only chance for interference between O-type and magnetic-acoustic gear, when streamed together, is during ship’s turns, which must be wide and slow.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Discharges from mine countermeasures equipment incidental to normal operations occur only during training exercises usually held between five and 12 n. m. from shore, and sometimes as far as 20 to 50 n. m. from shore.[8]

3.2 Rate

This discharge is not a flow; rather, it is the release of lubricant to the surrounding seawater by mechanical erosion or dissolution when equipment is towed. During training exercises, the conventional mine countermeasures equipment is deployed and towed behind the ship as it sweeps the area.[2] Based on information from the Naval Undersea Warfare Center and on planned maintenance system (PMS) requirements, small amounts of lubricants are applied to various parts of the towed equipment.[2,9] Thus, there is a potential for these lubricants to be released to the surrounding waters.

Due to differences in equipment and mission assignments between the two vessel classes, the discharges produced by the MHC 51 and MCM 1 Class vessels are different. For this reason, the two vessel classes are discussed individually, and producing the greatest discharge scenarios are developed for each vessel class. Calculations are based on all mine countermeasures vessels operating in U.S. waters (i.e., none are under repair or deployed overseas).

3.2.1 MHC 51 Class Vessels

An MHC 51 Class vessel averages about five training days per month, with a maximum of four two-hour exercises each training day.[10] Thus, for a given ship, the total number of exercises per year is equal to:

(5 days/month)(4 exercises/day)(12 months/year) = 240 exercises per year for each ship

For the nine existing MHC 51 Class vessels (Section 2.3), this is a total of 2,160 exercises per year.

MHC 51 Class vessels are equipped with SQQ-32 sonar and the SLQ-48 MNV. The sonar has no lubricated areas exposed to seawater during operation and, as discussed in Section 2.2, tow cables are not greased. Therefore, there is no potential for grease being released during SQQ sonar deployment.

The SLQ-48 MNV has two arms which are controlled by a remote operator, or “pilot”, to do work. Each arm has a cavity which receives approximately 2 ounces of DOD-G-24508 grease to prevent equipment binding.[11] A conservative assumption, however, is that all of the grease in the cavities is washed out during deployment (i.e., 4 ounces per deployment).

The lifting cable used for deploying the SLQ-48 MNV is lubricated with approximately 3 ounces of MIL-G-18458 grease. This cable is in contact with the water only during the vehicle's launching and recovery, during which time the vessel is stationary. Equipment experts estimate that during deployment this cable is in the water less than 1 minute, and during recovery for 3 to 5 minutes.[12] Therefore, the total amount of time the lift cable is in contact with seawater is approximately 5 minutes during each exercise.

The specification for the lift cable grease requires conformance with several chemical and physical standards, one of which is an adhesion test. In this test, grease is applied to a concave disk of known weight. The greased disk is then weighed to determine the weight of grease applied. The disk is submerged in 151°F water for 15 minutes, and then rotated at approximately 150 revolutions per minute for an additional 15 minutes. The disk is then weighed to determine the quantity of grease which has either eroded or dissolved. To pass this test, a minimum of 95% of the applied grease must remain on the disk as determined by the final weight of the disk after the test.[13]

For the deployment of the SLQ-48 MNV, the grease on the lift cable is exposed to comparatively milder conditions. The water temperature will be lower, the exposure time will be less, and because the vessel is stationary, there will be little or no mechanical erosion. The maximum estimate of the grease discharged from the lift cable is 5 percent of the applied grease. This would be equal to 0.15 ounces of grease discharged per deployment.

3.2.2 MCM 1 Class Vessels

MCM 1 Class vessel training exercises consist either of a sweeping or a hunting task, and the dimensions of the exercise area vary with each exercise. For example, an assigned area may measure as much as 30 by 90 miles. Each MCM is assigned one sweeping and one hunting task each month. Thus, as a conservative estimate, each MCM on average deploys various combinations of its countermeasures equipment 24 times a year, and performs each type of operation 12 times per year. Unless some problem is experienced with the equipment while deployed, it remains in the water for the duration of the exercise, which may last 24 hours a day for up to 5 days.[10,11]

For minehunting, the MCM Class 1 vessels use the same equipment as the MHC 51 Class vessels; the SQQ sonar and the SLQ-48 MNV. However, the MCMs use non-greased nylon lifting cables when launching and recovering the SLQ-48 MNV, so no potential exists for the release of cable grease to the surrounding water.[12]

The MCM mine neutralization vehicle hoist arrangement provides three weight-bearing cables to handle the 2,750 pound vehicle. This allows nylon cables to handle the load. The crane of the MHC 51 Class vessel attaches to the vehicle with only a single cable, which precludes the use of a nylon cable.

Neither the SQQ-30 nor the SQQ-32 sonar expose lubricants to the surrounding seawater. As noted previously, the largest discharge is a four ounce discharge of DOD-G-24508 grease from the arms of the SLQ-48 MNV during each of the 12 exercises conducted annually.

For minesweeping operations, either O-type gear is deployed, or magnetic and acoustic detonators are deployed. For the 12 sweeping exercises conducted annually, operational experience shows that O-type gear is deployed half of the time (six out of 12) and magnetic and acoustic detonators are deployed half of the time (six out of 12). In an O-type gear double sweep array, there are cables, chains, and wires, which are not lubricated. In addition, there are eight cutters, two snatch blocks, three shackles, and 13 swivels that are lubricated. The swivels have fittings through which MIL-G-23549 grease is applied; each swivel is then wiped clean. Only the threads of the shackles are greased. The bearing surfaces of the snatch block rollers are given a light coat of MIL-L-3150 oil. Since the bearing surfaces are recessed within the block, they are minimally exposed to seawater turbulence while being towed. The cutters are fabricated of a non-ferrous alloy. When retrieved, they are washed with freshwater, dried, and given a light coat of MIL-L-9000 oil before being stowed. No additional lubrication is applied before they are re-deployed.[14]

An estimate of the amount of lubricant (combined oil and grease) that is discharged is 1 ounce for each component, or 26 ounces during each of the six exercises using O-type gear.

8 cutters + 2 snatch blocks + 3 shackles + 13 swivels = 26 components total

For the six magnetic and acoustic exercises conducted each year, the MCM streams the magnetic minesweeping cable and either a high frequency A-MK4-V or a low frequency A-MK6-B acoustic detonator.[6] The only lubricant exposed to the turbulence of the seawater while streaming the magnetic and acoustic detonators is on the 30-inch diaphragm of the A-MK4-V detonator, which is coated with about 4 ounces of DOD-G-24508 grease.[8,15] The A=-MK6-B low frequency detonator does not have a diaphragm that requires grease. The magnetic minesweeping cable and the power cable to the acoustic detonators are buoyant; however, the streamed acoustic detonator does require a large O-type float in order to stream properly. A wire pendant of the desired length secures each acoustic detonator to its large float by a swivel whose zerk fitting has about 1 ounce of MIL-G-23549 grease pumped into it.[10] Therefore, when a high frequency acoustic detonator is streamed with the magnetic minesweeping cable, approximately five ounces of grease (four from the diaphragm and one from the swivel) are exposed to the sea. When the low frequency acoustic detonator is used, the amount of grease that could be released is one ounce (from the detonator's swivel to its buoy float).

3.3 Constituents

Several types of lubrication oils and greases are used on wetted mine countermeasures equipment based on information in maintenance requirements cards. Table 2 shows a list of the lubricant types and the lubrication schedules for the mine countermeasures equipment.[9] The greases are made from lubricating stocks generated during petroleum fractionation. These fractions contain organic compounds each generally having more than seventeen carbon atoms. Lubricating oils are composed of aliphatic, olefinic, naphthenic (cycloparaffinic), and aromatic hydrocarbons depending on their specific use. Lubricating oil additives include antioxidants, bearing protectors, wear resistors, dispersants, detergents, viscosity index improvers, pourpoint depressors, and antifoaming and rust-resisting agents.[16]

Until recently, lead was contained in the MIL-G-18458B grease procured by the Navy to lubricate the MHC's lift cable which deploys and recovers the SLQ-48 MNV. However, Amendment 5 to MIL-G-18458B dated 26 March, 1996, prohibits heavy metals (including lead) and salts of heavy metals as constituents of MIL-G-18458B grease.[13] As such, the Navy is no longer procuring grease containing lead or any heavy metals for use in lubricating mine countermeasures equipment. Consequently, lead will not be considered a constituent of this discharge.

There are no known bioaccumulators in this discharge.

3.4 Concentrations

Table 3a shows the percentages of the constituents in oils and greases used on the mine countermeasures wetted equipment. The total of the base constituents of oils and greases (i.e., the hydrocarbons -- mineral oils through the asphalts and waxes (e.g., the heavy paraffinic distillates)) range in concentration from approximately 25% to greater than 90%, with additives making up the balance of these lubricants. Tables 3b through 3d show the maximum concentrations from SLQ-48 arms, O-gear and cutters, and acoustic and magnetic devices, respectively.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The estimated annual lubricant mass loading shown in Table 4 is based upon the discharge scenarios described in Section 3.2, the number of exercises performed annually, and the number of vessels involved.

4.2 Environmental Concentrations

The estimated quantities of lubricant released to the environment during each mine countermeasures training exercise are shown in Table 4. The concentration after dilution in the environment can be estimated using the mass loadings from Table 4 and estimates of the volumes of water through which the equipment is towed during various exercises. These estimates are provided in Sections 4.2.1 through 4.2.4 for each of the source/vessel combinations identified in Section 3.2 and Table 4. Section 4.2.5 provides information on applicable water quality standards.

4.2.1 SLQ-48 MNV Arms

As shown in Table 4 and discussed in Section 3.2, the estimated maximum amount of grease discharged from the SLQ-48 MNV is 4 ounces (0.25 pounds (lbs)). This assumes that the screws that seal both cavities come unscrewed and fallout undetected, allowing all of the applied grease to be released. While this is based on equipment failure and does not reflect typical operating conditions, it does provide a conservative assumption regarding the amount of grease released during operations.

For MHC 51 Class vessels, minehunting operations are performed at a speed of 5 knots (30,381 feet per hour (ft/hr)) for a duration of 2 hours.[14] The calculated concentration of lubricant in the environment from SLQ-48 MNV arms assumed that:

- the SLQ 48 MNV creates a nine square feet (three feet by three feet) area of turbulence in the wake of the vehicle, as determined by dimensions of the vehicle's cross-sectional area;
- the discharge rate of grease is uniform throughout the exercise;
- the grease is uniformly dispersed throughout the traversed water volume

Based upon operational experience, it was determined that the SLQ-48 MNV generates a wake in the same manner as a surfaced submarine. Thus the frontal area of the vehicle, as determined by the dimensions of its cross-sectional area, creates a ninesquare feet (three feet by three feet) area of turbulence[17] where complete mixing occurs. Therefore, an area of nine square feet was used in the following formula to calculate the mixing and dispersion of oil and grease caused by the turbulence of the vehicle's wake rather than the frontal area of the arms.

The volume of water through which the equipment operates during a single exercise was calculated using the following formula:

Volume = (Area)(Time)(Speed)
Volume = (9 square feet)(2 hours)(30,381 ft/hr)
Volume = 546,858 cubic feet (ft^3) of water

Based on the assumptions listed above and the volume of water through which the equipment operates, the lubricant concentration in the environment was estimated as follows:

Mass lubricant	= (0.25 lbs lubricant)(453.6 grams (g)/lb)(1000 milligrams/g)
	= 113,400 milligrams (mg) lubricant
Volume of water	= (546,858 ft^3)(28.32 liters (L)/ft^3) = 15,487,019 L
Concentration	= 113,400 mg lubricant/15,487,019 L
	= 0.0073 mg/L, or 7.3 micrograms per liter (µg/L)

The calculated value of 7.3 µg/L is three orders of magnitude less than the most stringent state water quality criteria of 5,000 µg/L (Florida).

4.2.2 SLQ-48 MNV Lift Cable

From Table 4 and the discussion in Section 3.2.1, the maximum amount of grease released from the lift cable during each deployment of the SLQ-48 MNV is 0.15 ounce (0.0094 lbs). The grease would be released to the water in the immediate vicinity of the lift cable during deployment/retrieval of the SLQ-48 MNV since the vessel is stationary. The potential for environmental impact from this operation was estimated by determining the volume of water into which the grease would have to be dispersed to attain a concentration equal to the most stringent state water quality criteria: Florida's criteria of 5,000 µg/L, or 5 mg/L.

The calculated volume required for dilution of lubricant in the environment from the SLQ-48 MNV lift cable was based on the following assumptions:

- the top of the vehicle is covered by one foot of water during launching;
- the grease released is directly above the vehicle; and
- the lubricant disperses only in the horizontal plane; that is, the body of the vehicle prevents vertical dispersion

Based on these assumptions, the distance from the source beyond which the concentration is less than the most stringent water criteria (Florida), was estimated as follows:

1) (0.0094 lbs grease)(453.6 g/lb) = 4.3 g; equal to 4300 mg grease
2) 4300 mg ÷ (Vol.) = 5.0 mg/L; Vol. = 860 L required
3) (860 L)(1 ft^3/28.32 L) = 30.36 ft^3
4) 30.36 ft^3 = (1 ft)(π)(r^2); rearranging and solving for r, r = 3.1 feet

At a distance of approximately 3 feet beyond the lifting cable, the concentration of the grease is less than the most stringent water quality criteria.

4.2.3 O-type Mechanical Gear

From Table 4 and the discussion in Section 3.2, the maximum amount of lubricant released from O-type mechanical gear is 26 ounces (1.63 lbs). Each lubricated component (26 total components) of the O-type gear is a separate discharge point, has a cross-section of 48 in^2 (0.33 ft^2), and sweeps a volume of water equal to its cross-section multiplied by the distance towed through the water at seven knots. Operations with O-type gear deployed are limited to speeds of 7 to 8 knots (42,533 to 48,609 ft/hr).[14]

The equipment may remain deployed for several days (Section 3.2). Thus, the lubricants that are released from the equipment to the environment during minesweeping exercises with O-type mechanical gear will be dispersed over several miles.

An estimate of the concentration of lubricant in the environment was made based on the following assumptions:

- the equipment is deployed for 1 day; or 24 hours
- the rate of lubricant discharge is uniform throughout the exercise;
- the lubricant is uniformly dispersed throughout the traversed water volume

At 7 knots (42,533 feet per hour), the volume of water swept by the equipment during the training exercise was estimated as follows:

$$\text{Volume} = (\#\text{ of components})(\text{Cross-sectional area of each component})(\text{Time})(\text{Speed})$$
$$\text{Volume} = (26)(0.33\text{ square feet})(24\text{ hours})(42{,}533\text{ ft/hr})$$
$$\text{Volume} = 8.76 \times 10^{6}\text{ cubic feet (ft}^{3}\text{) of water}$$

Based on the assumptions listed above and the volume of water through which the equipment is towed, the lubricant concentration in the environment was estimated as follows:

Mass lubricant	= (1.625 lbs lubricant)(453.6 g/lb)(1000 mg/g)
	= 737,100 mg lubricant
Volume of water	= $(8.76 \times 10^{6}\text{ ft}^{3})(28.32\text{ L/ft}^{3}) = 2.48 \times 10^{8}\text{ L}$
Concentration	= $737{,}100\text{ mg}/2.48 \times 10^{8}\text{ L}$
	= 2.97×10^{-3} mg/L; or 2.97 µg/L in a 24-hour period

This concentration is three orders of magnitude less than Florida's discharge standard of 5,000 µg/L and is based on the conservative assumption that the equipment is in the water for only 24 hours.

4.2.4 Acoustic and Magnetic Mine Detonators

$$\text{Volume} = (\text{Number of components})(\text{Cross-sectional area of each component})(\text{Time})(\text{Speed})$$
$$\text{Volume} = (26\text{ components})(0.33\text{ ft})(24\text{ hours})(42{,}533\text{ ft/hr})$$
$$\text{Volume} = 8.76 \times 10^{6}\text{ ft}^{3}\text{ of water}$$

From Table 4 and the discussion in Section 3.2, the maximum amount of lubricant released from acoustic and magnetic mine detonation devices is five ounces (0.3125 pound). Operations are usually performed at speeds of 7 to 8 knots (42,533 to 48,609 ft/hr).[14] As with the O-type mechanical gear, the equipment may remain deployed for several days. Thus, any lubricant removed from the equipment will be dispersed into a large volume of water.

An estimated lubricant concentration was made based on the following assumptions:

- the equipment is deployed for 1 day; or 24 hours
- the rate of lubricant discharge is uniform throughout the exercise;
- the lubricant is uniformly dispersed throughout the traversed water volume;
- the acoustic device has a frontal area equivalent to a 36-inch diameter disk (7.07 square feet) (this assumption is based on allowing space for the housing around

the acoustic device), plus a 2- by 4-inch (0.055 ft^2) swivel.

At 7 knots (42,533 ft/hr), the volume of water swept by the equipment during the training exercise was estimated as follows:

$$\text{Volume} = (\text{Area})(\text{Time})(\text{Speed})$$
$$\text{Volume} = (7.07 + 0.055 \text{ square feet})(24 \text{ hours})(42{,}533 \text{ ft/hr})$$
$$\text{Volume} = 7.27 \times 10^6 \text{ ft}^3 \text{ of water}$$

Based on the assumptions listed above and the volume of water through which the equipment is towed, the lubricant concentration in the environment was estimated as follows:

Mass lubricant	= (0.3125 lbs lubricant)(453.6 g/lb)(1000 mg/g)
	= 141,750 mg lubricant
Volume of water	= $(7.27 \times 10^6 \text{ ft}^3)(28.32 \text{ L/ft}^3)$ = 205,886,400 L
Concentration	= 141,750 mg/205,886,400 L
	= 6.88×10^{-4} mg/L; or 0.688 μg/L

This estimated concentration of 0.688 μg/L is three orders of magnitude below the most stringent water quality criteria.

4.2.5 Water Quality Criteria and Discharge Standards

Table 5 shows water quality criteria and discharge standards that are relevant to the mine countermeasures equipment lubrication discharge and the estimated environmental concentrations of the constituents of the discharge.

4.3 Potential for Introducing Non-indigenous Species

Mine countermeasures operations do not result in water being transported from one geographical region to another. Any non-indigenous species which may become attached to countermeasures equipment while deployed are removed during equipment retrieval operations or subsequent preventive maintenance activities. For example, automatic cable layers remove virtually all of the water from the cable(s) as they are retrieved, and maintenance procedures require freshwater washdowns of the retrieved equipment such as cutters and swivels. Further, it is unlikely that any attached aquatic species would survive while the countermeasures equipment is stored on deck. Therefore, there is no significant potential for transporting non-indigenous species.

5.0 CONCLUSIONS

Mine countermeasures equipment lubrication discharge has little potential for causing adverse environmental effects because the small amounts of lubricants that are released disperse into very large volumes of water. The resulting concentrations are below the most stringent water quality criteria.

Further, most discharges from mine countermeasures equipment occur beyond 5 n.m. from shore in high-energy waters (i.e., those with significant wave energy to rapidly and widely disperse releases) and are unlikely to affect more sensitive coastal environments.

This conclusion is based on estimated environmental concentrations of lubricants resulting from each of the mine countermeasures operations. For each operation, the estimated concentration was below the most stringent water quality criteria. Estimates were based on either the volume of water through which mine countermeasures equipment operates, or the volume required to dilute the discharge to levels below the most stringent water quality criteria.

Finally, for mine countermeasures operations there is no potential for transporting non-indigenous species.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained, reviewed, and analyzed. Process information and assumptions were used to estimate the rates of discharge. Based on these estimates, the concentrations of lubricants in the environment resulting from this discharge were then estimated. Table 6 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Mine Countermeasures Equipment Lubrication. 5 September 1996.

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   d. MRC Control No. 47 4MNR N - Inspect A Mk 4 (V) acoustic device diaphragm.
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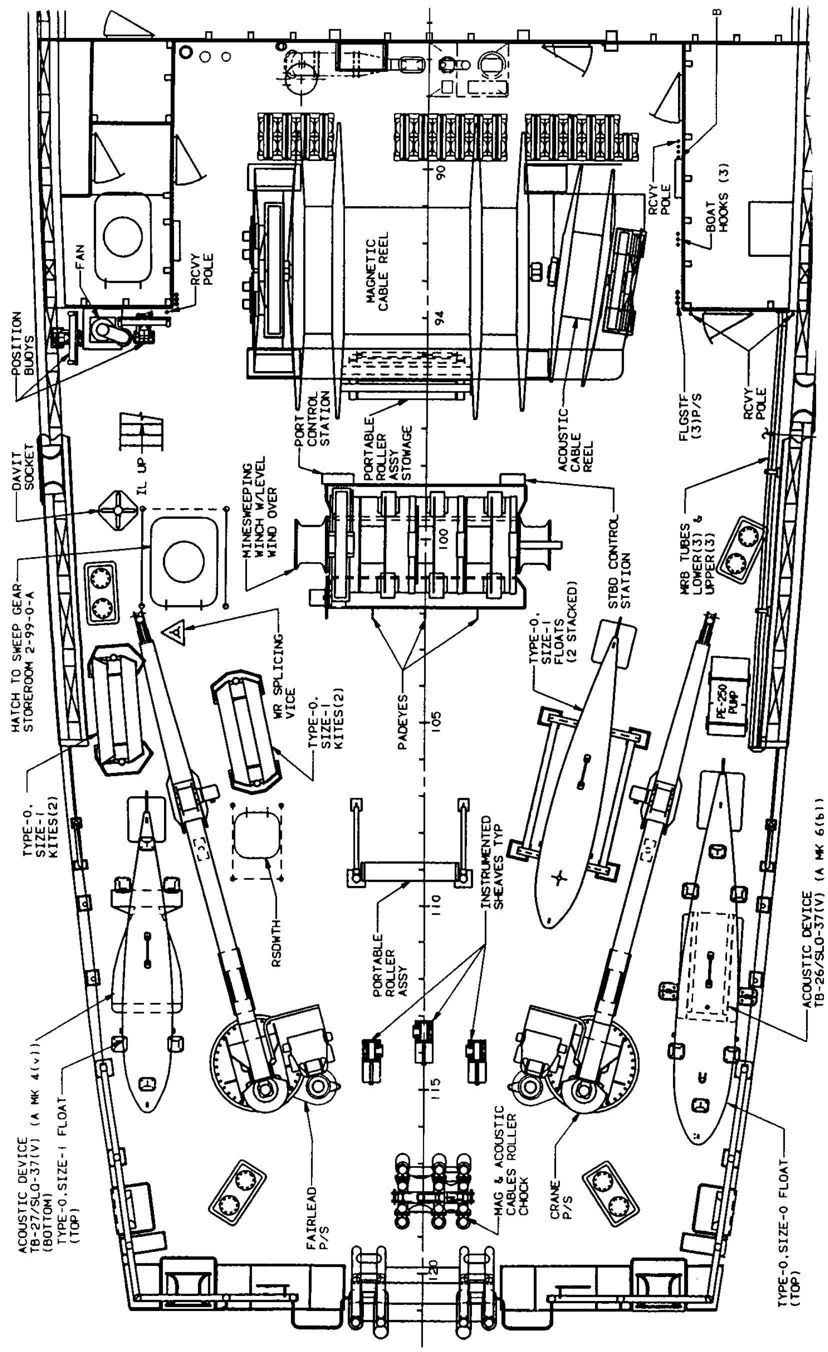

Figure 1. Mine Countermeasures Equipment on Deck

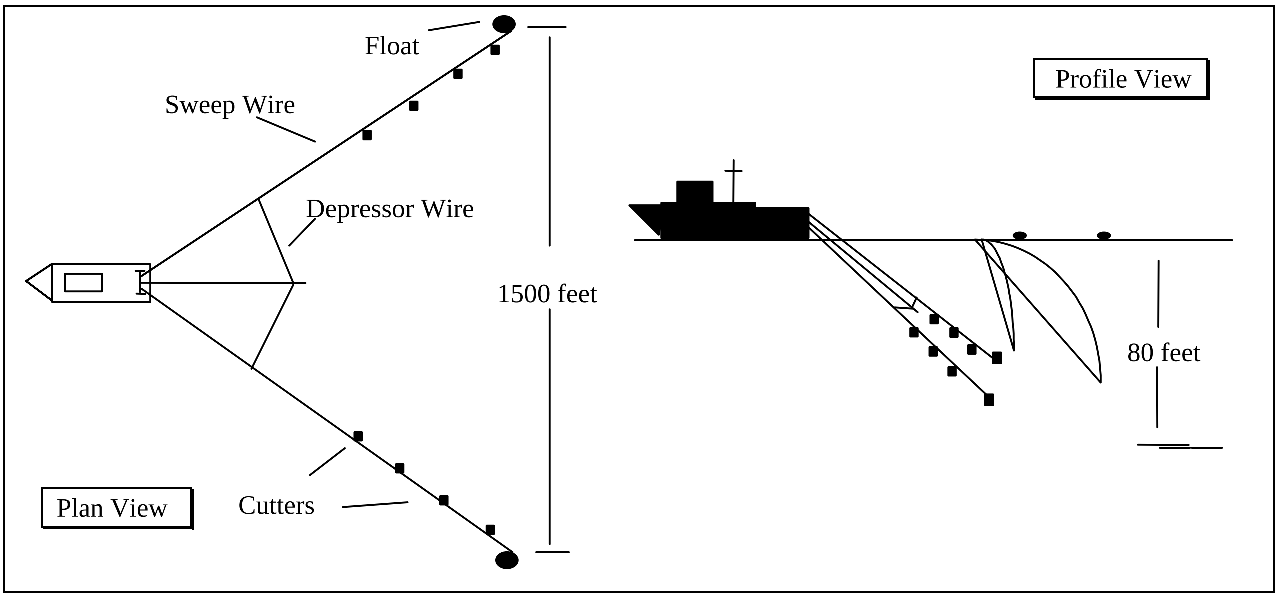

Figure 2. Overview of "O"-Type Minesweeping Operations

Table 1. Vessels Producing Mine Countermeasures Equipment Lubrication Discharge

Ship Class	Mission	Number of Vessels
MHC 51 (Osprey)	Harbor and channel clearing; deep water coastal minehunting	9
MCM 1 (Avenger)	Non-conventional minesweeping and detonation	14

Table 2. Lubricant Type and Schedule for Wetted Mine Countermeasures Equipment

Component	Applicable Ship Classes	Lubricant Mil Standard	Lubrication Schedule
Cutters	MCM 1 Class	MIL-L-9000	After each use
Snatch blocks		MIL-L-3150	Prior to and after each use
Swivels		MIL-G-23549	Quarterly, and prior to and after each use
Shackles		MIL-G-23549	Quarterly, and prior to and after each use
Towed acoustic device (diaphragm)		DOD-G-24508	Quarterly, after each streaming, or as a result of a sound measuring test
Multi-purpose crane lift wire for handling the SLQ-48 MNV	MHC 51 Class	MIL-G-18458B	Annually, or as required
SLQ-48 MNV arms	MHC 51 and MCM 1 Class	DOD-G-24508	Prior to each use

*G = grease, L = lubrication oil

Table 3a. Percentage of Constituents of Military Specification Oils and Greases

Component	MIL-G-18458B wire rope grease[a]	MIL-L-9000 engine oil	DOD-G-24508 ball and roller bearing grease[b]	DOD-G-24508 ball and roller bearing grease[c]	MIL-G-23549 general purpose grease	MIL-L-3150 general purpose lube oil
Base Constituents						
asphalt	25					
hydrocarbons						45-50
mineral oil (unspecified)				80	25	30-60
polyalphaolefins			70-80			
solvent refined, hydrotreated heavy paraffinic distillate		55-70				
solvent refined, hydrotreated residual oil		20-30			51	
Additives						
1-naphthaleneamine, n-phenyl				<2		
4-hydroxy-3, 5-di-tert-butylphenylpropionic acid thioclycolate					<1	
benzenepropanoic acid, 3,5-bis(1,1-dimethyl)-4-hydrooxyoctadecyl ester				<2		
calcium acetate			<5	<3		
calcium phenate		<15				
calcium sulfonate					4	
clay			5-10	<10		
Lithium Soaps	>54					
p,p-dioctyldiphenlamine				<2		
pentaerythritol				1		
polymers (unspecified)	<1					
sodium chromate, tetrahydrate			<1			
sodium nitrate			<2	1		
sodium phosphate, tribasic				<1		

Source: Ingredients/Identity Information section of lubricant-specific material safety data sheets from DoD Hazardous Materials Information System

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[a] Amendment 5 to MIL-G-18458B, March 26, 1996, prohibits heavy metals (including lead) and salts of heavy metals as constituents of MIL-G-18458B grease.

[b] As manufactured by Royal Lubricants Company Inc.

[c] As manufactured by Mobil Oil Company Inc.

Table 3b. Maximum Concentrations from SLQ-48 Arms

TOTAL RELEASE PER EXERCISE: 4 oz. GREASE RELEASED: DOD-G-24508 (100%) ESTIMATED TOTAL MAXIMUM CONCENTRATION: 7.3 µg/L			
Component	DOD-G-24508 ball and roller bearing grease[a]	DOD-G-24508 ball and roller bearing grease[b]	Maximum Concentration (µg/L)
Base Constituents			
mineral oil (unspecified)		80	5.8
polyalphaolefins	70-80		5.8
Additives			
1-naphthaleneamine, n-phenyl		<2	0.15
benzenepropanoic acid, 3,5-bis(1,1-dimethyl)-4-hydrooxyoctadecyl ester		<2	0.15
calcium acetate	<5	<3	0.37
clay	5-10	<10	0.73
p,p-dioctyldiphenlamine		<2	0.15
pentaerythritol		1	0.07
sodium chromate, tetrahydrate	<1		0.07
sodium nitrate	<2	1	0.15
sodium phosphate, tribasic		<1	0.07

Table 3c. Maximum Concentrations from O-Gear and Cutters

TOTAL RELEASE PER EXERCISE: 26 oz. GREASE RELEASED: MIL-G-23549 (53.8%); MIL-L-3150 (7.7%); MIL-L-9000 (30.8%) ESTIMATED TOTAL MAXIMUM CONCENTRATION: 2.97 µg/L				
Component	MIL-L-9000 engine oil	MIL-G-23549 general purpose grease	MIL-L-3150 general purpose lube oil	Maximum Concentration (µg/L)
Base Constituents				
hydrocarbons			45-50	0.11
mineral oil (unspecified)		25	30-60	0.14
solvent refined, hydrotreated heavy paraffinic distillate	55-70			0.64
solvent refined, hydrotreated residual oil	20-30	51		1.09
Additives				
4-hydroxy-3, 5-di-tert-butylphenylpropionic acid thioclycolate		<1		0.02
calcium phenate	<15			0.14
calcium sulfonate		4		0.06

[a] As manufactured by Royal Lubricants Company Inc.
[b] As manufactured by Mobil Oil Company Inc.

Table 3d. Maximum Concentrations from Acoustic and Magnetic Devices

TOTAL RELEASE PER EXERCISE: 6 oz. GREASE RELEASED: DOD-G-24508 (67%), MIL-G-23549 (33%) ESTIMATED TOTAL MAXIMUM CONCENTRATION: 0.688 µg/L				
Component	DOD-G-24508 ball and roller bearing grease[a]	DOD-G-24508 ball and roller bearing grease[b]	MIL-G-23549 general purpose grease	Maximum Concentration (µg/L)
Base Constituents				
mineral oil (unspecified)		80	25	0.425
Polyalphaolefins	70-80			0.369
solvent refined, hydrotreated residual oil			51	0.116
Additives				
1-naphthaleneamine, n-phenyl		<2		0.009
4-hydroxy-3, 5-di-tert-butylphenylpropionic acid thioclycolate			<1	0.002
benzenepropanoic acid, 3,5-bis(1,1-dimethyl)-4-hydrooxyoctadecyl ester		<2		0.009
calcium acetate	<5	<3		0.037
calcium sulfonate			4	0.009
clay	5-10	<10		0.092
p,p-dioctyldiphenlamine		<2		0.009
pentaerythritol		1		0.005
sodium chromate, tetrahydrate	<1			0.005
sodium nitrate	<2	1		0.014
sodium phosphate, tribasic		<1		0.005

[a] As manufactured by Royal Lubricants Company Inc.
[b] As manufactured by Mobil Oil Company Inc.

Table 4. Estimated Annual Lubricant Mass Loading

Source	Quantity per Exercise (oz)	Yearly Number of Exercises	Number of Vessels	Total Release (oz/yr)	Total Release (lbs/yr)
MHC 51 Class					
SLQ-48 MNV arms	4	240	9	8,640	540
SLQ-48 MNV Lift Cable	0.15	240	9	324	20
MCM 1 Class					
SLQ-48 MNV arms	4	12	14	672	42
O-gear, cutters	26	6	14	2,184	137
Acoustic and Magnetic	5	6	14	420	26
Total Mass Loading				12,240	765

Table 5. Water Quality Criteria and Discharge Standards

Source and Constituent	Environmental Concentration (μg/L)	Federal Discharge Standards (μg/L)	Most Stringent State Acute Water Quality Criteria[a] (μg/L)
SLQ-48 arms			
oil and grease	7.3[b]	Visible sheen* /15,000**	5,000 (FL)
SLQ-48 MNV Lift Cable			
oil and grease	30 ft^3 [c]	Visible sheen* /15,000**	5,000 (FL)
O-gear, cutters			
oil and grease	2.97	Visible sheen* /15,000**	5,000 (FL)
Acoustic and Magnetic			
oil and grease	0.688	Visible sheen* /15,000**	5,000 (FL)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

* Discharge of Oil. 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
** International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). MARPOL 73/78 as implemented by the Act to Prevent Pollution from Ships (APPS).

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[a] FL = Florida
b Estimated
[c] Volume required to disperse to most stringent water quality standard

Table 6. Data Sources

	Data Source			
NOD report Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents	PMS Cards			X
3.4 Concentrations	MSDS			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Motor Gasoline (MOGAS) Compensating Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the MOGAS discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3). This discharge may be referred to as “Motor Gasoline (MOGAS) and Compensating Overboard

2.1 Equipment Description and Operation

MOGAS is commercial gasoline identical to that supplied to gas stations for automobile use. It is carried aboard certain Navy, U.S. Coast Guard (USCG), Military Sealift Command (MSC), and Army vessels as fuel for vehicles, special warfare operational craft, portable bomb hoists, crash saws, and any other gasoline-operated, ship-support equipment.

The USCG, MSC, Air Force, and Army have no vessels with fixed MOGAS storage. Most vehicles and equipment are brought aboard fully loaded with fuel, and additional MOGAS is carried in portable drums or containers. On some Navy vessels, additional MOGAS is stored for replenishment purposes in permanently installed seawater-compensated tanks as shown in Figure 1. Compensating seawater is supplied at a pressure sufficient to force gasoline to the suction side of the gasoline pumps, and keep the tank full to prevent potentially explosive gasoline vapors from forming. Several methods are used to supply seawater to the tanks. Aboard amphibious transport dock (LPD 4 Class) ships, two dedicated seawater pumps take suction directly from the sea chest. On amphibious assault (LHA 1 Class) ships, seawater can be supplied one of two ways: 1) a compensating tank with a capacity of 8,000 to 10,000 gallons of seawater is installed such that water drains by gravity to the fuel tank as necessary; or 2) booster pumps located in the pump room supply seawater to the fuel tanks.

Immediately before a major overhaul, and in accordance with existing management practices, ships with permanently installed seawater-compensated MOGAS tanks will unload any remaining fuel to tanker trucks on the pier and transit out to beyond 50 nautical miles (n.m.). Using seawater pumps, the MOGAS tanks and system piping are flushed with three tank volumes of seawater. Air pressure is used to force the seawater out of the tank, after which steam is used to clean the tank and “cook-off” any remaining fuel remnants. The MOGAS tanks are then filled with seawater and the ship returns to port for the overhaul.

After overhaul and before re-deployment (approximately once a year) the vessel receives MOGAS from pierside tanker trucks. MOGAS that is on-loaded displaces the compensating seawater in the tank, pushing it overboard. Several management practices are in place to ensure that MOGAS is not discharged overboard during refueling operations. Without these management practices, there is a potential to cause an oil sheen in the surrounding waters. First, the MOGAS tanks are filled to no more than 80% of capacity.[1] The amount of fuel needed is calculated before loading, and the tanker truck is only filled with a volume of MOGAS such that completely filling a MOGAS tank with the entire contents of the truck would not cause the tank to overflow. Additionally, watch personnel are stationed at strategic locations on and around the ship and pier to observe refueling operations and report any abnormalities. Containment devices are placed around all refueling hose connections to contain any fuel spills or leaks, and containment booms are placed in the water around the ship being refueled.

An additional management practice controls the rate at which MOGAS is supplied from the tanker trucks. Small-diameter hoses (usually two inches) are used to deliver fuel at a flow rate of 50 gallons per minute (gpm) or less, that, in conjunction with diffusers built into the tank filling system piping, reduces turbulence and minimizes mixing of gasoline and seawater.

2.2 Releases to the Environment

The discharge consists of seawater used to replace, or compensate for, the space created in MOGAS tanks as the fuel is consumed. This seawater is discharged overboard as the MOGAS tank is refilled with gasoline. It is possible that this compensating seawater discharge overboard could contain traces of dissolved gasoline constituents.

2.3 Vessels Producing the Discharge

The USCG, MSC, Air Force, and Army have no vessels with fixed MOGAS storage, and therefore do not contribute to this discharge.[2,3,4] Eight LPD 4 Class, and five LHA 1 Class ships currently have installed MOGAS storage tanks that discharge compensating water during refueling. One LPD and one LHA Class ship are homeported overseas.

The most significant difference between LPD 4 and LHA 1 Class ships is MOGAS capacity. LPDs have a capacity to carry 26,000 gallons of MOGAS. LHAs have a capacity to carry 11,400 gallons of MOGAS.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Refueling always takes place pierside, and compensating seawater is discharged directly overboard as oncoming fuel displaces the seawater.

3.2 Rate

Tanker trucks with small diameter hoses (usually two inches) are used to deliver MOGAS to ships. The fill rate from these trucks is normally limited to 50 gpm or less. With the MOGAS tanks always full of seawater and fuel, compensating water is displaced directly overboard at the same rate as the incoming fuel.

The estimated amounts of compensating seawater discharged annually from ships with MOGAS storage tanks are presented in Table 1. The values in Table 1 are based on the operational experience of one refueling per ship per year, with a maximum of 80% of the tank capacity being displaced overboard by onloaded fuel.[1]

3.3 Constituents

MOGAS is a hydrocarbon based unleaded fuel containing over 150 individual compounds. The types of compounds found in gasoline include alkanes, alkenes, aromatics, metals, and additives. Most of these compounds are a very small fraction (less than 2%) of gasoline. The compounds that individually comprise at least 2% of gasoline include butane, pentane, hexane, isopentane, methylpentane, dimethylpentane, trimethylpentane, trimethylhexane, benzene, toluene, xylene, methyl-3-ethylbenzene, trimethylbenzene, and ethylbenzene. The exact composition of gasoline is unknown because gasoline manufacturers constantly adjust their product to meet performance, emissions, and cost demands.[5] Due to the variable composition and the different water solubilities of the individual components of gasoline, it is difficult to determine the solubility of MOGAS.

To identify the constituents in this discharge, two studies that determined the water soluble components of gasoline, as well as their solubilities, were used. The first study was conducted by the Naval Biosciences Laboratory in 1983, and the second was conducted in 1992 for a workshop on petroleum hydrocarbons.[5,6] Both studies measured the water soluble constituents of gasoline by placing gasoline on top of water, agitating the water, allowing equilibrium to be established, and analyzing the water through gas chromatography. In these analyses, a water fuel interface was established very similar to the interface within MOGAS tanks. In both cases, the water was removed from the bottom of the container to be analyzed, ensuring that emulsified fuel was not being measured. Since gasoline composition has changed over the years, the study performed in 1992 is considered to be more representative of current MOGAS constituents. The constituents identified in this study that are soluble in water are listed in Table 2.[5] Benzene, toluene, ethylbenzene, phenol, and naphthalene are priority pollutants. None of these compounds are bioaccumulators.

3.4 Concentrations

The concentrations of the water soluble gasoline constituents in the MOGAS compensating discharge are estimated from the studies performed to determine the solubility of gasoline components in water. The 1983 study reported a range of constituent concentrations based on the source of the gasoline. Benzene concentrations ranged from 19.1 to 42.5 milligrams per liter (mg/L), toluene from 17.3 to 61.4 mg/L, and xylenes from 9.5 to 27.7 mg/L.[6] The 1992 study provided a more detailed account of the concentrations, which all fell within the ranges reported in the 1983 study.[5] The estimated concentrations of MOGAS components present in the compensating overboard discharge are shown in Table 2.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents are compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Using the fleet wide MOGAS compensating water annual discharge volumes presented in Table 1, and the estimated constituent concentrations in Table 2, the total mass loadings for the priority pollutants present in this discharge were calculated using the following formula:

$$\text{Mass Loading (lbs/yr)} = (\text{Concentration (mg/L)})(\text{Volume (gal/yr)})(3.785\ \text{L/gal})(2.2\ \text{lbs/kg})(10^{-6}\ \text{kg/mg})$$

Table 3 provides the resulting mass loadings on a maximum discharge per event basis and on a total annual fleetwide basis.

4.2 Environmental Concentrations

As identified in Section 3.3, the constituents of concern are benzene, toluene, ethylbenzene, xylene isomers, phenol, and naphthalene. The estimated constituent concentrations in MOGAS compensating water discharges, and the corresponding most stringent state water quality criteria (WQC), are presented in Table 4. Benzene, toluene, ethylbenzene, phenol, and naphthalene concentrations exceed the most stringent state WQC. There are no relevant Federal or state WQC for xylene isomers.

4.3 Potential for Introducing Non-Indigenous Species

In those instances where vessels receive MOGAS prior to deployment and no overhaul period is pending, the possibility of non-indigenous species transport exists. Water from different ports could have entered the tanks during the previous deployment to compensate for consumed fuel. When shipboard MOGAS tanks are emptied of fuel, flushed, steam-cleaned, and then filled with seawater while in deep water before returning to port for overhaul, there is no significant possibility of non-indigenous species transport. Therefore, depending on the operational procedures and the deployment of the vessels, there may be a potential for the transfer of non-indigenous species.

5.0 CONCLUSIONS

MOGAS compensating discharge has the potential to cause an adverse environmental effect because there is a potential to cause an oil sheen in the waters surrounding the ship. Additionally, the possibility exists for the transfer of non-indigenous species, depending on the operational procedures of a particular vessel and the deployment schedule.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information was used to estimate the volume of discharge. Table 5 shows the source of the data used to develop this NOD report.

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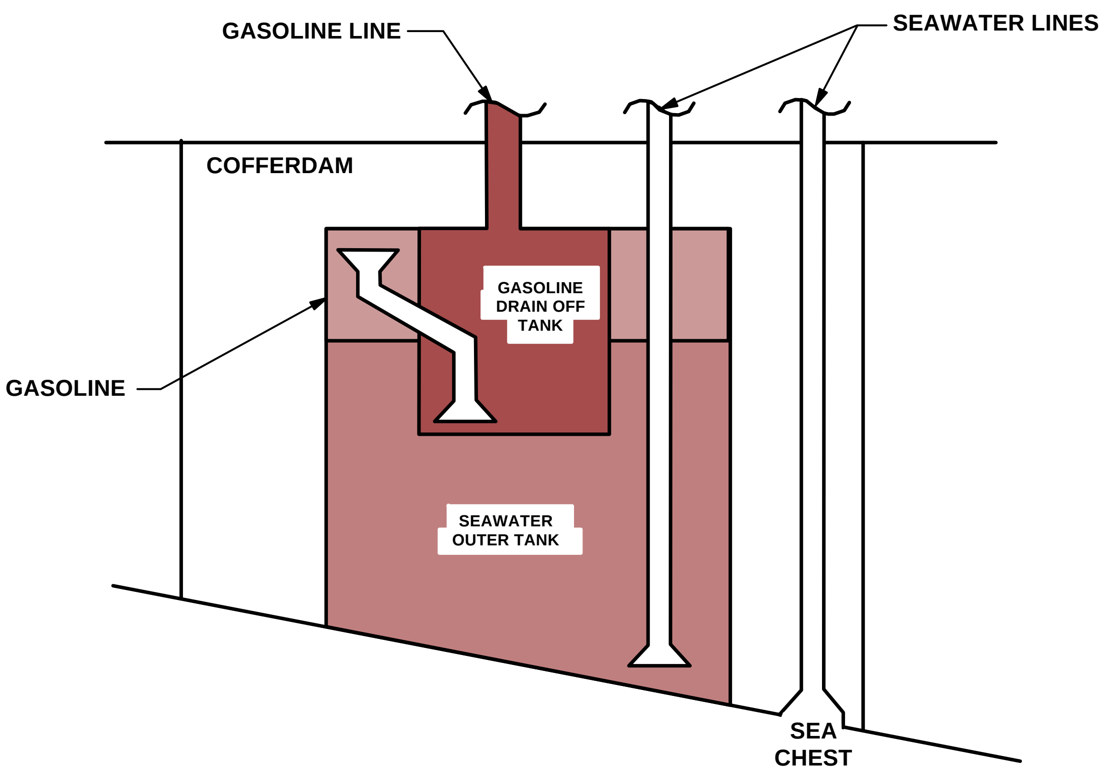

FIGURE 1
SEAWATER COMPENSATED
MOGAS
STOWAGE TANK

Table 1. Estimated Total Amounts of MOGAS Compensating Seawater Displaced Overboard Annually by Vessel Class in U.S. Ports

Vessel Class	No. of Vessels in U.S.	MOGAS Tank Capacity Per Vessel (gal)	Total Tank Capacity (gal)	Volume of Compensating Seawater Discharged Overboard Per Year[a]
LPD	7	26,000	182,000	145,600
LHA	4	11,400	45,600	36,480
			Estimated Total:	182,080

[a] Based on one complete in-port refueling per year per vessel, and a maximum of 80% of the tank capacity being displaced overboard by onloaded fuel

Table 2. Estimated Constituent Concentrations in MOGAS Compensating Overboard Discharge[5]

Compound	Concentration (mg/L)
Methyl-t-butyl ether (MTBE)	116
Benzene	29.5
Toluene	42.6
Xylene Isomers (3)	14.7
Ethylbenzene	2.4
C_5 and C_6 Alkenes and Alkadienes	0.5
C_1 to C_4 Phenols	1.2
C_3 to C_5 Benzenes	6.8
C_0 to C_3 Anilines	3.7
C_0 to C_2 Thiophenes	1.3
C_0 to C_2 Indanes and Indenes	1.2
C_0 to C_2 Naphthalenes	1.2
C_0 to C_2 Pyridines	0.4
C_0 to C_2 Indoles	0.3

Table 3. Estimated Annual Mass Loadings

Constituent	Estimated Concentration In Discharge (mg/L)	Maximum Discharge Event Mass Loading* (lbs)	Total Fleetwide Mass Loading** (lbs)
Benzene	29.5	5.1	45
Toluene	42.6	7.4	65
Xylene Isomers (3)	14.7	2.5	22
Ethylbenzene	2.4	0.4	4
Phenols	1.2	0.2	2
Naphthalenes	1.2	0.2	2

* Based upon a maximum discharge event volume of 20,800 gallons from an LPD 7 (assuming a maximum of 80% of the 26,000 gallon tank capacity being displaced overboard by onloaded fuel)

** Based upon a total annual discharge volume of 182,080 gallons

Table 4. Comparison of Estimated Discharge Concentrations with Water Quality Criteria

Constituent	Concentration (mg/L)	Federal Acute WQC (mg/L)	Most Stringent State Acute WQC (mg/L)
Benzene	29.5	None	0.07128 (FL)
Toluene	42.6	None	2.1 (HI)
Ethylbenzene	2.4	None	0.14 (HI)
Phenols	1.2	None	0.17 (HI)
Naphthalenes	1.2	None	0.78 (HI)

Notes:
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

FL = Florida
HI = Hawaii

Table 5. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	X			X
3.2 Rate			X	X
3.3 Constituents	X		X	X
3.4 Concentrations	X		X	X
4.1 Mass Loadings			X	X
4.2 Environmental Concentrations			X	X
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Non-oily Machinery Wastewater

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the non-oily machinery wastewater and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

The primary purpose of the non-oily machinery wastewater system is to segregate machinery wastewater from the wastes that collect in bilges so that non-oily machinery wastewater can be directly discharged overboard. This reduces the amount of bilgewater that needs to be treated with oil water separators (OWS) prior to discharge. Dedicated drip pans, funnels, and deck drains comprise the non-oily machinery wastewater system and collect non-oily machinery wastewater that is generated below the ship's waterline in machinery spaces. Non-oily machinery wastewater from systems and equipment located above a ship's waterline is often drained directly overboard. By separately collecting and preventing non-oily machinery wastewater from mixing with oily wastewater, non-oily wastewater is discharged without going through an OWS system.

For the systems below the waterline, non-oily machinery wastewater drains into the non-oily machinery wastewater drain tanks (generally one per machinery space) which have dedicated pumps that discharge directly overboard. These pumps normally operate automatically under control of high- and low-level sensors. Non-oily machinery wastewater tanks range in size from 100 gallons for smaller ships to 2,500 gallons for aircraft carriers. Figure 1 is a diagram of a typical non-oily machinery wastewater system.

The main sources of water to the non-oily machinery wastewater are:

- distilling plants start-up discharge,
- bleed air system leaks,
- chilled water condensate drains,
- fresh and saltwater pump drains,
- potable water tank overflows,
- leaks from propulsion shaft seals,
- low & high pressure air compressor condensate,
- leaks from valve stems and manifolds,
- seawater and freshwater relief valve leaks,
- leaks from pump packing gland seals,
- seawater duplex strainer leaks,
- propulsion engine jacket water cooler drains.

In limited cases, steam condensate is combined with non-oily machinery wastewater in the non-oily machinery wastewater drain tank. The combined wastewater are discharged overboard below the waterline. Information on steam condensate is provided in the steam condensate NOD report.

Of these listed non-oily machinery wastewater sources, distilling plants may be the major source of non-oily machinery wastewater. Distilling plants desalinate seawater to produce potable, boiler feed, and equipment cooling water. The freshwater initially produced by the distilling plants during start-up is normally discharged either overboard or to the non-oily machinery wastewater system until acceptable specified salinity levels are achieved. This period normally lasts about 15 minutes, at which time the discharge is discontinued. Also, the quality of the water produced during the normal operation of the distiller plants may occasionally be unsatisfactory; this water is discharged in the same manner as during start-up.

2.2 Releases to the Environment

The constituents of this discharge include potable water and seawater, metals from contact with tanks and piping, and other constituents associated with the construction and operation of the non-oily machinery wastewater system and equipment served by the system. The discharge either drains directly overboard continuously as it is produced, or is pumped overboard intermittently from non-oily machinery wastewater tanks.

2.3 Vessels Producing the Discharge

Non-conventionally powered Navy surface vessels and all newly constructed and some older conventionally-powered vessels have dedicated non-oily machinery wastewater systems. Most Military Sealift Command vessels and some of the older conventionally powered Navy ships do not have a separate non-oily machinery wastewater system, so the non-oily wastewater drains to the bilge.[1] U.S. Coast Guard vessels and small boats and craft of the Armed Forces do not have any dedicated non-oily machinery wastewater collection systems; instead, the non-oily machinery wastewater, which is mixed with bilgewater, is generally collected for shore side treatment as bilgewater. In addition, Army and Air Force vessels do not have separate non-oily machinery wastewater systems; this type of wastewater is drained directly to the bilge.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge occurs in port, during transit, and at sea.

3.2 Rate

The generation rate and discharge frequency of non-oily machinery wastewater varies considerably according to the mode of ship operation and its equipment operating status. This was demonstrated by the results of the recent flow characterization study of non-oily machinery wastewater onboard the following vessels: CVN 74, DDG 67, LHD 5, and LSD 44.[2] A cumulative discharge flow rate of 97,057,740 gallons/year was estimated for the vessel classes that these vessels represent. Non-oily machinery wastewater flow rates by vessel class were established by using the following formula:

Vessel Class Flow Rate = (# vessels/ship class)(flow rate)(# of days in port/ year)
CVN 68 Class = (7 vessels)(41,200 gal/day)(147 days in port/year) = 42,394,800 gal/year

Machine-specific non-oily machinery wastewater sources can generate volumes ranging from a few drips per minute in the case of small pumps and valves, to several thousand gallons per hour (gph) in the case of distilling units releasing their output during plant start-up. The volume of distillate directed to the non-oily machinery wastewater system during start-up ranges from less than 100 gph to about 4,000 gph depending on the size of the plant.

3.3 Constituents

Non-oily machinery wastewater discharge samples were obtained from four Navy ships. Samples were collected aboard an aircraft carrier (CVN 74), an amphibious assault ship (LHD 1), a dock landing ship (LSD 51) and a guided missile destroyer (DDG 57).[3] See Table 1 for the concentrations of constituents detected in shipboard non-oily machinery wastewater discharge samples. Table 2 lists a bioaccumulator and constituents that were detected in the non-oily machinery wastewater samples at concentrations that exceed Federal and/or state ambient water quality criteria (WQC). The priority pollutants bis(2-ethylhexyl) phthalate, copper, nickel, silver, and zinc were identified as being present in concentrations exceeding WQC. The only bioaccumulator identified in the discharge was mercury.

3.4 Concentrations

Concentrations of constituents detected in non-oily machinery wastewater samples collected from an aircraft carrier (CVN 74), an amphibious assault ship (LHD 1), a dock landing ship (LSD 51) and a guided missile destroyer (DDG 57) are presented in Table 1. Concentrations of a known bioaccumulator and the constituents that exceeded Federal and/or most stringent state WQC are presented in Table 2.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The mass loadings and the concentrations of discharge constituents after release to the environment are discussed in Sections 4.1 and 4.2, respectively. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Non-oily machinery wastewater discharge volumes (recorded by pump running time meters/event counters) were recorded daily aboard four ships from different ship classes over periods of time ranging from 22 to 29 consecutive days.[2] These were the same four ship classes that were sampled. The discharge flow data and log-normal mean concentrations were used to estimate mass loadings for those analytes detected. Mass loadings of all constituents detected are presented in Table 1. Table 2 shows mass loadings for constituents with log-normal mean concentrations that exceed water quality criteria and for the loan bioaccumulator detected, mercury. A sample calculation of the estimated mass loading for copper is shown below:

Mass Loading for Copper (Total):

Mass Loading = (Log-normal mean concentration)(Flow Rate)

$= (599.96 \text{ mg/L})(97{,}057{,}740 \text{ gal/yr})(3.785 \text{ L/gal})(1\text{kg}/10^9\text{mg})(2.2 \text{ lb}/1 \text{ kg})$

$= 485 \text{ lbs/yr}$

Mass loadings were determined using log-normal averages because the concentration data are expected to follow a log-normal distribution.

4.2 Environmental Concentrations

The log-normal mean discharge concentrations are compared to the Federal and most stringent state WQC in Table 3. Copper, nickel, silver, zinc, bis(2-ethylhexyl) phthalate, ammonia, nitrogen (as nitrate/nitrite and total kjeldahl nitrogen), and total phosphorous were present in shipboard non-oily machinery wastewater discharge samples, with log-normal mean concentration levels in excess of the most stringent established water quality criteria. Mercury was detected in two of four shipboard samples, but the log-normal mean concentration did not exceed WQC.

4.3 Potential for Introducing Non-Indigenous Species

The discharge from freshwater non-oily machinery wastewater originates from the potable water system and therefore, cannot introduce, transport, or release non-indigenous species. Non-oily machinery wastewater of seawater origin is pumped overboard in the same geographical area in which the seawater was taken. Therefore, transporting aquatic species from one geographic area to another as a result of this discharge is unlikely.

5.0 CONCLUSION

It is not clear whether non-oily machinery wastewater has the potential to cause an adverse environmental effect. Copper, nickel, silver, zinc, bis(2-ethylhexyl) phthalate, ammonia, nitrogen, and phosphorous exceed federal or most stringent state water quality criteria. However, flow rate data are not adequate for estimating the fleetwide generation rate for this discharge, and consequently, the mass loadings of these constituents for the fleet could not be calculated.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the discharge volume. Based on this estimate and on the reported concentrations of constituents, the mass loadings to the environment resulting from this discharge were then estimated. Table 4 shows the source of the data used to develop this NOD report.

Specific References

1. Point Paper, "Supplemental Information for Miscellaneous UNDS Discharge Streams", P. Weersing, Military Sealift Command Central Technical Activity, Code N72PC1, January 9, 1997.

2. Uniform National Discharge Standards Non-Oily Machinery Wastewater (NOMWW) Flow Characterization Report, CDNSWC-TM-63-98/62, March 1998.

3. UNDS Phase 1 Sampling Data Report, Volumes 1 - 13, October 1997.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

UNDS Ship Database, August 1, 1997.

Pentagon Ship Movement Data for Years 1991-1995, Dated March 4, 1997.

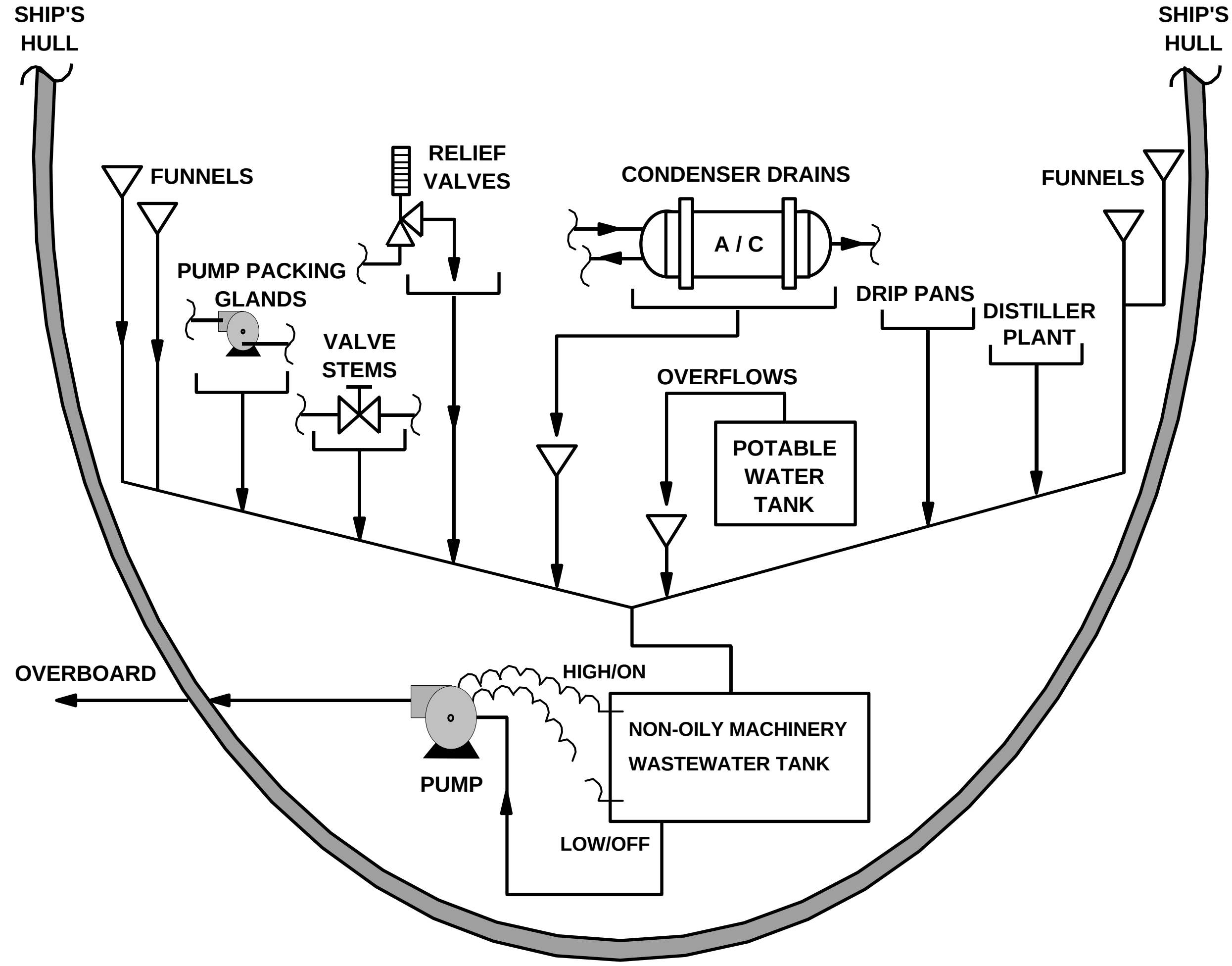

FIGURE 1
TYPICAL NON-OILY MACHINERY
WASTEWATER SYSTEM

Table 1. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	13.96	4 of 4	6	62	11284
Ammonia as Nitrogen	0.34	4 of 4	0.1	1	275
Biochemical Oxygen Demand	4.76	1 of 3	BDL	12	3696
Chemical Oxygen Demand	63.89	3 of 4	BDL	285	49608
Chloride	94.29	4 of 4	2	3050	73213
Hexane Extractable Material	5.02	1 of 4	BDL	40.5	3898
Nitrate/Nitrite	0.38	4 of 4	0.19	0.56	295
SGT-HEM	5.91	1 of 3	BDL	33	4589
Sulfate	139.13	4 of 4	9.8	1710	112457
Total Dissolved Solids	431.32	4 of 4	46	6300	348630
Total Kjeldahl Nitrogen	1.05	4 of 4	0.55	2.3	8.49
Total Organic Carbon (TOC)	4.27	3 of 4	BDL	21	3451
Total Phosphorous	1.03	4 of 4	.14	11	833
Total Recoverable Oil and Grease	4.73	4 of 4	.6	19.75	3823
Total Sulfide (Iodometric)	6.45	4 of 4	2	16	5213
Total Suspended Solids	11.34	3 of 4	BDL	46	9166
Volatile Residue	287.25	4 of 4	54	6350	232180
MERCURY	(ng/L)		(ng/L)	(ng/L)	(lbs/yr)
Mercury	4.48	2 of 4	BDL	2135	0.0036
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Aluminum					
Dissolved	30.83	1 of 4	BDL	68	24.92
Total	53.47	1 of 4	BDL	372.5	43.22
Antimony					
Dissolved	2.81	1 of 4	BDL	7.55	2.27
Total	2.57	1 of 4	BDL	5.5	2.08
Arsenic					
Dissolved	0.94	1 of 4	BDL	1.8	0.760
Total	0.57	1 of 4	BDL	1.2	0.461
Barium					
Dissolved	5.17	3 of 4	BDL	21.8	4.18
Total	7.03	3 of 4	BDL	34.95	5.68
Boron					
Dissolved	80.88	3 of 4	BDL	754	65.4
Total	89.19	3 of 4	BDL	833	72.1
Cadmium					
Dissolved	2.78	1 of 4	BDL	5.2	2.25
Total	2.80	1 of 4	BDL	5.4	2.26
Calcium					
Dissolved	3587.66	4 of 4	131.5	74650	2900
Total	4117.59	4 of 4	173	97950	3328
Copper					
Dissolved	148.76	4 of 4	34.35	1065	120
Total	599.96	4 of 4	34.2	3045	485

Iron					
Dissolved	20.90	2 of 4	BDL	89.15	16.9
Total	110.28	3 of 4	BDL	2505	89.1
Lead					
Dissolved	4.59	1 of 4	BDL	19.3	3.71
Total	5.10	1 of 4	BDL	29.35	4.12
Magnesium					
Dissolved	7775.80	4 of 4	316	196500	6285
Total	9258.79	4 of 4	455	251500	7484
Manganese					
Dissolved	7.40	3 of 4	BDL	26.15	6.0
Total	9.91	3 of 4	BDL	69.05	8.0
Molybdenum					
Dissolved	2.47	1 of 4	BDL	17.2	2.0
Total	2.79	1 of 4	BDL	31	2.26
Nickel					
Dissolved	76.10	3 of 4	BDL	237	61.5
Total	92.63	3 of 4	BDL	404	74.9
Silver					
Total	5.41	1 of 4	BDL	54.85	4.37
Sodium					
Dissolved	69616.18	4 of 4	3365	1750000	56270
Total	62604.54	4 of 4	1948.75	1955000	50602
Thallium					
Dissolved	4.72	3 of 4	BDL	15.7	3.82
Total	1.43	1 of 4	BDL	1.6	1.16
Tin					
Total	4.14	1 of 4	BDL	36.7	3.35
Titanium					
Total	4.05	2 of 4	BDL	9.75	3.27
Zinc					
Dissolved	140.24	4 of 4	23	847	113
Total	621.47	4 of 4	90.85	6125	502
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
2-Propanone	36.00	1 of 4	BDL	107.5	29.1
Bis(2-Ethylhexyl) Phthalate	10.78	1 of 4	BDL	75	8.71
Chloroform	6.93	1 of 4	BDL	18.5	5.6
N,N-Dimethylformamide	6.67	1 of 4	BDL	11	5.39
N-Hexacosane	6.06	1 of 4	BDL	10	4.9
Toluene	10.91	1 of 4	BDL	113.5	8.82

Notes:

(1) BDL = Below Detection Limit

(2) Mass loadings were calculated based upon the results of the UNDS Non-Oily Machinery Wastewater Flow Characterization Report involving four vessels: CVN 74, DDG 67, LHD 5, and LSD 44.[2]

(3) Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 2. Estimated Annual Mass Loadings of Constituents

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.34	4 of 4	0.1	1	275
Nitrate/Nitrite	0.38	4 of 4	0.19	0.56	295
Total Kjeldahl Nitrogen	1.05	4 of 4	0.55	2.3	8.49
Total Nitrogen[A]	1.43	-			303
Total Phosphorous	1.03	4 of 4	0.14	11	833
ORGANICS	(μg/L)		(μg/L)	(μg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	10.78	1 of 4	BDL	75	8.71
MERCURY	(ng/L)		(ng/L)	(ng/L)	(lbs/yr)
*Mercury**	4.48	2 of 4	BDL	2135	.0036
METALS	(μg/L)		(μg/L)	(μg/L)	(lbs/yr)
Copper					
Dissolved	148.76	4 of 4	34.35	1065	120
Total	599.96	4 of 4	34.2	3045	485
Nickel					
Dissolved	76.10	3 of 4	BDL	237	61.5
Total	92.63	3 of 4	BDL	404	74.9
Silver					
Total	5.41	1 of 4	BDL	54.85	4.37
Zinc					
Dissolved	140.24	4 of 4	23	847	113
Total	621.47	4 of 4	90.85	6125	502

BDL = Below Detection Limit
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

* Mercury was not found in excess of WQC; mass loading is shown only because it is a bioaccumulator.

Mass loadings were calculated based upon the results of the UNDS Non-Oily Machinery Wastewater Flow Characterization Report involving four vessels: CVN 74, DDG 67, LHD 5, and LSD 44.[2]

Table 3. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	Log-normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS (mg/L)					
Ammonia as Nitrogen	0.34	0.1	1	None	0.006 (HI)[A]
Nitrate/Nitrite	0.38	0.19	0.56	None	0.008 (HI)[A]
Total Kjeldahl Nitrogen	1.05	0.55	2.3	None	-
Total Nitrogen[B]	1.43			None	0.2 (HI)[A]
Total Phosphorous	1.03	0.14	11	None	0.025 (HI)[A]
ORGANICS (μg/L)					
Bis(2-Ethylhexyl) Phthalate	10.78	BDL	75	None	5.92 (GA)
Mercury (ng/L)					
*Mercury**	4.48	BDL	2135	1800	25 (FL, GA)
Metals (μg/L)					
Copper					
Dissolved	148.76	34.35	1065	2.4	2.4 (CT, MS)
Total	599.96	34.2	3045	2.9	2.5 (WA)
Nickel					
Dissolved	76.10	BDL	237	74	74 (CA, CT)
Total	92.63	BDL	404	74.6	8.3 (FL, GA)
Silver					
Total	5.41	BDL	54.85	1.9	1.2 (WA)
Zinc					
Dissolved	140.24	23	847	90	90 (CA, CT, MS)
Total	621.47	90.85	6125	95.1	84.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

* - Mercury was not found in excess of WQC; concentration is shown only because it is a bioaccumulator.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 4. Data Sources

	Data Source			
NOD Section	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment		X		X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate		X		X
3.3 Constituents		X		
3.4 Concentrations		X		
4.1 Mass Loadings		X		
4.2 Environmental Concentrations		X		
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Photo Lab Drains

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the photographic laboratory drains and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Shipboard photographic laboratory wastes result from the processing of color, black-and-white, and X-ray film. The chemicals used aboard vessels for these purposes are the same as those used at shore-based photographic facilities. This discharge is controlled by the Armed Forces by current guidance which requires containerization of all photo processing wastes for shore disposal when within 12 nautical miles (n.m.) of shore.[1]

The photographic wastewater processing system consists of three elements: a film processor, a washwater recycle system, and a fixer recycle and silver recovery subsystem. The film processor effluents include the developer and fixer solutions and the thiosulfate washwater stream. After the film is fixed, it goes through the washwater recycle system, where it is immersed in thiosulfate washwater and then sprayed with freshwater (rinsewater).[2] Black-and-white and X-ray film effluents are then containerized for shore disposal or directly discharged overboard via the ship's collection, holding, and transfer (CHT) system if outside 12 n.m. Fixer solutions must always be containerized for shore disposal within 12 n.m. Beyond 12 n.m. the fixer solution may be discharged overboard, provided the fixer solution is processed through a silver recovery unit, if one is available on-board.[3] A silver recovery unit uses an electrolytic recovery assembly to recover the silver from the recycled fixer solution.[2] The effluent from the recovery unit is then containerized, or discharged overboard if outside 12 n.m.[1] Color film processor effluent (small quantities) may be discharged directly overboard beyond 12 n.m. via the plumbing drain system.[3] In port, or in transit within 12 n.m., the effluent is containerized for shore disposal. In some cases, rinsewater is discharged to the CHT system in port for discharge ashore if local regulations permit.

The amount and frequency of waste generation across vessel classes will vary depending upon the vessels' photo processing capabilities (color and/or black-and-white), equipment, and operational objectives. Color film processing waste is generated from batch quantities of developer, fixer, and intensifier solutions. Black-and-white and X-ray film processing waste is generated from processor effluent, stop bath, detergents, and hardener solutions. Many vessels are now being outfitted with self contained automatic processors or digital processors. Automatic processors do not produce a continuous rinsewater stream. Digital processors do not use chemicals.[4]

2.2 Releases to the Environment

Photographic processing effluents are only discharged outside of 12 n.m. from shore. Black-and-white and X-ray photographic processing effluent is discharged overboard via the CHT system. Color film processor effluent is permitted to be discharged overboard above the waterline via the plumbing drain system.[1] The discharge can consist of stop bath, detergents, hardener, developer, fixer, and rinse solutions.

2.3 Vessels Producing the Discharge

Navy vessels such as aircraft carriers (CV/CVN), amphibious assault ships (LHD/LHA/LPD/LCC), and submarine tenders (AS) have photographic laboratory facilities, including color, black-and-white and X-ray photographic processors. Two Military Sealift Command (MSC) hospital ships (T-AH) have photo processing equipment, but neither is used on a routine basis or within U.S. contiguous or territorial waters. The U. S. Coast Guard (USCG) currently has two WAGB 400 Class icebreakers with photographic and X-ray processing capabilities, but does not discharge wastes overboard within 12 n.m. of shore.[5] The Army and the Air Force are not expected to produce this discharge because their vessels do not have photographic developing capabilities.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Naval Ships' Technical Manual (NSTM), Chapter 593, provides uniform guidance in the handling and disposal of photographic processing chemicals. While in port or in transit within 12 n.m., all discharges of X-ray, color and black-and-white photographic processing fixers, and developers are containerized for shore-side disposal. Film rinsewaters are not containerized in port due to their large volumes, but are disposed of in to the CHT system. The CHT system is connected to the pierside collection piping while the vessel is docked. Therefore, overboard discharges of photographic processing effluents do not occur from any vessel within 12 n.m. of shore, and most vessels containerize their waste even beyond this point.

Beyond 12 n.m., all photo processing chemicals, if not containerized, are directed to the CHT system where they are mixed with blackwater and discharged overboard.[3] Wastes that can be directed to the CHT system are black-and-white and X-ray film processing waste from processor effluent, stop bath, detergents, hardener solutions, and silver recovery unit effluent.

3.2 Rate

Discharge flow rate data were not obtained.

3.3 Constituents

Table 1 lists the chemical constituents identified in the most commonly used developing solutions and fixers, and in rinse waters on vessels of the Armed Forces. Silver is the only priority pollutant in this discharge. There are no known bioaccumulators identified in this discharge.

3.4 Concentrations

The range of photographic processing chemical concentrations was not obtained.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. Mass loadings are discussed in Section 4.1 and the concentrations of discharge constituents after release to the environment are discussed in Section 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Constituent mass loadings were not calculated since the discharge does not occur inside 12 n.m. Furthermore, discharge concentrations and flow rates are unknown.

4.2 Environmental Concentrations

Concentrations released to the environment were not calculated since the discharge does not occur inside 12 n.m. and the discharge concentrations are unknown.

4.3 Potential for Introducing Non-Indigenous Species

Potable water is used in photographic laboratories; therefore, there is no possibility for the introduction, transport, or release of non-indigenous species.

5.0 CONCLUSIONS

Existing data are insufficient to determine whether drainage from shipboard photographic labs has the potential (or has a low potential) of causing an adverse environmental effect.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources were obtained. Table 2 shows the sources of the data used to develop this NOD report.

Specific References

1. Naval Ships' Technical Manual (NSTM) Chapter 593 Appendix D, pp D-9 and D-10, Disposal Guidelines For Shipboard Hazardous Waste. September 1, 1991.

2. Laboratory Evaluation of a Photographic Wastewater Processing System, prepared by David W. Taylor Naval Ship Research and Development Center, Bethesda, MD. August, 1982.

3. UNDS Equipment Expert Meeting Minutes. Photo Laboratory Discharges - April 2, 1997.

4. Personal Communication Between John Julian, NAVSEA 03L13, and Sr. Chief Freeland, Naval Imaging Command, on Self Contained Automatic Processors and Digital Processors for use in Photographic Laboratory. September 23, 1997.

