New England Mercury Strategy and Loading Study

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Problem Description

Mercury contamination of waterbodies throughout New England has resulted in statewide fish-consumption advisories and the listing of virtually all fresh surface water on state lists of impaired waters (Clean Water Act Section 303(d) lists). An EPA report to Congress on mercury contamination concluded that the east-coast megalopolis from Virginia to Maine encompasses one of the densest mercury-emission source regions in the United States, and receives enhanced deposition (dry and wet) of mercury from both local sources and long-range transport. An EPA STAR report (October 2000) cites fish consumption as the dominant mercury exposure pathway for humans and wildlife.

EPA identified mercury as a concern in New England in the early 1990s. In 1989, EPA conducted an extensive fish-tissue sampling study in New England. Lakes previously considered to be pristine were found to have fish with high levels of methyl mercury, the most toxic form of mercury. Fish-eating birds (e.g., loons) and mammals have also been found to have high levels of mercury.

Due to the regional nature of the mercury problem, it is logical to take a regional approach (and, in some cases, national approach) to studying and, eventually, solving this problem. Not only is this more efficient, but it will also help assure consistency between states. EPA Region 1 supports this regional approach, and has been working closely with the New England states to reduce sources of mercury from air sources, such as municipal solid waste incinerators and medical waste incinerators, as well as from other sources, such as products like thermometers and thermostats and other mercury switches.

In 1998, the six New England Governors and five Eastern Canadian Premiers signed a Regional Mercury Action Plan to identify ways to reduce mercury in the Northeast. New England tribes are also concerned about mercury and have been conducting fish-tissue testing and fish-consumption surveys, and, like New England states, issuing fish advisories.

Project Objectives

The primary objective of the project is to develop regional GIS-based models that provides information about sources of mercury, the susceptibility of fish to mercury contamination, the influences of certain landscape and water-quality variables on mercury in fish tissue, and the relative magnitude of loading from mercury sources in watersheds throughout New England. One model will be used to estimate the amount of mercury reduction needed from sources, especially air deposition, necessary to meet EPA's mercury criterion of 0.3 mg/kg methyl mercury in fish tissue. All models will be used to evaluate management options for reducing mercury loads to waterbodies, and to help optimize future data-collection activities.

Summary of the Proposed Project

The project will combine two ongoing projects, (1) a "National Model" developed by EPA's Office of Water and (2) a "Regional Model" developed cooperatively by EPA Region 1, the US Geological Survey (USGS) National Water-Quality Assessment Program (NAWQA) office in New Hampshire, and the New England Interstate Water Pollution Control Commission (NEIWPCC) and the Northeast States for Coordinated Air Use Management (NESCAUM). Collaboration with other agencies and organizations, such as the Northeastern Ecosystem Research Cooperative (NERC) Mercury Research Group, will be pursued.

I. Hg Mercury Maps (the "National Model"): EPA's Office of Science and Technology (OST) has developed "Mercury Maps", a GIS tool which displays fish tissue and other data on a watershed-by-watershed basis. Specifically, Mercury Maps was developed to show those watersheds where fish-tissue concentrations exceed the new methyl mercury fish-tissue criterion (0.3 mg/kg methyl mercury in fish tissue). In addition, for watersheds in which air deposition is the predominant source of mercury, the maps provide estimates of the atmospheric load reductions needed to meet the new methyl mercury criterion. These estimated reductions are based on the assumption that fish-tissue concentrations will decline in direct proportion to reductions of mercury loads entering waterbodies.

The model used to produce these maps is a reduced form of the IEM-2M and MCM models used in the Mercury Study Report to Congress (MSRC) (US EPA, 1997b). To develop this reduced model, the equations of the IEM-2M and MCM models were reduced to steady-state and consolidated into a single equation relating the ratio of current/future air-deposition rates to current/future fish-tissue concentrations. This ratio-reduction model is discussed in detail in the peer-reviewed Mercury Maps report (USEPA, 2001). The technique is valid where other water-quality parameters, as well as watershed pollutant-delivery mechanisms are constant.

