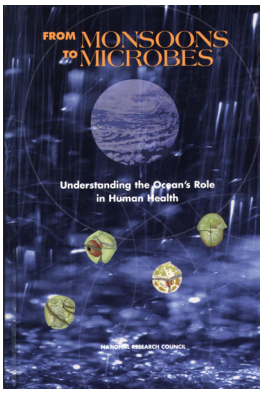
From Monsoons to Microbes

Understanding the Ocean's Role in Human Health



When fishermen report strange episodes of memory loss associated with an algal bloom, or when there is an announcement of a new cancer-fighting drug that is derived from a marine organism, people become aware of some of the potential hazards and benefits that the ocean has to offer.

Climate change and other factors influence the ocean's sweeping physical processes, causing a patchwork pattern of change in temperature, severity of storms, rainfall and drought, and ocean circulation. The world ocean actively influences the atmosphere as demonstrated by the El Nino phenomenon, which not only results in short-term disasters such as hurricanes and floods, but also impacts human health by reducing the availability of safe drinking water, sewage treatment and disposal, and emergency medical care (see Box 1).

To understand better the many ways the oceans impact human health, there is a strong need to connect many fields of research where human health and ocean systems meet. Challenges still remain to develop more accurate forecasting of climate and weather events, to anticipate the threats and the possible impacts of infectious diseases, to monitor the growth of toxic algal blooms, and to explore marine biodiversity to uncover new pharmaceuticals and animal models for biomedical research.

THREATS FROM THE OCEAN

Disease

In the final decade of the 20th century, waterborne diseases were as prevalent as they were at the start of the century. Disease incidence is increasing worldwide, promoted by both natural phenomena such as El Niño, and human activities, such as untreated sewage disposal.

The ocean acts as a conduit for many human diseases. Most illness comes from eating seafood, such as contaminated shellfish. Illness can also result from direct contact with contaminated seawater through swimming, boating, and fishing. Infectious diseases in the ocean may be waterborne diseases or vector-borne; both are spread by natural processes, ballast water of ships, and international seafood trade.

Most waterborne diseases are caused by viruses, such as the human caliciviruses that cause stomach upset and the rotaviruses responsible for widespread diarrheal disease that kills an estimated 870,000 children in the world each year. Disease can also be caused by bacteria that come either from human and animal waste or from sources in the sea. While factors such as climate change may have less effect on waterborne disease, changing demographics and development pressures (e.g., sewage contamination) contribute to the spread of these diseases.

Box 1. El Nino and Its Impacts

During an El Niño event, a mass of warm tropical surface water spreads across the eastern equatorial Pacific. These warm ocean waters charge the atmosphere with moisture and heat that brings unusually warm, wet weather to the west coasts of North and South America.

The 1998 El Niño phenomenon affected weather around the world. Storms fueled by the phenomena led to contamination of many bodies of water because of septic tank overflows. In 1990, the Peruvian coast experienced an El Niño event, which sparked the spread of cholera, a waterborne disease, through the region. In 1991, cholera quickly spread to the neighboring countries, and in 3 weeks, 30,000 were infected. It was hypothesized that *V. chloerae* grew in response to the warmer water and the contamination of water supplies affected by the heavy rains.

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Diseases that are carried by one organism and transmitted to another are called vector-borne diseases. For example, a mosquito is a vector that carries the protozoa that causes malaria in humans. The risk of malaria often increases following a severe weather event such as a hurricane or monsoon, because malaria control measures may be disrupted and excess rain may increase mosquito habitat. Mosquitoes also carry viruses that cause Rift Valley Fever and Dengue Hemorrhagic Fever.

Studying the aftermath of periodic events such as El Niño, which brings extremes of both rainfall and drought, aids our understanding of how global climate change might affect the spread of vector-borne diseases. In Venezuela and Colombia, the incidence of malaria deaths increased 35-37% in the years following El Niño, but the correlation was stronger for years when El Niño produced drought than for years with heavy rainfall. It is not yet clear why this is true, and data from other points on the globe show conflicting trends indicating that other factors, such as the quality of eradication programs, might play a bigger role than weather.

