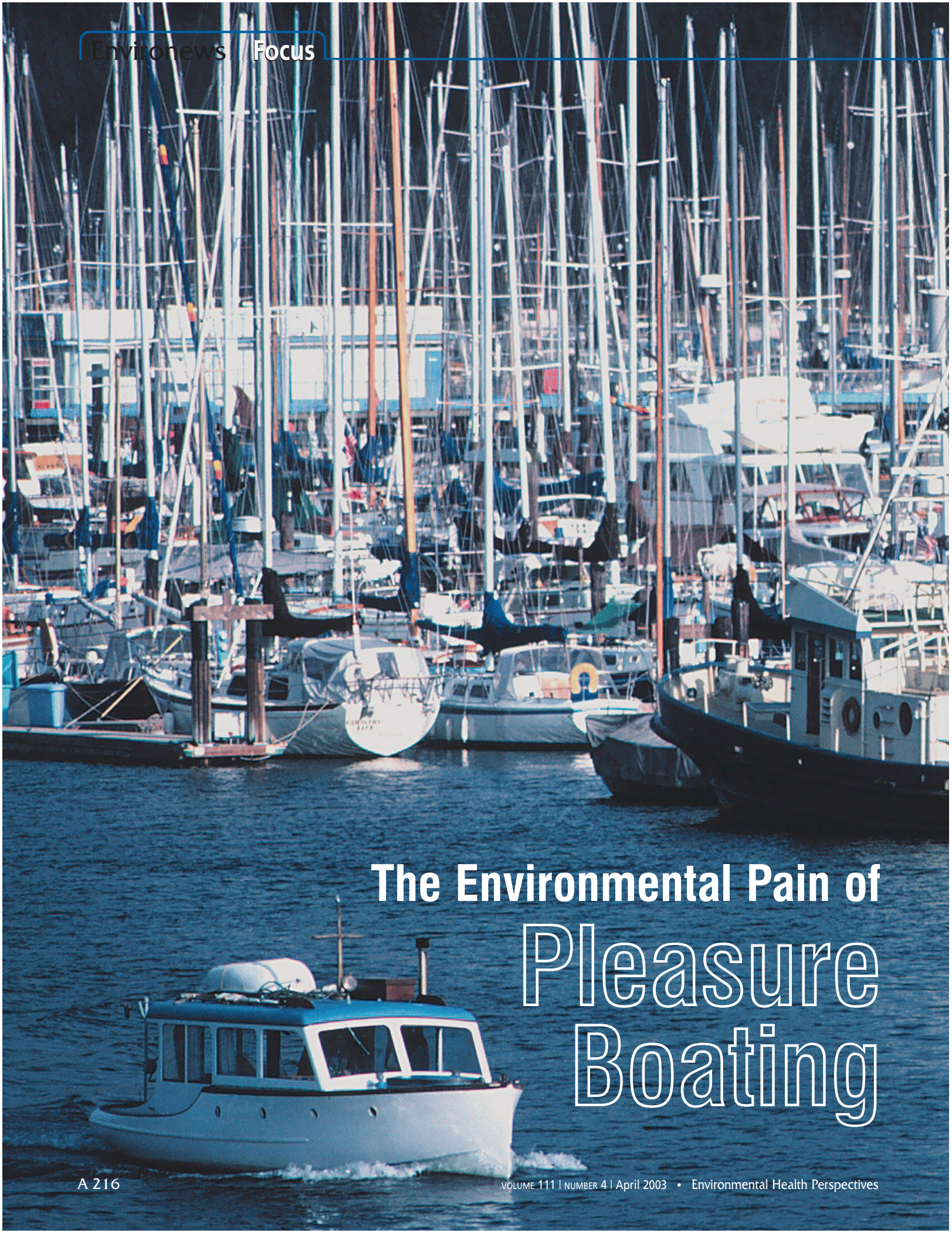

The Environmental Pain of Pleasure Boating

NOAA

It's front-page news when an oil tanker breaks apart, blackening the ocean, killing wildlife, and staining coastlines. But more, albeit less spectacular, damage to the environment—a "death from a thousand cuts"—may come from a much smaller source: recreational watercraft that put petroleum products, human and pet waste, trash, and potentially toxic metals into coastal waters, lakes, and rivers. These vessels also slice swaths through slow-to-heal marine vegetation. Even the sound from some watercraft can damage the hearing of the people operating them and disturb sea life.

