Mercury in the Global Environment: Marine Mammals

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Marine Mammals and Mercury

From the Antarctic to the Arctic, marine mammals move across large expanses of water, foraging on the smallest of animals (krill) or preying on the largest; all depend on healthy and uncontaminated food sources. Over the past century, however, mercury (Hg) released through human-derived processes, such as coal-fired power generation, has been entering and accumulating in the world's oceans.

The atmospheric deposition of mercury on an ocean surface is compounded by contributions from rivers (adding around 30 percent to the oceans) and the exchange of mercury from the ocean back into the air.

Methylation (the conversion of elemental mercury to organic methylmercury) in marine waters is greatest along near-shore areas of the continents, especially in estuaries and other wetlands, but it also occurs in the water column far from shore. The complexities of mercury and methylmercury cycling are still being investigated to better inform global models.

Illustrating Mercury's Impact

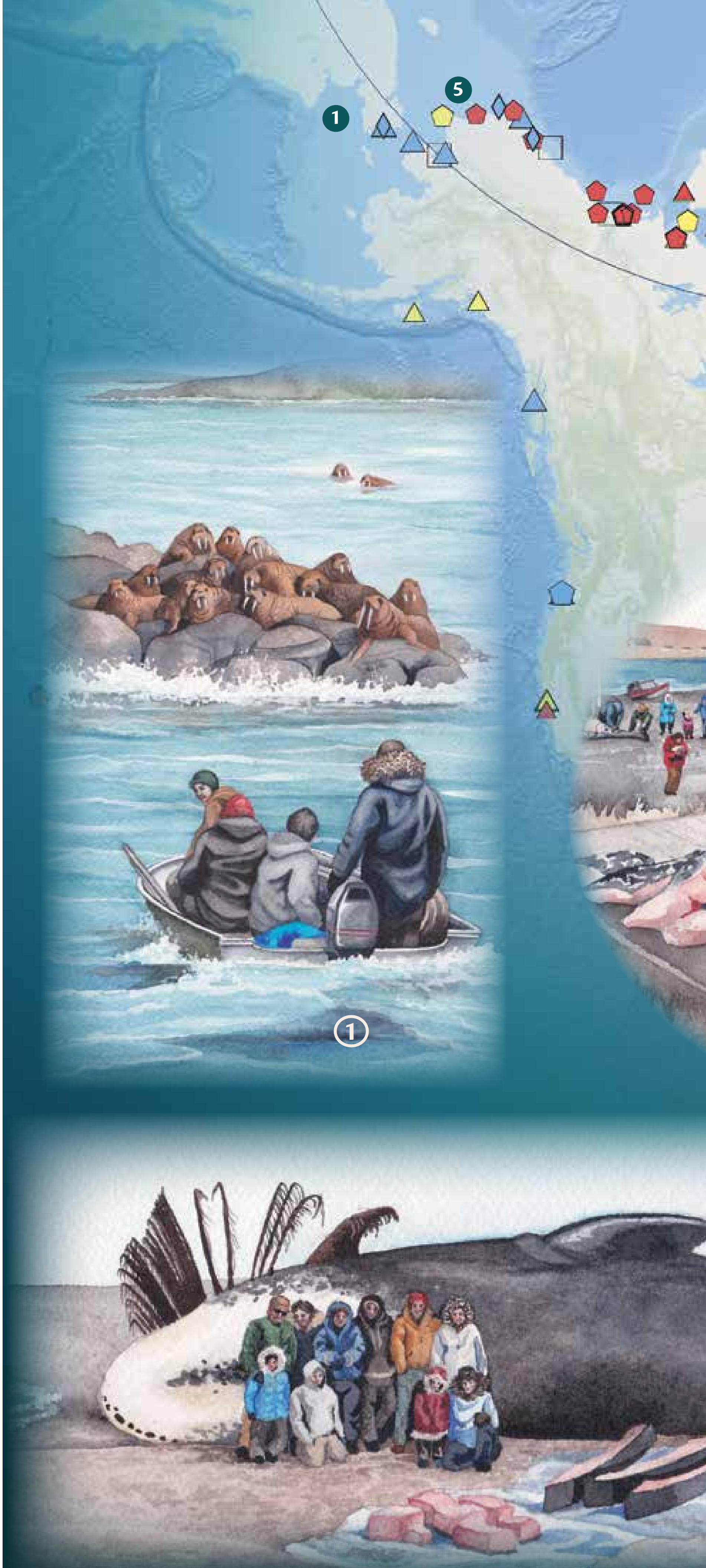
To help illustrate the impacts of methylmercury biomagnification (increasing toxicity as it moves up the foodweb) and bioaccumulation on marine mammals, we have identified five groups that are particularly affected. Because circulating mercury concentrations are higher in northern than southern hemisphere waters and because subsistence hunting for marine mammals is greatest in the Arctic, we emphasize a holarctic approach (Dietz et al. 2013).

