PROCEEDINGS

1997 AMERICAN FISHERIES SOCIETY FORUM ON CONTAMINANTS IN FISH

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PREPARED BY:

EVS ENVIRONMENT CONSULTANTS

Seattle, Washington

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1997 American Fisheries Society Forum on Contaminants in Fish

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LIST OF ACRONYMS

AFS	American Fisheries Society
ATSDR	Agency for Toxic Substances and Disease Registry
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
Beta HCH	beta hexachlorocyclohexane
DNR	Department of Natural Resources
DOE	U.S. Department of Energy
FDA	U.S. Food and Drug Administration
GM	General Motors Central Foundry Division
gpd	grams per day
MRL	minimum risk level
NHANES	National Health and Nutrition Examination Survey
NOAA	National Oceanic and Atmospheric Administration
NRDC	Natural Resources Defense Council
PCBs	polychlorinated biphenyls
ppb	parts per billion
ppm	parts per million
QA/QC	quality assurance/quality control
RfD	reference dose
STORET	Storage and Retrieval of U.S. Waterways Parametric Data
TMDL	total maximum daily load
USEPA	U.S. Environmental Protection Agency
WHO	World Health Organization
WIC	National Association of Women, Infants, and Children

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The following steering committee members and other individuals contributed their time and expertise to develop the forum's program and select priorities:

Jim Amrhein, Wisconsin Department of Natural Resources
Jeff Bigler, USEPA, Office of Water, Co-Chair
Gale Carlson, Missouri Department of Health
Betsy Fritz, AFS, Co-Chair
Karen Gourdine, USEPA, Office of Indian Affairs
Heraline Hicks, Agency for Toxic Substances and Disease Registry
Barbara Knuth, Past President, AFS Water Quality Section
Rosanna Kroll, Maryland Department of the Environment
Jerry Pardillo, National Tribal Environment Council
Jerry Pollock, California Environmental Protection Agency
Elizabeth Rockman, AFS
Jerry Schulte, President, AFS Water Quality Section
Larry Schwarzkopf, Fond du Lac Natural Resources Program
Bob Smith, USEPA, Office of Indian Affairs

This report was written on behalf of the AFS Water Quality Section. EVS Environment Consultants edited and formatted the report.

EXECUTIVE SUMMARY

The *1997 American Fisheries Society Forum on Contaminants in Fish* is the third forum convened since 1990 to discuss ways of improving methods for developing and communicating fish consumption advisories, interpreting emerging data from ongoing fish consumption studies, clarifying federal fish consumption guidelines, and developing a cooperative action plan for the future.

Many highly qualified scientists, public health specialists, and regulators made presentations at the conference held December 9 and 10 in Alexandria, Virginia. Conference participants included representatives from tribal organizations and governmental agencies in the United States and Canada.

The forum opened with the presentation of the 1997 Action Plan, which emphasized three major categories—training and guidance, information management, and interagency liaison. The Action Plan prioritized activities necessary to develop and effectively communicate fish advisories, make fish consumption advisory data available nationwide, and coordinate fish advisory research and legislation among federal, state, and tribal agencies.

The next session focused on populations that consume large quantities of fish, including Native American tribes, immigrants in the San Francisco Bay area, and sport fishers in the Great Lakes Region. The session included discussions of the tribal perspective on fish consumption advisories and how to communicate advisories to these high-risk populations, plus a review of findings from recent fish consumption studies conducted among these populations.

Concerns about public awareness and the effectiveness of fish consumption advisories were addressed in the following session. Representatives from New York and Wisconsin presented two different approaches to researching fish consumption advisory awareness and effectiveness. They discussed methods of developing and communicating fish advisories. A tribal perspective was also presented, emphasizing the negative impacts of fish consumption advisories on tribal economic and cultural traditions, as well as the potential for negative health impacts resulting from replacing fish protein in the diet with other protein sources.

The health benefits of decreased fish consumption were compared to associated health risks in the session on comparative dietary risk. Two presenters discussed risks to indigenous peoples of Alaska, including the psychological ramifications of curtailing

fishing activities and consequently damaging the cultural and economic structure of subsistence populations. Results of fish consumption studies in the Great Lakes region were also discussed, and the social significance of fishing was again highlighted. The last presentation of this session introduced a framework for further study of comparative dietary risks.

The second day of the forum opened with a session on mercury and health issues. Questions regarding the difference between the reference dose for methylmercury proposed in the U.S. Environmental Protection Agency's Mercury Report to Congress and the minimum risk level for methylmercury proposed in the Agency for Toxic Substances and Disease Registry's Draft Mercury Report were addressed. Results from studies conducted in the Faroe Islands and in the Seychelles on the health effects of human exposure to methylmercury through consumption of fish were also presented.

In the next session, the complexity of mercury contamination was discussed, including problems resulting from biomagnification of methylmercury through the food chain, increasing global emissions, and historical mercury deposits. The need for ongoing research on mercury source control and mitigation was emphasized.

In the final session, representatives from three U.S. states, Canada, and the Assembly of First Nations presented their approaches to developing and communicating fish consumption advisories for mercury.

The 1997 Forum successfully brought together representatives from the groups most critically interested in contaminants in fish. Consumers, regulators, public health officials, and scientists collaborated in moving forward the public discussion of this important issue. These proceedings capture all of the important content of this discussion, and can serve as a starting point for further discussion, policy development, and research on many fronts.

INTRODUCTION

The American Fisheries Society (AFS) organized and chaired the *1997 American Fisheries Society Forum on Contaminants in Fish.* This is the third forum convened since 1990 to discuss how to improve methods for developing and communicating fish consumption advisories, interpret emerging data from ongoing fish consumption studies, clarify federal fish consumption guidelines, and develop a cooperative action plan for the future.

Thirty-two scientists, public health specialists, and regulators participated in the conference held December 9 and 10 in Alexandria, Virginia. Conference participants included representatives from tribal organizations, Canada, and state and federal governments in the United States.

The goals of the conference included:

- Presenting a State-Federal Action Plan that clarifies and prioritizes the needs of States regarding the issuance of fish consumption advisories

- Presenting the latest results of human health studies involving fish consumption and the uptake of mercury

- Identifying methods of developing and communicating fish consumption advisories and evaluating their effectiveness in protecting public health

The following proceedings summarize the presentations made by conference participants. Audio tapes of the conference were transcribed verbatim and then condensed for publication. In order to capture the tone and the pertinent facts provided by each of the presenters, minimal editing was conducted. Since the document constitutes only a summary of the conference presentations and does not include any of the data or graphics used in the presentations, it is strongly recommended that any questions or requests for clarification be referred directly to the presenter.

WELCOME

Mr. Jerry Schulte, President
American Fisheries Society, Water Quality Section

At this time, I would like to officially welcome you all to the second annual American Fisheries Society Forum on Contaminants in Fish. My name is Jerry Schulte. I'm the current president of the Water Quality Section of AFS, and it is indeed an honor to host this meeting on behalf of AFS and U.S. Environmental Protection Agency (USEPA).

We have before us a very unique issue that is being dealt with in a very unique way through the combined efforts of AFS, USEPA, and state and tribal representatives. In reading background material for this forum today, I came across a statement that kind of characterized what this whole issue is about, and it said, "The combination of complex inexact science with economic and political reactions brings controversy to many advisories." Now, if that's not an understatement, I don't know what is, quite honestly. There are so many complex issues involved in this that we need to go through each one very, very thoroughly to understand what is going on.

How did we get here? It all started back in 1989, when USEPA commissioned AFS to do a survey of states to find out what different methods were being used to issue fish consumption advisories. Stemming from that survey came the development of the federal action plan of 1990. In that plan were several milestones that were accomplished over the course of the next five years.

At the end of 1995, it became apparent that we needed to get back together to determine what now needed to be done. So another meeting was held last year in 1996 and from that meeting has come the development of the second federal action plan. We're going to talk a little bit more about that here this morning with many of our presenters.

But first, I would like to recognize a lot of the people that made this particular meeting happen today. We've covered a lot of ground in the last seven years, and it has been through the efforts of many, many people. The people that helped put this particular forum together today—Jim Amrhein, Wisconsin Department of Natural Resources; Gerry Pollock, California Environmental Protection Agency; Rosanna Kroll, Maryland Department of the Environment; Heraline Hicks, Agency for Toxic Substances and Disease Registry; Barbara Knuth, Cornell University and former president of the AFS Water Quality Section; Jeff Bigler, USEPA; Betsy Fritz, AFS; Elizabeth Rockman, AFS; Larry Schwarzkopf, Fond du Lac Reservation; and Gale Carlson, Missouri Department of Health.

Mr. Paul Brouha, Executive Director
American Fisheries Society

I'm a certified angler, and if you may recall, those of you who were here last year, I came and said, "As an angler with my fishing rod, catching a fish out here in the Potomac, I still have a question, and that question is, but can I eat these fish?" Remember that? Well, I still have that as a very important question.

I was mulling it over and perhaps I, as an informed member of American society, have an answer to that question; but this year I mingled with the fishermen on the banks of the Potomac, and I observed other fishermen around the country as I was not only fishing, but traveling with my family, and what I observed was, increasingly, we have immigrants fishing, people who have English as a second language who are not very qualified to understand the nuances of various USEPA or U.S. Food and Drug Administration (FDA) standards.

As I was driving down King Street this morning I was listening to a National Public Radio show about welfare reform, in which they interviewed an angler named Tran who was fishing in San Francisco Bay. Tran is fishing there not because he's a sports angler, but because his food stamps have been cut off. He has no other options for a protein source, and so it becomes a little esoteric talking to Tran about contaminants and whether or not this is safe fish flesh.

We have, increasingly, populations of recent immigrants that are fishing as subsistence fishermen. We also have other minority populations of Americans, especially through the southeast, that are significant subsistence fishermen. Tribal people, for whom we had a workshop yesterday, are also, in some cases, disproportionately dependent on fish—that may or may not be contaminated—for their diet.

So I still challenge you, as we put together the recommendations for this report, to review it and make it the best document that it can be for your guidance.

But I note here that we still have only a moderate priority on addressing how effective our information is in penetrating to these populations, and I would perhaps once again reiterate, but can I eat those fish? And perhaps do it with a bit of a different shift than I did last year and commend you on hopefully working to make sure that these advisories are effective in reaching those populations.

Mr. Robert Perciasepe, Assistant Administrator for Water
U.S. Environmental Protection Agency

It's really a pleasure to be here with AFS again to talk about these important issues. I appreciate the leadership that AFS has been taking to bring folks together, along with USEPA, to keep our minds on this very important issue.

I think the subtext of some of this that you brought up—the challenges in front of us in terms of communicating risk to a very diverse group of users of American fisheries resources—is a very good underscore to a lot of the work and discussions that will go on over the next couple of days, because we'll get immersed in the science, in the policies, in the methods, but we have to recognize the ultimate goal is to have an informed public. Really, the ultimate goal is to have safe fisheries in the United States, so that we don't have to worry about advisories, and I'll talk about that a little bit.

You know, this is the 25th anniversary of the Clean Water Act, which is something that's important to USEPA since we're responsible for implementing it. But I think it's also important to folks in the United States because a tremendous amount of work has been done over the last 25 years. The waters of the country by most measures, and I think by all measures, are cleaner than they were 25 years ago. The amount of pollution has been reduced by billions of pounds from both industrial and municipal sources, and so we can be pretty proud as a nation of that progress.

Down the street here on King Street is the Potomac River and 25 years ago it was virtually a sewer, particularly to the south of the Washington metropolitan area. Today, while there are still problems that you mentioned in your opening comments, it is a tremendous asset to the community both in terms of fisheries—bass, warm-water fish have returned to large areas, and people make a living on the fisheries in that area—and from recreational and commercial perspectives. There are bikepaths; there is windsurfing; the whole view of the Potomac River has changed in the last 25 years.

That's just one place in the United States. I can talk to you about downtown Cleveland, downtown Baltimore, and many other areas of the country where the massive pollution problems we had in the late 1960s have given way and are no longer there, but we still have the more difficult problems, some of them the legacy of the industrial era.

I'm also particularly pleased with the tribal participation at this year's event, and I applaud everybody for making sure that happens. Tribal people have a long history of net fisheries and natural resources management. In fact, it's a very strong cultural aspect of most tribal cultures on the North American continent. It's strong and it's important, and

we can learn a lot from their view of natural resources, so I'm very happy that they are involved with our work and it's totally appropriate that they are here.

The 25 years of history that I mentioned, in only a very brief brushstroke, is in stark contrast, in a way, to the very difficult task we've had of maintaining a consensus about clean water in the United States at the national level. A debate continues to rage about protecting species, tribal rights, and how clean the water really should be. You know, when you're flying over it in a helicopter, it looks clean until you really check it in great detail. You fly over the dead zone in the Gulf of Mexico and it looks just like the rest of the Gulf of Mexico except that there's no oxygen in the water.

The debate is not as friendly, perhaps, as it was in 1972 when there was a great national consensus that something needed to be done and Congress enacted very strong legislation by huge margins. We're having a difficult time doing that, and it's with that backdrop that we are all meeting here. So, while some of these debates continue at the national level, we know in our professional lives some of the difficulties that are faced by the resources that we feel very strongly about.

Again, I want to thank AFS for the energy that you're bringing to this. I want to point proudly to—and reiterate what has already been said—the fact that the original reports and recommendations that have come from these meetings have virtually all been implemented. I think that's a testament to how important this issue is and how strongly we all feel that we're able to move ahead and implement some of the items in the action plan, whether it be the guidance documents, consumption rate studies—and we can now get into more detail of which populations are eating the fish, and which are more sensitive—or the annual summary of fish consumption listings.

What has been happening I think is quite interesting in that the annual consumption advisory listing is showing large increases in the number of advisories. This is both a blessing and a challenge, in a way, that we're getting more of this information. In 1993, we had 1,278 fish advisories, and in 1996 we had 2,193. That's a 72 percent increase.

So what are you talking about, Bob, with all that progress we've made under the Clean Water Act? It seems to be going in the wrong direction by one of our ultimate indicators—the flesh of the fish we are trying to protect. The Clean Water Act said fishable, swimmable water. At USEPA, we kind of think fishable means edible. So, therefore, we see a very important link here.

I could step back and say we're going in the wrong direction. Well, the truth of the matter is we're looking more. We're learning more about this issue as we've tackled those big problems and reduced a lot of the pollution. Now we're looking at the resident

problem in the sediments, the legacy issues of what's circulating in the ecosystem out there bioaccumulating, and we're finding that small amounts of certain kinds of compounds and elements are biomagnified in the ecosystem through food chains and other mechanisms; and we have this problem with us perhaps for quite awhile.

We're also learning that water pollution is not the only problem. Things that are being discharged from pipes are not the only problem. Runoff from the land, deposition from the atmosphere, and resident legacy issues in the sediments are all part of this longer term problem that we're going to have to tackle as a nation. So the more we know about this, the better we're going to be able to figure out what we have to do.

Masked inside that increase in fish advisories, though, are some bright lights. The nation's concern, and rightfully so, about some of the chemicals in those advisories, like dioxin, has begun to have an effect. In fact, the number of dioxin advisories has decreased. So inside that overall increase in advisories, we're actually starting to see a decline in advisories for compounds that have been specifically targeted. Of course, you know that mercury continues to be one of our biggest problems in fish flesh.

One of the things that you asked us to do was to clarify the differences between FDA and USEPA guidelines, and while I have to say that we are not perfectly described, last year we were able to come to an agreement with FDA and put out a letter jointly signed by myself, FDA, and Lynn Goldman from the USEPA Office of Pollution Prevention, Pesticides, and Toxic Substances. We sent the letter to all the states and tribes trying to clarify when it's appropriate to use FDA action levels for commercial fish versus the USEPA risk-based approach for fish from local water bodies. I think we're starting to make that differentiation and, hopefully, that has provided some good clarification.

I also have to say that, having done that, we feel more confident about working with you on those differentiations. I feel very strongly about the fact that if the federal, state, and tribal governments know there's a particular health risk, we have to let people know about it. That's part of our responsibility as public officials, part of the public trust that we have in our jobs. Making this happen is not an easy thing, and it's probably the centerpiece of a lot of the discussions that you will have over the next day.

We will act to make sure that the information is available to the public at the federal level, if that's what we have to do, but I feel strongly that this is something that has to be done, and is best done, at the state and local levels, and it is really our goal to make sure that happens.

Our knowledge of these things continues to increase, whether it be the health effects of eating contaminated fish, the location of waters where we have problems, or the art of

communication. But again, I think that we need to commit to each other that, to the best of our ability, we will make sure that the information about potential risk to subpopulations is communicated to those subpopulations.

There are new recommendations that you're going to be working on. Betsy Southerland, raise your hand, she's the one with the bull's eye target on her back. She'll be discussing in some detail later some of the USEPA responses to some of the ideas, and hopefully you'll be working on that through the day.

But I want to digress from this advisory and warning thing here for just a minute, if you'll bear with me a little bit longer, and talk about the fact that warnings are not enough. We need to figure out how to correct these problems and not just wring our hands about the fact that we have these problems. There are some things that we've been doing at the national level that I hope will help our work in this area.

During the last year we signed a bi-national toxins strategy with the government of Canada. It's an important strategy that recognizes that some of these problems are multinational. They're not just something that we can deal with in the United States. Especially when you start talking about mercury; it may very well be a global problem. It's going to require broader based action than just U.S. action to deal with it.

This strategy that we agreed to with the government of Canada has impacts in the entire United States. We, as a nation, agreed to a 50 percent reduction in the use and emissions of mercury by 2006. We also agreed to a 75 percent reduction in the releases of dioxins and furans by 2006. This is in an agreement with Canada, but those are nationwide goals that we have adopted in the United States.

On a more focused front, we are taking regulatory actions to deal with some of these persistent compounds. We anticipate, for instance, that the municipal and medical waste incinerator controls that we've been working on in the air program will result in a reduction of a lot of emissions, including dioxin emissions. Just that regulation alone will result in a reduction of 100 tons of mercury emissions to the air each year. We think that's significant.

We are also setting the stage for more action as we learn more, because these things are an evolving process. In 1989, when you first met, I don't know how much discussion there was about air deposition. There was probably some because it was starting to percolate at that time, but since then, there have been more studies conducted. This year USEPA published what's commonly called the second *Great Water Bodies Report*, as required in the 1990 Clean Air Act. In that report, we pretty clearly identified some of the

problems and put more information out in the public domain about air deposition and these compounds.

We now have to do an action plan based on that report. What are we going to do based on what we've seen in the *Great Water Bodies Report*? How are we going to use our existing authorities to start attacking that problem? We are working on a follow-up action plan that we hope will be ready, probably, sometime in the spring.

Somebody told me that we will be sending a mercury report to Congress. This mercury report has been delayed, but this is more than just a report to Congress. This mercury report is a fairly definitive analysis and assessment of the sources, trends in emissions, health effects, management alternatives, and research needs concerning mercury. I'm also very proud to say that in the aggregate, after all that work, our Science Advisory Board has recently concluded that all the major conclusions of the report are valid and useable and scientifically appropriate, including the reference doses (RfDs). The report has been extensively peer reviewed and re-peer reviewed, and peer reviewed again. So this is something that's coming out very shortly and will obviously further the discussion; I'll be mentioning a little bit more about this.

There are other reports in the federal system that are being developed that look at mercury, and I'm thinking in particular of the Agency for Toxic Substances and Disease Registry (ATSDR) toxicology reports that are ongoing. You'll hear more about that draft report during the course of the day from ATSDR. They have produced a draft; they are going to continue to review it, and I'll let them talk a little bit more about that when they are on the stage later today. This is ongoing work at ATSDR. It's a draft and it's not ready for use by states or other groups yet.

I think these reports—the *Great Water Bodies Report* and the mercury reports—are beginning to set the stage that we know more about this problem and where the sources are. When we look at what I talked about on the Clean Water Act, we find that we've sort of done the easy stuff with the sewage treatment plants and some of the larger industrial processes, and now we need to look at what the sources really are for these remaining problems. We find that they are much more difficult to deal with. The sources are from a lot of different places. They're ubiquitous; they're atmospheric; they're runoff from the land; they're sediment problems; and so we're going to need a multimedia approach if we're really going to attack these problems.

I want to briefly mention that on the occasion of the 25th anniversary of the Clean Water Act a month ago, in October, Vice President Gore directed the federal agencies to come up with an action plan to begin to deal with some of the remaining problems. He put the Department of Agriculture and USEPA in charge as co-chairs to come up with this action

plan in 120 days. That happened, by coincidence, to come out on Valentine's Day in February. So by Valentine's Day in February, we're going to figure out how to deal with all the rest of the water quality problems in the United States. So you can look forward to seeing that.

I'm glad you knowledgeable people can smile. Obviously, the action plan will have actions that will go on further than that. We're not going to fix all or define all those problems in 120 days. But I think what's important about the action plan, and I'm not going to go into great detail on this because some of you will probably hear more about it over the coming months, is that it has three major goals—enhancing protection from public health threats posed by water pollution, more effective control of polluted runoff, and promotion of water quality protection on a watershed basis.

None of these are odd ideas to anybody in the room, but in his memo to the federal agencies, the Vice President specifically identified steps to reduce the need for fish consumption advisories, and I don't think he was talking about changing the standard. That would be one way to implement that one, but I don't think he's talking about that. He's asking how we start to attack these particular problems that are causing contamination in fish.

An action plan will be produced in February. I can tell you public health is going to be an important part of that. Fish advisories are going to be one of the things that we'll be looking at, and how to start to deal with this in a more concerted way to prevent them, not just to do better jobs of talking about them. This is the real point of this whole second part of my discussion here. I just want to list very quickly some of the things that we are doing in the water program at USEPA moving in this direction.

We're planning to implement a national fish tissue survey next year. One of the problems we have with the fish advisories is, when you look at the national level, there are some places that are doing a really good job of collecting data, and there are some places that aren't doing as good a job. There are data gaps when you try to make assumptions nationally about what's happening out there. We're going to try to do this on some kind of periodic basis; some advice from you would be helpful on this. Maybe every five years we conduct a national fish flesh survey so we have a statistically valid view of what's happening out there with this important resource.

Revised water quality criteria: I mentioned the mercury study. We are committed, when the mercury study is done, to revising our water quality criteria on mercury. Some of the major differences will include bioaccumulation factors instead of bioconcentration factors and, obviously, a new RfD. Our target for that is this coming summer.

Enforcement and compliance: Remember, that's another part of USEPA that's pretty important to getting all those benefits of the last 25 years that I mentioned. Where we have problems, we're going to look at what the sources are doing and whether we can work on compliance with those sources.

Geographic targeting: We're working with the air program on a very innovative set of tools that we can deliver to states which will link air models to water models using the total maximum daily load (TMDL) process. So you will be able to start looking at air sources and what they might be contributing to a particular water problem and how you're going to work that into your TMDL process. You just need to look at the number of water bodies out there that are limited by mercury and you'll see where the utility might be. Of course, some of that may end up being a big national issue.

Pollution preventions from publicly owned treatment works: We've done a lot of work, particularly in the Great Lakes area, on reducing the amount of mercury from publicly owned treatment works without expensive end-of-pipe treatment, and we've been getting results. We've been working with everybody who is connected to it, from medical practitioners to dentists. I personally have been to a plant in Duluth, Minnesota, where some good work has been done.

Improved analytical methods: Detecting things like mercury at low levels and having approved laboratory methods to do it is an important part of what we need to do. USEPA is working hard to complete the cleaner methods of detecting mercury, and we hope to be able to do that by next summer.

So let me just say, in closing, that I want to commit USEPA to taking actions on your recommendations, working with you to develop new recommendations, and strongly supporting you on this very important public health issue. I think we have to recognize—my speech says it took decades, but I would suspect it took centuries for some of these problems to develop and it's going to take us a long time to solve some of them.

We've lopped off the big sources of pollution and we still have problems. We thought they would be gone, but they're not. We know now that it's a much more complicated thing. It's going to take a lot of work, but we can do it. We need to keep things in motion to do it. The work that you're doing is helping us do that, and I hope that the relationships we're developing help us to do things together. I think we need to do it for the future generations of the country. I would hate to think that my great-great-great-great grandchildren will never be able to go fishing like I have in my life.

Open Discussion

Jim Wiener, U.S. Geological Survey in La Crosse, Wisconsin: Added to the complexity is the realization in recent years that a number of human activities other than releases of mercury to the environment can, in fact, affect exposure of populations to methylmercury. A good example of that I think is the flooding of new reservoirs in Canada in particular, and elsewhere, which can result in 10-fold increases in mercury levels in fish as a result of increased methylmercury production in the flooded areas.

A question I have is, has there been any consideration of including actions in regulatory approaches which might fall under the heading of land use planning that might be used to reduce methylmercury exposure not as a result of emissions per se, but as a result of other actions that affect methylmercury production in the environment?

Mr. Perciasepe: Well, first of all, if there are things that can be done in that area, I think it would be interesting to have discussions about them. I'm not qualified to discuss the relationships between land use and what stimulates the production of methylmercury in the environment, so I couldn't answer the question specifically.

