
# Oceans and Human Health: Hand in Hand

## Objective

Students will understand the relationship between human health and the oceans by learning about water quality monitoring, oceans and medicine, and human health threats posed by polluted waters and harmful algal blooms.

## National Science Education Standards

Content Standard C: Life Science
- Interdependence of Organisms (9-12)

Content Standard F: Science in Personal and Social Perspectives
- Personal and Community Health (9-12)
- Environmental Quality (9-12)
- Natural and Human-Induced Hazards (9-12)
- Personal Health (5-8)
- Natural Hazards (5-8)
- Risks and Benefits (5-8)

## Warm-Up

Ask students to brainstorm all the ways in which the oceans affect their lives, either positively or negatively. Write their answers on the board. Ask them if/how their answers are related to human health, and discuss whether the relationship is direct or indirect.

## Introduction

Man has been studying the oceans for centuries, but only recently have we begun to understand a very important connection: how oceans and human health are inextricably linked. We hear about global warming and know it is a concern, but we are just learning what impacts warmer seas may have: increased incidents of harmful algal blooms, and easier spread of water-borne infectious diseases. When we pollute the environment, and specifically our oceans, we find that it has deleterious effects not only on marine life, but on our own lives as well. People get sick from swimming near sewage outfalls, and beaches may be closed when rainfall exceeds a certain amount. On a brighter note, the oceans also provide many positive contributions to human health. They are an obvious source of nutritional foods, and their inhabitants can serve as models for human diseases. Scientists are currently studying mud puppies, fish that are highly resistant to pollutants, to see if their genetic makeup suggests ways to protect humans from pollution. Our seas continue to provide us with many revolutionary pharmaceuticals: the cone snail produces a paralyzing toxin which is being used in modern medicine as a painkiller that is more effective than morphine, and is non-addictive. Research on the link between our health and the health of the oceans is ongoing, but one thing is certain: we know that we have barely scratched the surface of this valuable relationship.

The following materials focus on several aspects of oceans and human health: the importance of water quality monitoring in recreational waters, pharmaceuticals from the sea, and the public

health problems caused by harmful algal blooms (HABs). Background information on the effects of pollution on marine life is also included in the following table.

## Sources and Effects of Marine Pollution

| Type | Primary Source/Cause | Effect |
|---|---|---|
| Nutrients | Runoff approximately 50% sewage, 50% from forestry, farming, and other land use. Also airborne nitrogen oxides from power plants, cars etc. | Feed algal blooms in coastal waters. Decomposing algae depletes water of oxygen, killing other marine life. Can spur algal blooms (red tides), releasing toxins that can kill fish and poison people. |
| Sediments | Erosion from mining, forestry, farming, and other land-use; coastal dredging and mining | Cloud water; impede photosynthesis below surface waters. Clog gills of fish. Smother and bury coastal ecosystems. Carry toxins and excess nutrients. |
| Pathogens | Sewage, livestock. | Contaminate coastal swiming areas and seafood, spreading cholera, typhoid and other diseases. |
| Alien Species | Several thousand per day transported in ballast water; also spread through canals linking bodies of water and fishery enhancement projects. | Outcompete native species and reduce biological diversity. Introduce new marine diseases. Associated with increased incidence of red tides and other algal blooms. Problem in major ports. |
| Persistent Toxins (PCBs, Heavy metals, DDT etc.) | Industrial discharge; wastewater discharge from cities; pesticides from farms, forests, home use, etc.; seepage from landfills. | Poison or cause disease in coastal marine life, especially near major cities or industry. Contaminate seafood. Fat-soluble toxins that bio-accumulate in predators can cause disease and reproductive failure. |
| Oil | 46% from cars, heavy machinery, industry, other land-based sources; 32% from oil tanker operations and other shipping; 13% from accidents at sea; also offshore oil drilling and natural seepage. | Low level contamination can kill larvae and cause disease in marine life. Oil slicks kill marine life, especially in coastal habitats. Tar balls from coagulated oil litter beaches and coastal habitat. Oil pollution is down 60% from 1981. |
| Plastics | Fishing nets; cargo and cruise ships; beach litter; wastes from plastics industry and landfills. | Discarded fishing gear continues to catch fish. Other plastic debris entangles marine life or is mistaken for food. Plastics litter beaches and coasts and may persist for 200 to 400 years. |
| Radioactive substances | Discarded nuclear submarine and military waste; atmospheric fallout; also industrial wastes. | Hot spots of radio activity. Can enter food chain and cause disease in marine life. Concentrate in top predators and shellfish, which are eaten by people. |
| Thermal | Cooling water from power plants and industrial sites | Kill off corals and other temperature sensitive sedentary species. Displace other marine life. |
| Noise | Supertankers, other large vessels and machinery | Can be heard thousands of kilometers away under water. May stress and disrupt marine life. |