There are about 17 million boats in the United States, according to the Chicago-based National Marine Manufacturers Association (NMMA). This number includes all kinds of boats, from canoes to luxury yachts. Over the last decade or so, recreational use of the country's coastal regions has increased dramatically, says Virginia Lee, director of the Rhode Island Sea Grant's Sustainable Coastal Communities and Environments Extension Program at the University of Rhode Island. "Recreational boating is a dominant element of the coastal economy,"

she says. The NMMA estimates that retail sales of all boating products hit $29.25 million in 2002, up 30% from 1997 ($19.34 billion). There are about 30,000 businesses in the marine industry, employing about 500,000 workers. Marine consumers pay almost $400 million in boating-related taxes and fees annually. Each year marinas alone generate about $2 million in federal gas taxes.

Fortunately, experts say, the increasing popularity of recreational boating has been accompanied by many improvements in boating stewardship. New governmental programs provide financial support for clean boating programs, and new regulations require cleaner engines and the phasing out of some of the worst boating-related chemicals. New engine and boat designs also help. And campaigns by environmental organizations to promote clean boating are helping to spur a fresh sensitivity to the harm that common boating practices can do.

"There has been improvement. There's also a different ethic than there was. People are more aware of the environment and care more and want to do the right thing," says David Guggenheim, vice president for conservation policy at The Ocean Conservancy, a Washington, D.C., environmental group. "One of the problems, though, is that boating has become very popular. Just the sheer number of boaters is making the problem worse, despite the improvements."

Marina Matters

The environmental impacts from recreational boating can be grouped into four primary areas, says Harrison Bresee, a marina technical advisory specialist for the Virginia Sea Grant Marine Advisory Program at the Virginia Institute of Marine Science: operational hazards (such as habitat damage from propellers and noise), petroleum products, pollutants related to boat maintenance, and sewage. Marine pollutants can be nutrients, toxicants, or compounds that bind with sediments and get reintroduced to the water when the sediment is stirred up. Nutrients—primarily human or pet waste and discarded fish parts—can result in algal blooms and low dissolved oxygen. Toxicants—such as those from antifouling bottom paints—can kill life at the bottom of the marine food chain.

According to the U.S. Environmental Protection Agency (EPA) technical document *National Management Measures to Control Nonpoint Source Pollution from Marinas and Recreational Boating*, published in November 2001, gasoline, oil, diesel fuel, acids from batteries and cleaning compounds, and surfactants and solvents involved in boat maintenance (such as methylene chloride, tetrachloroethane, trichloroethene, and trichloroethylene) can wash into lakes, rivers, and coastal areas. "The concern," says Guggenheim, "is that many of these pollutants, particularly some of the heavy metals, become bonded to sediment or find their way into the food chain through either plankton or other organisms and then concentrate through the food chain—and that's a major environmental threat, as well as a major human health issue when it comes to fish consumption."

The areas with the highest concentrations of boats can be especially problematic. "The design of marinas becomes very important," says Guggenheim. "Many of these marinas don't flush very well, so you have locally very high concentrations of heavy metals and nutrients that become concentrated in sediments."

Fueling and fouling. Fueling of boats routinely involves spilling gas, diesel fuel, oil, and other toxicants into waterways.

William B. Folsom/NOAA

Just the construction of a marina can reduce water circulation. Bulkheads (waterfront retaining walls), protective jetties, landing docks, and other structures near the shore can limit water circulation in the basin, concentrating pollutants in the water column, sediments, and sea life, according to *National Management Measures*. These structures can also change the habitats in which they are built. They can displace shoreline vegetation, and their hard surfaces can provide homes for sea life such as shellfish that otherwise couldn't have survived. Such changes can radically change the ecological balance of marshy environments.

