










Mercury: A Threat to Biological Diversity

Mercury in the Global Environment

Mercury (Hg) is a pollutant of global importance that adversely affects human health and the environment. The Minamata Convention on Mercury, which became legally binding for all Parties in 2017, addresses issues related to the use and release of mercury including trade, industrial uses, and major sources of atmospheric emissions and releases of mercury into the environment, as well as long-term storage and disposal of mercury and mercury compounds.

Mercury and Ecosystem Health

Elemental mercury is converted to a more toxic and persistent organic form through the process of methylation, which occurs with the help of bacteria found primarily in wet areas. Methylmercury can then be bound in the food web where it can biomagnify and contaminate ecosystems. Methylmercury is a potent neurotoxin that has been associated with harmful effects in humans such as impaired motor function and vision, unhealthy fetal development, and learning disabilities.

Numerous studies have also shown that high mercury concentrations in fish can have negative impacts on fish growth, behavior, and reproduction. Fish-eating wildlife are shown to have decreased reproductive success when methylmercury concentrations in fish are high. Methylmercury can also have negative effects on behavior such as foraging or nest protection.

The Role of Bioindicators

Freshwater fish are widely used to monitor mercury in the environment. Young fish (<1 year) can reflect rapid changes of environmental mercury loads, while long-lived predatory fish commonly consumed by humans may indicate concern for human health. Fish communities can provide information on biomagnification of toxic substances within aquatic food webs.

Sea turtles can bioaccumulate methylmercury over time and can be important bioindicators of environmental mercury loads in marine ecosystems. In terrestrial ecosystems, **birds** are effective bioindicators of mercury pollution and can help highlight environmental concerns. Some **mammals** can be highly relevant for human health purposes (e.g., toothed whales), while others are relevant indicators of ecological integrity, such as fish-eaters (e.g., otters) or invertebrate eaters (e.g., bats).

Global Biotic Mercury Synthesis Database

Biodiversity Research Institute (BRI) has compiled mercury data from published literature into a single database, the Global Biotic Mercury Synthesis (GBMS). This database includes details about each organism sampled, its sampling location, and its basic ecological data. From each reference, mercury concentrations are averaged for each species at each location. Data from the GBMS database can be used to understand spatial and temporal patterns of mercury concentrations in biota. This information can also help establish baseline concentrations for a particular species and identify ecosystems most at risk to mercury inputs. This publication includes excerpts from our report Mercury in the Global Environment, which presents GBMS data on mercury concentrations in biota of concern in Article 19 of the Minamata Convention. Mercury concentrations from key biota are presented and compared geographically and taxonomically through Case Studies.

Mercury and Biological Diversity

The Convention on Biological Diversity (CBD), adopted in 1992, aims for conservation of biological diversity and the sustainable use of natural resources. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines, and energy. It also interferes with essential ecological functions. The underlying causes of biodiversity loss are often complex and stem from many interrelated factors.

The CBD is launching its post-2020 Global Biodiversity Framework (GBF) that sets out an ambitious plan to implement broad-based action to bring about a transformation in society's relationship with biodiversity and to ensure that, by 2050, the "shared vision of living in harmony with nature" is fulfilled. The mission of the framework for the period up to 2030, towards the 2050 vision is: "To take urgent action across society to conserve and sustainably use biodiversity and ensure the fair and equitable sharing In order to reduce threats to biodiversity, eight action-oriented targets were identified" (Table 2).

Integrating A One Health Approach

The Framework will advance a One Health approach that recognizes the connections between the health of humans, animals, and the environment. This effort promotes revising Biodiversity Target 14 to read: "By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities and the poor and vulnerable." Mercury as a contaminant that impacts human and ecosystem health clearly fits within this framework.

Greater Inclusion Needed for GBF

The threat chemical pollution poses to biodiversity on a global scale has been acknowledged in the Post-2020 Global Biodiversity Framework. In its current form, Target 7 proposes to regulate the release of chemicals to the environment and names specific indicators focusing on pesticides, nutrients, and plastic waste. We fully endorse the inclusion of these substances but believe that Target 7 must include the following per new supporting publications: non-agricultural biocides, PFAS, toxic metalloids including mercury, and endocrine disrupting chemicals.

Table 1. Connection between BRI's Global Biotic Mercury Synthesis Database and the Minamata Convention requirements.*

Project Objectives	Minamata Convention on Mercury Article	Linkages between GBMS and Minamata Convention Articles
Identify global biological mercury hotspots and link those hotspots to potential mercury source types.	**Article 12**: Contaminated Sites **Article 19**: Research, Development, and Monitoring	• Biotic mercury concentrations can help identify sites contaminated by mercury using mercury isotopes. • Biotic mercury concentrations can be used to inform human and environmental risk assessments.
Compile and present mercury data in an easy-to-access and easy-to-understand format through website portals.	**Article 14**: Capacity-building, Technical Assistance, and Technology Transfer **Article 17**: Information Exchange **Article 18**: Public Information, Awareness, and Education	• GBMS provides a model for database development used to compile and interpret biotic mercury concentrations. • GBMS facilitates the exchange of scientific information between the scientific community, the policy sector, and the general public.
Identify bioindicators (fish, sea turtles, birds, and marine mammals) for long-term monitoring to reflect relevant spatial and temporal trends.	**Article 16**: Health aspects **Article 19**: Research, Development, and Monitoring	GBMS represents a comprehensive database on mercury concentrations that: • can be used to inform models on mercury concentrations in environmental media; • is a tool for assessing potential risk of human exposure to mercury via fish consumption; • documents the fate of mercury in freshwater and marine ecosystems; • can provide countries with important information about fish mercury concentrations within their national waters.
Establish a baseline of mercury concentrations including spatial and temporal trends.	**Article 22**: Effectiveness Evaluation	• Mercury concentrations in GBMS provide a baseline of monitoring data for assessing the effectiveness of the treaty.

*GBMS represents a comprehensive, standardized, and cost effective approach for documenting and tracking changes in environmental loads of mercury as reflected in fish and wildlife. For more information on GBMS, see references on back page.

Table 2. Convention on Biological Diversity 2030 Action Targets (excerpted from the post-2020 Global Biodiversity Framework)

Action Targets: Reducing Threat to Biodiversity	
1	Ensure that all land and sea areas globally are under integrated biodiversity-inclusive spatial planning addressing land- and sea-use change, retaining existing intact and wilderness areas.
2	Ensure that at least 20% of degraded freshwater, marine ,and terrestrial ecosystems are under restoration, ensuring connectivity among them and focusing on priority ecosystems.
3	Ensure that at least 30% globally of land areas and of sea areas, especially areas of particular importance for biodiversity and its contributions to people, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
4	Ensure active management actions to enable the recovery and conservation of species and the genetic diversity of wild and domesticated species, including through ex situ conservation, and effectively manage human-wildlife interactions to avoid or reduce human-wildlife conflict.
5	Ensure that the harvesting, trade, and use of wild species is sustainable, legal, and safe for human health.
6	Manage pathways for the introduction of invasive alien species, preventing or reducing their rate of introduction and establishment by at least 50%, and control or eradicate invasive alien species to eliminate or reduce their impacts, focusing on priority species and priority sites.
7	Reduce pollution from all sources to levels that are not harmful to biodiversity and ecosystem functions and human health, including by reducing nutrients lost to the environment by at least half, and pesticides by at least two thirds and eliminating the discharge of plastic waste.
8	Minimize the impact of climate change on biodiversity, contribute to mitigation and adaptation through ecosystem-based approaches, contributing at least 10 $GtCO_2e$/year to global mitigation efforts, and ensure that all mitigation and adaptation efforts avoid negative impacts on biodiversity.

Recognizing the Connections

This publication illustrates how emissions and releases of mercury into the environment are connected to elevated body burdens in biota, especially high trophic -level organisms in ecosystems sensitive to methylmercury. Certain species within particularly sensitive ecosystems are subject to adverse impacts to their reproductive success and survival, therefore potentially causing great harm to biological diversity. Case Studies excerpted from BRI's report *Mercury in the Global Environment* present data on mercury concentrations in biota of concern in Article 19 of the Minamata Convention.

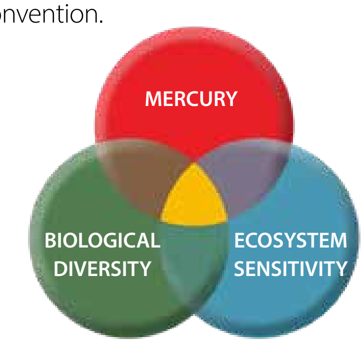


Figure 1. This diagram shows the interconnectedness of ecosystem sensitivity, mercury exposure, and biological diversity. The nexus of these three factors is of greatest concern where mercury may be playing a role in biodiversity loss.

Mapping Biological Diversity

In 2020, the CBD declared that biodiversity stands at a crossroads with regard to the legacy it leaves to future generations (GBO-5, 2020). Based on extensive review, it was clear that biodiversity is declining at an unprecedented rate, and the pressures driving this decline are intensifying.

The biodiversity maps on this spread show regions and species of concern. BRI's assessment of a region's mercury threat helps understand where mercury impacts (through reduced reproductive success in vulnerable species) may be playing a role in biodiversity loss.

The GBO-5 identified five areas of action that could reduce the rate of biodiversity decline. Action 3 focuses on pollution, invasive alien species and overexploitation, where there is a clear link to the Minamata Convention on Mercury.