An idea that will be explored during the pilot project is to group waterbodies according to the types and relative contribution of source categories. A preliminary assessment of the data suggests that waterbodies can be grouped into four types:

Type 1: Air deposition is the predominant source of mercury to the waterbody and existing Clean Air Act (CAA) regulations are likely to be sufficient to return waterbodies to compliance with water-quality standards. Existing air regulations to address mercury emissions include the Maximum Achievable Control Technology (MACT) provisions under Clean Air Act Section 112 for hazardous waste incinerators, as well as the MACT-like provisions of Clean Air Act Sections 111 and 129 to address municipal and medical waste incinerators.

Type 2: Air deposition is the predominant mercury source, but existing CAA regulations are unlikely to be sufficient for attainment of water-quality standards;

Type 3: Other sources in addition to air deposition are significant and existing regulations are likely to be sufficient for attainment of water-quality standards. . Other sources might include, for example, sources that discharge directly into waterbodies from industrial and municipal facilities.

Type 4: Other sources besides air deposition are significant, and existing regulations are unlikely to be sufficient for attainment of water-quality standards.

The pilot project will examine whether a TMDL could be developed on a regional basis for all those waterbodies which fall into a particular category. For this pilot project, we propose to examine the feasibility of a regional approach to TMDLs for those waterbodies which fall into the first category or

"type."

The Mercury Maps may also be useful for assessing natural background mercury loads from geologic sources throughout New England. Specifically, it may be possible to use a method similar to that used in a mercury TMDL for the Ouachita River Basin in Arkansas. Using this method, soil-erosion rates were multiplied by the estimated average concentrations of mercury in bedrock to derive estimates of natural background loads. A USGS study found that shale that contains high concentrations of metals can be a source of mercury to runoff or streams (USGS, 1970). For the most part, natural background levels of mercury from geologic sources in New England are not expected to be significant.

It is also possible to use the mercury maps to assess how various management actions might reduce the levels of mercury in fish tissue. For example, mercury emissions predicted for 2020 (by industry category, subcategory, and total) can be compared to 1990 conditions, and the impact of these emissions reductions on fish mercury levels can in turn be estimated. This analysis could take into account MACT controls under federal CAA authority that have already been implemented, as well as anticipated new MACT rules.

II. Regional Regression Model (the "Regional Model"): This model is proposed as a result of successful experience with another regional model, a GIS-based nutrient model known as SPARROW (Spatially Referenced Regressions on Watershed Attributes). The Region 1 SPARROW model was based on national and regional SPARROW models developed by Smith and others (1993 and 1997) at the USGS, and will be used to estimate nutrient concentrations, yields, and transport in New England watersheds, and to develop regional nutrient criteria and nutrient TMDLs. Success of this model for assessing nutrient contamination suggests that similarly formulated models could be used for performing regional assessments of other widespread contaminants, such as mercury and other Persistent Bioaccumulative and Toxic (PBT) chemicals.

The Regional Model for mercury will not be a true SPARROW model in that it will not model mercury transport in the aquatic environment, but rather it will be a multivariate regression model that will identify factors contributing to high levels of mercury in fish throughout New England, and to predict the susceptibility of mercury contamination in fish tissue. The underlying assumption for development of the Regional Model is that some degree of variability in the fish-tissue data can be explained by a combination of data describing physical watershed features and anthropogenic mercury sources. Models will likely be produced that are unique to fish species, family or trophic level of the fish.

The initial phase of model development has and will focus on compiling data, including data for both the dependent or response variable in the model (i.e., mercury in fish tissue) and for the independent or explanatory variables (i.e., watershed features, mercury sources, and water-quality data for water bodies where fish tissue has been analyzed). The second phase of model development will include statistical model building and presentation of results.

Existing mercury data for fish tissue for New England include EPA's National Survey of Mercury Concentrations in Fish (1990-1995) database (USEPA, 2000), state databases and files, US Fish and Wildlife data, USGS NAWQA data, and other special studies in the region. NERC's Mercury Research Group has already compiled a New England-wide mercury fish tissue data base and this data base will be initially used in the modeling effort. In addition, ancillary data associated with the tissue data will be gathered where available. This includes data on sampling locations and dates, fish species, size, and age, and waterbody type (i.e., lakes and streams).