The five marine mammal groups we feature in this publication include: toothed whales; baleen whales; pinnipeds (seals and walruses); people (in particular, aboriginal subsistence commmunities); and the polar bear. For each group, we include a chart and discussion detailing mercury body burdens.

The mercury data depicted on the map at right and used for the species data charts in this document are derived from Biodiversity Research Institute's (BRI's) Global Biotic Mercury Synthesis database (see page 8). Mercury concentrations are taken from the peer-reviewed literature and from datasets by the Arctic Monitoring Assessment Program (see page 5).

Map Legend

⬟ Toothed Whales	**Wildlife** – total Hg in muscle tissue as wet weight (ww)
♦ Baleen Whales	< 0.22 ppm (blue)
▲ Seals/Walruses	0.22–1.0 ppm (yellow)
■ Polar Bears	> 1.0 ppm (red)
✱ Humans	☐ Tissue type not assessed
	Humans – total Hg in hair tissue as fresh weight (fw)
	< 1.0 ppm (blue)
	1.0–3.0 ppm (yellow)
	> 3.0 ppm (red)



Marine Mammals of the Arctic

1) Walrus hunting in Russia; 2) Inuits butchering narwhal meat in the Canadian Arctic; 3) Polar Bears hunting ringed seal in Greenland; 4) Pilot whale hunting in the Faroe Islands; 5) An Alaskan Inuit community harvesting a bowhead whale.

Toothed Whales

Mercury in Toothed Whales

Toothed whales (Odontoceti) include about 88 species of whales, dolphins, and porpoises—from the sperm whale, to the many types of beaked whales, to the bottlenose dolphin. Considered the hunters of the cetacean family, they prey on squid, fish, and, in the case of orcas, birds, seals, and other mammals. Compared to baleen whales, toothed whales generally forage higher on the food web.

Long-finned pilot whales (Globicephala melas) are relatively abundant and reside in both the North Atlantic as well as in oceans across the southern hemisphere. For centuries, communities within the Faroe Islands have depended on pilot whales for food. In 2008, chief medical officers recommended that whaling activities be discontinued because these whales were found to have elevated levels of mercury. There are now recorded neurotoxicity risks, such as postnatal visuospatial deficits, in the Faroe Islands community exposed to elevated mercury exposure (Grandjean et al. 2014).

International law protects all cetaceans, but there are exceptions for aboriginal subsistence communities. Additionally, some nations oppose the moratorium on whaling. Few species are hunted for food consumption; those species that are regularly harvested include narwhal, beluga, and long-finned pilot whales.

Mercury and Human Health

Because methylmercury, the organic form of mercury, biomagnifies up a foodweb, average mercury concentrations in toothed whale muscle tissue regularly exceed thresholds for human consumption concerns, based on World Health Organization (WHO) human consumption standards (Figure 1). On average, pilot whale muscle tissue well exceeds safe mercury levels with average mercury concentrations nearly four times higher than the levels recommended. Pilot whales were regularly harvested on the Faroe Islands, where long-term studies have demonstrated adverse cognitive and other behavioral and physiological effects in people.

