Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs

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U.S. Environmental Protection Agency **U.S. Maritime Administration**

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- Department of Transportation's Maritime Administration
- National Oceanic and Atmospheric Administration
- United States Army Corps of Engineers
- United States Fish and Wildlife Service
- United States Coast Guard
- United States Department of the Navy
- United States Environmental Protection Agency

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EXECUTIVE SUMMARY

This guidance document was developed in response to the Maritime Administration's (MARAD) request for the U.S. Environmental Protection Agency (EPA) to provide national environmentally-based best management practices for the preparation of vessels to be sunk with the intention of creating artificial reefs in permitted artificial reef construction areas. It also satisfies the mandate of Section 3516 of the National Defense Authorization Act for Fiscal Year 2004, which requires that MARAD and EPA jointly develop guidance recommending environmental best management practices to be used in the preparation of vessels for use as artificial reefs.

Options for managing obsolete and decommissioned military and commercial vessels include re-use of the vessel or parts of the vessel, recycling or scrapping, creating artificial reefs, and disposal on land or at sea. This document discusses the preparation of vessels when employing the vessel management option of artificial reefing. Artificial reefs should be developed such that they enhance marine resources and benefit the marine environment. Strategically sited artificial reefs can not only enhance aquatic habitat, but also provide an additional option for conserving, managing, and/or developing fishery resources.

Although the best management practices presented in this document are intended for use when preparing vessels to serve as artificial reef habitat, the best management practices may have applicability to other in-water uses of vessels, such as the creation of recreational diving opportunities and placement as breakwaters or other types of barriers. It is recommended that these best management practices be implemented for all in-water uses of vessels, with the caveat that further vessel preparation beyond that employed for artificial reef habitat may be needed. When preparing a vessel for other permitted in-water uses, consideration should be given to vessel stability and integrity prior to and after final placement.

This guidance identifies materials or categories of materials of concern that may be found aboard vessels and specifically identifies where they may be found. For each material or category of material, this document provides a general clean-up performance goal and information on methods for achieving those goals in preparation of the vessel prior to sinking. Materials of concern include, but are not limited to: oil and fuel, asbestos, polychlorinated biphenyls (PCBs), paint, solids/debris/floatables, and other materials of environmental concern. Exhibit 1 provides a summary of the narrative clean-up goals for materials of concern.

This guidance does not substitute for any statute or regulation, nor is it a regulation itself. It does not impose legally binding requirements on any Federal agency, States, other regulatory authorities or the regulated community, and may not apply to a particular situation based upon the circumstances. Regulatory decision makers, both Federal and State, retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA may change this guidance in the future.

Exhibit 1. Summary of Narrative Clean-up Goals for Materials of Concern

Material of Concern	Narrative Clean-up Goal
Oil And Fuel	Remove liquid hydrocarbons (fuels, oils) and semi-solids (greases) so that: no visible sheen is remaining on the tank surfaces (this includes all interior fittings, piping, structural members) or on the water surface when the equipment is flooded after sinking; no film or visible accumulation (i.e., spills on decking or rugs) is remaining on any vessel structure or component.
Asbestos	Remove any loose asbestos and asbestos that may become loose during vessel sinking; remove or seal accessible friable asbestos.
Polychlorinated Biphenyls (PCBs)	Remove all solid material containing PCBs greater than or equal to (≥) 50 parts per million (ppm) unless a disposal permit has been granted under 40 CFR 761.62(c); remove all liquid materials containing PCBs.
Paint	Remove harmful exterior hull antifouling systems that are determined to be active; remove exfoliating and exfoliated paint.
Solids/Debris/ Floatables	Remove loose debris, including materials or equipment that are not permanently attached to the vessel that could be transported into the water column during a sinking event.
Other Materials of Environmental Concern	Remove other materials that may negatively impact the biological, physical, or chemical characteristics of the marine environment.

There are statutory requirements and associated regulations, as well as permit processes applicable to the process of preparing a vessel for reefing that are not highlighted in this document. The narrative clean-up goals for the materials of concern highlighted in this guidance should be achieved while preparing a vessel for all in-water uses as earlier mentioned.

INTRODUCTION

Several options exist for managing obsolete and decommissioned military and commercial vessels. These options include re-use of the vessel or parts of the vessel, recycling or scrapping, creating artificial reefs, and disposal on land or at sea. This document discusses the vessel management option of artificial reefing. This guidance document was developed in response to the Maritime Administration's (MARAD) request for the U.S. Environmental Protection Agency (EPA) to assist in identifying potential management options for their decommissioned vessel fleet. It also satisfies the mandate of Section 3516 of the National Defense Authorization Act for Fiscal Year 2004, which requests that MARAD and EPA jointly develop guidance recommending environmental best management practices to be used in the preparation of vessels for use as artificial reefs.

An interagency workgroup, chaired by EPA, was established to develop national environmentally-based best management practices for the preparation of vessels to be sunk with the intention of creating artificial reefs in permitted artificial reef construction areas. The workgroup was comprised of representatives from the EPA, U.S. Coast Guard, U.S. Navy, MARAD, U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration, and the U.S. Fish and Wildlife Service.

Although these best management practices are intended for use when preparing vessels to serve as artificial reef habitat, such best management practices may have applicability to other in-water uses of vessels, such as the creation of recreational diving opportunities and placement as breakwaters or other types of barriers. The best management practices presented in this document should be implemented for all permitted in-water uses of vessels; further vessel preparation may be needed based on the intended in-water use, such as breakwaters.

Objectives of the Guidance Document

This guidance satisfies the mandate of Section 3516 of the National Defense Authorization Act for Fiscal Year 2004, which amends existing law to require that MARAD and EPA jointly develop guidance recommending environmental best management practices (BMPs) to be used in the preparation of vessels for use as artificial reefs. These BMPs are to serve as national guidance for Federal agencies for the preparation of vessels for use as artificial reefs. Section 3516 provides that the BMPs are to (1) ensure that vessels prepared for use as artificial reefs "will be environmentally sound in their use as artificial reefs"; (2) "promote consistent use of such practices nationwide"; (3) "provide a basis for estimating the costs associated with the preparation of vessels for use as artificial reefs"; and (4) include measures that will "enhance the utility of the Artificial Reefing Program of the Maritime Administration as an option for the disposal of obsolete vessels." Appendix A provides further detail on Section 3516, and below is a description on how this document addresses the four requirements of the statute.

- The use of this guidance will ensure that vessels prepared for use as artificial reefs "will be environmentally sound in their use as artificial reefs." Best management practices are provided through performance goals that are directed at the level of cleaning and/or removing materials of concern aboard vessels. The preparation of vessels in this manner

will ensure that their use as artificial reefs is environmentally sound. The purpose of creating an artificial reef is to benefit the environment by enhancing aquatic habitat and marine resources, as well as providing an additional option for conserving, managing, and/or developing fisheries resources. This document describes appropriate vessel preparation that could achieve such benefits as an artificial reef and avoid negatively impacting the environment with pollutants. The performance goals provided in this document, if implemented and complemented with strategic siting, will maximize the opportunity for these vessels to benefit the environment as artificial reefs.

- The use of this guidance document will "promote consistent use of such practices nationwide" and in turn will also provide measures that will "enhance the utility of the Artificial Reefing Program of the Maritime Administration as an option for the disposal of obsolete vessels." The best management practices described in this document will serve as national guidance for the preparation of vessels for use as artificial reefs. As the use of vessels as artificial reefs is becoming a more common management option for obsolete MARAD vessels, the development of this guidance document is timely. Currently, no guidance of this kind is available. The use of this guidance document can enhance the utility of MARAD's Artificial Reefing Program by establishing a national approach to clean and prepare candidate obsolete vessels, while also promoting consistent use of such practices for vessel-to-reef projects.

- The use of this document will "provide a basis for estimating the costs associated with the preparation of vessels for use as artificial reefs." Neither worker safety issues nor specific costs associated with clean-up procedures are discussed in this document; this document only addresses environmental impact and protection issues. Although the best management practices were developed independent of worker safety issues and specific costs associated with clean-up, the guidance in this document can be used as a tool in estimating the cost for appropriate vessel preparation. The methods, approach, and level of effort for clean-up, as well as worker safety concerns, are directly dependent on the vessel's condition and the amount of materials of environmental concern that are found aboard. Vessels that pose potential safety risks would be expensive to clean and therefore may not be good candidates for reefing.

  Some portions of a candidate vessel may be economically salvageable. Salvage operations should occur first, in a manner that will minimize debris and contamination with oils or other products that have to be cleaned up at a later date. This activity should allow for improved access for subsequent clean-up efforts, and the salvage proceeds may help offset the costs for vessel preparation.

Operations associated with salvage, clean-up, and diver access have the potential to adversely impact vessel stability. Failure to consider the impact of these activities on vessel stability before and during scuttling operations could result in premature and uncontrolled capsizing and/or sinking of the vessel. Therefore, vessel stability considerations should be an integral part of the salvage, clean-up, modification (for diver access), transport, and sinking plans of a ship to reef project.

In the process of preparing a vessel for reefing, there are requirements and regulations, as well as

permit processes, to consider that are not highlighted in this document. The final preparation plan for any particular artificial reef project is case specific, and will depend on the characteristics of the vessel and final permitted artificial reef construction site, as well as regulatory considerations. Some legal authorities that may apply to vessel-to-reef projects are briefly described in Appendix B.

This guidance identifies materials or categories of materials of concern that may be present aboard vessels, indicates where these materials may be found, and describes their potential adverse impacts if released into the marine environment (Appendix C provides related information). The materials of concern include, but are not limited to: fuels and oil, asbestos, polychlorinated biphenyls (PCBs), paints, debris (e.g., vessel debris, floatables, introduced material), and other materials of environmental concern (e.g., mercury, refrigerants). With the exception of materials containing PCBs, it is not within the purview of this document to discuss Federal, State, or local regulations, although those requirements that are directly applicable to vessel preparation must also be met prior to vessel sinking and placement. Because the best management practices described in this document are directed at the environmental concerns associated with using vessels as artificial reefs, other sources of information should also be used with regard to preparation of the vessel from a diver safety perspective or for any other potential in-water uses (e.g., breakwaters or other types of barriers).

A detailed description and characterization of the potential sources of contamination from a vessel intended for use as an artificial reef should be conducted and a plan developed. The purpose of this plan is to assure that materials potentially contributing to pollution of the marine environment are addressed. Appendix D of this document presents information regarding the development of workplans; Appendix E provides information regarding general principles for clean-up operations.

This guidance does not substitute for any statute or regulation, nor is it a regulation itself. It does not impose legally binding requirements on any Federal agency, States, other regulatory authorities or the regulated community, and may not apply to a particular situation based upon the circumstances. Regulatory decision makers, both Federal and State, retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA may change this guidance in the future.

