METHYLMERCURY IN THE GULF OF MEXICO: STATE OF KNOWLEDGE AND RESEARCH NEEDS

Report of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
COMMITTEE ON THE ENVIRONMENT AND NATURAL RESOURCES
Interagency Working Group on Methylmercury

June 2004

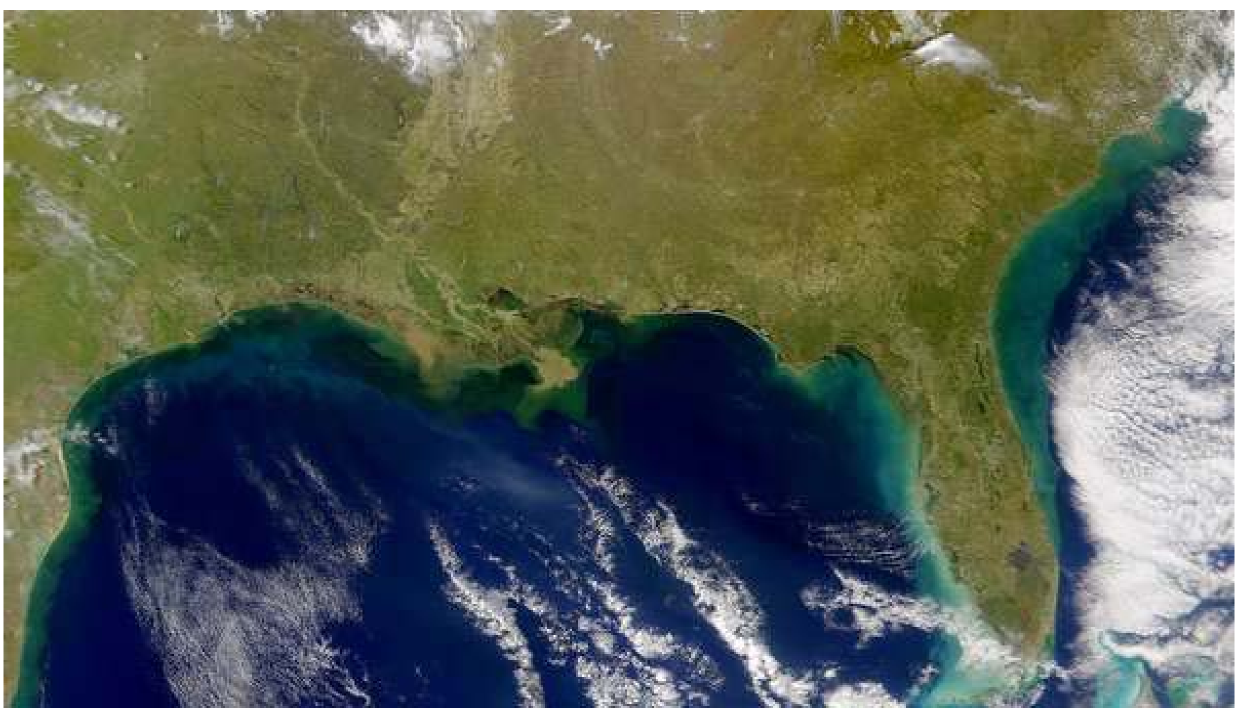

Image: NASA SeaWiFS

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
WASHINGTON, D.C. 20502

June 9, 2004

Dear Colleague:

The enclosed report provides a brief overview of the current state of knowledge of the occurrence and impact of methylmercury in the Gulf of Mexico region, and identifies data and information gaps that can be addressed by agencies working in the region. Implementation of the data collection and research efforts identified here will be accomplished through a process of interagency planning under the auspices of the Gulf of Mexico Program, the interagency technical body headed by the U.S. Environmental Protection Agency.

The National Science and Technology Council (NSTC) believes it is critical to continue and expand research and monitoring efforts to better understand the chemical and biological processes that control the bioaccumulation of methylmercury and its concentration in fish and shellfish, the primary pathway by which humans are exposed to the adverse health effects of methylmercury. The scientific community has made significant advances recently in the analysis of mercury in its various chemical forms, and our understanding of mercury in the environment is growing rapidly. It is vital to maintain this scientific momentum.

The NSTC Committee on the Environment and Natural Resources' Interagency Working Group on Methylmercury incorporated information from many sectors of the scientific community, including a number of federal and state agencies in developing this report. I thank them for their contributions and look forward to the continued progress in understanding and mitigating the effects of methylmercury on human health.