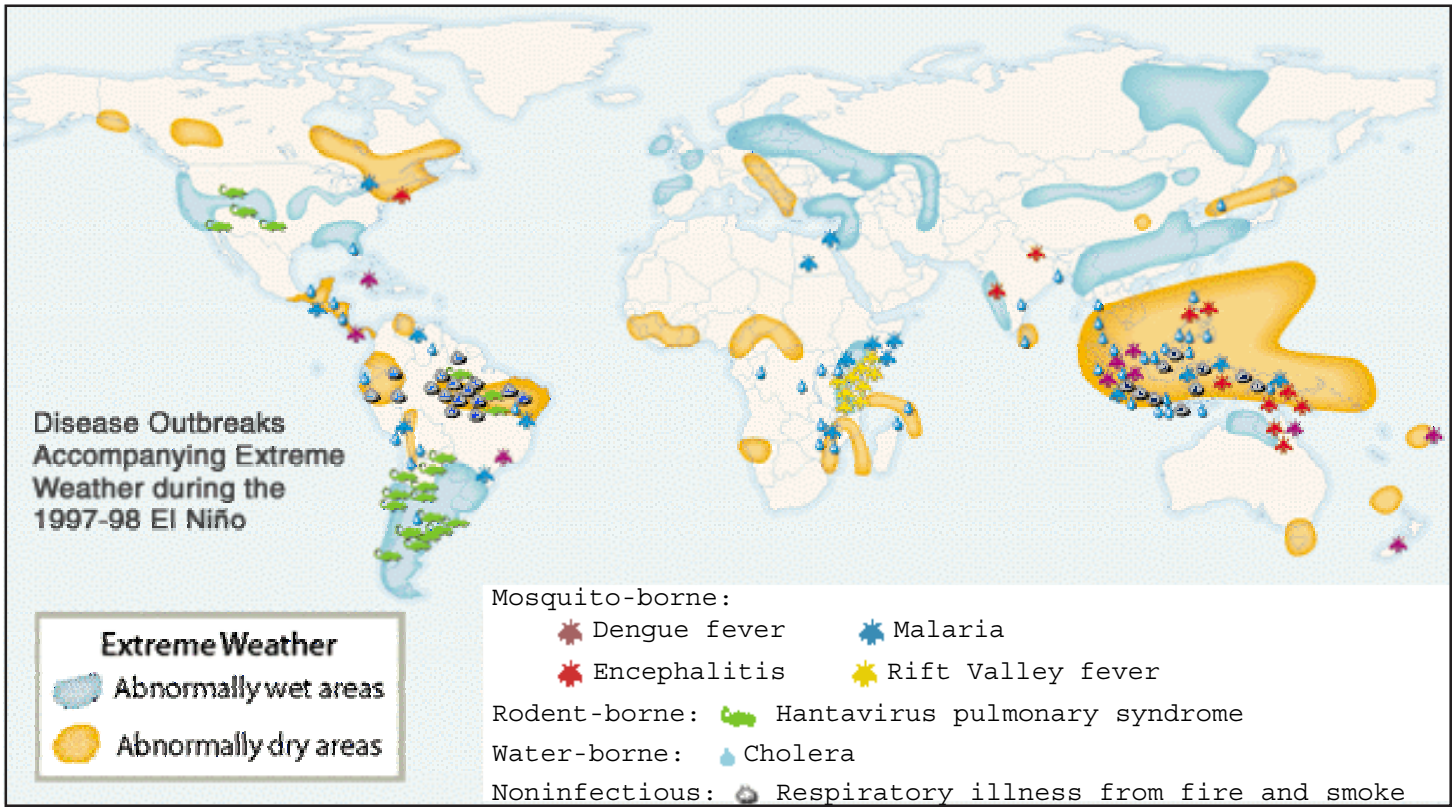
Algal Blooms

The single-cell algae known as phytoplankton can grow so numerous that they can cause a "red tide" or bloom that discolors the water into a red, reddish brown, green, or yellow-green color. Algal blooms can be a public health threat if the algae produces toxins that kill fish and marine mammals, or make shellfish poisonous, disrupting economies of coastal communities.

Harmful algal blooms are responsible for six different types of seafood poisoning, several of which can be lethal For example, amnesic shellfish poisoning is caused by an accumulation of domoic acid by shellfish, that, when eaten by humans, can impair short- and long-term memory. The most severe symptoms are inflammation of the stomach, dizziness, headache, seizures, disorientation, short-term memory loss, trouble breathing, and death.

Virtually all coastal regions of the United States are now subject to harmful algal blooms, and the range and frequency of blooms is increasing. The reasons for this expansion are unknown, but could include

El Niño and the Spread of Disease



Source: Dr. Paul Epstein, Harvard University

human-related factors such as nutrient enrichment (run-off from agriculture), climatic shifts, and more accurate reporting of algal bloom events.

