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Cruise Ship Discharge Assessment Report

Section 4: Oily Bilge Water

December 29, 2008

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Oily bilge water is the mixture of water, oily fluids, lubricants, cleaning fluids, and other similar wastes that accumulate in the lowest part of a vessel from a variety of different sources including engines (and other parts of the propulsion system), piping, and other mechanical and operational sources found throughout the machinery spaces of a vessel. On most cruise ships, oily bilge water can be managed in one of two ways: (1) retained onboard in a holding tank and discharged later to a reception facility on shore, or (2) treated onboard with an Oily Water Separator (OWS) after which the treated bilge water can be discharged overboard in accordance with applicable standards and regulations.

This section discusses the current state of information about bilge water, the laws regulating bilge water discharges from vessels, the types of equipment used to treat bilge water generated on cruise ships, the potential environmental impacts of cruise ship bilge water, and federal actions taken to address bilge water from cruise ships. The conclusion of this section lists a wide range of options and alternatives that could be considered when addressing oily bilge water from cruise ships.

4.1 What is bilge water and how much is generated on cruise ships?

Bilge water is the mixture of water, oily fluids, lubricants, cleaning fluids, and other similar wastes that accumulate in the lowest part of a vessel from a variety of different sources including the main and auxiliary engines; boilers, evaporators and related auxiliary systems; equipment and related components; and other mechanical and operational sources found throughout the machinery spaces of a vessel. It is not uncommon on ships for oil or water to leak into the bilge from these sources, various seals, gaskets, fittings, piping, connections, and from related maintenance and activities associated with these systems. These leaks, along with onboard spills, wash waters generated during the daily operation of a vessel, and waste water from operational sources (e.g., condensate from air coolers, etc.), collect in the bilge.

Machinery spaces onboard cruise ships are complex power plants used to develop propulsion energy, electrical energy, and fresh water, as well as manage sewage and other wastes generated throughout the vessel. The machinery spaces onboard are very large and are not too different from shore side power plants. Cruise ship machinery spaces consist of tanks, pumps, fittings, flanges, valves, control valves, and literally thousands of miles of piping and tubing, all used to manage the various fluids within the different systems. Although this menagerie of systems is designed to be leak free, many leaks develop due to lack of maintenance and repair of failed seals, gaskets, pump shaft seals, machinery casing gaskets and other components. The sizes of these leaks may vary tremendously and the size may be measured in ounces per minute or gallons per minute, depending on the severity of the leak. Further, the type of fluid leaked may vary, resulting in a complex mixture of fluids in the vessel's bilge. This mixture can be difficult to separate and the oil content may be difficult to monitor with some of the best equipment. Bilge water is the most common source of oil pollution from cruise ships (National Association of Attorneys General, 2000).

In addition to containing oil and grease, bilge water may contain solid wastes such as rags, metal shavings, paint, glass, and a variety of chemical substances (U.S. Environmental Protection Agency, 1997). Bilge water may contain various oxygen-demanding substances, volatile organic compounds, semi-volatile organics, inorganic salts, and metals. Bilge water also may contain other contaminants such as soaps, detergents, dispersants, and degreasers used to clean the engine room. These cleaning agents create an emulsion and prevent separation of oil and water. Moreover, they are often incompatible with Oily Water Separators and Oil Content Monitors. Due to the various sources that contribute to the production of bilge water, the composition of bilge water varies from vessel to vessel, and from day to day. Other waste streams discussed in this Assessment Report, such as sewage and graywater (see Sections 2 and 3, respectively), are typically contained within their own systems and might only be present in bilge water as a result of leaks.

The amount of bilge water that accumulates onboard can vary, and depends on a number of factors including the size of the ship, engine room design, preventative maintenance, and the age of the components. Accumulation of bilge water is ongoing and needs to be properly managed, because if too much accumulates, it can cause damage to the propulsion systems and ancillary machinery on the vessel, as well as present a fire hazard and impact the vessel's stability. Periodically, it is necessary to pump out the bilge spaces into a holding tank, which allows the vessel to maintain stability and eliminates potentially hazardous conditions from the accumulation of bilge water on the tank tops within the machinery spaces.

Large vessels such as cruise ships have several additional waste streams that contain sludge, waste oil, and oily water mixtures, including fuel oil sludge, lubricating waste oil, and cylinder oil, that can inadvertently find their way to the bilge. Sludge is produced by the constant purification of fuel, for the removal of contaminants improves low quality fuels and prevents damage to the ship's engines and highly machined components. As the fuel is purified by centrifuges virtually continuously, the contaminants removed by the oil purifiers eventually drain into a sludge tank. Lubricating oil needed for the ship's engines are processed in the same fashion – removing various solids, water, and byproducts of combustion that contaminate the oil. Cylinder oil comes from the oil injected along the cylinder walls in the engine and contains contaminants from the combustion process. All of these waste oils are typically drained to individual drain tanks and ultimately to a common sludge tank. The production of sludge derived from the fuel oil, unlike sludge derived from bilge water, remains fairly constant and is usually at least 1-2% of the heavy fuel oil consumed onboard. Among the impurities separated out by the purifiers are water and oily water.

Most often sludge and bilge water systems are separate. However, management practices on some ships may lead to cross contamination of the bilge water from the sludge tank. For example, if the same pumps and manifolds are used for transferring both sludge and bilge water, there may be residual sludge and oil in the pipes from sludge when that system is then used for the bilge system. Also, if the oily water from the sludge tank is removed and decanted to the bilge water holding tank, it may also bring with it greater concentrations of oil and sludge particles.

