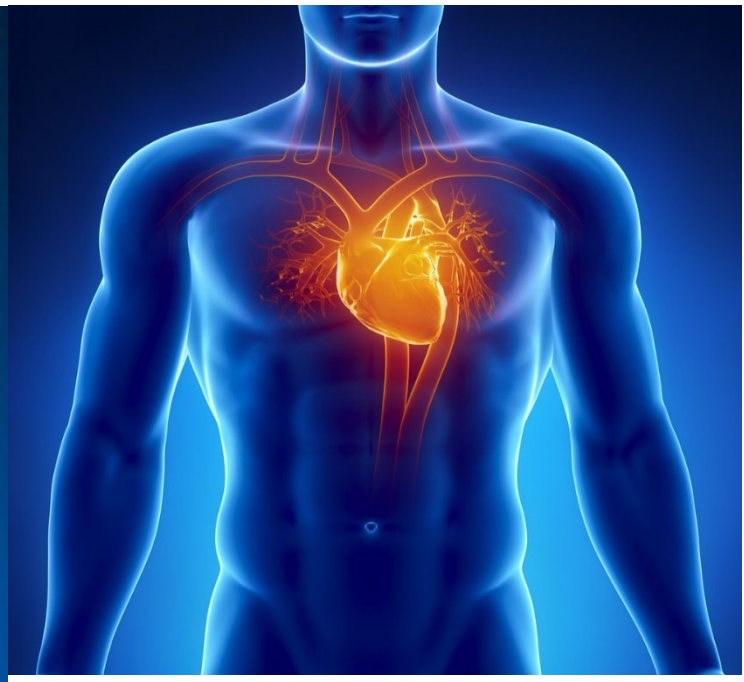
Interactions of Selenium with Environmental Contaminants in Fish and Seafood



Nicholas Ralston

Earth System Science & Policy

University of North Dakota

COMMON, BUT MISTAKEN IDEAS YOU MAY HAVE

Selenium is not essential for survival.

The brain doesn't need selenoenzymes to function.

Mercury only harms those with low selenium intakes.

Selenoenzyme activities in rats are different from in humans.

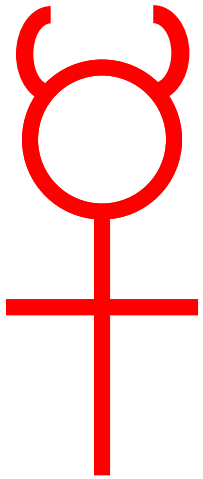
Inorganic selenium does not reflect activities of organic forms.

Selenium binds mercury and thus prevents it from causing harm.

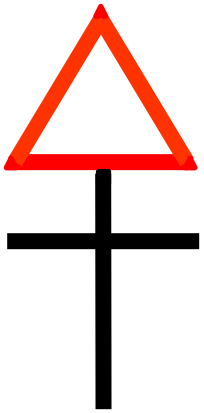
Mercury causes oxidative damage through Fenton-type reactions.

Selenoenzymes only counteract oxidative damage caused by mercury.

