APPLICATIONS OF THE GLOBAL BIOTIC MERCURY SYNTHESIS (GBMS)

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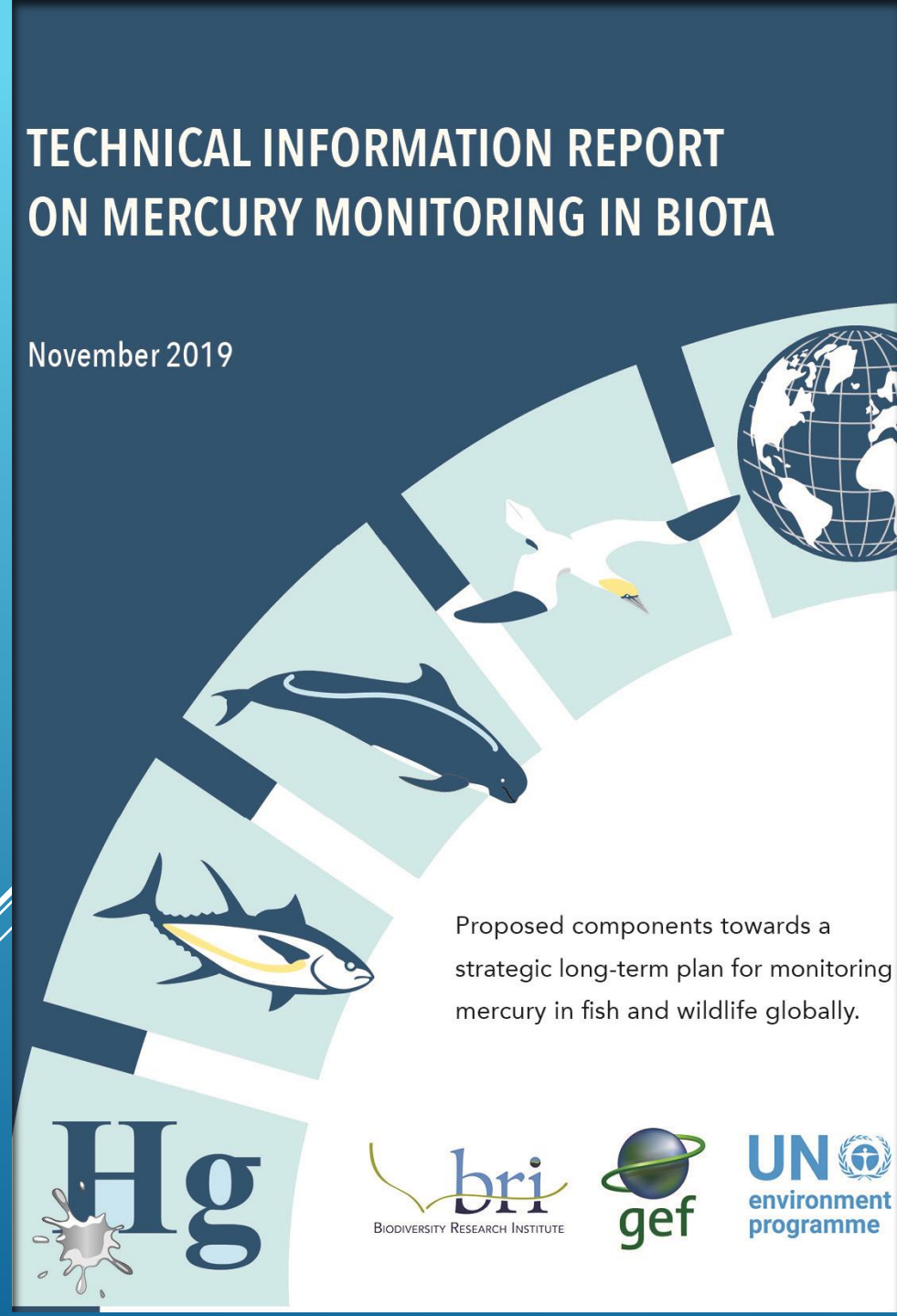


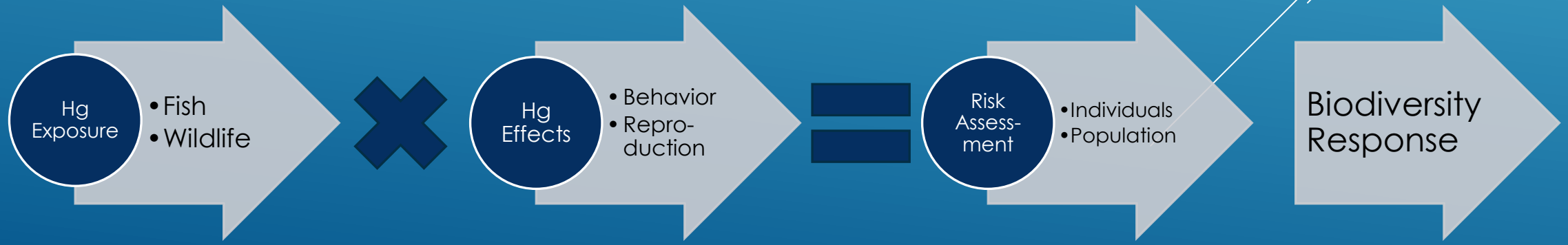
https://www.unenvironment.org/resources/report/technical-information-mercury-monitoring-biota

THE GBMS DATABASE –WHERE WE STAND TODAY

- **Only includes biota – with an emphasis on taxa of relevance to the Minamata Convention (Article 19)**
  - ✓ **Fish**
  - ✓ **Sea Turtles**
  - ✓ **Birds**
  - ✓ **Marine Mammals**
- **Based on existing, peer-reviewed published data**
- **Preferred tissue types are those regularly used for monitoring**
- **Biotic Hg dataset is comprehensive (but not yet complete)**

THE GBMS DATABASE – CONT'D WHERE WE STAND TODAY

- **Mercury concentrations in fish and wildlife are broadly known across all continents, major water bodies, and all oceans basins**
  - **Over million Hg numbers collected to date for >1,000 species representing >3,000 locations**
- **Effects thresholds for relevant outcomes are well known for fish, birds and mammals**
  - **And, they differ by taxonomic group and foraging guild**
- **When assessing both exposure concentrations and effects thresholds it is critical to assess biological Hg hotspots and contaminated sites**
  - **Needs to be in context of protected areas**