Pathways to the 2050 Vision for Biodiversity

GBO-5 showed that 'business as usual' trajectories are incompatible with any interpretation of a future in which human societies are living in harmony with nature by 2050. One of the "Main Pressures" identified was Pollution. Mercury contamination is one source of pollution that is negatively impacting many of the transitional pathways identified to achieving the 2050 vision.

The Biodiversity-inclusive One Health Transition

One Health contributes to reduced negative health impacts from many forms of pollution. One key component of this transition is to promote healthy diets as a component of sustainable consumption. The consumption of mercury-laden fish is seriously impacting many human communities. Preventing such pollution is the whole reason the Minamata Convention was formed.

The Sustainable Fisheries and Oceans Transition

A key part of this transition is to contribute to healthy coastal and marine ecosystems through reduced pollution including the sustainable marine harvest of fish that spawn in freshwater environments.

The Sustainable Freshwater Transition

This transition also focuses on combatting pollution and improving water quality. As mercury methylation and uptake into terrestrial and freshwater food webs primarily occurs through freshwater systems, this transition also has clear overlaps with the Minamata Convention objectives.

Marine Biodiversity

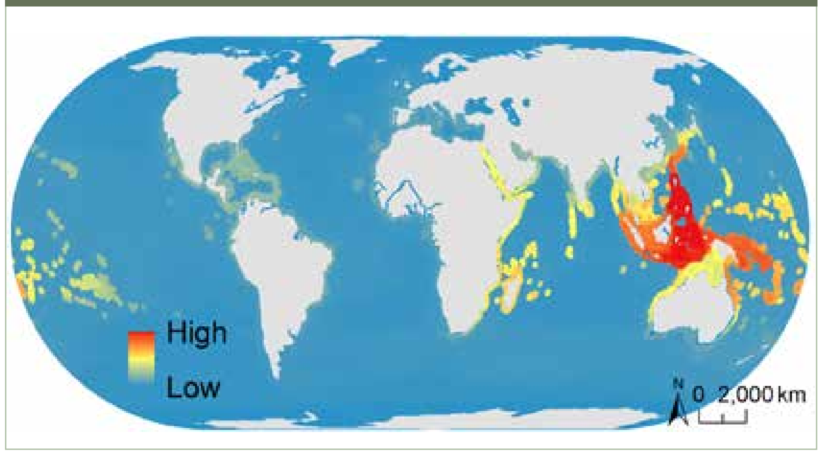


Figure 2. Marine biodiversity conservation priorities for all species from nine marine taxa (Jenkins et al. 2017). Priority scores were calculated based on species-specific occurrence,range size and accounting for current marine protected area (MPAs). *Source: BiodiversityMapping.org*

Fish Species Richness by Freshwater Ecoregion

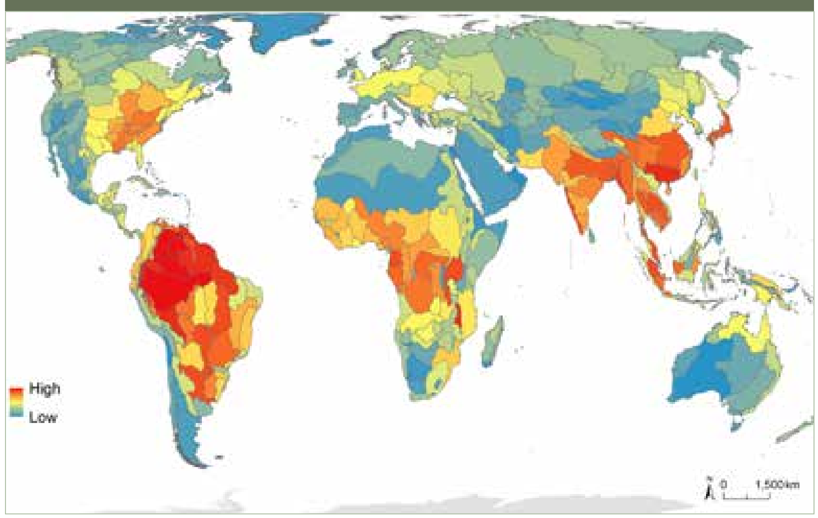


Figure 3. Freshwater fish diversity (species richness) by freshwater ecoregion (Abell et al. 2008).

Global Diversity Outlook

The second meeting of the Conference of the Parties for the Convention on Biological Diversity called for the preparation of a periodic report on biological diversity: Global Biodiversity Outlook (GBO). The GBO provides a summary of the status of biological diversity and an analysis of the steps being taken by the global community to ensure that biodiversity is conserved and used sustainably, and that benefits arising from the use of genetic resources are shared equitably. Towards a landmark new global post-2020 biodiversity framework: GBO-5 synthesizes scientific basis for urgent action. For more information, visit: **www.cbd.int/gbo/**

Bird Species Richness (seabirds excluded)

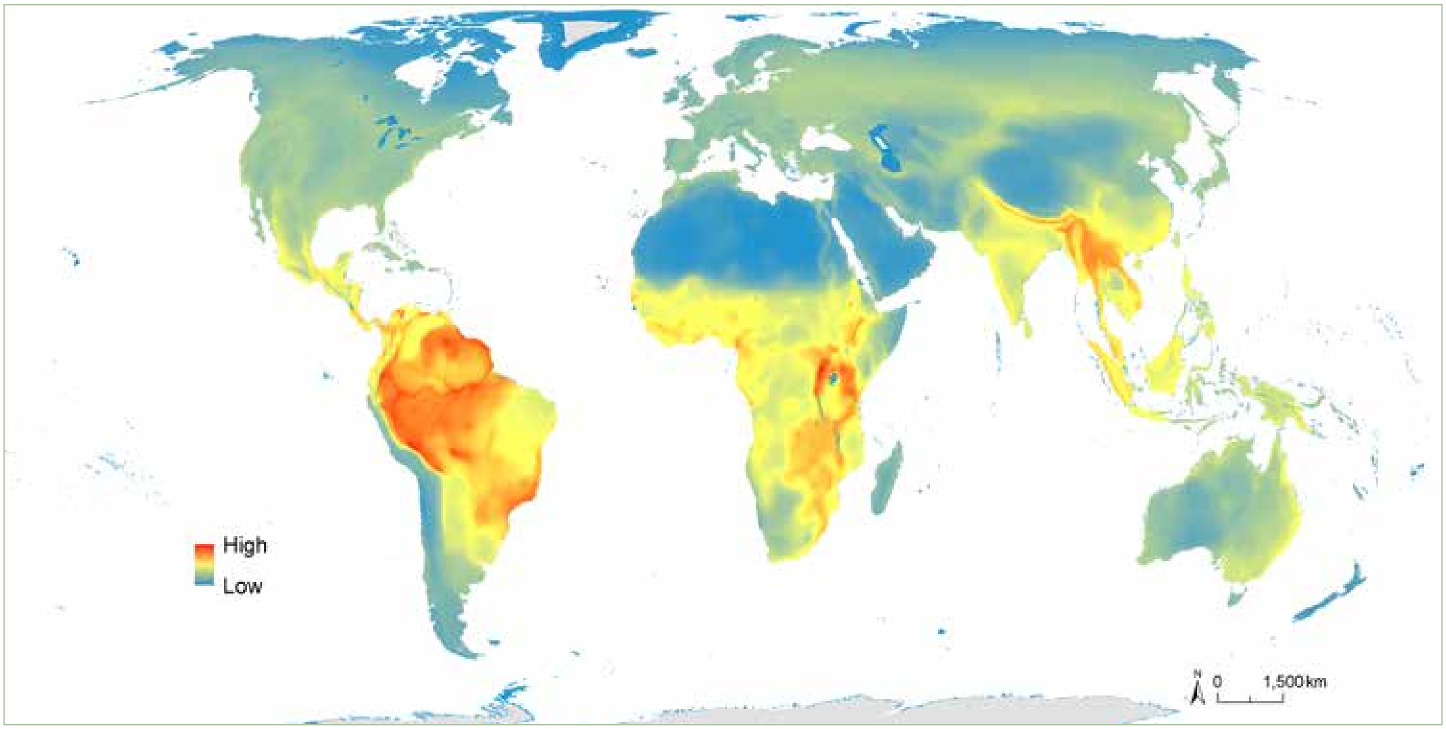


Figure 4. Terrestrial bird diversity (species richness) derived from breeding, non-breeding, and combined species range maps (Jenkins et al. 2013; Pimm et al. 2014). *Source: BiodiversityMapping.org*