5. Personal Communication Between LT. Joyce Aivalotis, U.S. Coast Guard and Dan Mosher of Malcolm Pirnie, Inc., on USCG Photographic Processing Procedures. April 28, 1997.

6. Personal Communication Between Albert Browne, NAVSEA 03L13, and Mr. Joseph MacDonald, NAVSEADET (PERA-CV), on Kodak Processor Chemistry Listings for Kreonite/Kodak RA-4, Black-and-White Imagemaker, and Kodak C-41 Color Imagemaker Processors. July 25, 1996.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

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USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, Proposed Rule under 40 CFR Part 131, Federal Register, Vol. 62, Number 150. August 5, 1997.

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Georgia Final Regulations. Chapter 391-3-6, Water Quality Control, as provided by The Bureau of National Affairs, Inc., 1996.

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Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Chemical Constituents Identified in the Most Commonly Used Photographic Developing Solutions and Fixers, and in Rinse Waters on Vessels of the Armed Forces[6]

1,3 - propylenediaminetetraacetic acid	Diethanolamine - sulfur dioxide	potassium hydroxide
2- aminoethanol	Diethanolamine - sulfur dioxide complex	potassium sulfite
4 - (N-ethyl- N-2-methanesulfonylaminoethyl) - 2 - methylphenylenediamine sesquisulfate monohydrate	diethylene glycol	propylene glycol
4 - (N-ethyl-N-2-hydroxyethl)-2-methylphenylenediamine sulfate	Formaldehyde	silver*
4 - (N-ethyl- N-2-methanesulfonylaminoethyl) - 2 - methylphenylenediomine sulfate	glacial acetic acid	sodium acetate
acetic acid	Hydroquinone	sodium bisulfite
aluminum sulfate	Hydroxylamine sulfate	sodium citrate
Ammonia	Isothiazolones	sodium metabisulfite
ammonium (ethylenodinitrilo) tetraacete) ferrate	lithium sulfate	sodium sulfite
ammonium acetate	methyl alcohol	sodium sulfosuccinate
ammonium bromide	N,N-diethylhydroxylamine	stilbene brightner
ammonium citrate	nitric acid	sulfuric acid
ammonium ferric ethylenediaminetetra acetic acid	Organosilicone fluid	tetra sodium ethylene diamine tetraacetrate
ammonium ferric propylenediaminetetraacetic acid	penitetic acid	triethanolamine
ammonium sulfite	potassium bicarbonate	
ammonium thiosulfate	potassium carbonate	
boric acid	potassium chloride	

* Priority Pollutant

Table 2. Data Sources

	Data Sources			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate (NA)				
3.3 Constituents	X			X
3.4 Concentrations (NA)				
4.1 Mass Loadings (NA)				
4.2 Environmental Concentrations (NA)				
4.3 Potential for Introducing Non-Indigenous Species				X

Note: NA = not applicable

NATURE OF DISCHARGE REPORT

Portable Damage Control Drain Pump Discharges

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the portable damage control drain pump discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Damage control (DC) systems are the fluid, electrical, and ventilation systems that contribute to combating fires, controlling or removing smoke and/or water, or transmitting power and communications. Facilities for dewatering compartments in the event of an emergency consist of fixed drainage systems within the vessel and portable equipment, such as electric submersible pumps, P-250 or P-100 pumps, and eductors (Figure 1). Portable DC dewatering equipment is used in emergencies to assist recovery from fire and flooding events by removing fluids from damaged compartments or from compartments without drainage systems located close to, or below, the waterline. Emergency situations are not incidental to the normal operation of the vessel and therefore not considered in this report. The only required operation which produces a discharge incidental to the normal operation of the vessel is during planned maintenance system (PMS) activities for the equipment. This report addresses only planned maintenance activity discharges from this equipment.

Three basic types of dewatering equipment used in damage control situations are described below.

- **Portable electric submersible pumps** are used to dewater compartments that do not have an installed drainage system. The pump is driven by an electric motor enclosed in a watertight case that allows the pump to operate while submerged. These pumps are fitted with strainers to prevent debris from clogging the impeller. This pump does not use a suction hose, and the fluid is discharged through a fire hose.

- **Portable engine-driven pumps** are designed for firefighting but can also be used for dewatering operations. Engine-driven pumps take suction through a hard rubber hose and discharge through a fire hose. The P-250 has a pumping capacity of 250 gallons per minute (gpm). The P-100 pump is driven by an air-cooled diesel engine and has a pumping capacity of 100 gallons per minute (gpm). The P-1 (Figure 2) and P-5 (CG-P1B and CG-P5) are gasoline-driven portable pumps used by the U.S. Coast Guard (USCG). The P-5 is similar in design to the P-1, but it has a larger pumping capacity. The P-1 has a pumping capacity of 120 gpm, and the P-5 has a pumping capacity of 200 gpm.[1,2]

- **Portable eductors** Portable eductors are actuated from the discharge of a P-250 or P-100 pump or through a fire hose using the vessel's installed firemain. A suction hose is not used with portable eductors because the eductor is submerged during operation. The eductor discharges through a fire hose which is lead directly overboard.

Maintenance schedules for the portable electric submersible pump and portable eductors do not include a requirement for operation that will produce a discharge.[3] The USCG P-1 and P-5 pumps are pre-packaged for transfer to a vessel in distress, and periodic maintenance schedules do not include a requirement to operate the pumps to produce a discharge. The maintenance schedules for the Navy, the Military Sealift Command (MSC), and Army P-100 and P-250 pumps include a requirement to operate the pumps monthly for 10 minutes and annually for 15 minutes: the annual check is concurrent with a monthly check.[4] Current USCG maintenance schedules require P-250 pumps to be operated for 30 minutes each month, but the maintenance procedures are expected to be changed to require only a 15 minute run each month.[5,6]

2.2 Releases to the Environment

During maintenance, P-250 and P-100 pumps are operated to demonstrate proper function by pumping seawater adjacent to the vessel via a hard rubber suction hose through the system and discharging it directly overboard through a fire hose.[7]

The P-250 pump uses a portion of the pump discharge to cool the engine exhaust. This cooling water is discharged separately from the pump discharge and is not considered part of this discharge stream. It is addressed in a separate NOD report entitled “Portable Damage Control

2.3 Vessels Producing the Discharge

All Navy, MSC, and USCG surface ships can discharge seawater from portable DC drain pumps. There are 906 emergency fire pumps on Navy surface vessels. The MSC maintains 137 pumps, and the USCG has 370 pumps on its surface vessels. The Army is currently equipped with 60 P-250 MOD 1 pumps and six P-100 pumps. The Air Force does not use portable pumps on any of their water craft. The numbers of individual pumps within the fleets are: [8,9,10,11,12,13,14]

	P-250 MOD 1	P-100
Navy	70	836
MSC	0	137
USCG	370	0
Army	60	6
Totals	500	979

The Navy is completely converting to P-100 pumps, and it is estimated that all P-250’s in Navy service will be replaced by P-100’s by the end of 1998.[8] The Army has also begun to replace P-250’s with P-100 pumps, but a timetable for complete conversion has not yet been developed

As mentioned previously, the USCG P-1 and P-5 pumps are pre-packaged for transfer to a vessel in distress. These pumps are not required to be operated during periodic maintenance so these pumps produce no discharge incidental to normal vessel operations.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

As part of equipment maintenance, the portable damage control equipment is operated within 12 nautical miles (n.m.).

3.2 Rate

Individual vessel discharge volumes from emergency pumps will vary depending on the numbers and types of pumps aboard each vessel. Therefore, flow rates will be calculated on a fleet-wide basis instead of a ship-by-ship basis.

Using standard maintenance operating schedules, pump inventory data, and pump discharge rates, discharge flow estimates were calculated as shown in Table 1. During monthly maintenance activities, the Navy, MSC, and Army run pumps for approximately 10 minutes and for approximately 15 minutes during annual maintenance checks. The USCG currently operates its pumps for 30 minutes per month. The resulting total annual discharge is approximately 49,062,500 gallons.

Approximate annual flow rates for representative ship types are listed below:

Ship Type	Pump Type Carried and Number per Ship	Pump Flow Rate (gpm)	Annual Operating Time (Minutes/Year)	Total Yearly Flow rate per Ship
Surface Combatant (DD, DDG, CG, FFG)	4 - P-100's	100	125	50,000
Large Auxiliary or Amphibious Ship (e.g.: AFS, AOE, LPD, LSD)	6 - P-100's	100	125	75,000
USCG Cutter (WHEC)	3 - P-250's	250	360	270,000
Army Watercraft (LCU-1600)	1 - P-250's	250	125	31,250

3.3 Constituents

The portable DC drain pump discharge is seawater that is pumped during maintenance activities. The seawater contacts rubber suction hoses and the rubber lining of firehoses. It also contacts the wetted components of the pump (e.g. impeller). The pumps and hoses are not expected to contribute measurable amounts of pollutants to the discharge because the residence times of the seawater within the equipment is less than 5 seconds.

3.4 Concentrations

The discharge is expected to be seawater with no measurable contribution of constituents from the pumping process.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings and environmental concentrations are discussed in Section 4.1 and 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The portable DC drain pump discharge is seawater that is pumped during maintenance activities. The seawater contacts rubber suction hoses and the rubber lining of firehoses. It also contacts the wetted components of the pump (e.g. impeller). The pumps and hoses are not expected to contribute measurable amounts of pollutants to the discharge because the residence times of the seawater within the equipment is less than 5 seconds.

4.2 Environmental Concentrations

The discharge is expected to be seawater with no measurable contribution of constituents from the pumping process.

4.3 Potential for Introducing Non-Indigenous Species

There is an insignificant potential for introducing non-indigenous species from this discharge. The seawater pumped through the portable DC drain pumps is discharged in the same location from which it was taken.

5.0 CONCLUSION

The portable DC drain pump discharge has a low potential for causing an adverse environmental effect because the discharge consists of seawater pumped and discharged at the same location from which it was taken. The pumps and hoses are not expected to contribute significant amounts of pollutants to the discharge because the residence time of the seawater within the equipment is less than 5 seconds.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the annual discharge volume. Table 2 shows the source of the data used to develop this NOD report.

Specific References

1. Gallagher, Larry, M. Rosenblatt & Son, Inc. Portable DC Dewatering Equipment, April 1997, Leslie Panek, Versar, Inc.

2. USCG COMDTINST M10470.10C - Chapter 2, Dewatering Pump Kit. Unknown date.

3. Maintenance Index Page (MIP) 6641/Z06-76, Damage Control Stations. April 1995.

4. Maintenance Index Page (MIP) 6641/008-B2, Portable Gasoline/JP-5 Driven Pump. November 1992.

5. USCG Uniform Maintenance Procedure Card (UMPC) R-M-014.

6. Personal Communication, LT Joyce Aivalotis USCG to M. Rosenblatt & Son, June 5, 1997.

7. Steinberg, Bob, M. Rosenblatt & Son, Inc. Portable DC Dewatering Equipment, January 1997, Leslie Panek, Versar, Inc.

8. Personal Communication (Fonecon): Steinberg, Bob, M. Rosenblatt & Son. Status of USN P-250 Replacement Program, 23 January 1998, Mark Hampson, NSWC

9. UNDS Equipment Expert Meeting Minutes - Emergency Fire Pump Wet Exhaust. March 26, 1997.

10. Personal Communication between Chief Warrant Officer Dunbar, USCG and Doug Hamm, Malcolm Pirnie, Inc., January 26, 1997 and March 27, 1997.

11. Personal Communication (Fonecon): Steinberg, Bob, M Rosenblatt & Son. Status of MSC P-250 Replacement Program, 5 February 1998, Joe Bohr, MSC Code N72PC

12. Saponara, N. et al. "UNDS Shipcheck of US Army Watercraft, Fort Eustis, VA, 21-22 January 1998: Trip Summary", undated

13. Personal Communication (Fonecon): Steinberg, Bob, M. Rosenblatt & Son, Inc. Army Purchases of P-100 Pumps, 14 January 1998, Paul Darley, W.S. Darley & Co.

14. Personal Communication (VoiceMail): Chew, Don, LCOL, USAF, HQ, USAF (ILTV).

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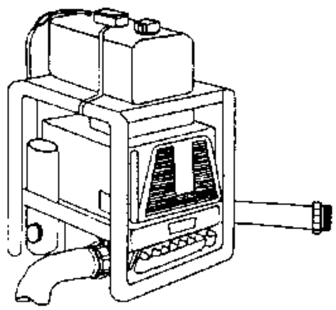
Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter

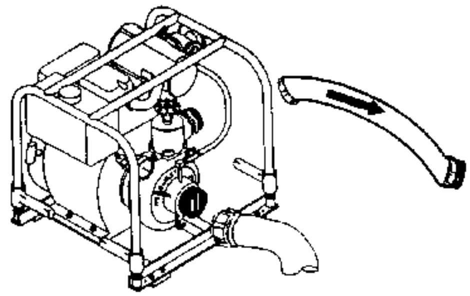
173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

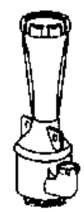
The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.



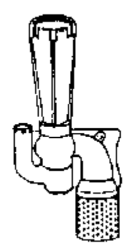
P-250 PUMP (MOD 1 OR MOD2)



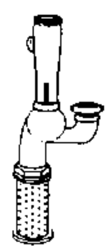
P-100 PUMP



PERI JET EDUCTOR



S-TYPE EDUCTOR



1-1/2" EDUCTOR

Figure 1. Dewatering Equipment

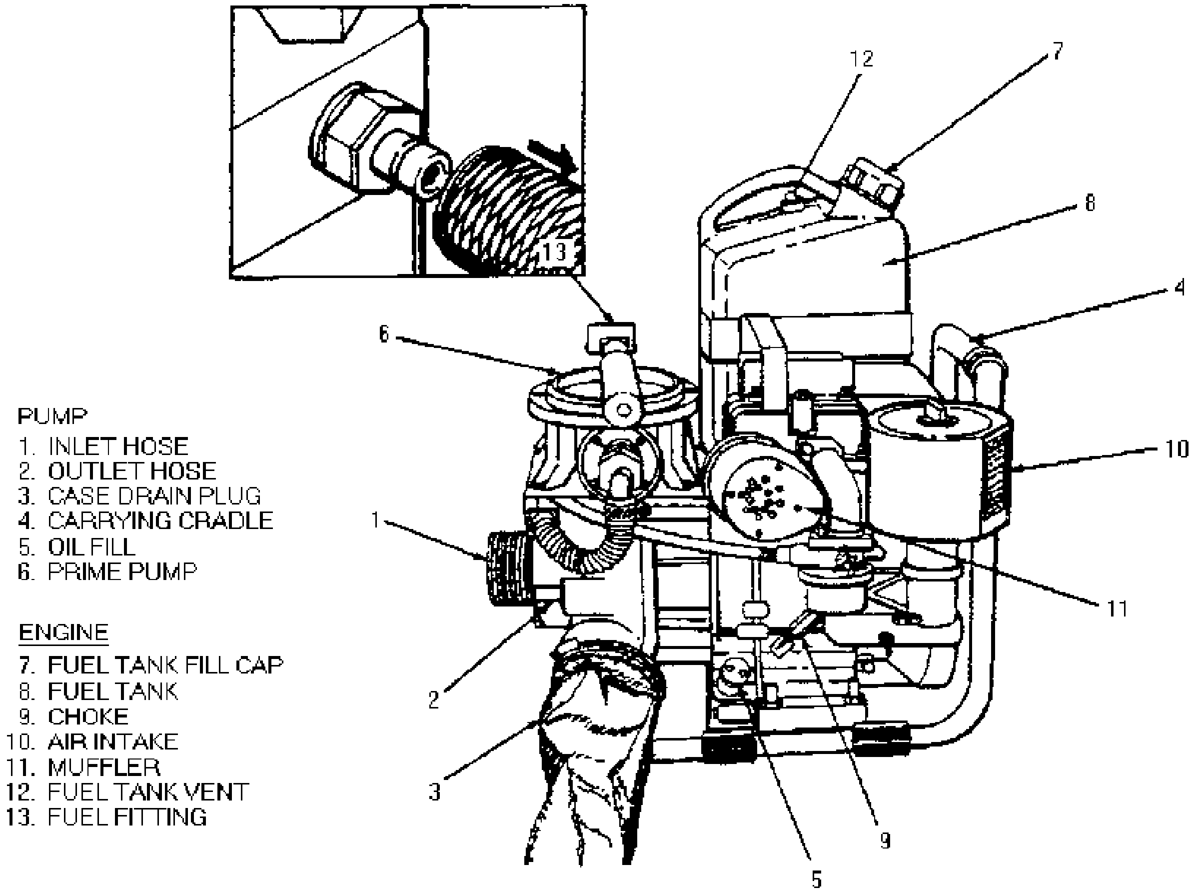


Figure 2. Portable Dewatering Pump (Model CG-P1B)

Table 1. Annual Discharge from Portable DC Drain Pumps

Service	Pump Model	Number of Pumps	Flow (GPM)	Annual Operating Time (Minutes/Year)	Annual Discharge (Gallons/Year)
Navy					
	P-250 MOD 1	70	250	125	2,187,500
	P-100	793	100	125	9,912,500
		Navy Total:			12,100,000
MSC					
	P-250 MOD 1	0	250	125	0
	P-100	137	100	125	1,712,500
		MSC Total:			1,712,500
USCG	P-250 MOD 1	370	250	360	33,300,000
Army	P-250 MOD 1	60	250	125	1,875,000
	P-100	6	100	125	75,000
		Army Total:			1,950,000
				Cumulative Total:	49,062,500

Table 2. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	Equipment manuals PMS cards			X
2.2 Releases to the Environment			X	X
2.3 Vessels Producing the Discharge	X			X
3.1 Locality	X			X
3.2 Rate	PMS cards			X
3.3 Constituents	X		X	X
3.4 Concentrations			X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Non-indigenous Species			X	

NATURE OF DISCHARGE REPORT

Refrigeration/AC Condensate

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the condensation discharge that is produced from air conditioner (AC) units, refrigerated spaces, and stand-alone refrigeration units and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

AC units provide cooling for ship spaces. When warm, moist air passes over the refrigeration coils of an AC unit, condensation forms that drips from the coils. This condensation is produced continuously while the AC unit is operating. In addition to AC units, vessels have refrigerated spaces for food and other perishable materials. These spaces are designed for both frozen and chilled cargo and commonly range in temperature from below 0 °F to 35 °F.[1] Condensation also forms from the normal operation of these refrigerated spaces when moist air is cooled below the dew point on the cold evaporator coils of the refrigeration system. The condensate is collected in drains in these refrigerated spaces.

Two types of refrigerated space systems are used: gravity-coil units and forced-air units. Gravity-coil units are typically used in older ships. They employ tinned-copper refrigerant piping which runs back and forth along one or more bulkheads in the refrigerated space.[1] Aluminum fins are attached to the piping to provide a large surface area for the exchange of heat. As the air cools, it becomes more dense and sinks below the comparatively warmer air, creating circulation without the need for a fan. One disadvantage to this type of cooling unit is that the tubing is bulky, so the use of gravity-coil units has been discontinued on newer Navy ships. Forced-air refrigeration units are more compact, self-contained, and use a fan to blow air across the coils. The forced-air units can be used not only in cold storage spaces, but also in other ship spaces.

On most surface ships, gravity coil refrigerant piping is made of tinned-copper.[1,2,3] The forced-air units have brazed-copper piping. Submarine refrigerated space refrigerant piping and evaporator coils are made of copper.[1]

Drip troughs (galvanized steel or tinned-copper) are installed under gravity-type cooling coils to collect condensate or water during defrosting.[1] The piping from these troughs is as short as practicable and leads to compartment drain piping. The forced-air units have drip pans made of galvanized steel or tinned-copper which are placed under the units to collect the condensate. Valved deck drains are also installed in refrigerated spaces that have operating temperatures above 32°F. Deck drains are installed in refrigerated spaces with operating temperatures below 32°F. At least one deck drain is installed in the passage or compartment outside the refrigerated food storage spaces.[1]

The condensate drainage is similar for vessels of all the Armed Forces: condensate produced above the waterline is directed overboard; condensate produced below the waterline is retained on board temporarily before it is pumped overboard. On most Navy ships, condensate is routed directly overboard or combined in a common condensate drain and discharged overboard if the space is above the waterline or to a condensate drain tank if the space is below the water line.[2] Some condensate may also be directed to the machinery space wastewater drain system, the wastewater receiving tank, the sewage collection, holding, and transfer (CHT) tank, or the bilge. On Army watercraft, condensate from refrigeration and air conditioning systems is not collected. Any condensate which forms is typically removed by natural evaporation; if a significant amount of condensate accumulates, it may be removed by mopping or wiping. On vessels of the other Armed Forces, the condensate is discharged to the bilge from spaces below the waterline.

On submarines, drains are installed in chilled stores space decks to remove water from condensation and defrosting. The drains are provided with an isolation valve and lead to a bilge collecting tank or sanitary tank.

2.2 Releases to the Environment

Refrigeration/AC condensate is generally released to the environment by direct gravity drainage overboard, or in some cases from a condensate drain tank or other collection points below the waterline. In addition to continuous condensate drainage, intermittent discharges from refrigerated spaces include water and mild detergents used for cleaning (generally weekly), and water from melting ice that is created when the spaces are defrosted (for gravity-coil units, weekly or when the thickness of the frost on the refrigeration coils exceeds 3/16 inch).[4] The water from cleaning and defrosting is discharged into the space drains or the deck drains.

Organic materials can be an infrequent part of the discharge from residual spilled food items that wash into the drainage. Although spilled food can be washed to drains occasionally, spills would normally be cleaned and disposed of as solid waste or into graywater drains.

Navy supply ships that carry refrigerated cargo for at-sea replenishment of Navy combatants use hot seawater spray to defrost the cargo spaces. This seawater, as well as the freshwater used to flush out any residual seawater after defrosting, is discharged through the refrigeration condensate drainage piping. The seawater is provided by the firemain and is heated to 100 °F by a dedicated heater prior to being sprayed at a maximum rate of 100 gallons per minute on the refrigeration coils. The vessel classes that employ heated seawater spray for defrosting are the AFS, AOE, AO, and AOR classes.[5]

Refrigeration condensate could contain trace amounts of metal from the refrigerant coils and drainage piping, but these concentrations are expected to be comparatively low (see Section 3.4).

2.3 Vessels Producing the Discharge

Navy and MSC vessels produce refrigeration and AC condensate; this includes 254 Navy surface ships, 94 Navy submarines, and 70 MSC ships.[2] In addition, an estimated 228 Coast Guard vessels and 4 Air Force vessels produce this discharge.

The primary difference between ship classes is the amount of condensate that is generated, which depends on ambient temperature, relative humidity, and the size and number of units per ship. USCG vessels also produce refrigeration and AC condensate, and use specifications similar to the Navy for refrigeration and AC units. Army watercraft have no collection or discharge of condensate from refrigeration or air conditioning systems.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Flows from refrigeration units and AC units can be discharged at any time, both within and beyond 12 nautical miles (n.m.) from shore. Operation of the refrigerated spaces and AC units in port or in transit is not significantly different from operation beyond 12 n.m. from shore.

3.2 Rate

No measurements are available to fully characterize the flow for refrigeration/AC condensate for all ship classes. The range of flow rates volumes will depend on the temperature and humidity of the air and the capacity of the cooling units.

Amphibious ships and aircraft carriers of the Navy tend to have the most air conditioning capacity because of their large contingent of personnel, and therefore, represent worst-case flow rates for AC condensate discharge. An estimate of AC condensate volume was developed for an amphibious ship and an aircraft carrier. The estimate was derived for typical ship operating conditions. The worst-case scenario assumes an unlimited supply of humid air (above 60°F) to the AC system. In reality, after the air has been dehumidified, the exchange rates with new air are much lower and will limit available moisture for condensate to about half the worst case amount. The estimate also assumed that condensate is generated when the outside air is 60°F dry bulb or higher.[6]

Based on the above conditions, an amphibious ship will generate no more than 3,840 gallons of condensate per day, and an aircraft carrier no more than 6,795 gallons per day. Vessels of the other Armed Forces tend be smaller and have fewer personnel, and therefore, will produce less AC condensate discharge.

3.3 Constituents

Refrigeration condensate could contain metals from the refrigerant coils and condensate drainage piping, and mild detergents from the occasional cleaning of the refrigerated spaces. AC condensate could contain small amounts of metal from the AC coils or the drain piping. These materials can include aluminum, bronze, copper, iron, lead, nickel, silver, tin, and zinc.

Food particles washed into the condensate drainage system from occasional food spills would increase the Biochemical Oxygen Demand (BOD) in the discharged water. Seawater used to defrost cargo spaces on Navy supply ships, and the freshwater used to flush residual seawater from the cargo spaces are also intermittent constituents of this discharge.

The priority pollutants of this discharge are copper, lead, nickel, silver, and zinc. None of the constituents of this discharge is a bioaccumulator.

3.4 Concentrations

Refrigeration/AC condensate can contain small amounts of metals from contact with refrigerant coils and condensate drainage piping. These concentrations are expected to be low for the following reasons:

1) Condensate is essentially pure water and is not a corrosive medium such as seawater;
2) Drainage lines are only fractionally full of condensate which indicates qualitatively low flow and low residence time;
3) Condensate drainage flow velocities and turbulence are extremely low. Therefore, erosion of metals in drainage is not a factor as it could be in pressurized seawater systems;
4) The residence time of condensate in drainage systems is low. The negligible increase in the residence time because of the slower flow does not increase the chance of entrainment of metals;
5) Copper drainage piping forms a protective corrosion-inhibiting film of cuprous oxide on surfaces in contact with water;[7] and
6) The low temperature of this discharge, both on refrigeration coils and in the condensate drainage piping, would tend to inhibit the corrosion process.

Food spills which could contribute some organic matter to the discharge are intermittent and limited to small amounts. Therefore, they are expected to contribute very little BOD to the discharge. Seawater is also a component of refrigeration condensate discharge of vessels with cargo refrigeration spaces.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. Mass loadings are discussed in Section 4.1 and the concentrations of discharge constituents after release to the environment are discussed in Section 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Mass loadings were not calculated for this discharge.

4.2 Environmental Concentrations

Refrigeration/AC condensate is essentially atmospheric moisture which condenses on refrigeration coils. For reasons stated in Section 3.4, concentrations of any of the potential constituents in this discharge are expected to be low. Therefore, the probability that this discharge results in any measurable effect on environmental concentrations is low.

4.3 Potential for Introducing Non-Indigenous Species

Because this discharge consists of atmospheric moisture, the potential for introducing non-indigenous species is not significant.

5.0 CONCLUSION

Mass loadings and environmental concentrations cannot be calculated with existing information; however, process information is sufficient to characterize the concentrations and loadings of constituents of this discharge.

Refrigeration/AC condensate has a low potential for adverse environmental effect because:

1) the liquid discharge is moisture condensed from the air;
2) concentrations of metals are expected to be low due to the non-erosive and non-corrosive nature of this discharge, and its low temperature; and
3) the contribution from detergents and from food residues is expected to be small and intermittent in nature.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 1 shows the sources of data used to develop this NOD report.

Specific References

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

Table 1. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	MSDS			X
3.4 Concentrations				X
4.1 Mass Loadings				X
4.2 Environmental Concentrations				X
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Rudder Bearing Lubrication

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the rudder bearing lubrication discharge and includes information on the equipment used, its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Rudder bearings support the rudder and allow it to turn freely. While there are small variations among similar rudder bearings systems, there are generally two major types of rudder bearings and two lubricating methods for each type, resulting in four different bearing/lubrication method combinations. They are:

- grease-lubricated roller bearings,
- oil-lubricated roller bearings,
- grease-lubricated stave bearings, and
- water-lubricated stave bearings.

Grease-lubricated Roller Bearings. The rudder stock arrangement for grease-lubricated roller bearings includes a void space between the lower bearing and the hull seal (Figure 1). This design prevents seawater from entering the bearing and causing damage. Water that leaks past the hull seal, as well as grease that leaks past the bearing seals, will enter the void space and drain to the bilge. Thus, discharges from grease-lubricated roller bearings contribute to the bilgewater discharge which is covered in a separate NOD report. Since 1970, grease-lubricated roller bearings have been preferred for use on rudder stocks.

Oil-lubricated Roller Bearings. There is no void space in the rudder stock arrangement used for oil-lubricated roller bearings and the bottom seal of the lower bearing serves as the hull seal (Figure 2). To prevent water from entering the bearing and causing damage, the oil is kept at a slight positive pressure relative to the surrounding seawater pressure by supplying the oil from an elevated “head” tank located above the waterline. If a leak occurs, this positive pressure will cause lubricating oil to leak directly into the sea.[1]

Stave Bearings (Grease and Water Lubricated). This type of bearing is typically located outside of the hull (Figure 3). Stave bearings, which are similar in appearance to the wooden staves that make up a barrel, are typically made of a phenolic-resin material. Depending on the actual type, these stave bearings may be lubricated by grease or water. Grease, when used, is forced into the bearing to lubricate the area where the rudder stock and staves meet. Water-lubricated stave bearings are designed with passages which allow seawater to flow through the bearing. For classification purposes, the bushings found on small boats and craft are included in this subheading due to the similarities in function and design.

Hull seals are used with all types of rudder bearings. A hull seal is installed where the rudder stock penetrates the hull. This seal prevents seawater from entering the ship and damaging the lower bearing, while in the case of oil-lubricated roller bearings it also keeps the oil in the bearing cavity from leaking to the sea. In many cases this seal is a type of lip seal but flax packing can be found on older ships. A lip seal consists of a rubber circular ring with a flexible lip. This lip has a narrow contact area that rubs on the circumference of the shaft, forming a seal. Flax packing seals in a similar fashion as several rows of the circular packing material rubs along the rudder stock. Minor leakage can occur in both cases and their rubbing contact will eventually cause wear on the rudder stock. Hull seals are inspected when the ship is in dry dock, typically every four or five years.

The potential of oil leakage from lip seals and flax packing is greatest when a vessel is underway and the rudder is in use rather than when pierside and the rudder is idle. When the vessel is underway, the action of turning exerts forces on the rudder and rudder stock that can cause a temporary gap in the seal or packing coverage. The harder the turn or higher the vessel speed, the greater these forces are and the greater the potential is for oil leakage and the amount of leakage.

The latest trend in rudder stock hull sealing is to use a face seal. These seals eliminate the minor leakage sometimes associated with lip seals and flax packing. Face seals move the sealing point away from the rudder stock to two circular, hard, mating faces. One half of the seal rotates with the rudder stock while the other half is rigidly attached to the hull of the ship. These mating faces are honed to very small tolerances and while rubbing together prevent liquids from seeping through their very fine and smooth contact area. Face seals used on rudder stocks are designed not to leak as a result of the forces placed on the rudder stock during turning.[1]

2.2 Releases to the Environment

The two releases possible are oil from oil-lubricated roller bearings and grease from grease-lubricated stave bearings.

2.3 Vessels Producing the Discharge

All Navy surface ships have rudder bearings, except for those with steerable thrusters or cycloidal propellers, such as the MHC 51 Class minesweepers.[1] Vessels belonging to the Military Sealift Command (MSC), U.S. Coast Guard (USCG), Army, and Air Force also have rudder bearings.

Most rudder bearings (roller or stave) are grease-lubricated. Only the AS 36/39 Class and AOE 1 Class ships, which form 4 percent of the total number of Navy ships, have oil-lubricated rudder bearings. The T-AFS 1 and T-AE 26 Classes of MSC are also fitted with oil-lubricated rudder bearings. USCG vessels do not have oil-lubricated rudder bearings. The rudder bearings or bushings found on small boats and craft are typically made of self-lubricating materials and are either not lubricated or use water for lubrication.

Surface ship rudders with oil-lubricated roller bearings and grease-lubricated stave bearings have the potential to produce an oil or grease discharge. Table 1 lists the rudder bearing type and lubrication method for each Navy ship class. There are currently five Navy ships that use oil lubrication for rudder bearings. Five AS 36/39 Class ships (submarine tenders) and four AOE 1 Class ships (fast combat support ships) were originally fitted with lip seals. Of the submarine tenders, AS 36 and AS 37 are being decommissioned.[2] The three remaining ships (AS 39-41) are currently scheduled to have their lip seals replaced with face seals. The replacements are expected to begin in 1999 and conclude in 2002.[1] Of the four AOE 1 Class ships, AOE 2 and AOE 3 have been fitted with face seals. The other two ships in the class are also scheduled to be fitted with the same type of face seal.[3] Therefore, any discharges of oil from the rudder bearings on Navy vessels is expected to be eliminated in the next 4 to 5 years. Of the MSC ships, the T-AE 35 had the face seal installed in December 1997.[4]

USCG ships use water- and grease-lubricated bearings on their rudder stocks, as summarized in Table 2.[5] Small boats and craft use bearings/bushings that are either self-lubricated or water-lubricated. The lubricity of the materials used in self-lubricated bearings/bushings is such that additional lubricants are not required; water-lubricated bearings/bushings are also made of special materials, but require water to be present on their contact surfaces for proper lubrication. Table 3 lists the rudder bearings/bushings found in USCG small boats and craft.[6] The upper bearing/bushing of these small boats and craft is typically self- or grease-lubricated because it may not contact the water, while the lower bearing/bushing is lubricated by being submerged in the water. The USCG is increasing the use of self-lubricated bearing material in its ships and is reducing the use of grease as a lubricating material in all areas exposed to the sea and weather.[5]

Table 4 lists MSC vessels, including the type of bearing, method of lubrication, and allowable leakage rates. Eight TAE 26 Class and eight TAFS 1 Class vessels have oil lubricated bearings.

Army and Air Force vessels have rudder bearings similar to those found on Coast Guard vessels of comparable size.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information which characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge can occur in port and while operating within 12 nautical miles (n.m.).

3.2 Rate

This discharge comprises the leaking of oil or the washout of grease from rudder bearings. For the oil discharge, rules-of-thumb for characterizing hull seal failure limit the hull seal leakage rates to one gallon per day at sea and one pint per day in port.[2] These rates are abnormally high and are typically associated with a malfunctioning or failing seal. Little or no leakage would be expected from a properly functioning and maintained seal.

3.3 Constituents

In general, greases and lubricating oils are made from lubricating stocks generated during petroleum fractionation. These fractions contain organic compounds that are generally larger molecules, containing more than 17 carbon atoms. Lubricating oils are composed of aliphatic, olefinic, naphthenic (cycloparaffinic), and aromatic hydrocarbons, as well as additives, depending on their specific use. Lubricating oil additives may include antioxidants, bearing protectors, wear resistors, dispersants, detergents, viscosity index improvers, pourpoint depressors, and antifoaming and rust-resisting agents.[7] Not all the additives may be present at one time. It is anticipated that the additives are similar to those found in commercial oils. There are no bioaccumulators expected to be present in this discharge.

3.4 Concentrations

The greases and lubricating oils used conform to MIL-G-24139 specifications and 2190TEP (MIL-L-17331) respectively.[1] Based on MSDS information, MIL-G-24139 grease contains 86% hydrotreated heavy paraffinic distillates, 6% clay, and 4% fatty acid amides. Lubricating oil 2190 TEP contains greater than 99% heavy hydrotreated paraffinic distillates and less than 1% additives.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loading

4.1.1 Oil

At Sea. A high estimate of the oil released by a ship at sea is one gallon of oil per day, as discussed in Section 3.2. It is also estimated that it takes 4 hours for a ship to cover the 12 n.m. transit zone. Therefore, during each transit (either into or out of port), one-sixth of a gallon of oil could be released. An AOE 1 Class ship averages 22 transits per year and an AS 36/39 Class ship averages 12 transits per year. Under this scenario, an AOE 1 Class ship could release (1/6)(22) = 3.7 gallons of oil and an AS 36/39 Class ship would release (1/6)(12) = 2.0 gallons of oil to the surrounding seawater each year. As stated in Section 2.3, two AOE 1 Class ships and 3 AS 36/39 Class ships have oil-lubricated bearings. The maximum estimated amount of oil released from Navy ships fleetwide per year within 12 n.m. would be (3.7)(2) + (2.0)(3) = 13.4 gallons. Using a specific gravity of 0.89 for oil (MSDS for 2190TEP), this translates into approximately 100 pounds per year (lbs/year).

Using the same logic for the MSC ships, eight T-AE 26 Class (8 transits) and eight T-AFS 1 Class (14 transits), the total mass loading would be:

(1/6 gallons)(8 transits)(8 ships) + (1/8 gallons)(14 transits)(8 ships) = 29.3 gallons or 218 lbs/year

Therefore, the total mass loading at sea during transit would be 100 + 218 = 318 lbs/year. However, the actual release rates will be much less because all ships of a class will not leak oil at such high rates, for such a long period of time, at the same time.

In Port. A high estimate of the oil released by a ship in port is one pint per day, as discussed in Section 3.2. Assuming that each of the two AOE 1 Class and three AS 36/39 Class ships spend 183 days per year in port, the total amount of oil released would be (1 pint)(5 ships)(183 days/yr) = 915 pints or 114 gallons per year. This translates into approximately 846 lbs/year.

For the eight MSC ships, the total amount of oil released in port would be:

(1 pint)(8 ships)(183 days/year) = 1,460 pints/year, 183 gallons/year, or 1,360 lbs/year.

Therefore, the maximum estimated mass loading in port would be 846 + 1,360 = 2,206 lbs/year. However, the actual release rates are expected to be much less because all ships of a class will not leak oil at such high rates, for such a long period of time, at the same time.

4.1.2 Grease

Grease washout occurs only from grease-lubricated stave bearings and only when the ship is moving and the rudder is in use. When the ship is first constructed or when the bearings are overhauled, approximately 2 pounds of grease are used for the entire bearing.[1] During the required, biweekly lubrication of these bearings, the grease is topped-off to replenish the amount lost while cruising at sea and, therefore, less than 2 pounds are used. Specifications for MIL-G-24139 grease require that no more than 5 percent of the grease may wash out when tested in accordance with the ASTM D-1264 method. It was estimated that for every two weeks underway (in accordance with the biweekly maintenance requirement), 5 percent of the grease is washed out and is subsequently replenished. Therefore, a maximum of 0.1 pounds of grease (5% of 2 lbs.) are estimated to be washed out every two weeks underway.

Since the release of grease only occurs through erosion while the ship is moving through the water, discharges of grease are not expected in port. The 0.1-pound biweekly washout estimate can be used to calculate the grease washed out per transit. Based on vessel monitoring data, each vessel, on average, makes 24 transits a year within the 12 n.m. zone.[8] Each round trip transit (including inbound and outbound transits) lasts approximately 8 hours (0.024 weeks). Therefore, on each transit, 0.0024 pounds of grease could be discharged (i.e. 0.1 pounds per week multiplied by 0.024 weeks). Fleetwide, for the 56 vessels that have stave bearings, the mass loading would be 3.23 pounds (0.0024 pounds per transit x 24 transits per vessel x 56 vessels) within the 12 n.m. zone.

4.2 Environmental Concentrations

4.2.1 Lubricating Oil

At Sea. An estimate was made of the amount of water swept by an AOE 1 Class ship while in transit. Any rudder bearing oil leaking while underway will be churned into this volume by the propellers. An AOE 1 Class ship is 107 feet wide. For a draft (depth of ship bottom) of 39 feet and a length of 12 n.m. (72,960 feet), the total volume of water swept is (107)(39)(72,960) = 304 million cubic feet or 8 billion liters. Therefore, on each transit through the 12 n.m. zone, for each AOE 1 Class ship, one-sixth of a gallon of oil (i.e., 630 mL) is released in 8 billion liters of seawater. Using a specific gravity of 0.89 for oil (MSDS for 2190TEP), this translates into a maximum estimated concentration of 7×10^{-5} milligrams per liter (mg/L).

A similar estimate can be made for an AS 36/39 Class ship that is 85 feet wide. For a draft of 25.5 feet and a length of 12 n.m. (72,960 feet), the total volume of water swept is (85)(25.5)(72,960) = 158 million cubic feet or 4.5 billion liters. Therefore, on each transit through the 12 n.m. zone, for each AS 36/39 Class ship, one-sixth of a gallon of oil (i.e., 630 mL) is released in 4.5 billion liters of seawater. This translates into a maximum estimated concentration of 1.2×10^{-4} mg/L.

MSC ships with oil-lubricated rudder bearings (T-AE 26 and T-AFS 1 Classes) have an average width of 80 feet and an average draft of 26 feet. Therefore, as calculated above for the Navy ships, the oil concentration resulting from these ships would be approximately 1.3×10^{-4} mg/L.

In Port. While in port the ship is stationary. Any oil that leaks from the rudder bearings will be mixed continuously with the water surrounding the rudder stock at the stern of the ship. The leakage of oil will be continuous over the day, so if the maximum allowable release of one pint daily (.125 gallons) were divided by 1440 minutes per day, the discharge rate would be 8.68×10^{-5} gallons per minute. It is assumed that local currents will displace 5 cubic feet of water (37.4 gallons) from the area around the rudder stock at least once per minute. Calculating the concentration of oil within the volume displaced during one minute yields a local concentration of about 2.1 mg/L.

4.2.2 Grease

Because grease-lubricated stave bearings are installed in several vessel classes, a vessel width of 80 feet and a draft of 25 feet were assumed in the calculations. Following calculations similar to the ones in Section 4.2.1, the total volume of water swept would be 255 million cubic feet or 7 billion liters. As calculated in Section 4.1, a maximum of 0.0024 pounds (or 1.1 grams) of grease is released during each trip. This translates into a concentration of 1.6×10^{-10} mg/L.

Based on the environmental concentrations estimated in Sections 4.2.1 and 4.2.2 above, a high estimate of the oil and grease concentration in the surrounding water would be 1.3×10^{-4} mg/L at sea, and 2.1 mg/L in port. These concentrations do not exceed federal discharge standards or the most stringent state water quality criteria, as shown in Table 5.

4.3 Potential for Introducing Non-Indigenous Species

There is no potential for the transport of non-indigenous species since seawater is not taken aboard or discharged.

5.0 CONCLUSIONS

The rudder bearing lubrication discharge has a low potential for causing an adverse environmental effect because the concentrations of oil and grease in the environment from rudder bearing lubrication while the ship is within the 12 n.m. zone are below relevant federal discharge standards and state water quality criteria.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources were obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on the reported concentrations of oil and grease components, the concentrations of oil and grease in the environment resulting from this discharge were then estimated. Table 6 lists the data sources used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes. Rudder Bearing Lubrication Leakage. September 26, 1996.

2. UNDS Round 2 Equipment Expert Meeting Minutes. Rudder Bearing Lubrication Leakage. March 6, 1997.

3. Personal communication between Penny Weersing (MSC) and David Eaton (MR&S) concerning Action Item RT1. April 16, 1997.

4. Personal communication between Rich Machinsky (MSC) and Dick Soule (MR&S). April 9, 1998.

5. Personal communication between LT Joyce Aivalotis (USCG) and David Eaton (MR&S). May 2, 1997.

6. Report of April 1997 Trip to USCG, Baltimore to Research Rudder Bearings on USCG Small Boats and Craft. January 13, 1998.

7. Patty's Industrial Hygiene & Toxicology, 3rd Ed., Volume 2B. 1981. John Wiley & Sons, New York, pp 3369, 3397.

8. Pentagon Ship Movement Data for Years 1991-1995. March 4, 1997.

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USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Florida. Department of Environmental Protection. Surface Water Quality Standards, Chapter 62-302. Effective December 26, 1996.

Georgia Final Regulations. Chapter 391-3-6, Water Quality Control, as provided by The Bureau of National Affairs, Inc., 1996.

Hawaii. Hawaiian Water Quality Standards. Section 11, Chapter 54 of the State Code.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

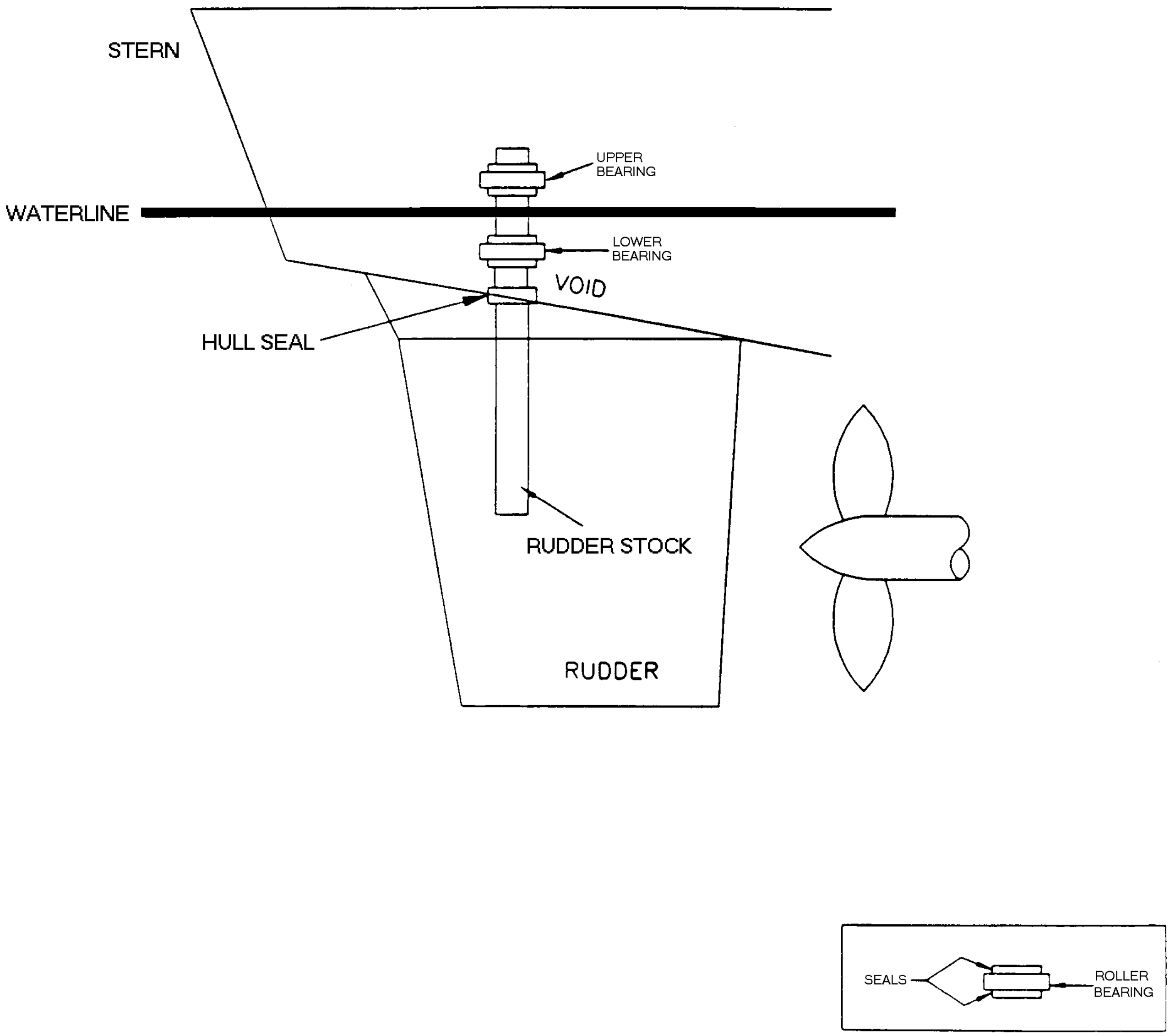

Figure 1. Rudder Grease-Lubricated Roller Bearings Generic Sketch

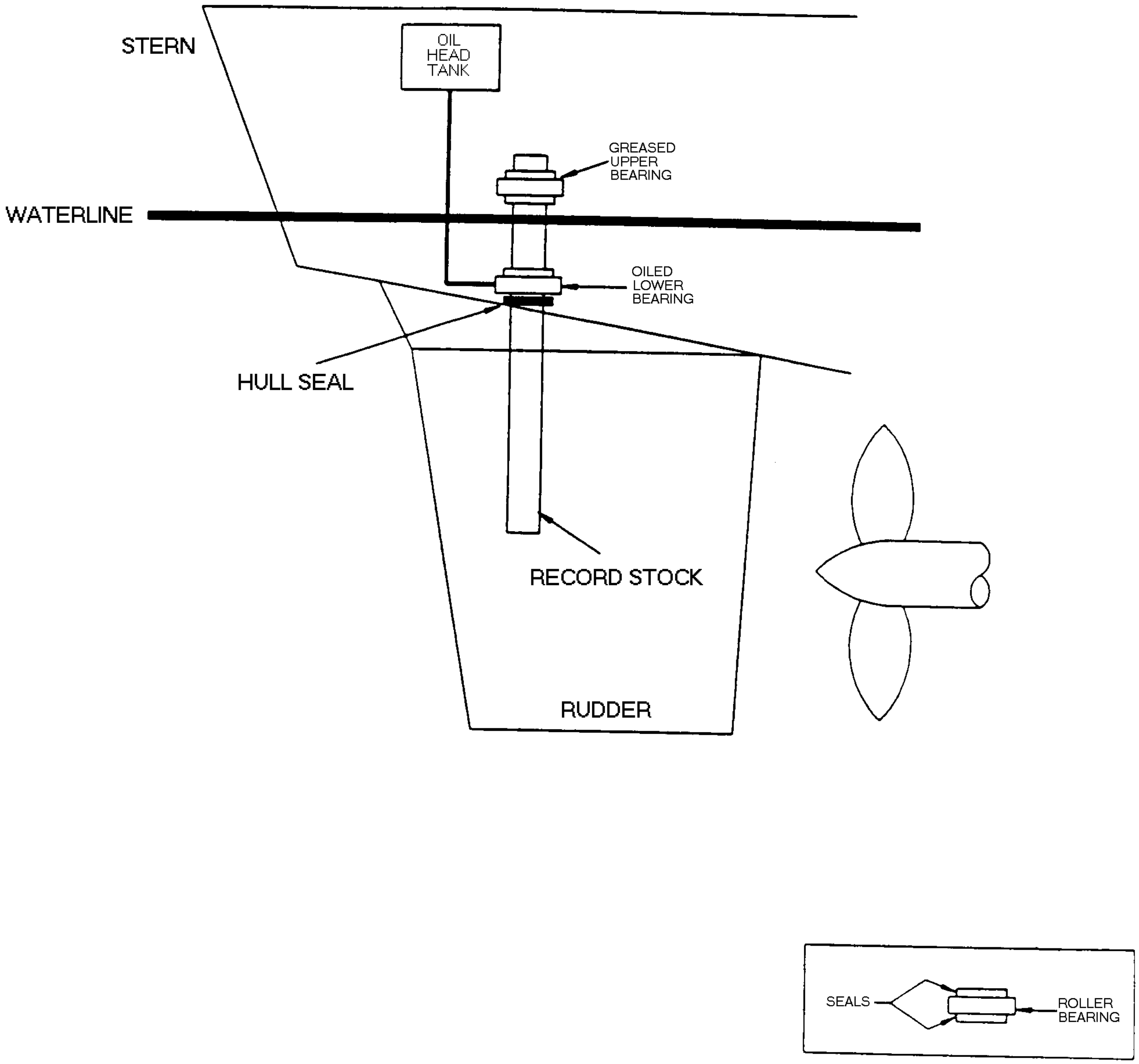

Figure 2. Rudder Oil-Lubricated Roller Bearings Generic Sketch

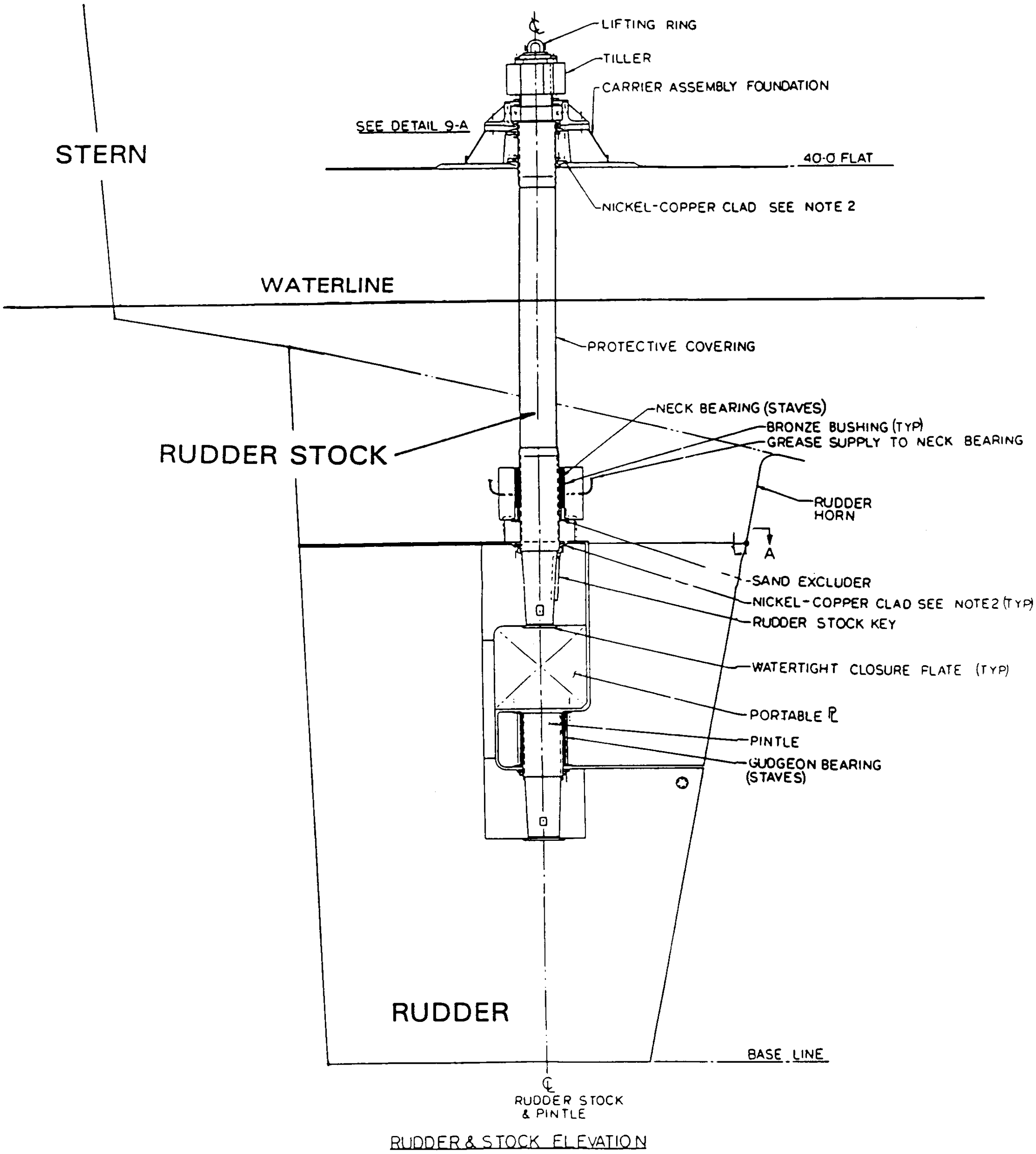

Figure 3. Rudder Stave Bearings (Example)

Table 1. Navy Ships - Lower Rudder Bearing Type and Lubrication Method

Ship Class	Lower Rudder Bearing & Type of Lubrication	# in Class
AGF 3	Stave Brg., Grease	1
AGF 11	Stave Brg., Grease	1
AO 177	Roller Brg., Grease	13
AOE 1	Roller Brg., Oil/Grease	2/2
AOE 6	Stave Brg., Grease	3
ARS 50	Stave Brg., Grease	4
AS 36/39	Roller Brg., Oil	3
ATS 1	Stave Brg., Grease	3
CG 47	Roller Brg., Grease	27
CGN 36	Stave Brg., Water	2
CGN 40	Stave Brg., Water	1
CV 62	Stave Brg., Water	1
CV 63	Stave Brg., Water	2
CV 67	Stave Brg., Water	1
CVN 65	Stave Brg., Water	1
CVN 68	Stave Brg., Water	7
DD 963	Roller Brg., Grease	31
DDG 51	Roller Brg., Grease	18
DD 993	Roller Brg., Grease	4
FFG 7	Roller Brg., Grease	43
LCC 19	Stave Brg., Grease	2
LHA 1	Roller Brg., Grease	5
LHD 1	Roller Brg., Grease	4
LPD 4	Stave Brg., Grease	9
LPH 2	Stave Brg., Grease	2
LSD 36	Stave Brg., Grease	5
LSD 41	Stave Brg., Grease	11
MCM 1	Stave Brg., Grease	14
MCS 12	Stave Brg., Grease	1
		223

Table 2. U.S. Coast Guard Cutters, Types of Bearing, and Lubrication

Cutter Class	No. in Class	Type of Bearing	Lubrication
399 WAGB	2	Laminated Phenolic Staves	Grease
378 WHEC	12	Micarta Bushing	Flax Packing/Grease
270 WMEC	13	Bushings	Grease/Water
210 WMEC	16	Micarta Bushing	Grease
140 WTGB	9	Staves	Water

Note: There is no information available on the following classes:

225 WLB	New production
175 WLM	New production
180 WLB	Decommissioned by 2001
157 WLM	Decommissioned by 2000
133 WLM	Decommissioned by 2000
160 WLIC	No information

Table 3. U.S. Coast Guard Small Boats and Craft (Types of Bearings and Lubrication)

Vessel/Craft	Type	Upper Rudder Bearing	Method of Lubrication	Lower Rudder Bearing	Method of Lubrication
26' MSB	motor surfboat	Thordon SXL bushing	self	Thordon SXL bushing	water
32' PWB	ports & waterways boat	Delrin or nylon bushing	self	Delrin or nylon bushing	water
44' MLB(S)	motor lifeboat (steel)	Micarta bushing	self	Micarta bushing	water
47' MLB	motor lifeboat	Thordon SXL	self	Thordon SXL bushing	water
52' MLB(S)	motor lifeboat (steel)	ball bearing	grease	Micarta bushing	water
55' ANB	aid to navigation boat	metal bushing	grease	metal bushing	grease
65' WLR	river buoy tender	spherical roller bearing	grease	Goodrich cutless bearing	water
65' WYTL	tug boat (steel)	roller bearing	grease	Micarta bushing	water
75' WLIC	inland construction tender	spherical roller bearing	grease	bronze bushing	grease
75' WLR	river buoy tender	spherical roller bearing	grease	Thordon XL bushing	water
82' WPB	patrol boat	spherical roller bearing	grease	Micarta bushing	water
110' WPB	patrol boat	spherical roller bearing	grease	bushing	water

Table 4. Military Sealift Command Ships
(Type of Rudder Bearings and Lubrication)

SHIP CLASS/NAME	APL	BEARING TYPE/LUBRICATION		ALLOWABLE SEAL LEAKAGE WATER OR OIL	REMARKS
		UPPER & LOWER RUDDER STOCK	PINTLE BEARING		
T-AE 26/ USNS KILAUEA	319010122	ROLLER BEARING/ OIL	STAVE/ WATER	1 PINT/DAY IN PORT/ANCHOR. 1 GALLON/DAY UNDERWAY	**RUDDER POST HAS NEW JOHN CRANE SPLIT SEAL INSTALLED DURING YARD PERIOD**
T-AFS 1/ USNS MARS	319010106	ROLLER BEARING/OIL			
T-AG 194/ USNS VANGUARD					NO DATA AVAILABLE
T-AGM 22/ USNS RANGE SENTINEL					NO DATA AVAILABLE
T-AGOS 21/ USNS EFFECTIVE		AEROSHELL GREASE 6SG6127 70026		1 PINT/DAY IN PORT/ANCHOR. 1 QUART/DAY FOR ALL OPERATING CONDITIONS	
T-AGS 45/ USNS WATERS	M319010192	ROLLER/GREASE	STAVE/ WATER	1 PINT/DAY IN PORT /ANCHOR. 1 GAL./DAY FOR ALL OPERATING CONDITIONS.	
T-AGS 60/ USNS PATHFINDER	N.A	N.A	N.A	N.A.	THIS CLASS HAS “ZEE” DRIVES . THERE ARE NO RUDDERS.
T-AH 19/ USNS MERCY					NO DATA AVAILABLE
T-AO 187/ USNS HENRY J. KAISER		ROLLER/GREASE		1 PINT/DAY IN PORT/ANCHOR. 1 QUART/DAY FOR ALL OPERATING CONDITIONS	
T-ARC 7/ USNS ZEUS					NO DATA AVAILABLE
T-ATF 166/ USNS POWHATAN					NO DATA AVAILABLE

The blank spaces in the table indicate that information is not available.

Table 5. Comparison of Environmental Concentration with Relevant Water Quality Criteria (mg/L)

Constituent	Concentration	Federal Discharge Standard	Most Stringent State Water Quality Criteria
oil and grease	1.3×10^{-4} (at sea) 2.1 (in port)	visible sheen[a]/15[b]	5.0 (FL)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

[a] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
[b] *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78) as implemented by the *Act to Prevent Pollution from Ships* (APPS)

Table 6. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents	X			X
3.4 Concentrations	X			X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species			X	X

NATURE OF DISCHARGE REPORT

Seawater Cooling Overboard Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes discharges from seawater cooling systems and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Seawater cooling systems on surface ships and submarines provide cooling water for heat exchangers, removing heat from the propulsion plant and mechanical auxiliary systems. Heat exchangers are provided for steam, diesel, and gas turbine propulsion plants and electric generating plants; air-conditioning (A/C) plants; air compressors; and electronic equipment. Seawater is provided to steam propulsion plants for the purpose of condensing exhausted steam from propulsion or electric generator turbines before the condensate is cycled back to boilers or steam generators.

Seawater cooling systems draw seawater either directly from hull connections (sea chests), or indirectly from the firemain that is supplied directly from a hull connection. The seawater is pumped through heat exchangers where it absorbs heat and is then discharged overboard at a higher temperature. At sea, the demands for seawater cooling are higher than pierside or at anchor because systems requiring seawater cooling tend to be in use and at a higher power output level while underway. Even while pierside, however, the demands for cooling of auxiliary systems may be significant. Conventional steam vessels were estimated to have a 24-hour start-up and securing cycle and nuclear vessels a 48-hour start-up and securing cycle.[1]

Typically, the demand for cooling water is continuous. The residence time of seawater in seawater cooling systems is relatively short, perhaps a minute or two for most portions of the cooling system. Some branch piping, however, may have relatively long residence times due to inactivity of equipment.[2]

Seawater cooling systems are designed to minimize flow-induced erosion of the piping system. The piping systems, where possible, have geometry (e.g., increase turn or elbow radii) or sizing to minimize turbulent flow. The materials of construction (e.g., copper, nickel, and titanium) are selected because of their resistance to seawater corrosion. Sea chests, heat exchangers, and other components could also contain sacrificial material such as waster pieces or zinc anodes to protect the system from corrosion.

Many boats and craft such as utility landing craft and rigid inflatable boats use keel coolers or stern flushing tubes.[1] Keel coolers use ship’s motion to pass water over exposed heat transfer coils in a recessed area of the boat keel. Stern flushing tubes are simple cooling systems in which engine cooling water is drawn from a hull connection and is discharged from the vessel’s stern, normally above the water line.

Sea chests and hull connections are equipped with sea strainer plates to prevent debris from entering the seawater cooling system (especially when in port or in coastal waters) and causing failures due to clogging.[3] The openings in these strainer plates vary in diameter from 1/4 inch to 1-1/2 inches and require periodic blowdowns to prevent clogging. This is accomplished by blowing low-pressure air or steam out through the plates.[3]

Some vessels add biofouling prevention chemicals to the seawater.[1,4] The contribution of anti-fouling additives to seawater cooling overboard discharge is addressed in the Seawater Piping Biofouling Prevention NOD report and will not be considered in this report.

In addition to seawater cooling while pierside, Navy vessels with non-conventional steam propulsion also fill their main steam condenser heat exchangers with fresh water if the vessel is going to be in port for an extended period. When vessels are in port for an extended period of time, they often deactivate their propulsion plants. During these periods, the main condenser is filled with fresh water because fresh water inhibits biofouling.[1] Freshwater layups for non-conventional main steam condenser heat exchangers are discussed in the Freshwater Layup NOD report.

2.2 Releases to the Environment

The releases to the environment consist of the seawater discharged overboard from the seawater cooling system with entrained or dissolved materials from the components of the seawater cooling system and bottom sediments that are brought onboard through the sea chest. The components of the seawater cooling system include: the sea chest, pumps, heat exchangers, pipes, fittings, and valves. The sea chests are constructed of steel and are painted with high durable epoxy paints, and they also contain steel or zinc sacrificial material.[1] The pumps are constructed of titanium, stainless steel, nickel alloys, bronze, and non-metallic composites.[1] Heat exchangers are copper-nickel alloys or titanium.[1] The pipes and fittings in seawater systems are primarily copper-nickel alloys, but fittings may also be bronze with silver-brazed joints.[1] Valves are constructed of bronze, nickel alloys, or aluminum alloys.[1] Some traces of hydraulic oil or other lubricants may enter the seawater from remotely operated valves or pumps. The metals that may enter the seawater include copper, nickel, lead, aluminum, tin, silver, iron, titanium, chromium, and zinc.

In addition, the discharge constitutes a thermal load. The maximum discharge temperature is 140 degrees Fahrenheit (°F) to prevent formation of soft scale (calcium carbonate) inside the pipes and heat exchangers.[1] The difference in temperature from influent to effluent is usually between 10 °F to 15 °F, but the range can be as much as 5 °F to 25 °F.[5]

Sea strainer plate blowdown consists of air or steam, and any solids blown off the strainer plate. Air bubbles rise to the surface and dissipate, while the solids fall to the bottom. Solids can include anything that has been held against the plate by the cooling water suction (e.g., debris and mud) plus biota that has grown on the plate over time (e.g., sea grass and slime).

2.3 Vessels Producing the Discharge

Ships, boats, and craft in the Navy, Military Sealift Command (MSC), U.S. Coast Guard (USCG), Army, and Air Force with the exception of some non-self propelled service craft such as barges, use seawater for cooling. Of the over 6,000 ships, boats, and craft in the Armed Forces, the vast majority of these vessels (over 5,000) consists of boats and craft. The majority of the seawater cooling overboard discharge, however, is generated by larger ships and vessels that have large, continuous seawater cooling demands. There are 673 such surface ships and submarines. The boats and craft in service use either intermittent cooling water or have keel coolers where there is no flow through the vessel. Table 1 lists the vessels that contribute to this discharge and the estimates for the number of transits, number of days in port, and number of days operating within 12 nautical miles (n.m.) by each ship class each year.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge occurs both within and beyond 12 n.m. of shore.

3.2 Rate

Seawater cooling flow rates can vary from several gallons per minute (gpm) for smaller, diesel-powered ships to flows of greater than 170,000 gpm for aircraft carriers during full-power steaming. While transiting, vessels tend to operate at levels sufficient to maintain steering control and do not require the maximum amount of seawater cooling. While anchored or pierside, seawater cooling flow rates are at their lowest because only certain auxiliary equipment is required. Table 2 lists examples of typical pierside and transit steaming flow rates for vessel classes.[6]

Tables 3a, 3b, and 3c provide estimates of discharge flow rates for various ship classes within 12 n.m. of shore based on available data. The number of transits were used to estimate the number of light-off and securing cycles for steam-powered vessels. The calculations use a typical transit time of 4 hours between 0 to 12 n.m.[7] For USCG vessels, operation within 12 n.m. of shore includes seawater cooling flow rates at pierside rates for 16 hours each day with the remaining 8 hours at typical underway flow rates. An example for the estimated annual flow of the WAGB 399 Class for operation within 12 n.m. of shore is calculated by the equation:

Estimated Annual Flows (gal), Operating Within 12 n.m.
= (Qty)(Operating Time)(60) [(16/24)(Pierside Flow) + (8/24)(Operating Flow)]

WAGB 399 Annual Flow (gal), Operating Within 12 n.m.
= (2)(2400 hrs)(60 min/hr) [(16/24)(800 gal/min) + (8/24)(4000)]
= 537,600,000 gal

Based on these estimates, the total annual flow of seawater cooling overboard discharge from Navy, MSC, Army, and USCG vessels is estimated as 390 billion gallons. Flow rates for Air Force vessels are not estimated.

3.3 Constituents

Seawater cooling overboard discharge is primarily seawater that contains trace materials from seawater cooling system pipes, fittings, valves, seachests, pumps, and heat exchangers. The expected constituents of seawater cooling discharge include copper, iron, aluminum, zinc, nickel, tin, titanium, arsenic, manganese, chromium, lead, and possibly oil and grease from valves and pumps. Of the constituents expected to be present in this discharge, arsenic, chromium, copper, lead, nickel, and zinc are priority pollutants. None of the expected constituents is a bioaccumulator.

The constituents from strainer plate blowdown include the material ejected from the strainer plate, such as biota, mud, or debris, trapped from the sea or harbor waters.

3.4 Concentrations

Influent and effluent samples were collected from the seawater cooling systems of five ships.[8] A summary of the analytical results are presented in Table 4. This table shows the constituents, the log-normal mean, the frequency of detection for each constituent, the minimum and maximum concentrations, and the mass loadings of each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for non-detected results.

The analytical data for a Coast Guard vessel were not used to calculate the log-normal mean concentrations in Table 4 because the data indicated a large average net decrease in effluent concentrations for total copper, nickel, tin, and zinc. For example, data for this vessel varied widely for total copper with an average influent concentration of 1,450 μg/L and an average effluent concentration of 419 μg/L, a net decrease of 1,031 μg/L. These concentrations are one to two orders of magnitude higher than data from the other ships. The Coast Guard vessel data were considered an anomaly and were excluded from log-normal mean concentration calculations to avoid biasing the data with large, negative net concentrations.

Variability is expected within this discharge as a result of several factors including material erosion and corrosion, residence times, passive films, and influent water variability. Pipe erosion is caused by high fluid velocity, or by abrasive particles entrained in the seawater flowing at any velocity. In most cases of pipe erosion, the problematic high fluid velocity is a local phenomenon, such as would be caused by eddy turbulence at joints, bends, reducers, attached mollusks, or tortuous flow paths in valves. Passive films inhibit metal loss due to erosion. Corrosion is influenced by the residence time of seawater in the system, temperature, biofouling, constituents in the influent, and the presence or absence of certain films on the pipe surface. All of these influences on metallic concentrations are variable within a given ship over time, and between ships.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on the discharge volume estimates developed in Tables 3a, 3b and 3c and the log-normal mean discharge concentrations and mass loadings are presented in Table 4. Table 5 is present in order to highlight constituents with log-normal mean concentrations that exceed water quality criteria (WQC). A sample calculation of the estimated annual mass loading for copper is shown here:

Mass Loading for Copper (Total)

Mass Loading = (Net Positive Log-normal Mean Concentration)(Flow Rate)

$(34.49\ \mu g/L)(3.785\ L/gal)(390{,}000{,}000{,}000\ gal/yr)(2.202\ lbs/kg)(10^{-9}\ kg/\mu g) \cong 112{,}100\ lbs/yr$

4.2 Environmental Concentrations

The log-normal mean discharge concentrations are compared to the Federal and most stringent state WQC in Table 6. Copper exceeds the Federal and most stringent state WQC. This can be attributed to two factors: 1) the copper concentrations of many harbors exceed the standard, and 2) other copper sources (e.g. copper hull coatings) of the vessel are located near the influent sea chest. Between 1 and 90 µg/L of copper naturally occurs in seawater.[9] Nickel and silver concentrations also exceed the Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) exceeds the most stringent state WQC.

4.3 Thermal Effects

The potential for seawater cooling overboard discharge to cause thermal environmental effects was evaluated by modeling the thermal plume generated under conditions tending to produce the greatest temperature rise and then compared to state plume thermal discharge requirements. Thermal effects of seawater cooling water overboard discharge were modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in the receiving water body. Thermal modeling was performed for three ships in three harbors (Mayport, FL; Norfolk, VA; and Bremerton, WA) to assess the potential thermal impact. The discharge was also assumed to occur during winter when the ambient water temperatures are lowest. Based on these models, Navy aircraft carriers are predicted to generate thermal plumes that, under conditions of low harbor flushing, low wind velocities, and maximum cooling water flow rates, would exceed the regulatory limits of Washington.[5] Thermal plumes from models of smaller ships (destroyers) do not exceed regulatory limits.[5] Of the five states having a substantial presence of Armed Forces' vessels, only Virginia and Washington have established thermal mixing zone dimensions.

4.4 Potential for Introducing Non-Indigenous Species

The seawater cooling water system has a minimal potential for transporting non-indigenous species, because the residence times for most portions of the system are short. Some portions of the seawater system lie stagnant where marine organisms may reside. However, these areas tend to develop anaerobic conditions quickly, except at the junctions with the active portions of the system, where oxygenated water continuously flows by and through the ship. The seawater is not a system where large volumes of water, under aerobic conditions, are transported over distances.

A small potential exists for transport of non-indigenous species because the blowdown procedure for the strainer plates may dislodge biota that has grown on the plate over time.

5.0 CONCLUSION

Seawater cooling overboard discharge has a potential to cause an adverse environmental effect because:

1) Nitrogen, copper, nickel, and silver concentrations in the discharge exceed Federal and the most stringent state water quality criteria, and the mass loadings of nitrogen, copper, nickel, and silver are significant; and

2) Some vessels could exceed some states' thermal mixing zone requirements while in port.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. System engineering information was used to estimate the rate of discharge. Table 7 shows the sources of data used to develop this NOD report.

Specific References

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7. Pentagon Ship Movement Data for Years 1991 - 1995, 4 March 1997.

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The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

UNDS Ship Database, August 1, 1997.