Mercury and Ecosystem Health

Average mercury concentrations in many species of toothed whales are highly elevated—potentially high enough to cause physiologial, behavioral, or reproductive harm (Wagemann et al. 1998, Wagemann and Kozlowska 2005; Dietz et al. 2013). Based on muscle samples, thresholds of harm are relatively still unknown. Species of greatest concern, based on existing data, include the false killer whale, striped dolphin, Risso's dolphin, bottlenose dolphin, and various species of beaked whales (all with average mercury concentrations greater than 4.0 ppm in the muscle).

Total Mercury Concentrations in Muscle Tissue from Toothed Whales (Odontoceti)

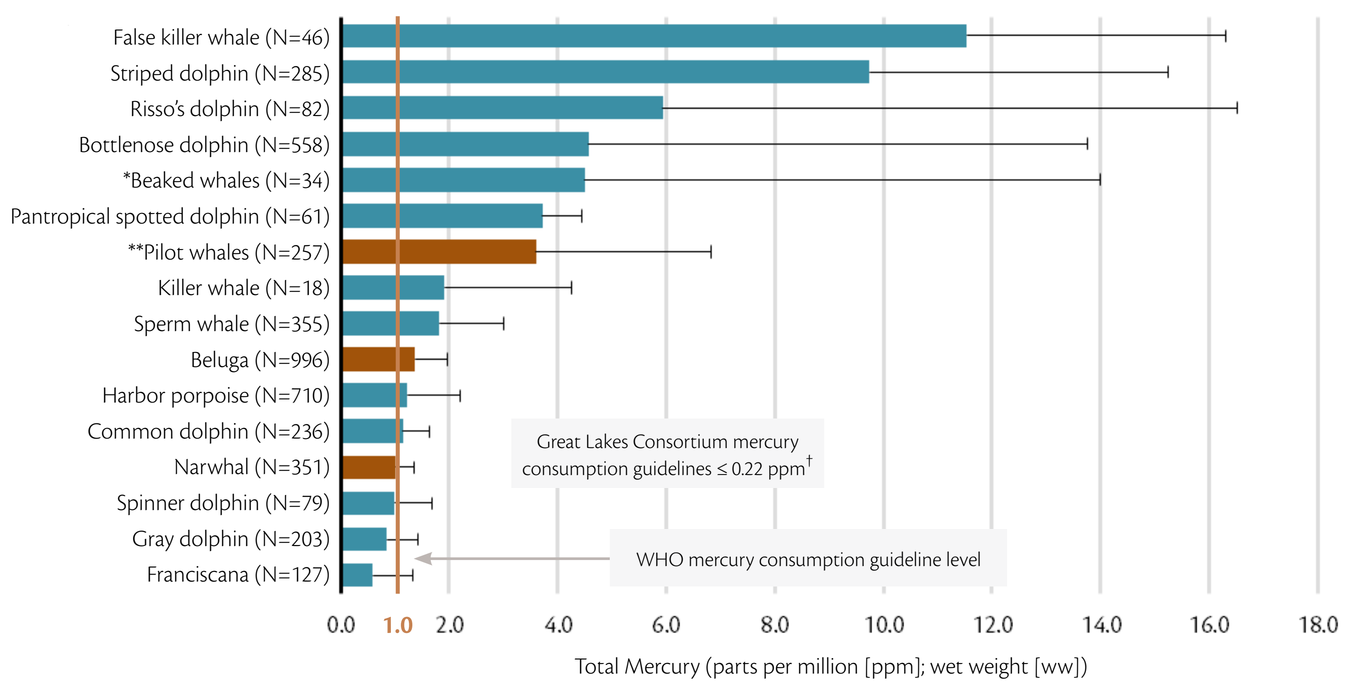


Figure 1. Average (+/– S.D.) total mercury concentration of muscle tissue from 16 species/groups of species. Rust bar indicates species consumed by humans.
*Data represent the weighted mean of samples from several species of beaked whale, Family Hyperoodontidae.
**Data represent the weighted mean from two species of pilot whale, the long-finned (*Globicephala melas*) and the short-finned (*G. macrorhynchus*).
†Based on meal guidelines for human weight of 60 kg/fish size of 170 grams (see BRI publication *Mercury in the Global Environment* for more information).