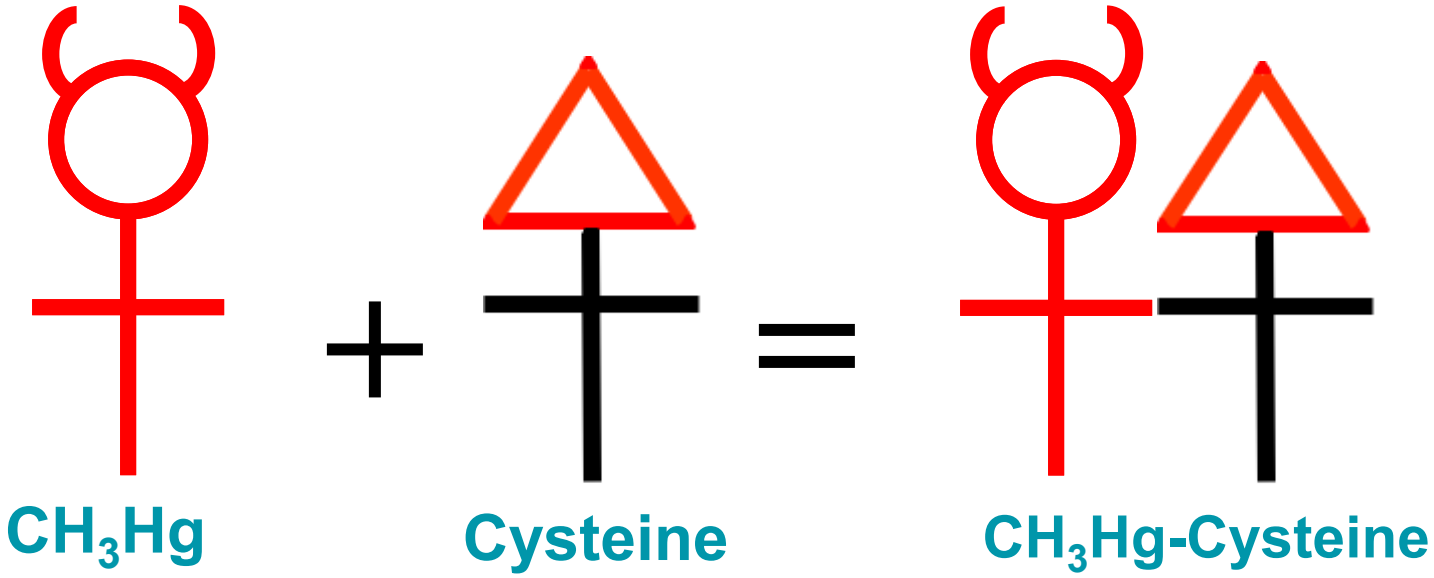
MERCURY



SULFUR



MERCURY BINDING WITH SULFUR



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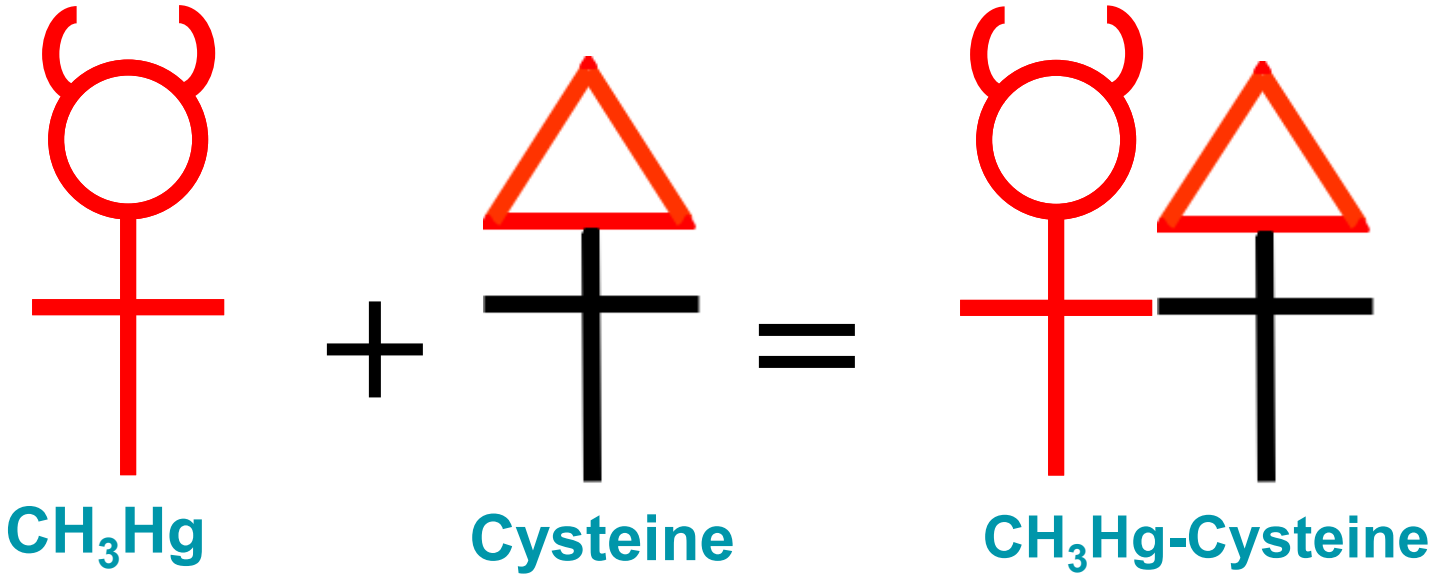
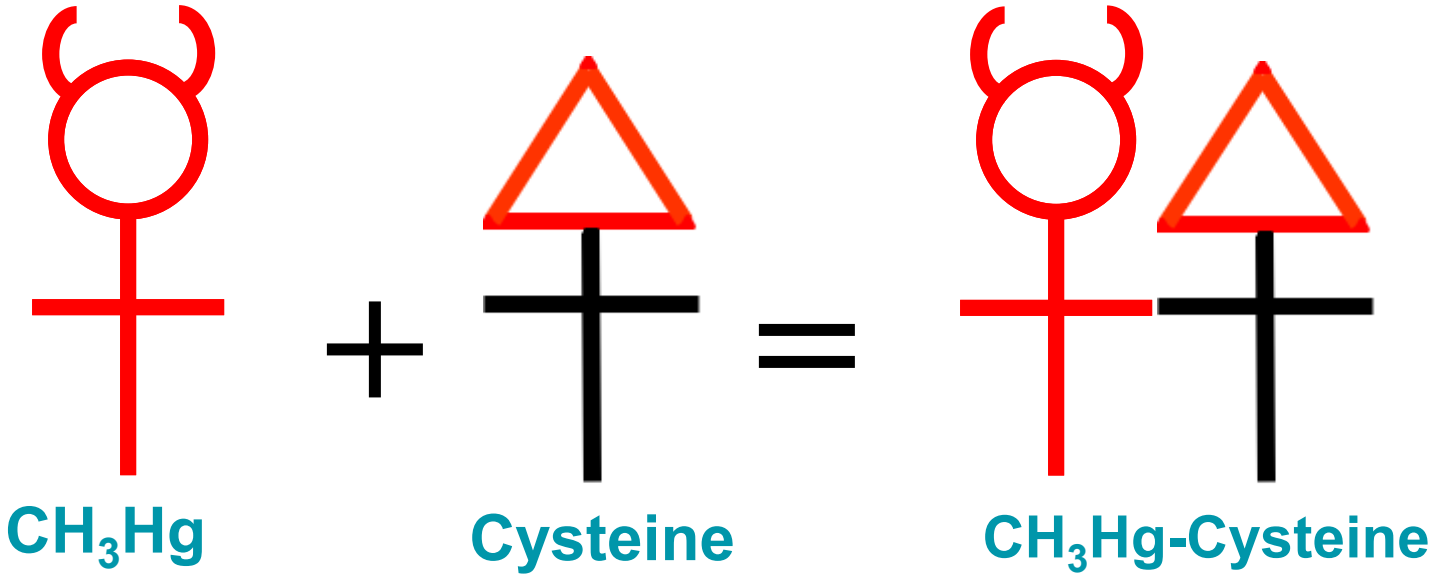


Intracellular thiols are ~300,000 μM, but methylmercury is toxic at 1 μM and severely toxic at 2.5 μM.

MERCURY BINDING WITH SULFUR



Intracellular thiols are ~300,000 μM, but methylmercury is toxic at 1 μM and severely toxic at 2.5 μM. This confused toxicologists.

MERCURY EXPOSURE EFFECTS ON CHILD HEALTH

CONVENTIONAL HYPOTHESIS: Maternal mercury exposures from eating seafood during pregnancy harms the health of children

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United Kingdom	IQ benefits		√	√
United States	IQ benefits		√	√
Spain	IQ benefits		√	√

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Spain	IQ benefits		√	√

These and many more recent epidemiological studies indicate mothers should eat more fish during pregnancy to improve their health and that of their children.

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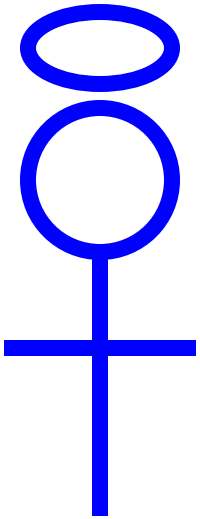
Spain	IQ benefits		√	√

The Conventional Hypothesis has been conclusively disproven.
This does not necessarily mean it is wrong. It may simply be incomplete.

SELENIUM



Selenium is required to make selenocysteine (Sec), the 21st genetically encoded amino acid. Humans express 25 genes that incorporate Sec.

SELENIUM PHYSIOLOGY

- Selenoenzymes are expressed in tissue specific distributions in all cells of all vertebrates.

