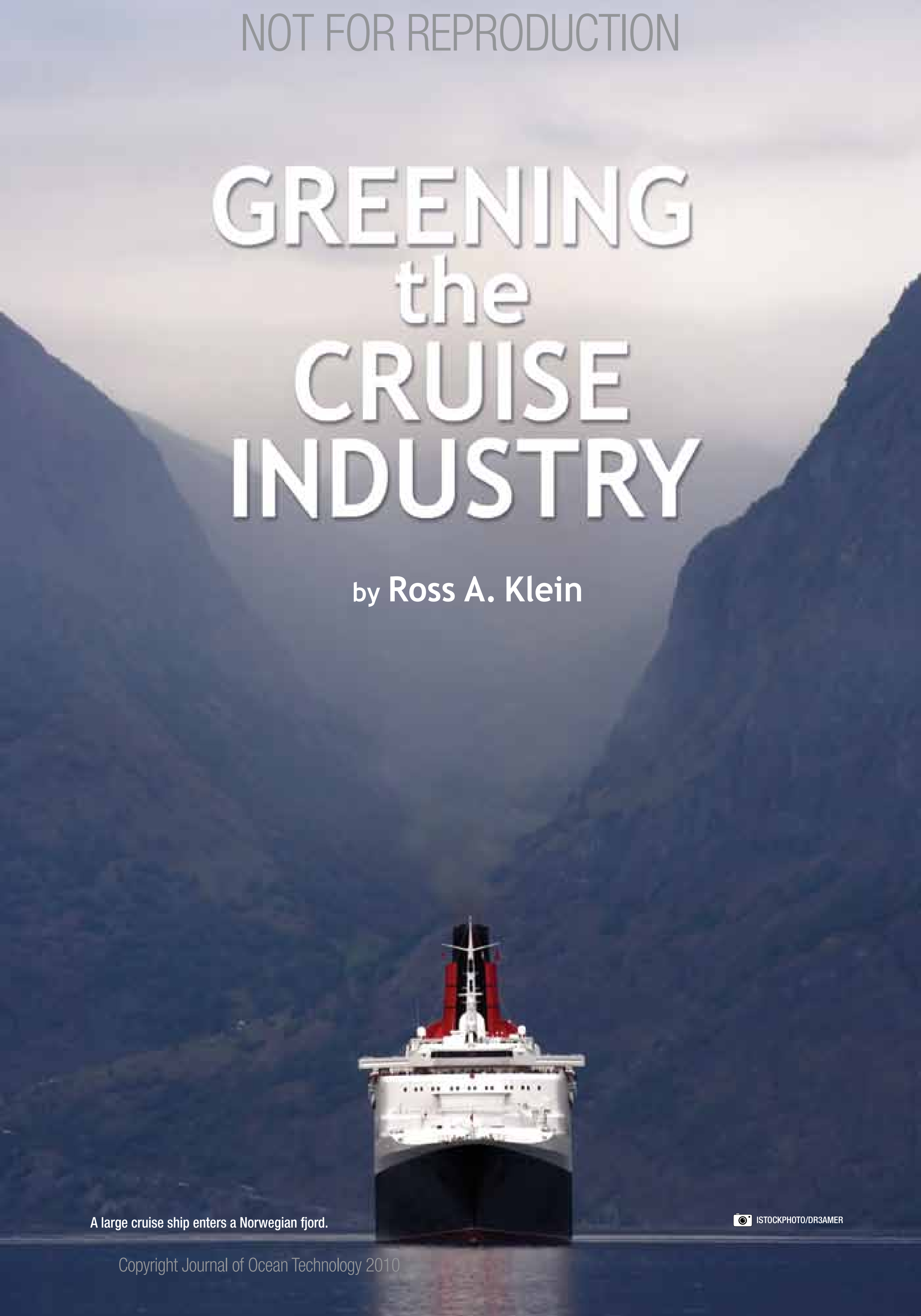
GREENING the CRUISE INDUSTRY

by Ross A. Klein



A large cruise ship enters a Norwegian fjord.