Baleen Whales

Mercury in Baleen Whales

There are 15 species of baleen whales (Mysticeti); they are distributed worldwide from the smallest species, the pygmy right whale, to the largest, the blue whale. Baleen whales are so named because, instead of teeth, they use baleen plates in their mouths to filter small food items from the sea water. Despite their large size, these whales subsist entirely on small invertebrates such as small crustaceans (e.g., krill) and zooplankton (e.g., copepods and amphipods).

Mercury and Human Health

Although the larger baleen whale species represent some of the largest animals on Earth, they are low trophic level organisms; as such, the biomagnification of methylmercury in baleen whales is limited. Therefore, all baleen whale body burdens are low in mercury, as indicated by data for species based on muscle tissue (Figure 2). Blubber, which is commonly eaten by Alaskan and Canadian Inuit, contains even less mercury than muscle tissue.

Minke whales (Balaenoptera spp.) are one of the more common baleen whales in the world and are the second smallest. They are harvested by several countries under the special research permit clause developed by the International Whaling Commission for the International Convention for the Regulation of Whaling signed in 1946 (now with 89 member countries).

Mercury and Ecosystem Health

The minke and fin whales have the highest muscle mercury concentrations in this group, but they are below consumption thresholds of concern for people. On average, bowhead whales have the lowest mean mercury concentrations—0.02 ppm. This is an order of magnitude lower than U.S. human health thresholds.

Arctic Monitoring and Assessment Programme

The Arctic Monitoring and Assessment Programme (AMAP) is a group working under the Arctic Council. As part of its varied activities and under the direction of Arctic Council Ministers, AMAP conducts science-based assessments that support future actions in order to improve the conditions of Arctic ecosystems.

The *AMAP Assessment 2011: Mercury in the Arctic* report (currently being updated) provides a detailed, yet highly accessible 210-page synthesis of the current study of mercury science in the North, as well as a number of science-based recommendations for future actions.

Among the various topics covered in the report, Arctic biota (in particular marine mammals) provided a large dataset from which conclusions could be drawn. For example, the work revealed a roughly 10-fold increase in mercury levels in Arctic marine mammals over the past 150 years, and that 90 percent of the mercury in these animals likely arises from human sources. The assessment also concluded that marine mammals have tissue mercury levels that likely exceed thresholds for biological effects.

For more information, visit: **http://www.amap.no**

Total Mercury Concentrations in Muscle Tissue from Baleen Whales (Mysticeti)