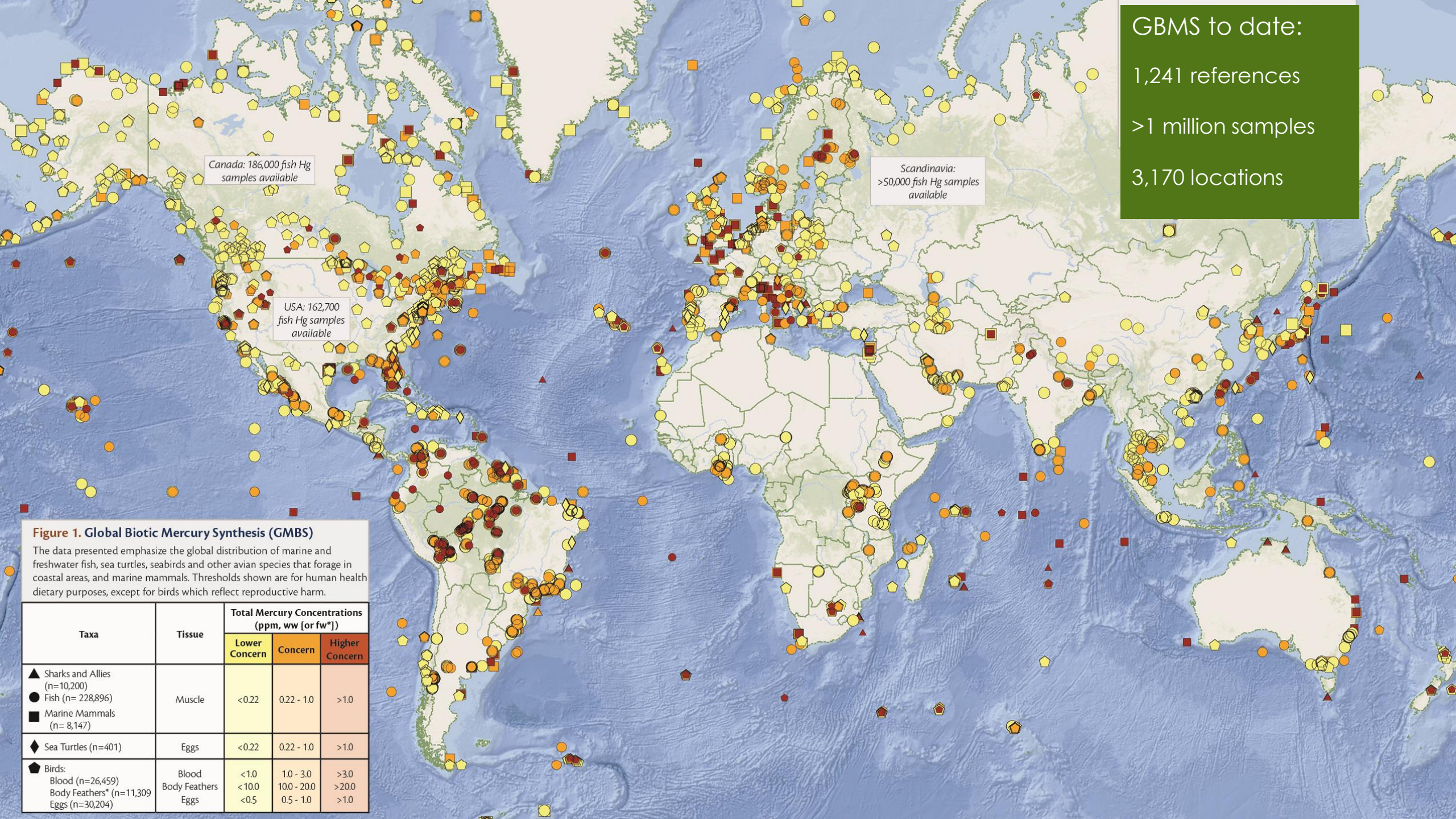
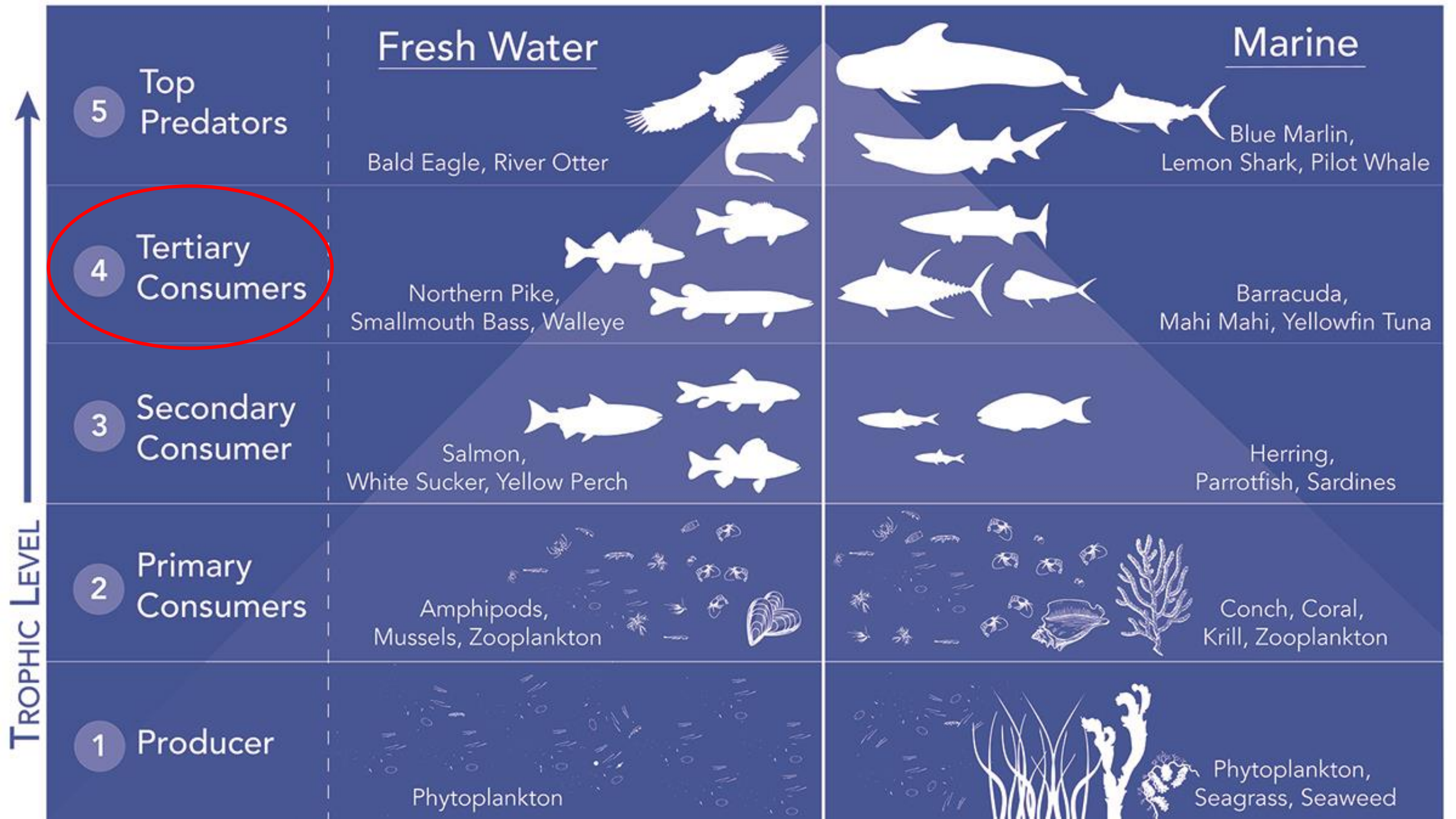