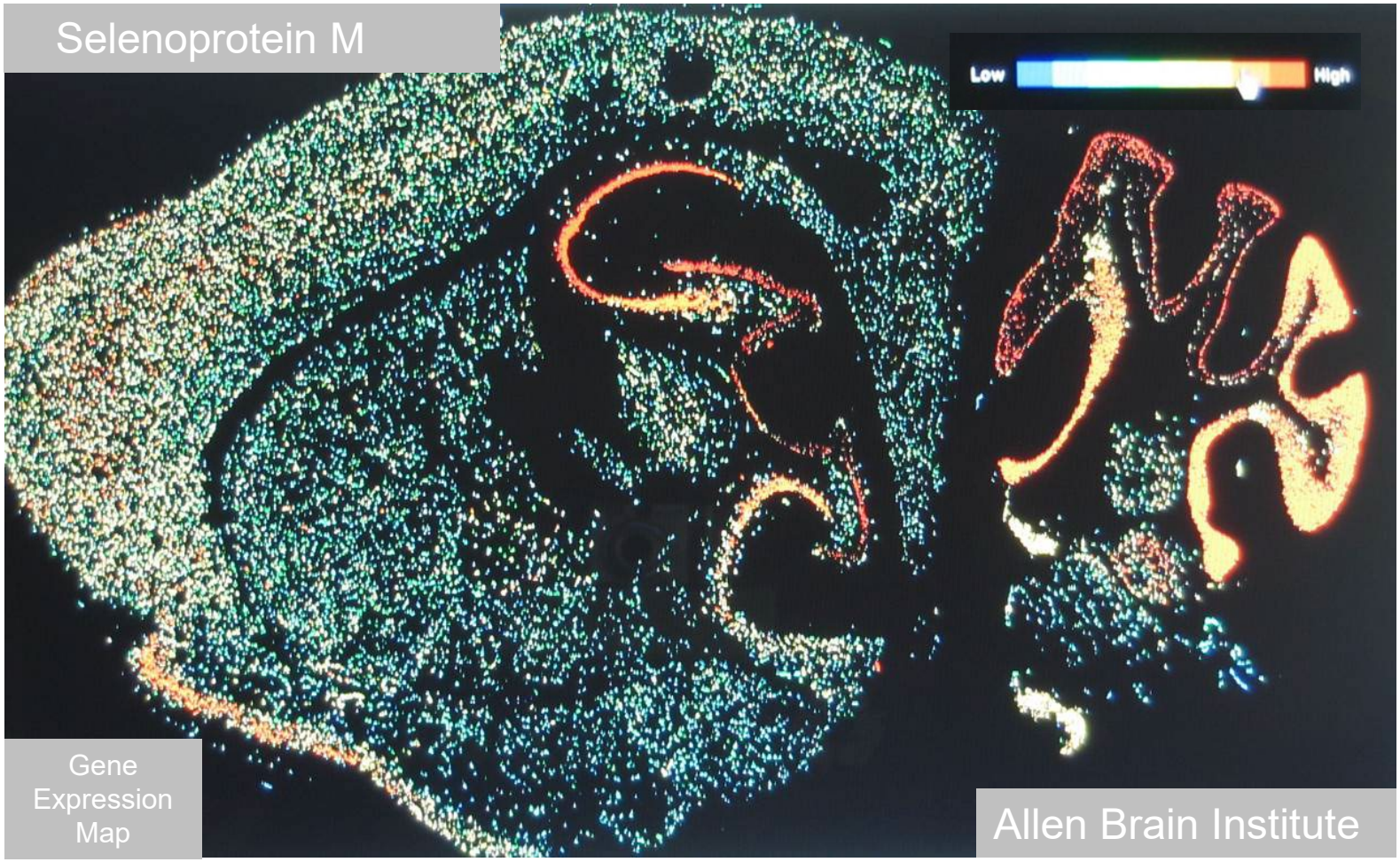
- Many selenoenzymes prevent and reverse oxidative damage to lipids and proteins. Still others participate in controlling calcium, thyroid hormone and other physiological functions.

- Selenoenzymes restore antioxidants such as vitamin C, thioredoxin, and glutathione to their functionally active forms.

- Selenoenzymes are particularly important in brain and other tissues with high lipid contents and high metabolic activities.

SELENOPROTEIN W mRNA IN BRAIN TISSUES

SELENOPROTEIN M mRNA IN BRAIN TISSUES



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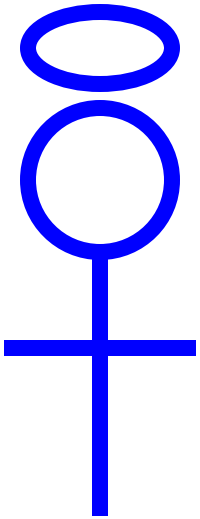
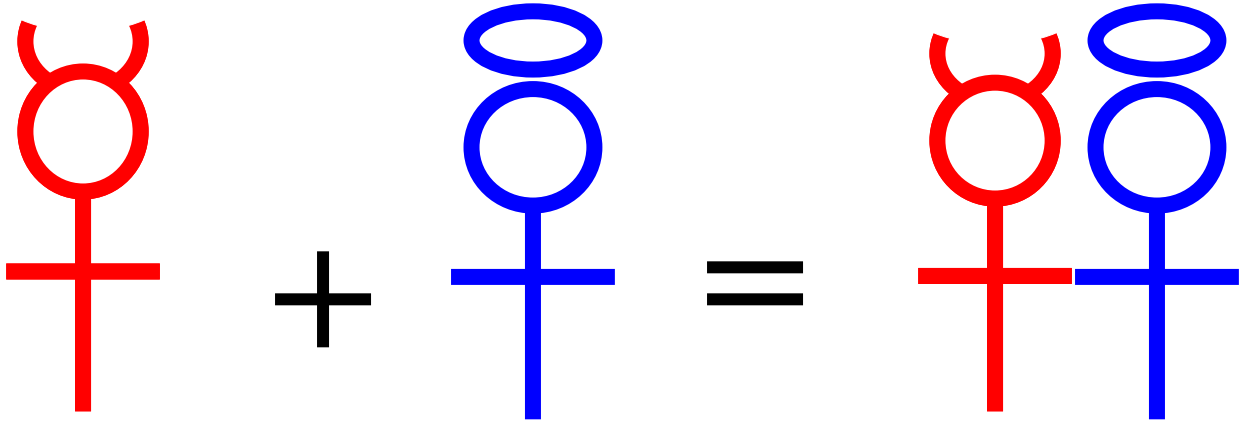


The average concentration of selenium in the body is ~1 μM.

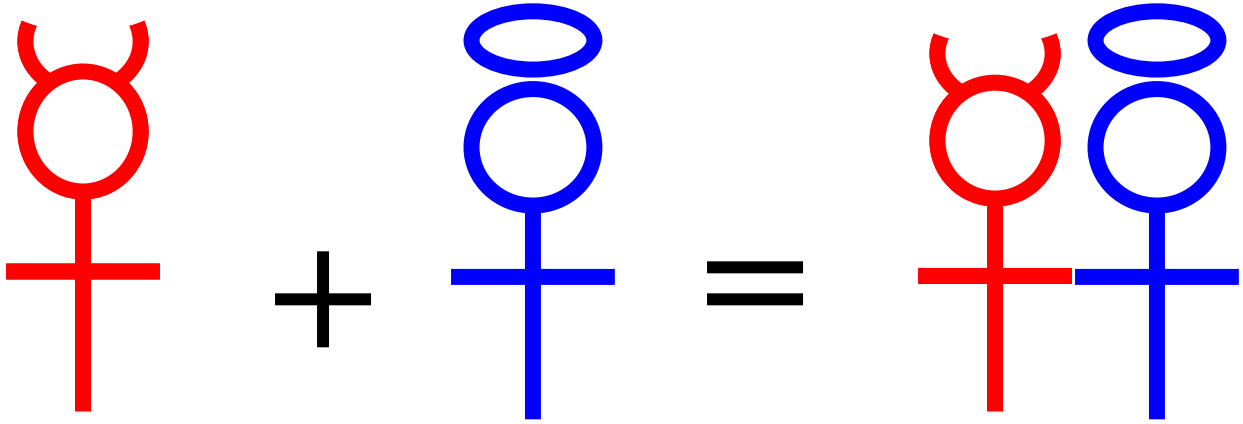
MERCURY SELENIDE



CH_3Hg Selenocysteine CH_3Hg-Selenocysteine

Mercury does not cause oxidative damage to proteins and lipids. Toxic (1 μM) and severely toxic (2.5 μM) mercury inhibits the selenoenzymes that normally prevent and reverse oxidative damage

