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Green Ships: Keeping Oceans Blue

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By Petros J. Katsioloudis

Some of today's ships can transport more than 5,000 passengers and crew and have the capacity to generate more than 11 million gallons of waste water every day.

(Credit: South African River Health Program)

Photo 1. While there are many ways that pollution finds its way into streams, rivers, and oceans, storm water drains are a major source of pollution.

The marine transport sector contributes significantly to air and water pollution, particularly in coastal areas (Capaldo et. al., 1999). In the oceans, the threat to marine life comes in various forms, such as overexploitation and harvesting, dumping of waste, pollution, alien species, land reclamation, dredging, and global climate change (Beatley, 1991).

Cruise ships, for example, are floating cities that produce enormous volumes of completely unregulated or inadequately regulated waste (Schmidt, 2000). Considering the fact that some of today's ships can transport more than 5,000 passengers and crew and have the capacity to generate more than 11 million gallons of waste water every day, as well as carry significant amounts of hazardous chemicals from onboard printing, photo processing, and dry cleaning operations, it is easy to argue their contribution to a global pollution of the environment (Schmidt, 2000).

The world's ships are primarily powered by diesel engines that consume less fuel than other propulsion systems and have replaced most of the steam turbine systems that were dominant in the 1940s (Corbett & Fischbeck, 1999). It is estimated that, annually, oceangoing ships emit 1.2–1.6 million metric tons of waste (Corbett & Koehler, 2003). Recent studies have shown an average of 15% of global nitrogen oxide and 5%–8% of global Sulfide Oxide emissions to be generated by oceangoing ships (Corbett et. al., 2007). According to a report published by the United States General Accounting Office (GAO), from 1993 to 1998 alone, cruise ships were involved in 87 confirmed cases of illegal discharges of oil, garbage, and hazardous wastes into United States waters and have paid more than $30 million in fines (GAO, 2000). In a particularly disturbing case, Royal Caribbean Cruises, Ltd. admitted to routinely dumping waste oil from several of its ships and deliberately dumping hazardous chemicals from photo-processing labs, dry-cleaning operations, and print shops into several U.S. harbors and coastal areas over a period of several years. After an extensive investigation, the company pled guilty to a total of 21 felony counts in six U.S. jurisdictions, and agreed to pay a record $18 million in criminal fines (Schmidt, 2000).

A congressional research report indicates that cruise ships carrying several thousand passengers and crew have been compared to "floating cities," and the volume of wastes that they produce is comparably large, consisting of sewage; wastewater from sinks, showers, and galleys (gray water); hazardous wastes; solid waste; oily bilge water; ballast water; and air pollution (Copeland, 2008).

Sewage

According to the Environmental Protection Agency (EPA), vessel sewage is more concentrated than domestic sewage because people on vessels use less volume of water for sanitary purposes than do people on land (EPA, 2000). The discharge of sewage from vessels into the water contributes to the degradation of the marine environment by introducing disease-causing microorganisms and excessive nutrients. Keckes (1983) indicates that sewage effluents, or municipal wastewaters as they are sometimes known, contribute to perhaps the most universal form of marine pollution. Their impact is usually on inshore waters, used for growing and/or harvesting shellfish, as well as for recreation. The effect of sewage on such filter-feeders as oysters, clams, and mussels is well known. These shellfish concentrate bacteria and viruses from sewage in the process of feeding. The consumption of raw or partially cooked shellfish that have been exposed to untreated sewage can thus lead to viral diseases such as hepatitis (Keckes, 1983).

