Trends in contaminants of concern in seabirds from the Pacific coast of Canada

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What's happening?

Decades of monitoring contaminant levels in seabirds on the Pacific coast of Canada show that some contaminants have decreased in concentration – reflecting source controls and regulations – while other contaminants have remained stable or have risen.

Seabirds make effective indicators for examining contamination of marine pollution. They are at the top of the food chain and accumulate high concentrations of contaminants. They also often have large ocean habitats, feeding as they move, and return annually to breed in one location where nonlethal eggs or tissue samples can provide information on contaminant levels over space and time (Figure 1).[1] As such, a variety of seabirds have been used to monitor contaminant levels and trends around the world.[2–4] Environmental contamination by mercury (Hg) and such chemicals as perfluoroalkyl substances (PFAS) and brominated flame retardants (BFRs) (e.g., polybrominated diphenyl ethers [PBDEs], hexabromocyclododecane [HBCDD]) are of concern since they accumulate in food webs, do not readily degrade, and are toxic. Time trends on mercury and emerging contaminant levels in seabirds are unavailable for many coastal regions around the world. However, Environment and Climate Change Canada has been extensively monitoring mercury concentrations and emerging contaminant concentrations (e.g., PFAS, PBDEs, and HBCDD) in seabirds on the west coast of Canada for several decades.

Seabirds as indicators of contamination

Figure 1. Different seabirds have different feeding strategies. For example, cormorants forage mainly on fishes in the nearshore environment. The rhinoceros auklet tends to feed on smaller fishes and zooplankton on the continental shelf. Pelagic seabirds such as the Leach's storm petrel range across the offshore zone, feeding on zooplankton and larval fishes. All seabirds return to breed in colonies where they can be sampled for contaminants. The inset graph depicts the time trend for the flame retardants PBDEs in the rhinoceros auklet eggs on the Pacific coast. Figure adapted from Elliott and Elliott (2013).

Why is it important?

Human activities release thousands of chemicals into the marine environment, many of which can be harmful to wildlife, including seabirds. Long-term monitoring of contaminant levels in seabirds and other animals at the top of the food chain provides us with insight into ocean health, and allows us to track environmental response to source controls and regulations.

Despite originating from very different sources, mercury (in the form of methylmercury), PFAS, and BFRs can travel long distances in the air and by ocean currents[6-8] and have been found to accumulate in food webs across the globe.[9-11]

Mercury is a naturally occurring element found in various forms.[12] Natural sources of mercury include volcanoes, forest fires, fossil fuels, petroleum, and cinnabar ore.[13] However, numerous human activities also release mercury, such as fossil fuel combustion, mining, smelting, solid waste combustion, fertilizers, and industrial wastewater disposal. Various consumer products contain mercury, such as thermometers, some electrical switches, dental fillings, and batteries.

Methylmercury is the most toxic form to animals and humans, and can accumulate to high levels in marine food webs.[14] Mercury exposure in birds can affect brain development, endocrine and immune function, reproduction, and survival.[15-17] For example, mercury affects reproductive success through poor egg viability[18] and by changes in behaviour.[19] Mercury in birds has also been associated with decreased nesting attempts and nest attentiveness.[20]

PFAS have been used in a wide range of industrial and consumer applications including firefighting foams, grease-proof paper, stain repellents in textiles, and processing aids in fluoropolymer manufacturing. The use of PFAS has released large amounts to municipal waste waters and directly to the air. PFAS compounds typically do not break down in the environment and may be toxic.[21]

Flame retardants (BFRs) are produced to reduce the flammability of textiles, plastics, and construction materials.[22] BFRs are toxic and have been found to disrupt hormone function in birds.[23-26]

What is the current status?