But if there are things that we can do, because mercury is out there—it's on the periodic table, as people like to tell me, and really in some forms it's not going to be able to bioaccumulate or get magnified in the various ecological systems; it has to be in the more organic form, like methylmercury, to do that. So if there are things that we can do that will inhibit the conditions that facilitate the formation of methylmercury, I would be interested in having discussions about them.

But I don't know to what extent those things might be amenable to regulation. You're talking about a ubiquitous situation. Whenever we start talking about regulating ubiquitous things it becomes much more difficult. But maybe we could distribute public information about that, particularly to local governments who have some land management responsibilities and could at least be taking it into account in local land use decision making, as opposed to any other larger scale activity. I don't know enough about the subject, but it's intriguing to me that there may be a relationship between land use and the stimulation of methylmercury.

Mr. King: Mercury seems to be a topic this morning in regard to contamination. I come from Alaska in the Bering Sea, one of the world's largest fisheries in the domestic setting, and nuclear contamination seems to be the issue there. Do you plan to tie in with the U.S. Department of Defense or the U.S. Department of Energy (DOE) in your efforts to curb something for checking water contamination?

Mr. Perciasepe: Again, I have to say I don't know enough about irradiating fish in the environment creating radioactive fish that would be a public health concern. I'm not saying that that doesn't happen. I just don't know enough about it to answer your question, but if there is information or reason to pursue that, I would be willing to have conversations with the DOE about what they know. But I don't know enough about that, I have to say.

You've heard me mention the things we're working on and, obviously, mercury was important, but there are many other persistent bioaccumulative toxins that we're working on, not just mercury. But most of them tend to be those long-chained lipophilics, organic compounds of our industrial society.

Mr. King: I'm not concerned about the specifics of scientific facts of what's going on. I know. We know. There are thousands of birds dying. Thousands of birds are dying; bottom fish are dying; bottom fish are being malformed. Fish is all we know. I said that yesterday at the tribal gathering. Fish is all we know. Fish is all we are.

I'm hearing some good thoughts and finally not just gestures about that fellow in San Francisco who got cut off from his cash outlet. Without cash—we can maintain with minimum cash, but without fish we can't survive. We'll die, and we are dying. It's just flat out genocide. We need to do something from someplace.

Where it's happening, I think the Native American policy states that we're to work with the tribes, not associations or consortiums of the do-gooders. We need you to come right down to where we're at and work with us, and get our feet wet and do some checking with our water quality equipment.

Mr. Perciasepe: Again, I apologize for not knowing about the situation in the Bering Sea.

Mr. King: I think maybe I'm blowing something here.

Mr. Perciasepe: I'm willing to look into it with you.

Mr. King: Maybe national security is involved, I'm not sure.

Mr. Perciasepe: Yes. Well, the things you mentioned are of concern and we need to look into that.

Mr. Brouha: I know Jim Wiener, who addressed the question to you for AFS, is preparing a briefing statement on mercury with the hope that we may be able to address

some of the challenges that we face in the reauthorization of the Clean Water Act as it relates to mercury. Do you think the administration is prepared to see something like that included in the Clean Water Act reauthorization? Are we ready yet, I guess is the question.

Mr. Perciasepe: We already made recommendations to Congress on what they ought to do about the Clean Water Act back in 1993, and we feel pretty comfortable with the recommendations we made there. Most of those recommendations are more systemic than going after a particular chemical, including more systemic attacks on persistent bioaccumulative toxins.

I think in the *Great Water Bodies Report*, which needs some clarification when we do a final determination in March on our existing authority under the air program, the question was whether or not the agency has adequate statutory authority to deal with the problems that were identified in that report. Our finding is that we think we do have adequate statutory authority to deal with the problems. When you look at the potential regulatory programs that could come out of the air program, the more we know, whether it be residual risk under the maximum available control technologies in the air toxins program or other venues in the authorities of the Clean Air Act, we think we have adequate authority.

What's been confusing in our communications of what that report means is some people have construed it to mean we think we have adequate regulations already interpreting the statutory authority. Our view on that is we may need more regulations on certain things from our existing statutory authorities.

In the Clean Water Act, the goal is zero discharge of pollutants. That's a long-term kind of thing. I can only visualize "Star Trek" technology really to try to deal with that, but I was listening to National Public Radio this morning about new particle accelerators where they're going to start to get into the guts of those atoms. But, not making light of that, the understanding of how to get to actual zero discharge is in the future, but we keep going toward that with each one of our successive technology standards.

I think we probably have adequate authority. We may not have adequate focus in the Clean Water Act on some aspects of the persistent bioaccumulative toxins, but we probably have adequate authority in the existing law to deal with the point source problem. We probably have inadequate authority to deal with the nonpoint source problem, and maybe some of the sediment problems. So it's a mixed bag out there.

I guess to summarize, Paul, I'd say we probably have more authority under our existing laws than we've utilized to date across the board, from the Resource Conservation and

Recovery Act, to the Clean Air and Clean Water Act. On the other hand, there are probably some gaps out there, and we would probably be more in favor of a systematic approach to persistent bioaccumulative toxins than piecing off work on each toxin individually.

Ultimately, when you start looking at this—and we just heard about potential nuclear problems—you really have to sort of look at this systemically, at what things are creating the risks across the board, and it may be very difficult. While mercury seems to be particularly ubiquitous in our fish flesh, when you're looking at overall risk reduction, you probably need to be much more broadly focused, so we'd be interested in your ideas.

AMERICAN FISHERIES SOCIETY PRESENTATION OF 1997 ACTION PLAN

Dr. Barbara Knuth, Past President
American Fisheries Society, Water Quality Section

It's a real pleasure to be here on behalf of AFS to formally present the 1997 federal-state action plan for fish consumption advisories to USEPA and to the rest of you, many of whom were here in 1996 to help initiate the process of developing this action plan. As you've heard, this particular effort grows out of a long and growing partnership between USEPA and AFS on this issue.

Today, what I'll do is provide a brief background on some of the issues that you've heard about already, referring to the 1990 forum, the Federal-State Forum on Fish Contaminants, and also talk a little bit about what happened at the 1996 forum. But really what I want to focus on is giving you an overview of the program recommendations included in the current action plan.

So just a bit of background. You already heard reference to the 1990 federal-state forum that was held in conjunction with the AFS annual meeting in Pittsburgh. Out of that meeting the federal assistance plan for state fish consumption advisories was developed, and seven assistance programs or assistance activities were proposed in that action plan.

In that action plan the desire for consistent federal risk assessment factors was expressed. Also expressed in that 1990 action plan was a desire for guidance in assessing fish consumption rates in various regions of the country; guidance and assistance on monitoring, sampling, and analysis programs; help developing consistent methods for issuing advisories; help developing consistent risk management guidance and approaches; ongoing quality assurance and quality control for fish tissue sampling; and help addressing risk communication issues and strategies.

Coming out of that set of seven action areas were a number of results that occurred in the five or six years after the action plan. Those included a series of guidance documents, a series of fish consumption studies, a number of trainings and workshops, and a national listing of fish and wildlife consumption advisories.

Following that was the 1996 forum, which many of you attended here in Alexandria. That forum had a twofold purpose. One was to evaluate progress on the 1990 action plan, and the other was to identify the potential priorities that would be needed in a new action

plan. It was that discussion of the potential priorities that led to the recommendations that I'll be presenting to USEPA today.

The list of potential priorities was identified in breakout groups. The ideas discussed in those groups were used as a basis for putting together a mail survey which was sent out to all of the states, to a number of federal agencies, a number of tribal commissions and organizations, and a number of nongovernmental organizations.

The mail survey then generated responses from all 50 states representing combined responses from 65 different agencies, and also included responses from seven federal agencies, one tribal commission, and four nongovernmental organizations. Those responses were then used to rank the high priority, medium priority, and low priority items that would go into the 1997 federal action plan.

There were 24 potential activities included in the mail survey, again generated from the 1996 forum discussion. There were very few differences in the state responses versus the non-state responses. The non-state respondents tended to give less weight to the need for comparative risk documentation and to funding state programs, but otherwise the rankings were very similar between the two groups.

There were some regional differences throughout the U.S. The southern and the western states tended to be more interested in methodologies, and the northern and eastern states tended to place more emphasis on funding, research, and interagency coordination.

So the proposed action plan activities that I'll review briefly were derived from the mail survey results, transcripts of the forum discussions, and Bob Kendall's and others' work to provide some synthesis and organization to this information.

Based on all of this, the action plan activities that are being presented to USEPA fall in three major categories—training and guidance, information management, and interagency liaison. What I will do first is review the specific topics that fall under each of these major categories, and then look at the specific recommendations in those topic areas in high, medium, and low priority areas.

The first category is training and guidance. The topics that fall into training and guidance are the need for instructional courses and workshops, and guideline and manual preparation.

The second general category is information management. The topics that fall in here are information transfer, in-house or USEPA data collation, and new research, analysis, and synthesis.

Then the third category is interagency liaison. This includes the coordination of activities among agencies and providing technical assistance.

So what I'll do now is to go through each of those major categories, look at each of the specific topic areas, and look at the high, medium, and low priority recommendations based on the survey results and the 1996 forum discussion.

Training and Guidance

Instructional Courses and Workshops: A high priority under instructional courses and workshops was regional, group-specific training provided by USEPA in all aspects of fish consumption advisory programs. The respondents and the forum participants desired a comprehensive scope in these trainings covering everything relevant to advisories including sampling, advisory rescission, and communication. Further, there was seen a need to customize those courses and workshops to meet the needs of particular audiences, which are clearly quite varied if you look at the types of agencies and tribal organizations that are involved. No medium or low priority items were identified for this topic.

Guideline and Manual Preparation: High priorities under guideline and manual preparation included developing guidelines for trimming and cooking fish to minimize contaminant intakes; addressing toxicant mixtures in advisories; including model communication strategies on how to get information out to people; estimating total human exposures to contaminants; and drafting coherent advisories that would be based on such estimates.

Medium priorities under guideline and manual preparation included developing a manual for fish consumption rate surveys, how to conduct them and interpret the information; and secondly, developing guidelines for rescinding advisories. Hopefully, you heard Mr. Perciasepe talk about the goal for rescinding advisories. Well, we need to know how to communicate that and how to set up methods to do that.

Low priority items under guideline and manual preparation included developing protocols for issuing advice to the public about safer fishing opportunities; developing protocols for managing uncertainties of risk assessment, uncertainties that would be either analytical or political, and dealing with a regulated community in negotiations about fish consumption advisories; and addressing the implications of fish consumption advisories for actions required by the Clean Water Act, particularly those dealing with water body impairments.

Information Management

Information Transfer: The first topic under information management is information transfer. High priority was placed on creating an electronic data center for disseminating information on the fish consumption advisory program nationwide, presumably World Wide Web-based. There were no medium or low priority items under this category.

USEPA Data Collection: Under USEPA data collation, high priority items included identifying federal and private funding sources for advisory programs, and maintaining a database on fish contaminants, including such topics as body burdens, modes of toxic action and interaction, and metabolites.

The medium priority item under USEPA data collation was maintaining an up-to-date, central database of fish consumption rates nationwide.

The low priority items under USEPA data collation included creating a list of fish tissue banks that would allow retrospective analysis of exposure; keeping the states and tribes apprised of emerging chemical threats that might need these retrospective analyses; providing and maintaining up-to-date lists of experts who could speak about specific contaminants and biomedical issues associated with those; and conveying emerging information on endocrine disrupters to states and tribes.

New Research, Analysis, and Synthesis: The high priority item under this category was commissioning a review of existing information about comparative dietary and nondietary risks associated with eating contaminated fish. Dietary risks, pretty self-explanatory. Nondietary risks include things like economic and cultural risks.

Medium priorities included funding research on advisory effectiveness in reducing human exposure to contaminants; funding research focusing on information related to the benefits of eating fish, and this included freshwater and marine fish, particularly on the benefit side with respect to omega-3 fatty acids; providing information on the impacts of spatial and temporal variations on contaminant loading and on the ecological processes that affect fish body burdens; and funding a benefit-risk analysis to summarize all this, focusing on the nutritional gains versus the health dangers associated with eating fish contaminated by toxicants.

Low priority needs in this area included summarizing background levels of fish contaminants, funding a second national survey of methods for issuing advisories, and evaluating the congressionally-mandated battery of tests for endocrine disrupters.

Interagency Liaison

Coordination of Activities: There are two high priority items under coordination of activities. The first was to convene an FDA-USEPA-state-tribal workshop to either clarify or reduce differences in federal procedures for evaluating human exposures to and risks from contaminants, and to develop guidelines to explain those differences and their outcomes to the public. The second item was to work with other agencies to improve quality assurance/quality control (QA/QC) programs.

Medium priorities in this category included coordinating federal fish and toxicant sampling programs so that more data would be useful and available to states and tribes, and facilitating regional compacts among federal, state, and tribal agencies to share and improve information relative to advisories, particularly for those waters that are shared by those jurisdictions. There were no low priority items in this area.

Providing Technical Assistance: Under technical assistance, the high priority item focused on establishing round-robin testing and accreditation systems for contaminant analysis laboratories. There were no medium priority items for technical assistance, but the low priority items focused on guiding states and tribes to update their data management systems, and helping states and tribes implement geographical information systems and other new technology for use in their advisory programs.

Summary

In summary, the recommendations for training and guidance focused on comprehensive regional and customized service and supports; and guidelines and manuals that would be developed in sequence according to a master plan on topics including trimming and cooking methods, toxicant mixtures, exposure estimates, fish consumption rate surveys, and advisory rescission protocols.

Information management focused on coordinating information production, collation, and delivery, and included Website development and maintenance. The topics of specific note here included funding sources, contaminant toxicology, fish consumption rates, comparative risks-benefits and tradeoffs, and advisory effectiveness.

Interagency liaison focused on coordinating parties to address mutual problems; upgrading analytical or management systems; clarifying and helping communicate differences between USEPA and FDA approaches and actions; improving QA/QC protocols and practices; and coordinating sampling.

U.S. ENVIRONMENTAL PROTECTION AGENCY RESPONSE TO 1997 ACTION PLAN

Dr. Betsy Southerland, Acting Director
U.S. Environmental Protection Agency
Office of Water, Standards and Applied Science Division

This is just our initial thinking on what we have underway or what we think we could ask for in future budget years. So it's our first cut at answering your needs. Please let us get some feedback from you. We've got the next two days, and please write in whenever you get a chance.

Training and Guidance

Instructional Courses and Workshops: In terms of instructional courses and workshops, the buzz word is, "commit to seek funding." That means I don't currently have funding, but I'm promising to get it. Again, you heard Bob Perciasepe. He's very supportive of this program. If he has anything to do with it, I'm sure we will get the resources. The problem is, of course, our appropriations come from Congress and we never know if it's going to be a good year or a bad year.

We will commit to seek funding to hold at least one state-tribal training workshop per year. It would be along the lines of the tribal training that we did yesterday, where we would try to give instruction on everything regarding the fish consumption advisory program—how to monitor, how to decide if your risk assessment indicates an advisory is needed, how to communicate that advisory, and how to make risk management decisions, because triggering an advisory is really expensive and affects a lot of people.

We will commit to seek funding to add fish issues to our Water Quality Standards Academy. Right now, we usually have about three big academies a year—all a week long—to train people from the governments of states and tribal bodies on how to conduct the water quality standards program. We could put together a module on how to handle fish advisories and add it to that.

The concern we have, though, is that state regulatory people from the environmental departments usually go to the academy, rather than health department people. So you have to give us some feedback. Do you think that's worth it, or are we training the wrong audience? Should we put more funds into having the fish consumption advisory training for health department people from the states and tribes instead?

We definitely can do this last one. We can start holding quarterly regional teleconferences to discuss issues related to fish contamination, and we could start doing that right away. We would like to do it on some kind of geographic regional basis so we would have a reasonable number of people on the phone lines and could talk to you once a quarter instead of once a year at these giant forums.

Guidelines and Manual Preparation: Providing guidelines on trimming and cooking fish was a big priority that you all had, one of your high priority items. Right now, we've got plans to update our *Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories, Volume I,* where we have our fish sampling and analysis information, to include this information. There's research on only a few contaminants in regard to whether or not they are eliminated in cooking, so it won't be comprehensive just because the research isn't there. But we're going to do a worldwide literature search again and let you know on which contaminants there is information about cooking and trimming losses. We also have a fairly generic fish contamination brochure that we can give out that emphasizes cooking and trimming methods.

Next, you wanted mixtures. That's a really tough technical topic. Right now, we're going to try to do the best we can with the most up-to-date guidance from USEPA on how to conduct risk assessments for mixtures. We also promise as soon as there are any late-breaking developments along that line, to add the new information, and get it out to you as an addendum to that volume.

You wanted total human exposures. This gets to the point that you may be exposed to a number of these chemicals in drinking water or through inhalation or other routes of exposure besides eating fish. We call this relative source contribution. We have right now a plan for the Office of Water to look at these kinds of multiple exposure sources. That was part of the big revision in our human health water quality criteria methodology that Bob Perciasepe mentioned.

For the first time, we're going to propose that when you're determining water quality standards to regulate the discharge of bioaccumulative pollutants to water bodies, you have to take into consideration the additional contributions a person has based on diet, drinking water, inhalation, and other routes of exposures to those pollutants. That will be very controversial. We're also looking at a pilot study to see how that will affect fish consumption issues. The reason it's controversial is you'll be moving in the direction of making more stringent water quality criteria standards, which means more stringent point source controls or more stringent loading restrictions on nonpoint source run-off. This is something we have not done before.

The human health methodology is going to include this relative source contribution approach and would be incorporated in our national guidance. Once all the public comment is received on this water quality criteria methodology, it will be incorporated in our guidance document.

You asked for a comprehensive manual on fish consumption rate surveys. We did a short one several years ago, just a listing of different types of approaches—e.g., you can do telephone calls, diaries, recall for short periods of time, or recall for long periods of time. During this fiscal year, we are developing and peer-reviewing a detailed document on how to conduct fish consumption surveys. We think it's more at the level that you requested, a detailed guidance as opposed to just a literature review of all the possible ways you can conduct the surveys.

We commit to seek funding to establish guidelines for rescinding fish consumption advisories. That means that we have nothing underway this year, additional funds would need to be requested. Plan a project on that for next year. Again, we welcome any suggestions you have for the specifics of what such a project should involve.

Establish protocols for advising the public. Fund research on the effectiveness of fish consumption advisories. Right now, we have a consortium that's going to work on improving effectiveness of fish consumption advisories. We hope to get some guidance out on this by the end of fiscal year 1998.

Provide guidelines on uncertainties. Right now, we have a 1996 document, *Framework for Risk Management, Volume III.* Again, it's not a cookbook. It's a general framework on how to handle uncertainties, how to take them into consideration when you're making a decision on how to set up your advisory and how to communicate it. Again, we welcome your suggestions on specifics to improve that. Since you knew that was out there when you made this a priority for additional work, there must be something else that you want us to do, and we would really appreciate some specifics.

Provide guidelines for dealing with the regulated community and the implications of advisories as related to the Clean Water Act. Right now in the Clean Water Act, there's a requirement that if you have an impaired use, your state has to list that impaired water body on an official listing. The impairment is directly related to whether your water body meets fishable, swimmable uses. We have put guidance out for listing impaired water bodies. If you have a fish consumption advisory, you need to list the water body because it automatically means the fishable use criterion is not met. We hope this has resulted in all water bodies under fish consumption advisories being listed on the official list of impaired water bodies. Once you get on this official list, called the Section 303(d) Clean

Water Act list, you have to calculate TMDLs and allocate the pollution loads to the point and nonpoint sources contributing to that impairment.

We have been sued in 20 some states over the past couple of years, and in that settlement negotiation and court-ordered process, USEPA is agreeing to back up the states in calculating these TMDLs for impaired waters. Right now, most of the settlement agreements state that these pollutant loading allocations will be completed in an 8- to 13-year timeframe. If the state fails to do so, USEPA is to provide the backup. This is the one really important new tool—again because it involves court-ordered deadlines and settlement agreements and so forth—to try to reduce pollutant loadings that are causing the fish consumption advisories. That's basically the guidance we have out now, and I can make that available to those interested. It's normally just given to your state regulatory agencies for water quality and not necessarily shared with the health department.

Information Management

Information Transfer and USEPA Data Collation: You wanted us to create an electronic data center; maintain an up-to-date database on contaminants in fish and on fish consumption rates; keep states and tribes apprised of emerging chemical threats; compile up-to-date lists of experts on these toxicants; and convey emerging information on endocrine disrupters. We're now lumping all these different items together in a central electronic database.

We commit to seek funding to expand our current homepage. Right now, we have the fish consumption advisory listing on there, the national database that we update with you every year. We could certainly expand that to include additional information, more detailed information, such as fish contaminant tissue levels. Right now we just have the advisory information and the basics on that. We could really expand, but that's a huge expansion of information if we actually include monitoring data on fish tissue.

Identify potential sources of federal and private funding for fish consumption advisory programs. That's a high priority. Right now, only two studies are funded out of our budget. We're currently doing one on Native fishing practices and fish that are essential to the Native diet in an area of Alaska. The analytical results of that study should be back in May of 1998. We're also finishing a tribal study in the upper Columbia River basin, and that sampling should be completed this fiscal year.

To do additional studies like this in the future, we would have to get additional funds. These studies are usually very expensive. They run a couple hundred thousand dollars or more because the fish sampling analyses are usually conducted for organic chemicals.

That means it's $1,500 to $2,000 per fish composite to run these samples, and we usually like to include a wide enough area and enough species that you could actually set up a fish consumption advisory based on the monitoring data that we collect through these studies. All we can do right now is to promise to get that request in to our budget people.

New Research, Analysis, and Synthesis: Commission a review of existing information about relevant comparative risk, look at the benefits of eating freshwater and marine fish, and fund a benefit-risk analysis of nutritional gain versus health danger. All these were priorities for you. Right now, we have underway a comparative dietary risk project where we want to look at health risks from consumption of contaminated fish and from lack of fish consumption compared to health benefits of consuming fish. General problems associated with comparisons of risk and a proposed approach to evaluate risk and benefits—that's going to be the subject of an afternoon session. Again, that document is underway and we hope to get it out by the end of fiscal year 1998.

Another request was to compile or support research to obtain information on spatio-temporal variation, contaminant loadings, and on the ecological processes. That's what I call food-chain kinetics. We have a single study underway called the *USEPA Mercury Fish Tissue Study*. Basically, we collected fish tissue monitoring data on mercury for the past five years. We've compiled that data in a central database and now we're trying to match that information up with all the other water quality information we have on the same water body.

This gets to the previous question that was asked for Bob Perciasepe, do we know what the cause of methylation is? Right now, we know that there's an atmospheric loading of mercury that's generic across the country, and we know there are other little local hot spots of mercury being discharged from sources other than atmospheric deposition, but we don't know what causes the differences in uptake of mercury in fish. We don't really know the cause and effect of methylation of mercury, and so this is going to be our first attempt to try to take your fish tissue data, merge it with our water chemistry information, and see if we can figure out some kind of cause and effect.

You asked us to summarize background levels of fish contaminants. We have requested to do a national chemical-residue-in-fish study in fiscal year 1999. We would actually try to look for background levels, as we did in a study 10 years ago. We looked at background sites that we thought would be clean, where we'd have fish tissue that was not contaminated, and we looked at a lot of suspected hot spots. When we did the 1980s study we put a big emphasis on collecting fish downstream of bleach kraft mills—the pulp and paper issue. Now, we've just put out the new pulp and paper rule which includes very strict controls on pulp and paper mills. We think it will eliminate dioxin fish advisories downstream of most of those mills. As a result, the new study will not

concentrate on pulp and paper mills. We will want to get input from the states, and from our other federal agency partners, on what fish contamination issues we should look into now. That study would include looking at bioaccumulative contaminants. Again, we'll be asking your advice on what chemicals we should monitor and what types of sites we should look for, including background sites.

You also asked us to fund a second national survey on methods for issuing fish consumption advisories. For those of you that have been with us since 1990, we originally had AFS do a survey that created this whole program. It was, again, a questionnaire which asked all of the states how do you monitor to support your fish advisories, how do you determine you need an advisory, and how do you communicate risk. That was done in 1990 in a very comprehensive way which led to the formation of this program. Right now, we don't have any special funding for that kind of a questionnaire. What we thought we could do, though, is try to expand the questionnaire for the national listing of advisories and see if we could get at that issue through a single questionnaire, as opposed to setting up a whole second one that's just on programmatic elements. But we need some feedback from you as to whether or not that's going to really increase the burden hours on filling out this national listing questionnaire and if you think you'd prefer to have a separate one.

Evaluate the congressionally-mandated test batteries for endocrine disrupters. If we get the funding for a 1999 bioaccumulation study of fish tissue, we are committed to looking at the presence or absence of endocrine disrupters in that study. Again, we need to work on the design of this study because that's a difficult issue right now. What do we mean by endocrine disrupters and what analysis are we going to perform to get at this issue.

Interagency Liaison

Coordination of Activities: You asked us to convene an FDA-USEPA-state-tribal workshop to try to clarify or, hopefully, reduce the differences in our procedures. In June 1996, USEPA and FDA sent out letters to the 50 governors differentiating between the advice that FDA gives you for commercial fisheries and the advice we recommend you use for your local fish consumption advisories.