Gray Water

Gray water from sinks, showers, galleys, and cleaning activities can contain detergents, oil and grease, and food waste; it is the largest source of liquid waste generated by cruise ships (Sweeting and Wayne 2003). An eight-day cruise can produce and dump over one million gallons of gray water into the ocean and pollute the coastal environment. Even though laws require ships to treat their wastewater, the human waste products generated and disposed of on these cruises may impact the environment. There is particular concern over cumulative environmental impacts caused by repeated visits to the same sensitive areas (USCOP 2004b), and even though the nature of the cruise-line industry depends on the health of the environment, the issue has not yet been solved. Obviously, passengers do not want to see polluted water, degraded habitat, and contaminated beaches (Sweeting and Wayne 2003); therefore, most of the companies do not pollute the environment intentionally (McCarthy, 2008). Industry standards on dumping in the oceans are set by the Cruise Lines International Association (CLIA). Members of CLIA hold themselves to high standards of waste discharge on cruise ships (McCarthy, 2008); therefore, eventually, good environmental practices will allow the industry to attract consumers who are seeking more environmentally responsible choices and force the companies that pollute the environment to stop doing so (Sweeting and Wayne 2003).

(Credit: Environmental Protection Agency)

Photo 2. Typical discharge from a seafood processing plant.

Hazardous Waste

Among several hazardous wastes that are generated on cruise ships are: dry cleaning sludge, waste from photo-processing laboratories and x-ray development (that contains silver, a toxic waste), paint waste and dirty solvents (that contain toluene, xylene, benzene, turpentine, methyl ethyl ketone, etc.), print-shop wastes (hydrocarbons, chlorinated hydrocarbons, and heavy metals), fluorescent lamp bulbs (mercury), and batteries (lead, corrosives, cadmium) (Schmidt, 2000). These toxic substances can cause scarring, death, or reproductive failure in fish, shellfish, and other marine organisms (Bruce et. al., 2000).

Solid Waste

The majority of solid waste generated on cruise ships includes large volumes of plastic, paper, wood, cardboard, food waste, cans, and glass. Much of this solid waste is incinerated onboard and the ash discharged at sea, while some is landed ashore for disposal or recycling (Schmidt, 2000). In the marine environment, the perceived abundance of marine life and the vastness of the oceans have led to the dismissal of the proliferation of plastic debris as a potential hazard (Laist, 1987). Floating plastic debris is known to have serious detrimental effects on a wide range of marine animals. Plastic can kill mammals, turtles, birds, and fish as a consequence of entanglement or ingestion. In 1975 the world's fishing fleet alone dumped into the sea approximately 135,400 tons of plastic fishing gear and 23,600 tons of synthetic packaging material (Cawthorn, 1989; DOC, 1990). The Coast Guard estimates that more than one million birds and 100,000 marine mammals die each year from eating or getting entangled in plastic debris (Schmidt, 2000).

Oily Bilge

Oil enters the marine environment from land runoff, natural seeps, vessels, pipelines, and offshore exploration and production platforms (Clark, 1992; Schmidt Etkin, 1999; Wiese et al., 2001). Vessels have contributed 64% of all accidental spills worldwide between 1978 and 1997, either through routine operations or large catastrophic spills, spilling an estimated total of 701,040 tons of oil into the marine environment (Schmidt Etkin, 1999). Research has shown that byproducts from the biological breakdown of petroleum products can harm fish and wildlife and pose threats to human health if ingested. Seabirds, for example, are the most conspicuous marine organisms and have been used as monitors of the marine environment (Montevecchi, 1993, 2001) and of the incidence of oil pollution for decades (Furness and Camphuysen, 1997).

Oil at sea is a threat to seabirds because it forms a thin layer on the ocean surface where many birds spend their time. The hydrophobic nature of oil causes plumage to readily absorb the oil, which decreases the birds' insulation, waterproofing, and buoyancy, leading to death due to hypothermia or starvation (Brown, 1990). Several types of toxic compounds in the oil, when ingested or inhaled, can also lead to debilitating or fatal effects due to their impact on internal organs (Fry and Lowenstine, 1985; Leighton, 1993; Briggs et al., 1997).