Organization of this Guidance Document

This document describes guidelines for the preparation of vessels in a manner that will ensure that the marine environment will benefit from their use as an artificial reef. Strategic siting is an essential component of a successful artificial reef project. Before the discussion of vessel preparation is presented, reef siting is briefly discussed.

For each material or category of material of concern identified above, this document provides a general performance goal and information on methods for addressing those goals in preparation of the vessel prior to sinking. Additional information for each material includes a description of its shipboard use and where it may be found on a vessel, as well as its expected impacts if released into the marine environment.

Although the best management practices presented in this document are intended for use when preparing a vessel to serve as artificial reef habitat, it is recommended that these best management practices be implemented for other in-water uses of vessels. Two such additional in-water uses include the sinking of vessels for recreational diving, and for placement as breakwaters or other types of barriers. These potential obsolete vessel management options are briefly described in this document.

SITING OF ARTIFICIAL REEFS

Artificial reefs can enhance marine resources and in turn benefit the marine environment; however, creating a successful reef entails more than randomly placing miscellaneous materials in ocean, estuarine, or other aquatic environments. Planning (including siting), long-term monitoring, and evaluation are necessary components of each project to ensure that the anticipated benefits of artificial reefs are attained. Improperly planned, constructed, or managed reefs may be ineffective, may cause conflict among competing user groups of the reef site, may increase the potential to over harvest targeted species, or may damage natural habitats. In such cases, the anticipated benefits of an artificial reef project may be negated.

Artificial reefs should not cause harm to existing living marine resources and habitats. Properly prepared and strategically sited artificial reefs can enhance fish habitat, provide more access to quality fishing grounds, and provide managers with another option for conserving, managing and/or developing fishery resources.

Placement of a vessel to create an artificial reef should:

- enhance and conserve fishery resources to the maximum extent practicable;
- facilitate access and use by recreational and/or commercial fishermen;
- facilitate, as appropriate, access and use by recreational divers;
- minimize conflicts among competing uses of water and water resources;
- minimize environmental risks and risks to personal and public health and property;
- be consistent with international law and national fishing law and not create an obstruction to navigation;
- use the best scientific information available; and
- conform to any Federal, State, or local requirements or policies for artificial reefs.

Artificial reef project planners should identify the habitat type and/or species targeted for enhancement and determine which biological, physical, and chemical site conditions will be most conducive to meeting the reef objectives. Once these siting conditions including community settlement and recruitment dynamics are determined, they should be used in identifying potential construction sites. Existing communities (e.g., infaunal, epifaunal, benthic, demersal, mid-water, surface-oriented) in the area where the artificial reef is to be placed should be considered prior to placement -- this should include monitoring to establish baselines for the fishing resources.

Caution should be exercised when developing artificial reefs in nearshore areas due to the increased potential for resource competition as well as competition for niche space. Improperly sited reefs might enhance a recreational fish resource at the expense of other species or habitat; it

may also alter the ecological balance of the area. For example, sandy estuarine habitat often provides critical nursery grounds for the juveniles of many species of bottom fish. During this life stage, the primary predator protection for these juvenile fish is the absence of large fish -- which are favored by recreational anglers. Often times, sandy estuarine locations tend to be popular choices for siting artificial reefs to attract large fish for recreational fishing, thereby altering existing predatory/prey interactions and creating resource competition. Strategic project planning can minimize these conflicts.

Artificial reefs should not be constructed such that they are placed on or threaten the integrity of natural habitats such as:

- existing coral reefs;
- significant beds of aquatic grasses or macroalgae;
- oyster reefs;
- scallop, mussel, or clam beds; or
- existing live bottom (i.e., marine areas supporting growth of sponges, sea fans, corals, and other sessile invertebrates generally associated with rock outcrops).

The goals and priorities of an artificial reef project should direct overall site selection. Within the identified target area, existing natural and artificial reefs and known bottom obstructions should be identified. Exclusion areas for potential artificial reef projects should include, but are not limited to:

- shipping lanes;
- restricted military areas;
- areas of poor water quality (e.g., low dissolved oxygen, dredged material disposal sites);
- traditional trawling grounds;
- unstable bottoms;
- areas with extreme currents, or high wave energy;
- existing right-of-ways (e.g., oil and gas pipelines and telecommunication cables);
- sites for purposes that are incompatible with artificial reef development; and
- areas designated as habitat areas of particular concern or special aquatic sites.

The bottom composition and configuration at an artificial reef site affects reef stability and longevity and should be carefully evaluated in the site selection process. In most cases, soft sediments such as clays, silts, and loosely packed sands should be avoided. Over time, artificial reef materials may sink into these sediments or become partially covered.

Caution should also be exercised where coastal physical processes can greatly influence a potential artificial reef site. Artificial reef planners should be aware that bottom sediments shift and may change significantly during storms, hurricanes, and geologic events. Materials that present large amounts of surface area may scour deeply into almost any bottom type, depending upon storm events, currents, or wave action.

The principle hydrographic factors to be considered in selecting sites for artificial reef placement include water depth, potential wave height, currents, and tides. Water depth is a significant siting criterion. Artificial reefs should be placed in water at sufficient depths in order to avoid creating a hazard to navigation – minimum clearance above the reef should accommodate the draft of the vessels expected to operate in the vicinity. Water depth at the site may critically affect artificial reef material stability and long-term structural integrity. In this case, average wave energy in large, open bodies of water as a function of water depth is the major concern.

Guidance for Preparing Vessels to Create Artificial Reef Habitat

OIL AND FUEL

Narrative Clean-up Goal: Remove liquid hydrocarbons (fuels, oils) and semi-solids (greases) so that: no visible sheen is remaining on the tank surfaces (this includes all interior fittings, piping, structural members) or on the water surface when the equipment is flooded after sinking; no film or visible accumulation (e.g., spills on decking or carpet) is remaining on any vessel structure or component.

Environmental Impacts

The impacts of fuel and/or oil introduced into the marine environment are influenced by a variety of factors, including the physical properties of the oil, whether the oil is petroleum based or non-petroleum based, and the hydrodynamic properties of the receiving waters. Each type of oil has distinct physical properties that affect the way it disperses and breaks down, the hazard it may pose to ecosystems, and the likelihood that it will pose a threat to manmade resources. For example, the rate at which surface dispersion occurs will help to determine the effect of an oil spill on the environment. Most oils spread horizontally into a smooth and continuous layer, called a "slick," on the water surface.

Petroleum based and non-petroleum based oils can have both immediate and long-term adverse effects on the environment. These oils can be dangerous, or even deadly to wildlife. Light refined petroleum products, such as gasoline and kerosene, spread on water surfaces. The risk of fire and toxic exposure is high, but the products evaporate quickly and leave little residue. Alternatively, heavier petroleum based refined oil products may pose lesser fire and toxic hazards and do not spread on water as readily. However, heavier oils are more persistent in the environment, and may present a greater clean-up challenge.

Many non-petroleum oils have physical properties similar to those of petroleum based oils. For example, their solubility in water is limited, they both create slicks on the water surface, and they both form emulsions and sludge. In addition, non-petroleum oils tend to be persistent, remaining in the environment for long periods of time.

Oil spills can harm the environment in several ways, including the physical damage that directly impacts wildlife and their habitats, and the toxicity of the oil and its constituents, which can poison exposed organisms. Spilled oil in the environment immediately begins to disperse and degrade, with concomitant changes in physical and chemical properties. As these processes occur, the oil threatens natural resources, including birds and mammals as well as a wide range of marine organisms linked in a complex food web. Some organisms can be seriously injured (non-lethal effects) or killed (lethal effects) very soon after contact with the oil in a spill (acute effects), however; non-lethal toxic effects are often more subtle and often longer lasting (chronic tests).

What are oil and fuel?

For purposes of this guidance, the term oil includes crude oil; petroleum and petroleum-refined

products (e.g., diesel fuel, gasoline, kerosene, and bunkers); and non-petroleum oils such as synthetic oils (e.g., silicone fluids), tung oils, wood-derivative oils (e.g., resin/rosin oils), animal fats and oil, and edible and inedible seed oils from plants.

Some common refined petroleum products and their characteristics are as follows:

- ***No. 2 Fuel Oil*** is a lightweight substance that flows easily, spreads rapidly, and disperses readily. It is neither volatile nor likely to form emulsions.

- ***No. 4 Fuel Oil*** is a medium weight substance that flows easily and is readily dispersed if treated promptly. It has a low volatility and moderate flash point.

- ***No. 5 Fuel Oil (Bunker B)*** is a medium to heavyweight substance with a low volatility and moderate flash point. Dispersion is very difficult and potentially impossible.

- ***No. 6 Fuel Oil (Bunker C)*** is a thick substance that is difficult to pump and requires preheating for use. No. 6 fuel oil may be heavier than water. It is not likely to dissolve, and is likely to form tar balls, lumps, or emulsions. No. 6 fuel oil is very difficult or impossible to disperse. It has a low volatility and moderate flash point and is especially persistent in the environment.

Where are oils and fuels found in a ship?

Diesel fuel and fuel oil may be contained in various tanks throughout a ship. For example, lubricating oil is found in engine sumps, drums of unused lubricating oil in ship storerooms or engineering spaces, and sludge in fuel and cargo tanks. Hydraulic systems and components also contain oils.

The vessel's piping and tank arrangements generally will contain some oil, fuel, sludge, and associated residues. Fuel oil may be found in both integrated and freestanding tanks throughout the ship. Lubricating oils may be found in a variety of tanks depending on their individual use. System oils are generally located in engine room sump tanks, while cylinder oils and lubrication oils will be stored in tanks dedicated for a specific purpose.

"Used oil" -- any oil that has been refined from crude oil or any synthetic oil that has been used and, as a result of such use, is contaminated by physical or chemical impurities -- also may be found on ships. Used oil includes spent lubricating fluids that have been removed from engine crankcases, transmissions, and gearboxes; industrial oils such as compressor, turbine, and bearing oil; metal working oil; and refrigeration oil.

Vessel Preparation

The aim of hydrocarbon clean-up is to remove liquid hydrocarbons (fuels, oils). Although it is impossible to remove all hydrocarbon contaminants, a very thorough clean-up is achievable. In general, all liquid hydrocarbons and semi-solids (greases) should be drained, flushed, and

cleaned from fuel/lube and fluid system equipment (including piping, interior fittings, and structural members) so that no visible sheen remains on the tanks or other associated fluid system structures or on the water surface when the equipment is flooded after sinking. The opening and cleaning of pipes varies according to the type of hydrocarbon product that was in the lines. No visual evidence of hydrocarbon weeping (oozing or releasing drops of liquid) should exist at openings. Suggested cleaning methods for liquid hydrocarbons (fuels, oils, and semi-solids) are found in Appendix F.