Figure 1. Global Biotic Mercury Synthesis (GMBS)

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


Trophic Level
Fresh Water
Marine
5
Top Predators
Bald Eagle, River Otter
Blue Marlin, Lemon Shark, Pilot Whale
4
Tertiary Consumers
Northern Pike, Smallmouth Bass, Walleye
Barracuda, Mahi Mahi, Yellowfin Tuna
3
Secondary Consumer
Salmon, White Sucker, Yellow Perch
Herring, Parrotfish, Sardines
2
Primary Consumers
Amphipods, Mussels, Zooplankton
Conch, Coral, Krill, Zooplankton
1
Producer
Phytoplankton
Phytoplankton, Seagrass, Seaweed

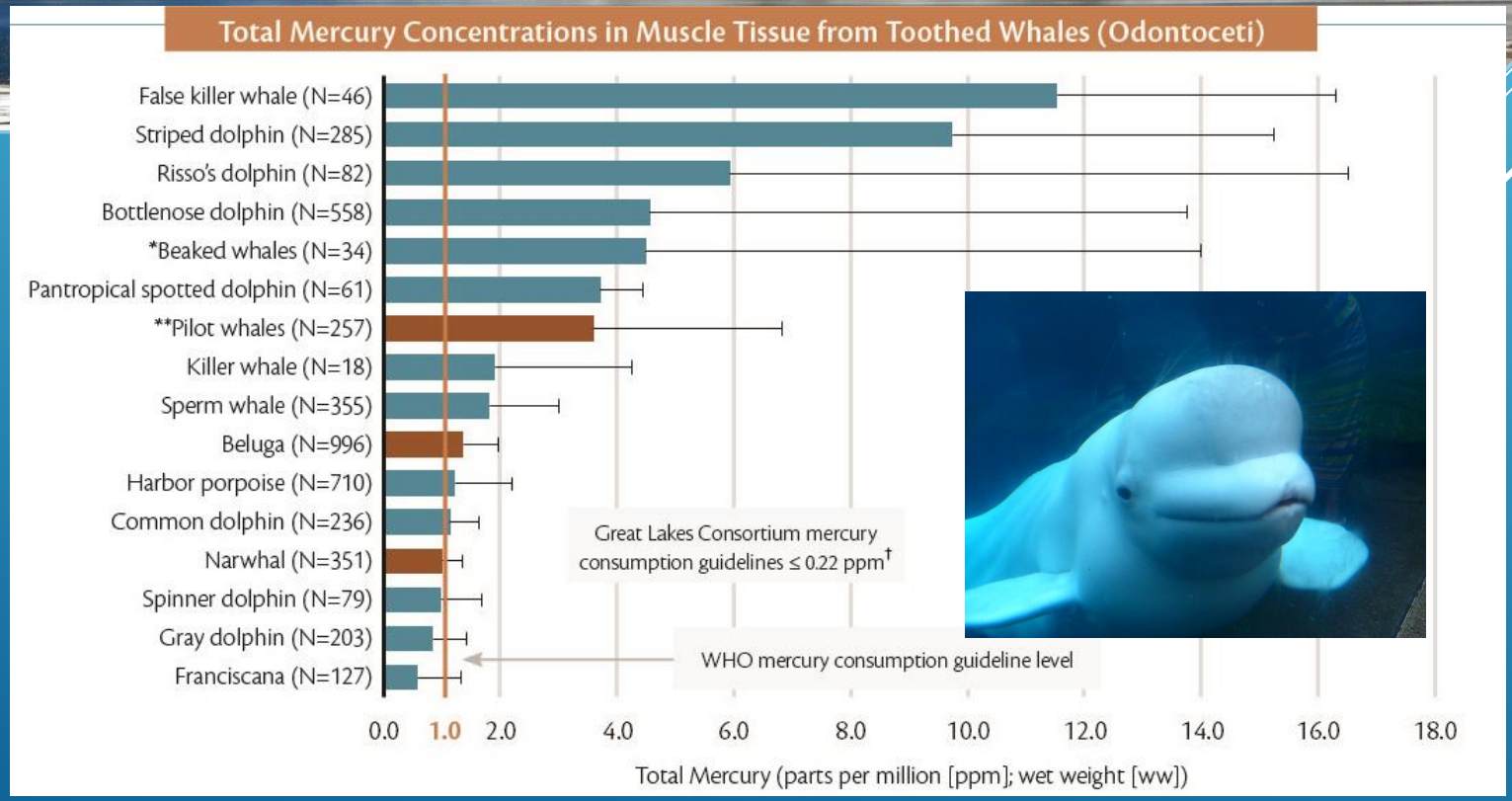
A provisional slate of some potential bioindicators for evaluating and monitoring environmental Hg loads (Evers et al. 2016 Sci. Total Environ. 569-570:888-903.)