Weather and Coastal Hazards

The most vivid and direct impacts of the oceans and human health arise in coastal areas that are subject to tsunamis, storm surges, heavy rainfall and flooding, and severe winds that can result in large losses of life. In October of 1998, Hurricane Mitch brought tragedy to Central America, when the storm stalled over Honduras for several days. This storm caused floods and landslides in the highlands and coastal regions. In Honduras, Nicaragua, Guatemala, and El Salvador, there were 9,000 deaths alone, with another 9,200 people missing.

In addition to loss of life, coastal hazards have several delayed, indirect impacts. Lingering economic losses from damage can cause an overall decrease in public health services as resources are diverted to other immediate needs. Lack of electrical power and transportation following an ocean-borne disaster can impair operations of hospitals, water plants, and health facilities. Hurricane Gilbert in Jamaica (1988) had a modest death toll, but left 22 hospitals or health centers out of service, reducing hospital bed capacity on the island by 90% for several days to weeks.

ADVANCES IN MEDICINE FROM THE OCEAN

Scientists have only begun to mine the ocean for its potential cures for disease and the unique ways it can help us better understand human physiology. The horseshoe crab helped scientists to understand the purpose of retinol in how eyes see; the giant squid to understand how nerve impulses work; sponges are used to find cures for cancer. However, there still remains a great need to research the many other species of the seas to see how they can contribute to medicines and treatments that the oceans have to offer.

Pharmaceuticals

The ocean became a major focus of natural drug discovery because it is somewhat unexplored in relation to drugs found from terrestrial sources. The ocean contains more than 200,000 species, which is only a small fraction of all of the species that are yet to be discovered. Because many marine species live in crowded habitats, cannot move from their environment, and have very basic immune systems, they have chemical compounds to help defend themselves against predators. The most developed pharmaceuticals from the ocean are cancer-fighting compounds from sponges. Of the more than 5000 chemical compounds found in marine organisms, more than 30% have been found in sponges.

Many marine plants and animals produce chemicals to protect themselves from enemies. Some of these chemicals have potential as pharmaceuticals.

Marine Models in Research

Scientists often use a comparative approach to biology, comparing the biology of marine animals with human biology. Sea stars, urchins, and sharks are used to see how the body fights infection and disease; sea urchins and clam eggs are used to understand cell biology and biochemistry; and the giant squid offers clues to how nerve impulses are conducted. These are just a few of the many marine organism models that have contributed to biological sciences.

UNDERSTANDING THE OCEAN TO IMPROVE PUBLIC HEALTH

What do we need to know to both reduce the impact of the ocean's hazards and enhance the benefits derived from it? Following are several recommendations from the report about the data collection and research that should be pursued to enhance our knowledge.

Controlling Infectious Diseases

- Collection of ongoing health statistics, especially in developing countries that lack an extensive public health infrastructure, would enable a better analysis of the effects of the ocean on health.

- Correct diagnoses of infectious ocean diseases are critical to reducing their impact.
- Tracking and predicting the spread of disease could be improved by accurately reporting the frequency, location, and date of disease outbreaks to the international health community.
- Disease surveillance programs should be evaluated for their scope and effectiveness.

Monitoring Harmful Algal Blooms

- More accurate species identification is needed to track species dispersal and identifying the type of toxins they emit.
- Increased monitoring of water conditions would allow comparisons of before, during, and after an algal bloom to determine the factors that lead to the spread of a bloom.
- Effective mitigation efforts will depend on identifying the causes of the increased incidences and distribution.

Research on Weather Hazards from the Ocean

- Additional climate change research may illustrate links with storm severity.
- Improved collection of global climate variations is needed to enhance storm prediction.
- Better forecasting of the landfall site could dramatically reduce the expense of the storm and disruption of coastal communities.

Research on Medicine from the Ocean

- Continued exploration of marine biodiversity is crucial to the discovery of new pharmaceuticals.
- Industry and academia partnerships should be encouraged to provide cross-disciplinary expertise and to offset the expense of investigating the potential medicinal value of marine species.
- New techniques to culture species need to be developed since harvesting of species either for research or extraction of a biologically-active compound is expensive and may deplete the natural population.
- Comparative anatomy studies of marine organisms are important to understanding how the human body functions.

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This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the Ocean Studies Board at 202-334-2714 or http://dels.nas.edu/osb. *From Monsoons to Microbes: Understanding the Ocean's Role in Human Health* is available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 1-800-624-6242; www.nap.edu.