TECHNICAL INFORMATION REPORT ON MERCURY MONITORING IN BIOTA

November 2019

Proposed components towards a strategic long-term plan for monitoring mercury in fish and wildlife globally.

Hg

bri
Biodiversity Research Institute

gef

UN environment programme

Disclaimer

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U.S. Acronyms for Mercury Monitoring in Biota

Arctic Monitoring Assessment Programme	AMAP
Artisanal small-scale gold mining	ASGM
Biodiversity Research Institute	BRI
Caribbean Region Mercury Monitoring Network	CRMMN
Coordinated Environmental Monitoring Program	CEMP
Dissolved Organic Carbon	DOC
European Union	EU
Food and Agriculture Organization	FAO
Global Biotic Mercury Synthesis	GBMS
Baltic Marine Environment Protection Commission – Helsinki Commission	HELCOM
Joint Assessment and Monitoring Program	JAMP
Mercury	Hg
Methylmercury	MeHg
Northern Contaminants Program	NCP
Small Island Developing States	SIDS
Total mercury	THg
United Nations Environment Programme	UNEP
United States Environmental Protection Agency	USEPA
World Health Organization	WHO

Executive Summary

Mercury (Hg) is a pollutant of global importance that adversely affects human health and the environment. Environmental concentrations of mercury have increased three-fold globally due to human industrial activities, and the world's freshwater ecosystems, estuaries and oceans are primary reservoirs where mercury is deposited and thereafter methylated.

People are commonly exposed to methylmercury through the consumption of fish, and some birds and marine mammals. However, there are gaps in our understanding about the relationship between anthropogenic releases of mercury and its subsequent bioaccumulation and biomagnification in freshwater and marine food webs, and how that may translate to exposure and risk at the local, regional, and global scale to fish, wildlife, and humans.

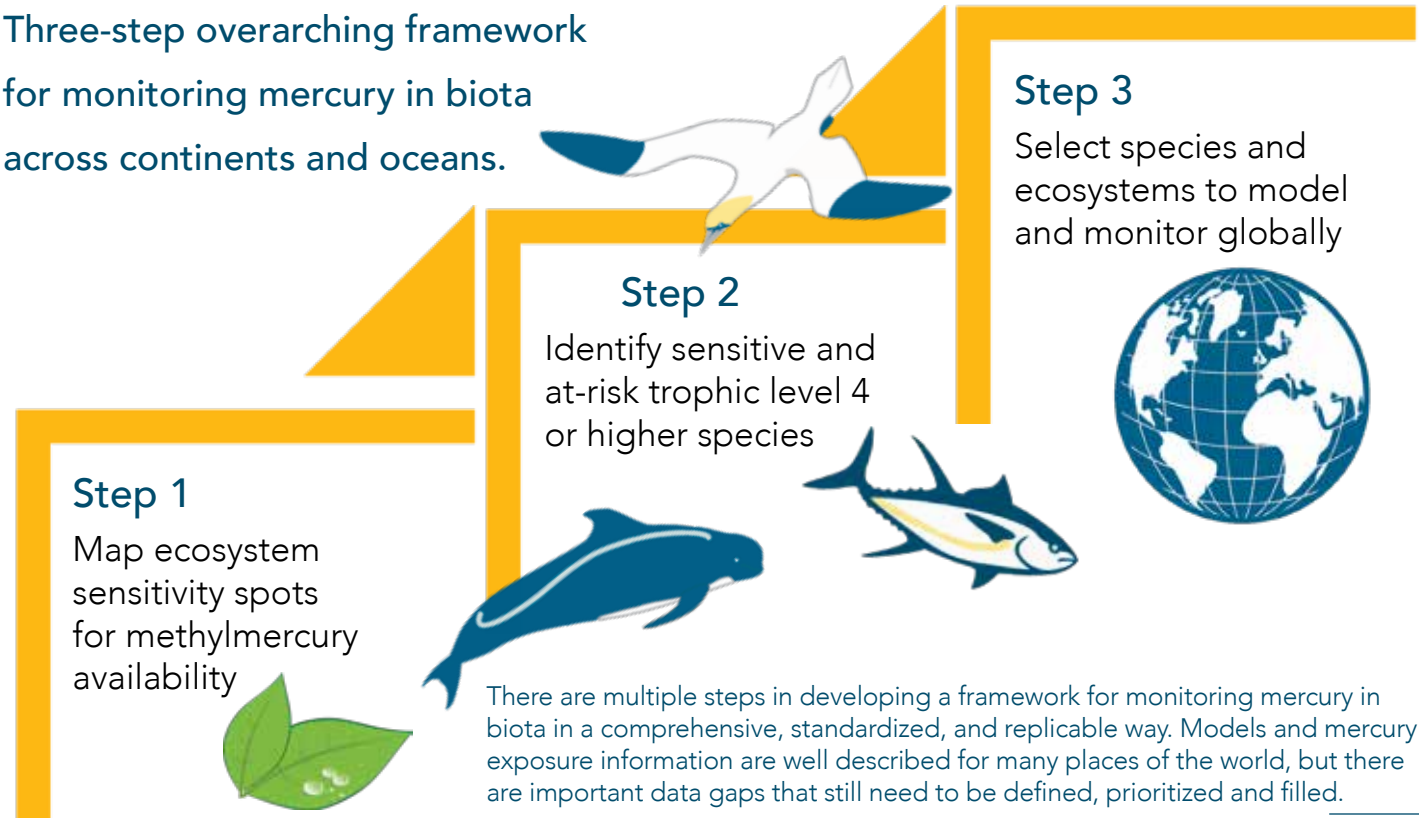
Monitoring mercury in biota (i.e., methylmercury availability) provides a pathway for understanding spatial gradients, temporal trends, and environmental magnitude of concern that cannot be ascertained in air, water, or sediment. Emphasizing upper trophic level biota for monitoring (i.e., trophic level 4 or higher) ultimately provides a confident ability to assess whether the global input of anthropogenic mercury into the environment is safe or harmful to fish, wildlife and humans. Because mercury methylation greatly varies according to many environmental factors, identifying ecosystem sensitivity spots is critical for attaining resource efficiencies (i.e., low cost, high reward information in a timely way).