If structural tanks are flooded, oil absorbent pads and excess loose oil absorbent material should be removed and liquid hydrocarbons should be cleaned from the tanks so that no visible sheen is present on the water surface. An alternative and very effective option for hydrocarbon clean-up is removal of the equipment and piping.

During vessel preparation, an economical way of managing used oil is recycling. It should be noted that additional used oil might be generated during the final preparation of the vessel prior to sinking. Such used oil should be removed from the vessel before sinking. It may be acceptable to leave old oil and grease in place if it is determined visually to be dried/solidified and therefore is not likely to cause a sheen.

Fuel and Oil Tanks

All fuels and lubricants should be drained from the tanks and the tanks flushed. Merely sealing tanks, whether as the sole means of fuel and oil tank preparation or in combination with partial tank draining, is insufficient. Over time, the integrity of the sealed tanks will eventually be compromised as marine growth density increases and the ship's underlying structural components decay. The placement of the Liberty ship Joseph L. Meek, sunk off Escambia County, Florida in 1976, demonstrated that corrosion of the ship's metal will eventually release residual fuel sealed in tanks into the environment. Although sealing the tanks without removing the contents is not sufficient for managing fuel and oil on a vessel intended to serve as an artificial reef, fuel/lube and fluid system equipment and piping intended to stay on the vessel should be sealed as necessary for the purpose of towing stability once the fuel/oil has been removed. Because these systems need to be opened during vessel preparation for draining and flushing the systems clean, sealing these systems may be necessary to help maintain vessel stability during transit to the designated artificial reef site.

There are several accepted and widely used methods to clean fuel and oil tanks. The appropriate method will be determined by the type of hydrocarbons in the tank, the amount of residue in the tank, and the extent of any hard or persistent deposits or residues. In general, lower quality fuels and heavy oils will require more cleaning effort. Similarly, tanks for dirty or water-contaminated oils will require more cleaning effort.

When cleaning tanks, the following factors should be considered: worker access and safety issues, machinery and resources available, and the methods or facilities available to deal with the cleaning residues. It may be necessary to experiment with several cleaning methods to see which best suits the particular circumstance.

Some methods for cleaning tanks are detailed in Appendix E. Regardless of the selected tank cleaning method, the effluent and water must be collected, treated, and disposed of in

compliance with applicable regulations. Large volumes will require the services of a pumper truck or barge, while smaller quantities should be collected and stored in drums. Caution should be used during all transfer operations to avoid spills. If transferring large quantities of oil or oil contaminated liquid, a containment boom around the vessel should be used to minimize the extent or spreading of an accidental release.

Structural and Non-structural Tanks
All structural and non-structural tanks are assumed to be contaminated by hydrocarbons until proven otherwise. Structural tanks include, but are not limited to: fuel storage/settling/service/day tanks, cargo tanks, oil tanks, structural hydraulic tanks, fresh water tanks, ballast tanks, stabilizer tanks, black and gray water tanks, voids, and cofferdams.

Tank interiors including deckheads should be cleaned of all hydrocarbons. No visible hydrocarbons should remain on the tank surfaces (this includes all interior fittings, piping, structural members), or on the water surface when flooded after sinking. No emulsified oil, as determined by visual inspection, should remain. Oil absorbent pads and excess loose oil absorbent material should be removed before sinking.

Gauges and Gauge Lines
Pressure gauges and gauge lines are assumed contaminated with the product that they were intended to measure. Fluid filled gauges should be removed. Pressure gauges and gauge lines should also be removed to prevent oil seepage from these lines. Lines that remain in place should be flushed, and the lines cleaned.

Special care should be exercised with mercury thermometers and pressure (typically vacuum) measuring devices. These should be removed intact from the vessel. Temperature gauges that do not contain any hazardous material can remain in its position. Other measuring instruments should be removed from the vessel or opened for cleaning, examination, and possible removal.

Combustion Engines
Combustion engines include any reciprocating engine in which fuel is consumed (diesel, gasoline, gases), stirling cycle engines, and gas turbines. The entire fuel/oil system should be drained and flushed. Any items (e.g., oil filters and strainer elements) that can not be flushed should be removed.

Combustion engines and associated manifolds should be thoroughly drained, flushed, and cleaned. Machinery need not be removed if it is completely drained and the sumps flushed and cleaned. Sometimes, engines are removed for reuse or to assure that all oil is removed before reefing. In some cases, it might be less expensive to remove and dispose of the engines than to clean the oil from them. Some methods for cleaning combustion engines are detailed in Appendix E.

Non-combustion Engines, Shafting, Gearing and Stern Glands
Main gear boxes and associated clutches should be drained of all lubricating oils. Internal gear sprayers, lubricating lines, and other components should be removed, or drained. External pedestal and thrust bearings should be drained.

Stern tubes and seals, if of the oil bath type, should be drained of oil. Note that draining the stern tubes and seals may require extraordinary measures to preserve the watertight integrity of the vessel during the clean-up and salvage operation.

Vessels that are equipped with thrusters, Z-drives, or other methods of unconventional propulsion systems will be addressed on a case-by-case basis. The objective is that no hydrocarbons remain in the propulsion system.

Steering Gear
Hydraulic pumps and associated piping and fittings should either be removed or drained and flushed clean. Hydraulic telemotor systems should be treated similarly. Grease lines and reservoirs for rudder heads should be removed from the ship, or opened and cleaned. Vessels with combined propulsion and steering systems should be addressed in the same manner as that which is provided under the above mentioned "non-combustion engines, shafting, gearing, and stern glands" subsection.

Auxiliary Machinery
Auxiliary machinery that has a liquid hydrocarbon as its working fluid should be completely drained and flushed clean. Auxiliary machinery refers to machinery and components that are not an integral part of the main propulsion system of the vessel. The term can include but is not limited to: pumps, motors, compressors, galley equipment, capstans, elevators, and cargo handling machinery. Many pieces of auxiliary machinery have a lubricating oil system or are in direct contact with liquid hydrocarbons.

All lubricating oil system components should be stripped from auxiliary machinery, drained and cleaned. Lubricating oil sumps should be drained and cleaned.

Hydraulics
Unless there is acceptable proof to the contrary, all hydraulic systems should be assumed to have employed a hydrocarbon based fluid. Hydraulic lines should be removed from the vessel, or opened and blown through with air until clear. Hydraulic fittings (valves and valve blocks of all types, cylinders, pumps, accumulators, filters, coolers) should be removed from the ship or drained clean. Hydraulic sumps should be opened and drained clean.

Grease
All grease reservoirs should be removed from the ship, or opened and cleaned. Grease lines should be removed or blown through until clear and all visible grease accumulations should be removed so that no visible sheen is remaining on the water surface when these structures are flooded after sinking. Machinery that employs grease-packed gearboxes (common on deck machinery), as well as grease packed couplings, stuffing boxes, chain sprockets, and worm drives should be opened and cleaned of grease. Grease on chains and sprockets should be removed. Greased cables should be cleaned or removed from the vessel so that no visible sheen is remaining on the water surface when these structures are flooded after sinking.

Sealed rolling element bearings that contain grease can be left in-situ. Grease in other fittings such as stuffing boxes and glands can be left in situ if the seals are intact and the quantities are

small (for example, less than 100 milliliters evenly distributed throughout the component). Any grease on the outside of the sealed bearings should be removed.

Bilge Areas
The bilge area includes all areas that would be subject to contact with oily water, or may be a catch area for spills from cargoholds or storerooms, and interior surfaces which may have been subject to hydrocarbon contamination through sprays, spills, or disposal. Bilge areas also include the plating and all surfaces of attached stiffeners and fittings. Bilge areas should be free of visible oils, greases, and sludge. Oil or grease films evident to the touch should be removed. Any debris contaminated with hydrocarbons should be removed. Any cleaning fluids used to clean the bilge should be removed from the vessel. Accumulations of loose oil absorbent material should be limited to those amounts that cannot reasonably be picked up with brooms and vacuums.

Cleaning bilges is frequently complicated by poor access caused by piping, gratings, and equipment. In many cases, it is cheaper and easier to remove the dirty or contaminated items that limit access than to clean the items as well as the bilge. Once clean, bilges are very vulnerable to recontamination. Note the following recontamination issues:

- Piping, valves, and fittings in hydrocarbon systems will continue to drip for some time after initial draining. Over a short period of time, these drips can lead to a major rework cleaning effort. Therefore, drips should be captured whenever possible; drip pans should be emptied frequently.

- Containers used for clean-up are vulnerable to tipping and spilling, especially in conditions -- such as poor lighting -- that are often found in vessels undergoing sinking preparation. Remove containers used for clean-up when they are full.

- Water should not be allowed to enter bilges unless it is part of a planned clean-up effort. Water that otherwise enters the bilge should be handled as oily wastewater.

In general, the approach and methods recommended for cleaning bilges are the same as for cleaning tanks.

Decks and Floor Coverings
Oil and grease films on deck coverings should be cleaned. Decks and floor coverings include ceramic tile, linoleum and linoleum tile, carpet, and continuous floor coverings. In compartments subject to hydrocarbon spills during the vessel's life (e.g., workshops, compartments with fuel or oil tank overflows or tank covers), the deck covering and underlayment should be examined for oil saturation. Floor coverings or underlayment that has been saturated with hydrocarbons should be removed from the vessel.

Bulkheads and Deckheads
Bulkheads and deckheads should be cleaned of oil and grease films. Where it is evident that a spill or accumulation resulting from leaks has occurred, coverings should be removed to reveal the full extent of the spill or accumulation.

ASBESTOS

Narrative Clean-up Goal: Remove any loose asbestos and asbestos that may become loose during vessel sinking; remove or seal accessible friable asbestos.

Environmental impacts

Asbestos is a naturally occurring mineral. The environmental impacts caused by asbestos are dependent upon 1) whether asbestos is reduced to fibers or is in a non-friable form; and 2) whether the asbestos is air-borne or water-borne.

Even though adverse impacts from asbestos are largely from inhalation -- which is not expected to be an issue in the marine environment -- vessel preparation should eliminate the possibility of pieces of asbestos breaking free from the vessel during the sinking operation or asbestos materials losing surface integrity after the vessel has been placed as an artificial reef. Loose asbestos pieces can lead to rafting and may be capable of washing ashore. These asbestos pieces could dry up, break apart, and be reintroduced into the atmosphere. Exposure to airborne asbestos can negatively impact human health via inhalation.