Design Initiative for Students

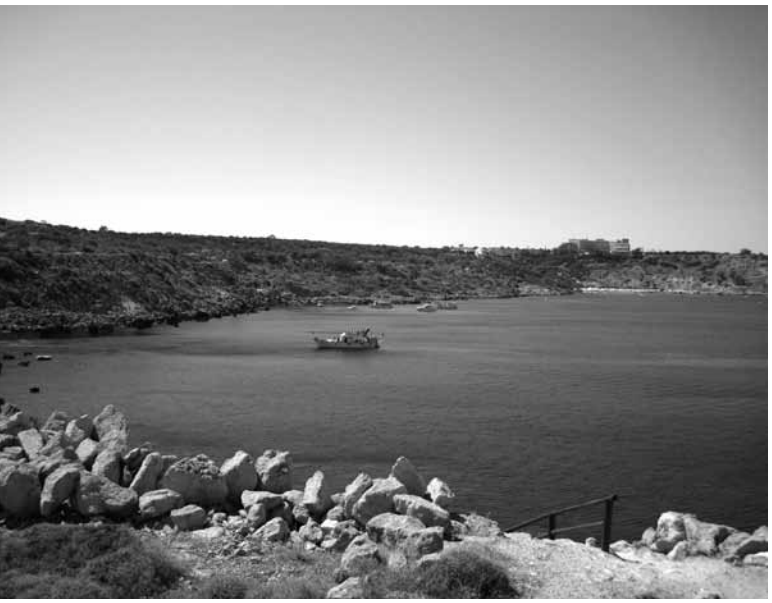
As students enter the class they will see an image of a local port after a busy morning during which several vessels have visited the area. The water and the surrounding port area are covered with a variety of plastics, land-based debris, dead birds, and fish. They will also see a shocking photograph with this caption below: "Your ignorance did this; Learn and save the environment."

After a few minutes ask the students if they know who is responsible for the mess at the port and if there is something they can do to save the habitat and keep the waters clean and healthy. Assign groups of three, where students will be responsible to investigate, conduct research, and identify problem solutions to save the environment. Once solutions are identified, they should be presented to the rest of the class, and a plan of work should be developed to solve the problem. Provide ideas such as a day trip to the port or the local beach to clean the area, or arrange a meeting with a local Coast Guard officer to discuss the issues. Introduce the students to several organizations, such as Greenpeace, and have them write letters expressing their opinions and concerns. Letters should be sent to the headquarters of Greenpeace, located at 702 H Street, NW, Washington, DC, 20001. Along with the coastal area cleaning, students can also study the underwater portion of the port with the use of an Underwater Remote-Operated Vehicle. Most Coast Guard centers own at least one unit. As an alternative, students can build a UROV themselves. For instructions on how to build a UROV on a small budget see article in *The Technology Teacher,* Volume 68, May/June 2009, entitled "Discovery of the Depths."

Activities such as the one described above are easy to correlate with technological literacy standards created by the International Technology Education Association. See Table 2 for correlations with ITEA's standards (ITEA, 2000/2002/2007).

The Nature of Technology	Technology and Society	Design
Std. 1: Students will develop an understanding of the characteristics and scope of technology.	**Std. 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology.	**Std. 8:** Students will develop an understanding of the attributes of design.
Std. 2: Students will develop an understanding of the core concepts of technology.	**Std. 5:** Students will develop an understanding of the effects of technology on the environment.	**Std. 9:** Students will develop an understanding of engineering design.
Std. 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	**Std. 6:** Students will develop an understanding of the role of society in the development and use of technology.	**Std. 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
	Std. 7: Students will develop an understanding of the influence of technology on history.	

Table 2. Correlation with *Standards for Technological Literacy.*
Adapted from the International Technology Education Association. (2000/2002/2007).



(Credit: Author)

Photo 3. Awareness, knowledge, and concern about sources of pollution and their control can go a long way toward keeping our streams, rivers, and oceans clean. Keeping the oceans clean is essential for our survival.

Summary

A famous quote of Arthur Clarke is often cited: "How inappropriate to call this planet Earth, when clearly it is Ocean." More than 70 percent of Earth's surface is liquid water, most of it sparkling blue oceans that cover nearly 140 million square miles of Earth, a greater area than all continents combined (McMillan & Musick, 2007). It is vital that we promote the manufacturing of Green Ships that don't pollute the environment and strengthen the laws that prohibit waste dumping so oceans stay clean and healthy; otherwise, the direct output of this concept—the existence of humanity in the years to come—will be questionable.

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