Mercury

Mercury trends have been measured in eggs from three seabirds species on the west coast of Canada: an offshore pelagic indicator, the Leach's storm petrel (*Oceanodroma leucorhoa*) (1968–2015); and two continental shelf indicators, the ancient murrelet (*Synthliboramphus antiquus*) (1968–2009) and the rhinoceros auklet (*Cercohinca monocerata*) (1970–2014). Mercury concentrations in seabirds on the west coast have shown no clear time trends (Figure 2), except for a decrease over time in murrelets (Figure 2) and in cases where diet changed.[27] This is consistent with observations in fish and mammals where trends have remained generally stable over the past 50 years.[28]

Seabird eggs from Atlantic Canada have also shown no clear trends. Despite three to five-fold increases in mercury deposition in the Pacific since the Industrial Revolution,[29] levels in seabirds have increased by less than two-fold during that period.[7] This is somewhat surprising because mercury levels in the Pacific Ocean surface waters have increased, presumably as a result of coal burning in Asia.[30,31] This disconnect between environmental emissions and accumulations in seabirds of the Pacific may be because mercury accumulation is constrained by availability of another element, called sulphur.[32]

Rhinoceros auklet at sea. (Photo: Kyle Elliot)

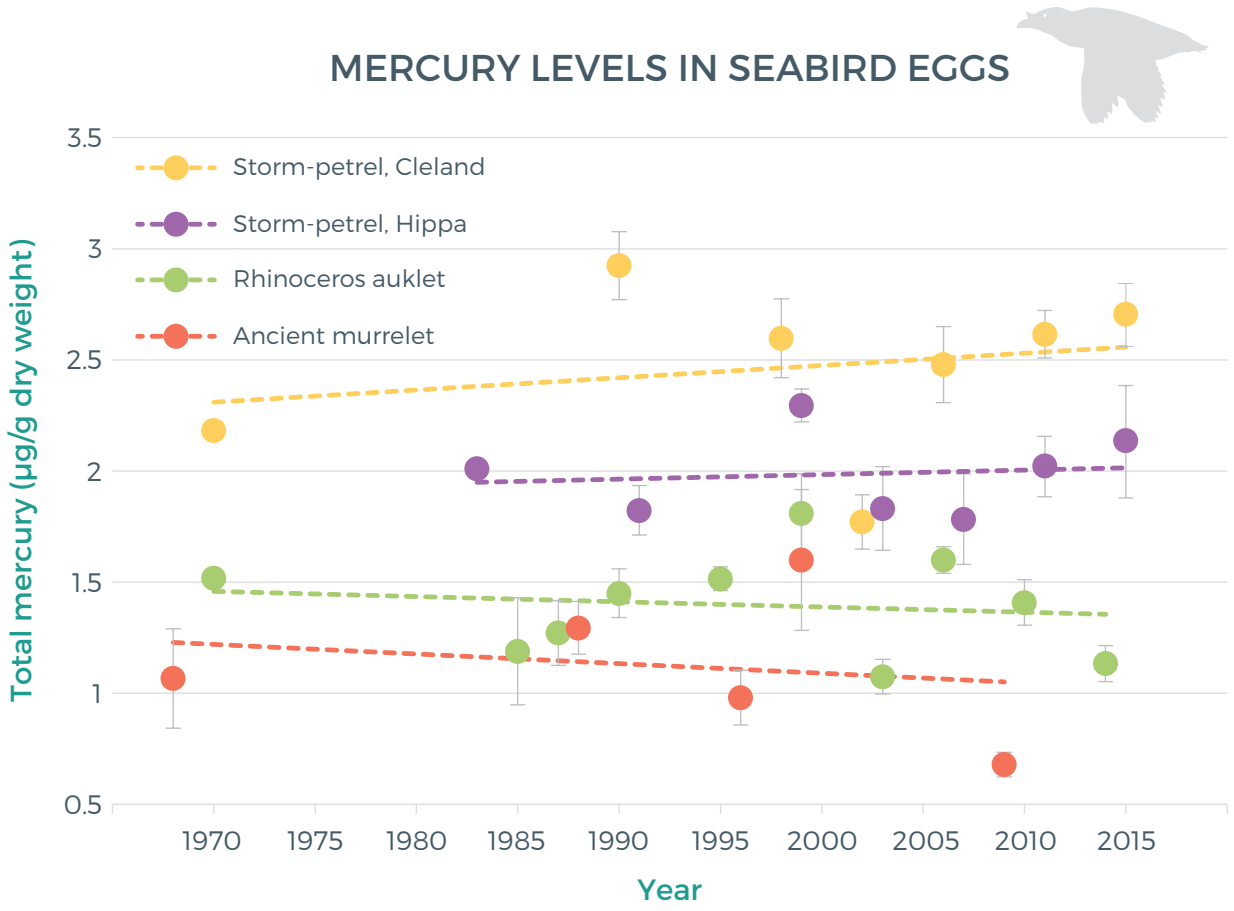

Figure 2. Mercury levels in seabird eggs show little discernable trends between 1968 and 2015 from the Pacific coast of Canada.

Perfluoralkyl substances (PFAS)

Trends in PFAS have been monitored pre- and post-production phase out of the chemicals. Eggs of two oceanic seabird species were tested: the continental shelf species, rhinoceros auklet (1990–2010); and the offshore pelagic indicator, Leach's storm petrel (1991–2011). Despite regulations implemented in North America in 2000 for some of these substances,[33,34] PFAS levels have not declined in petrels and auklets, and instead have increased over time. These results are consistent with trends in other wildlife (e.g., herring gulls (*Larus argentatus*) from Norway[35] and coastal German regions[36]) as well as selected seabirds from the Canadian Arctic.[37] Increasing concentrations of substances such as PFCA over time in wildlife are an ongoing cause for concern (Figure 3).