Once a vessel has settled on the ocean floor, asbestos remaining on the vessel (e.g., intact and undisturbed asbestos insulation) will be covered with bacteria over time. This in turn will cause the asbestos fibers to sink and remain contained within the reef matrix, minimizing any potential direct impacts to the marine environment. (see Appendix C)

What is asbestos?

Asbestos refers to a group of minerals that occur naturally as masses of long silky fibers. There are three main types of asbestos fibers:

- Chrysotile fibers (white asbestos) are fine, silky flexible white fibers. They are pliable and cylindrical, and arranged in bundles. This was the most commonly used asbestos in the United States.

- Amosite fibers (brown asbestos) are straight, brittle fibers that are light grey to pale brown. This was the most commonly used asbestos in thermal system insulation.

- Crocidolite fibers (blue asbestos) are straight blue fibers that are like tiny needles.

There are three other types of asbestos fibers: anthophyllite, tremolite, and actinolite. Unlike most minerals, which turn into dust particles when crushed, asbestos breaks up into fine fibers that may be too small to be seen by the human eye.

Individual asbestos fibers are often mixed with a material that binds them together, forming what is commonly called asbestos-containing material (ACM). There are two kinds of ACM: Friable

and non-friable.

- **Friable ACM** is any material containing more than 1% asbestos that, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure.

- **Non-friable ACM** is any material containing more than 1% asbestos that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure. Non-friable ACM is divided into two categories.

    1. **Category I** non-friable ACM includes asbestos-containing resilient floor coverings, packings, and gaskets.

    2. **Category II** non-friable ACM includes all other non-friable ACM that is not included in Category I.

Asbestos is resistant to abrasion and corrosion, inert to acid and alkaline solutions, and stable at high temperatures. It is strong yet flexible, non-combustible, conducts electricity poorly, and is an effective thermal insulator.

Where is asbestos found on a ship?

Asbestos on ships may be found in many materials, including, but not limited to:

- Bulkhead and pipe thermal insulation
- Bulkhead fire shields/fireproofing
- Uptake space insulation
- Exhaust duct insulation
- Electrical cable materials
- Brake linings
- Floor tiles and deck underlay
- Overhead and panel sheeting (cement and cellulose based)
- Steam, water, and vent flange gaskets
- Adhesives and adhesive-like glues (e.g., mastics) and fillers
- Sound damping
- Molded plastic products (e.g., switch handles, clutch facings)
- Sealing Putty
- Packing in shafts and valves
- Packing in electrical bulkhead penetrations
- Asbestos arc chutes in circuit breakers
- Pipe hanger inserts
- Weld shop protectors and burn covers, blankets, and any fire-fighting clothing or equipment
- Any other type of thermal insulating material

NOTE: Asbestos-containing material may be found underneath materials that do not contain

asbestos. Thermal system insulation and surfacing material found in vessels and vessel sections constructed after 1980 may be presumed to be free of asbestos containing material.

Vessel Preparation

Asbestos can be found throughout ships, from the bridge to the bottom of the bilge. Identifying the locations and types of asbestos onboard are essential for vessel preparation and should be considered early in the clean-up process. Once the type and location of asbestos and asbestos containing materials are identified, a determination should be made whether to remove, encapsulate, or leave the asbestos undisturbed.

The method of demolition is particularly important to the effective management of asbestos on board ships. If the sinking method for the vessel includes the use of explosives, asbestos-containing material that may become disturbed during detonation should be removed from the vessel.

In addition, any asbestos that is moved or disturbed (including during clean-up operations) or can potentially get dislodged as the vessel sinks should be removed from the vessel. Friable asbestos should be sealed as a precautionary measure to prevent releases of asbestos in high concentrations during the sinking event. Intact and undisturbed asbestos insulation need not be removed.

Engine Room and Engine Compartments

Removal or encapsulation of exposed, disturbed and deteriorated asbestos should be considered since it is likely that the asbestos will break free and create debris during sinking. If the asbestos is to be encapsulated, its integrity should not be impacted by the preparation for sinking as well as the sinking itself.

The primary source of friable asbestos is found on pipe wrappings around the main boilers and steam fittings. On most vessels the asbestos coating, which is 1 to 3 inches thick, is covered with canvas and is usually painted. If work needs to be done around the piping and the covering, causing the asbestos to be disturbed, the disturbed material should be removed. If the covering is deteriorated and it is likely that the asbestos will break free during sinking, then removal or encapsulation with an epoxy or other non-water soluble and non-toxic sealer should be considered.

Certain boilers and piping are covered with a very friable asbestos paste. Throughout the engine room there are numerous asbestos gaskets connecting piping and ductwork. If left intact, these gaskets usually will not release asbestos fibers. However, if the ductwork or piping needs to be cut or removed and vessel debris is created as a result, gaskets should be removed or encapsulated if possible.

In some engine rooms asbestos/cellulose sheets are found behind power and electrical panels or in the overhead where electrical service passes. Undisturbed, this material is not friable. However, once the sheets are exposed to the marine environment, the sheets loose their integrity and can break up and raft. Where possible, these sheets should be removed. Note that asbestos

cement sheets may also be used as panels on the vessel. However, these sheets are not water-soluble and therefore should not break apart when exposed to the marine environment. These sheets can stay in place unless cut, drilled or disturbed. Friable asbestos may also be found between bulkheads; this asbestos may remain in place because the asbestos is contained within the bulkheads. If, however, the bulkheads are drilled, cut, or disturbed, the friable asbestos that is now exposed should be encapsulated or removed.

Ship Interior and Living Spaces

Asbestos was also used in some hatch gaskets mixed with rubber throughout ships, especially in watertight spaces. Under normal circumstances this will only present a problem if grinders or torches are used. In such cases, the gaskets should be removed prior to disturbance. Asbestos/asphalt floor tile was common from the 1940's to the mid 1970's. This form of asbestos is manufactured with the asbestos encapsulated. If preparation of the vessel requires the tile to be disturbed via grinding, cutting, or burning, those pieces of tile should be removed. Asbestos sheets both with cement and cellulose may be found especially in the combat information center, the radio room and other spaces where electrical equipment may be found. Cellulose/asbestos panels should be removed but cement panels are safe. As an example, while inspecting an old Navy tug planned for reefing off the coast of Virginia, it was determined that the entire interior of the wheel house was paneled with cellulose/asbestos panels and had to be removed.

Exterior Spaces

There are a few areas on the exterior of ships where asbestos was used. Asbestos may have been mixed with paint and applied as a coating near some vents and hatches. Also, some hatches may have gaskets that contain asbestos. In either case, the material does not need to be removed unless these exterior areas require grinding or cutting.

POLYCHLORINATED BIPHENYLS (PCBs)

Narrative Clean-up Goal: Remove all solid material containing PCBs greater than or equal to (≥) 50 parts per million (ppm) unless a disposal permit has been granted under 40 CFR 761.62(c); remove all liquid materials containing PCBs.

Environmental Impacts

PCBs are persistent and bio-accumulative. PCBs bio-accumulate in fatty or lipid rich tissues. PCBs have a limited solubility in aqueous solutions and it is suspected that PCBs can leach into a marine or aqueous environment (sediment and water column) where they can be taken up by organisms in the food web. PCBs bioaccumulate in fish and other animals; PCBs also bind to sediments. As a result, people who ingest fish may be exposed to PCBs that have been released into the environment.

There is a risk of human exposure during vessel preparation and after sinking the vessel. During vessel preparation, typical routes of human exposure include inhalation, accidental ingestion, or dermal contact. After sinking, exposure routes may be limited to accidental ingestion of or contact with contaminated water or ingestion of contaminated fish, shellfish, or crustaceans. (see Appendix C)

What are PCBs?

PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs, which were domestically manufactured from 1929 until their manufacture was banned in 1979, have a range in toxicity and vary in consistency from thin light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications.

Where are PCBs found on a ship?

Although no longer commercially produced currently in the United States, PCBs are present in vessels deployed before the 1979 PCB ban. PCBs are found in both the solid (waxy) and liquid (oily) forms in equipment and materials on ships that were built leading up to the ban. The equipment and materials that may contain PCBs in concentrations of at least 50 ppm include:

- Cable insulation
- Rubber and felt gaskets
- Thermal insulation material including fiberglass, felt, foam, and cork
- Transformers, capacitors, and electronic equipment with capacitors and transformers inside

- Voltage regulators, switches, reclosers, bushings, and electromagnets
- Electronic equipment, switchboards, and consoles
- Adhesives and tapes
- Oil used in electrical equipment and motors, anchor windlasses, hydraulic systems, and leaks and spills
- Surface contamination of machinery and other solid surfaces
- Oil-based paint
- Caulking
- Rubber isolation mounts
- Foundation mounts
- Pipe hangers
- Fluorescent light ballasts
- Any plasticizers

Items containing PCBs may be found throughout a ship and are not easily identifiable or accessible. PCBs may be found in a variety of shipboard materials, but the location and concentration may vary from item to item and within classes of items. PCB containing materials can also vary from ship to ship, and even ships in the same class can contain differing amounts of PCB containing materials. While these materials may be found throughout a ship, several areas on ships may have an increased likelihood of containing PCB bearing materials: areas or rooms subject to high heat or fire situations such as boiler rooms, engine rooms, electrical/radio rooms, or weapons storage areas.

Vessel Preparation

Even though it is not the intent of this document to focus on regulatory requirements, PCBs are regulated for disposal under 40 CFR Part 761, and will be discussed in this context. The regulations require that materials containing PCBs ≥ 50 ppm cannot be disposed in the marine environment. Although the ship itself is being "reused" or "recycled" as an artificial reef, the PCBs have reached the end of their useful life and must be removed and disposed. Disposal requirements are referenced below (also see Appendix B).

Where there is reason to suspect that equipment or components may contain PCBs ≥ 50 ppm, either remove the equipment or component from the vessel, provide proof that the equipment or component is free of PCBs, or apply to EPA for a PCB disposal permit. Thermally removing PCB containing materials is prohibited, as PCBs may volatize or form dioxin or dioxin-like compounds. Because PCB sampling and analytical procedures can be expensive and time consuming, there may be situations when the cost of sampling and analysis far exceed the cost for removal and disposal. In such cases, previous ship to reef projects have shown that removal of all electrical cables and wires suspected of containing some level of PCBs is more economical.

Liquid Materials Containing PCBs

Remove all liquid filled electrical equipment suspected of containing PCBs or PCB contaminated dielectric fluid. Materials such as lubricating oils and greases used for winches and cargo-

handling machinery, hydraulic fluids, heat transfer fluids, and waste oils should be removed from the vessel as presented in the "Oil and Fuel" Section of this document.