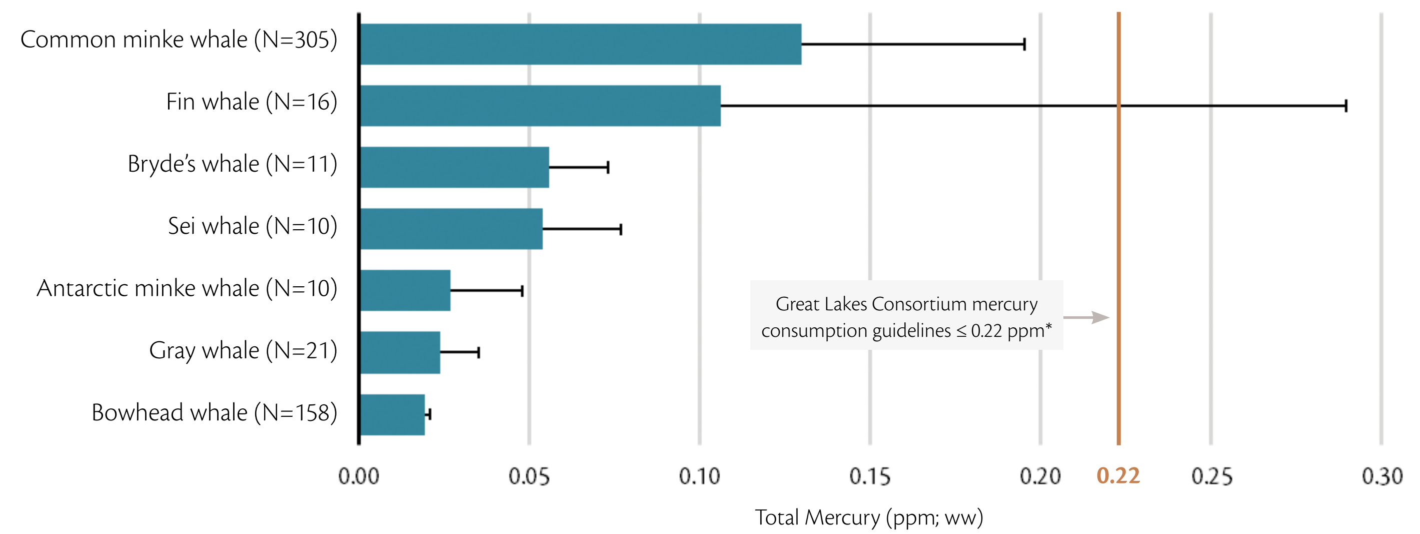


Figure 2. Average (+/−S.D.) total mercury concentration of muscle tissue from seven species. All species shown here are consumed by humans.

*Based on meal guidelines for human weight of 60 kg/fish size of 170 grams (see BRI publication *Mercury in the Global Environment* for more information).

Seals and Walruses

Mercury in Seals and Walruses

Seals and other pinnipeds, such as walruses and sea lions (33 species in total), are distributed around the world's oceans. Recent studies suggest that mercury concentrations in seals have increased approximately 10 times relative to pre-industrial concentrations (AMAP 2011).

Some pinnipeds, such as ringed seals, are considered high-trophic level predators and rely heavily on fish such as the Artic cod for their diet. Other species, including bearded seals and many walrus species, are more omnivorous, with diets that include benthic invertebrates. This variation in diet influences the risk of mercury exposure in these marine mammals.

Mercury and Human Health

Marine mammals are an important dietary component for indigenous peoples living in the Arctic. As the GBMS data illustrates (see map, page 2), mercury concentrations vary across species and geography (Figure 3). Mercury concentrations also vary in different

Far left: The walrus (Odobenus rosmarus), weighing up to 4,400 pounds (2,000 kg), forages on clams and other benthic invertebrates, a diet resulting in very low mercury body burdens. Left: the ringed seal (Pusa hispida) consumes a more varied diet with a preference for fish, which likely explains its higher ranking in muscle mercury concentrations over the walrus and other seals that forage less on fish.

parts of the animal. Seal blubber is low in mercury concentrations and is safer to eat than muscle, while mercury concentrations in liver and kidney are often higher than in muscle tissue.

Modern hunting pressures by indigenous peoples may result in the harvest of younger marine mammals on average, which effectively reduces the amount of mercury exposure in humans because younger seals generally have lower mercury concentrations than larger, older individuals (AMAP 2011).

Mercury and Ecosystem Health

Spatial variation in mercury concentrations in ringed seals suggests that the central and western Canadian Arctic is higher in mercury than other Arctic regions including Alaska, Greenland, Norway, and Russia (Rigét et al. 2005). Mercury in seals has also been shown to vary seasonally and is linked to variations in sea ice cover. Periods of greater sea ice are related to higher mercury concentrations, in part because seals are more reliant on fish. During warmer seasons when sea ice is reduced, seals are able to forage on a broader range of prey items, effectively reducing their exposure to mercury.