Source: Compiled by WorldWatch Institute

# The Santa Monica Bay Restoration Project
# Epidemiology Study (1996)

Concerned beachgoers and other advocates for Santa Monica Bay now know more than ever before about how safe it is to swim in Santa Monica Bay, thanks to a landmark epidemiology study conducted by the Santa Monica Bay Restoration Project (SMBRP).

The results, announced in May before a diverse audience of government agencies, environmental organizations, local dignitaries and media representatives, confirmed what health experts have long suspected but lacked the supporting data to definitively proclaim: To stay healthy, Bay swimmers should steer clear of flowing storm drains.

**Study findings revealed that individuals who swim in front of flowing storm drains are 50 percent more likely to develop a variety of symptoms than those who swim 400 yards away from the same drains.**

## Introduction

The epidemiology study, commissioned and co-designed by the SMBRP and conducted by epidemiologist Dr. Robert Haile of the University of Southern California School of Medicine, is the first in the country to examine whether there are adverse health effects associated with swimming in marine waters contaminated by urban runoff. According to study participants, the findings could also apply to any urban area in the country with recreational areas that are impacted by urban runoff. As a $750,000 cooperative venture partially funded through the non-profit Santa Monica Bay Restoration Foundation, the epi study included significant contributions of cash, grants, and in-kind services from a variety of federal, state and local agencies, private organizations and community groups.

The epidemiology study is one of 74 priority actions included in the Bay Restoration Plan, a blueprint to guide the recovery of Santa Monica Bay which was created by the SMBRP, and approved by Governor Pete Wilson in 1994 and by US EPA Administrator Carol Browner in 1995. "One of the reasons the Santa Monica Bay Restoration Project was created in the first place was because people were concerned about the possible health risks of swimming in the Bay," said SMBRP Director Catherine Tyrrell. "For years, swimmers and surfers have complained about eye, ear, skin and stomach problems which they believe stem from their contact with the Bay. But we lacked the proof to make the connection. With this study, we finally know that people can get sick from swimming in front of flowing Bay storm drains."

The study is a follow-up to an earlier multi-phase research project conducted by the SMBRP between 1989 and 1992. That effort found enteric viruses in runoff at three widely separated Bay storm drain locations, indicating that human fecal waste was present in the storm drain system. Because of the findings, signs have been posted since 1992 near storm drain outlets on beaches along the Bay, cautioning bathers to swim at least 100 yards from flowing drain outlets.

## The Study

During the course of the study, which was conducted from June through September 1995, a team of bilingual interviewers questioned 15,492 beachgoers of all ages who swam at three Santa Monica Bay beaches located near flowing storm drain outlets. They contacted the swimmers

again 9-14 days after their initial questioning to inquire as to the presence of a variety of symptoms, including: fever, chills, earache, skin rash, nausea, stomach pain, coughing, sore throat, a group of symptoms indicative of "highly credible gastrointestinal illness" (HCGI), and "significant respiratory disease" (SRD).

In addition, daily water samples were collected at and near the studied storm drain locations and analyzed for total and fecal coliforms, enterrococci, and E. coli. Water samples were also collected at storm drain sites and analyzed for enteric viruses.

## Findings

According to Dr. Haile, swimmers who do not follow the advice to steer clear of flowing drains could experience an increased risk for a broad range of adverse health effects including fever, nausea, and gastroenteritis, as well as cold and flu-like symptoms such as nasal congestion, sore throat, fever and/or cough. "Some 373 people out of every 10,000 can develop any of these symptoms if they swim in front of a flowing storm drain," said Dr. Haile. Increased health risks were also associated with swimming in areas with high bacterial indicator counts, and on days when water samples tested positive for enteric viruses.