Sincerely,

John H. Marburger, III
Director

Enclosure

ABOUT THE INTERAGENCY WORKING GROUP ON METHYLMERCURY

The National Science and Technology Council (NSTC), a cabinet level council, is the principal means for the President to coordinate science and technology policies across the Federal Government. NSTC acts as a "virtual" agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research to improving transportation systems and strengthening fundamental research. This council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, contact the NSTC Executive Secretariat at (202) 456-6101

In 2002, the Office of Science and Technology Policy and the Council on Environmental Quality re-convened representatives of Federal agencies under the NSTC's Committee on the Environment and Natural Resources (CENR) to form the Interagency Working Group on Methylmercury (Working Group). The NSTC had previously created an interagency working group on mercury and, in fact, the working group was actively engaged in the review and approval of the USEPA Mercury Study Report to Congress in 1997. The Federal agencies participating in the current Working Group are:

Environmental Protection Agency (USEPA)
U.S. Department of Health and Human Services (HHS)
- Food and Drug Administration (FDA)
- National Institutes of Health (NIH) /National Institute of Environmental Health Sciences (NIEHS)
- Centers for Disease Control/National Center for Environmental Health NCEH)
U.S. Department of the Interior (DOI)
- U.S. Minerals Management Service (MMS)
- U.S. Geological Survey (USGS)
- U.S. Fish and Wildlife Service (FWS)
U.S. Department of State (DOS)
U.S. Department of Commerce (DOC)
- National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service
Office of Oceanic and Atmospheric Research
National Ocean Service
Executive Office of the President
- Council on Environmental Quality
- Office of Management and Budget
- Office of Science and Technology Policy

INTRODUCTION

The Interagency Working Group on Methylmercury was formed in response to concern about potential adverse effects on human health associated with consumption of fish and shellfish in the Gulf of Mexico that contain methylmercury. The purpose of the Working Group is to assess the current state of knowledge and activities in Federal agencies regarding methylmercury in the environment and to make recommendations for research and monitoring. The Working Group focused on research and activities that will advance our understanding of methylmercury formation and fate in natural systems, to improve assessment of the risk of human exposure to the health effects of methylmercury, and to facilitate technological solutions to these problems. This report does not address the current state of scientific understanding of the biological mechanisms for adverse health outcomes that might be related to exposure to methylmercury. The Interagency Working Group is considering addressing this and other mercury-related topics, as appropriate, in the future.

The strategy of the Working Group was to:

1. Focus primarily, though not exclusively, on methylmercury because it is the chemical form of mercury posing the greatest health concern in the United States.
2. Examine methylmercury in the U.S. Gulf of Mexico region as a prototype for other regional, national, and topical studies. The Gulf of Mexico region was selected because of recent concern about mercury expressed by public, state, Congressional, and industrial stakeholders in the region.
3. Identify data and information gaps that can be addressed by Federal agencies, working with state and industrial stakeholders and partners.

This summary report briefly describes what we currently know about mercury in the Gulf of Mexico region (defined as the areas of Texas, Louisiana, Mississippi, Alabama, and Florida that border the Gulf of Mexico), which key pieces of information are lacking, and the research and information needed to close the knowledge gap and to reduce the risk of potential mercury exposure for humans in the region. This analysis is organized in the following categories:

1. Sources of mercury
2. Cycling, fate, and chemical form of mercury
3. Concentration and distribution of mercury
4. Risk characterization of methylmercury exposure
5. Risk mitigation and management
6. Structure and process to address mercury issues in the Gulf of Mexico region

For some aspects of mercury in the Gulf of Mexico, the only available information may be from another region or from a national or global study. When data and information are available specifically for the Gulf region, we summarize it briefly. However, this document is not intended to constitute an exhaustive treatment of all information about mercury. For more comprehensive treatments, we refer the reader to a number of previously published documents listed at the end of this report.

This report focuses on the human health effects of methylmercury ingestion in the Gulf of Mexico region. However, it is important to mention that methylmercury affects other species as well. The environmental impacts may be significant, but more importantly, information about methylmercury in wildlife may help us understand the dynamics of methylmercury in the environment, and impacts on wildlife may have economic impacts. Methylmercury may adversely affect the health and reproductive success of species such as large birds, raccoons, alligators, and the Florida panther (an endangered species). In the past, researchers have focused primarily on fish-eating wildlife as the species most likely to be affected by methylmercury exposure, although insect-eating birds such as the California Clapper Rail have also exhibited high levels of exposure. Recently, it has been demonstrated that bird species vary markedly in their susceptibility to methylmercury toxicity, but at the present time we do not understand what controls those differences. For birds, impaired reproductive success is considered the most sensitive change associated with methylmercury exposure.[1] Researchers have recently demonstrated that fish may also suffer decreased reproductive success from methylmercury exposure, although the potential effects on the fishing industry have not been addressed.[2] Investigations on wildlife effects are important and ongoing.

1. SOURCES OF MERCURY

What is known:

Mercury has historically been used in its metallic and inorganic forms in a wide variety of industrial products and processes. These uses have been reduced by more than 70% in the U.S.[3], though mercury released from those past uses remains in the environment in some form. Several of the Gulf States have taken aggressive action to mitigate the use and disposal of industrial mercury products. Though its use has declined, mercury continues to be used in a variety of industrial processes and products and is present in certain legacy applications (e.g., pressure meters). This report deals primarily with methylmercury, but other forms of mercury should not be ignored because they may be converted into methylmercury in the environment.