Table 1. Typical Ship Movement Data

Vessel Class	Quantity	Number of Transits/Vessel/Year	Hours per Transit	Days in Port/Vessel/Year	Days Operating within 12 n.m.
Surface Ships, Submarines					
Forrestal Class Aircraft Carriers CV 59	1	6	4	143	0
Kitty Hawk Class Aircraft Carriers CV 63	3	7	4	137	0
Enterprise Class Aircraft Carriers CVN 65	1	6	4	76	0
Nimitz Class Aircraft Carriers CVN 68	7	7	4	147	0
Ticonderoga Class Guided Missile Cruisers CG 47	27	12	4	166	0
California Class Guided Missile Cruisers CGN 36	2	11	4	143	0
Virginia Class Guided Missile Cruisers CGN 38	1	11	4	161	0
Spruance Class Destroyers DD 963	31	12	4	178	0
Arleigh Burke Destroyers DDG 51	18	11	4	101	0
Kidd Class Destroyers DDG 993	4	12	4	175	0
Oliver Hazard Perry Guided Missile Frigates FFG 7	43	13	4	167	0
Submarines, SSN, SSBN, All Classes	89	6	4	183	0
Blue Ridge Class Amphibious Command Ships LCC 19	2	8	4	179	0
Wasp Class Amphibious Assault Ships LHD 1	4	13	4	185	0
Tarawa Class Amphibious Assault Ships LHA 1	5	9	4	173	0
Iwo Jima Class Amphibious Assault Ships LPH 2	2	11	4	186	0
Austin Class Amphibious Transport Docks LPD 4	3	11	4	178	0
Amphibious Transport Docks LPD 7	3	12	4	188	0
Amphibious Transport Docks LPD 14	2	11	4	192	0
Anchorage Class Dock Landing Ships LSD 36	5	13	4	215	0
Whidbey Island Class Dock Landing Ships LSD 41	8	13	4	170	0
Harpers Ferry Class Dock Landing Ships LSD 49	3	13	4	215	0
Avenger Class Mine Countermeasures Vessels MCM 1	14	28	4	232	0
Osprey Class Coastal Minehunters MHC 51	12	28	4	232	0
Cyclone Class Coastal Defense Ships PC 1	13	18	4	105	0
Auxiliaries					
Emory S Land Class Submarine Tenders AS 39	3	6	4	293	0
Simon Lake Class Submarine Tender AS 33	1	6	4	229	0
Command Ships AGF	2	12	4	183	0
Jumboised Cimarron Class Oilers AO 177	5	10	4	188	0
Sacramento Class Fast Combat Support Ships AOE 1	4	11	4	183	0

Supply Class Fast Combat Support Ships AOE 6	3	6	4	114	0
Safeguard Class Salvage Ships ARS 50	4	22	4	208	0
Gyre Class Oceanographic Research Ships AGOR 21	1	11	4	113	0
T.G.Thompson Oceanographic Research Ships AGOR 23	2	11	4	113	0
Military Sealift Command					
Kilauea Class Ammunition Ships AE 26	8	4	4	26	0
Mars Class Combat Stores Ships AFS 1	8	7	4	148	0
Missile Range Instrumentation Ships AGM 22	1	4	4	133	0
Mercy Class Hospital Ships AH 19	2	2	4	184	0
Zeus Class Cable Repairing Ships ARC 7	1	2	4	8	0
Mission Class Navigation Research Ships AG 194	2	10	4	151	0
Stalwart Class Ocean Surveillance Ships AGOS 1	5	4	4	70	0
Victorious Class Ocean Surveillance Ships AGOS 19	4	5	4	107	0
Silas Bent & Wilkes Classes Surveying Ships AGS 26	2	6	4	44	0
Waters Class Surveying Ship AGS 45	1	1	4	7	0
John McDonnell Class Surveying Ships AGS 51	2	6	4	96	0
Pathfinder Class Surveying Ships AGS 60	4	6	4	96	0
Algol Class Vehicle Cargo Ships AKR 287	8	3	4	109	0
Maersk Class Fast Sealift Ships AKR 295	3	9	4	59	0
Henry J. Kaiser Class Oilers AO 187	13	6	4	78	0
Potawan Class Fleet Ocean Tugs ATF 166	7	16	4	127	0
US Coast Guard					
High Endurance Cutters WHEC 378	12	13	4	151	0
Medium Endurance Cutters WMEC 213	1	9	4	98	0
Medium Endurance Cutter, WMEC 230	1	11	4	167	0
Medium Endurance Cutters WMEC 210A	5	13	4	235	0
Medium Endurance Cutters WMEC 210B	11	9	4	149	0
Medium Endurance Cutters WMEC 270A	4	6	4	137	0
Medium Endurance Cutters WMEC 270B	9	7	4	164	0
Mackinaw Class Icebreaker WAGB 290	1	4	4	215	146
Polar Class Icebreakers WAGB 399	2	4	4	148	100
Island Class Patrol Craft WPB 110 (A,B & C)	49				
Point Class Patrol Craft WPB 82 (C & D)	36				
Juniper Class Buoy Tenders WLB 225	2	18	4	190	100
Balsam Class Buoy Tenders WLB 180A	8	18	4	190	100
Balsam Class Buoy Tenders WLB 180B	2	5	4	120	200
Balsam Class Buoy Tenders WLB 180C	13	16	4	123	200

Bay Class Icebreaking Tugs WTGB 140	9	1	4	215	146
Inland Buoy Tender WLI 100A	1	0	0	160	201
Inland Buoy Tender WLI 100C	1	0	0	160	201
Inland Buoy Tenders WLI 65303	2	0	0	160	201
Inland Buoy Tenders WLI 65400	2	0	0	160	201
Cosmos Class Inland Construction Tenders WLIC 100	3	0	0	160	201
Anvil Class Inland Construction Tenders WLIC 75A	2	0	0	160	201
Inland Construction Tenders WLIC 75B	3	0	0	160	201
Clamp Class Inland Construction Tenders WLIC 75D	2	0	0	160	201
River Buoy Tender WLR 115	1	0	0	160	201
River Buoy Tenders WLR 75	13	0	0	160	201
River Buoy Tenders WLR 65	6	0	0	160	201
Pamlico Class Inland Construction Tenders WLIC 160	4	0	0	160	201
White Sumac Class Coastal Buoy Tenders WLM 157	9	16	4	123	100
Keeper Class Coastal Buoy Tenders WLM 551	2	16	4	123	200
65 ft. Harbor Tugs WYTL (A, B, C & D)	11				
Army					
Logistics Support Vessel LSV	6	20	4	150	30
Landing Craft Utility LCU-2000	35	3	4	275	60
Large Tug LT-128	6	5	4	245	60
Total	**673**				

Table 2. Seawater Cooling Flow Rates, Examples (Naval Vessels)

Vessel Class	Pierside (gpm)	In Transit (gpm)
Aircraft carriers (CVN 68)	4,100	>170,000
Cruisers (CG 47)	1,650	7,000
Destroyers (DDG 51)	1,500	6,840
Frigates (FFG 7)	1,750	3,000
Amphibious assault ships (LHD 1)	3,000	up to 40,500
Submarines	2,000	10,000 - 12,000

Table 3a. Estimated Annual Flows, Seawater Cooling Water, Navy and MSC

		Estimated Flow Rates (gpm)					Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	Pierside		Start-up/ Securing	In Transit		Pierside	Start-up/ Securing	In Transit	Pierside	Start-up/ Securing	In Transit
Surface Ships, Submarines												
Forrestal Class Aircraft Carriers CV 59	1	4,100		170,000	170,000		3,432	288	48	844,272,000	2,937,600,000	489,600,000
Kitty Hawk Class Aircraft Carriers CV 63	3	4,100		170,000	170,000		3,288	336	56	2,426,544,000	10,281,600,000	1,713,600,000
Enterprise Class Aircraft Carriers CVN 65	1	4,100		170,000	170,000		1,824	576	48	448,704,000	5,875,200,000	489,600,000
Nimitz Class Aircraft Carriers CVN 68	7	4,100		170,000	170,000		3,528	672	56	6,075,216,000	47,980,800,000	3,998,400,000
Ticonderoga Class Guided Missile Cruisers CG 47	27	1,650		0	7,000		3,984	0	96	10,649,232,000	0	1,088,640,000
California Class Guided Missile Cruisers CGN 36	2	1,650		7,000	7,000		3,432	1,056	88	679,536,000	887,040,000	73,920,000
Virginia Class Guided Missile Cruisers CGN 38	1	1,650		7,000	7,000		3,864	1,056	88	382,536,000	443,520,000	36,960,000
Spruance Class Destroyers DD 963	31	1,500		0	6,840		4,272	0	96	11,918,880,000	0	1,221,350,400
Arleigh Burke Destroyers DDG 51	18	1,680		0	6,840		2,424	0	88	4,398,105,600	0	650,073,600
Kidd Class Destroyers DDG 993	4	1,500		0	6,840		4,200	0	96	1,512,000,000	0	157,593,600
Oliver Hazard Perry Guided Missile Frigates FFG 7	43	1,750		0	3,000		4,008	0	104	18,096,120,000	0	804,960,000
Submarines, SSN, SSBN, All Classes	89	2,000		11,000	11,000		4,392	576	48	46,906,560,000	33,834,240,000	2,819,520,000
Blue Ridge Class Amphibious Command Ships LCC 19	2	3,000	*	40,500	40,500	*	4,296	384	64	1,546,560,000	1,866,240,000	311,040,000
Wasp Class Amphibious Assault Ships LHD 1	4	3,000		40,500	40,500		4,440	624	104	3,196,800,000	6,065,280,000	1,010,880,000
Tarawa Class Amphibious Assault Ships LHA 1	5	3,000	*	40,500	40,500	*	4,152	432	72	3,736,800,000	5,248,800,000	874,800,000
Iwo Jima Class Amphibious Assault Ships LPH 2	2	3,000	*	40,500	40,500	*	4,464	528	88	1,607,040,000	2,566,080,000	427,680,000
Austin Class Amphibious Transport Docks LPD 4	3	3,000	*	40,500	40,500	*	4,272	528	88	2,306,880,000	3,849,120,000	641,520,000
Amphibious Transport Docks LPD 7	3	3,000	*	40,500	40,500	*	4,512	576	96	2,436,480,000	4,199,040,000	699,840,000
Amphibious Transport Docks LPD 14	2	3,000	*	40,500	40,500	*	4,608	528	88	1,658,880,000	2,566,080,000	427,680,000
Anchorage Class Dock Landing Ships LSD 36	5	3,000	*	40,500	40,500	*	5,160	624	104	4,644,000,000	7,581,600,000	1,263,600,000
Whidbey Island Class Dock Landing Ships LSD 41	8	3,000	*	0	40,500	*	4,080	0	104	5,875,200,000	0	2,021,760,000
Harpers Ferry Class Dock Landing Ships LSD 49	3	3,000	*	0	40,500	*	5,160	0	104	2,786,400,000	0	758,160,000
Avenger Class Mine Countermeasures Vessels MCM 1	14	1,650	*	0	7,000	*	5,568	0	224	7,717,248,000	0	1,317,120,000
Osprey Class Coastal Minehunters MHC 51	12	1,500	*	0	6,840	*	5,568	0	224	6,013,440,000	0	1,103,155,200
Cyclone Class Coastal Defense Ships PC 1	13	200	*	0	1,500	*	2,520	0	144	393,120,000	0	168,480,000
Auxiliaries												
Emory S Land Class Submarine Tenders AS 39	3	2,000	*	40,500	40,500	*	7,032	288	48	2,531,520,000	2,099,520,000	349,920,000
Simon Lake Class Submarine Tender AS 33	1	2,000	*	40,500	40,500	*	5,496	288	48	659,520,000	699,840,000	116,640,000
Command Ships AGF	2	2,000	*	40,500	40,500	*	4,392	576	96	1,054,080,000	2,799,360,000	466,560,000
Jumboised Cimarron Class Oilers AO 177	5	2,000	*	40,500	40,500	*	4,512	480	80	2,707,200,000	5,832,000,000	972,000,000
Sacramento Class Fast Combat Support Ships AOE 1	4	1,650	*	7,500	7,500	*	4,392	528	88	1,739,232,000	950,400,000	158,400,000
Supply Class Fast Combat Support Ships AOE 6	3	1,650	*	0	7,500	*	2,736	0	48	812,592,000	0	64,800,000
Safeguard Class Salvage Ships ARS 50	4	1,500	*	0	6,840	*	4,992	0	176	1,797,120,000	0	288,921,600
Gyre Class Oceanographic Research Ships AGOR 21	1	1,500	*	0	6,840	*	2,712	0	88	244,080,000	0	36,115,200
T.G.Thompson Oceanographic Research Ships AGOR 23	2	1,500	*	0	6,840	*	2,712	0	88	488,160,000	0	72,230,400

Military Sealift Command												
Kilauea Class Ammunition Ships AE 26	8	2,000	*	40,500	40,500	*	624	192	32	599,040,000	3,732,480,000	622,080,000
Mars Class Combat Stores Ships AFS 1	8	2,000	*	40,500	40,500	*	3,552	336	56	3,409,920,000	6,531,840,000	1,088,640,000
Missile Range Instrumentation Ships AGM 22	1	2,000	*	40,500	40,500	*	3,192	192	32	383,040,000	466,560,000	77,760,000
Mercy Class Hospital Ships AH 19	2	2,000	*	40,500	40,500	*	4,416	96	16	1,059,840,000	466,560,000	77,760,000
Zeus Class Cable Repairing Ships ARC 7	1	2,000	*	0	40,500	*	192	0	16	23,040,000	0	38,880,000
Mission Class Navigation Research Ships AG 194	2	1,500	*	6,840	6,840	*	3,624	480	80	652,320,000	393,984,000	65,664,000
Stalwart Class Ocean Surveillance Ships AGOS 1	5	1,500	*	0	6,840	*	1,680	0	32	756,000,000	0	65,664,000
Victorious Class Ocean Surveillance Ships AGOS 19	4	1,500	*	0	6,840	*	2,568	0	40	924,480,000	0	65,664,000
Silas Bent & Wilkes Classes Surveying Ships AGS 26	2	1,500	*	0	6,840	*	1,056	0	48	190,080,000	0	39,398,400
Waters Class Surveying Ship AGS 45	1	1,500	*	0	6,840	*	168	0	8	15,120,000	0	3,283,200
John McDonnell Class Surveying Ships AGS 51	2	1,500	*	0	6,840	*	2,304	0	48	414,720,000	0	39,398,400
Pathfinder Class Surveying Ships AGS 60	4	1,500	*	6,840	6,840	*	2,304	288	48	829,440,000	472,780,800	78,796,800
Algol Class Vehicle Cargo Ships AKR 287	8	2,000	*	0	40,500	*	2,616	0	24	2,511,360,000	0	466,560,000
Maersk Class Fast Sealift Ships AKR 295	3	2,000	*	0	40,500	*	1,416	0	72	509,760,000	0	524,880,000
Henry J. Kaiser Class Oilers AO 187	13	2,000	*	0	40,500	*	1,872	0	48	2,920,320,000	0	1,516,320,000
Potawan Class Fleet Ocean Tugs ATF 166	7	1,650	*	0	7,500	*	3,048	0	128	2,112,264,000	0	403,200,000
	-------- 399									---------------------- 177,600,801,600	---------------------- 160,627,564,800	--------------------- 32,269,468,800

* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.

Seawater Cooling Total: 370,497,835,200

Table 3b. Estimated Annual Flows, Seawater Cooling Water, USCG

		Estimated Flow Rates (gpm)					Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	Pierside		Operating within 12 n.m.	In Transit		Pierside	Operating	In Transit	Pierside	Operating within 12 n.m.	In Transit
US Coast Guard												
High Endurance Cutters WHEC 378	12	1,200	*	6,000	6,000	*	3,624	0	104	3,131,136,000	0	449,280,000
Medium Endurance Cutters WMEC 213	1	800	*	4,000	4,000	*	2,352	0	72	112,896,000	0	17,280,000
Medium Endurance Cutter, WMEC 230	1	800	*	4,000	4,000	*	4,008	0	88	192,384,000	0	21,120,000
Medium Endurance Cutters WMEC 210A	5	800	*	4,000	4,000	*	5,640	0	104	1,353,600,000	0	124,800,000
Medium Endurance Cutters WMEC 210B	11	800	*	4,000	4,000	*	3,576	0	72	1,888,128,000	0	190,080,000
Medium Endurance Cutters WMEC 270A	4	800	*	4,000	4,000	*	3,288	0	48	631,296,000	0	46,080,000
Medium Endurance Cutters WMEC 270B	9	800	*	4,000	4,000	*	3,936	0	56	1,700,352,000	0	120,960,000
Mackinaw Class Icebreaker WAGB 290	1	1,000	*	5,000	5,000	*	5,160	3,504	32	309,600,000	490,560,000	9,600,000
Polar Class Icebreakers WAGB 399	2	800	*	4,000	4,000	*	3,552	2,400	32	340,992,000	537,600,000	15,360,000
Island Class Patrol Craft WPB 110 (A,B & C)	49											
Point Class Patrol Craft WPB 82 (C & D)	36											
Juniper Class Buoy Tenders WLB 225	2	800	*	4,000	4,000	*	4,560	2,400	144	437,760,000	537,600,000	69,120,000
Balsam Class Buoy Tenders WLB 180A	8	100	*	500	500	*	4,560	2,400	144	218,880,000	268,800,000	34,560,000
Balsam Class Buoy Tenders WLB 180B	2	100	*	500	500	*	2,880	4,800	40	34,560,000	134,400,000	2,400,000
Balsam Class Buoy Tenders WLB 180C	13	100	*	500	500	*	2,952	4,800	128	230,256,000	873,600,000	49,920,000
Bay Class Icebreaking Tugs WTGB 140	9	100	*	500	500	*	5,160	3,504	8	278,640,000	441,504,000	2,160,000
Inland Buoy Tender WLI 100A	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
Inland Buoy Tender WLI 100C	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
Inland Buoy Tenders WLI 65303	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
Inland Buoy Tenders WLI 65400	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
Cosmos Class Inland Construction Tenders WLIC 100	3	50	*	50	50	*	3,840	4,824	0	34,560,000	43,416,000	0
Anvil Class Inland Construction Tenders WLIC 75A	2	50	*	250	250	*	3,840	4,824	0	23,040,000	67,536,000	0
Inland Construction Tenders WLIC 75	3	50	*	50	50	*	3,840	4,824	0	34,560,000	43,416,000	0
Clamp Class Inland Construction Tenders WLIC 75D	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
River Buoy Tender WLR 115	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
River Buoy Tenders WLR 75	13	50	*	50	50	*	3,840	4,824	0	149,760,000	188,136,000	0
River Buoy Tenders WLR 65	6	50	*	50	50	*	3,840	4,824	0	69,120,000	86,832,000	0
Pamlico Class Inland Construction Tenders WLIC 160	4	100	*	50	50	*	3,840	4,824	0	92,160,000	96,480,000	0
White Sumac Class Coastal Buoy Tenders WLM 157	9	100	*	500	500	*	2,952	2,400	128	159,408,000	302,400,000	34,560,000
Keeper Class Coastal Buoy Tenders WLM 551	2	100	*	500	500	*	2,952	4,800	128	35,424,000	134,400,000	7,680,000
65 ft. Harbor Tugs WYTL (A, B, C & D)	11	50	*	250	250	*	3,840	4,824	0	126,720,000	371,448,000	0
	---------									--------------------	--------------------	--------------------
	227									11,562,192,000	4,376,928,000	1,194,960,000
* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.									**Seawater Cooling Total:**			**17,134,080,000**

Table 3c. Estimated Annual Flows, Seawater Cooling Water, Army

		Estimated Flow Rates (gpm)					Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	**Pierside**		**Operating within 12 n.m.**	**In Transit**		**Pierside**	**Operating**	**In Transit**	**Pierside**	**Operating within 12 n.m.**	**In Transit**
Army												
Logistics Support Vessel LSV	6	110		110	110		2,400	320	160	95,040,000	12,672,000	6,336,000
Landing Craft Utility LCU-2000	35	140		140	140		4,400	936	24	1,293,600,000	275,184,000	7,056,000
Large Tug LT-128	6	100	*	100	100	*	3,920	920	40	141,120,000	33,120,000	1,440,000
	-----									----------------	----------------	------------------
	47									1,529,760,000	320,976,000	14,832,000
* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.										**Seawater Cooling Total:**		**1,865,568,000**

Table 4. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Effluent - Influent Log Normal Mean	Mass Loading
	Seawater Cooling Dedicated Influent				Seawater Cooling Dedicated Effluent					
Metals	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)	(lbs/yr)
Aluminum										
Dissolved	59.7	2 of 5	BDL	207.0	59.84	3 of 5	BDL	175	0.12	390
Total	147.4	4 of 5	BDL	296.0	151.1	4 of 5	BDL	399.0	3.69	11,993
Arsenic										
Dissolved	1.97	2 of 5	BDL	12.60	2.26	1 of 5	BDL	18.50	0.29	943
Total	1.48	1 of 5	BDL	11.30	4.24	3 of 5	BDL	56.60	2.76	8,970
Barium										
Dissolved	15.37	5 of 5	5.80	23.90	18.02	5 of 5	10.10	21.85	2.65	8,613
Total	21.69	5 of 5	15.80	26.60	21.59	5 of 5	15.25	26.50	-0.10	(a)
Boron										
Dissolved	2090	5 of 5	1740	2340	2082	5 of 5	1705	2435	-8.17	(a)
Total	2059	5 of 5	1710	2340	2027	5 of 5	1590	2360	-32.08	(a)
Calcium										
Dissolved	196248	5 of 5	164000	223000	197497	5 of 5	163000	229000	1248.60	4,058,145
Total	195870	5 of 5	164000	220000	192465	5 of 5	155000	218500	-3405.42	(a)
Chromium										
Dissolved	5.47	1 of 5	BDL	10.70	~	0 of 5	BDL	BDL	~	(b)
Total	~	0 of 5	BDL	BDL	7.71	2 of 5	BDL	35.50	7.71	25,059
Copper										
Dissolved	9.86	3 of 5	BDL	18.80	40.55	5 of 5	11.90	1040.00	30.69	99,747
Total	14.88	4 of 5	BDL	27.30	49.37	5 of 5	7.55	1135.00	34.49	112,098
Iron										
Dissolved	11.82	1 of 5	BDL	173.0	12.69	2 of 5	BDL	214	0.87	2,828
Total	227.5	5 of 5	90.6	399.0	241.2	5 of 5	87.65	546.5	13.73	44,625
Lead										
Dissolved	~	0 of 5	BDL	BDL	4.12	1 of 5	BDL	3.40	4.12	13,391
Total	4.19	1 of 5	BDL	2.40	~	0 of 5	BDL	BDL	~	(b)
Magnesium										
Dissolved	617279	5 of 5	485000	741000	620084	5 of 5	470500	758500	2804.72	9,115,777
Total	613048	5 of 5	483000	743000	613252	5 of 5	435500	739000	204.53	664,754
Manganese										
Dissolved	10.58	5 of 5	5.90	24.80	12.44	5 of 5	5.80	26.40	1.86	6,045
Total	18.03	5 of 5	12.20	31.40	19.99	5 of 5	13.35	28.55	1.96	6,370
Molybdenum										
Dissolved	4.31	3 of 5	BDL	7.20	5.89	5 of 5	3.25	11.10	1.58	5,135
Total	3.73	3 of 5	BDL	5.10	3.44	3 of 5	BDL	5.50	-0.29	(a)

Nickel										
Dissolved	~	0 of 5	BDL	BDL	15.4	2 of 5	BDL	96.4	15.39	50,020
Total	~	0 of 5	BDL	BDL	19.6	3 of 5	BDL	95.0	19.55	63,541
Silver										
Total	~	0 of 5	BDL	BDL	2.77	1 of 5	BDL	5.90	2.77	9,003
Sodium										
Dissolved	5065465	5 of 5	3650000	6300000	5248566	5 of 5	4250000	6505000	183101.78	595,109,334
Total	5195468	5 of 5	3810000	6390000	5062513	5 of 5	3730000	6300000	-132954.92	(a)
Thallium										
Dissolved	6.25	1 of 5	BDL	15.30	6.2	1 of 5	BDL	25.0	-0.02	(a)
Total	9.37	2 of 5	BDL	35.60	5.5	1 of 5	BDL	10.8	-3.89	(a)
Tin										
Dissolved	~	0 of 5	BDL	BDL	4.02	2 of 5	BDL	5.50	4.02	13,066
Total	3.44	1 of 5	BDL	4.30	5.19	3 of 5	BDL	35.50	1.75	5,688
Titanium										
Total	4.60	3 of 5	BDL	9.00	5.42	3 of 5	BDL	15.80	0.82	2,665
Vanadium										
Dissolved	5.48	1 of 5	BDL	12.10	5.7	2 of 5	BDL	11.9	0.20	650
Zinc										
Dissolved	18.29	5 of 5	15.80	20.80	30.00	5 of 5	14.15	50.25	11.71	38,059
Total	21.27	5 of 5	13.40	54.80	35.75	5 of 5	11.75	78.40	14.48	47,062
Classicals	(mg/L)		(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	68.5	5 of 5	49.0	84.0	62.8	5 of 5	38.0	94.0	-5.67	(a)
Ammonia as Nitrogen	0.10	3 of 5	BDL	0.22	0.12	4 of 5	BDL	0.24	0.02	65,010
Chemical Oxygen Demand	140.2	5 of 5	70.00	289.0	141.5	4 of 5	BDL	265.0	1.28	4,160,617
Chloride	9270	5 of 5	7600	11000	9641	5 of 5	7750	12900	370.61	1,204,661,245
HEM	~	0 of 5	BDL	BDL	~	0 of 5	BDL	BDL	~	(b)
Nitrate/Nitrite	0.06	4 of 5	BDL	0.45	0.08	4 of 5	BDL	1.71	0.02	65,010
Sulfate	1222	5 of 5	972	1600	1236	5 of 5	930	1440	14.53	47,229,508
Total Dissolved Solids	17618	5 of 5	14800	20700	16966	5 of 5	14300	20500	-651.92	(a)
Total Kjeldahl Nitrogen	0.58	5 of 5	0.20	1.70	0.68	5 of 5	0.34	1.30	0.10	325,048
Total Organic Carbon	1.7	2 of 5	BDL	3.6	2.0	3 of 5	BDL	2.9	0.32	1,040,154

Total Phosphorous	0.08	4 of 5	BDL	0.31	0.07	4 of 5	BDL	0.20	-0.01	(a)
Total Recoverable Oil & Grease	2.1	5 of 5	0.8	12.0	1.29	5 of 5	0.90	2.30	-0.85	(a)
Total Sulfide	4.0	5 of 5	2.0	7.0	5.4	5 of 5	2.0	35.0	1.35	4,388,151
Total Suspended Solids	23.7	5 of 5	20.0	32.0	20.3	5 of 5	10.0	72.0	-3.40	(a)
Volatile Residue	1117	4 of 5	BDL	20700	465	4 of 5	BDL	20600	-652.05	(a)
Organics	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)	(lbs/yr)
4-Chloro-3-Methylphenol	~	0 of 5	BDL	BDL	6.93	1 of 5	BDL	46.00	6.93	22,524

BDL = Below Detection Limit
~ = Value could not be calculated because samples are BDL
(a) = Mass loading was not determined for parameters for which the influent concentration exceeded the effluent.
(b) = Mass loading was not determined for parameters for which the effluent has a frequency of zero detections.
Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., “non-detect” samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a “non-detect” sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 5. Estimated Annual Mass Loadings of Constituents

Constituent[*]	Log-normal Mean Influent (μg/L)	Log-normal Mean Effluent (μg/L)	Log-normal Mean Concentration (μg/L)	Estimated Annual Mass Loading (lbs/yr)
Ammonia as Nitrogen	100	120	20	65,010
Nitrate/Nitrite	60	80	20	65,010
Total Kjeldahl Nitrogen	580	680	100	325,048
Total Nitrogen[A]				390,058
Copper				
Dissolved	9.86	40.6	30.7	99,700
Total	14.88	49.37	34.49	112,100
Nickel				
Dissolved	~	15.4	15.4	50,100
Total	~	19.6	19.6	63,700
Silver				
Total	~	2.77	2.77	9,000

* Mass loadings are presented for constituents that exceed ambient WQC and for bioaccumulators only. See Table 4 for a complete listing of mass loadings.
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 6. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Chronic WQC	Most Stringent State Chronic WQC
Classicals (μg/L)					
Ammonia as Nitrogen	20	BDL	240	None	6 (HI)[A]
Nitrate/Nitrite	80	BDL	1710	None	8 (HI)[A]
Total Kjeldahl Nitrogen	680	340	1300	None	-
Total Nitrogen[B]	760			None	200 (HI)[A]
Metals (μg/L)					
Copper					
Dissolved	40.55	11.90	1040.00	2.4	2.4 (CT, MS)
Total	49.37	7.55	1135.00	2.9	2.9 (FL, GA)
Nickel					
Dissolved	15.4	BDL	96.4	8.2	8.2 (CA, CT)
Total	19.6	BDL	95.0	8.3	7.9 (WA)
Silver					
Total	2.77	BDL	5.90	0.92	1.2 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA= Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 7. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	X			X
3.4 Concentrations		X		
4.1 Mass Loadings		X	X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	
4.4 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Seawater Piping Biofouling Prevention

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)--either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the seawater piping biofouling control discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3). This report does not cover discharge of seawater cooling water from systems which use copper piping as the only biofouling preventative--this discharge is covered in the separate “Seawater Cooling Overboard Discharge” Nature of Discharge report.

2.1 Equipment Description and Operation

The detrimental effects of marine biofouling on vessel performance have long been recognized by the Navy. The effects from biofouling are fouled surfaces of shipboard piping, heat exchangers and other related equipment used to distribute seawater aboard vessels resulting in flow restrictions and loss of heat transfer efficiency. Seawater cooling systems on vessels are used to provide cooling water for propulsion plant and auxiliary system heat exchangers. Heat exchangers remove heat directly from the main propulsion machinery, the electrical generating plants, air conditioning plants, and directly or indirectly from all other equipment requiring cooling. Seawater cooling systems draw seawater either directly, via a hull connection (sea chest), or indirectly, via a seawater header or the firemain that is supplied directly from a hull connection. The seawater is pumped through heat exchangers where the seawater absorbs heat and is then discharged overboard.

Preventing biofouling in seawater cooling system heat exchanger tubes is essential for maintaining peak heat exchanger operation and optimum propulsion plant performance. Marine biofouling prevention is accomplished on certain vessels with on-board chlorinators that inject low concentrations of sodium hypochlorite, a chlorine solution, at or near seawater cooling system intakes. See Figure 1 for a schematic diagram of a typical shipboard chlorinator treatment system. Chlorinators convert some chloride in seawater into a sodium hypochlorite solution in an electrolytic cell. The hypochlorite solution from the cell is then piped to the seawater intake or to junction piping at or near the seawater intake, where it is metered into the seachest. This provides treatment of the seawater prior to passing through the cooling system piping and components. The chlorine solution inhibits the growth of biofouling organisms or prevents them from attaching to the interior surfaces of seawater cooling system piping and components. A sampling connection at the outlet of the heat exchangers allows chlorine concentration levels to be monitored, and the injection rate to be modified as necessary.

In addition to chlorination, Military Sealift Command (MSC) vessels use two other methods to control biofouling; chemical dosing using an ethyl alcohol based chemical seawater dispersant, and anodic biofouling control systems.[1]

Chemical dosing as a means of biofouling control involves the periodic injection of a proportioned amount of an ethyl alcohol based chemical dispersant into the seawater cooling system at or near the point of seawater intake, usually a seachest, and is currently used on one MSC oiler. See Figure 2 for a schematic diagram of a typical shipboard chemical dosing treatment system. The means of injection may include a gravity head tank and flowmeter, an eductor dosing system, or a pump and tank system directed to a seachest. The chemical is flushed through the system and then discharged with the seawater.

Anodic biofouling control systems are designed for continuous operation. See Figure 3 for a schematic diagram of a typical shipboard anodic biofouling control system. Several systems are currently in use. Each anodic system works on the same principle: an impressed current applied to copper anodes accelerates the dissolution of copper ions. The anodes are usually mounted in the sea chest of the vessel. Copper ions inhibit the propagation of marine life and prevent biofouling.

2.2 Releases to the Environment

The purpose of chlorinating seawater is to protect the cooling system against biofouling caused by the attachment of living organisms. A chlorination system generates “free chlorine” in the form of a solution of sodium hypochlorite. This free chlorine reacts with various materials in seawater, including living tissue, as described in Section 3.3. Seawater discharged from cooling systems that are protected from biofouling with chlorine systems can contain residual free chlorine as well various reaction products resulting from the reaction of the free chlorine with organic material, ammonia, and bromide ion (see Section 3.3). In seawater, free chlorine and resulting reaction products are collectively called “chlorine produced oxidants” or CPO.

It is expected that the cooling water discharged from the MSC vessel that chemically doses its seawater cooling systems will contain the ethyl alcohol based dispersant. For those MSC vessels with anodic treatment systems, constituents from the copper anodes used are expected in the discharge.

2.3 Vessels Producing the Discharge

Refer to Table 1 for Navy and MSC vessel discharges. All other Armed Force vessels do not use seawater piping biofouling control methods or equipment.[2,3,4]

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Seawater biofouling treatment systems continuously discharge both within and beyond 12 nautical miles (n.m.) of shore as long as seawater cooling systems are in operation.

3.2 Rate

Table 1 presents estimated flow rates by ship class for pierside and underway conditions.[3,4,5]

Seawater cooling water flows vary with propulsion plant operating conditions and the system cooling requirements. There is a greater demand for cooling water when a vessel is underway because the propulsion plant is operating. However, the time spent underway while transiting within 12 n.m. is small compared to the time a vessel spends pierside and beyond 12 n.m. While pierside, the demand for seawater cooling is primarily from auxiliary equipment such as electrical generators, and air conditioning and refrigeration plants.

Anodic biofouling control systems are manually controlled systems normally pre-set for a current output of 0.2 amps,[6] which results in the generation of approximately 0.237 g copper/hr based on the following Faraday's Law calculation:

{(0.2 amps) (63.54 g copper/mole) (1 coulomb/amp-sec) (3,600 sec/hr)} /
{(2 equivalents/mole) (96,484 coulomb/equivalent)}

= 0.237 g copper/hr

3.3 Constituents

Seawater dosed with sodium hypochlorite contains free chlorine in the form of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). Free chlorine undergoes four important types of reactions in natural waters: (1) oxidation of reduced materials and subsequent conversion to chloride ion; (2) reaction with ammonia and organic amines to form chloramines, collectively called combined chlorine; (3) reaction with bromide to form hypobromous acid (HOBr) and hypobromite (OBr^{--}), called "free bromine;" and (4) reaction with organics to form chloro-organics. Free bromine reacts in a manner similar to free chlorine, oxidizing reduced material or forming bromamines (combined bromine) or bromo-organics. Most common analytical methods for quantifying chlorine in water measure the sum of all free and combined chlorine and bromine in solution, but do not measure the chloro- and bromo-organics. The results of such measurements in seawater are reported as CPO. The Navy injects enough free chlorine to meet the chlorine demand, and ensure that there is sufficient excess CPO throughout the system to protect against biofouling.

Seawater treated with the chemical seawater dispersant contains primarily ethyl alcohol and ammonium chloride. Other constituents of this dispersant are unknown.[1]

For those MSC vessels with installed anodic biofouling control systems, components of copper ions are expected in the discharge.

Copper is the only priority pollutant in this discharge. There are no known bioaccumulators in this discharge.

3.4 Concentrations

On submarines, sodium hypochlorite solution containing hypochlorous acid and hypochlorite ion is injected continuously into seawater piping systems to maintain a CPO concentration of 100 µg/L at a sampling point within the system (i.e. before the point of discharge from the submarine). The actual CPO concentration at the point of discharge from the submarine is not measured. However, based on monitoring during initial system setup and system design data, the CPO concentration in seawater cooling overboard discharge is lower than the 100 µg/L concentration at the sample point. The concentrations of CPO discharged from MSC vessels are assumed to be similar to the concentrations discharged from submarines (i.e., 100 µg/L) because there are no available chlorine discharge data for MSC vessels.

Every three days, over the course of one hour, twelve liters of the chemical dosing seawater dispersant is metered into a 9,200 gallons per minute (gpm) cooling water system aboard one MSC oiler.[1] Assuming all of the chemical added is also discharged, based on this ratio, a concentration of approximately 6 mg/L in the discharge would result. The ethyl alcohol based dispersant is expected to degrade rapidly and to be less than 6 mg/L after mixing with the receiving waters.

Copper ion emission concentrations resulting from the use of anodic biofouling control systems is dependent on the current (amperage) output and the seawater flow rate. The current output is manually set (0.2 amps typically) and is not adjusted when seawater pumps are put on or taken off line which changes the seawater flow rate. For a flow rate of 1,000 gal/min and current output of 0.2 amps, the resultant concentration will be 1.04 µg/L based on the unit conversion calculation below:

Concentration = (mass copper) / (volume water)
mass copper = 0.237 g/hr
volume water = 1,000 gal/min (3.785 L/gal) (60 min/hr) = 2.27×10^5 L/hr
concentration = (0.237 g/hr) / (2.27×10^5 L/hr) = 1.04×10^{-6} g/L = 1.04 µg/L

A flow rate of 1,000 gal/min, was used for this sample calculation only. 1,000 gal/min is a round number and close to the flow rate of many fire pumps. Similar calculations can be performed for other flow rates, with the resultant concentrations presented in Table 1.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Mass loadings were calculated in Table 2 based on ship movement data and the flow rates of seawater estimated from Table 1.[7] Calculations in Table 2 assumed that a chlorine concentration of 100 μg/L is continuously present in the seawater discharge. Most common analytical methods for quantifying chlorine in water measure the sum of all free and combined chlorine and bromine in solution. The results of such measurements in seawater are reported as CPO. The Navy injects enough "free chlorine" to meet the chlorine demand, and ensure that there is sufficient excess CPO throughout the system to protect against biofouling. The total estimated mass loadings for chlorine as CPO in Table 2 were calculated to be 2,538 pounds per year. The following is a sample calculation for the SSN 688 at pierside:

Cl_2 Mass Loading	=(0.1 mg/L)(1.41×10^8 gal/yr)(3.7854 L/gal)(2.2 lb/kg)(1 kg/1×10^6 mg)
	=117 lb/yr
Cl_2 concentration	=0.1 mg/L (Mean concentration)
Flow rate	=141,000,000 gal/yr
Conversion gals to liters	=3.7854 L/gal
Conversion kg to lb	=2.2 lb/kg
Conversion mg to kg	=1 kg/1×10^6 mg
Cl_2 Mass Loading	=117 lb/yr

The dispersant dosing treatment system injects 12 liters of dispersant 26 times per year.[1] At a weight of 8.23 pounds per gallon (lb/gal), a total of 678 pounds (82 gallons) of the dispersant are added to over 1.033 billion gallons of seawater cooling water while in port. It was assumed that with only 48 hours of transit time annually (with an average of 4 hours per transit), dispersant dosing evolutions would not take place during transit.

Dispersant Mass Loading	=	(26 inj/yr)(12 L)(8.23 lb/gal)(.2642 gal/liters)
	=	678 lb/yr
Injections per year	=	(78 days in port)/(Inject every 3 days) = 26 inj/yr
Amount Injected	=	12 liters per injection
Conversion gals to lb	=	8.23 lb/gal
Conversion liters to gal	=	.2642 gal/liters
Dispersant Mass Loading	=	678 lb/yr

For the 19 MSC vessels with anodic biofouling control systems, using the copper discharge rate of 0.237 g copper/hr and the estimated annual seawater discharge flow rates from these vessels (Table 1 and 2), yields a total copper mass loading of 25.0 pounds per year.

4.2 Environmental Concentrations

Table 3 compares the constituent concentrations from Section 3.4 with the Federal and most stringent state water quality criteria for CPO and copper. The estimated concentrations of

CPO exceed the most stringent state water quality criteria.

Based on monitoring and system design data, CPO levels are estimated to be less than 100 μg/L for seawater discharges on submarines. There are no Federal water quality criteria for chlorine. The most stringent state water quality criteria is 7.5 μg/L. The concentration value of 100 μg/L is measured as CPO which is primarily chlorine but can also include a small amount of bromine.

A computer model was used that plotted chlorine plumes (using existing and planned chlorine discharge levels) from various vessels in Mayport, Florida. Mayport is the smallest of the five major naval ports. Plume dimensions at critical concentrations (7.5, 10, and 13 μg/L) were compared with mixing zone limitations enforced by the states of Virginia and Washington. Virginia and Washington are used because they are the only states with clearly defined mixing zones. Only the chlorine plume from the MSC vessels did not meet the mixing requirements of the selected states. This plume spread out during the later stages of mixing and exceeded certain mixing zone width requirements.[8] The computer model did not assume expected decay of CPO, which would result in smaller mixing zones.

4.3 Potential for Introducing Non-indigenous Species

Biofouling prevention systems do not present an opportunity for transport of non-indigenous species. The anti-biofouling systems are designed to prevent organisms from attaching to any part of seawater systems so they are discharged directly overboard in the same geographical area in which they are pulled into the system.

5.0 CONCLUSION

Seawater piping biofouling control discharge has the potential to cause an adverse environmental effect. For chlorinator biofouling prevention systems, chlorine is discharged in significant amounts at concentrations expected to exceed ambient state water quality criteria. The use of anodic biofouling control systems results in the discharge of copper overboard. The copper concentration being significantly lower than water quality criteria, and the annual mass loading being very low, the discharges from anodic biofouling control have a low potential for causing adverse environmental effects.

6.0 DATA SOURCES AND REFERENCES

Table 4 lists the data source of the information presented in each section of this NOD report.

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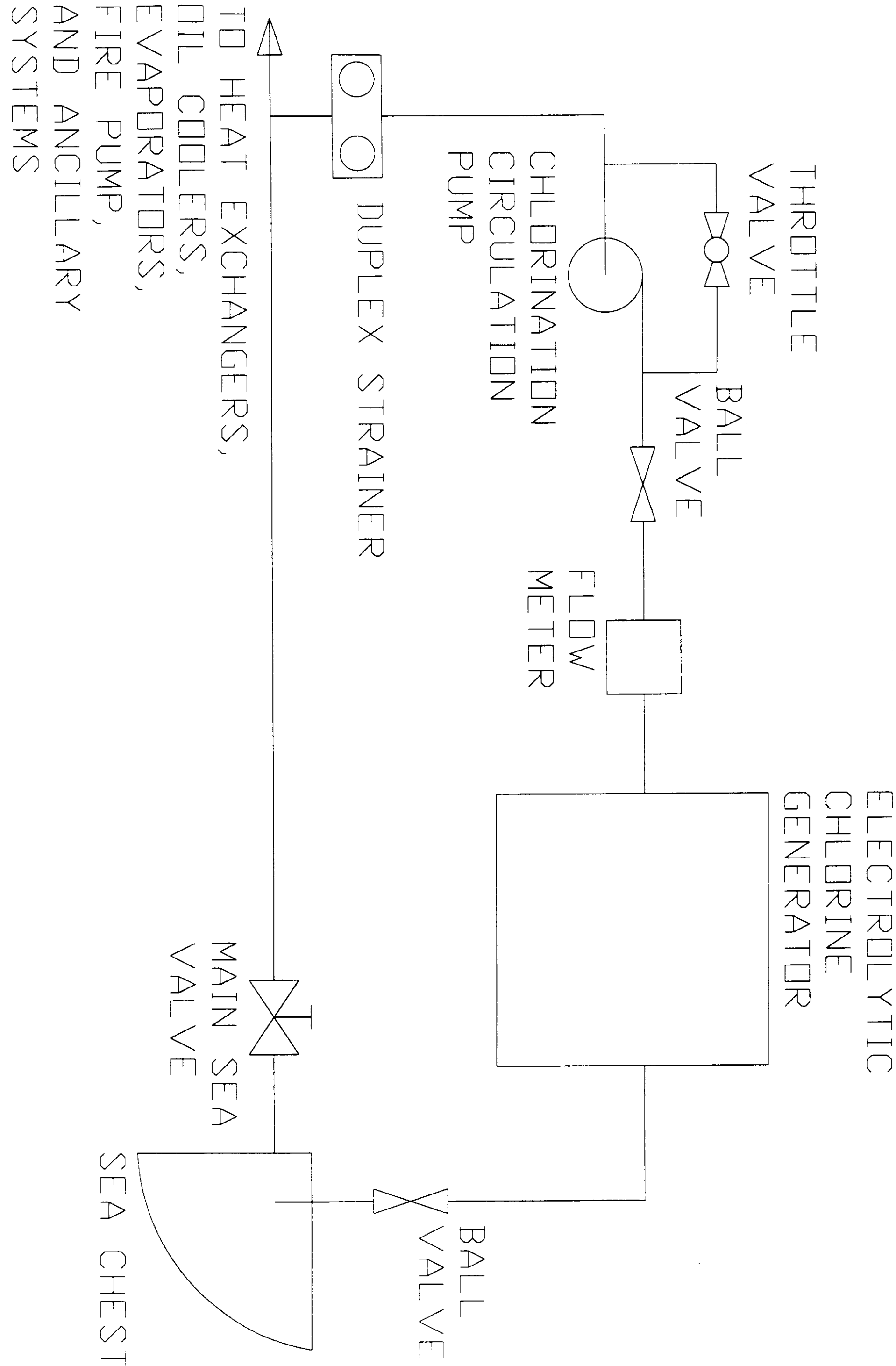

Figure 1. Chlorination Systems Schematic

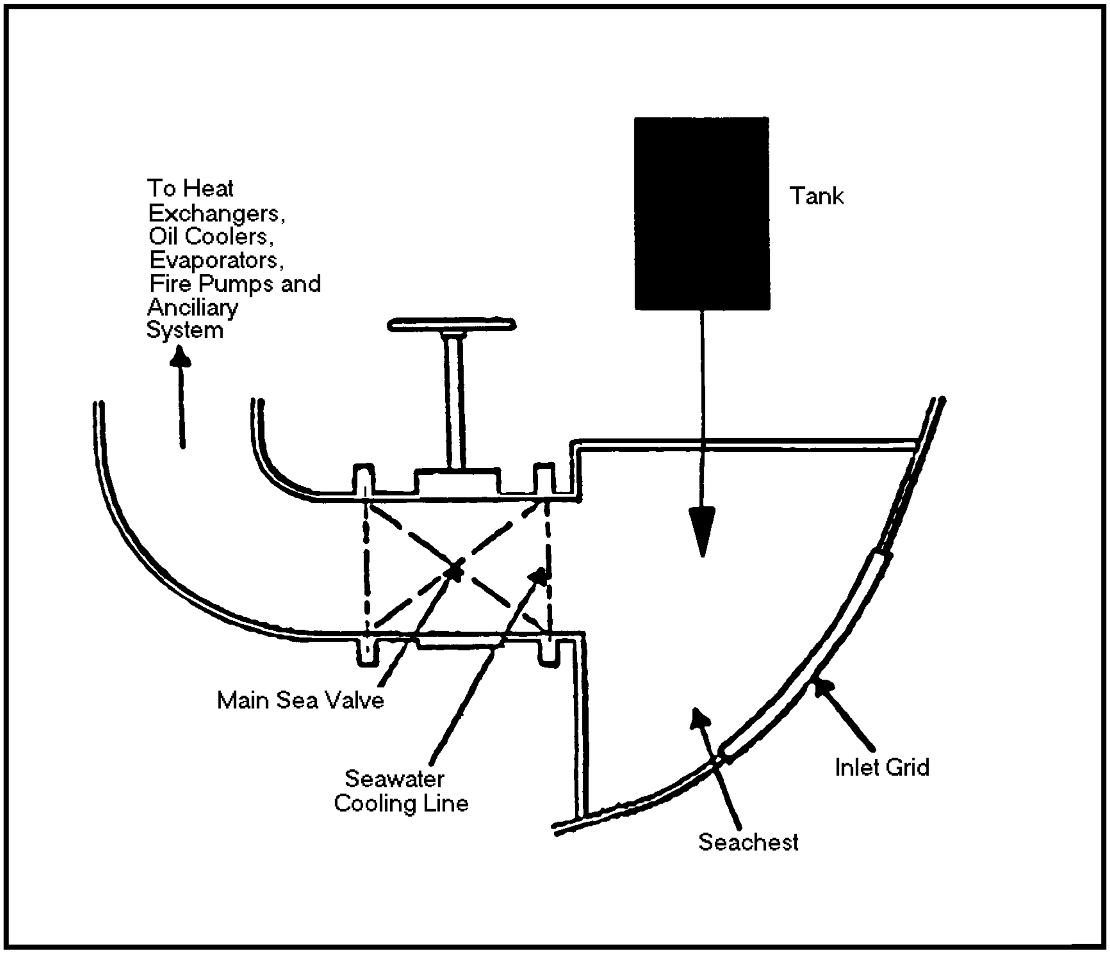

Figure 2. Typical Installation of Chemical Dosing System

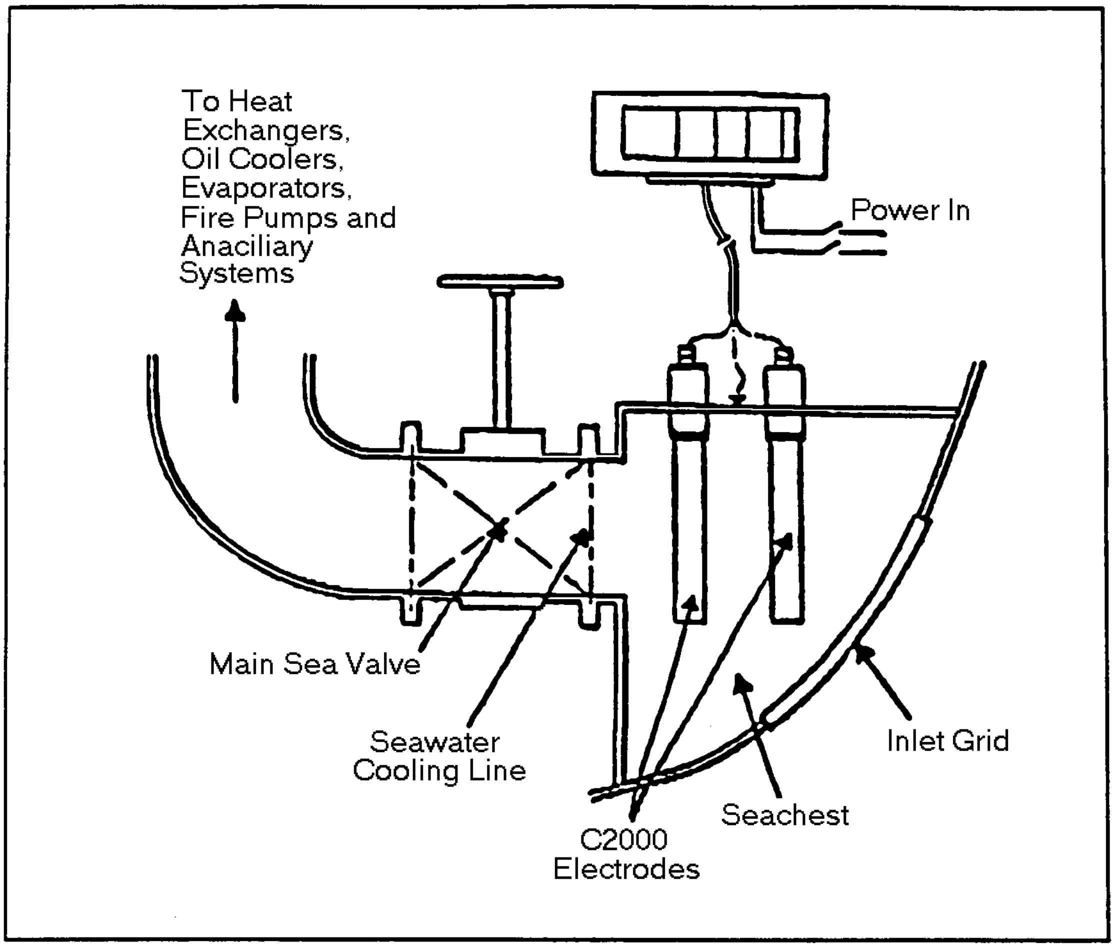

Figure 3. Typical Installation of Anodic Biofouling Control System

Table 1 - Estimated Annual Seawater Cooling Water Discharge Volumes for Vessels With Seawater Piping Biofouling Control Systems

Ship Class	Biofouling Control System	No. of Ships	No. of Transits per Year[1]	No. of Days In Port[1]	No. of Hours In Transit (<12 n.m.)[2]	Estimated Flow by Ship Class Pierside (gal/min)	Estimated Flow by Ship Class Underway (gal/min)	Concentrations (µg/L) pierside[3] U/W	Total Estimated Discharge Pierside (gal/year)	Total Estimated Discharge In Transit (<12 n.m.) (gal/year)
SSN 688 (Mod 25)	Chlorinator	4	14	183	56	133	192,000	100 [6]	141,000,000	1,790,000
T-AH	Chlorinator	2	8	184	32	2,000	40,500	100 [6]	1,070,000,000	156,000,000
T-AFS	Chlorinator	3	14	148	56	2,000	40,500	100 [6]	1,280,000,000	408,000,000
T-AO	Chemical Dosing[4]	1	12	78	48	9,200	40,500	6,000 [7]	1,030,000,000	117,000,000
T-AGS	Anodic[5]	5	12	96	48	1,500	6,840	0.69 0.15[8]	1,040,000,000	98,500,000
T-AGOS 1 Class	Anodic[5	6	8	70	32	1,500	6,840	0.69 0.15[8]	907,000,000	78,800,000
T-AGOS 19 Class	Anodic[5	4	10	107	40	1,500	6,840	0.69 0.15[8]	924,000,000	65,700,000
T-AGM	Anodic[5	1	8	133	32	2,000	40,500	0.52 0.026[8]	383,000,000	77,800,000
T-ATF	Anodic[5	3	34	166	136	1,650	7,500	0.63 0.14[8]	1,180,000,000	184,000,000

(1) In accordance with information presented in Reference 7.
(2) Assuming an average transit time of 4 hours per vessel.
(3) Differing pierside and underway (U/W) concentrations apply to vessels with anodic biofouling control systems
(4) It is assumed that the same volume of chemical dispersant injected is also discharged (representing worst case).
(5) Anodic biofouling control system concentrations were calculated based on a copper generation rate of 0.237 g/hr (Section 3.4)
(6) Concentration of Chlorine as CPO
(7) Concentration assuming the dispersant is 100% ethanol (representing worst case)
(8) Concentration of copper

Table 2 - Estimated Annual Mass Loading Calculations for Seawater Cooling Water Discharges from Vessels With Seawater Piping Biofouling Control Systems Currently Installed Onboard

Ship Class	Biofouling Control System	Total Estimated Discharge Pierside (gal/year)	Total Estimated Discharge In Transit (<12 n.m.) (gal/year)	Estimated Flow by Ship Class Pierside (gal/min)	Estimated Flow by Ship Class Underway (gal/min)	Concentrations µg/L pierside [1] U/W	Estimated Mass Loading Pierside (lb/yr)	Estimated Mass Loading In Transit (lb/yr)	Total Mass Loading by Type of System Pierside (lb/yr)	Total Mass Loading by Type of System In Transit (lb/yr)
SSN 688 (Mod 25)	Chlorinator	141,000,000	1,790,000	133	133	100 [4]	117	1.5		
T-AH	Chlorinator	1,070,000,000	156,000,000	2,000	40,500	100 [4]	883	130	2,066	472
T-AFS	Chlorinator	1,280,000,000	408,000,000	2,000	40,500	100 [4]	1,066	340		
T-AO	Chemical Dosing[2]	1,030,000,000	117,000,000	9,200	40,500	6,000 [5]	678	Note (7)	678	Note (7)
T-AGS	Anodic[3]	1,040,000,000	98,500,000	1,500	6,840	0.69 0.15[6]	6.02	0.125		
T-AGOS 1 Class	Anodic[3]	907,000,000	78,800,000	1,500	6,840	0.69 0.15[6]	5.25	0.100		
T-AGOS 19 Class	Anodic[3]	924,000,000	65,700,000	1,500	6,840	0.69 0.15[6]	5.35	0.083	24.48	0.54
T-AGM	Anodic[3]	383,000,000	77,800,000	2,000	40,500	0.52 0.026[6]	1.66	0.017		
T-ATF	Anodic[3]	1,180,000,000	184,000,000	1,650	7,500	0.63 0.14[6]	6.21	0.213		

(1) Differing pierside and underway (U/W) concentrations apply to vessels with anodic biofouling control systems
(2) It is assumed that the same volume of chemical dispersant injected is also discharged (representing worst case)
(3) Anodic biofouling control system concentrations were calculated based on a copper generation rate of 0.237 g/hr (Section 3.4)
(4) Concentration of Chlorine as CPO
(5) Concentration assuming the dispersant is 100% ethanol (representing worst case)
(6) Concentration of copper
(7) It is assumed that with only 48 hours of transit time annually (with an average of 4 hours per transit), chemical dosing evolutions would not take place during this time.

Table 3. Environmental Concentrations and Water Quality Criteria (μg/L)

Constituent	Concentration (μg/L)	Federal Chronic WQC (μg/L)	Most Stringent State Chronic WQC (μg/L)
CPO	100	-	7.5 (CT, HI, MS, NJ, VA, WA)
Copper	0.52 - 0.69	2.4	2.4 (CT, MS)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

CT = Connecticut
HI = Hawaii
MS = Mississippi
NJ = New Jersey
VA = Virginia
WA = Washington

Table 4. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment			X	X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	X		X	X
3.4 Concentrations	X		X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	X

NATURE OF DISCHARGE REPORT

Small Boat Engine Wet Exhaust

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipments or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the small boat engine wet exhaust discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Small boat engines commonly use seawater to both cool and quiet their exhaust. Seawater passes through the heat exchanger, gear oil cooler, and aftercooler (if equipped), and is then injected into the exhaust. When injected, some of the gaseous and solid components of the exhaust transfer into the cooling water. The cooling water then discharges into the receiving water. Any cooling water that is not injected into the exhaust is directed overboard.[1] For purposes of this analysis, it was assumed that all cooling water cycled through the engine is injected into the air exhaust.

Small boats are powered by either inboard or outboard engines. Inboard engines usually develop greater power than outboards. In addition, inboard engines are generally diesel fueled while outboard engines typically use gasoline. Inboard and outboard engines can be either two- or four-stroke. The majority of small boat outboard engines are two-stroke gasoline engines. The moving parts of gasoline-powered, two-stroke outboard engines are lubricated with oil that is pre-mixed with gasoline. Thus, the oil is continuously burned with the gasoline. In four-stroke engines, lubricating oil is circulated and not intentionally introduced into the combustion chamber.[2]

A diagram of a typical two-stroke diesel engine air system is included as Figure 1. A diagram of a typical inboard wet-exhaust system is included as Figure 2. Although engine design may vary based on boat class, general process flow will be similar for all water-cooled, small boat engines.

2.2 Releases to the Environment

This discharge consists of water injected as a cooling stream into the exhaust system of small boat engines. Exhaust constituents generated during the operation of the engines can be transferred to the engines' water cooling streams and discharged as wet exhaust. Inboard engines usually discharge wet exhaust above the water line. Outboard engines generally discharge their wet exhaust underwater through the propeller hub.

2.3 Vessels Producing the Discharge

There are approximately 3,300 Navy, 1,560 U.S. Coast Guard (USCG), 209 Army, and 1,454 Marine Corps small boats currently using seawater for cooling engine exhaust. Of the total number of small boats in the military fleet, 3,822 have inboard engines and 2,701 have outboard engines.[3] Air Force and Military Sealift Command (MSC) small boats have not been included in this analysis; however, their inclusion does not significantly affect this reports conclusion.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Based on their limited range, all small boats are expected to operate within 12 nautical miles (n.m.).[1]

3.2 Rate

Approximately one-third of the small boat fleet is equipped with outboard engines. Based on engine specifications, outboard engines can discharge up to 20 gallons per minute (gpm).[4] This rate was used as the fleet-wide average for outboard-driven small boats.

Inboard diesel engines generally have a higher discharge rate than outboard engines, and can discharge up to 100 gpm.[5] This estimate assumes that all cooling water flows through the engine and is discharged into the exhaust. Many small Armed Forces boats have twin engines, yielding a total flow rate up to 200 gpm per vessel. However, to take into account vessels with single engine installations, and for vessels with engines discharging less than 100 gpm per engine, a flow rate of 150 gpm per vessel was used as the average fleet-wide flow rate for boats with inboard engines.

Table 1 summarizes the estimated annual small boat engine wet exhaust flow rate by service. Flow rates were calculated for each service based on a monthly average operating time of 25 hours, and each vessel discharging 150 gpm of wet exhaust for inboards and 20 gpm for outboards.[4,5,6] The total fleet-wide discharge is approximately 11 billion gallons per year.

3.3 Constituents

The main constituents from all engines are oxides of nitrogen (NO_x), organic compounds (including hydrocarbons (HCs)), carbon monoxide (CO), and particulates. The HC constituents are primarily the result of incomplete combustion. Since diesel fuels have a different composition than regular gasoline, the distribution of constituents in the exhaust differ between the two engine types. In general, diesel engines produce higher particulate emissions and lower organic emissions than gasoline-powered engines.[7]

3.3.1 Outboard Engines

As mentioned in Section 2.1, almost all outboard engines are two-stroke gasoline powered engines. Some limited studies have been done on the impact of engine exhaust on water quality. A 1995 study measured the rate of introduction of volatile organic compounds (VOCs) into water during the operation of gasoline powered two-stroke and four-stroke outboard engines. In this study, a 10-horsepower (hp) outboard engine of each type was operated in an enclosed tank, and the increase in VOCs such as benzene was measured. The results were given in terms of milligram (mg) of compound per 10 minutes (min) of operation (e.g. 2800 mg benzene/10 min). Therefore, the number was a bulk measurement of the rate of accumulation of the compound in the water.[8]

The study reported that the VOC compounds found in water for both two-stroke and four-stroke engines were almost exclusively aromatic hydrocarbons. In most cases, other types of HCs were not found. The amount of VOCs found in the water on a power basis (grams per horsepower-hour (g/hp-hr) was equivalent to approximately 10% of the total HCs emitted in the exhaust. The VOC compounds measured in the 1995 study and the rate of accumulation are shown in Table 2.[8] Of the compounds listed in Table 2, benzene, toluene, ethylbenzene, and naphthalene are priority pollutants. No bioaccumulators are suspected to be present in this discharge.

3.3.2 Inboard Engines

To support the air quality management planning process, EPA has published emission factors for various industrial sources, including stationary diesel engines up to 600 hp. These emissions factors relate quantities of released materials to fuel input, as nanogram per joule (ng/J) fuel input, or power output, as in g/hp-hr. Although intended for stationary diesel engines, these emission factors may be used to approximate diesel engine emissions for small boats and craft for the following reasons:

- For diesel engine families with 1994 emissions certification, more than 90 percent have HC emissions of 0.5 g/hp-hr or less.[9] According to the manufacturer's specification sheet, the HC emissions rate for a typical diesel engine in use by the Armed Forces is 0.45 g/hp-hr.[5] This demonstrates that the emissions from the typical diesel engine used by the Armed Forces is similar to industry standard diesel engines.

- The EPA emission factor for total organic carbon (TOC) emitted by diesel engines is approximately 1.1 g/hp-hr.[7] Because HCs are a subset of TOC, these emissions rates appear to be appropriate for an order of magnitude estimate.

Table 3 lists the emission factors for constituents present in the air exhaust of diesel engines.[7] Through contact with the cooling water, many of these constituents have the potential to be introduced into the water. Of the compounds shown in Table 3, benzene, toluene, acrolein, naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene are priority pollutants. None of the constituents listed in Table 3 are bioaccumulators.

3.4 Concentrations

3.4.1 Outboard Engines

The 1995 study measured the VOC accumulation in water from the exhaust of 10-hp (7.3 kilowatt (kW)) two-stroke engines. Because the typical two-stroke outboard engine used by the Armed Forces is a 100 hp (74.6 kW) engine, the results from the 10-hp engine are not directly transferable. However, one pertinent observation was reported in the 1995 study which permits the results of the smaller engine to be "scaled" up for a larger engine. This observation was that the concentration of VOC in the water was related primarily to the level of HC emissions in the exhaust. The higher the level of HC emissions in the engine air exhaust, the higher the level of VOC found in the water.[8] This indicates that if the level of total HC emissions for a larger engine can be estimated, the VOC concentrations for the compounds given in the 1995 study can reasonably be estimated by comparing the total HC emission rates.

In 1996, EPA published a rule regulating the emissions of gasoline-powered marine engines. The rule gives an equation for HC output which describes the current emission rates of two-stroke engines for the power output range from 2 hp to 300 hp. This equation is given as:

$$\boxed{HC = [151+(557/P^{0.9})], \text{ or } 300 \text{ g/kW-hr, whichever is lower.}}$$

In this expression, P is the power in kW, and HC is the hydrocarbon emissions rate in g/kW-hr.[10] The relationship between power and emissions is different for 4-stroke and 2-stroke engines. However, in the absence of a similar equation for 4-stroke engines, it was assumed that 4-stroke engine emissions follow the same trend in emissions output on a normalized basis (power basis) as two-stroke engines.

Using the typical two-stroke outboard engine size of 100 hp and the EPA equation, the normalized output for HC is 162.5 g/kW-hr. Therefore, the total emissions rate is approximately 12,122 g/hr. Using the 7.3 kW engine power and the 267 g/kW-hr HC emissions rate reported in the 1995 study for the two-stroke engine, the total HC emissions rate is 1,949 g/hr. The ratio of HC emissions for these two engine sizes can be calculated as shown below:

Estimate the hydrocarbon emissions ratio for a 100 hp (74.6 kW) engine
Total emissions rate (7.3 kW engine): = (HC)(P) = (267 g/kW-hr) (7.3 kW) = 1,949 g/hr
Projected emissions rate (74.6 kW engine): = (HC)(P) = (162.5 g/kW-hr)(74.6 kW) = 12,122 g/hr
Emissions ratio = 12,122/1,949 = 6.2

If it is assumed that there is a direct relationship between the HC emissions rate and the VOC introduction rate, the rates of VOC introduction measured in the 1995 study can be multiplied by the HC emissions ratio. Using this approach, Table 4 provides the estimated VOC introduction rates for two-stroke outboard engine wet exhaust. An example calculation for benzene is provided below:

Benzene introduction rate for a 7.3 kW engine is 2800 mg/10 min (from 1995 study)
Hydrocarbon emissions ratio for a 74.6 kW engine equals 6.2 (from above calculation)
Benzene introduction rate equals (6.2)(2800 mg/10 min) = 17,360 mg/10 min

A similar procedure can be followed to estimate the VOC introduction rate for four-stroke engines. For these engines, a typical engine size is 90 hp. Again, using the EPA equation, the normalized output for HC in a 90 hp (67.1 kW) engine is 163.6 g/kW-hr. Therefore, the total emissions rate is approximately 10,961 g/hr. Using the 7.3 kW engine power and the 267 g/kW-hr HC emissions rate reported in the 1995 study for the two-stroke engine, the total HC emissions rate for the two-stroke engine in the 1995 study is 1,949 g/hr. For a 90 hp engine, the hydrocarbon emissions ratio therefore is 10,961/1,949 or 5.62. Using this ratio, Table 4 shows the estimated VOC introduction rate for four-stroke outboard engines. A sample calculation for the introduction rate of benzene is given below:

Benzene introduction rate for a 7.3 kW engine is 110 mg/10 min (from 1995 study)
Hydrocarbon emissions ratio for a 67.1 kW engine equals 5.62 (from above calculation)
Benzene introduction rate equals (5.62)(110 mg/10 min) = 618.2 mg/10 min

To estimate the concentration of the constituents in the wet exhaust, the flow rate must be used. From Section 3.2, the approximate wet exhaust flow rate for outboard engines is 20 gpm. The constituent concentration can be estimated by assuming all the VOCs introduced into the exhaust enters the water. Table 4 shows the estimated concentrations for the constituents in both two-stroke and four-stroke outboard engines. A sample calculation is presented below:

Wet Exhaust Flow rate:	20 gpm
Benzene introduction rate:	17,360 mg/10 min
Concentration = (17,360 mg/10 min)(1 min/20 gal)(1 gal/3.7854 L) = 22.9 mg/L	

3.4.2 Inboard Engines

The constituent concentrations for the discharge of inboard engines were determined through a multi-step calculation. Using emission factors for mid-size stationary diesel engines given in Table 3 and diesel engine output specifications, the concentrations in air exhaust were estimated. The transfer of air exhaust constituents into the water was estimated using Henry's Law, which relates the partial pressure of a gas in the atmosphere to the concentration of the gas in water. Table 5 provides the estimated constituent concentrations in the inboard engine wet exhaust. A sample calculation for the concentration of benzene is presented in the calculation sheet at the end of the report.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The estimated mass loadings shown in Table 6 and Table 7 were based on the total number of small boats in the Navy, USCG, Army, and Marine Corps; on a monthly average operating time of 25 hours; and each boat discharging 150 gpm of wet exhaust for inboards and 20 gpm for outboards.[4,5,6] The concentration data for two-stroke engines were used because the majority of Armed Forces outboard engines are two-stroke. This approach is conservative because constituent concentrations in two-stroke engine wet exhaust are higher than concentrations in four-stroke engine exhaust.

Mass loading sample calculations:

Table 6, Outboard Engine for benzene is:

(22.93 mg/L)(0.97 billion gallons/yr)(3.785 liters/gallon)(1 kg/10^6 mg) = 84,186 kg/yr

Table 7, Inboard Engine for benzo(a)pyrene is:

(7.69×10^{-5} mg/L)(10.31 billion gallons/yr)(3.785 liters/gallon)(1 kg/10^6 mg) = 3.0 kg/yr

4.2 Environmental Concentrations

The concentrations and mass loading estimates described above are likely an overestimate because of non-equilibrium effects. The method used to estimate the concentrations of the diesel exhaust components in wet exhaust using Henry’s Law assumed sufficient residence time inside the engine for the aerosols in the exhaust to reach equilibrium with the cooling water. However, due to the short residence time of both air and water in the exhaust system, equilibrium conditions are unlikely. Residence time in the exhaust system is expected to be less than one second. Because equilibrium conditions are unlikely, less constituents will dissolve in the cooling water.

Based on cited research, chemical constituents in the wet exhaust from small boat engines can be present at concentrations that exceed water quality criteria (WQC). Table 8 summarizes estimated discharge concentrations and WQC for constituents of this discharge. Benzene, toluene, ethylbenzene, and naphthalene in two stroke outboard engines exceed the most stringent state WQC. Benzene and ethylbenzene in four-stroke outboard engine wet exhaust, and total PAHs in inboard engine wet exhaust each exceed the most stringent state WQC.

4.3 Non-Indigenous Species

The residence time of cooling water in small boat engines is very short; therefore, the wet exhaust is discharged within yards of where the cooling water was taken aboard. Because seawater is not transported during small boat operations, it is unlikely that the operation of small boat engines could transport or introduce non-indigenous species.

5.0 CONCLUSIONS

Constituents found in small boat engine wet exhaust discharge are estimated to be discharged in significant amounts that exceed water quality criteria. Therefore, this discharge has the potential to cause adverse environmental effects.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information, equipment specifications, average annual use, and fleet-wide inventories were considered in estimating the rate of discharge. Estimated constituent concentrations were calculated using solubility principles and published emissions data. Additional constituent concentrations were obtained from previously completed research. Table 9 shows the sources of data used to develop this NOD report.

