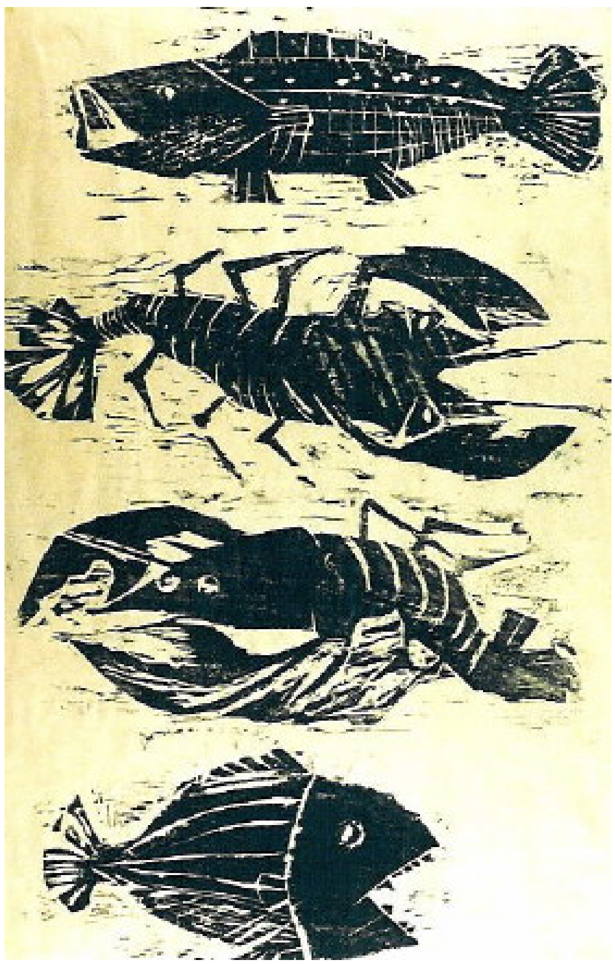
Making Sense of State Fish Advisories

A Policy-Maker's Guide to Mercury, Fish and Public Health
March 2005



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“National fish consumption advisories that are based solely on assessment of risk of exposure to contaminants without consideration of consumption benefits result in overly restrictive advice that discourages eating fish even in areas where such advice is unwarranted. In fact, generic fish advisories may have adverse public health consequences because of decreased fish consumption and substitution of foods that are less healthy.

“Public health is on the threshold of a new era for determining actual exposures to environmental contaminants, owing to technological advances in analytical chemistry. It is now possible to target fish consumption advice to specific at-risk populations by evaluating individual contaminant exposures and health risk factors. Because of the current epidemic of nutritionally linked disease, such as obesity, diabetes, and cardiovascular disease, general recommendations for limiting fish consumption are ill conceived and potentially dangerous.”

> – Scott M. Arnold, PhD, Tracey V. Lynn, DVM, MS, Lori A. Verbrugge, PhD and John P. Middaugh, MD, (2005) *American Journal of Public Health*, vol. 95, 393-397

“We do not believe that there is presently good scientific evidence that moderate fish consumption is harmful to the fetus. However, fish is an important source of protein in many countries and large numbers of mothers around the world rely on fish for proper nutrition. Good maternal nutrition is essential to the baby’s health. Additionally, there is increasing evidence that the nutrients in fish are important for brain development and perhaps for cardiac and brain function in older individuals.”

> – Dr. Gary Myers, a leading scientist of the *Seychelles Island Child Development Study* in his July 29, 2003’s testimony to the U.S. Senate Environment and Public Work Committee

“Fish intake by the mother during pregnancy and by the infant postnatally, was associated with higher mean [child] development scores. For example, the adjusted mean MacArthur comprehension score for children whose mothers consumed fish four or more times per week was 72 ... compared with [a score of] 68 among those whose mothers did not consume fish. ...Although the total cord mercury levels increased with maternal fish intake, our data did not suggest adverse developmental effects associated with mercury.”

> – Daniels et al. (2004) *Epidemiology*, vol. 15, 395-402

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Executive Summary

This paper focuses on currently wide-spread and growing State fish consumption advisories. State notices are attributed to health concerns about "contaminants" such as traces of fish methylmercury (MeHg) in a wide range of aquatic systems including lakes, rivers, watershed basins and coastal zones. State issued advisories are in addition to – and sometimes conflict with – federal advisories.

The 2003 National Listing of Fish Advisories (NLFA) released by the U. S. Environmental Protection Agency (EPA) in August 2004 is the 12th annual listing since the first such collection of locally issued fish advisories and safe eating guidelines in 1993. Despite EPA caution against inappropriate extrapolation or inferences from NLFA statistical data, there is a persistent pattern of public misinformation and alarmism suggesting that trends in the number of fish advisories evidence progressively worsening mercury (Hg) "pollution" of U.S. fresh water and marine fish. EPA rejects this notion.

Corollary to the scientifically weak notion of increasing levels of mercury in fish is the hypothesis directly linking traces of the biologically active form of mercury (MeHg) in fish to Hg emissions from industrial sources, especially coal-fired power plants. Computer models based on this hypothesis *tend to predict a linear response*, but there are *little data to support their predictions.*

The science reported in current peer-reviewed literature strongly suggests that methylmercury has existed in fish and fish consumers (human and wildlife) since both evolved on earth. This natural and historical condition predominately derives from Earth's geology and marine ecodynamics.

State advisories vary widely and can appear confusing, subjective and even arbitrary. Advisory rules often are set according to differing thresholds, definitions, needs, and political pressures within each State.

EPA's own ultra-precautionary approach to MeHg influences final determinations of "safe" versus "unsafe" underlying the various and disparate State fish advisories. Ominously, there appears to be a trending tendency for some States rationalizing *even lower fish MeHg criteria* for issuing fish consumption safety advisories. Such decisions appear based on a dose-challenged belief that if less exposure is good then near-zero exposure must be better.

This hyper-cautious approach seems to accord little to no consideration to potential loss of substantial nutritional benefits derived from fish consumption, especially for pregnant women and children. **The employment of "precaution" in formulating fish advisories seems to work strictly in one direction only – toward tighter regulation and away from better public health.** This is particularly grave relative to women's health impacts such as pre-term delivery and low birth weight, fetal brain development, cardiac health, breast cancer, type 2 diabetes, postpartum depression, bipolar disorders, and even suicidal ideation. (Alaska's reluctance to issue any consumption advisories for fish caught in its waters appeared to be based on such a thoughtful balancing of health concerns.)

In other words, calls for reductions in fish consumption inherent in fish advisories, should be balanced against concerns for widespread, unintended public health loss. **The most fundamental principle for any fish consumption advisory must be to *do no harm*.** Policy makers should weigh the indisputable fact that *sometimes excessive or wrong regulation can be as, or more, deleterious than none at all.*

This requires considering some pertinent questions concerning risk. How cautious is caution? Is there a point at which caution itself becomes harmful; where hyper-precaution becomes irrational to the point of becoming the greater risk; a point at which the resulting alarmism can damage public health by frightening consumers away from nutritional fish consumption?

A more rational, informed and calm framework for dealing with MeHg exposure through fish consumption is urgently needed.

[n.b.: This paper is meant to be a reference, covering a wide range of literature and issues associated with State issued fish consumption advisories and their rationale; it also demonstrates that the subject of mercury and human health is more complex and far less alarming than often portrayed. It is also meant to be read more than once, including the extensive endnotes. Much important information and references have been placed in the endnotes in order to help the main text flow well]

Section 1 – Some Frequently asked Questions

QUESTION #1: What is an advisory and how are advisories developed?

ANSWER #1: According to EPA,

> "If elevated concentrations of chemicals, such as mercury or dioxin, are found in local fish and certain water-dependant wildlife (such as ducks or turtles), then a State may issue health advice to the public in the form of fish consumption advisory. A fish consumption advisory may include recommendations to limit or avoid eating certain fish species caught from specific water bodies or, in some cases, from specific water body types (e.g., all lakes). An advisory may be issued for the general population, or for specific groups such as recreational and subsistence fishers, or for sensitive subpopulations such as pregnant women, nursing mothers, and children. A consumption advisory is not a regulation, but rather a voluntary recommendation issued to inform people."[1]

QUESTION #2: Why are there so many more advisories now than 12-13 years ago?

ANSWER #2: The issuing of an *increasing* number of fish advisories runs counter to available evidence showing *decreasing* trends in many pollutants (including mercury) since the 1970s. It seems clear, therefore, that the increase in the number of advisories is *not* related to reputed increased levels of methylmercury (MeHg) in fish, or to increasing pollution. The increase in advisories *likely* represents political decisions influenced by a range of factors (See **Section 5**).

EPA specifically noted that:

> "The increase in the number of river miles placed under advisory in *2003 is due to new State-wide mercury river advisories in three States*: Washington, Montana, and Wisconsin. State-wide advisories are issued as a precautionary measure when fish monitoring data indicate widespread contamination has been detected in certain species of fish or certain types of water bodies (e.g., rivers)." [Emphasis added]

In other words, when States transition from more limited "site-specific" advisories to State-wide advisories a very large amount of lake acres and rivers miles are suddenly added to EPA's data base in that year, with little or no relevance to actual increases in air pollution or levels of MeHg in fish tissue compared to the previous year. EPA's cautions anticipated many popular claims that are now misrepresenting fact and reality.

QUESTION #3: How many States have State-wide advisories?

ANSWER #3: In the 2003 National Listing of Fish Advisories released August 2004, a total of 45 States had issued at least one fish mercury advisory. 21 States (Connecticut, Florida, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, North Dakota, Ohio, Pennsylvania, Rhode Island, Vermont, Washington, and Wisconsin) had issued State-wide advisories for mercury in at least one species of fish in inland freshwater lakes and rivers. As explained by EPA, a State-wide advisory is issued mainly as a *precautionary* measure rather than any fact-based documentation of actual increased contamination from industrial sources.

In addition, 12 States (Alabama, Florida, Georgia, Hawaii, Louisiana, Maine, Massachusetts, Mississippi, North Carolina, Rhode Island, South Carolina, and Texas) had issued State-wide advisories for fish mercury in their coastal waters. The Micmac tribe of Maine had issued two State-wide tribal advisories warning against mercury in their freshwater and marine fish/seafood, including lobster.

QUESTION #4: What do fish advisories really mean? On what are they based?

ANSWER #4: Actual monitoring efforts for detecting contaminants is not only costly but also highly limited by EPA and State ability to adequately measure and sample fish in local waters. Clearly, it takes only one measurement of fish mercury above a certain pre-defined level of acceptance (i.e., more commonly 0.5 ppm or 0.3 ppm) to trigger a fish consumption advisory (See **Sections 3, 6, 7** for more details). Fish advisories are issued with the good intention of avoiding un-necessary risk of over exposures to toxic contaminants like MeHg in fish. Most fish consumption advisories are careful to emphasize the benefits of fish nutrition; but often confusion and fear rather than clarification results from highly negative and emotional messages spread by the media campaigns of special interest organizations – potentially leading to substantial drops in consumption of fish.

QUESTION #5: Does a fish (consumption) advisory mean real risk?

ANSWER #5: The amount of MeHg in fish consumed by most American is very low. The State of Alaska views greater health dangers from a lack of sufficient intake of fish, rich in high-quality protein, omega-3 polyunsaturated fatty acids, sulfur-containing amino acids, vitamin E, selenium, lysine, iodine, copper, calcium, zinc, iron, manganese, etc. This is why Alaska suggests no consumption restriction, while urging their high fish consuming population, including *"pregnant women, women who are breast feeding, women of childbearing age, and young children"*, to eat more fish caught from Alaskan waters (see **Section 6**). Existing medical evidence under both clinical and epidemiological settings suggest that the trace levels of MeHg in U.S. fish are not likely to suddenly overwhelm the well-established health benefits gained from consuming a variety of fish from restaurants, grocery stores and even most caught recreationally in local waters.

Also, trace levels of MeHg found in fish are likely no different from levels in fish long before any possibility of industrial contamination (sic). It is very rare to find claims of MeHg poisoning through regular (i.e., chronic) low dose fish consumption paralleling the two tragic incidences of *direct* high dose MeHg poisonings from industrial waste dumping in Minamata Bay and Niigata City, Japan during the 1950s and 1960s, respectively.

QUESTION #6: Does an advisory in one State mean the same thing as an advisory in another State? Is there any uniformity?

ANSWER #6: There is no uniformity among States. The evidence shows that different States not only use different fish mercury threshold ("safety") levels for issuing their advisories but often adopt different standards of proof for potential harm and definitions for assessing exposure risk to MeHg in fish. There are also differing designations (age ranges) for defining population subgroups, like children.

Further confusion stems from apparent conflict of interests and goals between federal fish advisories for commercial fish and individual State advisories for local freshwater fish. For example, Maine, Wisconsin, Minnesota and Washington have recently urged FDA and EPA *not* to distribute federal fish advisories to doctors' offices and public health clinics in their States (See **Section 8**).

QUESTION #7: What are the sources of mercury in fish and what are the uncertainties?

ANSWER #7: The biologically active form of mercury found in fish tissue is called methylmercury or MeHg. Chemically MeHg is written as CH_3Hg^+ with additional chemical elements such as carbon and hydrogen. Elemental mercury (Hg) has to undergo a series of biological, chemical and physical processes to be converted to methylmercury (MeHg), and then accumulated in fish tissue. It is through the pathway of fish consumption that the case is being made that human health is at possible risk; but *actual* health harm requires exposure to an exceptionally, uncommonly large dose of MeHg. It is very important to clarify that coal-fired power plants do *not* emit MeHg. Careful and extended analyses by EPA have been unable to scientifically find that public health is *directly* at risk from Hg emissions from power plants.

There is little doubt that levels of MeHg ultimately accumulating in fish tissue depends primarily upon environmental and ecosystem factors such as amounts of sulfate, sunlight and organic matter, pH level or temperature of water, amounts of bacteria or zooplankton. MeHg levels in fish do not depend simply on the amount of elemental Hg available for conversion. This is why a distinguished group of scientists[2] recently concluded that a simple change in bacterial activity alone could "cause an *increase* in fish mercury concentrations even as atmospheric deposition [from industrial mercury emission sources] *decreases*" [Emphasis added]. (See **Section 9**)

QUESTION #8: What does RfD stand for?

ANSWER #8: Reference Dose. According to EPA's definition, reference dose is defined as "an estimate of a daily exposure to the human population (including sensitive subpopulations) that is likely to be without a risk of adverse effects when experienced over a lifetime."

QUESTION #9: What is EPA's fish mercury advisory threshold value?

ANSWER #9: The current value is 0.3 ppm (parts per million).

Section 2 – Fish Advisory Listings: Introduction and Overview

This paper focuses on currently wide-spread and growing State fish consumption advisories. State notices are attributed to health concerns about trace "contaminants" such as traces of fish methylmercury (MeHg) in a wide range of aquatic systems including lakes, rivers, watershed basins and coastal zones. They are in addition to the federal advisory[3] issued jointly by the EPA and the U.S. Food and Drug Administration (FDA) in March 2004 to minimize exposure for sensitive sub-groups, such as the offspring of women who are or might become pregnant, nursing mothers and young children. The federal joint advisory concerns primarily trace levels of MeHg in commercial ocean or farmed fish.

The 2003 National Listing of Fish Advisories[4] (NLFA) released by EPA[5] in August 2004 is the 12th annual listing since the first collection of locally issued fish advisories and safe eating guidelines in 1993. EPA offered a few summary statistics, routinely misinterpreted in media reports:

- The 2003 NLFA database lists 3,094 total advisories in 48 States, the District of Columbia, and the U.S. Territory of Samoa (**Figure 2-1**). The water bodies under advisory represent: (i) 35% (or about 14.2 million acres) of the nation's total lake acres; (ii) 24% (or about 846 thousand miles) of the nation's river miles; (iii) 75% of the nation's contiguous coastal water (including 92% of the Atlantic coast, 100% of the Gulf coast and 37% of the Pacific coast) and (iv) 100% of the Great lakes and their connecting waters.
- The mercury-specific fish advisories for 2003 numbered at 2,362, an increase of some 160% since 1993 (**Figure 2-2**). Forty-five States now issue mercury advisories, a steady increase from only 27 States in 1993.
- 21 States (Connecticut, Florida, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, North Dakota, Ohio, Pennsylvania, Rhode Island, Vermont, Washington, and Wisconsin) have issued State-wide advisories for mercury in at least one specie of fish in all their inland freshwater lakes and rivers. Twelve States (Alabama, Florida, Georgia, Hawaii, Louisiana, Maine, Massachusetts, Mississippi, North Carolina, Rhode Island, South Carolina, and Texas) have issued State-wide advisories for fish mercury in their coastal waters. The Micmac tribe of Maine has issued two State-wide tribal advisories to warn against mercury in their freshwater and marine fish/seafood (including lobster[6]).
- State fish consumption advisories based on the five most measured contaminants (mercury combined with PCBs, chlordane, dioxins, and DDT) accounted for 98% of all advisories in effect in 2003. From 2001 to 2003, *mercury-only* advisories rose to account for about 86-92% of all advisories. In other words, only about 8% of fish advisories are non-mercury related. Since 1993, the lake acres and river miles covered by all states fish consumption advisories for all contaminants have been steadily and systematically increasing (**Figure 2-3)**.

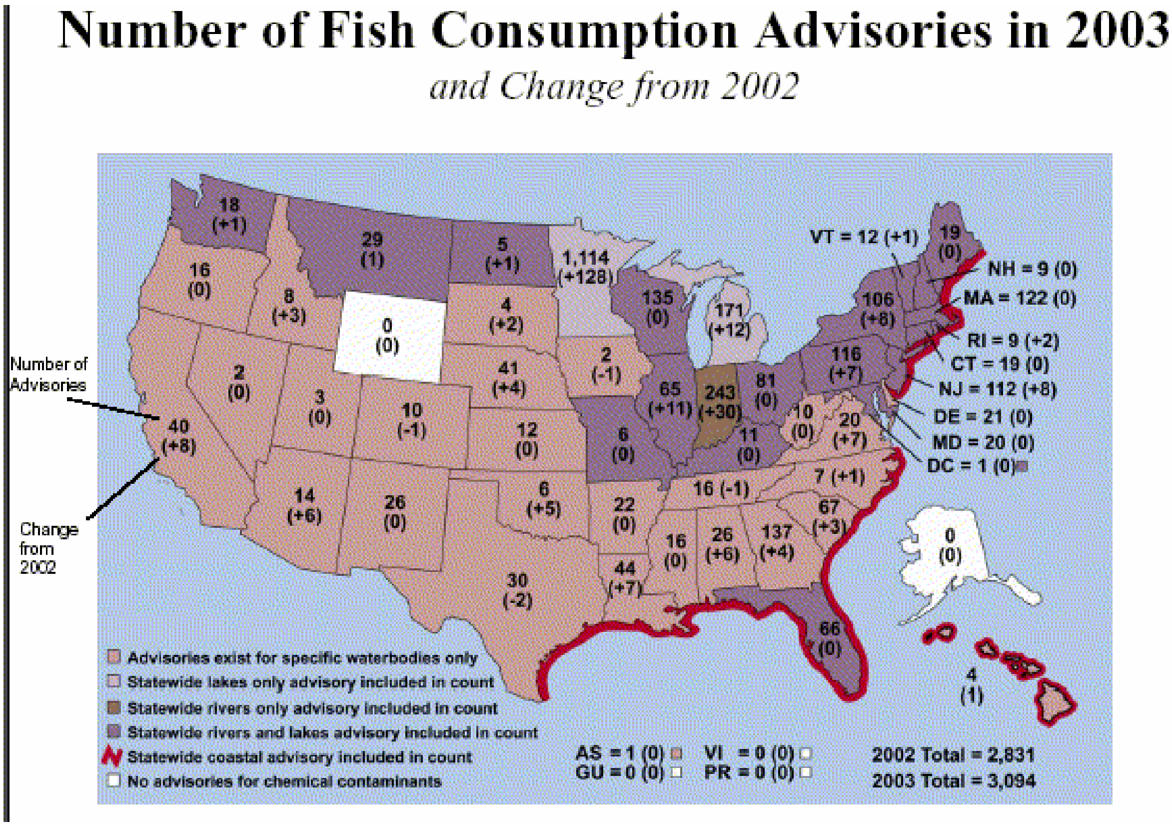


Figure 2-1: Changes in total number of fish consumption advisories from 2002 (totaled 2831) to 2003 (totaled 3094).
(Adapted from EPA's August 24, 2004 Briefing Package
at http://www.epa.gov/waterscience/fish/advisories/index.html)

Despite EPA caution against inappropriate extrapolation or inferences from NLFA statistical data, there is clearly an ongoing pattern of public misstatements suggesting that the increasing number of public fish advisories are evidence of progressively worsening mercury "pollution" of U.S. fresh water and marine fish.