Solid Materials Containing PCBs (non-liquid PCBs)

Remove all solid materials containing PCBs ≥ 50 ppm, which includes but is not limited to felt gasket and faying material, cables, paints, rubber gaskets as well as battle lanterns and fluorescent light ballasts. EPA recognizes that non-liquid PCBs may be difficult to locate and remove and that removal may jeopardize the integrity of the ship. If non-liquid PCBs ≥ 50 ppm are to remain in the vessel, then 40 CFR Part 761 requires you to obtain a PCB disposal permit under 40 CFR 761.62(c).

PAINT

Narrative Clean-up Goal: Remove harmful exterior hull antifouling systems that are determined to be active; remove exfoliating and exfoliated paint.

Environmental Impacts

Scientific investigations by governments and international organizations have shown that certain anti-fouling systems (AFS) used on vessels pose a substantial risk of both acute and chronic toxicity and other adverse impacts to ecologically and economically important non-target marine organisms. Because this document addresses vessels that would be sunk for the creation of artificial reef habitat, the presence of biocides and other anti-fouling systems that inhibit marine growth are antithetical to this purpose. Furthermore, because anti-fouling systems can be reactivated via physical disturbance and/or biological degradation (e.g., scouring during a storm event or burrowing caused by marine organisms) over time, anti-fouling systems that retain potency may become harmful or be reactivated following the sinking. (see Appendix C)

What types of paint and anti-fouling systems are used on ships, and where are they found?

Paint and preservative coatings can be found on both interior and exterior surfaces of a ship. Particularly on older ships, paint may be flammable or may contain toxic compounds, such as polychlorinated biphenyls (PCBs), heavy metals (e.g., lead, barium, cadmium, chromium, and zinc), and biocides. Lead compounds, such as red lead tetraoxide (Pb_3O_4) and lead chromate, have been used extensively in marine paint. Other paints containing biocides, such as organotin (including compounds such as tributyl tin), have been used on the hulls of ships to prevent the buildup of marine organisms (e.g., bacteria, protozoa, barnacles, and algae).

Paints
Paint above the water line (topside paint) is not designed to leach because these paints are designed to protect topside surfaces from physical degradation and do not typically contain antifoulant biocides like that of anti-fouling coatings. However, these paints may contain biocides added as in-can preservatives.

Anti-fouling System
For most types of candidate vessels for reefing, the paint-related contaminants of concern are limited to exterior hull coatings below the water line. These hull coatings consist primarily of antifouling (AF) agents (biocides) such as copper, organotin compounds, and zinc.

Vessel Preparation

Anti-fouling Underwater Hull Coatings
If there is minimal active biocide remaining on the vessel, no preparation to the underwater hull area is necessary. It can be assumed that biocide activity is minimal if the anti-fouling coating

on a candidate vessel is more than twelve years old **and** essentially all the underwater hull area is covered with marine growth.

When assessing the efficacy of the anti-fouling system (AFS), existing documentation relating to the anti-fouling properties of the hull coating could provide supporting information when determining if such coatings should be removed. Sources for such supporting information include, but are not limited to the following: a document search on the type and age of the existing AFS, the most recent repainting or dry-dock cycle, the most recent underwater hull cleaning, and when necessary, a physical, underwater hull examination by trained divers or remote operating vehicles. Repair and maintenance records for the vessel should provide the dates when the vessel was last removed from the water for hull maintenance.

If anti-fouling coatings on candidate vessels are at least twelve years old, the AF coatings can be left in place without further evaluation, as they are likely to be no longer harmful. If satisfactory evidence relating to underwater hull coating types and coating application dates is not available, and if the AF coating seems to be inhibiting fouling growth according to established AF paint efficacy, further evaluations should be carried out to ascertain the current anti-fouling properties of the coating.

If there is a lack of documentation, lack of fouling presence, or a reason to believe that the AFS is active, further evaluation of the AFS should be conducted. If it is determined that the AFS is active, the system should be removed to prevent the release of the AFS's harmful biocides.

Interior and Exterior, Above the Waterline Paints

In some cases, interior and exterior paints onboard vessels may contribute to debris/floatable materials or contain other contaminants of concern. Interior paint and paint above the waterline should be evaluated according to the practices presented under the PCB and Debris sections when appropriate. If paint is found to contain PCBs, then the protocols found in the "PCB" section of this document should be followed. If paint exhibits physical damage such as blistering, peeling, or pitting that contributes to vessel debris (such as paint chips or flakes) that might float or could be transported into the water column during a sinking event, then the protocols under the "Solids/debris/floatables" section of this document should be followed. Exfoliating paint (paint that is blistering, peeling, and pitting) and exfoliated paint (paint chips and flakes) should be removed.

SOLIDS/DEBRIS/FLOATABLES

Narrative Clean-up Goal: Remove loose debris, including materials or equipment not permanently attached to the vessel, which could be transported into the water column during a sinking event.

Environmental Impacts

Marine debris consists of solid materials of human origin discarded at sea. Floatable material/debris is any unsecured foreign matter that floats, remains suspended in the water column, or washes up on shore. Floatable materials can travel long distances in the ocean and be deposited far from their source.

The degradability of floatable materials and marine debris influences the persistence of these items in the marine environment. Most marine debris is man-made and does not biodegrade readily. The longer that introduced materials remain in the marine environment, the greater the threat they pose to the environment.

Some potential impacts of solids/debris/floatables to the marine environment include:

- Marine life is endangered by entanglement, ingestion, or both; injury, infection, and death may often occur when marine animals encounter debris of this nature;
- Alteration of the ecosystem and its processes may occur throughout the water column as a result of debris introduced into the marine environment. For example, floating debris may act as an attractant for marine animals that would try to use it as shelter or a food source, thereby potentially causing injury or death and altering behavior and/or distribution of indigenous species. Debris settling on the bottom would change benthic floral and faunal habitat structure, potentially causing a direct deleterious impact on members of the benthic community (i.e., injury or mortality) or indirect impact to other species linked in the benthic food web;
- Recurring clean-up costs for coastal communities impacted by the debris; and
- Danger to navigation (e.g., hull damage, damage to propellers, and damage to cooling and propulsion systems).

What are solids/debris/floatables?

Solids, debris, and floatables are loose materials that could break free from the vessel during transportation and placement as an artificial reef, thereby adversely affecting the ecological or aesthetic value of the marine environment or posing a risk to humans or animals (i.e., land animals). These materials can consist of vessel debris, introduced debris, and clean-up debris. Vessel debris refers to material that was once part of the vessel or was generated during vessel clean-up operations and has been removed or disconnected from its original location on the vessel. Clean-up related debris is material that was not a part of the vessel, but rather was brought on the vessel during preparation operations.

Where are solids/debris/floatables found on ships?

Solids, debris, and floatables can be found anywhere within the vessel as well as on the decks.

Vessel Preparation

Vessel Debris
All material or equipment that is not an integral part of a permanently attached appurtenance and that could become separated from the vessel during sinking should be removed from the ship prior to sinking. Ship's surfaces (e.g., decks, bulkheads, overheads, and surfaces of appurtenances) should be thoroughly cleaned to remove all dirt, loose scale, trash, exfoliating paint, paint chips, hazardous materials, and other foreign matter. Deck drains should be proven clear of debris.

When assessing vessel debris removal, consideration should be given to the following:

- no vessel debris contaminated with hydrocarbons or hazardous material should remain in the vessel;
- vessel debris that is heavy and/or bulky fitted equipment, and was disconnected or otherwise detached from the structure of the vessel for cleaning or inspection can remain in its original compartment subject to issues of diver safety. Otherwise, vessel debris should be contained in a sealed compartment or structural tank that is below the waterline of the ship and underneath the largest section of the superstructure;
- vessel debris should not be placed in a compartment or structural tank that will be sealed until both the compartment and the debris have been inspected; and
- vessel debris remaining on the vessel should always be negatively buoyant.

Any vessel debris determined to be acceptable to remain on the vessel for sinking should be clean in the context of this guidance.

Clean-up Related Debris
Clean-up debris that was introduced to the vessel solely for cleaning purposes and final preparation of the vessel should always be removed. This would include items such as tools, generators, warning tape, and temporary wooden covers.

Introduced Debris
Foreign material placed on the vessel solely for disposal is not acceptable. However, introduced material of a permanent or commemorative nature (e.g., plaques, markers, clean concrete, or rock for ballast) is permissible.

OTHER MATERIALS OF ENVIRONMENTAL CONCERN

Narrative Clean-up Goal: Remove other materials that may negatively impact the biological, physical, or chemical characteristics of the marine environment.

Environmental Impacts

When placed in the marine environment, materials of environmental concern can have adverse effects on fish, wildlife, shellfish, recreation, or municipal water supplies. Adverse effects on the environment include any of the impacts mentioned in the preceding sections of the document. The magnitude of the impact of these materials on the marine environment will be related to the nature of the material, the level of toxicity, and the ecological resources that could come in contact with "other material of environmental concern."

What are other materials of environmental concern?

Refer to the list provided below.

Where are other materials of environmental concern found on ships?

Other materials of environmental concern can be found anywhere within the vessel as well as on the decks.

Vessel Preparation

Shipboard equipment or materials with constituents that can leach into the water column (e.g., petroleum products, batteries, and/or mercury containing switches) should be removed from the vessel prior to sinking. Fluorescent light tubes and ballasts should be removed. Waste water resulting from clean-up processes, including but not limited to decontamination, rain water collection, and water from rinsing of tanks and lines, should be properly collected and disposed.

Antifreeze and Coolants
Antifreeze and coolant mediums, other than untreated sea water, should be drained and removed from the vessel and the equipment should be flushed.

Batteries
All batteries should be removed from the vessel. This includes batteries that are part of fitted equipment.

Fire Extinguishing Systems
Fire extinguishing systems should be fully decommissioned. Except for fire-fighting systems that employ untreated seawater or fresh water, all fire-fighting compounds should be removed from the ship. Storage containers, if left *in situ*, should be cleaned, flushed, and re-closed for

transit. Any lines that have been charged with any fire-fighting product other than untreated seawater or fresh water should be treated as for fuel and oil piping.

Refrigerants and Halons
All refrigerants and halons should be removed from the vessel.

Mercury
Ship system components using mercury (e.g., some gyroscopes, vacuum measurement gauges, some laboratory equipment, some light switches, some older radar displays) should be removed from the vessel. All portable thermometers and other measuring equipment employing mercury should be removed intact from the vessel. Any other extent mercury or items containing mercury should be removed from the vessel. Note that there is a health hazard associated with airborne mercury.

Lead
Lead ballast bars, shielding and fittings should be removed from the vessel if the reef site is located in fresh or brackish water.