## Epi Study Action Agenda

The SMBRP outlined a list of actions that agencies have agreed to implement as a result of the study's findings. Designed to better inform and further protect the public on several fronts, these actions will be carried out by a variety of government agencies. Prominently featured in the Epi Study Action Agenda are tasks which expand on efforts to educate and advise the public regarding safe swimming choices.

Strikingly colored new bilingual warning signs have been created which read **"WARNING! STORM DRAIN WATER MAY CAUSE ILLNESS. NO SWIMMING."** They will be posted on either side of all flowing storm drains in Los Angeles County, and will also be accompanied by crossed warning flags. In addition, lifeguards will actively warn swimmers away from areas directly in front of storm drain outlets when swimming.

Other actions that will be carried out by local agencies include implementing source control measures to reduce the input of pathogens (organisms that cause disease in humans) and other contaminants into storm water runoff. Diverting dry-weather flows from problem storm drains to wastewater treatment facilities, investigating and correcting malfunctioning septic systems, and improved response to and control of sewage spills are among the tasks to be undertaken.
The Epi Study Action Agenda also calls upon regulatory agencies to incorporate epi study findings into monitoring programs, and for revising recreational water quality standards/criteria if appropriate. In addition, members of the public are being asked to practice "good housekeeping" at their homes and workplaces to help prevent Bay pollution.

For further information on the epidemiology study, please request a copy of the full technical document or the 13-page Public Summary by e-mailing SMBRP@earthlink.net or writing us at 101 Centre Plaza Drive, Monterey Park, CA 91754.

## Student Activities

1) Investigate what kind of beach/water quality monitoring program exists in your town or state
2) Find out what the BEACH Act says
3) Research what kinds of pollutants are found in untreated sewage, and what effects they may have on human health.

## Additional Resources

Natural Resources Defense Council's annual publication: "Testing the Waters"
http://www.nrdc.org/water/oceans/ttw/exesum.asp

Boston Harbor Homepage
http://www.mwra.state.ma.us/harbor/html/harbpol.htm

Heal the Bay
http://www.healthebay.org/

# The Ocean PharmaSea

Courtesy of Terry Kirby Hathaway from the North Carolina Aquarium

The oceans contribute to our health and lifestyles more than we think!

Polysaccharides that come from **red algae** are used to treat peptic ulcers. Carrageenan, a compound from Irish moss, is used in foods and cosmetics. Agar is used in labs all over as a culture medium.

**Brown algae** manufacture a compound, stypoldione, that seems to inhibit cell division of viruses like herpes and human immunodeficiency viruses (HIV).

One of the first compounds derived from marine animals was discovered in the 1960's in a Caribbean **sponge**. This compound exhibits antitumor activity against non-Hodgkin's lymphoma. Still another sponge indigenous to Palau contains a calcium-blocking compound that is used to inhibit pain from bee stings and maybe cobra venom C it has the benefits of steroids without the side effects.

From **jellyfish**, two compounds have been found: one that is an active agent against tissue inflammation (a potential killer of cancer cells) and one that accelerates the heart beat.

A compound from **soft corals** is an anti-inflammatory. It is used in a skin cream that protects against skin damage.

Palytoxin, found in a Hawaiian **hard coral**, destroys healthy and cancerous cells. Research is looking towards selective binding (kills unhealthy cells and leaves healthy cells alone). Coral skeletal structure is remarkably similar to human bone; it helps speed the regrowth of bone grafts.

Bryostatin-1 comes from a **bryozoan**. It is a cancer-fighting compound, active against leukemia, renal cancer, and melanoma; and is in human clinical trials at present.

The radula from the **cone snail** injects a paralyzing toxin (conotoxin) into its prey. One component of conotoxin is currently being used as a pain killer in a drug called SNX-111. This drug is 100-1000 times more effective than morphine and is non-addictive. Currently undergoing more intensive clinical trials.

Mercene, an extract from **clams**, was injected into cancerous mice that lived and bred normally. Autopsies showed scar tissue where tumors had been. No anti-tumor activity is exhibited from clams in polluted waters!