The Alaska Department of Environmental Conservation (2000) reported that cruise ships operating in Southeast Alaska produced 1,300 to 5,300 gallons of bilge water every 24 hours. Table 4-1 shows the bilge water production and treatment capacities based on ship tonnage.

Table 4-1. Maximum Daily Volume of Bilge Water Production

Ship Tonnage (Gross Tons)	Passenger and Crew Capacity	Bilge Water Production (max. gallons/day)	Bilge Water Treatment Capacity (max. gallons/day)
22,000	1,100	1,000	5,000
46,000-48,000	1,500-2,160	3,000	4,000
50,700-55,400	1,850-2,380	5,000	5,000
76,000-78,000	2,700-3,200	2,640	6,400

Source: ADEC, 2000

It should be noted that although there could be a proportional relationship between ship tonnage and bilge water produced, many variables exist that can easily cause a smaller vessel to produce more bilge wastes than a larger vessel. For example, a vessel with just six small 1/8 inch size leaks and four ¼ inch leaks without substantial pressure behind them can produce over 1.43 millions gallons per year or the equivalent of 15 metric tons per day. Bilge ingress values or total accumulations can vary widely across a fleet of sister vessels simply due to one or a few mechanical concerns.

4.2 What federal laws apply to bilge water from cruise ships?

4.2.1 International Convention for the Prevention of Pollution from Ships and the Act to Prevent Pollution from Ships

The International Convention for the Prevention of Pollution from Ships (MARPOL)
MARPOL Annex I, *Regulations for the Prevention of Pollution by Oil,* addresses oil pollution and lists oil prevention requirements for machinery spaces on all ships covered by the Convention and provides requirements for cargo areas of oil tankers. The requirements of MARPOL Annex I cover all petroleum products, including crude oil, fuel oil, oily waste, oily mixtures located in the bilge, and petroleum products in cargo spaces of oil tankers. In 1983, the United States ratified MARPOL Annex I.

The Act to Prevent Pollution from Ships (APPS)
The Act to Prevent Pollution from Ships (APPS; 33 U.S.C. § 1901 et seq.) is the federal law implementing those provisions of MARPOL that have been ratified by the United States. With respect to implementation of Annex I, APPS applies to all U.S. flagged ships anywhere in the world, and to all foreign flagged vessels operating in the navigable waters of the United States. Violations of APPS or MARPOL may lead to detention of the vessel in port, denial of port entry, or the initiation of civil or criminal enforcement proceedings.

Applicable Coast Guard regulations

The Coast Guard generally has the primary responsibility to prescribe and enforce the regulations necessary to implement APPS in the United States. The following Coast Guard regulations pertain to the management of the discharge of oil or oily mixtures into the sea from ships[1]:

- Coast Guard regulations (33 CFR 151.10) provide that, when within 12 nautical miles (nm) of the nearest land, any discharge of oil or oily mixtures into the sea from a ship is prohibited except when all of the following conditions are satisfied:
  - (1) The oil or oily mixture does not originate from cargo pump room bilges;
  - (2) The oil or oily mixture is not mixed with oil cargo residues;
  - (3) The oil content of the effluent without dilution does not exceed 15 parts per million (ppm);
  - (4) The ship has in operation oily-water separating equipment, a bilge monitor, bilge alarm, or combination thereof, as required by Part 155 Subpart B; and
  - (5) The oily-water separating equipment is equipped with a 15 ppm bilge alarm; for U.S. inspected ships, approved under 46 CFR 162.050 and for U.S. uninspected ships and foreign ships, either approved under 46 CFR 162.050 or listed in the current International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC) Circular summary of MARPOL approved equipment.

- Coast Guard regulations (33 CFR 151.10) provide that, when more than 12 nm from the nearest land, any discharge of oil or oily mixtures into the sea from a ship is prohibited except when all of the following conditions are satisfied:
  - (1) The oil or oily mixture does not originate from cargo pump room bilges;
  - (2) The oil or oily mixture is not mixed with oil cargo residues;
  - (3) The ship is not within a special area;
  - (4) The ship is proceeding en route;
  - (5) The oil content of the effluent without dilution is less than 15 ppm; and
  - (6) The ship has in operation oily-water separating equipment, a bilge monitor, bilge alarm, or combination thereof, as required by Part 155 Subpart B.

  Additional Coast Guard regulations (33 CFR 151.13) prohibit the discharge of oil or an oily mixture within MARPOL special areas unless the above requirements are met and the vessels oily-water separating equipment is equipped with a device that stops the discharge automatically when the oil content of the effluent exceeds 15 ppm.

  Further, Coast Guard regulations (33 CFR 151.10) provide that if the bilge water cannot be discharged in compliance with these standards, then it must be retained onboard or discharged to a designated reception facility. However, both MARPOL and the APPS regulations exempt emergency discharges needed to save the ship or save a life at sea.

[1] Sections 151.09 through 151.25 of the Coast Guard regulations at Chapter 33 CFR do not apply to: 1) a warship, naval auxiliary, or other ship owned or operated by a country when engaged in noncommercial service; 2) a Canadian or U.S. ship being operated exclusively on the Great Lakes of North America or their connecting and tributary waters; and 3) a Canadian or U.S. ship being operated exclusively on the internal waters of the United States and Canada; or 4) any other ship specifically excluded by MARPOL.

Emergency discharges or other exceptional discharges must nevertheless be accurately recorded in ship records and reported to the nearest port state or Coast Guard Captain of the Port.