Most anthropogenic mercury entering the environment now results from combustion of mercury-containing fuels or waste. Global emissions of mercury to the atmosphere from both natural and anthropogenic sources are estimated to be between 4400 metric tons per year and 7500 metric tons per year, much of which is anthropogenic[4]. The USEPA estimates that U.S. annual direct emissions of mercury from industrial processes totaled 191 metric tons (210 short tons) in 1990, 168 metric tons (185 short tons) in 1996, and 107 metric tons (118 short tons) in 1999, primarily from emissions of coal fired power plants, coal and wood-fired industrial boilers, hazardous waste combustion and chlorine production. [5]

Some of the mercury emitted into the atmosphere occurs as vaporized elemental mercury that may be transported over very long distances in the atmosphere. Thus, mercury deposited from the atmosphere may contaminate parts of the Earth far from any source. Some of the mercury emitted is in ionic form, which may be deposited relatively close to its source. Thus, mercury deposited from the atmosphere in a particular area may be a mixture from nearby and distant sources.

Mercury may be deposited directly into waterways, or may ultimately reach waterways if atmospheric mercury is deposited in water or on land and then washed into streams. Annual atmospheric deposition of mercury into the waters of the Gulf of Mexico cannot currently be estimated with any precision, and the contribution of total mercury from the Mississippi River is estimated to be more than 10 metric tons per year, though it is highly variable because of variability in both river flow and mercury content of the river water[6]. Introduction of mercury into the Gulf of Mexico from offshore oil and gas drilling has been estimated to be 0.8 metric tons per year[7], and significant past deposition from chlor-alkali plants and other sources has also been documented[8]. It is important to remember that, as a chemical element, mercury is neither created nor destroyed in the environment; once deposited it may be remobilized at a later date. The next section describes those processes in more detail.

What is not known:

Estimates have been made for total mercury emissions and fluxes on a national and global basis, but there is no comprehensive national or global measurement of mercury emissions from natural or anthropogenic sources. These estimates have been made using the best data available, and estimates will certainly improve as additional measurement data become available in the future. The United Nations Environmental Programme is planning a compilation of global mercury use, distribution, and emissions, but that report will not provide for collection of new data.

Within the Gulf of Mexico region, the relative importance of different source types and source regions to mercury deposition is not known. Atmospheric mercury cycling is complex and many uncertainties remain, but substantial progress is being made in developing techniques for providing such source-apportionment for mercury deposition.[9,10] This type of information is important for prioritizing actions to reduce the loading.

As described in the next section, the ultimate source of the mercury may be less important than how it is deposited and what happens to it after deposition.

Little is known about these processes in the marine or brackish environment.

Research and information priority areas:

The Working Group has identified the following research and information priority areas regarding the identification of mercury sources in the Gulf of Mexico region:

a. A systematic assessment of historic and current sources of mercury emissions (U.S. and foreign) in the Gulf of Mexico region is needed. These sources include (but are not limited to) coal-fired power plants, waste incineration plants, historic or existing chlor-alkali plants, and oil and gas drilling and refining operations. Information regarding the proportions of the different forms of mercury (elemental, gaseous ionic, particulate) emitted from each source is also needed.

b. A systematic monitoring program of atmospheric deposition directly to land and water is needed across the Gulf of Mexico region, perhaps by expanding the existing Mercury Deposition Network. Such a monitoring program should include measurements of deposition (both wet and dry), atmospheric concentrations of the different chemical forms of mercury, co-pollutants, and meteorology. To facilitate such measurements, a method for measuring dry deposition is needed.

c. A systematic monitoring program is needed to measure concentrations and chemical forms of mercury entering the Gulf of Mexico in rivers and streams, both in dissolved form and associated with sediment particles.

d. Natural sources of mercury need to be identified that impact the Gulf of Mexico region, including sediments and wetlands.

e. Atmospheric modeling, supported by atmospheric measurements for model evaluation and improvement, is needed to estimate the amounts and source-receptor relationships for mercury deposition to the Gulf region. Receptor modeling techniques should include back trajectory analysis.

f. Continued research is needed on development of sampling and analytical techniques for improved measurements of mercury and its chemical form in air, fresh water, salt water, soils, sediments, and biota.

2. CYCLING, FATE, AND CHEMICAL FORM OF MERCURY

What is known:

How does mercury, which is generally emitted in a gaseous elemental or ionic form, end up as methylmercury in the muscle tissue of fish? The answer involves a number of complex physical and chemical processes that are not well understood. The cycling, fate, and chemical form of mercury in natural environments, its uptake by biota, its bioaccumulation in the food chain, and its occurrence in fish are all areas that require continued research.

The study of mercury cycling, fate, and chemical form is evolving rapidly, principally because the analytical technology necessary to make the critical measurements has only recently been developed. In addition, mercury research in the atmospheric sciences has evolved substantially over the past five years[11,12], with a number of important studies coming from the terrestrial-ocean interface of the Arctic and Antarctic. These researchers have hypothesized that the near-surface oceanic halogen cycles serve to oxidize considerable amounts of mercury from the atmosphere and thereby dramatically increase the net deposition rate of mercury to the Earth's surface. However, little of this type of work has been done in lower latitudes, and thus we do not currently know if the ocean-continental interface is a general area of high deposition or if this is unique to polar settings. Such processes may be important in understanding mercury cycling in the Gulf of Mexico.