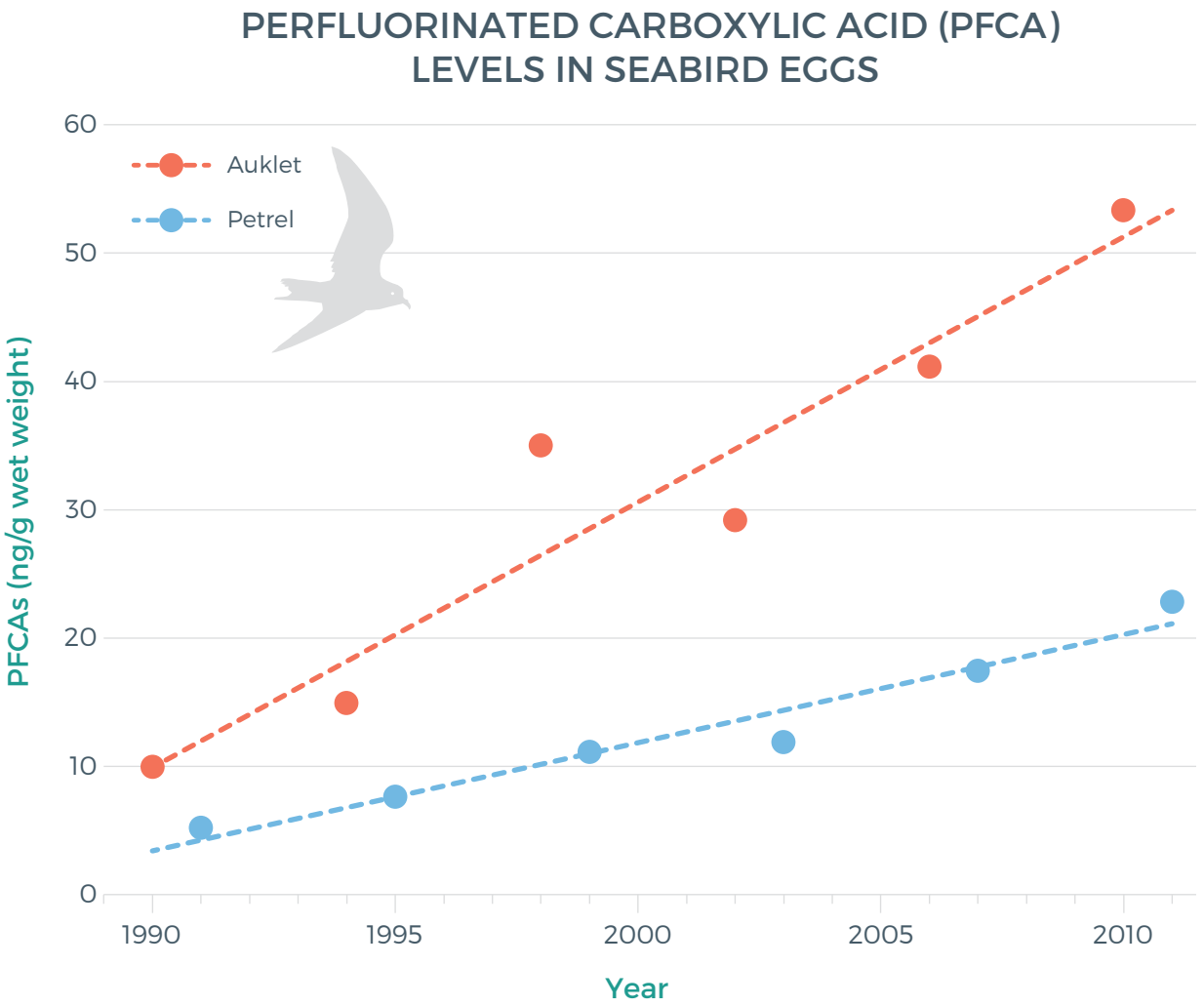

Figure 3. Perfluorinated carboxylic acid (PFCA) levels in seabird eggs are increasing over time.

Brominated Flame Retardants

The levels of PBDEs declined in rhinoceros auklet eggs following regulations of two (penta- and octa-BDE) of the three BFR mixtures in 2004 (Figure 4). However, that trend was not apparent for storm-petrel eggs collected at Hippa Island (Figure 4), which may be the result of this population of birds feeding farther from North America and closer to Asia. The brominated flame retardant (HBCDD) is higher in storm-petrel eggs compared to auklet eggs. This may be due to the fact that petrels feed further from shore and closer to Asia.