Marinas provide a treasure trove of potential ecological disruptors, including slips, mooring pins, launch ramps, gas docks, sewage pumpout stations (if used improperly), boating supply stores, and boatyards where vessels are repaired and maintained. It can be difficult, however, to gauge the amount of pollution a marina generates. According to *National Management Measures*, because marinas are often downhill and downstream from surrounding communities, they can be the recipients of significant quantities of nonpoint-source pollution. As a result, it can be difficult to distinguish the pollution marinas generate from that they accumulate. In fact, according to Lee, because boats invariably operate at the end of watersheds, it is often difficult to isolate the contributions of pleasure boats in general from those of other nonpoint pollution sources.

Such factors have hit the Chesapeake Bay hard, says Glenn Page, director of conservation at the National Aquarium in Baltimore. The bay was teeming with life just a few decades ago, Page says, with a surfeit of marine life that supported a thriving fishing industry. But now, he says, that industry "is on the ropes, and unless there is an enormous amount of political will, it doesn't have a tremendously bright future." Admittedly, there have been many contributors to the bay's demise besides pleasure boating, including commercial shipping, small- and large-scale commercial fishing, nonpoint-source pollution draining from major urban centers, and as much as 1 billion gallons of nitrogen-laden wastewater sewage daily, according to the nonprofit Chesapeake Bay Foundation.

Seagrasses represent another ecosystem at risk. Much of the

damage to seagrasses is from nonpoint-source pollution, some is from dredging—including for pleasure boat marinas and the channels that lead to them—and some is from the activity of recreational boats themselves. "You see aerial photographs of eelgrass beds just crisscrossed right and left, practically denuded by propellers," says Andre Mele, executive director of the environmental group Hudson River Sloop Clearwater and author of the 1995 book *Polluting for Pleasure*. When small boats slice a path through seagrass beds, the many cuts they leave behind can take years to heal, he says, crippling entire ecosystems. Page says roughly 90% of the Chesapeake Bay's seagrasses have been lost.

This is a serious problem because seagrasses have been shown to create their own microclimate of improved water quality, explains Page. "They add oxygen to the water, which is an important aspect of water quality. They provide enormous habitat value for food and also refuge from prey. It's the nursery grounds for a lot of juvenile fish. It's really the center of activity for enormous amounts of estuarine marine life. So they are critically important."

Petroleum Pollution

About 12 million marine engines power watercraft in the United States. According to the 1996 EPA fact sheet "Boating Pollution Prevention Tips," in many areas of the country marine engines are among the leading sources of hydrocarbon (HC) and nitrogen oxide (NO_x) emissions. These emissions are precursors to smog and ground-level ozone, which can aggravate asthma and cause lung inflammation and chest pains. But as significant as airborne emissions, Mele says, are the vast quantities of petroleum products that recreational boats leak during operation and fueling. "If you do the numbers, there's [the equivalent of] at least 15 Exxon *Valdez* oil spills going on in America's waterways every year," he says. "That's a lot of fuel, and of course because it's coming out of one little boat at a time, nobody really notices or cares to do anything."

Gasoline, diesel fuel, and oil frequently spill out of pleasure boats at fuel docks. At gas docks and in harbors around the country, it's common to see the telltale iridescent sheen of fuel and oil on the water. "Boats are designed to spill," says Eric Olsson, an oil spill prevention education specialist at the Washington Sea Grant Program in Seattle. "That's their flow gauge—[people fueling boats] literally look over the side and fill it until it shoots out. It's become part of the operation of filling your boat." And unlike gas stations on land, most gas dock fuel nozzles do not have automatic shutoff valves. As a result, Olsson says, marine gas docks are an ongoing source of petroleum in the water column, petroleum that can persist in an ecosystem.

Gasoline, sometimes mixed with oil, also spills out of boats—especially those with two-stroke engines—during operation. Other petroleum-based products, including kerosene, diesel fuel, and antifreeze, can spill from boats in dry dock or while in the water. In boatyards that aren't surrounded with protective gutters—and very few areas require such devices—rain can carry these spilled products to the water.

Petrochemicals can settle in the shallow areas of waterways where the first links in the food chain—fish eggs, larvae, algae, zooplankton, and crustaceans—are found. According to research published in the October 1997 issue of *Environmental Toxicology and Chemistry*, extremely low levels of HCs can produce catastrophic effects in fish, including chromosomal damage, growth reduction, and increased mortality rates.