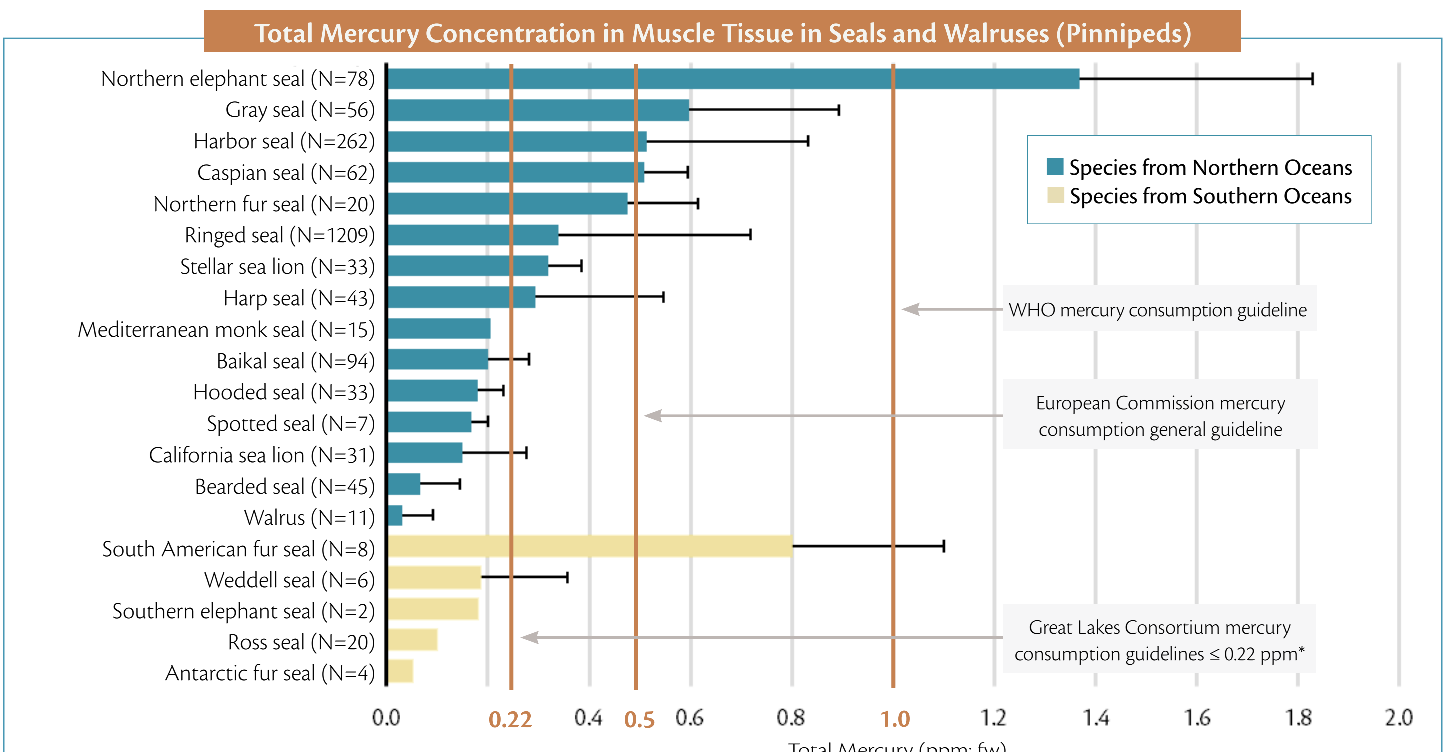


Figure 3. Average (+/− S.D.) total mercury concentrations of muscle tissue for several pinniped species. Antarctic or southern ocean species tend to have lower mercury concentrations when compared to species of similar trophic position in northern oceans. (Note: fur seals do not follow this pattern.)
*Based on meal guidelines for human weight of 60 kg/fish size of 170 grams (see BRI publication *Mercury in the Global Environment* for more information).

Mercury: A Risk to Human Populations

At the top of the global foodweb, humans are subject to a substantial risk due to the presence of methylmercury in aquatic ecosystems. Communities such as the Inuit of North America and the Faroese are most at risk because they subsist on marine mammal species, such as toothed whales, that tend to have high methylmercury concentrations (Grandjean et al. 1997; AMAP, 2011; Dietz et al. 2013).

However, Arctic peoples are not the only populations burdened with potentially hazardous bioaccumulation of dietary methylmercury, as evidenced by hair mercury concentrations measured in humans from around the world (Figure 4). Fishing communities in the Seychelles, Cook Islands, and Japan rely on top trophic-level fish species including tuna, sharks, and swordfish; these communities are also at risk of accumulating potentially harmful levels of methylmercury.