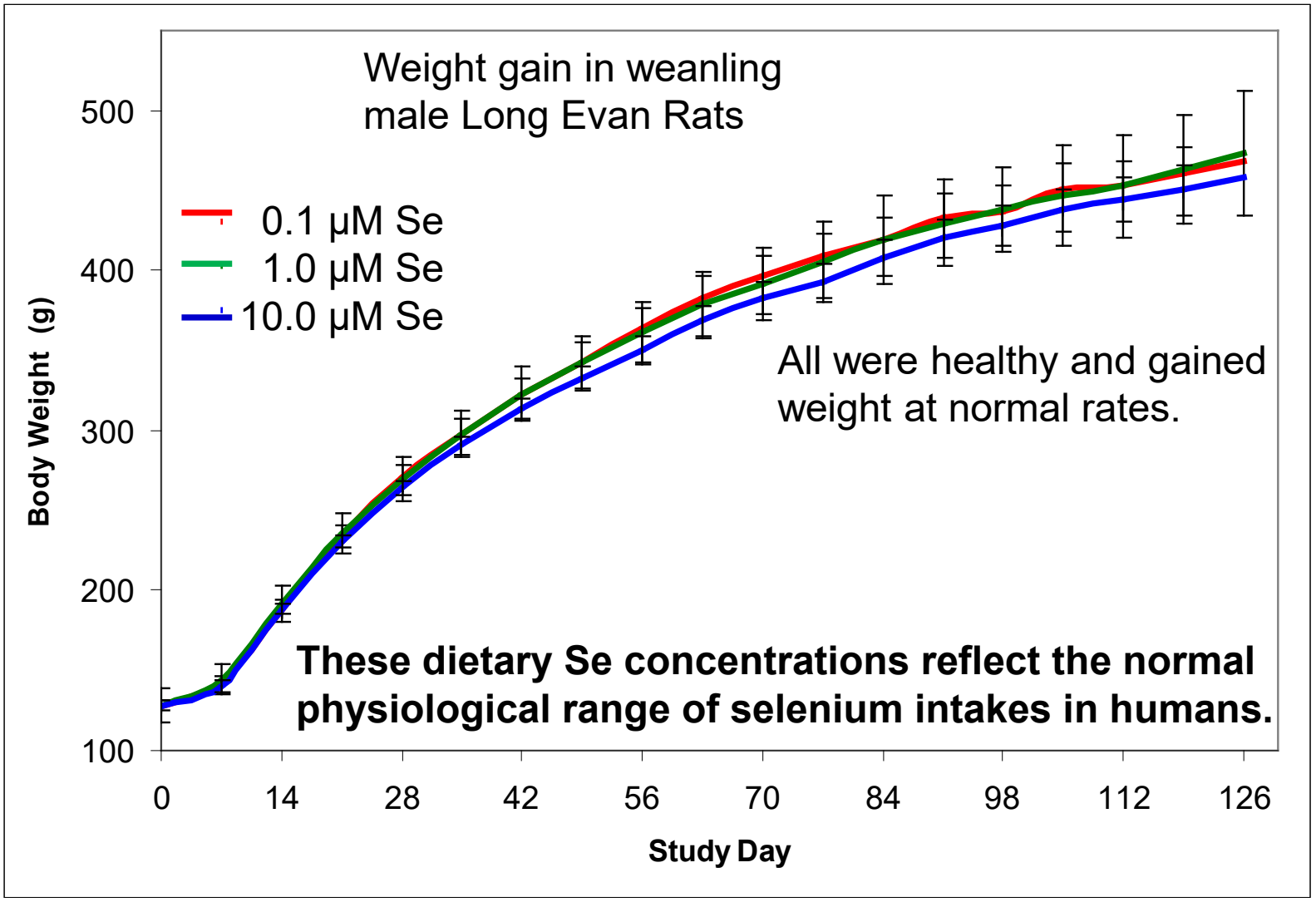
MERCURY SELENIDE



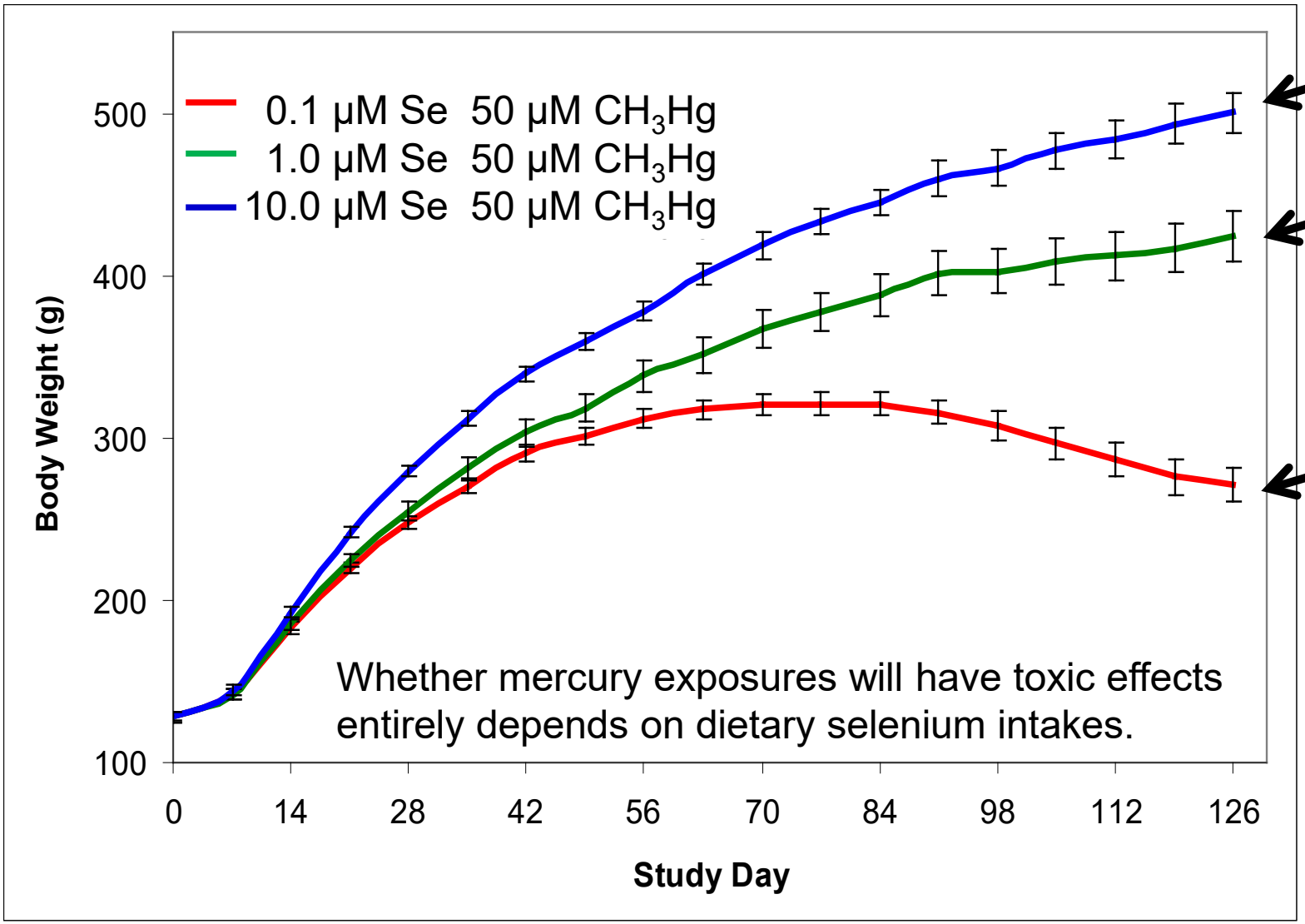
CH_3Hg Selenocysteine CH_3Hg-Selenocysteine