"The hydrocarbon content of a lot of our sediments now is frightening," says Seba Sheavly, director of The Ocean Conservancy's Office of Pollution Prevention and Monitoring. "And it's deep. There are parts of the New Jersey area in salt marshes where you can go down fifteen to twenty feet and find a layer of contamination that has been pushed down over the years, and there is no filtration any more [because the plants and shellfish that perform this function have been exterminated]. . . . There is a maximum capacity that an environmental system can tolerate, and we exceed it righteously all the time."

Raw gasoline and oil are bad enough, Mele says, but combusted petroleum does the most damage. "The PAHs [polycyclic aromatic hydrocarbons, which are produced when petroleum is combusted] are the scary thing," he says. "PAHs are unlike many components of gasoline and oil; they are persistent in the water column." Just a thin layer of petroleum at the water's surface can block the light upon which aquatic plants and photosynthetic zooplankton depend, and reduce the oxygen available for aquatic organisms' respiration, according to *National Management Measures*. A single quart of oil can leave a slick that covers two acres, states an Ocean Conservancy handbook titled *Good Mate: Recreational Boating & Marina Manual*.

In the 14 August 2002 *Federal Register*, the U.S. EPA published a proposal to require emission controls on boat fuel systems. The EPA proposal would require modifications to the current boat fuel hose, vent controls such as a pressure relief valve to reduce diurnal emissions, and permeation measures on plastic tanks. If these standards are established, the next step would be developing systems that prevent spills during fueling, says John McKnight, director of environmental and safety compliance for the NMMA.

Surface evidence of deeper problems. Hydrocarbons from fuel oil contaminate waters and sediment in fragile ecosystems.

Scott Taylor

Engine Trouble

Most of the petroleum products that spill during operation come from two-stroke engines, says Sean Smith, public lands director for Bluewater Network, an environmental

nonprofit in San Francisco. In fact, he says, two-strokes account for about 75% of all recreational engines, but account for far more than their share in spills. Two-stroke engines dominate recreational boating because they hold significant advantages over four-strokes. They are about one-third the weight, they are cheaper to make, they are simple to maintain, they rev up quickly, and they can run when tilted, even upside down.

But two-strokes have two critical disadvantages; they are loud, and they are inefficient. Not only do they waste gas, but most of this wasted gas, which is mixed with oil, goes out the exhaust pipe and into the water or air; two-strokes release 1.1 billion pounds of HC emissions each year, according to Bluewater Network. In two-stroke designs that include carburetors—by far the most common type—about one-third of the fuel is wasted, says Smith.

Two-stroke-engine watercraft not only pollute vastly more per hour than cars, they are much dirtier than other marine engines. According to "New Regulations for Gasoline Marine Engines," a 1999 fact sheet published by the California Air Resources Board, the average 90-horsepower four-stroke marine engine produces 11 grams of reactive organic gases and NO_x in an hour of operation. A conventional 90-horsepower two-stroke produces 164 grams per hour. The newer direct-injection two-stroke falls in the middle, at 45 grams per hour.

The most environmentally harmful two-stroke marine craft, Smith says, are the personal watercraft such as Jet Skis® and Waterbikes®. Virtually all personal watercraft house a two-stroke engine. And unlike most other two-stroke-powered watercraft, when personal watercraft are on the water, they typically are ridden at full-bore. After all, their fundamental purpose is to provide a fast, thrilling, wet ride.

According to the California Air Resources Board fact sheet, a typical personal watercraft with a two-stroke engine generates more smog-producing emissions in seven hours of operation than a 1998 passenger car driven 100,000 miles. That's why some local governments in California have banned high-emission two-stroke engines (those with carburetors and direct-injection engines manufactured before 1999) from 11 lakes.

According to "Jetski Position Paper," published in 1999 by Bluewater Network and revised in April 2002, personal watercraft produce noise levels in the range of 85–102 decibels. The American Hospital Association recommends wearing hearing protection at noise exposures above 85 decibels, which is about the level of a noisy city street. "Furthermore," states the paper, "the design of [personal watercraft] results in noise that is particularly disturbing to humans and particularly dangerous to marine wildlife." According to the paper, the high-frequency whine of the watercraft make them difficult for animals and birds to hear them until they are almost upon them. [See also "Trampling Paradise: Dream Vacation—Environmental Nightmare?" *EHP* 108:A214–A219 (2000).]