For example:

> *U.S. Senator Jim Jeffords (I-VT): "This listing clearly indicates we are moving in the wrong direction on mercury pollution." (*AP News*, August 24, 2204)
>
> *"Fish warnings up due to mercury pollution-EPA." (*Reuter's Planet Ark* headline, August 25, 2004)
>
> *August 24, 2004 press release by the Sierra Club's Executive Director, Carl Pope[7] – "Today the Environmental Protection Agency announced in its 2003 National Listing of Fish and Wildlife Advisories[8] that 766,872 miles of America's rivers and 13,068,990 lake acres *are contaminated*

with so much poisonous mercury that the fish aren't safe to eat -- that is a more than 60 percent increase for river miles and an eight percent increase for lake acres since the 2002 report." [Emphasis added] [see **Figure 2-4** for an explanation as to why this statement could be viewed as alarmist and promotional, having ignored EPA's clear explanation that the increase is particularly related to the issuance of recent State-wide advisories by Montana and Washington**,** switching from their previous year's site-specific advisories]

* "In the U.S., the consequences [of "mercury pollution" from China] are being detected not just in the air people breathe but in the food they eat. The U.S. Environmental Protection Agency recently reported that a third of the country's lakes and nearly a quarter of its rivers are now so polluted with mercury that children and pregnant women are advised to limit or avoid eating fish caught there." (December 17, 2004, *Wall Street Journal* article[9])

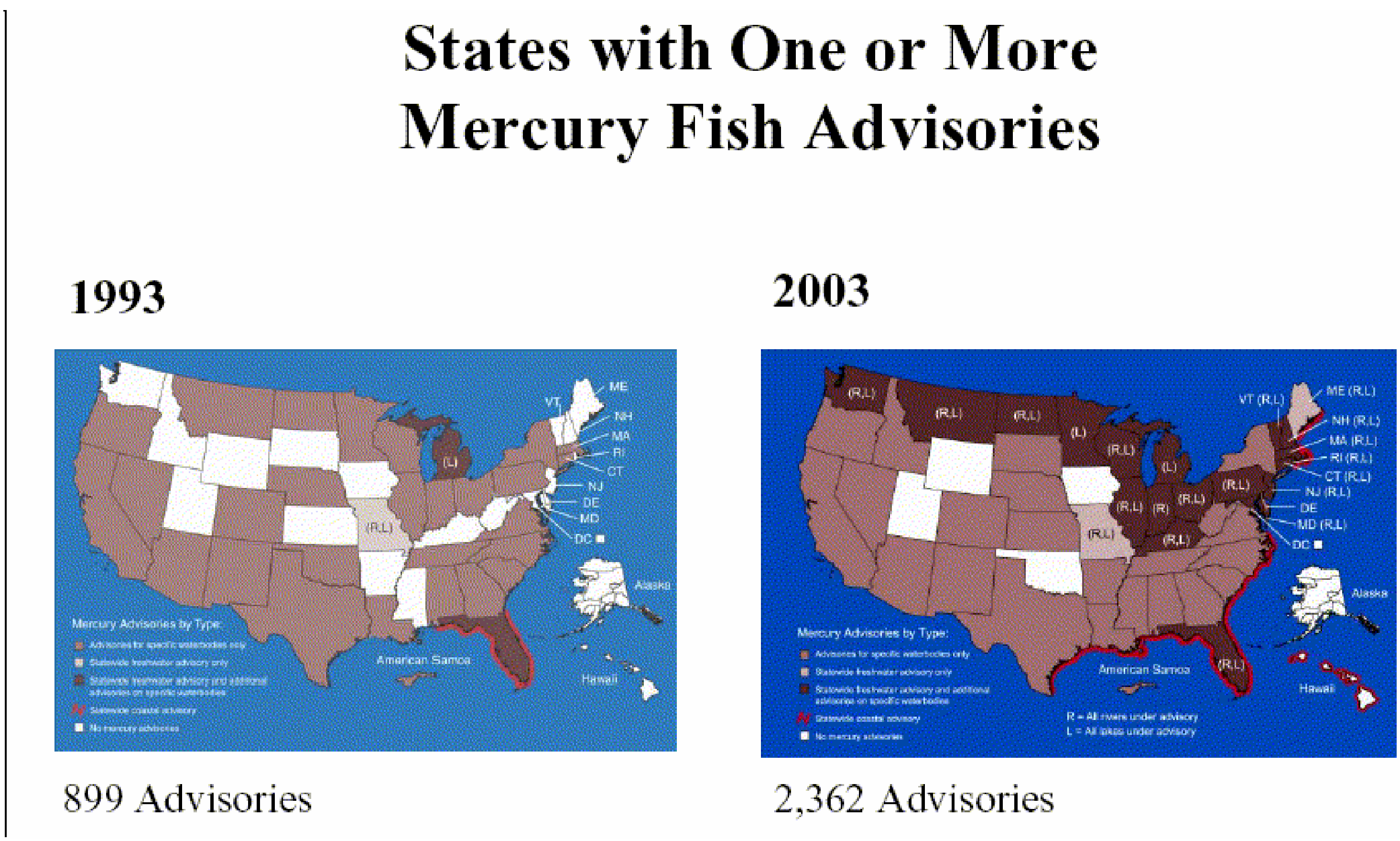


Figure 2-2: Mercury-specific advisories issued in 2003 versus those in 1993.
(Adapted from EPA's August 24, 2004 Briefing Package
at http://www.epa.gov/waterscience/fish/advisories/index.html)

As indicated in the Q&A section of its fish advisory web site,[10] EPA anticipated some misuse of NLFA data:

> **Q:** "Why have the number of advisories and the geographic extent of advisories steadily increased over the past 15 years?
>
> **A:** EPA believes that the increase in advisories is primarily due to *increased sampling* of previously untested waters by States and tribes *and not* necessarily due to *increased levels or frequency* of contamination." [Emphasis added]

In other words, EPA rejects the notion that its NLFA data points to increasing levels of trace MeHg in fish caught in U.S. waters. Instead, the increase in total volume of aquatic systems under advisories is primarily derived from the on-going socio-political decisions of the individual States regarding the scope of their fish advisories (**Figure 2-4**) rather than any actual increase in fish mercury content over time. These individual State decisions run the gamut from State-wide coverage (Montana) to none at all (Alaska).

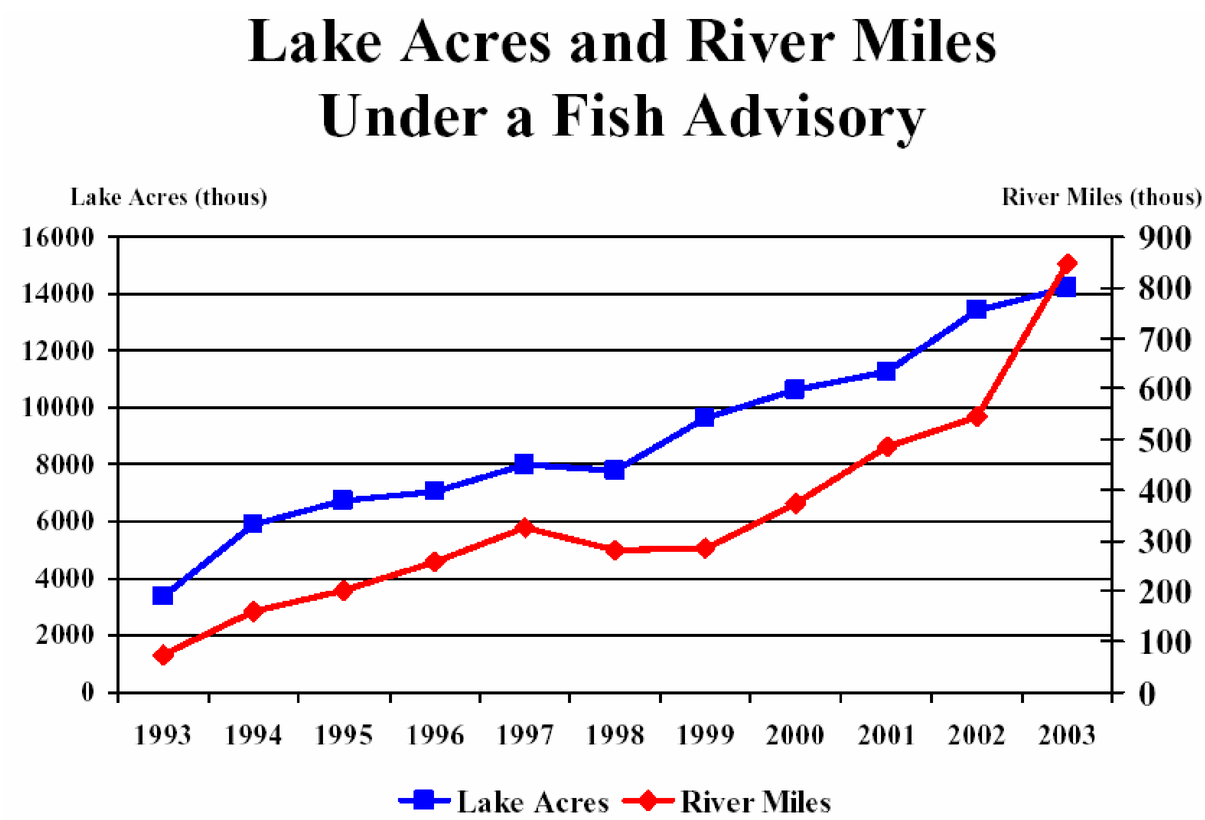


Figure 2-3: Number of river miles and lake acres under a fish advisory (for all contaminants including mercury) from 1993 through 2003. Mercury-only advisories account for about 86-92% of all advisories from 2001-2003. See discussion under **Section 5** on how and why these two "statistics" could not be attributed to any actual

increase in mercury pollution and the ultimate increase in the biologically more toxic form of mercury, methylmercury or MeHg, in fish caught in U.S. waters.
(Adapted from EPA's August 24, 2004 Briefing Package
at http://www.epa.gov/waterscience/fish/advisories/index.html)

Corollary to the notion of increasing levels of mercury in fish is the hypothesis directly linking traces of the biologically active form of mercury (MeHg) in fish to Hg emissions from industrial sources, especially coal-fired power plants. This claim is more fully examined in **Sections 8, 9, 10**. Suffice it here to point out that proponents of harsh mercury regulatory regimes to reduce Hg emissions to minimal levels or zero anticipate *linear* reductions of MeHg in fish. Their declared primary aim is to improve fetal and early childhood health by reducing maternal exposure to trace MeHg through fish consumption. The assumptions underlying their actions are seriously questioned by science.

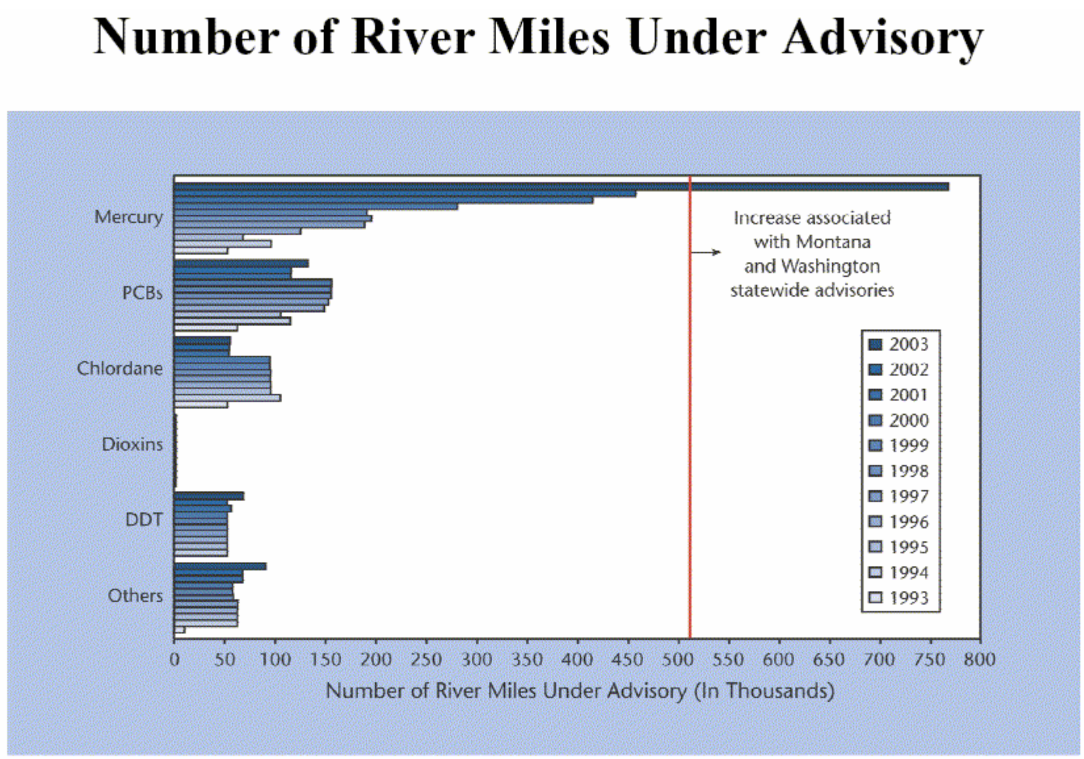


Figure 2-4: Number of river miles under a fish advisory for all contaminants from 1993 through 2003. EPA clearly warned that the large increase (i.e., more than 60% increase in one year!) in the number of river miles under mercury advisories from about 473 thousand miles in 2002 to about 767 thousand miles in 2003 is related particularly to the issuance of State-wide advisories by Montana and Washington[11] from their previous year's site-specific advisories. Unfortunately, EPA's cautions have been largely ignored.
(Adapted from EPA's August 24, 2004 Briefing Package
at http://www.epa.gov/waterscience/fish/advisories/index.html)

A distinguished research team led by the University of Maryland's R. Mason recently concluded[12]:

> "It is not clear whether changes in mercury input will result in a linear change in mercury methylation [i.e., creating MeHg]. Computer models, such as one developed for the Florida Everglades, *tend to predict a linear response*, but there are *little data to support the predictions*…. [D]ecision makers need more than mercury concentrations to be able to ensure *defensible* interpretation of the indicators, such as MeHg in fish. *Other necessary information* includes land use; food-web structure; the introduction of exotic species; point-source discharges; changes in climate, atmospheric chemistry, and acidic deposition; and hydrological regimes (e.g., retention time and water level fluctuation). ... Other factors, such as sulfate and organic matter that impact bacterial activity, could also *possibly cause an increase in fish mercury concentration even as atmospheric deposition decreases*." [Emphasis added]

The science literature strongly suggests that methylmercury has most likely existed in fish and fish consumers (human and wildlife) since both evolved on earth. This natural and historical condition likely derives from Earth's geology and marine ecodynamics. Indisputably, mercury is ubiquitous in both land and aquatic environments. Earth's oceans alone contain tens of millions of tons of mercury, with deep ocean vents likely the dominant source of MeHg production ending up naturally and persistently over time in ocean fish.[13] (**Section 9** offers a brief discussion of the largely misunderstood processes for the creation and destruction of MeHg.)

It is also indisputable that fish is a nutritious, highly abundant resource for maintaining overall health for many, especially those within subsistent cultures. Fish is known to be rich in essential high-quality protein, omega-3 polyunsaturated fatty acids, sulfur-containing amino acids, vitamin E, selenium, lysine, iodine, copper, calcium, zinc, iron, manganese and more. Existing medical evidence from both clinical and epidemiological settings suggest that the trace levels of MeHg in our fish are not likely to suddenly overwhelm well-established nutritional benefits derived from consuming a variety of fish found in restaurants, grocery stores and most local waters. To increase the existing large margin of safety for the most sensitive groups − the offspring of pregnant and nursing women and young children less than 6 years of age − one may choose to lower intake of certain species of fish, allowing for a lowering of mercury in the body (which takes 50 to 200 days to reduce by half). For the anxious, it is certainly reasonable to follow the March 2004 joint FDA/EPA fish advisory that pregnant women and young children avoid "Shark, Swordfish, King Mackerel, or Tilefish."[14]

For these reasons, policy makers should be vigilant about alarmist misuse of NLFA and other data which fosters the injurious and irresponsible public misperception that fish is not safe for consumption. Contrary to an expanding body of published peer-reviewed literature, the repetition of such claims in the media often only serves to frighten away fish consumers. This potentially denies them a wide range of proven health benefits inherent in fish nutrition.[15] Most fish advisories are *not* intended to inhibit consumption, but rather to suggest varying levels of personal precaution based on MeHg levels in particular fish. This report demonstrates that many of the current State advisories are scientifically problematic.

Section 3 – How Accurate are State Fish Advisories? Are They Really that Useful?

This section provides a basic overview on what constitutes fish advisories, and the soundness of their scientific base. State advisories vary widely in accepted standards of exposure. They also may be confusing and misleading to fish consumers (see **Section 8**).

Federal Actions

First, a historical note on the progressive development of FDA fish mercury guidelines, according to the "Mercury Timeline" offered on the website of Senator Patrick Leahy (D-VT)[16].

1969 – FDA sets an "administrative guideline" of 0.5 ppm for "mercury" in *ocean fish.*
1974 – FDA converts "administrative guideline" to what is termed an "action level."
1979 – FDA raises the "action level" from 0.5 ppm to 1 ppm which is said to be equivalent to a limited consumption rate of 0.5 μg of "mercury" per kg of body weight (b.w.) per day by the National Marine Fisheries Agency.
1984 – The 1 ppm action level was converted from a "mercury" standard to one based on methylmercury (MeHg) – the biologically active form of mercury.[17]

EPA's documentation confirms FDA's current action level of 1 ppm.[18]

Thus, FDA has the responsibility to make sure that *commercial* marine fish and seafood contain MeHg levels no higher than 1 ppm.[19] FDA's action level, according to some commentators, is "the limit at or above which FDA will take legal action to remove a product from the market."[20] As proof that FDA has taken its responsibility seriously, there exist pre-1979 reports of "large-scale confiscation of swordfish and the lesser-scale confiscation of tuna, as a consequence of the establishment by the U.S. Food and Drug Administration of a maximum permissible level of 0.5 parts per million (ppm) for mercury in fish."[21]

Details on how to estimate a fish tissue level from an assumed consumption limit of methylmercury in fish is discussed in **Section 7.**

State Actions

State consumption advisories for freshwater or recreational fishing in coastal waters may have been issued at various fish mercury concentration levels. For example, in the December 10-11, 2002 Workshop on Advisories for Mercury in Gulf Marine Fish,[22] five Gulf State representatives summarized their approaches to establishing an advisory as follows:

- Alabama: 1 ppm − consumption advisory issued
- Florida: >1.5 ppm − no consumption; 0.5-1.5 ppm − 1meal/month for sensitive subpopulation or 1 meal/week for general population; < 0.5 ppm − no restrictions

- Louisiana: 0.5 ppm
- Mississippi: 1.0 ppm − consumption advisory issued;1.5 ppm − no consumption
- Texas: 0.7 ppm

As a second example of diversity in advisory standards, the Minnesota Pollution Control Agency (2004) recently reported that any river in Minnesota would be considered "impaired" if a particular top predator species at certain standard size (i.e., 550 cm for northern pike) recorded mercury levels exceeding the predefined threshold of 0.2 ppm. In other words, a fish advisory will be issued for Minnesota rivers if a 550 cm-long northern pike is tested with a tissue mercury reading above 0.2 ppm.

Science Behind the Advisories

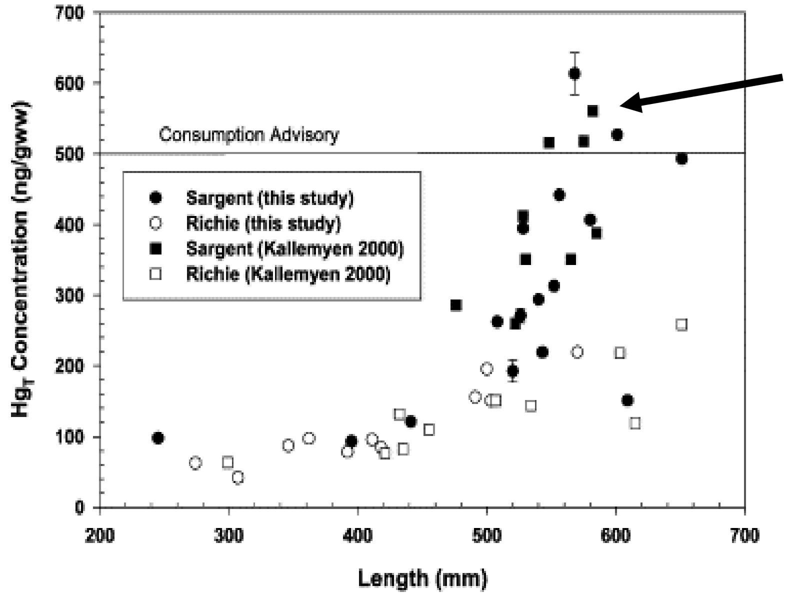
But are State issued advisories based on a sound understanding of the natural factors affecting MeHg in fish? **Figures 3-1** and **3-2** reveal some challenges for understanding the meaning of mercury levels in fish and the environment upon which advisories are based.

