Deep blue waters seem to soothe the emotions, relax the mind, and invigorate the spirit. After all, we live on the Ocean Planet, with salt water covering almost three-quarters of the earth. The oceans drive our weather systems, are a source of oxygen, water, and nutritious foods, and even have applications to biomedicine. In addition to having positive effects on our mental and emotional states of being, the oceans can also affect our physical health.

An informal study conducted at the New England Aquarium in Boston, Massachusetts, found that only one in ten visitors could identify a single way in which their health is affected by the oceans. In contrast to environmental issues, which are consistently ranked relatively low in public opinion polls, human health is often a chief public concern, according to the Center for Health and the Global Environment at Harvard Medical School. Yet the public is virtually unaware that the oceans can have both positive and negative impacts on their personal health. Within the past decade, the topic of Oceans and Human Health has started to become visible on the public radar screen.

**The Ocean Pharmacy**

In addition to providing protein as a food source, there are other ways that the oceans help us to improve and maintain our health. They are a very promising frontier for sources of new medicines. Marine organisms tend to have unique and varied mechanisms for defending themselves, whether it is through harboring toxins or having antibiotic properties to fight bacteria and viruses in their environment. For centuries, people have used nature as a source for healing remedies to treat disease. The vast majority of our medicines are derived from the land, but the ocean’s potential for providing healing compounds has barely been tapped. Many marine plants and animals live their lives attached to the ocean bottom, so have developed specialized substances to ward off predators, attract mates, or communicate. Some of these substances form the basis for pharmaceuticals that are useful to humans.

“If, for example, a sponge is trying to prevent a coral from invading its space, it may produce a chemical to prevent the coral cells from growing and dividing,” says Dr. Shirley Pomponi, Vice President and Director of Research, Harbor Branch Oceanographic Institution at Florida Atlantic University. “It is not unusual, therefore, that these same chemicals may also be effective in inhibiting the uncontrolled growth of cancer cells in humans.”

As another example, a substance in a deep water sponge has been found to inhibit the proliferation of cancer cells. Another sponge species serves as a source of compounds that can decrease inflammation, and may be useful in treating allergies, arthritis, or other inflammatory diseases. The bryozoan *Bugula* is a source of bryostatins, which have anti-tumor properties. Although the oceans hold enormous potential for new drug discovery, it can take about 10-15 years for a marine-derived drug to become available for human use once it is discovered. Extensive pre-clinical research must be done to understand how a substance works and to ensure that it is safe for humans.

Searching for marine-derived pharmaceuticals has its challenges. Research expeditions using submersibles for deep-sea exploration are expensive, and time at sea is limited. Even if a substance is found in shallow water, adequate supplies of that substance or the organism producing it usually do not exist and must be synthesized in a laboratory. This can be a tedious and time-consuming process that may or may not

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Humans have inner ears nearly identical to those of toadfish, so these fish are useful for studying balance.

Meet with success. Another alternative to harvesting is aquaculture, or farming of the host organism. Politics and ethics also play a role in the search for biopharmaceuticals, particularly if ocean exploration is being conducted in areas that are outside the jurisdiction of the U.S. For example, if a medicine was developed based on an organism that is endemic to a certain area, should the country that governs those waters be paid a portion of the profits from the new drug? If the organism was harvested extensively, should the revenue sharing be greater than if only a few samples had been taken? These are some of the questions that researchers, legislators, and environmental managers must consider when bioprospecting takes place.

**Marine Organisms as Research Partners**

The study of marine animals can have useful and important applications in the field of biomedicine. For example, humans have inner ears nearly identical to those of toadfish, so these fish are excellent for studying balance.

If you’ve ever experienced an intravenous treatment at a hospital, there’s a chance that those fluids were tested for impurities by using a compound produced by the horseshoe crab. (see “The Horseshoe Crab Conundrum”, *Wrack Lines* 8:1.) This animal is also helpful in teaching us about vision. Its eye has about 1000 photoreceptors, which process visual information and relay it to the brain. In contrast, the human eye has only about 100 photoreceptors.