The Personal Watercraft Industry Association points to the development of four-stroke personal watercraft as evidence of the industry's commitment to environmentally sound technologies. Manufacturers, say association spokespersons, have invested enormous resources in the last few years to create personal watercraft that are as much as 75% cleaner and 70% quieter than 1998 models.

Recent U.S. EPA regulations place limits on the amount of pollution that outboard, personal watercraft, and jet boat gasoline marine engines can emit, and are pushing manufacturers to design new, cleaner marine products. (These standards don't apply to stern-drive or inboard engines, which use cleaner four-stroke engines.) By 2006 the average emissions for a given manufacturer's products must be no more than 25% that of the typical 1996 engine.

The regulations, however, apply only to new engines. It will take many years before the new, cleaner engines outnumber older, highly polluting models. Because marine engines are used infrequently compared to automobile engines, they tend to have longer lives. The U.S. EPA estimates that by 2020 there will be a 50% reduction in HC emissions, and that not until 2025 will a 75% reduction be achieved. The California EPA has accelerated the process. In California, a typical marine engine was required to be 75% cleaner by 2001, and by 2008 a typical engine must be 90% cleaner. In 2008, a marine engine in California will be allowed to emit only one-third as much reactive organic gases and NO_x as allowed under federal regulations.

To meet the new federal EPA requirements, motor manufacturers are introducing four-stroke outboard engines, four-stroke personal watercraft, and cleaner versions of the direct-injection two-stroke. These new two-strokes still release more HCs than four-strokes, but like their dirtier carbureted brothers, they are lighter, faster, and less expensive than four-strokes.

Although direct-injection two-strokes are an important step toward more benign marine engines, says McKnight, even cleaner engines should arrive by the end of the decade. "We're trying to look for further emission controls on marine engines, to develop the next generation of marine engines with catalyst systems," he says. These engines would incorporate a device similar to a car's catalytic converter that would be part of the engine manifold. This technology is still being developed, however, and the engines must be proven durable and safe to use in a marine environment.

Personal fun—public menace? Personal watercraft have exploded in popularity, but they create noise, pollution, and ecosystem hazards.

Corbis

Metal Menace

Potentially toxic metals appear in myriad marine operations. Copper works as a biocide and is released from boat-bottom paint in normal use; that's how it prevents barnacles from growing on hulls. It also finds its way into water when hulls are scraped as part of normal boat maintenance. Many other metals are found as well. In addition to copper, some marina waters and sediments have been found to have high concentrations of zinc, tin, chromium, and lead, states the same document.

Arsenic, chromium, and copper leach from docks, pilings, and other structures built of wood treated with chromated copper arsenate. Arsenic also is used in boat paint pigments, which may enter the water during careless painting or scraping. Zinc is used as a source of sacrificial electrons to prevent corrosion of other metal parts that are exposed to seawater. Mercury serves as the contact for float switches in bilge pumps, shower-water storage tanks, and thermostats. A float switch can contain as much mercury as 100 fluorescent lamps. Housings for these switches can corrode while in use, especially in salt water.

Tributyltin, a form of tin used in antifouling paints, has been found at toxic concentrations in waterways throughout the United States as well as in Chinese and Italian coastal waters. Tributyltin has been found to bioaccumulate in sea life, including dolphin, tuna, and sharks. Tributyltin is extremely toxic to aquatic life, especially bivalves. It is an endocrine disruptor in mammals, and makes oysters susceptible to infection and death from pathogens.

Because of tributyltin's high toxicity, however, its use is now restricted in U.S. waters. And starting in 2003, international law established by the International Maritime Organization has banned new application of tributyltin to ships of any size, with 2008 the deadline to remove the material from old applications entirely. But years of use have left many sediments contaminated. Disturbing these sediments can release contaminants back into water, where they can work their way up the food chain ultimately to human consumption, according to *National Management Measures*.

Copper, the primary active component in most common antifouling bottom paints, is the metal most often found in toxic concentrations in marina sediments, according to several reports by the North Carolina Division of Environmental Management. Levels of copper that are toxic to sea life have been found at several marinas in the Chesapeake Bay, according to *National Management Measures*.