Black and Gray Water
Remove black water (sewerage) and gray water (waste water from sinks, showers, galleys, dishwashers) from the vessel; flush the lines.

Radioactive Materials
Ex-warships, research vessels, and a few other types of vessels may have used equipment containing low-level radioactive material. Residual radioactivity and any source of non-naturally occurring radioactive materials such as luminescent devices should be removed if determined appropriate. The Navy is more familiar with addressing this material aboard vessels, and as such, the Navy has guidance and established procedures regarding the removal and disposal of radioactive materials. For this reason, it is recommended that the procedures for removal and disposal of radioactive materials follow that provided in DLA INST 4145.8, "Material Management for Radioactive Items in the DoD" and implementing instructions. Another reference that may be useful is the American National Standard Institute's standard N13.12-1999, "Surface and Volumetric Radioactivity Standards for Clearance." This document contains tables of surface contamination criteria developed to allow users of radioactive material to demonstrate that the material or equipment can be safely released with no further regulatory control.

Invasive Species
Assess the presence of invasive species that could be transported to and survive at the artificial reef location on the hull of the ship or from other locations on or in the vessel such as ballast and bilge tanks. If a viable invasive species is found that may be expected to survive at the artificial reef site, that species should be removed or eliminated; the vessel should be clean of all such living organisms.

Considerations for Other In-water Uses of Obsolete Vessels

DIVING OPPORTUNITIES

The narrative goals set out under the section "Guidance for Preparing Vessels to Create Artificial Reef Habitat" also should be achieved while preparing a vessel for diver opportunities. For example, if preparation for diver use calls for the removal of wall paneling that will in turn expose any materials of concern that were identified in the aforementioned section, the respective narrative goals should be addressed (e.g. if asbestos is exposed once the panel is removed, the objectives of the asbestos narrative goal should be met).

Additional vessel preparation to support the in-water use of recreational diving may include:

- Removal of sharp and protruding objects along the divers' access path which could snag on divers' equipment or otherwise pose a danger to the divers.

- Removal of doors and access hatches and widening of openings to allow safe access for divers.

- Widening of corridors by removal of some wall paneling and provision of large openings in the exterior of the ship to allow light to penetrate and ensure safe diver access.

- Sealing entrances into restrictive compartments such as the boiler rooms and engine rooms to ensure diver safety.

When preparing the vessel for diver opportunities, careful consideration also should be given to vessel stability (for transport and sinking operations) as well as vessel integrity (for the life of the vessel once placed at the reef site).

BREAKWATERS/BARRIERS

Although the best management practices (BMPs) presented in this document are intended for use in preparing ships for artificial reef habitat, they are also applicable to in-water uses of vessels such as breakwaters or other types of barriers. It is recommended that the BMPs be used for preparing a vessel to serve as a breakwater; however, additional vessel preparations are most likely necessary. Placement of a vessel in a high energy environment (e.g., where there is significant wave, current, or tidal action) would likely result in more rapid degradation of a vessel structure than if placed at typical reef locations. If ships are to be placed in high intensity/energy environments, additional vessel preparation measures will be necessary.

Each project should be analyzed to determine what additional preparations are necessary beyond those recommended for preparing vessels to serve as reef habitat. For example, non-friable asbestos and intact/undisturbed or sealed friable asbestos deemed acceptable to remain on the vessel if used as reef habitat may need to be removed to prevent any release of asbestos that may occur when placed in a persistently high energy environment. For the same reason, it may also be necessary to remove negatively buoyant vessel debris as well as some affixed ship components and fixtures.

Water depth at a breakwater site may critically affect a vessel's stability and long-term structural integrity. In this case, average wave energy in large, open bodies of water as a function of water depth is the major concern. The vessel itself may break apart over time if placed in a high energy wave environment.

Wave interaction with a vessel serving as a breakwater can be destructive; however, the magnitude of such destruction to the vessel is difficult to predict. The wave interaction is primarily dependent on wave height, wave speed, depth of the breakwater, as well as the composition and configuration of the "vessel" breakwater itself. Wave energy can resuspend bottom sediments, causing siltation on the vessel or destabilization of the vessel's structure which could in turn move short distances or entirely off the original breakwater site. Planning for worst-case storms may be required at breakwater sites where movement of the vessel would be detrimental to various ecosystem components.

Appendix A

National Defense Authorization Act for Fiscal Year 2004

The National Defense Authorization Act for Fiscal Year 2004 (PL 108-136) included two provisions relating to the use of vessels as artificial reefs. One such provision, § 3516 (PL 108-136, Div. C, Title XXXV, § 3516, Nov. 24, 2003, 117 Stat. 1795), amended the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (PL 107-314, Div. C, Title XXXV, § 3504(b), Dec. 2, 2002, 116 Stat. 2754; 16 U.S.C. 1220 note) to read in pertinent part as follows:

Title XXXV – Maritime Administration
Subtitle A – Maritime Administration Reauthorization
Section 3516. AUTHORITY TO CONVEY OBSOLETE VESSELS TO UNITED STATES TERRITORIES AND FOREIGN COUNTRIES FOR REEFING

(b) **Environmental Best Management Practices for Preparing Vessels for Use as Artificial Reefs**.—

(1) Not later than March 31, 2004, the Secretary of Transportation, acting through the Maritime Administration, and the Administrator of the Environmental Protection Agency shall jointly develop guidance recommending environmental best management practices to be used in the preparation of vessels for use as artificial reefs.

(2) The guidance recommending environmental best management practices under paragraph (1) shall be developed in consultation with the heads of other Federal agencies, and State agencies, having an interest in the use of vessels as artificial reefs.

(3) The environmental best management practices under paragraph (1) shall --

(A) include recommended practices for the preparation of vessels for use as artificial reefs to ensure that vessels so prepared will be environmentally sound in their use as artificial reefs;

(B) promote consistent use of such practices nationwide;

(C) provide a basis for estimating the costs associated with the preparation of vessels for use as artificial reefs; and

(D) include mechanisms to enhance the utility of the Artificial Reefing Program of the Maritime Administration as an option for the disposal of obsolete vessels.

(4) The environmental best management practices developed under paragraph (1) shall serve as national guidance for Federal agencies for the preparation of vessels for use as artificial reefs.

(5) Not later than March 31, 2004, the Secretary of Transportation, acting through the Maritime Administration, and the Administrator of the Environmental Protection Agency shall jointly establish an application process for governments of States, commonwealths, and United States territories and possessions, and foreign governments, for the preparation of vessels for use as artificial reefs, including documentation and certification requirements for that application process.

(6) The Secretary of Transportation shall submit to Congress a report on the environmental best management practices developed under paragraph (1) through the existing ship disposal reporting requirements in section 3502 of Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (as enacted into law by Public Law 106-398; 1654A-492) [Pub.L. 106-398, Div. C, Title XXXV, § 3502, Oct. 30, 2000, 114 Stat. 1654A-492, which is not classified to the Code]. The report shall describe such practices, and may include such other matters as the Secretary considers appropriate.

The second such provision, § 1013 (PL 108-136, Div. A, Title X, § 1013, Nov. 24, 2003, 117 Stat. 1590), amended Title 10 of the United States Code by adding section § 7306b. New § 7306b (a) authorizes the Secretary of the Navy to transfer vessels stricken from the Naval Vessel Register for use as an artificial reef. New § 7306b (c) requires the Secretary of the Navy to ensure that the preparation of a vessel transferred pursuant to 10 U.S.C. § 7306b (a) for use as an artificial reef is conducted in accordance with the environmental best management practices developed pursuant to 16 U.S.C. § 1220 note and applicable environmental laws. The complete text of Section 1013 of the National Defense Authorization Act for Fiscal Year 2004 is as follows:

Title X – General Provisions
Subtitle B – Naval Vessels and Shipyards
Section 1013. TRANSFER OF VESELS STRICKEN FROM THE NAVAL VESSEL REGISTER FOR USE AS ARTIFICIAL REEFS.

(a) AUTHORITY TO MAKE TRANSFER- Chapter 633 of title 10, United States Code, is amended by inserting after section 7306a the following new section:

`Sec. 7306b. Vessels stricken from Naval Vessel Register: transfer by gift or otherwise for use as artificial reefs

`(a) AUTHORITY TO MAKE TRANSFER- The Secretary of the Navy may transfer, by gift or otherwise, any vessel stricken from the Naval Vessel Register to any State, Commonwealth, or possession of the United States, or any municipal corporation or political subdivision thereof, for use as provided in subsection (b).

`(b) VESSEL TO BE USED AS ARTIFICIAL REEF- An agreement for the transfer of a vessel under subsection (a) shall require that--

`(1) the recipient use, site, construct, monitor, and manage the vessel only as an artificial reef in accordance with the requirements of the National Fishing Enhancement Act of 1984 (33 U.S.C. 2101 et seq.), except that the recipient may use the artificial reef to enhance diving opportunities if that use does not have an adverse effect on fishery resources (as that term is defined in section 2(14) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1802(14)); and

`(2) the recipient obtain, and bear all responsibility for complying with, applicable Federal, State, interstate, and local permits for using, siting, constructing, monitoring, and managing the vessel as an artificial reef.

`(c) PREPARATION OF VESSEL FOR USE AS ARTIFICIAL REEF- The Secretary shall ensure that the preparation of a vessel transferred under subsection (a) for use as an artificial reef is conducted in accordance with--

`(1) the environmental best management practices developed pursuant to section 3504(b) of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (Public Law 107-314; 16 U.S.C. 1220 note); and

`(2) any applicable environmental laws.

`(d) COST SHARING- The Secretary may share with the recipient of a vessel transferred under subsection (a) any costs associated with transferring the vessel under that subsection, including costs of the preparation of the vessel under subsection (c).

`(e) NO LIMITATION ON NUMBER OF VESSELS TRANSFERABLE TO PARTICULAR RECIPIENT- A State, Commonwealth, or possession of the United States, or any municipal corporation or political subdivision thereof, may be the recipient of more than one vessel transferred under subsection (a).

`(f) ADDITIONAL TERMS AND CONDITIONS- The Secretary may require such additional terms and conditions in connection with a transfer authorized by subsection (a) as the Secretary considers appropriate.

`(g) CONSTRUCTION- Nothing in this section shall be construed to establish a preference for the use as artificial reefs of vessels stricken from the Naval Vessel Register in lieu of other authorized uses of such vessels, including the domestic scrapping of such vessels, or other disposals of such vessels, under this chapter or other applicable authority.'.

(b) CLERICAL AMENDMENT- The table of sections at the beginning of such chapter is amended by inserting after the item relating to section 7306a the following new item:

`7306b. Vessels stricken from Naval Vessel Register: transfer by gift or otherwise for use as artificial reefs.'.