- In addition, Coast Guard regulations (33 CFR 151.25) provide that vessels of 400 gross tons and above shall fully maintain an Oil Record Book Part I (Machinery Space Operations) and vessels of 150 gross tons and above that carry 200 cubic meters or more of oil in bulk shall also maintain an Oil Record Book Part II (Cargo/Ballast Operations). The Oil Record Book is subject to routine inspection by the Coast Guard. (33 CFR 151.23; 151.25(g)). In pertinent part, the APPS regulations require:

  (a) Each oil tanker of 150 gross tons and above, ship of 400 gross tons and above other than an oil tanker, and manned fixed or floating drilling rig or other platform shall maintain an Oil Record Book Part I (Machinery Space Operations). An oil tanker of 150 gross tons and above or a non oil tanker that carries 200 cubic meters or more of oil in bulk, shall also maintain an Oil Record Book Part II (Cargo/Ballast Operations).

  * * *

  (d) Entries shall be made in the Oil Record Book on each occasion, on a tank to tank basis if appropriate, whenever any of the following machinery space operations take place on any ship to which this section applies--

  (1) Ballasting or cleaning of fuel oil tanks;

  (2) Discharge of ballast containing an oily mixture or cleaning water from fuel oil tanks;

  (3) Disposal of oil residue; and

  (4) Discharge overboard or disposal otherwise of bilge water that has accumulated in machinery spaces.

  * * *

  (g) In the event of an emergency, accidental or other exceptional discharge of oil or oily mixture, a statement shall be made in the Oil Record Book of the circumstances of, and the reasons for, the discharge.

  (h) Each operation described in paragraphs (d), (e) and (f) of this section shall be fully recorded without delay in the Oil Record Book so that all the entries in the book appropriate to that operation are completed. Each completed operation shall be signed by the person or persons in charge of the operations concerned and each completed page shall be signed by the master or other person having charge of the ship.

  (i) The Oil Record Book shall be kept in such a place as to be readily available for inspection at all reasonable times and shall be kept onboard the ship.

  (j) The master or other person having charge of a ship required to keep an Oil Record Book shall be responsible for the maintenance of such record.

MARPOL contains additional requirements on what information must be recorded in an Oil Record Book, including the details of overboard discharges of "bilge water which has accumulated in machinery spaces"[2] (MARPOL, Annex I, Appendix III(D)). MARPOL also requires the logging of any failure of the oil discharge monitoring and control equipment (Id. at Appendix III(F)). MARPOL also requires that any accidental or other "exceptional" discharge be recorded in the Oil Record Book (Id. at Appendix III(G)). In short, cruise ships must maintain an accurate record of overboard discharges per this requirement.

4.2.2 Oil Pollution Act and Clean Water Act

The Oil Pollution Act of 1990 (OPA; 33 U.S.C. § 2701 et seq.) is a comprehensive statute designed to expand oil spill prevention, preparedness, and response capabilities of the federal government and industry. It amends section 311 of the Clean Water Act (CWA; 33 U.S.C. § 1321) to clarify federal response authority, increase penalties for spills, establish Coast Guard response organizations (including elements of the National Strike Force, district response advisory staff, Coast Guard personnel, and equipment of ports within the district), require tank vessel and facility response plans, and provide for contingency planning in designated areas. CWA section 311, as amended by OPA, applies to cruise ships and prohibits discharge of oil or hazardous substances in harmful quantities into or upon U.S. navigable waters, or into or upon the waters of the contiguous zone, or which may affect natural resources in the U.S. Exclusive Economic Zone (which extends 200 miles offshore).

EPA regulations (40 CFR 110.3) provide that for the purposes of section 311(b)(4) of the CWA, discharges of oil in quantities that the Administrator has determined may be harmful to the public health or welfare or the environment of the United States include discharges of oil that:

- violate applicable water quality standards, or

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[2] The MARPOL Protocol, Annex I, Appendix III, in pertinent part requires logging of the following information:

(D) Non-automatic discharge overboard or disposal otherwise of bilge water which has accumulated in machinery spaces

13. Quantity discharged or disposed of.
14. Time of discharge or disposal (start and stop).
15. Method of discharge or disposal:
    - .1 through 15 ppm equipment (state position at start and end);
    - .2 to reception facilities (identify port);
    - .3 transfer to slop tank or holding tank (indicate tank(s); state quantity transferred and the total quantity retained in tank(s).

* * *

(F) Condition of oil discharge monitoring and control system

20. Time of system failure.
21. Time when system has been made operational.
22. Reasons for failure.

* * *

(G) Accidental or other exceptional discharges of oil

23. Time of occurrence.
24. Place or position of ship at time of occurrence.
25. Approximate quantity and type of oil.
25. Circumstances of discharge or escape, the reasons therefore and general remarks.

- cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines, or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.

4.2.3 National Marine Sanctuaries Act

The National Marine Sanctuaries Act (NMSA; 16 U.S.C. § 1431 et seq.), as amended, established a national program to designate certain areas of marine environments as areas of special national significance that warrant heightened care. The primary purpose of the law is to protect marine resources and ecosystems, such as coral reefs, sunken historical vessels, or unique habitats, from degradation while facilitating public or private uses compatible with resource protection.

NMSA authorizes the National Oceanic and Atmospheric Administration (NOAA) to designate as National Marine Sanctuaries areas of the marine environment that have special aesthetic, ecological, historical, or recreational qualities, and to provide comprehensive and coordinated conservation management for such areas. The National Marine Sanctuary Program manages 13 sanctuaries and the Papahānaumokuākea Marine National Monument (together referred to as "sites"). Designated sites are managed according to site-specific management plans developed by NOAA that typically prohibit by regulation the discharge or deposit of most material. Under NOAA's implementing regulations for NMSA, regulations for most sites allow for discharges incidental to the normal operation of a vessel but exclude oily wastes from bilge pumping. Since the regulations do not specify a limit, this has been interpreted as prohibiting any detectable amount of oil.