Figure 3-1 shows five northern pike caught in Sargent Lake (Michigan) containing total Hg (Hg_T) levels above 0.5 ppm (or 500 ng/g marked in the figure), triggering a consumption advisory. In neighboring Lake Ritchie with fish tissue Hg_T levels below 0.3 ppm, no advisories are listed, according to a recently published study (Gorski et al. 2003).[23]

This appears to make sense at first. The lake containing *fish* exceeding the prescribed Hg_T limit is under advisory. The lake below the set *fish* limit is not. But there are complications.

Researchers discovered that the actual measured levels of total mercury in the *waters* of Lake Ritchie (non-advisory) are *higher* than those in Sargent Lake (advisory), suggesting a more complicated picture of *how* mercury is accumulated in fish. This is why the authors of this study concluded, "At this stage [of research understanding], we are *unable* to identify lakes where mercury concentrations will exceed consumption advisories without *direct* measurement of mercury concentrations in fish [which can be costly and labor intensive]." In other words, States relying on mercury levels in water as a *proxy* for indicating levels in fish from those waters may be deceived, resulting in the issuing of "false alarm" advisories.

It is often the case that concentrations of total mercury (Hg_T) and methylmercury (MeHg) in *water* samples are *not* useful predictors of mercury concentration in *fish*. Contrast the mercury values in northern pike from Lake Sargent (advisory lake) with those from Lake Richie (non-advisory lake). Despite the fact that Hg_T in Sargent Lake *pike* (filled symbols) is significantly higher than Lake Richie *pike* (open symbols), both the HgT and MeHg *water* measurements are slightly higher in Lake Ritchie, the non-advisory lake.



Five of these 5-6 year old pike from Sargent Lake are above 0.5 ppm

Gorski et al. (2003) Science of the Total Environment, vol. 304, 327-348

Figure 3-1: A comparison of mercury levels in northern pike caught in both an advisory lake (Sargent Lake) and a non-advisory lake (Lake Ritchie). Sargent Lake is labeled an advisory lake because five of its northern pike have mercury levels above Michigan's fish advisory threshold level of about 0.5 ppm (or 500 ng/g). Sargent and Ritchie are inland lakes of Isle Royale National Park, Lake Superior, MI.

Also, as evidence of layered-precaution, Michigan's advisory for *not* consuming northern pike from Sargent Lake (like all similar State advisories) makes the implicit assumption that Sargent Lake fishermen will *always* be unfortunate enough to catch *only* those few northern pike **(see figure 3-1)** with mercury levels above 0.5 ppm (*instead* of those pike measured with very "safe" mercury levels at 0.1 ppm), and then eat them *every* day, for an entire *life time* (the definition of an RfD for exposure).[24]

Figure 3-2 shows that mercury levels in young and adult perch caught in Sargent Lake and Lake Ritchie are both generally low. But more importantly, the perch mercury levels are largely similar. Thus, if perch instead of northern pike were considered the fish of choice, then no fish consumption advisories would be necessary for either Sargent Lake or Lake Ritchie.

Another science-based challenge for State officials is related to the dependence of fish mercury levels on fish growth rates. Recently, scientists from the University of Quebec examined walleye pike in 12 lakes located in four different regions of Quebec in order to determine this relationship.[25] They found that:

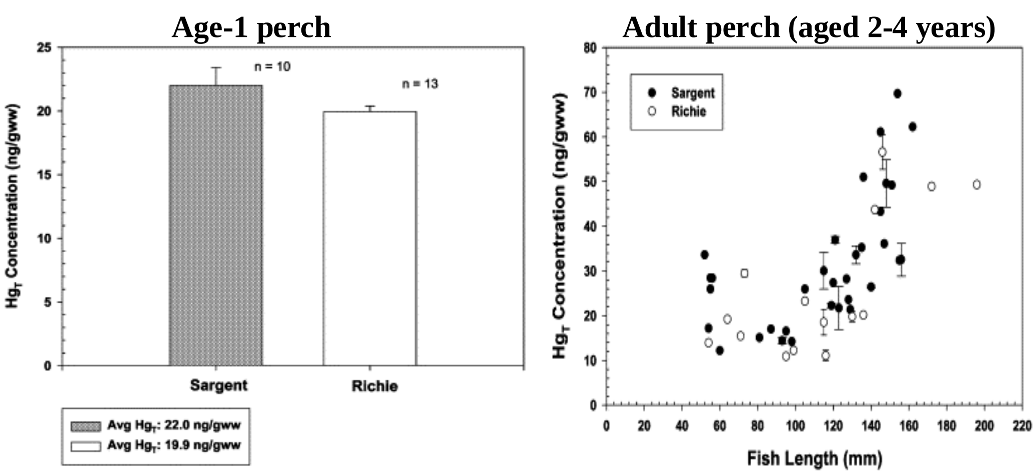
> "When all walleye populations of the 12 lakes were considered together, growth rates were significantly correlated to Hg concentration ($r=0.9244$; $P< 0.001$). This suggests that faster-growing walleyes will have *lower* Hg concentrations than slow-growing fish at a given length. The growth rate as a biological factor dominates all other environmental factors to account for differences in Hg concentrations in walleye populations studied. ... For … regular fisher[men] and their families, the fact that a walleye of edible interest, say between 350 and 450 mm in total length, contains between 0.1 and 1 ppm of Hg in its flesh is quite puzzling as the consumption of certain specimens from certain lakes can pose a serious health risk. To identify which fish from which lake can be safely consumed, governmental institutions have commonly used normative approaches. In that case, mean Hg concentrations in walleye of each of the 12 lakes can be calculated according to a given standardized length of 350 mm, for example. Under these conditions, Fig. 5 [not re-shown in this report] shows that standard Hg concentrations in walleye range from 0.13 ppm in Lake Waconichi to 0.79 ppm in Lake Malartic. Combining these calculations to the threshold of 0.5 ppm of Hg in fish flesh, classic fish consumption advisories would recommend limiting fish consumption for 5 of the 12 lakes considered. Should Health Canada *lower* the warning threshold of Hg in fish from 0.5 to 0.3 ppm or even less, the situation of "safe" vs. "unsafe" lakes *would change drastically*. This whole situation is then *quite confusing* for fish consumers. *More accurate* ways of deciding whether one can safely eat fish (walleye) from different lakes should be sought. We therefore propose to *include* fish growth rates when establishing walleye consumption advisories." [Emphasis added]

In other words, the amount of Hg in fish depends not only on fish *size* (i.e., as shown in **Figures 3-1 and 3-2**), but also on the *rate* of fish growth. Thus, fish in different lakes under *different growth environments* can contain mercury levels either below or above the level of concern adopted by a State for its advisory. This situation is especially confusing and potentially dangerous to public health if it steers people away from eating fish.

A third challenge for State regulators lays in the question of *what* is actually being measured in the fish tissue – total mercury (Hg_T) or methylmercury (MeHg)? MeHg is a potent neurotoxin known to affect human health at *very high and uncommon* **dose** levels.[26] Hg is *less so unless in extreme exposure situations.* It is known that there are long lists of independent biological, chemical and physical processes and factors governing the conversion of Hg into MeHg.[27] Thus, **it is crucial to know the specific form of mercury regulators are targeting for measurement in order to judge the scientific validity of an advisory.**

"At this stage, we are unable to identify lakes where mercury concentrations will exceed consumption advisories without direct measurement of mercury concentrations in fish"

Factors causing five of the northern pike in Sargent Lake to exceed the fish consumption advisory level of 0.5 ppm are not certain. The Hg_T in age-1 and adult yellow perch from both lakes are similar.



Gorski et al. (2003) Science of the Total Environment, vol. 304, 327-348

Figure 3-2: No significant difference in Hg_T between the Age-1 (one year old) perch and adult perch for both the advisory lake (Sargent Lake) and the non-advisory lake (Lake Ritchie). All perch caught from both lakes are below the Michigan's fish advisory threshold level of about 0.5 ppm (or 500 ng/g).

In this context, it important to be aware of a potentially misleading assumption marketed in EPA's June 2001 fact sheet, reporting on the status of the 2000 National Listing of Fish and Wildlife Advisories (NLFWA, the predecessor of the 2003 NLFA):

> *"Because of the higher cost of methylmercury analysis, EPA recommends that total mercury rather than methylmercury concentrations be determined in state fish contaminant monitoring programs. EPA also recommends that the assumption be made that all mercury is present as methylmercury in order to be most protective of human health."* [Emphasis added]

In other words, although actual MeHg may range between 70-98% of the Hg_T measured in fish tissue, EPA and some State agencies argue for erring on the side of *further caution* – assuming *all* 100% of the measured Hg_T in the fish tissue as MeHg. For example, a measurement of 0.6 ppm of Hg_T consisting of only 0.4 ppm of MeHg would trigger issuance of a *false* advisory where MeHg = 0.5 ppm were the threshold. This could result in needless harm to public health by provoking restrained fish consumption based on technical imprecision in the definition of "mercury."

It has been estimated that 90% or more of the methylmercury concentrations in fish tissues come from the fish's dietary intake.[28] Yet it should also be noted that for food web components lower in the food chain, like zooplankton, aquatic insects and mussels, the relative percentage of Hg_T as MeHg ranges from only 15% to 80%.[29]

Therefore, **it is essential that EPA and State agencies justify to policy makers, health professionals and consumers why all fish tissue mercury must erroneously be presumed to be in the form of MeHg.**

Section Summary

There's little wonder that State advisories can appear confusing, subjective and even arbitrary.

It is clear that fish consumption advisories in the NLFA program are *intended* to serve and protect public health, particularly specific subpopulations such as the offspring of pregnant women and small children that *may* be more susceptible to large and persistent exposures to MeHg. But the more relevant issues focus on questions of whether fish advisories really accomplish this, or instead actually cause confusion, needless anxiety and threats to public health from fish-constrained diets.

This concern is further illustrated by the co-sharing of waters and fish between the States of Montana and Wyoming. A September 2001 USGS report[30] found that 5 samples of walleye caught from the Bighorn Lake, geographically shared between Montana and Wyoming, measured a mean Hg_T level of 0.68 ppm. The 0.68 ppm level is sufficient to trigger a consumption advisory in the State of Montana, but not in Wyoming. The State of Wyoming simply does not issue *any* advisories. What should Bighorn Lake fishermen think? Is a walleye consumer in Wyoming any less "safe" than one in Montana?

Section 4 – Some of the Assumptions Underlying State Fish Advisories are Likely Scientifically Wrong

Once in place, State fish advisories might *never* be removed given the rationale for current policy: regulatory prescriptions seeking the elimination of power plant Hg emissions *presume* reductions will lead to a *linear* reduction of MeHg in ocean and freshwater fish, in turn leading to a reduction in human exposure through fish consumption. Once the fish have been returned (sic) to "safe" levels of mercury, then one presumes advisories would be lifted. But the underlying hypothesis and model connecting Hg power plant emissions to MeHg levels in fish tissue is scientifically unsupportable.

EPA and most State officials (Alaska seemingly a noted exception) appear to discount the vast body of literature challenging such invalid model; opening the way for serious unintended, negative economic, political and health outcomes.

This section presents *a sample* of available fish mercury data challenging the premise that anthropogenic industrial emissions and deposition of Hg to air and water has led to heightened levels of MeHg in fish over time. In rejecting the hypothesis, evidence strongly suggests that (1) MeHg has likely always been present in fish, (2) current MeHg levels in fish over time vary naturally, and (3) the natural production (and destruction) of MeHg is *not* limited by the amount of Hg available in aquatic systems. Hence, claims directly connecting fish mercury levels to minor[31] U.S. power plant Hg emissions confirm a serious misunderstanding of both real-world observations and scientific evidence.

To begin, **Figure 4-1** shows recent results by Kraepiel et al. (2003)[32] finding no increase in MeHg levels for Yellowfin tuna caught in 1998 relative to a similar cohort caught in 1971. The theoretical expectation (similar to EPA's) was that methylmercury concentrations "should have increased by 9 to 26%" over the interval "if methylation occurred in the mixed layer or in the thermocline [of the Pacific oceans]." The theory was *not* proven. Further, Zhang et al. (2002)[33] has estimated that China's mercury emissions from coal combustion are increasing at the rate of 5% per year (from available data from 1978 through 1995), which is consistent with the theoretical expectation of increased amounts of methylmercury in the waters of the Pacific Ocean *if* the Hg-to-MeHg conversion process is sensitive to industrial emissions loading. On the contrary, Kraepiel et al. (2003) clearly concluded that "[s]uch an increase is statistically *inconsistent* with the constant mercury concentrations measured in tuna. We conclude tentatively that mercury methylation in the oceans *occurs in deep waters or in sediments*."[34] [Emphasis added] This is why the relatively small man-made sources of mercury emissions can neither overwhelm nor directly alter the natural cycling of the very large amount of mercury readily available in the environment and biosphere.

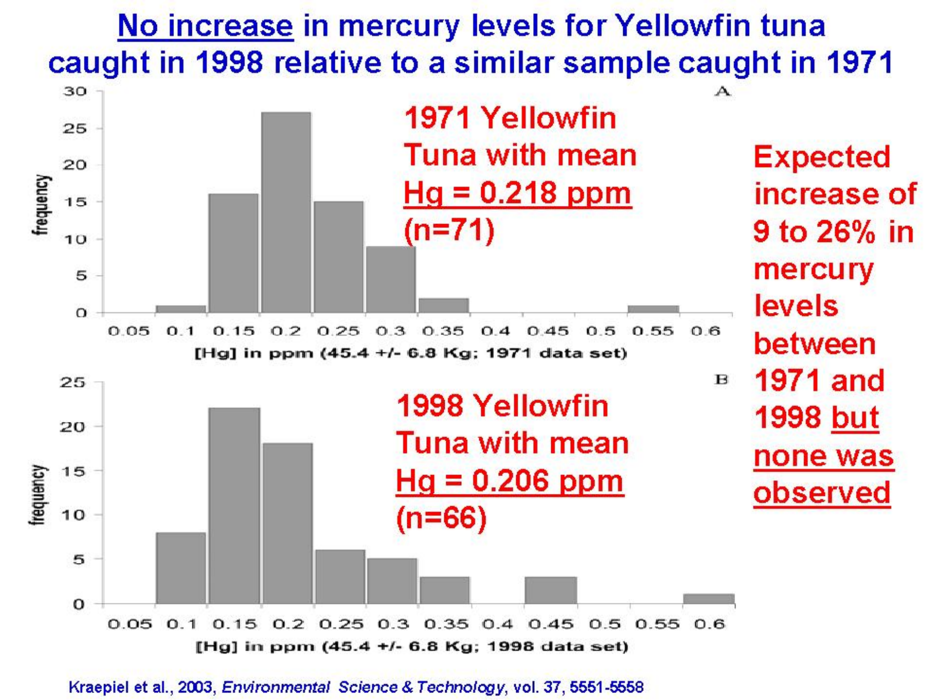


Figure 4-1: No significant change in the measured levels of mercury in Pacific Yellowfin tuna for similar weight-size samples caught in 1971 versus those caught in 1998.

Another study **(Figure 4-2)** found that although one can find clear increases of MeHg concentration in western Atlantic blue hake as fish length increases, one can hardly see any significant changes in the fish mercury-size relation between fish samples caught in 1880s and samples caught in the 1970s. The authors of the paper concluded:

> "This result supports the idea that the relatively high concentrations of mercury found in marine fish that inhabit the surface and deep waters of the open ocean result from *natural* processes, *not* 20th century industrial pollution."[35] [Emphasis added]

This research clearly suggests that MeHg concentrations in ocean fish are *not likely to be changed or modified* by small alterations of inorganic Hg sources (either anthropogenic or natural). This is why popular claims or any indirect suggestions that EPA's proposed Clean Air Mercury Rule (CAMR) will lead to a measurable reduction in MeHg accumulated in ocean and fresh water fish are *factually misleading*.[36]

No evidence of increasing trend or any change in Hg of deep-sea fish (blue hake): 1970s versus 1880s fish

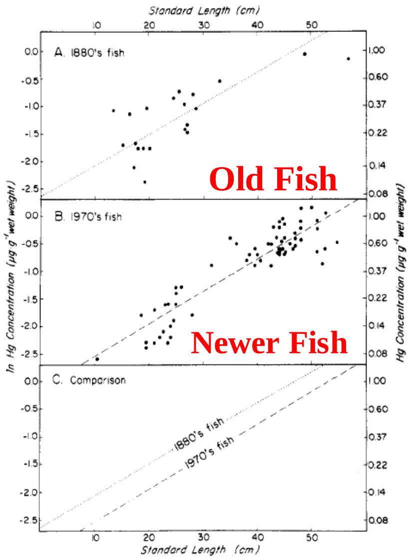


Figure 2. Linear regression analysis of the natural logarithm of mercury concentration vs. length in the deep-sea fish *Antimora rostrata*. (A) Fish collected in the 1880s; (B) fish collected in the 1970s; (C) comparison of regression lines for the 1880s fish and 1970s fish.

"To test for a change in mercury content in the last century, two samples of the deep-sea fish named blue hake (*Antimora rostrata*) were analyzed. *Antimora rostrata* is resident throughout the world's oceans at depths of 1000-3000 m but does not venture into depths shallower than 800 m [actually about 200 m in the cold waters of the polar region]; therefore, this deep-sea species is not exposed to local estuarine, coastal, or atmospheric inputs of mercury. A sample of 21 specimens collected in the 1880s was compared with a sample of 66 specimens collected in the 1970s in the western North Atlantic Ocean. In both recent and old fish mercury increased as a function of length, but comparison of the two concentration vs. length relationships shows that there has not been an increase in mercury concentration in deep-sea fish in the last century. This result supports the idea that the relatively high concentration of mercury found in marine fish that inhabit the surface and deep waters of the open ocean result from natural processes, not 20th century industrial pollution."

Barber et al. (1984) Environmental Science & Technology, vol. 18, 552-555; Barber et al. (1972) Science, vol. 178, 636-639

Figure 4-2: The mercury-fish length relation for Atlantic blue hake caught in the 1970s and 1880s. No clear change in the mercury-fish length relation between the two eras suggests that mercury levels in blue hake are largely unrelated to any trends in man-made mercury emissions.