**Mussels** showed scientists the first marine super glue! It is used to repair corneas and retinas, and may soon work to secure dentures and dental fillings.

LAL, or limulus amoebocyte lysate, is an extract from the blue blood of the **horseshoe crab** that is used to detect meningitis, septic shock and other forms of bacterially-related diseases.

The **blue crab** has an exoskeleton from which chitin, a crystalline polymer, can be extracted. Chitin is used in absorbable, non-allergenic sutures. Chitosan (derivative of chitin) has various uses in food, cosmetics, and drugs.

**Sea squirts** produce didemnin-B, a compound that works against leukemia, melanoma, and ovarian cancer. It is similar to cyclosporin, and immuno-suppressor that decreases transplant rejection. Another compound encourages skin grafts and suppresses T-lymphocyte production. Currently scheduled for human clinical trials.

Squalamine, a potent antibiotic found in the liver of **dogfish sharks** works differently than other antibiotics, so it may be useful in fighting diseases that have become drug resistant. It also seems to inhibit the growth of blood vessels around some tumors. Research on shark cartilage continues.

The nerve toxin tetrodotoxin is concentrated in the liver, ovaries, and intestines of **puffer fish**. It blocks the channel in nerves through which sodium flows. No sodium = paralyzed nerve. The drug derived from tetrodotoxin is currently used in eye surgery.

## Student Activity

1. Pretend that you are a newspaper reporter. Choose one of the following groups of marine organisms -- sponges, algae, or corals -- and carefully research how this group of organisms contributes to pharmacology. Then write a one-page article on the topic, keeping in mind that it should grab the reader's attention and be as accurate as possible.

Harmful Algal Blooms can be introduced when teaching about water quality, food chains and webs (phytoplankton), and health.

*From "The Harmful Algae Page," National Office for Marine Biotoxins and Harmful Algal Blooms, Woods Hole Oceanographic Institution.*

## What Are Harmful Algal Blooms (HABs)?

Harmful algae are microscopic, single-celled plants that live in the sea. Most species of algae or phytoplankton are not harmful and serve as the energy producers at the base of the food web, without which higher life on this planet would not exist.

Occasionally, the algae grow very fast or "bloom" and accumulate into dense, visible patches near the surface of the water. "Red Tide" is a common name for such a phenomenon where certain phytoplankton species contain reddish pigments and "bloom" such that the water appears to be colored red. The term "red tide" is thus a misnomer because they are not associated with tides; they are usually not harmful; and those species that are harmful may never reach the densities required to discolor the water.

Unfortunately, a small number of species produce potent neurotoxins that can be transferred through the food web where they affect and even kill the higher forms of life such as zooplankton, shellfish, fish, birds, marine mammals, and even humans that feed either directly or indirectly on them. Scientists now prefer the term, HAB, to refer to bloom phenomenon that contain toxins or that cause negative impacts.

## Humans at the Top of the Food Web

The consumption of shellfish (e.g. mussels, clams) is one the most common ways for algal toxins to reach the highest levels of the food web affecting humans. In the United States, state management programs are responsible for monitoring the concentration of the toxins in shellfish and closing the shellfish beds for harvest if the levels rise above dangerous limits. Marketable shellfish are generally considered to be safe, but in spite of these precautions, there are known illnesses.

One dramatic example was from 1990, when six fishermen almost died from eating mussels during a fishing trip on Georges Bank, a productive offshore finfish and shellfish area 100 miles east of Cape Cod, MA. After a hard day of fishing, the fishermen settled down in the ship's galley to eat a pot of steamed mussels that they had incidentally caught in their nets. The Captain, who had joined the meal later than the rest of the crew, witnessed his fellow fishermen become incapacitated due to the paralytic effects of the toxin. He himself also became ill, but was capable of sending an urgent radio message to the US Coast Guard. The Coast Guard airlifted the men to the nearest hospital located on Nantucket Island, MA where they were treated using respiratory therapy to sustain their breathing and prevent them from dying due to paralysis of the lungs. Fortunately, all the men recovered and were back fishing within a few weeks. The event, presumably caused by a massive *Alexandrium* bloom transported offshore from areas along the northeast coast, closed the surf clam industry on Georges Bank to further harvest. Georges Bank is an offshore area too vast to monitor and is outside the states' jurisdiction, so the

US government maintains jurisdiction and currently has a ban in place for the harvest of surf clams which are known to retain the toxins for many years.