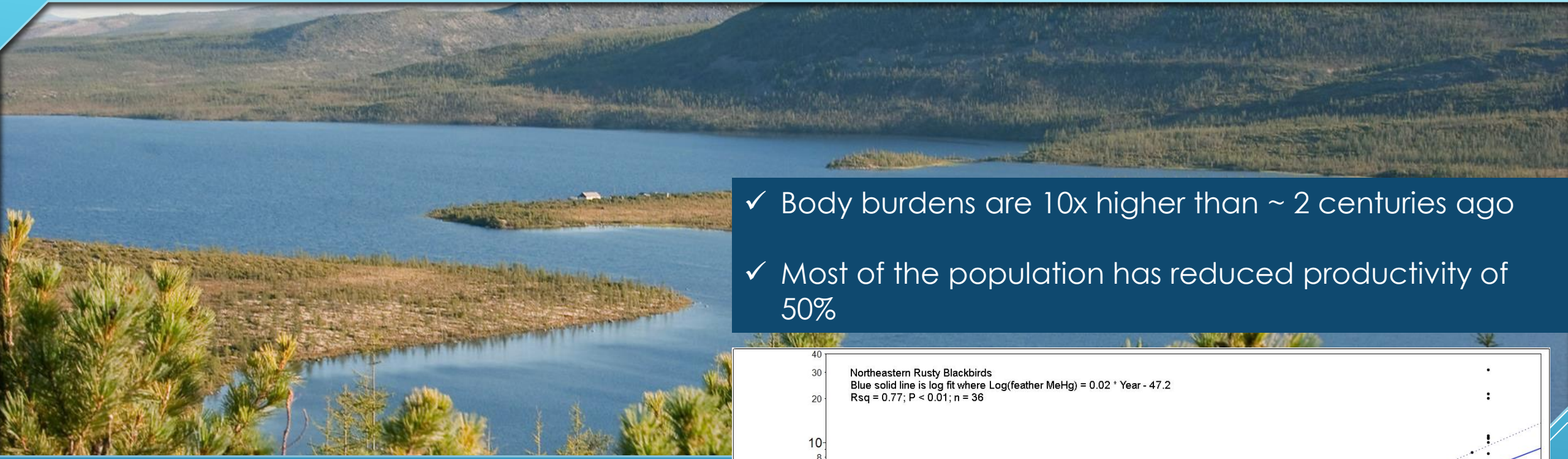
Target Terrestrial Biomes	Associated Aquatic Ecosystems	Ecological Health Bioindicators				Human and Ecological Health Bioindicators		
		Freshwater and Marine Fish	Freshwater Birds	Marine Birds	Marine Mammals & Sea Turtles	Freshwater Fish	Marine Fish	Marine Mammals
Arctic Tundra	**Arctic Ocean and associated estuaries, lakes, rivers**	Sticklebacks[1] (freshwater); Arctic Cod[2] Sculpin[3] (marine)	Loons[4,5]	Fulmars[6] Murres[6]	Polar Bears[7] Seals[8]	Arctic Char[9] Arctic Grayling[10]	Halibut[11] Cod[11]	Beluga[12, 2] Narwhal[12, 2]
Boreal Forest and Taiga	**North Pacific and Atlantic Oceans and associated estuaries, lakes, rivers**	Perch[13] (freshwater); Mummichogs[14] (marine)	Loons[15] Eagles[16] Osprey[17] Songbirds[18] (Warblers, Flycatchers, Blackbirds)	Osprey[19] Petrels[20]	Mink[21,22] Otter[21,22] Seals[23]	Catfish[11] Pike[10] Sauger[10] Walleye[10]	Flounder[11] Snapper[11] Tuna[11]	Pilot Whale[24]
Temperate Broadleaf and Mixed Forest	**North Pacific and Atlantic Oceans, Mediterranean and Caribbean Seas, and associated estuaries, lakes rivers**	Perch[13] (freshwater); Mummichogs[14] Rockfish[11] Sticklebacks[25] (marine)	Loons[4] Grebes[5,26] Egrets[27] Herons[27] Osprey[17] Terns[26] Songbirds[18] (Warblers, Wrens Flycatchers, Blackbirds, Sparrows)	Cormorants[28] Osprey[5,19] Terns[26,28]	Otter[21,22] Sea Turtles[29] Seals[23]	Bass[10,30,31] Bream[11] Mullet[11] Walleye[31]	Barracuda[11] Mackerel[11] Mullet[11] Scabbard-fish[11] Sharks[11,32] Tuna[11,32]	
Tropical Rainforest	**South Pacific and South Atlantic and Indian Oceans and associated estuaries, lakes, rivers**	Catfish[23] Piranha[34] Snook[11] (freshwater); Bay Snook[11,34] (marine)	Egrets[27] Herons[27] Kingfishers[35] Songbirds[36] (Wrens, Thrushes, Flycatchers)	Albatrosses[37,38] Noddy[39] Shearwaters[39] Terns[39] Tropicbirds[39]	Otter[40] Sea Turtles[29] Seals[41]	Catfish[11] Snakehead[11]	Barracuda[11] Grouper[42] Sharks[43,44] Snapper[11] Swordfish[11,45] Tuna[11,45]	

- ✓ Body burdens exceed thresholds for 13 of 16 toothed whales
- ✓ Some species average 10x above thresholds