To go beyond that, we will commit to try to organize a workgroup. We need to talk to FDA about their participation and setting something up. I'm sure that we can make good progress on characterizing risk associated with local commercial operations. This is a big issue in the Great Lakes, where people are concerned about the obvious overlap between commercial and recreational fisheries. We think we can work on incorporating potential exposure from commercial fish into local advisories. Again, there's this relative source

contribution. Do you assume that all the fish a person eats is from the recreational supply, or do you factor in mercury that's contributed from fish in the commercial supply?

Then, finally, differences between FDA and USEPA recommendations regarding recommended risk assessment methods or toxicity profiles—that's a tougher nut to crack because we each have our own procedures for coming up with RfDs and with cancer potency factors, but we could certainly add that to the agenda of the workgroup once it's set up.

Work with the National Oceanic and Atmospheric Administration (NOAA) and other agencies to improve and facilitate the QA/QC programs on fish tissue; work to coordinate our own sampling programs in the federal community; and establish round-robin testing and an accreditation system. The accreditation system is a very controversial issue.

Right now, we can definitely tell you we're going to coordinate with NOAA on our fish tissue study. That's actually one of the action items in Vice President Gore's clean water action plan that we're working on right now. We'll design the study with your assistance and we will certainly share the results with you as soon as we get them. Again, the design process takes place this fiscal year. We wouldn't even begin monitoring until 1999.

Facilitate regional compacts among federal, state, and tribal agencies to share and improve information on advisories. Right now, the interstate water regulatory agencies we work with most closely are from the Great Lakes states. They have a protocol for consistent advisories that was based on the developmental toxicity of polychlorinated biphenyls (PCBs) in fish tissue. We've been working with the Great Lakes states on this for the past year. Again, they had a special workshop yesterday to get organized for further efforts along that line. We've also worked with the state of Virginia. They had a need for a regional advisory protocol on PCBs and so we worked with them. Maybe through these regional conference calls that will be set up on a quarterly basis we'll come up with other interstate water issues and you'll want some assistance like we provided in the Great Lakes and Virginia. I think that would grow out of the conference calls.

Providing Technical Assistance: Provide technical assistance to guide states and tribes in upgrading their data management systems, and incorporating geographic information systems in the fish advisories. Right now, we have two things that we offer to you. Again, we need criticism or comment back on this. Storage and Retrieval of U.S. Waterways Parametric Data (STORET) has been USEPA's big central database on water quality information that all the states, or anyone else, can enter data into. There has been a long-term concern, since it is open to everybody, about QA/QC problems.

There's a new modernized STORET that is now capable of storing fish tissue data. It has been greatly improved and has the additional capability of storing purpose-of-study and QA/QC information. That should, hopefully, eliminate previous concerns about the data that goes into STORET. So that's one database that we can offer to the states to store their information in.

We also, under the TMDL program, have developed a CD-ROM for every state in the country. All land use information and the water body network are included on that CD-ROM. What we can do is add the fish advisories to that information and make those CD-ROMs available if you're interested. The actual purpose of the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model was to do the fate and transport modeling needed to back-calculate loading allocations to point and nonpoint sources, but you could also use the CD-ROM to just display maps of the water bodies and of where fish consumption advisories are, and have that along with your land use information.

If you're interested in that, I need some feedback because we'd have to do a little bit of work to make it a more useable tool for your purpose. Again, it was originally set up to do fate and transport modeling analyses.

Open Discussion

Mr. Greg Denton, State of Tennessee: I notice some of the regulatory aspects of this were consistently voted as low priorities. I wondered if you all had an opinion on whether that was simply due to the makeup of the people filling out the surveys. I know it appeared to me that the majority of states use a state health department to issue advisories rather than the state pollution agency. I wonder if there was any comparison between how the regulatory agency in a state prioritized these issues and how the health department, which typically does not have a regulatory role, prioritized these issues.

Dr. Southerland: Yes, definitely that's the split. Of course, I feel its important to have the split because we work with the regulatory agencies all the time. For instance, the biggest funding that we have this year and for outyears is going to be to support all these TMDL sediment agreements and law suits. So there will be enormous amounts of money put into the program over the next, again, 8 to 13 years to meet all these deadlines for determining the pollutant loading allocations and getting these impaired waters off the list.

I think it was important for us to target the health departments for our budget initiatives and additional technical assistance, because you really do not have a voice in our major budget discussions right now if it's not through this program. So I think you're

absolutely right, I think it would be a different priority list entirely, but I wasn't concerned about that. I thought it was a valuable way for the health departments to try to get their voice heard.

Mr. Denton: As long as USEPA doesn't assume it's low priority to deal with regulatory agencies, or do TMDLs, or know who at USEPA to call with technical questions.

Dr. Southerland: No, that's our base program and, again, it has a huge boost this year with a lot of resources being put in there.

Mr. Henry Anderson, Wisconsin Health Department: I do think you need to look at the differences, and I also want to commend you for your very comprehensive and optimistic plan to address all these issues. The follow-up to that is, would it be possible for us to get copies of all your slides?

Dr. Southerland: We want to get them out to you and we also want you to really give this some thought. I know some people just do not have the time to keep giving us written responses. Everybody is so darn busy. So I'm open to just talking during the breaks and after the conference, but I also offer you the invitation—at any time that you have five seconds—to sit down and write a thoughtful response to this. If we've really missed the boat, misinterpreted what you asked for, or if what we've got planned is just not going to do the job, please write to us.

For example, the fish consumption rate survey project—I thought we were really helping out but everybody said it's just too superficial, we need something more detailed. So we're redoing it. But rather than doing a lot of rework, if you could tell us up front the specifics of what you want, we might do it right the first time instead of taking two or three shots at it.

Mr. John Millett, Water Policy Report: I was very interested in the relative source contribution approach to water quality standards and I wanted to know how that would work.

Dr. Southerland: There's a precedent for that in the drinking water maximum contaminant level goal program. When they do a drinking water analysis, they always factor in additional exposure routes for that chemical. We never did that for the surface water quality criteria and standards program. We took each pollutant individually and said, well, if this were your only exposure to the chemical, this would be the regulatory number that we recommend for your standard. What they have found is that for a number of these pollutants, for example, dioxin, there's plenty of sources of dioxin other than just fish. So, if you read that exposure analysis draft document on dioxin, it's in poultry, it's

in beef, it's in other dietary products. So, in that particular case, it was not appropriate to make the assumption that the only dioxin you would ever be exposed to was from fish consumption. That's how it would work and will be proposed this fiscal year with the new human health water quality criteria methodology.

Mr. King: When you implement your subsistence study, you have to make it comprehensive so it won't be another token tribal-USEPA thing. Tomorrow morning, as we continue to try to survive, the Supreme Court is hearing our case. Don't let us take it to the Supreme Court, please.

Dr. Southerland: I'm all in favor of avoiding the courts for anything. Yes, I would like to work all these things out collaboratively with you as opposed to meeting in courts. So, again, I think it's a great opportunity to try to get some additional funding to do these on-the-ground studies and to have good guidance out there. That's all we've been doing so far, is giving you good guidance on how to do the studies so that they will be scientifically defensible, and now we need to see if we can get additional funds to actually support those studies.

INTRODUCTION:
SPECIAL TOPICS SESSION

Dr. Tudor Davies, Moderator
U.S. Environmental Protection Agency
Office of Science and Technology

In this session that I'm pleased to moderate this morning we have three topics that are very, very important to all of us. The first is how the tribal nations are dealing with the issue of fish consumption advisories; the second topic is communication; and the third topic is how we look at the benefits of removing fish consumption advisories.

The first topic is on tribal issues dealing with fish consumption. We have to recognize that tribal people are some of the highest fish consumers in the nation. Fish consumption in many tribes is part of the cultural heritage and is an enormously important source of protein as part of tribal tradition and culture. To help us better understand the issues that they're dealing with, I'm pleased to have these two gentlemen here today. They can provide us with recommendations for the state and tribal governments that work with the tribal nations on these issues.

The second topic is that the Natural Resources Defense Council (NRDC) has a different way of communicating with the public and with the press than we as federal and state officials do. We've been fascinated to see how they can take the same data and get significantly more attention placed on it than can the rest of us dealing with almost the same issues. They can focus and galvanize public action on some of these issues in a way that the rest of us aren't able to. So I am fascinated to see what NRDC will be saying in its report on contaminated fish.

The third topic today is a great challenge to us in these days when we have to justify going further in terms of controlling sources. Whether they be local, national, or global sources of bioaccumulative contaminants, we have to justify the benefits of implementing control programs. I think the ATSDR studies on the health effects of consuming contaminated fish from the Great Lakes have been a great benefit to us in developing some of this information. We're going to have to look for much more in the future, so we can evaluate the quantifiable and the nonquantifiable benefits of taking these contaminants out of our wildlife.

CONTAMINANTS IN FISH AND WILDLIFE: A TRIBAL PERSPECTIVE

Mr. John Persell
Minnesota Chippewa Tribe

The paucity of water quality data for tribal aquatic resources led me to seek the establishment of the Minnesota Chippewa Tribal Research Lab in 1979. From aquatic biocriteria research in our early years, to gaining federal drinking water certification, to fish tissue analysis and fish consumption advisory publication, the Tribal Lab has survived because of the tribes' commitment to environmental quality.

I use the word "survive" in referring to the growth and development of the Tribal Lab because many people today forget what our reservations were like before casinos—unemployment 50 to 80 percent, tarpaper shacks for houses, conditions flippantly dismissed or forgotten by those who begrudge current tribal economic development efforts. Many Indian people left the reservations to find work. Those who stayed subsisted on the productivity of lakes, rice beds, the woods, or developed tolerances for treaty rations, otherwise known as commodities.

Those of you familiar with Minnesota may know the extent of lakes, wetlands, and the diversity of waters at this apex of three major North American watersheds. The Chippewa of Minnesota have reserve resource rights on approximately one-third of the waters in Minnesota, including Lake Superior. Only in recent years have these rights been reaffirmed through the federal judiciary.

My brief overview of the tribal perspective on fish and wildlife contamination may be best presented in three parts. One, the Indian view of resources; two, the tribal-federal relationship; and, three, the application of science to resource management protection.

First, let me present a tribal view of natural resources by quoting from the Minnesota Chippewa Tribe's natural resource protection ordinance, which was adopted by the tribal government in 1981. Section 300, Minnesota Chippewa Tribe Policy:

> This ordinance is enacted to provide uniform standards which are necessary to supplement each reservation's conservation code so that hunting, fishing, trapping, wild rice, and all other natural resources of the tribe may be preserved and protected. Where such reservation laws

and standards do not exist and are not promulgated, these laws and standards will apply.

The Minnesota Chippewa Tribal Executive Committee finds that water is the primary resource of the natural resource system. Thus, protecting the quality and the quantity of the water resource is the primary objective of these laws. And further, the interrelationships of water and other natural resources is such that management of soil, timber, air, and mineral resources has both direct and indirect effects upon the quality and quantity of the water, fish, wild rice, and wildlife resources. These and all other interactions of resources will be considered when planning and management activities are engaged.

These laws and standards which are contained herein will be interpreted to meet the goals of the above stated policy.

With that view of resources presented, let me address the second part of my perspective overview, the tribal-federal relationship. Tribes have a unique trust relationship with the federal government emanating from the many tribal-federal treaties which were drawn over the past several hundred years. Many of these treaties are the backbone of tribal resource rights. The quality of the resources was acceptable when the treaties were agreed upon and the tribes expected the resource quality to remain acceptable by the very nature of their provision as negotiated treaty rights. Thereby, we hold the federal government responsible for our contaminated fish and wildlife.

Recent publications by USEPA celebrated the 25-year anniversary of the Clean Water Act, and we join in that celebration, though it took another 15 years for tribes to be included in that act. A statement from one of the Clean Water Act anniversary publications reads, in part, "States and tribes are ultimately responsible for protecting their citizens from harmful levels of pollutants in fish caught to eat." This statement implies that tribes are responsible for consumption-specific advisory information to protect our tribal members who consume fish at subsistence levels. These levels are known to be significantly greater than for the general population or average consumer.

We can, and will, advise our tribal members. All we ask is for USEPA to ensure that adequate funding is available to tribes for this critical work. Be mindful, however, that the responsibility we accept for warning our citizens about the unhealthful consumption of these contaminated resources does not in any way diminish the federal responsibility for permitting pollutants to contaminate our resources.

The third element of my perspective overview is the application of science to resource management and protection. The tribe has maintained the pursuit of scientific information for several reasons, including the advancement of science and science education. Historically, Indian people have been underrepresented in the science professions. Also, the tribal government has a need for trusted information regarding critical tribal health and welfare issues such as the contamination of our drinking water, fish, and wildlife.

Tribal engagement of the federal government on environmental issues is not a new phenomenon, but tribal scientists participating in this process has relatively recent roots. The learning curve encountered in this process has, indeed, been most enlightening. Tribes have learned that it is the general policy of the federal government to refer to fish and wildlife contamination as "risks." Furthermore, these risks may be assigned a number for the purpose of integrating the risks into a risk assessment process. The end product of this risk assessment process then may be communicated to the public in the form of a consumption advisory or a cost-benefit analysis for a Superfund cleanup.

While consumption advisories may be necessary for risk communication, we must keep in the front of our minds that contamination is a symptom of a problem. The belief that pollution is a prerequisite to prosperity must be changed.

In closing, let me say that tribes are gaining experience in dealing with the symptoms of fish and wildlife contamination. As I present one of our tribal fish consumption advisories to tribal members, I'm often asked what the tribal government is doing about the problem. If we here today were forced to take only one thing from this conference, I would ask for that one thing to be a strengthened resolve to address the fish and wildlife contamination problems which we all share.

Mr. Daniel Kusnierz
Penobscot Indian Nation

I've worked with the Penobscot Nation as the water resource program manager since early 1993. The unique nature of the Penobscot Indian Nation's reservation exemplifies the importance of clean water and aquatic resources to the tribe. The reservation consists of islands and the surrounding waters in the Penobscot River north of Old Town, Maine. It is the largest watershed in the State of Maine, the Penobscot River, and the second largest in New England. It is used extensively by tribal members for traditional activities including hunting, fishing, and gathering for sustenance.

However, currently, tribal members cannot fully exercise their legal reserved right of sustenance fishing without fear of eating fish contaminated with dioxin, coplanar PCBs, furans, and mercury. Likewise, they fear eating fiddlehead ferns because of health advisories that are posted on the river because of the dioxin and mercury that are found in the fish.

Probably the one issue that we hear about the most relates to the different consumption rates that tribal members have versus the general public. This is because consuming fish and wildlife for sustenance is important in the traditional tribal diet and culture. So tribal members eat more fish than the average public does.

With regard to fish, USEPA is currently using 6.5 gpd as a consumption rate for use in their various risk assessments. Many fish consumption surveys have been done throughout the country, including the Columbia River study, which showed the Columbia River tribes are eating an average of around 60 gpd. Likewise, USEPA's estimate of the 90th percentile of recreational fishermen, which USEPA is interpreting as meaning subsistence fishermen, is about 140 gpd. These rates differ greatly throughout the country based on individual tribes and the resources that they have.

Also, tribal members have different consumption rates of seafood. Some of the work being done in Cook Inlet right now shows that the consumption of seafood by tribal members is 50 times the average rate of what the general population eats, so some sort of default rates need to be established for use in determining how to protect sustenance fishing rights of tribes when site-specific data does not exist.

Another important factor that needs to be considered with regard to tribes is that different species are utilized by tribes than the average or general public. For example, the Penobscot Nation consumes snapping turtles, muskrats, and fiddlehead ferns; the tribes in Alaska are consuming seals, octopus, goose tongue, kelp, and whales; the Passamaquoddys in Maine are eating porpoise; and many tribes are eating beaver and other species.

Also, the medicinal plants that tribes use, the very plants that they're trying to use to maintain or improve health, could very well be plants that may actually impair health, or there's fear that they may impair health, so they're not being used. Likewise, there are different parts of organisms that tribal members eat that may be different than what the average person eats. These may include things such as brains from muskrat, livers, and other organs.

So tribes are doing their own studies, or USEPA is starting to do some studies on behalf of tribes, but these studies need to continue and we need to make sure that they're

reflecting contaminants work for tribal uses of the specific tribes, because these do differ from location to location.

Another important consideration has to do with the spiritual and cultural implications of contamination. Catching and consuming fish from traditional areas is very important to tribes. This differs greatly from a tribal member going to McDonald's and getting a fillet of fish or purchasing fish over the counter at a grocery store. There are inherent qualities associated with going into the watershed and collecting the traditional fish and wildlife that tribal members have consumed since time immemorial.

What we see happening is a loss of culture through generations of contamination. If advisories are placed on rivers that say do not eat fish or limit consumption of fish, tribal members may stop carrying out those traditional fishing practices. If that goes on for a generation or two, the knowledge of those locations, and how to prepare those foods, and the ceremonial purpose is not handed down and can be lost. That is something that cannot be easily replaced.

Likewise, there's a spiritual significance of certain species, such as the bald eagles. For example, the Fish and Wildlife Service did a biological opinion for bald eagles that were nesting on the Penobscot River, and made a no-jeopardy decision that related to eagle populations nationwide. But the Penobscot Nation has a spiritual connection with the eagles on its reservation, and those particular eagles are in jeopardy. So there's a whole different perspective that needs to be obtained.

Likewise, many tribes have sustenance rights or subsistence rights. However, the amount of consumption that's allowed under advisories is often far below levels needed for subsistence or sustenance. The Penobscot Nation encountered this problem when the National Pollutant Discharge Elimination System (Clean Water Act) was issuing a permit to a bleached kraft paper mill which discharges dioxin into the river. The permit assumed a fish consumption rate of 6.5 gpd. The tribe commented on that and provided information that the tribe was actually eating fish at a much greater rate. USEPA issued a permit to the discharger based on a consumption rate of 11 gpd. That rate may reflect what some of the tribal members were eating, but it's not the level that we're trying to attain, because at that level the tribe cannot exercise its sustenance rights, and the federal trust responsibility that USEPA has toward Indian tribes requires that sustenance levels are protected.

Another issue relates to the numerous contaminants and sources of contaminants. The reality is that fish and wildlife are contaminated with more than one contaminant. It's a very difficult issue to try to address, given the lack of scientific understanding of how

these contaminants interact. However, this must be addressed to ensure adequate protection.

Another issue that I'm glad to see is on the agenda and will be discussed more later is risk communication. There's a real concern that the people who are most at risk are not getting the message of the advisories, that they're not understanding what it is they can and cannot eat.

The issues that I've just raised need to be considered and applied when permitting and setting water quality standards, not only when setting advisories. Some tribes have developed water quality standards to ensure protection. However, most have not. It is, therefore, USEPA's trust responsibility to go beyond boilerplate permitting. They must identify each tribe's resources, rights, and issues and attempt to protect them.

Current risk assessment methodology is flawed. Most of the issues that I've just raised, and that John has raised, have little to do with science, yet USEPA and the tribes and states try to look to science to resolve these issues. There is a basic difference between tribal and regulatory perspectives on water quality. Trying to address tribal values in current risk assessment methodology is the proverbial square peg in a round hole. It just doesn't fit. It is not the tool that we should be using.

Therefore, we need to look at devising a new tool, perhaps something more along the lines of the National Environmental Policy Act, and consider alternatives including reduced pollution or no pollution and the economic benefits that come from such things.

Open Discussion

Mr. King, Nunivak Island, Alaska: We need you, like Daniel just described, to work with us, not insult us to be part of an advisory group. We know, folks. Don't plan on us, work with us.

Mr. Kusnierz: John and I are both part of the technical staff that has been developed. The tribes are trying to develop some of their technical staff so that they can play the risk assessment game and try to get some of these issues addressed, but what I would really encourage you folks to do is to go out and meet with individual tribes and actually speak to the leaders of the tribes, the people that have the strong cultural ties to the resources. They convey the importance of that much better than John or I could ever do.

Ms. Elaine Krueger, State of Massachusetts Health Department: I would like to support some of what you said about risk assessment as a methodology. What we're really talking about here is protecting public health. Public health agencies have

generally not relied on risk assessment as a tool to practice public health. Public health agencies have, of course, been making common sense public health advisories for many, many years now, not just since 1989.

I think we really have to be very careful when we use risk assessment as a tool, because we want to use the best science, but we don't want it reduced to a mindless, number-crunching exercise that comes down to arguing about one study when there's a whole body of literature out there. We have to exercise critical thinking in a broader, more integrated way, because I think using risk assessment can sometimes lead to overregulating, and in other cases can lead to underregulating.

In some cases, for example in 1994 when our state put out a statewide advisory on mercury for pregnant women, if we looked at the actual, strict number-crunching, we probably wouldn't have been able to justify doing that; but if you look at the common sense aspects of it from a holistic public health point of view, of course you had to do it.

So I think there's a lot of danger in risk assessment, and while I think we need to use it because it is part of the scientific body of tools that we have in our tool chest, it is certainly a very narrow view to just use that.

NATURAL RESOURCES DEFENSE COUNCIL NATIONAL FISH CONTAMINATION REPORT

Dr. Amy Kyle
Natural Resources Defense Council

In San Francisco, we have a lot of people who fish from the bay for cultural reasons, for economic reasons, and a lot of people who don't speak English very well, or at all, who are impacted by fish contamination. We have a lot of these issues with people who consume fish from San Francisco Bay and elsewhere in California, and this prompted the San Francisco Foundation and the Switzer Foundation's interest in reviewing the overall situation of contaminants in fish. So the perspective that we're taking is probably a little bit different from the perspective that you have as state people working on implementing this program.

Our approach to this is we recognize that states are the principal actors on contaminants in fish. State people have the major expertise and data related to fish tissue. They are the people who are really running these programs. We also recognize that states face a lot of constraints from funding, the political leadership, and so on, but I want to acknowledge at the outset that we recognize the key role that states play in this. This meeting is focusing on state needs and interests in developing the action plan. We're looking at technical assistance, training, data needs, analytic needs, and so on.

As I said, our perspective is a little different. We're looking at this whole issue from the outside, from the perspective of what you might call right-to-know—what do people in the public who might be interested in contaminants in their fish need to know, what can they find out, what can't they find out. We're also looking at it a little bit from the perspective of moving more toward prevention. I think someone said earlier that advisories alone are not enough, that we also need to solve some of the underlying problems. So we're very interested in moving in that direction.

We're interested in these ethical issues that are raised by the fact that some people are bearing the burdens of this pollution, people who are trying to use these resources, be they people fishing for sustenance in Maine, or people from Mekoryuk or Port Graham in Alaska, or the people who are fishing in San Francisco Bay. They're bearing the burdens of this pollution. I think there are some ethical issues there, too, about why should that be and what steps can we take to solve that.

So, in terms of what we did for our analysis, we went through several steps. First of all, I tried to describe the major contaminants and effects. We did somewhat of a simple literature review to look at current research with regard to the principal contaminants in fish, and then we spent quite a bit of time looking at the advisories themselves.

There's a lot of information available about state advisories because of the work that USEPA has done to collect that into a database. So that information is relatively easily available and so it met our criterion of looking at data that would be relatively accessible to the public. We went through and looked at the advisories and tried to summarize information from the advisories in regard to what sorts of fish are most affected, what contaminants are found, and what patterns we see by region.

One of the audiences for the report is people who are interested in finding out about contaminants in their state, so we're trying to summarize this information in a way that tells people basically what's out there for their state. Of course, in some cases we've had to summarize it more than others. The Great Lakes advisories are very extensive, so we've had to summarize more there than in some other areas, but we have tried to pull together the patterns that are existing in that data.

Then the next thing we did was to analyze what kind of protections exist now for the public. We looked at commercial fish, though I'm not going to talk about that today, and then we looked at the state advisory programs. Now, I wouldn't say that we looked at them in a tremendous amount of detail because we have a limited amount of funding and we're trying to use relatively available sources. So we used the information that's available from the database and the surveys and overview reports. We didn't go to the extent of trying to interview every state separately, though we did develop some case studies for California, New York, and New Jersey to look at a couple more issues in detail.

Then the last thing, as I said, is that we tried to develop recommendations to improve protections and move more toward prevention.

As I say, the audience for this report is mixed and that poses a little bit of a challenge. This just summarizes our data sources, but what we're really trying to do is combine three things. We're trying to pull together information for the general public about these advisories. Then we're trying to provide a useful analysis for a policy audience, including a policy audience less informed than the one in this room, about what needs to be done with regard to contaminants in fish, particularly at the national level. Then the last thing we are trying to achieve is to put together a document that would be a useful resource for the types of local groups that we have in San Francisco that are working on these issues.

We have several groups that are working with the Laotian population in Richmond, other Asian populations in Oakland, and other people fishing off the pier in San Francisco. The feedback that we got from them was that they're very interested in having a summary of the health effects research that they could then draw on as they work on these issues, and that's the sort of thing that's not readily available to them. So that's a third audience for our report.