Specific References

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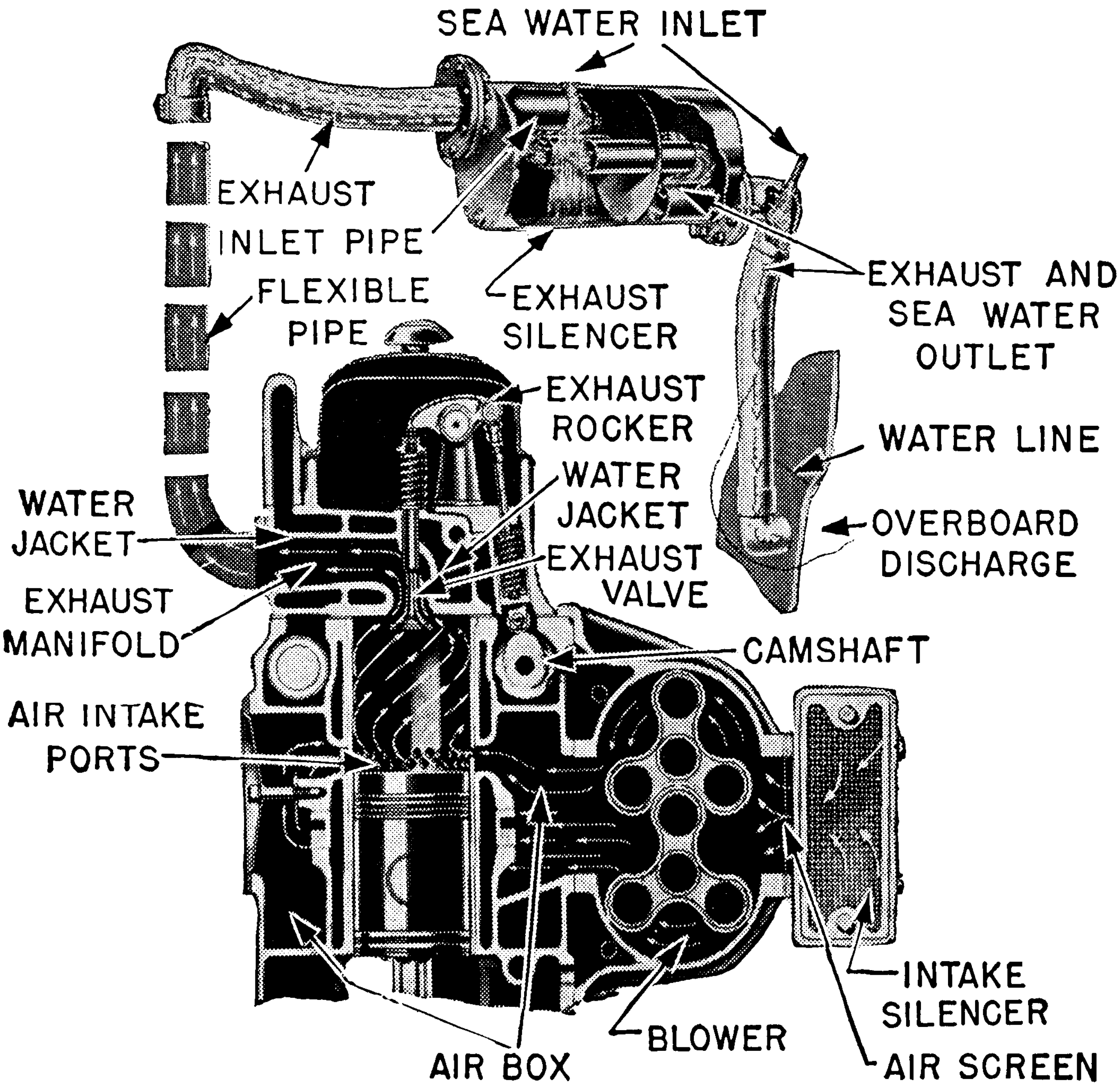

Figure 1. Air Systems of a Two-Stroke Cycle Engine (GM71)[11]

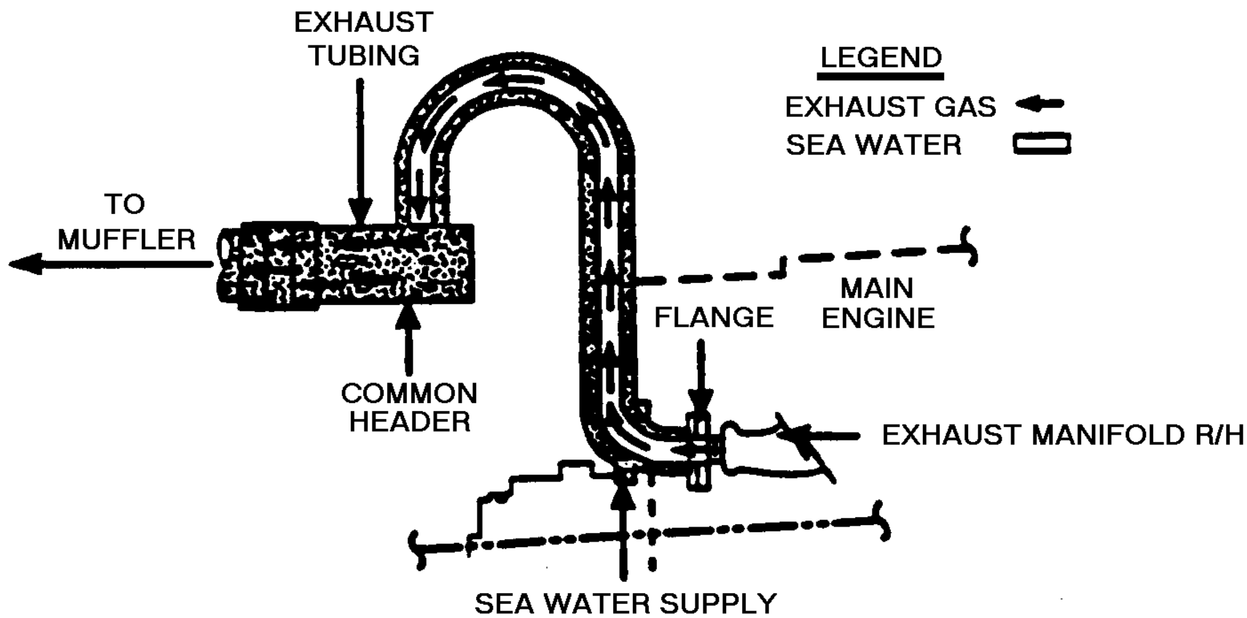

Figure 2. Typical Water Jacketed Elevated Loop[12]

Table 1. Estimated Annual Small Boat Wet Exhaust Discharge Flow Rates[3,4,5,6]

Service (fleet)	Number of Small Boats	Estimated Annual Discharge* (billions of gallons)
Navy (inboard)	2,500	6.75
Navy (outboard)	800	0.29
USCG (inboard)	620	1.67
USCG (outboard)	940	0.34
Army (inboard)	152	0.41
Army (outboard)	57	0.02
Marine Corps (outboard)	904	0.32
Marine Corps (inboard)	550	1.48
Totals (inboard)	3,822	10.31
Totals (outboard)	2,701	0.97
Totals (combined)	6,523	11.28

* Based on 150 gpm for vessels with inboard engines, 20 gpm for vessels with outboard engines, and an average operating time of 25 hours/month.

Table 2. Wet Exhaust Constituents Emitted from Two and Four-Stroke 10 Horsepower Gasoline Outboard Engines[8]

Constituent	Amount in Wet Exhaust from Two-Stroke Outboard Engines (mg/10 min)*	Amount in Wet Exhaust from Four-Stroke Outboard Engines (mg/10 min)
Benzene	2800	110
Toluene	8500	260
Ethylbenzene	2000	22
p/m-Xylene	6900	71
o-Xylene	3600	37
3 4-Ethyltoluene	3400	26
Mesitylene	1200	10
2-Ethyltoluene	870	8.7
Pseudocumene	4500	40
Hemellitene	1200	13
Indane	840	4.7
Indene	270	6.5
Naphthalene	1400	13
2-Methylnaphthalene	930	5.5
1-Methylnaphthalene	350	2.7
Formaldehyde	970	100

***Note:** Majority of small boat outboard engines in the Armed Forces are two-stroke engines

Table 3. Organic Compound Emission Factors for Diesel Engines[7]

Constituent	Emission Factor	
	(lb/MMBtu)*	(ng/J)
Benzene	0.000933	0.40119
Toluene	0.000409	0.17587
Xylenes	0.000285	0.12255
Formaldehyde	0.00118	0.5074
Acetaldehyde	0.000767	0.32981
Acrolein	0.0000925	0.039775
No_x	4.41	1896.3
CO	0.95	408.5
CO_2	164	70520
Naphthalene	0.0000848	0.036464
Acenaphthylene	0.00000506	0.0021758
Acenaphthene	0.00000142	0.0006106
Fluorene	0.0000292	0.012556
Phenanthrene	0.0000294	0.012642
Anthracene	0.00000187	0.0008041
Fluoranthene	0.00000761	0.0032723
Pyrene	0.00000478	0.0020554
Benzo(a)anthracene	0.00000168	0.0007224
Chrysene	0.000000353	0.00015179
Benzo(b)fluoranthene	9.91E-08	0.000042613
Benzo(k)fluoranthene	0.000000155	0.00006665
Benzo(a)pyrene	0.000000188	0.00008084
Indeno(1,2,3-cd) pyrene	0.000000375	0.00016125
Dibenz(a,h) anthracene	0.000000583	0.00025069
Benzo(g,h,i) perylene	0.000000489	0.00021027

* lb/MMBtu = pounds per million British thermal units

Table 4. Estimated Concentrations of Wet Exhaust Constituents from Two- and Four-Stroke Gasoline Outboard Engines

Constituent	Introduction Rate Two-Stroke Engines (mg /10 min)*	Introduction Rate Four-Stroke Engines (mg /10 min)*	Estimated Concentrations in Engine Wet Exhaust (mg/L)	
			Two-Stroke	Four-Stroke
Benzene	17360	618.2	22.93	0.82
Toluene	52700	1461.2	69.62	1.93
Ethylbenzene	12400	123.64	16.38	0.16
p/m-Xylene	42780	399.02	56.51	0.53
o-Xylene	22320	207.94	29.48	0.27
3 4-Ethyltoluene	21080	146.12	27.85	0.19
Mesitylene	7440	56.2	9.83	0.07
2-Ethyltoluene	5394	48.89	7.13	0.06
Pseudocumene	27900	224.8	36.86	0.3
Hemellitene	7440	73.06	9.83	0.1
Indane	5208	26.41	6.88	0.035
Indene	1674	36.53	2.21	0.048
Naphthalene	8680	73.06	11.47	0.1
2-Methylnaphthalene	5766	30.91	7.62	0.04
1-Methylnaphthalene	2170	15.17	2.87	0.02
Formaldehyde	6014	562	7.94	0.74

*Note: The majority of small boat outboard engines in the Armed Forces are two-stroke engines.

Table 5. Estimated Concentrations of Wet Exhaust Constituents from Diesel Inboard Engines

Constituent	Concentration in Air Exhaust (moles/ft^3)	Concentration in Discharge (mg/L)
Benzene	3.21E-08	1.87E-04
Toluene	1.19E-08	6.78E-05
Xylenes	7.22E-09	4.91E-05
Formaldehyde	1.06E-07	7.58E-01
Acetaldehyde	4.68E-08	4.83E-02
Acrolein	4.44E-09	6.15E-04
Nox	3.95E-04	1.82E-02
CO	9.11E-05	1.97E-03
CO2	1.00E-02	1.11E+01
Naphthalene	1.78E-09	2.19E-04
Acenaphthylene	8.93E-11	2.16E-06
Acenaphthene	2.47E-11	6.58E-06
Fluorene	4.72E-10	3.81E-04
Phenanthrene	4.43E-10	8.17E-04
Anthracene	2.82E-11	3.46E-05
Fluoranthene	1.01E-10	3.84E-06
Pyrene	6.35E-11	4.43E-04
Benzo(a)anthracene	1.98E-11	9.18E-04
Chrysene	4.15E-12	2.13E-04
Benzo(b)fluoranthene	1.05E-12	5.28E-06
Benzo(k)fluoranthene	1.65E-12	2.49E-06
Benzo(a)pyrene	2.00E-12	7.69E-05
Indeno(1,2,3-cd) pyrene	3.65E-12	3.45E-03
Dibenzo(a,h) anthracene	5.63E-12	5.05E-03
Benzo(g,h,i) perylene	4.75E-12	5.80E-03

Table 6. Estimated Annual Fleet-Wide Mass Loading of Wet Exhaust Constituents from Outboard Engines

Constituent	Concentrations (mg/L)	Estimated Mass Loading	
		(kg/yr)	(lbs/yr)
Benzene	22.93	84,196	185,600
Toluene	69.62	255,595	562,500
Ethylbenzene	16.38	60,140	132,600
p/m-Xylene	56.51	207,483	456,400
o-Xylene	29.48	108,252	238,700
Naphthalene	11.47	42,098	92,800
2-Methylnaphthalene	7.62	27,965	61,700

* These values were based on an annual flow rate of 0.97 billion gallons/year (see Section 4.1). Mass loadings are based on estimated emissions from a 100 HP, two-stroke engine.

Table 7. Estimated Annual Fleet-Wide Mass Loading of Wet Exhaust Constituents from Diesel Inboard Engines

Constituent	Concentration in Discharge (mg/L)	Annual Mass Loading (Kilograms)	Annual Mass Loading (Pounds)
Polyaromatic Hydrocarbons (PAHs)			
Naphthalene	2.19E-04	8.56E+00	18.9
Acenaphthylene	2.16E-06	8.44E-02	0.186
Acenaphthene	6.58E-06	2.57E-01	0.566
Fluorene	3.81E-04	1.49E+01	32.8
Phenanthrene	8.17E-04	3.19E+01	70.3
Anthracene	3.46E-05	1.35E+00	2.98
Fluoranthene	3.84E-06	1.50E-01	0.330
Pyrene	4.43E-04	1.73E+01	38.1
Benzo(a)anthracene	9.18E-04	3.58E+01	79.0
Chrysene	2.13E-04	8.32E+00	18.3
Benzo(b)fluoranthene	5.28E-06	2.06E-01	0.454
Benzo(k)fluoranthene	2.49E-06	9.72E-02	0.214
Benzo(a)pyrene	7.69E-05	3.00E+00	6.61
Indeno(1,2,3-cd) pyrene	3.45E-03	1.35E+02	297
Dibenzo(a,h) anthracene	5.05E-03	1.97E+02	434
Benzo(g,h,i) perylene	5.80E-03	2.26E+02	499

* These values were based on an annual flow rate of 10.31 billion gallons/year (see Section 4.1)

Table 8. Comparison of Estimated Concentrations of Wet Exhaust Constituents and Water Quality Criteria (μg/L)

Constituent	Estimated Discharge Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Outboard Engines			
Two-Stroke			
Benzene	22,930	None	71.28 (FL)
Toluene	69,620	None	2,100 (HI)
Ethylbenzene	16,380	None	140 (HI)
Naphthalene	11,470	None	780 (HI)
Four-Stroke			
Benzene	820	None	71.28 (FL)
Ethylbenzene	160	None	140 (HI)
Inboard Engines			
Acenaphthylene	2.16E-03	None	0.031 (FL)[1]
Phenanthrene	8.17E-01	None	0.031 (FL)[1]
Chrysene	2.13E-01	None	0.031 (FL)[1]
Benzo(a)pyrene	7.69E-02	None	0.031 (FL)[1]
Benzo(a)anthracene	9.18E-01	-	0.031 (FL)[1]
Benzo(b)fluoranthene	5.28E-03	-	0.031 (FL)[1]
Benzo(k)fluoranthene	2.49E-03	-	0.031 (FL)[1]
Indeno(1,2,3-cd) pyrene	3.45	-	0.031 (FL)[1]
Dibenzo(a,h) anthracene	5.05	-	0.031 (FL)[1]
Benzo(g,h,i) perylene	5.80	-	0.031 (FL)[1]
TOTAL PAHs (Inboard Engines)	16.3 [1]		0.031 (FL)[1]

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

FL = Florida
HI = Hawaii

1: Florida criteria for total PAHs is for the total of the following individual PAH compounds: acenaphthylene, benzo-(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and phenanthrene. Estimated discharge concentrations for total PAHs represent a sum of these chemicals.

Table 9. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	X			X
2.2 Releases to the Environment	X		X	X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	X			X
3.2 Rate	X		X	X
3.3 Constituents	X		X	X
3.4 Concentrations	X		X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	

Calculation Sheet
Benzene

Background:

Henry's Law was used to estimate the concentration of components in wet exhaust from small boat inboard diesel engines. This calculation sheet shows the calculation for the concentration of benzene in the wet exhaust. Calculations for the other exhaust components were similar.

A heat balance was used to determine the approximate wet exhaust equilibrium temperature. The temperature was determined using an air exhaust flow rate of 2,190 cfm at 870 °F, and a water injection rate of 100 gpm at 60 °F. 60 °F is believed to be an appropriate average because most large military ports are located in areas with similar average water temperatures. For this calculation, we assume the exhaust gas to have thermal properties similar to air.

ΔH: Change in enthalpy, m: mass of air or water, Cp: Specific heat capacity of air or water

$\Delta H_{exhaust\ gas} = \Delta H_{water}$

$\Delta H_{exhaust\ gas} = mCp\ (200\ °F - T)$

$= (2{,}190\ ft^3/min)\ (0.0601\ lb_m/ft^3)\ (0.24\ Btu/lb_m°F)\ (870\ °F - T)$

$= 31.59\ Btu/°F\ min.\ (870\ °F - T)$ **(1)**

$\Delta H_{water} = mCp\ (T - 60\ °F) = (100\ gal/min)\ (8.345\ lb_m/gal)\ (1\ Btu/\ lb_m\ °F)\ (T - 60\ °F)$

$= 834.5\ Btu/°F\ min\ (T - 60\ °F)$ **(2)**

Setting (1) = (2) we obtain the following:

$31.59\ Btu/°F\ (870\ °F - T) = 834.5\ Btu/°F(\ T - 60\ °F)$

$31.59\ (T) + 834.5\ (T) = 870\ °F\ (31.59) + 834.5\ (60\ °F)$

$T = \mathbf{89.5\ °F} = (9/5)\ °C + 32 = \mathbf{32\ °C}$

This temperature was then used to determine the appropriate values for Henry's Law constants, which vary with temperature.

At dilute concentrations, the concentration of benzene dissolved in water can be found from Henry's Law:

$$X_{exhaust} = (H_a)\ (X_{water})\ /\ (P_t)$$

Where:

$X_{exhaust}$: Mole Fraction of Benzene in Exhaust
H_a: Henry's Law Constant (Adjusted Reference 7)
X_{water}: Mole Fraction of Benzene in Water
P_t: Total Exhaust Pressure (atm)

Rearranging, Henry's Law can be rewritten as:

$$X_{water} = (X_{exhaust})\ (P_t)\ /\ H_a$$

The mole fraction of benzene in exhaust can then be converted into a concentration of benzene in the wet exhaust in mg/L using the molecular weight of benzene.

Given Conditions and Assumptions:

55.56 moles H_2O in 1 liter, [(1000 g/liter) (mole H_2O / 18 g) = 55.56 moles H_2O / liter]
Exhaust temperature of 870 °F
2,190 cfm air exhaust flow rate for 228 kW diesel engine
0.401 ng/J generation rate of benzene
Backpressure (P_t) on engine is approximately 1.147 atm
Molecular weight of benzene is 78.11 grams per mole (78,110 mg/mole)
Based on a water temperature of 32 °C (305.15 K), Henry's Law constants (in atm) for the constituents are the following:

Constituent	**H_a (atm)**
Benzene	**6.52E+02**
Toluene	7.94E+02
Xylenes	7.64E+02
Formaldehyde	2.05E-01
Acetaldehyde	2.09E+00
Acrolein	1.98E+01
No_x	6.81E+04
CO	1.37E+05
CO_2	3.85E+03
Naphthalene	5.09E+01
Acenaphthylene	3.08E+02
Acenaphthene	2.84E+01
Fluorene	1.01E+01
Phenanthrene	4.74E+00
Anthracene	7.11E+00
Fluoranthene	2.61E+02
Pyrene	1.42E+00
Benzo(a)anthracene	2.41E-01
Chrysene	2.18E-01
Benzo(b)fluoranthene	2.47E+00
Benzo(k)fluoranthene	8.19E+00
Benzo(a)pyrene	3.22E-01
Indeno(1,2,3-cd) pyrene	1.43E-02
Dibenzo(a,h) anthracene	1.52E-02
Benzo(g,h,i) perylene	1.11E-02

The conversion of Henry's Law constants into common units is presented at the end of the calculation sheet.

<u>Solution:</u>
1) Total number of moles per cubic foot in the air exhaust, including constituents and circulated air, n_t

The number of moles per cubic foot can be determined using the ideal gas law; $PV = n_tRT$

Where:
- P: Pressure within the exhaust piping, 1.147 atm
- V: Volume of space occupied by gas (assume 1 ft^3)
- R: Gas constant, 0.08206 L-atm/ K-mol
- T: Temperature, 305.15 K

Rearranging the ideal gas law equation and solving for n_t/V:

$$n_t/V = P/RT$$

$$n_t/V = (1.147\text{atm}) / ((0.08206 \text{ L-atm/ K-mol}) (1 \text{ ft}^3/28.32 \text{ L}) (305.15 \text{ K})) = 1.30 \text{ moles/ ft}^3$$

2) Concentration of benzene in air exhaust, A_b

A_b= (0.401 ng/J) (228 kW) (3.6 x 10^6 J/kW-hr) (10^{-9}g/ng) (1000 mg/g) (min./2190 f^{t3}) (hr/60 min)

= 2.50 x 10^{-3} mg/ft^3

= (2.50 x 10^{-3} mg/ft^3) (mole benzene/78,110 mg) = 3.2 x 10^{-8} moles benzene/ft^3 exhaust

3) Mole fraction of gas in exhaust, P_a

$P_a = A_b$ / total molar concentration

P_a = (3.2 x 10^{-8} moles benzene/ ft^3 exhaust) / (1.30 total moles/ ft^3 exhaust)

P_a = 2.46 x 10^{-8} moles benzene/ mole exhaust

4) Mole fraction of gas in water, X_{water}

$X_{water} = (X_{exhaust}) (P_t) / H_a$

X_{water} = (2.46 x 10^{-8}) (1.147 atm) / (652 atm)

X_{water} = 4.33 x 10^{-11} moles benzene/ mole water

5) Concentration of gas in water:

Per 1 liter of water;

Moles benzene = (4.33 x 10^{-11} moles benzene/mole H_2O)(55.56 moles H_2O/ 1 liter) = 5.19 x 10^{-9} moles/L

= (2.4 x 10^{-9} moles/L) (78,110 mg benzene/mole) = **1.87 x 10^{-4} mg/L benzene**

Determination of Henry's Constants

Henry's constants for the constituents were available, but units and temperature for the constants varied between the references used. Henry's constants with the following units were available:

1) H_1, atm
2) H_2, atm-m^3/mol

For purposes of clarity, the same calculation was used for each constituent. It was therefore necessary to convert all of Henry's constants to atm units, (1).

1) Conversion H_2 (atm-m^3/mol) to H_1 (atm):

$H_1 = (H_2 \text{ atm-m}^3/\text{mol}) (55.6 \text{ mol water / L}) (\text{L} / 10^{-3} \text{ m}^3 \text{ water}) = (H_2) (55{,}600)$

Henry's constants with the following temperatures in degrees Celsius were available:

(1) 20 ^{o}C
(2) 24 ^{o}C
(3) 25 ^{o}C
(4) 40 ^{o}C
(5) 32 ^{o}C

Henry's constants increase on average about threefold for every 10 ^{o}C rise in temperature for most volatile hydrocarbons.[a] Therefore, with an increase in temperature the constants increase by a factor of $\Delta H = 3^{(\Delta T/10)}$. All of the constants were converted to 32 ^{o}C constants using the following conversions.

For Henry's constant at 32 ^{o}C and converting from Henry's constants at 20 ^{o}C , 24 ^{o}C, 25 ^{o}C, and 40 ^{o}C respectively:

$H_{32} = (H_{20})$ (3.74),

$H_{32} = (H_{24})$ (2.41),

$H_{32} = (H_{25})$ (2.16), and

$H_{32} = (H_{40})$ / (2.41)

<u>Example - Henry's Constant Calculation</u>

For Acrolein, Henry's constant was available in atm-m^3/mol for 20^{o}c ($H_a = 9.54 \times 10^{-5}$)
H_a (atm) = (9.54×10^{-5} atm-m^3/mol) (55,600 mol/m^3) (3.74)
H_a = 19.8 atm

Using these methods, the constants were converted to atm units as shown in the table on the following page.

Table of Henry's Constants

Degrees **Source** **Units**	32 degrees Cooper atm	20 degrees USEPA (atm*m^3/mol)	25 degrees Mackay (atm*m^3/mol)	25 degrees Mackay Kpa m^3/mol	40 degrees CH2M Hill (atm*m^3/mol)	**32 degrees** **Henry's Constants** **atm**
Benzene				**5.50E-01**		**6.52E+02**
Toluene				**6.70E-01**		**7.94E+02**
Xylenes				**6.45E-01**		**7.64E+02**
Formaldehyde		**9.87E-07**				**2.05E-01**
Acetaldehyde					**9.05E-05**	**2.09E+00**
Acrolein		**9.54E-05**				**1.98E+01**
Nox	**3.18E+04**					**3.18E+04**
CO	**6.35E+04**					**6.35E+04**
CO2	**1.95E+03**					**1.95E+03**
Naphthalene		1.15E-03	**4.24E-04**	4.30E-02		**5.09E+01**
Acenaphthylene		**1.48E-03**				**3.08E+02**
Acenaphthene		9.20E-05	**2.37E-04**	2.40E-02		**2.84E+01**
Fluorene		6.42E-05	**8.39E-05**	8.50E-03		**1.01E+01**
Phenanthrene		1.59E-05	**3.95E-05**	4.00E-03		**4.74E+00**
Anthracene		1.02E-03	**5.92E-05**	6.00E-03		**7.11E+00**
Fluoranthene		6.46E-06	**2.17E-03**	2.20E-01		**2.61E+02**
Pyrene		5.04E-06	**1.18E-05**	1.20E-03		**1.42E+00**
Benz(a)anthracene		**1.16E-06**				**2.41E-01**
Chrysene		**1.05E-06**				**2.18E-01**
Benzo(b)fluoranthene		**1.19E-05**				**2.47E+00**
Benzo(k)fluoranthene		**3.94E-05**				**8.19E+00**
Benzo(a)pyrene		**1.55E-06**				**3.22E-01**
Indeno(1,2,3-cd) pyrene		**6.86E-08**				**1.43E-02**
Dibenz(a,h) anthracene		**7.33E-08**				**1.52E-02**
Benzo(g,h,i) perylene		**5.34E-08**				**1.11E-02**

Bold: Original Referenced Number

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SMALL BOAT ENGINE WET EXHAUST
MARINE POLLUTION CONTROL DEVICE (MPCD) ANALYSIS

Several alternatives were investigated to determine if any reasonable and practicable MPCDs exist or could be developed for controlling discharges from small boat engine wet exhaust. An MPCD is defined as any equipment or management practice, for installation or use onboard a vessel, designed to receive, retain, treat, control, or eliminate a discharge incidental to the normal operation of a vessel. Phase I of UNDS requires several factors to be considered when determining which discharges should be controlled by MPCDs. These include the practicability, operational impact, and cost of an MPCD. During Phase I of UNDS, an MPCD option was deemed reasonable and practicable even if the analysis showed it was reasonable and practicable only for a limited number of vessels or vessel classes, or only on new construction vessels. Therefore, every possible MPCD alternative was not evaluated. A more detailed evaluation of MPCD alternatives will be conducted during Phase II of UNDS when determining the performance requirements for MPCDs. This Phase II analysis will not be limited to the MPCDs described below and may consider additional MPCD options.

MPCD Options

Small boats of the armed forces are equipped with either two- or four-stroke compression ignition diesel or two-stroke spark ignition gasoline engines. During the operation of small boat engines, seawater is used to cool and quiet engine exhaust. As seawater is introduced into the engine exhaust, combustion by-products are captured by the seawater stream, and are discharged into the receiving water.

Three potential MPCD options were investigated. The purpose of these MPCDs would be to reduce or eliminate the release of hydrocarbons, oil and grease, volatile organic compounds, and semi-volatile organic compounds into the marine environment. The MPCD options were selected based on initial screenings of alternate materials and equipment, pollution prevention options, and management practices. They are listed below with brief descriptions of each:

Option 1: Employ dry exhaust systems on new boats and craft with inboard engines -This option would require that new small boats and craft to be equipped with inboard engines to be outfitted with dry exhaust systems wherever practicable.

Option 2: Convert small boats and craft with inboard engines to a dry exhaust system - This option would involve converting small boats and craft that are currently discharging wet exhaust at or below the waterline to dry exhaust systems.

Option 3: Procure new outboard engines with reduced emissions to meet new emissions requirements being imposed in 1999 - This option would involve replacing existing outboard engines with new "low emission" outboard engines either all at once or through attrition. These new outboards would meet EPA emission requirements which will be taking effect in 1999.

MPCD Analysis Results

Table 1 shows the results of the MPCD analysis. It contains information on the elements of practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a final determination for each option. Based on these findings, Option 1 -- building small boats and craft with inboard engines and dry exhaust systems, and Option 3 -- procure new outboard engines with reduced emissions to meet new emissions requirements, offer the best combination of these elements and are both considered to represent a reasonable and practicable MPCD.

Table 1. MPCD Option Analysis and Determination

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 1. Employ dry exhaust systems on new boats and craft with inboard engines	This option would require a practicability study for new small boat and craft that have inboard engines.	Higher acoustic and thermal signatures of dry exhaust systems are anticipated and could affect selected mission/operational profiles for some large special warfare boats. A boat and craft class study would be necessary to assess operational impact.	Changing the existing design would impose additional design costs including engineering analysis, drawing development, and design history documentation. Costs associated with actual installation of the dry exhaust systems are limited to material costs because labor costs for installing each type of system are approximately the same.[1]	Dry exhaust systems would eliminate the exhaust / seawater discharge on boats and crafts on which they are installed. Dry exhaust systems would disperse pollutants over a larger area reducing the potential for causing a sheen.	This option appears to be practicable for most new boats and craft with inboard engines. This option would eliminate the wet exhaust discharge from new small boats and craft, on which it is practicable to install a dry exhaust system.
Option 2. Convert small boats and craft with inboard engines to a dry exhaust system	Installing dry exhaust systems on existing small boats would require many modifications because of the large number of small boat configurations. Feasibility studies would be necessary for each boat class as it may not be physically possible to install a dry exhaust system on many boat classes.	Higher acoustic and thermal signatures of dry exhaust systems is anticipated and could affect selected mission/operational profiles for some large special warfare boats. A boat and craft class study would be necessary to assess operational impact.	Converting existing inboard engines would result in costs for: feasibility studies, engineering design, installation drawing development, alteration record preparation, Boat Information Book update, material, and installation. It is estimated that $36M would be required to study, design, and install this change on small boats/craft in the Navy.[1]	The dry exhaust system would eliminate the exhaust/seawater discharge on vessels where the installation is practicable. Dry exhaust systems would disperse pollutants over a larger area reducing the potential for causing a sheen.	This option does not appear to be practicable due to space and weight limitations on small vessels, and due to high cost on all boats and craft.

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 3. Procure new outboard engines with reduced emissions to meet new emissions requirements being imposed in 1999	Space and volume requirements are expected to be similar to those of existing engines. In some select cases, an increase in weight may occur and therefore slightly effect the boat's trim angle. Some new engines are expected to weigh about 15% more than existing engines. Limited horsepower ranges currently available, may require two outboards where one was sufficient before.	This MPCD is not expected to cause any significant change in war fighting capabilities or ship mobility. Assuming that the boat is supplied with similar horsepower and other characteristics as previous engines, the operational impact will be negligible.	The costs associated with this option include: feasibility study, design, development, alteration record preparation, Boat Information Book update, maintenance record / preventative maintenance documentation update, material, and installation costs. Replacing all existing small boat and craft outboard engines in the Navy would cost an estimated $9.0M. Implementing this option through attrition would impose a considerably lower annual cost of $34,000.[1]	New technology outboard engines will significantly reduce engine emissions.[2] New EPA regulations are likely to encourage the widespread use of four-stroke, fuel injection, and advanced two-stroke engines. Engine manufacturers claim a 94% reduction in hydrocarbons with four-stroke engines.	This MPCD appears to be practicable with the exception of converting all existing craft to reduced emission engines, as the cost of conversion often exceeds the value of the craft. The reduced emission engine, which burns fuel more completely and directly, will reduce the amount of pollution significantly.

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[1] NSWC Comments on NOD Report Review, March 18, 1997.

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NATURE OF DISCHARGE REPORT

Sonar Dome Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the sonar dome discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Sonar domes are located on the hulls of submarines and surface ships. Their purpose is to house electronic equipment used for detection, navigation, and ranging. Figures 1 through 4 show typical hull-mounted submarine and surface ship sonar domes.

Sonar domes on Navy surface ships are made of rubber. On submarines, they are made of steel or glass-reinforced plastic (GRP) with a 1/2-inch rubber boot covering the exterior. Military Sealift Command (MSC) T-AGS Class ships have sonar domes made of GRP. Zinc anodes are fastened to the exterior of steel sonar domes, and are contained within all the sonar domes, for cathodic protection. Figure 5 shows a Navy surface ship rubber dome, prior to installation.

Sonar domes can be filled with fresh and/or seawater to maintain their shape and design pressure. Most surface ship sonar domes are initially filled with freshwater, and any water that is lost underway is replenished with seawater from the firemain system. Sonar domes on FFG 7 Class frigates and some MSC ships are filled with seawater. Submarine sonar domes are connected to the sea through a small tube to equalize pressure, but water inside the dome has limited exchange with seawater.[1]

Table 1 summarizes sonar dome types, applications, and characteristics. The larger AN/SQS-53 and AN/SQS-26 sonar domes on cruisers and destroyers are located at the bow, and the smaller AN/SQS-56 domes on frigates are mounted on the keel. Submarine sonar domes are located at the bow. MSC T-AGS Class ships have several small sonar domes at various locations on the hull. The T-AGS Class sonar domes listed as free flood in Table 1, have ports which are open to the sea.

Table 2 shows materials that compose sonar domes, and components and materials inside sonar domes. Components and materials interior to sonar domes can include piping, sacrificial anodes, paint and the interior material surface of the sonar dome itself. Materials on the exterior surface of the sonar dome consist of the exterior material surface of the dome itself, any paints or coatings applied to the dome, and in some cases, sacrificial anodes.

There have been changes in the composition of the rubber material in Navy surface ship sonar domes. Prior to 1985, all sonar domes contained tributyltin (TBT) antifoulant on the interior and exterior, to prevent or minimize marine growth. The TBT was impregnated into the outermost 1/4-inch layers (both exterior and interior) of the rubber. Figure 6 shows the plys or layers of a surface ship rubber sonar dome. Since 1985 rubber sonar domes have been manufactured with TBT only on the exterior surface. This type of sonar dome has been backfitted on older ships when they require sonar dome replacement, and has been installed on all new ships since 1990. Submarine sonar domes do not contain TBT. Instead, the exterior rubber boots are coated with a copper-based antifouling paint.[2] Table 3 lists the surface ships that have no TBT in the interior of their sonar domes.

Sonar domes are emptied for sonar dome maintenance or replacement, and are always emptied when a vessel is in drydock. Some maintenance can be performed pierside. Sonar domes are emptied by first pressurizing them with air, to force as much water as possible through the installed eductor piping. Once this step is complete, eductors are used to remove all remaining water in the dome. The total volume of water discharged exceeds the sonar dome volume because the seawater used to operate the eductors is discharged along with water from the sonar dome.

The water emptied from the sonar dome interior is: 1) discharged overboard, if the vessel is waterborne, or 2) collected for proper management ashore, if the vessel is in drydock.

2.2 Releases to the Environment

There are two sonar dome discharges, discharges of the water from the interior of sonar domes and external discharges. Discharges of water from the interior of the sonar dome result from maintenance evolutions that require the sonar dome to be emptied. External discharges result from continuous leaching of TBT or other anti-fouling compounds from the sonar dome exterior.

2.3 Vessels Producing the Discharge

Only Navy and MSC vessels are equipped with sonar domes; the other Armed Forces ships are not. Sonar domes are equipped on the following types and classes of Navy and MSC ships:

- cruisers (CG and CGN Classes);
- destroyers (DD and DDG Classes);
- frigates (FFG Class);
- submarines (all SSN and SSBN Classes); and
- MSC T-AGS Class ships.

Tables 1 and 4 list the classes and populations of sonar dome-equipped vessels. Eighty-three of the Navy surface ships have the larger AN/SQS-26 or SQS-53 sonar domes, and 43 have the smaller SQS-56 domes. Seventy-two active submarines have the smaller BQQ-5, BQR-7 or BSY-1 sonar domes, and the 17 others have much larger BQQ-6 sonar domes.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Discharges from the interior of sonar domes only occur while vessels are pierside. Discharges from the external surface of sonar domes occur both within and beyond 12 nautical miles (n.m.) of shore, as materials leach continuously from the exterior of the dome. Discharges from the external surface of sonar domes were studied by the Naval Command, Control and Ocean Surveillance Center to characterize the environmental effects in San Diego harbor.[3]

3.2 Discharge Rate

Discharge from the interior of sonar domes is intermittent, depending on when the dome is emptied for maintenance. The average volume of water discharged for maintenance or repair activities is estimated based on input from naval shipyards. Sonar dome discharge volume varies with the dome type (size) and the method used to empty the dome. Norfolk and Pearl Harbor Naval Shipyards report that between 23,000 and 38,000 gallons is typically emptied from AN/SQS-53 sonar domes.[4,5] Table 4 contains the estimated annual discharge for sonar done-equipped vessels, based on the vessel class populations, sonar dome water capacity, and number of sonar domes expected to be emptied per year. On average, sonar domes on surface ships are emptied two times per year. Submarine sonar domes are normally emptied once per year.[2] Table 4 indicates a total annual discharge estimate of about 9.3 million gallons of interior sonar dome effluent, with just under 4.0 million of that being from sonar domes with internal TBT coatings.

Discharge from the external surface of a sonar dome is not a liquid discharge; rather, it is the leaching of anti-fouling agents into the surrounding water, and cannot be characterized by a volumetric flow rate. A Navy study was conducted in San Diego Bay in 1996 to determine TBT release rates from rubber sonar domes. Release rates from the external surfaces were determined by attaching a closed capture system to the sonar domes exteriors of three ships. The sampled sonar domes ranged in age, at 3, 10 and 20 years since installation. Table 5 shows that the average release rate for TBT from the external surfaces of the sonar domes was 0.36 $\mu g/cm^2/day$ (micrograms per square centimeter per day), which results in an average release of 0.27 grams of TBT per day per ship.[3]

3.3 Constituents

Table 2 shows the components and materials in sonar domes that can contribute constituents to the sonar dome discharge. The specific constituents depend on vessel class, the age of the dome, and the source of water that fills the dome. Discharges from the interior of sonar domes can include copper, nickel, tin and zinc which corrodes, erodes, or leaches from piping, sacrificial anodes, paint, or other material inside the dome. If the interior of the dome is impregnated with TBT, discharges will also include that constituent. The potable water and/or seawater that fills the sonar dome is also a source of constituents in discharges from the interior.

In addition to these constituents, the interior effluent can contain compounds that are produced by degradation of the materials or reaction of material with the water. For instance, TBT, which might be found on both the interior and exterior of surface ship rubber sonar domes, degrades to dibutyltin (DBT) and monobutyltin (MBT).

External discharge constituents will include the TBT impregnated into the exterior of rubber sonar domes, or copper from copper based antifoulant coating on GRP and steel domes. Discharge from copper based and other antifoulant coatings are addressed separately, by the Hull Coating Leachate NOD Report.

Sampling of the water within the interior of sonar domes was conducted to identify and measure constituents, and was done according to procedures specified by the Navy. Samples from the interior of sonar domes were manually collected from the sonar dome piping systems of Navy surface ships and submarines, prior to discharge. The three sampling activities, Norfolk and Pearl Harbor Naval Shipyards and the Naval Command, Control and Ocean Surveillance Center did not all sample for the same constituents, as shown in Table 6. The tests that were performed on the samples included gas chromatography, hydride derivization and atomic absorption for TBT, and Toxicity Characteristic Leaching Procedure (TCLP) for metals. Tests done on sonar domes have indicated that the constituents of discharges from the interior of sonar domes are copper, nickel, tin, zinc, TBT (also known as tetra-normal-tributyltin), DBT and MBT. External sonar dome discharge constituents are TBT, DBT, MBT, copper, and zinc.[3,4,5,6]

Of the discharge constituents listed above, copper, nickel, and zinc are priority pollutants. None of the discharge constituents are bioaccumulators.

3.4 Concentrations

A summary of results of sampling discharges from the interior of sonar domes is contained in Table 6. Altogether, previous Navy studies have analyzed the water from the interior of sonar domes on 31 surface ships and submarines, with some vessels sampled multiple times. In addition to the metals and compounds listed in Section 3.3, four samples from the USS South Carolina were analyzed for Chemical Oxygen Demand (COD) and four samples from the USS Conolly were analyzed for both Total Suspended Solids (TSS) and Total Organic Carbon (TOC). The results of the sampling are summarized below:[3,4,5]

The average concentrations of the metal constituents are listed in Table 6.

Among the classical pollutants, COD levels ranged from 20 to 180 milligrams per liter (mg/L), with an average of 123 mg/L. Total organic carbon levels ranged between 4 and 6 mg/L. Total suspended solids were all below 4 mg/L.

TBT concentrations ranged from 1 to 470 micrograms per liter (μg /L), with an average of 74 μg/L. Only one sample has been taken for concentrations of MBT and DBT. The results were 5 and 33 μg/L, respectively.

The firemain system is normally used to replenish sonar dome water lost on surface ships while underway and to educt the final water remaining when a sonar dome is emptied. However, the seawater from the firemain has a negligible effect on the constituent concentrations in this report. The salinity of the samples was low, indicating that little make-up seawater was added to the sonar domes during operations. The sonar dome sampling procedure requires samples to be taken from the dome, not from the emptied water, so firemain water that powers the eductors will not dilute or contribute constituents to the samples.

The above analytical results only address discharges from the interior of the sonar domes, and do not account for the discharge from the external surfaces. The external surface TBT release rates and estimated mass loadings are included in Sections 3.2 and 4.1, respectively.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The amount of water discharged fleet-wide from the interior of sonar domes was estimated using:

1) the amount of water generated from each type of sonar dome when that sonar dome is emptied;
2) the frequency of maintenance requiring sonar domes to be emptied;
3) the number of vessels with each type of sonar dome; and
4) the average concentrations of each of the constituents.

The estimated fleet-wide mass loadings for copper, nickel, tin, and zinc were calculated by the following formula:

$$\text{Mass Loading (lbs/yr)} = \text{(avg. concentrations in } \mu\text{g/L) (discharge in gal/yr) (3.7854 L/gal) (2.2 lb/kg) (}10^{-9}\text{ kg/}\mu\text{g)}$$

For example, copper:

$$\text{Mass Loading} = (303\ \mu\text{g/L}) (9{,}278{,}800 \text{ gal/yr}) (3.7854 \text{ L/gal}) (2.2 \text{ lb/kg})(10^{-9} \text{ kg/}\mu\text{g}) = 23.4 \text{ lbs/yr}$$

This calculation of mass loadings from sonar domes overestimates the actual mass loadings because:

1) All discharges are assumed to occur pierside, but some of the discharges actually occur in drydock, where they are managed under shipyard discharge permits.
2) All discharges are assumed to occur within U.S. territorial waters, but some of the discharges actually occur outside U.S. territorial waters.
3) Results of discharge sample measurements which were below detection levels were assumed to be at the detection level.

The average constituent concentrations from Table 6, and a total estimated annual discharge volume of 9.3 million gallons per year for all vessels, taken from Table 4, were used to calculate the mass loadings. Based upon this information and the above formula, the annual mass loadings for metals were calculated to be 23 pounds for copper, 11 pounds for nickel, 15 pounds for tin, and 122 pounds for zinc.

The estimated fleet-wide mass loading for TBT, DBT and MBT generated from sonar dome interiors was calculated by the same formula (above), using a 3.96 million gallon discharge volume per year for those vessels in Table 4 that could have TBT inside the sonar dome. Using the average TBT concentration of 74 μg/L, the annual mass loading estimate for TBT is 2.4 pounds per year due to discharges of water from the interior of the sonar dome. Although not representative of all vessels, the one sample in which DBT and MBT were measured is used to calculate fleet-wide mass loading for those constituents, using the same 3.96 million gallon discharge volume , since DBT and MBT are degradation products of TBT. Based on the single sample concentrations of 33 and 5 μg/L for DBT and MBT, respectively, the estimated mass loadings are 1.1 and 0.2 pounds per year, respectively.

The calculation for TBT mass loading from the exteriors of surface ship rubber sonar domes was performed using the following formula:

Sonar Dome External Discharge TBT Mass Loading (lbs/yr) =
(avg. release rate in g/day) (0.00205 lbs/g) (no. of ships with rubber domes) [avg. days/yr in port + ((no. transits/yr) (4 hrs/transit)÷ 24 hrs/day)]

(0.27 g/day) (0.00205 lbs/g) (126 ships) (158 days/yr in port + ((12 transits/yr)(4 hrs/transit)÷ 24 hrs/day)) = 12.6 lbs/yr

This formula uses the release rate from Table 5, which is based on sampling the discharge from the external surface of rubber sonar domes on three Navy surface ships, two of which had older sonar domes, and the newer DDG 51 Class USS John Paul Jones.[3] The formula also uses 158 days/yr as the estimated annual in-port time for each ship. The result is a TBT annual mass loading of 12.6 pounds due to discharges from the external surface of the sonar dome.

Therefore, the estimated maximum TBT mass loading within 12 n.m. for surface ships equipped with rubber sonar domes is 15.0 lbs/yr. This is the sum of 2.4 lbs/yr from discharges from the interior of the sonar domes and 12.6 lbs/yr from discharges from the external surface.

The estimated mass loadings generated from sonar dome interior and exterior discharges are presented in Table 7.

4.2 Environmental Concentrations

Table 8 compares the concentrations of constituents in sonar dome discharge with the most stringent water quality criteria (WQC) for that constituent. For sonar dome discharge, the constituents known to be present are TBT, DBT, MBT, copper, nickel, tin, and zinc. As a result of the comparison, the mean concentrations of TBT, copper, nickel, and zinc each exceed their respective Federal and most stringent state acute WQC. The interior concentrations can be compared to acute values and the exterior concentrations compared to chronic values. Neither DBT, MBT, nor tin has a relevant WQC.

4.3 Potential for Introduction of Non-Indigenous Species

Most sonar domes do not have the potential for the transfer of non-indigenous species in discharge of water from the interior of the sonar dome, or for transfer from the external surface. Non-indigenous species transfer would occur primarily during the emptying and replenishment of water in the interior of the sonar dome, and that is normally performed at a vessel's homeport or a shipyard. TBT on the interior surface of older rubber sonar domes and the exterior of all rubber sonar domes prevents attachment of marine organisms and could inhibit their growth.

Sonar domes filled with freshwater have little potential to be a mechanism for transfer of non-indigenous species in the water that fills the dome. There is minimal exchange with seawater. Only a small volume of water from the ship's potable water or surrounding seawater is added to the existing potable water in the dome between emptying and replenishment events to make up for any loss of sonar dome water during operations. Therefore, the opportunity to introduce non-native organisms into the surrounding water is limited.

Non-free-flood sonar domes filled with seawater have the potential for transfer of non-indigenous species. These types of sonar domes are found on FFG 7 Class Navy frigates. However, the non-indigenous species transfer potential is considered very low for the following reasons: 1) the maintenance requiring sonar dome emptying and replenishment is normally performed at the ship’s home port, so water taken on will be discharged in the same locality; 2) most of the sonar domes have TBT on the interior surface because the ships were built prior to 1990; and 3) the residence time inside these sonar domes is long (on the order of 6 months), making the probability of survival of non-indigenous species more remote.[1]

5.0 CONCLUSIONS

Discharges from sonar domes has a low potential for causing adverse environmental effect. Although concentrations of organotins (MBT, DBT, and TBT), copper, nickel, and zinc discharged from sonar dome interiors exceed water quality criteria mass loadings of these substances are small (3.7, 23, 11, and 122 pounds per year, respectively). Exterior releases of TBT are also expected to be small (12.6 pounds annually).

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 9 lists data sources for this report.

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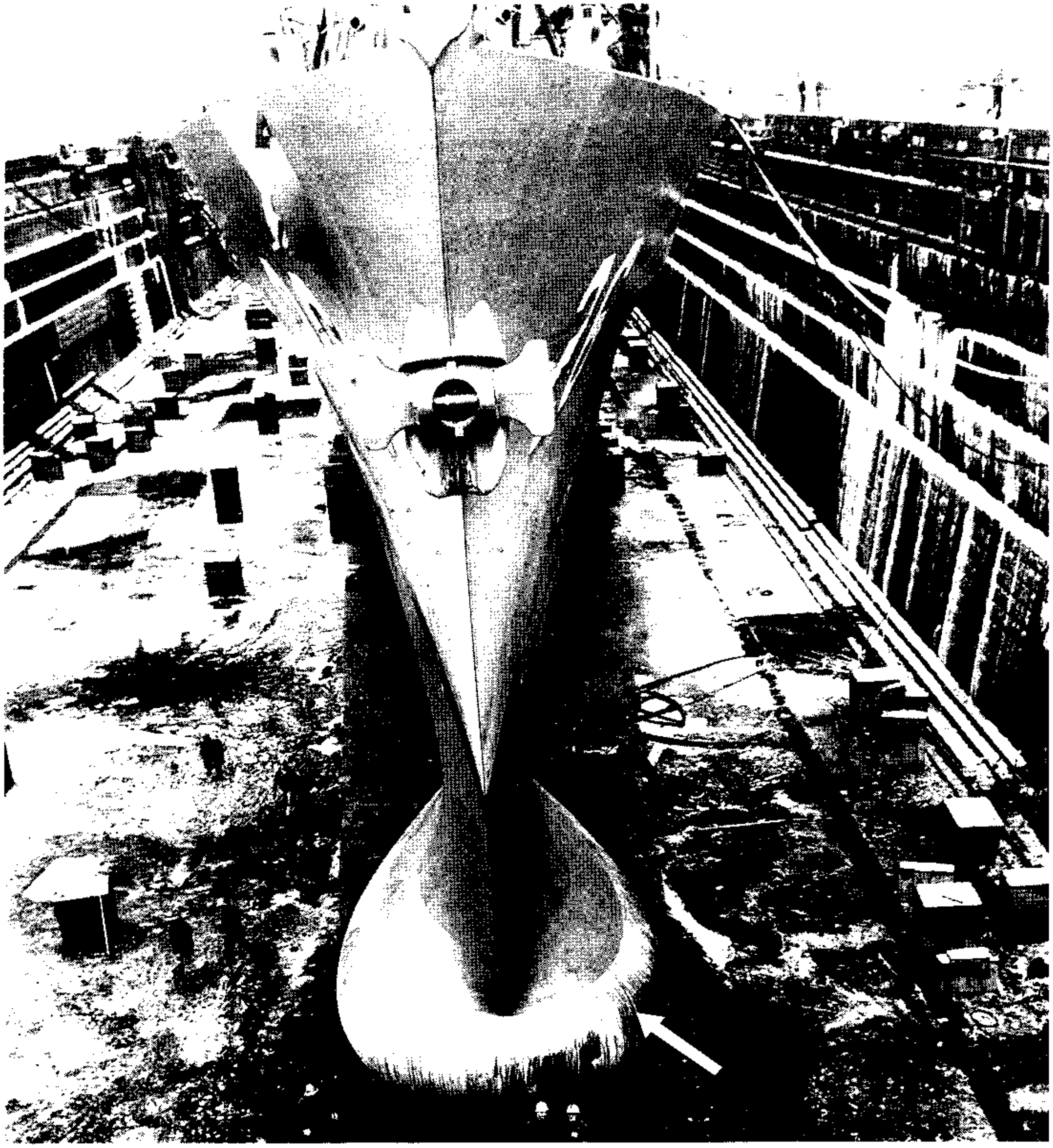

Figure 1. SQS-26 Sonar Dome in the Cruiser Belknap (CG 26)

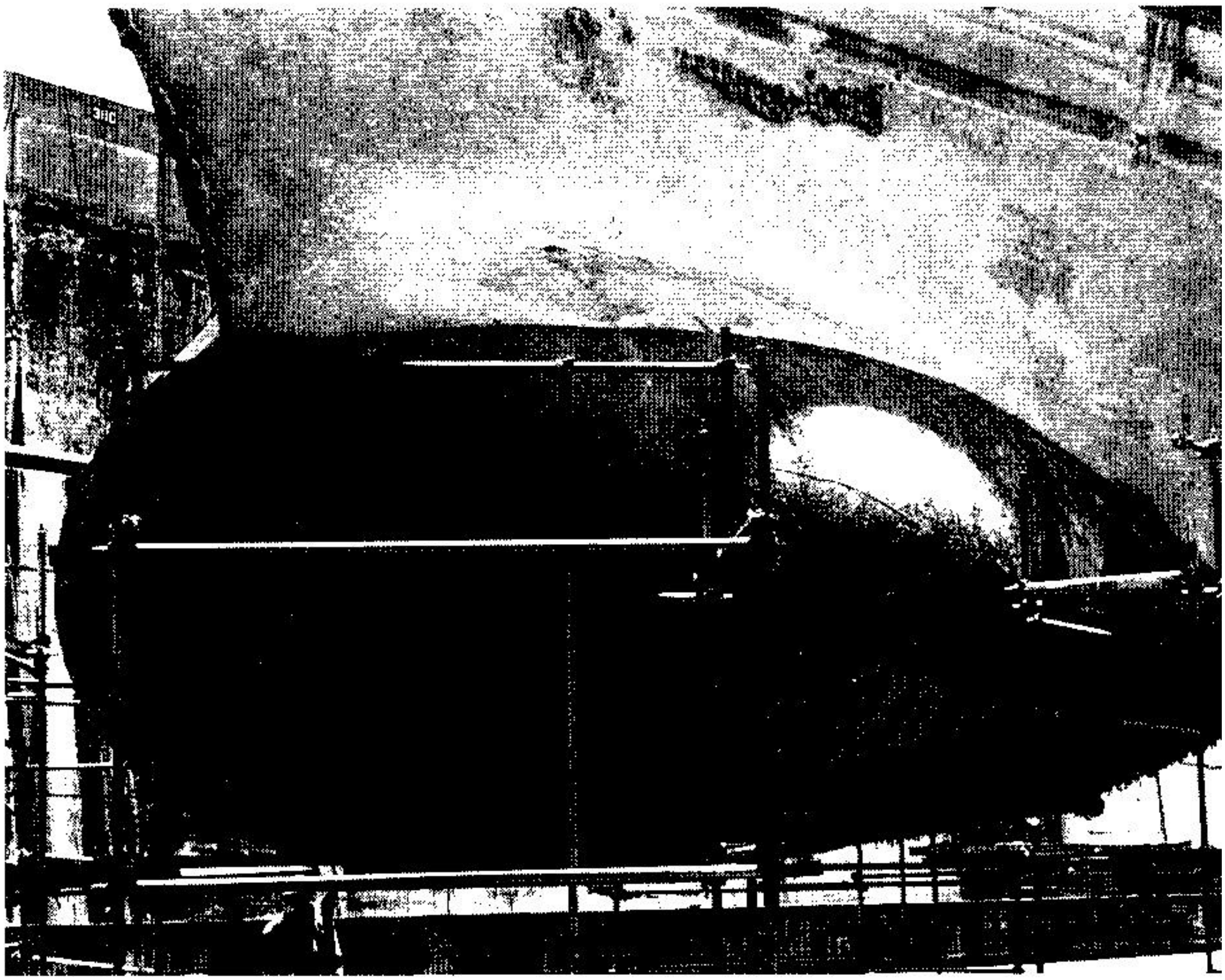

Figure 2. SQS-26 Sonar Dome on the Frigate Knox.

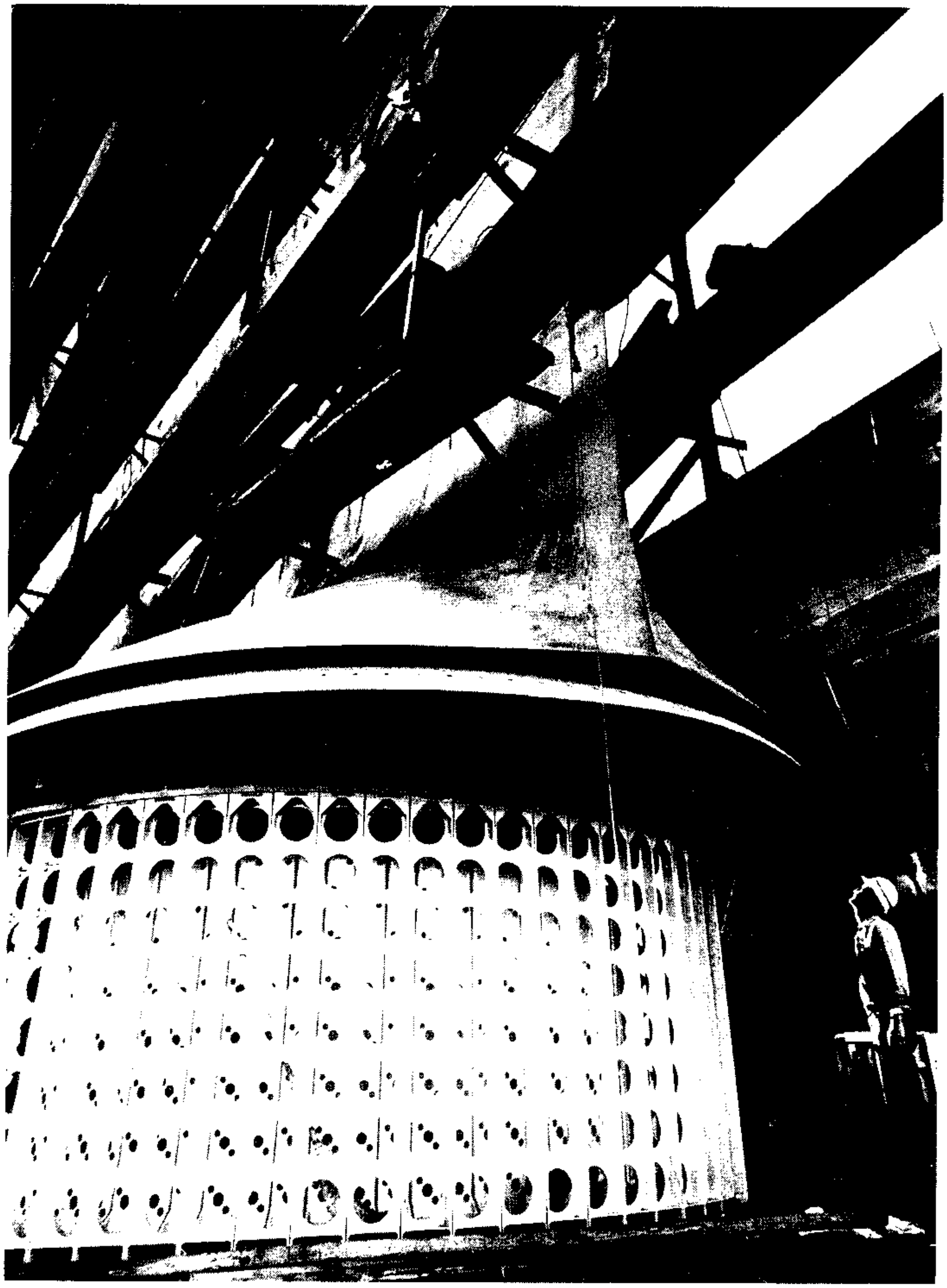

Figure 3. SQS-53 Transducer Housing on a Spruance-Class Destroyer.

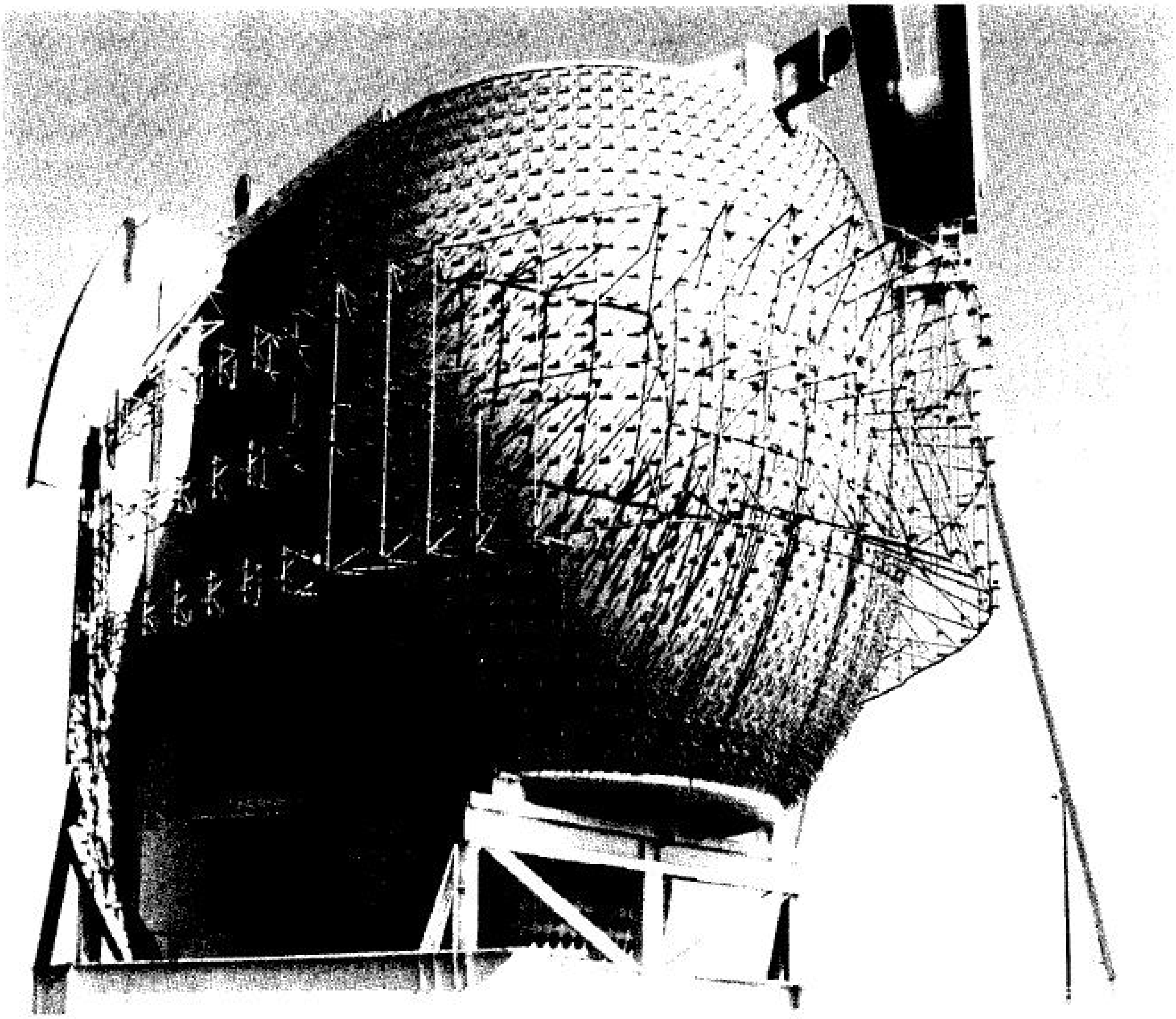

Figure 4. Spherical, Bow-Mounted Array Housing for the BSY-2 Combat System.

Figure 5. Surface Ship Rubber Sonar Dome Prior to Installation.

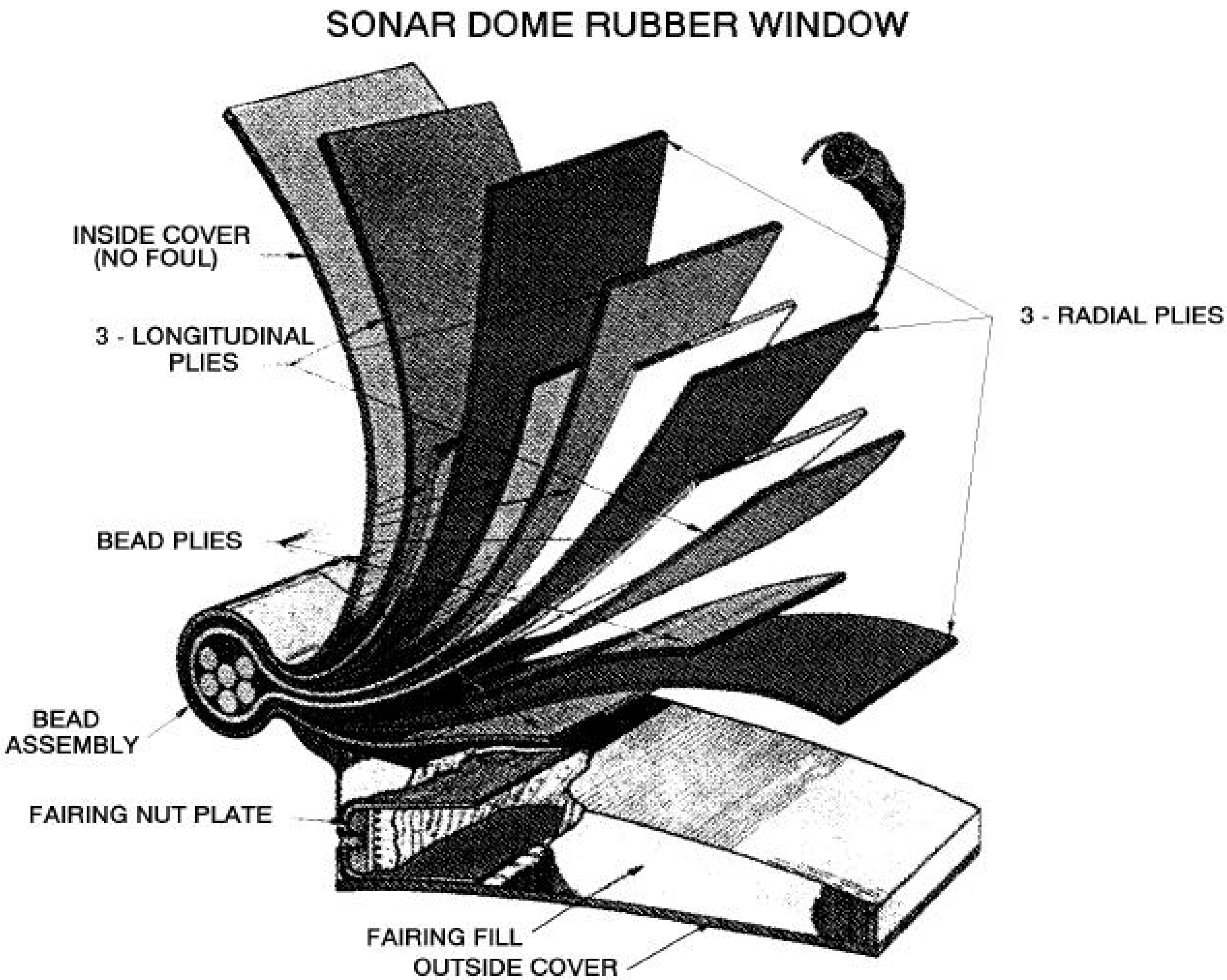

Figure 6. Surface Ship Rubber Sonar Dome Layers.

Table 1. Types and Characteristics of Sonar Domes[1,2,7]

Sonar Type	Ship Class	No. of Vessels	Dome Material	Dome Water Volume (gal, approx.)	Discharge Volume per Event (est.)
AN/SQS-53	CG 47, DDG 51, DD 963, DDG 993	80	Rubber/TBT	24,000	30,000
AN/SQS-26	CGN 36, 38	3	Rubber/TBT	24,000	30,000
AN/SQS-56	FFG 7	43	Rubber/TBT	5,000 *	6,000
AN/BQQ-5	SSN 688 (through 750), SSN 637, SSN 671	47	GRP or steel	35,000	35,000
AN/BQQ-6	SSBN 726	17	GRP or steel	74,000	74,000
AN/BQR-7	SSN 640	2	GRP or steel	35,000	35,000
AN/BSY-1	SSN 688 (from 751)	23	GRP or steel	35,000	35,000
EM100	MSC T-AGS 51	2	GRP	N/A *	N/A (free flood)
EM1000	MSC T-AGS 60 (62 & 63)	2	GRP	N/A *	N/A (free flood)
EM121A	MSC T-AGS 60	4	GRP	300	300**
SEABEAM	MSC T-AGS 26	2	GRP	511	300**
TC-12NB	MSC T-AGS 60	4	GRP	25	300**
TR-109	MSC T-AGS 60	4	GRP	75	300**

* Filled with seawater
** 300 gallons is representative of the two larger sonar dome types on MSC ships

Table 2. Sonar Dome Materials[1,2]

Component/Compound	External to dome		Internal to dome	
	Surface Ships	Submarines	Surface Ships	Submarines
Tributyltin	X		X	
Copper-nickel piping			X	X
Tin (other than TBT, DBT, MBT)			X	X
Zinc anodes			X	X
Glass-reinforced plastic	X	X	X	X
Steel components	X	X	X	X
Epoxy-based paints		X	X	X
Rubber	X	X	X	X
Antifouling paint (Cu & other based)	X	X		

Note: Not all surface ships have TBT internal or external to the sonar dome(s).

Table 3. Ships With TBT-Free Sonar Dome Interiors[1,2]

Class	Vessels in Class	Number in Class
CG 47 Class	CG 51, CG 73	2 of 27 ships
DD 963 Class	DD 972, 979, 987	3 of 31 ships
DDG 51 Class	DDG 54, 56-67, 69, 71, 74	16 of 18 ships
DDG 993 Class	DDG 993	1 of 4 ships
T-AGS 26, 51, 60 Classes	All	8 of 8 ships
SSNs & SSBNs	All	89 of 89 vessels

Based on equipment experts and sampling analysis results.

Table 4. Annual Sonar Dome Interior Discharge by Ship Class[1,2,4,5,6]

Ship Class	Total Ships	Ships with Internal TBT	Gallons per Drainage Event (est.)	Drainage Events per Year	Gallons per Year (ships with internal TBT*)	Gallons per Year (all vessels)
CG 47	27	25	30,000	2	1,500,000	1,620,000
CGN 36	2	2	30,000	2	120,000	120,000
CGN 38	1	1	30,000	2	60,000	60,000
DDG 51	18	3	30,000	2	180,000	1,080,000
DD 963	31	28	30,000	2	1,680,000	1,860,000
DDG 993	4	3	30,000	2	180,000	240,000
FFG 7	43	20	6,000	2	240,000	516,000
T AGS	8	0	300	2	0	4,800
SSN 637	13	0	35,000	1	0	455,000
SSN 640	2	0	35,000	1	0	70,000
SSN 671	1	0	35,000	1	0	35,000
SSN 688	56	0	35,000	1	0	1,960,000
SSBN 726	17	0	74,000	1	0	1,258,000
TOTAL:	**223**	**82**	**N/A**	**N/A**	**3,960,000**	**9,278,800**

* Could have TBT inside sonar dome, based on Table 6.
N/A = not applicable

Table 5. Tributyltin Release Rates from Exterior of Sonar Domes[3]

Sampled Vessel	Sample Date	Tributyl tin (TBT) Release Rate	
		$\mu g/cm^2/day$	grams/day
DDG 53 USS John Paul Jones	12-96	0.89	0.62
CG 59 USS Princeton	12-96	0.06	0.09
DD 976 USS Merrill	12-96	0.14	0.10
Average:		**0.36**	**0.27**

Table 6. Constituent Concentrations in Sonar Dome Interior Discharge (parts per billion, or μg/L, except as noted)[3,4,5]

Vessel	Date of Sample	Tributyl-tin (TBT)	Dibutyl-tin (DBT)	Mono-butyltin (MBT)	Copper	Nickel	Tin	Zinc	Chemical Oxygen Demand	Total Suspended Solids	Total Organic Carbon
CGN 40 USS Mississippi	2-7-94	85	-	-	-	-	-	-	-	-	-
DDG 52 USS John Barry	3-28-94	470	-	-	-	-	-	-	-	-	-
FF 1079 USS Bowen	4-1-94	82	-	-	-	-	-	-	-	-	-
CGN 37 USS South Carolina	5-23-94	-	-	-	-	-	-	-	170***	-	-
CGN 37 USS South Carolina	5-23-94	-	-	-	-	-	-	-	120***	-	-
CGN 37 USS South Carolina	5-23-94	-	-	-	-	-	-	-	20***	-	-
CGN 37 USS South Carolina	5-23-94	-	-	-	-	-	-	-	180***	-	-
DD 968 USS Radford	6-30-94	58	-	-	-	-	-	-	-	-	-
DD 968 USS Radford	6-30-94	35	-	-	-	-	-	-	-	-	-
CG 48 USS Yorktown	7-7-94	58	-	-	-	-	-	-	-	-	-
CG 74 USS Ticonderoga	7-25-94	48	-	-	-	-	-	-	-	-	-
DD 988 USS Thorn	8-26-94	41	-	-	-	-	-	-	-	-	-
DD 963 USS Spruance	12-1-94	14	33	5	-	-	-	-	-	-	-
DD 984 USS Leftwich	10-94	-	-	-	920	660	<DL	110	-	-	-
SSN 648 USS Aspro	11-94	-	-	-	220	<DL	<DL	5390	-	-	-
SSN 717 USS Olympia	11-94	-	-	-	220	<DL	<DL	1040	-	-	-
CG 73 USS Port Royal	1-95	-	-	-	1350	300	<DL	1520	-	-	-
SSN 672 USS Pintado	2-95	-	-	-	190	<DL	250	1870	-	-	-
SSN 697 USS Indianapolis	3-95	-	-	-	160	<DL	190	2370	-	-	-
FFG 37 USS Crommelin	4-95	-	-	-	<DL	<DL	210	<DL	-	-	-
DDG 53 USS John Paul Jones	4-95	-	-	-	660	140	<DL	2900	-	-	-
FFG 37 USS Crommelin	5-95	-	-	-	190	160	<DL	1010	-	-	-
SSN 724 USS Louisville	6-95	-	-	-	<DL	<DL	160	130	-	-	-
SSN 677 USS Drum	7-95	-	-	-	130	<DL	260	5310	-	-	-
SSN 715 USS Buffalo	8-95	-	-	-	<DL	<DL	240	<DL	-	-	-

Table 6. (Continued)

Vessel	Date of Sample	Tributyl-tin (TBT)	Dibutyl-tin (DBT)	Mono-butyltin (MBT)	Copper	Nickel	Tin	Zinc	Chemical Oxygen Demand	Total Suspended Solids	Total Organic Carbon
CG 65 USS Chosin	9-95	-	-	-	1630	590	<DL	2130	-	-	-
DDG 59 USS Russell	12-95	-	-	-	<DL	<DL	<DL	180	-	-	-
DD 979 USS Conolly	1-31-96	-	-	-	-	-	-	-	-	<4***	5***
DD 979 USS Conolly	1-31-96	-	-	-	-	-	-	-	-	<4***	6***
DD 979 USS Conolly	1-31-96	-	-	-	-	-	-	-	-	<4***	5***
DD 979 USS Conolly	1-31-96	-	-	-	-	-	-	-	-	<4***	4***
DDG 60 USS Hamilton	1-96	-	-	-	180	<DL	<DL	8300	-	-	-
SSN 675 USS Bluefish	1-96	-	-	-	<DL	500	1100	260	-	-	-
DDG 60 USS Hamilton	1-96	-	-	-	450	<DL	<DL	880	-	-	-
SSN 717 USS Olympia	3-96	-	-	-	100	<DL	290	570	-	-	-
SSN 715 USS Buffalo	3-96	-	-	-	<DL	<DL	280	830	-	-	-
FFG 57 USS Reuben James	5-96	-	-	-	<DL	<DL	100	300	-	-	-
SSN 752 USS Pasadena	6-96	-	-	-	<DL	130	280	<DL	-	-	-
SSN 680 USS Wm H. Bates	6-96	-	-	-	<DL	100	310	220	-	-	-
DDG 56 USS John McCain	9-96	-	-	-	120	<DL	<DL	630	-	-	-
DDG 53 USS John Paul Jones	12-96	36.67	-	-	-	-	-	1500	-	-	-
CG 59 USS Princeton	12-96	30.53	-	-	-	-	-	2600	-	-	-
DD 976 USS Merrill	12-96	0.62	-	-	-	-	-	800	-	-	-
DD 984 USS Leftwich	12-96	2.8	-	-	-	-	-	-	-	-	-
MINIMUM*		**1**	**N/A****	**N/A****	**50**	**50**	**50**	**50**	**20*****	**<4*****	**4*****
MAXIMUM		**470**	**N/A****	**N/A****	**1,630**	**660**	**1100**	**8,300**	**180*****	**<4*****	**6*****
AVERAGE*		**74**	**33****	**5****	**303**	**145**	**194**	**1577**	**123*****	**<4*****	**5*****

A hyphen (-) denotes the sample was not analyzed for that parameter
DL = detection limit (50 µg/L)
N/A = not applicable
* Measurements below Detection Limit (DL) were set equal to the DL
** DBT and MBT based on only one sample
*** Units are mg/L

Table 7. Estimated Sonar Dome Mass Loadings

Constituent	Loading (lbs/yr)	Discharge Origin	
		External	Internal
Copper	23.4		X
Nickel	11.2		X
Tin	15.0		X
Zinc	121.9		X
TBT	2.4		X
TBT	12.6	X	
DBT	1.1		X
MBT	0.2		X

Table 8. Comparison of Measured Values in Sonar Dome Interior Discharge with Water Quality Criteria (μg/L)

Constituent	Mean / Max Reported Concentration	Federal Acute WQC	Federal Chronic WQC	Most Stringent State Acute WQC	Most Stringent State Chronic WQC
TBT	74 / 470	0.37[a]	0.01[a]	0.001 (VA)	0.001 (VA)
Copper	303 / 1,630	2.4	2.4	2.4 (CT, MS)	2.4 (CT, MS)
Nickel	145 / 660	74	8.2	8.3 (FL, GA)	7.9 (WA)
Zinc	1,577 / 8,300	90	81	84.6 (WA)	76.6 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

CT = Connecticut
FL = Florida
GA = Georgia
MS = Mississippi
VA = Virginia
WA = Washington

[a] Proposed water quality criteria, August 7, 1997

Table 9. Data Sources

NOD Report Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation	Navy 3M MRC*			X
2.2 Releases to the Environment	Navy 3M MRC*			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	Design Documentation		X	X
3.3 Constituents	Naval Shipyards			X
3.4 Concentrations	NRaD San Diego			
4.1 Mass Loadings	NRaD San Diego		X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species				X

* MRC: Maintenance Requirement Card

NATURE OF DISCHARGE REPORT

Steam Condensate

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes steam condensate discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Many surface ships in the Navy and Military Sealift Command (MSC) use steam from shore facilities when in port to operate auxiliary systems, such as laundry facilities, heating systems, and other hotel services.[1] Shore steam is piped above ground from land based boiler plants at pressures between 100 and 150 pounds per square inch (psi) to connections on the pier. The steam is routed via hoses from pier connections to topside connections on the ships.[1] Within the ship, the steam is routed through the ship's auxiliary steam lines to the equipment. The heat exchangers and shipboard piping are usually fabricated of copper/nickel alloy and carbon steel, but can also contain titanium, copper, or nickel. Steam distribution systems on all naval ships use comparable designs and consistent standards for system materials; therefore, there is little variation in steam distribution and condensate collection system design between ships. In the process of supplying heat to the ship systems, the steam cools and most condenses into water. This condensed water is referred to as condensate.