4.3 What technologies are available to manage oily bilge water from cruise ships?

In order to maintain vessel stability and eliminate potentially hazardous conditions from the accumulation of bilge waste, it is necessary to periodically pump out the bilge spaces into a holding tank. The bilge water then can be managed in one of two ways: (1) retained onboard in a holding tank and discharged later to a reception facility on shore; or (2) treated onboard with an Oily Water Separator (OWS). The treated bilge water then can be discharged overboard in accordance with applicable standards and regulations while the petroleum products extracted by the OWS (i.e., oily waste) are retained in a dedicated holding tank onboard (and later could be incinerated and/or off-loaded in port). The international standard established by MARPOL Annex I, and implemented into United States law by APPS, is that machinery space waste including bilge water may be discharged overboard if it contains a concentration of 15 ppm oil or less, and, for ships beyond the 12 nm limit, provided that the ship is underway. MARPOL and APPS also require that the discharge be made through 15 ppm equipment, namely an OWS and Oil Content Monitor; this equipment must be fitted with the appropriate alarms and stopping devices for ships to discharge in special areas.

The holding tank may contain other oily water mixtures including decanted water from the fuel and lubricating oil sludge tanks. In addition to removing the waste from the bilge area, a holding tank can allow for some separation of the oil and water. Bilge water may be discharged

overboard after processing by an Oily Water Separator and passing through a bilge alarm, more commonly known as an Oil Content Monitor that is designed to detect when the effluent exceeds an oil content of greater than 15 ppm. The required pollution prevention equipment also includes an automatic stopping device (typically a three-way solenoid valve) that when triggered by the Oil Content Monitor, will automatically divert the oily water mixture back into a holding tank. APPS and MARPOL define machinery space waste as an oily water mixture.

The amount of machinery space waste, as mentioned above, may be reduced through the use of water-lubricated shaft bearing systems. While traditional propeller shaft bearing systems use oil as a lubricating and cooling medium, water-lubricated propeller shaft bearing systems use seawater instead of oil. This substitution can have benefits should a ship experience a shaft bearing leak, for instead of potentially leaking oil, seawater would be leaked. Depending on where the failure in the propeller shaft bearing system occurs, the use of water-lubricated systems can potentially reduce the potential for oily waste mixtures to leak into the bilge. Water-lubricated shaft bearing systems are currently installed on a number of Carnival's larger ships (Carnival Corporation and PLC, 2006).

Under MARPOL, all ships over 400 gross tons are required to have equipment installed onboard that limits the discharge of oil into the oceans to 15 ppm when a ship is en route. Such ship equipment allows for compliance with both international regulations (MARPOL) and Coast Guard regulations that require the oil content of the discharged effluent to be less than 15 ppm and that it not leave a visible sheen on the surface of the water. Regulations also require that all oil or oil residues that cannot be discharged in compliance with these regulations, be retained onboard or discharged to a reception facility.

Conventional bilge water systems use an OWS to remove oil to meet regulatory standards prior to discharge. These systems use the techniques of centrifugal force, coalescence, gravity, and other methods to isolate oil from water (Table 4-2 describes some OWS technologies). The management of bilge water by most vessels consists of the following steps:

1) Bilge water is pumped into a holding tank, which is usually of sufficient size to hold the water for several days.
2) Bilge water is processed by an OWS to extract oil and petroleum products from the bilge water. Different cruise ships may use different types of OWS (e.g., centrifugal, filtration, and gravity based systems).
3) The treated bilge water from the OWS is discharged overboard provided that the OWS is certified by the Coast Guard, using International Standards Organization 9377-2:2000; the discharge does not have an oil content of greater than 15 ppm; and the discharge does not leave a visible sheen on the surface of the water.
4) All oil or oil residues that cannot be discharged in compliance with the abovementioned requirements – generally the oily waste collected by the OWS – is retained in a holding tank until it can be incinerated onboard or off-loaded to a land-based treatment facility (CELB, 2003).

Table 4-2. Oily Water Separator Technologies

Description/Capabilities of OWS Devices	Processing Capacity
– Removes oil and grease using naturally-occurring microbes – Continuous monitoring of hydrocarbons in effluent – Typically reduces oil content to 1-5 ppm	Up to 5400 gallons/day)
– Designed to separate and remove free and emulsified oil – System can treat bilge and sludge – Oil content meter (bilge alarm calibrated to measure 15 ppm oil content)	12 - 24 m^3/day (or 53 - 106 gallons/day)
– Utilizes fluid velocity reduction, differential specific gravity, and coalescences to separate nonsoluble oil, solids, and entrained air from oily water; uses ultra-filtration membranes – Provides efficient removal or reduction of oil content to less than 5 ppm	Up to 44 gallons/minute
– High-speed centrifugal separation system for treatment of large bilge water volumes at sea – Generally reduces oil content to below 5 ppm – Continuous operation (24 hours/day)	Approximately 400 - 1320 gallons/hour

Sources: EnSolve, 2008(a and b); Senitec, 2006 and 2008; Coffin World Water Systems, 2008; Alfa Laval, 2008

All vessels are required to have a bilge alarm or bilge monitor integrated into the piping system to detect whether the treated bilge water that is being discharged from the oily water separator has turbidity levels calibrated to be equivalent to samples containing an oil content greater than 15 ppm. If the monitor senses that the oil in the bilge water exceeds 15 ppm, the system is required to stop the overboard discharge and divert the effluent back to a holding tank. Any bilge water found to contain oil or oil residues with an oil content greater than threshold levels must be retained onboard or discharged to a designated reception facility. According to the Center for Environmental Leadership in Business (CELB) (2003), several cruise lines now often use two oily water separators to assure that effluent levels meet or exceed the 15 ppm limit. Also, California's multi-agency Cruise Ship Environmental Task Force Report to the Legislature (2003) identified some of the more modern oil water separator systems that include a series of filters to further scrub oil from the bilge water prior to discharging. As mentioned earlier, all discharges from the OWS system are required to be logged in the cruise ship's oil record log book.

