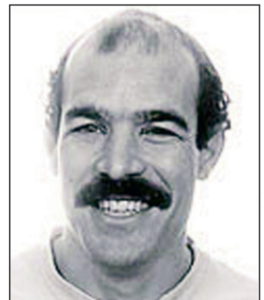
Maintaining the integrity and health of the coastal zone is essential to the quality of marine biological resources and, ultimately, of human life.

Environmental Health and the Coastal Zone

John Stegeman



Andrew R. Solow

The intersection of human health and the ocean occurs overwhelmingly in the coastal zone. The coastal zone extends from the upland penetration of tidal rivers to the edge of the continental shelf, which can extend 100 miles or more beyond the coast itself. The world's coastlines, including temperate, tropical, and polar coasts, have been estimated to total about 372,000 miles (Smithsonian Institution 2002). The coastal ocean, the most biologically productive part of the marine environment, supports a dazzling level of biological diversity, including coral reefs, marine mammals, and economically important fisheries.

Major portions of marine resources harvested are from the coastal zone. These resources include food as well as material resources used in industrial and biomedical applications. One example of the latter is the production of *Limulus* amoebocyte lysate, proteins from the blood of horseshoe crabs, used clinically to detect endotoxins in intravenous fluids. The value of all marine ecologic resources and services from the coastal zone has been estimated to be $21 trillion (McGinn 2002).

The recently convened Presidential Ocean Commission (U.S. Commission on Ocean Policy 2002) has received reports that there are serious threats to the coastal environment from coastal population growth, pollution, and over-fishing. Approximately 50% of the world's population lives within 200 km of the coast, and this percentage is expected to increase in the future. This large and growing population affects the coastal ocean in a number of ways, including nutrient loading, toxic contamination, and habitat alteration. Each of these has effects on coastal ecosystems and on the health and economic well-being of human populations living near the coast.

A variety of human activities contribute nitrogen, phosphorus, and other nutrients to the coastal ocean: for example, the agricultural and residential use of fertilizer, the disposal of human and animal waste, and the burning of fossil fuels. These nutrients are carried to the ocean by groundwater and surface water, as well as through atmospheric deposition. Nutrient loading to the coastal ocean has also increased with the loss of wetlands that can intercept and utilize nutrients before they reach the ocean.

In the coastal ocean, nutrients stimulate the growth of phytoplankton or algae, marine plants that form the base of the marine food web. This can have benign or even beneficial effects; it is no coincidence that some of the most productive fisheries in the world are near the mouths of rivers that carry nutrients to the ocean. However, nutrient loading can cause serious problems. Thus, many species of algae produce toxins that threaten both human health and the health of marine organisms. The frequency and geographic distribution of these so-called harmful algal blooms appear to have increased over recent decades, and this increase may be due to increased nutrient-loading.

Excess growth of phytoplankton can also cause clogging of corals and other coastal environments that serve as habitat for fish, seabirds, and other animals. Another serious problem can occur when large quantities of phytoplankton die and sink to the bottom, where they decay through the action of aerobic bacteria. If the quantity of phytoplankton is large, then, under certain oceanographic conditions, oxygen in the bottom waters is depleted leading to environmental hypoxia. In the United States, the best-known hypoxic area is off the coast of Louisiana; this so-called Dead Zone is caused by the discharge of nutrients to the Gulf of Mexico by the Mississippi River. Since its discovery, the Dead Zone has grown to the size of New Jersey. Hypoxia can result in the loss of commercial species and large-scale changes in the biological communities that inhabit the seafloor.

As with nutrients, toxic pollution in the marine environment is of greatest concern in the coastal ocean, where chemicals may affect animal populations and may be vectored to human consumers. One particularly dramatic form of toxic contamination is associated with oil spills. Major oil spills such as the *Argo Merchant*, the *Amoco Cadiz*, and the *Exxon Valdez* have received, by far, the most attention, but such spills account for only about 5% of oil entering the ocean (National Research Council 2002). Sewage treatment plants discharge twice as much oil into U.S. waters as that resulting from tanker spills (National Research Council 2002). Other significant sources of oil include routine operations of ships and boats, runoff from roadways, and natural oil seeps. Relatively little is known about the effects of low-level oil contamination.

More serious perhaps is the prolonged contamination from waste disposal practices affecting harbors and estuaries. High prevalences of neoplastic diseases, especially liver cancer, in bottom-dwelling fish in Puget Sound (Washington State) and Boston Harbor (Massachusetts) were well documented in the 1980s. These diseases in fish were attributed to the high levels of chemicals in those locations that were introduced from sewage or industrial waste disposal practices (Myers et al. 1991). Interestingly, there was a beneficial fallout from those situations. The study of the fish neoplastic diseases encompassed the etiology and pathogenesis, including molecular events, providing an understanding of the susceptibility of coastal species to chemically induced diseases. Also, when the waste disposal practices are altered (improved), the prevalence of the diseases drops substantially (Moore et al. 1996).

Some regions have been severely contaminated by industrial chemicals for decades. For example, in parts of New Bedford Harbor, Massachusetts, a marine Superfund Site, total polychlorinated biphenyls range from 2% to 10% of the sediments by weight in the most severely contaminated places (Weaver 1984). In the past decade some fish populations in this and other severely contaminated locations have been reported to develop a resistance to the toxicity of the chemicals present (Prince and Cooper 1995). As with the fish neoplastic diseases, studies of these fish, such as of the salt marsh minnow, *Fundulus heteroclitus*, are revealing the molecular basis underlying resistance to the toxicity of these compounds.

Reconciling coastal development and the maintenance of a quality environment represent an enormous management challenge to both public and private interests. Wise management of coastal areas will require an understanding of the nature of dynamic physical, chemical, and biological interactions in the coastal zone, knowledge of how changes in other components of the Earth system affect coastal zones and their role in global cycles, and insight into how to best use these areas as coastal populations increase. Maintaining the integrity and health of the coastal zone is essential to the quality of marine biological resources and, ultimately, of human life.

John Stegeman is senior scientist and chair of the Biology Department at the Woods Hole Oceanographic Institution and he has served on the Board of Scientific Counselors of the National Toxicology Program. His area of research is molecular toxicology and markers of exposure.

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