Our knowledge of mercury in biota is well known in the Northern Hemisphere as well as some ocean basins, however, large gaps remain in other geographic areas. To best track global and regional biotic mercury exposure over time and space, we need to synthesize existing information with new data in a structured and strategic way. Global models will be critical for understanding current needs and prioritizing future patterns.

The elements for a dual approach proposed herein is to conduct biotic mercury monitoring across continents and oceans basins using representative bioindicators that can confidently provide information for decision makers to assess the effectiveness of the Minamata Convention on Mercury at both regional and global spatial levels at temporal scales of interest.

Cost effective, standardized, and replicable monitoring of mercury in biota can be reliably conducted. Examples of existing networks and recent projects are given. This plan will provide the information needed for decision makers to protect human health and the environment.

Three-step overarching framework for monitoring mercury in biota across continents and oceans.



There are multiple steps in developing a framework for monitoring mercury in biota in a comprehensive, standardized, and replicable way. Models and mercury exposure information are well described for many places of the world, but there are important data gaps that still need to be defined, prioritized and filled.

1.0 Introduction: Why is it important to monitor mercury in biota?

Inorganic mercury enters ecosystems through the air (e.g., from coal-fired power plants and incinerators), water (e.g., from chlor-alkali facilities and artisanal small-scale gold mining), and land (e.g., from landfills and other contaminated sites; Kocman et al. 2017, Streets et al. 2017, Hsu-Kim et al. 2018, Martinez et al. 2018, Obrist et al. 2018, Mason et al 2019). Once in the environment, mercury can be converted to methylmercury by bacteria and other microbes (Gilmour et al. 2013, Yu et al. 2013).

Methylmercury is toxic, and can accumulate in the tissues of fish, wildlife and humans, causing numerous negative health effects (Basu et al. 2018, Evers 2018, Buck et al. 2019). The extent to which mercury is methylated and made available in the environment is complex and can be influenced by many factors.

Specific ecological conditions can facilitate the production and bioavailability of methylmercury. For example, bacteria often produce more methylmercury under moderate amounts of sulphate and low oxygen conditions (Gilmour et al. 1998, Hsu-Kim et al. 2013); these conditions are especially prevalent in wetland ecosystems (Branfireun et al. 1996).

Furthermore, areas with certain types of dissolved organic carbon (DOC) from decaying terrestrial organic matter may generate and transport methylmercury more readily than areas that are low in DOC (Schartup et al. 2015). Freshwater ecosystems that are acidified due to deposition of sulfur oxides from sources such as fossil fuel combustion may be important environments that methylate more mercury that others (Branfireun et al. 1999, Driscoll et al. 2007, Wyn et al. 2009).

In areas where wet and/or dry mercury deposition is relatively low or moderate, effects on biota may be disproportionately high if conditions promote methylmercury production. Conversely, ecosystems with low methylation potential may have low levels of methylmercury despite heavy anthropogenic mercury contamination.

The decoupling of inorganic mercury sources with methylmercury production and bioavailability is evident at local (Evers et al. 2007) and landscape levels (Eagles-Smith et al. 2016).

The complexity of mercury cycling makes it challenging to predict exposure levels in upper trophic level fish and wildlife from environmental mercury concentrations alone (Gustin et al. 2016, Sunderland et al. 2016). Therefore, identifying appropriate bioindicators based on their relationship with sensitive ecosystems is a critical first step in assessing risk to ecological and human health in response to the responsibilities of monitoring mercury under the Minamata Convention (Figure 1).

Freshwater wetlands in Northern Hemisphere biomes are good examples of areas with higher mercury methylation