## Human Illness Associated with Harmful Algae

Man is exposed principally to the naturally-occurring toxins produced by harmful algae through the consumption of contaminated seafood products. The most significant public health problems caused by harmful algae are:

Amnesic Shellfish Poisoning (ASP)
Ciguatera Fish Poisoning (CFP)
Diarrhetic Shellfish Poisoning (DSP)
Neurotoxic Shellfish Poisoning (NSP)
Paralytic Shellfish Poisoning (PSP)

Each of these syndromes are caused by different species of toxic algae which occur in various coastal waters of the US and the world. With the increase in interstate and international transport of seafood, as well as international travel by seafood consumers, there are virtually no human populations that are free of risk. Since 1978, illnesses in the US due to natural algal toxins have included PSP, NSP, CFP, and ASP. No incidents of DSP have yet been verified in this country. Although records are incomplete because reporting to the Centers for Disease Control (CDC) is voluntary, evidence indicates that ciguatera was responsible for about half of all seafood intoxications. A growing body of evidence indicates that incidents of ASP are on the increase and that DSP may shortly make its debut in the United States, since the causative organisms occur throughout the temperate coastal waters of the US.

## Amnesic Shellfish Poisoning (ASP)

**Causative organisms:** *Pseudo-nitzschia* sp.
**Toxin produced:** Domoic Acid

ASP can be a life-threatening syndrome. It is characterized by both gastrointestinal and neurological disorders (Bates et al., 1989). Gastroenteritis usually develops within 24 hours of the consumption of toxic shellfish; symptoms include nausea, vomiting, abdominal cramps, and diarrhea. In severe cases, neurological symptoms also appear, usually within 48 hours of toxic shellfish consumption. These symptoms include dizziness, headache, seizures, disorientation, short-term memory loss, respiratory difficulty, and coma. In 1987, four victims died after consuming toxic mussels from Prince Edward Island, Canada. Since that time, Canadian authorities have monitored both the water column for the presence of the causative diatom, and shellfish for the presence of the toxin, domoic acid. Shellfish beds are closed to harvesting when the domoic acid concentration reaches 20 µg/g shellfish meat. Fish and crab viscera can also contain domoic acid, so the risk to human consumers and animals in the marine food chain is more significant than previously believed.

## Ciguatera Fish Poisoning (CFP)

**Causative organisms:** *Gambierdiscus toxicus*, *Prorocentrum* spp., *Ostreopsis* spp., *Coolia monotis*, *Thecadinium* sp. and *Amphidinium carterae*
**Toxins produced:** Ciguatoxin/Maitotoxin

CFP produces gastrointestinal, neurological, and cardiovascular symptoms. Generally, diarrhea, vomiting, and abdominal pain occur initially, followed by neurological dysfunction including reversal of temperature sensation, muscular aches, dizziness, anxiety, sweating, and a numbness and tingling of the mouth and digits. Paralysis and death have been documented, but symptoms are usually less severe although debilitating (Miller, 1991). Recovery time is variable, and may take weeks, months, or years. Rapid treatment (within 24 hours) with manitol is reported to relieve some symptoms. There is no antidote, supportive therapy is the rule, and survivors recover. Absolute prevention of intoxication depends upon complete abstinence from eating any tropical reef fish, since there is currently no easy way to measure routinely ciguatoxin or maitotoxin in any seafood product prior to consumption.

## Diarrhetic Shellfish Poisoning (DSP)

**Causative organisms:** *Dinophysis sp.*
**Toxin produced:** Okadaic Acid

DSP produces gastrointestinal symptoms, usually beginning within 30 minutes to a few hours after consumption of toxic shellfish (Yasumoto and Murato, 1990). The illness, which is not fatal, is characterized by incapacitating diarrhea, nausea, vomiting, abdominal cramps, and chills. Recovery occurs within three days, with or without medical treatment.