Appendix B

Some Legal Authorities that may Apply to Vessel-to-Reef Projects

This appendix identifies certain statutes, regulations, and executive orders that may apply to artificial reef projects. It is not an exhaustive list.

Clean Water Act ' 404 (33 U.S.C. 1344)
Placement of fill material (including structures such as those used to create artificial reefs) in inland waters and the territorial sea require a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers (Corps). In issuing these permits, the Corps must determine that the permit would not cause or contribute to violations of applicable water quality standards or cause or contribute to significant degradation of waters of the United States. EPA may prohibit, withdraw, or restrict the use of a site if EPA determines that the placement of the artificial reef will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas.

Clean Water Act ' 401 (33 U.S.C. 1341)
Under Section 401 of the Clean Water Act, Section 404 permits for proposed discharges of dredged or fill material are subject to State certification as to compliance with applicable State water quality standards. No such permit may be issued unless State certification is obtained or is waived under Section 401.

Rivers and Harbors Act of 1866 ' 10 (33 U.S.C. 403)
Section 10 of the Rivers and Harbors Act (RHA) requires a permit from the U.S. Army Corps of Engineers for the construction of any structure (including artificial reefs) in or over any "navigable water of the United States" (see 33 CFR Part 329), the excavation from or deposition of material in such waters, or any obstruction or alteration in a navigable waters of the United States. Structures or work outside the limits of navigable waters of the United States also require a Section 10 permit if the structure or work affects the course, location, or condition of the waterbody in such a manner as to impact on its navigable capacity. Under the Outer Continental Shelf Lands Act (43 U.S.C. 1333(e)), Section 10 permit requirements also apply to the creation of structures on the Outer Continental Shelf of the United States, including artificial reefs. 33 C.F.R. 322.(3)(b).

Liberty Ship Act (16 U.S.C. '' 1220, et seq.)
This Act allows States to apply to the Secretary of the Department of Transportation (DOT) for the use of DOT owned obsolete vessels as an artificial reef for the conservation of marine life. This Act requires that the State application to DOT include a certification from EPA that the proposed use of the vessel will be compatible with "applicable water quality standards and other appropriate environmental protection requirements" (16 U.S.C. '' 1220 (b)).

National Fishing Enhancement Act of 1984 (33 U.S.C. '' 2101, et seq.)
This Act applies to artificial reefs in waters of the United States or on the Outer Continental Shelf for the purpose of enhancing fishery resources. The Act obligates NOAA to issue a national artificial reef plan that addresses issues such as siting and design criteria. This Act also amends the Liberty Ship Act by moving responsibility for Liberty Ships from the Department of

Commerce to the Department of Transportation, as well as moving responsibility of all obsolete vessels owned by the Department of Transportation to States that apply for and acquire them. In addition, this Act establishes further requirements to be applied by the Corps in the exercise of its permitting authority over artificial reefs.

Coastal Zone Management Act of 1972 (16 U.S.C. '' 1452, et seq.)
The Coastal Zone Management Act establishes a Federal/State partnership to provide for the comprehensive management of coastal resources. States develop management programs based on enforceable policies and mechanisms to balance resources protection and coastal development needs. The Federal consistency provisions require that all Federal activities (including direct Federal actions and Federal financial assistance to state and local governments) be consistent to the maximum extent practicable with the enforceable policies of a state's Federally-approved coastal management program. Any applicant for a Federal license or permit must be consistent with the enforceable policies of a State's coastal management program.

Toxic Substance Control Act (15 U.S.C. '' 2601, et seq.)
The Toxic Substance Control Act bans the manufacture, processing, use, and distribution in commerce of PCBs and directs the EPA to set regulations for the disposal of PCBs. The PCB program has historically used a limit of ≥50 ppm for the disposal of PCBs. PCBs ≥50 ppm are regulated for disposal at 40 CFR 761. The sinking of ships containing PCBs at regulated levels (≥50 ppm) is considered PCB disposal and requires approval under §761.62(c) from the U.S. EPA. PCBs may be found in a variety of shipboard materials but the location and concentration may vary from item to item and within classes of items. There are two ways to determine regulatory status of items suspected to contain PCBs: 1) assume "worst case" (≥50 ppm) and remove the suspect item(s), or 2) sample and analyze the items for PCB concentration.

Federal Insecticide, Fungicide, and Rodenticide Act Amendments of 1988 (7 U.S.C. 136-1367)
EPA has used its authority under FIFRA to regulate antifoulant paints, including those containing organotins, copper, and other compounds. Such paints which make antifoulant claims are pesticides under FIFRA. As part of the partial conclusion of the TBT Special Review, EPA used its FIFRA authority to impose requirements, such as certification and training for applications and other label requirements dealing with TBT applications and disposal.

Organotin Antifouling Paint Control Act of 1988 (33 U.S.C. 2401-2410)
Organotin-based antifoulant systems are also regulated pursuant to OAPCA, which presently prohibits use of organotin-antifouling paints on vessels under 25 meters in length (excluding aluminum hulls, outboard motors, and external drive units), and restricts the leaching rate of organotin antifoulant paints used on larger vessels.

Additional Legal Authorities that may Apply to Vessel-to-Reef Projects

- Endangered Species Act (16 U.S.C. 1531)
- Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801, et seq.)

- Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2901-2912, et seq.)
- Marine Mammal Protection Act of 1972 (16 U.S.C. 1361, 1371-1384 note, 1386-1389, 1401-1407, 1411-1418, 1421-1421h)
- Migratory Bird Conservation Act (16 U.S.C. 715-715r)
- National Marine Sanctuaries Act (16 U.S.C. 1431, et seq.)
- Fish and Wildlife Coordination Act (16 U.S.C. 661-666c)
- National Environmental Policy Act of 1969 (42 U.S.C. 4321, 4331-4335, 4341-4347)
- National Marine Sanctuary Program Regulations (15 C.F.R. Part 922)

Some Executive Orders that may Apply to Vessel-to-Reef Projects

- Executive Order Number 12962 (60 FR 30769) - Recreational Fisheries
- Executive Order Number 11990 (42 FR 26961) - Protection of Wetlands

Appendix C

*Information related to materials found on scuttled vessels that may have potentially hazardous effects on the marine environment**

*****The text provided in this appendix is an excerpt from the 2003 "*Draft Policy Statement of the National Marine Sanctuary Program: Artificial Reef Permitting Guidelines.*"

Scuttled Vessels

The scuttling of vessels requires particular attention in this policy because of their size and potential toxicological effects on the environment. As discussed above, sunken ships potentially attract divers away from natural reefs and thus may be beneficial to natural reefs in NMSs. However, there is a wide array of concerns that must be addressed before intentionally sinking a ship.

The removal of petroleum products, hazardous materials, paint cans, batteries, plastics, oil, and fuel is specified on the U.S. Coast Guard's Ocean Disposal/Artificial Reef Inspection form. Additionally, under the Toxic Substances Control Act (TSCA), the EPA has the authority to gather information on and regulate chemical substances and mixtures imminently hazardous or presenting unreasonable risk of injury to public health or the environment. Despite these controls, some materials of concern may still remain on items used as artificial reef material. Such materials include: asbestos, polychlorinated biphenols (PCBs), iron, lead paint, and antifouling paint. The NMSP should consider the risks associated with materials remaining on vessels to be used as artificial reefs.

Asbestos is the name given to six naturally occurring minerals that are used as insulators and fire retardants. Several studies have investigated the effects of asbestos on fish (Batterman and Cook 1981, Belanger *et al.* 1990, Belanger *et al* 1986, Woodhead *et al.* 1983). The findings indicate that asbestos concentrations on the order of 10^6 to 10^8 fibers/L may cause epidermal lesions, epithelial hypertrophy, kidney damage, decreased orientation and swimming ability, degradation of the lateral line, reduced growth, and increased mortality in fish. Undisturbed, non-friable (not easily crumbled) asbestos has been found to be relatively harmless (Garcia and Salzwedel 1995, Montoya *et al* 1985).

PCBs may still exist in water-tight gaskets, cable insulation, paint, transformers, capacitors, and other components of decommissioned Navy vessels (Matore *et al.*1996, Eisler and Belisle 1996). These chemicals have been implicated in: reduced primary productivity in phytoplankton; reduced hatchability of contaminated fish and bird eggs; reproductive failure in seals; altered steroid levels and subsequent reproductive impairment in fish and sea stars; reduced fertilization efficiency in sea urchins; and reduced plasma retinal and thyroid hormone levels potentially leading to increased susceptibility to microbial infections, reproductive disorders and other pathological alternation in seals and other marine mammals (Adams and Slaughter-Williams 1988, Brouwer *et al.* 1989, Clark 1992, den Besten *et al*. 1991).

Antifouling paints typically containing tributyltin (TBT) and copper (Cu) are often used to paint vessel hulls to inhibit the growth of organisms below the water line. An IMO convention to control the use of harmful anti-fouling systems on ships was adopted on October 5, 2001. The convention will prohibit the use of harmful organotins, including TBT, in anti-fouling paints

used on ships and establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. TBT has been found to be toxic to non-target, non-fouling organisms at low levels (approximately 7.5-10.5 ng TBT/L). One of its most marked effects has been the induction of shell thickening and growth anomalies in oysters and imposex[2] in the dogwhelk *Nucella lapillus* potentially leading to sterility (Gibbs *et al.* 1998). The discovery of the highly toxic nature of TBT-based paints has led many countries to ban the use of these paints for non-aluminum hulled vessels less than 25 meters in length. Copper, though an effective antifoulant, has not been shown to cause extensive effects on non-target organisms at relatively low levels. When present in high concentrations, however, copper can be toxic to aquatic life (Sorrenson 1991). In a study conducted when a cargo ship collided with part of the Great Barrier Reef and remained grounded for 12 days, sediment containing 8.0 mg kg super(-1) TBT, 72 mg kg super(-1) Cu and 92 mg kg super(-1) Zn was found to significantly inhibit larval settlement and metamorphosis (Negri *et al.* 2002). At this level of contamination, larvae survived but contracted to a spherical shape and swimming and searching behavior ceased. At higher contamination levels, 100% mortality was recorded. These results indicate that the contamination of sediment by anti-fouling paint has the potential to significantly reduce coral recruitment in the immediate vicinity of the site and that this contamination may threaten the recovery of the resident coral community unless the paint is removed.