Ocean fish are so rich in selenium, eating them prevents mercury toxicity by preventing the induced selenium deficiency which would keep brain selenoenzymes from performing their essential functions.

DIETARY SELENIUM AND GROWTH



SELENIUM "PROTECTION" STUDY



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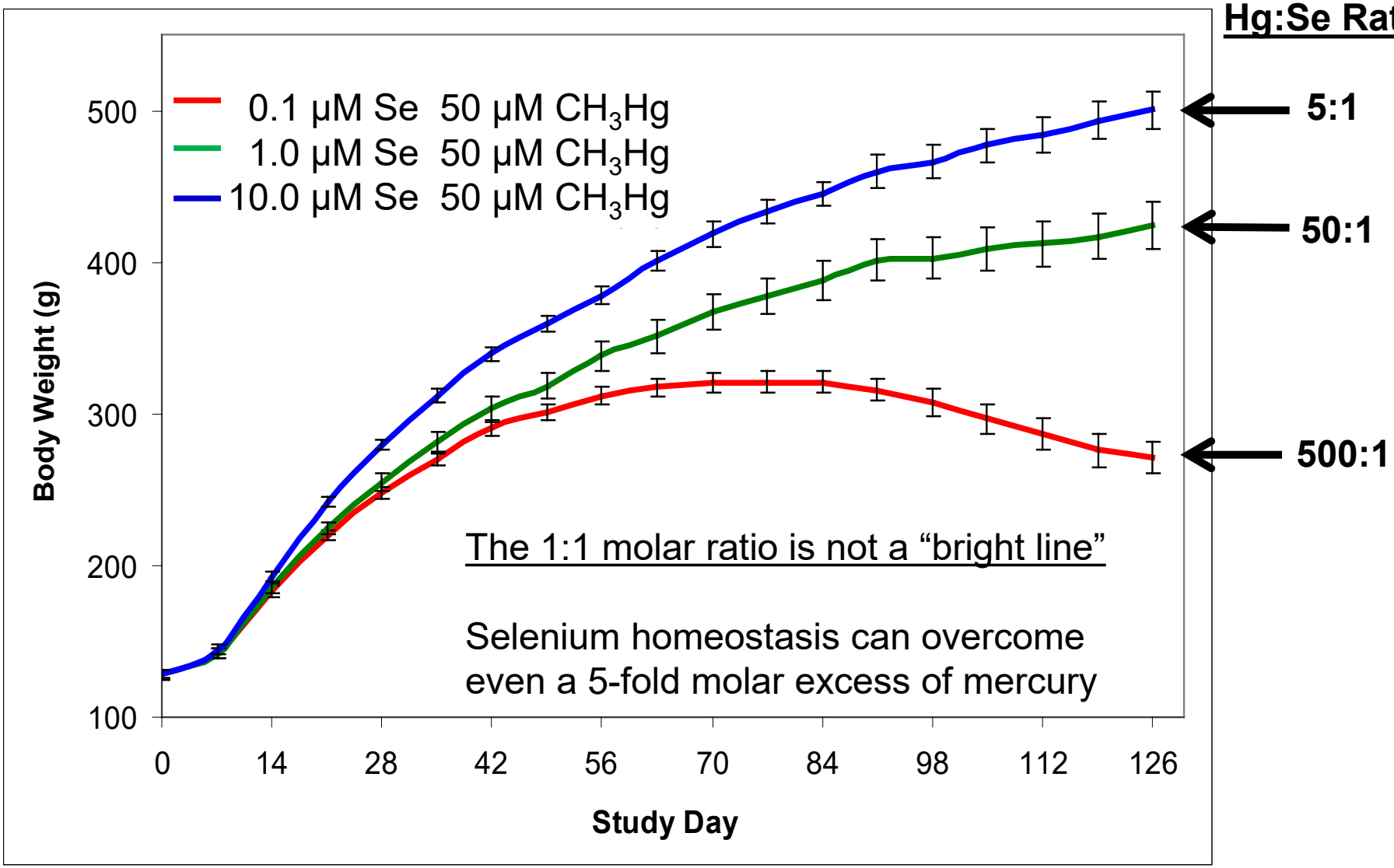
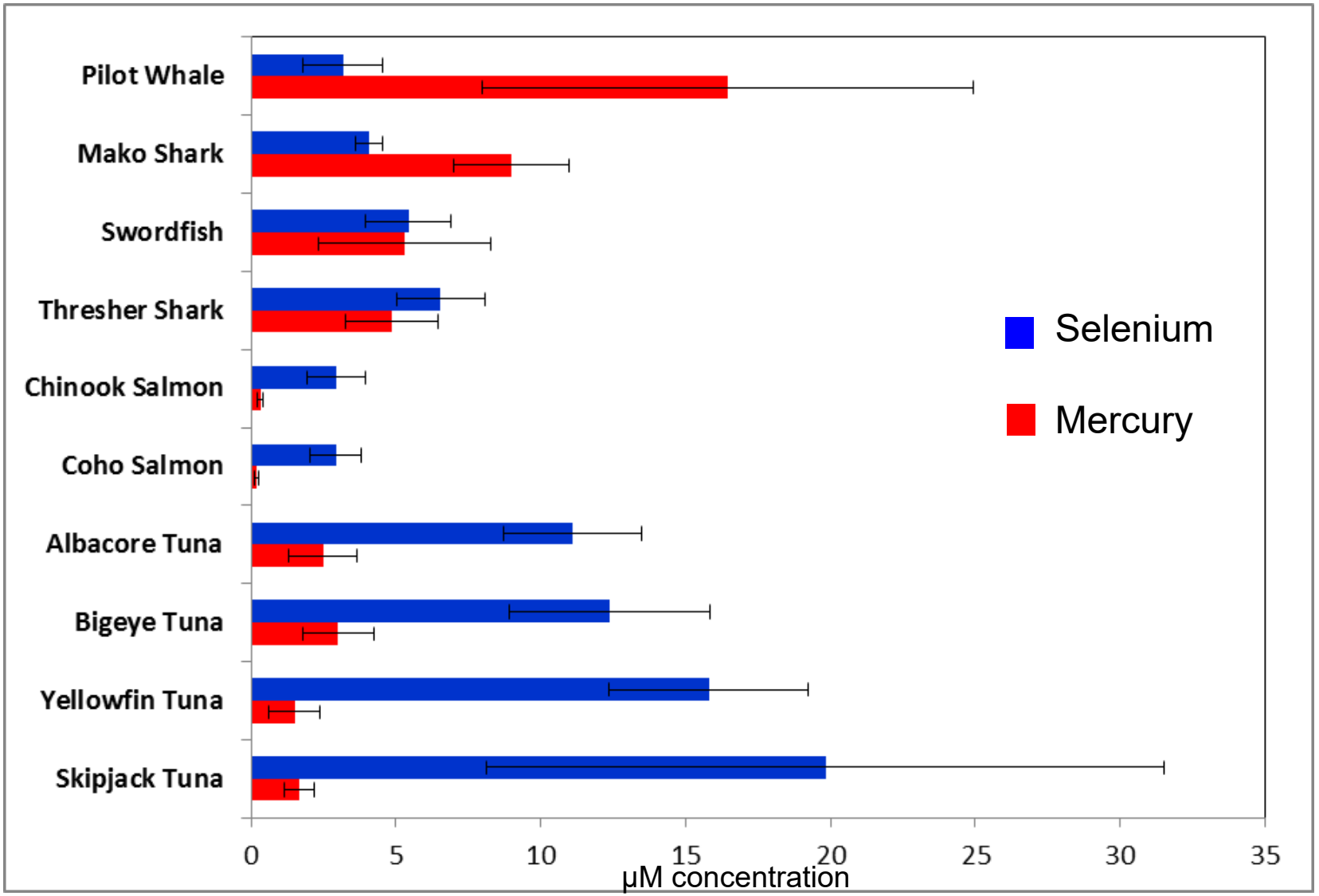
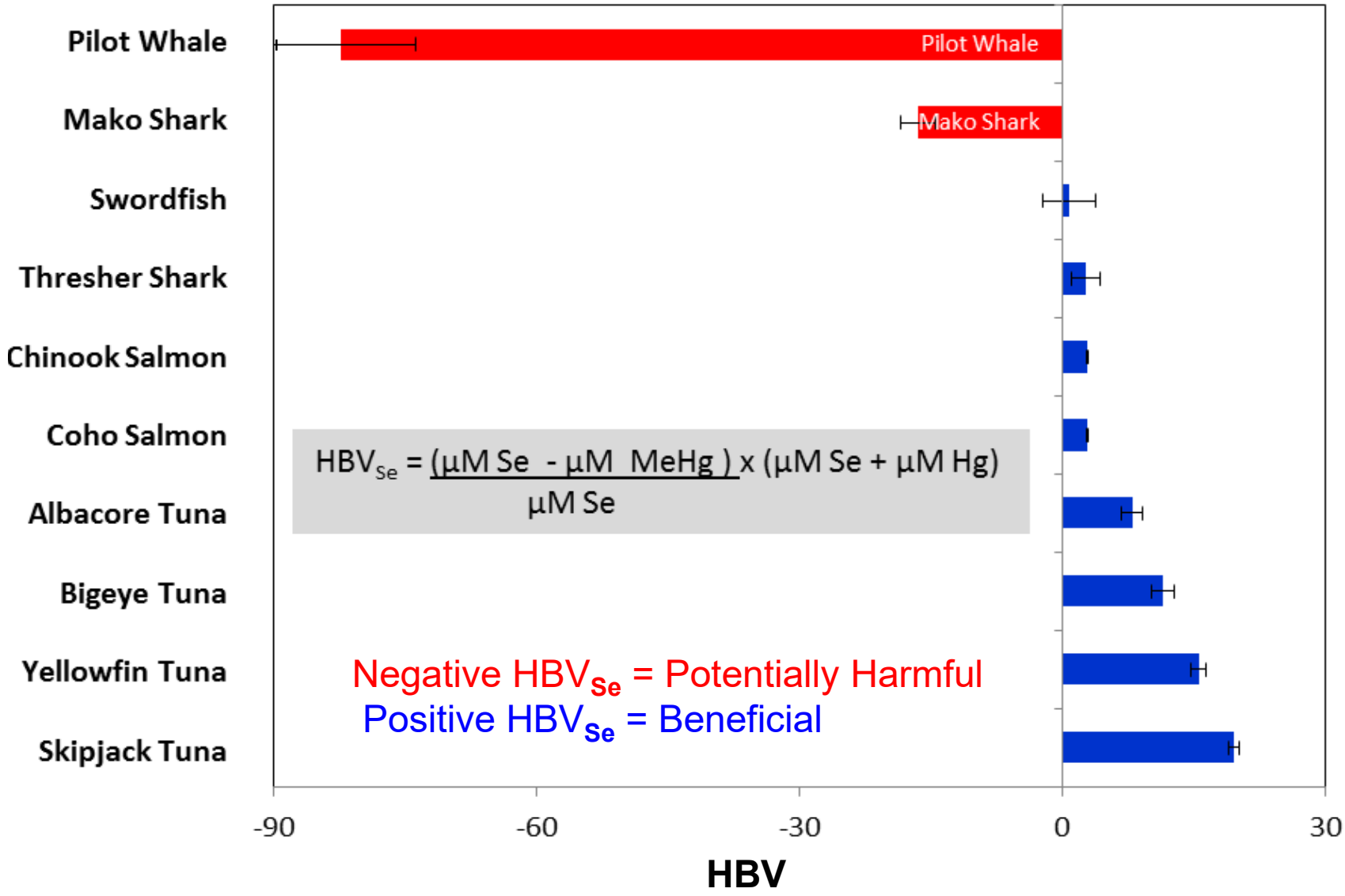