Figure 4-3 compares mercury levels in various samples of tuna, including those from canned tuna more recently compiled by FDA and EPA. Dated fish samples from the Smithsonian museum (1878-1909) indicate a relatively elevated mercury level associated with past sources and exposure unrelated to modern power plant mercury emissions. These old samples contain a mean level of about 0.38 ppm, significantly exceeding the mean levels of 0.29 ppm and 0.15 ppm for the 1971-1972 samples and the large FDA (1993) 220-canned tuna samples, respectively. The authors of this important research concluded:

> "The data for both tuna and swordfish [not discussed in this report] lend support to the contention that the **mercury levels now being found in wide-ranging ocean fish are *not* primarily the consequence of man-made pollution but are *of natural* origin**."[37] [Emphasis added]

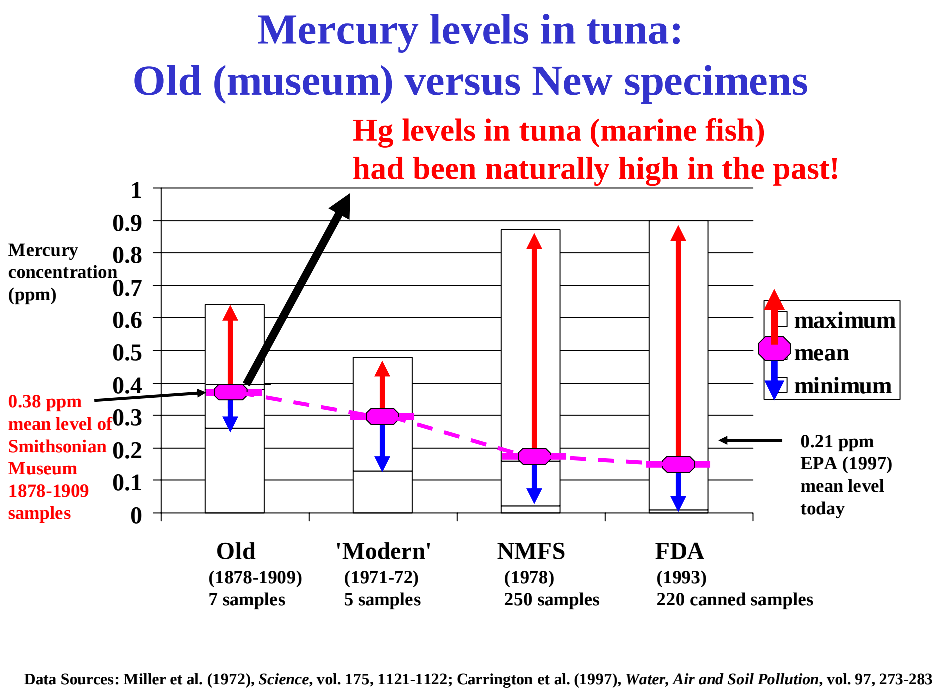
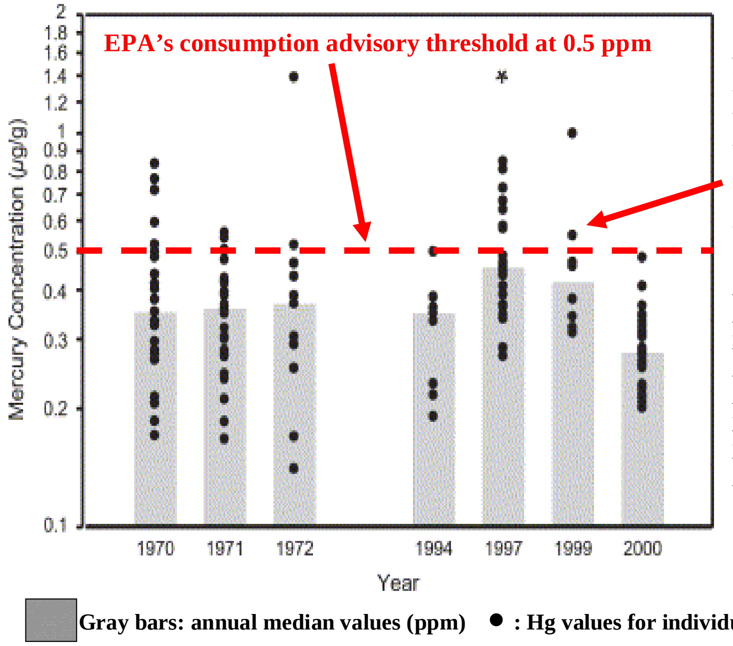


Figure 4-3: Comparison of mercury levels in old 1878-1909 tuna samples from the Smithsonian Museum and modern 1971-72 samples. Additional values are tuna mercury measurements performed by National Fisheries and Marine Services in 1978, FDA's canned tuna samples as well as the EPA's canned tuna samples.

Figure 4-4 adds new evidence against the theory of an increasing trend in MeHg fish levels by examining concentrations in the tissue of striped bass from the San Francisco Bay area over the period 1970-2000.[38] The result shows that in any given year there is at least one striped bass sample containing mercury values above EPA's consumption advisory threshold value of 0.5 ppm. Perhaps even more significant, those striped bass with mercury concentration values above 0.5 ppm *had no apparent connection* to any power plant or industrial Hg emissions.

Figure 4-4 reveals another important finding from the Greenfield et al. (2004) study. Even though no accumulation trend was noted for mercury in striped bass in the 1970-2000 intervals, significant declines in the late 1990s were noted for other contaminants like DDT and chlordane in San Francisco Bay fish tissues. The authors suggest that these declines may be linked to known curtailed usage of the two chemicals in the 1970s and 1980s. Thus, the combined findings suggest a more complicated and complex chain of methylation and bioaccumulation of mercury in fish than supposed in EPA's current modeling efforts. That is, compared to other contaminants it appears that the pathway and behavior of mercury transformation and accumulation in fish differs significantly from that of other contaminants.

<u>No evidence of increasing trend in Hg concentration</u> in striped bass caught off San Francisco Bay area from 1970-2000



Note that at any given year there is at least one striped bass with Hg level at or above the EPA's consumption advisory threshold of 0.5 ppm since 1970 with no apparent tie to any US power plant Hg emission sources. Also <u>although no increasing trend is clear for Hg, declines were noted in the fish tissue's DDT and chlordane in the late 90s. Those declines may be related to the use curtailment of these two chemicals in the 70s and 80s.</u>

Greenfield et al. (2004) Science of the Total Environment, in press

Figure 4-4: Mercury levels for stripped bass caught in San Francisco Bay. The results clearly shown that at any given time, available measurements of the stripped bass mercury levels had exceed the EPA's consumption levels set either at 0.5 ppm or even 0.3 ppm.

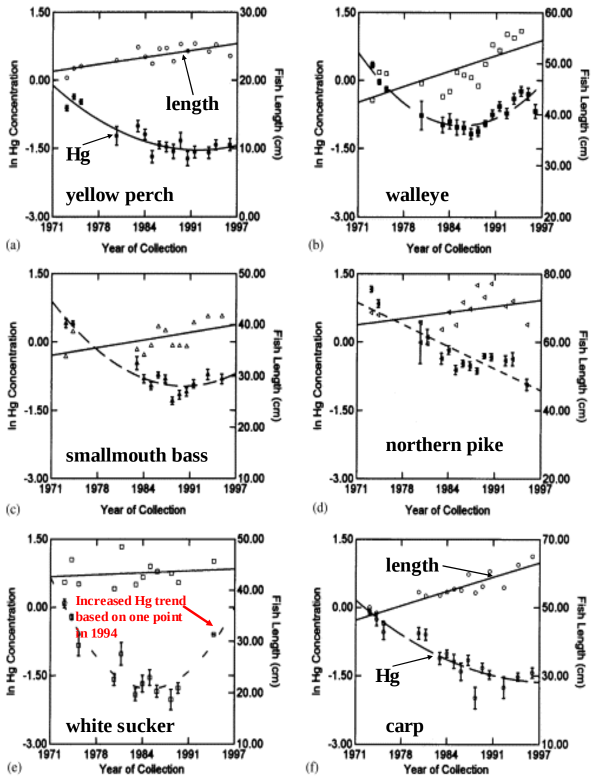
A similar tendency was recently reported[39] for levels of contaminants in fish from upper River Thames in Britain by a group of zoologists from Oxford University and Cornell University. These authors concluded that although the recent decrease in the contamination level of PCBs may be partly associated with industrial and human activities, it was *difficult* to find such associations for mercury.

Figure 4-5 presents recently published fish mercury data sets for various sport fish species (yellow perch, walleye pike, smallmouth bass, northern pike, white sucker, and carp) caught from 17 "areas of concern for mercury contamination" in the Canadian **Great Lakes** from 1971 to 1997. The results again evidence that **historical changes in mercury concentrations *are not* simply to be expected from local industrial Hg emissions**. In fact, the author concluded that[40]

> "Differences observed [among different areas of concern] did *not* consistently parallel expectations associated with historical presence of chlor-alkali plants in the vicinities of some locations." [Emphasis added]

Equally important, the author also noted that "An attempt to correlate the fish tissue mercury with the frequency of occurrence of infantile cerebral palsy at AOC [areas of concern] was unsuccessful." This fact illustrates the great difficulty in confirming various popular claims regarding trace MeHg causing serious childhood neurological health complications.

Hg concentration in sport fish from Canadian Great Lakes areas of concern: No link to occurrence of infantile cerebral palsy



"The tissue mercury concentration in six species of fish collected at the 17 Areas of Concern [AOC] ... were analyzed. A linear increase in Hg concentration with fish length was found, but slopes differed among locations. The temporal pattern over the period 1971-1997 differed across species in fish collected in Lake St. Clair; in at least two species there was evidence of increased mercury concentration during the 1990s that had been suggested in an earlier analysis. AOC differed significantly in observed tissue concentrations. Differences observed did not consistently parallel expectations associated with historical presence of chlor-alkali plants in the vicinities of some locations. An attempt to correlate the fish tissue mercury with the frequency of occurence of infantile cerebral palsy at AOC was unsuccessful."

Weis (2004) Environmental Research, vol. 95, 341-350

Figure 4-5: Mercury content in for 6 fish species from the so-called "area of concern" for mercury contamination (and 10 other toxic substances) in the Canadian Great Lakes and their trends since 1971

Section 5 – Working Hypothesis for Explaining Recent Fish Advisory Trends

This section expands previous comments on EPA's 2003 NLFA advisories concerning the apparent dramatic rise in total U.S. river miles and lake acres under fish advisories. From 1993-2003, the river miles advised increased from 74.5 thousand miles to 846.3 thousand, an overall jump of almost 800% in just 10 years. A similarly remarkable statistical increase occurred for the lake acres advised, from a low of 3.4 million acres to 14.2 million acres, a sharp rise of more than 400% in the same decade (see **Figures 2-3, 2-4**).

Despite these statistics, it could be reasonably argued that the systematic increase of river miles and lake acres advised in the U.S. is *unrelated* to the state of MeHg levels in fish tissue or any increased in risk of MeHg exposure to consumers. There are at least five reasons to support this point of view.

First**,** as EPA's 2003 NLFA fact sheet highlights, U.S. industrial emissions of mercury have declined by almost 50% since 1990, rendering unpersuasive the assertion that the rising trend of rivers and lakes advised is due to increasing mercury "pollution" from U.S. industrial sources (see **Figure 10-1** below).

Second**,** measured estimates of atmospheric deposition of Hg either through dry air deposition or wet rain deposition show no particular pattern of increase in many locations through out the U.S. It is unconvincing that increased advisories for river miles, lake acres or even dramatically large percentages for coastal zones of the Atlantic, Gulf of Mexico and Pacific (see **Figure 2-1**) resulted from increased "pollution" levels for the 1993 to 2003 time frame.

Third**,** recreationally-caught or non-commercial fish *is not a large portion* of the total consumption of fish/seafood products in the U.S. Thus, large increases in the number of river miles and lake acres advised simply cannot be related to actual lake or river fish consumption or any real increase in risk of exposure to MeHg from those fish. Based on the recent statistics from the United Nations Food and Agriculture Organization, domestic fresh water fish may account for as little as 0.5% of the total U.S. fish/seafood consumption.[41] This fact alone illustrates that EPA's NLFA may already represent widespread extreme precaution based on limited risk to a small group of actual freshwater fish consumers.

Fourth**,** there is no clear sign of any dramatic increase in fish tissue MeHg for inland watershed or ocean fish warranting immediate alarm or the broad triggering of local fish consumption advisories. **Figure 5-1** shows a rather significant *decrease* in the mercury content in yellow perch tissue from the western basin of Lake Erie. **Figure 5-2** shows plausible trends in fish tissue mercury (including peamouth, largescale sucker, northern squawfish, yellow bullhead, black crappie, walleye, and yellow perch) from sites in the Northwestern U.S. These data came from the earlier National Contaminant Biomonitoring Program (NCBP).[42] Clearly, although there may be remaining questions about technical and statistical precision concerning these older measurements, the evidence clearly suggests no rising trend warranting increases in fish advisories. (See **Section 4** for discussion about mercury levels in fish over time.)

All the above data on fish tissue MeHg concentrations and U.S. industrial Hg emissions clearly point to the **lack of any factual basis for attributions of sharp and dramatic increases in the number of State advisories to climbing levels of industrial emissions.**

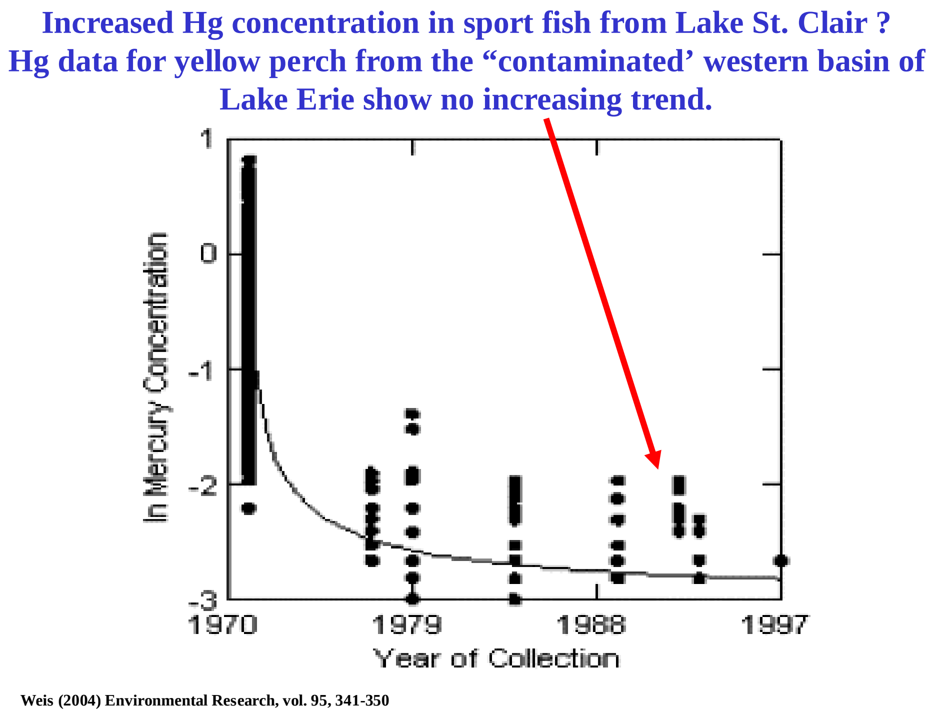


Figure 5-1: Mercury concentration in yellow perch from Lake Erie from 1971 through 1997 show a dramatic *decrease*. The mercury concentration levels range from about 0.05 ppm to 2.72 ppm.

Fifth**,** another puzzling aspect (see **Figure 5-3**) is that while the number of advisories has *increased* dramatically since about 1993, over that same period the number of fish tissue-mercury *records* upon which the advisories are supposedly based dramatically *declined*.[43] This suggests that the large increase in State advisories *cannot* be explained[44] by any actual increased monitoring efforts or actual increased measurements performed at a greater number of U.S. rivers and lakes. This observation is surprising considering that many governmental authorities, including the EPA, have given the impression that our waters have been increasingly monitored or continuously measured, especially over the last 10 years.

One could conclude that the *rising* trends for several important variables contained in the National Listing of Fish Advisories collected over the decade, especially with regard to mercury as a toxic contaminant, are ***not related*** **to the** ***reputed*** **increases in "pollution" by industrial mercury emissions, or to any** ***reputed*** **increases of the MeHg in fish**

tissue. What might be observed here is **a phenomenon of State advisories being largely driven by unwarranted socio-political pressures, media transmitted alarmism and professionally run campaigns** seeking draconian reductions in power plant emissions, at any cost. (See further explanation and discussion in **Sections 7, 8, 9, 10**)

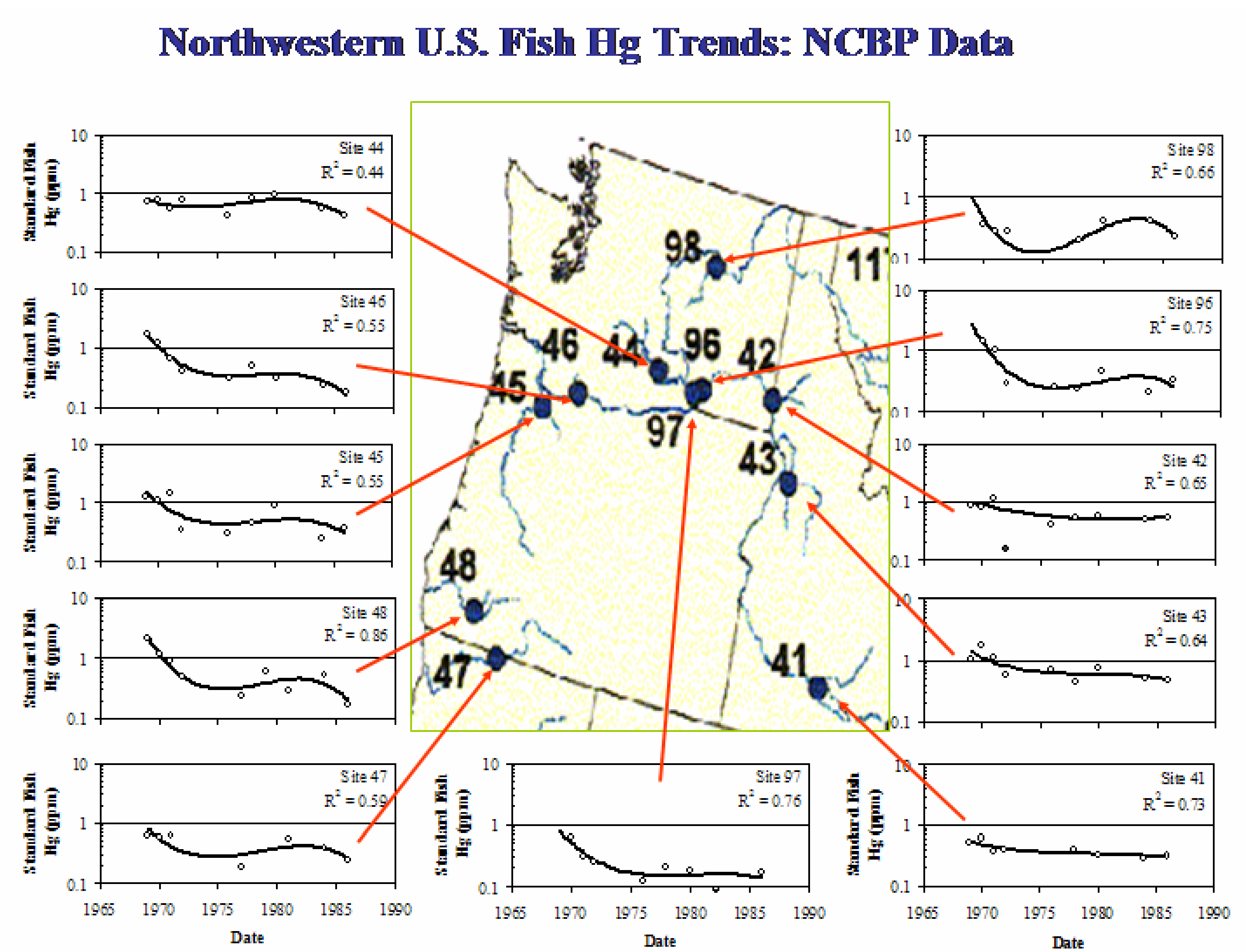
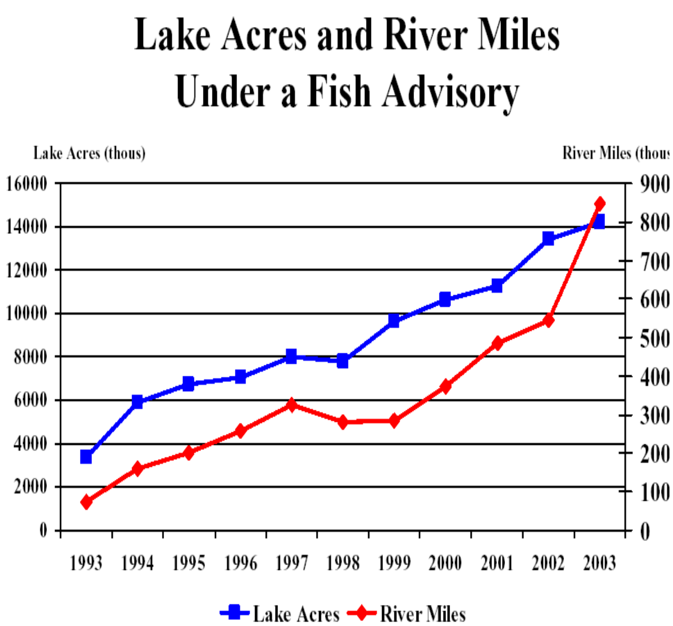


Figure 5-2: *No dramatic increase* in Fish tissue mercury trends from 1969 to 1986 for fish collected from the Northwestern U.S. (Collected under the National Contaminant Biomonitoring Program, NCBP, maintained by the U.S. Fish and Wildlife Service (based on the January 25-28, 2004 presentation at the EPA's National Forum on Contaminants in Fish by Stephen Wente, USGS, and colleagues)

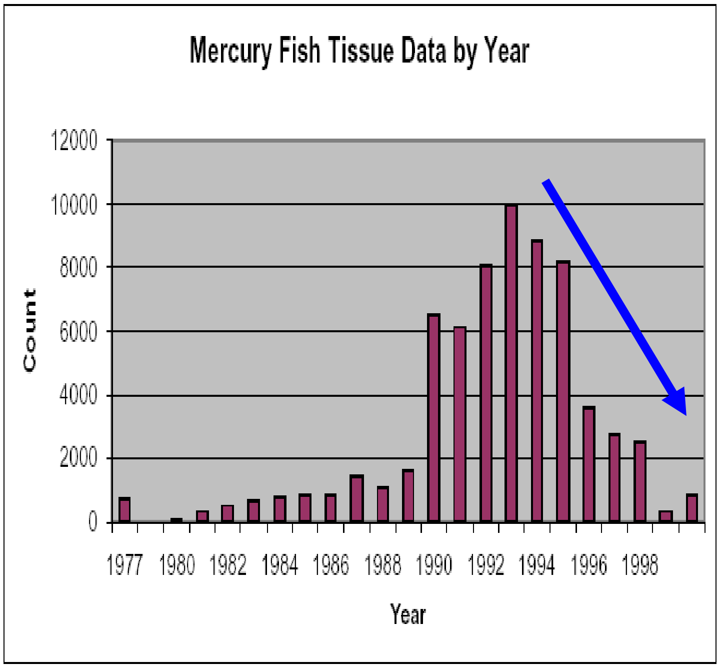
Why the Sharp Lake+River Advisory Increases Since 1993? Fish-mercury Data Actually Decreased Substantially Since the Peak in 1993!