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Introduction

A cruise ship produces large volumes of a number of waste streams that significantly contribute to water and air pollution. While some waste streams such as oily bilge water and emissions from burning fuel are common to all sea-going vessels, this is not the case for all waste streams. With its large number of passengers and crew, wastes such as sewage, grey water, solid waste, and air emissions from incinerators are substantially greater from a cruise ship than for other ships – a Congressional Research Service report published in 2009 estimates that 24% of the solid waste generated by vessels worldwide (by weight) comes from cruise ships even though they comprise a small proportion of all ocean going vessels. In addition, because cruise ship operations tend to concentrate in the same geographic locations and along the same sea routes, their cumulative impact on local areas can be significant. While this may be true of all ships using shipping lanes, the nature of cruise tourism means cruise ships frequent pristine areas such as Alaska's and British Columbia's Inside Passage and have significant traffic between ports in the Caribbean – routes not as heavily traveled by commercial ships (e.g., cargo ships, tankers, etc.).

It is fair to say a cruise ship is not the most environmentally friendly form of transportation. For example, a cruise ship on average discharges three times more carbon emissions than aircraft, trains, or even passenger ferries. Charles Starmer-Smith reports in the *Daily Telegraph* on a 2008 study that found:

> Carnival, which comprises 11 cruise lines, said in its [2007] annual environmental report that its ships, on average, release 712 kg of CO_2 per kilometre … This means that 401 g of CO_2 is emitted per passenger per kilometre, even when the boat is entirely full. This is 36 times greater than the carbon footprint of a Eurostar [train] passenger and more than three times that of someone traveling on a standard Boeing 747 or [even] a passenger ferry.

But the problem is greater than just CO_2. A moderate-sized cruise ship on a one-week voyage with 2,200 passengers and 800 crew members is estimated to generate up to 210,000 gallons of human sewage (this would fill approximately six large swimming pools); one million gallons (the equivalent of 30 swimming pools) of grey water (water from sinks, baths, showers, laundry, and galleys); and eight tons of garbage (the weight of a school bus). This is in addition to air emissions from incinerators and engines.

This essay summarizes the various waste streams from, and environmental impacts of, cruise ships. It offers some suggestions as to how technology may be used to deal with these challenges.

Cruise Ship Waste Streams

Sewage and Waste Water

Black water, otherwise known as human sewage, is the waste from cruise ship toilets and medical facilities. A large cruise ship with 4,000 passengers and 1,600 crew produces more than eight gallons of sewage per day per person – cumulatively as much as 45,000 gallons per day; or over 300,000 gallons during a one-week cruise of a large ship. These wastes contain harmful bacteria, pathogens, disease, viruses, intestinal parasites, and harmful nutrients. If not adequately treated, they can cause bacterial and viral contamination of fisheries and shellfish beds. In addition, nutrients in sewage, such as nitrogen and phosphorous, promote algal growth. Algae consume oxygen in the water; the lack of oxygen can be detrimental or lethal to fish, coral, and other aquatic life.

Sewage typically has been treated by a Type II marine sanitation device (MSD), a flow-through device that breaks up and chemically or biologically disinfects waste before discharge. These devices are designed to produce effluent containing no more than 200 fecal coliform for 100 millilitres, and no more than 150 milligrams per litre of suspended solids. Whether MSDs achieve that standard was called into question in 2000 when the State of Alaska found that 79 of 80 samples from

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cruise ships were out of compliance. According to the Juneau port commander for the Coast Guard, the results were so extreme that it might be necessary to consider possible design flaws and capacity issues with these Coast Guard-approved treatment systems. The problems identified in 2000 with MSDs continue today.