The condensate passes through a series of traps and orifices and collects in insulated drain collection tanks in the lowest points of the machinery spaces. The tanks are usually made of carbon steel or galvanized carbon steel. When a ship is making its own steam, the condensate in these drains is recycled as boiler feedwater. When taking on shore steam, this condensate is discharged overboard because shore facilities do not have infrastructure to receive returned condensate from ships. The condensate normally is pumped to a topside riser connection for discharge overboard. The overboard discharge pump is controlled automatically, by means of a float switch or similar device in the collection tank. In limited cases, the condensate is combined with non-oily machinery wastewater in the non-oily machinery wastewater drain tank for discharge overboard below the waterline. Discharge of steam condensate as a component of non-oily machinery wastewater is discussed in the non-oily machinery wastewater NOD report.

The naval facilities that provide shore steam to ships are designed and operated in accordance with Navy standards.[2] These facilities are required to sample and test shore steam and provide certification to ships that the steam meets the following requirements:[3]

- pH — 8.0 to 9.5
- conductivity — 25 μmho/cm^2 max. (micromhos per square centimeter)
- dissolved silica — 0.2 ppm max. (parts per million)
- hardness — 0.10 epm max. (equivalents per million)
- total suspended solids — 0.10 ppm max.

2.2 Releases to the Environment

Steam condensate discharge can contain metals or treatment chemicals entrained in or eroded from the shore facilities and ships' steam systems. Steam condensate is discharged at elevated temperatures relative to the receiving waters. The discharge can be periodic or continuous based on the condensate flow rate, size of the condensate collection tank, and design of the collection tank's pumping control system. The discharge occurs 5 to 10 feet above the waterline. A portion of the condensate flashes into steam when discharged at ambient air pressure.

2.3 Vessels Producing the Discharge

Currently 179 Armed Forces surface ships discharge steam condensate. The classes and numbers of Navy and MSC ships that discharge shore-supplied steam condensate overboard are listed in Table 1. Submarines do not take on shore steam and do not discharge steam condensate because the design of their steam systems do not provide shore steam connections. The U.S. Coast Guard (USCG) does not discharge steam condensate because USCG vessels run their auxiliary boilers on a continuous basis. Also, most USCG homeports do not have readily available shore steam.[1] Army, Air Force, and Marine Corps vessels do not discharge steam condensate in port.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Steam condensate is discharged only in port when shore steam is supplied to ships. There are 179 ships that produce steam condensate discharge located in 10 ports along the coastal U.S. The larger ships producing this discharge are located in the ports of Norfolk, VA, Mayport, FL, San Diego, CA, Pearl Harbor, HI, and Everett and Bremerton, WA. In some ports, the ships are at several locations within the port instead of being centered at one set of piers.

3.2 Rate

The discharge rate of steam condensate is directly related to the amount of shore steam provided per hour to a ship. Table 2 provides the total estimated heating load for each ship class. These loads were obtained from a handbook on dockside utilities and reflect the sum of the constant (year round, such as, galley, laundry, hot water) and intermittent (seasonal) heating loads for the ship.[2] This handbook contains estimated steam load requirements for various ship classes at 10, 30, 50 and 70 degrees Fahrenheit (°F). For estimating purposes, the condensate discharge volumes were based on an average outside air temperature of 50 °F (Table 2). A survey of meteorological data indicates that the 50 °F data is estimated to represent the average outside air temperature of most naval ports. Column (b) in Table 2 shows the equivalent number of gallons per year of condensate discharged at 180 °F that was obtained by applying the appropriate conversion factors to the figures in Column (a) and multiplying it by the number of days in port as listed in Table 1 (taken from the Ship Movement Data[4]) as shown below.

Condensate Drain, gal/yr = (Loads, lbs/hr)(0.12 gal/lb)(24 hr/day)(No. of days in port per year)

Column (c) is obtained by multiplying the figures in Column (b) by the number of ships in the class. Condensate flow rates for ships where steam requirement data was unavailable were interpolated based on the ship's size and similarities to other ship classes. Based upon the calculations presented in Table 2 for an average air temperature of 50 °F, the average steam condensate flow rate for all ship classes is 4,500 gallons per day per ship. As mentioned in Section 2.2, a small portion of the condensate will flash to steam as it is discharged; however, no data are available to determine the exact amount of the discharge that is steam. Therefore, to provide an upper bound on the flow that will enter the water, it is assumed that all of the discharge will be water.

3.3 Constituents

Steam condensate is primarily water that contains materials from the shore steam piping, ship piping, and heat exchangers and boiler water chemicals. This discharge was sampled for constituents that had a potential for being in the discharge. Based on the steam condensate process, system designs, and analytical data available, analytes in the metals, organics, and classicals classes were tested.[1,5] Sampling was conducted on the LHD 1, CG 68, LSD 51, and T-AO 198 in accordance with the Rationale for Discharge Sampling Report.[5] The results of the sampling are provided in reference 6. Table 3 provides a list of all constituents and their concentrations that were detected in the discharge. Discharges of steam condensate are expected to be warmer than ambient water temperatures with a maximum overboard discharge temperature of 180 °F because this is the maximum operational temperature that condensate discharge pumps can withstand.

Antimony, arsenic, cadmium, copper, lead, nickel, selenium, thallium, zinc, benzidine and bis(2-ethylexyl) phthalate are priority pollutants that were detected in this discharge. There were no bioaccumulators detected in this discharge.

3.4 Concentrations

The concentrations of detected constituents are presented in Table 3. This table shows the constituents, the log-normal mean, the frequency of detection for each constituent, the maximum and minimum concentrations, and the mass loadings for each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for nondetected results.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on the discharge volume estimates developed in Table 2, mass loadings are presented in Table 3. Table 4 is present in order to highlight constituents with log-normal mean concentrations that exceed water quality criteria. A sample calculation of the estimated annual mass loading for copper is shown here:

Mass Loading for Copper (Dissolved)
Mass Loading = (Net Positive Log-normal Mean Concentration)(Flow Rate)
(13.44 μg/L)(3.785 L/gal)(296,000,000 gal/yr)(g/1,000,000 μg)(lb/453.593 g) ≅ 33 lbs/yr

4.2 Environmental Concentrations

The constituent concentrations in the steam condensate discharge and their corresponding Federal and the most stringent state water quality criteria (WQC) are listed in Table 5. The copper and nickel concentrations exceed the Federal and the most stringent state WQC. Ammonia, nitrogen (as nitrate/nitrite and total kjeldahl nitrogen), and phosphorous exceeds the Hawaii WQC. Benzidine and bis(2-ethylhexyl) phthalate exceed the Georgia WQC.

4.3 Thermal Effects

The potential for steam condensate to cause thermal environmental effects was evaluated by modeling the thermal plume generated by the discharge and then comparing the model results to state thermal discharge water quality criteria. Thermal plumes from steam condensate discharge were modeled primarily using the Cornell Mixing Zone Expert System (CORMIX) model. Additional modeling of discharge plume characteristics was conducted using CH3D, a three-dimensional hydrodynamic and transport model. The models were used to estimate the plume size and temperature gradients in receiving water bodies.[7, 8] Modeling was performed for discharges from an aircraft carrier (CVN – 68 Class) and an underway replenishment vessel (AOE-1 Class).

The discharge plumes were modeled for the Navy ports in Norfolk, VA and Bremerton, WA. Virginia and Washington State are the only states that have established thermal mixing zone criteria in the form of allowable plume dimensions and ambient temperature increases in the receiving water body. Other coastal states require thermal mixing zones be established on a case-by-case basis during the discharge permitting process, taking into account site- and discharge-specific information. Typically, criteria are developed to restrict the increase in the ambient water temperature and the extent of the plume in the water body to limit the duration of exposure for organisms passing through the plume, to prevent mortalities of bottom-dwelling organisms, and to prevent long-term effects such as migratory or community changes. State criteria for Virginia and Washington are summarized in Table 6.

The Virginia thermal regulations state that the discharge shall not cause the receiving ambient water temperature to increase by more than 3 °C at the edge of an allowable mixing zone. Virginia's allowable mixing zone for a thermal plume permits the plume to extend over no more than one-half the width of the receiving watercourse. In addition, the plume shall not extend downstream a distance greater than five times the width of the receiving watercourse at the point of discharge.[7]

The Washington thermal criteria vary depending upon the waterbody classification established by the State. The water in the vicinity of the Navy port at Bremerton has been classified by Washington as a Class A waterbody. The State thermal criteria for a Class A waterbody requires that discharges shall not result in the receiving water temperature exceeding 16 °C at the edge of an allowable mixing zone. If the water temperature exceeds 16 °C due to natural conditions, no discharge shall raise the receiving water temperature by greater than 0.3 °C at the edge of an allowable mixing zone. If the water temperature does not exceed 16 °C due to natural conditions, the Washington criteria provide a formula to determine the allowable incremental temperature increase at the mixing zone boundary. Washington has established the mixing zone to permit the plume to extend over a horizontal distance no greater than 200 feet plus the depth of the water over the discharge point, and no greater than 25% of the width of the water body.[7]

The aircraft carrier and amphibious vessel were modeled for Norfolk in winter conditions because these situations result in the greatest steam condensate discharge. Modeling for Bremerton was performed for all months of the year because, while cold (i.e., winter) conditions result in the greatest flow rate, the warm (i.e., summer) conditions result in the lowest allowable temperature increase.

Based on the CORMIX modeling, steam condensate discharges do not exceed Virginia thermal mixing zone criteria. CORMIX model predictions do indicate that steam condensate discharge from an aircraft carrier into the inlet in Bremerton can exceed Washington's thermal mixing zone criteria. The model predictions indicate that the discharge from AOE-1 Class vessels are not expected to exceed criteria. The AOE-1 Class is the next largest generator of steam condensate typically found in Bremerton.

There are several real-world considerations applicable to this discharge that CORMIX is not designed to simulate. These limitations result in over-conservative predictions. Such considerations include the effect of tidal action and turbulent mixing beyond the plunge zone (i.e. area of initial mixing from a discharge above the waterline) on the discharge plume. The additional mixing from tidal action and turbulence would be expected to reduce plume size. In addition, when applied to steam condensate discharge, CORMIX underestimates the initial mixing that occurs when the discharge enters the water. Since the version of CORMIX used for this exercise is designed for submerged release, the modeling effort was performed assuming the discharge hose touches the water surface. The fact that the discharge is known to occur 5-10 feet above the surface could not be simulated. The result is that the entry velocity assigned by CORMIX, based on flow rate and discharge pipe diameter, does not reflect accurately the true entry velocity, which is expected to be greater due to the acceleration from gravity. With higher entry velocities, the initial mixing would be greater and the plume size would be smaller. To illustrate, the CORMIX prediction for Bremerton Harbor estimates a plume depth of only 4 cm based on an initial discharge velocity of 1.67 meters per second (m/s). If the acceleration due to gravity from a 5-10 foot drop were considered, the entry velocity would increase significantly, to 5.7 m/s. The resulting plume depth would be considerably deeper and would result is more mixing with receiving water. Another occurrence that the CORMIX model can not simulate is the loss of heat to the atmosphere, especially during free-fall.

Because of the CORMIX model limitations for this discharge, the Navy and EPA modeled the steam condensate thermal plume from an aircraft carrier in Bremerton Harbor using the hydrodynamic and transport model CH3D. CH3D is expected to predict more accurately the plume dimensions than CORMIX because CH3D simulates the mixing of the buoyant plume with ambient flows by ways of advection and turbulent mixing both horizontally and vertically in the water column. CH3D is still expected to provide an overestimate of the plume size because this model does not account for the full extent of initial mixing in the plunge zone. CH3D estimates that the thermal plume for an aircraft carrier moored at the pier at Bremerton would extend a distance of 80 m from the discharge port along the vessel hull, not extending past the end of the hull. The plume would also extend outward no more than a distance of 30 m from the vessel hull at any point along the hull. CH3D predicts that, during the first 24 hours after discharge, the plume would cover only 5% of the width, 2% of the length, and 0.07% of the total surface of Sinclair Inlet.

Although the modeling described above indicates that the thermal plume from steam condensate released from an aircraft carrier may exceed Washington criteria in a small, localized area, the EPA and Navy do not consider that the plume results in a significant environmental impact. Such a localized plume would have a low potential for interfering with the passage of aquatic organisms in the water body and would have a limited impact on the organisms that reside in the upper water layer (sea surface boundary layer). In addition, because the discharge is freshwater (no salinity) and warmer than the receiving water, the plume floats in the surficial layer of the water body and has no impact on bottom-dwelling organisms. Therefore, EPA and DOD do not consider that the thermal loads from steam condensate discharge have the potential to cause an adverse environmental impact.

4.4 Potential for Introducing Non-Indigenous Species

This discharge does not present the potential for the transport of non-indigenous species because: the source of the steam is potable water from the same geographic area; it is discharged in the same vicinity; and it enters the ship as steam above 212 °F.

5.0 CONCLUSIONS

Steam condensate discharge has a low potential to cause an adverse environmental impact. This conclusion is based on the following two findings:

1) Although concentrations of copper, nickel, benzidine, bis(2-ethylhexyl) phthalate, phosphorous, and nitrogen exceed the most stringent water quality criteria, the mass loadings for these constituents are small. The distribution of the ships among several ports and within the ports themselves disperses the discharge (multiple discharge points) into a variety of receiving waters.
2) There are only two states that have established thermal mixing zone criteria in the form of codified plume dimensions (Washington and Virginia). The thermal criteria of other coastal states require thermal mixing zones be established on a case-by-case basis during the permitting process. The discharge is predicted to meet Virginia and Washington State thermal criteria with the exception of an aircraft carrier in the port at Bremerton, Washington.. However, conservative modeling of discharge from an aircraft carrier at Bremerton predicts thermal plumes that would cover only 5% of the width, 2% of the length, and 0.07% of the total surface of Sinclair Inlet. Since the plume is restricted to such a localized area, the EPA and DoD do not consider that the plume results in an adverse environmental impact and no further analyses are required.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Information from a military handbook on dockside services was used to calculate the rate of discharge. Sampling data from four surface ships provided concentrations, and mass loadings were calculated from the rate and the concentrations. Table 7 shows the sources of data used to develop this NOD report.

<u>Specific References</u>

1. UNDS Equipment Expert Meeting Minutes - Steam Condensate Drain, September 12, 1996.

2. Military Handbook - 1025/2, Dockside Utilities for Ship Service, 1 May 1988.

3. Naval Ship's Technical Manual (NSTM), Chapter 220, Vol. 2, Revision 7, Boiler Water/Feed Water Test & Treatment. pp 22-6, 22-7, and 22-50. December 1995.

4. Pentagon Ship Movement Data for Years 1991-1995, March 4, 1997.

5. UNDS Rationale for Discharge Sampling, Undated.

6. UNDS Phase I Sampling Data Report, Volumes 1-13, October 1997.

7. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 1997.
8. NAVSEA. Supplemental Thermal Effects Analysis. March 1999.

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Rawson, K.J.; and E.C. Tupper. Basic Ship Theory 2, Second Edition, Longman Group London and New York. 1978.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

Summary of Meteorological Data to Determine Air and Water Temperatures, October 1997.

UNDS Ship Database, August 1, 1997.

Table 1. Vessel Classes Generating Steam Condensate Discharge

VESSEL CLASS	VESSEL DESCRIPTION	QUANTITY OF VESSELS PER CLASS	NUMBER OF DAYS IN PORT PER YEAR
CVN 68	Nimitz Class Aircraft Carriers	7	147
CV 63	Kitty Hawk Class Aircraft Carriers	3	137
CVN 65	Enterprise Class Aircraft Carriers	1	76
CV 59	Forrestal Class Aircraft Carriers	1	143
CG 47	Ticonderoga Class Guided Missile Cruisers	27	166
CGN 38	Virginia Class Guided Missile Cruiser	1	161
CGN 36	California Class Guided Missile Cruisers	2	143
DDG 993	Kidd Class Guided Missile Destroyers	4	175
DD 963	Spruance Class Destroyers	31	178
AGF 11	Austin Class Miscellaneous Command Ship	1	183
AGF 3	Raleigh Class Miscellaneous Command Ship	1	183
LCC 19	Blue Ridge Class Amphibious Command Ship	2	179
LHD 1	Wasp Class Amphibious Assault Ship	4	185
LHA 1	Tarawa Class Amphibious Assault Ship	5	173
LPH 2	Iwo Jima Class Amphibious Assault Ship	2	186
LPD 4	Austin Class Amphibious Transport Docks	3	178
LSD 49	Harpers Ferry Class Dock Landing Ships	3	170
LSD 41	Whidbey Island Class Dock Landing Ships	8	170
LSD 36	Anchorage Class Dock Landing Ships	5	215
MCM 1	Avenger Class Mine Countermeasures Vessels	14	232
T-AE 26	Kilauea Class Ammunition Ships	8	26
T-AFS 1	Mars Class Combat Stores Ships	8	148
AO 177	Jumboised Cimarron Class Oilers	5	188
T-AO 187	Henry J. Kaiser Class Oilers	12	78
AOE 1	Sacramento Class Fast Combat Support Ships	4	183
AOE 6	Supply Class Fast Combat Support Ships	3	114
T-AG 194	Mission Class Navigation Research Ships	2	151
T-AGM 22	Compass Island Class Missile Range Instrumentation Ships	1	133
T-ARC 7	Zeus Class Cable Repairing Ships	1	8
ARS 50	Safeguard Class Salvage Ships	4	208
T-AH 19	Mercy Class Hospital Ships	2	184
AS 33	Simon Lake Class Submarine Tenders	1	229
AS 39	Emory S Land Class Submarine Tenders	3	293

Notes:
Number of days inport per year for each ship class taken from the Ship Movement Database.
Vessel classes receiving shore steam are identified in Military Handbook 1025/2, Dockside Utilities for Ship Service.

Table 2. Steam Condensate Discharge By Vessel Class At Outdoor Temperatures of 50 Degrees F

VESSEL CLASS	ACTIVE	(a) Total Heating Load in lbs/hr per vessel	(b) Condensate Drain in gallons/yr per vessel	(c) Condensate Drain in gallons/yr per vessel class
CVN 68	7	15,000	6,582,090	46,074,627
CV 63	3	13,000	5,316,418	15,949,254
CVN 65	1	15,000	3,402,985	3,402,985
CV 59	1	13,000	5,549,254	5,549,254
CG 47	27	1,100	545,075	14,717,015
CGN 38	1	3,400	1,634,030	1,634,030
CGN 36	2	3,400	1,451,343	2,902,687
DDG 993	4	1,800	940,299	3,761,194
DD 963	31	1,800	956,418	29,648,955
AGF 11	1	2,650	1,447,612	1,447,612
AGF 3	1	2,650	1,447,612	1,447,612
LCC 19	2	7,700	4,114,328	8,228,657
LHD 1	4	6,300	3,479,104	13,916,418
LHA 1	5	6,300	3,253,433	16,267,164
LPH 2	2	5,800	3,220,299	6,440,597
LPD 4	3	4,400	2,337,910	7,013,731
LSD 49	3	3,600	1,826,866	5,480,597
LSD 41	8	3,600	1,826,866	14,614,925
LSD 36	5	3,600	2,310,448	11,552,239
MCM 1	14	1,000	692,537	9,695,522
T-AE 26	8	2,300	178,507	1,428,060
T-AFS 1	8	3,350	1,480,000	11,840,000
AO 177	5	3,350	1,880,000	9,400,000
T-AO 187	12	3,350	780,000	9,360,000
AOE 1	4	5,600	3,059,104	12,236,418
AOE 6	3	5,600	1,905,672	5,717,015
T-AG 194	2	1,500	676,119	1,352,239
T-AGM 22	1	2,700	1,071,940	1,071,940
T-ARC 7	1	2,700	64,478	64,478
ARS 50	4	500	310,448	1,241,791
T-AH 19	2	500	274,627	549,254
AS 33	1	6,500	4,443,284	4,443,284
AS 39	3	6,500	5,685,075	17,055,224
			Total =	**295,504,776**

Notes:
Source: Military Handbook 1025/2, Dockside Utilities for Ship Service.
Total heating load values include constant loads and intermittent loads.
Intermittent loads were taken at 50 °F outside air temperature.
Calculations based on water at 212 °F.

Table 3. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	2.78	4 of 4	1	15	6,852
Ammonia as Nitrogen	0.18	4 of 4	0.12	0.37	444
Biochemical Oxygen Demand	6.56	3 of 4	BDL	21	16,169
Chemical Oxygen Demand (COD)	16.87	2 of 4	BDL	54	41,581
Chloride	3.60	3 of 4	BDL	14	8,873
Nitrate/Nitrite	0.44	4 of 4	0.3	0.81	1,085
Sulfate	1.98	3 of 4	BDL	3.6	4,880
Total Dissolved Solids	18.9	2 of 4	BDL	102	46,585
Total Kjeldahl Nitrogen	0.80	4 of 4	0.24	2	1,972
Total Organic Carbon (TOC)	4.07	3 of 4	BDL	12	10,032
Total Phosphorous	0.09	3 of 4	BDL	0.27	222
Total Recoverable Oil and Grease	1.15	4 of 4	0.6	2.3	2,835
Total Sulfide (Iodometric)	13.3	4 of 4	4	40	32,880
Volatile Residue	18.9	2 of 4	BDL	102	46,585
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Antimony					
Total	7.13	1 of 4	BDL	26.8	18
Arsenic					
Total	0.74	2 of 4	BDL	2.3	2
Barium					
Dissolved	1.02	1 of 4	BDL	4.4	3
Total	0.8	1 of 4	BDL	1.65	2
Cadmium					
Total	2.86	1 of 4	BDL	6.1	7
Calcium					
Dissolved	98.6	3 of 4	BDL	336	243
Total	146	4 of 4	61.6	334	359
Copper					
Dissolved	13.4	2 of 4	BDL	49.0	33
Total	20.1	3 of 4	BDL	91.0	49
Iron					
Dissolved	20.0	2 of 4	BDL	262	49
Total	22.6	2 of 4	BDL	527	56
Lead					
Dissolved	3.58	3 of 4	BDL	12.7	9
Total	4.38	3 of 4	BDL	18.9	11
Magnesium					
Dissolved	77.8	1 of 4	BDL	982	192
Total	77.2	1 of 4	BDL	949	190

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Manganese					
Dissolved	1.17	2 of 4	BDL	6	3
Total	2.57	4 of 4	1.85	5.1	6
Molybenum					
Dissolved	1.72	1 of 4	BDL	3.7	4
Nickel					
Dissolved	10.3	1 of 4	BDL	22	25
Total	11.6	1 of 4	BDL	34.7	28
Selenium					
Total	2.87	1 of 4	BDL	3.5	7
Sodium					
Dissolved	482	3 of 4	BDL	8220	1,188
Total	432	2 of 4	BDL	8280	1,065
Thallium					
Dissolved	1.18	2 of 4	BDL	13.3	3
Titanium					
Total	2.73	1 of 4	BDL	6.4	7
Vanadium					
Dissolved	5.25	1 of 4	BDL	10.5	13
Zinc					
Dissolved	13.94	4 of 4	7.15	21.9	34
Total	11.35	3 of 4	BDL	23.0	28
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
4-Chloro-3-Methylphenol	6.84	1 of 4	BDL	30	17
Benzidine	32.8	1 of 4	BDL	73.5	81
Bis(2-Ethylhexyl) Phthalate	19.4	2 of 4	BDL	112	48

BDL = Below Detection Limit
Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., “non-detect” samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a “non-detect” sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 4. Estimated Annual Mass Loadings of Constituents

Constituent*	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.18	4 of 4	0.12	0.37	444
Nitrate/Nitrite	0.44	4 of 4	0.3	0.81	1085
Total Kjeldahl Nitrogen	0.80	4 of 4	0.24	2	1972
Total Nitrogen[A]	1.24				3057
Total Phosphorous	0.09	3 of 4	BDL	0.27	222
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Benzidine	32.8	1 of 4	BDL	73.5	81
Bis(2-Ethylhexyl) Phthalate	19.4	2 of 4	BDL	112	48
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Copper					
Dissolved	13.4	2 of 4	BDL	49.0	33
Total	20.1	3 of 4	BDL	91.0	49
Nickel					
Dissolved	10.3	1 of 4	BDL	22	25
Total	11.6	1 of 4	BDL	34.7	28

* Mass loadings are presented for constituents that exceed WQC. See Table 3 for a complete listing of mass loadings.

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	Log-normal Mean (µg/L)	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Federal Chronic WQC (µg/L)	Most Stringent State Chronic WQC (µg/L)
Ammonia as Nitrogen	180	120	370	None	6 (HI)[A]
Nitrate/Nitrite	440	300	810	None	8 (HI)[A]
Total Kjeldahl Nitrogen	800	24	2000	None	-
Total Nitrogen[B]	1240			None	200 (HI)[A]
Total Phosphorous	90	BDL	270	None	25 (HI)[A]
Benzidine	32.8	BDL	73.5	None	0.000535 (GA)
Bis(2-Ethylhexyl) Phthalate	19.4	BDL	112	None	5.92 (GA)
Copper					
Dissolved	13.4	BDL	49.0	2.4	2.4 (CT, MS)
Total	20.1	BDL	91.0	2.9	2.9 (GA, FL)
Nickel					
Dissolved	10.3	BDL	22	8.2	8.2 (CA, CT)
Total	11.6	BDL	34.7	8.3	7.9 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington
BDL = Below Detection Limit

Table 6. Summary of Thermal Effects of Steam Condensate Discharge

Ship Modeled	Discharge Temp (°F)	Average Air Temp (°F)	Discharge Flow (gallons per hour)	Ambient Winter Water Temp (°F)	Predicted Plume Length (m)	Allowable Plume Length (m)	Predicted Plume Width (m)	Allowable Plume Width (m)
Washington State (1.5°C ΔT)								
CVN*	180	50	1,866	50	80	73	30	400
AOE	180	50	672	50	2.3	73	10**	400
Virginia (3.0°C ΔT)								
CVN	212	40	2,207	40	689	32,000	203	3,200
LCC	212	40	1,007	40	180	32,000	70.1	3,200

Note: Flow rates for Virginia were calculated based on a linear interpolation of the data available in reference 2 for 30°F and 50°F air temperature.
*Indicates CH3D model predictions after the first 24 hours after discharge. All other predictions are based on CORMIX model results.
**CORMIX output displays the plume width to the point where ΔT ≅ 0°C.

Table 7. Data Sources

	Data Sources			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment		X		X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents		X		
3.4 Concentrations		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	X
4.4 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Stern Tube Seals & Underwater Bearing Lubrication

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the stern tube seals and underwater bearing lubrication discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Vessels of the Armed Forces have one or two propeller shafts, except for aircraft carriers, which have four shafts. Stern tube seals, stern tube bearings, and intermediate and main strut bearings are components associated with the propeller shaft. Figure 1 shows the location of these components. The stern tube seals prevent seawater entry into the vessel at the inboard end of the stern tube bearing. Stern tube bearings support the weight of the propeller shaft where the shaft exits the vessel. Intermediate and main strut bearings are outboard bearings that support the weight of the propeller and shafting outboard of the vessel. Submarines do not have strut bearings. Instead, submarines have a self-aligning bearing aft of the stern tube that supports the weight of the propeller. Both stern tube and strut bearings are constructed with a bronze backing, and lined with rubber strips (called staves), or babbitt metal. Babbitt is an alloy of tin and lead and is commonly used as a bearing material. However, babbitted bearings are oil lubricated and the lube oil is circulated in a closed system with no discharge to the environment. Babbitt wear material is collected in the oil filter of stern tube oil lubricated systems. Depending on the vessel type, lubrication for the stern tube seals, stern tube, and strut bearings is accomplished by seawater, freshwater, or oil.[1]

Some small boats and crafts use surrounding seawater for cooling and a greased bearing for lubrication. As such, the surrounding seawater is at a greater pressure than the greased bearing on small boats, and if there is any leakage, seawater will leak into the bilge of the small boat instead of the grease being discharged to the surrounding seawater. Any grease released into the bilge of small boats and crafts is discussed in the Surface Vessel Bilgewater/OWS Discharge NOD report.

2.1.1 Seawater Lubrication

Seawater lubrication is used in all Navy and U.S. Coast Guard (USCG) vessels. Seawater is supplied from either the firemain or auxiliary machinery cooling water system on surface ships and is supplied from the auxiliary seawater system on submarines. Submarines flood their trim tanks with seawater and use this water to cool and lubricate the stern tube seals while in port. For all surface ships and submarines, seawater enters a seal cavity, where some of it is used to lubricate the seal faces. The remainder passes aft through channels between staves in the stern tube bearing, cooling and lubricating the bearing, and finally exiting to the sea at the aft end of the bearing. Seawater flow through the stern tube bearing is maintained at all times, except when conducting maintenance or disassembly, regardless of whether the vessel is in port or underway. The residence time of the seawater flow is short. For example, the residence time of water in the stern tube of a DDG 51 Class ship is approximately 13 seconds.[2] Similar short residence times for stern tube lubricating water on other vessel classes is expected. Strut bearings are not provided with forced cooling or lubrication. Instead, strut bearings use the surrounding seawater flow for lubrication and cooling when the vessel is underway.

On surface vessels, copper-nickel alloy (70% copper/30% nickel) piping is normally used for the stern tube seal lubrication system. On submarines, nickel/chromium piping is used. The lubricating seawater also comes into contact with the propeller shaft, bearing surfaces, zinc anodes, bearing staves, the seals, and bearing bushings.

Shafts are made of forged steel. Bearing surfaces are sleeved with copper-nickel (80% copper / 20% nickel) or fiberglass. Zinc anodes provide corrosion protection in the bearing housings. Stern tube and strut bearing staves are made of bonded synthetic rubber (typically Buna-N (nitrile)). The estimated life of the staves is 5 to 7 years. Although the staves surround the shaft on all sides, the bottom staves (approximately 40% of the staves) support the shaft weight and are susceptible to maximum wear. In submarines, the wear rate of the rubber is approximately 10 to 20 mils (one mil equals 0.001 inch) per year. In surface vessels with controllable pitch propellers, the wear rate is 40 mils per year, and in surface vessels with fixed pitch propellers, the wear rate is 20 to 30 mils per year.[3]

The rotating seat of a typical stern tube seal on a surface vessel is made of phosphor bronze (an alloy of bronze and phosphorous). The stationary face insert was originally made of Teflon-impregnated asbestos. However, a majority of the asbestos components have been replaced with a phenolic material.[1] Seals used in submarines are comprised of silicon carbide and carbon graphite because they are exposed to more severe operating conditions. The life of stern tube seals is approximately 5 years and they have a very small area exposed to wear, compared to the bearings. Therefore, wear products from seal components constitute a very small percentage of this discharge.

The lubricated components of a propeller shaft are shown in Figure 1. A cross-section diagram of a typical seal is provided as Figure 2.

2.1.2 Freshwater Lubrication

On very rare occasions in port, freshwater may be used for lubricating the shaft seal on submarines. This occurs on approximately four submarines per year, for one week each.[4] Normally, while a submarine is in port, shaft seal lubrication is provided from seawater stored in the submarine's trim system. After an extended in port period, this supply of seawater will eventually become depleted. At that time, freshwater is used to fill the trim system to provide shaft seal lubrication. On these occasions, a potable water fill hose from the pier is connected to the trim tank. This freshwater is typically mixed with the residual seawater in the tank (estimated at a 50% mixture of seawater and freshwater), and is used for lubricating the shaft seals. The cooling water is discharged to the sea in the manner described in Section 2.1.1.

2.1.3 Ambient Water Lubrication

All Army watercraft use ambient water for lubrication of stern tube seals and underwater bearings. Ambient water, either freshwater or saltwater, is used in all operational locations, depending upon where the vessel is located (i.e., in fresh or saltwater). Army watercraft do not use potable water for lubrication while in port and do not use pressurized water to force feed underwater bearings.

2.1.4 Oil Lubrication

A number of Military Sealift Command (MSC) vessels are fitted with oil-lubricated stern tube and strut bearings, which do not produce any of the discharge described in this report. Oil-lubricated seals exist in a variety of configurations. All have anti-pollution design features, that prevent oil from leaking to the sea under normal operating conditions.[5] On the T-AO 187 Class ships, each of the two shaft systems contains 2,300 gallons of oil. Some common system design features to prevent oil releases are:[1]

- Use of multiple sealing rings at both the inboard and outboard ends of the stern tube.
- Methods to maintain pressure in the stern tube cavity lower than the sea water pressure outside. This ensures that, in the event that the outboard seal leaks, water will leak into the cavity rather than oil leaking out. Any water which accumulates as a result of a leak into the cavity is managed as Surface Vessel Bilgewater/OWS Discharge.
- Positive methods for determining seal leakage.

2.2 Releases to the Environment

For surface vessels, this discharge consists of seawater from the firemain system or auxiliary machinery water cooling water system with the additional constituents described in Section 2.1 that are entrained as the seawater flows through the system. The lubricating water is released to the environment through the after end of the stern tube bearing. In the case of submarines, the discharge will occasionally consist of freshwater with chlorine.

2.3 Vessels Producing the Discharge

Almost all classes of surface vessels and submarines of the Armed Forces have shaft seals and bearings that require lubrication. The exceptions are a few vessel classes such as the MHC 51 Class, that use unconventional means of propulsion such as cycloidal propellers.[1] Army watercraft use packing rings to seal hull penetrations of the shaft and do not use mechanical seals for this purpose.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Flow of water through the shaft seals and stern tube bearings is maintained at all times. Therefore, this discharge occurs both within and beyond 12 nautical miles (n.m.).

3.2 Rate

3.2.1 Seawater Lubrication

For surface ships, flow rates of seawater through the stern tube bearing are approximately 2 gallons per minute (gpm) per foot of bearing length and 3 gpm for seal lubrication. The seawater flow rate through submarine shaft seals while underway is 16 gpm for SSN 688 Class and 18 gpm for SSBN 726 Class submarines. A discharge of 10 to 20 gpm per shaft is typical for most vessels.[1] For purposes of this report, a flow rate of 20 gpm has been used. It was assumed that there are 274 surface ships, each with two shafts and 89 submarines, each with one shaft. Based on operational knowledge, 5% of the vessels' underway time is spent within 12 n.m. and 50% of the vessels' time is spent pierside.[6] These are conservative estimates, because most vessels have flow rates that are lower than 20 gpm and though there are 24 four-shaft vessels in the Navy, there are 65 single-shaft vessels that were considered to be two-shaft vessels. Thus, this analysis overestimates the number of shafts producing this discharge by 17. When surface ships are idle in port, full water flow is maintained through the stern tube bearing and seals. The total annual fleetwide discharge volume was calculated as follows:

Total fleetwide annual discharge (gallons/year) = (20 gallons/minute flow rate) (60 min/hr) (24 hr/day) (365 days/year) [(274 surface ships) (2 shafts/ship) + (89 submarines) (1 shaft per submarine)] (0.55 (5% of vessel's underway time is within 12 n.m. and 50% of vessels' time is in port)) = 3,682,879,200 gal/year

3.2.2 Freshwater Lubrication

When submarines are idle in port, flow is maintained at 4 gpm for attack submarines (e.g. SSN 688 Class) and 9 gpm for Missile Submarines (e.g. SSBN 726 Class).[3,7] Approximately 81% of active submarines are attack submarines (SSNs) and 19% are ballistic missile submarines (SSBNs). Hence, the weighted freshwater flow rate per submarine is approximately (0.81)(4 gpm) + (0.19)(9 gpm) ≈ 5 gpm.

Total fleetwide annual discharge (gallons/year) = (5 gallons/minute flow rate) (60 min/hr) (24 hr/day) (7 days/year) (1 week per year) [(4 submarines) (1 shaft per submarine)] = 201,600 gal/year

3.3 Constituents

3.3.1 Seawater Lubrication

Seawater for lubrication of stern tube bearings is supplied either from the firemain or the auxiliary seawater cooling main, depending on the vessel class. Additional information on firemain systems and the seawater cooling system can be found in their respective NOD reports.

When the shaft is turning, the most likely constituent to be present in the discharge is rubber. Metals, if any, can be present in the discharge and include copper and nickel, the materials of construction of the stern tube. The priority pollutants in this discharge include copper and nickel. None of the potential constituents in this discharge are bioaccumulators.

3.3.2 Freshwater Lubrication

Because the shaft is not turning under idle conditions, there is no wearing of the bearing materials. The freshwater from the port facility is typically chlorinated for disinfection. Therefore, the discharge could contain small amounts of chlorine plus the same priority pollutants listed in Section 3.3.1. None of the potential constituents are bioaccumulators.

3.4 Concentrations

Firemain and freshwater are used to lubricate stern tube seals and bearings. The lubricating water briefly contacts the bearings and seals when compared to the rest of the firemain; the firemain piping system is much longer than the length of the stern tubes (5.5 feet each) and hence the residence time of seawater in the firemain system is much greater than the 13 second residence time in the stern tube seal and bearing lubrication system of a typical surface vessel. Freshwater data were also used.

3.4.1 Seawater Lubrication

The concentrations of the constituents, as shown in Table 2, were estimated using corrosion rates for the materials of construction, the surface area of the materials exposed to seawater, and the rate of seawater lubricating the stern tube.[2]

3.4.2 Freshwater Lubrication

Water treatment plants typically add sufficient chlorine or monochloramine so that the finished water leaving the plant has a total residual chlorine (TRC) level of approximately 2.0 mg/L.[8] As water flows through the distribution system, TRC is depleted through its bactericidal action and due to reactions with other chemicals in the water and on piping and other surfaces.

By the time the water reaches the tap, TRC levels have been reduced to approximately 1.0 mg/L. After water is taken aboard a submarine into the trim tank and before its discharge after being used as a stern tube seal lubricant, several factors cause the TRC level to continue to decline. For example, the TRC-containing freshwater is mixed with the seawater that remains in the trim tank and as a result, is diluted by about 50% based on the fact that trim tanks are about 50% full of seawater while pierside. This results in an immediate reduction of the TRC concentration to approximately 0.5 mg/L. In addition, organic matter in the residual seawater in the trim tank will cause further rapid depletion of TRC levels. Although not measured specifically, the amount of TRC in the trim tank water used to lubricate the shaft seal is likely to be at least as low as the levels measured in the freshwater used to layup condensers in submarines. TRC levels in such systems were reduced from 1.2 mg/L to 0.028 mg/L in two hours. Please refer to the Freshwater Layup NOD report for additional information. Using the average flow rate from the trim tank, it requires approximately 17 hours to drain the trim tank.

The estimated contributions of the freshwater lubrication process to the discharge are unknown but thought to be minor. This is because the shaft is not turning while pierside so there is no bearing wear. In addition, the lubricating water only contacts the lubrication system components for a short period of time because of the constant flow of water from the trim tank, through the bearing, and then to the sea. For a typical surface ship (DDG 51 Class) the residence time of water in the stern tube is approximately 13 seconds[2] and similar residence times for stern tubes on other vessel classes is expected. With residence times of this order, there is little time to accumulate erosion or corrosion products from the bearing lubrication system materials of construction.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

4.1.1 Seawater Lubrication

An estimate of the rubber discharge was made based on data for DDG 51 Class vessels. The DDG 51 Class was chosen because it is a mid-size vessel with a significant population in the fleet. The available data includes:

	Stern Tube	Strut
Bearing Length	66 inches	96 inches
Number of Staves	26	26
Stave Width	3.18 inches	3.18 inches

Using this data, the total length of rubber material exposed to wear was calculated to be 351 feet per shaft by the equation:

((66 inches + 96 inches) bearing length per shaft) (26 staves per shaft)/(12 inches per foot) = 351 feet of bearing material per shaft

DDG 51 Class ships have two shafts; therefore, the total length of bearing material per ship is 702 feet. Because DDG 51 Class ships have controllable pitch propellers, a wear rate of 40 mils (0.04 inch) on each stave occurs per year. Approximately 40% of the staves carry the weight of the shafting and thus are subjected to this wear rate. The total volume of rubber that is worn annually from the staves per ship was calculated as follows:

Volume of Rubber Per Ship = (702 feet of rubber) (3.18 inches/(12 inches/foot) width of staves) (0.04 inch/(12 inches/foot) wear depth) (0.4 percentage of staves subject to wear) = 0.25 cubic feet

The density of Buna-N (nitrile) rubber is 61.8 pounds per cubic feet (lbs/ft^3). Therefore, 15.4 pounds [(61.8 lbs/ft^3) (0.25 ft^3)] of rubber are contained in the discharge from each ship annually. Based upon the assumptions described in Section 3.2.1, ships spend approximately 5% of their underway time within 12 n.m.[6] Thus, 0.76 pound of rubber is discharged by each vessel within 12 n.m. Bearing wear does not occur while the vessel is alongside the pier or at anchor because the shafts are not turning.

Using 0.76 pound of rubber as an average for each surface ship and 0.38 pound for each submarine (due to the single shaft configuration of submarines), the total annual mass loading for 274 ships (excluding boats and crafts) and 89 submarines was calculated by the equation:

Total Annual Mass Loading of Rubber = (0.76 pound/ship) (274 ships) + (0.38 pound/submarine) (89 submarines) = 242 pounds

A total of 242 pounds of rubber is discharged annually for all vessels. This is a conservative estimate because many vessels have a wear rate of less than 40 mils per year and many surface vessels do not have two shafts.

Concentrations of rubber were then calculated as follows:

Concentration of rubber in mg/liter = (242 pounds per year) (453,600 mg/pound) / [(334,807,200 gallons per year) (3.785 liters/gallon)] = 0.09 mg/liter

The total annual mass loadings for the metal constituents of seawater lubrication was calculated based on materials of construction in the stern tube, corrosion rates for those materials, and the surface area of the material exposed to seawater for a DDG 51 Class ship. The material of construction is a copper-nickel alloy (80% copper and 20% nickel). The available data includes[2]:

> Surface area exposed to seawater = 7,254 square inches (in^2)
> Corrosion rate of copper nickel = 7.0 micrometers per year (μm/yr)
> Density of copper nickel = 8.9×10^6 grams per meter cubed (g/m^3)

Total Annual Mass Loading of Copper and Nickel = (corrosion rate) (density) (area) (percent of time within 12 n.m.) = 160.4 grams per year

Based on these analyses, one DDG 51 stern tube has the potential to discharge 128.3 grams or 0.28 pound of copper and 32.1 grams or 0.07 pound of nickel annually within 12 n.m. of shore. Applying this estimate to all vessels of the Armed Forces results in a total annual mass loading of 180 pounds of copper and 45 pounds of nickel.

4.1.2 Freshwater Lubrication

The weighted average of the freshwater flow rate to the stern tube bearings on a submarine is approximately 5 gallons per minute (19 liters per minute) when the submarine is idle in port. Assuming a 1.0 mg/L TRC concentration in the freshwater (see Section 3.4.2) and that the freshwater will be diluted by an equal amount of seawater remaining in the trim tank when the freshwater is added, the TRC mass loading per submarine per day was calculated by the equation:

TRC Mass Loading = (Freshwater flow rate) (TRC concentration) (Dilution factor) = (19 L/min) (0.001 grams/L) (50%) (60 min/hour) (24 hours/day) = 13.7 grams TRC per day per submarine

Because submarines rarely use freshwater to lubricate the shaft seal, it is assumed that there are four submarines that use this method annually for shaft seal lubrication and each for a total of one week. Based on the assumptions in Section 2.1.2, the total annual TRC mass loading for submarines was calculated by the equation:

Annual TRC Mass Loading = (13.7 grams TRC/day/sub) (7 days/year) (4 subs) = 383 grams TRC/year = 0.383 kg TRC/yr = 0.84 pounds TRC/yr

The estimated mass loadings for this discharge are provided in Table 1.

4.2 Environmental Concentrations

Table 2 shows the concentration of the priority pollutants that are present in the discharge from seawater-lubricated bearings compared to acute water quality criteria (WQC). Only copper exceeds water quality criteria. – The concentration of copper is derived from corrosion rates for copper, the surface area of the material exposed to seawater, and the rate of seawater lubricating the stern tube.

The freshwater lubrication discharge from submarines consists of freshwater that could have low concentrations of TRC. Although not measured specifically, the amount of TRC in the trim tank water used to lubricate the shaft seal is likely to be at least as low as the levels measured in the freshwater used to lay up boilers and condensers in submarines. TRC levels in such systems were reduced from 1.2 mg/L to 0.028 mg/L in two hours.

The rubber staves are abraded during the shaft rotation into small particles that do not dissolve, are relatively inert, and hence are largely not bioavailable.

4.3 Potential for Introducing Non-Indigenous Species

The transport of non-indigenous species is not a concern for this discharge because the flow through the shaft seals is continuous, the residence time of seawater is 13 seconds for a DDG 51 Class ship, and the seawater is not held on board for this purpose; therefore, there is little opportunity to transfer non-indigenous species. Similar residence times are expected for all other vessel classes.

5.0 CONCLUSIONS

The constituents in stern tube seal and underwater bearing lubrication have a low potential to cause an adverse environmental effect because:

1) Oil lubricated stern tube seals and bearings cannot release oil to the environment under normal ship operations.

2) For seawater lubricated stern tube seals and bearings, there is very little contribution of constituents to the seawater lubrication fluid from the stern tube seal system, other than rubber, copper, and nickel because of the very short time that the fluid is in contact with the stern tube seal system. Rubber is released to the environment because the rubber bearing staves wear. Copper and nickel are introduced because they are materials of construction of the stern tube. While copper concentrations can exceed chronic WQC, the mass loadings are not considered sufficient to pose an adverse environmental effect.

3) Freshwater lubricated stern tube seals and bearings are used only on submarines and only rarely (estimated to be four submarines, each for one week per year) when the seawater in the trim tanks normally used for lubrication is exhausted. The freshwater lubrication discharge TRC concentration is expected to be as least as low as the levels measured in the freshwater used to lay up condensers in submarines.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 3 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Shaft Seal Lube/Stern Tube Seals/Underwater Bearing Lubrication. September 10, 1996.

2. Personal Communication Between Miles Kikuta (MR&S) and David Kopack (SEA 00T) and Gordon Smith (SEA 03L). December 11, 1998.

3. Personal Communication Between George Stewart (MR&S) and Sanjay Chandra (Versar). April 25, 1997.

4. Personal Communication between Bruce Miller (MR&S) and LCDR Warren Jederberg, Submarine Force, Pacific Environmental Officer of 15 October, 1997.

5. Personal Communication Between George Stewart (MR&S) and Sanjay Chandra (Versar). March 14, 1997.

6. UNDS Ship Database, August 1, 1997.

7. Commander Submarine Force, U.S. Atlantic Fleet Letter 5090 Serial N451A/4270 of 13 December 1996 in Response to UNDS Data Call.

8. American Water Works Association. Optimizing Chloramine Treatment. AWWA Research Foundation, 1993.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Florida. Department of Environmental Protection. Surface Water Quality Standards, Chapter 62-302. Effective December 26, 1996.

Georgia Final Regulations. Chapter 391-3-6, Water Quality Control, as provided by The Bureau of National Affairs, Inc., 1996.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, pg 15366. March 23, 1995.

Committee Print Number 95-30 of the Committee of Public Works and Transportation of the House of Representatives, Table 1.

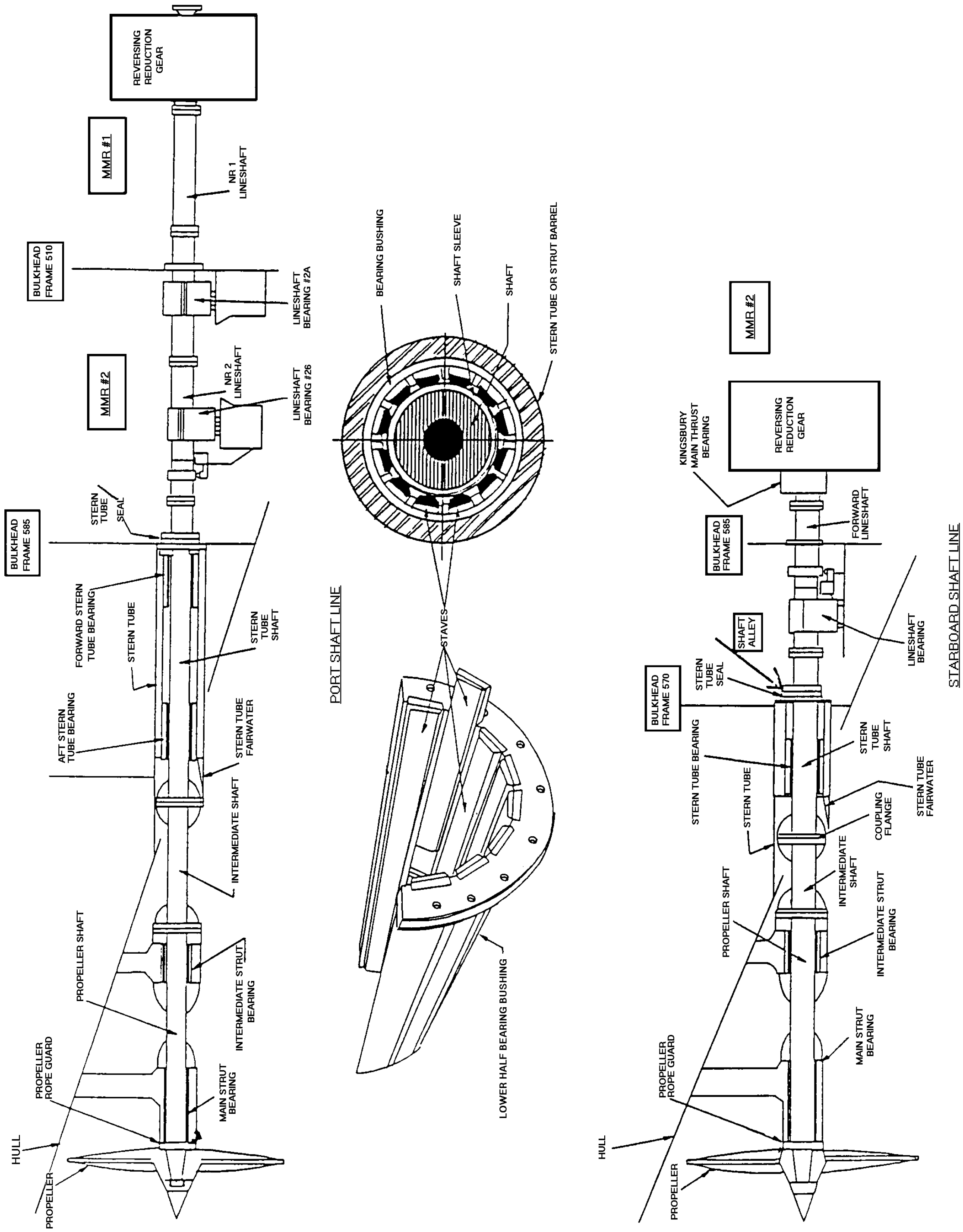

Figure 1. Port and Starboard Shaft Lines

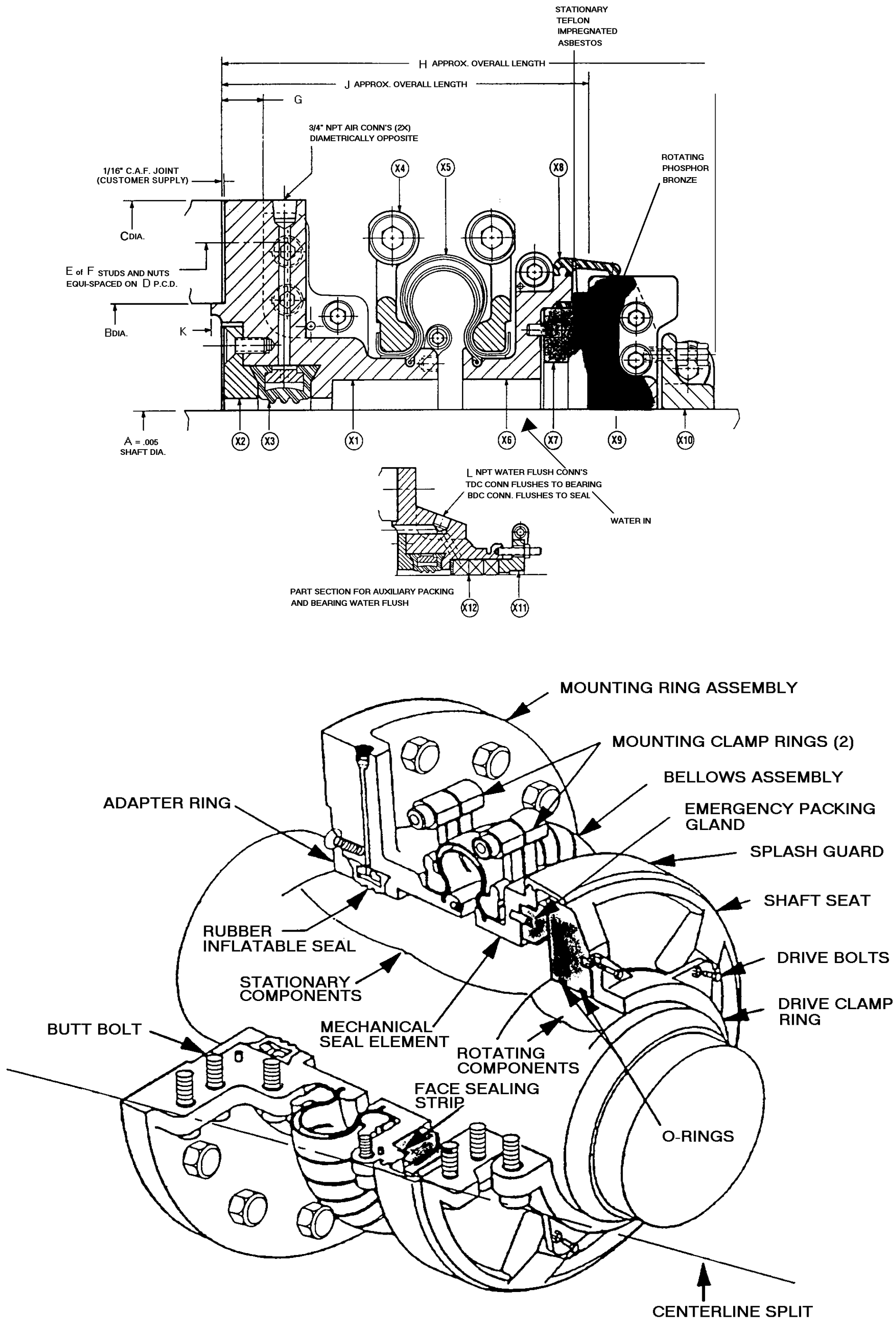

Figure 2. Type MX9 Inboard Water Lubricated Fully Split Seal

Table 1. Estimated Fleet-Wide Mass Loadings for Stern Tube Seals and Underwater Bearing Lubrication

Constituent	Estimated Mass Loadings (lbs/yr)
TRC	0.84
Rubber	242
Copper	180
Nickel	45

Table 2. Comparison of Calculated Data with Water Quality Criteria (μg/L)

Constituents	Calculated Concentration Log-normal Mean Effluent	Federal Chronic WQC	Most Stringent State Chronic WQC
TRC	NA*		7.5 (CT, HI, MS, NJ, VA, WA)
Total Copper	5.8	2.9	2.9 (FL, GA)
Total Nickel	1.5	8.3	7.9 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

CT = Connecticut
FL = Florida
GA= Georgia
HI = Hawaii
MS = Mississippi
NJ = New Jersey
VA = Virginia
WA = Washington

NA* = Not available. Concentrations estimated in Section 3.4.2.

Table 3. Data Sources

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents			X	X
3.4 Concentrations			X	X
4.1 Mass Loadings			X	X
4.2 Environmental Concentrations				X
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Submarine Acoustic Countermeasures Launcher Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the submarine acoustic countermeasures launcher discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Navy submarines are equipped with acoustic countermeasures devices that, once launched, improve submarine survivability by generating sufficient noise to be observed by hostile torpedoes, sonars, or other monitoring devices. The only acoustic countermeasure systems used by the Navy that result in a discharge are Countermeasures Set Acoustic (CSA) Mk 2 launch systems. Other countermeasures systems do not generate a discharge within 12 nautical miles because their launch tubes are always open to the ocean.[1] Countermeasures devices are launched from the CSA Mk 2 systems for training purposes.

The CSA Mk 2 system encompasses the countermeasure device, a gas generator, an externally-mounted launch tube, and all associated electronic controls for the countermeasure device. Figures 1 and 2 provide the location of the launch tubes on submarine hulls, and the location of components within the launch tube, respectively. Figure 3 shows the mechanism by which gas is captured within the launch tube. A gas generator at the rear of the launch tube provides the propulsive charge for launch of the countermeasure device. When the generator is activated, hot gasses expand, forcing a metal “ram” plate and the countermeasure device out of the launch tube. The ram plate lodges in the end of the launch tube, which forms a watertight end cap after launch. For vessel and crew safety, a check valve and bleed holes in the ram plate are used to allow equalization of internal gasses and liquids with external pressures that vary as the submarine changes depth. The one-way check valve allows seawater to flow into the tube after launch, but does not allow any of the liquids to be released through the opening. The seawater that flows into the tube mixes with the gasses generated by the ammonia perchlorate gas generation propellant, which results in an acidic liquid. The ram plate contains three 3/8-inch diameter bleed holes with plugs that dissolve approximately 3 days after the launch, allowing limited contact between the tube contents and the environment.[2] Each launch assembly, with the exception of the acoustic countermeasure device, is identical on all submarines, regardless of vessel class or hull location.

While the submarine is underway and the launch tubes are underwater, the bleed holes allow some exchange of the launch tube liquid contents with the seawater outside of the launch tube. Actual discharge rates are very difficult to obtain due to the non-homogeneous nature of the liquid mixture, the continuous dilution of the liquid contents through the bleed holes, and variations in seawater flow surrounding the bleed holes due to changes in submarine speed and maneuvers. On some submarines, launch assemblies are located above the waterline when the submarine is traveling on the ocean surface. On these submarines, most of the liquid contents of the launch assemblies drain freely from the bleed holes onto the submarine hull before entering the water. The location of the bleed plug holes prevent the expended launch tube from completely draining; approximately one-quarter to one-half gallon (1 to 2 liters) of the liquids remain, depending on the orientation of the ram plate within the launch tube.[1] On other submarines where the launch assembly is always below the water surface, the liquid drains through the same bleed holes directly into the harbor during the assembly's replacement.

In order to protect workers from exposure to the potentially acidic water that remains in the tube subsequent to launch, the Navy has started adding a one-pound packet of sodium bicarbonate to the system to neutralize pH levels.[3] Also, the Navy is reducing cadmium in the discharge by removing hardware with cadmium-containing coatings from Navy stock.[3] All launchers will be equipped with these changes by the end of March 1999.[4]

2.2 Releases to the Environment

Within three days following the launch of a countermeasure device, bleed hole plugs in the ram plate dissolve, which allows pressure equalization of the launch assembly contents with the external seawater environment. The liquid contents of the launch tube are slowly exchanged with seawater through these bleed holes while the submarine is moving. While the submarine is stationary, little or no exchange with seawater occurs. For the submarines where the launch tubes are located above the waterline, most of the liquid contents of the launch tube freely drain through the bleed holes each time the submarine surfaces. For the submarines with launch tubes located below the waterline, the major discharge occurs when the tubes are replaced pierside while the submarine is stationary. The largest potential volume discharge event would occur when all countermeasure launch tubes have been expended, there has been no discharge through the bleed holes while the submarine was underway, and all launch tube contents are released at one time in port. Therefore, for this analysis, it was assumed that all of the discharge from the CSA Mk 2 system occurs during pierside replacement of the launch assembly.

2.3 Vessels Producing the Discharge

The CSA Mk II system is installed on 24 Navy submarines of two different classes: four vessels of the Ohio (SSBN 726) Class, and 20 vessels of the Los Angeles (SSN 688) Class. Launch assemblies on Ohio Class vessels are located above the waterline when the submarine is surfaced; assemblies on Los Angeles Class vessels are located below the waterline. In addition, the number of launch assemblies differs by vessel class. Ohio Class vessels have 16 launch assemblies while Los Angeles Class vessels have 14 assemblies.[2] Neither the Army, Air Force, U.S. Coast Guard, nor Military Sealift Command own or operate submarines.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Submarine countermeasures operations during training exercises typically occur outside of 12 n.m. in the open ocean. Discharges from launch tubes located above the waterline may occur within and beyond 12 n.m. while the submarine is underway on the surface as the effluent drains from the bleed holes. Some additional leakage from these launch tubes could occur pierside while the launch tubes are removed from the submarine. Discharges from launch tubes located below the waterline could also occur pierside when the launch tubes are offloaded. A small amount of exchange between all submerged launch tubes and the surrounding waters could occur continuously within and beyond 12 n.m.

3.2 Rate

The volume of the launch tube is approximately 17 gallons (65 liters). Approximately 60 expended launch tubes are removed annually fleetwide.[2] Therefore, approximately 1020 gallons of effluent is generated per year. For the purposes of this report, the discharge event volume was assumed to be 17 gallons, although in the cases where launch assemblies are above the waterline, some of the launch tube effluent would be discharged prior to a launch assembly replacement operation, and under normal circumstances even those tubes located below the waterline do not discharge their entire contents.

When a submarine is traveling on the ocean surface, liquid contents of the launch assemblies that are located above the waterline were estimated to discharge at a rate of one gallon per minute through bleed holes. During a discharge event in port, the liquid contents are released through the same bleed holes while being transported from the submarine to the pier, and therefore also discharge at a rate one gallon per minute. For the purposes of this report, it was assumed that all liquids in the launch assembly are discharged into surrounding waters before the assembly is placed on the pier.

3.3 Constituents

Table 1 summarizes the analytical data from sampling of an actual gas generator and launch tube assembly, with a sodium bicarbonate packet in place and no cadmium-containing coatings.[5] The constituents detected in sampling, i.e., lead, copper, cadmium, and silver, were expected based upon the known components of the gas generator (e.g., ammonia perchlorate propellant), hardware coating components, and solder within the system electronics.[1] In addition to analyzed concentrations, based upon knowledge of the components of the gas generator, exhaust gas products that may become a part of the discharge can include hydrochloric acid, carbon dioxide, water vapor, carbon monoxide, nitrogen, alumina, iron (II) chloride, titanium dioxide, hydrogen, and iron (II) oxide.[6] Table 2 provides a complete listing of the types and quantities of gas generator exhaust gas products. Of the discharge constituents, lead, copper, cadmium, and silver are priority pollutants. There are no bioaccumulators that have been identified in this discharge.

3.4 Concentrations

Table 1 provides a summary of the analytical results obtained from sampling of the launch tube water immediately following a launch, and sampling five days after launch.[5] Of the two data sets, the analytical data from sampling five days after launch is more representative of the actual pierside discharge because typical submarine operational schedules do not allow for immediate replacement of the launched countermeasures devices. In reality, submarines usually continue for months until a scheduled maintenance port call results in a launch tube change out and discharge of launch tube water. For the data shown in Table 1, where a concentration value was found to be below the detection limit, the mean concentration value was calculated using one-half of the detection limit. The pH of the launch tube water five days after launch was 7.2, which is similar to the pH of seawater (~8).

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The total annual discharge volumes provided in Section 3.2 were used to estimate potential constituent mass loadings as follows:

Mass Loading (lbs/yr) =
(avg. concentrations in μg/L) (discharge in gal/yr) (3.785 L/gal) (2.205 lb/kg) (10^{-9} kg/μg)

Analytical data from sampling five days after launch was used to calculate mass loadings because that data set is more representative of the actual pierside discharge than data from sampling immediately following launch. Even this overstates the potential mass loading, as most submarines will continue to operate for months after the launch, before changing the launch tubes. For example, the mass loading for copper was estimated as:

(80 μg/L)(1020 gal/yr)(3.785)(2.205)(10^{-9}) ≈ 7 x 10^{-4} lbs/yr, or approximately 2 ten-thousandths of an ounce per discharge event

Table 3 provides annual fleet-wide mass loadings and discharge event mass loadings for the metallic constituents listed in Table 1.

4.2 Environmental Concentrations

Table 4 compares the concentrations of the Mk 2 system discharge to Federal and the most stringent state water quality criteria (WQC). Copper, cadmium, and silver concentrations are above both the Federal and most stringent state WQC. Lead was detected in only one of the ten samples; lead in this sample exceeded the most stringent state WQC.

4.3 Potential For Introducing Non-Indigenous Species

There is a low potential for this discharge to transport non-indigenous species because:

1) the 17-gallon launch tube is capped immediately following the launch of a countermeasure device, with the only means of seawater entry being a one-way check valve and three 3/8-inch diameter bleed holes. Therefore, there is limited opportunity for organisms to ever enter the launch tube;
2) because launches of countermeasure devices are estimated to take place 60 times a year fleetwide and typically take place in the open ocean;
3) any deep ocean water organism would be unlikely to survive in near-shore waters.[7]
4) the total volume of the discharge per year is small.

5.0 CONCLUSION

Submarine acoustic countermeasures launcher discharge has a low potential to cause an adverse environmental effect from constituents and the introduction of non-indigenous species because:

1) The constituent mass loading is low. For example, the mass loading of copper into receiving waters during one of the 60 discharge events per year would be two ten-thousandths of an ounce.

2) The small volume of the discharge, combined with the low likelihood that the organisms taken on could survive in port, make it unlikely that the discharge could transport viable non-indigenous species.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Equipment expert information was used to estimate the rate of discharge. The constituents and concentrations in this discharge were obtained from process knowledge and analytical data. Table 5 shows the sources of the data used to develop this NOD report.

<u>Specific References</u>

1. UNDS Equipment Expert Meeting - Submarine Acoustic Countermeasures Launcher Discharge, 12 June, 1998.

2. UNDS Data Call Response, Countermeasure Set, Acoustic (CSA) Mk 2, PMS415D5, Naval Sea Systems Command, 20 February 1998.

3. Engineering Change Proposal (ECP) CR-GG77-E0002, Naval Surface Warfare Center (NSWC) Crane Division, 5 April 1997.

4. Personal Communication between Ken Burt, PMS415, Naval Sea Systems Command, and Gordon Smith, SEA 03L, Naval Sea System Command, 23 February 1998.

5. Analysis of Products from Expended Propellant Billet Gas Generators, Naval Surface Warfare Center, Crane, Code 4052, Ser 4052/7073, 13 May 1997.

6. Excerpts from Naval Surface Warfare Center (NSWC) Crane Division Preliminary Report for the Saltwater Immersion and Pressure Testing of the ADC Mk 3 Mod 0 with Lithium Battery, EDD 95-068, NSWC Crane Division, May 1995.

7. "Stemming the Tide," Controlling Introductions of Nonindigenous Species by Ships' Ballast Water, Committee on Ships' Ballast Operations, National Academy Press, Washington D.C., 1996, p. 36.

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USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants. 57 FR 60848. December 22, 1992.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, Proposed Rule under 40 CFR Part 131, Federal Register, Vol. 62, Number 150. August 5, 1997.