California's Cruise Ship Environmental Task Force Report (2003) identified the following potential problems associated with OWS systems:

- Data recorders can be manipulated or shut off and not record all discharges;
- Oil-water interface detectors (oil content monitor) can easily get out of calibration and allow more oil to be discharged than legally allowed;
- Piping systems can be re-routed to bypass the oil-water detectors;
- Substances such as cleaning solvents are not removed from bilge water and are routinely discharged with the liquids into the ocean; and
- Bilge water tanks are used to dispose of other hazardous materials, both liquids and solids, illegally because the bilge alarm/bilge monitor will not detect these other substances.

In an attempt to improve the integrity of Oily Water Separators, as of 2007 a number of cruise lines have purchased a bilge water processing system "White Box" (Marinfloc AB, 2007a). The "White Box" is a proprietary system considered to be a tamper resistant fail-safe for overboard discharges of processed bilge water, serving as the final monitoring and control device through which processed bilge water passes prior to discharging overboard. The "White Box" System basically includes the pressure control valve, oil content meter, flow control box, 3-way valve, flow meter, flow switch, 3-way rinse valve, and a recorder (Marinfloc AB, 2005). All the equipment is built into a lockable cabinet. The system monitors the oil content in the water from the oily water separator or bilge water cleaning system. When the water from either of these systems is clean enough for discharge, a valve is opened and the water is pumped overboard. Before the water is discharged, it passes through a flow meter with a pulse transmitter connected to the recorder which records and stores the following information (Marinfloc AB, 2006a):

- time when the overboard pumping starts;
- oil content meter level over a discharge cycle;
- total quantity of water pumped overboard in a discharge cycle; and
- time when the overboard pumping stops.

Further, the "White Box" can be supplied with a more sophisticated recorder that enables the ship's position and course to be recorded as well (Marinfloc AB, 2006a). According to the Carnival cruise line's Environmental Management Report (Carnival Corporation and PLC, 2006), all Carnival ships route all bilge water destined for overboard discharge, including that stored in clean bilge water holding tanks, through a bilge water processing system "White Box."

The "White Box" is one of many commercially available control technologies designed to make bypassing more difficult. Other ideas are relatively simple, such as placing a unique number tag on every overboard flange in order to prevent unauthorized discharges or locking the overboard valve. Any technological solution to deter deliberate pollution, however, remains subject to compromise by an engineer determined to circumvent treatment. Other means to treat oily wastes in bilge water that are being explored include electro-chemical flocculation, biological digestion, membrane polishing, oil absorption, and incineration (Bryant, 2001).

A number of cruise lines have purchased equipment that breaks emulsions in oily bilge water (Marinfloc AB, 2007b). Cleaning agents, emulsifiers, solvent, or surfactants used for cleaning purposes may cause bilge water to emulsify. As stated in MEPC 107(49), "with the possibility of emulsified bilge water always present, the 15 ppm Bilge Separator must be capable of separating the oil from the emulsion to produce an effluent with an oil content not exceeding 15 ppm." The use of an emulsion breaking bilge water cleaning system can help achieve this. After free oil is separated from preheated oily bilge water, the remaining emulsified bilge water is directed to a circulation tank where a flocculent and small amount of service air is fed into the water at which point a circulation pump causes mixing. Flocks are then skimmed off, and the remaining water goes through a number of filtering stops. The effluent water from the emulsion breaking bilge water cleaning system then passes through the OWS monitor. Bilge water less than 15 ppm can be discharged accordingly; bilge water exceeding 15 ppm is returned to the bilge water holding tank or settling/primary tank. (Marinfloc AB, 2006b).

Under the Cruise Lines International Association (CLIA) member agreement identified earlier, bilge and oily water residue should be processed prior to discharge to remove oil residues, such that oil content of the effluent is less than 15 ppm as specified by MARPOL Annex I. In accordance with MARPOL Regulation 20 and U.S. regulations (33 CFR 151.25) as appropriate, CLIA member lines report that they have agreed that every cruise ship of 400 gross tons and above shall be provided with an oil record book which shall be completed on each occasion whenever any of numerous specified operations take place on the ship. Those operations include the following (CLIA, 2006):

a. ballasting or cleaning of fuel oil tanks;
b. discharge of dirty ballast or cleaning water form the fuel oil tanks above;
c. disposal of oily residues; and
d. discharges of bilge water that accumulated in machinery spaces.

4.4 What are the potential environmental impacts associated with inadequately treated bilge water from cruise ships?

In an examination of oil pollution in the marine environment, the Urban Harbors Institute (2000) indicates that about 70% of such oil pollution is due to chronic pollution from municipal and industrial wastes or runoff, dumping of waste oil, release of oily bilge water, and from other-than-tanker transportation. Bilge water is the most common source of oil pollution from cruise ships (National Association of Attorneys General, 2002). Cruise ships have the potential to create oil pollution through discharges of inadequately treated oily bilge water as a result of a faulty or malfunctioning OWS, human error, malfunctioning bilge monitors, or a deliberate OWS bypass.