Hypothesis: Fish advisory increases are *not* due to increased monitoring as claimed by EPA (August 2004), but are more likely reflective of socio-political pressures and public health concerns/scares.

Data collected in the EPA's National Listing of Fish and Wildlife Advisories (NWFLA) Fish Tissue Database [which contains a total of ~69,000 fish tissue mercury records to date (but only 35,000 calibrated to USGS's EMMMA project--January 2005)]



Adapted from EPA's August 24, 2004's presentation on the 2003 Fish Advisories



Adapted from EPA's September 2001's *Mercury Maps* report (EPA-823-R-01-009)

Figure 5-3: A working hypothesis that the increase in the lake acres and rive miles advised under the NLFA from 1993 to present may not be derived from increased monitoring (as claimed by EPA, August 2004) or increases in fish tissue MeHg (as variously claimed in the media), but instead may be largely driven by unwarranted socio-political pressures and health alarmism.

Section 6 – Specific Examples of Individual State Advisories: Alaska, Maryland, Pennsylvania, and Virginia

As explained in the EPA's official 2003 NLFA web site[45]:

> "EPA simply provides as a service to the public a central "one-stop" repository for the convenience of the public. EPA has issued guidance that provides information for the States to assist in developing methods of monitoring, gathering and assessing information about their fish populations but it is not mandatory. *The States have primary responsibility for these decisions.* Thus the basis for each State fish advisory varies. *Each State determines the scope and extent of monitoring, how to decide which waters should be placed under advisory,* etc., thus the information is highly variable and difficult to draw conclusions or trends." [Emphasis added]

Thus, in order to enhance an understanding of fish advisories, this section compares and contrasts advisories in the various States. Herein, we select three neighboring eastern States for comparison: Maryland, Pennsylvania and Virginia. We add Alaska for the purpose of exhibiting that State's rationale for issuing no consumption restriction at all.

EPA's NLFA has provided several important and useful web links for State advisory research:

(1) http://map1.epa.gov/scripts/.esrimap?name=Listing&Cmd=StContacts
This site contains contact information for advisory coordinators in all 50 States, Tribes and Canadian provinces.

(2) http://epa.gov/waterscience/fish/states.htm
This site provides quick links to fish advisory programs in all 50 States and U.S. territories.

(3) http://oaspub.epa.gov/nlfwa/nlfwa.bld_qry?p_type=tisrpt&p_loc=on
This site details fish mercury measurements available for many in-State locations. **Table 6-1** summarizes available mean composite fish mercury concentrations and the status of the 2002[46] fish advisory program with data available for the 39 States reported in *The National Survey of Mercury Concentrations in Fish—Data Base Summary 1990-1995* by the EPA.[47] The table further provides States' power plant mercury emissions for a relative comparison of local mercury emission source, fish tissue mercury and related or unrelated fish consumption advisories. Entries for **Table 6-1** may require further improvements and it is intended only to provide a broad overview of the fish mercury data and fish mercury advisories in each State since such data sets are rarely compiled or made available in a single table.

Table 6-1: Mercury concentrations in freshwater fish, number of State mercury advisories (in 2002), and power plant mercury emissions for 39 U.S. States (with data available)

State	# of fish records	Mean fish Hg (ppm)	# of mercury advisories	Power plant mercury emissions (lbs)
AL	208	0.364	11	4931.3
AZ	51	1.147	5	1254.5
AR	809	0.673	20	1011.8
CA	386	0.151	13	8.7
CT	618	0.464	11	71.1
DE	48	0.078	5	207.1
FL	2819	0.604	65	1921.3
GA	667	0.172	122	2977.5
IL	99	0.159	4	5989.1
IN	502	0.172	155	4883.7
IA	130	0.146	n/a	1949.2
KS	193	0.164	n/a	1650.0
KY	200	0.276	2	3479.9
LA	1021	0.318	29	1006.7
ME	352	0.499	4	4.1
MD	317	0.041	2	1820.1
MA	550	0.285	99	292.2
MI	4199	0.233	85	3082.6
MN	5361	0.225	984	1264.7
MS	378	0.575	11	679.1
MO	390	0.126	1	2744.2
NE	271	0.184	17	833.1
NH	169	0.359	7	37.0
NJ	373	0.530	86	196.1
NM	350	0.454	26	2180.1
NY	968	0.394	32	1027.4
NC	2808	0.383	2	3076.2
OH	1457	0.133	35	7109.0
OK	342	0.289	n/a	1722.0
OR	554	0.304	12	168.3
PA	276	0.232	76	9958.6
SC	498	1.085	62	1067.7
TN	230	0.253	2	2250.1
TX	199	0.210	13	10045.2
VT	201	0.464	9	0
VA	58	0.534	3	1266.3
WA	56	0.133	3	529.7
WV	104	0.173	1	4931.8
WI	3364	0.264	81	2263.9

Alaska:

Alaska issues **no** fish consumption advisories. The Office of Public Health issued a series of notices explaining its position on advisories (all emphasis added unless otherwise noted):[48]

> Mercury and National Fish Advisories Statement from Alaska Division of Public Health Recommendations for Fish Consumption in Alaska
>
> State of Alaska Epidemiology Bulletin
>
> Bulletin No. 6
> June 15, 2001
> Recommendations for Fish Consumption in Alaska

* The national fish advisories from the U.S. Environmental Protection Agency (USEPA) and U.S. Food and Drug Administration (USFDA) issued January 25, 2001 were *general advisories and were not based upon data on mercury levels in fish from Alaska*. The FDA has acknowledged that mercury levels in Alaska fish are far below the average levels upon which the FDA issued their advisory. As a result, the FDA amended their original advisory, recommending that consumers contact local health or food safety authorities for specific consumption recommendations.

* The Alaska Division of Public Health has reviewed data on the levels of mercury in Alaska fish and humans. Fortunately, *mercury levels are very low* in the most frequently consumed fish from Alaska, such as salmon, cod, halibut, pollock, sole, and herring. *Mercury levels in salmon are among the lowest found*.

* Extensive scientific research has documented the numerous health, social and cultural, and economic *benefits* of eating fish.

* Eating fish provides inexpensive and readily available nutrients, vitamins, essential fatty acids, antioxidants, calories and protein that contribute to *significant health benefits*.

* Proven health benefits include protection from *cardiovascular disease* and diabetes, and *improved maternal nutrition and neonatal and infant brain development*.

* The subsistence lifestyle and diet are of great importance to the self-determination, cultural, spiritual, social and overall health and well being of Alaska Natives.

* The known benefits of fish consumption *far outweigh* the *theoretical* and *controversial* potential *adverse health effects* from mercury found in Alaska fish.

* Substitution of other less healthy, less nutritious food for Alaska fish would result in *far greater harm* to health.

* The report, "Brain Food. What women should know about mercury contamination of fish," published by the U.S. Public Interest Research Group (USPIRG) Education Fund and the Environmental Working Group, Washington, D.C., is NOT a credible source of health and dietary recommendations for Alaskans, and the Alaska Division of Public Health does NOT support its recommendations. [Emphasis in original]

* The Alaska Division of Public Health continues to *strongly* recommend that all Alaskans, including *pregnant women*, women who are breast feeding, women of childbearing age, and *young children* continue *unrestricted* consumption of fish from Alaskan waters.

* An extensive collaborative program of research and monitoring of mercury in Alaska fish and in Alaskans who consume fish is needed and is being developed to increase the amount of data on mercury levels and follow trends in the future.

This statement has been endorsed by the following agencies and organizations:

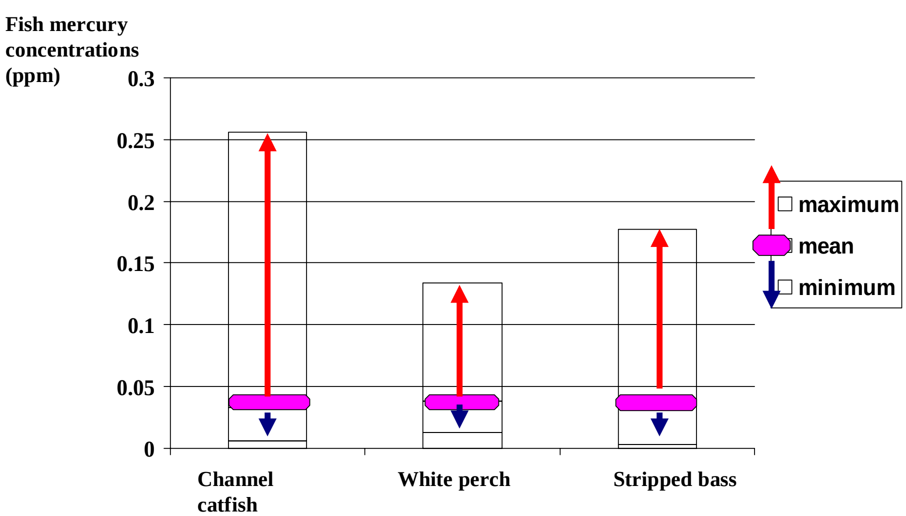
Alaska Department of Environmental Conservation
Alaska Department of Health and Social Services
Alaska Native Health Board
Alaska Native Science Commission
Alaska Native Tribal Health Consortium
Aleutian/Pribilof Islands Association, Inc.
Institute for Circumpolar Health Studies, University of Alaska Anchorage
North Slope Borough
University of Alaska Fairbanks
Yukon Kuskokwim Health Corporation

The above observations by Alaska when compared to other states certainly support EPA's NLFA statement that State fish advisories vary quite dramatically from one State to another. It must be further noted that in order to protect its citizen from exposure risk to methylmercury from fish, the state of Alaska is actively pursuing several mercury biomonitoring programs. For example the Alaska Division of Public Health offers free and confidential hair mercury testing to all pregnant women in Alaska and the data collected thus far from 39 Alaskan communities yielded median and mean hair mercury levels of 0.47 ppm and 0.71 ppm, respectively for those pregnant women (see results summarized in endnote 80). Another set of measurements for currently non-pregnant women of childbearing age gave the median and mean hair mercury concentrations of 0.63 ppm and 1.2 ppm, respectively. Finally, the Alaska Native Tribal Health Consortium has also recently measured cord-blood mercury levels from 81 mother-infant pairs from Barrow and Bethel areas. The average cord-blood mercury concentrations were 1.5 ppb for Barrow and 6.5 ppb for Bethel samples. According to scientists from the Alaska Division of Public Health, these average blood mercury concentration levels are well below the Health Canada guideline of 20 ppb and the World Health Organization so-called No Observable Effect Level of 56 ppb in blood mercury.[49]

Maryland:

In 2003, Maryland is one of 21 States with a State-wide fish consumption advisory, covering about 78 thousand acres of lakes and reservoirs and 17 thousand miles of its freshwater rivers and streams. In terms of industrial emissions, Maryland accounts for a 2002 estimated total of 3295 lbs/year, and according to the EPA 1999 statistics[50] power plant-only mercury emissions account for 1820 lbs/year. Maryland ranks 20th nationally in mercury emissions.

Fish mercury levels for the top-3 most abundant freshwater fish from Maryland are not high
(all below the EPA's fish advisories thresholds of 0.3 to 0.5 ppm)



Data source: *The National Survey of Mercury Concentrations in Fish—Data Base Summary 1990-1995* (EPA-823-R-99-014)

Figure 6-1: Fish mercury levels for the top-3 most abundant freshwater fish (channel catfish, white perch, and stripped bass) found in Maryland waters.

Figure 6-1 shows the mercury concentrations in the three most abundant freshwater fish sampled for the State of Maryland: Channel catfish, white perch, and stripped bass. Together with the mean value shown in **Table 6-1**, the mercury concentration levels for the fresh water fish in Maryland are low – none even exceeding the 0.3 ppm advisory threshold recommended by EPA. Yet, Maryland has adopted a State-wide advisory.

The official *Guide to Safer Fish Consumption for Women and Children in Maryland* warns:

> **"**In Maryland, mercury is the main contaminant of concern in freshwater game fish and certain types of store-bought fish … If you are pregnant or expect that you may become pregnant in the future, this is a good time to begin following the guidelines. Babies born to mothers who have a lot of mercury in their bodies may develop more slowly and have problems learning."

The statements in the Maryland "guide" are ambiguous and scientifically in dispute, and do not appear derived from the actual fish data. Secondly, it appears Maryland has chosen to ignore the documented positive health and nutritional benefits of fish consumption on pregnancy, birth and childhood development[51] (See this endnote for a more detailed challenge to the health advisory by Maryland's Department of Environment).

Thus, it seems reasonable to conclude that most fish advisories issued in Maryland are rooted more in ultra-precautionary grounds than actual data or danger related to mercury contaminated fish found in Maryland's waters.

Pennsylvania:

In 2001, Pennsylvania initiated a State-wide consumption advisory for mercury that now covers 161.5 thousand acres of its lakes and 54 thousand river miles. Pennsylvania accounts for about 15,041 lbs/year (in 2002) in mercury emissions, ranking it one of the top emitters in the nation.

Figure 6-2 shows mercury concentrations in the three most abundant freshwater fish sampled in Pennsylvania: smallmouth bass, largemouth bass, and brown trout. Except for a few individual high-end values, mean values of Hg_T concentrations seem moderate with all three fish species not exceeding EPA's recommended fish advisory value of 0.3 ppm.

Similar to Maryland, the Pennsylvania Department of Environmental Protection specifically warned:

"Health problems that *may* [original emphasis] result from the contaminants [i.e., namely PCBs, chlordane, and mercury listed in the webpage] found in fish range from small changes in health that are hard to detect to birth defects and cancer. Mothers who eat highly contaminated fish for many years before becoming pregnant may have children who are slower to develop and learn."

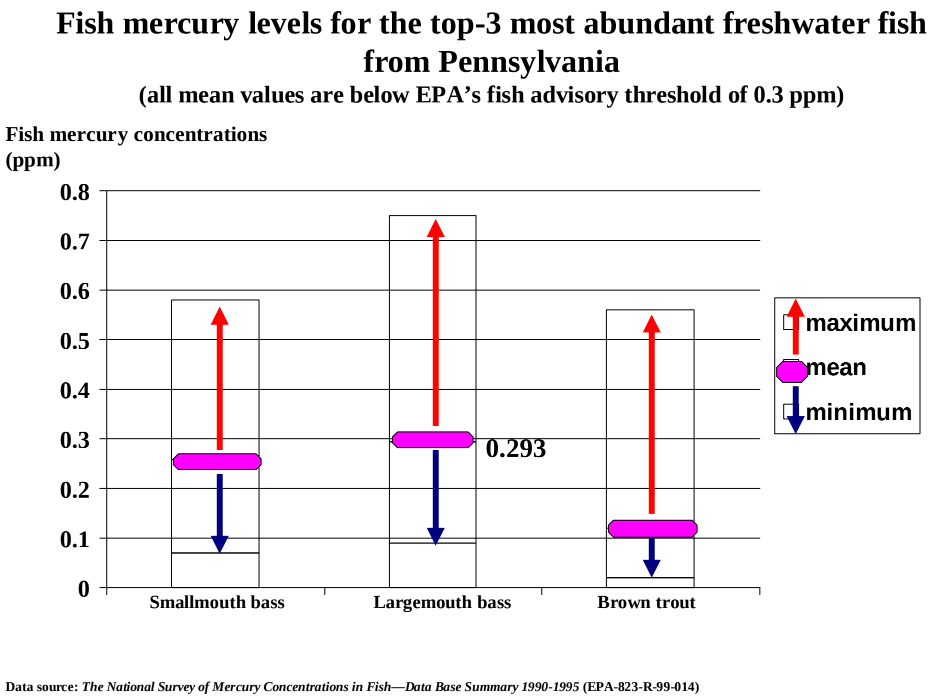


Figure 6-2: Fish mercury levels for the top-3 most abundant freshwater fish (smallmouth bass, largemouth bass, and brown trout) from Pennsylvania.

Thus, fish consumption advisories in Pennsylvania, like Maryland, appear motivated as much by political considerations as by a comprehensive documentation of high mercury levels for fish caught in its rivers and lakes.

Virginia:

EPA estimates that Virginia power plants accounted for Hg emissions of 1266 lbs/year in 1999, ranking 23rd in the nation. Unlike its two neighboring States that share some of its watersheds and rivers, Virginia has not issued a *State-wide* fish consumption advisory. Instead, Virginia addressed its fish mercury concerns on a case-by-case basis.

The Virginia Department of Health official website labels PCBs "the most common contaminant resulting in fish consumption advisories in Virginia." Thus, in contrast to both Maryland and Pennsylvania, Virginia considers mercury less a public health issue than PCBs for recreationally caught fish.

Figure 6-3 shows Hg_T concentrations in three abundant freshwater fish: Redfin darter, papio, ocean pout. While mean levels are relatively high, the highest mercury value for the redfin darter and papio caught in Virginia waters are as high as 8 ppm and 5 ppm, respectively. Clearly, such high values are considered likely exceptional rather than usual, as the Virginia Department of Health did not consider these values alarming enough to trigger widespread consumption advisories. It should also be noted that mean mercury values for the top-2 species (redfin darter and papio) are above the EPA's threshold value of 0.3 ppm for recommending fish consumption advisories, but Virginia has apparently decided to focus on PCB contamination, which appears more prevalent and health-threatening than MeHg in fish. (It is worth remembering that Hg_T levels may not reflect actual values for MeHg levels due to presumptions discussed in **Section 3**.)

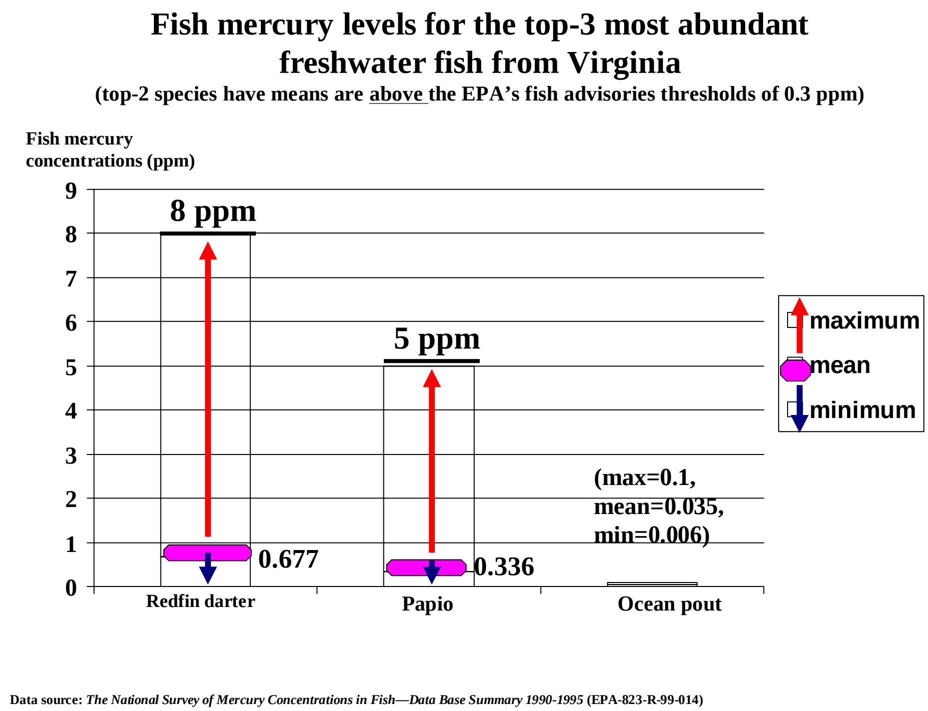


Figure 6-3: Fish mercury levels for the top-3 most abundant freshwater fish (redfin darter, papio, ocean pout) from Virginia.

