INDICATOR 11

How prevalent are selected contaminants of emerging concern in the Casco Bay ecosystem?

CBEP Goal: Reduce toxic pollution in Casco Bay; minimize adverse environmental impacts to ecological communities from the use and development of land and marine resources.

Why Is It Important to Monitor Contaminants of Emerging Concern?

Many common synthetic chemicals, which were not recognized as pollutants in the past, are now being detected in aquatic ecosystems throughout the world, where they are accumulating in the tissues of wildlife and humans. Those "contaminants of emerging concern" persist in the environment along with the more traditionally monitored persistent pollutants like polychlorinated biphenyls (PCBs), organochlorine pesticides (OCs) and heavy metals. They are typically introduced into the air and water through municipal, agricultural, and industrial wastewater sources, and are transported by wind and water currents.

Among that new class of contaminants are polybrominated diphenyl ethers (PBDEs), used as flame retardants in commercial and residential textiles, furniture foam, and electronics since the 1970s. The primary forms are penta, octa- and deca-PBDE. Those lipophilic (fat-loving) molecules can accumulate in the fatty tissues of organisms, leading to negative health effects. Another important class of emerging contaminants is perflorinated chemicals (PFCs), industrial chemicals whose common uses include stain repellents, Teflon coatings, cleaning agents, and fire-fighting foam. They are highly resistant to degradation, and persist in the environment. Two forms, perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) are most common in the environment and in organisms (Goodale 2008).

Despite some recent restrictions on their use, those chemicals have been used in a variety of consumer and household products for over four decades. They cause cancers, endocrine disruption, reproductive and neurodevelopmental effects in animals, and are associated with reproductive and endocrine-disrupting effects in people (Birnbaum and Staskal 2004, Jensen and Leffers 2008).

The recent monitoring studies described below indicate that those contaminants are found in seal and bird populations in Maine.

MERI

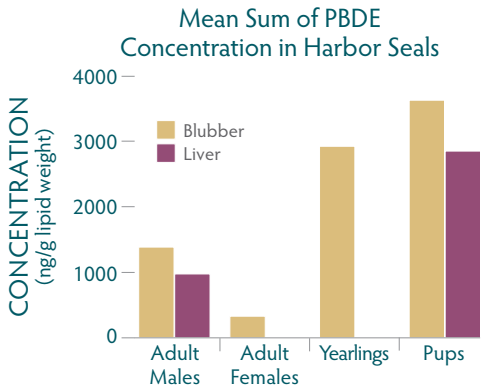
The *Seals as Sentinels* project indicated that seal pups had higher levels of PBDEs and PFCs than adults, reflecting their high exposure to the compounds from their mothers' milk.

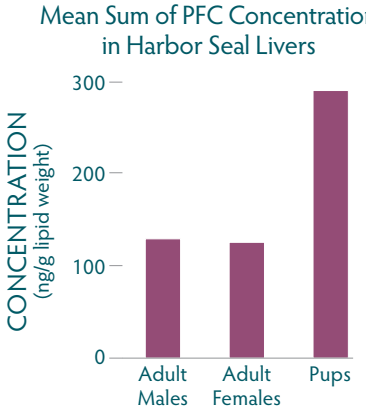
Status and Trends

Contaminants of Emerging Concern in Seals from Casco Bay and the Gulf of Maine

Since 2001, Dr. Susan Shaw and her co-workers at the Marine Environmental Research Institute (MERI) in Blue Hill, Maine, have been conducting a long-term investigation, *Seals as Sentinels*, that analyzes the levels and effects of environmental pollutants in harbor seals (*Phoca vitulina concolor*) along the northwest Atlantic coast. To date, the study has measured 395 compounds in 487 tissue samples from 181 stranded and live seals from Canada to Long Island, New York, including Casco Bay.

As top predators, seals accumulate persistent organic pollutants (POPs) from the fish they consume, and pass them on to their pups in their milk. High concentrations of chemicals such as PCBs can weaken the immune system of seals and increase their susceptibility to disease (Shaw 2007). In recent years, Gulf of Maine seals have been plagued by disease outbreaks, including a die-off in 2006 that claimed the lives of 800 animals (Shaw *et al.* 2005, 2007). Similar mass mortalities and reoccurring epidemics linked with contaminant stress are common among harbor seals worldwide. Recently, the *Seals as Sentinels* study found





high levels of contaminants of emerging concern, including PBDEs and PFCs, in harbor seal tissues. (Shaw *et al.* 2008, 2009a,b; see graphs). It was the first study to reveal that PBDEs and PFCs have permeated the northwest Atlantic Ocean environment.