To reduce the levels of copper and other substances flowing into San Diego waters, regional governments and agencies have developed one of the country's most aggressive chemical control programs. "The boatyards in the San Diego area have been regulated for environmental practices since the late 1980s," says Leigh Johnson, a marine advisor at the University of California's Sea Grant Extension Program. "They do not allow any runoff from the boatyard to go into the water. They have little curbs all around the edges. They have drain systems that catch any water that is either from washing the boats or from rain, and transport it to a filtration system where the toxic elements are removed. And then ultimately the filtered water goes to the sewage treatment plant."

A drain on the environment. Toxic solvents used in boat maintenance can wash into watersheds.

All of that is fine for boats that are on shore. But most of the copper lost to the sea comes from boats that are in the water. That's why marine environmentalists have started to recommend nontoxic substitutes for copper-based bottom paints [see "Keeping Copper off Boat Bottoms," p. A209 this issue].

Because nontoxic bottom paints aren't, well, toxic, they don't kill the barnacles and other creatures that want to make boat hulls home. Instead, these alternatives make it harder for animals to get a grip in the first place and easier to wash off if they do. Some of these paints are epoxy-based, which offers a harder, smoother surface than fouling growth has evolved to grab. Others are silicone-based, creating a surface so slippery that fouling growth slides off when the boat exceeds about 20 knots (about 23 miles per hour). For boats that can't reach 20 knots, which includes most sailboats, the growth must be scrubbed away. "When you have a nontoxic coating on the bottom of the boat, it does not stop the fouling growth," Johnson explains. "So what you need to do is have a companion strategy, which can involve people going under the boat and diving to wipe away the growth, or in some cases there are people installing boat washes."

Head-On Hazards

Marine heads—the nautical term for a toilet—vary from a simple discharge overboard to three types of U.S. Coast Guard–approved treatment systems. The term "head" arises from the boards that support a ship's bowsprit, which was the farthest forward part of old-time sail rigging. Sailors would straddle these "headboards" in lieu of a proper toilet. Many modern pleasure boats use a system that is no more sophisticated or sanitary: a bucket whose contents are dumped overboard.

Under the Clean Water Act, this practice is legal in many waters if the bucket isn't attached to the boat. But if a boat of any size has an installed head, federal law requires that it be connected to a Coast Guard–approved marine sanitation device (MSD). Type I MSDs use chemicals, heat, or electricity to kill bacteria. Type II MSDs, at 1,000-plus pounds and $5,000-plus, are too heavy and expensive for most recreational boats. Most Type III MSDs include a holding tank. Since 1978 all boats made in the United States with installed heads have been required to include holding tanks. Some of these tanks can be emptied only by pumping out, but others have a valve that permits them to be emptied overboard. Type II or III MSDs are required on any boat that is longer than 65 feet.

Federal law prohibits the discharge of untreated human waste in U.S. territorial waters (within 3 nautical miles—or about 3.45 miles—of the coast) and in the Great Lakes. In addition, some local governments, such as areas in California and British Columbia, don't allow the discharge of *any* sewage, treated or untreated. In these cases, waste must be stored in holding tanks to be emptied at pumpout stations. But too often, says Sheavly, pleasure boat owners either discharge waste just outside the 3-mile limit or ignore the rules altogether.

In clear waters, especially in underenforced offshore areas, the effects can be apparent. "In Maho Bay in Saint John in the [U.S.] Virgin Islands there's a huge population of 'live-aboards' and people who move between the islands on boats and hardly ever touch land," Sheavly says. "You can actually see—from aerial shots after a heavy holiday

weekend or week—plumes [of sewage] in the water. The water's not meant for all this sewage. Fish poop is not a problem. Human poop is."

High levels of coliform bacteria have been found in areas where there are high concentrations of recreational boats. The state/federal San Francisco Estuary Project indicates that a direct relationship has been found between the number of boats in a sampled area and increased levels of coliform bacteria in the water column and in shellfish. According to the Tacoma–Pierce County Health Department, sewage discharges from recreational boaters and marinas are a primary reason behind the closure of 40% of Puget Sound's shellfish beds.