Section 7 – Most States Adopt EPA's Ultra-Precaution as Basis for Fish Advisories

Science is clear that methylmercury (MeHg) content in fish varies drastically across species, across size within same species and across ecosystems. This section examines the assumptions EPA uses in its formula for determining "safe" levels of MeHg in fish. The EPA recommended value of 0.3 ppm is the fish mercury threshold adopted by many States for setting their own advisories. Any errors made by EPA at this stage, such as its scientifically unjustified preference for ultra-precaution in health exposure to MeHg, get multiplied by State actions.

Because of the great importance, a number of examples are presented supporting the contention that EPA's assumptions of "safe" MeHg health exposure reference dose, or RfD, are extreme and may be endangering public health. Making matters even worse, there appears a trend of some States rationalizing even *lower* fish tissue residue criteria for issuing advisories.

In its January 2001 report *Water Quality Criterion for the Protection of Human Health: Methylmercury*,[52] EPA derived a new fish tissue residue criterion (**TRC**) value of 0.3 ppm MeHg utilizing the following formula:

$$\mathbf{TRC} = \frac{\mathbf{BW \times (RfD - RSC)}}{\mathbf{FI}}$$

where

TRC = Fish tissue residue criterion (in mg of MeHg/kg fish) for freshwater and estuarine fish

RfD[53] = Reference dose of 0.0001 mg MeHg/kg body weight/day (**or 0.1 μg/kg (b.w.)/day**).[54] The RfD is sometimes referred to as the "safe dose" amount of MeHg that an individual can consume *daily* over a *life-time* without adverse effects.

RSC = Relative source contribution estimated to be 2.7×10^{-5} mg MeHg/kg body weight/day (or 0.027 μg/kg (b.w.)/day) to be subtracted from the RfD to account for marine fish consumption

BW = Human body weight---assumed in the 2001 EPA report/analysis to be 70 kg for adults

FI = total sum of fish intake from 3 ecosystem tropic levels assumed to be an intake of about 17.5 g/day or 0.0175 kg/day

This formula yields an estimated fish tissue MeHg value of about **0.3 ppm** (parts per *million*) *if* one inserts all the above "default" input values supplied by EPA.

Therein lays the arbitrariness in EPA's formula results. For example, if one adopts into the formula an *alternative* MeHg RfD value of **0.3 μg/kg (b.w.)/day,** as preferred by the Center for Disease Control's (CDC) Agency for Toxic Substances and Disease Registrar (ATSDR 1999),[55] then a *less* precautionary value for the threshold fish tissue MeHg of **1.1 ppm** could be established. This value would, in turn, trigger far fewer State fish advisories, less public confusion and alarm, and fewer potential public health problems from fish-restricted diets. The RfD value of **0.3 μg/kg (b.w.)/day** *was* the previously accepted EPA "safe" MeHg dose value in the 1980s, before the ultimate lowering to the currently assumed value of **0.1 μg/kg (b.w.)/day** in 1995[56] (see this extensive endnote for further details).

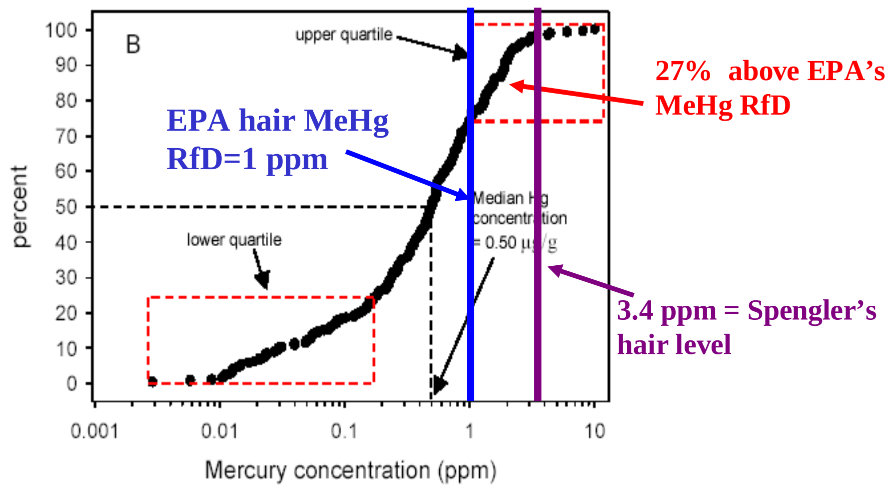
There is another reasonable alternative RfD value available to EPA. A panel of risk assessment *experts* – convened in January and February of 1998[57] – derived a set of "site-specific" MeHg RfDs ranging from **0.3 to 1.0 μg/kg (b.w.)/day**, with the median value of **0.54 μg/kg (b.w.)/day.** This range of values is believed *more appropriate* for fish-eating populations, like those in Lacava Bay, Texas. Accordingly, *if* this expert-derived RfD mean value of **0.54 μg/kg (b.w.)/day** were adopted, then a threshold value of fish tissue MeHg as high as **2 ppm** would be tolerable before triggering a fish advisory. In other words, if **2 ppm** was the adopted threshold, then *almost no State fish advisories would seem necessary.*

To further judge the *extreme* precautionary, potentially health-threatening approach inherent in EPA's current MeHg RfD, consider the following evidence.

First, it is clear from the ethical guidelines established by the Institutional Review Board of the National Center for Health Statistics of the CDC – the governing body which approved the recent National Health and Nutrition Examination Survey (NHANES) mercury survey for U.S. women and children – that caution notices are issued to NHANES participants *only if* their total hair mercury levels are above *15 ppm* or total blood mercury exceeds *200 ppb* [parts per *billion*] (McDowell et al., 2004).[58] In contrast, EPA considers hair levels safe only *below 1 ppm*, and blood levels safe only *below 5.8 ppb*. Again, these levels are dramatically more conservative than the ethical guidelines established by the Institutional Review Board of the CDC.

Secondly, it is strikingly obvious from the latest results of Japanese hair mercury measurements of 8665 individuals – collected in 10 different Japanese locations between 1999 and 2002[59] – that the *overwhelming majority* of Japanese, i.e., *87%*, has hair mercury levels *exceeding* the mercury "safety" level set by EPA's RfD. Since there is no detectable epidemic of mental impairment in either Japanese adult or child populations, the study could reasonably be interpreted as further confirming the *ultra-precautionary* nature of the current EPA RfD level for MeHg. That is to say, actual levels of concern for MeHg exposure occur at much higher levels (i.e., 80 to 220 ppb in blood mercury) than the RfD value of 5.8 ppb in blood mercury connected to the EPA's fish advisory formula.

Indicator of extremity in EPA's MeHg RfD? Hair mercury levels from 260 members of the Society of Environmental Journalists (SEJ) + the coordinator (Spengler) of the SEJ study?



70 out of the 260 SEJ members (or 27%) have hair Hg levels above EPA's recommended "safe exposure level" of 1 ppm

Senn, Lincoln & Spengler (2005) *SEJ Mercury Biomarker Study Report* [available at http://www.hsph.harvard.edu/water/SEJHgStudy.pdf] (a project funded by the Heinz Endowment)

Figure 7-1: Hair sample survey for 260 members of the Society of Environmental Journalist (SEJ) attending December 2004 Pittsburgh meeting. 27% (or 70 members) had tested hair levels above EPA's recommended "safe exposure level" of 1 ppm.

Third, consider an odd survey result for hair mercury levels for 260 members of the Society of Environmental Journalist (SEJ) attending a December 2004 meeting in Pittsburgh (**Figure 7-1**). Up to 27% (70 members) of attendees tested had hair mercury levels *above* what is considered "safe" by EPA's RfD. **Is one thus justified in assuming a large portion of environmental journalists may be neurologically impaired?** If not, then an alternative interpretation of the results could raise further suspicion that EPA's MeHg RfD is *overly conservative and ultra-precautionary*.

The coordinator for this SEJ study, Professor John Spengler of the Harvard School of Public Health, found his own hair mercury level to be 3.4 ppm (which is *more than 3 times* the EPA limit; see **Figure 7-1**), upon which he commented:

> "But I'm not going [to be] apoplectic about it because I know if I just watch my consumption, I can moderate that over time ... and *there's that safety margin* [i.e., a factor of 10] ... that I suspect I'd have to be *much higher for much longer* to *really* have symptoms." [Emphasis added]

Thus, the evidence is clear that States should *not* consider EPA's fish mercury TRC (or tissue residue criterion) described in the formula above as a strict "bright line" above which fish are unsafe to eat. Other varying factors, including the sizeable safety margin of 10 inserted into EPA's MeHg RfD (as noted in Professor Spengler's remarks), can further skew final determinations of "safe" versus "unsafe" underlying the various and disparate State fish advisories.

Nevertheless, there appears a popular tendency for some States rationalizing *even lower fish MeHg criterion* for issuing fish consumption safety advisories.[60] This tendency also appears based more on political preference for levels of precaution than science-derived levels of real harm.

For example, it was recently reported[61] that "the method employed by the Vermont Department of Health to set tissue advisories, based on 'normal' fish consumption patterns, yields a maximum tissue Hg concentration of approximately *0.2 ppm*. Above this value, limited fish consumption is advised for some portion of the population." [Emphasis added]

Similarly, the Minnesota Pollution Control Agency (December 15, 2004 report[62]) recently proposed that Minnesota's target threshold level for mercury in fish should be *0.2 ppm* rather than EPA's 0.3 ppm criterion, arguing that there is a "higher consumption rate" in that State.[63] At or below this new criterion pregnant women, women intending to become pregnant and children under 15 years of age are recommended to consume only one meal of Minnesota fish per week; if the Minnesotan's fish mercury is above 0.2 ppm, then only one meal per month is advised.

Tendencies toward more stringent, lower thresholds for triggering fish consumption advisories may come at a costly price for the public health, especially potentially endangering the health of women and children.

Section 8 – "First Do No Harm" – Potential for Public Confusion and Negative Health Consequences

Extracts from the growing body of scientific literature presented in this paper make clear the serious hurdles and troublesome problems relative to current fish advisories, whether from individual States for local, non-commercial fish or from federal agencies like FDA and EPA for fish commercially harvested or farm raised.

This section examines a particularly urgent concern over the prevalent confusion and diminished public health protection resulting from seemingly arbitrarily set advisories. Advisory rules appear to be set mostly according to *differing thresholds of believed harm, tolerance for levels of caution, definitions of risk subgroups and related political pressures* within each State. This sometimes results in mismatches and conflicting goals/interests between State and federal authorities. There seems to be little or no consideration given to potentially enormous loses of nutritional benefits derived from fish consumption, especially for pregnant women and children. **The employment of precaution in formulating advisories seems to work only in one direction – toward more regulation and away from better public health.**

This situation is exemplified by the inconsistent designation of children at risk among States. For example, Maryland target children aged 6 or under because it believes "their development is at risk from these contaminants (both mercury and PCBs)."[64] Similarly, Kentucky's State-wide advisory suggests that "women of childbearing age and children 6 years and younger are advised to eat no more than one meal per week of freshwater fish from Kentucky rivers, steams and lakes because of the presence of mercury."[65]

In contrast, Midwestern States like Nebraska seek an even more protective advisory range by specifying its mercury advisory is for "pregnant women, infants and children under 15."[66] Massachusetts keys its fresh water fish consumption advisories to children under age 12.[67] Finally, recent (December 2002) workshop participants on consumption advisories for mercury in Gulf marine fish (Alabama, Florida, Louisiana, Mississippi and Texas) could not agree on the "age of children" for their advisories.[68]

Also troublesome and confusing for the public are the open disputes between federal and State agencies over conflicting purposes, interests and goals for fish consumption advisories. For example, the January 13, 2005 issue of *Inside EPA's Clean Air Report* reported that officials from Maine, Washington, Minnesota and Wisconsin openly requested that FDA and EPA *not* distribute to in-State doctors' offices and public health clinics the FDA/EPA federal fish consumption advisory brochures issued in March, 2004. One Maine official was quoted scolding EPA and FDA for their refusals to comply:

> "I want to formally express how disillusioned we are that your agencies decided not to work with us on the delivery of advice to Maine families on eating fish. First, the default U.S. Environmental Protection Agency advice for recreationally caught fish is inappropriate for Maine because we have a State-wide advisory that is *far more restrictive*. ... Second, your brochure is

> duplicative of what we are already doing. ... Third, it is critical that risk communication efforts be accompanied by evaluation studies to assess whether the efforts are successful. We have such a study under way. [This joint advisory response and awareness survey by Maine and Wisconsin is discussed below]... Fourth, your brochure is not written at the appropriate literacy level and therefore we question its usefulness. We have felt compelled to take the unprecedented step of writing to Maine health care providers to request that they do not distribute your materials for the reasons discussed above." [Emphasis added]

In the same news report, a Wisconsin official was quoted saying, "We wanted [the federal government] to work with us collaboratively. It does not make sense for them to mail out brochures when we are doing the same thing. We want an integrated approach. There is no communication right now. We may end up with two programs, but not because of a plan." In addition, Washington is specifically challenging the federal recommendation on consumption of canned tuna because it is less restrictive. The Washington State Department of Health forwarded a letter to officials with the Women, Infant & Children program[69] – serving over 150,000 women, infants and children in 240 local clinics – saying:

> "The Washington State Department of Health has been providing information to your clinic/practice regarding exposure to chemical contaminants in fish. You may soon be receiving a new brochure from [EPA and FDA] regarding mercury in fish. The brochure is quite similar to our . . . brochure. We are concerned, however, about the clarity of the FDA/EPA brochure regarding canned tuna consumption."

Such open quarrels among the State officials and federal agencies will likely serve to discredit both, creating distrust and disapproval among the public.

However, what do we know thus far regarding *public response and reaction* to either the federal fish advisories or advisories by individual States?

As for States, in a paper for *Risk Analysis*,[70] Colleen Flaherty and colleagues at the University of Wisconsin-Madison reported their survey results:

> "We interviewed [138 male] ice anglers in Monona Bay, Wisconsin during the 2001-2002 ice fishing season to determine risk associated with fish consumption and methyl mercury (MeHg) intake. The majority of anglers (95%) were *not* at risk of mercury toxicity because they ate less fish than would be required to create health problems. The remaining 5% of ice anglers *barely exceeded* the mercury toxicity threshold, with the exception of one angler who exceeded the threshold by 0.926 ppm. ... Fish consumption by ice anglers was independent of awareness of consumption advisories, education, income, and age." [Emphasis added]

Another newly published paper,[71] reports results of a collaborative project between the Wisconsin Department of Public Health and Maine's Bureau of Health, assessing mercury awareness in 12 States – half with State-wide advisories, the other half with only site-specific advisories at the time of the survey in 1998-1999. After a random telephone survey of 3015 women of childbearing age conducted from December 1998 through December 1999, researchers reported:

> "While 92% of these women had consumed fish or shellfish during the past year, less than one third (29%) of them had eaten any sport-caught fish. More than two thirds of the women who consumed sport fish were *not* aware that their States had issued fish consumption guidelines to protect against methylmercury exposure. Hair mercury levels [measured for 414 women in the sample] ranged from 0.005 to 4.62 ppm and were positively correlated to fish consumption rates (P<0.0001). Women who ate sport-caught fish did *not* have significantly higher hair mercury levels than others (mean 0.51 vs. 0.48 ppm). Among women who ate sport fish, advisory awareness had *no* effect on their mercury exposure. Demographic indicators associated with higher hair mercury levels included residence in northeastern USA, marital status of married, college education, annual household income greater than $75,000, and Asian race." [Emphasis added]

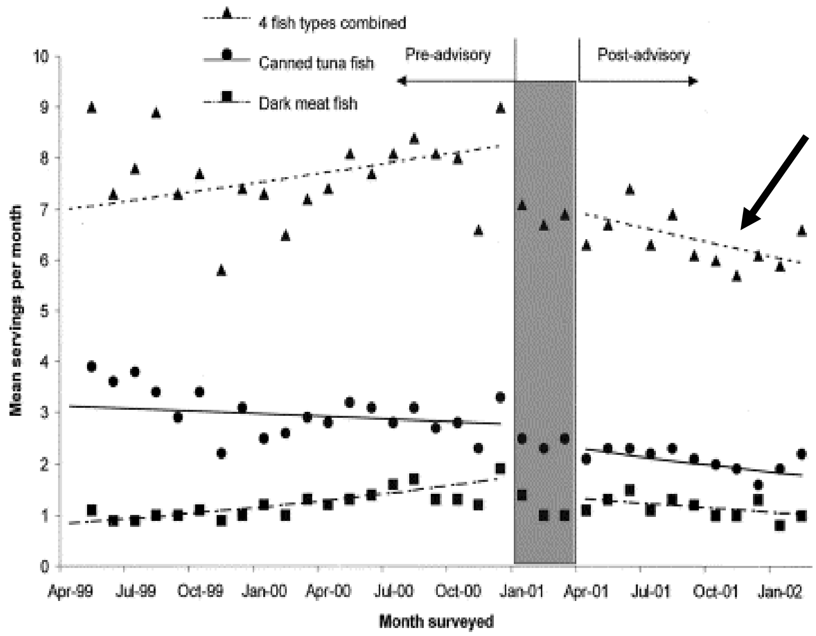
These researchers also documented that 50 women (12% of the 414 women sampled) had a hair mercury level greater than the 1 ppm safety guideline established by EPA's MeHg RfD, and that *most of these women did not* consume sport-caught fish; their exposures are largely explained by consumption of commercially sold fish, including frequent meals of canned tuna.

These findings point to a relatively *less* important exposure risk through sport fish than popular commercial fish.

Now, what are the public reactions to fish consumption advisories issued by FDA or EPA? Do the advisories pose an unintended risk to the public health they are supposed to protect?

Figure 8-1 suggests a rather direct reaction by a group of pregnant women from the greater Boston area to FDA's January 2001 commercial fish consumption advisory.[72] This response appears distinctly stronger compared to the reaction of State-wide or site-specific fish advisories for recreationally caught freshwater fish discussed above. Simply explained, the reaction could be consistent with the demographic tendency of higher awareness by more educated women to public advisories. This group of pregnant women from eastern Massachusetts is described by the researchers as "relatively older and well educated women."

Pregnant women *are* responding to FDA's fish advisory; But at what price to them and their babies' health due to restricting fish (omega-3 fatty acids) intake?



Fish consumption is declining after FDA's advisory and numerous media reports on "mercury contamination of fish"

Oken et al., (2003), Obstetrics & Gynecology, vol. 102, 346-351

Figure 8-1: Mean consumption of canned tuna, dark meat fish (i.e., mackerel and swordfish) and total fish (top-most curve) by 2235 pregnant women in the greater Boston area participated in Project Viva. A significant drop in mean total consumption was detected after the FDA's federal fish consumption advisory (for commercially caught fish) was issued in January 2001.