There are four main forms of mercury (chemical symbol Hg) in the environment: elemental mercury – Hg(0), ionic or divalent mercury– Hg(II), mercury adsorbed on particles – Hg(p), and organic mercury or methylmercury – CH_3Hg. The majority of mercury in the atmosphere is the gaseous form, elemental mercury (Hg(0)). Gaseous mercury is converted in the atmosphere to the more water soluble divalent form of mercury, Hg(II), which is rapidly removed from the atmosphere in precipitation. Divalent mercury also binds with particulate material to form Hg(p), which is also rapidly removed from the atmosphere and deposited in terrestrial and aquatic systems.

Typical combustion processes, e.g., incinerators, emit three of these forms of mercury, and each form behaves differently: 1) elemental mercury, believed to have a half-life of about one year and to travel globally; 2) particle-bound mercury, which, depending on the particle size, can deposit over a wide range of distances; and 3) ionic mercury, predominantly in water soluble forms, which may deposit from the atmosphere relatively quickly, even in the absence of precipitation. Methylmercury has not been found to be emitted from combustion sources. In the atmosphere, ionic mercury is measured as water soluble ionic gaseous mercury. Based on factors such as stack height, meteorology, terrain, and the physical and chemical characteristics of emitted mercury, atmospheric mercury can be transported and deposited at varying distances, resulting in impacts on the following scales:

1. ***Local scale:*** These impacts result from deposition relatively close to an emissions source. For example, a significant fraction of mercury emitted primarily as ionic gaseous mercury is expected to be deposited near the emission source[13].

2. ***Regional scale:*** These impacts result from deposition associated with long-range transport of emissions beyond the local scale but generally within a 1000-kilometer range. For example, depending on atmospheric conditions, ionic gaseous mercury emitted from a tall stack might have regional scale impacts.

3. ***Continental scale:*** These impacts result from emissions being transported distances beyond a 1000-kilometer radius and depositing across an entire continental area. For example, ionic gaseous mercury and a small amount of elemental mercury lofted high in the atmosphere by convective currents or adsorbed on fine aerosol particles might have continental scale impacts.

4. ***Global scale:*** These impacts result from emissions that become part of the global pool, where they can remain for months or years. For example, elemental mercury (or ionic gaseous mercury chemically reduced to elemental mercury before deposition) can be transported in air for many months, eventually being oxidized and deposited at any location around the globe.

Once deposited on the ground, the potential for mercury to become an environmental problem depends largely on whether the deposition location is favorable for the conversion of elemental or ionic mercury to methylmercury, a process called methylation. Mercury that is deposited in environments that are conducive to methylation poses an increased hazard. Research suggests that aquatic sediments are where the methylation process most commonly occurs. Especially favorable sites for these processes are wetlands, low-pH and low-alkalinity lakes, recently inundated areas (i.e., reservoirs), systems rich in natural organic acids (e.g., low-land southeastern coastal streams), and streams where pronounced water level fluctuations occur.

Most of the scientific understanding of the environmental mercury cycle is derived from research conducted on inland, freshwater ecosystems. Less is known about the mercury-to-methylmercury conversion processes in estuarine and marine ecosystems, where important linkages between atmospheric deposition, watersheds, riverine, estuarine, and marine systems may affect the production and bioaccumulation of methylmercury. It has recently been suggested that mercury may be methylated in the deep ocean.[14] Coastal wetlands, salt marshes, and estuaries are believed to be significant producers of methylmercury as conditions in these locations are favorable for supporting anaerobic bacteria that facilitate methylation. Given that the majority of human exposure to methylmercury comes from the consumption of fish and shellfish, better understanding of the methylation process in marine environments is critical not only for the Gulf of Mexico region, but globally as well.

Most researchers agree that specific naturally-occurring microbes are the primary methylating agents in the environment. In particular, anaerobic sulfate reducing bacteria are considered to be the most important biological processors, thus creating an important link between sulfur and mercury cycles[15]. In some freshwater systems methylmercury formation is limited by sulfate availability. However, in marine and estuarine systems sulfate is never limiting.

Methylmercury biomagnifies upward in the food web, resulting in higher concentrations of mercury in predatory fish and in other predatory species. The specific mechanism of entry into the food web is unknown, but likely includes uptake of dissolved methylmercury from the water and sediments of aquatic systems. Thus, methylmercury formed in shallow freshwater and estuarine systems near the coasts could be transported to offshore marine settings and bioaccumulate there.

Effective modeling of methylmercury bioaccumulation in marine systems requires information about diets, migratory patterns, and life histories of organisms at each stage of the process. Good general information is currently available for predator fish, a few avian species, and a few mammals from freshwater environments. However, much less is known about mercury bioaccumulation in marine systems.