Iron, an essential element like copper, can be contributed to the environment from steel hulls of sunken vessels. As an essential element, iron levels will tend to be closely regulated by organisms, and thus, it is unlikely that any pollution-derived effects will be observed except in severe and localized cases (Thompson 1990). Corals living in seawater with high iron concentrations have been shown to incorporate the iron into their skeletons (Brown *et al.* 1991). Studies on phytoplankton and macroalgae indicate that in areas where plant nutrients such as nitrate and phosphate are abundant the availability of iron is actually a limiting factor in growth and biomass (Coale *et al.* 1996, Frost 1996, Matsunaga *et al.* 1994, Takeda 1998, Wells *et al.* 1995). Hence the concern of unnatural iron inputs from artificial reefs seems to center not on the occurrence of adverse toxicological effects in marine organisms, but rather on the alteration of the composition of natural assemblages of algae and species which compete with algae.

Lead paint has been used on the interiors of some vessels. Lead has no biological function and, therefore, exhibits accumulation trends in organisms (Thompson 1990). Corals have been shown to incorporate lead into their skeletons (Dodge and Gilbert 1984). Unicellular algae and sea urchins appear to be the most sensitive marine organisms (Berhard 1980). Growth inhibition has been observed in the algae species *Thalassiosira pseudonana* and *Porphyridium marinum* exposed to lead as well as in sea urchins.

Despite the potential toxicological effects of the chemicals discussed above, adverse effects will not occur unless the chemicals are present at or above their effective concentrations. The South Carolina Department of Natural Resources completed an assessment in the mid-1990s on the levels of PCB and heavy metals in biota found on ex-military ships used as artificial reefs. Over 100 samples were collected from locations along the South Carolina coast. Of the 80 tissue samples analyzed for PCBs, only 19 were found to contain concentrations above the 100 ppb weight wet limit of quantitation and all were well below the U.S. Food and Drug Administration’s alert action level of 2000 ppb weight wet. (Note that being below safe levels for human consumption does not necessarily mean there are no adverse effects on the marine

organism itself.) No significant differences were detected in the tissues of organisms collected from vessels know to contain PCB-laden materials, vessels suspected to have PCB-laden materials, and natural hard bottom control sites. Although some of the collected samples were moderately high in a particular heavy metal, no clear correlation was found between high metal levels and a particular type of sample site. Gastropods, however, did contain much higher levels of lead, possibly attributed to the fact that they would graze directly on the painted surfaces. South Carolina concluded that the PCB and metal levels detected in the study did not indicate increased hazards around military ships used as artificial reefs.

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Appendix D

Developing Workplans for Vessel Preparation Prior to Reefing

Determining the type and location of the potential sources of contamination from a vessel intended for use as an artificial reef should be conducted as part of a workplan for vessel clean up and preparation. The purpose of such a workplan is to assure that materials of concern potentially contributing to pollution of the marine environment are addressed prior to reefing. The development of a workplan also can allow for more effective clean-up efforts during vessel preparation by guiding activities such as salvage operations and possibly diver safety preparations in a manner that minimizes debris and contamination that must be cleaned up or properly disposed.

Information which may be useful in the preparation of a workplan could include:

- Asbestos documentation for the vessel;
- PCB documentation for the vessel;
- Documentation that naval vessels have been previously demilitarized and certified to be radiologically decontaminated;
- Documentation that refrigerants and halons have been removed from shipboard systems;
- Information on hazardous materials onboard the vessel;
- Information on exterior hull paint which could include paint type and date of last application;
- General drawings of machinery, compartments, and tank layouts;
- Description of vessel dimensions including size, weight, and superstructure materials;
- Tank soundings describing the volume and contents of fuel oil tanks prior to preparation for reefing;
- List of items with beneficial reuse potential to be salvaged prior to sinking;
- Assessment of applicable laws and regulations, including permit requirements; and
- Reef site surveys and proposed site preparation.

An assessment of the above mentioned information could then direct the preparation actions needed for the reef project workplan. Some general workplan actions include:

- Assess vessel drawings and dimensions;
- Identify which items will remain on the vessel;
- Identify items to be salvaged prior to sinking;
- Estimate economic viability of the reef project (including permit costs and timeframes);
- Determine if the vessel is a good candidate (i.e., does the workplan fall within reasonable time and financial commitments);
- Coordinate with all regulatory agencies, local, regional, State and Federal, as well as stakeholders, during all project phases;
- Apply for and receive the appropriate permits for the project;
- Remove hazardous materials and clean vessel;

- Inspect vessel to clear all findings (that the workplan for removal of materials as well as the vessel clean-up is met);
- Conduct vessel stability analysis;
- Develop strategy for vessel sinking;
- Notify NOAA to update nautical charts once the ship has settled on the ocean floor; and
- Deploy relevant aids to navigation and mooring/marker buoys at the site.

Appendix E

General Principles for a Vessel Clean-up Operation

In order to prepare a vessel intended to create an artificial reef, a workplan should be developed to direct cleaning operations – as described in Appendix D. Salvage operations should take place first, being careful to minimize debris and contamination with oils or other products that will need cleaning sometime during the vessel preparation. Other vessel clean-up preparations to be considered include:

- Re-use/recycle/dispose of all or some vessel components – besides ferrous scrap materials, there may be high value components onboard the vessel, such as non-ferrous metals (e.g., copper, aluminum, nickel), and re-useable equipment such as generators, machines, pumps, and cranes;
- Generally, clean-up operations should begin at the highest part of the compartment or tank and proceed downwards to the bilge;
- Deal with the large concentrations of oil and hazardous products early in the operation;
- Keep compartments clean and make concerted efforts to avoid spillage during salvage and clean-up operations; and
- Consider removing, instead of cleaning, heavily contaminated machinery and piping. Removal may be quicker and less expensive. Removal may also allow for less overall effort in clean-up as access to the contaminated machinery and piping is improved and ongoing contamination from drips and seepage is minimized.

Appendix F

Suggested Cleaning Methods for Liquid Hydrocarbons (fuels, oils) and Semi-solids (greases)

Tanks

Methods for cleaning tanks include but are not limited to:

- Mechanical Cleaning: Mechanical cleaning involves mechanical removal of sludge and remaining fluids and wiping down all surfaces with oil absorbent material. Although manpower intensive, this cleaning method limits the spread of contamination and does not require large volumes of fluids that are expensive to dispose.

- Steam or Hot Water Cleaning: This method is quite effective, although it requires special equipment and generates large volumes of oily water. If this method is considered, a plan should be developed so that oily water generated during this cleaning method is dealt with in accordance with all applicable regulations. Surfactants or soaps are not recommended, as they tend to emulsify any oil present and make the oily water exceptionally difficult to treat. This would likely create higher disposal costs. In tanks where deckheads and sides are reasonably free of contamination, pressure washing can cause significant contamination of these otherwise clean surfaces through splashing, misting, and carry-over.

- Solvent Washing: Solvent washing may be an option where there are especially difficult residuals or deposits that need removal. Note that the use of solvents will require special handling and disposal of all liquid product generated as wastes.

In rare cases, especially where low-grade fuels have been stored, it may be necessary to resort to advanced tank cleaning methods such as ultrasonic or special solvents. It may also be advantageous to use a combination of several different methods, depending on the nature and location of the contamination. In general, mechanical cleaning would be the first method to try, followed by steam/hot water washing, then solvent washing in extremely difficult situations. Whatever method is selected, the effluent and water should be collected and treated. Large volumes will require the services of a pumper truck or barge, while smaller quantities should be collected and stored in drums and removed from the vessel. Caution should be used during all transfer operations to avoid spills. If transferring large quantities of oil or oil contaminated liquid, a boom around the vessel should be used to minimize the extent or spreading of a release.

Fuel and Oil Pipe Fittings, Piping with Manifolds, and Filling Points

Filling points: All filling stations or deck fittings that were used for receiving fuels, oils or other hydrocarbons should be opened and cleaned. Access to the filling stations and deck fittings is necessary to ensure that they are completely drained and free of hydrocarbons. This will typically require access from the bottom and the top.

Fuel and Oil Piping Including Manifolds: Fuel and oil piping (including non-segregated ballast systems) should be drained of all product. The cleaning and opening of pipes

varies according to the type of product that was contained in the lines. In general, the more viscous the product, the more opening of pipes and cleaning activity will be required. For very viscous products (e.g., No. 6 fuel oil or Bunker C fuel as described in the "Oil and Fuel" section of this document), all piping and fittings should be fully opened for visual inspection.

Vertical piping runs should have all valves completely opened and any blanking flanges or spectacle plates removed for cleaning. Horizontal piping runs should be opened at low spots. Once draining of piping systems is completed, no visual evidence of hydrocarbon weeping should exist at openings.

Fuel and Oil Piping Fittings: Fittings consist of valves, site glasses, coolers, siphon breakers, and filters. A visual examination of internals, or a cut through the lowest point of the fitting may be useful. Where fittings are of complex construction or have more than one oil-tight compartment (as in coolers), then access to all sub-compartments or components may be necessary. No visual evidence of hydrocarbon weeping should exist at openings.

Unless the piping is clearly identified as being part of a non-hydrocarbon system or there is clear evidence to indicate that the system was not part of a hydrocarbon containing system (e.g., seawater piping to coolers, fresh water piping to domestic spaces), it should be assumed that the piping contained hydrocarbons. Fittings should be cleaned, or removed from the vessel.

Bilge Compartments and Piping

All piping that runs through the bilge areas of machinery spaces should be assumed to be contaminated by hydrocarbons until proven otherwise. Piping in bilge spaces should follow the clean-up suggestions as presented in the subsection above entitled "Fuel and Oil Piping Including Manifolds."

Combustion Engines

Structure: Remove access panels, explosion doors, handhold doors, maintenance panels, gear covers, bearing covers/retaining plates, as necessary to remove oil. Visible oil should be removed from all internal components. The surrounding and support structure should be made accessible for inspection, especially the area under the engine. At least one main bearing should be opened to determine if the design allows oil to be trapped, thereby indicating whether all bearings should be opened and cleaned.

Fuel System: All fuel system components should be cleaned or removed from the engine. These include injectors, carburetors, supply, distribution and return lines, filters, pumps, relief valves, pressure regulating mechanisms, governors, and heat exchangers. Removal of these items will prevent fuel seepage from their connections. If these items are to be sunk with the vessel, they should be opened, cleaned, and prepared for inspection.

Lubricating Oil System: Lubricating oil sumps should be drained and opened for cleaning and visual inspection. This may require that additional access openings be made. All lubricating oil piping, both internal and external to the engine, should either be removed or drained. Lubricating oil system components should either be cleaned or removed from the vessel. Internal oil gallery plugs should be removed. Pedestal and thrust bearings should be drained. Engine driven oil pumps should be pulled or cleaned. Engine oil filling and dirty oil drainage arrangements should be removed or cleaned.

Other Systems: Other components and systems susceptible to contamination with hydrocarbons (e.g., superchargers, turbochargers, air filters) should be examined visually and cleaned if hydrocarbons are present.

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