An alternative to MSDs are Advanced Wastewater Treatment Systems (AWTS). The cruise industry in recent years has adopted the use of AWTS (an advanced form of Type II Marine Sanitation Device) on many ships – most often on ships visiting Alaska's Inside Passage where such systems are required for continuous discharge in state waters. AWTS are a vast improvement over MSDs, yielding what the industry refers to as drinking-water quality effluent. However, this terminology must be treated with skepticism. Such water cannot be recycled for onboard human consumption nor can it be used in the laundry because sheets and towels apparently turn grey. Both the Environmental Protection Agency (EPA) and the State of Alaska have found that even the best Advanced Wastewater Treatment Systems still had difficulty with a number of constituents. The AWTS do not adequately address nutrient loading, which means they pose similar problems as MSDs with regard to nitrogen and phosphorous. As well, they are not consistently effective with copper, nickel, zinc, and ammonia, and have exceeded Alaska Water Quality Standards for concentrations of chlorine and tetrachlorethylene. Sixty percent of ships permitted to discharge in Alaska waters violated discharge limits in 2008, logging 45 violations involving seven pollutants. In 2009, 72% of ships permitted to discharge in Alaskan waters violated Alaska discharge limits during the season, racking up 66 violations involving nine pollutants.

Most Type II MSDs and AWTS filter solids from sewage. This yields on average 4,000 gallons of sewage sludge per day. In some cases (about one in sixteen ships with an AWTS), sewage sludge is dewatered and then incinerated. In other cases sludge is dumped at sea. Discharge of sludge is normally permitted beyond three or four miles of shore. These sludges have a high oxygen demand and are detrimental to sea life. Sewage sludge poses the same problem as sewage, but in a more concentrated form. One option is to require sewage sludge to be dewatered and incinerated on board; however, incineration creates an air quality problem and the ash must be disposed of somewhere. Dumping the ash overboard raises new problems. Another option is to require sewage sludge to be held on board and offloaded for treatment in port. The problem with dumping ashes or sludge at sea is that both negatively impact the health of the marine environment and consequently the ability for the oceans to serve as a carbon sink. Healthy oceans, with their biodiversity, are able to absorb large volumes of CO_2; however, as biodiversity and health wanes, this capacity significantly decreases.

Grey water – the wastewater from sinks, showers, galleys, laundry, and cleaning activities aboard a ship – is the largest source of liquid waste from a cruise ship: as much as 90 gallons per day per person; or over half a million gallons per day per ship with 4,000 passengers and 1,600 crew. Like sewage, grey water can contain a variety of pollutants, including fecal coliform bacteria, detergents, oil and grease, metals, organics, petroleum hydrocarbons, nutrients, food waste, and medical and dental waste. The greatest threat posed by grey water is from nutrients and other oxygen-demanding materials. A study by VTT Technical Research Center in Finland found that cruise ship wastewater contributes annually into the Baltic Sea 356 tons of nitrogen and 119 tons of phosphorus, both of which have a negative impact on the health of the marine environment.

Like other ocean-going vessels, a typical large cruise ship will generate an average of eight metric tons of oily bilge water for each twenty-four hours of operation. According to Royal Caribbean's 1998 Environmental Report, this can amount to an average of 25,000 gallons of oily bilge water on a one-week voyage. This water collects in the bottom of a vessel's hull from condensation, water lubricated shaft seals, propulsion system cooling, and other engine room sources. It contains fuel, oil, wastewater from engines and other machinery, and may also include solid wastes such as rags, metal shavings, paint, glass, and cleaning agents. The risks posed to fish and marine organisms by oil and other elements in bilge water are great. In even minute concentrations oil can kill fish or have numerous sub-lethal effects such as changes in heart and respiratory rates, enlarged livers, reduced growth, fin erosion, and various biochemical and cellular changes. Research also finds that by-products from the biological breakdown of petroleum products can harm fish and wildlife and pose threats to human health if these fish and wildlife are ingested. Ships underway are permitted to discharge bilge water when it has been passed through a fifteen parts per million (ppm) oily water separator and does not cause a visible sheen.