Data for the independent or explanatory model variables that will be collected as part of this project

include:

-Point source releases of mercury (location and mercury-release amounts) from on-going USEPA and NESCAUM efforts
-Mercury atmospheric-deposition estimates for New England from the National Atmospheric Deposition Program's Mercury Deposition Network, on-going USEPA deposition modeling studies, and other mercury deposition modeling results.
-Water-quality features (e.g., water pH, color, and alkalinity) of waterbodies with mercury tissue data. This information will be derived from state databases, the ENSR, Inc., lake and stream nutrient database recently prepared for USEPA, Region 1, and other regional and local databases.
-Watershed features that have been generated from the New England SPARROW model, such as land use, population, presence of municipal and industrial wastewater point sources, wetlands, soils, stream networks, streamflow and watershed boundaries.

In addition, there may be an attempt to generate deposition shadows (i.e., the geographical areas expected to be most impacted by deposition from air sources of mercury in New England). The shadows will incorporate mercury-loading data as well as prevailing wind patterns to estimate the potential for mercury deposition.

All data compiled and generated for this Regional Model will be maintained in data management systems that will allow linkage to GIS. Response-variable data will be stored initially in ACCESS or SAS; explanatory data will be maintained in ARC/INFO format.

III. New England Mercury Strategy and Loading Study: The National and Regional modeling efforts described above are complementary. The goal is to combine the two models into a GIS-based system that shows information about susceptibility of fish and watersbodies to mercury contamination, and the relative magnitude of source loadings in watersheds throughout New England. In addition, the combined models may provide tools for estimating the amount of mercury reduction needed from sources, especially air deposition, necessary to meet the methyl mercury fish-tissue criterion.

Specifically, the National Model (described in (I) above) will serve as an initial planning tool. The Regional Model (described in II above) will then be used to give more detailed information on waterbodies at risk for mercury contamination in fish tissue, including identification of factors that contribute to risk. Both Mercury Maps and EPA/USGS modeling results could then be used to explore possible approaches to developing mercury reduction strategies.

Benefits to Region:

This project addresses one of EPA's highest priorities: to obtain better information on the sources and severity of mercury contamination in New England, and the factors that contribute to environmental risks from mercury. In addition, this project will provide EPA and New England states information necessary to meet statutory requirements to develop TMDLs for waters impaired by mercury.

Products Expected:

This project will result in regional GIS-based multi-variate regression models that can predict the risk of mercury contamination in fish throughout New England. Specific functions and uses of the GIS-based mercury model include:

- Will integrate information on mercury from diverse databases for the New England region.
- Will provide a means of linking mercury loading to mercury contamination in fish tissue.
- Will serve as a tool for understanding factors that contribute to elevated mercury levels in fish tissue (e.g., atmospheric deposition patterns, basic water chemistry, stream density, watershed size, specific land uses, presence/absence of wetlands)
- Will serve as a tool for prioritizing EPA efforts to reduce health risks associated with mercury in New England
- Will help EPA and states target collection of fish tissue (i.e., will promote cost efficiency) to waterbodies that are more likely to have contaminated fish.
- Will provide information for the development of regional approaches for mercury reductions, including information about sources of mercury, the relative magnitude of loading from sources, and potential actions for attaining EPA's methyl mercury fish-tissue criterion

The combined model will provide useful scientific data, modeling predictions, and GIS graphics for use by a variety of EPA programs and groups, including the EPA New England REMAP mercury program, the EPA New England Children's Health initiative, the Casco Bay Air Deposition study, the Regional Air Toxics Subcommittee, the EPA Regional Mercury Workgroup, the EPA-ORD Mercury Research Strategy, the New England Governors/Eastern Canadian Premiers Regional Mercury Task Force (NEG/ECP), and the New England/Canadian Hg monitoring initiative for the Gulf of Maine.

Project Participants and Collaborating Agencies

NEIWPCC (water), NESCAUM (air), and NEWMOA (waste)
New England States
EPA Regional Mercury Workgroup
EPA Region 1 offices (OEP, OES, OEME)
EPA Headquarters
Northeastern Ecosystem Research Cooperative (NERC) Mercury Research Group
Mercury Consortium (a.k.a.Northeast Mercury Research Group)
New England Governors/Eastern Canadian Premiers Regional Mercury Task Force (NEG/ECP)
USGS (Pembroke, NH, and Reston, VA, offices)

Schedule and budget

To be determined

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