Here are some other examples of marine biomedical models:

- Sea urchins are helpful in understanding cell biology. They lay an abundance of eggs, and researchers are studying how their cells divide after fertilization. The urchin is being used as a model for studying fetal alcohol syndrome in humans.
- Winter flounder is being used as a model to examine how kidney cells transfer toxins from the blood into the urine for excretion.
- The spiny dogfish shark is helping scientists learn more about vision and fluid formation in the eye.
- The squid has a huge axon, or part of a nerve fiber, which is 1000 times larger than axons in vertebrates. Studies on nerve conduction from the squid are forming the basis for diagnosing and treating nerve disorders in humans.

This is only a small sampling of the many different marine animals that are helping us learn about ourselves and our health. The field of biomedical modeling keeps expanding, as we discover more about the ocean’s inhabitants and the similarities we share with them.

**Sentinel Species**

A sentinel species, or indicator species, is one which can offer early warning signs of environmental stress. The absence or presence of a sentinel species can provide clues as to the overall health of an ecosystem. Since 1986, winter flounder and blue mussels have served as sentinel species for Long Island Sound as part of the National Status and Trends Program.

**Oceans, Climate Change, and Health**

Since oceans are heavily responsible for driving our weather, changes in climate can pose risks to human health. One way that a warmer planet and variable ocean, atmosphere and weather patterns can affect public health is through mortality due to higher storm surges.
(as a result of sea level rise) from a hurricane, tsunami, or other natural event. But developing countries are at the greatest risk for public health impacts from environmental hazards.

Storm surges may carry contaminated water ashore and people may become ill from water-borne diseases. Hospitals may sustain physical damage and staff may not be able to provide enough care for those who need it. Other health care services may be disrupted. Disease outbreaks may occur. For example, in the early 1960’s, a major hurricane struck the Caribbean island of Haiti, just after insecticide spraying had taken place to combat malaria-carrying mosquitoes. More insect breeding sites formed after the storm and the interruption in the mosquito control program resulted in a severe disease outbreak.

Another impact of climate change on human health is water-borne infections which occur through contact with contaminated drinking water, recreational water, or food. This may result from human actions, such as improper disposal of sewage, or from weather events. Rainfall can influence the transport and dissemination of infectious disease carriers, while temperature affects their growth and survival.

Beach closings are often a result of contaminants in coastal waters. According to the Connecticut Council on Environmental Quality, the agency which monitors long-term trends in Connecticut’s environment, “the average coastal town has had to close its beaches for two to four days in each of the past six years, usually because of pollution washed into the water by heavy rains.” Most closings are in the western half of the state.

According to the World Health Organization, during the 1990’s there were approximately 600,000 deaths in the world due to natural disasters, and tens of millions more people were impacted. Nearly 95% of those people who died were in poor countries. Developing countries tend to take the brunt of climate change impacts, yet they are the least equipped to deal with them.

The table at the bottom of this page summarizes the potential hazards of a changing climate and their health impacts.

All of the potential impacts of climate change on oceans may sound daunting, but the good news is that scientists, policymakers, and the public are increasing their awareness of the impacts of climate change. This has happened fairly rapidly (think ten years ago, when we rarely heard about it in the media). We are quickly learning about what types of environmental changes need long-term monitoring and understanding to help offset the impacts of a warmer planet, and we are taking action.

Harmful Algal Blooms

In addition to being impacted by climate change, the oceans can serve as vectors for waterborne diseases such as cholera, or illnesses that occur when we consume contaminated seafood. Sometimes, this contamination can be the result of certain types of algal blooms, which can have negative health effects on humans and marine animals. These particular phytoplankton are microscopic single-celled plants that occur in aquatic environments.

Large blooms of algae occur frequently and naturally in marine and freshwater environments. Harmful algal blooms like this overabundance of blue-green algae can have toxic effects on marine animals and humans.