That's not surprising, considering that the untreated sewage that a single weekend boater releases into a waterway increases bacterial levels by the same amount as the treated sewage from 10,000 people, according to "How Boat Sewage Discharges Affect the Environment," a webpage published by the San Francisco Estuary Project at **http://www.abag.ca.gov/bayarea/sfep/programs/boated/Sewage.html**. Marine sewage can cause such human health problems as viruses, infectious hepatitis, cholera, typhoid, and parasites, sickening swimmers, water skiers, scuba divers, windsurfers, and others who contact contaminated water.

High levels of sewage can also result in abnormally low levels of dissolved oxygen. As organic matter—whether human or pet waste, discarded fish parts, or galley garbage—decomposes in water, it consumes oxygen, depriving sea life of the oxygen it needs. According to a 1990 study by the North Carolina Division of Environmental Management, dissolved oxygen in a sample of regional marinas was substantially lower than in surrounding waters. Low dissolved oxygen levels were attributed to excessive quantities of organic matter and poor flushing, which is typical of marinas.

Sewage discharged from watercraft can be worse for the environment than other sewage sources. It is usually more concentrated, and it often contains treatment chemicals such as chlorine and formaldehyde as disinfectants or to reduce odors. Most commercial products used in heads are thought to be biodegradable. But using too much or the wrong type of a product can poison marine life. Because marine sewage contains high concentrations of nutrients, including nitrogen and phosphorus, it can also contribute to algal blooms.

The solution, environmentalists say, is to not allow the discharge of any sewage—treated or untreated—into any waters. Most American lakes and other freshwater bodies that have no navigable connections to other bodies of water (such as reservoirs) are already classified as "no-discharge zones." Many states, including California, Florida, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Mexico, New York, Rhode Island, Texas, Vermont, and Wisconsin, have established additional no-discharge zones. Federal law says that overboard pumping systems must be disabled in these zones.

The catch, Bresee says, is that many marinas don't have pumpout facilities. "Marinas are really a marginal business," he says. "They don't make a lot of money sometimes. . . . Some of the smaller marinas have a hard time putting money toward anything that is not a direct revenue source. And they say pumpout is a nonrevenue source. The bigger marinas see it as a service. It's just like having a bathroom; you've got to have one."

In 1992, to help marinas of all sizes install pumpout facilities, the federal government began providing funds to states through the Clean Vessel Act. States that choose to participate can grant marinas 75% percent of the cost to install marine sewage facilities, which can include dockside pumpout stations, portable toilet dump stations, and mobile pumpout vessels. The only condition is that marinas must keep pumping out affordable by charging no more than $5 per pumpout. Federal funds don't cover maintenance costs, however. Pumpout facilities are expensive to maintain, and once they are open to the public, the repair frequency skyrockets, says Johnson.

Still, "there are a lot more pumpouts because the federal government has provided money," Bresee says. And pumping out—rather than just dumping sewage overboard—naturally means cleaner water, says Lee. She helped monitor a harbor in Block Island, Rhode Island, for fecal coliform bacteria. "There is a huge increase in the summer, then a dramatic decrease off season," she says, indicating that pleasure boats were dirtying the waters. Then a mobile pumpout boat was installed. "When that went into place, it showed a measurable improvement in the fecal coliform bacteria in the harbor."

Sewage solution. Dockside pumpout stations are a far cleaner alternative to just dumping sewage overboard.

William B. Folsom/NOAA

Full Steam Ahead

In the last decade and a half, educational programs—some targeted to preventing oil spills only and others to clean boating practices in general—have sprung up throughout the country. The Ocean Conservancy's educational Good Mate Program, for example, reaches an estimated 250,000 people a year. "Clean Marina" programs, voluntary certifications that states administer using federal funds, are encouraging marinas to adopt best-practices plans.

"There are certain practices that could help eliminate spills—require people to tie up in a certain location so they can view the gauges, have shutoffs on the pump, provide spill collars—and that's being done more and more," says Olsson, who for more than a decade has educated Washington State

boaters on petroleum-spill prevention. But education and regulation go hand in hand, he says. "Signage helps; if [boaters] know they're going to get reported or think they're going to get reported, they probably won't top off the tank."