The Effects of Mercury in Humans

Methylmercury is a potent neurotoxin that has been associated with harmful effects to humans such as impaired motor function, vision, and fetal development, as well as learning disabilities and other neurobehavioral deficits (Grandjean et al. 1997; Passos and Mergler 2008; Hong et al. 2012). Acute methylmercury poisoning is often referred to as Minamata disease, named after a tragic contamination event on Minamata Bay, Japan.

In 2013, the Minamata Convention on Mercury was opened for signature and entered into force on August 16, 2017. To date, more than 70 countries have ratified the Convention. The primary goal of the Convention is to protect human health and the environment from anthropogenic sources of mercury contamination. In collaboration with United Nations Environment and IPEN, BRI is helping countries meet the goals of the Convention by compiling a new and standardized global database that includes mercury concentrations in humans.

Many Small Island Developing States and other countries, especially in the Arctic, depend on uncontaminated shellfish, fish, and marine mammals.

Total Mercury Concentrations in Human Hair

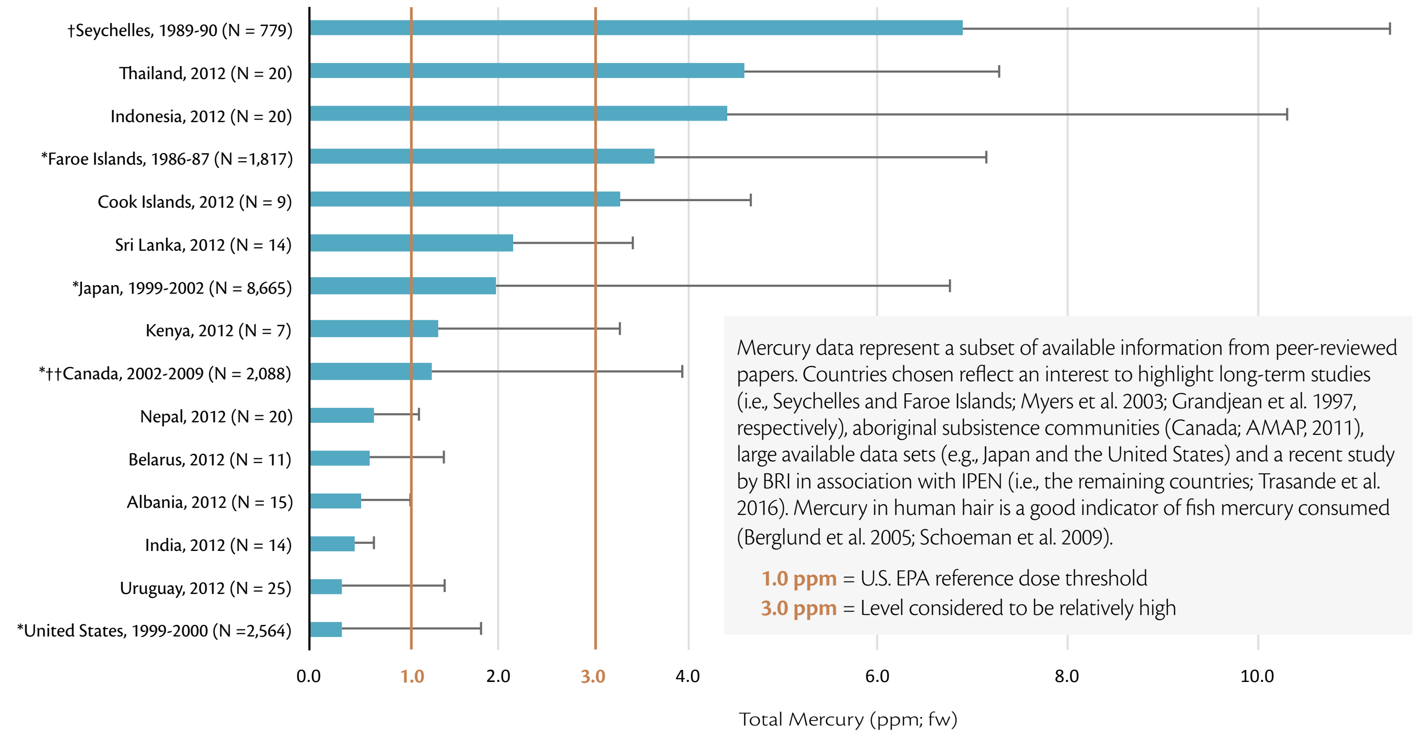


Figure 4. Average (+/– S.D.) total mercury concentrations in human hair from selected countries including year of data collection.

† All data reported as total mercury (THg) concentrations except Seychelles data that was reported as methylmercury (MeHg) concentration. The Seychlles MeHg concentrations reported are the initial concentrations of 779 mother-infant pairs and were determined using maternal hair THg values from hair grown during pregnancy and sampled as part of an ongoing study known as the Seychelles Child Development Study.

†† Data for Canada respresent indigenous subsistence hunting/fishing populations.

* Standard deviations estimated from reported confidence intervals, interquartile ranges, and standard errors in lieu of reported standard deviations.

Polar Bears

Polar Bears, Sea Ice, and Mercury Exposure

Perhaps the most charismatic of Arctic wildlife, polar bears live most of their lives on sea ice, hunting pinnipeds and marine mammals. Concerns about warming Arctic temperatures and rapid melting of sea ice have increased awareness about polar bears and the entire Arctic ecosystem.