Mammal Species Richness

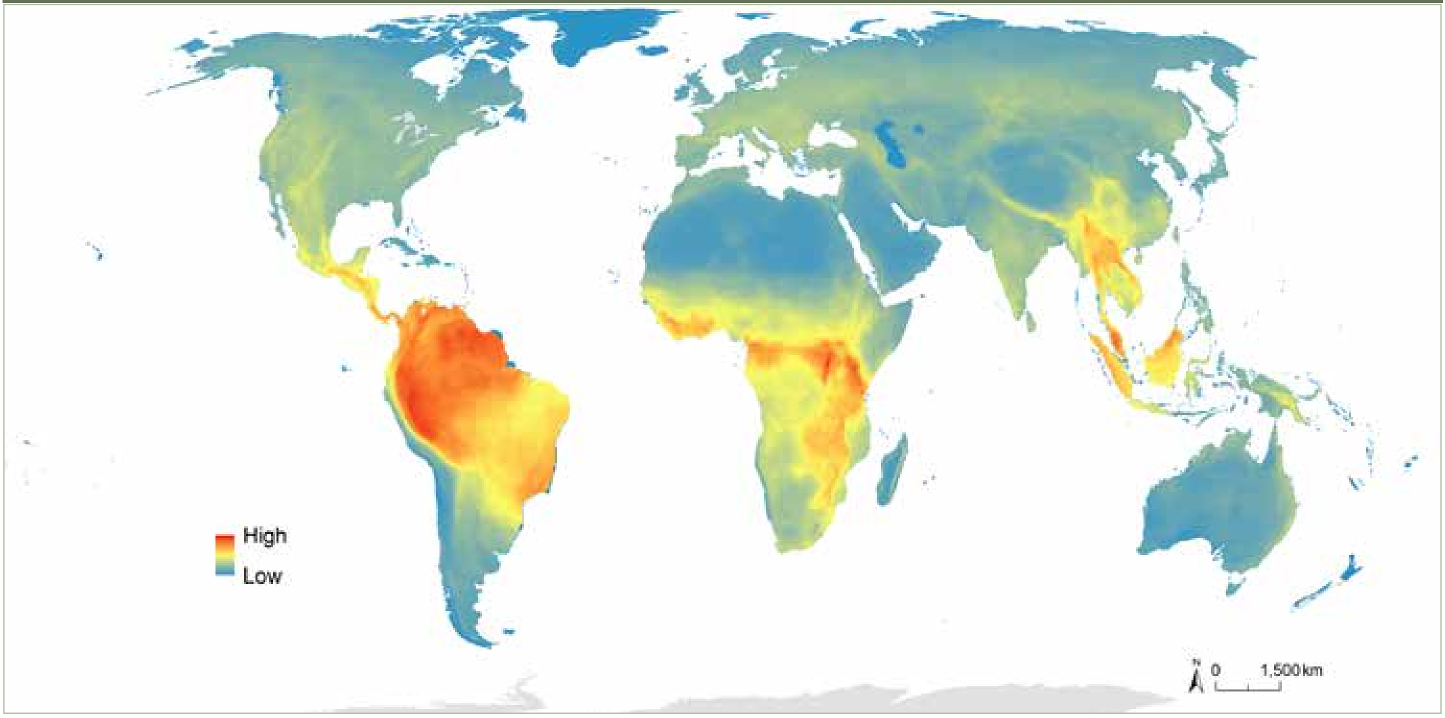


Figure 5. Terrestrial mammal diversity (species richness) derived from species range maps (Jenkins et al. 2013; Pimm et al. 2014). *Source: BiodiversityMapping.org*

Assessing the Threat of Mercury

Combined Mercury Threat Assessment

The combination of ecosystem sensitivity and risk of multiple mercury inputs defines the overall threat of mercury contamination. Based on a well-established threat assessment methodology (Vörösmarty et al. 2010) we applied a simple 1:1 relationship—i.e., ecosystem sensitivity and risk are each weighted the same when they are combined together to assess overall threat ranking. The relative weights of other mapping inputs were primarily weighted equally based on expert input. It is our intent that over time, and with additional information from the field, that the relative weights of mapping input factors may be altered to better reflect reality.

Assessing Impacts to People and Nature

Humans are exposed to mercury primarily through diet; methylmercury is the predominant form of mercury found in fish (Sunderland, 2007). Exposure is known to cause adverse health effects particularly in young children and developing fetuses (Basu, et al. 2018).

Elevated mercury levels in fish can cause fish to suffer behavioral changes and reduced reproductive success. Mercury exposure can subsequently have adverse effects through the twin processes of biomagnification and bioaccumulation on the behavior and reproductive success of those that eat fish, including people, other mammals, and fish-eating birds.

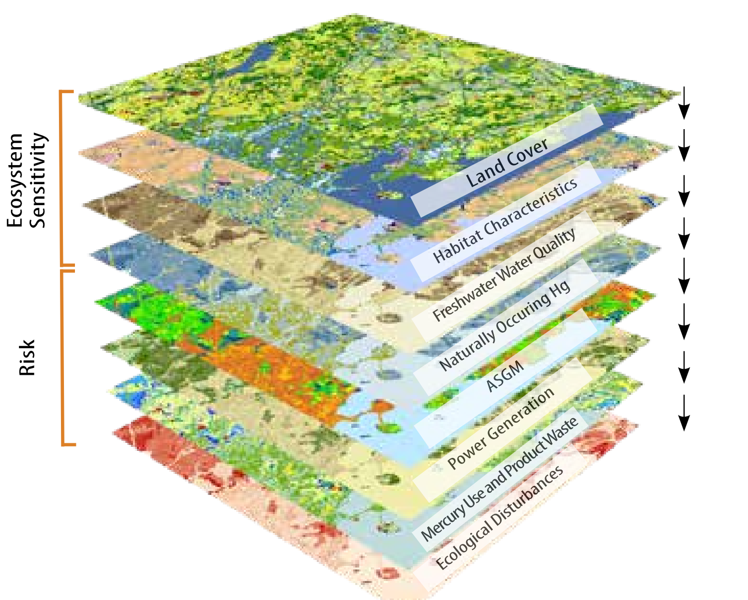


Figure 6. GIS Layer Selection - By combining spatial information on the distribution of habitats and species with the extent and severity of mercury contamination, it is possible to measure the ecosystem response and risk exposure to methylmercury availability. These data can be mapped to specific locations to better inform natural resource managers, regulators, and other decision makers to help prioritize resources to best protect human and ecosystem health.

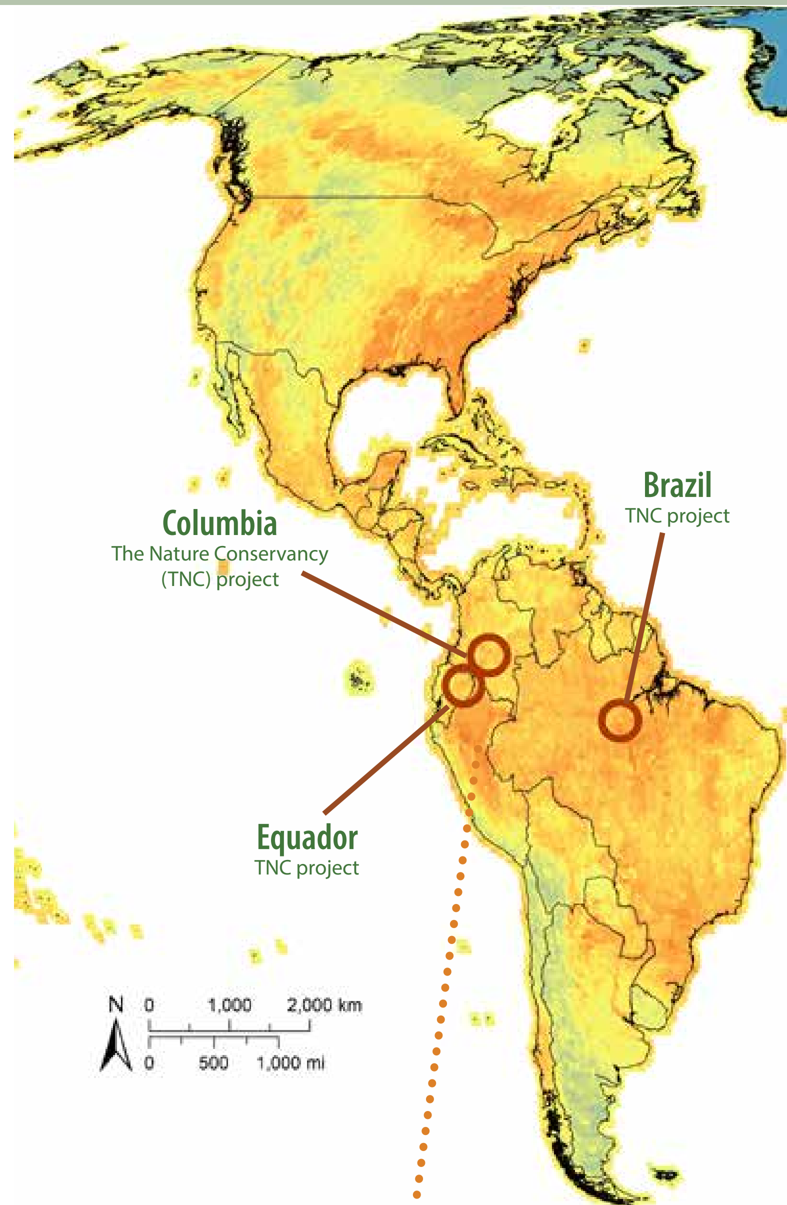


Figure 7.

Global map illustrating mercury threat assessments; call outs show specific study areas.