The authors (Oken et al. 2003) also reported:

> "We observed diminished consumption of dark meat fish, canned tuna, and white meat fish after the national mercury advisory. These decreases resulted in a reduction in total fish consumption of approximately 1.4 servings per month (95% confidence interval of 0.7, 2.0) from December 2000 to April 2001, with ongoing declines though the end of the study period [February 2002]. There was no change in shellfish intake. After dissemination of federal recommendations, pregnant women in this cohort reported *reduced* consumption of fish, including tuna, dark meat fish [i.e., mackerel and swordfish], and white meat fish. *Because these fish may confer nutritional benefits to mother and infant, public health implications of these changes remain unclear*."[73] [Emphasis added]

Oken et al. placed a special emphasis on this last point concerning potential negative public health impacts flowing from diminishing fish consumption by pregnant women:

> "[F]urther research is needed into the relative risks and benefits of fish intake during pregnancy. *The same fish that concentrate mercury contain long-chain polyunsaturated fatty acids that may benefit both the pregnant woman and her infant.* It is *not yet clear* whether the risks of mercury outweigh the health benefits of a seafood diet for adults or children." [Emphasis added]

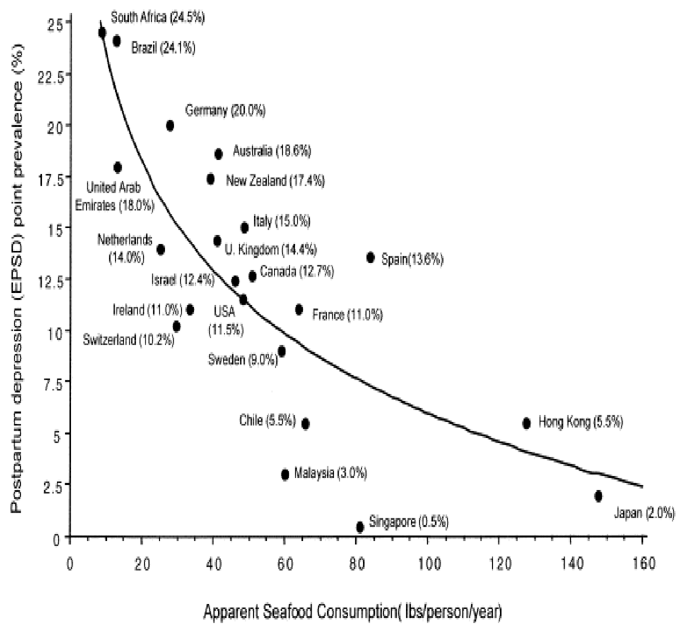
Dr. Charles Lockwood, now chairman of Obstetrics and Gynecology at the Yale School of Medicine, in his previous capacity as the chairman of the 46,000-member American College of Obstetricians and Gynecologists' panel on obstetric practice, commented:

> "We would like to urge the NIH [National Institutes of Health] and other federal agencies to support research to establish in a much more rigorous way what mercury does to the developing infant's brain. ... *I suppose at this point, if we are left with increasingly concerning information about the lack of a lower limit of mercury exposure, pregnant women will stop eating fish,* but there are *a lot of health benefits* of eating fish and it is a relatively cheap source of protein. There may be some *additional benefits* of reducing oxidative stresses that might induce pre-eclamsia or pre-term delivery; may affect fetal growth restriction by impairing placentation. So, there are *lots of reasons* to think that fish might be useful for pregnant women to take in ..."[74] [Emphasis added]

Along this same vein, a group of scientists from the National Institute of Environmental Health Sciences and the Institute of Child Health at the University of Bristol, UK reported important conclusions about the beneficial effects of marine fatty acids on the well being of young children, in the July 2004 issue of the scientific journal, *Epidemiology:*[75]

> "Fish intake by the mother *during* pregnancy and by the infant postnatally, was associated with *higher* mean [child] development scores [in a cohort of 7421 British children]. For example, the adjusted mean MacArthur [vocabulary] comprehension score for children [15 months old] whose mothers consumed fish *four or more times per week* was 72 ... compared with [a score of] 68 among those whose mothers did not consume fish. ... *Although the total [umbilical] cord mercury levels increased with maternal fish intake, our data did not suggest adverse developmental effects associated with mercury.* In a small study of subjects in [this] ALSPAC [Avon Longitudinal Study of Parents and Children] study, maternal DHA[76] levels were associated with *improved* visual stereoacuity among offspring at 3.5 years of age. ... *Fish intake during pregnancy has the potential to improve fetal development because it is a good source of iron and long chain omega fatty acids, which are necessary for proper development and function of the nervous system."* [Emphasis added]

Higher Prevalence Rates of Postpartum Depression With Low Seafood Consumption



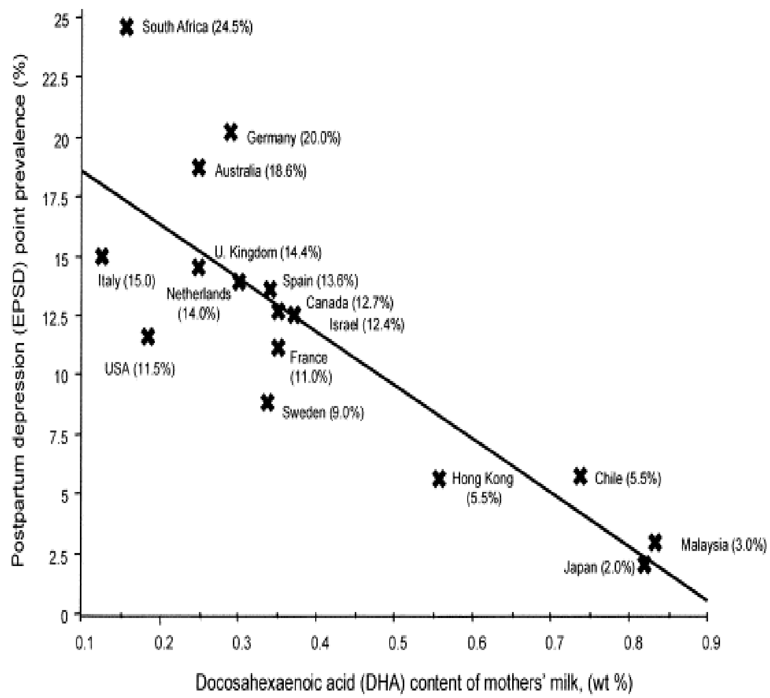
Hibbeln (2002) Journal of Affective Disorders, vol. 69, 16-29

Figure 8-2: Higher prevalence rates of postpartum depression with low seafood consumption.

Recent research[77] by Dr. Joseph Hibbelin of the National Institutes of Health calls attention to another serious risk associated with low intake of fish or omega-3 fatty acids, *Postpartum depression.* Available cross-national statistics clearly suggest a greater risk of postpartum depression with both low seafood consumption (**Figure 8-2**) and low DHA content in the nursing mothers' milk (**Figure 8-3**). Dr. Hibbelin summarized:

> "The findings in these cross-national analyses were clearly consistent with the hypothesis that *inadequate dietary intake of omega-3 fats and the subsequent maternal depletion of omega-3 fats during pregnancy are associated with an increased risk of major postpartum depressive symptoms.* Both lower concentrations of DHA in mothers' milk and lower national rates of seafood consumption were *robustly correlated* with higher rates of major postpartum depressive symptoms in several models of analysis. These data suggest that the nearly 50-fold difference in prevalence rates of major postpartum depressive symptoms across countries is *substantially associated* with omega-3 fatty acid nutritional status." [Emphasis added]

Higher Prevalence Rates of Postpartum Depression With Low DHA Content in Mothers' Milk



Hibbeln (2002) Journal of Affective Disorders, vol. 69, 16-29

Figure 8-3: Higher prevalence rates of postpartum depression with lower DHA omega-3 fatty acids in mothers' milk.

Dr. Gary Myers, a leading scientist from the Seychelles Island Child Development Study, made another important health point in his July 29, 2003's testimony to the U.S. Senate Environment and Public Works Committee:[78]

> "*We do not believe that there is presently good scientific evidence that moderate fish consumption is harmful to the fetus*. However, fish is an important source of protein in many countries and large numbers of mothers around the world rely on fish for proper nutrition. Good maternal nutrition is *essential* to the baby's health. Additionally, there is *increasing evidence* that the nutrients in fish are important for *brain development* and perhaps *for cardiac and brain function* in older individuals." [Emphasis added]

The medical literature is rich with potential mitigations for a host of serious negative health conditions, especially those related to child birth and physiological and mental development of infants and young children, attributed to routine intake of omega-3 polyunsaturated fatty acid gained via fish consumption. A few of these conditions are:

(a) pre-term delivery and low birth weights, and physiological and mental development of infants and young children

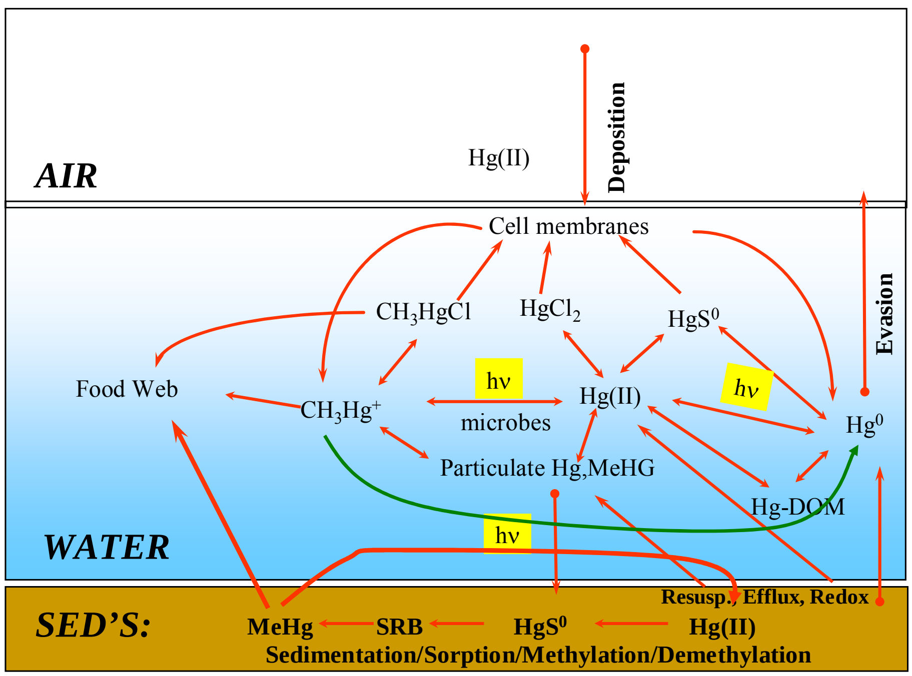
(b) cardiovascular disease (CVD) + coronary heart disease (CHD) + sudden deaths
(c) breast cancer
(d) prostate cancer
(e) endometrial (inner lining of uterus) cancer
(f) treatment of kidney disorder patients
(g) Alzheimer disease
(h) rheumatoid arthritis
(i) type 2 diabetes in women and CHD in type 2 diabetic women
(j) postpartum depression, major depression, bipolar disorders, schizophrenia and even suicidal ideation

In other words, ***any call for reduction in fish consumption, inherent in fish advisories, must necessarily take extreme precaution against promoting any widespread unintended public health threats. The most fundamental principle for any fish consumption advisory must be to do no harm in the first place.*** Policy makers should weigh in their deliberations the indisputable fact that sometimes excessive or over-regulation can be as, or more, dangerous than none at all. This appears to be the more prudent approach taken by public health officials in the high fish-consuming State of Alaska which has population that is supposed to be the most vulnerable to the risk exposure of MeHg in fish.

Section 9 – Life Cycle of Mercury

This section briefly emphasizes the long chain of factors and processes governing the complex conversion of elemental mercury (Hg) emitted by nature and power plants into the biologically more active form of methylmercury (MeHg), and the ultimate accumulation/destruction of MeHg in fish organs and tissues (**Figure 9-1**).

The Aquatic Mercury Cycle Conceptual Model



Adapted from (USGS) David Krabbenhoft's ppt presentation

Figure 9-1: The complex biological, chemical and physical pathways and interactions leading raw inorganic mercury [Hg^0 or Hg (II)] to be methylized and demethylized to make more or less MeHg [or $CH3Hg^+$], ultimately ending up in fish tissue. (SED stands for "sediments.")

According R. Mason and colleagues (2005),[79] the correlated factors of sulfate-organic matter-bacterial activity could "possibly cause an *increase* in fish mercury concentration *even as atmospheric deposition decreases*." The key point is that science-based observations reveal that both the production and destruction processes of MeHg ending up in fish *do not* depend exclusively on the amount of Hg available in a water system. Hence, key biological and chemical processes driving the methylation and demethylation – and the ultimate bioaccumulation of MeHg in fish tissue – *completely overwhelm* any insignificant contributions of elemental Hg from U.S. power plant emissions. This is because there already exist millions of tons of naturally occurring Hg in Earth's water, soil and sediment, ever-ready and ever-available for conversion into MeHg. ***This explains why it is not difficult to find high, even extremely high, levels of MeHg in both***

fish and humans[80] in the past several centuries, at a time lacking mercury emissions from power plants or other industrial applications.

In other words, the actual scientific evidence/understanding for Hg-MeHg conversion and MeHg bio-accumulation *do not* support the possibility for a direct or clear link between hypothesized Hg reductions from U.S. power plants and MeHg reductions in fish.

There are numerous driving, dependent variables and factors involved in the complex biological, chemical and physical transformation of Hg in MeHg. Some of the most recently discussed in the scientific literature are:

(i) levels of MeHg are independent of raw Hg levels (Marvin-DiPasquale et al. 2003; Paller et al. 2004; Bonzongo & Lyons 2004)
(ii) pH and sulfate (Bonzongo & Lyons 2004)
(iii) leaf litter inputs and microbial growth (Balogh et al. 2003)
(iv) roles of visible light (Seller et al. 1996), UVA (Lalonde et al. 2004), diurnal MeHg and solar radiation (Siciliano et al. 2005)
(v) experimental treatments with sulfate (Harmon et al. 2004)
(vi) sulfate, organic matter, and bacterial activity (Mason et al. 2005)
(vii) water temperature and fish body weight (Trudel and Rasmussen 1997)
(viii) algal bloom-induced biodilution of MeHg in zooplankton Daphnia (Pickhardt et al. 2002)
(ix) dependence of MeHg on species of zooplankton (Masson & Tremblay 2003)
(x) "MeHg accumulation paradox" (Schaefer et al. 2004)
(xi) seasonal cycle of MeHg before and after control flooding (St. Louis et al. 2004)
(xii) 48 environmental variables including land use, various catchment areas and lake characteristics, lake water chemistry and fish stocks (Soneston 2003)

Section 10 – Conclusions

An aphorism observes that:

> *For every complex problem, there is a solution that is simple, neat and wrong.*[81]

Many current U.S. fish advisories likely fit the category of solutions that simply do not offer any real improvements for public health. As demonstrated by the vast literature reviewed in this paper, the ongoing and recent increases in the number of U.S. river miles and lake acres under fish advisories has had little to do with any actual reputed increased in mercury pollution or contamination of U.S. inland and coastal waters. In fact, at the same time State advisories were dramatically *increasing* (**Figure 2-3**), local U.S. industrial emissions of Hg were just as dramatically *declining* **(Figure 10-1)**.

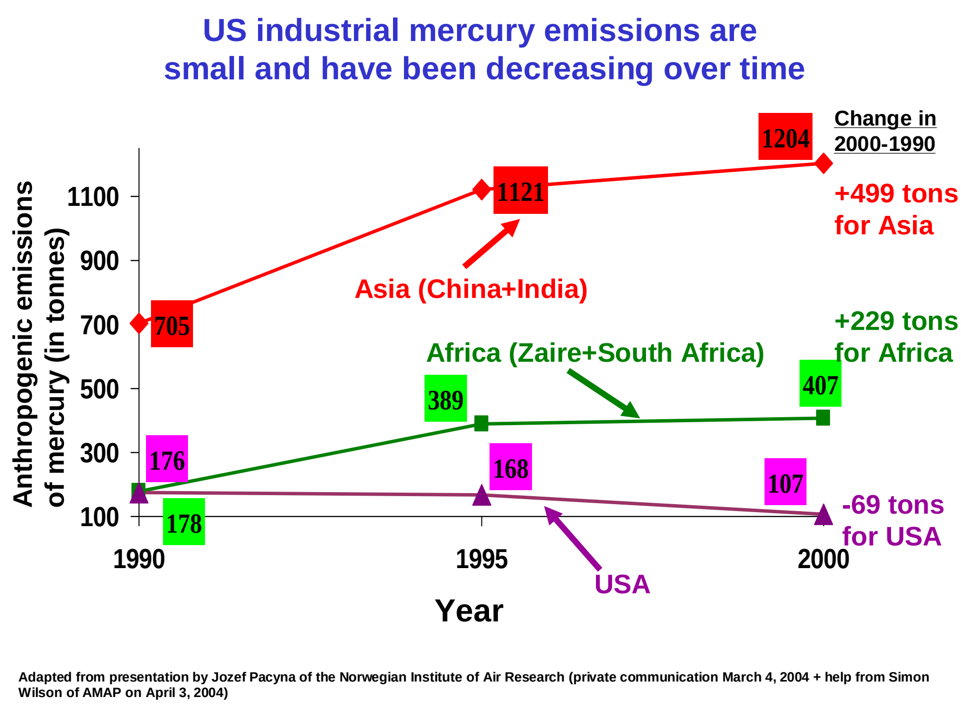


Figure 10-1: From 1990 to 2000, U.S. mercury emissions have reduced from estimated 176 tonnes to about 107 tonnes annually. Estimates of current U.S. emissions represent less than 1% of world annual totals.

Instead, one finds **layers of misunderstanding and misrepresentation of the underlying science** which often appears rooted in socio-political pressures promoting the application of varying levels of precaution to policy formulation (see discussion in **Section 7**).

Therefore, policy makers should consider the pertinent questions. How cautious is caution? Is there a point at which caution itself becomes harmful; where **hyper-caution becomes irrational to the point of becoming the greater risk**; a point at which the resulting alarmism can damage public health by frightening consumers away from nutritional fish consumption (see **Section 8**)? Alaska's approach to fish advisory policy seems to weigh these critical policy questions differently than, say, Wisconsin – or Wyoming (another State with no fish advisories) than neighboring Montana.

In this context, particularly *harmful* is the seemingly simple and neat solution being pressed upon an unsuspecting public by EPA and zero-mercury advocates: that reducing anthropogenic emissions of Hg *will* lead to definite, linear and beneficial reductions of MeHg levels in fish. Scientific evidence and data simply do *not* support this hypothesis.

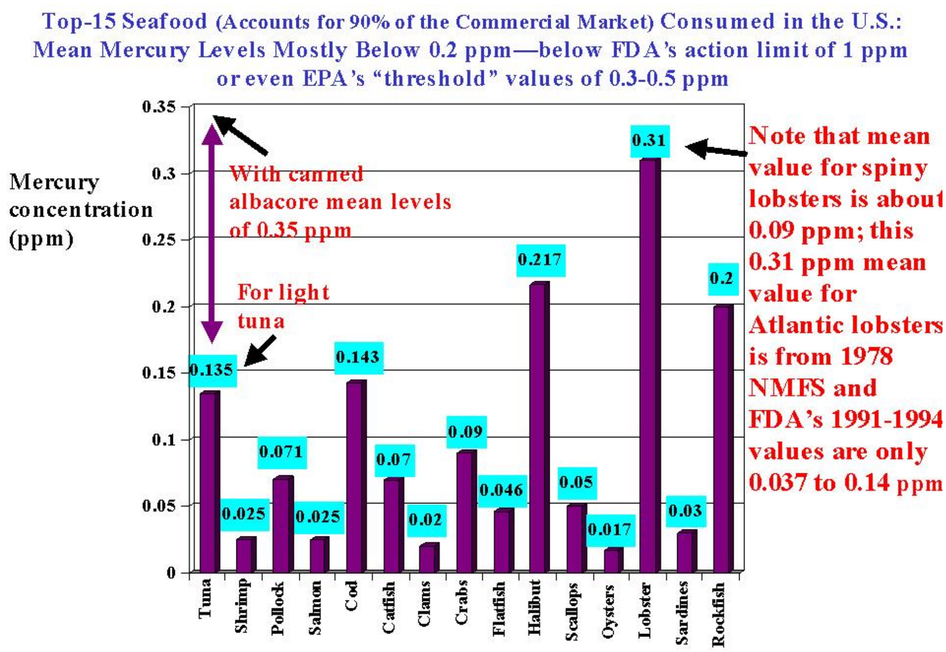
MeHg bioaccumulation and methylation are *historically* occurring via factors other than the levels of elemental mercury (Hg) available either from the *naturally* pre-existing mercury in the soil, water and air or from lesser emissions from human activity. The scientific literature to date strongly and overwhelmingly suggests that meaningful management of Hg is likely impossible since even **a total elimination of all industrial emissions**, especially those from U.S. coal-fired power plants, will almost certainly not be able to affect the trace, or even high, levels of MeHg that have occurred in fish tissue over century-long time periods. A more rational and informed framework for dealing with the relatively low risk of MeHg exposure through fish consumption is required.[82]

Some of the independent analyses and conclusions reached here are supported by a March 2005 publication[83] in the prestigious *American Journal of Public Health* by scientists and researchers from the Alaska Division of Public Health, which concluded that:

> "National fish consumption advisories that are based solely on assessment of risk of exposure to contaminants without consideration of consumption benefits result in overly restrictive advice that discourages eating fish even in areas where such advice is unwarranted. In fact, generic fish advisories may have adverse public health consequences because of decreased fish consumption and substitution of foods that are less healthy.
>
> Public health is on the threshold of a new era for determining actual exposures to environmental contaminants, owing to technological advances in analytical chemistry. It is now possible to target fish consumption advice to specific at-risk populations by evaluating individual contaminant exposures and health risk factors. Because of the current epidemic of nutritionally linked disease, such as obesity, diabetes, and cardiovascular disease, general recommendations for limiting fish consumption are ill conceived and potentially dangerous."[84]

ENDNOTES

[1] From http://epa.gov/waterscience/fish/advisories/questions.htm
[2] Mason et al. (2005) *Environmental Science & Technology*, vol. 39, A14-A22.
[3] http://www.epa.gov/waterscience/fishadvice/advice.html
[4] Formerly titled the National Listing of Fish and Wildlife Advisories (NLFWA). EPA explains that the term wildlife was dropped from the title for the 2003 listing because the national database has mainly focused on advisory activities for fish consumption, and water-dependent wildlife advisories currently represent less than one percent of the total number of advisories.
[5] http://epa.gov/waterscience/fish/advisories/index.html (retrieve Technical Fact Sheet EPA-823-F-04-016).
[6] Caution is advised regarding potential confusion in terms for mercury levels in lobsters reported in the publicly available FDA's database. A very high-mean value of 0.31 ppm for Atlantic lobsters, with the highest measured mercury level in lobster being 1.31 ppm (http://www.cfsan.fda.gov/~frf/seamehg.html), was measured under the 1978 National Marine and Fisheries Services survey. On the other hand, the latest 1991-1994 FDA's measurements (http://www.cfsan.fda.gov/~frf/seamehg2.html) for "lobsters" have relatively low values from 0.037 to 0.14 ppm with a mean value of about 0.09 for the 9 spiny lobsters sampled in 1991-1993 (see Figure). One would hope the Micmac tribe in Maine is aware of the statistical range of MeHg levels in all seafood, including lobster. A broad-based statewide advisory for Maine lobster may not be the best approach for addressing their concerns for trace levels of MeHg in seafood.