In the Gulf of Mexico, individual bordering states have fish monitoring programs for mercury in marine and estuarine fish that are quite variable in scope (number of fish sampled, data record length, and geographic coverage). New and/or ongoing fish monitoring efforts by the NOAA National Marine Fisheries will greatly add to this knowledge base, although much more critical information is needed in the Gulf of Mexico.

What is not known:

There remains considerable uncertainty regarding atmospheric transformations of mercury and the atmospheric pathway followed by mercury emitted from a particular source. Thus, little can be concluded from the literature on atmospheric cycling, fate, and chemical form of mercury in the Gulf Coast region. A notable exception is the monitoring and research done in the southern peninsula of Florida where there are a number of Mercury Deposition Network (MDN) sites, and a long-term (about two years) record of the quantity and chemical form of atmospheric mercury is reducing the uncertainty. There are a few additional MDN sites located in other states bordering the Gulf, but those sites do not measure dry deposition and are not numerous enough or in optimal locations to accurately estimate fluxes and chemical forms of mercury generally across the Gulf. In fact, there are no offshore MDN sites in the Gulf of Mexico region, and extremely few studies on offshore mercury deposition rates. Potential use of oil and gas platforms in the Gulf of Mexico may provide an opportunity to close this critical data gap. Modeling can be used to help estimate levels between measurement sites and between measurement events, and models may be used to investigate implications of changes in the system.

Importantly, there is little information currently available on mercury methylation in marine systems. Information for a few of the major estuaries of the U.S., including San Francisco Bay, Florida Bay, Long Island Sound, and Chesapeake Bay, demonstrates active mercury methylation in estuarine sediments[16,17]. With the abundance of coastal wetlands, salt marshes and estuaries in the Gulf of Mexico region, it would appear that these environments are likely sources of methylmercury.

Because so little is known about the specifics of the mechanisms for methylation and uptake of mercury in the Gulf of Mexico region, it is not clearly known how total mercury levels relate to levels of methylmercury, the most important toxic form. In other words, measurements of total mercury in air, water, soils, or sediments do not necessarily represent the bioavailability of methylmercury.

Research and information priority areas:

The Working Group has identified the following research and information priority areas regarding the cycling, fate, and chemical form of mercury in the Gulf of Mexico region:

a. More research is needed on the atmospheric pathway and emission sources of mercury depositing in the Gulf of Mexico Region. This research would use expanded monitoring data recommended above, would include both natural and anthropogenic sources, and would account for evasion (evaporation) of mercury after initial deposition.

b. More research is needed on methylation mechanisms in estuarine and marine environments and in coastal wetlands.

c. Fate and transport models of mercury cycling in estuarine and coastal wetlands are needed, building upon the modeling techniques developed in the Everglades and other wetlands.

d. Determination of the chemical form of mercury is needed in various environmental media, and for different locations and environments within the Gulf of Mexico region.

e. Research is needed to determine how methylmercury is incorporated into the food web in the Gulf of Mexico and in adjacent estuaries and coastal wetlands.

3. CONCENTRATION AND REGIONAL DISTRIBUTION OF MERCURY IN FISH

What is known:

Mercury data for fish and shellfish in the Gulf of Mexico region are collected by a number of agencies and may be found in several reports and databases such as the Gulfwide Mercury in Tissue Database[18]. All of the states in the Gulf of Mexico region have fish monitoring programs upon which they base fish consumption advisories. In addition, the Gulf States (and other southern states) have been coordinating their mercury analysis methodologies for fish tissue via the Southern States Mercury Task Force, which meets annually. However, several states are just beginning to monitor estuarine and marine fish. The Gulf States Marine Fisheries Commission adopted a "Methylmercury in Marine Fish: A Gulf-Wide Initiative" in 2002, which recommended initiating a coordinated Gulf-wide mercury in fish survey to fill in data gaps.

Currently, NOAA Fisheries' National Seafood Inspection Laboratory is conducting a limited Synoptic Survey of Total Mercury in Recreational Finfish of the Gulf of Mexico (4 of 31 estuaries) to provide preliminary data, sampling methodologies, logistics, and statistics to compare mercury levels in various species of fish from multiple geographic locations. After completion in July 2004, a broader survey will be designed to determine the mercury levels in fish in the remaining 27 estuaries and multiple sections of the offshore Gulf of Mexico.

A regional database - the Gulfwide Mercury in Tissue Database - was created with recent GIS-based tissue monitoring data contributed by the five Gulf States (Florida, Alabama, Mississippi, Louisiana, and Texas), the USEPA Environmental Monitoring and Assessment Program, the NOAA National Ocean Service's National Status and Trends Program, and the NOAA Fisheries' GulfChem study. The study area for the database includes waters within the 94 USGS 8-digit hydrologic unit code watersheds that comprise the major estuarine drainage areas of the Gulf of Mexico, and the nearshore and deeper waters of the Gulf of Mexico.