Findings

Exposures: So with that introduction, I'm going to go through the findings in a couple of different areas and then talk about the recommendations. In terms of the findings, when we really started to look at the advisories data, we were actually kind of surprised how many water bodies were affected by the advisories. I think that one limitation of the advisory database is that it doesn't clearly represent the statewide advisories that exist. There are a number of statewide advisories, especially in the Northeast and eastern states, that cover a lot of water bodies but count as one advisory, basically, when you look at the database. So sometimes it's hard to get a sense of the extent of what's covered by the advisories from the types of statistics that are readily drawn from the database. I guess I'd have to say, even coming into this issue knowing that there was a lot of contamination out there, we were really surprised by the extent of the advisories.

A second area where we noted a lot of advisories is in the coastal area, the coastal and estuarine advisories. There are quite a number of those that, again, aren't captured very well in the summary statistics because you don't have a measure for the number of coastal or estuarine miles. So there are some things that, if you look at the database in detail, don't come out very well in the summaries. That really struck us as we looked at this.

Exposures are quite significant for some people. Especially for developing children who, it seems to me, are the group most likely to be affected just because the pollutants that are most common in fish are pollutants that are transmitted from mother to child *in utero* and then through lactation, and they're pollutants that also affect the development process. They are developmental toxicants. I think an important issue from our perspective—and it's not new, but perhaps needs more emphasis—is the extent to which this can be an issue for the development of children.

Of course, populations of people who consume a lot of fish are also more affected. We were somewhat surprised by the lack of information about good ways to capture fish consumption data on subsistence users. There aren't good default values or methods for that. So I think that the comments that we heard earlier about the significance of looking at those upper-end exposures are really very important.

Fish is still the major source of exposure for mercury and PCBs today. I know people think that the PCB problem has gone away since we banned PCBs. As I look at the data, I'm not so sure. It seems to me that maybe the decrease in PCBs has plateaued and maybe we need to be taking another look at what to do about PCBs. We've already talked about mercury. I know people are well aware of that. And fish is still a major source of exposure to dioxin. Again, I think the fact that fish is the most important source of exposure to mercury and PCBs is something that people don't appreciate that much and is an important finding for us.

Right-to-Know: With regard to right-to-know, again this is an area where our perspective will differ from yours. We're looking from the outside at what people want to know about fish, state programs, and advisories, and what information is available to them. States know a lot and people who work in this area know a lot—that information may not be accessible if you're looking from the outside. So this is an area where our perspective differs a little bit.

But the first thing I would highlight is the question of data about fish tissue concentrations of these contaminants. Collecting that data is something that has not been a high priority for the states, probably because you already have the data for your state. You know what you've got and what your trends are, but looking at it from a national perspective, it's really hard to figure out what's happening in terms of fish tissue data. I think probably a lot of the best data is collected by states, but it's not centrally available anywhere. I noted that on your action plan you're thinking of compiling that—which I think is an important thing—and doing another survey, but in order to get into a prevention, problem-solving mode, we need to be able to see where the problems are and what the trends are in these different pollutants. I really feel that we're not able to do that very well right now on a national scale. So I would suggest that, from a policy perspective, this deserves more attention than perhaps it's gotten in this forum, recognizing again that in Betsy's presentation today she said you were moving on several of those areas.

The second thing is, and this is about the advisories, we've had some discussion about the effectiveness of advisories, and I think that's a concern for everyone. How effective are these advisories in conveying information to people who need it? There's certainly more information about the advisories than the fish tissue concentrations because of the centralized database that we have, and many states do a pretty good job of publicizing them. So you can find out more about them, though not necessarily about their effectiveness. So that's an area where it's easier for people to get information.

Then the last thing is the state programs themselves—how health protective are these state programs? We've really looked at what it would take for somebody to understand

how protective their state advisory is. Is it based on a current RfD or an FDA tolerance? Is it based on a thorough monitoring? What is it based on? I have to say that there's really no way to find that out very easily from outside the state system.

State Programs: It's hard for somebody from the outside to really assess where they stand in terms of the protectiveness of the state programs, which seem to vary quite a bit. If you look at adjoining states, we will often see some things that are covered in one state, but maybe not in the next state. The three areas that we highlight are risk assessment methods, the extent of monitoring that's been done, and public information distribution and outreach. So those are areas of concern.

Recommendations

Health: With regard to health, a key recommendation is—and, again, this builds on the words of the previous speakers—to ensure that people at the upper ends of the exposure distribution are effectively protected in these advisories. All the methods and analyses that are based on the average consumer are going to miss the people who are important here. So from a health perspective, that's a very important thing to focus on for everyone. A lot of states do a good job with that, but not all. That's a particular concern. Also, the issues related to the concerns about women and children are very important.

Protective RfDs are key to the extent that we are using a risk assessment approach. People have criticized that approach, have talked about the limitations of it, but to the extent that we are going to use risk assessments, we need to have good RfDs and cancer potency values. We don't have those for all of the contaminants in fish. The PCB RfDs are not based on the types of mixtures that you actually find in fish. They're still based on the old aroclor mixtures. We don't have a RfD for dioxin, and the dioxin reassessment seems to be a perpetual exercise. Mercury RfD has been controversial, but at least it's done and it's well-founded. Some of these other major contaminants, we really don't have anything very good to work with, and that's a problem. I don't know how you can really do good risk assessments on those chemicals when you're lacking RfD and cancer potency values.

States: With regard to the state and federal programs, our recommendations have to do with the issues I raised before. We need to have a better way of assessing these state programs. Maybe this is a little bit of a touchy issue for you all. I don't know. I know that there's a lot of interest in the states taking the lead on this. There are good reasons to leave states in charge of these programs, but I think that there needs to be some stronger review, if not oversight, of some of these key areas, particularly, as I say, of the assessment methods that are used and the amount of sampling that's getting done.

We need some way to describe how much sampling should be getting done and then assess how much is getting done, which is complicated because it includes water bodies, fish, and contaminants. There are three dimensions. You probably don't need to measure everywhere, but we need to make sure we're measuring where we should and have some way to assess that, and we really don't have that now. So that's something that's hard to get a grip on when you're trying to evaluate these state programs.

Then, as I say, the degree of health protectiveness and the analysis is something that also is very hard to assess from the outside. So from our perspective, we think we need some oversight or standards—some way of getting a grip on these issues.

Prevention: Then moving on to prevention. Advisories alone will not solve the problems that we have here, and we all know that. That's not news. I think our perspective is that we need more focus on eliminating sources of these persistent toxic substances. The U.S.-Canada framework is a very good start. There are some good ideas in there.

Perhaps the bottom line here is that our current methods don't deal with persistence. We assess things that are persistent the same as we assess things that aren't. We need to focus on getting these things that are going to be around forever out of the environment now, rather than waiting until they reach toxic levels. Of course, some of them already have.

We're suggesting a specific strategy for each pollutant that's common in fish. Our analysis suggests that there's not going to be a one-size-fits-all. You're going to have to really look at the source mix, control measures, and so on for each of these pollutants individually. As I say, we did acknowledge the framework in the Great Lakes as a good start and hope that will be implemented in a meaningful way.

Conclusion

I hope that you will all consider giving a little more weight to moving the whole program forward or moving the whole issue forward, rather than focusing on your state programs, which I realize is your principal concern.

First is the issue about the fish tissue data. I really think that we need to have some good centralized data, so we can see what's happening across the nation geographically and over time, so that we can move forward on prevention programs.

Secondly, we do think that there is a role at the federal level for oversight or review of state programs, so that we have some common parameters and people can tell what kind

of program they have in their state, how protective is it likely to be, and so on. We would hope that perhaps this group would endorse the idea of moving toward prevention strategies as something that's very important to do, and endorse the steps USEPA has taken in that regard.

A specific recommendation is to develop standard ways to determine how much of what should be assessed has been assessed. We have river miles, we have lake acres—that doesn't seem to work too well when we start talking about how much monitoring we have done.

I would add one other thing to that. There's been a lot of discussion about the water quality standards framework. It doesn't work that well for substances that aren't soluble in water, so maybe we need to be thinking about sediments and other types of tissue monitoring. I'm just not sure that those water quality tools are working for these contaminants and that's why we're seeing so much of this stuff in fish even as we don't see it in water.

Perhaps it would be useful to have some sort of forum like this to talk about prevention. This is a good forum for the advisories but, as we broaden our focus, maybe we need a little bit of a different type of forum.

Open Discussion

Participant: Is your report available?

Dr. Kyle: I'm sorry. I meant to mention that. It should be out late this winter or early this spring. It has not yet been released.

Mr. Bob Vanderslice, Rhode Island Department of Health: What you've described as a federal program, that's what we traditionally do with our environmental programs, and this one doesn't have funding or a mandate. So, you have a great idea. It's the same with indoor air or any other unfunded, unregulated problem. It's really not a regional or a state problem, it's a national problem. I think we'd all admit that, and there's a whole bunch of other problems that we try to deal with by having states muddle through as best we can, in the case of Rhode Island, or do a great job, in the case of other states.

Dr. Kyle: Well, I think you're right. I think it does need a national focus. Whether it's a statutory mandate or not, I'm not sure. I haven't reviewed that, but I think you're right.

UPDATE ON THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY GREAT LAKES HEALTH STUDIES

Dr. Heraline Hicks
Agency for Toxic Substances and Disease Registry

The Great Lakes is a very dynamic ecosystem which consists of the five Great Lakes states and, of course, the St. Lawrence River. More than 10 percent of the U.S. population resides in the Great Lakes area.

The International Joint Commission has identified 11 critical Great Lakes pollutants in the basin. These include organochlorine compounds, heavy metals, polycyclic aromatic hydrocarbons, and benzopyrenes. We are investigating these 11 critical pollutants in our Great Lakes program, as well as other chemicals of concern depending on the lake, river, tributary, or stream.

Our program was created in 1990 by an amendment to the Great Lakes Critical Programs Act. Our program was designed to investigate and characterize the association between consumption of contaminated Great Lakes fish and short- and long-term harmful health effects. We are focusing on presumed at-risk populations in all of our studies. These populations include Native Americans, sport anglers, the elderly, nursing infants, and fetuses.

As of October 1st, we started our sixth year of research in the Great Lakes area. We administer grants to academic state institutions and state health departments in the Great Lakes area. At this point, we have identified exposure pathways and body burden levels in our at-risk populations and we're now investigating the potential association between exposure and adverse health effects in these populations.

We're also trying to identify sensitive human health endpoints, such as behavioral, reproductive, developmental, neurological, and immunological health effects resulting from exposure to these persistent toxic substances. We're investigating the father's exposure, the mother's exposure, and how that exposure may affect their newborn children.

Within our research program, we're also identifying and improving analytical methodology to detect these contaminants in various environmental media, whether it be soil, mud, or biological samples. One of our main goals is to try to increase collaboration

among our awardees and state health departments, in looking at this issue within the Great Lakes area. Most importantly, we want to provide public health information from our findings to our study participants, state health departments, government agencies, and all interested parties in the Great Lakes area.

In regard to academic research programs, I should mention we are funding 10 research grants across the Great Lakes. Again, they're going to state academic institutions and state health departments. Of course, these also involve federally-recognized Native American tribes across the Great Lakes.

In regard to exposure, we are finding in our studies that individuals are still being exposed to persistent toxic substances in the Great Lakes, such as PCBs, mercury, DDE, dioxins, and furans. We have documented exposure to these chemicals in various populations. Fish consumption, as mentioned earlier, remains the pathway of exposure to these persistent toxic substances in the Great Lakes. We have ongoing research looking at various routes of exposure—fish, wildlife (like duck and other game), air, water, soil, and vegetables from individuals' gardens—but we still find that fish appears to be the main pathway of exposure to these chemicals, especially to the organochlorine compounds.

We are also finding a significant trend of increasing body burden with increased fish consumption. These body burden levels are three to four times higher than those of the general population.

One of our studies is of a Native American community in upstate New York, the Mohawk, Akwesasne reservation. The principal investigator there is Dr. Edward Fitzgerald from the State University of New York at Albany. His study focuses mainly on the Native American men. Some work was done earlier by ATSDR in our Division of Health Studies to look at the women in this group. We found detectable levels of various compounds like DDT, mirex, hexachlorobenzene, and others in breast milk of these women.

Dr. Fitzgerald is now looking at the men within this group. We found that men ate more locally caught fish than women prior to starting this study, at least eight fish meals per month. The mean PCB concentration in these men was more than twice that of the women.

Two years prior to starting this study with us, men consumed more than 100 fish meals per year on average, whereas women consumed approximately 30 fish meals per year. As time goes on, you see a trend. Even though the rate of local fish meal consumption is decreasing, men are still consuming more fish than women. In the last year of the study,

men were consuming about 25 fish meals per year, and women approximately 10 fish meals per year. In regard to concentrations of PCBs in their serum, again you see a trend. The greater the concentration of PCBs, the greater the number of men, and the lower the concentration of PCBs, the greater the number of women. So even though men and women both decreased their fish consumption, we find that PCB concentrations in the serum of men are still very high.

Here we're talking about PCBs in ppb. The mean concentration was 3 ppb. The maximum was 31.7 ppb in the men in this study. Background concentration level is considered to be anywhere between 5 to 7 ppb, and in the literature you might even see somewhere as high as 10 ppb.

Even though the mean PCB concentration in the preliminary findings of this study was 3 ppb, we have a maximum of 31.7 ppb, and at least one-third of this population had PCB concentrations of 25 ppb or higher. So, again, we're above the background levels of 5 to 7 or even 10 ppb.

We also found in this study that serum PCB concentrations in these men positively related to the number of locally caught fish meals they consumed every year. We also found that serum PCB concentrations in men increased with age.

Looking at DDE in this population of men, the mean concentration was 3 ppb, and concentrations ranged from 0.3 to 13.7 ppb, with background being about 11 ppb. Even with a background level of 11 ppb, with our values ranging from 0.3 to 13.7 ppb within this population, one-third of the men in this study had concentrations above background. They were somewhere between 12 and approximately 14 ppb. The background concentration is based on National Health and Nutrition Examination Survey (NHANES) data on the general U.S. population.

Another study looking at older populations in the Great Lakes area is being conducted by Dr. Susan Schantz at the University of Illinois at Urbana. This population includes individuals ranging in age from 50 to 70 years, and there are some individuals in this study who are 80 years of age. The individuals here are classified either as non-fish eaters or fish eaters. Non-fish eaters are those people who consumed less than six pounds of Great Lakes sport-caught fish per year. Fish eaters are those who consumed more than 24 pounds of Great Lakes-caught fish per year.

Again, the trend is obvious. The higher the PCB concentration, the greater the number of fish eaters. The lower the PCB concentration, the greater the number of non-fish eaters. In this study, the mean PCB concentration for the fish eaters was 16 ppb, and for the non-

fish eaters it was 6 ppb. Seventy-five percent of the individuals who were considered fish eaters had concentrations of PCBs between 14 and 65.2 ppb.

We looked at DDE levels in this population and the same trend is obvious. The higher the DDE concentration, the greater the number of fish eaters. The lower the DDE concentration, the greater the number of non-fish eaters. The mean DDE concentration for fish eaters in this study population was 15.9 ppb. For non-fish eaters, it was 7.3 ppb.

We looked at mercury in this same population and again, the same trend. The higher the mercury concentration, the more fish eaters. The lower the mercury concentration, the more non-fish eaters. The mean value for mercury was 2.3 ppb for the fish eaters and 1.1 ppb for the non-fish eaters. The maximum mercury concentration found in this study for fish eaters was 9 ppb, and for non fish eaters it was 4 ppb.

Because of the PCB, DDE, and mercury levels that we found, this population is now undergoing neuropsychological testing to look at things such as cognitive function and motor skills.

The last exposure study I want to tell you about is one that's being conducted by a five-state consortium in the Great Lakes. The principal investigator of that study is Dr. Henry Anderson. He did a pilot study looking at frequent sport fish consumers across three of the Great Lakes areas. These consumers are basically charter boat captains and their spouses. Looking at Lake Michigan, the range ran from 10 fish meals per year to as high as 172 fish meals per year.

Consider the FDA value of 6.5 gpd per person for fish consumption. Look at the individual consuming 172 fish meals per year. If you take a standard fish meal of, say, 8 ounces times the number of fish meals consumed, the result is more than 30 times the FDA value of what is considered the norm for the general population. Individuals are consuming a great number of fish meals in the Great Lakes area.

In this study, they looked at the blood concentrations of dioxins, furans, and coplanar PCBs in 625 individuals who consume fish from Lakes Michigan, Huron, and Erie. Dioxin concentrations were elevated above background in individuals who consume fish from any of the three lakes. Furan concentrations were elevated above background in individuals who consume fish from Lake Huron or Lake Michigan. PCB concentrations were also elevated above background in individuals who consume fish from Lake Huron or Lake Michigan. In this study, background concentrations are those found in the general U.S. population.

So what about health effects related to exposure? What are we finding now in our studies? Dr. Thomas Darvill, at the University of New York at Oswego, is looking at newborns born to women who consumed Great Lakes fish from Lake Ontario. These women consumed Great Lakes fish for at least 16 years—six years prior to their pregnancy, during their pregnancy, and after their pregnancy. Their newborns were tested between 12 and 24 hours and 25 and 48 hours after birth.

They found during those two time periods that newborns born to these individuals had a greater number of abnormal reflexes, less mature autonomic responses, and were very easy to startle. These are very subtle neural, behavioral, developmental differences but, again, at a very early point in time, 12 to 24 hours after birth, and again 25 to 48 hours after birth. This work was published in the *Journal of Great Lakes Research* last year.

Most recently, Dr. Darvill has new preliminary findings. We're finding now, for the first time, that in women who consume contaminated Great Lakes fish, their fish consumption pattern and exposure to contaminants may affect the temperament of their children. The same children from the previous study were examined at 24 months of age. Four areas of temperament were measured: activity level, soothability, smiling and laughter, and fear.

Children whose mothers consumed Great Lakes fish for at least a 16-year period had a lower level of activity. They played less and were very inactive. Once agitated, it took those children a longer time to become settled, at ease. They were very easily agitated, and it took a much longer time for them to come to a soothed resting state. The characteristics of smiling and laughter were exemplified less in the group of children who were exposed to contaminants *in utero* than in those who were not exposed. The children who were exposed *in utero* also exhibited more fear than those who were not.

We're not really sure what all of this means. Dr. Darvill is still working on this data, but again, it's a hint that temperament of a child may be affected by the mother's exposure to contaminated fish from the Great Lakes area.

Studies examining diabetes, muscle and joint pain, liver disease, and memory loss are being conducted by Dr. John Dillinger, who is affiliated with the University of Wisconsin in Milwaukee. He's working with the Great Lakes Intertribal Council, a dozen tribes of the Ojibwa in upstate Michigan, Wisconsin, and Minnesota, as well as the Great Lakes Indian Fish and Wildlife Commission. These studies will be presented at a meeting he's going to have with the Ojibwa Tribe during the week of May 18th to discuss these data and to develop strategies for the future.

What he's finding is that fish consumption significantly correlated with clinical symptoms in the Ojibwa Tribe. Native Americans had elevated levels of PCBs, which

correlated with self-reported diabetes, muscle and joint pain, and liver disease. The mean PCB blood level was 4 ppb and the maximum was 10 ppb.

Individuals who had very high PCB concentrations also worked at a pegboard performance test. This test evaluated visual and motor coordination as well as spatial coordination. Dr. Dillinger found that those with the higher PCB concentrations did poorly on the tests. PCB concentrations were associated with the consumption of lake trout.

The study examined mercury as well, and found that hair mercury levels greater than 1.3 ppm were significantly associated with memory loss and diabetes in this group. Going back and looking at the fish consumption, what he found was that individuals who consumed large amounts of walleye—and the walleye in this area were contaminated with mercury—reported these symptoms.

This work is ongoing at the University of New York in Buffalo. The principal investigator is Dr. John Vena and his group has the largest established study population from the Great Lakes area. There were 10,000 people in his study population. What they're finding is that in women who have been consuming Great Lakes fish for seven or more years there is an increase in what we call the mean time to pregnancy.

They are also finding, in the preliminary work, that the risk of infertility is elevated in women who consumed contaminated Great Lakes fish over a period of seven or more years. Again, these are fish from Lake Ontario, along the St. Lawrence River. A significant menstrual cycle reduction was also indicated in women who reported eating at least one fish meal per month of contaminated Great Lakes sport fish. This work is ongoing, but it has been accepted for publication in the *American Journal of Epidemiology* and it should be coming out some time this month. The rest of the work is ongoing, and they have two other publications that should be going to press very soon.

The last study I want to tell you about is going on at Michigan State; Dr. Nigel Panet and Dr. Jeanne Courval are looking at sport-caught fish consumption and conception failure. In this study, fish consumption patterns of 625 married couples were examined. Consumption goes from zero to more than 1,000 fish meals per year. Conception failure is considered as trying for 12 months without conceiving. Preliminary findings indicate that conception failure is reported by 50 percent of this population. Looking at the men's fish consumption patterns, the women's fish consumption patterns, and developing a model for conception failure—throwing in variables like age, race, sex, whether you smoke or drink, where you live along Lake Michigan—the data seems to indicate that only in men is there an increased risk of conception failure based on the greater number of fish meals consumed.

So the question becomes, what does this mean? Work is ongoing but this may be a hint as to why there are reports in the literature and on the news about decreased sperm counts in men exposed to persistent toxic substances.

We are a public health agency and we are concerned with public health interventions and education. One hundred percent of the waters in the Great Lakes area were under some kind of advisory in 1996. We have an increase in advisories across different tributaries, rivers, and streams. We have a 26 percent increase from 1995 to 1996 in regard to mercury advisories. Also, an increase of 41 percent for PCB advisories in the Great Lakes area.

The number of advisories and bodies of water under advisory also rose from 1995 to 1996, a 26 percent increase. Again, more advisories over more waters. Lastly, we now have 5 percent of our nation's river miles under advisory. That was not prevalent in 1995.

So what does all this mean for us as a public health agency? We must have means of public health intervention. The program we have established for ourselves is based on the disease paradigm for health—surveillance, education, prevention, and impact.

In conclusion, when we talk about fish consumption, one must consider the benefits of eating fish. We must be concerned particularly with populations that have elevated levels of exposure or physiological sensitivity. Again, our at-risk populations include women, children, unborn fetuses, the Native Americans, and the elderly. Our concern must be with this segment of the population. Health education is critical to informing individuals about their risks. Most importantly, the thing we must continue to do is reduce the load of toxic chemicals in the sediments and in the fish in the Great Lakes area.

INTRODUCTION: AWARENESS AND EFFECTIVENESS OF CONSUMPTION ADVISORIES

Dr. Henry Anderson, Moderator
Wisconsin Bureau of Public Health

We have three presentations. Just as a mode of introduction, I think one of the key things to remember is we always have a lot of discussion about sampling and the science of advisories, and when we get to the implementation phase, we tend to not pay as much attention to how well our message is being received. We could have the strongest science in the world, the most accurate and excellent advisory; if it's unintelligible to the target audience, we clearly need to make some adjustments.

So, today, in our first session this afternoon, we're going to address the issue of evaluation and assessment of advisories and look at some examples of projects that have been underway for some time that I think are good examples. In this particular area especially, it's critically important to have partnerships, to have consortium, to have lots of input from organizational groups.

NEW YORK STATE CONSUMPTION SURVEY

Dr. John Vena
University of Buffalo

I was asked to speak today about the advisories and knowledge and awareness of the advisories in the New York State Angler Study. I'd like to talk about some background of the western New York study, how we constructed the cohort, then describe consumption levels, awareness and knowledge of the advisories, and changes made in behavior as a result of the advisories. Then I will talk about changes in the advisories that New York State made as a result of those findings. The findings that I'm going to present were initially reported in September 1993. This report was published by the Department of Natural Resources and is called *Health Advisory Knowledge: Related Attitudes and Behavior with a Focus on Lake Ontario.*

[*At this point, Dr. Vena showed a fishing guide for New York State depicting a salmonid, although the New York State advisory says not to eat these fish. They are above the FDA tolerance limit for mirex and dioxin, and they also contain PCBs, methylmercury, etc. He also showed a brochure promoting sport fishing along the Seaway Trail with a sportswoman on the cover, although the advisory says women of reproductive age aren't supposed to eat any fish from Lake Ontario.*]

We instituted the New York State Angler Study because we wanted to know not only how much fish people catch, but if they eat them, if they are aware of the advisory, and if they know what the advisory says. Also, with the funding from ATSDR, we've expanded that to follow up on reproductive developmental health effects, body burden measures, etc. But the initial cohort was established by funding from the Great Lakes Protection Fund. Again, the idea was to assess risk perception and do some initial body burden studies, and then with further funding from ATSDR, we've expanded that to include other things.

Let me quickly describe the methods. We selected 30,000 sport fishers who purchased a license in New York State in 16 counties. We restricted the study to people 18 to 40 years of age so we could cover reproductive and developmental health. Forty-three percent of licenses sold in New York State were sold in these 16 counties, and we selected these counties because we wanted to concentrate on Lake Ontario.

We mailed a self-administered questionnaire to these 30,000 individuals in mass mailings. We sent a reminder postcard, a second letter with a questionnaire, and then a

third follow-up letter. We asked about fish consumption using a retrospective food frequency dietary assessment method. The content of the questionnaires included questions about the number, species, and size of fish eaten; general cooking methods and current consumption; number of years of fish consumption; Lake Ontario and specific species; and the knowledge and awareness of advisories. A section was included on the spouses of the anglers.