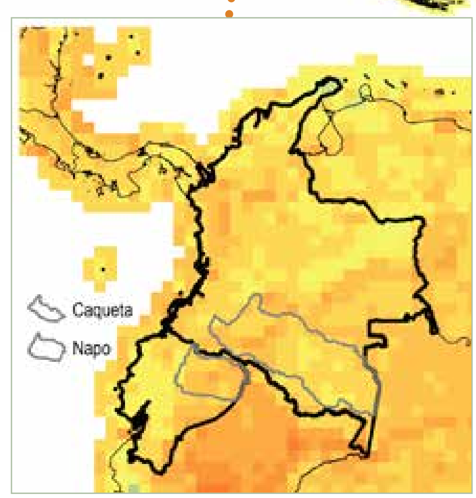
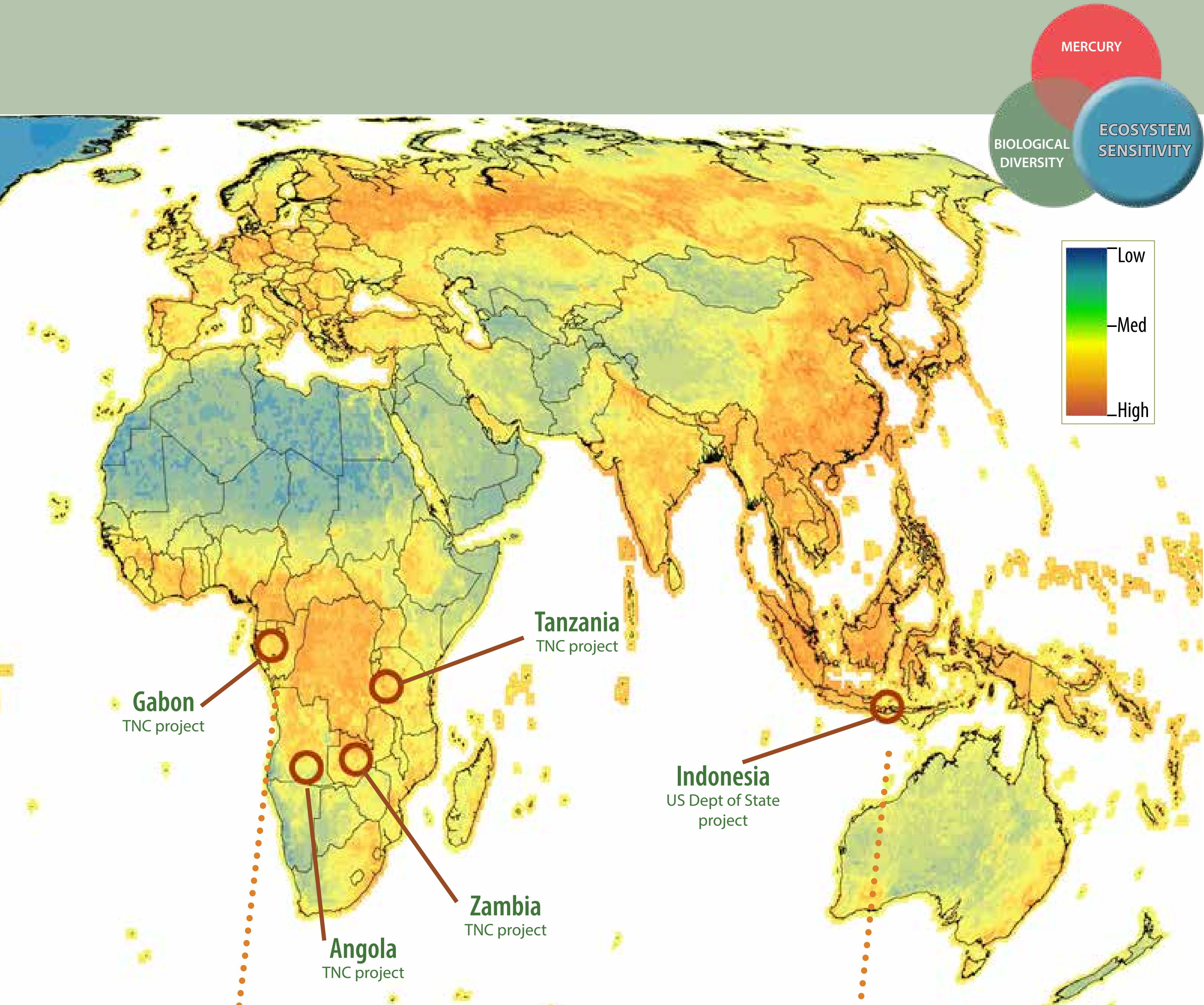


Figure 7A. Enlargement of Colombia and Ecuador Mercury Threat map with Caquetá and Napo Watersheds highlighted to show landscape-scale variability.



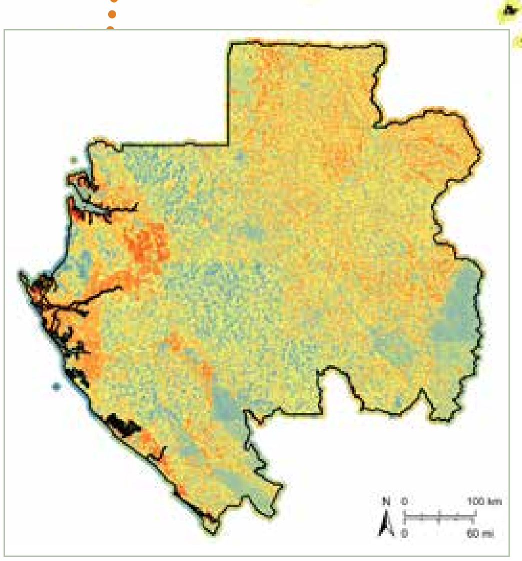


Figure 7B. Regional map of Ecosystem Sensitivity in Gabon illustrating additional detail possible from an RMTA vs. the GMTA.

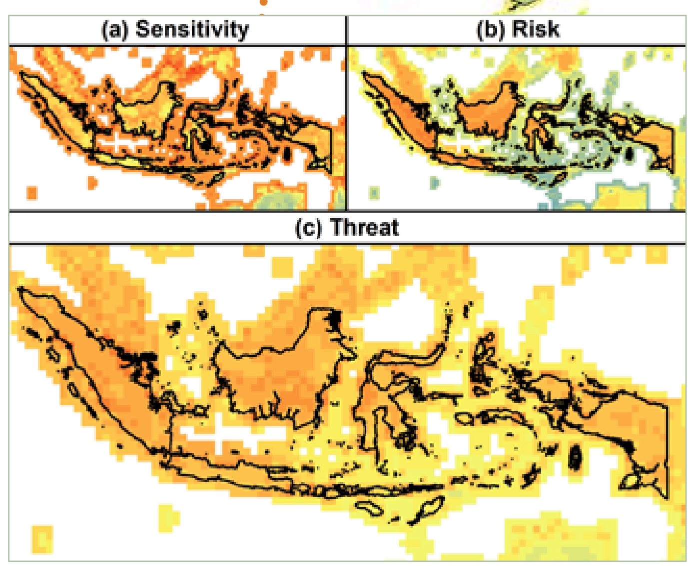


Figure 7C. Enlargement of Indonesia to illustrate how higher mercury risk in Indonesia has a greater influence than lower ecosystem sensitivity scores on the overall threat assessment.

Mapping Mercury in Biota

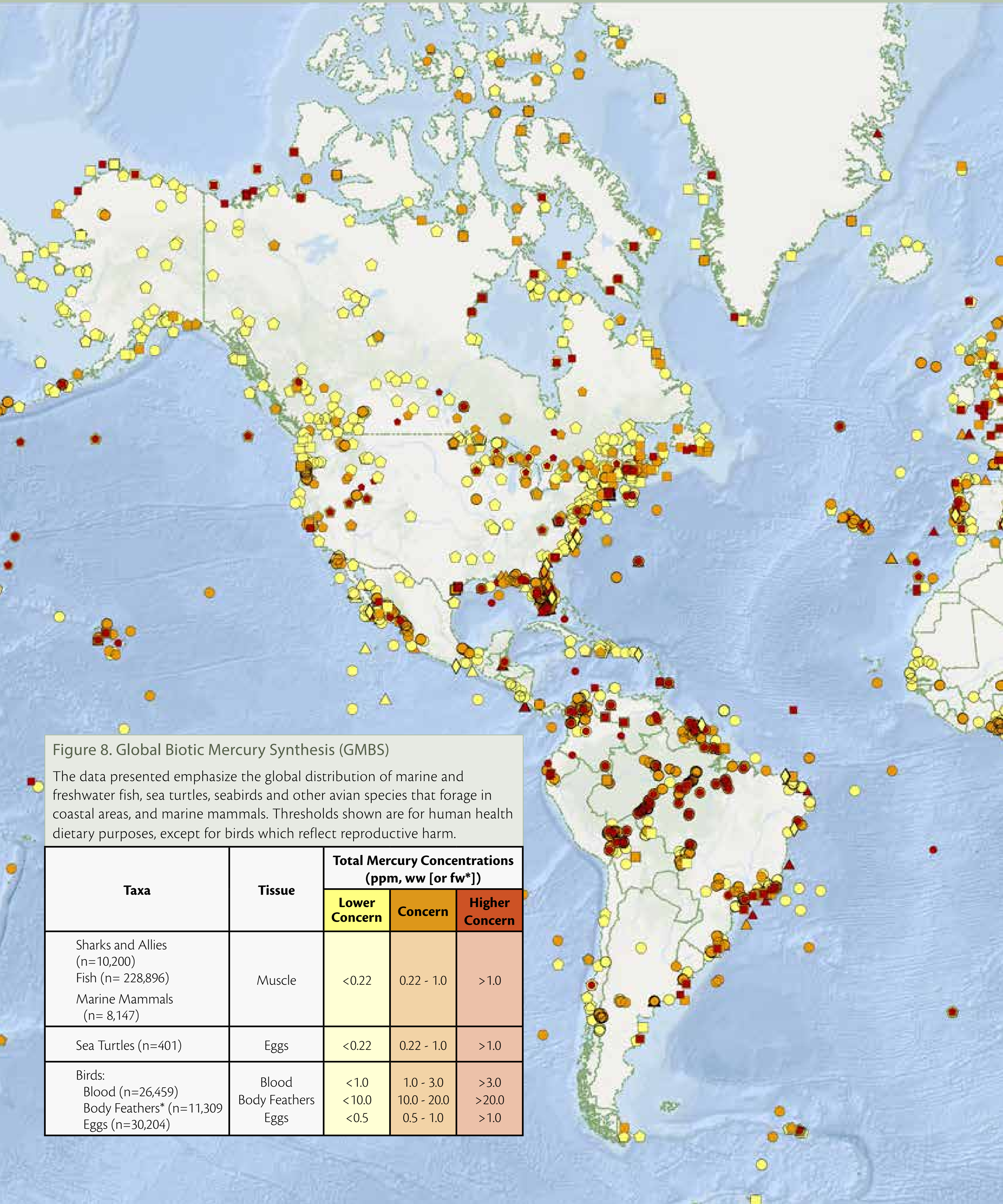
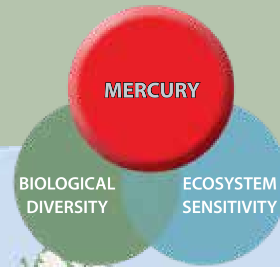


Figure 8. Global Biotic Mercury Synthesis (GMBS)

The data presented emphasize the global distribution of marine and freshwater fish, sea turtles, seabirds and other avian species that forage in coastal areas, and marine mammals. Thresholds shown are for human health dietary purposes, except for birds which reflect reproductive harm.