What is not known:

Analysis of existing data may prove fruitful, and a number of studies have been based on existing information. However, despite a large number of analyses by a variety of state and Federal agencies in the region for the purpose of issuing fish advisories, the distribution of mercury in Gulf fish is not known in sufficient detail to conduct many needed scientific investigations. Given the large number of offshore, nearshore and inshore water bodies, water body sub-basins, fish species, and species size ranges, filling in the data matrix becomes an exceedingly large and resource intensive task. [See examples of Federal agency activities in the boxes below.] As a result, the distribution of methylmercury in Gulf fish is not known in adequate detail and there are substantial gaps in the data. Additional monitoring is necessary that has the potential to identify locations in the Gulf where there are higher levels of methylmercury, the species containing the most methylmercury, and the sizes of the fish that contain hazardous amounts of methylmercury.

Ongoing Federal activities in the Gulf of Mexico: NOAA

The National Seafood Inspection Laboratory, in cooperation with Gulf States and other Federal laboratories, is participating in an ongoing study to compare the accuracy of these laboratories' mercury analyses in fish tissue using multiple methods in order to ensure continued high quality analyses.

Additionally, NOAA's National Ocean Service conducts a Mussel Watch Project that provides a synoptic and reasonably long-term dataset for mercury in biological (oyster) tissues in the Gulf of Mexico. A recent review of these data showed that the total mercury concentration in oyster tissues was generally low, and the median mercury concentration at sites in the Eastern Gulf of Mexico (off Florida, Alabama and Mississippi) was slightly higher – but perhaps not significantly so – than in the Western part (off Louisiana and Texas).

The National Seafood Inspection Laboratory, in cooperation with USEPA's Gulf of Mexico Program and Gulf states, is conducting a pilot program for sampling and analysis of estuarine and offshore fisheries in the Gulf of Mexico, and will develop a comprehensive survey design and logistics for implementation.

NOAA's Mississippi-Alabama Sea Grant College Program, USEPA's Mobile Bay National Estuary Program, Mobile Bay Watch, and The Forum: Partners for Environmental Progress sponsored "The Mercury Forum" in 2002 which identified increased mercury monitoring in fish, biota, and environment as a priority recommendation.

Ongoing Federal activities in the Gulf of Mexico: NOAA Fisheries' Synoptic Survey

Estuarine Sampling and Modeling: Selected estuarine finfish are being collected from estuaries with varying degrees of mercury contamination. Previously collected mercury data in oysters from these estuaries will be modeled against the finfish mercury levels. If the modeling finds that the low levels of mercury in oysters can be used as a surrogate for the finfish mercury levels, then the 31 estuaries of the Gulf Coast could be modeled for their finfish mercury levels using NOAA's Mussel Watch's previously collected oyster mercury data for the 31 Gulf estuaries.

Reef and Rig Sampling: Selected reef finfish are being collected from oil and gas drilling rigs and non-oil and gas drilling rig reefs. The samples will be tested to determine if a statistical difference exists in the mercury level in the reef finfish caught near the drilling rigs versus those caught near the non-rig reefs. If no difference is observed, then a generic Gulf-wide modeling of the mercury levels in reef fish could be possible. Conversely, if the mercury levels in the reef finfish taken from the vicinity of the rigs are statistically higher than those taken at non-rig reefs, then additional surveys will be required.

Migratory Species Sampling: Selected highly migratory finfish species are being collected from off the Florida Gulf and Texas Coasts. The samples will be tested to determine if a statistical difference exists between the fish taken from these geographic regions of the Gulf. If no difference can be determined, then a generic Gulf-wide modeling of the mercury levels in these species may be possible. Conversely, if a difference is observed, then additional surveys will be required.

<u>Ongoing Federal activities in the Gulf of Mexico: USEPA Gulf of Mexico Program</u>

"Mercury in the Gulf Project" has the following components:

In 2000, the USEPA Program generated a report "The Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico" which assessed the status of the mercury in fish tissue data and recommends filling in the data gaps by initiating a Gulf-wide monitoring program with particular attention being given to fish length measurements.

The Program maintains an ongoing compilation of the mercury in fish data from the Gulf States and makes that data available online.

The Program conducts analyses of the compiled Gulf States mercury in fish data in order to assess the coverage of the data geographically in the Gulf and adjacent estuaries.

In cooperation with the USGS, the Program maintains an online geographic information system to display the mercury in fish data on maps for visualization purposes.

Research and information priority areas:

The Working Group has identified the following research and information priority areas regarding the concentration and regional distribution of mercury in fish in the Gulf of Mexico region:

a. A systematic monitoring program should include methods to measure bioaccumulation of methylmercury on representative fish and shellfish species.

b. Uniform mercury concentration data for fish across the Gulf of Mexico are needed, and additional information is needed about fresh water, estuaries, near shore Gulf waters, and deep Gulf waters, a variety of commercial and recreational species, a range of sizes for each species. The Gulfwide Mercury in Tissue Database might be expanded to accommodate these data.