- PBDEs were detected in 42 harbor seal blubber samples and 56 liver samples at levels among the highest reported worldwide for the species, reflecting the heavy usage of these compounds in North America.
- PBDEs are rapidly working their way up the food web. Biomagnification rates calculated for persistent PBDEs show they are readily transferred from fish to seal tissues, and become highly concentrated in top predators. People eat many of these fish: flounder, hake, and herring, for example.
- PFCs are also widespread in the Gulf of Maine; they were detected at substantial levels in liver tissues of 68 harbor seals.
- Unlike the pattern for PCBs, which are higher in seals near densely populated urban centers, there was no clear urban to rural trend in the distribution of PBDEs and PFCs. (Those compounds originate from multiple urban and rural sources, *e.g.*, wastewater treatment plants, farmland sludge, landfills, and airports.)
- Seal pups had higher levels of PBDEs and PFCs than adults, reflecting their high exposure to the compounds in their mothers' milk. The highest level of PBDEs was found in a female pup from mid-coast Maine (25700 ng/g lw). A male pup from Massachusetts Bay had the highest level of PFCs (1430 ng/g ww).

Contaminants of Emerging Concern in Birds of Casco Bay

Chris DeSorbo, BRI

Collecting osprey eggs in Casco Bay for analysis of contaminants, including PBDEs and PFCs.

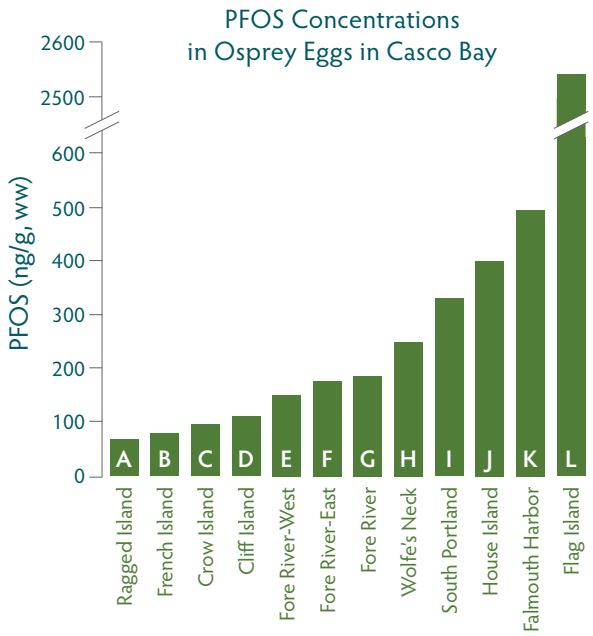
With support from CBEP and other partners, in 2007, BioDiversity Research Institute (BRI) began the first study to measure PBDEs, PFCs, PCBs, OCs and mercury in eggs from 23 species of birds in Maine from marine, estuary, river, lake and terrestrial habitats. The suite of chemicals studied was found in all the species sampled across all types of ecosystems, with the highest contaminant loadings in southern coastal Maine. That pattern suggests that while atmospheric deposition is an important transport pathway, local point sources near the urban and industrial areas of the southern coast are also important. For PCBs, PBDEs, PFCs, and OCs, birds with a high level of one chemical tended to also have elevated levels of the others.

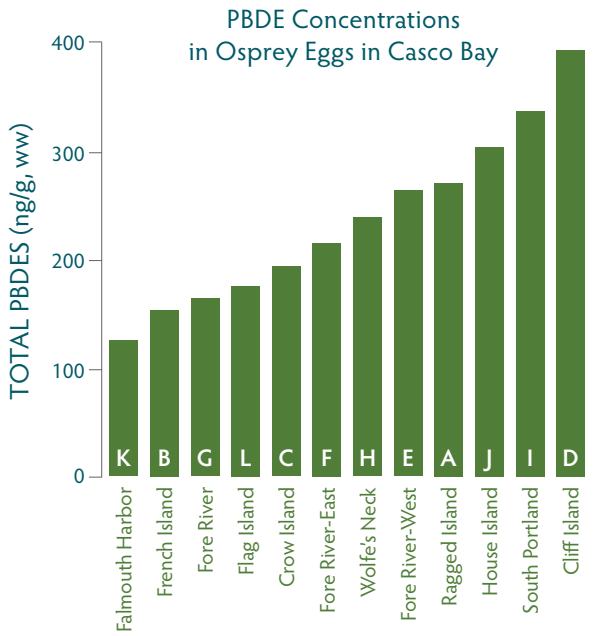
The study indicated that osprey (*Pandion haliaetus*) in the greater Portland area had some of the highest levels of PCBs, PBDEs, and PFOs seen in 14 species sampled there. As foraging predators, osprey accumulate contaminants and pass them to their offspring. Of six osprey samples collected along the Maine coast, the sample from the Portland Breakwater Light (Bug Light) had the highest total contaminant load, and levels of PFOs three times greater than the threshold for adverse effects (Goodale 2008). A follow-up study of osprey from Casco Bay was funded by CBEP to determine if the high PFOS levels observed in the Bug Light sample were found elsewhere in Casco Bay (Goodale 2010).