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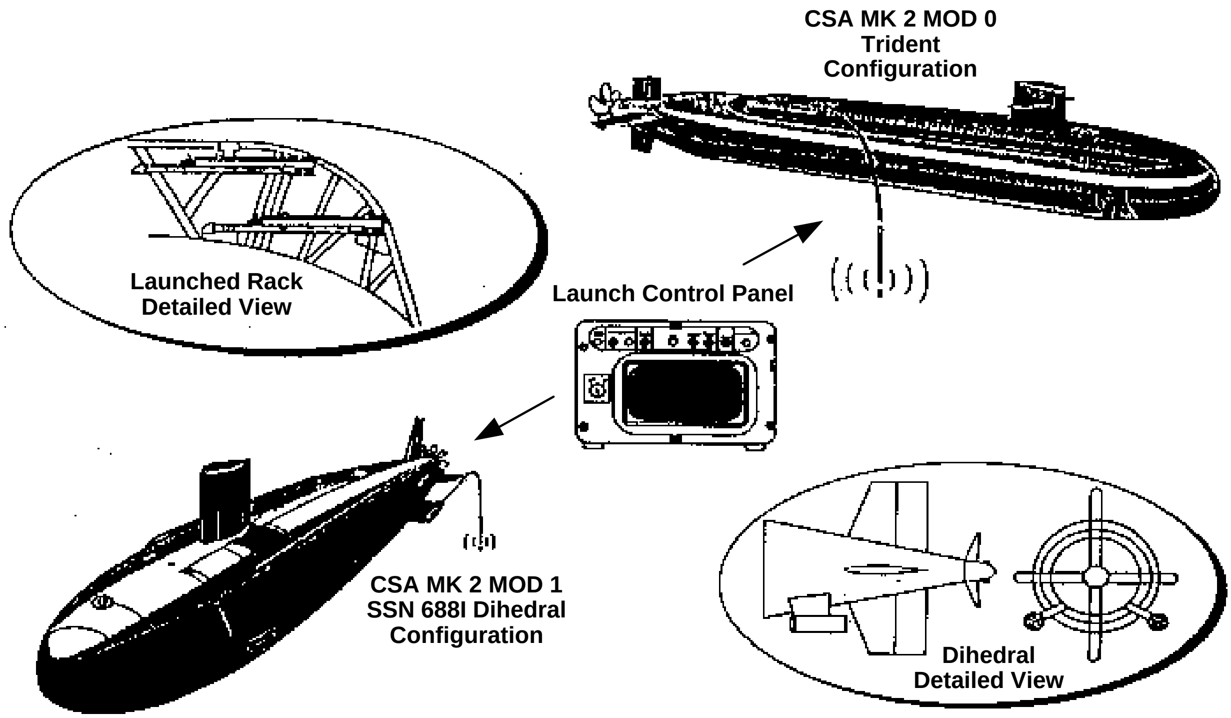

UNCLASSIFIED

Figure 1. Configuration of CSA Mk 2 Launchers
on SSBN 726 and SSN 688 Class Vessels

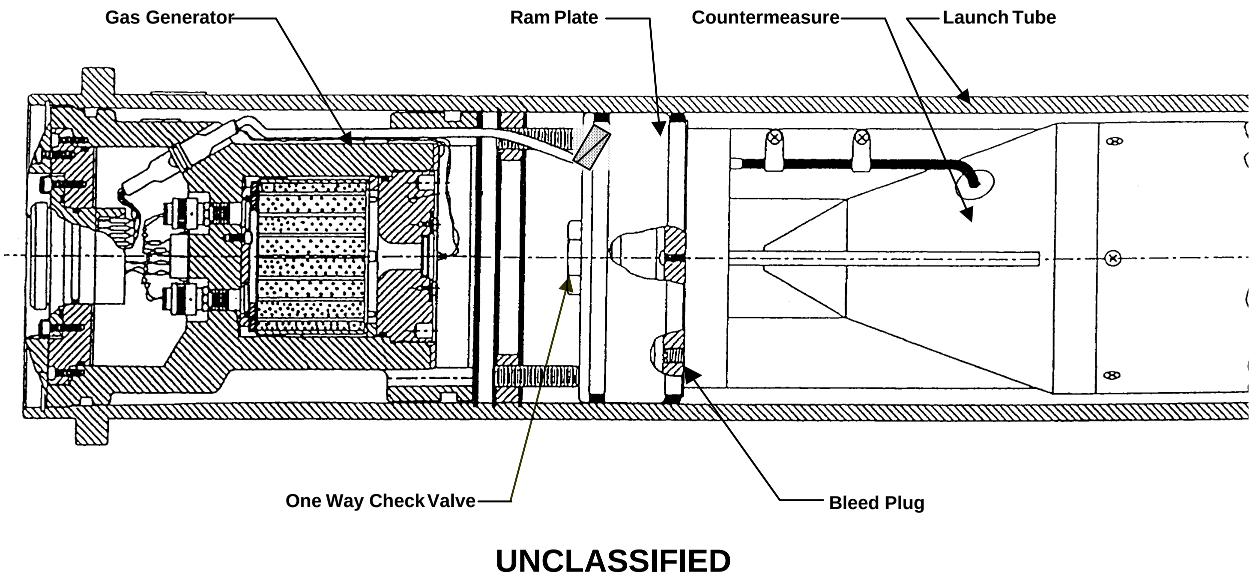

Figure 2. Location of Countermeasures Launcher Components Within a Launch Tube

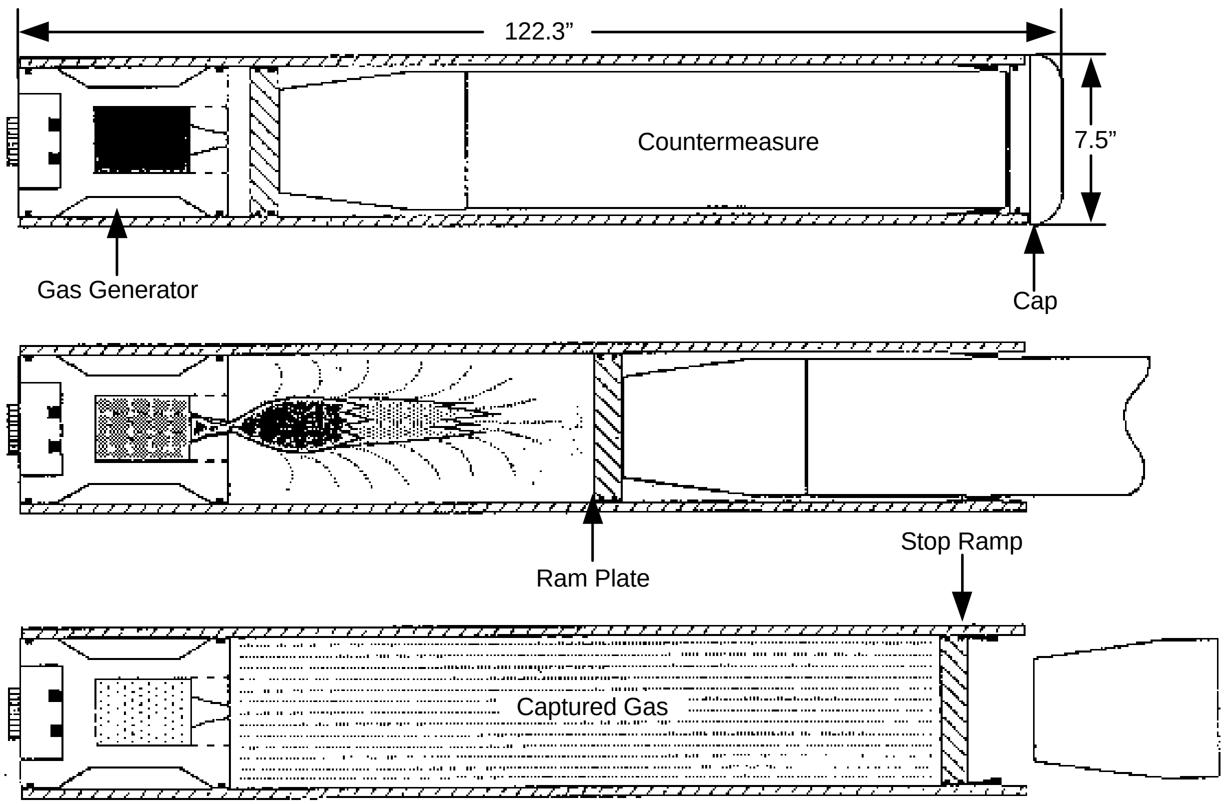

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Figure 3. Countermeasure Launch Process

Table 1. Constituent Concentration Data Immediately and Five Days Following Launch [5]

Constituent	Dissolved Concentrations Immediately Following Launch							Mean value	Dissolved Concentrations Five Days Following Launch							Mean value
Metals	µg/L															
Barium	BDL[a]	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL[a]	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead	BDL[b]	BDL	BDL	BDL	BDL	BDL	200	110	BDL[b]	BDL	BDL	BDL	BDL	BDL	BDL	100
Copper	100	160	290	800	180	860	260	380	70	40	70	90	60	170	80	80
Cadmium	70	630	60	740	120	290	440	340	40	150	100	20	20	90	30	60
Chromium	BDL[c]	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL[c]	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Silver	BDL[d]	20	BDL	20	BDL	40	20	20	20	BDL[d]	BDL	BDL	BDL	30	BDL	10
Other																
pH	7.2	6.0	6.0	5.7	6.3	5.3	5.9	5.8*	7.5	7.1	6.9	7.0	7.4	7.2	7.5	7.2*

[a] BDL = below detection limit; detection limit for barium is 1000 µg/L
[b] Detection limit for lead is 200 µg/L
[c] Detection limit for chromium is 80 µg/L
[d] Detection limit for silver is 20 µg/L

* Mean pH calculated using arithmetic average of [H+] values

Table 2. Gas Generator Exhaust Gas Products [6]

Exhaust Gas Product	Mass per Gas Generator (g)
HCl	23.036
CO_2	21.860
H_2O	16.846
CO	14.096
N_2	9.345
Al_2O_3	2.832
$FeCl_2$	2.068
TiO_2	1.998
H_2	1.803
FeO	1.523
P_2	0.002
PN	0.054
CH_4	0.004
NH_3	0.001
$FeCl_3$	0.001
PO_2	0.001
PO	<0.001
PH_3	<0.001

Table 3. Estimated Annual Mass Loadings

Constituent	Loading (lbs/yr)	Loading per Discharge Event* (ounce/event)
Cadmium	0.0005	0.0001
Copper	0.0007	0.0002
Lead	0.0009	0.0002
Silver	0.00009	0.00002

* based upon 60 maximum-volume discharge events per year

Table 4. Comparison of Discharge Constituents with Water Quality Criteria (μg/L)

Constituent	Mean Concentration or Value	Federal Acute WQC	Most Stringent State Acute WQC
Cadmium	60	42	9.3 (FL, GA)
Copper	80	2.4	2.4 (CT, MS)
Lead	100	210	5.6 (FL, GA)
Silver	10	1.9	1.2 (WA)

FL = Florida
GA = Georgia
CT = Connecticut
MS = Mississippi
WA = Washington

Table 5. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	X			X
3.4 Concentrations	X			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations				X
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Submarine Bilgewater

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the submarine bilgewater discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Bilgewater in submarines is a mixture of discharges and leakage from a wide variety of sources, which drain to the lowest compartment (bilge) of the submarine. Bilgewater includes seawater accumulation, normal water leakage from machinery, and fresh water washdowns. It can contain a variety of constituents including cleaning agents, solvents, fuel, lubricating oils, and hydraulic oils.[1]

The submarine's drain system has a series of non-oily bilge collecting tanks, oily bilge collecting tanks, and a waste oil collecting tank or tank complex. The Ohio (SSBN 726) Class ballistic missile submarines and the planned New Attack Submarine (NSSN) use a waste oil collecting tank complex partitioned into oily and clean sides. Los Angeles Class (SSN 688) attack submarines use a waste oil collecting tank without the partitioning, where gravity separation of oil occurs.[1]

Non-oily waste is sent via a segregated drain system to the nonoily bilge collecting tanks, where it is discharged overboard. Waste that is oily or could possibly be oily, goes to the waste oil collecting tank (WOCT) through a separate drain system. Submarine classes with partitioned tanks, as listed above, use gravity separation enhanced by tank baffles to achieve some measure of oil/water separation. The SSN 688 Class submarines use the aft bilge collecting tank (ABCT) to receive and settle the bilgewater and non-oily drainage. The bottom portion of the water as separated in the tank is discharged overboard.[2] The upper portion of the ABCT which would have any potential for containing oily waste is transferred to the WOCT. The lower portion of the WOCT can be pumped overboard outside of 50 nautical miles (n.m.), but the upper portion must be held for future transfer to appropriate shore/disposal facilities.[1]

While most submarines of the U.S. fleet operate as described above, the Sturgeon Class (SSN 637) has bottomless bilge collecting tanks open to the sea, from which water is discharged by displacement whenever bilge pumps are activated. Watches are set to monitor for a sheen whenever oily water is to be pumped to the tank in port; pumping to the bilge collecting tank is to cease if a sheen is reported.[1]

2.2 Releases to the Environment

Onboard SSN 688 Class submarines, clean drains and the lower portion, or water phase, of the separated bilgewater in the ABCT are pumped overboard as necessary regardless of distance from shore. The lower portion of the liquid in the WOCT can be disposed of outside of 50 n.m.[2] The upper portion, or oily waste, from all of the drains, bilge water, and other sources must be held on board until the submarine has access to appropriate shore or disposal facilities.

2.3 Vessels Producing the Discharge

The Navy currently operates five classes of submarines (presented in Table 1) that generate bilgewater. However, not all of these classes discharge bilgewater to the environment. Pierside, submarine bilgewater is transferred to shore facilities. In transit, SSBN submarines do not discharge bilgewater within 12 n.m. SSN 688 Class submarines discharge some of the water phase of the bilgewater collecting tank between 3 and 12 n.m.[3]

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

In most submarine classes, submarine drain and plumbing drain systems are used to receive all drains and route them to their respective holding tanks. In these classes, discharges which may contain any oily waste are not to be released within 50 n.m., except in emergencies. Per OPNAVINST 5090.1B, submarines are instructed to: [2]

> *...pump all oily waste to the waste oil collection tank (WOCT). When the tank is full, after allowing for adequate separation time, and the ship is outside 50 n.m. [nautical miles], submarines shall pump the bottom, water phase of the WOCT overboard.*

The upper, oil phase from the WOCT is discharged only to authorized shore facilities.

The location of this discharge varies by class and the activities of the submarine. The operational factors that affect the location of bilgewater discharge include the operating depth, type of operations, the submarine's requirement for quiet operations, and the duration of the operations.

SSBN 726 Class submarines discharge all bilgewater either to shore facilities when pierside, or hold bilgewater for discharge when outside 50 n.m. The SSN 688 Class discharges some of the water phase of the bilgewater collecting tank between 3 and 12 n.m. due to the limited size of the holding tank.[3] For the SSN 637 Class submarines, discharges of bilgewater can occur at any location when the bilge pumps are activated.[1]

3.2 Rate

The rate of this discharge varies considerably by class and with the submarine activities. The volume of bilgewater generated can depend on the crew size, operating depth, the submarine's requirement for quiet operations, the type of operations, the duration of operations, and their location.

As shown in Table 1, there are three major submarine classes which generate bilgewater. These are the SSBN 726 Class, the SSN 688 Class, and the SSN 637 Class. The SSN 637 Class submarines are currently being phased out of service. At the present time, the entire class is expected to be retired by the year 2001.[4] Because of this, total discharge rates for SSN 637 Class submarines will not be estimated.

Pearl Harbor Naval Station estimates that 2,000 to 3,000 gallons of bilgewater are generated per submarine per day when pierside; the classes of vessels were not specified.[5] For the SSBN 726 and SSN 688 Class submarines, the following annual per-vessel flow estimates were provided:[3]

SSBN 726	31,500 gallons to shore facilities 0 gallons while transiting within 12 n.m. 300,000 gallons outside 12 n.m.
SSN 688	54,000 gallons to shore facilities 80,540 gallons while transiting within 12 n.m. 400,200 gallons outside 12 n.m.

Available data indicate that for the other submarine classes, no bilgewater is discharged within 50 n.m. Since bilgewater transferred to shore facilities is not released to the environment, the above information indicates that only the SSN 688 Class submarines actually discharge submarine bilgewater within 12 n.m. from shore.

Based on the value of 80,540 gallons per submarine per year discharged from the SSN 688 Class vessels between 3 and 12 n.m., a total flow was calculated as follows:

(80,540 gal/vessel/year) (56 SSN 688 Class subs) = 4.5 million gallons/year

3.3 Constituents

Potential constituents which have been detected in previous studies include oil and grease, copper, cadmium, lead, nickel, iron, zinc, mercury, lithium bromide, citric acid, chlorine, phenol, cyanide, sodium bisulfite, and the pesticides heptachlor and heptachlor epoxide. Submarine bilgewater could possibly have high levels of total suspended solids (TSS) and chemical oxygen demand (COD).[6,7]

Heptachlor, heptachlor epoxide, phenol, cyanide, copper, cadmium, lead, nickel, silver, and zinc are priority pollutants. Mercury is the only bioaccumulator.

3.4 Concentrations

Table 2 summarizes concentration data from a sampling effort involving 10 submarines. Samples in that program were analyzed for oil, 13 metals, pesticides, PCBs, and 46 organics (vinyl chloride and 45 semivolatile organics).[6,7] The sampling involved four SSBN 726 Class submarines, four SSN 688 Class submarines, and two SSN 637 Class submarines. Samples were taken from submarines that held their bilgewater while operating. Samples are representative of discharges normally made outside 12 n.m.

Samples from open bilge compartments on all three classes of submarines were found to contain an average of 20 parts per million (ppm) oil; bilgewater tanks averaged 76 ppm oil. In calculating arithmetic averages, six samples having values of greater than 1,000 ppm oil were excluded. These were considered not representative of bilgewater discharged within 12 n.m. and would be handled normally as waste oil and retained for shore disposal. These six samples ranged from 1,030 to 820,000 ppm of oil. The arithmetic average of the 52 oil samples, ranging between the detection limit of 5 ppm and 1,000 ppm, is 30 ppm. Including the 23 nondetects, the result would be an arithmetic mean of 22.3 ppm when each non-detect sample was set equal to the detect limit of 5 ppm.

Each sample was also analyzed for 13 metals. Eighteen pesticides, 7 PCBs, 45 semivolatile organics (base neutral aromatics), and one volatile organic (vinyl chloride) were analyzed for in the 81 samples. Table 2 presents concentration ranges and the average concentration calculated. No PCBs, semivolatiles, or vinyl chloride were detected in any sample. Six of the 81 samples contained detectable levels of the pesticides heptachlor and heptachlor epoxide.[6,7]

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

The total annual mass loadings were calculated based upon the estimated discharge volume for SSN 688 Class vessels and the average concentrations of constituents in submarine bilgewater. The results are presented in Table 3.

4.2 Environmental Concentrations

Concentration data presented in Table 2 are measured concentrations in the discharge, and do not reflect any dilution afforded by the receiving water.

Table 4 shows the water quality criteria (WQC) that are relevant to submarine bilgewater, and compares measured concentrations of constituents to WQC. Reported levels of oil and grease for bilgewater exceed the Federal and the most stringent state WQC. Mercury, heptachlor, and heptachlor epoxide exceed the most stringent state WQC. Average measurements of constituents in the discharge exceed the Federal and the most stringent state WQC for copper, nickel, silver, and zinc. While there is no relevant Federal WQC, chlorine concentrations exceed the most stringent state WQC. Cadmium concentrations exceed the most stringent state WQC, but do not exceed the Federal WQC.

4.3 Potential for Introducing Non-indigenous Species

Non-indigenous species are not likely to be transported by submarine bilgewater. There is limited seawater access to bilge compartments. Bilgewater storage capacity limitations require processing bilgewater on a frequent basis, resulting in discharge in the same geographic area in which it was generated.

5.0 CONCLUSIONS

Concentration data from submarine bilgewater were used to estimate constituent loadings within 12 n.m. from shore. These data and estimates were based on the existing management practices (i.e. shoreside bilgewater collection, discharging only the water phase, and refraining from discharging within 12 n.m.). Discharges between 3 and 12 n.m. occur while the vessels are underway thereby dispersing the pollutants. Removal of the existing practices could significantly increase amounts of constituents discharged above WQC and discharge standards, especially oil. Submarine bilgewater could potentially be discharged in port if these existing practices were not in place. Therefore, submarine bilgewater, uncontrolled, has the potential to cause an adverse environmental effect.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 5 shows the sources of data used to develop this NOD report.

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1. UNDS Equipment Expert Meeting Minutes, Submarine Bilgewater. August 12, 1996.

2. OPNAVINST 5090.1B. Environmental and Natural Resources Program Manual. November 1, 1994.

3. Data Call Response, Commander, Submarine Force, U.S. Atlantic Fleet. Submarine Discharge Questionnaire. December 13, 1996.

4. Personal Communication Between Mr. R.B. Miller (M. Rosenblatt & Son, Inc.) and Mr.

Paul Murphy (NAVSEA PMS 392A33) of October 15, 1997.

5. Data Call Response, Pearl Harbor Naval Station. October 11, 1996.

6. Bilge Water Sampling Study. Final Report. September 30, 1996. Electric Boat Corporation.

7. NSSN Review, June 5, 1996. Subject: Fleet Bilge Water Sampling. Presented by: James Triba, NSSN Seawater Systems, Electric Boat Corporation.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

Table 1. Submarines Producing Bilgewater Discharges

Vessel Class	Description of Vessel	Number of Vessels
SSBN 726	Ohio Class Ballistic Missile Submarine	17
SSN 637	Sturgeon Class Attack Submarine	13
SSN 640	Benjamin Franklin Class Attack Submarine	2
SSN 671	Narwhal Class Attack Submarine	1
SSN 688	Los Angeles Class Attack Submarine	56

Table 2. Concentrations of Contaminants in Submarine Bilgewater Discharge (mg/L)[6,7]

Parameter	Range (mg/L)	Arithmetic Mean (mg/L)*
Oil	<5 - 820,000	30 mg/L (note a)
Arsenic	<0.01	<0.01
Barium	<0.01 - 3.3	0.014
Cadmium	<0.005 - 0.2	0.02
Chromium	<0.01 - 1.7	0.050
Copper	0.065- 15	1.42
Iron	<0.2 - 20	1.89
Lead	<0.01 - 0.074	0.01
Manganese	<0.01 - 1.7	0.12
Mercury	<0.0002 - 0.0007	0.00007
Nickel	<0.04 - 11	0.98
Selenium	<0.005 - 0.021	0.005
Silver	<0.01 - 0.035	0.006
Zinc	<0.02 - 11	1.36
Heptachlor		0.000005
17 other pesticides		note b
Heptachlor epoxide		0.000003
PCBs	<0.001	<0.001
1 VOA plus 45 SVOAs [note c]		note b
Ammonia	<0.1 - 68	6.95
Chlorine	0.0 - 1.6	0.21
COD	<15 - 4500	595
Cyanide	<0.01 - 0.03	0.004
pH	2.94 - 8.95	6.9
Phenols	<0.01 - 5.4	0.19
Surfactants	ND - 0.807	0.16
TSS	<7 - 2400	177

Note a - The average of 30 mg/L provided in the primary reference[6] omitted all nondetects and all (six) oil values > 1,000 milligrams per liter (mg/L). The average of the 75 samples less than 1,000 ppm (including nondetects, assumed to equal the detection limit) is 22.3 mg/L.
Note b - No samples had detectable levels.
Note c - VOA is volatile organic analyte; SVOA is semivolatile organic analyte
Values preceded by “<” are non-detects

Table 3. Estimated Mass Loadings of Constituents from Submarine Bilgewater Discharges (lbs/yr)

Pollutant	Concentration (mg/L)	688 Class 3-12 n.m.
Oil	30.01	1130
Copper	1.42	53.4
Lead	0.01	0.38
Nickel	0.98	36.9
Silver	0.006	0.23
Zinc	1.36	51.2
Ammonia	6.95	262
Chlorine	0.21	7.90
Barium	0.014	0.53
Cadmium	0.02	0.75
Chromium	0.05	1.9
Mercury	0.00007	0.0026
Selenium	0.005	0.19
Heptachlor	0.000005	0.00019
Cyanide	0.004	0.15
Phenol	0.19	7.15
Surfactants	0.16	6.02

Table 4. Comparison of Measured Constituent Values and Water Quality Criteria (μg/L)

Constituent	Average Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Mercury*	0.07	1.8	0.025 (FL, GA)
Heptachlor	0.005	0.053	0.00011 (GA)
Heptachlor epoxide	0.003	0.053	0.00021 (FL)
Phenol	190	-	170 (HI)
Cyanide	4	1	1 (CA, CT, FL, GA, HI, MS, NJ, VA, WA)
Oil	3,0010	visible sheen[a] / 15,000[b]	5000 (FL)
Copper	1420	2.4	2.4 (CT, MS)
Nickel	980	74	8.3 (FL, GA)
Silver	6	1.9	1.2 (WA)
Zinc	1360	90	84.6 (WA)
Chlorine	210	-	10 (FL)
Cadmium	20	42	9.3 (FL, GA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
NJ = New Jersey
VA = Virginia
WA = Washington

* Bioaccumulator

[a] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
[b] *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 as implemented by the *Act to Prevent Pollution from Ships* (APPS)

Table 5. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment	Data Call responses			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	Data Call responses			X
3.2 Rate	Data Call responses		X	
3.3 Constituents	X			X
3.4 Concentrations	X			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X			
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Submarine Emergency Diesel Engine Wet Exhaust

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the submarine emergency diesel engine wet exhaust liquid discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

All submarines have emergency diesel engines for use during emergency situations, such as providing electric power or emergency ventilation. However, emergency diesel engines are routinely used during training exercises, pre-underway checks, and quarterly performance analyses. All submarines have air induction and diesel exhaust systems for emergency diesel engines. Air induction systems bring in outside air for combustion in the emergency diesel engines, while exhaust systems discharge the combustion by-products overboard. Prior to discharge, the exhaust gases are cooled by seawater injection into the exhaust. Water is injected to reduce radiant energy from the exhaust piping and to reduce corrosion of the exhaust piping from high temperatures.

Each submarine is equipped with one emergency diesel engine. Refer to Figure 1 and Figure 2 for a representation of the wet exhaust system.

2.2 Releases to the Environment

The exhaust-water mixture is vented from the exhaust stack into the atmosphere. Some of the water mist with entrained or dissolved exhaust products will settle into the seawater surrounding the exhaust stack. For the purposes of this analysis, it is assumed that all of the discharge settles to the water's surface.

2.3 Vessels Producing the Discharge

The Navy is the only branch of the Armed Forces that operates submarines. All active submarines in the fleet produce this discharge. For this report, information on the discharge rates from the three main submarine classes was used, representing 86 of the 89 active submarines. The classes of submarines producing emergency diesel wet exhaust discharge analyzed in this report are summarized in Table 1.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Each vessel operates the emergency diesel engine an average of 60 hours annually within 12 n.m. of shore.

3.2 Rate

Table 1 provides discharge rates for individual classes of submarines. Discharge rates vary for each vessel class, from approximately 7 gallons per minute (gpm) to 15 gpm, and are dependent on the water injection rate into the exhaust system.[1,2,3,4] For this analysis, it was assumed that all of the water injected into the exhaust system is eventually discharged to the receiving water body. This represents an overestimate for total flow volumes, because much of the injected seawater has the potential to vaporize.

3.3 Constituents

Constituents of exhaust from diesel engines include both organic and inorganic substances. These substances originate primarily from the diesel fuel and also from engine lubricants. Most of the substances that originate from the diesel fuel are products of combustion. Some diesel fuel can pass through the engine unburned, along with combustion products in the exhaust.[5]

Inorganic substances in diesel exhaust include combustion products such as carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulfur (SO_x), and metals. The specific substances and their concentrations in the exhaust depend on a number of factors, including the composition of the fuel, engine temperature, engine use, and engine condition. Many of the organic substances in diesel exhaust condense into particulates, that is, the oily soot visible in the exhaust.[6]

Standard air emissions factors for large stationary diesel industrial engines were used to study the constituents in this discharge. EPA has published emission factors for large stationary diesel engines 600 hp and over. These emissions factors relate quantities of released materials to fuel input, as nanograms per Joule (ng/J), or as power output, as in grams per horsepower-hour (g/hp-hr). Although intended for stationary industrial diesel engines, these emission factors can be used to approximate emergency diesel engine emissions.[6]

Table 2 lists the emission factors for constituents present in the air exhaust of large diesel engines.[6] As the cooling water is injected into the air exhaust, many of these constituents have the potential to be introduced into the water. Of the compounds shown in Table 2, benzene, toluene, acrolein, naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene are priority pollutants. This discharge is not expected to contain bioaccumulators.

3.4 Concentrations

Using submarine diesel engine power output specifications, the concentrations of the chemical constituents in the engine exhaust were estimated for each submarine class. By making the assumption that all constituents in the discharge liquid resulted from exhaust gases dissolving in the cooling water under equilibrium conditions, it is possible to estimate the concentration of constituents in the liquid using Henry's Law. Henry's Law describes the solubility of gases in a liquid and relates the concentration of a constituent in a liquid to the partial pressure of the constituent in the gaseous phase surrounding the liquid. The calculation sheet at the end of this report presents the assumptions made for this approach and provides a sample calculation for the concentration of benzene in the wet exhaust of a SSN 688 class submarine. Estimated concentrations are presented in Table 3.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Mass loadings were calculated for constituents that exceed WQC using annual flow volumes (Table 1) and estimated constituent concentrations (Table 3). Annual flow volumes were calculated using the cooling water injection rate (Table 1) and an average operational time of 60 hours annually within 12 n.m. of shore, per submarine.[1] Fleet-wide mass loadings for individual chemical constituents were calculated through the following equation and are shown in Table 4.

$$\text{Annual Mass Loading (kg)} = \text{(Concentration in Discharge (mg/L))(Annual Discharge (gal))(3.785 L/gal)}(10^{-6}\text{ kg/mg})$$

The mass loading calculations are an overestimate. Calculations using Henry's Law assumed that equilibrium conditions exist. However, due to the low residence time (<1 second) of both exhaust products and water in the wet exhaust system, equilibrium conditions are unlikely.[7] Therefore, constituent concentrations are expected to be lower than calculated.

4.2 Environmental Concentrations

A comparison of estimated constituent concentrations to corresponding Federal and most stringent state water quality criteria (WQC) is presented in Table 5. The estimated concentrations of phenanthrene, benzo(a)anthracene, chrysene, indeno(1,2,3-cd)pyrene, dibenzo(ah)anthracene, and benzo(g,h,i)perylene individually exceed the most stringent state

(Florida) WQC. Concentrations have been based on a water temperature of 60^oF. Since the majority of submarines are located in warm water ports, it is believed that 60^oF is a reasonable assumption for an average water temperature. Concentrations may increase at colder temperatures because of increased constituent solubilities. However, even if concentrations triple, none of the individual constituents will exceed federal water quality criteria and only one additional individual compound (benzo(a)pyrene) will exceed Florida criteria for total PAHs. All other constituent concentrations are below relevant WQC.

4.3 Potential for Introducing Non-Indigenous Species

Because water intake and discharge occur at the same location, there is no significant threat of non-indigenous species introduction to receiving waters.

5.0 CONCLUSION

This analysis concluded that submarine emergency diesel engine wet exhaust has a low potential for adverse environmental effect. Although total PAHs (the total of the following individual PAH compounds: acenaphthylene, benzo-(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and phenanthrene) exceeded water quality criteria for the most stringent state (Florida), the annual Fleet-wide mass loading was only 0.056 pounds from 86 vessels.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 6 shows the sources of data used to develop this NOD report.

<u>Specific References</u>

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3. Perry Buckberg, NAVSEA 03X33. Submarine Diesel Exhaust Temperatures, 13 November 1997, Russ Hrabe, M. Rosenblatt & Son, Inc.

4. UNDS Equipment Expert Meeting - Submarine Emergency Diesel Engine Exhaust. 3 September 1996.

5. Faukner, M.G.; E.B. Dismukes; and J.R. McDonald. Assessment of Diesel Particulate Control: Filters, Scrubbers, and Precipitators. U.S. Environmental Protection Agency. EPA-600/7-79-232a. October, 1979.

6. United States Environmental Protection Agency Office of Air Quality Planning and Standards. Compilation of Air Pollution Emission Factors. AP-42, Fifth Addition, November, 1996.

7. Doug Hamm (MPI). Interoffice Memo: Estimation of Residence Time. March 4, 1998.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.

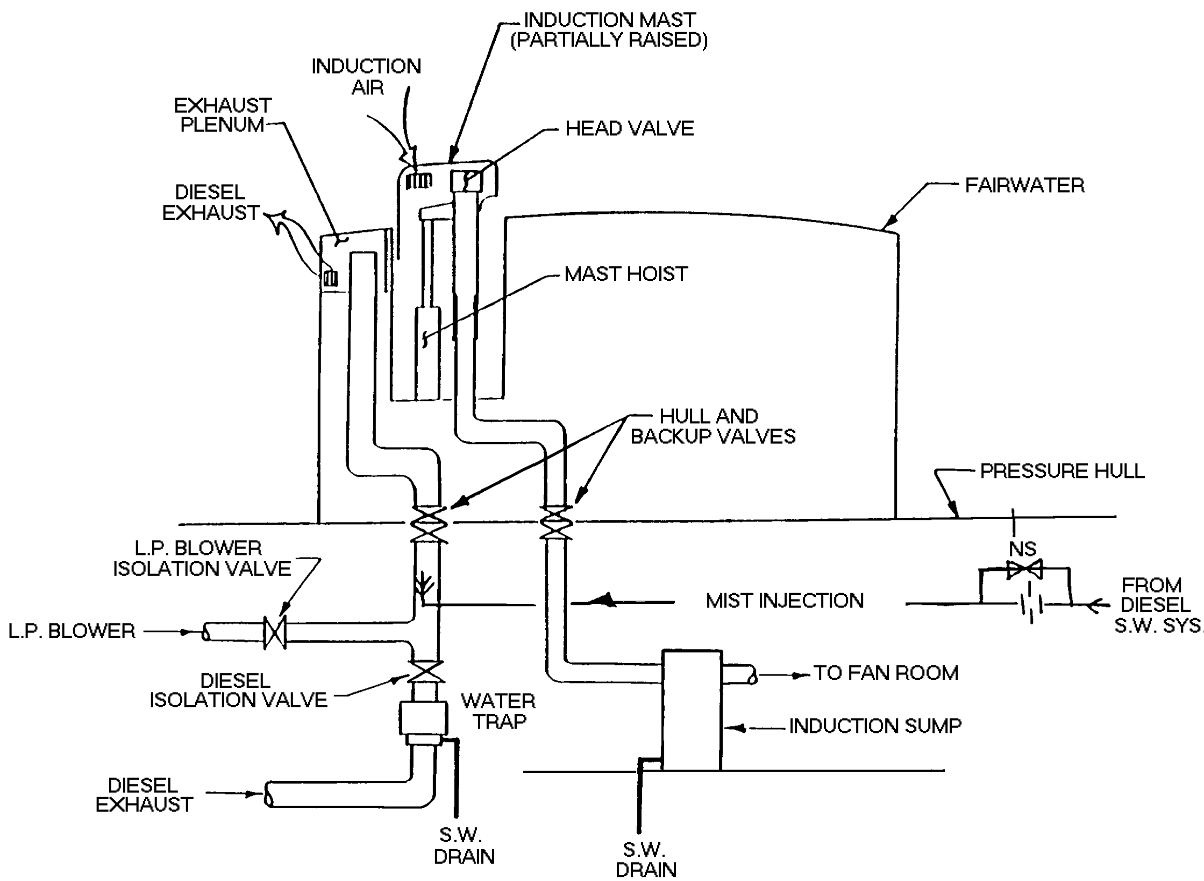

Figure 1. Typical Submarine Diesel Exhaust System

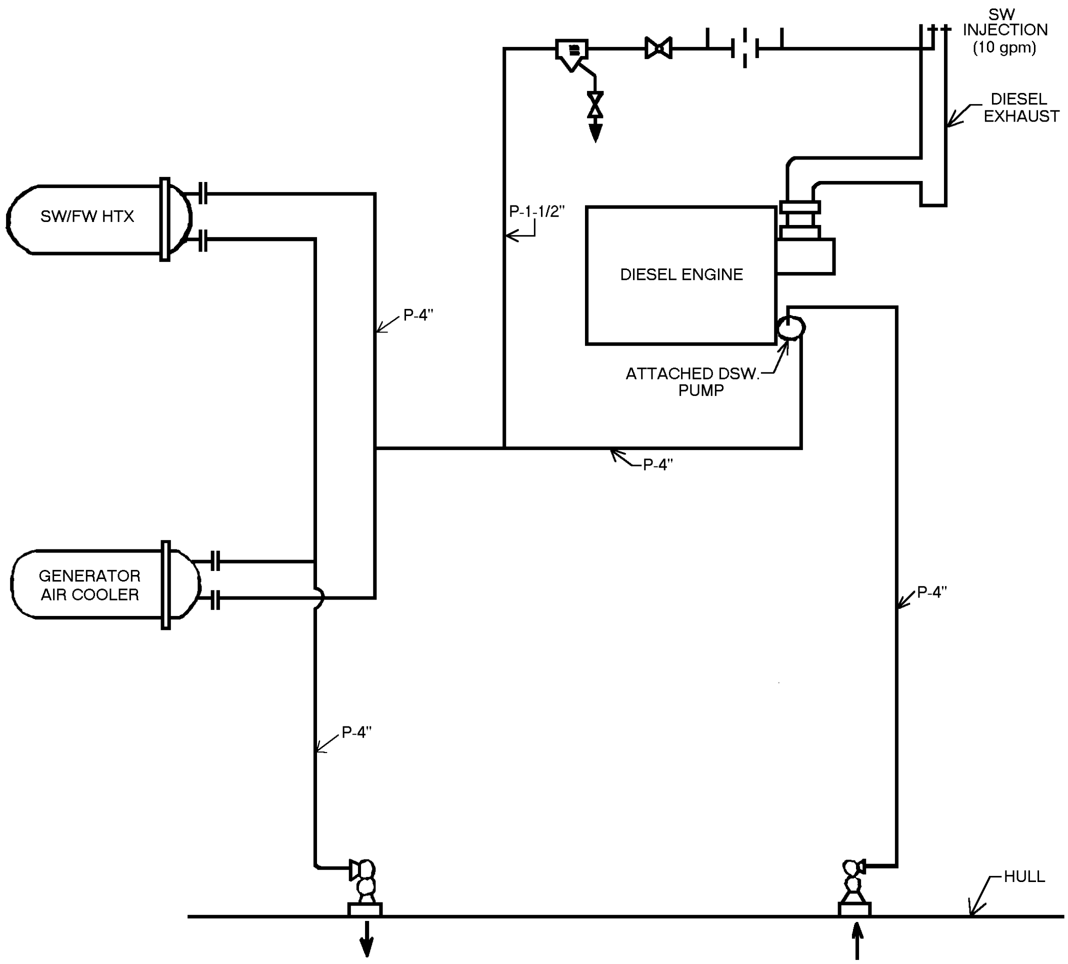

Figure 2. Typical Submarine Diesel Seawater System

Table 1. Emergency Diesel Engine Applicable Vessels, Air Exhaust and Cooling Water Flow Rates, and Estimated Annual Discharge

Submarine Class	No. of Submarines	Air Exhaust Flow Rate (cubic feet per minute)	Cooling Water Injection Rate (gallons per minute)	Annual Discharge per Submarine (gallons)*	Annual Discharge for Class (million gallons)
SSN 688 (Los Angeles Class)	56	6500	11.5	41,400	2.3
SSBN 726 (Ohio Class)	17	8600	15.0	54,000	0.92
SSN 637 (Sturgeon Class)	13	3600	7.0	25,200	0.33
Total	86	N/A	N/A	N/A	3.55

***** Based on 60-hour operating time annually per submarine

Table 2. Emission Factors for Large Uncontrolled Stationary Diesel Engines[6]

Constituent	Emission Factor	
	(lb/MMBtu)[a]	(ng/J)[b]
Benzene	7.76E-04	0.3337
Toluene	2.81E-04	0.1208
Xylenes	1.93E-04	0.0830
Formaldehyde	7.89E-05	0.0339
Acetaldehyde	2.52E-05	0.0108
Acrolein	7.88E-06	0.0034
NO_x	3.2	1376
CO	0.85	365.5
CO_2	165	70950
Naphthalene	1.30E-04	0.0559
Acenaphthylene	9.23E-06	0.0040
Acenaphthene	4.68E-06	0.0020
Fluorene	1.28E-05	0.0055
Phenanthrene	4.08E-05	0.0175
Anthracene	1.23E-06	0.0005
Fluoranthene	4.03E-06	0.0017
Pyrene	3.71E-06	0.0016
Benzo(a)anthracene	6.22E-07	0.0003
Chrysene	1.53E-06	0.0007
Benzo(b)fluoranthene	1.11E-06	0.0005
Benzo(k)fluoranthene	2.18E-07	0.0001
Benzo(a)pyrene	2.57E-07	0.0001
Indeno(1,2,3-cd) pyrene	4.14E-07	0.0002
Dibenz(a,h) anthracene	3.46E-07	0.0001
Benzo(g,h,i) perylene	5.56E-07	0.0002

[a] Gaseous emission factors expressed in pounds per million British thermal unit (lb/MMBtu)
[b] To convert from lb/MMBtu to ng/J, multiply by 430

Table 3. Estimated Concentrations of Exhaust Constituents in Wet Diesel Exhaust (mg/L)

Submarine Class: Engine Power/Exhaust Rate:	SSN688, LA Class (800kW, 6500 cfm)	SSBN 726, Ohio Class (1000kW, 8600 cfm)	SSN 637, Sturgeon (460kW, 3600 cfm)
Exhaust Constituents			
Benzene	.000018	.000017	.000019
Toluene	.000005	.000005	.000006
Xylenes	.000004	.000004	.000004
Formaldehyde	.005749	.005431	.005969
Acetaldehyde	.00018	.00017	.000187
Acrolein	.000006	.000006	.000006
NOx	.013364	.008234	.009049
CO	.001814	.001714	.001884
CO_2	9.028866	8.530179	9.373719
Naphthalene	.000038	.000036	.00004
Acenaphthylene	.0000004	.0000004	.0000005
Acenaphthene	.000002	.000002	.000003
Fluorene	.000019	.000018	.00002
Phenanthrene	.000129	.000122	.000134
Anthracene	.000003	.000002	.000003
Fluoranthene	.0000002	.0000002	.0000002
Pyrene	.000039	.000037	.000041
Benzo(a)anthracene	.000039	.000036	.00004
Chrysene	.000105	.000099	.000109
Benzo(b)fluoranthene	.000007	.000006	.000007
Benzo(k)fluoranthene	.0000004	.0000004	.0000004
Benzo(a)pyrene	.000012	.000011	.000012
Indeno(1,2,3-cd) pyrene	.000434	.00041	.00045
Dibenz(a,h) anthracene	.000339	.00032	.000352
Benzo(g,h,i) perylene	.000751	.00071	.00078

Note: Concentrations have been based on a water temperature of 60^0F. **Bold** indicates that water quality criteria is exceeded (see Table 5).

Table 4. Fleet-Wide Estimated Annual Mass Loadings of Wet Diesel Exhaust Constituents Within 12 n.m. of Shore

Submarine Class: **Engine Power:** **Exhaust Rate:** **No. Vessels:**	**SSN688 Class** 800 kW 6500 cfm 56 Vessels	**SSBN 726 Class** 1000 kW 8600 cfm 17 Vessels	**SSN 637 Class** 460 kW 3600 cfm 13 Vessels	**TOTAL FLEET WIDE**	
Constituent	(kg)	(kg)	(kg)	**(kg)**	**(lbs)**
Polycyclic Aromatic Hydrocarbons (PAHs)					
Naphthalene	0.00033	0.00013	0.00005	0.00051	0.00112
Acenaphthylene	0.000004	0.000001	0.000001	0.000006	0.00001
Acenaphthene	0.00002	0.00001	0.000003	0.00003	0.00007
Fluorene	0.00017	0.00006	0.00002	0.00025	0.00056
Phenanthrene	0.00112	0.00042	0.00017	0.00171	0.00378
Anthracene	0.00002	0.00001	0.00000	0.00003	0.00008
Fluoranthene	0.000002	0.0000008	0.0000003	0.000003	0.00001
Pyrene	0.00034	0.00013	0.00005	0.00052	0.00115
Benzo(a)anthracene	0.00034	0.00013	0.00005	0.00051	0.00113
Chrysene	0.00091	0.00035	0.00014	0.0014	0.00308
Benzo(b)fluoranthene	0.00006	0.00002	0.00001	0.00009	0.0002
Benzo(k)fluoranthene	0.000003	0.000001	0.0000005	0.00001	0.00001
Benzo(a)pyrene	0.00010	0.00004	0.00002	0.00016	0.00035
Indeno(1,2,3-cd) pyrene	0.00377	0.00143	0.00057	0.00577	0.01272
Dibenz(a,h) anthracene	0.00295	0.00112	0.00044	0.00451	0.00995
Benzo(g,h,i) perylene	0.00654	0.00247	0.00098	0.01	0.02204

Note: **Bold** indicates that water quality criteria is exceeded (see Table 5).

Table 5. Comparison of Discharge Concentrations and Water Quality Criteria (μg/L)

Constituent	Estimated Discharge Concentration[1]	Federal Acute WQC	Most Stringent State Acute WQC
Polyaromatic Hydrocarbons (PAHs)			
Acenaphthylene	0.0005	None	0.031 (FL)[2]
Phenanthrene	**0.134**	None	0.031 (FL)[2]
Benzo(a)anthracene	**0.04**	None	0.031 (FL)[2]
Chrysene	**0.109**	None	0.031 (FL)[2]
Benzo(b)fluoranthene	0.007	None	0.031 (FL)[2]
Benzo(k)fluoranthene	0.0004	None	0.031 (FL)[2]
Benzo(a)pyrene	0.012	None	0.031 (FL)[2]
Indeno(1,2,3-cd) pyrene	**0.45**	None	0.031 (FL)[2]
Dibenzo (a,h) anthracene	**0.352**	None	0.031 (FL)[2]
Benzo(g,h,i) perylene	**0.78**	None	0.031 (FL)[2]
Total PAHs[2]	**1.89**		**0.031 (FL)[2]**

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

Bold number indicates that water quality criteria is exceeded.
HI = Hawaii
FL = Florida

1: Highest concentration of three submarine classes
2: Florida criteria for total PAHs is for the total of the following individual PAH compounds: acenaphthylene, benzo-(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and phenanthrene. Estimated discharge concentrations for total PAHs represent a sum of these chemicals.

Table 6. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment			X	X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents			X	X
3.4 Concentrations			X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species			X	X

Calculation Sheet
Benzene

Background:

Henry's Law was used to estimate the concentration of components in wet exhaust from submarine emergency diesel engines. This calculation sheet shows the calculation for the concentration of benzene in the wet exhaust of SSN 688 Class submarines. Calculations for the other exhaust components were similar.

An energy balance was used to determine the approximate wet exhaust equilibrium temperature. The resulting temperature was determined using an air exhaust flow rate of 6,500 cfm at 200 °F, and a water injection rate of 11.5 gpm at 60 °F. For this calculation, we assume the exhaust gas to have similar thermal properties to air.

ΔH: Change in enthalpy, m: mass of air or water, Cp: Specific heat capacity of air or water

$\Delta H_{exhaust\ gas} = \Delta H_{water}$

$\Delta H_{exhaust\ gas} = mCp\ (200°F-T)$

$= (6{,}500\ ft^3/min.)\ (0.0601\ lb_m/ft^3)\ (0.24\ Btu/lb_m°F)\ (200°F - T)$

$= 93.76\ Btu/°F\text{-}min.\ (200°F-T)$ **(1)**

$\Delta H_{water} = mCp\ (T-60°F) = (11.5\ gal/min.)\ (8.345\ lb_m/gal)\ (1\ Btu/\ lb_m\ °F)\ (T-60°F)$

$= 95.97\ Btu/°F\text{-}min.\ (T-60°F)$ **(2)**

Setting (1) = (2) we obtain the following:

93.76 Btu/°F-min. (200°F -T) = 95.97 Btu/°F-min. (T-60°F)

93.76 (T) + 95.97 (T) = 200°F (93.76) + 95.97 (60°F)

T = **129.18 °F** = (9/5) °C + 32 = **54°C**

This temperature was then used to determine the appropriate values for Henry's Law constants, which vary with temperature.

At dilute concentrations, the concentration of benzene dissolved in water can be found from Henry's Law:

$$X_{a,\ exhaust} = (H_a)\ (X_{a,\ water})\ /\ (P_t)$$

Where:

$X_{a,\ exhaust}$: Mole Fraction of Benzene in Exhaust
H_a : Henry's Law Constant (atm)
$X_{a,\ water}$: Mole Fraction of Benzene in Water
P_t : Total Exhaust Pressure (atm)

Rearranging, Henry's Law can be rewritten as:

$$X_{a,\ water} = (X_{a,\ exhaust})\ (P_t)\ /\ H_a$$

The mole fraction of benzene in exhaust can then be converted into a concentration of benzene in the wet exhaust in mg/L using the molecular weight of benzene.

Given Conditions and Assumptions:

55.56 moles H_2O in 1 liter [(mole H_2O / 18 g H_2O) (1000g / Liter H_2O) = 55.56 moles H_2O/L]
Exhaust temperature of 200°F (Reference 3)

6,500 cfm air exhaust flow rate for 800 kW diesel engine
0.334 ng/J generation rate of benzene
Backpressure on engine is approximately 70% above atmospheric when surfaced (P_t = 1.70 atm)
Molecular weight of benzene is 78.11 grams per mole (78,110 mg/mole)
Based on a water temperature of 54 °C (327.15 K), Henry's Law constants (in atm) for the constituents are the following:

Constituent	**H_a (atm)**
Benzene	**7.30 E+03**
Toluene	8.89E+03
Xylenes	8.56E+03
Formaldehyde	2.30E+00
Acetaldehyde	2.34E+01
Acrolein	2.22E+02
No_x	4.01E+04
CO	7.85E+04
CO_2	3.06E+03
Naphthalene	5.71E+02
Acenaphthylene	3.45E+03
Acenaphthene	3.19E+02
Fluorene	1.13E+02
Phenanthrene	5.31E+01
Anthracene	7.96E+01
Fluoranthene	2.92E+03
Pyrene	1.59E+01
Benzo(a)anthracene	2.70E+00
Chrysene	2.44E+00
Benzo(b)fluoranthene	2.77E+01
Benzo(k)fluoranthene	9.17E+01
Benzo(a)pyrene	3.61E+00
Indeno(1,2,3-cd) pyrene	1.60E-01
Dibenz(a,h) anthracene	1.71E-01
Benzo(g,h,i) perylene	1.24E-01

The conversion of Henry's Law constants into common units is presented at the end of the calculation sheet.

Solution:
1) Total number of moles per cubic foot in the air exhaust, including constituents and circulated air, n_t

The number of moles per cubic foot can be determined using the ideal gas law; $PV = n_tRT$

Where:

P: Pressure within the exhaust piping, 1.7 atm
V: Volume of space occupied by gas (assume 1 ft^3)
R: Gas constant, 0.08206 L-atm/ K-mol
T: Temperature, 327.15 K

Rearranging the ideal gas law equation and solving for n_t/V yields:

$$n_t/V = P/RT$$

$$n_t/V = (1.7\text{atm})(28.32\text{ L}/\text{ft}^3)/((0.08206\text{ L-atm}/\text{K-mol})(327.15\text{ K})) = 1.79\text{ moles}/\text{ft}^3$$

2) Concentration of benzene in air exhaust, A_b

$$A_b = (0.334\ \text{ng/J})\ (800\ \text{kW})\ (3.6 \times 10^6\ \text{J/kW-Hr})\ (10^{-9}\text{g/ng})\ (1000\ \text{mg/g})\ (\text{min./6500 f}^{t3})\ (\text{Hr/60 min.})$$

$$A_b = 2.47 \times 10^{-3}\ \text{mg/ft}^3 = (2.47 \times 10^{-3}\ \text{mg/ft}^3)\ (\text{ g/1000 mg})\ (\text{ mole benzene / 78.11 g})$$

$$= 3.17 \times 10^{-8}\ \text{moles benzene/ft}^3\ \text{exhaust}$$

3) Mole fraction of gas in exhaust, $X_{a,\ exhaust}$

$$X_{a,\ exhaust} = A_b/\text{total molar concentration}$$

$$X_{a,\ exhaust} = (3.17 \times 10^{-8}\ \text{moles benzene/ ft}^3\ \text{exhaust}) / (1.79\ \text{total moles/ ft}^3\ \text{exhaust})$$

$$X_{a,\ exhaust} = 1.77 \times 10^{-8}\ \text{moles benzene/ mole exhaust}$$

4) Mole fraction of gas in water, $X_{a,\ water}$

$$X_{a,\ water} = (X_{a,\ exhaust})\ (P_t) / H_a$$

$$X_{a,\ water} = (1.77 \times 10^{-8})\ (1.70\ \text{atm}) / 7300\ (\text{atm})$$

$$X_{a,\ water} = 4.12 \times 10^{-12}\ \text{moles benzene / mole water}$$

5) Concentration of gas in water:

Per 1 liter of water;

$$\text{Moles benzene} = (4.12 \times 10^{-12}\ \text{moles benzene / mole } H_2O)\ (55.56\ \text{moles } H_2O/\ 1\ \text{liter}) = 2.29 \times 10^{-10}\ \text{moles/L}$$

$$(2.29 \times 10^{-10}\ \text{moles/L})\ (78.11\ \text{g benzene/mole}) = 1.8 \times 10^{-8}\ \text{g/L benzene}$$

$$(1.8 \times 10^{-8}\ \text{g/L})\ (1000\ \text{mg/g}) = \mathbf{1.8 \times 10^{-5}\ mg/L\ benzene}$$

Determination of Henry's Constants

Henry's constants for the constituents of concern were available, but units and temperature for the constants varied between the references used. Henry's constants with the following units were available:

1) H_1, atm
2) H_2, atm-m^3/mol

For purposes of clarity, the same calculation was used for each constituent of concern. It was therefore necessary to convert all of Henry's constants to atm units, (1).

1) Conversion from H_2 (atm-m^3/mol) to H_1(atm):

H_1 = (H_2 in atm-m^3/mol) (55.6 mol water / L) (L / 10^{-3} m^3 water) = H_2 * (55,600)

Henry's constants with the following temperatures in degrees Celsius were available:

(1) 20 ^oC
(2) 24 ^oC
(3) 25 ^oC
(4) 40 ^oC

Henry's constants increase on average about threefold for every 10 ^oC rise in temperature for most volatile hydrocarbons.[a] Therefore, the constants will increase by a factor of $\Delta H = 3^{(\Delta T/10)}$. All of the constants were converted to 54 ^oC constants using the following conversions

For Henry's constant at 54 ^oC, and converting from Henry's constants at 20 ^oC, 24 ^oC, and 25 ^oC respectively:

$H_{54} = (H_{20})\ (41.9)$

$H_{54} = (H_{24})\ (27)$

$H_{54} = (H_{25})\ (24.2)$

$H_{54} = (H_{40})\ (4.66)$

Example - Henry's Constant Calculation

For Acrolein, Henry's constant was available in atm-m^3/mol for 20 ^oC ($H_a = 9.54 \times 10^{-5}$)
Therefore, at 54°C, Henry's constant will be:

H_a (atm) = (9.54×10^{-5} atm-m^3/mol) (55,600 mol/m^3) (41.9)
H_a = 222 atm

Using this approach, the constants were converted to atm units as shown in the table on the following page.

Table of Henry's Constants

Temperature **Source** **Units**	**54 °C** **Cooper[b]** **(atm)**	**20 °C** **USEPA[c]** **(atm-m³/mol)**	**25 °C** **Mackay[d]** **(atm-m³/mol)**	**40 °C** **CH2M Hill[e]** **(atm-m³/mol)**	**H_a for 54 °C** **(atm)**
Benzene			**5.43E-03**		7.30 E+03
Toluene			**6.61E-03**		8.89E+03
Xylenes			**6.37E-03**		8.56E+03
Formaldehyde		**9.87E-07**			2.30E+00
Acetaldehyde				**9.05E-05**	2.34E+01
Acrolein		**9.54E-05**			2.22E+02
NO_x	**4.01E+04**				4.01E+04
CO	**7.85E+04**				7.85E+04
CO_2	**3.06E+03**				3.06E+03
Naphthalene			**4.24E-04**		5.71E+02
Acenaphthylene		**1.48E-03**			3.45E+03
Acenaphthene			**2.37E-04**		3.19E+02
Fluorene			**8.39E-05**		1.13E+02
Phenanthrene			**3.95E-05**		5.31E+01
Anthracene			**5.92E-05**		7.96E+01
Fluoranthene			**2.17E-03**		2.92E+03
Pyrene			**1.18E-05**		1.59E+01
Benzo(a)anthracene		**1.16E-06**			2.70E+00
Chrysene		**1.05E-06**			2.44E+00
Benzo(b)fluoranthene		**1.19E-05**			2.77E+01
Benzo(k)fluoranthene		**3.94E-05**			9.17E+01
Benzo(a)pyrene		**1.55E-06**			3.61E+00
Indeno(1,2,3-cd) pyrene		**6.86E-08**			1.60E-01
Dibenz(a,h) anthracene		**7.33E-08**			1.71E-01
Benzo(g,h,i) perylene		**5.34E-08**			1.24E-01

Bold: Original Referenced Number

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b. Cooper, David and F. Alley, Air Pollution Control, A Design Approach. Waveland Press, Inc., 1986.

c. United States Environmental Protection Agency Office of Air Quality Planning and Standards. Ground-Water and Leachate Treatment Systems Manual. R-94, January 1995.

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NATURE OF DISCHARGE REPORT

Submarine Outboard Equipment Grease and External Hydraulics

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS are being developed in three phases. The first phase (which this report supports) will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs) -- either equipment or management practice. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the submarine outboard equipment grease and external hydraulics discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

This discharge occurs when grease applied to a submarine's outboard equipment is released to the environment by erosion from the mechanical action of the seawater while the submarine is underway and, to a much lesser extent, by slow dissolution of the grease into seawater. The discharge also includes any hydraulic oil that could leak past the seals of the hydraulically operated external components of a submarine.

2.1.1 Grease from Outboard Equipment

Submarine outboard equipment that requires lubrication includes steering and diving control mechanisms and control surface bearings. Grease is applied quarterly while a submarine is in port.[1] Figure 1 shows the various grease points on a submarine that can come into contact with seawater under partially or completely submerged conditions. Of these, the ones that are operated within 12 nautical miles (n.m.) and could release grease to the environment are the retractable bow planes, and the fairwater (sail planes). The retractable bow plane components require the largest amount of grease for operation. Figure 2 is a cut-away diagram of the retractable bow plane cavity where grease is applied to its various components.

Bow Plane Mechanisms. The retractable bow planes are a set of fins or control surfaces that are housed within the envelope of the hull and are extended to provide depth control while the submarine is moving underwater. These bow planes have mechanisms that slide in and out causing the bow planes to change position in response to commands from the helm. The sliding components are lubricated by an automatic system that applies grease every time they move back and forth. This movement may cause some grease to loosen and detach from the components and deposit in the bow plane compartment (20 feet wide by 6 feet long by 5 feet high) which is in contact with the sea through a narrow, half-inch-wide gap around each bow plane. Because of this relatively narrow opening to the sea as well as a protective brush that covers this gap completely around the retractable bow plane, the probability of loose grease in the cavity washing out of the compartment is low. Currently, only 22 submarines have retractable bow plane compartments, but future design trends will increase this number.[2]

Fairwater Plane Mechanisms. Submarines that do not have retractable bow planes have control surfaces that perform a similar function, but which are located on the sail structure. These are the fairwater planes. Currently, there about 72 submarines in the fleet with fairwater planes. Fairwater planes have components similar to the retractable bow planes that also lubricated by greasing, but the components do not contact seawater while the submarine is within

12 n.m. because the fairwater planes are located well above the water line when the submarine is surfaced.

2.1.2 External Hydraulics

The external hydraulic system on a submarine supplies hydraulic fluid under pressure to operate the following equipment:

- masts (e.g. radio antennas, radar, electronic counter measures, etc.), periscopes, and their associated fairings (e.g., hydrodynamic covers for the various masts and periscopes needed to reduce the turbulence while the submarine is running submerged with the masts and/or periscopes raised);

- retractable bow plane actuator mechanisms; and

- secondary propulsion motor hoist cylinders located outside the pressure hull.

Figure 3 shows the location of masts, antennas, and periscopes on a submarine's hull. The secondary propulsion motor hoist cylinders (not shown in the figure) are located in an aft ballast tank.

Navy submarines use specially formulated oil in their external hydraulic systems. The hydraulic oil is normally pressurized to approximately 1,400 pounds per square inch (psi) and stored in a reservoir that holds approximately 200 gallons. The total amount of hydraulic oil in the system, including that in piping and the reservoir, is approximately 250 gallons. On submarines that have hydraulically-operated retractable bow planes (22 of 94 submarines), the total amount of hydraulic oil is approximately 400 gallons.[3] Of those items identified above operated by the external hydraulic system, only the retractable bow plane actuator mechanisms will have any possible release to the environment. In the case of the masts, antennas, and periscopes, they are located well above the waterline, well away from any contact with the seawater, where there is no possible erosion of the any oil film generated by the equipments' operation. In the case of the secondary propulsion motor, it is only operated in rare emergency situations, and as such is not covered by the UNDS criteria.

2.2 Releases to the Environment

Grease transport is produced through the mechanical action of the water against components covered with grease. Underway, some of the loose grease in the bow plane compartment can be eroded by the mechanical action of the flowing seawater. The amount of grease released is directly proportional to the force of turbulent water in the vicinity of the grease resulting in erosion, which, in turn, is directly proportional to submarine speed. Within 12 n.m., a submarine's speed is low by comparison to its speed when submerged. It increases speed once it submerges. Therefore, the amount of mechanical erosion within the 12 n.m. zone is less than when the submarine is in open ocean.

Very little, if any, grease is discharged when a submarine is pierside because the outboard equipment is not being actuated, and the erosive action of seawater is minimal when the submarine is stationary.

Periodically, when the submarine is dry docked (typically every two years), grease that has accumulated in the retractable bow plane compartment is removed and disposed of in an approved manner by a qualified shore facility.[1]

Under normal operating conditions, little hydraulic oil is released within 12 n.m. of shore. Within this zone, the snorkel masts and the antennas are above the water line and do not contact seawater (except for an occasional sea spray). Hydraulic oil may be released when the external hydraulic systems are tested during outbound transits. Leaked oil, if any, is likely to be small quantities that adhere to the component surface. Only when the submarine submerges (beyond 12 n.m.) will the oil be washed away. Oil releases from bow planes generally remain in the upper area of the cavities surrounding the planes. Because of the small size, configuration, location of the bow plane cavity opening, and minimal seawater turbulence, transport of trapped oil to the sea is unlikely. Further, only 22 of the 94 submarines in service have hydraulically operated bow planes. The secondary propulsion motor is available as a backup option to maneuver close to port when needed. Typically, tugs are available for this purpose and the secondary propulsion motor is not used under normal operating circumstances.

2.3 Vessels Producing the Discharge

All submarines have lubricated outboard equipment and external hydraulic systems. Because all submarines belong to the Navy, this discharge is not produced by vessels belonging to the Army, Air Force, U.S. Coast Guard, and the Military Sealift Command.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas; Section 3.2 describes the rate of the discharge; Section 3.3 lists the constituents in the discharge; and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Outboard equipment grease can be discharged within 12 n.m. of shore. The amount is dependent on how much contact there is between the seawater and the greased components, and how fast the vessel is traveling. Most hydraulically operated outboard equipment does not contact seawater within 12 n.m. of shore because submarines usually run surfaced in this zone and the outboard equipment is mostly above the waterline. Submarine dive points are outside the 12 n.m. zone except for those dive points off the coast of the Hawaiian islands and Washington state.[4,5]

3.2 Rate

This discharge is the washout of oil and grease when lubricated components and components with hydraulic oil come in contact with flowing seawater.

Grease. A rough estimate of grease discharge can be made based on the total amount used. Each attack submarine (SSN) uses approximately 425 pounds of grease annually, while each missile submarine (SSBN) uses an estimated 800 pounds annually.[2] Approximately 81% of the submarine fleet are SSNs and 19% are SSBNs. On a weighted average basis, therefore, each submarine uses approximately 496 pounds of grease each year.

The grease is released primarily by the mechanical action of the seawater against the greased submarine components and, therefore, happens only when the submarine is underway. Each submarine enters and leaves port approximately six times per year.[3,6] A typical one-way trip through the 12 n.m. zone lasts approximately 4 hours; therefore, the total annual transit time through that zone is 48 hours per submarine ((6) (4) (2) = 48).[6] A submarine typically spends 6 months, or 183 days, moving in the water so transit time accounts for less than 1.1% of this total time at sea. Therefore, 1.1% of the total grease used can be assumed to be released during transits.[3,4.] The resulting 1.1% of the 496 pounds of grease per vessel per year is equivalent to a discharge rate of approximately 5.5 pounds of grease for each vessel per year within 12 n.m.

Hydraulic Oil. Hydraulic oil is retained in the system by internal and external seals; the former prevents hydraulic oil from leaking into the submarine, while the latter prevents oil from leaking outside the hull. Because some leaks still occur, the Navy has established acceptable leak rates.[7] For newly installed seals, the specification allows "a slight wetting of the tailrod or other visible part of the sealing area." In addition to the "slight wetting" qualitative criterion, the specification also provides a quantitative leak rate standard of one drop every 25 cycles for each inch (or fraction) of rod (length) or seal diameter. For example, a cylinder with a 2.25-inch diameter rotating tailrod would be allowed to leak at a rate of three drops every 25 cycles. A cycle is defined as moving from a fully retracted position to a fully extended position and back.[7]

The specification also contains seal replacement criteria. If leaks occur when a component is not operating, the seal should be replaced when the leak rate is four milliliters (mL) or more per hour for each inch (or fraction) of seal diameter. If leaks occur when a component is cycled, the seal should be replaced when a leak rate of one mL or more per inch of seal diameter (or fraction) for every 10 cycles is observed.

Leak rate standards can be used to estimate the amount of oil that leaks into the sea from external hydraulic systems seals. For example, the two bow planes, when deployed, are each 7.5 feet long. At a rate of one drop of oil every 25 cycles for each inch of rod length, the acceptable leak rate for the two diving planes, which are a combined 15 feet long, is 180 drops (15 feet = 180 inches) every 25 cycles. Assuming that 10 drops are equivalent to one mL,[2] 18 mL of oil will leak every 25 cycles. Therefore, each time the bow planes are extended and retracted (one cycle), approximately 0.72 mL (18 mL/ 25 cycles) of oil will be released but will likely remain in the bow plane cavity. Assuming six outbound transits per year for each vessel and that the vessel cycles its retractable bow planes twice during each transit, this would result in a discharge rate of 8.64 mL of oil discharged per vessel per year. This calculation assumes that external hydraulic systems are tested during outbound transits only.

3.3 Constituents

This discharge consists of Termalene #2 grease and hydraulic oil. Termalene #2 consists of mineral oil, a calcium-based rust inhibitor, an antioxidant, and dye.[8] Hydraulic oil consists of heavy paraffinic distillates and additives.

In general, greases are made from lubricating stocks generated during petroleum fractionation. These fractions contain organic compounds (C_{17} or higher). Lubricating oils are composed of aliphatic, olefinic, naphthenic (cycloparaffinic), as well as aromatic hydrocarbons, depending on their specific use. Lubricating oil additives include antioxidants, bearing protectors, wear resisters, dispersants, detergents, viscosity index improvers, pourpoint depressors, and antifoaming and rust-resisting agents.[9] Lubricating oils and greases could have priority pollutants. No bioaccumulators are expected.

3.4 Concentrations

The discharge consists of 100% grease and oil in their pure form as they are washed away from the vessel's surface due to mechanical action of water. Because the oil or grease do not become mixed with water until they contact the surrounding seawater, concentrations in the discharge cannot be defined in the conventional sense. It is known that the hydraulic oil consists of 95-99% heavy paraffinic distillates.[10] The remainder consists of additives.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. In Section 4.3, the potential for transfer of non-indigenous species is discussed.

4.1 Mass Loading

4.1.1 Grease From Outboard Equipment

Using the assumption that 100% of the applied grease is washed away, the annual amount of grease discharged by each submarine within 12 n.m. is 1.1% of the total grease used (Section 3.2), or approximately 5.5 pounds per vessel per year. Based on 94 submarines, the total amount of grease discharged within 12 n.m. on an annual basis is 517 pounds.

4.1.2 External Hydraulics

Based on a per vessel discharge rate of 1.44 mL per vessel per transit (six transits per vessel per year) or 8.64 mL per vessel per year and given that there are 22 submarines currently existing in the fleet that contribute to this discharge, the fleet wide mass loading is 190 mL per year. This is equivalent to 0.0029 pound (lb) per vessel per transit (at a density of 7.51 lb/gallon) or 0.3755 lb of oil released per year by the entire submarine fleet.

4.2 Environmental Concentrations

As a submarine moves, it creates a disturbance in the surrounding seawater. This disturbed volume of seawater may be thought of as a mixing zone in which discharges from the submarine would be dispersed. This volume of seawater was estimated and used in concentration calculations. A sample calculation for a SSN 688 Class submarine is presented below. The calculation was based on the following assumptions:

- SSN 688 Class submarine has a total width of 33 feet.[11]
- Width is the diameter of the vessel's cross section.
- A mixing zone of 10 feet around the hull, based on the width of wake behind a typical SSN.
- The discharge is mixed uniformly throughout the mixing zone over the entire transit.
- The submarine is only partially submerged, at an approximate depth of 28 feet

1) Cross-sectional area = (area of submarine cross section and disturbed width) - (area of the chord representing that portion of the circle above the surface of the water)
area = $[(3.14)(33/2 + 10)^2]$ - [area of a chord of height 15 ft of a circle of radius 26.5 ft]
area = $2{,}206\ ft^2 - 514\ ft^2 = 1692\ ft^2$

2) Volume of water swept = (area) (12 n.m. distance)
volume = $(1{,}692\ ft^2)(72{,}960\ ft) = 1.23 \times 10^8\ ft^3$, or **123 million cubic feet**

The width of submarines ranges from 31.8 feet (SSN 637 Class) to 42.3 feet (SSN 21 Class).[11] Therefore, the range of volume of water swept, using similar calculations to those above, would be 118 million cubic feet to 158 million cubic feet per submarine per transit.

4.2.1 Grease from Outboard Equipment

To develop environmental concentration estimates for grease, it is assumed that the 5 pounds of grease discharged per year are evenly distributed over the 12 transits through the 12 n.m. zone. Therefore, for each transit, approximately 0.46 pound (5.5 pounds of grease per submarine per year divided by 12 transits per year) of grease is discharged. Based on the previous calculations, the smallest volume of water swept by a submarine is 118 million cubic feet by the SSN 637 Class. Therefore, the concentration in the environment was estimated as presented below: (Note: The calculations were based on the area swept by the SSN 637 class hull as it represents the smallest swept area.)

$$0.46 \text{ pound of grease} \div 1.18 \times 10^{8}\ \text{ft}^{3} \text{ of water}$$
$$= 208.6 \text{ g of grease in } 3.34 \times 10^{9} \text{ Liters of water}$$

$$\mathbf{= 6.2 \times 10^{-8}\ g/L = 0.062\ \mu g/L}$$

This estimated concentration was based on 100% of the grease being washed away. Most grease discharged remains in hull cavities and is removed from the submarine during maintenance. Although open to seawater, the 0.5-inch-wide gaps around retractable bow planes are well shielded by close-fitting brushes, and the seawater in the compartment or cavity is quiescent compared to water moving over the hull. Therefore, the rate of grease erosion will be lower than the amount calculated.

4.2.2 External Hydraulics

To estimate environmental concentrations for hydraulic oil, the following assumptions are made:

- Volume of water swept by the submarine is 118 million ft^3 or 3.34×10^9 liters per transit.
- The discharge rate of hydraulic oil is 0.0029 lb per vessel per transit uniformly distributed throughout the transit.

Based on the above assumptions, the environmental concentration can be estimated as follows:

1) Oil released = 0.0029 lbs = 1.32 g of oil released per vessel per transit
2) Concentration = (g of oil released) ÷ (liters of water)
= (1.32 g) ÷ (3.34×10^9 L)
= 3.95×10^{-10} g/L = 3.95×10^{-4} µg/L

4.2.3 Total Releases

Based on the environmental concentrations estimated above, the total oil & grease concentration in the surrounding water would be the sum of individual concentrations, i.e., 0.062 µg/L + 0.000395 µg/L = 0.062395 µg/L, or approximately 0.06 µg/L. This concentration does not exceed federal discharge standards and state water quality criteria as shown in Table 1.

4.3 Potential for Introducing Non-Indigenous Species

Non-indigenous species are not introduced by this discharge because seawater is not taken aboard or discharged when this discharge is generated.

5.0 CONCLUSIONS

The submarine outboard equipment grease and external hydraulics system discharge has a low potential to cause an adverse environmental effect. This is due to the small amounts of lubricant released when the vessel is underway is dispersed to concentrations below water quality criteria. The estimated concentrations of oil and grease in the environment that results from movement of submarines, is 0.06 ppb, which is far below Federal and most stringent state water quality criteria. These concentrations were estimated based on the volume of water (3.3 billion liters) swept by a submarine while in transit through the 12 n.m. zone, and the conservatively estimated amount of oil and grease released during transit (1.44 mL and 0.46 pounds, respectively).

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on the reported concentrations of oil and grease components, the concentrations of oil and grease in the environment resulting from this discharge were then estimated. Table 2 shows the sources of the data used to develop this NOD report.

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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

Table 1. Comparison of Environmental Concentration with Relevant Water Quality Criteria

Constituent	Concentration	Federal Discharge Standard	Florida Acute Water Quality Criteria
Oil & Grease	6 μg/L	visible sheen[a] / 15,000 μg/L [b]	5,000 μg/L

Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

[a] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.