4. RISK CHARACTERIZATION FOR METHYLMERCURY EXPOSURE

What is known:

Humans acquire methylmercury burdens primarily by eating fish and shellfish that contain methylmercury. Because fish and shellfish provide important nutritional health benefits in our diet, it is critical to understand which populations are most adversely affected and to reduce their exposure to methylmercury in fish. The adverse health effects of methylmercury exposure have been documented (see, for example, the National Research Council report, Toxicological Effects of Mercury, and the USEPA Mercury Study Report to Congress) and ongoing research is continually providing new information. The risk of experiencing methylmercury toxicity from eating fish or shellfish for a particular group depends on the methylmercury content of the fish and the amount of the fish consumed. Using data from the National Health and Nutrition Examination Survey (NHANES), researchers have correlated the frequency of eating fish to elevated blood mercury levels[19,20]. Because the developing fetus is most sensitive to exposure to methylmercury, women of childbearing age are regarded as the population of greatest interest, and guidelines for fish consumption are contained in a consumer advisory from the FDA and USEPA (shown below). Approximately eight percent of women of childbearing age in the U.S. have blood mercury concentrations above USEPA's reference dose for methylmercury[21].

EPA and FDA Advice For:
Women Who Might Become Pregnant
Women Who are Pregnant
Nursing Mothers
Young Children

(March 2004)

Fish and shellfish are an important part of a healthy diet. Fish and shellfish contain high-quality protein and other essential nutrients, are low in saturated fat, and contain omega-3 fatty acids. A well-balanced diet that includes a variety of fish and shellfish can contribute to heart health and children's proper growth and development. So, women and young children in particular should include fish or shellfish in their diets due to the many nutritional benefits.

However, nearly all fish and shellfish contain traces of mercury. For most people, the risk from mercury by eating fish and shellfish is not a health concern. Yet, some fish and shellfish contain higher levels of mercury that may harm an unborn baby or young child's developing nervous system. The risks from mercury in fish and shellfish depend on the amount of fish and shellfish eaten and the levels of mercury in the fish and shellfish. Therefore, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) are advising women who may become pregnant, pregnant women, nursing mothers, and young children to avoid some types of fish and eat fish and shellfish that are lower in mercury.

By following these 3 recommendations for selecting and eating fish or shellfish, women and young children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury.

1. Do not eat Shark, Swordfish, King Mackerel, or Tilefish because they contain high levels of mercury.

2. Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.

   - Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish.

   - Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your two meals of fish and shellfish, you may eat up to 6 ounces (one average meal) of albacore tuna per week.

3. Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch from local waters, but don't consume any other fish during that week.

Follow these same recommendations when feeding fish and shellfish to your young child, but serve smaller portions.

For more information: **http://www.cfsan.fda.gov/~dms/admehg3.html** or **www.epa.gov/ost/fish**

Other subpopulations are at elevated risk of methylmercury toxicity because of their fish eating habits. Far higher blood levels than those observed in the NHANES study have been found in: 1) fishermen, 2) people eating fish for health reasons, and 3) people with a cultural or ethnic preference for fish.[22,23,24,25,26,27]

The average fish and shellfish consumption per person in the United States is approximately 15 pounds per year. In coastal areas where residents have access to fresh locally caught seafood, and to seafood they catch themselves, the average per capita consumption is believed to be significantly higher. For example, a Florida seafood consumption survey found that the average annual per capita fish and shellfish consumption (statewide) was about 37 pounds with 91% of the seafood being saltwater species. Some of the species reported as consumed in the Florida survey were species known to be high in methylmercury (e.g., king mackerel, sharks, swordfish, etc.). This Florida consumption rate may be more representative of the coastal areas in the Gulf of Mexico region (and elsewhere) than the national average. Therefore, special attention should be given to certain coastal area residents as some may be consuming more seafood and likely ingesting more methylmercury than their inland counterparts (except for people eating high amounts of seafood for health or cultural reasons). In addition, the coastal areas are believed to have a higher percentage of a high-risk sub-population as residents (i.e., saltwater recreational and commercial fishermen and their families) because they may consume quantities of seafood above the national and Florida coastal averages.[28]

What is not known:

Few data are available that quantify the patterns of fish consumption, methylmercury body burden, and potential health effects associated with methylmercury exposure in the Gulf of Mexico region.

Measurement of methylmercury in blood or hair provides an integration of the day-to-day variation in quantities of methylmercury consumed, but data on blood and/or hair mercury concentrations from people living in the Gulf of Mexico region are sparse.

Research and information priority areas:

The Working Group has identified the following research and information priority areas regarding the health effects and risk assessment of methylmercury in the Gulf of Mexico region:

a. Identify at-risk sub-populations: Broad surveys are needed in the Gulf States (especially in the coastal counties) to identify the highest risk sub-populations. These surveys need to include determination of fish consumption, as well as blood and/or hair mercury concentrations in sub-populations considered at risk because of higher than average fish consumption based on known demographic factors.

b. Characterize the risk for sub-populations: Risk characterizations are needed for at-risk subpopulations in the Gulf of Mexico region. Thorough and systematic characterizations are needed for the quantities of fish consumed, methylmercury intake, mercury or methylmercury exposures based on monitoring of blood and/or hair concentrations, and the potential health impacts of fish and shellfish consumption on the selected at-risk subpopulations. Initial efforts would be most effective if combined with contamination monitoring for major fishing zones and shoreline contamination.