Starting in May of 2009, ten additional eggs were collected at Casco Bay sites and analyzed for PCBs, PBDEs, PFCs (including PFOs), and OCs. The combined results of osprey egg studies in 2007 and 2009 are summarized in the figures on the opposite page.

Kevin Cole

Wayne Boardman





Results of 2007 and 2009 osprey egg sampling in Casco Bay. PCBs, PBDEs, PFCs and OCs were found in all of the eggs sampled. Deca-PBDE was detected in 10 of 12 eggs collected in Casco Bay during the two sampling seasons. PFOS in an egg collected from Flag Island were the highest ever seen in Maine wildlife, and among the highest ever observed in a bird egg. Fully 75 percent of osprey eggs had PFOS concentrations exceeding the threshold for negative health effects established for chickens (100 ng/g, wet weight). No spatial trend was detectable among the samples, suggesting that point sources, watershed characteristics and food web dynamics may all play a role in exposure to contaminants (Goodale 2010). While osprey are highly mobile and there is no certainty about where birds are exposed to contaminants, research indicates that the toxic contaminants in eggs come from food consumed in the bird's local breeding territory (Hobson *et al.* 1997, Elliott *et al.* 2007).

Solution and Actions

The studies raise concerns about the long-term health of marine mammals and birds in the region and, more critically, the overall health of the food web and the ecosystem. Data from *Seals as Sentinels* have influenced policy decisions, including two recent Maine laws: LD 1658 (2007) which bans the neurotoxic flame retardant deca-PBDE from furniture, foam mattresses and electronics, and LD 2048 (2008) which requires manufacturers to disclose the toxic chemicals they add to baby products and children's toys, and authorizes the state to require safer alternatives whenever available. Data from the BRI bird egg study were provided as testimony during the development of LD 2048.

Penta- and octa-PBDE mixtures have been banned in Maine since 2006 and are no longer in production in the United States (DEP 2007a). PFOS, formerly an ingredient in Scotchguard brand stain repellent, was phased out by its primary US manufacturer in 2000. Nevertheless, large reservoirs of BFRs and PFCs, like PFOS, still exist in consumer products, ensuring ongoing inputs to the environment for decades to come (Shaw and Kannan 2009).

PPCPs (pharmaceuticals and personal care products) are also important contaminants of emerging concern. A cocktail of painkillers, hormones, antibiotics, beta-blockers and other drugs, along with household products like soaps, hairspray and sunscreens, enters the waste stream when washed off, excreted or discarded. Research suggests that some PPCPs can result in impacts to biota, although their cumulative and synergistic effects in aquatic systems are still unknown. The complexity of the possible mixtures and their limited biological degradability make removal from municipal wastewater a major challenge (Ternes *et al.* 2004). Addressing PPCPs at the source is an important control strategy. In 2007, Maine became the first state to pass legislation authorizing a mail-in program for unused and unwanted medicines. Maine DEP is also working with communities on one-day collection events. (To learn more about the Safe Medicine Disposal for ME program visit http://www.safemeddisposal.com.)

Given the vulnerability of Gulf of Maine and Casco Bay wildlife, as well as concerns for human health, monitoring for the presence of emerging contaminants and their effects in Casco Bay and the larger Gulf of Maine ecosystem will continue to be an important challenge.

ME DEP

Researchers from the Maine Department of Environmental Protection (DEP) collect white suckers for Cumulative Effects Assessment.

Endocrine Disruptors: Maine DEP Cumulative Effects Assessment

Endocrine disruptors are contaminants of emerging concern that disrupt the normal functioning of hormonal systems. They include man-made chemicals such as pesticides and plasticizers, pharmaceuticals, or hormones that are excreted in animal or human waste (EPA 2009). Since 2000, Maine DEP has been conducting Cumulative Effects Assessments (CEA) of fish populations in Maine rivers, measuring the effects of exposure to endocrine disruptors on survival, growth and reproduction. Studies have examined fish collected upstream and downstream of major discharges. Between 2007 and 2009, DEP conducted CEA studies in the Presumspcot River. Male and female white suckers (*Catostomus commersoni*) were caught in overnight gill net sets at stations in Windham and Gorham above the Westbrook wastewater treatment plant and the SAPPI mill – sites of the major discharges into the Presumpscot River – and at a station below the discharges.

Although there were individual metabolic or physiological responses for one or both sexes, indicating endocrine disruption below Westbrook compared to stations upstream, there is no consistent evidence of endocrine disruption in white suckers at the population level in the river below Westbrook. Growth rates and abundance appear to be lower below Westbrook. Those data are consistent with a 2006-2007 study of fish communities in the Presumpscot River that found reduced species richness, abundance, and biomass downstream of Westbrook (Yoder and Hersha 2009). The causes may be natural differences in habitat exacerbated by past or present discharges of sediments or other pollutants from municipal and industrial activities and urban runoff from Westbrook (DEP 2008, 2010).

Cynthia Stroud

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