Source: Carrington and Bolger (2002) Risk Analysis, vol. 22, 689-699 + updates in Carrington and Bolger (2003)'s Intervention Analysis Draft Report

[7] http://www.sierraclub.org/pressroom/releases/pr2004-08-24a.asp August 24, 2004's press release "SIERRA CLUB STATEMENT ABOUT INCREASING LEVELS OF MERCURY POLLUTION" by Carl Pope, Sierra Club's Executive Director.
[8] As noted, the 2003 national listing was re-labeled simply as National Listing of Fish Advisories where the term "Wildlife" is now dropped; the Sierra Club may be unaware of the change or what was actually said in the August 24, 2004 release of the 2003 NLFA by EPA.
[9] p. A1 "A Hidden Cost of China's Growth: Mercury Migration" by Matt Pottinger, Steve Stecklow and John Fialka.
[10] http://epa.gov/waterscience/fish/advisories/questions.htm
[11] EPA's NLFA also noted the addition of rivers to Wisconsin's preexisting statewide advisory in 2003.
[12] Mason et al. (2005) *Environmental Science & Technology*, vol. 39, A14-A22.
[13] Kraepiel et al., 2003, Environmental Science & Technolocy, vol. 37, 5551-5558

[14] available at http://vm.cfsan.fda.gov/~dms/admehg3.html or http://www.epa.gov/waterscience/fishadvice/advice.html
[15] See: How Safe Are We From the Fish We Eat? at http://www.scienceandpolicy.org/
[16] http://leahy.senate.gov/issues/environment/mercury/index.html
[17] November 19, 1984 issue of Federal Register, vol. 49.
[18] See pp. 4-7 and 4-8 in the January 2001 report *Water Quality Criterion for the Protection of Human Health: Methylmercury* by EPA (EPA-823-R-01-001).
[19] See this FDA URL (look under mercury) http://vm.cfsan.fda.gov/~lrd/fdaact.html
[20] See for example http://www.pbs.org/now/science/mercuryinfish.html
[21] p. 1121 of Miller et al. (1972) Science, vol. 175, 1121-1122.
[22] See workshop summary report at http://www.southeasternfish.org/Seafood%20Safety/Mercury/Dec02_Hg_Consump_Adv_Wkshp_Summary_DRAFT_v11.pdf
[23] Gorski et al. (2003) Science of the total environment, vol. 304, 327-348.
[24] When balanced against the potential loss of health-enhancement gained from eating fish and the recognition of already built-in layers of precaution, officials could reasonably exercise caution in the other direction (for the benefit of better health and longer lives of consumers) and not issue any advisory for such relatively low and sparse Hg_T fish measurements.
[25] Simoneau et al. (2005) Environmental Research, in press (available online November 17, 2004).
[26] Industrial sources like the U.S. power plants do not emit concerned amounts MeHg.
[27] It is rarely mentioned that there are also a host of natural processes for the *destruction* of MeHg.
[28] See for example, Wiener et al. (2002) Ecotoxicology of mercury. In: Hoffman et al. (Eds.), *Handbook of Ecotoxicology*, 2nd Edition, CRC Press, Boca Raton.
[29] See e.g., Gorski et al. (2003) Science of the total environment, vol. 304, 327-348. One might also consider the rate of destruction of MeHg in fish tissue, which is poorly understood, as discussed in Trudel and Rasmussen (1997) Environmental Science & Technology, vol. 31, 1716-1722.
[30] Brumbaugh et al. (2001) *A National Pilot Study of Mercury Contamination of Aquatic Ecosystems Along Multiple Gradients: Bioaccumulation in Fish* (Biological Science Report USGS/BRD/BSR-2001-0009).
[31] Best estimates are that Hg emissions from U.S. power plants account for less than 1% of total world annual emission budget (Pacyna et al. 2003, Freidli et al. 2003). See in addition Pyle and Mather (2003, Atmospheric Environment, vol. 37, 5115-5124) for updated information on mercury emission from volcanoes which was previously underestimated
[32] Kraepiel et al. (2003) Environmental Science & Technology, vol. 37, 5551-5558.
[33] Zhang et al. (2002) Ambio, vol. 31, 482-484.
[34] p. 5551 of Kraepiel et al. (2003) Environmental Science & Technology, vol. 37, 5551-5558.
[35] p. 552 of Barber et al. (1984) Environmental Science & Technology, vol. 18 (no. 7), 552-555.
[36] For a more in-depth examination of EPA's CAMR, see CSPP's "EPA NODA Comments" at http://ff.org/centers/csspp/pdf/EPANODAComments-121804.pdf or www.scienceandpolicy.org
[37] p. 1122 of Miller et al. (1972) Science, vol. 175, 1121-1122. There is a puzzling attempt in a recent report (Code RL32420 entitled *Mercury in the Environment: Sources and Health Risks*) by Linda-Jo Schierow of the *Congressional Research Service* (CRS) to discredit this important pioneering paper by Miller et al. (1972). The June 3, 2004 CRS report claimed in its footnote 48 that Miller et al. (1972) "reported the study in a letter to the editor of *Science*, it was not peer-reviewed, and is [thus] an insufficient basis for drawing any conclusions." This is clearly mistaken. The March 10, 1972 Miller et al.'s contribution **is** a peer-reviewed REPORT rather than a LETTER TO EDITOR for *Science* magazine. One of the members of this 1972 Miller et al. team is F.S. Rowland, the co-recipient of the 1995 Nobel Prize for Chemistry.
[38] Greenfield et al. (2004) Science of the Total Environment, in press.
[39] Yamaguchi et al. (2003) Chemosphere, vol. 50, 265-273.
[40] p. 341 of Weis (2004) Environmental Research, vol. 95, 341-350.
[41] Total fresh water catch in the United States is reported as 27.4 thousand metric tons. The total food supply from fish and fish products in the United States is reported as 5657 thousand metric tons. Even assuming that all the fresh water catch is consumed domestically, domestic fresh water fish accounts for less than 0.5% of U.S. consumption. (Source: Food and Agriculture Organization of the United Nations,

"Trade in Fish and Fishery Products, Fish Consumption, Fishers and Fleet Information, tables CM 1.1 and CM 1.2).

[42] See for example, Schmitt and Brumbaugh (1990) Archives of Environmental Contamination and Toxicology, vol. 19, 731-747.

[43] The records are compiled in the National Listing of Fish and Wildlife Advisories.

[44] A slim possibility is to consider summing up the fish mercury data cumulatively so that starting from 1993 each measurement only adds up to a larger total in 2003, hence providing the impression of an ever increasing trend of fish mercury data measured. But this approach fails to explain the rather large systematic increase in the river miles and lake acres advised each year, and is especially unable to explain the large (>60%) increase in river miles advised from 2002 to 2003. For the latter case, the earlier explanation offered by EPA about the switch of state of Washington and Montana from its previous site-specific advisories to state-wide advisories seems more plausible.

[45] http://epa.gov/waterscience/fish/advisories/questions.htm

[46] The 2003 information is not directly available.

[47] Adopted from Table 4-1 on page 4-3 of *The National Survey of Mercury Concentrations in Fish—Data Base Summary 1990-1995* (EPA-823-R-99-014, September 1999).

[48] http://www.epi.hss.state.ak.us/bulletins/docs/b2001_06.htm

[49] See the detailed discussion and reporting of this active mercury biomonitoring program in Alaska in "Use of traditional foods in a healthy diet in Alaska: Risks in perspective" State of Alaska Epidemiology Bulletin, vol. 8, No. 11, December 2, 2004.

[50] from http://www.epa.gov/ttn/atw/combust/utiltox/stxstate2.pdf

[51] See for example Olsen and Secher (2002) British Medical Journal, vol. 324, 447-450 where the authors concluded that "*Low consumption of fish was a strong risk factor for preterm delivery and low birth weight. In women with zero or low intake of fish, small amounts of n-3 fatty acids—provided as fish or fish oil—may confer protection against preterm delivery and low birth weight.*" [Emphasis added]
Next, consider Daniels et al. (2004) Epidemiology, vol. 15, 395-402 where these authors reported the beneficial effects of marine fatty acids on the well being of young children: "Fish intake by the mother during pregnancy and by the infant postnatally, was associated with *higher* mean [child] development scores [in a cohort of 7421 British children]. For example, the adjusted mean MacArthur [vocabulary] comprehension score for children [15 months old] whose mothers consumed fish four or more times per week was 72 ... compared with [a score of] 68 among those whose mothers did not consume fish. ... Although the total cord mercury levels increased with maternal fish intake, our *data did not suggest adverse developmental effects associated with mercury***.** In a small study of subjects in [this] ALSPAC [Avon Longitudinal Study of Parents and Children] study, maternal DHA levels were associated with improved visual stereoacuity among offspring at 3.5 years of age. ... *Fish intake during pregnancy has the potential to improve fetal development* because it is a good source of iron and long chain omega fatty acids, which are necessary for proper development and function of the nervous system." [Emphasis added]
Additional reviews of the current literature for mercury and health related issues can be examined at http://www.scienceandpolicy.org/: (1) Fish, mercury and cardiac health, (2) How safe are we from the fish we eat? and (3) Analysis of the Sierra Club's alarmist claims about the health impacts of mercury.

[52] EPA report # EPA-823-R-01-001 available at http://www.epa.gov/waterscience/criteria/methylmercury/document.html

[53] EPA's current RfD value is derived from a controversial epidemiological study of Faroe Island (Denmark) populations who consumed binge-quantities of whale meat and blubber, exposing them to a cocktail of toxic chemicals including PCBs and DDT.

[54]This is a tiny amount. It stands for 0.1 microgram (0.0000001 grams) of MeHg per kilogram (1,000 grams) of body weight per day.

[55] ATSDR (Agency for Toxic Substances and Disease Registry), Toxicological Profile for Mercury (Update). Atlanta, Georgia: U.S. Department of Health and Human Services, Public Health Service, 1999.

[56] It is noted that the epidemiological basis for EPA's derivation of its RfD value at 0.1 μg/kg (b.w.)/day in 1995 was the Iraqi poisoning-exposure scenario, and the final change was in 2001 where the basis for its "new" MeHg RfD was switched to the Faroe Island Children Study after the publication of *Toxicological Effect of Methylmercury* by NRC (2000). The current value for the EPA's MeHg RfD is still 0.1 μg/kg (b.w.)/day *despite* the dramatic switch in its epidemiological exposure baseline. For a more comprehensive

review and assessment of the history and science of MeHg RfD derivations, consult the presentation by Michael Dourson (December 3, 2004 talk at the American Legislative Exchange Council meeting). For a more formal publication, see Dourson et al. (2001) Neurotoxicology, vol. 22, 677-689.

Here are two additional, concise summaries regarding EPA's derivations of its RfD:

(1) Dourson et al. (2001) noted that in 1995 EPA established a RfD of 0.1 μg MeHg/kg (b.w.)/day based on an episodic MeHg exposure from the Iraqi seed grain poisoning incidence. Professor Tom Clarkson of the University of Rochester remarked that "People have been taking our old data from Iraq and coming out with very low numbers for tolerable exposure. We who had done the study knew their numbers were not very solid. That's why we undertook [the] extensive Seychelles study. " Realizing the little relevance of that epidemiological study, EPA shifted the basis of its RfD to the Faroe Island study in 2001. Despite this drastic switch in the basis for the RfD derivation and with different rationale for the "less-than-default" uncertainty factor of 10, the new value of RfD remained to be 0.1 μg MeHg/kg (b.w.)/day.
(2) Crump et al. (2000) noted that EPA's early derivation of RfD from the Iraqi study was based on grouped value of Benchmark Dose Lower Limit (BMDL) value of 11 ppm in maternal hair. But a full assessment of the data by Crump et al. (1995) yielded BMDL values of 54 to 152 ppm which is consistent with "other analyses of the Iraqi data showing there was no conclusive evidence of a mercury effect below a maternal hair level of 80 ppm."
Thus, there is evidence that EPA's RfD values have been excessively low which "may do more harm than good." (Crump et al., 2000, Environmental Health Perspectives, vol. 108, 257-263; Crump et al., 1995, Risk Analysis, vol. 15, 523-532)

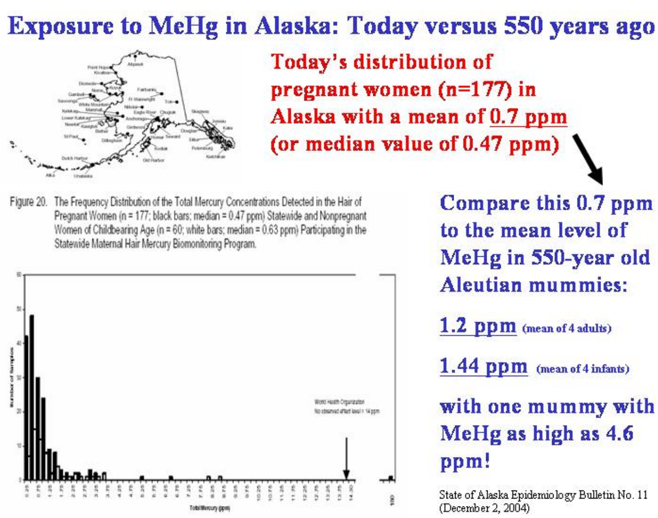
What one member, Joseph Jacobson, of the NRC (2000) panel on Toxicological Effects of Mercury said about EPA's 1995 RfD on MeHg:

> "The Iraqi data were used as the basis for the EPA risk assessment for methylmercury that was in effect through the end of the 1990s. [But] the Iraqi population was exposed at higher levels than in Japan [than those in Minamata Bay] and the exposure took place over much shorter period of time ... a very atypical, if not unique occurrence ... Moreover, the exposure levels in the Iraqi poisoning were so high that most of the points on the dose-response curve far exceeded the BMDL [BenchMark Dose Level] of 11 ppm derived by the EPA. This BMDL was computed by extrapolating downward into a range in which the Iraqi study provided virtually no data points. Nevertheless, for many years the Iraqi data were the best available." (p. 668 of Jacobson, 2001, Neurotoxicology, vol. 22, 667-675)

[57] Convened under the leadership of Michael Dourson of the non-profit organization, Toxicology Excellence for Risk Assessment (TERA). Two reports generated for the derivation of this site-specific RfD are available at http://www.tera.org/peer/MeetingReports.html (look under Methylmercury RfD).
[58] McDowell et al. (2004) Environmental Health Perspectives, vol. 112, 1165-1171.
[59] Yasutake et al. (2004) Journal of Health Science, vol. 50 (2), 120-125.
[60] It should not be taken lightly the two typographical errors in the current Wisconsin Department of Natural Resources' *Statewide Mercury Advisory Background* webpage (see http://dnr.wi.gov/org/water/fhp/fish/pages/consumption/mercury.shtml last accessed February 25, 2005) which suggests that "The changes in mercury advice result from the National Research Council's report, 'Toxicological Effects of Methylmercury' (2002). This report concluded that the standard the U.S. Environmental Protection Agency's (EPA) reference dose is appropriate to determine whether to issue consumption advice for fish. A reference dose is defined as "an estimate of a daily exposure to the human population (including sensitive subpopulations) that is likely to be without a risk of adverse effects when experienced over a lifetime." The use of this new reference dose required that consumption advice be issued when fish exceeded 0.05 parts per million (ppm) mercury. Most of Wisconsin's fish contain at least that amount based on past testing. Thus, consumption advice is appropriate for most fish." For the first

error, (2002) should be replaced by (2000), and for the second, the value of "**0.05 ppm**" should be corrected to read **0.5 ppm**.

[61] Kamman et al. (2004) *Biogeochemistry of Mercury in Vermont and New Hampshire Lakes-An Assessment of Mercury in Water, Sediment and Biota of Vermont and New Hampshire Lakes* (comprehensive final project report dated May 2004).
[62] "Minnesota's Total Maximum Daily Load Evaluation of Mercury in Fish Tissue" (preliminary draft dated December 15, 2004 as prepared by Minnesota Pollution Control Agency).
[63] First mentioned on p. vi. On pp 8-9 of the report, it was stated that the transition from EPA's original 0.3 ppm threshold to 0.2 ppm threshold for Minnesota is justified because people in Minnesota consume about 30 grams of fish per day rather than the national average of 17.5 grams per day assumed by EPA. Hence, the Minnesota Pollution Control Agency derived a fish mercury threshold value of 0.3 X (17.5/30.0) = 0.17 ppm, rounded to the nearest digit to give the "official" threshold of 0.2 ppm for the threshold for fish consumption advisories in Minnesota.
[64] http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/index.asp (look under "Statewide Fish Consumption Guidelines for Women and Children Brochure").
[65] http://www.water.ky.gov/sw/advisories/fish.htm
[66] http://www.ngpc.state.ne.us/fishing/guides/fishguide/FGadvisories.asp
[67] http://www.mass.gov/dph/beha/fishlist.htm
[68] See workshop summary report at http://www.southeasternfish.org/Seafood%20Safety/Mercury/Dec02_Hg_Consump_Adv_Wkshp_Summary_DRAFT_v11.pdf
[69] See http://www.doh.wa.gov/cfh/WIC/about_wic.htm
[70] Flaherty et al., "Human Mercury Toxicity and Ice Angler Fish Consumption: Are People Eating Enough to Cause Health Problems?" (2003) Risk Analysis, vol. 23, 497-504.
[71] Knobeloch et al. (2005) Environmental Research, vol. 97, 220-227.
[72] Project Viva http://www.dacp.org/viva.html
[73] Oken et al. (2003) Obstetrics & Gynecology, vol. 102, 346-351.
[74] From the July 24, 2002's FDA food advisory committee on methylmercury, transcript available at http://www.fda.gov/OHRMS/DOCKETS/ac/02/transcripts/3872t2.htm
[75] Daniels et al. (2004) Epidemiology, vol. 15, 395-402.
[76] DHA (docosahexaenoic acids) is one of the essential omega-3 fatty acids required for maintaining good health.
[77] Hibbeln (2002) Journal of Affective Disorders, vol. 69, 15-29.
[78] http://epw.senate.gov/108th/Myers_072903.htm
[79] Mason et al. (2005) *Environmental Science & Technology*, vol. 39, A14-A22.
[80] A comparison of MeHg levels in ancient and modern Alaskans found a higher mean level in 550-year old mummies.



[81] Often paraphrased and attributed to newspaperman and commentator, H. L. Mencken (1880-1956).
[82] See "How Safe are We from the Fish We Eat?" (http://www.scienceandpolicy.org/).
[83] Arnold et al. (2005) American Journal of Public Health, vol. 95, 393-397.
[84] Anyone seriously interested in the risk perspectives of fish in a healthy diet should read the State of Alaska Epidemiology Bulletin vol. 8, No. 11, December 2, 2004: http://www.epi.hss.state.ak.us/bulletins/docs/rr2004_11.pdf