Sea Grant
Woods Hole
Focal Points
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Research Update:

Contaminants in the Marine Environment and their Effects on Marine Mammals

Background industrial chemicals including pesticides, PCBs (polychlorinated biphenyls), and dioxins turn up in every environment on Earth, from the Antarctic to the Arctic. Petroleum hydrocarbons are found in sea surface film throughout the world. The oceans have served as a repository for a multitude of wastes and receive effluent from rivers, streams, and groundwater. Atmospheric deposition of polycyclic aromatic hydrocarbons (PAHs) and other hydrocarbons adds to the burden of pollutants in the marine environment. Industrial smokestacks, incinerators, outfall pipes, automobiles, lawn chemicals, agricultural chemicals, homes, businesses, commercial ships, and motorized pleasure craft are all sources of contaminants.

Many of these chemicals are fat-soluble and come to reside in the fatty tissues of marine animals, including cetaceans. Some of these chemicals have been characterized as endocrine disrupters; some are believed to reduce reproductive success, to interfere with developmental processes, and/or to suppress immune function. Other chemicals, such as PAHs, do not bioaccumulate in marine mammals but may have adverse impacts on the health of cetaceans through repeated exposure and metabolic response.

Photo: Carolyn Ashbaugh

A group of socializing right whales, off Billingsgate Shoals.

Ethical, legal, and logistical considerations make it impossible to experiment on living cetaceans in the wild. In order to study contaminant impacts in free living cetaceans, biopsies of living animals and the study of recently dead animals have become techniques of choice. Frequent strandings of pilot whales and Atlantic white-sided dolphins in New England over the years have provided researchers with an abundance of tissue samples. Cetacean tissue samples have also been obtained from strandings in other regions, entanglements, fisheries bycatch, biopsies, and the native hunt for beluga whales.

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Current Sea Grant Research

Sea Grant supports the work of WHOI biologists John Stegeman, Mark Hahn, and Michael Moore and a number of their WHOI colleagues and students in studies of toxic chemicals and their effects in cetaceans and other marine mammals. Over the next decade, these researchers hope to characterize the extent of contamination in cetacean species and to differentiate the relative risks of damage to organ systems, reproductive success, and immune suppression in different species of cetaceans.

Hahn and Stegeman have conducted extensive research to characterize the susceptibility of various species across many phyla, both vertebrate and invertebrate, to environmental contaminants. The WHOI researchers are conducting toxicological studies of beluga whales, small-toothed cetaceans that inhabit highly contaminated coastal waters in the Gulf of the St. Lawrence, as well as other high latitude coastal waters. Much like the miners' canaries of the 19th century whose deaths warned of toxic gas build up in the mines, beluga whales may tell us much about biological contamination in coastal waters today.

Work by Stegeman and colleagues is detecting pronounced increases in a biochemical effect of contaminant exposure in many organs of beluga from the Gulf of the St. Lawrence and the Arctic. The approach his team has used has been adapted to analyze the molecular change in blood vessels in small biopsy samples from many cetaceans. Cloning of the cytochrome P450 genes involved in the biochemical response is underway to refine the analysis and interpretation.

Work by Hahn and Ph.D. candidate Brenda Jensen includes cloning susceptibility genes (e.g., the aromatic hydrocarbon or Ah receptor), conducting cell culture bioassays to assess susceptibility, and analyzing blood samples for immunotoxicology.

Archived Tissue Collection Continues to Grow

As part of their overall research program on marine mammals, Stegeman and Moore have developed a program to archive tissues from cetaceans and other marine mammals and to make tissue samples available to researchers in labs around the world. This program is part of an effort to characterize the types of chemical contaminants found in cetaceans, the metabolic response to such contaminants, and tissue damage caused by exposure to these contaminants. Different laboratories around the world specialize in research on different pollutants and are able to evaluate different metabolic pathways. By using the expertise of many researchers in a multi-institutional program, Stegeman, Hahn, and Moore are able to coordinate research on cetacean toxicology on a global scale. Additionally, collaborators around the globe are able to obtain marine mammal specimens from different oceans. In recent years, samples have included blubber biopsies from the North and South Atlantic and North and South Pacific Oceans. A single cetacean may provide tissue samples to many laboratories around the world.