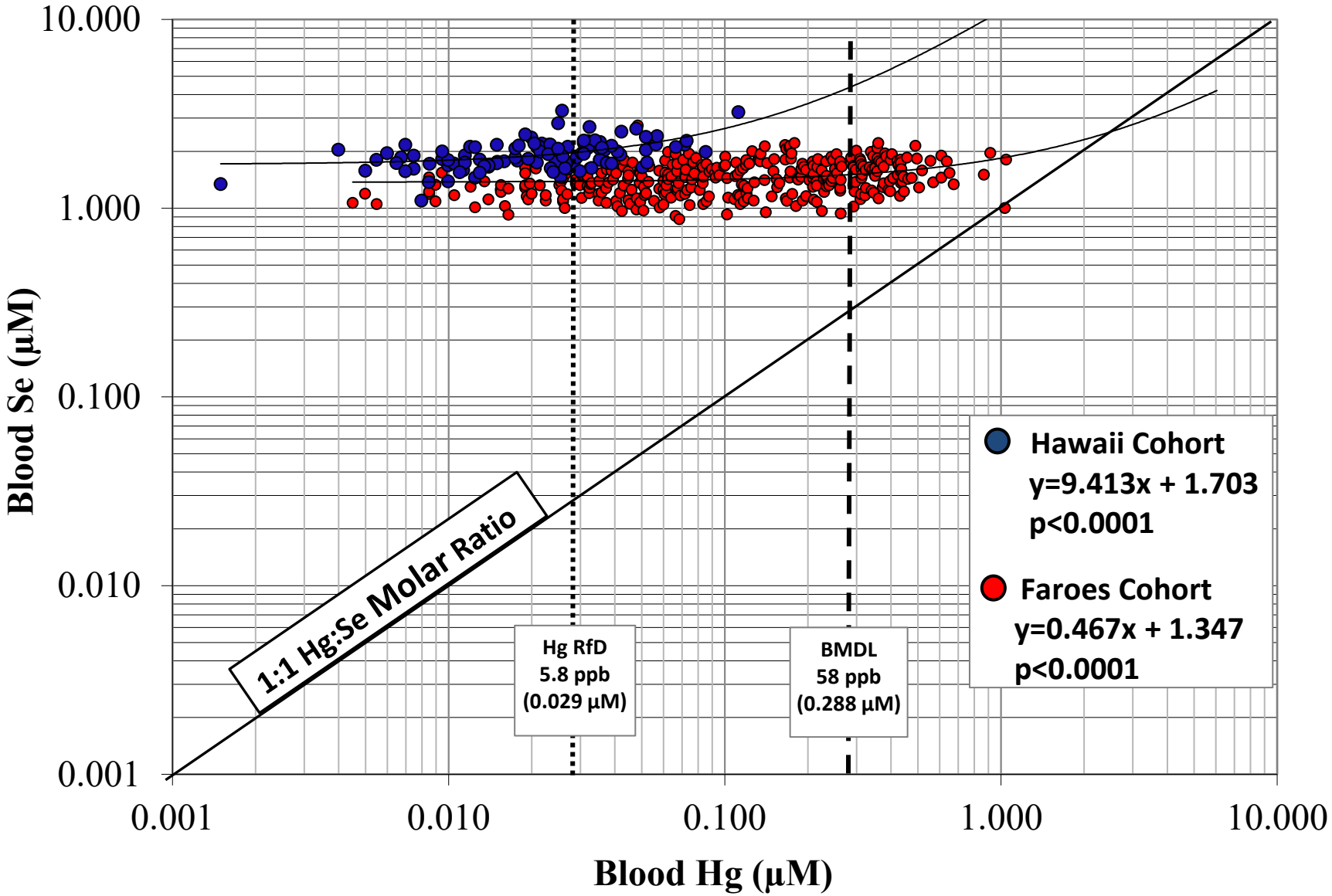
MERCURY AND SELENIUM CONTENT OF SEAFOODS



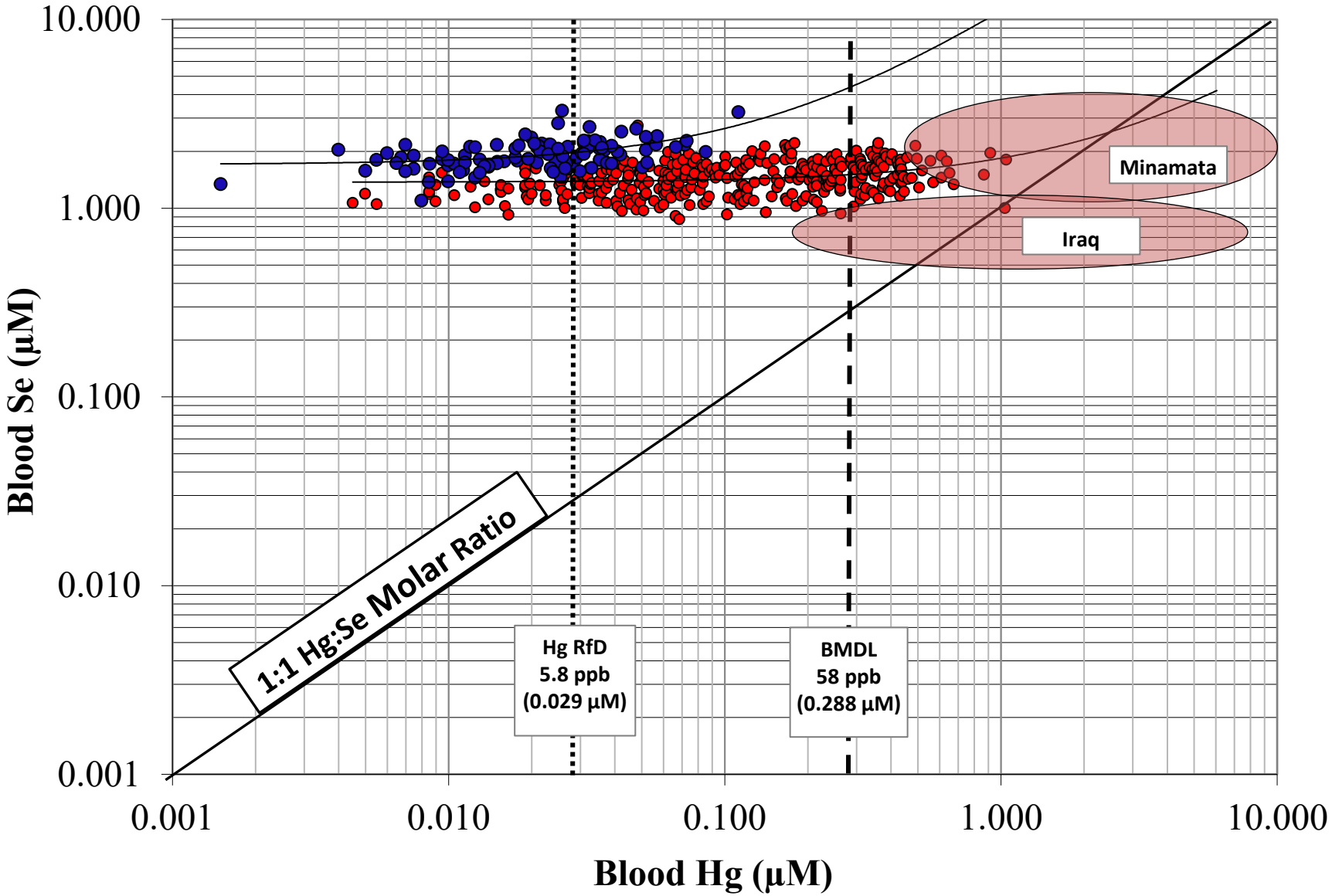
SEAFOOD SELENIUM HEALTH BENEFIT VALUES (HBVs)



FAROES VS. HAWAIIAN STUDY CORD BLOOD Hg & Se



WHAT ABOUT CORD BLOOD Hg & Se ELSEWHERE?