Taxa	**Tissue**	**Total Mercury Concentrations (ppm, ww [or fw*])**		
		Lower Concern	**Concern**	**Higher Concern**
Sharks and Allies (n=10,200) Fish (n= 228,896) Marine Mammals (n= 8,147)	Muscle	<0.22	0.22 - 1.0	>1.0
Sea Turtles (n=401)	Eggs	<0.22	0.22 - 1.0	>1.0
Birds: Blood (n=26,459) Body Feathers* (n=11,309 Eggs (n=30,204)	Blood Body Feathers Eggs	<1.0 <10.0 <0.5	1.0 - 3.0 10.0 - 20.0 0.5 - 1.0	>3.0 >20.0 >1.0



BRI's Global Mercury Projects

BRI has partnered with UN agencies, country ministries, IGOs and NGOs around the world (n = 74 countries) to better understand mercury exposure to people and the environment, and to help Parties meet goals of the Minamata Convention. To view an interactive map of where we have conducted sampling or assisted countries from 2014-2018, visit:

www.briwildlife.org/minamata

Our Analytical Approach

Throughout this booklet we use the terms mercury (Hg), methylmercury (MeHg) and total mercury (THg). For analytical techniques we specify wet weight (ww), fresh weight (fw), or dry weight (dw) in parts per million (ppm).

Mercury concentrations in the GBMS database[1] represent various tissue types depending on the taxon reported. All teleost fish, shark, and marine mammal Hg concentrations represent muscle tissue on a ppm, ww basis.

The database also summarizes Hg concentrations in sea turtle eggs (ppm, ww); bird blood and eggs (ppm, ww); and bird body feathers (ppm, fw).

Where appropriate, Hg data reported as dw are converted to ww using a percent moisture content specific to the taxon and tissue type—fish tissue, eggs, and blood: 80% moisture; marine mammal muscle: 72%; liver: 70%; kidney: 77%; and skin: 73% (Yang et al. 2003). In instances where marine mammal Hg concentrations are reported in literature for only liver, kidney, or skin, tissue data are converted to muscle equivalents using regressions created using paired muscle-tissue Hg concentrations reported in other published literature included in the database.

[1]Because >95% of the Hg in all tissues herein is methylmercury (e.g., Bloom 1992), THg concentrations from the published sources are not converted to methylmercury. Hg concentrations are not normalized by organism size.

in the quest to conserve life on earth, many global environmental conventions have been initiated. As the threat of climate change continues to increase, a noticeable gap has emerged—the integration of these global conventions to achieve more than any single convention can on its own.

The Need to Integrate Information

The Minamata Convention on Mercury made a clear decision at COP (4.2) in March 2022 to work collaboratively with the Convention for Biological Diversity. The development of the Global Biodiversity Framework and the identification of Target 7 to reduce the threat of pollution creates a distinct area of overlap between the two conventions.

A major question remains—how to make this happen? One major step towards integration can and must be the effective and efficient sharing of information to improve impact and policy effectiveness assessments. For example, the UNEP World Environment Situation Room maintains information on biodiversity and threats.

Global Mercury Inventories

UNEP has also been working with BRI to develop a mercury inventory toolkit and to create a mercury dashboard (Figure 9) to capture the latest information on the sources of mercury contamination in countries. This information is generated via Minamata Initial Assessments (MIAs) as part of each country's commitment to participating in the Minamata Convention. The dashboard aggregates national mercury inventories developed using UNEP's Toolkit for the identifications and quantification of mercury releases. These comprehensive inventories are core activities for developing countries and countries with economies in transition to understand and identify the sources of mercury emissions and releases within their borders. The dashboard allows users to interactivity explore emerging patterns in mercury inputs and releases by region and sector and follow the pathways of the mercury cycle using a full life-cycle approach.

Effectiveness Evaluation

In order to assess the effectiveness of the global conventions, and the countries that participate in these conventions, a necessary next step is to develop better ways to integrate information on biodiversity, threats to biodiversity, and efforts to reduce these threats. In response toward the long-term need for evaluating the Convention's effectiveness in reducing global environmental mercury loads, the Minamata Convention is working with Parties and other stakeholders through an Open Ended Scientific Group forum. These efforts by UNEP help to pave the way for improved information sharing and knowledge flow.

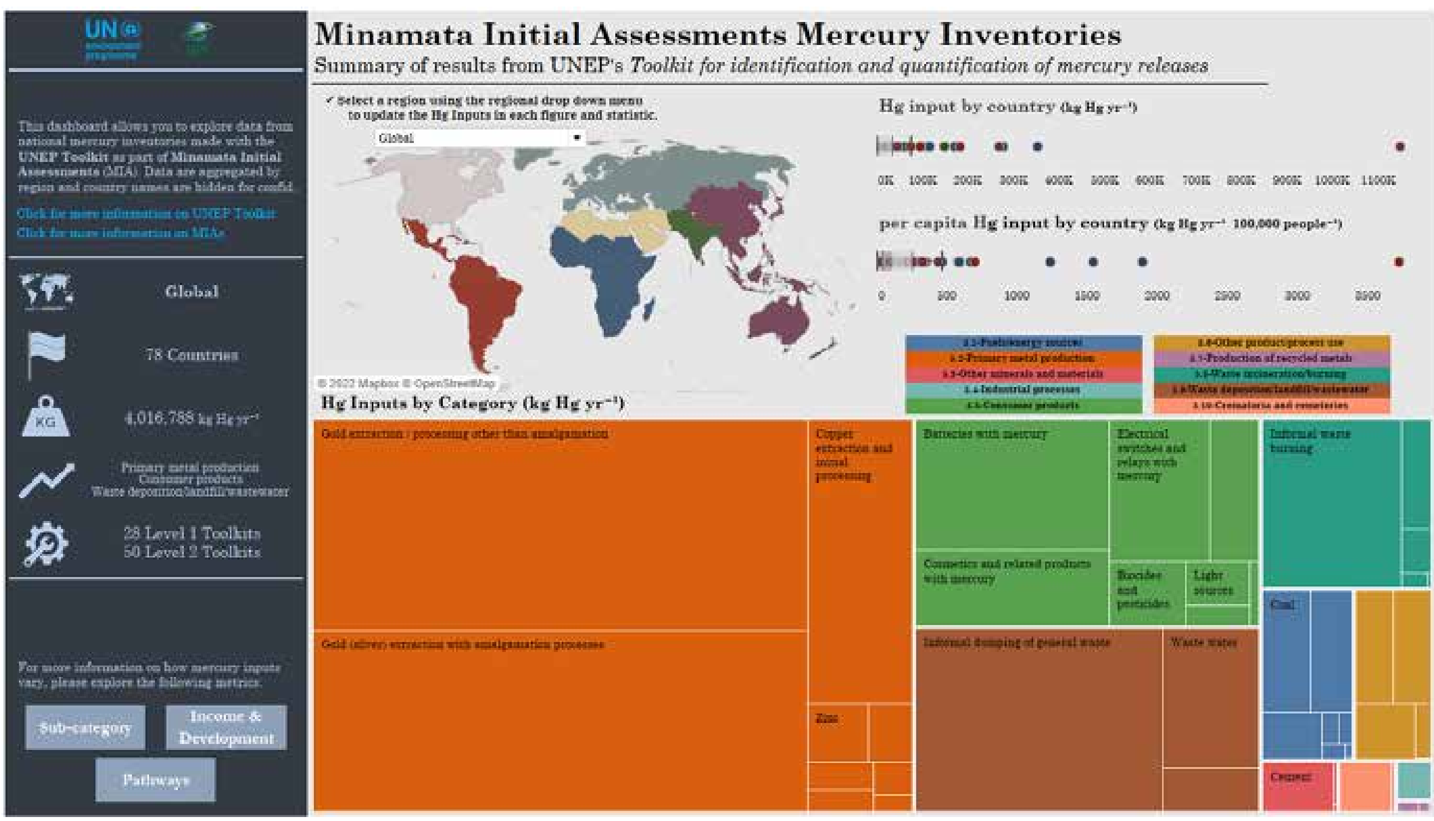


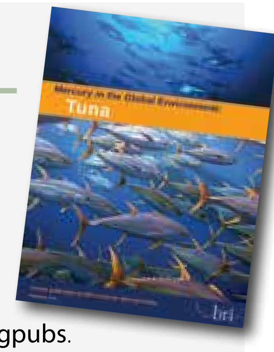
Figure 9. UNEP dashboard with recent information on mercury contamination generated by Minamata Initial Assessments undertaken by the Minamata Convention.