Solid Waste

In addition to liquid waste, a cruise ship produces a large volume of non-hazardous solid waste. This includes huge volumes of plastic, paper, wood, cardboard, food waste, cans, glass, and the variety of other wastes disposed of by passengers. A 2002 report issued by The Ocean Conservancy estimated that each passenger accounts for 3.5 kilograms of solid waste per day. With better attention to waste reduction this volume in recent years has been cut nearly in half. But the amount is still significant – more than eight tons a week from a moderate sized cruise ship.

Glass and aluminum are increasingly held on board and landed ashore for recycling when the itinerary includes a port with reception facilities. Food and other waste not easily incinerated is ground or macerated and discharged into the sea. According to the EPA, these "… food wastes can contribute to increases in biological oxygen demand, chemical oxygen demand, and total organic carbon; diminish water and sediment quality; adversely effect marine biota; increase turbidity; and elevate nutrient levels." They may be detrimental to fish digestion and health and cause nutrient pollution.

Air Pollution

There are two sources of air emissions from cruise ships: incinerators and engines. Each presents its own set of issues. Cruise ships incinerate and burn a variety of wastes, including hazardous wastes, sewage sludge, medical and bio-hazardous waste, outdated pharmaceuticals, and other solid wastes such as plastics, paper, metal, glass, and food. In addition, it may burn 1 to 2.5 tons per day of oily sludge in its incinerators and boilers. The emissions from onboard incineration and its ash can include furans and dioxins, both found to be carcinogenic, as well as nitrogen oxide, sulfur oxide, carbon monoxide, carbon dioxide, particulate matter, hydrogen chloride, toxic and heavy metals such as lead, cadmium and mercury, and hydrocarbons. In contrast to incinerator use on land, which is likely to be strictly monitored and regulated, incinerators at sea operate with few limits. There are no national or international standards limiting emissions from ship incineration.

Air emissions from ship engines are an obvious source of pollution because many ships burn bunker fuel. An estimated 60,000 people died worldwide in 2002 as a result of under-regulated shipping air emissions and that number is estimated to grow by 40% by 2012 due to increases in global shipping traffic.

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According to the U.S. EPA, oceangoing ships each year emit 870,000 tons of nitrogen oxide, a key contributor to smog and greenhouse gas – the EPA does not distinguish cruise ships from other oceangoing vessels. In the early 2000s, Oceana likened a cruise ship's environmental impact to the equivalent of 12,000 automobiles. More recently, a 2007 study suggests that bunker fuel on average has almost 2,000 times the sulfur content of highway diesel fuel used by buses, trucks, and cars, and that one ship can make as much smog-producing pollution as 350,000 cars. A number of cruise ships began using gas turbine engines in the late 1990s and early 2000s, well before the spike in fuel costs in 2007. These gas turbines are considerably better than conventional cruise ship engines in terms of sulfur and nitrous oxide emissions, but produce significantly higher volumes of CO_2.

Most bunker fuel today averages 3% sulfur content. New international standards will require a reduction of ship fuel sulfur content to 0.5% in 2020 or 2025. In contrast, California already requires use of marine gas oil, or marine diesel oil, with a sulfur content of no more than 0.5% by weight in all diesel engines within 24 nautical miles of the coast (sulfur content of marine gas oil drops to 0.1% sulfur in 2012). Use of lower sulfur fuel reduces particulate matter 58%, sulfur 99.6%, and oxides of nitrogen 11%. Cruise lines resist low sulfur fuels because of cost. The North American Emission Control Area, announced by the U.S. and Canada and approved by the International Maritime Organization in 2009, would reduce sulfur content to 0.1% in 2015, but is opposed by the cruise industry because it would add $15 to $20 to the cost of a cruise per passenger per day.