[b] *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 as implemented by the *Act to Prevent Pollution from Ships* (APPS)

Table 2. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents				X
3.4 Concentrations	X			X
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	X

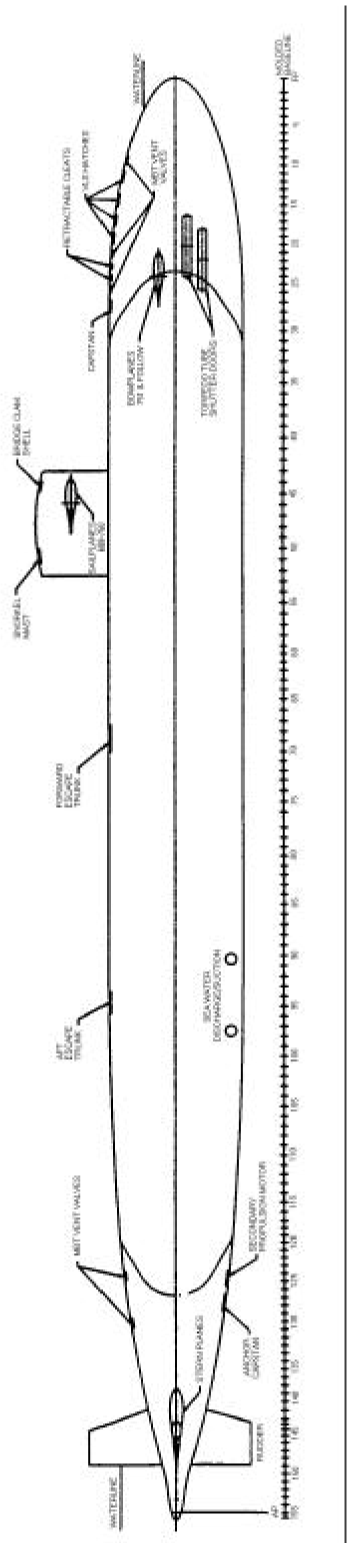

Figure 1. Submarine Points of Contact of Grease and Seawater

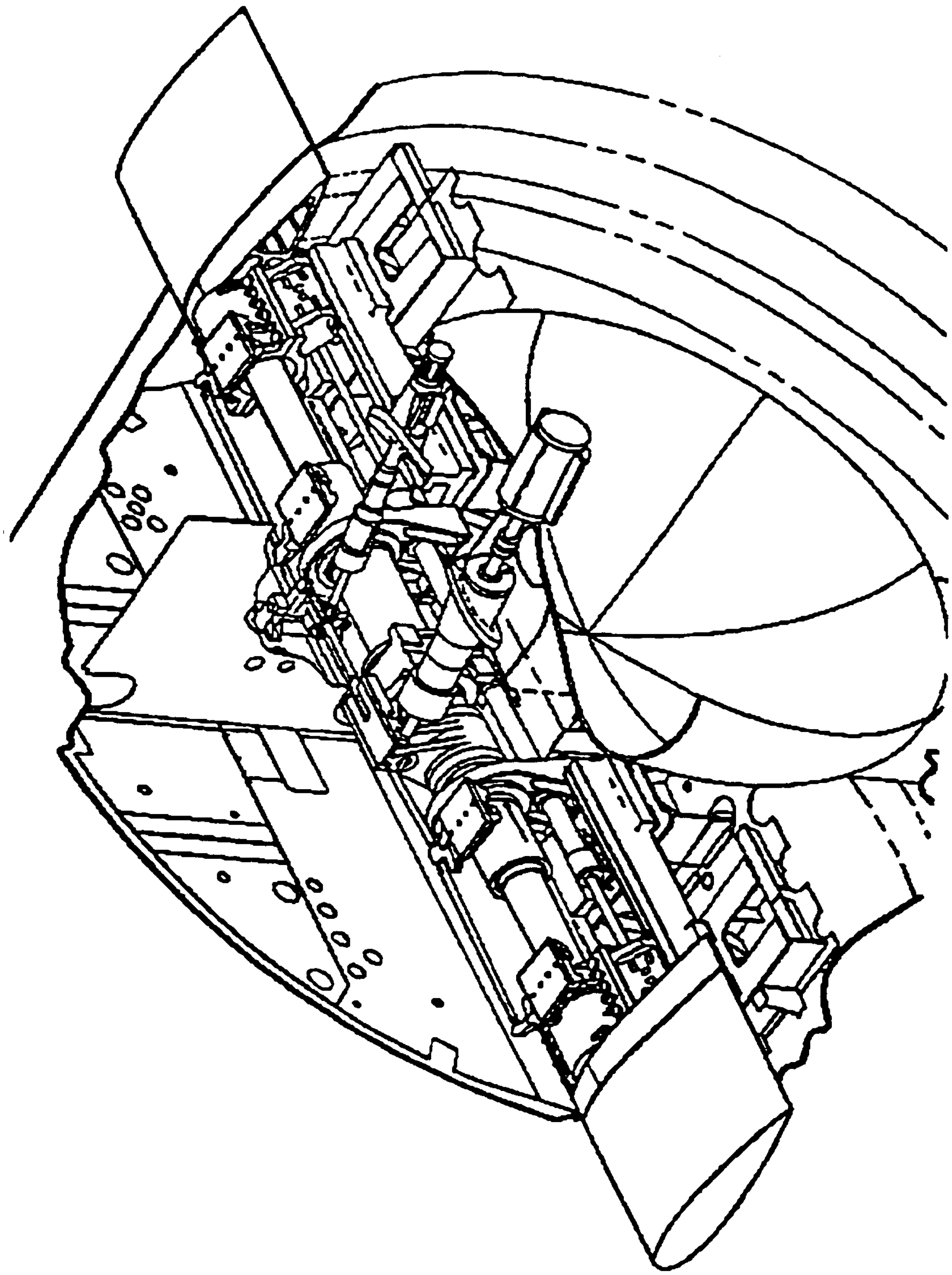

Figure 2. Retractable Bow Plane Arrangement (Typical)

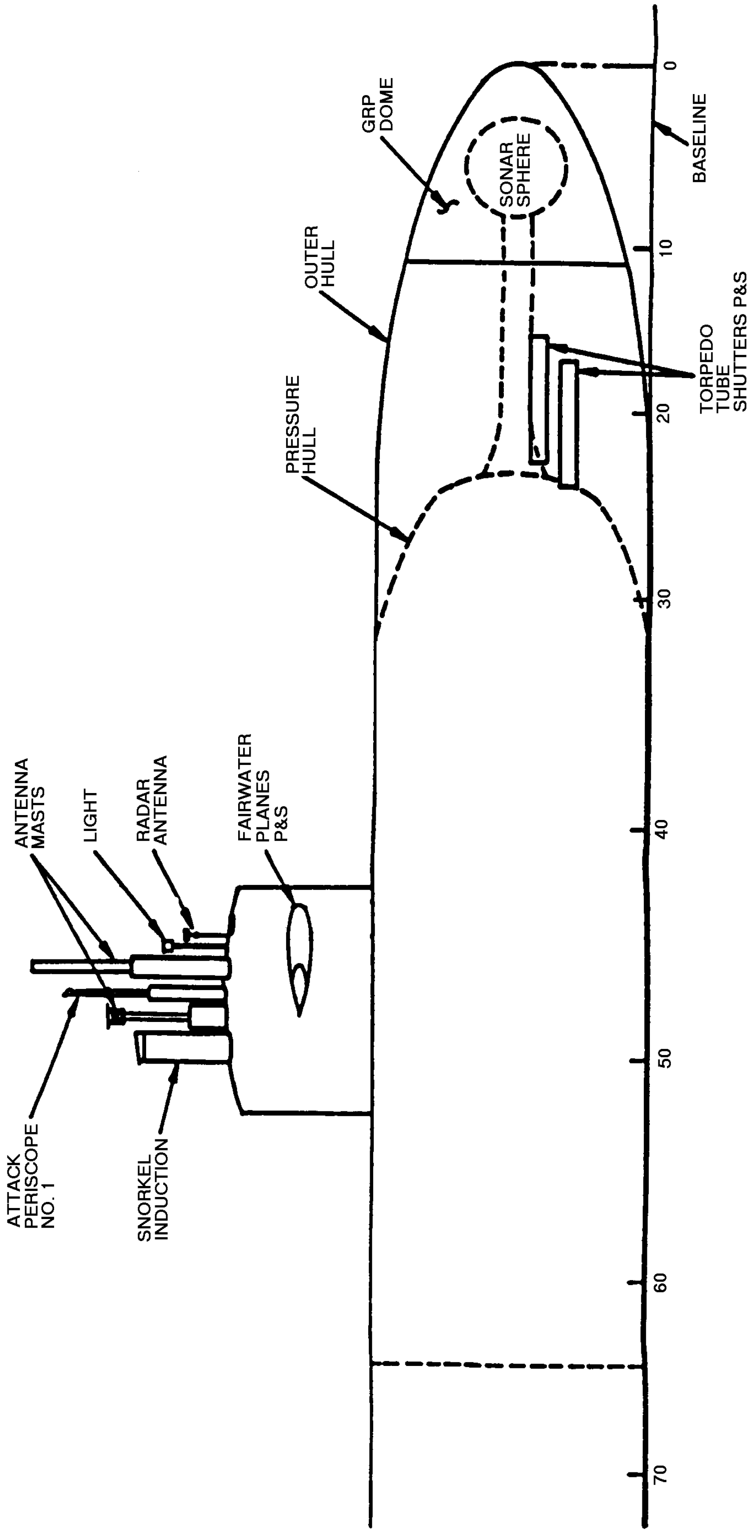

Figure 3. Location of Masts, Antennas, and Periscopes

NATURE OF DISCHARGE REPORT

Surface Vessel Bilgewater/Oil Water Separator (OWS) Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the armed forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that have been identified as candidates for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the armed services with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contain sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the bilgewater/OWS discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

2.1.1 The Bilge Area

The lowest inner part of the hull where liquid drains from the interior spaces and the upper decks of the vessel is referred to as the bilge. The primary sources of drainage into the bilge are the main engine room(s) and the auxiliary machinery room(s), which house the vessel's propulsion system and auxiliary systems (i.e., steam boilers and water purification systems), respectively. Other spaces that collect and contain fluid drainage in their bilge are the shaft alley, steering gear rooms, pump rooms, and air conditioning and refrigeration machinery rooms. Some oil lab sink drains are also directed to the bilge. The liquid collected in the bilge is known as "bilgewater" or "oily wastewater".

2.1.2 Composition of Bilgewater

The composition of bilgewater varies from vessel to vessel; the composition of bilgewater also varies from day to day on the same vessel. Certain wastestreams, including steam condensate, boiler blowdown, drinking fountain water, and sink drainage located in various machinery spaces, can drain to the bilge. The propulsion system and auxiliary systems use fuels, lubricants, hydraulic fluid, antifreeze, solvents, and cleaning chemicals, as part of routine operation and maintenance. Small quantities of these materials enter the bilge as leaks and spills in the engineering spaces. On some older vessels, excess potable water produced by onboard water purification systems is directed to the bilge, although this practice is being phased out.[1] On some Navy and Coast Guard vessels, water from gas turbine washdowns can contribute to bilgewater generation; these washdowns are described in the Gas Turbine Water Wash NOD report.

2.1.3 Bilgewater Treatment and Transfer System

Every surface vessel has an onboard system for collecting and transferring bilgewater. Vessels pump collected bilgewater to a holding tank which the Navy refers to as the oily waste holding tank (OWHT). Some vessels are capable of transferring bilgewater from the OWHT to shore facilities while pierside. OWS systems are installed on vessels, as appropriate, to reduce the oil content of bilgewater prior to overboard discharge. These systems receive bilgewater from the OWHT and use gravity-phase separation, coalescence, centrifugal separation, or combinations of these technologies to treat the waste.

A commonly used Navy OWS is a coalescing plate gravity separator. This type of separator has a horizontal set of oleophilic plates. Oil droplets rise and coalesce as they flow through the plates. The droplets cling to and wet the oleophilic plates once they rise to a plate's underside. When sufficient oil has accumulated, large oil droplets rise through weep holes in the plates and flow to the top of the OWS. The separated oil is then transferred to a waste oil tank (WOT). Figure 1 is a process flow diagram of the standard OWS system used on most Navy vessels.

On some vessels, oil content monitors (OCMs) are installed to prevent the discharge of unacceptable effluent. If the oil content is above the set point limit, the OCM alarms and diverts the OWS effluent back to the OWHT for reprocessing until an acceptable oil concentration reading is obtained.

In addition to the oil removed by the OWS, waste oil from routine maintenance is also collected in the WOT and held for pierside disposal.

Synthetic lubricant oils (SLOs) are not collected in the WOT, and measures are taken to prevent their introduction into the bilge. SLOs have a specific gravity close to that of water and cannot be separated in the OWS. These oils are normally found in engine spaces and are collected in drip pans located underneath the engines. The drip pans drain through segregated piping to dedicated collection tanks. SLOs within these tanks are disposed of on-shore separately from non-synthetic waste oils. Therefore, SLOs, except for tank overflows, are not likely to be in bilgewater at significant levels.

Some ships (e.g., DDG 51 Class destroyers) use non-oily machinery wastewater collection systems that segregate oily wastewater from non-oily wastewater. These ships collect non-oily machinery wastewater in dedicated collection tanks instead of the bilge, and discharge it directly overboard. All oily wastewater collects in OWHTs and is processed by a shipboard OWS or off-loaded for shore facility treatment.

2.2 Releases to the Environment

Untreated bilgewater is expected to contain oil and grease (O&G), an assortment of oxygen-demanding substances, and organic and inorganic materials. These materials include volatile organic compounds (VOCs), semi-volatile organic, inorganic salts, and metals. OWS effluent releases to the environment contain the same constituents present in bilgewater but with lower concentrations of O&G and oil-soluble components.

2.3 Vessels Producing the Discharge

All vessels produce bilgewater. OWS systems have been installed on most vessels of the Armed Forces. Some small boats and craft are not outfitted with OWS systems; thus, bilgewater is stored for shore disposal. Table 1 lists all surface vessels equipped with OWSs. Submarine bilgewater is addressed in the Submarine Bilgewater NOD report.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information which characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

The Armed Forces do not discharge untreated bilgewater to surface waters. On ships without OWS systems, untreated bilgewater is held for transfer to a shore treatment facility. Bilgewater treated by an OWS can be discharged within or beyond 12 nautical miles (n.m.). On Navy vessels with an OWS and OCM, oil concentrations must be less than 15 parts per million (ppm) prior to discharge. However aboard Navy vessels, discharge of bilgewater with an oil concentration less than 100 ppm is allowed outside 12 n.m. if concentrations less than 15 ppm cannot be achieved because of operating conditions.

3.2 Rate

Bilgewater generation rates vary by vessel and vessel class because of the differences in vessel age, shipboard equipment (e.g., type of propulsion system), operations, and procedures. Vessels with non-oily machinery wastewater collection systems will generate significantly less bilgewater because of their capability to keep non-oily waste streams out of the bilges. The DDG 51 and CVN 68 class ships are two examples of ship classes that have non-oily machinery wastewater collection systems. Other factors influencing bilgewater generation rates are whether a vessel is operating in-port or at-sea, and when in port, whether it is operating in an auxiliary steaming mode or receiving shore electrical/steam power (cold iron mode). In the auxiliary steaming mode, a vessel provides its own services while moored at the pier (i.e., power, freshwater, etc.). In the cold iron mode, a vessel receives these services from shore facilities, minimizing the amount of shipboard equipment in operation. Older vessels without non-oily machinery wastewater collection systems have historically generated more bilgewater while operating in the auxiliary steaming mode than in the cold iron mode because of the discharge of utilities wastewater to the bilge.

Table 2 shows the in-port bilgewater generation rates for certain destroyers (DD 963 and DDG 51 Classes) and aircraft carriers (CVN 68 Class). For the destroyers, bilgewater generation rates were developed by monitoring the levels of bilgewater in the bilges.[1,2] Aircraft carrier class (CVN 68) data was gathered from an analysis of a carrier's (CVN 74) OWS operator log sheets in order to determine the amount of bilgewater that had passed through the OWS over an extended period of time, thus providing an estimate of the bilgewater generation rate.[3]

Table 3 summarizes the bilgewater/OWS flow rates that were developed for an aircraft carrier class (CVN 68), "other ship classes," and the overall fleet based on the average values from Table 2. The assumptions that were made in developing the estimates are summarized as follows:

1. The average and maximum daily bilgewater OWS discharge flow rates for a carrier (CVN 74) of 3,000 and 25,000 gallons per day (gpd), respectively, represents the average and maximum daily bilgewater/OWS flow for all aircraft carriers.

2. The destroyer (DD 963) bilgewater flow estimate of 1,000 to 3,000 gpd represents a typical range of flows for other U.S. Navy surface ship classes. An average of 2,000 gpd is assumed to be the average bilgewater generation rate.

3. Aircraft carriers spend approximately 147 days in port annually.

4. Other ships are in port for approximately 193 days annually.

The calculations used to estimate the total fleet bilgewater OWS effluent discharge to surface waters within 12 n.m. are presented as follows:

CVN 68 Class

$$\mathbf{F_{CVN}(flow\ rate)} = (\mathbf{R_{CVN}})(\mathbf{D_{CVN}})(\mathbf{N_{CVN}})$$

$\mathbf{R_{CVN}}$ = ship flow rate, gpd

$\mathbf{D_{CVN}}$ = days in port annually per ship

$\mathbf{N_{CVN}}$ = number of ships

$\mathbf{F_{CVN}}$ = (3,000) (147) (11) = **4.9 million gallons per year**

Other Ship Classes

$$\mathbf{F_{O}(flow\ rate)} = (\mathbf{R_{O}})(\mathbf{D_{O}})(\mathbf{N_{O}})$$

$\mathbf{F_{O}}$ = (2,000) (193) (220) = **84.9 million gallons per year**

Overall Fleet

$\mathbf{F_{FLEET}}$ = $\mathbf{F_{CVN}}$ (million gals/year) + $\mathbf{F_{O}}$ (million gals/year)

$\mathbf{F_{FLEET}}$ = 4.9 + 84.9 = **89.8 million gallons per year**

It should be noted that bilgewater generation rates are based on data available from existing reports for U.S. Navy ships and does not include "estimates of bilgewater" from ships of other services.

3.3 Constituents

Information about the constituents of bilgewater comes from several studies conducted aboard Navy vessels and at Navy ports, in addition to the UNDS Phase I testing. During these previous studies, samples of bilgewater were collected from a variety of Navy vessels, including aircraft carriers, cruisers, destroyers, dock landing ships, tank landing ships, amphibious assault ships, amphibious transport docks, and submarines. There have been no similar studies or documentation available for the other services.

Bilgewater samples collected in the previous studies were analyzed for a variety of parameters, such as classicals, metals, and organics (including pesticides). Over 25 priority pollutants were identified from these samples, including metals such as arsenic, copper, cadmium, chromium, lead, mercury, selenium, and zinc; and organics such as benzene, the BHC isomers (isomers of hexachlorocyclohexane), ethyl benzene, heptachlor, heptachlor epoxide, naphthalene, phenols, phthalate esters, toluene, trichlorobenzene, and trichloroethane. The bioaccumulators identified in these samples were the BHC isomers and mercury. A variety of substances that are neither priority pollutants nor bioaccumulators were also detected, including metals such as barium and manganese and organics such as chloroform and xylene.

The analytical results from these studies are shown in Tables 4 through 8. The results provide a general overview of the constituents that have historically been detected in bilgewater and the effluent from bilgewater OWS treatment.

3.4 Concentrations

The concentrations of constituents detected during UNDS Phase I testing of bilgewater/OWS effluent samples collected aboard an aircraft carrier (CVN 74) are summarized in Table 9. Many of the same constituents that were detected in the previous studies were also detected in the aircraft carrier samples. This includes classicals, oil & grease as indicated by hexane extractable materials (HEM) or total petroleum hydrocarbons (TPH) as indicated by silica gel treated hexane extractable materials (SGT-HEM), certain metals, and the bioaccumulator, mercury. Neither pesticides nor PCBs were detected in the aircraft carrier bilgewater/OWS samples. Table 10 presents the general statistics of the aircraft carrier data.

Analytical results from previous bilgewater studies are shown in Tables 4 through 8. These tables provide concentrations of constituents that have historically been detected in bilgewater and the effluent from bilgewater OWS treatment.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. Estimated constituent mass loadings are presented in Section 4.1. In Section 4.2, the available concentration data for the discharge constituents are evaluated, including comparison with federal and state water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loading

Validated bilgewater/OWS constituent concentration data from the aircraft carrier [4] and the flow rate estimates referenced in NOD report Section 3.2 were used to estimate the mass loading of pollutants to the environment. Historical data were not used to estimate mass loadings because these data were not validated.

Table 11 provides a bilgewater/OWS effluent mass loading summary for all constituents detected in the aircraft carrier samples. Sampling data have identified copper, nickel, and zinc as exceeding Federal water quality criteria (in addition to the most stringent state criteria) in the bilgewater/OWS samples analyzed. Also, the concentrations for ammonia, nitrogen (as nitrate/nitrite and total kjeldahl nitrogen), phosphorous, iron, and total petroleum hydrocarbons exceeds the most stringent state water quality criteria.

The constituent loading estimates are based on the assumption that vessels with an on-board OWS system will always process bilgewater through the system and discharge the effluent overboard while in-port, rather than off-loading untreated bilgewater to shore facilities for disposal.

Sample calculations for TPH, as indicated by SGT-HEM, are provided to show how the total fleet constituent discharges to surface waters less than 12 n.m. from shore were calculated. The assumptions and calculations are presented below.

1. The total amount of OWS effluent discharged annually from aircraft carriers is 4.9 million gallons (Table 3).

2. The sample data from CVN 74 (Table 10) are assumed to be representative of all aircraft carriers.

$$\mathbf{M(tph)_{CVN}}\text{ (pounds/year)} = (\mathbf{V_{CVN}}\text{ (million gals/year)})\ (\mathbf{C_{CVN}}\text{ (mg/Liter)})\ (\mathbf{CF})$$

where: $\mathbf{V_{CVN}}$ = Total bilgewater/OWS generation rate/year

$\mathbf{C_{CVN}}$ = TPH (SGT-HEM) concentration

$$\mathbf{CF} = \text{conversion factor} = 8.34 = \frac{(3.785\text{ liters/gal})\ (1\text{x}10^6\text{ gals/million gals})}{(454\text{ grams/pound})\ (1{,}000\text{ mg/gram})}$$

$$\mathbf{M_{CVN}} = (4.9)\ (9.64)\ (8.34) = \mathbf{394\ pounds/year}$$

The mass loading of constituents for the entire fleet can be estimated by multiplying the estimate for aircraft carriers by a discharge ratio. The discharge ratio is the total fleet discharge rate divided by the total discharge from aircraft carriers. Use of this ratio to estimate fleet mass loadings assumes sample data from CVN 74 (Table 10) is representative of all vessels of the armed forces.

2. Ratioing the total flow for the fleet (89.8 mgd) to the aircraft carrier class (CVN 68) flow for (4.9 mgd) , and multiplying the aircraft carrier loading by the ratio.

$$\mathbf{M_{FLEET} = (F_{FLEET} / F_{cvn}) (M_{CVN})}$$

$$\mathbf{M_{FLEET}} = (89.8/4.9)(394)=7220 \textbf{ pounds/year}$$

4.2 Environmental Concentrations

Table 11 identifies bilgewater OWS effluent constituents in the aircraft carrier samples whose log mean average concentrations (dissolved and/or total) were above Federal water quality criteria, and/or the most stringent state water quality criteria. With regard to oil concentration data, the samples were analyzed for HEM and SGT-HEM. The HEM values correspond to oil and grease and the SGT-HEM values correspond to total petroleum hydrocarbon (TPH) which is a subset of oil and grease.

4.3 Potential for Introducing Non-indigenous Species

There is a low potential for transporting non-indigenous species in this discharge. There is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances.

5.0 CONCLUSIONS

Surface vessel bilgewater and OWS discharges have the potential to cause an adverse environmental effect for the following reasons:

1) Bilgewater, if discharged without treatment, would contribute significant amounts of oil to the environment at concentrations exceeding water quality criteria and discharge standards.

2) OWS effluent contributes significant amounts of oil to the environment at concentrations exceeding water quality criteria and discharge standards.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on the reported concentrations of oil and grease constituents, the concentrations of the oil and grease constituents in the environment resulting from this discharge were then estimated.

Table 12 shows the source of the data used to develop this NOD Report.

1. Bilgewater Characterization and Generation Surveys Aboard DD-963 Class Ships. April, 1981. David Taylor Naval Ship Research and Development Center. Report #: DTNSRDC/SME-81/09.

2. In-Port Oily Wastewater Generation on USS ARLEIGH BURKE (DDG 51), NSWCCD-TR-63-96/37. November 1996.

3. USS John C. Stennis (CVN 74) OWS log sheets obtained from CVN 74 by J. Jereb of DLS Engineering Assoc. and submitted to Malcolm-Pirnie via facsimile on February 13, 1997.

4. Correspondence from Commander, Naval Surface Warfare Center, Carderock Division, Philadelphia Site to Commander, Naval Sea Systems Command (Code 03L13), Uniform National Discharge Standards (UNDS) Sampling Program Data, Ser 631/225, 1-6310-280, dated June 19, 1997.

5. The Characterization of Bilgewater Aboard U.S. Navy Ships. October 1992. Naval Surface Warfare Center Carderock Division. Tech. Report #: CDNSWC/SME-CR-10-91.

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Florida. Department of Environmental Protection. Surface Water Quality Standards, Chapter 62-302. Effective December 26, 1996.

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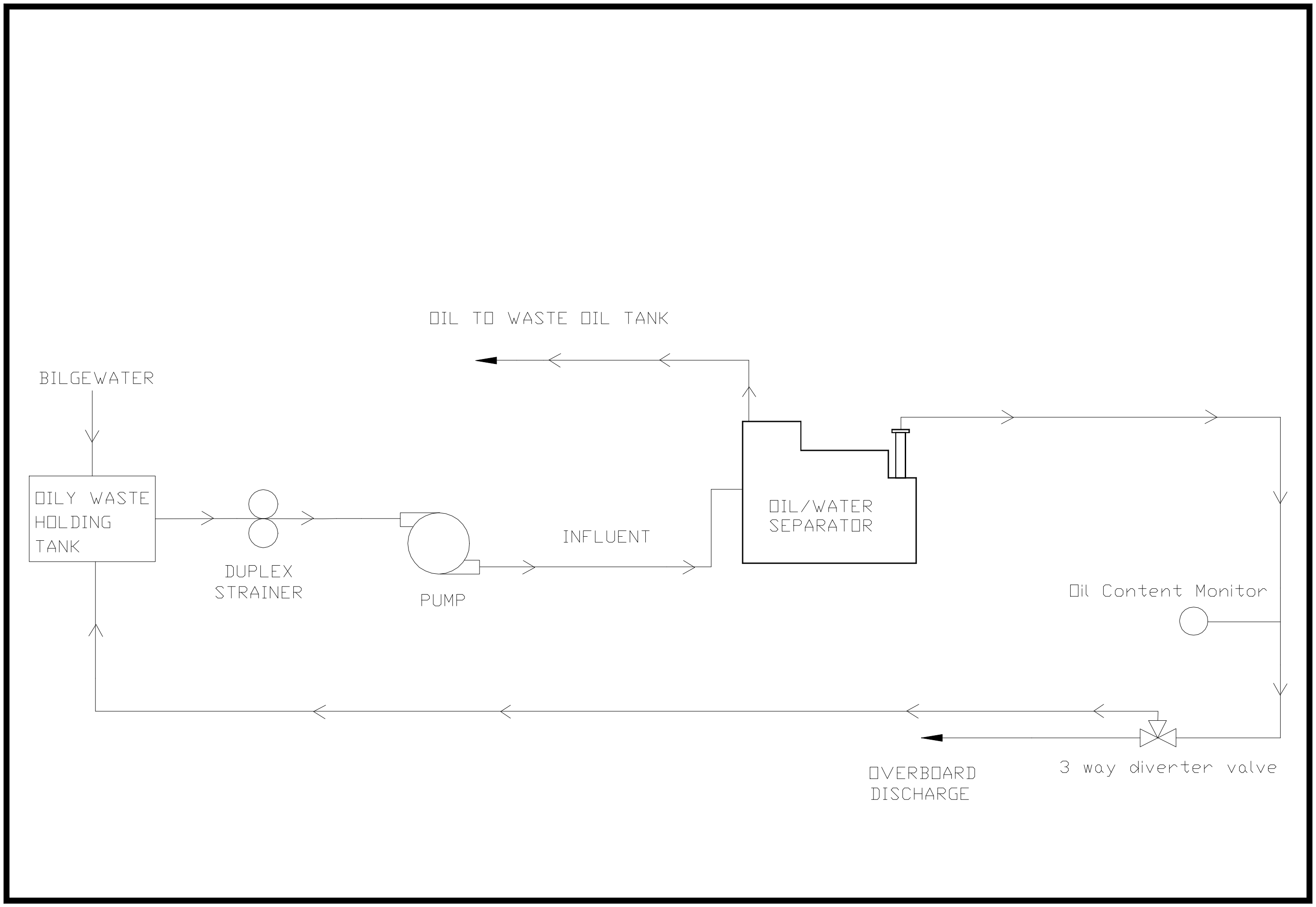

Figure 1. U.S. Navy Oil Water Separator (OWS) Process Flow Diagram (Typical)

Table 1. Vessels Equipped With Oil/Water Separator Systems

SHIP CLASSIFICATION INFORMATION						TRANSIT INFORMATION	
CLASS ID NO.	ARMED SERVICE	CLASS NAME	SHIP TYPE	NO. OF SHIPS	PROPULSION SYSTEM	TRAN-SITS	DAYS IN PORT
AE 26	MSC	Kilauea	Ammunition Ship	8	Steam	4	26
AFS 1	MSC	Mars	Combat Store Ship (ROS)	8	Steam	7	148
AG 194	MSC	Vanguard	Navigation Research Ship	2	Steam	10	151
AGF 3	NAVY	Austin (Converted)	Miscellaneous Command Ship	1	Steam	NA	NA
AGF 11	NAVY	Austin (Converted)	Miscellaneous Command Ship	1	Steam	NA	NA
AGM 22	MSC	Converted Haskell	Missile Range Instrumentation Ship	1	Steam	4	133
AGOS 1	MSC	Stalwart	Ocean Surveillance Ship	5	Diesel	4	70
AGOS 19	MSC	Victorious	Ocean Surveillance Ship	4	Diesel	5	107
AGS 26	MSC	Silas Bent and Wilkes	Surveying Ship	2	Diesel	6	44
AGS 45	MSC	Waters	Surveying Ship	1	Diesel	1	7
AGS 51	MSC	John McDonnell	Surveying Ship	2	Diesel	6	96
AGS 60	MSC	Pathfinder	Surveying Ship	4	Diesel	NA	NA
AH 19	MSC	Mercy	Hospital Ship (ROS)	2	Steam	2	184
AKR 287	MSC	Algol	Vehicle Cargo Ship (ROS)	8	Steam	3	109
AKR 295	MSC	NA	Vehicle Cargo Ship (ROS)	3	Diesel	NA	NA
AO 177	NAVY	Jumboised Cimarron	Oiler	5	Steam	10	188
AO 187	MSC	Henry J. Kaiser	Oiler	12	Diesel	6	78
AOE 1	NAVY	Sacramento	Fast Combat Support Ship	4	Steam	11	183
AOE 6	NAVY	Supply	Fast Combat Support Ship	3	Gas	6	114
AR	NAVY	Vulcan	Repair Ship	6	Steam	8	131
ARC 7	MSC	Zeus	Cable Ship	1	Diesel	2	8
ARS 50	NAVY	Safeguard	Salvage Ships	4	Diesel	22	208
AS 33	NAVY	Simon Lake	Submarine Tender	1	Steam	6	229
AS 39	NAVY	Emory S Land	Submarine Tender	3	Steam	6	293
ATF 166	MSC	Powhatan	Fleet Ocean Tug	7	Diesel	16	127
BD	ARMY	264B	Barge Derrick(Floating Cranes)	12	Diesel	NA	NA
BO	USCG	NA	Buoy Boat	5	Diesel	NA	NA
BOSL	USCG	NA	Stern Loading Buoy Boat	14	Diesel	NA	NA
CG 47	NAVY	Ticonderoga	Guided Missile Cruiser	27	Gas	12	166
CGN 36	NAVY	California	Guided Missile Cruiser	2	Nuclear	11	143
CGN 38	NAVY	Virginia	Guided Missile Cruiser	1	Nuclear	11	161
CV 63	NAVY	Kitty Hawk	Aircraft Carrier	3	Steam	7	137
CVN 65	NAVY	Enterprise	Aircraft Carrier	1	Nuclear	6	76
CVN 68	NAVY	Nimitz	Aircraft Carrier	7	Nuclear	7	147
DD 963	NAVY	Spruance	Destroyer (Typical)	31	Gas	12	178
DDG 51	NAVY	Arleigh Burke	Guided Missile Destroyer	18	Gas	11	101
DDG 993	NAVY	Kidd	Guided Missile Destroyer	4	Gas	12	175
FFG 7	NAVY	Oliver Hazard Perry	Guided Missile Frigate	43	Gas	13	167
LCC 19	NAVY	Blue Ridge	Amphibious Command Ship	2	Steam	8	179
LCU	ARMY	2000	Utility Landing Craft	48	Diesel	NA	NA
LHA 1	NAVY	Tarawa	Amphibious Assault Ship	5	Steam	9	173
LHD 1	NAVY	Wasp	Amphibious Assault Ship	4	Steam	13	185

Table 1. Vessels Equipped With Oil/Water Separator Systems (cont'd)

SHIP CLASSIFICATION INFORMATION						TRANSIT INFORMATION	
CLASS ID NO.	ARMED SERVICE	CLASS NAME	SHIP TYPE	NO. OF SHIPS	PROPULSION SYSTEM	TRAN-SITS	DAYS IN PORT
LPD 4	NAVY	Austin	Amphibious Transport Dock	3	Steam	11	178
LPD 7	NAVY	Austin	Amphibious Transport Dock	3	Steam	12	188
LPD 14	NAVY	Austin	Amphibious Transport Dock	2	Steam	11	192
LPH 2	NAVY	Iwo Jima	Amphibious Assault Helicopter Carrier	2	Steam	11	186
LSD 36	NAVY	Anchorage	Dock Landing Ship	5	Steam	13	215
LSD 41	NAVY	Whidbey Island	Dock Landing Ship	8	Diesel	13	170
LSD 49	NAVY	Harpers Ferry	Dock Landing Ship	3	Diesel	NA	NA
LST 1179	NAVY	Newport	Tank Landing Ship	3	Diesel	13	191
LSV	ARMY	Frank S Besson	Vehicle Landing Ship	6	Diesel	NA	NA
LT	ARMY	100 / 130	Large Tug	25	Diesel	NA	NA
MCM 1	NAVY	Avenger	Mine Countermeasure Vessel	14	Diesel	28	232
MHC 51	NAVY	Osprey	Minehunters Coastal	12	Diesel	NA	NA
WAGB 290	USCG	Mackinaw	Icebreaker	1	Diesel	NA	NA
WAGB 399	USCG	Polar	Icebreaker	2	Diesel	4	139
WHEC 378	USCG	Hamilton/Hero Class	High Endurance Cutter	12	Diesel	13	151
WIX 295	USCG	Eagle	Sail Training Cutter	1	Diesel	7	188
WLB 180A	USCG	Balsam	Seagoing Tender	8	Diesel	18	190
WLB 180B	USCG	Balsam	Seagoing Tender	2	Diesel	5	120
WLB 180C	USCG	Balsam	Seagoing Tender	13	Diesel	16	123
WLB 225	USCG	Juniper	Seagoing Tender	2	Diesel	NA	NA
WLI 65303	USCG	Blackberry	Buoy Tender, Inland	2	Diesel	NA	NA
WLI 65400	USCG	Bayberry	Buoy Tender, Inland	2	Diesel	NA	NA
WLI 100A	USCG	Blue Bell	Buoy Tender, Inland	1	Diesel	NA	NA
WLI 100C	USCG	Blue Bell	Buoy Tender, Inland	1	Diesel	NA	NA
WLIC 75A	USCG	Anvil/Clamp	Construction Tenders, Inland	2	Diesel	NA	NA
WLIC 75B	USCG	Anvil/Clamp	Construction Tenders, Inland	3	Diesel	NA	NA
WLIC 75D	USCG	Anvil/Clamp	Construction Tenders, Inland	2	Diesel	NA	NA
WLIC 100	USCG	Cosmos	Construction Tenders, Inland	3	Diesel	NA	NA
WLIC 115	USCG	?	Construction Tenders, Inland	1	Diesel	NA	NA
WLIC 160	USCG	Pamlico	Construction Tenders, Inland	4	Diesel	NA	NA
WLM 157	USCG	Red	Buoy Tender, Coastal	9	Diesel	NA	NA
WLM 551	USCG	Keeper	Buoy Tender, Coastal	2	Diesel	NA	NA
WLR 65	USCG	Ouachita	Buoy Tender, River	6	Diesel	NA	NA
WLR 75	USCG	F/Gasconade	Buoy Tender, River	13	Diesel	NA	NA
WLR 115	USCG	Sumac	Buoy Tender, River	1	Diesel	NA	NA
WMEC 210A	USCG	Reliance	Medium Endurance Class	5	Diesel	13	235
WMEC 210B	USCG	Reliance	Medium Endurance Class	11	Diesel	9	149

Table 1. Vessels Equipped With Oil/Water Separator Systems (cont'd)

SHIP CLASSIFICATION INFORMATION						TRANSIT INFORMATION	
CLASS ID NO.	ARMED SERVICE	CLASS NAME	SHIP TYPE	NO. OF SHIPS	PROPULSION SYSTEM	TRAN-SITS	DAYS IN PORT
WMEC 213	USCG	Diver	Medium Endurance Class	1	Diesel	9	98
WMEC 230	USCG	Storis	Medium Endurance Class	1	Diesel	11	167
WMEC 270A	USCG	Bear	Medium Endurance Class	4	Diesel	6	137
WMEC 270B	USCG	Bear	Medium Endurance Class	9	Diesel	7	164
WPB 82C	USCG	Point	Patrol Craft	28	Diesel	NA	NA
WPB 82D	USCG	Point	Patrol Craft	8	Diesel	NA	NA
WPB 110A	USCG	Island	Patrol Craft	16	Diesel	2	72
WPB 110B	USCG	Island	Patrol Craft	21	Diesel	7	137
WPB 110C	USCG	Island	Patrol Craft	12	Diesel	5	157
WTGB 140	USCG	Bay	Icebreaking Tug	9	Diesel	1	8
WYTL 65A	USCG	NA	Harbor Tug	3	Diesel	NA	NA
WYTL 65B	USCG	NA	Harbor Tug	3	Diesel	NA	NA
WYTL 65C	USCG	NA	Harbor Tug	3	Diesel	NA	NA
WYTL 65D	USCG	NA	Harbor Tug	2	Diesel	NA	NA
			TOTAL:	640	AVG:	9	145
			Subtotals:				
			Navy	231		13	197
			MSC	70		5	92
			USCG	248		8	140
			Army	91		NA	NA

Notes:
1. NA = Information not available
2. One transit = travel from one port to another, or from one port to sea and returning back to same port.

Table 2. In-Port Bilgewater Generation Rates[1,2,3]

Ship Class	Gal/Day (Range)	Avg Gal/Day
DD 963	1,000-3,000	2,000
DDG 51	N/A	335
CVN 68*	5,000-25,000	3,000

* Values based on recording information over a 30 day period. All bilgewater was processed by the OWS during six individual days, in volumes ranging from 5,000 to 25,000 gallons per processing event. The total volume processed over 30 days was 91,000 gallons, yielding an average daily processing rate of 3,000 gallons per day.

Table 3. In-Port Bilgewater/OWS Discharge Rates From U.S. Navy Ships

Ship Class	Average Daily Flow per Ship (gals/day)	Annual Flow per Ship (gals/yr)		Total Annual Flow (million gals/yr)	
		Days in Port	Total Flow	No. of Ships	Total Flow
Aircraft Carriers	3,000	147	441,000	11	4.9
All Other Ships (Avg.)	2,000	178	356,000	220	84.9
				Total:	89.8

Table 4. Ship Study Bilgewater Pollutant Summary[5]

	Biddle CG 34	Vincennes CG 49 with OWS	San Jacinto CG 56 with OWS	Roosevelt CVN 71	C. DeGrasse DD 974	H.W. Hill DD 986	Belleau Wood LHA 3	Vancouver LPD 2 with OWS	Pensacola LSD 38 with OWS	Manitowoc LST 1180 with OWS	Louisville SSN 724
TSS (mg/L)	1,440	38	19	519	233	548	1205	62	29	114	169
COD (mg/L)	5,600	530	760	5,400	18,000	11,000	66,000	780	470	1,600	1,100
TOC (mg/L)	644	129	34.6	116	264	4,620	19,040	34	31	224	247
BOD (mg/L)	583	NA	6,740	554	>14,000	842	13,000	<142	98	335	0
O&G (mg/L)	46	27	8	1,550	725	765	5,220	20	4	32	164
Phenols(µg/L)	600	110	30	<5,000	<10	40	2,600	10	10	20	310
Cu (µg/L)	6,400	540	430	1,050	5,320	1,180	1,720	790	300	360	1,450
Fe (µg/L)	46,000	810	260	2,560	28,000	18,900	14,600	1,130	1,620	2,600	1,030
Zn (µg/L)	4,300	810	190	1,900	6,560	1,390	16,200	1,590	410	2.5	2,720
Cd (µg/L)	67	10	5	21	156	44	280	<3	<5	14	82
Ag (µg/L)	10	<10	10	<50	<10	<10	80	10	<10	<10	<10
Ni (µg/L)	3,500	270	130	170	890	550	650	400	210	120	1,590
Mn (µg/L)	3,000	220	20	140	1,350	1,150	370	61	110	210	269
Pb (µg/L)	230	20	<20	<30	2,900	30	270	20	50	<50	60
As (µg/L)	3	6	6	3	7	<4	18	10	4	2	4
Ba (µg/L)	170	63	60	85	<100	60	122	16	40	50	57

Note: Values are not necessarily representative. Concentrations were determined from only one sample per ship class per constituent.

NA : Information not available

< : Less than

Table 5. Ship Study OWS Influent and Effluent Contaminant Concentration Data[5]

Parameter	Units	USS VINCENNES (CG 49)		USS SAN JACINTO (CG 56)		USS VANCOUVER (LPD 2)		USS PENSACOLA (LSD 38)		USS MANITOWOC (LST 1180)	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
COD	mg/L	660	530	810	760	900	780	520	470	2,800	1,600
BOD	mg/L	NA	NA	94	6,740	<142	<142	101	98	341	335
TOC	mg/L	145	129	56.8	34.6	42	34	39	31	570	224
TSS	mg/L	34	38	62	19	123	62	41	29	2,684	114
O&G	mg/L	37	27	143	8	47	20	10	4	2,593	32
Ammonia	mg/L	2.2	1.1	<0.10	<0.10	0.18	0.29	<0.10	<0.10	NA	NA
Fecal Coliform	cts/100 ml	NA	NA	49	94	NA	NA	110	49	2	240
Total Phenols	mg/L	130	110	10	30	10	10	20	10	NA	20
Cyanide	mg/L	<10	<10	<10	10	<30	<50	10	40	<10	NA
Arsenic	µg/L	4	6	6	6	8	10	4	4	6	2
Barium	µg/L	59	63	20	60	10	16	30	40	40	50
Cadmium	µg/L	9	10	<5	5	<3	<3	<5	<5	17	14
Chromium	µg/L	<10	<10	<10	<10	<10	<10	<50	<50	770	590
Copper	µg/L	830	540	490	430	2,930	790	560	300	430	360
Iron	µg/L	770	810	280	260	1,240	1,130	2,960	1,620	2,.900	2,600
Lead	µg/L	50	20	<20	<20	40	20	<50	<50	50	<50
Manganese	µg/L	230	220	10	20	51	61	80	110	250	210
Nickel	µg/L	290	270	100	130	310	400	250	210	120	120
Selenium	µg/L	3	<2	12	8	15	17	2	2	40	40
Zinc	µg/L	800	810	80	190	670	1,590	380	410	3,000	2,500
Bis(2-ethylhexyl) phthalate	µg/L	<200	<10	<200	<100	11.2	61.8	<100	<100	<200	<200
4-Nitrophenol	µg/L	<400	<20	<200	<100	10	<20	<100	<100	<200	<200
Phenanthrene	µg/L	<200	23.7	<200	<100	<10	<10	<100	<100	<200	<200
1,2,4-Trichlorobenzene	µg/L	<200	28.3	<200	<100	<10	<10	<100	<100	<200	<200
1,1,1- Trichloroethane	µg/L	<5	<5	<50	<50	NA	<5	<50	<500	45,000	6,000
Alpha-BHC	µg/L	0.047	0.077	<0.05	<0.05	0.02	<0.02	<0.05	<0.05	<0.25	<5
Beta- BHC	µg/L	<0.999	<0.580	<0.5	<0.5	4.45	<0.10	<12	<5	<2.5	<50
Gamma-BHC	µg/L	<0.02	<0.02	16	60	<0.02	<0.02	<0.05	0.5	<0.25	<5
Heptachlor	µg/L	0.460	0.209	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.25	<5
Heptachlor Epoxide	µg/L	0.379	0.274	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.25	<5
NA = Data not available											

Note: Values are not necessarily representative. Concentrations were determined from only one sample per ship class per constituent.

Table 6. Naval Station San Diego Bilgewater Characterization Data Summary[6] (Calendar Years 1993 through 1995)

Parameter	No. of Analyses	Values Above MDL (units in µg/L)				
		No. Of Values	Min.	Max.	Median	Std. Dev.
Oil & Grease	45	45	5	12,900	146	2,234
Phenols	83	12	15	901	116	0.309
Antimony	(a)	(a)	(a)	80	(a)	(a)
Arsenic	(a)	(a)	(a)	1	(a)	(a)
Cadmium	84	33	10	610	20	118
Chromium	85	31	20	2,320	70	492
Copper	85	84	10	80,400	420	9,250
Lead	85	52	39	3,360	100	509
Nickel	85	83	20	10,300	150	1,590
Selenium	1	0	NA	NA	NA	NA
Silver	84	14	4	1,440	23	398
Thallium	(a)	(a)	(a)	277	(a)	(a)
Zinc	82	80	100	97,000	688	14,500
Benzene	82	29	0.5	179	30	42
Chloroform	81	1	47	47	47	NA
Ethyl Benzene	81	38	6	1,360	50	221
Methylene Chloride	68	18	5	4,220	16	1,000
Tetrachloroethane	82	7	7	74	18	24
Toluene	80	52	5	2,220	77	383
Xylene	17	12	28	9,440	16	2,600
2,4-Dimethyl Phenol	82	14	30	840	89	23
Fluorene	83	41	5	1,890	42	411
Naphthalene	79	37	11	3,070	85	613

NOTES: (a) References contain summary tables and raw data laboratory logs that are incomplete. Summary tables indicate single peak results for antimony, arsenic and thallium in 1993. However, log sheets showing the corresponding data are not included. The above statistical analysis is based on log sheet data that was provided, except for the maximum values shown for the three metals, which were obtained from the PWC summary table for 1993.

(b) NA = Information not available.

Table 7. Navy Destroyer (DDG 64) OWS Effluent Discharge Data Summary[7]

May to September, 1996						
		Values Above MDL (µg/L)				
Parameter	**No. of Analyses**	**No. Of Values**	**Min.**	**Max.**	**Median**	**Std. Dev.**
Oil in Water (Navy)	28	28	13	670	151	205
Arsenic	11	6	10	70	20	23
Barium	18	18	30	535	118	124
Cadmium	18	3	10	10	10	NA
Chromium	18	10	10	60	20	16
Copper	18	18	430	6,110	1,.410	1,400
Lead	18	15	10	195	40	62
Iron	18	18	300	4,620	1,280	1,210
Manganese	18	18	20	150	48	41
Mercury	18	2	10	10	10	NA
Nickel	18	18	140	1,510	320	317
Selenium	11	11	70	210	100	40
Silver	18	1	10	10	10	NA
Zinc	18	18	480	8,880	2,190	1,930

July 30, 1996 (µg/L)						
	Sample A		Sample B		Sample C	
Parameter	**NRL**	**LLI**	**NRL**	**LLI**	**NRL**	**LLI**
Oil and Grease (EPA 418.1)	---	29	---	70	---	66
Petroleum Hydrocarbons	---	38	---	73	---	70
MBAS	---	0.13	---	0.11	---	0.16
Benzene	79	50	77	49	70	55
Ethylbenzene	71	59	59	54	64	54
Methylene Chloride	<5	64	<5	63	<5	20
Toluene	170	80	170	78	150	81
Xylene (total)	460	289	450	266	410	264
Diethyl Phthalate	---	<10	---	10	---	12
2,4-Dimethylphenol	---	110	---	110	---	110
Dimethyl Phthalate	---	11	---	12	---	13
Fluorene	---	12	---	17	---	20
Naphthalene	---	63	---	61	---	14
Phenanthrene	---	16	---	27	---	30
Phenol	---	46	---	47	---	30

NOTES:
(a) Volatile and semi-volatile analysis performed on random samples collected over two hour period. Sample A during first hour. Samples B and C during second hour.
(b) LLI = Lancaster Labs Inc. NRL = Naval Research Laboratory.
(c) --- = Samples were not analyzed by LLI for the parameters shown.
(d) NA = Information not available
(e) < = less than

Table 8. Auxiliary Ship (AS 36) OWS Effluent Discharge Data Summary[7] (May 2 through September 12, 1996)

Parameter	Method Detection Level	No. of Analyses	Values Above MDL (µg/L)				
			No. of Values	Min.	Max.	Median	Std. Dev.
Oil in Water	NA	44	44	0.5	93	5.4	20.1
BOD	NA	8	8	1	34	3.5	10.1
COD	NA	14	14	26	260	61	79.5
TSS	NA	10	10	1	57	12.5	16
Antimony	600	14	0	NA	NA	NA	NA
Arsenic	10	14	0	NA	NA	NA	NA
Beryllium	5	14	0	NA	NA	NA	NA
Cadmium	10	14	0	NA	NA	NA	NA
Chromium	20	14	0	NA	NA	NA	NA
Copper	NA	14	14	44	661	257	166
Lead	100	14	0	NA	NA	NA	NA
Iron	NA	11	11	786	2,200	1,050	427
Mercury	0.2	14	1	1.6	1.6	NA	NA
Nickel	NA	14	14	75	471	117	103
Selenium	10/5	14	0	NA	NA	NA	NA
Silver	30	14	0	NA	NA	NA	NA
Thallium	10	14	14	NA	NA	NA	NA
Zinc	NA	14	14	164	1,100	382	283

NOTE: NA = Information not available.

Table 9. Aircraft Carrier (CVN 74) Oil/Water Separator Influent/Effluent Raw Data[4]

		CVN 74-OWSI-01		CVN 74-OWSI-02		CVN 74-OWSI-03		CVN 74-OWSI-04	
Parameter	**Units**	**Influent**	**Effluent**	**Influent**	**Effluent**	**Influent**	**Effluent**	**Influent**	**Effluent**
COD	mg/L	132	179	258	258	86	148	195	148
BOD	mg/L	31	5	17	11	18	18	22	10
TOC	mg/L	28	9	24	21	26	20	19	11
TSS	mg/L	38	64	38	46	36	48	70	23
O&G	mg/L	50	22	269	17	42	36	122	27
TKN	mg/L	1.6	1.7	2.0	1.7	1.4	1.6	1.2	1.0
Ammonia	mg/L	0.14	<0.10	0.19	0.17	0.15	0.17	<0.10	<0.10
Nitrate + Nitrite (As N)	mg/L	054	0.20	0.44	0.30	0.50	0.40	0.62	0.0
Total Phosphorous	mg/L	3.2	1.2	3.7	2.7	3.9	2.2	3.1	2.0
TDS	mg/L	7,360	16,620	5,570	9,720	5,920	10,260	8,970	13,320
Chloride	mg/L	4,126	9,742	3,616	7,359	3,531	8,125	3,956	8,040
Sulfate	mg/L	498	1,290	411	643	446	780	643	958
Sulfide	mg/L	5	2	10	8	10	8	10	5
Total Alkalinity	mg/L	36	64	40	46	40	48	48	58
Cyanide	µg/L	<10	<10	<10	<10	<10	<10	NA	<10
Aluminum	µg/L	69(B)	229	74(B)	108(B)	83(B)	104(B)	143(B)	220
Antimony	µg/L	<20	<2	<20	2.6(B)	5.6(B)	<20	<20	<10
Arsenic	µg/L	<10	33	<1	3(C)	<1	33(B)	<1	<1
Barium	µg/L	49	32	50(B)	43(B)	55(B)	40(B)	44(B)	34(B)
Beryllium	µg/L	1(B)	<1	<1	<1	<1	<1	<1	<1
Cadmium	µg/L	6	<5	5.7	<5	5.1	5.6	<5	<5
Chromium	µg/L	<10	<10	<10	<10	<10	<10	<10	<10
Copper	µg/L	581	284	567	426	554	363	574	316
Iron	µg/L	455	482	471	442	560	432	610	531
Lead	µg/L	<46	<46	<46	<46	<46	<46	<46	<46
Manganese	µg/L	34	29	34	33	37	30	35	31
Nickel	µg/L	304	98	318	245	321	208	277	162
Selenium	µg/L	<20	<20	<31.5	41(C)	<20	<20	26(C)	<20
Silver	µg/L	5(B)	<5	<5	5(B)	<5	<5	<5	<5
Thallium	µg/L	<10	<10	<10	<10	<10	<10	<10	<10
Zinc	µg/L	1,590	519	1,760	1,330	1,840	1,110	1,350	786
Bis(2-ethylhexyl) phthalate	µg/L	<10	<10	30	<10	22	<10	38	<10
N,N-Dimethylformamide	µg/L	99	33	124	88	102	65	85	58
Toluene	µg/L	14	<10	12	<10	13	<10	12	<10
Xylene (o+p)	µg/L	24	<10	20	13	19	<10	19	12

Note: (a) < = less than

Table 10. Summary of Detected Analytes: Oil/Water Separator Effluent Data

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
					(lbs/yr)
Oil Water Separator Effluent					
Classicals (mg/L)					
ALKALINITY	53.51	4 of 4	46	64	40,013
AMMONIA AS NITROGEN	0.09	2 of 4	BDL	0.17	67
BIOCHEMICAL OXYGEN DEMAND	8.78	3 of 4	BDL	18	6,565
CHEMICAL OXYGEN DEMAND (COD)	178.34	4 of 4	148	258	133,356
CHLORIDE	8273.63	4 of 4	7360	9740	6,186,728
HEXANE EXTRACTABLE MATERIAL	23.54	4 of 4	17.5	27	17,602
NITRATE/NITRITE	0.27	4 of 4	0.2	0.4	202
SGT-HEM	9.64	4 of 4	6	16	7,208
SULFATE	887.29	4 of 4	643	1290	663,484
TOTAL DISSOLVED SOLIDS	13238.57	4 of 4	9720	21600	9,899,334
TOTAL KJELDAHL NITROGEN	1.5	4 of 4	1.1	1.7	1,122
TOTAL ORGANIC CARBON (TOC)	14.53	4 of 4	9.3	21	10,865
TOTAL PHOSPHOROUS	1.81	4 of 4	1.2	2.7	1,353
TOTAL RECOVERABLE OIL AND GREASE	39.96	4 of 4	15.05	173	29,881
TOTAL SULFIDE (IODOMETRIC)	5.03	4 of 4	2	8	3,761
TOTAL SUSPENDED SOLIDS	42.46	4 of 4	23	64	31,750
VOLATILE RESIDUE	13285.59	4 of 4	9770	21600	9,934,494
Hydrazine (mg/L)					
HYDRAZINE	0.15	4 of 4	0.095	0.2	112
Mercury (ng/L)					
MERCURY	51.8	4 of 4	32.05	79.8	0.04
Metals (μg/L)					
ALUMINUM					
Total	154.49	4 of 4	104	230.5	116
ANTIMONY					
Total	6.15	1 of 4	BDL	2.6	5
ARSENIC					
Total	6.09	2 of 4	BDL	33	5
BARIUM					
Dissolved	34.98	4 of 4	27.8	41.8	26
Total	36.58	4 of 4	30.65	42.9	27
BORON					
Dissolved	1562.43	4 of 4	1280	2030	1,168
Total	1505.6	4 of 4	1240	1945	1,126

CADMIUM					
Total	3.06	1 of 4	BDL	5.6	2
CALCIUM					
Dissolved	135123.39	4 of 4	105000	184000	101,040
Total	129848.08	4 of 4	104000	172500	97,096
COPPER					
Dissolved	162.56	4 of 4	116	201	122
Total	341.25	4 of 4	277.5	426	255
IRON					
Total	472.36	4 of 4	432	531	353
MAGNESIUM					
Dissolved	392878.32	4 of 4	262000	486000	293,780
Total	423465.92	4 of 4	333000	593500	316,653
MANGANESE					
Dissolved	26.21	4 of 4	22.2	31.1	20
Total	30.35	4 of 4	28.25	32.5	23
MOLYBDENUM					
Dissolved	21.29	4 of 4	18.6	24.3	16
Total	9.29	2 of 4	BDL	28.1	7
NICKEL					
Dissolved	176.4	4 of 4	109	247	132
Total	168.54	4 of 4	97.75	245	126
SODIUM					
Dissolved	3606853.89	4 of 4	2680000	5200000	2,697,078
Total	3585080.31	4 of 4	2770000	5000000	2,680,796
TIN					
Total	16.59	1 of 4	BDL	41.2	12
TITANIUM					
Total	4.5	2 of 4	BDL	9.2	3
ZINC					
Dissolved	855.7	4 of 4	511	1260	640
Total	878.8	4 of 4	514	1330	657
Organics (μg/L)					
N,N-DIMETHYLFORMAMIDE	57.3	4 of 4	32.5	88	43
O+P XYLENE	7.9	2 of 4	BDL	13	6
Pesticides (μg/L)					
2,4-DB	1.66	2 of 4	BDL	2.88	1
DICAMBA	0.29	3 of 4	BDL	0.48	0.2
MCPA	28.45	1 of 4	BDL	58.9	21
MCPP	113.25	4 of 4	41.3	167	85
PYRETHRIN I	183	1 of 1	183	183	137

Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 10 a. Estimated Annual Mass Loadings of Constituents

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading (lbs/yr)
Classicals (mg/L)					
AMMONIA AS NITROGEN	0.09	2 of 4	BDL	0.17	67
NITRATE/NIRITE	0.27	4 of 4	0.2	0.4	202
TOTAL KJELDAHL NITROGEN	1.5	4 of 4	1.1	1.7	1,122
TOTAL NITROGEN[A]	1.77				1,304
TOTAL PHOSPHOROUS	1.81	4 of 4	1.2	2.7	1,353
SGT-HEM	9.64	4 of 4	6	16	7,208
Mercury (ng/L)					
MERCURY	51.8	4 of 4	32.05	79.8	0.04
Metals (µg/L)					
COPPER					
Dissolved	162.56	4 of 4	116	201	122
Total	341.25	4 of 4	277.5	426	255
IRON					
Total	472.36	4 of 4	432	531	353
NICKEL					
Dissolved	176.4	4 of 4	109	247	132
Total	168.54	4 of 4	97.75	245	126
ZINC					
Dissolved	855.7	4 of 4	511	1260	640
Total	878.8	4 of 4	514	1330	657

Notes:
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 11. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute Water Quality Criteria	Most Stringent State Acute Water Quality Criteria
Classicals (mg/L)					
AMMONIA AS NITROGEN	0.09	BDL	0.17	None	0.006 (HI)[A]
NITRATE/NITRITE	0.27	0.2	0.4	None	0.008 (HI)[A]
TOTAL KJELDAHL NITROGEN	1.5	1.1	1.7	None	-
TOTAL NITROGEN[B]	1.77			None	0.2 (HI)[A]
TOTAL PHOSPHOROUS	1.81	1.2	2.7	None	0.025 (HI)[A]
TPH (SGT-HEM)	9.64	6	16	visible sheen[a] / 15[b]	5 (FL)
Mercury (ng/L)					
MERCURY*	51.8	32.05	79.8	1800	25 (FL, GA)
Metals (µg/L)					
COPPER					
Dissolved	162.56	116	201	2.4	2.4 (CT, MS)
Total	341.25	277.5	426	2.9	2.5 (WA)
IRON					
Total	472.36	432	531	None	300 (FL)
NICKEL					
Dissolved	176.4	109	247	74	74 (CA, CT)
Total	168.54	97.75	245	74.6	8.3 (FL, GA)
ZINC					
Dissolved	855.7	511	1260	90	90 (CA, CT, MS)
Total	878.8	514	1330	95.1	84.6 (WA)

Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.
* - Mercury was not found in excess of WQC; concentration is shown only because it is a bioaccumulator.

CA= California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

[a] *Discharge of Oil*, 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.

[b] *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78). MARPOL 73/78 as implemented by the *Act to Prevent Pollution from Ships* (APPS)

Table 12. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	Equipment Literature			X
2.2 Releases to the Environment	OPNAVINST 5090.1B			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	X		X	X
3.3 Constituents	X	X		X
3.4 Concentrations	X	X		
4.1 Mass Loading	X		X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species				X

NATURE OF DISCHARGE REPORT

Underwater Ship Husbandry

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the underwater ship husbandry discharge and includes information on: the equipment that is used and its operation (Section 2.1), the general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

For the purpose of this evaluation, underwater ship husbandry is defined as the inspection, grooming, maintenance, and repair of hulls and hull appendages performed while a vessel is waterborne. In the case of repairs, they may be classified as permanent (equivalent to dry-dock repair); temporary (to be reworked at the next scheduled dry-docking); and emergency (allowing the ship to transit to a facility for further repair). Underwater ship husbandry includes the following operations:[1,2]

- hull cleaning,
- fiberglass repair,
- welding,
- sonar dome repair,
- non-destructive test/inspection,
- masker belt repairs, and
- paint operations, and
- SEAWOLF propulsor layup.

All of these activities are typically conducted while ships are pierside. Cleaning of underwater hulls is the major activity within this category, and is performed on a routine basis.[1] Layup of SEAWOLF propulsors occurs approximately 6 times per year.[3] The remaining operations are unplanned repair activities incidental to normal vessel operation.[1]

2.1.1 Underwater Hull Cleaning

Underwater hull cleaning is performed to remove fouling organisms which have adhered to a vessel and its appendages.[4] Biological growth is undesirable since it increases ship drag, thereby increasing fuel consumption and decreasing speed. Hull cleanings can be either full cleanings or interim cleanings. Full cleanings are those which include the entire painted underwater hull surface, propellers, and propeller shafts. Interim cleanings include the cleaning of propellers and shafts only.

Hull Coating Systems. Ablative hull coating systems are typically comprised of two coats (layers) of epoxy anticorrosion (AC) paint applied to the bare hull and two coats of copper antifouling (AF) paint applied over the AC coating. The function of the AC coat, in conjunction with cathodic protection, is to prevent hull corrosion. The AC coat also provides bonding between the hull and the AF topcoats. AF topcoats control biological growth by ablating and/or leaching antifouling agents into the surrounding water (as described in the Hull Coating Leachate

NOD report). The total design thickness of this system is 20 mils (1 mil = 0.001 inches), of which 10 mils are the AF coating, although the actual application may be thicker.[5]

Most ships of the Navy, Military Sealift Command (MSC), and U.S. Coast Guard (USCG) use AF paint qualified to MIL-PRF-24647 "Paint System, Anticorrosive and Antifouling, Ship Hull."[6,7] While several types of AF topcoats conform to this specification, the most common types are ablative, copper-based coatings.[8] An ablative coating thins as it erodes or dissolves. Through this action, a fresh layer of antifouling agent (e.g. copper) is exposed, maintaining the paint's antifouling properties. Self-polishing AF paints are a type of ablative coating which undergoes chemical hydrolysis when it comes into contact with the slightly alkaline seawater. Any toxic agents which are chemically bound to the paint matrix will be released at a rate dependent upon the rate of hydrolysis.

Other vessels of the Armed Forces use non-ablative paint systems which do not appreciably diminish in thickness during service.[7] Non-ablative paints containing tributyltin (TBT) are still found on some aluminum-hulled small craft because some copper-based paints are incompatible with aluminum hulls.[8] However, TBT paints are no longer approved for any Navy vessel, including aluminum-hulled craft, effective as of fiscal year (FY) 1998.[5,9]

Coating Service Life. Ablative copper AF coatings for naval vessels are designed to meet five-, seven-, or ten-year dry-docking periods.[9] Typically, ablative copper AF coatings remain free of fouling for about three years after application before they require in-water hull cleaning.[10] After the first cleaning, they typically require an annual hull cleaning, which is usually performed just prior to deployments, to optimize fuel consumption underway. This is only a guideline, since the frequency of cleaning is also influenced by the ship's schedule and location.[4]

Inspection and Evaluation. Navy vessels are inspected quarterly and before deployments, and are assigned a Fouling Rating (FR) on a scale of 0 to 100.[1,4] This rating is established by comparing photographs of the fouled hull with photographic standards representing values on the FR scale. The criteria for performing hull cleaning is FR 40 or higher (for ablative and self-polishing paint systems) over 20% of the ship's hull; or the presence of FR 50 or higher (for non-ablative paint systems) over 10% of the ship's hull.[4]

Underwater Hull Cleaning Process. Underwater hull cleaning can be accomplished with hand-held rotary brush units, self-propelled multi-brush cleaning vehicles, water jets, and hand-held scrapers.[4] Most often, it is conducted by divers using the Submerged Cleaning and Maintenance Platform (SCAMP) or the similar SeaKlean multi-brush systems.[1] These mechanical devices are held next to the hull from the thrust and suction generated by a large impeller, which pumps seawater at approximately 13,500 gallons per minute (gpm). While the brushes rotate and sweep biofouling off of the hull, the system moves forward at a maximum rate of 1 foot per second (ft/sec), but typically at 0.75 ft/sec. A small percentage of the hull, gratings, and struts; which are inaccessible to these multi-brush machines, must be cleaned using hand-held single-brush cleaning units.[10]

2.1.2 Other Underwater Repair, Maintenance, And Inspection Processes

Fiberglass Repair. Two activities comprise this class of ship husbandry: fiberglass hull repairs and fiberglass propeller shaft coating repairs. Methods for performing underwater fiberglass hull repairs are still under development, and therefore are not a standard operation. Shafts are coated with fiberglass to prevent corrosion. A confirmed or suspected failure in the fiberglass coating may require an underwater repair, if dry-docking is not imminent.[1]

Fiberglass shaft repairs are performed by divers working in a dry underwater enclosure, or "habitat," having an opening in the underside for diver access.[11] When coating shafts with fiberglass, glass reinforced plastic (GRP) wrapping is applied in accordance with MIL-STD-2199, "Glass Reinforced Plastic Coverings for Propeller Shafting." In this procedure, the shaft is first cleaned with a solvent, typically acetone, to remove grease and oil. Next, four wrappings of fiberglass tape/cloth are made and fixed with a viscous epoxy or polyester resin which hardens into an insoluble plastic. The cure time and working life of the resin vary with the individual brand, temperature, and humidity. However, the total cure time is on the order of 24 hours. The working life of the resin, after the addition of the hardener, is significantly less. The specification states that resin systems may have a working life from 30 minutes to six hours at 73 °F and as short as 18 minutes at 90 °F. The specification recommends that a new resin pot be prepared for each wrapping, because it may harden between wrapping passes.[12]

Welding. There are two types of underwater welding: dry habitat and wet welding. An underwater enclosure is used for dry habitat welding, the use of which is required for slower cooling of high strength steels. A high-flow air system filters and exhausts the welding fumes and provides a safe atmosphere for the welder. In wet welding, operations are performed under submerged conditions. Specially coated welding rods allow the flux to bond with the wet surface. Before welding, the area is cleaned with scrapers, chipping hammers, or hand-held brushes.[11,13]

Sonar Dome Repair. Minor repairs to the exterior of rubber sonar domes can be accomplished by divers. The most common repair is patching the rubber window. A diver removes loose rubber, prepares the edges to receive a patch, and affixes a rubber patch with an amine polymer.[11]

Non-Destructive Test/Inspection. Underwater magnetic particle testing is used as a non-destructive inspection method to detect or define surface or near-surface cracks in ferrous metal structures prior to repair. It may also be used for welding quality assurance. An electromagnet is used to magnetize a localized area on the hull surface. A slurry of fluorescent iron flakes is then applied to the weld or crack with a squeeze bottle. These particles align with the defective area, facilitating inspection.[11,14]

Masker Belt Repairs. Masker emitter belts are installed at the forward end of the ship's machinery spaces and run vertically down both sides of the external hull. The masker belt is a continuous length of copper-nickel pipe that emits air bubbles through small holes to mask ship noise. The pipe is epoxied into a fairing channel that is welded to the hull. The channel ensures that the hull shape remains “fair,” or smoothly curved, so the masker belt does not protrude and increase drag. Waterborne repairs by divers consist of cutting away damaged belt sections and installing replacement sections. An insert is used to join the replacement with existing sections. Finally, an epoxy sealer is applied to ensure a positive air seal.[11]

Paint Operations. Underwater touchup painting is required after welding, shaft lamination repairs, and masker belt repairs. Touchup painting is also performed to repair paint damage or deterioration on surfaces such as rudders, dielectric shielding for the cathodic protection system, struts, and stern tubes. Epoxy paint is mixed on the surface (above water), supplied to the diver, and applied to the affected area with a brush or roller.[11]

SEAWOLF Propulsor Layup. The newly commissioned SEAWOLF attack submarine utilizes vinyl covers to prevent fouling of the propeller (also called propulsor) when it is in port for extended periods. The covers, referred to as the Propulsor Protective Covering System (PPCS), restrict sunlight and the supply of fresh nutrient-rich water into the propulsor. Reducing the amount of fouling that occurs on the propulsor in port reduces the need for underwater cleaning of the propulsor.[2]

2.2 Releases to the Environment

2.2.1 Underwater Hull Cleaning

Underwater hull cleaning is accomplished by divers operating hand-held rotary brush units, self-propelled multi-brush cleaning vehicles, water jets, and hand-held scrapers.[4] These tools sweep or dislodge biofouling from the wetted surface of the hull and appendages.[1] The discharge from the cleaning process consists of seawater (from the impeller of the cleaning vehicle), living and dead marine organisms, and antifouling paint.[10] Variables affecting the amount of this discharge include hull surface area, condition of the paint system, degree of fouling, brush selection, conditions in the water, and the skill of the operators.

2.2.2 Other Underwater Repair, Maintenance, And Inspection Processes

Fiberglass Repair. A two component system consisting of an epoxy resin and a hardener is mixed topside and transferred to the underwater habitat to accomplish the fiberglass repairs.[15] Due to the rapid curing time of the resin system, it is applied to the surface to be repaired soon after mixing, and then covered with glass tape. Releases of fiberglass and resin can occur when materials fall through the open bottom of the enclosure.[11] Since the resin being applied quickly solidifies, any releases from the enclosure will fall to the bottom of the harbor.

Welding. Small amounts of welding consumables can enter the marine environment upon entry into or exit from the dry welding habitat, or by passing directly into the water during wet welding.[11] Slag, which is molten refuse material from the welding process, may fall from the welding area into the water column. Some spent welding rods and welding gases may also be released.

Sonar Dome Repair. When the diver removes the loose rubber from the sonar dome and affixes a rubber patch with adhesive, a discharge of solid rubber waste and/or adhesive may result.[11]

Non-Destructive Test/Inspection. The slurry of iron flakes applied to the weld is discharged directly into the water column.[11]

Masker Belt Repairs. Waterborne repairs consist of cutting away damaged belt sections and installing replacement sections as described in Section 2.1.[11] Portions of the damaged belt or some of the epoxy sealer can be released during this operation.

Paint Operations. While a diver is performing underwater touchup painting with epoxy coatings, some paint can be incidentally released into the water in the vicinity of the painting operation.[11] Neither the epoxy resin nor the amine compound of the primary products in use are water-soluble.[16]

SEAWOLF Propulsor Layup. Use of the PPCS creates a relatively isolated volume of water of approximately 21,000 gallons inside the propulsor. The chemistry of this volume of water can change over time, primarily due to the generation of small amounts of chlorine from the installed Impressed Current Cathodic Protection (ICCP) system and the decay of trapped organic matter. (Descriptions of the purpose and function of ICCP systems can be found in the Cathodic Protection NOD report). Releases to the environment resulting from the layup of the propulsor include decaying organic matter, chlorine, and Chlorine Produced Oxidants (CPO). CPO is used to describe the combination of oxidant species that may, in this case, be formed by the ICCP system in both primary and secondary reactions, and includes various chlorinated and brominated species.[17]

2.3 Vessels Producing the Discharge

All Navy surface ships and submarines undergo periodic underwater ship husbandry.[1] However, the predominant discharge is from underwater hull cleanings. Underwater cleanings are performed on larger vessels between dry-docking periods. The Navy, with the greatest number of large vessels, produces this discharge more frequently than the other Armed Forces. The U.S. Coast Guard (USCG), Military Sealift Command (MSC), Army, and Air Force dry-dock their vessels more frequently, at which time hull cleaning is performed.[18, 19, 20] Small boats and craft are typically removed from the water for maintenance and repairs.[1] Layup of SEAWOLF Propulsors is currently limited to the SEAWOLF Class of attack submarines. The first of this class, SSN 21, was commissioned in the fall of 1997, with a total of 3 submarines planned. The next attack submarine class, commonly referred to as the "New Attack Submarine," is also expected to use a PPCS type system.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Underwater ship husbandry is conducted pierside.[1]

3.2 Rate

Because of the variability in vessel surface area and in the volume of these releases for underwater ship husbandry, rates are discussed in terms of frequency of the event.

3.2.1 Underwater Hull Cleaning

On average, each Navy surface ship will receive five underwater hull cleanings every six years.[1] These statistics vary regionally depending on fouling rates, water temperatures, and the coating service life. Vessels in Pearl Harbor, HI, for example, would have higher fouling rates, and, therefore, a higher cleaning frequency than those in Norfolk, VA. An average of 136 full cleanings (including the hull surface, propeller, and shaft) are performed annually fleetwide, based on the following four years of data:[21]

1993: 131 vessels
1994: 131 vessels
1995: 135 vessels
1996: 148 vessels

An additional 170 interim cleanings (i.e., the cleaning of propellers and shafts only) are estimated to occur each year.[1]

Although flow rates from the SCAMP have not been measured, based on impeller characteristics, motor speed, and expected efficiency, the flow rate has been estimated to be 13,500 gallons per minute (gpm), or 51,100 liters per minute (L/min).[10]

3.2.2 Other Underwater Repair, Maintenance, and Inspection Processes

Table 1 lists the estimated releases from Navy underwater ship husbandry activities other than hull cleaning.[22] Coating shafts with fiberglass is performed on an infrequent basis. Sonar dome repairs are necessary only on submarines and surface combatants equipped with sonar equipment. The other listed activities apply to all vessels. Since the other services have fewer large ships than the Navy, these activities are expected to be less frequent among vessels of the other Armed Forces. For example, there have been three documented instances of underwater weld repairs conducted on MSC vessels in the past five years, and no rubber dome or fiberglass repairs.[23]

Fiberglass Repair. On Navy vessels, fiberglass shaft coatings are estimated to be applied 12 times per year. Based on operational experience, it is estimated that approximately one quart of resin could possibly be released per fiberglass wrapping event. Given this amount, it is estimated that 12 quarts (11.4 liters) of the resin system (i.e., resin mixed with hardener) could possibly be released per year.[22]

Welding. Small amounts of welding consumables can enter the marine environment through the dry habitat or directly when wet welding is performed.[11] Slag and spent welding rods may also be released. From operational experience, it is estimated that approximately five pounds of slag or spent welding rod are discharged during each underwater welding operation, and approximately 12 of these operations are performed fleet-wide each year on Navy ships.[22] Metals from the welding operation will not be readily dissolved in the surrounding waters and will fall to the harbor floor.

Sonar Dome Repair. A discharge of solid rubber waste and/or adhesive can result from this operation. This is a site-specific operation, and this discharge is dependent on the size of the patch being repaired. It is estimated that 19 Navy surface ships and submarines undergo sonar dome repairs yearly.[22] Rubber pieces from the sonar dome repair operations will not be dissolved in the surrounding water and will settle on the harbor floor.

Non-Destructive Test/Inspection. During magnetic particle inspection, a slurry of iron flakes is discharged directly through the water column. It is estimated that 20 Navy vessels undergo magnetic particle inspections yearly.[22]

Masker Belt Repairs. Waterborne repairs consist of cutting away damaged belt sections and installing replacement sections. Based on operational experience, it is estimated that six Navy vessels undergo masker belt repairs yearly.[22] Releases can occur from the removal of the damaged belt and the application of the epoxy sealer.[11] Similar to the epoxy resin used in propeller shaft repair, the epoxy sealant will quickly solidify into a hard, insoluble material.

Paint Operations. While a diver is performing in-water touchup painting with epoxy coatings, some paint can be incidentally released into the water in the vicinity of the painting operation. It is estimated that roughly 60 operations of this type are performed on Navy vessels annually.[24] The surface area involved may be as small as two square feet for a weld touchup, or as large as 1,500 square feet when several areas of the ship require touchup painting. The amount of paint released will vary with the size of the area painted and the skill of the operator.[1] The release of material during these operations is accidental and highly variable.

SEAWOLF Propulsor Layup. Current operational procedures require the PPCS to be installed with 12 hours after entering port when the in port time is expected to be greater than 72 hours.[2] Exceptions to this requirement exist for maintenance and engine testing, during which the PPCS will be removed, or perhaps not installed at all. This is similar to the requirement for putting the main condensers of earlier submarine classes on a fresh water layup for which an estimate of 6 times per year was developed.[3]

3.3 Constituents

Materials associated with underwater ship husbandry activities and which may be constituents of the various discharges are discussed in this section.

3.3.1 Underwater Hull Cleaning

The primary constituents found in the hull cleaning discharge are copper and zinc from the antifouling paint. These constituents are priority pollutants; neither are bioaccumulators. TBT is not a constituent of concern since small craft with aluminum hulls are not typically cleaned waterborne.[1]

3.3.2 Other Underwater Repair, Maintenance, And Inspection Processes

The primary constituents which may be found in the discharge from underwater repair, maintenance, and inspection processes other than hull cleaning are listed in the following paragraphs. Constituents which are classified as bioaccumulators or priority pollutants are identified.