Most tuna species are large marine apex predators and many are regularly listed on fish consumption advisories (Kaneko and Ralston 2007). However, tuna are consistently among the top five commodities in the global fish market. Skipjack, albacore, and yellowfin are the species most commonly utilized by the tuna canning industry, while bluefin tuna species are especially desired for direct consumption (FAO 2004).

Figure 10 compares mercury data from GBMS in nine tuna species showing FAO capture totals. The most highly sought after tuna species, skipjack tuna, also has the lowest mean mercury concentration. Yellowfin and albacore tuna have average mercury concentrations slightly above the GLC/USEPA consumption guideline of 0.22 ppm, while Atlantic and Pacific bluefin, bigeye, and blackfin tunas exceed the EC threshold guideline of 0.5 ppm. Bluefin tuna generally have high mean mercury concentrations but represent a relatively small portion of the overall tuna capture.

Recent research suggests that present atmospheric mercury deposition rates will result in an approximate doubling of mercury concentrations by 2050, particularly in the North Pacific Ocean (Sunderland et al. 2009). Assuming methylmercury production and bioaccumulation follow current patterns, such deposition rates will likely result in significant increases in mercury concentrations in apex marine predators such as tuna

Mercury in the Global Environment: Tuna



This new BRI publication helps illustrate the impacts of methylmercury biomagnification and bioaccumulation on nine species of tuna, highlighting mercury levels in the most popular tuna food sources. To download this and other BRI publications, visit: **www.briloon.org/hgpubs**.

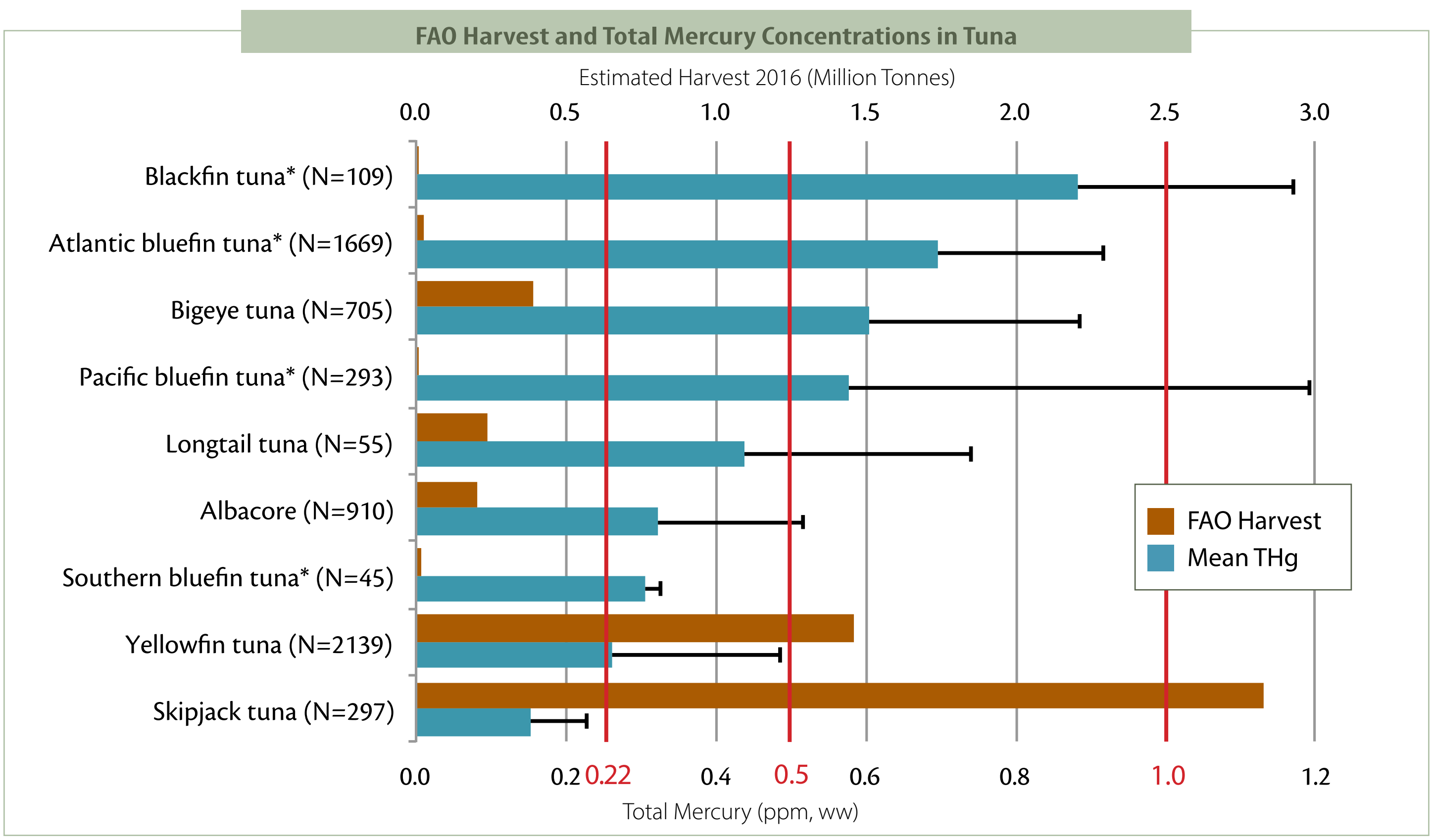


Figure 10. Average (+/– SD; N=sample size) THg concentration in muscle tissue of nine tuna species compared with the FAO harvest estimate in tonnes. *FAO harvest is less than 15,000 tonnes.

Freshwater Fish

Long-term mercury monitoring in freshwater fish is common for many countries and allows for spatial and temporal changes to be observed over relatively large regions (Monson 2009, Monson et al. 2011, Eagles-Smith et al. 2016).

Biomonitoring in Temperate Areas

Freshwater fish are commonly used as a monitoring and assessment tool for mercury contamination in lakes. In North America (Figure 14) and across parts of Europe (e.g., Scandinavia), mercury monitoring has been conducted for decades across a wide range of freshwater ecosystems (i.e., ponds, lakes, reservoirs, rivers).

Broad taxonomic differences in gamefish mercury body burdens observed in the order Perciformes and Esociformes illustrates the variation that should be considered for large-scale mercury biomonitoring efforts for temperate lakes and rivers (Figure 11).

These data provide critical information that are used in the development of fish consumption guidelines for the protection of human and ecological health.

Total Mercury Concentrations in Perciformes and Esociformes in North America

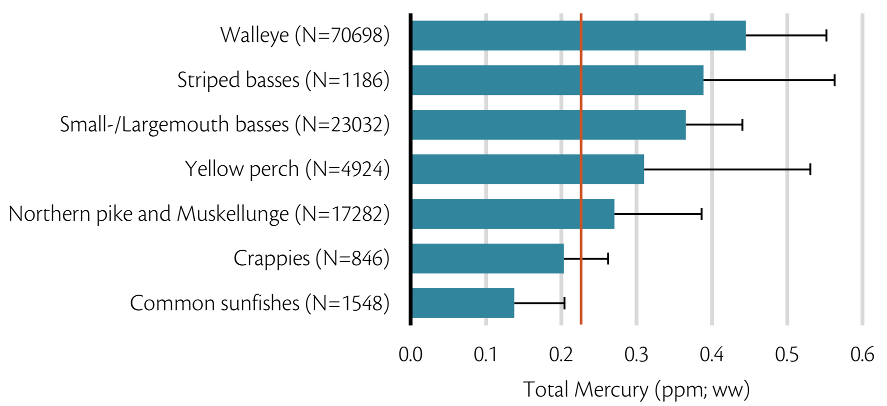


Figure 11. Average (+/– SD; N=sample size) THg in freshwater fish for seven genera showing the GLC human health threshold of 0.22 ppm, ww.

Biomonitoring in Tropical Areas

The GBMS database includes numerous studies from tropical regions where ASGM activities are perceived as the primary source of mercury released into the environment. Paired comparisons of mercury concentrations in fish from the same taxonomic classification (i.e., order) between temperate and tropical areas broadly indicates that tropical fish tend to have higher mercury concentrations than their temperate counterparts (i.e., four of six pairings are higher for tropical fish; Figure 12). For example, tropical catfish have higher average mercury concentrations— they are often associated with ASGM activities—whereas catfish from temperate areas may less likely be associated with contaminated areas.

The walleye, a common freshwater game-fish of North American lakes, is widely used in Canada and in the U.S. Great Lakes Region for mercury monitoring efforts related to human health.