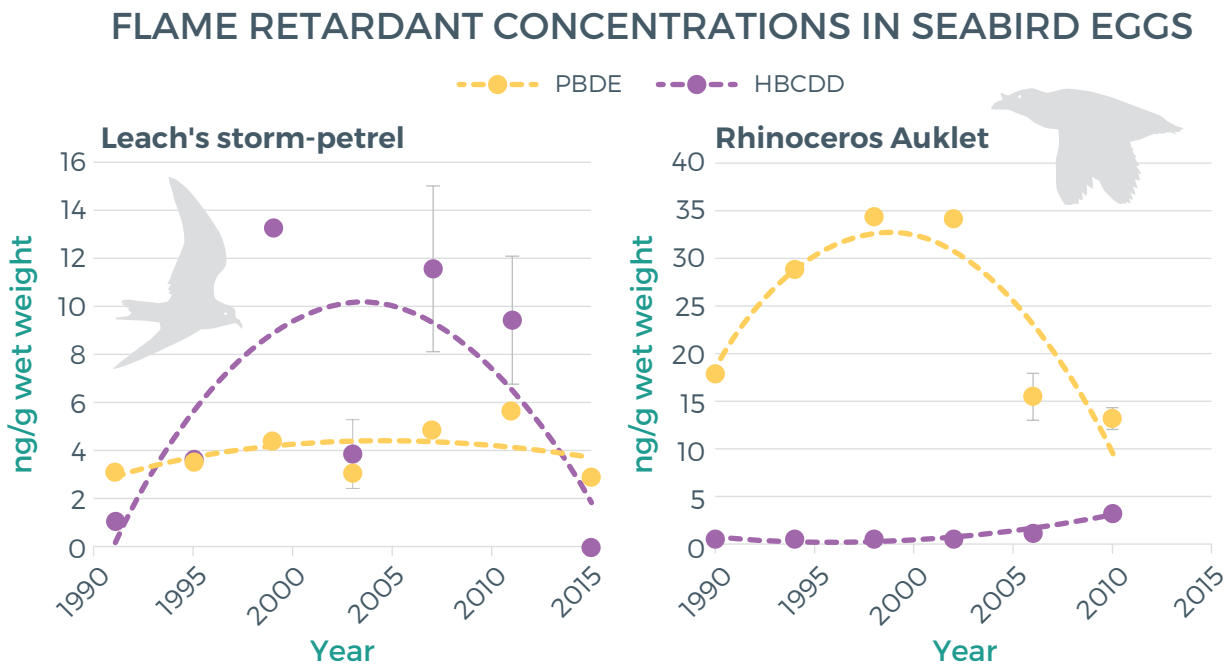

Figure 4. HBCDD and PBDE concentrations over time in Leach's storm-petrel eggs from Hippa Island and rhinoceros auklet eggs from Cleland Island. Figure modified from Miller et al. (2014)[38]

What is being done?

Mercury has been released in large quantities from multiple sources, with coal burning representing a major source. In April of 2017, the Government of Canada signed onto the Minamata Convention, an international agreement to reduce human-related mercury emissions. Prior to Minamata, Canada had legislation on mercury emissions from coal-fired facilities, the USA had a Mercury and Air Toxics Standard, and the European Union had an Industrial Emissions Directive. Further, many of the coal burning plants in these countries had emission control systems in place, which were helping to significantly lower mercury emissions. China and India on the other hand, have rapidly growing populations and economies which presents a challenge when attempts are being made to bring all plants up to acceptable emission limit standards.

The Stockholm Convention on persistent organic pollutants (POPs) regulates more than 30 chemicals and groups of chemicals of which PBDEs, HBCDD, and PFAS are included. The goal of this treaty is to eliminate the release of contaminants which accumulate in food webs, do not degrade in the environment, and are toxic. In 2000, the 3M Company – the major global producer of one PFAS compound known as PFOS – announced a phase out of the production of some PFAS and other related products. Further restrictions in the US, Canada, and Europe were implemented throughout the 2000s,[39] however, the production of some PFAS in China continue.

There are three major PBDE products: PentaBDE, OctaBDE, and DecaBDE, of which two (Penta- and OctaBDE) were added to Stockholm Convention in 2009, and DecaBDE and HBCDD have been added to the elimination list. Lower PBDE levels in North American and European wildlife reflect these controls, however, the increasing HBCDD levels in seabird eggs are troubling. That said, the inclusion of HBCDD under the Stockholm Convention should lead to reductions of this chemical in wildlife.

Rhinoceros auklet with forage fish. (Photo: Kyle Elliott)

Monitoring of all these contaminants have been ongoing for decades due to their high production volume, occurrence in the environment, and toxic potential. Continued monitoring of a range of wildlife found at all levels in the food chain – which include seabirds – will provide a better basis to inform the public about contaminants, to understand the causes of contaminant trends in marine ecosystems, and to track environmental response to source controls instituted under international conventions.

What can you do?

Individual and Organization Actions:

- Use less energy: coal-fired electricity generation is the largest source of mercury emissions to the environment, and hydro-electric dams also increase mercury levels in water reservoirs.
- Reduce your uses of mercury, PFAS, and brominated compound-containing products. For example:
  - Use energy efficient LED bulbs which are a mercury-free alternative for lighting. Fluorescent bulbs contain very small amounts of mercury, but are still more energy efficient than incandescent bulbs and can also help reduce overall mercury emissions.
  - Purchase "green" furniture that does not contain flame retardants.
- Avoid purchasing non-stick pans, household cleaners, clothing, furniture, packaged food containers, and stain repellants that can contain PFAS.
- Continue to educate yourself and share what you have learned with others.

Government Actions and Policy:

- Support federal and national programs for marine pollution to promote long-term monitoring that will protect ocean and human health from human made chemicals.

Footnotes

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