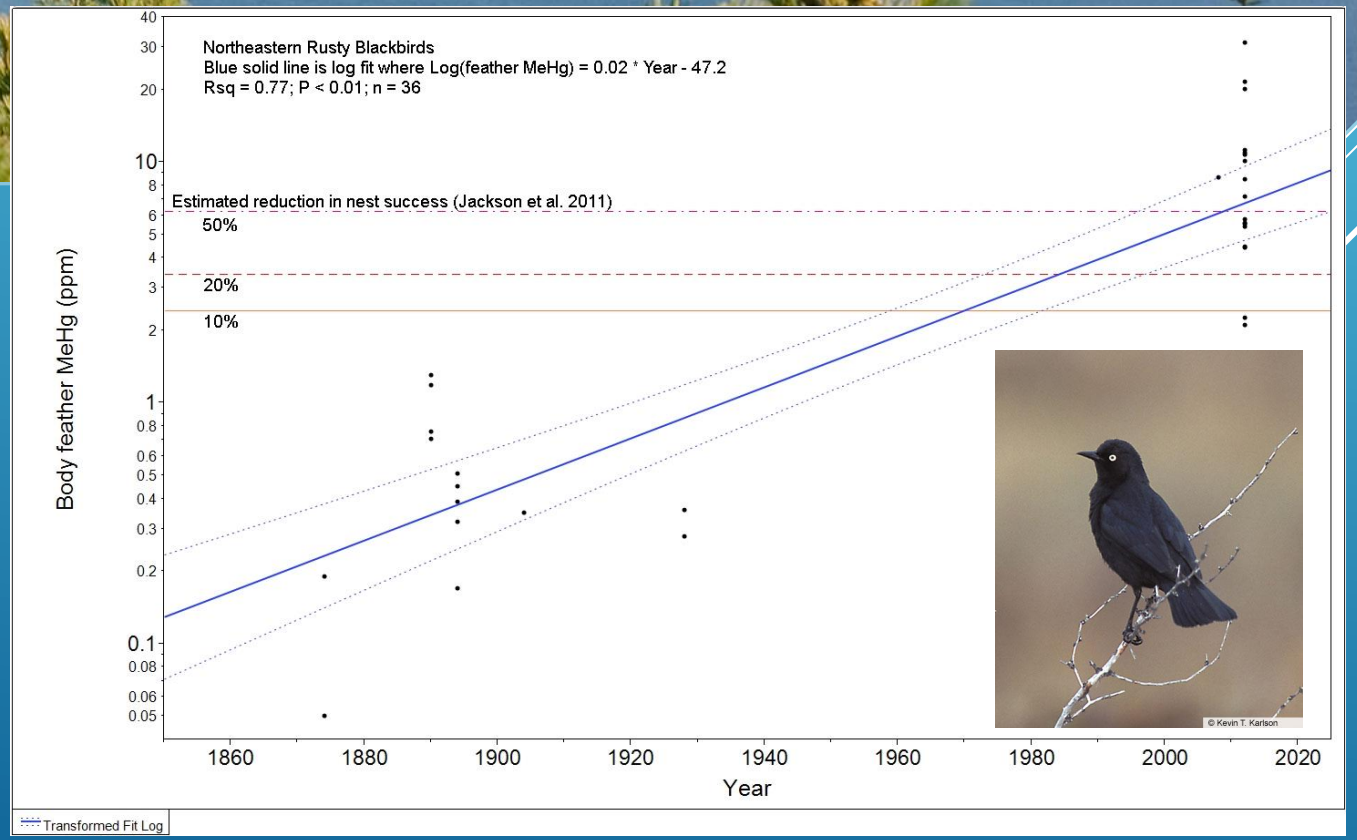
ARCTIC TUNDRA AND ARCTIC OCEAN BIOME

- ARCTIC CHAR, YELLOW-BILLED LOONS AND IVORY GULL, BELUGA WHALES AND NARWALS



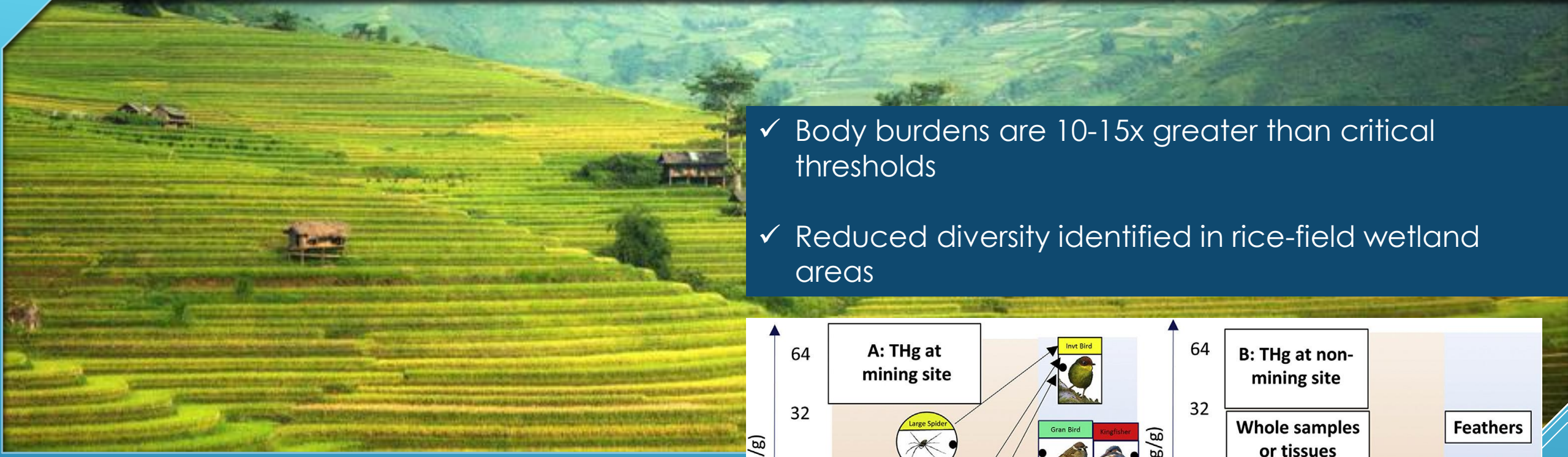


- ✓ Body burdens are 10x higher than ~ 2 centuries ago
- ✓ Most of the population has reduced productivity of 50%