Total Mercury Concentrations in Six Paired Orders of Fish by Region

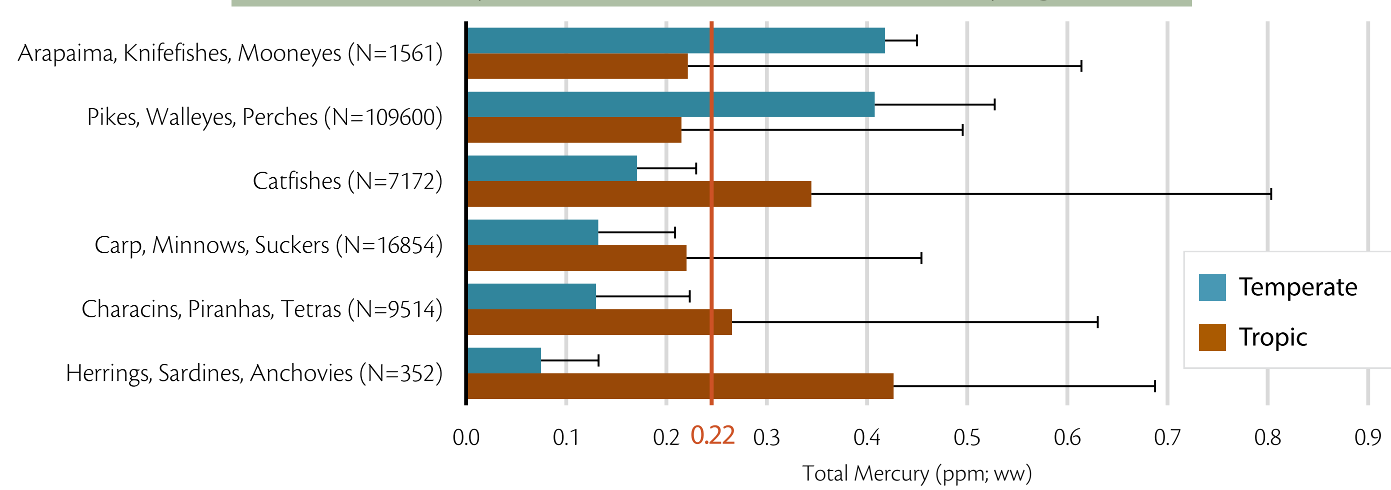


Figure 12. Average (+/– SD; N=sample size) THg in freshwater tropical and temperate fish for six orders, showing the GLC human health threshold of 0. 22 ppm, ww.

Sea Turtles

The seven species of sea turtles are found across all warm and temperate waters, often migrating hundreds of miles between nesting and feeding grounds. All marine waters can create elevated levels of mercury body burdens in biota, including sea turtles. And, while sea turtles are long-lived and slow growing (creating an opportunity for methylmercury to bioaccumulate over time), most species forage on seagrass, sponges, and slow moving animals such as zooplankton and jellyfish—all of which occupy the lower parts of the food web and therefore create minimal opportunities for methylmercury to biomagnify.

Yet, sea turtles can be important bioindicators of short-term (e.g., blood sampling) and long-term changes (e.g., scute sampling) of environmental mercury loads in marine ecosystems.

Several studies have used sea turtles for developing biomonitoring efforts for mercury in coastal areas (e.g., southeastern United States; Day et al. 2005), where subtle negative impacts were measured in health parameters for the loggerhead sea turtle (Day et al. 2007). Mercury has been measured in five of the seven species of sea turtles and those data are contained in the GBMS database (Figure 13).

Areas where sea turtles may need to be monitored for elevated levels of mercury include the Caribbean Sea (especially the Gulf of Honduras), Mediterranean Sea, Arabian Sea, and other constrained marine areas such as bays.

Sea turtles and their eggs may be consumed and their mercury concentrations can have adverse impacts on human and ecological health—in some coastal Pacific communities, researchers have identified potential human health concerns of sea turtle egg consumption because of mercury and other heavy metals (Ross et al. 2016).

Turtle eggs can contain elevated levels of methylmercury and may pose a threat to human health if consumed. While all sea turtle species are protected by various national and international laws, consumption of their eggs remains a common practice in some communities and countries.

Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

A network of biologists, managers, community leaders, and educators in more than 40 Caribbean nations and territories, WIDECAST seeks to bring the best available science to legislation and policy; to education, training and outreach; to conservation and advocacy; and to in situ research and population monitoring for the recovery and sustainable management of depleted sea turtle populations. Mercury biomonitoring can help track the success of environmental mercury reduction as part of the Minamata Convention. For more information, visit: **www.widecast.org**

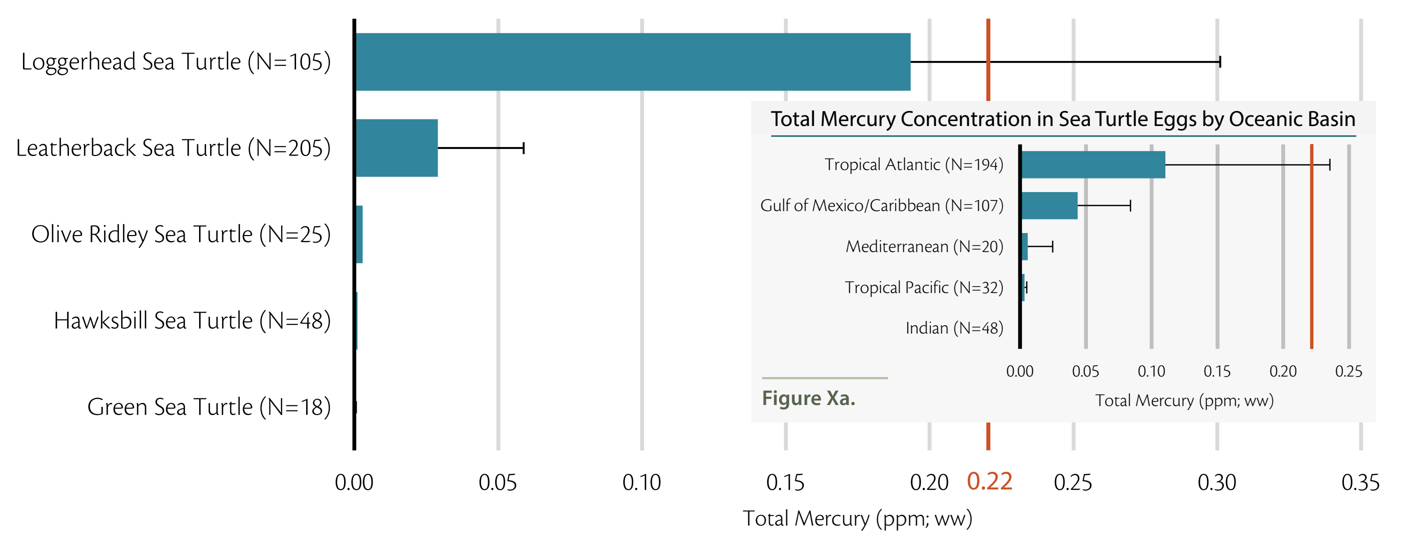


Figure 13. Average (+/– SD; N=sample size) THg in sea turtle eggs by species. Inset graph shows average total mercury concentrations of sea turtle eggs from five major ocean basins. See Table 2 (page 10) for mercury consumption guidelines.

Birds

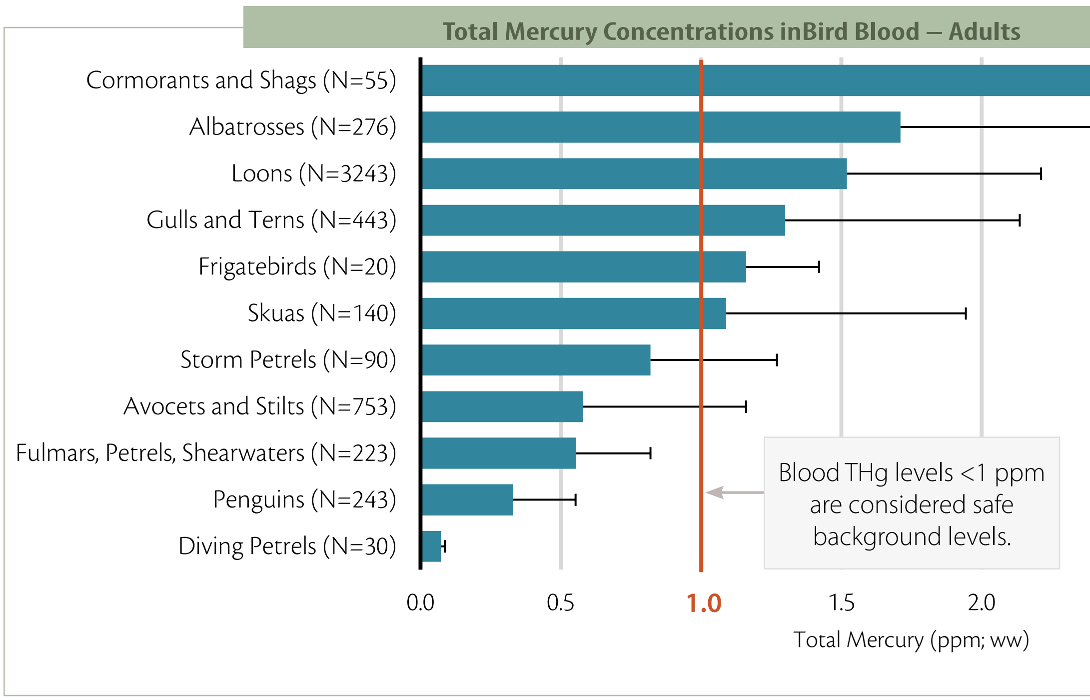
Yellow-billed Loons (*Gavia adamsii*) are long-lived, fish-eating birds that breed on the high tundra and are at high risk to mercury contaminations.

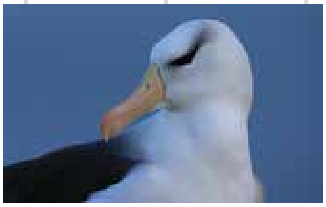
Birds are excellent bioindicators for measuring the availability of methylmercury in aquatic and terrestrial environments. Hundreds of studies from around the world have documented mercury body burdens in birds—using a combination of eggs, blood, and/or feathers. The physiological, behavioral, and reproductive effects of methylmercury on birds viewed through these and other tissues can be confidently identified while using a scalable outcome, such as reproductive success. Mercury concentrations and associated toxicity thresholds vary by species, particularly among foraging guilds (e.g., piscivores versus invertivores).