Because the sampling scheme was based on fish licenses, and ethnicity and race are not on the licenses, we couldn't oversample ethnic minority groups. Eight percent of the license holders were women. We got a 40 percent response rate, with 48 percent among women. In all the studies I do, women are better participators than men. The numbers for the minority groups are small, but we've done testing of non-responders and we came up with about 1 percent minority license holders, so it's about right.

The mean number of years fished ranged from 13 to 19 among ethnic groups. So some of these individuals have been fishing these waters for half their lives. Mean days fished in the last year ranged from 30 to 40 days. Some people fished more than 180 days in the last year.

About 5 to 30 percent of the respondents in each of the ethnic groups consumed "do not eat species"—catfish, lake trout, chinook salmon, and rainbow trout over certain sizes—in the previous year. Higher percentages of minority groups were eating the "do not eat species." Roughly 15 percent were eating lake trout and chinook salmon. Among blacks, catfish were consumed at the highest percentage. Lake trout and chinook were consumed most by natives.

There are ethnic differences in fish preparation. A much smaller percentage of blacks remove the skin or trim the belly fat than other groups. A much higher percentage of blacks tend to eat the skin and the whole fish or cut a steak; a much higher percentage of whites fillet the fish.

Ninety percent of the whites were aware that there was an advisory for eating fish in New York State. Hispanics, natives, and asians were also quite aware, with the lowest awareness of 75 percent in blacks. When we looked at gender, females were slightly less aware than males among hispanics and whites. In particular, only 40 percent of black females were aware of the advisory.

Younger people were less aware than older people. This is troubling because some of the advisories were targeting women of reproductive age and children under age 15. The only group that was different was the native population, in which 100 percent of the 18-25 year-old natives were aware. This might be related to cultural differences.

Not surprisingly, education was also strongly related to awareness. The lesser educated were less aware, particularly among blacks and Asians. The people with higher incomes were more aware, which may be correlated with education.

We examined the frequency of fish consumption in relation to awareness of the fish advisory. For whites, the people who ate a little more were a little bit more aware, but not significantly so. Among blacks and Asians, it appeared that the people who ate more were less aware. So in some instances, the people who were less aware were in fact eating more fish. When we looked closely at the data for whites we found that those eating more are the guys with the boats and the downriggers who are in the upper income and education ranges. They're aware of the advisory, but they choose to adopt the practices of cleaning and trimming and decide they'll take the risk.

Overall, the awareness is pretty high, which is good. However, although awareness was high, a lower percentage knew accurately what the advisory said. Only 25 percent of whites correctly identified the advisory recommendation of eating only one fish meal per week from any New York state waters. The percent correct was lower in the group unaware of the advisory. Only about 50 percent of whites and 30 percent of blacks knew that the advisory stated that women of child-bearing age and children shouldn't eat any contaminated fish from certain bodies of water. Only 7 percent of black females knew the details of the advisory for women of child-bearing age and children, so this group is obviously not getting the message.

About 60 to 70 percent of the respondents said they made changes because of the advisory. Ten to 20 percent said they no longer eat fish and 40 to 50 percent said they eat less. A small percentage said they eat more, but they select species or bodies of water that are not contaminated. Thirty to 40 percent said they changed their preparation. Another 20 to 30 percent said they changed the location. A certain 10 to 20 percent said they changed species, and then again a smaller percentage said they made fewer fishing trips. So, although they may not be able to tell you exactly what the advisory says, they are making some changes in response to it.

About 60 percent of whites don't give any of their fish away and about 8 percent gave more than 25 percent of their fish away. Among blacks, 30 percent gave more than 25 percent of their fish away. Among Hispanics, 11 percent gave more than 25 percent of their fish away. This tells us that a good percentage of minorities, especially blacks, give their fish away to neighbors. So if the advisory isn't going to get to those people receiving the fish, then the dissemination method of the advisory has to be different for them.

In summary, ethnic differences were seen for sport fish consumption, species preference, cooking and preparation, amount of catch given away, and awareness and knowledge of the advisory. Overall awareness of the advisory was high. Awareness was less among younger people, those with lower income, and those less educated. Female anglers were less aware, and non-white anglers, in particular blacks, were less aware. The accurate knowledge of the advisory recommendations was low. The anglers are making changes. Among those aware, about 60 percent made changes in response to the advisory.

As a result of this report, and maybe other information as well, New York State developed geographic, area-specific advisories. They are one or two-sheet advisories that are distributed in specific areas and that target unlicensed low income groups. The state also developed a Fish Advisory Compliance Project to identify non-English-speaking populations and find other ways of disseminating the area-specific, two-page advisories to them. They also targeted bait and tackle shops; health service providers, particularly providers for minority populations; and local community agencies to help disseminate information instead of just relying on the sport fishing guide and newspaper. Unfortunately, the funding for that project is out and the program has ended.

Another change made was that advice for women of child-bearing age and children in the advisory was reworded, made clearer, and bolded. As other people have mentioned, the advisory isn't the answer to everything; we could probably do a better job. The response from New York State has been good in that they tried to develop a specific program. We need to do more of that, evaluate whether it is working, and do a better job of increasing the awareness and knowledge of the advisory.

TRIBAL PERSPECTIVE: AWARENESS AND EFFECTIVENESS OF ADVISORIES

Ms. Alice Tarbell
First Environment Research Projects

I am the director of a community-based research group from the Akwesasne Mohawk Nation called the First Environment Research Projects. Our group works in conjunction with the School of Public Health at State University of New York-Albany and the Akwesasne Task Force on the Environment. Together, these organizations are part of the Superfund basic research program, which is currently conducting three human health studies to examine possible health effects caused by PCB exposure.

The Akwesasne Task Force is a community-based grassroots organization formed in 1987 to address environmental problems facing our community. It's composed of members of the Mohawk community and staff of environmental agencies and organizations within Akwesasne who share a common concern for the environment and the effects of various toxic substances on human and non-human health.

Akwesasne, also known as the Seramdis Mohawk Reservation, is a Mohawk community of approximately 10,000 to 12,000 members. Its territory is located along the St. Lawrence River between New York and western Quebec and eastern Ontario. The St. Lawrence River has been part of the homeland for the Mohawk people for centuries. This river and its tributaries have been a rich source of fish, wildlife, medicines, and other important resources.

The people of Akwesasne have seen many changes in the St. Lawrence River in the past 100 years. The most prominent was the construction of the St. Lawrence Seaway and the Moses-Saunders Power Dam, which attracted three major industries to our area, the General Motors Central Foundry Division (GM), Reynolds Metals, and the Aluminum Company of America. These facilities are located directly upwind, upstream, and up-gradient from our community in the town of Messena, New York. The GM plant is less than 100 feet from our western border.

Toxicants released from each of these neighboring industries have contaminated Mohawk lands, air, and waterways which have, in turn, endangered the traditional land usage and subsistence fishing. These industries have contaminated the St. Lawrence River and its tributaries through surface water run-off or by direct discharge, thus creating one of the largest sites in the U.S. contaminated by PCBs, polycyclic aromatic hydrocarbons,

phenols, volatile organics, fluorides, and metals. As a result, GM was placed on the Superfund national priority list in 1983, and Reynolds Metals and the Aluminum Company of America were also designated as state Superfund sites.

Areas of contamination in Akwesasne due to nearby industries include industrial lagoons, unlined industrial landfills, disposal areas, sediments, riverbanks, and wetlands in the St. Lawrence and Raquette Rivers. It is estimated that almost one million cubic yards of materials are contaminated with PCBs at a concentration higher than 1 ppm, the standard set by the St. Regis Mohawk tribe. Over half of this material is contaminated at a concentration higher than 50 ppm, New York State's definition of hazardous waste. After learning of problems at the GM facility, the Mohawk people sought the help of a New York State Department of Environmental Conservation and Wildlife pathologist and a New York State Department of Health chemist to do independent research. Together with the members of the tribe's environment division, they collected and analyzed a variety of environmental samples for PCBs and insecticides.

This overhead displays some of the initial results of samples taken from the GM site, and these were made public in July of 1986. When you take a look at these results, you'll see that a PCB concentration of 2 ppm was set as a limit for fish, and 3 ppm was set as a limit for poultry. A PCB concentration of 50 ppm in soil is considered hazardous waste. So some of these results came as a pretty rude awakening for the people in our community.

In addition to these results, extremely high concentrations of PCBs were discovered in sturgeon caught in the St. Lawrence River near the St. Regis Mohawk Reserve. The sturgeon contained 12.2 ppm PCB concentrations in its liver, 3.41 ppm in its meat, and 7.95 ppm in its eggs. New York State considers any fish with a PCB concentration of at least 2 ppm as unfit for human consumption. Concerns for human health were raised since sturgeon and other fish were eaten on a regular basis by the Mohawk people. As a result the St. Regis Mohawk Environmental Health Department issued a health advisory in July 1986. The initial advisory stated that fish taken from the St. Lawrence River should not be eaten by women of child-bearing age or by any children under the age of 15, and that all others should eat no more than one meal or half a pound per week of fish from any body of water in or around the St. Regis Mohawk Reserve.

Concern about whether or not it was safe to breastfeed infants prompted Mohawk midwife Katsi Cook to initiate discussions with the scientists about performing analyses which eventually led to the ecological analysis of the food chain, including fish, wildlife, and human breast milk. The Akwesasne Mother's Milk Project began in 1986. This focused on the analysis of organic chlorides in mother's milk, in the fetal cord blood, and maternal and infant urine. During this project, pregnant and nursing women were contacted and asked about their residential, occupational, social, and dietary histories.

A conclusion of this study was that the Mohawk mothers have eaten relatively large quantities of local fish. However, subsequent consumption has declined dramatically over time from a mean of 2 local fish meals per month before pregnancy to a mean of less than 0.5 meals per month during pregnancy. This change is presumably the result of fish consumption advisories in the region of the St. Lawrence River for pregnant women and women of child-bearing age. It also attests to the concerns of the Mohawk mothers about the potential effects of exposure on their children and their willingness to change their behavior accordingly. However, one-third of the Mohawk mothers still ate local fish at least once during pregnancy.

Beginning in 1992, a second phase of the Mother's Milk Study began, very similar to the first, but with a few additional questions. The women were interviewed prenatally as well as one, three, and six months postpartum. They were interviewed at each time period, and along with breast milk being collected, serum samples were now being collected. These interviews asked more questions regarding whether or not the women were aware of the fish advisory, how they became aware of it, and what effect, if any, it had on their fish consumption and preparation. They were also asked if the advisory affected the species of fish they ate and whether or not their fishing locations had changed.

In 1993, another study, the Men's PCB Assessment Study, was introduced in conjunction with the women's breast milk study. The men's study concentrated on male partners, fathers, brothers, or uncles who had lived in the same household as the women in the breast milk study. Participants of this study were interviewed about residential, occupational, recreational, social, and dietary histories and serum samples were collected. Like the women's study, the men's study also questioned each participant regarding knowledge of the local fish advisory and any behavior changes following the advisory.

Preliminary results of the men's study showed that 97.8 percent of the men surveyed were aware of the advisory. For 66.2 percent, the advisory had an impact on their fish consumption; 54.4 percent changed the number of fish meals per month; 47.1 percent changed the number of fish they ate per meal; 23.5 percent changed the location they had fished; 19.4 percent changed the type of species they consumed; and 11.8 percent changed their fish preparation methods.

For Mohawk women interviewed from 1992 to 1995, 91.3 percent were aware of the advisories; 49.3 percent exhibited a change as a reflection of this advisory; 31.4 percent changed the number of fish meals per month; 37 percent changed the amount of fish per meal they ate; 7.8 percent changed their fishing location; 5.8 percent changed the species of fish consumed; and 1.9 percent changed their fish preparation methods.

So as shown by these results, it appears that our people are aware of the fish advisory and that it has been effective in discouraging fish consumption among residents of the Mohawk Nation. We have found that this information was most effectively communicated by two forms of media, newspaper and radio, perhaps because they are locally owned and operated. We also found that much of the transfer of this information took place from person to person as you would find in many small, close-knit communities. More studies are currently underway which are asking similar questions, but through a random selection of households, to produce data for a larger cross-section of our population and find out to what extent people are adhering to the advisory.

We found that, as far as where they fish, they stay away from the area toward the industrial plants and they have moved further downstream. It should be noted that the fish advisory used in our community is updated periodically to reflect any changes in state or federal guidelines, information on the contaminants in fish, or recommendations for fish preparation.

As a result of the advisory, both men and women have slightly or greatly decreased their consumption of locally-caught fish and thus their body burdens of PCBs and other contaminants have been lowered. Some people view this as a success story, but this is far from being a solution. Other effects of compliance to the advisory include economic, cultural, and health impacts.

Economically, the decrease in fish consumption resulted in a decline in the fishing industry. Some estimate that over 50 percent of the economy at Akwesasne was associated with fishing. Since the advisory, the unemployment rate has risen. The loss of jobs related to the fish industry has had a cultural impact because of the need to search for work elsewhere. The family network has been affected along with other culturally significant values. Fathers and sons are no longer seen on the river day after day. The skills taught with this trade are diminishing. Fewer and fewer young people today possess the skills that were once passed down from one generation to the next. The decrease in fish consumption in our community may have also resulted in certain health impacts. Many of our people have turned to less healthful sources of protein which may have contributed to a rise in certain health problems, such as heart disease, hypertension, and diabetes.

Given these impacts on our way of life, one cannot state that our story is a successful one. We have tried to lessen the severity of these impacts by developing ways to overcome some of these situations. The Akwesasne Task Force on the Environment has introduced two aquaculture projects with the goal of producing a source of clean fish. In the Small Aquaculture Project, fish are raised in fish ponds, and in the Large Cage Aquaculture Project, fish are raised in pens in one of the local rivers. These projects are still in their

infancy, but the future looks promising. Many people in our community have taken an interest in developing this into a large-scale business.

To offset some of the cultural impacts, such as the loss of traditional skills related to fishing, the Akwesasne Task Force on the Environment has also offered courses to adolescents to teach them these valuable skills with the aid of local fishermen and trappers. The project titled *Life Skills on the Land* was introduced to help educate younger community members in these disappearing skills.

As part of an outreach project, the First Environment communications program held an alternative proteins workshop. Its goal was to provide information and training on how to prepare meals using alternative sources of protein. A chef from a vegetarian restaurant was the instructor for this workshop, which was also videotaped for community use.

In conclusion, these are just some of the examples of how one community has tried to deal with the negative impacts of such a loss of an important part of our lives. It would be recommended for any community or agency issuing an advisory against the consumption of fish to consider solutions to the problem and not just leave the people with no other choice but to accept the impacts and their negative consequences.

Open Discussion

Mr. Milton Clark, USEPA: What are USEPA or Canadian environmental agencies doing to remediate the contaminated sediments in that area? Is there a plan under the Superfund or any other government program to reduce contamination?

Ms. Alice Tarbell: The funds for our current projects fall under the Superfund basic research program. They offer the assistance to help monitor human health issues. USEPA has also been working with the nearby industries, particularly the GM facility, to help remediate the problems. Part of the river was dredged at their outfall area a year ago, I believe, and sediments were put on top of the riverbank but were not covered. That created another problem because the sediments remained uncovered all summer, which is the time of year PCBs volatilize more quickly. They were just recently covered, and negotiations are going on with USEPA now to try to settle on a minimum cleanup level for the remaining sediments and waste sites.

FRAMEWORK FOR ASSESSING THE AWARENESS AND EFFECTIVENESS OF MERCURY ADVISORIES

Dr. Henry Anderson
Wisconsin Bureau of Public Health

In this country, the vast majority of fish come from rivers, lakes, and inland waters and the predominant problem in most of those areas is mercury, but what I'm going to talk about here is awareness and effectiveness of sport fish consumption advisories. I was glad to hear this morning that USEPA was going to move toward giving us some guidance as to how to do surveys, how to find out, how to evaluate.

What I'm going to talk about is one of the things that I've found to be very useful for most state health departments, like Wisconsin—we think of ourselves as a big little state, unlike New York, California, or Texas which are big big states. For most of us, we're spread pretty thin in health departments, and when a request for proposal for a grant comes out it's tough to organize in a 60-day period. So for the ATSDR grants, we got together with other state health departments and put together a group proposal. The majority of the grants went to universities, with the exception of those that went to the group of five state health departments that got together to work on this particular project.

With our consortium we have a very nice workgroup to try to address some of these very complex issues. It offers us an opportunity to bring other resources to bear as needed. Since we frequently don't have our own labs, we have to involve universities, and we've got the federal government involved.

We had three specific activities. I'm only going to talk about the fish consumption and advisory awareness survey in the Great Lakes. In the December issue of *Environmental Health Perspectives,* a paper will appear entitled *Health Advisories for Consumers of Great Lakes Sport Fish: Is the Message Being Received?*

This particular project targeted adult residents of the eight Great Lakes states. Now, that's different from what you heard from John Vena, who targeted the anglers or individuals holding licenses. This was a different type of approach and, again, it's dependent on residents who have phones. So every survey technique has its strengths and weaknesses. If we're going to get to some of the minority populations, or the low income groups, or, in Wisconsin, our Native populations, telephone access is more problematic and you have to think in terms of other types of survey tools to get that information. For this project, we wanted to characterize the current fish consumption patterns for all types

of fish and, since we were being funded, to look at Great Lakes sport-caught fish, and come up with some estimates of advisory awareness and measures of compliance specifically among consumers of the Great Lakes fish.

So this is a survey that was conducted by telephone using random digit dial, during 1993 to 1994. We didn't ask if they had licenses. It was just whoever we got on the phone at the time. Roughly 8,000 interviews, 2,000 per season (because we were asking for some recall of when people ate fish and we wanted to balance it by the season of the year), and approximately 1,000 persons per state were targeted for completion.

We gathered basic demographic information, and information on frequency of fish consumption and sources of fish consumed. Because of the costs of doing these types of surveys and the large number of individuals, and because we were focusing on Great Lakes fish, we started out by asking did you eat any fish in the last year, then, did you eat any sport fish in the last year, and if you ate sport fish, were those fish from the Great Lakes. If they said yes to the Great Lakes, then we tried to get into some detail related to species eaten and awareness of the advisory specific to the Great Lakes. The information I'm going to show you is from that portion of the population who said they'd eaten Great Lakes sport fish in the last year.

For those of you who like how we approached this, it was fairly sophisticated. Because of the random digit dial sampling scheme, you can, in fact, apply sampling weighting factors and do some post-stratification weighting to come up with actual estimates of numbers of individuals who ate fish. We then looked at a multivariable logistic regression, determining age, as well as consumption issues, and then state. SUDAAN software is one that allows you to apply these various weighting factors specifically to these types of sampling projects.

The response rate is not how many people you actually reached on the phone and who replied to you. Since we're trying to extrapolate to the whole population, we also have to take into account those that we aren't able to contact, but whose phone number was selected. It varies by state, from 51 to 75 percent as you reach the Midwest and upper Midwest. We seem to be getting a little bit better response rate there than in some of the larger metropolitan areas. In more urban areas people either tend to have call screening or phone machines, are not very happy, or tend to be fairly negative, where the more rural populations tend to view being contacted for a survey as an honor and like to participate.

Persons without a high school degree were underrepresented in the weighted sample. When we come up with our weighted estimates, roughly 12 percent of the people had no fish consumption in the last year. Sixty-one percent of the people ate commercial fish only. About 18 percent said they ate non-Great Lakes sport fish only.

In our general population, when we took out the people who are sport fish eaters, we came up with an estimated consumption rate of 14.9 gpd for individuals eating commercial fish.

Those who were non-Great Lakes sport fish consumers ate more fish on average than their counterparts in the general population who ate commercial fish. Those who fished and ate fish out of the Great Lakes actually ate a greater amount. I think this confirms that anglers are an exposed group. Largely, they like fish, which may be partially why they're fishing, and they tend to eat their catch as well. But the general population is also now eating more fish than we have attributed to them in the past.

In the Great Lakes area a lot of people are eating sport fish from waters other than the Great Lakes. You can see in Minnesota with its 5,000-plus lakes, everybody has their own lake and they all eat their own fish from their own lake. So 54 percent had eaten sport fish, but a very small percentage had eaten fish from one of the Great Lakes.

Roughly 49 percent of those who had eaten Great Lakes fish in the prior year were aware of the advisory. Blacks and other minorities were less aware, although they had eaten the fish; females were about half as aware; the lower the level of education, the less likely they were to be aware; and the more fish they consumed, the greater the awareness, which is somewhat contradictory.

Roughly 58 percent of males were aware, females at 39 percent. The non-white population, again, relatively small, but only 22 percent of them were aware. Those with college degrees were roughly three times as likely to be aware as those with less than a high school education.

Cooking and cleaning was the advice followed the most. Again, females who were less aware tended to not follow the cooking and cleaning advice, where the males reported they were following the advice. You can see consumption frequency; about half of them were following that recommendation. Forty-three percent were impacted by fishing location issues.

Roughly half of the consumers were unaware. We took this same information and used the weighting schemes to come up with how many people are eating Great Lakes fish, an interesting number. Our estimate was roughly two- to three-fold as many people were eating fish as licenses were sold in the state. So, just as John Vena showed, people are giving their fish away, giving it to family members who are unlicensed. There are far more people consuming fish than just those who are licensed to catch them.

Racial minorities, women, and persons with no high school education are low awareness groups. Again, as John showed, we really need to focus on sending multiple messages that target low awareness groups and work on what message we want to send to them.

So we got together with the consortium to begin to address the issue of mercury. The Great Lakes advisory is a PCB advisory. When we talk about targeting cooking and cleaning, that's really a chlorinated issue. There's no relevance with regard to mercury. With mercury, we don't really care how you're cooking and cleaning them, so we have a mixed message of advice for mercury versus chlorinated compounds.

What we're going to do is focus on women of child-bearing age, 18 to 45 years old, who consume sport fish. We're going to work with focus groups in Maine and Wisconsin to help refine the questions and how we approach them. Then phase two, as I'll talk about in a minute, is to implement and evaluate some kind of pilot advisory.

In phase one, we will hopefully use the annual fish monitoring survey that goes out about the first of the year to get a sense of how much effort is going into promoting mercury advisories in various states, so we can evaluate different approaches and strategies in different states.

The other part of this phase is to do a telephone survey in about 20 states. At this point, we are hoping to use some of the information we collect to compare the types of advisories for mercury. There's the generic, across-the-board, one meal a week type of advisory like the ones in New York you heard about, versus those like Wisconsin has. In Wisconsin we have specific advice, page after page for every lake, every species, and for different sizes. What we want to know is, when it gets down to the person who is making a decision, does the advisory really work effectively? So we're going to be looking at advisory formats and different degrees and types of communication efforts, and then we want to look at different geographic areas.

Phase two hasn't been funded yet, but will get into implementing some of the phase one tasks and doing some interventions in Maine and Wisconsin. The whole intent is to use these as pilots, so that we can have some field-tested and evaluated interventions that are a little different than just putting out a brochure or including information in a license package.

In this survey, we're going to characterize patterns of fish consumption, estimate advisory awareness, and ask specific questions regarding awareness or understanding of the toxicity of mercury. Again, as I say, none of this has been finalized, so we'd really like to have you talk to us and share your questions or your experience with us.

Our goal at this point is to be in the field with this survey during the peak of the summer fishing season, August to October. Our target is to interview 2,000 to 4,000 women of child-bearing age.

Generally, a brochure is one of the poorest ways to get information out. There are other ways to distribute information that we may not be using effectively, like the media, newsprint, so we're hoping to get a sense of how that works.

Open Discussion

Mr. Jim Bedford, Michigan: I was just curious if, in doing these surveys, you ran into much apathy. We've studied advisory awareness, but in Michigan we find a lot of the sports anglers groups that seem to have a lot of pull with our state government are very apathetic about advisories and pooh-pooh it. They don't see any dead bodies, so there's not a problem. Did you see any of that in your surveys?

Dr. Anderson: I don't think we saw much of that. Again, we did not target the license holders. It's certainly possible that some of those who didn't participate—again, in our project with charter captains, there isn't a person who runs a business like that that doesn't have an answering machine on all the time. You leave a message, "This is your state health department. Call us back. We've got some questions we'd like to ask you," and the response rate often is not terribly good. So you have to try to get through. Certainly, the phone survey people with the caller ID sort of thing, there are some tricks one can use.

But usually we've found when we get with our survey folks, when they reach a person on the phone, they tend to participate quite well. Again, they don't really know that this is about the advisory. That information all comes at the end. It's more dietary issues and things like that.

Mr. Gary Ginsberg, Connecticut: First, I'd like to say that we would be happy to participate and see how we're doing in getting the word out relative to everybody else. One question regarding Southeast Asian immigrants. Are you going to try to make sure that you get a certain degree of representation in your random digit dialing or is it just going to be totally random?

Dr. Anderson: We have not decided at this point. The question is, in the relatively small sample size here, at least in our experience, and I think others' working with these minority communities, telephone interviews are not the best way to go. Our surveys are predominantly conducted in English. If you reach somebody who doesn't speak English, it's much more problematic to, first, identify what the language is, and then find an

interviewer with those language skills. So at this point, I don't think we're going to use this vehicle to target those groups. Certainly, that is a weakness and those of us with these specific populations ought to get together to talk about how we have approached them.