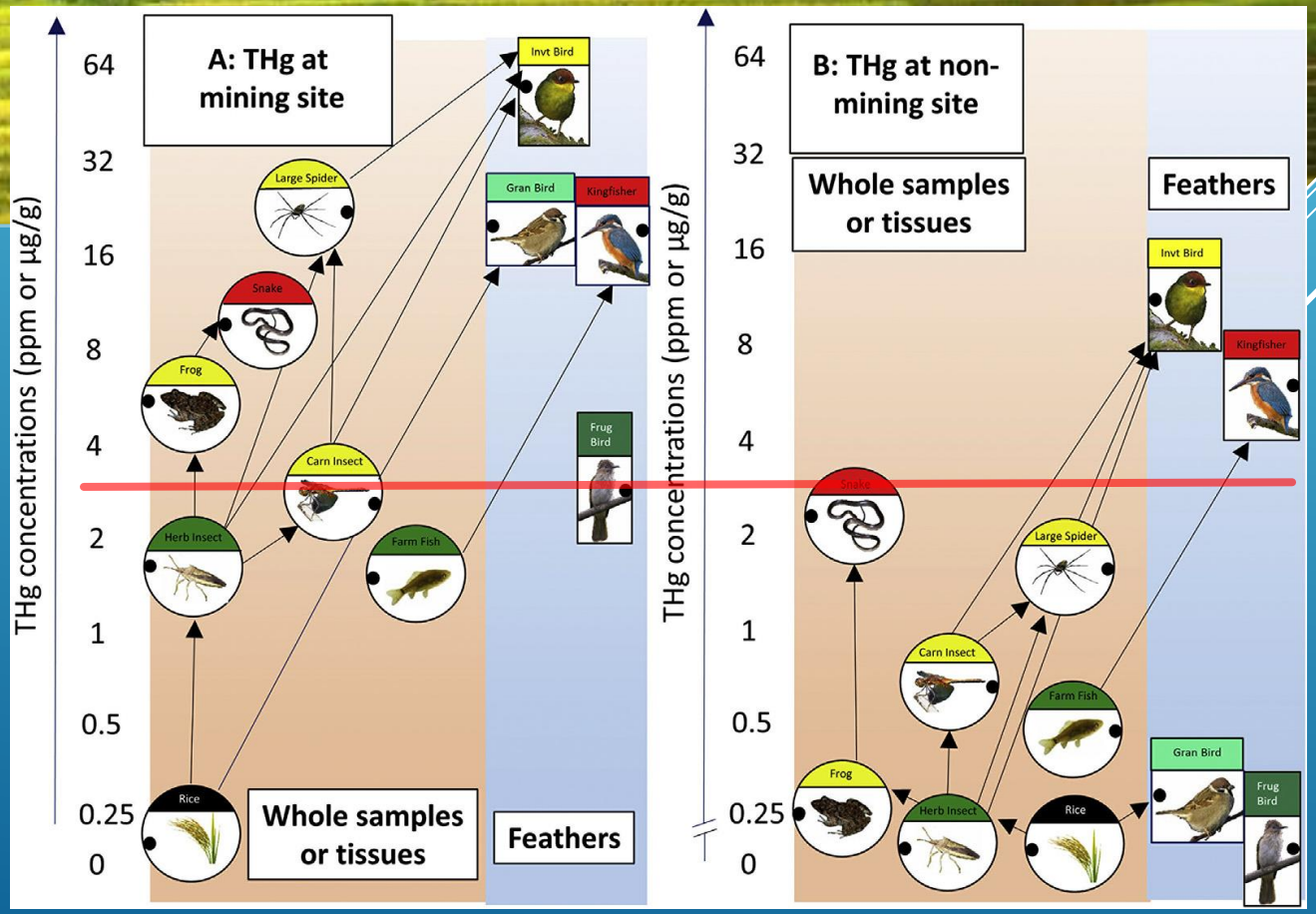
BOREAL FOREST AND TAIGA AND NORTH ATLANTIC/PACIFIC BIOME

— PILOT WHALE, COMMON LOON, RUSTY BLACKBIRD, NORTHERN PIKE

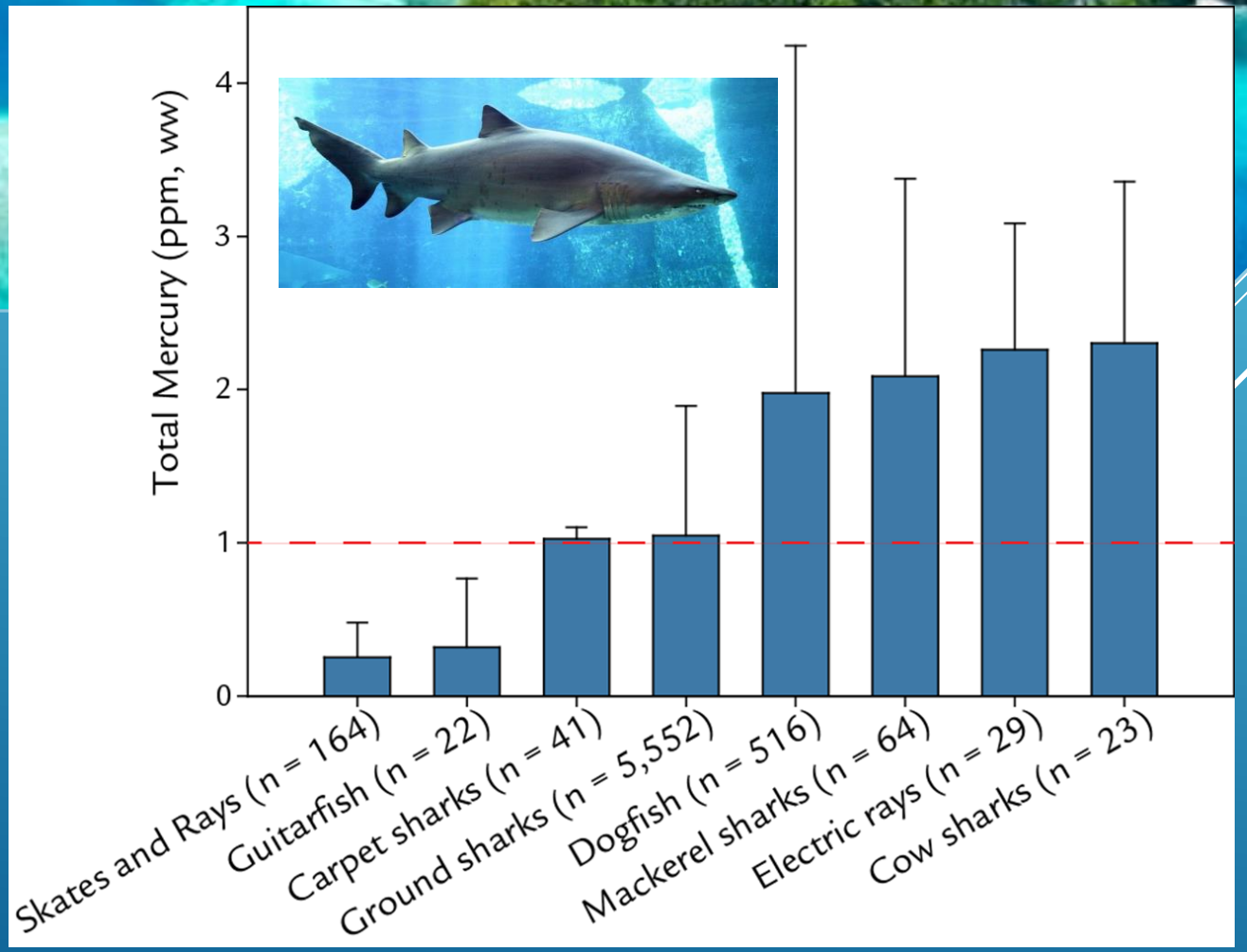


- ✓ Body burdens are 10-15x greater than critical thresholds
- ✓ Reduced diversity identified in rice-field wetland areas

TEMPERATE BROADLEAF AND CENTRAL OCEAN BASINS BIOME – LEMON SHARK, BARRACUDA, OSPREY, SALTMARSH SPARROW



- ✓ Body burdens average higher than threshold levels for 6 shark families
- ✓ Effects from mercury are still relatively unknown



TROPICAL RAINFOREST/ SOUTH PACIFIC-ATLANTIC BIOME – TIGER SHARK, GOLIATH GROUPER, RINGED KINGFISHER, WANDERING ALBATROSS

PROPOSED 3-STEP OVERARCHING FRAMEWORK FOR MONITORING MERCURY IN BIOTA ACROSS CONTINENTS

Step 1

a. Map ecosystem sensitivity spots based primarily on wetland GIS layers at the continental level

b. Identify Ramsar Convention wetland areas

Step 2

a. Identify overlap with artisinal small-scale gold mining (ASGM) areas

b. Identify overlap with areas important for aquatic-based animal foods (e.g., fishing)

c. Identify greatest overlap with IUCN red listed species

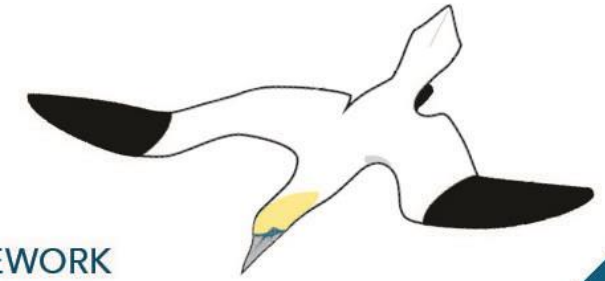
Step 3