Piscivores, or fish-eating birds, can regularly have elevated mercury levels from foraging in freshwater, brackish, and marine ecosystems. In the GBMS database there are 46,572 individuals measured for mercury in 45 countries based on 294 peer-reviewed papers (mercury data compilation to date has emphasized piscivores). Bird families with average blood mercury concentrations >1.0 ppm (below of which is relatively safe) include Phalacrocoracidae (cormorants), Diomedeidae (albatrosses), Gaviidae (loons or divers), Laridae (gulls and terns), Fregatidae (frigatebirds), and Stercorarius (skuas; Figure 14).

Across the world's freshwater and brackish ecosystems, gulls and terns are broadly used for determining environment mercury loads. Conversely, other fish-eating birds that have elevated blood mercury levels, such as cormorants, frigatebirds, and skuas, are less likely to be used for biomonitoring purposes. Finally, while the data are not shown, the Osprey, an obligate fish-eating raptor, has a wide distribution and is one of the few species that can be used as a global standard.

The Saltmarsh Sparrow (*Ammodramus caudacutus*), an invertebrate-eating songbird, lives in estuaries along the North Atlantic and often has elevated mercury body burdens. Songbirds are often at higher risk to mercury than associated and larger fish-eating birds because they occupy upper levels in the food web.





The Black-browed Albatross (Thalassarche melanophrys) is a long-lived seabird with elevated mercury.

Figure 14. Average (+/- SD; N=sample size) adult blood mercury concentrations (ppm, ww) for eleven selected bird families.

MERCURY CASE STUDY

Marine Mammals

Bowhead whales (Balaena mysticetus) are regularly harvested by Native peoples in Alaska and Russia for food and contain very low levels of mercury in their bodies.

While tracking seafood mercury concentrations commonly emphasizes shellfish and fish, marine mammals should also be considered for human health assessment purposes. Marine mammals are a traditional component of the diet of many subsistence communities around the world, particularly in the Arctic. Research suggests that mercury emissions originating at lower latitudes are regularly transported to and deposited in the Arctic, and there is now added concern that warmer temperatures may be rapidly remobilizing formerly bound mercury stores from thawing glaciers, sediment, and permafrost (AMAP 2011).

Increased levels of mercury in fish and wildlife within the Arctic may be resulting from increasing mercury inputs as well as changes in the Arctic ecosystems. Based on data from our GBMS database, average marine mammal muscle tissue mercury concentrations are generally above safe consumption levels in all ocean basins. Because human communities within the Arctic Ocean can depend on marine mammals, mercury concentrations in those mammals are of special concern.

Beluga whales, narwhals, and pilot whales are commonly harvested and often have muscle mercury concentrations that exceed human health consumption guidelines of one meal per month (i.e., based on mercury concentrations between 0.22 and 0.95 ppm, ww; Figure 15). The effect thresholds for marine mammals are poorly understood, but based on effect thresholds for terrestrial mammals, mercury exposure could be having significant adverse impacts on the reproductive success of marine mammals.

Mercury in the Global Environment: Marine Mammals

From the Antarctic to the Arctic, marine mammals move across great expanses of water. These animals are adversely affected by mercury pollution accumulating in the world's oceans. This BRI publication helps illustrate the impacts of methylmercury biomagnification (increasing toxicity as the toxin moves up the foodweb) and bio-accumulation on marine mammals, with an emphasis on Arctic ecosystems. To download this and other BRI publications, visit: **www.briloon.org/hgpubs**.

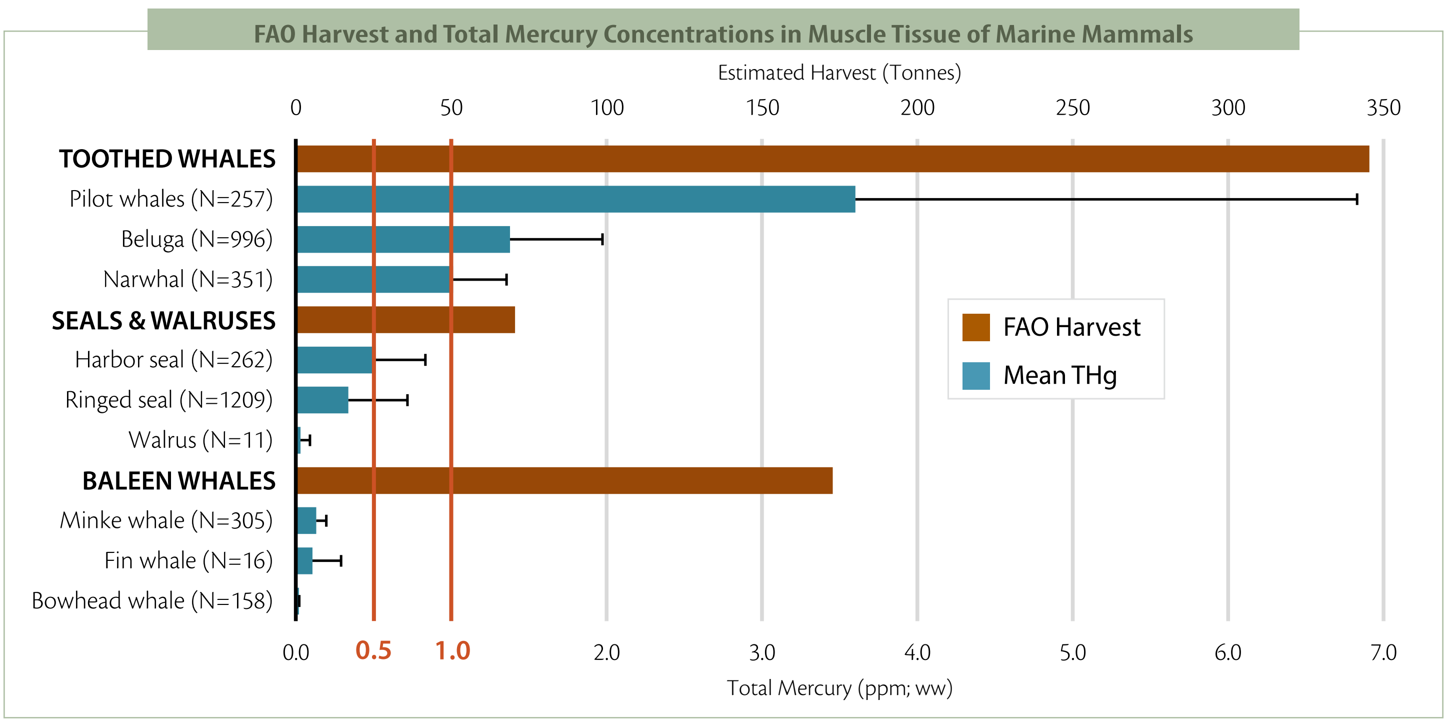


Figure 15. Average (+/– SD; N=sample size) THg concentration in muscle tissue of nine marine mammal species compared to the 2013 FAO harvest estimate in tonnes, divided by sub-order. See Table 2 (page 10) for mercury consumption guidelines.

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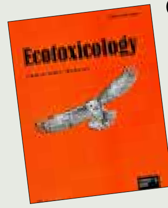
Announcing a Special Issue on Mercury



Global Environmental Mercury Loads in Biota and Impacts on Biodiversity

CALL FOR SUBMISSIONS

We welcome papers that present syntheses of taxa groups of interest, geographic areas, or biomes.

For more information visit: **briwildlife.org/hgcenter**

BRI's Center for Mercury Studies

BRI's mission is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers. BRI staff have worked on the topic of mercury in the environment for the nearly three decades and endeavor to collect original field data, interpret their results in scientific outlets, and relay information to decision makers in an accessible format.

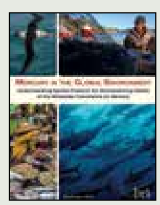
Co-directors

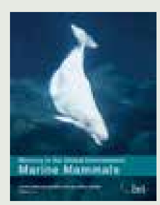
David Evers, Ph.D., *BRI Executive Director, Chief Scientist*

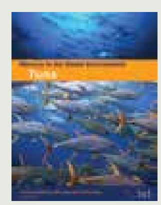
Celia Chen, Ph.D., *Dartmouth College, Director of the Dartmouth Toxic Metals Superfund Research Program.*

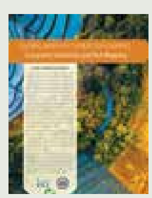
Scientific Communications from BRI

Our report ***Mercury in the Global Environment*** includes data on mercury concentrations from key biota, which are presented and compared geographically and taxonomically through Case Studies. Companion pieces provide greater detail on mercury in Marine Mammals and Tuna.

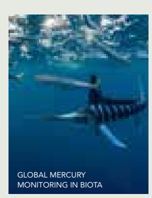








Global Mercury Threat Assessment: Ecosystem and Risk Mapping details a new approach to assessing the potential threat of mercury to biota, biodiversity, ecosystem services, and people. In this publication, we combine maps of ecosystem sensitivity with maps of mercury contamination risk.



Understanding the threat of environmental mercury loads requires biotic monitoring. This report, ***Global Mercury Monitoring in Biota***, presents a dual approach to conduct biotic mercury monitoring across continents and ocean basins using representative bioindicators.

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