The impacts from oil pollution can vary depending upon numerous factors. The Port of Cordova, Alaska, has produced educational materials for harbor and non-harbor users explaining that "one pint of spilled oil can cause a sheen over an acre of water and kill the marine organisms that live on the surface" (Urban Harbors Institute, 2000). The National Research Council (2003) states that the effect of a release of petroleum is not directly related to the volume, rather the effect is a "complex function of the rate of release, the nature of the released petroleum (and the proportions of toxic compounds it may contain), and the local physical and biological ecosystem exposed." Other factors include the season, weather conditions, and the surrounding environment. Consequently, even a small spill at the wrong place, at the wrong time can result in significant damage to individual organisms or entire populations.

Oily bilge water may contain emulsified oil and grease, diesel, hydraulic oil, lube oil, and a full range of marine fuel oils. Oil is composed of thousands of compounds in varying quantities; some oils are more harmful to the environment and more toxic than others. The toxicity of many of the individual compounds contained in petroleum can be significant, and even small releases can kill or damage organisms from the cellular- to the population-level (National Research Council, 2003). Recent studies suggest that polycyclic aromatic hydrocarbons (PAHs), even in low concentrations, can have a deleterious effect on marine biota. PAHs are known human carcinogens and occur in varying proportions in crude oil and refined products (National Research Council, 2003). Environment Canada (2006) further indicates that the different

physical and chemical properties of crude and refined oils influence the physical and biological effects of an oil spill, the behavior of a slick, and the effectiveness of clean-up operations.

Lighter petroleum products, such as gasoline or diesel fuels, can dissipate and evaporate quickly but are highly toxic and create severe environmental impacts. In contrast, the medium and heavier oils do not evaporate, and therefore may require intensive structural and shoreline cleanup. Although heavier oils are less toxic than light oils, the heavy oils can harm waterfowl and fur-bearing mammals through coating and ingestion. Also, heavy oils can sink and create prolonged contamination of the sea bed and create tar balls that can scatter along beaches. (U.S. Government Accountability Office, 2007).

Table 4-3 provides a description of oil types and the interactions that occur when such oil types are released into the marine environment. This table does not take into account the fact that bilge waste is a mixture of different oils and frequently contains an emulsion due to the use of surfactants and degreasers such as soap. Surfactants and degreasers, which are often incompatible with the proper use of pollution prevention equipment, may also have an impact on the introduction of oil into the marine environment.

Table 4-3. Description of Oil Types and the Interaction When Released into the Marine Environment

Oil Type	Removal and Response	Environmental Impact
Very light oils (jet fuels, gasoline)	Highly volatile (they will evaporate within 1-2 days). It is rarely possible to clean up the oil from such spills.	Highly Toxic: Can cause severe impacts to shoreline resources.
Light oils (diesel, no. 2 fuel oil, light crudes)	Moderately volatile, but will leave a residue after a few days. Clean-up can be very effective for these spills.	Moderately Toxic: Has the potential to create long-term contamination of shoreline resources.
Medium oils (most crude oils)	Some oil (about one-third) will evaporate in 24 hours. Clean-up is most effective if conducted quickly.	Less Toxic: Oil contamination of shoreline can be severe and long-term, and can have significant impacts to waterfowl and fur-bearing mammals.
Heavy oils (heavy crude oils, No. 6 fuel oil, bunker C fuel)	Little or no oil will evaporate. Clean-up is difficult.	Less Toxic: Heavy contamination of shoreline resources is likely, with severe impacts to waterfowl and fur-bearing mammals through coating and ingestion.

Source: U.S. Government Accountability Office, 2007

When considering the types of fuels and oils that cruise ships use, the California Cruise Ship Environmental Task Force Report (2003) indicates that cruise ships generally run their main engines on intermediate fuel (IFO 180 or IFO 380). This fuel is also referred to as "bunker fuel" and requires heating to reduce its viscosity in order to be properly atomized and combusted. The California Cruise Ship Environmental Task Force Report also notes that marine gas oil or a blend of marine gas oil and bunker fuel may be used by some ships during maneuvering.

According to the National Research Council (2003), the discharges from bilge water are considered to be moderate in terms of their loss by evaporation and dissolution, formation of tar balls, and potential for long-distance transport. In addition, vessel discharges pose a low risk of vertical mixing because the releases are generally viscous (National Research Council, 2003).

Oil released into the marine environment immediately begins to move and weather, breaking down and changing its physical and chemical properties. Some of these processes occur immediately after the spill, while others occur over time. Some of the processes include dissolution, sedimentation, movement, bio-degradation, evaporation, weathering, and dispersion. As these processes occur, the oil threatens surface resources and a wide range of subsurface marine organisms, which are linked in complex food chains. Some organisms may be seriously injured or killed very soon after contact with the oil in a spill, however, non-lethal toxic effects are more subtle and often longer lasting (U.S. Environmental Protection Agency, 2006).

Oil can kill marine organisms, reduce their fitness through sublethal effects, and disrupt the structure and function of marine communities and ecosystems. The chemical contaminants in oil can poison marine life, disrupt feeding, or cause chronic disease, reproductive failure and deformities – ultimately impacting the survival rates of the affected species. Contaminants concentrate in the sea surface microlayer which is an important area for the early development of many fish and other marine species with planktonic life stages. Effects of contaminants on eggs and larvae found at the sea surface in sites along U.S. coasts include mortality, malformation, and chromosome abnormalities. (Urban Harbor Institute, 2000).