"Over the course of the last dozen years people are becoming more and more sensitive to oil spills. It's a different culture than the overboard pumping of sewage," says Ed Barrett, harbormaster of Port of Friday Harbor in northwest Washington and vice president of the Pacific Coast Congress of Harbormasters and Port Managers. "There are still growing pains in the oil spill department. I would say by and large the waters are much cleaner than they used to be, and people are more sensitive to that, but it's not because they're feeling warm and fuzzy about the environment; . . . it's more like 'gosh, I don't want to get fined.'" The Coast Guard and state environmental agencies can level fines of $5,000–50,000 to people who spill petroleum products, even accidentally, if they're not cooperative in the clean up, Barrett says.

As long as boating continues to increase in popularity, protecting environmental and human health in marine areas will be an uphill battle, some experts say. Educational and regulatory programs can help, but every year new boaters—often unaware of the damage their new toys can inflict on the environment—hit the water. Millions of recreational boats of all types, some using the dirtiest possible engines, some with flaking toxic bottom paints, some with no way to process or contain sewage, means millions of potential sources of pollution.

Still, says Lee, "Within the last decade marinas have realized that clean water is good business." Furthermore, says McKnight, it's good business to develop cleaner, quieter, more efficient boats, engines, and other marine products. "A lot of these companies have become stock-held companies, and they're coming out with newer and better technologies because their stockholders are demanding it," he says. "The companies that have the best, cleanest technology can say [so], and they're going to sell it in the marketplace."

"If each individual boat could be declared a point source, and somehow that could be transformed into a requirement to get permits under [the National Environmental Policy Act]," Mele says, "maybe we could move this thing along a little bit faster." Lacking such regulation, Page says, the most effective strategy is to provide voluntary environmental programs and education for marine enthusiasts. "Boaters can be the best conservationists of the water," he says.

Scott Fields

PhotoDisc

Ocean Centers to Dive into the Mysteries of the Deep

Hoping to unlock the veritable treasure chest of medicinal potential awaiting discovery in the depths of the world's oceans, the NIEHS and the National Science Foundation announced on 21 November 2002 a $6 million grant program that will establish four Centers for Oceans and Human Health (COHHs). These new centers will bring together experts in such fields as environmental epidemiology, public health, preventive medicine, ocean chemistry, and computational biology to conduct interdisciplinary research and technology development regarding the numerous potential benefits and risks posed by marine organisms. Each COHH will be either thematically or geographically organized and will support three or more related research projects, two or more facility cores, and several short-term pilot projects.

Marine organisms represent the world's greatest source of chemical diversity. As more than 50% of the drugs currently on the market include naturally derived ingredients, the study of marine organisms should lead to further discoveries of compounds for pharmaceutical purposes. It is estimated that most of the total number of marine species have yet to be discovered. COHH researchers will be working to locate and evaluate unidentified species and to establish new methods of culturing them for research and clinical purposes. They will also be studying the molecular mechanisms of marine toxins, which could aid in the development of drugs to block toxic processes and detect toxins in seafood.

A second focus of the centers will be waterborne diseases, a leading cause of death in children worldwide. COHH projects will concentrate on using genomic and proteomic approaches to determine the pathogenicity and biology of these organisms and to discover new and better means of detecting them in water and shellfish. COHH researchers may also use nearshore oceanography to study pathogen transport in areas of possible human exposure and to help local governments design and site new or replacement sewage and runoff systems.

Understanding the environmental conditions that promote large harmful algal blooms is yet another topic the new centers will address. Over the last 30 years the range and incidence of these blooms has increased along U.S. coastlines, and more work is needed to determine the potential impact of these outbreaks on human health [see "Toxic Tides," *EHP* 106:A326–A331 (1998)]. The potential pathways of the toxins produced by harmful algal blooms—which can cause various acute, subacute, and chronic human diseases, including neurotoxic and liver disorders—need to be identified so that therapies can be developed.

Although both agencies have been conducting related work for several years, it was not until after a December 2001 roundtable (see **http://www.niehs.nih.gov/translat/OHH-fin.pdf** for the meeting report) that they established the plan for these joint centers. They hope to use this earlier research to support the COHH program and create a more complete base of knowledge of the still largely unstudied realm where human health and marine life intermingle.

For more information on the COHH program, contact Allen Dearry at the NIEHS (dearry@niehs.nih.gov) or Don Rice at the National Science Foundation (drice@nsf.gov). **–Erin E. Dooley**