Fiberglass Repair. The primary constituents found in the discharge from fiberglass repair activities are proprietary resins and fiberglass. The resin material is fluid for only a short period of time; will not be dissolved in the surrounding water; and will fall to the harbor floor, where it will complete its curing. The hardener can contain triethylenetetramine; tetraethylenepentamine; 2,4,6-tris(dimethylaminomethyl)phenol; and amidoamine.[25]

Welding. The primary constituents found in the discharge from underwater welding are metals in the slag associated with welding rods. These may contain chromium, iron, nickel, beryllium, manganese, and trace quantities of other metals.[11] Chromium, nickel, and beryllium are priority pollutants.

Sonar Dome Repair. The primary constituents found in the sonar dome repair discharge are rubber from the patches and the sealant. The sealant adhesive contains epoxy resin, amine polymer, iron oxide, and silica.[11]

Non-Destructive Test/Inspection. The primary constituents found in the discharge from crack or weld inspection are fluorescent iron powder or flakes, water conditioner, and a surfactant mixture suspended in water.[26] The particles used are required by specification to be non-toxic, finely divided ferromagnetic material free from rust, grease, oil, paint, or other materials which can interfere with their proper functioning.[14]

Masker Belt Repairs. The primary constituents found in the discharge from masker belt repairs are portions of the damaged belt and adhesive. Sealant adhesive contains amine polymer, iron oxide, and silica.[11]

Paint Operations. The primary constituents found in the discharge from touchup paint operations are epoxy paint which contains 4,4'-methylene dianiline, benzyl alcohol, and traces of epichlorohydrin.[11]

SEAWOLF Propulsor Layup. Constituents from the layup of the SEAWOLF propulsor will include decaying organic matter, and CPO that may build-up in the enclosed volume of the propulsor. CPO is the primary constituent.

3.4 Concentrations

3.4.1 Underwater Hull Cleaning

The Navy studied the environmental effects of in-water hull cleaning on six ships during the period from 1991-1993. Measurements of total copper were taken directly within the SCAMP discharge plume for three of these ships.[10] This data serves as the basis for the analysis of copper concentrations in and loading from the SCAMP effluent.

Table 2 summarizes both dissolved (0.45 micron filtered) and total (unfiltered) copper concentrations from the effluent of the SCAMP for the three ships.[10] Samples were collected in the plume created by the cleaning operation near the point of discharge, and thus are representative of the highest anticipated levels in the marine environment attributable to underwater hull cleaning. The mean for total copper in the samples ranged from 1,565 micrograms per liter (μg/L) to 2,619 μg/L. The dissolved fraction was 4 to 9 percent of the total copper (66 μg/L to 146 μg/L). Zinc levels were not measured in this study, but can be roughly estimated from the original ratio of constituents in the paint. Assuming a ratio of 2.5 parts copper to 1 part zinc, it can be estimated that the total zinc concentration is 626 to 1,048 μg/L.[27]

3.4.2 SEAWOLF Propulsor Layup

The concentration of organic matter in the released volume of water will be related to the amount of biological matter in the harbor water when the PPCS is installed. The concentration of CPO will be proportional to the current output of the ICCP system and the length of time the PPCS is installed, and inversely proportional to the oxidizable component of the harbor water at the time of PPCS installation.

Typical in port ICCP system output for the SEAWOLF Propulsor is less than 1 ampere. An equation based on Faraday's Law is used to determine the maximum CPO generation rate of 1.3 g Cl/hr.

Generation Rate of Chlorine Produced Oxidants (CPO)

$$= (1\text{ amp})\,(1\text{ coulomb/amp-sec})\,(3{,}600\text{ sec/hr})\,(35.45\text{ g chlorine/mole})\,(\text{mole}/96{,}484\text{ coulomb})$$
$$= 1.323\text{ g chlorine/hr} \approx 1.3\text{ g/hr}$$

Since ICCP systems (i.e., anode materials and system operating voltage) are designed to maximize cathodic protection provided to the hull, and generation of chlorine or CPO is a secondary reaction, actual CPO generation rates are expected to be significantly lower.

This generation rate of CPO will be further offset by the consumption of CPO in the harbor water. In the first stage of CPO decay, a portion of the CPO disappears within one minute, consumed by the instantaneous oxidant demand. This first decay is assumed to be a 25% reduction, based upon a range of values reported for studies performed in waters between $0^{o}C$ and $33^{o}C$.[28, 29] Following this, decay is assumed to occur at a rate of 50% concentration reduction per hour. While actual decay rates for CPO will vary significantly due to temperature, flow, and amount of biological matter, these average decay rates can be used to determine an estimate of the resultant CPO concentration and mass loading as shown in Calculation Sheet 1.[30] The resultant concentration and mass loading converge to steady-state values of 18 µg/L CPO and 1.4 g CPO per event, respectively, in the enclosed volume of water after ten hours of system operation.

One set of field was data obtained for this application, and in this, a CPO concentration of less than 40 µg/L was measured in the enclosed water of the propulsor over a 52 day period.[31,32] This testing was accomplished in the context of local environmental limits for CPO of 0.2 ppm (200 µg/L), and test results only confirmed CPO concentrations within the lowest range of the test apparatus (0.0 ppm to 0.04 ppm) rather than precise values.[32] This is in agreement with the 18 µg/L estimated from the previous CPO decay calculation. The larger of the two estimates (40 µg/L) will be assumed for subsequent calculations.

3.4.3 Other Underwater Repair, Maintenance, and Inspection Processes

In accordance with the specifications, the concentration of magnetic particles in the slurry used for underwater weld inspection is between 0.1% and 0.7% by volume.[14] The remainder of the suspension is water. The estimated release amounts from other underwater ship husbandry activities are infrequent and in small quantities. In addition, these discharges are mostly insoluble and are unlikely to remain suspended in the water column or be dissolved. Pollutant concentrations resulting from fiberglass repair, welding, sonar dome repair, masker belt repair, and painting were not estimated.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents are compared with water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

4.1.1 Underwater Hull Cleaning

Differences in ship assignments and deployments create different rates of hull fouling on individual vessels. However, the decision to initiate hull cleaning operations is based on visual inspection and by ship performance indicators as outlined in NSTM, Chapter 081.[4] Based upon this standard approach to assessing the need for cleaning, it is reasonable to assume that cleaning operations are initiated under similar fouling conditions. Therefore, the SCAMP discharges sampled are assumed to provide a reasonable basis for the approximation of SCAMP discharges fleet-wide. The total volume of a release from an underwater hull cleaning operation is proportional to the area of the hull cleaned. Therefore, the total volume of the discharge is related to the class of ship, with larger releases generated from the cleaning of larger hull areas.

For the purposes of calculating mass loading from ships and the fleet, the mean concentration of the copper in the SCAMP discharge from the three vessels studied was used. The total copper was measured to be 1,950 μg/L and the dissolved copper fraction averaged approximately 107 μg/L, or approximately 5.5%.[10]

In order to calculate the mass loading, data are needed on the flow rate (F) from the SCAMP impellers, and the rate (R), or area cleaned per unit time. The mass of copper released (Cu) per unit area cleaned (A) can be calculated by the following formula:[10]

Cu/A = (Cu concentration) (F/R)
where Cu is in grams (g)
A is in square meters (m^2)
Cu concentration is in grams per liter (g/L)
F is in liters per minute (L/min)
R is in square meters per minute (m^2/min)

Using the following assumptions, a sample calculation of the mass of copper released per unit area cleaned is provided below:

SCAMP flow rate is 51,100 L/min (equivalent to 13,500 gpm), (Section 3.2)
Cu concentration = 0.00195 g/L (mean concentration)
Flow rate (F) = 51,100 L/min
Cleaning rate (R) = 20.8 m^2/min (225 ft^2 /min)
(based on 45 ft/min travel speed, and a 5 ft wide cleaned path)
Cu/Area = (0.00195 g/L) (51,100 L/min) / (20.8 m^2/min)
Copper release= 4.8 g Cu per m^2 of surface cleaned

Assuming the entire hull area exposed to the water is cleaned, the wetted surface area of the ships can be used for the area cleaned. The wetted surface area of the ships was taken directly from tables in NSTM Chapter 633, "Cathodic Protection," or estimated by the following formula presented in the same source:[33]

$$S = 1.7(L)(d) + (V/d)$$

where: S = wetted surface area (ft^2)
L = length between perpendiculars (ft)
d = molded mean draft at full displacement (ft)
V = molded volume of displacement ft^3
(for seawater, 35 ft^3 of water per ton displacement)

As an example for an individual ship, from the NSTM the Spruance Class destroyer has a wetted hull area of 35,745 ft^2 (3,321 m^2).[33] Therefore, the mass loading is estimated to be 15.9 kilograms (kg), or 35 pounds (lbs) total copper released during a full hull cleaning.

Fleetwide Hull Cleanings. A list of Navy vessels which received full hull cleanings during the period from 1993-1996 was used to determine a weighted average mean hull surface area cleaned annually.[21] This weighted average was estimated to be 2,973 m^2. The estimated copper release rate and the mean hull wetted surface area can be applied to all Navy ships to derive a total mass release fleet-wide. Dissolved copper releases are based on the average ratio (5.5%) of dissolved to total copper measured.[10]

Mean wetted hull area (all vessels) = 2,973 m^2
Approximate number of Navy vessels cleaned annually = 136
Total area cleaned annually = 404,328 m^2 (assuming full hull cleanings)
Total copper release = (4.8 g/m^2) (404,328 m^2) = 1,941 kg/yr; or 4,279 lbs/yr
Dissolved copper release = (1,941 kg/yr) (5.5%) = 108 kg/yr; or 238 lbs/yr

Since zinc was not measured in the Navy studies, it was assumed that releases from hull cleaning contain the same copper to zinc ratio (2.5:1) as is found in AF paint prior to its application.[27] The annual mass loading for zinc was estimated.

Total zinc release = (1,941 kg Cu/yr) / (2.5 (Cu/Zn ratio)) = 776 kg/yr; or 1,712 lbs/yr

4.1.2 SEAWOLF Propulsor Layup

Based on information previously provided, the annual mass loading of CPO due to the layup of the SEAWOLF propulsor is estimated to be a maximum of 19 g of chlorine.

Annual mass loading = (concentration)(volume per discharge)(number of discharges)

Maximum concentration = 40 μg/L (see Section 3.4.2)
Volume per discharge = 21,000 gal (3.785 L/gal) = 79,500 L
Number of discharges per year = 6

Mass loading per event = 3.2 g CPO
Maximum annual mass loading = 1.9 x 10^7 μg, or 19 g CPO

4.1.3 Other Underwater Repair, Maintenance, And Inspection Processes

Based on the information presented in Section 3.2 and Table 1, the total discharges associated with underwater ship husbandry operations outside of underwater hull cleaning are as follows:

- 12 quarts of fiberglass resin released annually from shaft coatings over the course of 12 events
- Approximately 60 pounds of welding consumables released annually, including spent welding rods and slag over 12 events

The estimated release amounts from other underwater ship husbandry activities are infrequent and in small quantities. In addition, these discharges are mostly insoluble and are unlikely to remain suspended in the water column or be dissolved.

4.2 Environmental Concentrations

Total copper has been measured in the effluent stream near hull cleaning operations at levels of approximately 1,600 to 2,600 μg/L.[10] These measured copper concentrations exceed water quality criteria (WQC) by three orders of magnitude. Dissolved copper in those same tests ranged from 66 to 146 μg/L, which is 28 to 61 times the Federal criterion for copper.

Using the compositional ratio of copper to zinc in antifouling paint, zinc concentrations in the release from underwater hull cleaning are estimated to be approximately 780 μg/L. This value exceeds WQC by one order of magnitude.

Table 3 shows Federal and most stringent state WQC relevant to the underwater ship husbandry discharge in comparison with the measured copper concentrations and estimated zinc concentrations from the SCAMP discharge.

For the SEAWOLF propulsor lay-up, most states have ambient WQC for CPO of 7.5 - 13 μg/L. The sole measured concentration available reported the concentration as being between 0 and 40 μg/L.

4.3 Potential for Introducing Non-Indigenous Species

Transport of non-indigenous species on the hulls of commercial vessels has been documented.[34] Although the cleaning practices, frequency of transits, and operating locations differ for the Armed Forces, there is the potential for non-indigenous species to be transferred. Fouling and the presence of marine organisms is most serious around intakes, grates, and sea chests.

5.0 CONCLUSIONS

Underwater ship husbandry has the potential to cause an adverse environmental effect because measured concentrations of copper and estimated concentrations of zinc from underwater hull scrubbing exceed ambient water quality criteria and these constituents are discharged in significant amounts. The potential also exists for introducing non-indigenous species during hull cleaning.

Discharges from the other ship husbandry operations are infrequent, and are small in terms of volume or mass loading. Therefore, these discharges have a low potential for environmental effect.

6.0 REFERENCES

To characterize this discharge, information from various sources was obtained, reviewed, and analyzed. Process information, engineering studies, and engineering analyses were used to estimate the rates of discharge and the concentrations of copper and zinc released to the environment. Table 4 shows the sources of data used to develop this NOD report.

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Table 1 - Releases Associated with Underwater Ship Husbandry on Navy Vessels (Exclusive of Hull Cleaning)[22]

Operation	Material Released	Quantity Released per Event	Events per Year
Underwater Fiberglass Repair	fiberglass resin	1 quart	12
Underwater Welding	epoxy paint, welding consumable, slag	5 lbs. (welding consumables)	12
Rubber Sonar Dome or Sub Tile Repair	rubber sealant, epoxy	minimal	16 (surface ships) 3 (submarines)
Non-Destructive Testing	iron flakes, dye, surfactant	minimal	20
Masker Belt Repairs	epoxy paint and filler; rubber sealant	minimal	6
Paint Operations Underwater/Waterline	epoxy paint	minimal	60
Propulsor Protective Covering System (PPCS)	chlorine produced oxidants (CPO)	3.2 g	6

Table 2 - Total And Dissolved Copper Concentrations From In-Water Hull Cleaning Effluent Generated By SCAMP[10]

Vessel Name	Cu, µg/L (Filtered)	% Dissolved	Cu, µg/L (Unfiltered)
USS Fort Fisher (LSD 40)	66	4	1,668
USS Tuscaloosa (LST 1187)	141		1,475
	146		1,520
	137		1,600
	125		1,597
	135		1,633
mean:	136.8	8.7	1,565
standard deviation:	+/- 7.0		+/- 58.3
USS Ranger (CV 61)	106		2,499
	116		2,503
	118		3,287
	120		2,441
	124		2,362
mean:	116.8	4.5	2,619
standard deviation:	+/- 6.0		+/- 338
Grand Mean:	106.5	5.5	1950
standard deviation:	29.8		474

Table 3. Comparison of Constituent Concentrations with Water Quality Criteria (μg/L)

Constituent	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Copper (total)	1950	2.9	2.5 (WA)
Copper (dissolved)	107	2.4	2.4 (CT, MS)
Zinc (total)	780	95.1	84.6 (WA)
CPO	0 - 40	-	10 (FL)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

CT = Connecticut
FL = Florida
MS = Mississippi
WA = Washington

Table 4. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment	X			X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate	X			
3.3 Constituents	MSDS			X
3.4 Concentrations	X			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

Chlorine Produced Oxidants (CPO) generation rate (R) = 1.3 g/hr
PPCS volume (V) = 21,000 gal (3.785 L/gal) = 79,485 L

C_0 = concentration after first minute (considered "time zero" due to first stage decay)
$= [(1.3 \text{ g/hr}) (0.75) (10^6 \mu\text{g/g})] / (79,485 \text{ L}) = 12.3 \mu\text{g/L}$
C_t = concentration at a given time (t)
$C_t = C_0 e^{(-kt)}$, where k = decay constant
$\ln (C_t/C_0) = \ln (e^{(-kt)}) = -kt$
For t = 1 hr and $C_0 = 12.3 \mu\text{g/L}$, $Ct = (12.3\mu\text{g/L}) (50\%) = 6.15 \mu\text{g/L}$
$\ln (C_t/C_0) = \ln (12.3/6.15) = \ln (0.5) = -0.693 = -kt$
$k = - (-0.693) / (1 \text{ hr}) = 0.693 / \text{hr}$
$C_t = C_0 e^{(-kt)} = (12.3 \mu\text{g/L}) e^{(0.693t)}$

However, since CPO is generated simultaneously with the decay of previously introduced CPO, a steady state concentration will be reached when the decay rate equals the generation rate, which can be expressed as:[30]

$k(C_{ss}V) = 0.75R$
k = decay constant (hr^{-1})
$C_{ss}V$ = (steady state CPO concentration) (volume) = mass (g)
R = generation rate (g/hr)

$C_{ss} = 0.75R / (kV)$
$C_{ss} = 17.7 \mu\text{g/L}$

Mass = 1.4 g CPO/event or 8.4 g CPO/yr

Calculation Sheet 1. CPO Concentration and Mass from SEAWOLF Propulsor Layup

UNDERWATER SHIP HUSBANDRY
MARINE POLLUTION CONTROL DEVICE (MPCD) ANALYSIS

Several alternatives were investigated to determine if any reasonable and practicable MPCDs exist or could be developed for controlling discharges from underwater ship husbandry activities. An MPCD is defined as any equipment or management practice, for installation or use onboard a vessel, designed to receive, retain, treat, control, or eliminate a discharge incidental to the normal operation of a vessel. Phase I of UNDS requires several factors to be considered when determining which discharges should be controlled by MPCDs. These include the practicability, operational impact, and cost of an MPCD. During Phase I of UNDS, an MPCD option was deemed reasonable and practicable even if the analysis showed it was reasonable and practicable only for a limited number of vessels or vessel classes, or only on new construction vessels. Therefore, every possible MPCD alternative was not evaluated. A more detailed evaluation of MPCD alternatives will be conducted during Phase II of UNDS when determining the performance requirements for MPCDs. This Phase II analysis will not be limited to the MPCDs described below and may consider additional MPCD options.

MPCD Options

Underwater ship husbandry activities include inspecting, grooming, maintaining, and repairing hulls and hull appendages while a vessel is waterborne.[1] Underwater hull cleaning is, by far, the most common underwater ship husbandry process and has the highest potential for environmental impact. Underwater hull cleaning is performed for numerous reasons including fuel savings, extending service life of hull coatings, and extending the interval between dry dockings and associated coating replacement. To determine the practicability of mitigating the potentially adverse environmental effects of these activities, three potential MPCD options were investigated. The purpose of these MPCDs would be to reduce or eliminate the release of antifouling agents, specifically copper and zinc, into surrounding waters during underwater hull cleaning operations. The MPCD options were selected based on initial screenings of alternate materials, equipment, pollution prevention options, and management practices. They are listed below with brief descriptions of each:

Option 1: Vary hull cleaning brush type and brush pressure - The goal of this option would be to more closely match brush stiffness and pressure to the degree of fouling to minimize antifouling coating removal. More brush types would be developed, and several different brush types may be used and interchanged during the cleaning of any one vessel. By properly selecting brushes, effective cleaning can be conducted with a minimal release of antifouling agents and associated discharges.

Option 2: Mandate the maximum allowable frequency of underwater hull cleaning - This option would reduce the number of hull cleanings permissible within a given time period or at any one location to limit the amount of discharge within each harbor.

Option 3: Collect water discharged from the multi-brush cleaning vehicle - This option would provide a means to collect the discharge from the underwater hull cleaning vehicles to prevent water that contains antifouling agents from entering the surrounding environment.

MPCD Analysis Results

Table 1 shows the findings of the investigation of the selected MPCD options. It contains information on the elements of practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a final determination for each option. Based on these findings, Option 1 -- varying hull cleaning brush type and brush pressure -- offers the best combination of these elements and is considered to represent a reasonable and practicable MPCD.

Table 1. MPCD Option Analysis and Determination

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 1. Vary Hull Cleaning Brush Type & Brush Pressure	New brush types would have to be developed so they could more closely match the hull fouling condition. Monitoring and controlling brush pressure and aggressiveness would further enhance cleaning procedures.	Using different cleaning brushes should not reduce vessel capabilities as hulls would still be required to be cleaned to current standards. However, interchanging brush types will potentially increase cleaning time, thereby slightly decreasing vessel availability.	Cleaning costs will likely increase if the brushes have to be switched more frequently or if the discharge has to be monitored. Additional costs associated with development of new brushes would be incurred.[2]	Varying brush type and pressure will reduce copper and zinc mass loading due to a reduction in brush aggressiveness by an estimated 10% to 20% depending on the age and type of antifouling coating system.[1]	Developing and manufacturing new brushes: 1) can be implemented, 2) is cost effective, and 3) will reduce mass loading. Therefore, this MPCD option warrants further consideration.
Option 2. Mandate the maximum allowable frequency of underwater hull cleaning	Pre-cleaning inspections are currently performed and compared to hull cleaning criteria to prevent unwarranted hull cleanings. Any further prohibitions on cleaning frequency could potentially negate the benefits of hull cleaning.[3]	Reducing the frequency of hull cleanings would increase hull fouling causing increased fuel consumption, decreased maximum vessel speed, and increased acoustic signature, and, therefore, adversely affect vessel mobility and readiness.	Reducing cleaning frequency will increase annual fuel costs by up to $75,000 for a typical cruiser.[4,5]	Although reducing the number of cleaning events may reduce total load, the increased aggressiveness required to clean a more heavily fouled hull could result in equal or greater total discharge. This option may necessitate more frequent paintings. Newly applied coatings have been shown to have much higher copper release rates than old coatings, so the more ships with newer coatings could increase loadings.	This option results in a performance penalty and increased fuel costs with questionable environmental benefit.
Option 3. Collect Water Discharged From the Multi-Brush Cleaning Vehicle	Installing discharge hoses on existing cleaning units does not seem to be possible due to the	Collecting effluent during cleaning operations will increase cleaning time, resulting in reduced vessel	If this option is proven to be feasible, there would be higher costs associated with: 1) technology	A new hull cleaning device has the potential to reduce mass loading of copper and zinc by 100% if	Although this option would eliminate the discharge, if the new hull cleaning device proves to be

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
	diameter of the hose required, the expected flow rate, and the head required to discharge to the pier. Operating such a device could compromise diver mobility and safety. Alternatively, a new hull cleaning device that would collect cleaning effluent is in early stages of development and the practicability of this device has yet to be determined. This effort is several years away from completion.	availability. If cleaning effectiveness is reduced, this would adversely affect acoustic signature, fuel consumption, vessel speed, and vessel mobility.	development, 2) increased cleaning time, and 3) waste treatment and disposal.	no discharge escapes collection during cleaning operations.	successful, this may become a viable alternative. Adapting a collection system to the current diver-based technology is not feasible.

REFERENCES

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[3] Naval Ships' Technical Manual S9086-CQ-STM-010 R3 Chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships. 4 August 1997.

[4] Hundley, L. L. and Tate, C. W., Sr. (David W. Taylor Naval Ship Research and Development Center). "Hull Studies and Ship Powering Trial Results of Seven FF 1052 Class Ships," DTNSRDC-80/027. March 1980.

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NATURE OF DISCHARGE REPORT

Welldeck Discharges

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for “..discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ...’[Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes the welldeck discharges and includes information on the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Several Navy ship classes have a welldeck in the aft section of the ship for embarking, storing, and disembarking landing craft. These welldecks range from 50 to 78 feet in width, 168 to 440 feet in length, and 20 to 30 feet in height.[1] During an amphibious operation or beach assault, the ship can be positioned anywhere within proximity of land. However, the operations are more likely to occur near the 12 nautical mile (n.m.) limit so the ship is less susceptible to enemy gunfire from shore. The landing craft carried onboard the ship serve to ferry U. S. Marine Corps (USMC) personnel, vehicles, and equipment to and from shore. Depending on the type of landing craft used, the ship might fill ballast tanks with seawater to lower the ship so that the welldeck floods with water (see Figure 1).

The types of craft that typically operate from these ships are utility landing craft (LCUs), air-cushion landing craft (LCACs), and assault amphibian vehicles (AAVs). LCUs have diesel engines to power the propellers. LCACs are gas-turbine-driven hovercraft. AAVs propel themselves through the water with waterjets, but use tracked running gear on land. Although AAVs can enter and exit the welldeck independently, they are also carried onboard LCUs and LCACs. Mechanized landing craft (LCM), once common to amphibious operations, are no longer carried by amphibious ships.[1,2]

Vehicles and equipment are stored in the vehicle storage areas forward of the welldeck. These areas are located on two levels and are connected by ramps. Vehicles and equipment are also stored onboard the LCUs and LCACs in the welldeck but not in the welldeck itself due to space constraints. Similarly, containers and products are not stored in the welldeck but rather in the vehicle storage areas or elsewhere on the ship. Examples of the vehicles carried onboard include light armored vehicles (LAVs), AAVs, tanks, jeeps, trucks, high mobility multipurpose wheeled vehicles (HMMWVs), and motorcycles. Examples of equipment carried onboard include howitzers and trailers.[2]

The floors of the welldeck are lined with pressure treated lumber. The walls are lined with either pressure treated lumber or synthetic batter boards except near the stern gate where the walls are lined with rubber panels.

Vehicle and equipment maintenance is performed where the vehicles and equipment are stored, which can include on the deck of a host LCU or LCAC. Waste products and spills produced during vehicle maintenance are collected and held in accordance with shipboard procedures for spill containment. Oily patches on the decks are cleaned with a detergent.[2]

There are five primary overboard discharges from a welldeck: (1) washout from the welldeck when the ship ballasts to embark or disembark landing craft; (2) water or detergent and water mixture used for LCAC gas turbine engine washes; (3) graywater and condensate that can be discharged from the LCUs; (4) freshwater wash to remove salt and dirt from vehicles, equipment, and landing craft; and (5) U.S. Department of Agriculture (USDA) washes of the welldeck, vehicle storage areas, and all vehicles, equipment, and landing craft. These discharges can occur almost anywhere within 12 n.m., except for the USDA work which occurs pierside.

2.1.1 Welldeck Washout

Washout occurs when the welldeck is flooded to allow landing craft to enter or exit the ship. However, LCACs and AAVs do not need the welldeck to be flooded to enter or exit, although some water will naturally enter. Therefore, this discussion is primarily applicable to LCU operations. The ship submerges the welldeck by flooding clean ballast tanks with seawater.[3] See Figure 1. When the welldeck is submerged, any debris or fluid in the welldeck is mixed with the seawater and will eventually flow to the open sea.

2.1.2 LCAC Engine Washes

The LCAC engine washes are performed on the four gas turbine engines provided for propulsion and the two auxiliary power units (APUs) provided to supply electrical power. There are two types of LCAC engine washes: thorough preventive-maintenance washes that uses a detergent to remove engine deposits and those performed daily with only distilled water to remove salt deposits. During winter conditions, methanol may be added to the mixture to prevent the wash water from freezing.[4]

Preventive-maintenance washes are scheduled every 25 operating hours for the gas turbines and quarterly for the APUs. Because the purpose of these washes is to prevent engine degradation, any noticeable reduction in engine performance will usually result in a wash. There are currently two separate methods used to perform these washes but both involve flushing distilled water and detergent through the engine while it is being rotated on the starter. One method uses an automated cleaning system, if installed, and a detergent called ZOK-27. The other, a more manual procedure, uses a detergent called B&B 3100 (MIL-C-85704). Following the detergent wash, a separate distilled water wash is performed to flush out the engine. APUs are washed in a similar way except that the detergent is Stoddard Solvent, FedSpec P-D-680, type III.[2,3]

Daily washes are performed when the LCACs have been operating, but not if preventive maintenance washes are scheduled for the same day. This wash consists of a rinse of distilled water through the propulsion gas turbines, but not the APUs. However, if a cleaning system is installed it may also be used for the daily wash as it is for the preventive maintenance wash.

2.1.3 Landing Craft Discharges

LCU crews live aboard their craft in the welldeck. As such, they generate graywater (i.e., water from drains, sinks, and showers) as well as condensate from air conditioning systems. The graywater and condensate produced is drained to the welldeck. LCUs do not create blackwater (sewage) because the crew uses the ship's sanitary facilities.[3] LCACs do not have living spaces, do not produce graywater, and do not discharge condensate into the welldeck.[2] For more information on graywater, see the Graywater NOD Report.

2.1.4 Vehicle, Equipment, and Landing Craft Washes

Dirty vehicles and equipment returning to the ship are washed ashore, if possible. They also will receive a freshwater wash on the ramp leading from the welldeck to the vehicle storage area. The engine compartments are not washed.[2] The wash water flows into the welldeck and is drained overboard or pumped overboard by an eductor. The motive water for the eductors in the welldeck and vehicle storage areas is provided by the firemain.

The aluminum structure of an LCAC is unpainted and susceptible to the corrosive effects of seawater. To prevent this corrosion, the exterior is washed with fresh water at the conclusion of daily operations. If the LCACs are not being used, a biweekly wash is required.[5] No cleaners or detergents are used for these washes. LCUs and AAVs are not washed in the welldeck.

2.1.5 USDA Washes and Inspections

The USDA requires that vehicles, equipment, craft, and internal shipboard areas that have contacted foreign soil be thoroughly washed and inspected to prevent the importation of non-indigenous species. These washes and inspections are performed prior to returning to, or upon return to, the U.S. These washes and inspections fall into three categories; those done on the welldeck and vehicle storage areas, those done on the vehicles and equipment, and those done on the landing craft. These three operations normally occur in foreign ports, but can occur in the U.S. or U.S. territories. [2]

The welldeck and vehicle storage areas are washed when all of the vehicles, equipment, and landing craft that can be off-loaded are removed. Those that remain are too large to fit down the exit ramp on the side of the ship. Their normal path is through the stern gate. One example is the M-9 armored combat earthmover (ACE) which is 10.5 feet wide and 8.75 feet high. During the washes all surfaces (decks, bulkheads, and overheads) are cleaned. The process for the welldeck begins with a seawater wash of all surfaces followed by a freshwater wash. Unlike the welldeck, the vehicle storage areas are only washed with fresh water. Following the washes, the USDA inspects to ensure that no foreign species, soil, or plants are in those areas. All of the water effluent drains overboard or is pumped overboard by an eductor.[2]

The vehicles and equipment are washed pierside, except for those discussed above that cannot be off-loaded. They will be washed and inspected in the welldeck. The process begins with the vehicles and equipment being parked in a designated contaminated area. Each, in turn, is then moved to an area to have the interior cleaned. They are then moved to the wash racks and thoroughly washed (including the engine compartments) with fresh water. The wash racks are long wheel ramps that allow the undersides of the vehicles to be washed and inspected. Following the wash, each vehicle or piece of equipment is inspected by the USDA for foreign organisms, plants, and soil, and then moved to a designated clean area to await reloading on the ship. The effluent from the vehicles and equipment washed in the welldeck drains overboard or is pumped overboard by an eductor.[2]

The landing craft are also washed and inspected. LCACs, however, are not usually given a special wash because enough sea spray is created in their operation that all the exterior surfaces are flushed free of foreign organisms, plants, and soil before the LCAC boards the ship at sea and is inspected. LCUs are washed with fresh water in the welldeck or pierside and then inspected.[2]

2.2 Releases to the Environment

Effluent is discharged to the environment by washout or surge when landing craft are operating in the welldeck. Effluent from the various washes performed in the welldeck are discharged as it drains overboard from the welldeck or is pumped overboard by an eductor.

Welldeck washout and the effluent from the washes can contain fresh water, distilled water, firemain water, graywater, air-conditioning condensate, sea-salt residues, paint chips, wood splinters, dirt, sand, organic debris, oil, grease, fuel, detergents, combustion by-products, and lumber treatment chemicals.

2.3 Vessels Producing the Discharge

Only the Navy has ships with welldecks. Ship classes with welldecks include general purpose amphibious assault ships (LHAs), multipurpose amphibious assault ships (LHDs), amphibious transport docks (LPDs), and dock landing ships (LSDs). While there are differences among welldeck designs, the primary process variance is due to the type and number of landing craft onboard. Applicable data is listed below.[1]

Ship Class	No. of Ships	Welldeck Dimensions	Landing Craft Loading Schemes
LHA 1	5	268'x 78'	4 LCU, 1 LCAC, or 45 AAV
LHD 1	4	267'x 50'	3 LCAC or 2 LCU
LPD 4	8	168'x 50'	1 LCU or 28 AAV
LSD 36	5	430'x 50'	4 LCAC, 3 LCU, or 52 AAV
LSD 41	8	440'x 50'	4 LCAC, 3 LCU, or 64 AAV
LSD 49	3	265'x 50'	2 LCAC or 1 LCU

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Welldeck discharges can occur both within and beyond 12 n.m.

3.2 Rate

3.2.1 Welldeck Washouts

The flow from a welldeck washout can be estimated based on the welldeck dimensions listed in Section 2.3. The washout volume was estimated by multiplying the dimensions of the welldeck (length and width in feet) by the approximate height of water needed by an LCU (5' [2] The numbers shown in parenthesis are estimated values for the amount of water entering the welldeck during LCAC operations (using an assumed depth of 4 inches of water spread uniformly across the welldeck). The water in the welldeck during LCAC operations is the result of the surge created when the LCACs enter the ship and is not the result of ballasting.

Ship Class	Estimated Gallons Per Washout (or Surge)
LHA 1	1,100,000 (52,000)
LHD 1	700,000 (33,000)
LPD 4	440,000 (0, no LCACs)
LSD 36	1,130,000 (54,000)
LSD 41	1,150,000 (55,000)
LSD 49	700,000 (33,000)

On average, an amphibious ship will have one six-month deployment every two years. During such a deployment, ballasting/deballasting will take place approximately 40 times (unless LCACs are deployed in which case the seawater surge will enter the welldeck 40 times).[2] It is variable how many times the ballasting/surge will take place within U.S. waters or how many local exercises will take place during that two year period. This is because the amount of time that a ship spends in U.S. waters varies from ship to ship.

3.2.2 LCAC Gas Turbine Engine Washes

Approximately 12 gallons of distilled water is used for a propulsion gas turbine daily wash. The flow from a detergent wash would be 12.5 gallons of distilled water/detergent mix followed by 12 gallons of distilled water rinse for a total of 24.5 gallons. For each APU, the flow from a detergent wash would be 0.375 gallon of distilled-water-detergent mix followed by a 0.25 gallon distilled water rinse for a total of 0.625 gallon. Thus, each LCAC is capable of producing 48 gallons of effluent from the daily washes of the four propulsion gas turbines and 99.25 gallons of effluent if all of the engines (four propulsion and two APUs) are washed with a water-detergent mix.[2,6]

3.2.3 Graywater and Air Conditioning Condensate

LCUs discharge graywater into the welldeck because they do not have the capability to collect and hold graywater. Air-conditioning condensate is also not collected.

During the transit of an amphibious ship from port to 12 n.m., the LCU would have 4 hours to generate graywater. The rate of graywater generation for Navy personnel is given as 30 gallons per person per day. Thus, an LCU with a typical load of six crew members could generate 180 gallons of graywater per day or 30 gallons of graywater during the 4-hour transit period. However, little or no graywater is produced and discharged within 12 n.m. because the crew of the LCU is occupied with preparations for, or stand down from, welldeck operations.

The generation of graywater on an LCU while the host ship is operating within 12 n.m. has not been estimated since the time that a host ship will be operating within 12 n.m. varies. LCU air-conditioning capacity varies from 5 to 8 tons which, under severe heat and humidity conditions, can produce 30 to 48 gallons of condensate per day.

3.2.4 Vehicle, Equipment, and Landing Craft Washes

When returning to the ship, vehicles and equipment receive a freshwater wash on the ramp leading from the welldeck to the vehicle storage area. This freshwater wash uses a 1.5-inch firehose at a rate of about 95 gallons per minute (gpm).[2] The wash typically takes 30 seconds, so it is estimated that 48 gallons of fresh water is used per wash. A typical ship contains about 100 to 125 vehicles and pieces of equipment, so approximately 4,800 to 6,000 gallons could be discharged if all of the vehicles and equipment are returned to the ship and washed consecutively.

The exterior wash of the LCACs is performed at the end of daily operations. This wash also uses a 1.5-inch firehose at a rate of 95 gpm and lasts for about 10 minutes. Estimates from LCAC personnel indicate that about 1,000 gallons of water are used per LCAC, which is consistent with a 10 minute wash at 95 gpm.[2] Since the number of LCACs carried onboard a ship can vary as shown in Section 2.3, 1,000 to 4,000 gallons of water could be released by these washes. However, if the LCACs are not being used, only a biweekly wash is required.[5]

3.2.5 USDA Washes and Inspections

The welldeck and vehicle storage areas are washed differently. The welldeck is first washed with seawater via the firemain, and then washed with fresh water. The vehicle storage areas are only washed with fresh water. Each wash takes about 45 minutes. The seawater wash of the welldeck uses a 1.5-inch firehose at a rate of about 95 gpm of seawater. Based on the estimated time of 45 minutes, about 4,275 gallons are used. The freshwater wash of the welldeck also uses a 1.5-inch firehose at a rate of about 95 gpm. Again, based on the estimated time of 45 minutes, about 4,275 gallons are used. The upper and lower vehicle storage areas are washed separately with fresh water, each taking about 45 minutes, and using a 1.5-inch firehose at a rate of about 95 gpm. To summarize these estimates, 4,275 gallons of firemain water and 4,275 gallons of fresh water are used to wash the welldeck and 8,550 gallons of fresh water are used to wash both vehicle storage areas.

The vehicles and equipment are washed with a 1.5-inch firehose at a rate of about 95 gpm of fresh water. Each vehicle or piece of equipment takes about 5 minutes to wash. Therefore, about 475 gallons of water are used. If five to ten vehicles or pieces of equipment were unable to be off-loaded, 2,375 to 4,750 gallons of water could be used.

The duration of the landing craft washes for calculation purposes will be estimated at 15 minutes using a 1.5-inch firehose at rate of about 95 gpm of fresh water. Therefore, about 1,425 gallons could be used for each landing craft. The washing of the LCACs in this manner is unlikely however, so the loading of one to four LCUs (from Section 2.3) is used to yield a range of effluent produced which is 1,425 to 5,700 gallons.

3.3 Constituents

The potential constituents of this discharge include:[2,3]

- air-conditioning condensate
- automotive grease
- B&B 3100 detergent (MIL-C-85704)
- bromine (from the wash water)
- chlorine (from the wash water)
- detergent
- gas turbine fuel, JP-5 (MIL-F-5624E)
- graywater
- lumber-treatment chemicals
- methanol
- motor oils
- naval distillate fuel, F-76 (MIL-F-16884)
- nickel, copper, zinc, and other metals
- solvent P-D-680 type III (petroleum distillate)
- vehicle diesel fuel, F-34 (MIL-T-83133)
- ZOK-27 water-soluble detergent

ZOK-27 contains ethanol and 2-butoxyethanol, while B&B 3100 contains solvent-refined heavy naphthenic distillate and petroleum solvents. Marine diesel fuel (F-76) contains petroleum mid-distillates, antisetting agents, and flow improvers.

It is possible that lube oils, greases, and fuel oils can be spilled on welldeck surfaces. However, spills will be quickly wiped up in accordance with shipboard practices, so any oils or greases found on welldeck surfaces will exist as surface films. Such surface films may contain benzene, toluene, ethylbenzene, and xylenes which are the common constituents of lighter petroleum products. These chemicals are also priority pollutants, as are various metals (e.g., copper and nickel) which are in firemain water and could be present in greases, oils, and fuels.[7]

There are no constituents present in welldeck discharges that are bioaccumulators.[8]

3.4 Concentrations

The constituent concentrations have not been estimated. The concentration of metals in the firemain water is discussed in the Firemain Systems NOD Report.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. A discussion on the mass loadings is presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are discussed along with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Since numbers that quantify the constituents of the various components of this discharge are unknown and variable, mass loading calculations cannot be performed with any accuracy. However, generalized statements regarding the mass loadings can be made based upon the physical features of the discharge.

4.1.1 Welldeck Washouts

Spills from vehicle and equipment maintenance within the welldeck could potentially result in the discharge of substances such as oil. These spills can leave a residue on the deck. However, spills are controlled by shipboard procedures for spill containment and clean-up. Oily patches on the decks are cleaned with a detergent.[2] The small amounts of constituents remaining as surface films in the welldeck do not support the production of significant mass loadings.

4.1.2 LCAC Engine Washes

The degree to which engine contaminants are removed by the wash water is unknown and the amounts of engine washes within 12 n.m. are unknown. Since there are many LCACs and not all of them are operating each day or are not within U.S. waters, it will be assumed that 1 LCAC is operating each day in U.S waters and requires an engine wash. Since the gas turbine engines are relatively clean, it is assumed that, at most, a few tablespoons of hydrocarbon constituents will be removed by each wash. Using these numbers, only 3-5 gallons of hydrocarbon constituents would be released by the engine washes, per year, in U.S. waters.

4.1.3 Graywater and Air Conditioning Condensate

As discussed in section 3.2.3 above, it is estimated that 30 gallons of graywater can be discharged from an LCU while the host ship is transiting to 12 n.m. LCUs are not normally carried onboard amphibious ships since LCACs are favored. Assuming 10 LCUs are carried onboard ships during a year, and assuming that each ship transits the 12 n.m. zone 6 times per year, it is estimated that, at most, 1800 gallons of graywater will be released per year during transit. These assumptions overestimate the amounts of graywater produced because it is unlikely that each LCU on a host ship is discharging graywater at the maximum design rate during the entire 12 n.m. transit. Graywater production is likely to be much lower during transit because the LCU crew is occupied with preparations for, or stand down from, welldeck operations. In port, mass loadings of graywater can equal the design rate so each LCU could produce 180 gallons per day (32,760 gallons per year assuming 6 months in port).

Based on the discussions in the Refrigeration/AC Condensate NOD Report, the condensate discharge contains little or no constituents and insignificant mass loadings are expected.

4.1.4 Vehicle, Equipment, and Landing Craft Washes

These washes are directed at the external surfaces of vehicles, equipment, and landing craft. The engine compartments are not washed. Any hydrocarbon constituents would be present as films on exterior surfaces. Assuming that a tablespoon (29.6 mL) of oil was present and washed off per vehicle, landing craft, etc., and that 1000 are washed in U.S. waters per year, only about 4 gallons of oil would be released per year. However, it is felt that a tablespoon is an overestimate of the amount of oil that could be removed by such washes.

4.1.5 USDA Washes and Inspections

Although somewhat similar to 4.1.3 discussed above, the vehicle portion of these washes are substantially longer and include a high-pressure wash of the engine compartments external to the vehicles. However since these washes are almost entirely performed shoreside, only the effluent from those vehicles washed in the welldeck has the potential to enter the water. Assuming 20 vehicles per year are given this wash while in U.S. waters, and half a pint (473 mL) of oil is removed from each, only 1.25 gallons of oil would be released per year. However, these assumptions will tend to overestimate of the amount of oil that could be removed by such washes.

The other portion of this discharge, the washing of the welldeck and vehicle storage areas, will only occur several times a year, at most, since the USDA washes and inspections are normally conducted while the ship is still overseas. Furthermore, the hydrocarbon constituents present will be in the form of surface films so significant mass loadings are not expected.

4.2 Environmental Concentrations

Since numbers that quantify the volumes and constituents of the various components of this discharge are unknown and variable, concentrations cannot be performed with any accuracy. However, generalized calculations and statements regarding the mass loadings can be made based upon the known physical features of the discharge.

4.2.1 Welldeck Washout

Spills from vehicle and equipment maintenance within the welldeck could potentially result in the discharge of substances such as oil. The spills can coat the deck with a residue. However, the spills are controlled by shipboard procedures for spill containment and clean-up. Oily patches on the decks are cleaned with a detergent.[2] The small amounts of constituents remaining as surface films in the welldeck do not support the production of significant mass loadings. The large water volumes involved (see 3.2.1) and the small volumes contained in the surface films do not appear to support the production of significant contaminant concentrations in the washouts and it is not expected that they will exceed federal or state water quality criteria. The visual criteria for oily discharges is that the discharge does not cause a sheen while the Act to Prevent Pollution from Ships limits the oil content of the discharge to 15 parts per million (approximately 15 mg/L). Florida has set a criterion of 5,000 micrograms per liter (µg/L) with no visible sheen.

4.2.2 LCAC Engine Washes

Since this discharge comprises a low volume of water which passes through an engine and is in contact with hydrocarbons, it is believed that water quality criteria can be exceeded. A rough estimate of contaminant concentrations can be performed to check the validity of assuming that hydrocarbon concentrations in the discharge can exceed water quality criteria. It does not seem unreasonable to assume that one teaspoon (4.9 mL) of hydrocarbon constituents could be deposited within the gas turbine engine and washed away in the discharge. The 4.9 mL placed in 12 gallons (45.42 L) of water (daily wash) will yield a hydrocarbon concentration of about 108,000 ppb of oil which exceeds the Florida water quality criterion of 5,000 ppb of oil. This rough calculation supports the assumption that water quality criteria can be exceeded. There is also the possibility that trace amounts of metals could be present that exceed federal and state water quality criteria. Furthermore, the nature of the detergent wash will liberate more hydrocarbon constituents and it is still assumed that water quality criteria can be exceeded, even though twice as much water is used.

4.2.3 Graywater and Air Conditioning Condensate

As discussed in section 3.2.3 above, it is estimated that 30 gallons of graywater can be discharged from an LCU while the host ship is transiting the 12 n.m. zone, or 180 gallons per day in port. LCU graywater has not been sampled, but it is possible that graywater sampling data for surface ships can be applied to the LCUs. According the Graywater NOD Report, the measured concentrations of several metals in the discharge exceed ambient water quality criteria and the estimated loadings of nutrients, solids, and oxygen-demanding substances are high.

As discussed in section 3.2.3 above, it is estimated that 30 to 48 gallons of air-conditioning condensate can be produced each day. Based on the Refrigeration/AC Condensate NOD Report, this discharge contains little or no constituents and has a low probability of producing an environmental effect.

4.2.4 Vehicle, Equipment, and Landing Craft Washes

Although concentrations have not been calculated, the low volumes of water that are mixed with small amounts of hydrocarbon constituents, are not considered to exceed federal or state water quality criteria or to have an environmental effect.

4.2.5 USDA Washes and Inspections

The discharge from the USDA washes of the welldeck and vehicle storage areas will contain dirt, debris, detergents, and hydrocarbons in concentrations that could possibly exceed federal discharge standards or state water quality criteria. The washes of the welldeck will also contain metals from the ship's firemain.

4.3 Potential for Introducing Non-Indigenous Species

Although washes and inspections are required by the USDA for the vehicles, equipment, landing craft, welldeck, and vehicle storage areas, the potential for introducing non-indigenous species exists when the washes occur in U.S. ports. The wash water effluent could potentially carry non-indigenous species from the ship into the water. It should be noted that the USDA washdowns are intended to prevent transfer of non-indigenous species to land and the viability of any waterborne species introduced is questionable since they generally would have been exposed to air for extended periods of time prior to their introduction into U.S. coastal waters (i.e., for the most part, these species would have been removed from vehicles and deck surfaces and thus it would not be a water-to-water transfer, in contrast to species transfers from ballast water systems).

5.0 CONCLUSIONS

If uncontrolled, discharges from the well deck could possibly have the potential to cause an adverse environmental effect because oil drippings spilled during vehicle and equipment maintenance would leave an oil film on the deck surface. When the welldeck is flooded, the oil film can be washed from the deck by the incoming water. An oil sheen could possibly be discharged when water within the welldeck is discharged. However, current management practices provide for the clean-up of oil and other substances spilled during routine maintenance. These practices reduce the possibility of discharging an oil sheen.

6.0 DATA SOURCES AND REFERENCES

To characterize the discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge. Information to determine the concentrations and loadings of constituents is not available. Table 1 shows the sources of data used to develop this NOD report.

Specific References

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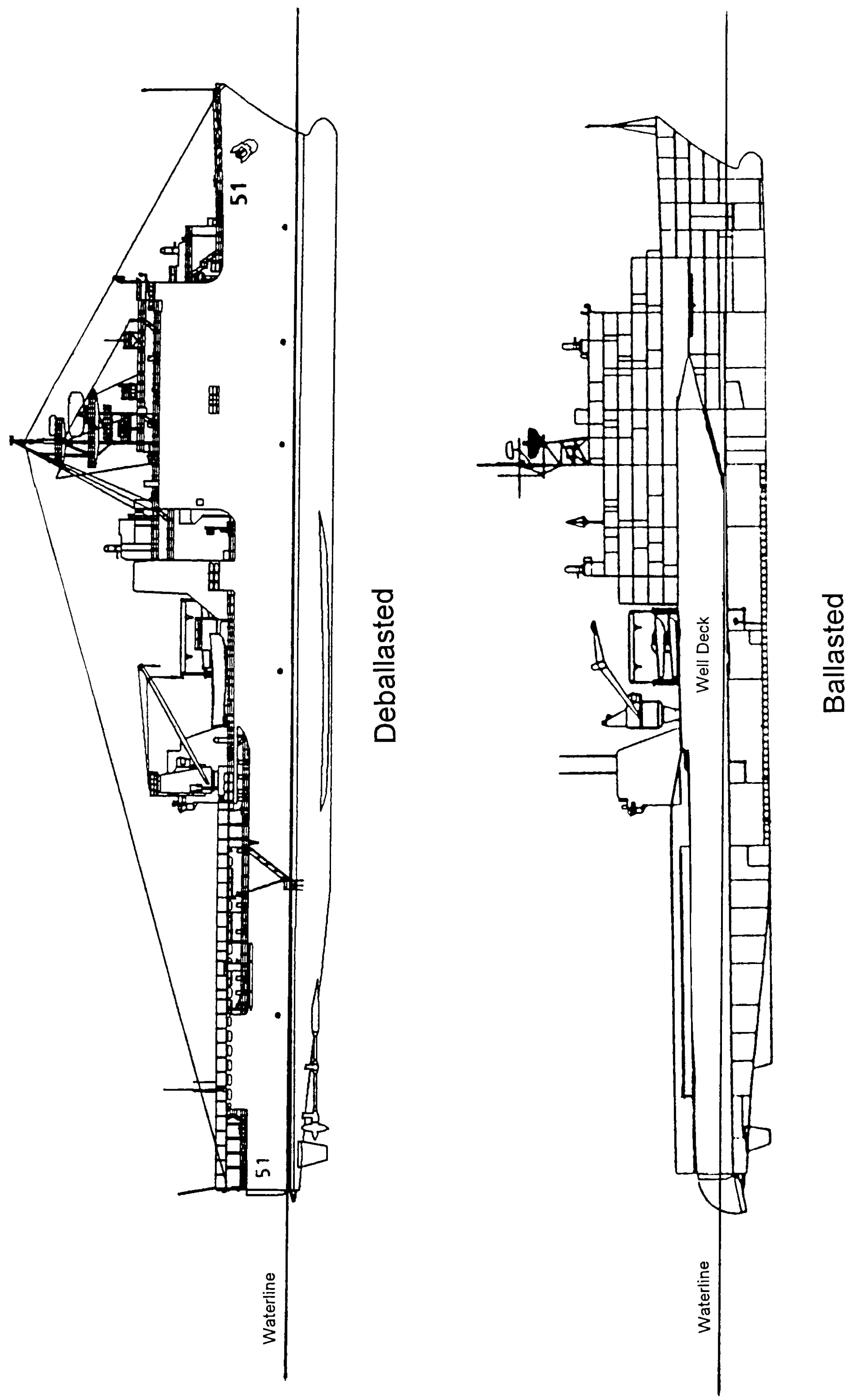

Figure 1. Basic View of an Amphibious Ship Ballasted and Deballasted

Table 1. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	
3.3 Constituents	MSDS		X	
3.4 Concentrations		X	X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations			X	
4.3 Potential for Introducing Non-Indigenous Species				X

Appendix B
Matrix of Navy Vessels and Discharges

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
AC							X							X						X			X		
AFDB 4				X			X						X	X									X		
AFDB 8				X			X						X	X									X		
AFDL 1				X			X						X	X									X	X	
AFDM 3				X			X						X	X									X	X	
AFDM 14				X			X						X	X									X	X	
AGER 2			X	X			X						X	X				X					X	X	
AGF 3	X		X	X			X		X	X	X		X	X		X	X	X					X	X	
AGF 11	X		X	X			X		X	X	X		X	X		X	X	X					X	X	
AGOR 21	X		X	X			X		X		X		X	X		X		X					X	X	
AGOR 23	X		X	X			X		X		X		X	X		X		X					X	X	
AGSS 555			X	X	X		X		X				X	X				X	X			X		X	
AO 177	X		X	X			X		X	X	X		X	X		X		X					X	X	
AOE 1	X		X	X		X	X		X	X	X	X	X	X		X		X					X	X	
AOE 6	X		X	X		X	X		X	X	X	X	X	X		X		X					X	X	
AP			X				X							X						X			X		
APL							X						X	X									X		
AR			X				X						X	X									X	X	
ARD 2			X				X						X	X				X					X	X	
ARDM				X			X						X	X				X					X	X	
ARS 50	X		X	X			X		X		X		X	X		X		X					X	X	
AS 33	X		X	X			X		X	X	X		X	X		X	X	X					X	X	
AS 39	X		X	X			X		X	X	X		X	X		X	X	X					X	X	
ASDV				X			X						X	X				X		X			X		
AT				X			X							X				X		X			X		

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
ATC				X			X							X				X		X			X	X	
BH							X							X						X			X		
BT							X							X									X		
BW							X							X						X			X		
CA							X							X						X			X		
CC							X							X						X			X		
CG 47	X		X		X	X	X		X	X	X	X	X	X		X	X	X			X		X	X	
CGN 36	X		X	X			X		X	X	X		X	X		X	X	X			X		X	X	
CGN 38	X		X	X			X		X	X	X		X	X		X	X	X			X		X	X	
CM							X							X						X			X	X	
CT							X						X	X						X			X		
CU							X							X						X			X	X	
CV 59	X	X	X	X			X		X	X	X		X	X		X	X	X					X	X	
CV 63	X	X	X	X			X		X	X	X		X	X		X	X	X			X		X	X	
CVN 65	X	X	X	X			X		X	X	X		X	X		X	X	X					X	X	
CVN 68	X	X	X	X			X		X	X	X		X	X		X	X	X	X				X	X	
DB							X							X						X			X		
DD 963	X		X		X	X	X		X	X	X	X	X	X		X	X	X			X		X	X	
DDG 51	X		X		X	X	X		X	X	X	X	X	X		X	X	X			X		X	X	
DDG 993	X		X		X	X	X		X	X	X	X	X	X		X	X	X			X		X	X	
DSRV-1				X			X						X	X			X	X					X		
DSV 1				X			X						X	X			X	X					X		
DT							X							X						X			X		
DW							X							X						X			X		
FFG 7	X		X	X		X	X		X	X	X	X	X	X		X	X	X			X		X	X	

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
HH							X							X						X			X		
HL							X							X						X			X		
HS							X							X						X			X		
IX							X						X	X						X			X		
IX 35							X						X	X						X			X		
IX 501							X						X	X						X			X		
IX 308				X			X						X	X						X			X		
LA							X							X						X			X		
LCAC 1							X				X	X	X	X									X		
LCC 19	X			X			X		X	X			X	X		X	X	X					X	X	
LCM(3)				X			X						X	X				X					X	X	
LCM(6)				X			X						X	X				X					X	X	
LCM(8)				X			X						X	X				X					X	X	
LCPL				X			X						X	X				X					X		
LCU 1610				X			X						X	X				X					X	X	
LCVP				X			X							X				X		X			X		
LH							X							X						X			X		
LHA 1	X		X	X			X		X	X	X		X	X	X	X	X	X					X	X	X
LHD 1	X		X	X			X		X	X	X		X	X		X	X	X					X	X	X
LPD 4	X		X	X			X		X	X	X		X	X	X	X	X	X					X	X	X
LPD 7	X		X	X			X		X	X	X		X	X	X	X	X	X					X	X	X
LPD 14	X		X	X			X		X	X	X		X	X	X	X	X	X					X	X	X
LPH 2	X		X	X			X		X	X	X		X	X		X		X					X	X	
LSD 36	X		X	X		X	X		X	X	X		X	X		X		X					X	X	X
LSD 41	X		X	X		X	X		X	X	X	X	X	X		X		X					X	X	X

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
LSD 49	X		X	X		X	X		X	X	X	X	X	X		X		X					X	X	X
LST 1179	X		X	X			X		X	X	X		X	X		X		X					X	X	
MC							X							X						X			X		
MCM 1	X		X	X		X	X		X		X		X	X		X		X					X	X	
MHC 51	X		X	X			X		X		X		X	X		X		X					X	X	
ML							X							X						X			X		
MM							X							X						X			X		
MW							X							X						X			X		
NM							X							X						X			X		
NS				X			X						X	X		X		X		X			X		
PB				X			X							X				X		X			X	X	
PBR				X			X							X				X		X			X	X	
PC 1	X		X	X			X		X		X		X	X				X					X	X	
PE							X							X						X			X		
PF							X							X						X			X		
PG							X							X						X			X		
PK							X							X						X			X		
PL				X			X							X				X		X			X		
PR							X							X						X			X		
PT							X							X						X			X		
RB				X			X							X				X		X			X		
RX				X			X							X				X		X			X		
SB							X							X									X		
SC							X							X						X			X		
SES 200				X			X						X	X				X					X		

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
SLWT				X			X							X				X		X			X		
SS							X							X						X			X		
SSBN 726			X	X	X		X		X		X		X	X				X	X			X		X	
SSN 637			X	X	X		X		X		X		X	X				X	X			X		X	
SSN 640			X	X	X		X		X		X		X	X				X	X			X		X	
SSN 671			X	X	X		X		X		X		X	X				X	X			X		X	
SSN 688			X	X	X		X		X		X		X	X				X	X			X		X	
ST							X							X						X			X		
TC							X							X						X			X		
TD							X							X						X			X		
TR				X			X							X				X		X			X	X	
UB				X			X							X				X		X			X		
VP							X							X						X			X		
WB							X							X						X			X		
WH							X							X						X			X		
WT							X							X						X			X		
YC							X							X									X		
YCF							X							X									X		
YCV							X							X									X		
YD							X							X									X		
YDT							X							X									X		
YFB							X						N	X						X			X		
YFN							X							X									X		
YFNB							X							X									X		
YFND							X							X									X		

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
YFNX				X			X							X				X					X	X	
YFP							X							X				X					X		
YFRN							X							X				X					X		
YFRT							X							X				X		X			X		
YFU 83							X							X				X		X			X	X	
YFU 91							X							X				X		X			X	X	
YGN 80							X						X	X									X	X	
YL							X							X						X			X		
YLC			X				X							X									X		
YM							X							X						X			X		
YMN							X							X									X		
YNG							X							X									X		
YO 65			X				X							X				X		X			X	X	
YOG 5			X				X							X				X		X			X	X	
YOGN			X				X							X				X					X		
YON							X							X				X					X		
YOS							X							X				X					X		
YP 654							X						X	X				X		X			X	X	
YP 676							X						X	X				X		X			X	X	
YPD							X							X									X		
YR							X							X									X		
YRB							X							X									X		
YRBM							X							X									X		
YRDH							X							X									X		
YRR							X							X									X		

Appendix B
Navy Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
YRST							X							X									X		
YSD 11							X						X	X				X		X			X	X	
YSR							X							X									X		
YTB 752							X						X	X				X		X			X	X	
YTB 756							X						X	X				X		X			X	X	
YTB 760							X						X	X				X		X			X	X	
YTL 422							X						X	X				X		X			X	X	
YTM							X						X	X						X			X		
YTT 9			X				X						X	X				X		X			X	X	
YWN			X				X							X									X		

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
AC														
AFDB 4						X	X							
AFDB 8						X	X							
AFDL 1						X	X							
AFDM 3						X	X							
AFDM 14						X	X							
AGER 2			X			X	X	X						
AGF 3	X		X			X	X	X	X	X	X			
AGF 11	X		X			X	X	X	X	X	X			
AGOR 21			X			X	X	X			X			
AGOR 23			X			X	X	X			X			
AGSS 555			X								X		X	X
AO 177	X		X			X	X	X		X	X			
AOE 1	X		X			X	X	X	X	X	X			
AOE 6	X		X			X	X	X	X	X	X			
AP								X						
APL						X	X	X						
AR								X						
ARD 2			X			X	X							
ARDM						X	X				X			
ARS 50	X					X	X	X	X	X	X			
AS 33	X					X	X	X	X	X	X			
AS 39	X					X	X	X	X	X	X			
ASDV											X			
AT								X			X			

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
ATC			X					X			X			
BH														
BT														
BW														
CA														
CC														
CG 47	X		X			X	X	X		X	X			
CGN 36	X		X			X	X	X		X	X			
CGN 38	X		X			X	X	X		X	X			
CM			X											
CT														
CU			X											
CV 59	X	X	X			X	X	X		X	X			
CV 63	X	X	X			X	X	X		X	X			
CVN 65	X	X	X	X		X	X	X		X	X			
CVN 68	X	X	X	X		X	X	X		X	X			
DB														
DD 963						X	X	X			X			
DDG 51						X	X	X			X			
DDG 993						X	X	X			X			
DSRV-1											X			
DSV 1											X			
DT														
DW														
FFG 7			X			X	X	X			X			

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
HH														
HL														
HS														
IX														
IX 35														
IX 501								X						
IX 308								X						
LA														
LCAC 1														
LCC 19	X		X			X	X		X	X	X			
LCM(3)			X								X			
LCM(6)			X								X			
LCM(8)			X								X			
LCPL											X			
LCU 1610			X			X	X				X			
LCVP											X			
LH														
LHA 1	X		X			X	X	X	X	X	X			
LHD 1	X		X			X	X	X	X	X	X			
LPD 4	X		X			X	X	X	X	X	X			
LPD 7	X		X			X	X	X	X	X	X			
LPD 14	X		X			X	X	X	X	X	X			
LPH 2	X		X			X	X	X	X	X	X			
LSD 36	X		X			X	X	X	X	X	X			
LSD 41	X		X			X	X	X	X	X	X			

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
LSD 49	X		X			X	X	X	X	X	X			
LST 1179	X		X			X	X	X	X	X	X			
MC														
MCM 1			X		X	X	X	X	X		X			
MHC 51	X		X		X	X	X	X	X					
ML														
MM														
MW														
NM														
NS											X			
PB			X								X			
PBR			X								X			
PC 1			X			X	X	X			X			
PE														
PF														
PG														
PK														
PL											X			
PR														
PT														
RB											X			
RX											X			
SB														
SC														
SES 200											X			

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
SLWT											X			
SS														
SSBN 726	X		X	X				X		X	X	X	X	X
SSN 637	X		X	X				X		X	X	X	X	X
SSN 640	X		X	X				X		X	X	X	X	X
SSN 671	X		X	X				X		X	X	X	X	X
SSN 688	X		X	X				X		X	X	X	X	X
ST														
TC														
TD														
TR			X								X			
UB											X			
VP														
WB														
WH														
WT														
YC														
YCF														
YCV														
YD														
YDT														
YFB						X	X							
YFN						X	X							
YFNB														
YFND						X	X							

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
YFNX			X			X	X				X			
YFP						X	X							
YFRN														
YFRT														
YFU 83			X											
YFU 91			X											
YGN 80			X											
YL														
YLC														
YM														
YMN														
YNG														
YO 65			X											
YOG 5			X											
YOGN														
YON														
YOS														
YP 654			X											
YP 676			X											
YPD														
YR														
YRB														
YRBM						X	X							
YRDH						X	X							
YRR														

Appendix B
Navy Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
YRST														
YSD 11			X											
YSR														
YTB 752			X											
YTB 756			X											
YTB 760			X											
YTL 422			X											
YTM														
YTT 9			X											
YWN														

Appendix C
Matrix of MSC Vessels and Discharges

Appendix C
MSC Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
AE 26	X		X	X			X		X		X		X	X				X					X	X	
AFS 1	X		X	X			X		X		X		X	X				X	X				X	X	
AG 194			X	X			X		X		X		X	X				X					X	X	
AGM 22			X	X			X		X		X		X	X				X	X				X	X	
AGOS 1	X		X	X			X		X		X		X	X				X	X				X	X	
AGOS 19	X		X	X			X		X		X		X	X				X	X				X	X	
AGS 26	X		X	X			X		X		X		X	X				X	X		X		X	X	
AGS 45	X		X	X			X		X		X		X	X				X	X		X		X	X	
AGS 51	X		X	X			X		X		X		X	X				X	X		X		X	X	
AGS 60	X		X	X			X		X		X		X	X				X	X		X		X	X	
AH 19	X		X	X			X		X		X		X	X				X	X		X		X	X	
AO 187	X		X	X		X	X		X		X		X	X				X	X				X	X	
ARC 7	X		X	X			X		X		X		X	X				X					X	X	
ATF 166	X		X	X		X	X		X		X		X	X				X	X				X	X	

Appendix C
MSC Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
AE 26	X		X			X	X	X		X	X			
AFS 1	X		X			X	X	X		X	X			
AG 194	X		X			X	X	X		X	X			
AGM 22	X		X			X	X	X		X	X			
AGOS 1			X			X	X	X			X			
AGOS 19			X			X	X	X			X			
AGS 26	X		X			X	X	X			X			
AGS 45			X			X	X	X			X			
AGS 51			X			X	X	X			X			
AGS 60			X			X	X	X			X			
AH 19	X		X			X	X	X		X	X			
AO 187			X			X	X	X		X	X			
ARC 7	X		X			X	X	X		X	X			
ATF 166			X			X	X	X			X			

Appendix D
Matrix of Coast Guard Vessels and Discharges

Appendix D
Coast Guard Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
ANB							X							X						X			X		
ANB(X)							X							X						X			X		
ATB							X							X						X			X		
BU							X							X						X			X		
BUSL							X							X						X			X		
FR							X							X						X			X		
LC							X							X						X			X		
MCB							X							X						X			X		
MLB							X							X						X			X		
MSB							X							X						X			X		
PSB							X							X						X			X		
PWB							X							X						X			X		
RHIB							X							X						X			X		
RHIL							X							X						X			X		
RHIM							X							X						X			X		
SKI							X							X						X			X		
SPC							X							X						X			X		
SRB							X							X						X			X		
TANB							X							X						X			X		
UTB							X							X						X			X		
UTL							X							X						X			X		
W/P							X							X						X			X		
WAGB 290	X		X	X		X	X	X	X		X	X	X	X			X	X					X	X	
WAGB 399	X		X	X		X	X	X	X		X	X	X	X			X	X					X	X	
WHEC 378	X		X	X		X	X	X	X		X	X	X	X			X	X					X	X	

Appendix D
Coast Guard Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
WIX 295	X		X	X		X	X	X	X		X		X	X			X	X					X	X	
WLB 180A							X	X	X		X		X	X				X					X	X	
WLB 180B							X	X	X		X		X	X				X					X	X	
WLB 180C							X	X	X		X		X	X				X					X	X	
WLB 225							X	X	X		X		X	X				X					X	X	
WLI 100A							X	X			X			X				X					X	X	
WLI 100C							X	X			X			X				X					X	X	
WLI 65303							X	X			X			X				X					X	X	
WLI 65400							X	X			X			X				X					X	X	
WLIC 100							X	X			X			X				X					X	X	
WLIC 160							X	X			X			X				X					X	X	
WLIC 75A							X	X			X			X				X					X	X	
WLIC 75B							X	X			X			X				X					X	X	
WLIC 75D							X	X			X			X				X					X	X	
WLM 157							X	X			X			X				X					X	X	
WLM 551							X	X			X			X				X					X	X	
WLR 115							X				X			X				X					X	X	
WLR 65							X				X			X				X					X	X	
WLR 75							X	X			X			X				X					X	X	
WMEC 210A			X	X		X	X	X	X		X		X	X			X	X					X	X	
WMEC 210B			X	X		X	X	X	X		X		X	X			X	X					X	X	
WMEC 213			X	X		X	X	X	X		X		X	X			X	X					X	X	
WMEC 230			X	X		X	X	X	X		X		X	X			X	X					X	X	

Appendix D
Coast Guard Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
WMEC 270A			X	X		X	X	X	X		X		X	X			X	X					X	X	
WMEC 270B			X	X		X	X	X	X		X		X	X			X	X					X	X	
WP							X				X			X				X					X	X	
WPB 110A							X	X			X		X	X				X					X	X	
WPB 110B							X	X			X		X	X				X					X	X	
WPB 110C							X	X			X		X	X				X					X	X	
WPB 82C							X	X			X		X	X				X					X	X	
WPB 82D							X	X			X		X	X				X					X	X	
WTGB 140							X	X			X			X				X					X	X	
WYTL 65A							X	X			X			X				X					X	X	
WYTL 65B							X	X			X			X				X					X	X	
WYTL 65C							X	X			X			X				X					X	X	
WYTL 65D							X	X			X			X				X					X	X	

Appendix D
Coast Guard Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
ANB														
ANB(X)														
ATB														
BU														
BUSL														
FR														
LC														
MCB														
MLB														
MSB														
PSB														
PWB														
RHIB														
RHIL														
RHIM														
SKI														
SPC														
SRB														
TANB														
UTB														
UTL														
W/P														
WAGB 290	X		X			X	X	X			X			
WAGB 399	X		X			X	X	X			X			

Appendix D
Coast Guard Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
WHEC 378	X		X			X	X	X			X			
WIX 295			X			X	X	X			X			
WLB 180A			X			X	X	X			X			
WLB 180B			X			X	X	X			X			
WLB 180C			X			X	X	X			X			
WLB 225			X			X	X	X			X			
WLI 100A			X			X		X			X			
WLI 100C			X			X		X			X			
WLI 65303			X			X		X			X			
WLI 65400			X			X		X			X			
WLIC 100			X			X		X			X			
WLIC 160			X			X		X			X			
WLIC 75A			X			X		X			X			
WLIC 75B			X			X		X			X			
WLIC 75D			X			X		X			X			
WLM 157			X			X		X			X			
WLM 551			X			X		X			X			
WLR 115			X			X		X			X			
WLR 65			X			X		X			X			
WLR 75			X			X		X			X			
WMEC 210A	X		X			X	X	X			X			
WMEC 210B	X		X			X	X	X			X			
WMEC 213	X		X			X	X	X			X			
WMEC 230	X		X			X	X	X			X			

Appendix D
Coast Guard Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
WMEC 270A	X		X			X	X	X			X			
WMEC 270B	X		X			X	X	X			X			
WP			X			X		X			X			
WPB 110A			X			X		X			X			
WPB 110B			X			X		X			X			
WPB 110C			X			X		X			X			
WPB 82C			X			X		X			X			
WPB 82D			X			X		X			X			
WTGB 140			X			X		X			X			
WYTL 65A			X			X		X			X			
WYTL 65B			X			X		X			X			
WYTL 65C			X			X		X			X			
WYTL 65D			X			X		X			X			

Appendix E
Matrix of Army Vessels and Discharges

Appendix E
Army Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
BC							X							X											
BD							X				X		X	X				X					X		
BG							X							X									X		
BK							X							X											
CF							X							X				X		X			X		
CHI							X							X				X		X			X		
FB							X							X				X					X		
HF							X							X				X		X			X		
J-BOAT							X							X				X		X			X		
LCM-8 MOD 0							X							X				X		X			X		
LCM-8 MOD 1							X							X				X		X			X		
LCU-1600				X			X				X		X	X				X					X		
LCU-2000				X			X		X		X		X	X				X		X			X		
LSV				X			X		X		X		X	X				X					X		
LT-100				X			X				X		X	X				X					X		
LT-128				X			X		X		X		X	X				X					X		
PB							X							X						X					
Q-BOAT							X							X				X		X			X		
ST-45				X			X				X		X	X				X					X		
ST-65				X			X				X		X	X				X					X		
SLWT							X							X				X		X			X		
T-BOAT							X							X				X		X			X		
WORKBOATS																				X					

Appendix E
Army Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
BC			X											
BD			X			X		X						
BG			X											
BK			X											
CF			X								X			
CHI			X								X			
FB			X								X			
HF			X								X			
J-BOAT			X								X			
LCM-8 MOD 0			X								X			
LCM-8 MOD 1			X								X			
LCU-1600			X			X					X			
LCU-2000			X			X	X	X			X			
LSV			X			X		X			X			
LT-100			X			X	X	X			X			
LT-128			X			X	X	X			X			
PB			X											
Q-BOAT			X								X			
ST-45			X								X			
ST-65			X								X			
SLWT			X								X			
T-BOAT			X								X			
WORKBOATS														

Appendix F
Matrix of Marine Corps Vessels and Discharges

Appendix F
Marine Corps Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
CRRC							X													X			X		
RRC							X													X			X		

Appendix F
Marine Corps Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Submarine Emergency Diesel Engine Wet Exhaust	Sub Outboard Equip. Grease & External Hydraulics
CRRC														
RRC														

Appendix G
Matrix of Air Force Vessels and Discharges

Appendix G
Air Force Vessel Discharges to be Regulated

Ship Class	Aqueous Film Forming Foam	Catapult Water-Brake Tank & Post-Launch Retraction Exhaust	Chain Locker Effluent	Clean Ballast	Compensated Fuel Ballast	CPP Hydraulic Fluid	Deck Runoff	Dirty Ballast	Distillation & Reverse Osmosis Brine	Elevator Pit Effluent	Firemain Systems	Gas Turbine Water Wash	Graywater	Hull Coating Leachate	MOGAS Compensated Overboard Discharges	Non-Oily Machinery Wastewater	Photo Lab Drains	Seawater Cooling Overboard Discharge	Seawater Piping Biofouling Prevention	Small Boat Engine Wet Exhaust	Sonar Dome Discharge	Submarine Bilgewater	Surface Vessel Bilgewater/OWS Discharge	Underwater Ship Husbandry	Welldeck Discharges
MR							X		X		X		X	X				X					X	X	
P							X							X						X			X		
TR							X							X						X			X		
U							X							X						X			X		

Appendix G
Air Force Vessel Discharges Not to be Regulated

Ship Class	Boiler Blowdown	Catapult Wet Accumulator Discharge	Cathodic Protection	Freshwater Lay-up	Mine Countermeasures Equipment Lubrication	Portable Damage Control Drain Pump Discharges	Portable Damage Control Drain Pump Wet Exhaust	Refrigeration/AC Condensate	Rudder Bearing Lubrication	Steam Condensate	Stern Tube Seals & Underwater Bearing Lubrication	Submarine Acoustic Countermeasures Launcher Discharge	Sub Emergency Diesel Engine Wet Exhaust	Sub Outboard Equipment Grease & External Hydraulics
MR			X					X			X			
P														
TR														
U														