The group has archived approximately 90 biopsies from North Atlantic right whales and 90 from Southern right whales, mainly from South Africa. Biopsies taken from living whales are roughly the size of a pencil eraser; the skin portion is used in genetic work, whereas the underlying plug of blubber is used to characterize contaminants and metabolic responses to contaminants. Seventeen blue whale biopsies from the St. Lawrence estuary and the north shore of Quebec and nine blue whale biopsies from Iceland have been archived from the Mingan Island cetacean study. Seventeen bottlenose whale biopsies from Nova Scotia have also been added to the collection. Collaborations with two non-profit centers, the Center for Coastal Studies in Provincetown, Massachusetts, and the Cetacean Research Unit in Gloucester, Massachusetts, have made available approximately 30 humpback biopsies.

In addition to biopsies from living animals, tissue from necropsies of four North Atlantic right whales and four Southern right whales from Argentina are available to researchers. Strandings and mortality from fisheries bycatch have yielded 25 pilot whales, 20 Atlantic white-sided dolphins, 5 minke whales, 13 harbor porpoise, and 25 common dolphins. Other cetacean species represented in the archived samples include one finwhale, one bottlenosed dolphin from Georgia, one striped dolphin, one Gervais' beaked whale, three Sotheby's beaked whales, one blue whale, a Dall's porpoise, and a few killer whales.

Looking to the Food Chain for Clues

A complication in assessing the exposure of cetaceans to environmental contaminants is the highly migratory behavior of many cetacean species. One approach to understanding the effects of contaminants on marine mammals involves studying contaminant concentrations in the food chain and biochemical responses of contaminant exposure in marine mammals. In the case of the North Atlantic right whale, the most endangered of the great whales, scientists have begun studies of marine zooplankton. In particular, researchers are looking at copepods, a small crustacean that is low on the food chain and is a food of choice for right whales. Each tiny copepod contains fat stores, the energy source from which right whales may grow to 50 or 60 tons. The fat stores of the copepod are lipid-rich energy stores that may also be a potential site for accumulation of hydrocarbon contaminants.

By examining the concentration of contaminants in copepods collected at different sites and comparing the biochemical response or metabolic markers of contaminant exposure in biopsied tissue samples from those same sites, Moore hopes to find a link between food chain contamination

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and effects in the North Atlantic right whale. Moore reports, "We have found that levels of contaminants in the food chain of right whales suggest that aromatic hydrocarbons in copepods may be a source of biochemical response in these animals." Copepod samples collected from the Bay of Fundy and Cape Cod Bay had as much as ten-fold higher concentrations of hydrocarbon contaminants than samples collected from Georges Bank. Metabolic response to hydrocarbon exposure (as measured by expression of Cyp1A) was highest in the samples of right whale tissue from the two nearshore sites, even though total hydrocarbon concentrations (PCB plus PAH) in right whale samples were low.

Of the species sampled most extensively by the WHOI researchers for contaminant concentrations and metabolic responses to exposure—northern right whales, long finned pilot whales, and Atlantic white-sided dolphins—the pisciverous Atlantic white-sided dolphin exhibits the highest levels of contamination. Pilot whales that consume squid, herring, and mackerel have lower levels of contamination than the Atlantic white-sided dolphins, but higher levels than the zooplankton eating right whales.

The investigations of this research team, that are in part supported by Sea Grant, will be useful in monitoring for changes in global and regional contamination and in evaluating trophic level risks of contamination to various species of cetaceans.

For more information about the research or outreach projects profiled in *Focal Points*, contact WHOI Sea Grant at the address listed above.