Participant: Do you participate in the behavioral risk factor survey?

Dr. Anderson: Yes.

Participant: And can you just incorporate some of these in there for the minority populations?

Dr. Anderson: Actually, that's a possibility. I know Andy Smith put a module into the behavioral risk factor survey on advisories. He will speak tomorrow. That is a potential vehicle to do this nationally. Just having had experience working with the group, every state is independent and unless you had a lot of money, and even with money these days, so many people want to use the behavioral risk factor survey, have a module to add to it, that we just thought going independent on the one-year timeframe we had was the line of least resistance.

Participant: What's the possibility of including a state with no advisories as some kind of an interesting control?

Dr. Anderson: I think there are only five. As I understand it, there are only five states that don't have some type of fish advisory in place. That could be done. I'm not sure what—other than how good are people at guessing or trying to assess on the phone. Are they saying, "Oh, yes, there must be. Since you're asking, there must be. Yes, I don't want to sound dumb, I'm aware." Then when you say specifics, they say, "Oh, you caught me."

We've actually found that the people, surprisingly, are very honest. It's all anonymous, it's on the phone and, if you get them to answer, they tend to do a pretty good job.

ALASKA COMPARATIVE DIETARY RISK STUDY

Dr. Grace Egeland
Formerly with the State of Alaska

I'd like to talk about some of the work in Alaska. The global distribution of pollutants through atmospheric transport is well-documented and what happens in the rest of the world has an impact on the Alaskan food chain. Volatile organochlorine compounds produced in temperate industrialized zones are known to be taken up into the atmosphere and transported to the Arctic where they're distilled by the cold temperatures and settle down into the Arctic environment.

In Alaska, we also have mercury issues related to both natural and anthropogenic sources. Rich cinnabar deposits and volcanic off-gassing are examples of natural sources of mercury. In addition, global distribution of mercury from industrial activities contribute to mercury in the environment where microorganisms methylate the mercury and it then bioaccumulates within the food chain. Exposures to trace metals and persistent organochlorines in the Arctic primarily occur through the subsistence diet which is integral to the overall health and well-being of indigenous peoples.

During the 10th International Congress on Circumpolar Health, elders that attended called for a balanced approach to evaluating the risks and weighing the benefits. Elders also suggested that the fear associated with contaminants may actually cause greater harm than the contaminants themselves. An Inuit woman, Rhoda Gray from Canada, came up to me and said, "You know, you use the term risk very differently from the way it's translated in the villages. Risk is translated in a phrase to mean walking on thin ice, imminent danger, impending doom or death."

As a scientist, we talk about risk, and we may be talking about a one in a million chance of something that is not as imminent and hazardous as falling through thin ice in the Arctic. So that really made me begin to talk more to people about risk communication. That's a top priority, because that's why we have problems with fish advisories. Instead of avoiding one particular fish or maybe a liver of a fish, the entire lake may be determined to be contaminated and unfit for subsistence, and so I think we have a lot to learn in this area.

In response to the elder's concern about risks and perspective, the title of our report is *The Use of Traditional Foods in a Healthy Diet: Risks and Perspective.* Risk assessment is a very valuable tool. RfDs developed from risk assessment are extremely useful for

regulatory purposes, and we want them to be set at levels of risk that are too small to observe. We want to be extra conservative and assume worst case scenarios so that the environment can be made as clean as possible, all in an effort to reduce emissions and regulate cleanup standards. At the same time, when exposures of concern coexist with nutrient exposures of known or potential health benefits, we need to look at a broader context. Available to most of us are choices. An advisory isn't going to have the profound effect on us that it will have on subsistence populations.

Marine mammals are excellent dietary sources of protein, omega-3 fatty acids, nutrients, and some selected antioxidants such as selenium and vitamin E. They are low in saturated fat, and we know that the omegas promote prenatal nutrition, infant growth, and development. The omegas, for the most part, have also been found to prevent cardiovascular disease, and there may be other potential benefits. There's a growing wealth of literature about the role of omegas in human health.

What is subsistence? Subsistence provides community and individual self-reliance. It's also a source of meaningful and productive work, especially in areas where wage-paying jobs are few. It provides social interaction and the social bonds that promote cohesive communities. It preserves cultural identity and allows grandparents to pass on the ways of the past to grandchildren. It provides physical activity which has physiological and psychological health benefits. Also, I'm told there's spiritual connection to psychological health and well-being as related to subsistence. Finally, in its entirety, it's a viable socioeconomic system. Decisions related to evaluating food safety, issuing advisories, or determining strategies for minimizing exposures need to occur within the context of a value system that supports subsistence.

Alaska Department of Fish and Game periodically collects data on what fish and wildlife are being consumed in Alaska. Fish is a food staple in Alaska. Other food sources include shellfish, caribou, moose, venison, and small game meats like ptarmigan.

A variety of plants in Alaska are consumed. There's wild rhubarb, fiddlehead ferns, sourdock, willow leaves, seaweeds, and berries. Even though the vegetation may be scarce compared to other places, it's full of nutrients. For example, 100 g of dried black or ribbon seaweed can provide nearly half of the recommended dietary allowance (RDA) for protein, over half of the iron needed by a female, all the iron needed by a male, 100 percent of the RDA for riboflavin, half of the RDA for niacin and vitamin A, and one-third of the RDA for ascorbic acid.

We looked a little bit at replacement costs. To ship food out to rural areas and make shopping trips into major cities can be an economic burden and, depending on the average income of the area, can actually require a sizeable percentage of the income. These

reasons—socioeconomic value, cultural identity—make subsistence a very important aspect of life in Alaska.

Among the fish species most commonly consumed in Alaska is salmon. It ranks the highest in an 11-community survey conducted by Dr. Nobmann with the Alaska Area Native Health Service. Of growing popularity in Alaska in dietary surveys is the consumption of beef or pork frankfurters. Compare the amount of calories in a three-ounce serving of king salmon to frankfurters. You get about twice the amount of protein with a king salmon serving as you do from the frankfurters, with half the fat. With ringed seal, a three-ounce serving of flesh provides a considerable amount of protein and iron, with much less fat than frankfurters.

Traditional foods tend to be very high in unsaturated fat as opposed to saturated fat. Corn oil, seal oil, and peanut butter all look similar in their unsaturated fatty acid profile. However, the unsaturated fatty acids are quite different. Corn oil comes from the omega-6 polyunsaturated fatty acid family. Seal oil consists of both monounsaturated fatty acids and omega-3. Peanut butter more or less contains monounsaturated fatty acids. So as dietary patterns shift as a result of acculturation and, sometimes, advisories, it's not just the benefits of the traditional foods that are being lost, but the increase in risk that's associated with the other foods that are being consumed.

In terms of looking at the polyunsaturated fatty acids, there are two essential fatty acid families, the alphalinolenic omega-3 family and the omega-6 linolenic acid, which comes from vegetable oils, like corn oil. Alphalinolenic—flax seed oil is a good example. Dark green leafy vegetables can also be a dietary source.

In the nutrition literature, we'll see more about the omega-3 and omega-6 ratios in our diet. The end products, the EPA and the DHA—these are the long chain omega-3s—and the arachidonic acid, lead to different metabolically active metabolites in our systems that have different effects. So, for example, arachidonic acid will lead to active metabolites that will have a vasoconstriction effect and also a blood aggretory or clumping effect, whereas EPA from the omega-3 family will lead to vasodilation and reduction in blood clotting.

These are just examples of how what's going on in us cellularly is affected by our dietary intake. Fish and marine mammals represent a direct dietary source of EPA and DHA, which you would otherwise need to get from certain green leafy vegetables and other seed oils which aren't commonly available because the shelf life of the alphalinolenics is quite poor. They're easily oxidized.

I'm not going to spend too much time on cardiovascular disease. Most studies show the protective effect of fish consumption. One good example is the Chicago Western Electric study, where 35 g of fish consumed per day was associated with a 42 percent reduction in risk of myocardial infarction deaths. Also, to bring the data a little bit closer to home, Louisiana State University did a study where they looked at adipose omega-3 fatty acids and how they were correlated with atherosclerotic lesions. They did find an association, as we would have expected.

I'd like to talk a little bit about NIDDM (diabetes). The etiology, as we know, is complex and multifactorial, just like many other chronic diseases, but there's data available that shows that a high saturated fat intake increases insulin resistance. There's a study in which they tracked Finnish and Dutch men over time and found a high saturated fat intake was related to insulin resistance. There's also very good animal literature.

What's not as consistent, though, is information on the omega-6 to omega-3 ratio in the diet, and also whether omega-3s in and of themselves are important. There are some data that show that they may improve insulin action. I think there needs to be more work done on this.

There also have been studies looking at skeletal and muscle phospholipids in the Pima Indians, and they found that polyunsaturated fatty acids in the phospholipids were related to an increased insulin sensitivity, which goes along and confirms some of the animal data. There was also a study done in Alaska of Natives of the Yukon and Kuskokwim. In this 15-village study of individuals living near the Yukon and Kuskokwim Rivers, a decrease in the risk of NIDDM and impaired glucose tolerance was observed in relation to daily seal oil and salmon consumption after controlling for age, ethnicity, body mass, and gender.

In Alaska we do have observable increases in diabetes in the population. In the past, the Alaska Natives had very low or rare events, and now, among the Inuit, or all the Eskimos combined, the rate is about eight cases per 1,000. Among the Aleut, the rate is higher. It's 24 to 27 per 1,000, and that represents about the same as what it is in the lower 48 states.

I'm not very certain about the role of fish in NIDDM, but the process of an advisory could relate to a whole range of changes in behavior and eating. For example, decreased subsistence might relate to decreased physical activity. If we're not exercising, we have different types of muscle fibers in our body and our muscle fibers respond to insulin differently. The more you exercise, the more you're going to respond to insulin. So it's an example of how an advisory might have an impact in a way we wouldn't foresee.

The point I want to drive home is the importance of keeping the food supply safe. There are not just risks associated with the pollutants, but also with taking the fish out of the diet.

I also want to talk about prenatal nutrition, infant growth, and development. I've heard people ask—is a population that benefits the same as a population at risk? I think if we look at prenatal mercury or PCB exposures, that's a valid question. If it's only beneficial in terms of cardiovascular disease, we'd be telling older people to eat the fish and maybe the pregnant women not to, but in the arena of prenatal nutrition, there's an entire and vastly growing area related to fatty acid composition and infant growth and development.

Seventy percent of our brain cells are formed prior to birth, and a large component of the lipids in our brains consist of DHA, which is omega-3. DHA is present in large amounts in the brain, nerve synapses, and retina. The third trimester is very important for neuro and vascular growth where large amounts of DHA and arachidonic acid are being mobilized to the fetus.

Also, there are data indicating that omega-6s and omega-3s are needed for optimal development of the brain, retina, visual cortex, and motor skills. Some of this data comes from premature infant formula studies where premature babies are fed a standard infant formula and an experimental group is fed another formula with DHA and arachidonic acid. They observed beneficial effects on vision and cognitive testing in the experimental group.

There have been some fish oil supplementation trials. In Denmark, 40 percent of the population reports no fish intake. So they did a fish oil supplementation trial during pregnancy, the third trimester, and they found that fish oil supplementation was related to increased gestational age and birth weight. They also observed decreases in pregnancy-induced hypertension, but they were not statistically significant. The sample size was relatively small.

Also, the Mayo Clinic looked at the fatty acid profiles of pregnant and lactating women and compared them to those of nonpregnant, nonlactating women. They found that during pregnancy and lactation women have 57 percent of the normal values for the sum of omega-3s, and 35 percent of the normal value for DHA postpartum. So there are nutritionists out there that are saying that women should eat more fish during pregnancy to help supply the demands of the developing fetus.

Basically, there's been very little fish monitoring data done in Alaska. We have more marine mammal monitoring data. Basically, marine mammals have the ability to demethylate mercury, and so what we'll find is the liver will have pretty high levels of

total mercury, but it's inorganic for the most part and it's readily excreted. In fish, however, the majority of the mercury is methylmercury and it's readily absorbed.

All the data I've seen on marine mammals, when there's methylmercury data available, have fallen below the FDA tolerance level of 1 ppm, but if you looked at total mercury, you'd actually find some pretty high levels.

There have been some hair monitoring studies done in Alaska in the past in which they found hair mercury concentrations comparable to the World Health Organization (WHO) guidelines of about 5 ppm. More recently, in Nome, because of concern about past, current, and future mining activities, a large-scale study was done. Given the amount of fish consumed, they were expecting much higher mercury concentrations in the hair and were surprised when they results came back at 1 ppm. They went back and selected 80 women, 50 of whom were self-reported heavy consumers of traditional foods. Again, the data came back with very low hair mercury concentrations. The USEPA guidelines would relate to about a 1 or 1.2 ppm hair mercury concentration.

There are also risks associated with restrictive fish consumption advisories. Obviously, there are times when risk assessment advisories are needed, as we've heard today, but there's health risk associated with alternative foods; there's loss of nutritional and health benefits associated with fish consumption; there's negative overall health implications of dietary and lifestyle changes in subsistence populations; there's a high cost associated with replacement foods; and then we also have to consider the social, economic, and health ramifications of the breakdown of subsistence.

RfDs and provisional tolerable weekly intakes by WHO are very useful guideposts and they should be used within a larger context, a broad, multidisciplinary, public health context. I think we all specialize so much that we need to be talking to each other, and to as many experts as we can in a variety of fields, when developing complex nutritional advisories. Also, this needs to be done within the context of the value of subsistence, and there's no one that can better support that than the indigenous peoples, so indigenous involvement and leadership is crucial.

Open Discussion

Dr. Dourson: Did you do any chemical analysis of the salmon when you did the comparison to frankfurters? And did you do any chemical contamination analysis of the frankfurters?

Dr. Egeland: No. What I did is I got on the World Wide Web. The U.S. Department of Agriculture has a site and you can plug in any kind of food you want and it'll tell you

what's in it. But, in terms of contaminants, I didn't see it in the U.S. Department of Agriculture database, so it's just nutritional value. In terms of the king salmon, there's been one study on salmon, only 16 fish, done by FDA. The mercury levels are very low and comparable to what is in the USEPA guidance document showing 0.05 ppm total mercury. Salmon is the leading fish consumed, so that's good news.

Dr. Andrew Smith, Maine Bureau of Health: In looking at the epidemiological data and health benefits, do you have a sense of whether or not there's a clear dose-response in terms of benefits once you start getting above a meal a week? In our limited review of it, there seemed to be a pretty clear benefit of going from no fish consumption up to low or moderate levels of consumption, but then it starts to become rather ambiguous. After you get above a meal a week, are there really additional benefits? If you could comment on that, I'd greatly appreciate it.

Dr. Egeland: I'll briefly say that there's a yin and a yang in that consuming too much omega can relate to prolonged bleeding and other potential adverse effects. I would say that probably the majority of people in our American society could benefit from increased fish consumption.

I would say that your question is right on target and that the information isn't really there right now. We do know that at very high levels there are effects—prolonged bleeding, immunosuppression—which can actually be beneficial if you're looking at certain types of arthritis, for example, but can also be detrimental. So there's always this balance that needs to be taken into account.

I didn't see much in terms of the prenatal nutrition literature about a guideline for how much a pregnant woman needs. I think the cardiovascular literature is the best characterized. I think the NIDDM area is poorly characterized right now.

GREAT LAKES FISH EATERS PROJECT: DIETARY SURVEY AND ASSESSMENT OF POTENTIAL HEALTH RISKS AND BENEFITS

Dr. Judy Sheeshka
University of Guelph

In our first study we're measuring fishing activity and, within this context, we're collecting data about the family, community, and culture, as well as about regulatory fishing guidelines. So we're asking people if, for example, they are aware of the Ontario guide to eating sport fish, and how they might use that guide.

Our second study focuses more specifically on people who report eating large amounts of fish from the Great Lakes Areas of Concern. In particular, we're interested in finding out from them how they make their decisions about the species they'll eat; the size of fish they'll keep—do they keep the large ones or throw them back; where they fish; the way they prepare the fish; and the parts of the fish they eat. We have lots of data, for example, that shows different cultural groups eat very different parts of the fish, not just the boneless, skinless fillet.

We're then trying to put both fishing activity and eating behaviors in the context of a very broad health perspective. At the level of social health, for example, we know one of the benefits for people who fish is the opportunity for family closeness and for friendships that are built along the shoreline. One of the risks, they tell us, is that if you eat your catch, you suffer a certain social stigma and you have to put up with people constantly telling you that you're nuts to eat fish out of the Great Lakes.

At the level of environmental health, there are lots of potential benefits associated with the use of a common resource because it provides opportunities for education and conservation activities. At the same time, we all know that there's also the potential for depletion of this resource and that's an environmental concern.

At the level of psychological well-being, people unanimously tell us that they fish for fun and for pleasure, and that if you're an avid fisherman, you also get satisfaction from developing a highly honed set of skills. But at the same time, your psychological well-being may suffer if you eat your fish and have to worry about what the possible effects of that might be on the health of you and your family.

We began our first study of fishing activity in 1995 and now we have data from the spring, summer, and fall fishing seasons in five Areas of Concern. The objectives of our study are to document the level of consumption of fish and wildlife, looking at parts eaten; document the use of advisories; and characterize eaters and noneaters to see what differences these two groups may have.

We used a combination of quantitative and qualitative research methods. We hired university students, and trained them to go out along the shoreline and talk to every person they encountered fishing. They not only talked to these people, they administered 10-page questionnaires. They did this in five different languages—English, Mandarin, Cantonese, Vietnamese, Polish, and Hungarian. Our survey focused on five areas: the metro Toronto Area of Concern, Hamilton Harbor, Niagara Falls region, the Detroit River Area of Concern, and the St. Clair Area of Concern.

For a subset of participants, after we administered the 10-page questionnaire on the shore, we asked them if they would mind if we tape recorded a conversation with them. This conversation lasted anywhere from 15 to 60 minutes, depending on how much people wanted to tell us. The focus of the interview was on their perceptions of health, the environment, and fishing and the connections among them.

These tape recorded interviews broadened our investigation of risks and benefits to include attitudes, opinions, and behaviors offered from an insider or fisher's perspective. Through the words of the fishers, we have been able to understand more of the social and cultural benefits of fishing and eating fish, which for many is an important part of the experience.

Fishers were eligible to participate if they were of age 14 or older, and if we hadn't interviewed them before. As we were doing this over a three-year period, we had a tendency to hit the same people over and over again. In total, we had 5,600 fishers that we contacted over the three years along the shoreline, and 83 percent of these people were eligible and agreed to participate in our study. We have 4,637 completed questionnaires so far. The major reason for nonparticipation was an inability to find a common language.

Participants' education ranged from no formal education to multiple university degrees. Their income ranged from below $15,000 a year to over $60,000 a year, and household size from one person to 15. I can't underscore enough that this clearly says there's no typical fisher along the shoreline.

Our qualitative analysis demonstrated that fishing offers older individuals productive, challenging, and social outdoor activity at a time when many retired people are feeling

unproductive and isolated. Others, who were on disability allowance or looking for employment, told us that fishing "keeps me from going insane" or "gets me out of the house" and is "better than watching TV all day long." Fishing is preventive medicine, a proactive way to cope with life's stresses.

On average, 51 percent of the fishers released all of their catch, 41 percent ate some or all of it, 20 percent gave some away, and 1 percent admitted to selling their catch. People fished primarily for fun, pleasure, an opportunity to be with nature, and to spend time with family and friends.

The fishers who did not eat their catch were more likely to be male, younger, single, better educated, and have higher incomes. They fished less and they gave less fish away to others. When we asked those people who didn't eat their fish what concerns they had and why they didn't eat their fish, about half of them said they had concerns related to pollution of the water or contamination of the fish.

So focusing now on those people who ate their catch, we categorized them according to their level of consumption. Fifty-two percent ate between one and 11 meals of Great Lakes fish from these specific contaminant hot spots during the previous year. They may have eaten much more fish than that from other Areas of Concern, but we were just asking them about the area in which we interviewed them. Twenty-two percent ate between 12 and 25 meals per year, and we called them moderate consumers. Twenty-one percent ate 26 to 95 meals per year, and we classified them as high consumers.

We had 6 percent of our sample who ate anywhere from 96 to over 1,000 meals per year of Great Lakes fish from the particular Area of Concern where we interviewed them. The very high consumers were likely to be older, have less education, and less income.

We asked eaters, "What do you like about the fish you eat from around here?" Two-thirds of them reported that the fish tastes good. That's the primary motivation for eating the fish where they do. Eaters value the fish they catch because it's fresh, they know the source, and they can inspect it themselves for tumors, worms, or other abnormalities.

There are two types of consumers of Great Lakes fish. There are those people who catch their own fish and those who receive fish from others. For example, we interviewed one participant who reported eating 66 meals of fish from Hamilton Harbor and the Niagara River, two very highly contaminated areas, during the previous year. This person doesn't fish at all, so fish is widely distributed.

Overall, of those people who eat their catch, most of them share it with their immediate families and, over and above that, 29 percent give it away to people outside their families.

This includes other fishers along the shoreline, as well as friends and neighbors. Remarks by fishers convey not only the extent of this sharing, but also the satisfaction of giving, particularly to those less fortunate. Sharing fish becomes a means of taking care of each other and a reciprocal act of friendship, particularly along the shoreline. The following quote demonstrates this generosity. "A lot of fish I catch, I give away to people that really need it, like my neighbors downstairs. They're going through a rough time with their jobs and money."

It was the rare fisher who admitted that fishing helps out with the grocery bill. Once the subject was raised, most people we interviewed started tabulating the costs of the gas, lines, lures, coffee, cigarettes if they smoked, and their initial investment in the equipment, and almost unanimously agreed that buying fish was cheaper. And they were very adamant about this point.

Some fishers do, however, admit that if they didn't catch their own fish, they likely wouldn't eat so much. Market and grocery store fish is considered to be markedly inferior, particularly with respect to freshness. This appears to be most important to Asian-Canadian fishers. For these interviewees, having fish that is fresh is of paramount importance, and they spend much time in interviews talking about how frustrating it is shopping in Canada, where the fish comes mainly frozen or processed. Thus, to give away extra fish is to insure that it's eaten at its very best and not wasted.

Eaters also mentioned the health benefits—for example, that fish is low in fat or is better for you than red meat—sometimes noting that this depends on how they cook it and whether or not it came from contaminated waters to start with.

For some people, eating locally-caught fish offers continuity with family or community traditions. These fishers find it difficult to articulate why they eat their catch because it's such a natural part of their life.

We asked those who eat their catch, "Do you have any concerns about the fish you catch around here?" About half of them said yes. It's interesting to note that those who eat their catch and those who do not eat their catch both have exactly the same concerns about contaminated water, contaminated fish, tumors or deformities that they notice on fish, and dwindling fish stocks. So there's no difference between the concerns of people who eat the fish and the concern of those who don't.

The people that eat their fish are people who take pride in hosting family fish fries, who have developed mouth-watering recipes for carp, and who have been told by their doctors to eat more fish because it's good for them and it's low in fat. These are the people who described eating smelt from the Niagara River by saying, "It's like eating candy."

Eaters felt they needed to defend their enjoyment of their catch against criticisms of potential harm. Many spoke of the risks incurred from pesticides, herbicides, hormones added to livestock and poultry, from their own smoking habits, and from driving a car. They saw fish consumption as merely one risk in many that they're exposed to daily. Most of them were not unaware of the contaminant risks associated with eating the fish that they were eating, but instead, they make their judgments about eating fish in the context of these other risks in their lives. For them, the benefits outweigh the risks.

Our second study focuses specifically on those people identified as high consumers of fish. We've recruited them along the shoreline and then asked them if they would be interested in having their diet and blood analyzed, and if they'd participate in this second study. We've also done extra community recruitment in the Toronto and Hamilton Vietnamese communities, because we've identified these groups as high consumers of Great Lakes fish. Currently, we have 80 subjects recruited, 26 of whom are Vietnamese Canadians, five Chinese Canadians, and we're hoping to continue our recruitment in the next couple of years, because the sample size is still rather small.

We use three questionnaires to collect information on fish consumption; parts eaten; preparation and cooking methods; perceptions of risks; food security, which has to do with the likelihood you would run out of food, for example, and experience food shortages, or the likelihood you would have to obtain food from nonsocially desirable sources, like a food bank; health and reproductive history; and demographics. The questionnaires are administered during three home visits by a trained dietician. The dietician also collects three recalls of foods eaten during the previous 24 hours to enable us to have an estimate of a person's usual diet.

Fasting blood samples are taken for the analysis of PCBs; selected organochlorine pesticides; mercury; lead; lipids, including omega-3 fatty acids; serum ferritin, which is blood level of iron; hemoglobin; and white blood cells.

A tape recorded long interview is also conducted in the home, and this time it focuses simply on fish preparation, fish consumption practices, and risks and benefits tradeoffs. We provide a fourth home visit to all participants to give them the results of their diet and blood analyses, and to provide some guidance on consumption, if that's warranted.