SELENOENZYME INHIBITION HYPOTHESIS

MATERNAL METHYLMERCURY EXPOSURES IN EXCESS OF SELENIUM INTAKES RESULT IN ADVERSE CHILD DEVELOPMENT OUTCOMES

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Seychelles	Beneficial	17.3	√		
United Kingdom	Beneficial	20.2	√		
United States	Beneficial	14.4	√		
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Results of epidemiological studies of maternal methylmercury exposures are consilient with the selenoenzyme inhibition hypothesis.

SUMMARY

- As the most potent intracellular nucleophile, selenocysteine is the primary target of soft electrophile neurotoxicants including mercury.
- Ocean fish are rich in selenium and have positive HBVs. Only certain types of shark or large specimens of swordfish or halibut do not.
- Therefore, eating ocean fish improves selenium status and protects against effects of high exposures to soft electrophiles such as mercury.

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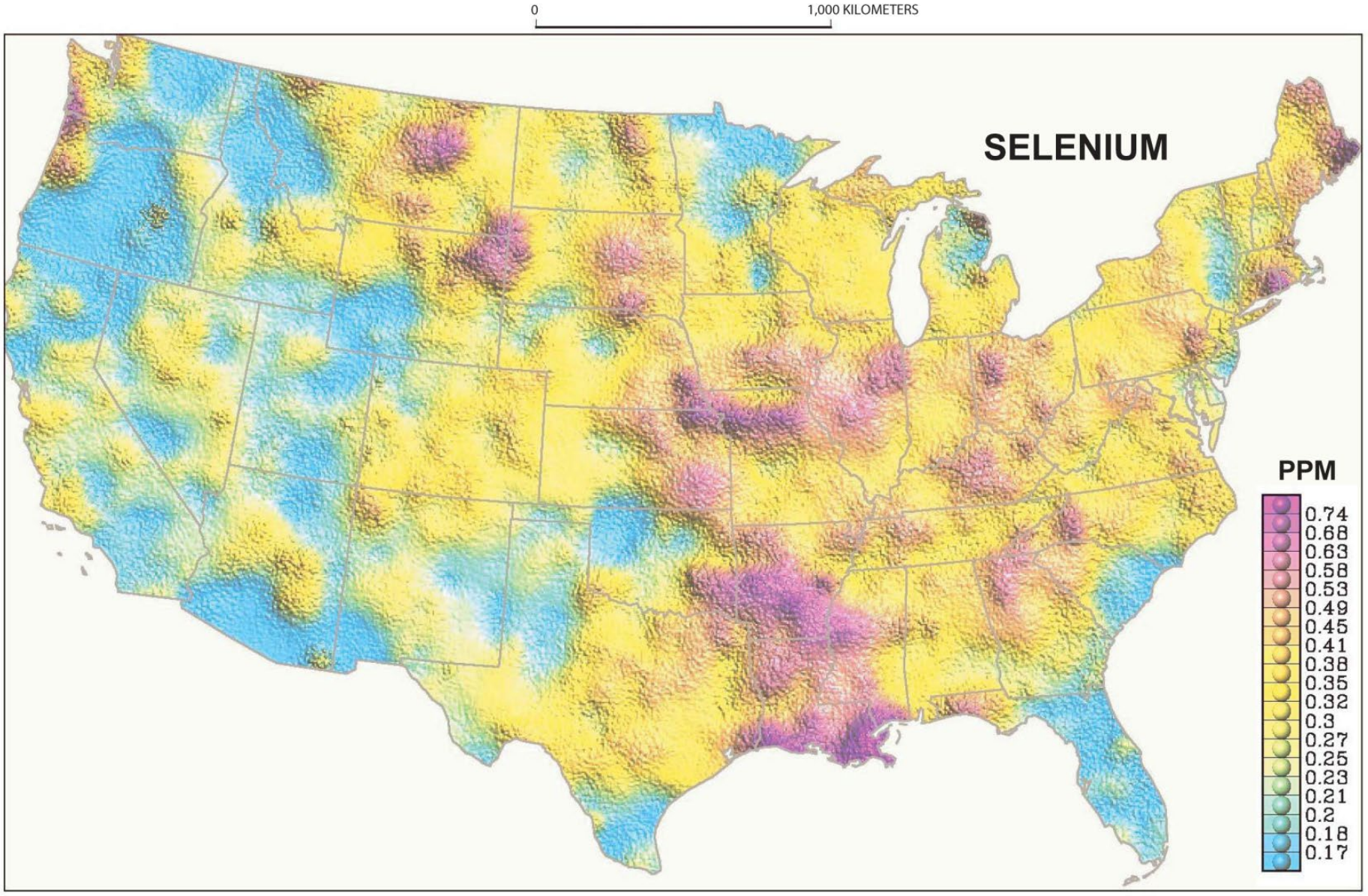
- Therefore, eating ocean fish improves selenium status and protects against effects of high exposures to soft electrophiles such as mercury.
- The ocean is selenium rich, but freshwater bodies depend on local soil selenium levels. Soil selenium can be highly variable.

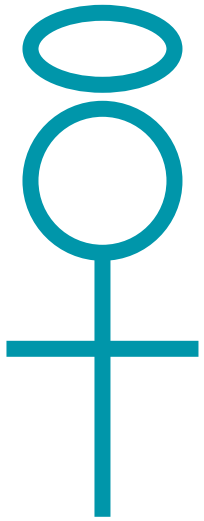
SOIL SELENIUM CONTENTS



SUMMARY 2.0

- Mercury bioaccumulation in freshwater fish and risks associated with mercury exposures are both inversely related to selenium.
- There is an urgent need to assess mercury-selenium relationships and evaluate risks to freshwater fish consumers, particularly among subsistence populations living in low selenium areas.
- *Primum non nocere* (First, do no harm) should guide all aspects of public health including when establishing regulations.
- In other words, the precautionary principle is recursive. While minimizing risk, adverse effects due to lost benefits must be fully considered by public and environmental health policy makers.

ACKNOWLEDGEMENTS:



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