a. Select focal 5-10 ecosystem sensitivity spots that have the most overlap with ASGM areas, important fishing areas, and IUCN red listed species per continent

b. Use trophic level 4 or higher bioindicators

Evers, D.C. and E. Sunderland. 2019. Technical Information Report on Mercury Monitoring in Biota: Proposed components towards a strategic long-term plan for monitoring mercury in fish and wildlife globally. UN Environment Programme, Chemicals and Health Branch, Geneva, Switzerland. 40 pp.

PROPOSED 3-STEP OVERARCHING FRAMEWORK FOR MONITORING MERCURY IN BIOTA ACROSS **OCEANS**



Step 1

a. Identify distinctions among ocean basins of interest

b. Collect FAO commercial fisheries data

Step 2

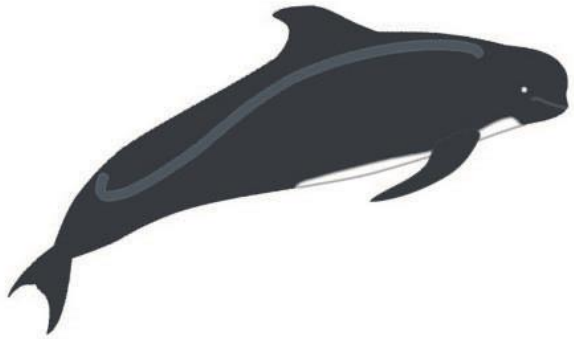
a. Identify tuna and billfish trophic level 4 or higher species of greatest commercial and recreational concern by ocean basin

b. Identify tuna, billfish and other species that reflect temporal trends and spatial gradients

Step 3

a. Select focal trophic level 4 or higher species per ocean basin

b. Conduct a power analyses based on the species/ groups selected and their known mercury concentrations within that ocean basin to determine sample size