Exposure of marine organisms to petroleum hydrocarbons can result in mortality due to acute toxicity or physical smothering. Additionally, possible long-term impacts include: impaired survival or reproduction; chronic toxicity of persistent components; and habitat degradation (Peterson and Holland-Bartels, 2002). Oil, even in minute concentrations, can kill fish or have various sub-lethal chronic effects (CRS, 2007), as well as severely damage coral reefs. According to the Bluewater Network (2000), ingestion of oil can kill birds or lead to starvation, disease, and predation of these animals. A Canadian study has estimated that 300,000 seabirds are killed annually in Atlantic Canada as a result of illegal discharges of oil from ships (Wiese, 2002). In that report, Wiese (2002) indicates that the analysis of oil collected from bird plumage in Atlantic Canada and the North Sea over the last 10 years showed that over 90% of the oil collected was composed of heavy fuel oil mixed with lubricant oil – the type found in bilges of large ocean-going vessels. In addition to the strong evidence for the impact of massive contamination associated with an oil spill, there is increasing evidence that chronic, low-level exposures to hydrocarbons in the sea can have a significant effect on the survival and reproductive performance of seabirds and some marine mammals (National Research Council, 2003).

According to CELB (2003), any oils that remain on the surface can interfere with larvae development and marine birds; heavier oils can sink to the bottom of the ocean and contaminate the sediment, causing potential long-term impacts to benthic habitats. According to CELB (2003), diesel fuel is acutely toxic to fish, invertebrates, and seaweed, although in open water this fuel dilutes quite rapidly. CELB (2003) further states that spills can be particularly toxic to

crabs and shellfish in shallow, confined near-shore areas because in these organisms oil bio-accumulates – often over a period of several weeks after exposure.

As stated by the Urban Harbors Institute (2000), "while overall concentrations of oil toxins from chronic sources might be lower compared to concentrations following a catastrophic spill in the marine environment, chronic pollution can be equally toxic to marine life if sustained over extended periods of time." The Urban Harbors Institute further suggests that "while contingency planning for large oil spills is important and mandated by the Oil Pollution Act, planning for the small and recurrent contributions to water quality problems from chronic sources is equally important." Chronic source contributions from cruise ships (i.e., cruise ships discharge oily bilge water treated to 15 ppm) should be considered in the context of cumulative impacts of repeated discharges because cruise ships frequently transit an established route and port destinations. In fact, the National Research Council (2003) identified that research on the cumulative effects of multiple types of hydrocarbons in combination with other types of pollutants is needed to assess the toxicity and organism response under conditions experienced by organisms in polluted coastal zones.

4.5 What action is the federal government taking to address oily bilge water from cruise ships?

The federal government's bilge water management efforts have focused on responding to oil spills and developing preventative programs. The Coast Guard is the primary federal agency responsible for monitoring and enforcing requirements for cruise ship discharges. In addition to monitoring and enforcing standards, the Coast Guard has been working with the IMO to develop new international performance standards for oil pollution prevention equipment.

The National Park Service (NPS) manages cruise ship waste streams indirectly in Glacier Bay National Park through competitively awarded concession contracts. The NPS has jurisdiction over the submerged lands and marine waters of Glacier Bay National Park up to 3 miles from the mean high tide line and including all of Glacier Bay proper. Glacier Bay is a well known, very popular attraction for the cruise ship industry in Alaska. Recent environmental reviews and decisions allow up to two cruise ship entries per day into Glacier Bay proper during the primary visitor season. Cruise ship operations in the park are authorized under concession contracts, which are awarded under a competitive solicitation and prospectus process. Impact on park resources is a general standard selection criterion for park concessions. The NPS uses waste stream management as one of a number of selection criteria in this regard. In the past, cruise ship operators have usually proposed to minimize the impact of waste streams by committing to a no-discharge policy while in the park (even if legal under applicable law) for sewage, graywater, ballast water, bilge water, cooling water, hazardous waste, and solid waste. If awarded a contract, companies must comply with their proposal. Typically cruise ships operate in the park for 8-10 hours and then depart. Cruise ships do not dock or transfer any wastes to shore while in the park.

EPA has developed a water permit program for pollutant discharges incidental to the normal operation of vessels. Under a U.S. District Court decision, the existing EPA regulations that

exclude discharges incidental to the normal operation of a vessel from Clean Water Act permitting were vacated (revoked) as of December 19, 2008. The District Court's decision to vacate that exclusion was recently upheld by the Ninth Circuit Court of Appeals. *NW. Envt'l Advocates et al. v. EPA*, 537 F.3d 1006 (9th Cir. 2008). As explained in section 1.1, as of December 19, 2008, discharges incidental to the normal operation of vessels (such as bilge water) into waters of the U.S. from cruise ships 79 feet or longer in length will be subject to National Pollution Discharge Elimination System permitting.

In a report produced by the U.S. General Accounting Office (now the Government Accountability Office) in 2000, 87 confirmed illegal discharges from foreign-flagged cruise ships in U.S. waters were identified during the period from 1991-1998. Of the 87 cases, 81 incidents involved illegal discharges of oil or oil-based products. The report indicated that about three-fourths of these cases were accidental, resulting from human or mechanical error, while the remainder were either intentional or the lack of information pertaining to the case made it difficult to determine the cause. The report also stated that a few of the 87 cases of illegal discharges involved multiple illegal discharge incidents that numbered in the hundreds over the 6-year period. (U.S. General Accounting Office, 2000.)