Seasonal variation in polar bear mercury concentrations is related to sea ice fluctuations and availability of prey. Higher mercury concentrations have been observed in spring and autumn when bears have access to sea ice and to prey that are using the sea ice. During summer months, when sea ice is at a minimum and hunting is more difficult, mercury concentrations are lower. Similarly low mercury concentrations have also been observed during winter months when prey are more difficult to locate (AMAP 2011).

Risk of Maternal Transfer of Mercury to Fetus and Cub

Research has shown that adult female polar bears have higher mercury concentrations in hair than adult males. It has been suggested that female bears generally target smaller prey items, such as ringed seals (mostly fish-eaters) that are higher in mercury while males prey upon larger pinnipeds such as bearded seals and walruses (that primarily forage on mollusks). Males may also have reduced mercury exposure because of greater consumption of blubber, which is low in mercury.

Elevated mercury concentrations in female polar bears and the transfer of mercury to the polar bear fetus represent a potential long-term conservation concern that could affect future populations of polar bears. While there are currently no data on mercury transfer from mother to fetus in polar bears, the potential impacts require attention and further research (Cardona-Marek et al. 2009).

Global Biotic Mercury Synthesis

The Global Biotic Mercury Synthesis (GBMS) database is a collection of mercury exposure data in biota that are published in peer-reviewed journals.

For this *Marine Mammal* report, we summarize data from 132 published journal articles, representing 74 species at 295 unique locations from 1,395 total individuals.

GBMS also serves as the basis for understanding spatiotemporal patterns of exposure and risk for UN Environment's ***Global Mercury Assessment–2018***.

For more information, visit:
www.briloon.org/hgcenter/gbms

Credits

Editing and Production: Deborah McKew; **Editorial Assistance:** Kate Taylor; **Map and Charts:** Sarah Johnson; **Illustrations:** Shearon Murphy**: Photography:** Beluga whale © Shutterstock–John Wollwerth; page 4: Long-finned pilot whales © Shutterstock–Durk Talsma; page 5: Minke whale © Fotolia–mojo-jojo; page 6: Ringed seal © Hemis/Alamy Stock Photo, Walruses © Fotolia–outdoorsman; page 7: Eskimo in S. Greenland © LOOK Die Bildagentur der Fotografen GmbH/Alamy Stock Photo; page 8: Young polar bear © Fotolia–robertharding.

Polar bears (Ursus maritimus) are threatened on multiple fronts including mercury contamination and habitat loss. Climate change will likely increase Arctic environmental mercury loads.

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