Results from the first 32 participants in our study, 16 of whom we classified as Euro-Canadian because of their backgrounds and 16 we grouped together as Vietnamese/ Chinese because they were Asian immigrants to our country, showed marked differences in socioeconomic profiles. Participants in the Vietnamese/Chinese group included 38 percent who had only primary level education and, with one exception, these were all female. Ninety-four percent of them had incomes less than $30,000 and, in Canada, if

you have a family, you're probably approaching the low income cutoff at $30,000. So this group was very different in sociodemographic characteristics than our Euro-Canadian group.

The Euro-Canadian group had an average intake of 60 meals of Great Lakes fish during the past year, compared to an average of 44 for the Vietnamese/Chinese group. However, the Vietnamese/Chinese group ate five times more inland sport fish from other sources and twice as much processed or frozen purchased fish. So clearly, they are very high consumers of fish overall.

They eat different species, though. The species eaten most by Euro-Canadians were yellow perch, smallmouth bass, chinook salmon, walleye, and rainbow trout. In contrast, among the Vietnamese/Chinese group, rock bass, white bass, freshwater drum, brown bullhead, rainbow smelt, and rainbow trout were the most popular Great Lakes species.

Striking differences in the amounts of their fish meals have undoubtedly contributed to the different dietary profiles we see in these groups. Preliminary results suggest that the Vietnamese/Chinese group are much more likely to meet the Canadian recommendations for healthy diets. Their diets are much more likely to contain 50 to 55 percent of their calories from carbohydrates, 30 percent or less of their calories from fat, and between 15 and 20 percent of their calories from protein, which is the goal for the whole population. I guess I must stress that this isn't due solely to eating fish, but rather it's the whole nature of their diet being rice-based and carbohydrate-based, as compared to other, Caucasian practices. However, both groups were at risk for selected nutrients, such as iron and calcium, and this was particularly true of the women in the groups.

Both the Euro-Canadian and the Vietnamese/Chinese groups had participants with higher than normal levels of the bad cholesterol, the LDL cholesterol, signifying that they had greater risk for cardiovascular disease. Omega-3 fatty acid ratios, which, as Grace explained, are a very positive kind of lipid in our diet, were clearly higher among the Vietnamese/Chinese group than among the Euro-Canadians. The next step in our analyses will be to examine these ratios and relate them to total reported fish consumption.

Persistent organochlorine levels were similar for both groups, with three exceptions. Levels of mirex, beta hexachlorocyclohexane (HCH), and metabolites of DDT were considerably higher among the Vietnamese/Chinese than among the Euro-Canadians. The mirex levels may reflect more fish eaten from the Niagara River and Lake Ontario, while the other two may reflect residues in foods imported from Vietnam. One aspect of our study we clearly need to follow up on is foods that are imported from outside of Canada, and try to obtain some data on them.

Similarly, arithmetic mean levels were higher for both inorganic and organic mercury in the Vietnamese/Chinese group. We had one Vietnamese woman of reproductive age above our provisional guideline of 10 μg/L, and one Chinese man above the guideline of 20 μg/L. Sources of inorganic mercury were not immediately apparent when we did an occupational exposure questionnaire with people, but the higher intakes of fish from the inland lakes may account for the higher levels of organic mercury observed in the Vietnamese/Chinese group. This group had five times as many fish meals from inland lakes as the other group did.

In conclusion, I feel that we've been successful in documenting the broad range of perspectives there are about how fishing and eating fish relate to health. We've also found some contaminant levels that are of concern, but in only a few of our eaters so far. We obviously need to collect further data to be able to quantitatively estimate the contaminant-related risks and the nutrition-related benefits and the tradeoff between the two.

Open Discussion

Mr. Spencer Garrett, National Marine Fisheries Service: Did you take fasting blood samples of those individuals who ate 1,000 meals per year?

Dr. Sheeshka: No. We actually have quite a difficult time recruiting people into our eaters study, because many of the people who have high levels of consumption also have strong cultural beliefs about giving blood. Some of those may be outlier values, and we verified that value, the 1,000 meals per year, but we've not been able to take blood samples from individuals like that. We also had many people reporting levels between 400 and 600 meals of Great Lakes fish per year.

ARCTIC MONITORING AND ASSESSMENT PROGRAM

Dr. James Berner
Alaska Native Health Service

I've been asked to summarize the data from the Arctic Monitoring and Assessment Program—the AMAP report. The AMAP is one program in a treaty that the United States has signed along with the other eight Arctic nations that have indigenous populations and make up the Arctic Council. The AMAP was designed and charged with the mission in 1991 to take a look at how geophysical, oceanographic, climatological, biological, and human health factors relate to levels of contaminants in the Arctic.

First, it's important to know that this is truly an international effort. The U.S. has contributed some, but not a lot of data to this, and has contributed no human health data to the AMAP report.

When looking at the North Pole, there's a ridge in the ocean that sort of separates this basin from the rest of the Arctic circulation; keep that in mind. These are shallow oceans and the circulation of both wind and water is key to understanding how the contaminants that were looked at in the AMAP phase one report are transported in and out of the Arctic.

You need to understand that my perspective on this is one of child health. It's my responsibility to develop a reasonable public health strategy for Alaska Natives that deals with the issues that the AMAP report has uncovered and plots a reasonable approach to the future. It's a key issue with me to keep Alaska Natives able to eat their subsistence diet. That's very important. It couldn't even economically be replaced.

The predominant input of water is from river systems on the Russian land mass. That's fairly important to remember, because we haven't got a clue what's coming out of most of these rivers.

With regard to surface and subsurface ocean currents, there's a fair amount of water that's Atlantic surface and intermediate layer water entering up between Greenland and Scandinavia. The surface water and subsurface water circulate in opposite directions. This is called the Beaufort Gyre. Its action mixes, blends, and then redistributes the pollutants that enter the Arctic Ocean through the air and the water, so that eventually it's not unreasonable to assume that something coming in here isn't going to eventually find its way throughout the Arctic Basin.

Wind currents also influence pollutant distribution, especially from the Kola Peninsula of Russia, which is one of the most famous airborne polluting sites on the planet. It sends a plume of pollutant debris into the Arctic, borne by the prevailing winds. The surface winds are affected to some degree; they're influenced by water and land mass, in that there's a major influx of wind through the Bering Strait off the continental Russian land mass, and again up through these straits between Greenland and Scandinavia.

The AMAP air monitoring program has taken a look at the origin of the pollutants that it samples at these three stations, and incidentally, more stations are being installed. There's a mercury monitoring station that's going in at Barrow shortly. Many PCBs and HCH, which was one of the compounds that was in the talk just before this one, originate not from this point source, but actually from a large area here in Russia. PCBs, incidentally, are still being produced in Russia, and in India, so we aren't out of the woods yet with respect to PCBs. Because the Arctic is cold, it acts as a sink, and pollutant delivery is faster than pollutant removal, which is another one of the big issues.

Again, from Europe there's a fair influx of airborne pollutants. Fairly clean air comes in through the Bering Strait, and the Bering Sea itself is relatively clean compared to some other areas.

A serious effort was made to estimate whether contaminants were entering or leaving the Arctic faster. Egress is about twice as fast as ingress, mostly in water, but to some extent in atmospheric input from Russia. For that reason, you would think we're in pretty decent shape, with removal going along pretty nicely through volatilization and movement of surface ice and water currents, and ingress apparently at a level that's easily countered by egress.

However, HCH in the surface waters of the Arctic Ocean and the other surfaces of the Pacific indicates that there's a gradient from south to north. If it's being removed in such an efficient fashion, it makes you wonder why that's the case.

I think the answer comes from the Russian river systems; they represent a gross underestimate of what's really coming in. We have nothing except a few scattered Russian reports of what's coming in from their industry and petroleum refineries from the Russian land mass down the great Russian river systems that drain into the Arctic Basin.

To sum up what the AMAP report says, "Measurements of hydrocarbon in fish tissue show that fish from the southern Beaufort Sea are more contaminated than fish from the northeast Pacific Ocean," which is considered a clean environment. "The concentrations of hydrocarbons are similar to those in fish from Atlantic waters. Other biota from Alaska also show indications of some contamination with petroleum hydrocarbons."

This is a quote from the report, and it goes on to call this "marginal contamination." I would certainly have to agree with that. I think that's probably an accurate description of it at this point. It's there to find. The water's clearly got HCH in it. So does the sediment. HCH here is sort of a marker for the movement of other structurally similar compounds.

Now, a look at subsistence food consumption levels in Alaska. People from southwestern Alaska on the Yukon-Kuskokwim Delta consume about 220 kilos of fish a year, marine mammals to a lesser extent, and terrestrial mammals a little less than that. In Barrow, marine mammals are in fact the major contributor to the subsistence diet. The diet there is about 220 or 230 kilos per person per year, so about 600 to 800 gpd of subsistence food. The Barrow residents on the North Slope consume bowhead whale, walrus, bearded seal, and ringed seal; they also consume polar bear, caribou, moose, whitefish, freshwater fish mostly, and a little bit of salmon, though not nearly as much as in southwestern Alaska.

That, in my view, makes the quality of subsistence food my key public health responsibility. Subsistence foods are critical, culturally, traditionally, and from a health standpoint, for Alaska Natives. Now, I think, we can't ignore the fact that there's major exposure going on here, and a certain amount of planning needs to take place to make sure that the food supply remains safe and Alaska Natives remain safe with it.

Now, I think, the human health recommendations from AMAP nicely reflect a balance between concerns for what's in the subsistence diet and the benefits of the subsistence diet. "Weighing the well-known benefits of breast milk and traditional food against the suspected, but not yet fully understood effects of contaminants, it is recommended that consumption of traditional foods continue, with recognition that there is a need for dietary advice to Arctic peoples, so they can make informed choices concerning the foods they eat. Second, breast feeding should be continued and promoted." I agree 100 percent with those two recommendations.

We've now come to a spot in the AMAP process where we have to carefully examine what's been found and plan the next step. One of the toughest areas in science is teratology, proving that something has an adverse effect on an unborn child. If that was an easy process, none of this would be so difficult, but humans in the fetal stage of their development are clearly at the most sensitive stage of life. They're our sentinel species, and they can suffer devastating effects from things that don't affect adults at all.

We've all had a heads up with that with thalidomide and congenital rubella infections. Rubella's hardly noticeable in an adult woman, but it's devastating to a fetus. But it's not devastating to all fetuses to the same degree, so there's a degree of resistance in humans

that spans a full spectrum. So it's hard to say, at any given level, that a compound is going to have a given effect on a particular baby.

Bioavailability for most of these compounds we're concerned about—there are a few exceptions, like methylmercury—is a guess. We don't know how much of these things we regularly absorb when we eat foods that have them in it. If we absorb a lot, there may be more of an effect. If we don't absorb as much of it, that may make that particular foodstock perfectly safe.

So from my perspective, we're going to be monitoring cord blood, umbilical cord blood, and maternal blood in Alaska. We're going to do it in a fashion that takes a sample cohort each year from each of our coastal hospitals, our small coastal facilities, and looks at cord blood and maternal blood. Over time, that's going to give us some useful trend data.

The other thing that needs to be done, that I think sometimes isn't done very well or is perhaps reported for the sensational value of the claims, is connecting contaminant levels with known outcomes in infants and children. I think that is a very risky business. It took us years to determine that alcohol was bad for a developing fetus, but finally it's been shown. I think it's going to take us a lot longer, because the effect is not nearly as profound, to say that these compounds have a distinct effect that is separable from the other things that we know affect developing fetuses, like intellectual level of the parents, alcohol, or cigarette smoking.

A variety of things can affect a developing fetus and cause developmental delay; mild developmental delay, or a few IQ points difference in a population, is a very, very soft outcome to ascribe to a single compound. We rarely find these compounds in humans in single doses. They're always mixtures. We know very little about mixture toxicology. Almost nothing's been done to look at that. I think the key to understanding some of these things a little better is going to be in mixture toxicology and in studying long-term effects on children exposed at the levels which we're seeing now, which are reasonably low, to see if any association to health effects can in fact be made.

Open Discussion

Participant: Where does your funding come from and is your funding enough?

Dr. Berner: In fact, USEPA's Office of International Programs is, I think right now, from the human health and environment standpoint, the lead agency in the AMAP process. They have become interested in helping us look at contaminant issues in Alaska Native infants. They were supportive of the child health approach to this. I frankly told

them that I thought a one-time look is not too useful, I think you need to follow this over time with trends, and that's the only way you can make sense out of it, and they've agreed with that. So I think starting in this next year, we'll begin a systematic sampling of maybe 20 percent of the birth cohort at each of four coastal facilities in Alaska. We will see what that shows.

Dr. Dourson: One of the conclusions of the AMAP program, as you read it, looked like a comparative risk kind of conclusion, where you've looked at the levels of contaminants in various fish and other food sources, and then you've looked at the benefits, perhaps, of the food sources to human health and socioeconomic or other cultural aspects, and you've decided or maybe made a judgment in favor of continuing the traditional foodstuffs. Was that a quantitative analysis or was it more judgmental, and what is AMAP going to do in the future with that kind of comparison?

Dr. Berner: Well, you're right. It was a judgment. It was a public health judgment, and it was not based on any given set of guidelines, because, in fact, the sampling process for animal species—I didn't touch on that, but it's a hit and miss proposition. It's difficult to tell, in an animal you've sampled, where that animal's fed, for one thing, and the migratory patterns of others like it. So it's hard to say if the projection you make from the consumption exposure you determine from a given animal specimen is valid on the very next animal that a village takes. So that's all a guess, and because of the nature of the guess and the degree of uncertainty in exposure and the levels in cord blood, which in fact is pretty hard data, it was felt that there was no justification to tell people stop their subsistence diets. As you can see, to replace 600 pounds a year of subsistence food in Barrow would be economically impossible anyway.

COMPARATIVE DIETARY RISK FRAMEWORK

Dr. Mike Dourson
Toxicology Excellence for Risk Assessment

This presentation is on a project called Comparative Dietary Risk. It's funded through a cooperative agreement between USEPA and Toxicology Excellence for Risk Assessment. The project actually got underway this summer, and what I'd like to do is give you an overview of the project, and then, as we do this, ask for your help in completing it.

The project goals are to increase knowledge of comparative risks posed by dietary changes made as a result of fish consumption advisories; to construct a conceptual framework of the potential health risks and benefits of consuming fish, specifically the potential health outcomes of not consuming fish, and the health risks from consuming chemically contaminated fish; and to show the impact of fish consumption advisories on individuals' and communities' diets, health, and lifestyles.

Well, who could use the results? We anticipate that tribal and state officials deciding whether and how to use fish consumption advisories might be one group, but also individuals that are seeking to manage their personal risks. We see this developing project as a tool to use with local data and conditions. It's not necessarily a description of national risks and benefits.

Goals of the project include creating a series of scientific publications, producing a comprehensive document of the work, and providing a framework to be used by local decisionmakers on a site-specific basis. The project research team is represented by the disciplines of anthropology, toxicology, public health, nutrition, risk assessment, communication, science policy, and comparative risk.

Our project approach has four stages. Data collection and evaluation is where we are now. Afterwards, we plan to get the research team together and draft a conceptual framework. We're then going to test and evaluate the framework using specific locations. Then we're going to have a review workshop and produce a final document.

Throughout this whole process we're going to post information to our advisory group, invite them to participate in conference calls, and keep everybody informed through electronic mail about where we are in particular stages.

What I'd like to do for the balance of the talk is go through and describe the first stage in more detail, the data collection and evaluation stage. There are three ways we're approaching this. We're going to look at what kinds of information are needed to assess the risks and benefits. There are several publications that talk about comparative risks. The principle one that we're using is by Grahm and Wiener, *Risk Versus Risk.* We're also going to talk about target risk, the risk from the chemicals in the fish flesh—the contaminants, I should say. And then we'll look at the countervailing risks and benefits. A decision not to eat the fish will have countervailing dietary risks, but there's also a nondietary, cultural aspect to changing over from fishing or eating fish to not eating fish. We're going to look at both dietary and nondietary risks.

We spent some time, as a research and advisory group, trying to figure out what areas of data we need to collect. As a toxicologist, it seemed pretty easy to me to say, well, we need toxicity of chemical constituents. That was my narrow focus and that seemed reasonable, but of course, there are other areas, such as nutritional and chemical content of different protein sources; characteristics of the different types of fish; the effect of population characteristics on measures of exposure, which would be not only dietary risks, but nondietary risks; and then finally, the one I was more familiar with, toxicity of chemical constitutients.

A comparison of nutritional and chemical content of different protein sources would be useful. You go through different protein sources, and ask, well, how much omega-3 fatty acid is in chicken? Or how much cholesterol is in beef? Or what types of dioxin might you find in pork? Those are the kinds of questions that the research team is trying to answer. We are going to look at different protein sources, such as beef, chicken, pork, vegetable diets, and maybe a diet without protein. We want to look not only at vitamins, minerals, and calories, but also at the chemical contaminants in each of those protein sources.

The chemical contaminants that we are focusing on initially are dioxins, PCBs, methylmercury, and a DDT/DDE series. We are seeking input on other chemicals to use in this initial screen. With this initial screen, we plan to build some case studies and develop the framework, so if you in the audience have your favorite chemical or one that you think should be in this initial screen, we'll take comment on it.

We are going to use national food supply data to get information on different protein sources. Obviously, for noncommercial fish, we're going to be gathering information from specific sites to use as a comparison.

There are different characteristics of fish to use for comparison—the fatty omega-3s, the percent of body fat, the feeding behavior, and other aspects of the particular species are

important. We're not sure how they all interrelate yet. At this stage, we're still gathering data, and synthesizing how these all relate will be a different phase, hopefully not too much later.

Population characteristics include cultural factors, some of which we heard about today; socioeconomic considerations, like the economic hardship of replacing 200 kg of subsistence food per year; location; previous or current chemical exposures; source and types of fish consumed; consumption rate; preparation and cooking methods; and what foods fish are replacing. We're going to gather data in all these areas.

The research team has developed a series of 20 worksheets to gather this data. How all this data comes in—it might be very quantitative, it might only be qualitative—and how this integrates is still an area that—a month or two down the road we're going to actually try to build a conceptual framework that fits a lot of this data in.

Toxicity or benefit of chemicals by fish species—this is an area that I'm more familiar with. There's going to be a series of questions asked for each particular contaminant, and then for each particular species in the examples that we'll be using. So we're asking is the toxicity immediate or delayed? Is it a reduced birthweight, which is a rather immediate effect, maybe a developmental effect, or a delayed type of effect, such as cancer. The magnitude and severity of the effects are something that toxicologists have made some judgments on, which are different than the perceived severity and acceptability that other scientists can bring to the table.

The probability of outcome—one of the decisions, at least initially, is to focus on not only the mean, let's say, the upper limit lifetime cancer risk, but also the median risk. For the benefits, we're looking at the relative risk and the upper 95 percent confidence limit.

For noncancer toxicity, we're looking not only for the RfD, but for some measure of risk above RfD. That problem has cropped up in USEPA program offices. In the Office of Water, it's called the unreasonable risk to health. In the Office of Pesticide Programs, it's called RfD exceeders. No doubt other people have other terms for it. EPA's published some models to actually capture a sense of risk above RfD.

We're going to try to pattern the uncertainty in risk with upper confidence limits or some measure of confidence in the overall assessment. USEPA provides confidence levels with RfDs, and they give a sense of confidence with all their cancer potency estimates as well.

We are also going to, as we fill out this set of data tables, look for specific species of fish to initially focus on. We have some ideas of different fish species to use, but again, that's

another area where we could get your opinions, on what types of fish to focus on, largemouth bass or whatever, because this type of data gathering is occurring right now.

Now, if you look at some of the early publications on comparative risk, there have been some conceptual models published. The one published several years ago by Paul Anderson, who is one of our research team members, talked in terms of the decrease in cardiovascular disease as you ate more and more fish, and a concurrent increase in cancer, hypothetical cancer risks. So that's one conceptual framework that people have at least seen published, yet there might be other conceptual frameworks here.

However, there are other, nondietary risks that may not be easy to quantitate, such as the loss of cultural diversity as people remove a particular food source from the way they live. Getting a handle on that type of risk and quantifying it is an area for active discussion among our research team, our advisory group, and others in the audience who may have some insight on that. So, weighing the target and countervailing risks and benefits is easy with some and not easy with others.

Then if we could quantify, somehow get a scale, to do this comparison, that would be very useful. The research team hasn't had any bright insights yet, but I'm sure, as we collect more data, we'll get closer to that.

Finally, are data needed for the proposed approach available? After getting a lot of data, we may not find this kind of information available.

Well, after we develop the conceptual model, which we anticipate starting now and continuing into next year, we hope to test and evaluate the model. To do that, we're going to focus on specific sites. We're going to look at indigenous consumption of largemouth bass in the Everglades, because one of our research team members is down there studying largemouth bass and methylmercury exposure. That might be one example of a particular site we focus on.

There are other opportunities. Judy Sheeshka just mentioned an opportunity in Canada of which we were not aware even two months ago. That might provide an opportunity to study exposures and perhaps some health risks, and develop a case study.

As for project schedule, we're now in the data collection stage. January through August we want to develop the conceptual framework and evaluate it. Then September through December, or perhaps earlier, we'd like to have the review workshop and produce a final document.

So in summary, if people don't eat contaminated fish, what do they replace the fish with in their diets? We've been asking that question for some time. What are the consequences to their health and well-being for both dietary and nondietary considerations? How can agencies and individuals weigh the risks and benefits of consuming contaminated fish? If change in the diet is not an option, and it may not be, how does one provide a better understanding of the risks and benefits of eating contaminated fish?

Well, these are important questions, and with your help we hope to provide some answers. We will create a section on our homepage, our Toxicology Excellence for Risk Assessment Website, to showcase some of the initial work from the research and invite you to review it as appropriate.

Open Discussion

Dr. Sheeshka: I just wanted to clarify, in response to Spencer's question, we throw out the outliers in our data and they weren't represented in any of the mean values I reported to you. I just wanted to clarify that.

Mr. Dennis Boren, USEPA Office of Water: I was curious if you'd be factoring other foods into the dietary assessment. Namely, fruits, vegetables, and grains, and I'm thinking in terms more of inorganic chemicals and pesticides.

Dr. Dourson: At this point, we're including a vegetarian diet, so we will study protein from vegetarian sources, and a nonprotein diet. So we're focusing on protein sources and comparing different protein sources first. That's I think a partial answer to your question. The other thing that we are doing with the protein sources is looking at the fatty omega-3s. We're looking at minerals, such as selenium—I think that was one of the antioxidants that Grace had alluded to before—and other chemicals, as a means of comparing the various protein sources.

At this point, we're gathering data and we're trying to gather more data than we probably need, so it's probably wise to gather this data too. As we build a conceptual framework, the research team wants to focus on a few things, on a few chemicals, maybe only on a few constituents of the protein source, and maybe only a few different types of fish in order to get a handle on what a conceptual model would look like.

We've had several meetings and conference calls where you see these very different areas of science and lots of information, and at first blush is it's really hard to do this comparison. There have been some opportunities where the areas seem to overlap and you can see where fits occur. That's just my personal thought on this research so far, and

other people have expressed that same kind of idea; but there are other areas that it just doesn't look like there's a fit yet. I think we just have to wade through more data.

Mr. Tom Atkeson, Florida Department of Environmental Protection: I'm with the Florida Department of Environmental Protection, but I'd like to preface that by saying that prior to taking this job five or six years ago, I worked for the Health Department in Florida in the environmental epidemiology program for nine years. One of the things that is a thread through this afternoon's discussions, at least, is the sort of tension in the minds of a lot of people here about whether or not we're doing more harm than good in making statements about the desirability of eating fish from many of our waters. I'm talking about organic contaminants, and my particular specialty is mercury.

One of the things that I think needs to be kept in mind, and perhaps is another dimension of the analysis that you will be doing, is to remember that these contaminants are not naturally occurring. Even mercury, which is of course on the periodic table, is presently cycling through the environment at a substantially higher rate than it was in preindustrial times.

So having stated the problem that there are excessive levels of certain contaminants in fish, you see the need for what Mr. Perciasepe was talking about this morning, to begin to try to reduce the levels of these contaminants in our environment. There really shouldn't be a conflict between the managers of fishery resources and public health people in this concern about whether the expression of the problem is doing more harm than good. The real solution to the problem I see is that we must ultimately bring the levels of these compounds in our environment back down to where they should be. Our goal is to make the fish safe to eat, not to make people quit eating fish.

Mr. Spencer Garrett: No, I just want to apologize to Judy. I was the one that talked about the outlier, and I in no way meant to infer that the outlier was included. It was discarded. Rather, the point that I was trying to make was that it would be very interesting, in fact fascinating, if you would, to have the appropriate clinical data on these high-end users, whether they be 1,000 meals a year or we've now found a different subpopulation which consumes even more than that. That was the nature of my remark. I certainly would like to associate my remarks with the gentleman from Florida, who just indicated that there's absolutely no need for this creative tension, unless it is creative tension, that we have between the various disciplines.