In an effort to curb the number of illegal oil discharges, the federal government is taking criminal enforcement actions to address violations of bilge water quality and treatment requirements. More specifically, the Coast Guard has a robust enforcement regime involving all vessels regarding violations of MARPOL Annex I. The Coast Guard conducts inspections of all cruise vessels operating in United States ports and waters quarterly and annually. These inspections typically include examination and testing of pollution prevention equipment and review of Oil Record Books. The Coast Guard works closely with the U.S. Department of Justice. Through this cooperation, criminal enforcement actions have been taken for intentional discharges of oily bilge waste. The most common violations of bilge water quality and treatment requirements include the intentional falsification of Oil Record Books to conceal the deliberate bypassing of the OWS entirely or tampering with the monitoring equipment. Tampering has included disabling or modifying the Oil Content Monitor or flushing the device with freshwater to prevent sampling of the actual effluent. Inspections of vessels have found the following problems:

- Data records that are manipulated or data recorders that are disabled;
- Poorly maintained OWS equipment and related piping systems;
- Crew error or lack of crew training;
- Bilge alarms/monitors that are out of calibration due to poor maintenance (thereby allowing bilge water discharges that exceed 15 ppm of oil);
- Piping systems that are re-routed to bypass the bilge alarms/monitors; and,
- Improper use of cleaning chemicals and surfactants which degrade OWS efficiency and conceal oil discharge sheens.

Deliberate discharges of untreated bilge water might be accompanied by efforts to deceive port state control officials by falsifying the Oil Record Book. Several port states (i.e., the country the cruise ship visits) have reacted by increasing their scrutiny of OWS systems and diligence for oil record book keeping (OECD, 2003). The U.S. is taking a lead in enforcement actions for such criminal violations. To date the U.S. has prosecuted over 75 cases involving intentional discharges of oily bilge waste from vessels in general, with over $150 million collected in

criminal fines since 2000. Many of the major cruise ship companies calling on U.S. ports have been convicted of such violations, including, Royal Caribbean, Holland America, Carnival and Norwegian Cruise Line Limited. As a result of the prosecutions, all the companies have been at one time placed on probation with a requirement to implement Environmental Compliance Plans.

4.6 Possible Options and Alternatives to Address Oily Bilge Water from Cruise Ships

Based on the public comments received on the draft of this report as well as other information gathered, listed below are a wide range of options and alternatives that address oily bilge water from cruise ships. Identification of any particular option does not imply any EPA recommendation or preference for future action, or that EPA has determined that any of these options are necessary or feasible, or that EPA believes a change to the status quo is warranted, or that EPA or any other entity has the legal authority to implement that option.

Prevention & Reduction

- Establish standards or best management practices for operation, maintenance, and/or training that will decrease the contaminants in bilge water and/or the volume of treated and/or untreated oily bilge water on cruise ships.
- Conduct research to determine the presence of hazardous wastes (other than oil) entering the bilge that will be eventually discharged, given that present treatment processes target oil.
- Encourage cruise lines to switch to water-based lubricants wherever possible to reduce total production of petroleum-based oily wastes onboard the ship.
- Conduct research on the environmental benefits of alternative lubricants, such as bio-oils, taking into account additional environmental risks and damages caused by failures of machinery and systems that use bio-oils.
- Encourage recycling of lubricants and other waste oils from oil storage systems.

Control: Discharge Standards

- States could enact laws prohibiting the discharge of any petroleum product into marine or fresh waters.
- Require the highest attainable reduction of oil concentration in bilge water through application of the best available technology economically achievable.
- Treat effluents from oily bilge water to an oil content <15 ppm en route and provided that the ship is operating outside special areas.
- Review current Coast Guard vessel inspection and enforcement programs and practices, including those applicable to oily wastewater treatment and discharge, to determine if modifications are necessary.
- Evaluate the need for increased oily water separator performance standards.
- Prohibit the addition of any hazardous waste into the bilge area to then be managed/treated as oily bilge water.
- Require more stringent standards in areas frequented by multiple cruise ships in order to adequately address cumulative impacts.

Control: Geographic Restrictions on Discharge

- Ban discharges of untreated or treated oily bilge water in all U.S. waters.
- Require discharge to proper shore-side facilities.

Enforcement & Compliance Assurance: Monitoring

- Conduct an assessment of the concentrations of metals and organic contaminants in treated bilge water to determine the presence of other pollutants in the discharge.
- Require sampling and testing of oily bilge water discharges to ensure that it meets applicable standards by:
    - government agencies with enforcement authority,
    - third-parties, and
    - cruise lines.
- Require onboard observers to monitor sampling, monitoring, and other effluent-related requirements to oversee discharging practices, equipment operation and maintenance, and the completion and submittal of accurate Oil Record Books.

Enforcement & Compliance Assurance: Reporting

- Require the installation of electronic transponders to signal land-based authorities when a waste discharge line is opened or closed.
- Require cruise ship operators to immediately notify appropriate agencies in the event of an OWS malfunction.
- Require that cruise ship operators provide advance notification from ships planning to discharge in U.S. waters.
- Require that the cruise ship operators notify all appropriate agencies of all discharges of oily bilge water.
- Publicize the APPS whistleblower provisions under 33 U.S.C. 1908(a) to passengers and crew members in order to encourage both to aid in the detection of illegal pollution by alerting authorities when witnessing activities they believe to be illegal.

Enforcement & Compliance Assurance: Inspections & Enforcement

- Revise current inspection practices to more aggressively identify noncompliant OWS equipment and include more detailed inspection of a vessel's piping system to identify rerouting of discharges to circumvent bilge monitors and alarms.
- Provide states enforcement authority to take actions when discharges occur where otherwise prohibited; require substantial penalties for violations of those laws and require the full recovery of all costs arising from enforcement of such laws.
- Establish penalties for failure to meet applicable standards and regulations pertaining to oil content in bilge water discharges.
- Establish a funding mechanism based on the polluter-pays model that will provide revenues to develop and implement a comprehensive regulatory scheme.
- Impose uniform requirements on all ships as a condition of port entry and within waters under the jurisdiction of the U.S. consistent with international law, regardless of flag state.

- Prohibit or otherwise restrict noncompliant vessels (and sister ships, depending on the degree of involvement by parent companies) from operating in sensitive areas of the marine environment under U.S. jurisdiction.

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