5. RISK MANAGEMENT AND MITIGATION

What is known:

Effective steps have been taken in the United States and globally to reduce or eliminate the use and release of elemental or ionic mercury in products and industrial processes. Efforts to further reduce the use of industrial mercury are continuing. Recent reductions in methylmercury in the Florida Everglades are likely the result of targeting specific mercury sources within the region[29], and similar reductions may be possible for some estuarine and marine water bodies in the Gulf of Mexico region. Efforts to reduce mercury emissions from coal-fired power plants in the United States are ongoing, both legislatively and through the rulemaking process. Similar efforts may be required on a global scale, since the circulation of mercury from combustion sources is global in scope. In recognition of the global nature of the mercury issue, the United Nations Environmental Programme (UNEP) initiated a Global Mercury Programme in 2003.

The risk of methylmercury exposure may be reduced through careful monitoring and communication of mercury levels in fish. Information about methylmercury levels in fish that can be communicated to at-risk populations is still very valuable. State and Federal agencies currently issue advisories about mercury in fish. Forty-seven states have issued mercury fish advisories, including all of the states in the Gulf of Mexico region. A Gulf-wide advisory is currently under consideration; USEPA's Gulf of Mexico Program, in cooperation with the Gulf States and other Federal agencies, currently is assisting the states in developing a harmonized Gulf-wide consumption advisory for king mackerel as a pilot project for coordinating and standardizing other species specific consumption advisories. Currently, Gulf states' public communication efforts center on fish consumption advisories, which are often posted on the web, in local newspapers, on signs near contaminated water bodies, in brochures distributed with fishing licenses, and at recreational retail outlets. There are also opportunities to enhance the effectiveness of the risk communications by using other modes of public education and outreach tailored to specific audiences. For example, meetings, workshops, newsletters, newspaper columns, television and radio, and presentations to civic groups all help to deliver the message to potential seafood consumers. To advance these efforts, NOAA's Mississippi-Alabama Sea Grant College Program, Marine Extension Service has conducted risk communication training for the Marine Extension Services in Texas, Louisiana, and Florida, and continued efforts to improve the communication of risk should result in a more fully informed public. In addition, the Food and Drug Administration and the USEPA will deploy an outreach plan to accompany their recent advisory on the consumption of fish and shellfish.

What is not known:

Although there are numerous fish advisories designed to warn the public about consumption of fish with elevated methylmercury levels, there is little information on the effectiveness of these advisories, especially for certain at-risk subpopulations such as subsistence fisherman, commercial fishermen, and some recreational fishermen.

While evaluating changes in consumption of species containing elevated levels of methylmercury, it is also important to evaluate related changes in consumption of species containing low levels of methylmercury. It is important to know whether the general population reduces consumption of high-mercury fish by reducing their consumption of all fish, which would reduce the nutritional benefits of fish consumption.

Research and information priority areas:

The Working Group has identified the following research and information priority areas regarding risk management and mitigation for mercury in the Gulf of Mexico region:

a. An evaluation is needed on the success of current mercury education programs and advisories, including the extent to which states follow USEPA/FDA guidelines when issuing advisories and whether such advisories are effectively decreasing people's potential mercury exposures without impacting the nutritional benefits of fish consumption.

b. An education and outreach strategy is needed that includes the development of new and more effective materials to educate both the highest risk sub-populations and the general public about the level of risks associated with the consumption of seafood with elevated mercury levels, without impacting the nutritional benefits of fish consumption.

6. STRUCTURE AND PROCESS TO ADDRESS MERCURY ISSUES IN THE GULF OF MEXICO REGION

The Interagency Working Group on Methylmercury recommends that the research and information priority areas identified in this report be provided to the Program Director of the USEPA Gulf of Mexico Program for consideration in the science and budget planning processes of the Program. The Gulf of Mexico Program is an interagency group headed by the USEPA that addresses science and technical issues in the Gulf of Mexico region, and this group is already involved in methylmercury monitoring. Its membership includes the following Federal departments and agencies:

U.S. Environmental Protection Agency
Department of Commerce
Department of Interior
Department of Health and Human Services
Department of Energy

The Gulf of Mexico Program should consider reviewing these needs annually to develop and update a research strategy for Federal agencies to address mercury issues in the Gulf of Mexico region that will be implemented through the planning and budget processes of member agencies.

The Gulf of Mexico Program should communicate and coordinate these activities with the States of Texas, Louisiana, Mississippi, Alabama, and Florida, as well as with the Gulf States Marine Fisheries Commission and the Gulf of Mexico Fishery Council and parallel activities outside the Gulf of Mexico region.

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