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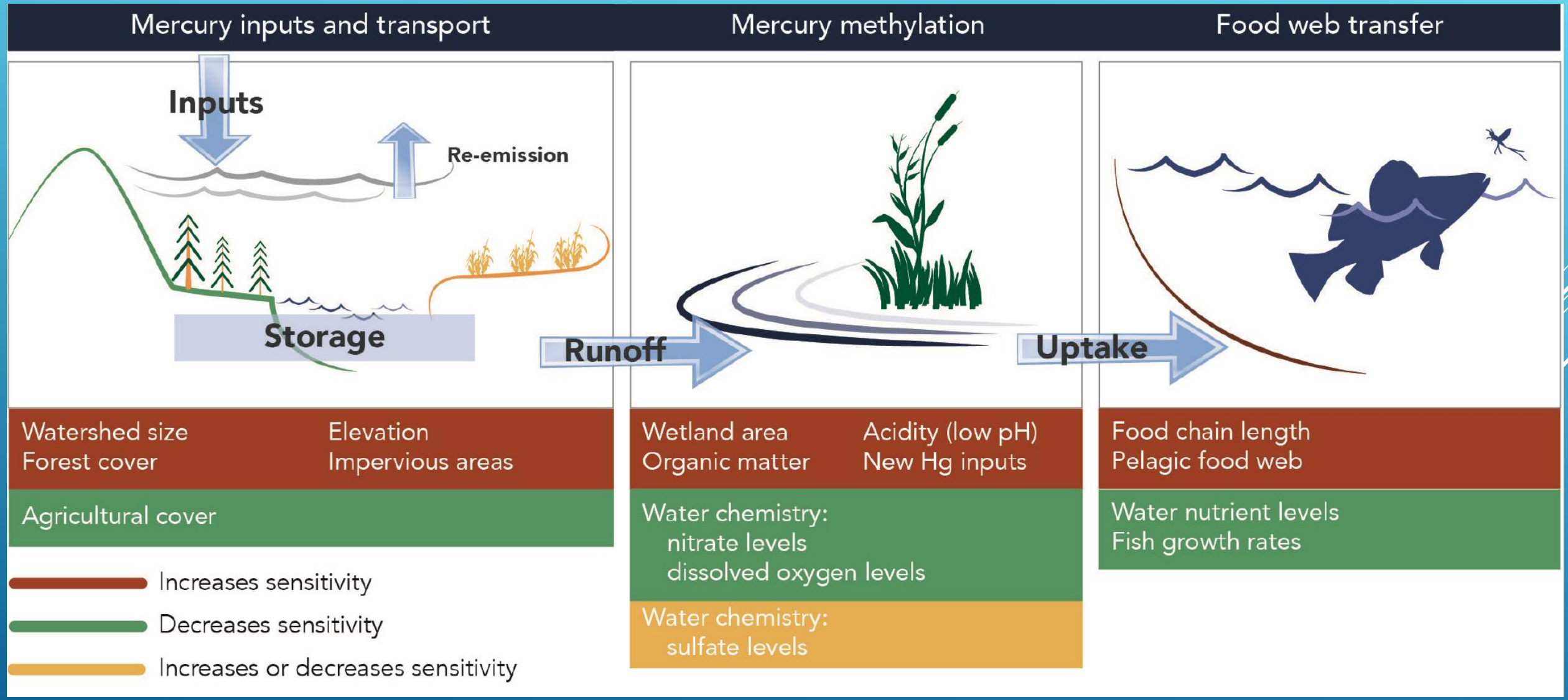
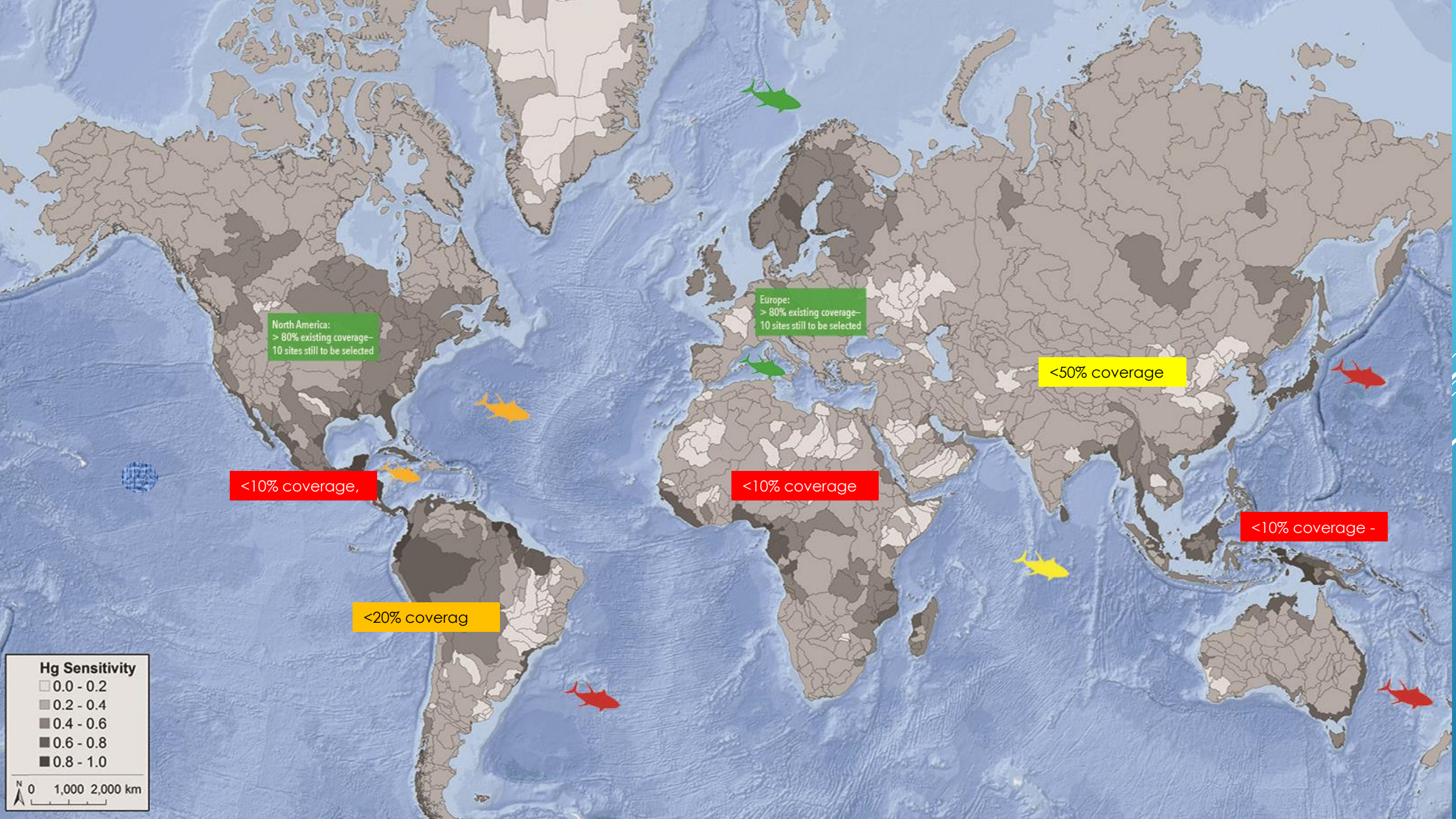
Ecosystem Sensitivity (i.e., biological Hg hotspots) variables of importance




North America:
> 80% existing coverage--
10 sites still to be selected
Europe:
> 80% existing coverage--
10 sites still to be selected
<50% coverage
<10% coverage,
<10% coverage
<10% coverage -
<20% coverag
Hg Sensitivity
0.0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
N
0
1,000
2,000 km