An initiative to reduce air pollution, which appeared at first blush to have potential, was introduced in June 2007 by Holland America Line. It announced a pilot project that used a saltwater air emission scrubber on its ship *Zaandam*. The scrubber was supposed to reduce emissions, chiefly sulfur. But at the end of the summer cruise season in the Pacific Northwest it was learned that the scrubber system, which uses seawater pumped through the stacks to chemically scrub sulfur and other contaminants from ship emissions and then dumps the water back overboard, was actually contributing to increased greenhouse gases. Research out of Sweden and the U.K. indicated that when sulfuric acid is added to seawater by scrubbers, carbon dioxide is freed from the ocean surface. Each molecule of sulfuric acid results in release of two molecules of carbon dioxide as the ocean attempts to retain its alkaline balance.

Prospects for Greening Cruise Ships

There have been many notable technological advances that have been applied to cruise ships. There are changes in hull design, use of environmentally safe coatings to increase the smoothness of hulls, and deployment of strategies to reduce energy use on board and fuel usage generally. There have also been positive developments in systems for onboard sewage treatment. AWTS have been a positive shift from Type II MSDs; however, as seen in the most recent results in Alaska, there are still problems. Perhaps the largest technological challenge is the space a cruise ship is willing to allot for a sewage treatment system. Technology is available for more effective water treatment; however, not within the space normally provided by ship designers and cruise lines. With mounting environmental legislation (including the Clean Cruise Ship Act of 2008 before the U.S. Congress) and regulations (e.g., the 2009 National Pollutant Discharge Elimination System, which requires a Vessels General Permit for discharge of grey water and 25 other types of incidental vessel discharges – from ballast water to deck runoff – within one mile of the U.S. coastline), cruise ships increasingly are under pressure to more effectively and demonstrably treat wastewater and sewage.

Another challenge relates to oily bilge water. The benchmark of 15 ppm for discharge of oily waste has been in place for decades even though technology exists for reducing oil content to 5 ppm. Ships operated by Azamara

Cruises and Seabourn Cruises have installed a system, manufactured by EnSolve Biosystems, that consistently achieves this level. While this technology would be good for all ships, cruise ships in particular could be an early adopter of this technology given the cosmetic value of being seen as environmentally progressive.

Sewage sludge presents another set of issues. The volume suggests dewatering and incineration are the best option, assuming the ash is retained on board for proper disposal on land. However, only one in seven AWTS have dewatering capability – six do not. Is there technology available for this purpose within the space constraints of a cruise ship? Even if there were, there would still be concern about the incinerator itself. While there are regulations for incinerators on land, those at sea are largely unregulated. No doubt, those at sea will be regulated, at least to a certain distance, from the shoreline.

The final set of issues relate to air emissions related to fuel. The problem is not only air pollution from sulfur and nitrous oxides, but also CO_2. Environmental concerns about sulfur and nitrous oxides will likely reduce as regulations requiring lower sulfur fuel come into force. But concern about CO_2 will continue. As discussed above, this was a key issue around the salt-water scrubber for engine emissions – it reduced ship emissions but increased release of CO_2. Current research into designs for on-ship carbon capture and storage technology to reduce maritime CO_2 emissions could be a solution; however, its results are many years off.

The cruise industry has not always been an early adopter of new technology. They have when it has direct economic value, either in cost savings or increased revenue; however, in many other cases has chosen against best technology for the same reasons – cost and impact on generating revenue. Many of the pollution concerns discussed in this essay are unique to cruise ships among ships. Unlike tankers and cargo ships that carry dozens of crew, a cruise ship is a small town populated by as many as 7,000 people. As seen, they produce a lot of waste, but do not always treat it with the best available technology.

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Dr. Ross A. Klein is an internationally recognized authority on the cruise ship industry. The Memorial University of Newfoundland professor of social work has published four books on the industry, six reports for non-governmental organizations, and has more than a dozen articles and book chapters in academic and non-academic venues. He has given invited testimony to the US House of Representatives and US Senate, and has been an expert witness in a range of lawsuits involving cruise lines. Dr. Klein is online at www.cruisejunkie.com.