## Neurotoxic Shellfish Poisoning (NSP)

**Causative organism:** *Gymnodinium breve*
**Toxins produced:** Brevetoxins

NSP produces an intoxication syndrome nearly identical to that of ciguatera. In this case, gastrointestinal and neurological symptoms predominate. In addition, formation of toxic aerosols by wave action can produce respiratory asthma-like symptoms. No deaths have been reported and the syndrome is less severe than ciguatera, but nevertheless debilitating. Unlike ciguatera, recovery is generally complete in a few days. Monitoring programs (based on G breve cell counts) generally suffice for preventing human intoxication, except when officials are caught off-guard in previously unaffected areas.

## Paralytic Shellfish Poisoning (PSP)

**Causative organisms:** *Alexandrium* spp.,*Gymnodinium catenatum, Pyrodinium bahamense*
**Toxins produced:** Saxitoxins

PSP, like ASP, is a life threatening syndrome. Symptoms are purely neurological and their onset is rapid. Duration of effects is a few days in non-lethal cases. Symptoms include tingling, numbness, and burning of the perioral region, ataxia, giddiness, drowsiness, fever, rash, and staggering. The most severe cases result in respiratory arrest within 24 hours of consumption of the toxic shellfish. If the patient is not breathing or if a pulse is not detected, artificial respiration and CPR may be needed as first aid. There is no antidote, supportive therapy is the rule and survivors recover fully. PSP is prevented by large-scale proactive monitoring programs (assessing toxin levels in mussels, oysters, scallops, clams) and rapid closures to harvest of suspect or demonstrated toxic areas.

## Student Activities

1. Find out if there have been any harmful algal blooms in waters near you in the last few years. What kind of organism was involved? Was it dangerous to other marine life, or to humans? What was believed to be the cause of the bloom?

2. *Pfiesteria* is an algal bloom that has been featured in the news in recent years. Investigate whether it poses a serious health threat to humans, and under what conditions it is believed to thrive.

3. Ask students if they or anyone they know has ever gotten sick from something related to the ocean. Ask the students what illnesses humans or other organisms can contract from the ocean. Assign students to groups. Each group is responsible for researching an illness on the above list. Presentations on their assigned illness will be made to the class. The presentation must include:

- Description of organism responsible for the illness, including a picture or other visual aid
- Locations of recent outbreaks
- How humans contract the illness
- Symptoms of illness
- Length of beach/fishing closure, if applicable
- Treatment, if available
- Severity / Potential mortality rate
- Preventative steps, or ways to reduce the outbreak
- Does the illness occur in isolation or in conjunction with other HABs
- Description of organisms other than humans that are affected by the HAB

Assessment for this activity: Groups are assigned an illness, and they act out the symptoms related to the ailment, and the other students are responsible for diagnosing them, based on what they learned from each other's presentations.

## Assessment

1. Discuss how the following types of pollution affect marine life: nutrients, pathogens, and plastics.

2. What are Harmful Algal Blooms and why do they pose threats to human health? Discuss two types of seafood poisoning, including the type of toxin produced, and several physical symptoms.

3. List three marine organisms (plants or animals) and describe their contributions to human health.

## Additional Resources

The Harmful Algae Page
http://www.whoi.edu/redtide/

Sea Grant Focal Points, April, 1998 newsletter
http://www.epa.gov/owow/estuaries/coastlines/summer98/harmfulalga.html

Bigelow Laboratory -- Toxic and Harmful Algal Blooms
http://www.bigelow.org/hab/

Links to many more HAB sites
http://www.coexploration.org/habs/html/resources.html

Blue Flag Beaches
http://www.blueflag.org/

Pfiesteria
http://www.boatus.com/cleanwater/outreach/pfiesteria.htm

## Oceans and Human Health Links

International Center for Oceans and Human Health
http://www.bbsr.edu/icohh/icohh.html

National Sea Grant Office article on *Marine Environmental Health Linkages to Human Health*
http://www.seagrantnews.org/news/19990120cpbrief_health/

Environmental Health Perspectives: The State of the Oceans, Parts 1 and 2
http://ehp.niehs.nih.gov/members/2004/112-5/focus.html
http://ehp.niehs.nih.gov/members/2004/112-8/focus.html