<table>
<thead>
<tr>
<th>Environmental Hazard</th>
<th>Impact on Human Health</th>
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<tbody>
<tr>
<td>Natural disasters</td>
<td>Injury, death, food/water shortages, increase in infectious diseases</td>
</tr>
<tr>
<td>Temperature increase</td>
<td>Increase in heat exhaustion, heat strokes, cardiovascular and respiratory problems</td>
</tr>
<tr>
<td>Increased air pollution and allergens</td>
<td>Respiratory illnesses, including increased risk of asthma</td>
</tr>
<tr>
<td>Flooding and heavy rains</td>
<td>Emergence and resurgence of infectious diseases, impact on food supply</td>
</tr>
<tr>
<td>Rising sea levels</td>
<td>Drowning, displacement and migration, change in coastlines</td>
</tr>
<tr>
<td>Droughts and wildfires</td>
<td>Decreased water supply, malnutrition, injury and death</td>
</tr>
</tbody>
</table>

Source: National Environmental Education Foundation web site http://www.neefusa.org/
freshwater environments and are the result of the interaction of factors such as currents, available nutrients (e.g., nitrogen), temperature, sunlight, and disturbances in an ecosystem. The algae may become so numerous that they make the water appear brown, red, green, or yellowish. Only some of them pose threats to human health, most often when we eat seafood that has been contaminated with certain types of toxin-producing algae. These types of blooms are called Harmful Algal Blooms, or HABs. Specific economic impacts of HABs can be felt when bans are placed on shellfish and finfish harvesting, recreational areas are closed, or when fish kills occur.

Research has shown that a HAB known as “red tide” can affect human lung function. Red tides are caused by a dinoflagellate that can release toxins into the air, which we then inhale into our lungs. Fortunately, if we remove ourselves from the reach of the aerosolized toxins, our respiratory systems can recover fairly quickly.

The good news about HABs is that researchers are becoming increasingly knowledgeable about what causes these blooms, and the effects that the algal toxins have on human health. Outbreaks of poisonings from HABs can be prevented through the monitoring of red tides and temporary closing of harvest areas when they occur. Reporting cases of poisoning when they occur might help medical practitioners to more easily diagnose them.

William Gerwick, natural products chemist and a national leader in the frontier of marine pharmaceutical discovery, is turning the negative properties of blue-green algae into a positive. “We found that blue green algae are like little chemical factories,” Gerwick told Sea Grant. “They’re just amazing at their creation of unusual organic molecules that have, for the most part, very toxic qualities. But we want to take advantage of and utilize these toxic properties and see if they have a potential utility in treatment of cancer and other diseases.”

**Taking Action on Oceans and Human Health**

Although the study of Oceans and Human Health has been ongoing for several decades, it has only recently made its way onto the public and legislative radar screens. In 2004, the U.S. Commission on Ocean Policy recommended that a more interdisciplinary approach should be taken to fully understand how humans impact the oceans, and how the oceans impact us. As a partial response, Congress passed the Oceans and Human Health Act of 2004. It provided for the formation and funding of seven national Centers of Excellence in Oceans and Human Health, grants programs, scholarships, traineeships, and public education initiatives. It helped to move the entire Oceans and Human Health initiative forward by formally recognizing the value of this interdisciplinary field, giving it funding support, and providing a mechanism for accountability on the progress of Oceans and Human Health research.

Connecticut Sea Grant, UConn, Mystic Aquarium, and NOAA Fisheries-Milford were awarded one of five NOAA Oceans and Human Health Traineeship Grants to support graduate students and post-doctoral fellow training in the area of diseases in marine organisms, emerging pollutants, and harmful algal blooms. Such training will help produce leaders who understand the relationship between marine ecosystems and human health.

It can be humbling to realize how much we still don’t know, and sometimes it’s easy to feel overwhelmed by the numerous challenges we need to overcome in keeping our planet healthy. But we must also remember that there are many people out there dedicated to understanding this Ocean Planet, with the intent of managing it sustainably, and ultimately protecting it. Congress has taken notice by passing and funding the Oceans and Human Health Act, the scientific community is going full force with its research, and the public is starting to learn about the importance of our relationship to the oceans. Hopefully, we will come to appreciate that if we take care of our oceans, they will take care of us.

**About the Author:** Melissa Ryan is a graduate of the University of Connecticut and Clayton College of Natural Health. She is director of education and outreach for the Ocean Technology Foundation based in Mystic, Connecticut, and lead program instructor for NOAA’s Office of Ocean Exploration. She has developed and taught several online courses on Oceans and Human Health.