MERCURY AND HEALTH ISSUES

Dr. Steve Ellis, Moderator
EVS Environment Consultants

The five presenters of this morning's session will be talking about methylmercury, which typically constitutes greater than 95 percent of the total mercury present in fish and shellfish tissue. Methylmercury is a neurotoxicant that can have serious adverse effects on the development and functioning of the human central nervous system, particularly when exposure occurs prenatally. Methylmercury is a contaminant of significant public concern, given its prevalence in fish and shellfish throughout the country. In fact, in 1996, more than 75 percent of the fish advisories in the country were due wholly or in part to methylmercury concentrations in fish tissue.

A key aspect to determining whether human exposure to methylmercury in fish may result in adverse human health effects is the development of RfDs, or minimum risk levels (MRLs). Currently, USEPA supports an oral RfD for methylmercury of 0.1 μg/kg/day, which is based on neurological effects seen in Iraqi children who had been exposed prenatally to methylmercury fungicide in grain.

During today's session, you will be hearing about the USEPA RfD, the Iraqi study, and two other ongoing studies that are looking at methylmercury exposure in seafood. These other two studies are the Seychelles child development study and the Faroe Islands study.

Many of you may have seen ATSDR's draft toxicological profile for mercury. In that document, they have put forward an MRL for methylmercury that is five times higher than USEPA's RfD. It's based on preliminary data from the Seychelles child development study.

Key aspects in looking at these three studies, the Iraqi study, the Seychelles child development study, and the Faroe Islands study, are issues such as the length and magnitude of exposure, the presence and treatment of confounding factors, the size of the cohorts that were used as a basis for the conclusions of these studies, the use of uncertainty factors, as well as the battery of tests that are used to measure child development.

So during this discussion session we hope to see a very critical examination of these three studies and gain a greater understanding of the factors as they apply to these three studies.

STATE PERSPECTIVE

Dr. Andrew Smith
Maine Bureau of Health

I intend to be very brief to give maximum time possible to the four following talks. I'd like to underscore the importance of the five-fold difference between the USEPA RfD and the ATSDR proposed MRL. For those of you who deal frequently with cancer risk assessment, like we do, normally when we see a five-fold difference in numbers, we think little of it, given the crudeness of the exercise. But in this particular case, a five-fold difference really has quite a significant impact, and that's what I would like to try to emphasize.

I would like to contrast the mercury advisories in Maine using USEPA's current RfD with the proposed draft MRL issued by ATSDR. This overhead shows a map of Maine, and the dots show you lakes where we have data on mercury in fish. The color coding shows the need for advisories on those lakes based on the average concentration of mercury in major game fish species caught in that lake, using USEPA's RfD. Red means no consumption; levels are so high we would recommend no consumption of any fish from those lakes for the sensitive population. Yellow is limited consumption, and green is unlimited consumption, meaning levels are so low we do not consider a need to issue any advisory. Based on USEPA's RfD, Maine has a significant mercury problem, prompting statewide advisories and a considerable impact on access to fisheries.

This overhead is the same figure using the five-fold higher MRL proposed by ATSDR. This shows that Maine no longer has a very big mercury problem. I would suspect that a number of other states could make similar figures from their data. So the message here is that Maine is very interested in the current debate over the RfD versus the MRL.

I confess, this brings back memories of the late 1980s and early 1990s when we were dealing with a debate over whether to use FDA's dioxin action level or to use an USEPA risk-derived action level. Those are not particularly fond memories for me.

One message I would like to give the federal agencies is that we have an enormous impact on a resource when we're issuing statewide advisories or very extensive advisories, especially in a state with a heavy reliance on tourism, so our job is made easier when there is a clear and consistent message from federal agencies. It is exceedingly difficult when we receive conflicting messages.

I am very aware that we can interpret the signs differently; it's important to have scientific debate. But I want to underscore the difficulty it would pose in Maine in issuing fish consumption advisories if we're looking at very different numbers. I encourage the federal agencies to try to work collaboratively with the new information as fast as they can to come up with a consistent message.

MERCURY REPORT TO CONGRESS

Dr. Katie Mahaffey
U.S. Environmental Protection Agency

The Mercury Report to Congress is a very large, comprehensive risk assessment that deals with the effects of ambient emissions of mercury on wildlife and human health. The report is huge. The first draft was approximately 1,700 pages and the subsequent draft is not considerably shorter.

Today I will talk about the methodology used; expected outcomes; and about adjustments made between the 1995 edition and the current edition based on recommendations from the USEPA Science Advisory Board. I would like to focus on the comparison of USEPA's benchmark dose to findings from the Seychelles study and the Faroe Islands study which is probably of greatest interest to this group.

The report is required by the Clean Air Act of 1990. A draft was prepared in December 1995, but at the time of release a decision was made to delay the report in anticipation of results from the Seychelles study. In the interim it was referred to the USEPA Science Advisory Board. There has been a second draft prepared which is currently at the Office of Management and Budget. The revisions made in the report deal with revised modeling of the fate and transport. It remains quite true that methylmercury is the primary chemical species of concern from ambient emissions of mercury.

We modified the approach that we used for wildlife assessment in the report. One of the major recommendations from the Science Advisory Board was to incorporate contemporary data from several national surveys of dietary intake released earlier this year. These include results from the third NHANES, the 1994 CSFII, and the 1995 CSFII. These are major studies of dietary intake for the broad national population. All three of these give population-based estimates of dietary intake and certainly include fish and shellfish.

Of particular interest is that these surveys are not going to specifically address the higher-end consumers who may be most influenced by the state advisories. On the other hand, we know from these dietary surveys that people relying heavily on sport fish also consume commercially available fish. So many of the numbers in the reports should be helpful to the states in terms of understanding background mercury exposures, to which you would then add exposures through sports fish consumption.

We have also, at the recommendation of the Science Advisory Board, incorporated findings from laboratory-based mercury exposures of non-human primates, because there was a very strong feeling from the Science Advisory Board that these data greatly supported the RfD that USEPA has used. So we use the findings from the animal studies to help us interpret and corroborate the human epidemiological data. This was done largely before the Faroe Islands data became available, and I think these data are probably very helpful in understanding and bringing together both the animal studies and the human epidemiological data.

In terms of the diet methodology, we have results from the major national population surveys and we have also made a very strong effort to incorporate findings from subpopulations whose consumption patterns may differ from the general population. There are some 13 studies of angler populations, about 80 studies of Native American groups, and a couple of studies from urban, low-income populations. We also have some dietary analyses from the Canadian aboriginal peoples published by Environment and Health Canada as an indication of consumption patterns in circumpolar regions.

The dietary data presented in the report rely on the major studies, in particular those where we are fortunate to have a combination of 24-hour recall data and food frequency data. All the major surveys have the 24-hour recall data, and these are useful in indicating the species of fish that are consumed and give us a very strong idea of the portion sizes of fish consumption at various percentiles.

Obviously, the values for the mean and median are particularly strong. As you move out to the percentiles further away from the mean, the ability to detect these percentiles and generalize them is increasingly difficult. However, because of the consistency across the national surveys, we feel that our data for the 95th percentile are very good. We also have longer-term data than those from 24-hour recalls which are important because mercury is a chronic toxin, so exposures over a period of, say, a month become important.

We were very fortunate that the people who designed the third NHANES included food frequency data for the population 12 years of age and older, so that we could combine those data with the 24-hour recall data to estimate month-long patterns of fish and shellfish intake and mercury exposure.

Another thing to know about this report is that the concentrations of mercury used in the report are average values for commercial species of fish and shellfish. Exposures would be much higher had we chosen a higher concentration. Substantially higher levels of mercury exposure would result had we used some of the state's data on concentrations of mercury in fish from local water bodies.

The report provides information on quantities of marine, freshwater, and estuarine fish and shellfish consumed as additional data to include in risk assessments because one of the things often in question is how much fish people actually eat.

Findings in the draft report should be of great help to state risk assessors. We think that two populations are of concern, women of childbearing age and young children. Young children are of concern because their mercury exposures on a body weight basis are substantially higher than those of adults. This reflects the fact that children consume more by way of caloric intake relative to body weight than adults, simply as a function of metabolic processes.

We are limited because food frequency data are available only for people 12 years of age and older. So we have used the adult food frequency data to estimate frequency of fish and shellfish consumption by children. Not everybody feels that this is a valid assumption. So we are clearly stating the issues, describing what we have done, and will let you make your own interpretation of the extent to which the child's pattern of fish and shellfish intake resembles that of the adults.

The area probably of greatest concern to this group is the RfD. The RfD is derived using a safety factor of 10 from USEPA's benchmark dose for methylmercury. The methylmercury benchmark dose was based on Iraqi data from 81 maternal-infant pairs, using the concentration of mercury in the maternal hair as the primary guide.

A question often raised is why do we think mercury in grain has anything to do with mercury in fish? The answer is that mercury in both cases is very highly bioavailable. It's available in excess of 95 percent of the dietary intake. The calculations of the amount of mercury that would need to be ingested to produce hair mercury levels this high come from human metabolic studies where the mercury was consumed from fish, so the biokinetic portion of this RfD is based on mercury in fish. So any discussion about the resemblance of grain to fish is only partially applicable. I personally think it's not relevant here because the maternal hair mercury levels were measured in the biokinetic part.

Again, the benchmark dose comes from the lower bound of the 95 percent confidence limit on a 10 percent prevalence of effects of mercury in the 81 mother-infant pairs from Iraq, including delays in walking, delays in talking, and neurological scores.

After preparation of USEPA's first draft, data were released from a prospective epidemiological study in Seychelles. Dr. Myers will be describing this study later in the program. The findings indicate that they did not observe effects of mercury on child development, given the testing paradigms used in the study, which are based particularly

on Bayley scales of infant development as measured at 19 and 29 months, and subsequently I believe there are data at 66 months. It is my understanding that the National Institute for Environmental Health Sciences, one of the primary sponsors of the initial study, is funding an additional piece of research in Seychelles using the kinds of testing paradigms that were used in the Faroe Islands. I think there will be more to come from the Seychelles studies as these additional testing regimens are explored.

A very important number to keep in mind is that the median level for maternal hair mercury in the Seychelles study was approximately 6 ppm, with a range of about 0.5 to around 27 ppm. I forget their interquartile numbers, but I think there were fairly few people who have hair mercury concentrations in the range of 20 ppm, and probably fairly few above 15 ppm. We'll come back to this.

In the recently released Faroe Islands study, they did clinical examination and did not see clear-cut changes associated with mercury exposure. They did very extensive neuropsychological assessments, which Bobby will talk about in depth. They found that the neuropsychological dysfunctions were greatest in the areas of language, attention, memory, and, to a lesser extent, in visuospatial and motor functions. Further, they found that they still see significant effects even when they exclude people whose hair mercury concentrations are greater than 10 ppm.

Now, what does this mean? Remember, our benchmark dose is 11 ppm. We're saying this is the lower bound of a confidence limit that is associated with a low prevalence of clinically evident effects. The Faroe Islands study is saying that by using much more subtle tests of child development, they are still able to see effects at maternal hair mercury levels under 10 ppm. The geometric average for hair mercury in this group was around 4 ppm; 15 percent of the mothers had hair mercury levels above 10 ppm; and their interquartile range, meaning the 25th through the 75th percentiles in their data, range from around 2.5 up to around 7.7 ppm maternal hair mercury.

As you can see, the benchmark of 11 ppm, the lower bound of the confidence limit where we had clinically evident effects, represents the lower border of that type of effect. But when you look at far more subtle indices of child development, there are still identifying effects under 10 ppm.

How does this square with the benchmark dose? Because we used a safety factor of 10 in going from the benchmark dose to the RfD, we are still protective against the occurrence of subtle effects of methylmercury exposure on child development. I believe the data speak for themselves in terms of why this application of the safety factor to the Iraqi data is something that, in this case, appears to be protective against the kind of subtle effects identified in the Faroe Islands study.

There are many more results in the report which we hope to release shortly. There is, I believe, a federal commitment to revisiting these important studies when they become complete. We're not exactly sure when that will be, and I think it depends on how rapidly these additional findings become available.

The RfD for methylmercury, both based on our own judgments and the recommendations from the Science Advisory Board, is 0.1 μg/kg/day.

That concludes the descriptions of what is in the report. We look forward to your continued interest in the findings of the report. I think the substantial amount of data on fate and transport, wildlife effects, dietary exposures to mercury both from commercially available fish and shellfish sources, and amounts of fish consumed should be very helpful to states in formulating their own policies on advisories and risk assessments.

FAROE ISLANDS STUDY

Dr. Roberta White
Boston Veterans Administration Medical Center

I am the neuropsychologist on the Faroe Islands study. Dr. Phillipe Granchan has been in charge of putting the study together, getting the funding, and analyzing the data. Paul Vie is our principal investigator in the Faroe Islands who was key to assembling the cohort and carrying out this very large and complicated study. Faroese and Japanese co-investigators also participated in this international project.

The story about the Faroe Islands study really starts 30-some years ago in Minamata, Japan where an increased incidence in cerebral palsy occurred in the area around Minamata Bay and was found to be related to methylmercury exposure. It is interesting that mothers who were ingesting methylmercury in seafood seemed to be normal, and often the children didn't show any symptoms for about three months. Neuropathological studies on the children in Minamata Bay who developed Minamata disease from prenatal exposure to methylmercury show widespread brain damage, with lesions throughout the brain. This is much more extensive than the kinds of effects seen in adult exposure to methylmercury. It appears that the infant brain exposed prenatally is particularly vulnerable to the neurotoxic effects of methylmercury. This makes sense in terms of brain development, which can be particularly disrupted prenatally, and also probably in very early childhood and infancy.

In addition to the neuropathological findings, there were some behavioral findings showing sensory disturbance, mental retardation, and other neurological disorders at a greater rate of prevalence in Minamata Bay than control areas. These sources of information are limited because of inadequate confounder analysis. We don't know much about the age at which people were exposed to different levels of methylmercury. At the time we started the Faroe Islands study, we felt the neurobehavioral measures that had been used previously were a little gross and not highly sensitive.

The Faroe Islands are 19 islands in the North Atlantic, somewhat north of Norway and Scotland, with a Nordic population. They speak Faroese, which is similar to old Norwegian. They are a protectorate of Denmark. Methylmercury exposure in the Faroe Islands occurs through consumption of pilot whale. Pilot whales are caught in the Faroe Islands from pods that come close to the islands. The division of the meat from the kills and the participation in the kills is a very ancient part of the Faroese culture, and this is a traditional food in the Faroe Islands.

The original birth cohort assembled included 1,047 children out of 1,386 live births that occurred between March 1, 1986 and December 31, 1987. Prenatal methylmercury exposure was measured at birth in terms of cord blood, mercury in cord blood, and maternal hair mercury. This slide shows median and interquartile range, 25th to 75th percentile, and the minimum and maximum doses. This shows the relationships between different measures of methylmercury exposure. These are in the paper that recently appeared in *Neurotoxicology and Teratology*. The correlation between cord blood and maternal hair is about 0.8.

We tested 917 of the eligible children from the original cohort when they were between the ages of 6.5 and 7.5 years. We looked at possible measures affecting cognitive function, including neurobehavioral risks like having had a skull fracture or a head injury; current health status; and scores on the child behavior checklist. We measured or estimated maternal intelligence by using the Raven's test, which is a test of non-verbal problem-solving ability. We also assessed socioeconomic factors. The children underwent functional neurology testing and visual function testing in audiometry. They also underwent a battery of neurophysiological tests, including visual evoked potentials, brain stem auditory evoked potentials, postural sway, and ECG R-R interval variability, which is an autonomic measure.

In addition, we used a comprehensive battery of neuropsychological tests, covering a number of behavioral domains. We looked at the child's ability to name objects, a test of language; pay attention; do fine manual motor coordination tasks; put together things like block designs; and draw. We also looked intensively at their ability to learn and remember new information presented both verbally and visually.

Statistical analyses results that I will present today are based on multiple regression analyses using the data. We controlled for many potential confounders in the analyses, including gender; exact age, because it's over a year-long age range and children can vary quite a bit in a year at that age; maternal intelligence; socioeconomic status; whether they were in child care; what town they were brought up in; and computer knowledge, because some of the tests were given by computer.

As an example of how the confounders worked, we asked about the children's computer experience and learned that boys had used computers much more than girls. We found that boys were much better on the finger-tapping test than girls. We also found that children with more computer experience performed the finger-tapping test much better. So we controlled for those variables when we looked at the finger-tapping data.

We did another test on the computer called the continuous performance test, devised for this study. In this test the child looked at a computer screen and saw a series of animal

silhouettes flashing up one at a time. Every time they saw the cat, they were supposed to press a button. We measured reaction time with this test. Children with the lowest cord blood mercury at birth have the fastest reaction times on the continuous performance test. Children with the lowest exposure to mercury are more likely to be in the group having the fewest errors. The children with the highest cord blood mercury are more likely to be in the highest error group.

We also conducted the digit span test, an attention test in which the child repeats digits forward after they are presented to them. The children with the lowest cord blood mercury performed better than the children with the highest cord blood mercury.

We saw similar results for the Boston naming test, in which the child looks at a series of drawings and names the object depicted. It's a test of lexical and language development. We were particularly interested in this test because it is really a measure of cortical brain function. This slide shows you the results for both years adjusted for all confounders. We took one test from each of the behavioral domains mentioned—fine motor coordination, attention, visuospatial functioning, language, and memory—and this slide shows the relationship. These bars show the percentage of children from each exposure group in the lowest 25 percent performance category for each test. The representation is much higher in the children with the higher cord blood mercury levels.

We have a number of conclusions. First of all, our follow-up was highly successful, reaching over 90 percent of the children from the original cohort. We found our test battery to be feasible. We didn't see any children that we would diagnose with Minamata disease on examination. We did not see any mercury-related deficits or effects on the physical examination, visual or auditory testing, or on the neurophysiological test.

We did, however, see significant relationships, and many more than I presented to you just now, in the domains of language, attention, and memory function; and to a lesser extent, but still present, in visuospatial and motor abilities. We feel our findings are robust. There was minimal confounding due to PCBs. We've looked at that extensively, and we're looking at another PCB-exposed cohort, and that confounding was otherwise limited.

Now, you may ask, what does this mean? So what? The kids did a little bit worse on a few tests of neurobehavioral function. I think the results are important for a number of reasons. It's clear that there is some effect at maternal hair mercury levels between 3 and 10 ppm, below what has previously been considered by some to be a standard for effect. Secondly, the findings suggest that the effects on brain function are diffuse. Thirdly, these effects are showing up at age 7, which in the Faroe Islands is when the children enter school. So it may have implications for school work.

We do not know if these effects persist, and we do not know what the functional, real-life outcomes associated with these effects are going to be. We are now applying for funding to look at how children are doing in school and to retest their neurobehavioral functions. What makes me really concerned about these results are lessons we learned from lead that subtle effects at low levels are much more meaningful than might be apparent at first glance.

SEYCHELLES ISLANDS UPDATE

Dr. Gary Myers
University of Rochester

This is a special year for Rochester because it was just 25 years ago today that we started our studies in Iraq. As you all are probably aware, Iraq was one of the major disasters in terms of mercury poisoning in the world, although Minamata has probably received more press than Iraq. In fact, there were probably about 10 times as many people in Iraq who were poisoned by methylmercury as in Minamata.

We went to Iraq and looked at whether children throughout the country had been exposed to mercury *in utero*. On the basis of a number of women who were pregnant at the time of the epidemic, we conducted studies looking at mercury exposure in relationship to outcome. There were two major outcomes in Iraq. The first was what we called retarded walking. The mothers reported whether their children walked before or after 18 months of age. In Iraq, the mercury concentrations in maternal hair were several hundred ppm compared to lower ranges you would expect to find in people from Western nations. The abnormal children start showing up somewhere around 20-25 ppm maternal hair mercury, and there are a few in this questionable area between 10 and 50 ppm maternal hair mercury. This shows that there may be effects at low levels. In fact, when we looked at the data from Iraq, we felt we had a moral responsibility to look for low-level effects elsewhere.

So we did. We set out to look at a fish-eating population to see if we could find low-level effects of methylmercury from exposure through a diet high in fish. There aren't many places easily studied. The Faroe Islands is a good place to look at the issue. It turns out that the Seychelles islands is another good one, although we had a couple of false starts in other places that became very difficult. Part of the problem is sorting out the confounding factors in these incredibly complex analyses, which plagues all studies looking at low-level effects. Dr. White has already addressed some of the confounders in the Faroe Islands study.

My colleague, Dr. Marsh, found the Seychelles by writing to *National Geographic* and asking where in the world people eat the most fish. They listed four places. The first three he went to were impossible to study, but Seychelles, just north of Madagascar, is a great place to look at this issue for a number of reasons which I'll tell you in a moment. The primary question and the reason we went to Seychelles in the early 1980s was to find effects in that population at low levels of exposure to mercury from eating fish.

The Seychelles studies have been complicated, with lots of collaborations, including the Republic of Seychelles, the University of Rochester Medical Center, the U.S. National Institute of Environmental Health Sciences, the U.S. FDA, the University of Lund, and WHO. We've done two studies in Seychelles with two separate cohorts. The first one is the pilot study, but today I will focus on the more significant study that we call the main study.

The first reason we went to Seychelles is because they eat a high fish diet, about 12 fish meals a week. The mercury content of fish in Seychelles is really not much different than elsewhere around the world. It's very low. There are no recognized local sources of pollution. The highest measure of mercury we found in any fish was about 3 ppm in Mako shark; most concentrations are well below 0.5 ppm. Some carnivorous fish have a bit higher concentrations, at about 0.5 ppm. Most of the fish that the people consume locally have concentrations below 0.5 ppm. The exposure range is somewhere between 1 and around 27 ppm in the main study.

The other reason the Seychelles is a good place to study is the high birth rate, around 1,500 per year. They have excellent prenatal care and the population is quite healthy. There are abundant health centers and more than 95 percent of the women get prenatal care and deliver in the local hospital under obstetric care. They have focused on preventive medicine, and put a significant focus on infants and children.

The population is stable and very cooperative. The majority of them live on a single island, which simplifies things significantly because it's easier for them to get to the evaluations. We've had good support from both Ministry of Health and now the Ministry of Education. We've started looking at the relationship of school problems and other things within our cohort.

The study has been totally double-blind. No one in the Seychelles knows any individual mercury values, which is remarkable. A few people have asked, but, by and large, they have not pressed us to release those. As far as we know, none of them are in the toxic range.

The study design is a longitudinal study. We enrolled the children when they were 6.5 months old and they have been examined periodically since that time. We have examined them now on four separate occasions, and we're currently involved in the fifth evaluation and planning the sixth evaluation of this same cohort. We've had an excellent return of these individuals. We started with 740 individuals at 6.5 months of age, and at 66 months, 5.5 years, we had only gone down to 712.

Our pilot study guided the main study, in which we expanded our testing. In the main study we have much better information about whether the children meet exclusion criteria and much better information about all the covariates. Our testing was all done at a central site, and the main study was confined to the island of Mahe, where 95 percent of the people live, simply for logistical reasons. The Seychelles has established a child development center where all the testing has taken place. It's a suite of several rooms that are soundproofed and where we can do the testing under optimal conditions.

Our approach has been to test children in age windows, meaning that at 6.5 months, children were eligible for enrollment only if they were within two weeks of that age at the time they were tested. If they were outside that window, they were not included. We continued that approach at 19 and 29 months of age, and spread the window out to three months at 66 months of age. The children were enrolled as they turned 6.5 months over an entire year's period, so their birth dates vary over an entire year. As they come up for their birthday, we fit them into our testing scheme.

In our study we took the approach to exclude from the beginning things that we know cause problems in development. So there were some general exclusions. There were children who enrolled but immigrated out of the islands and couldn't be followed up; children who were outside the age range; and a few expatriate children. The exclusion criteria for mothers included alcoholism; severe eclampsia (seizures); insulin diabetics; and attempted suicide. We excluded children who had low birth weight; neonatal seizures; head trauma or meningitis (known to cause developmental problems); repetitive seizures and known epilepsy; and several other severe abnormalities.

The covariates we looked at for children included gender, birth weight, birth order, gestational age, medical history, and breastfeeding. Maternal covariates include age, alcohol use, tobacco use, medical history, and education. We have given the mothers, or in some cases the caregivers, the Raven's test. We have done the HOME score, which is the home observation for the educational environment, as a covariate.

We have an analysis plan because we are looking for adverse effects of methylmercury rather than doing an exploratory study. For every endpoint we've used either linear or logistic regression models. We've used full models and reduced models. We've looked at each model with and without the gender interaction, because males in some studies, in Iraq, Canada, and elsewhere, seem to be more sensitive. We've looked for influential points, but haven't found one yet in Seychelles. We have looked at results both before and after removing statistical outliers. All of our testing has used two-tailed statistical tests with a 0.05 significance level.

At each age we had a set of tests. At 6.5 months, we used the Denver test and the Fagen test of visual recognition memory, which has a subtest of visual attention. At 19 months, we used two parts of the Bayley. At 29 months, we used the same two parts, the mental and physical developmental indices, and some parts from the infant behavior record, which is a subjective scale that the examiner does at the end of the evaluation. At 66 months we expanded our testing to include the McCarthy, the preschool language test; the Woodcock-Johnson, the child behavior checklist; and the Bender. Currently, we're in the process of examining the children at 96 months of age with a variety of tests including many used in the Faroe Islands, as well as some others. The 96-month testing is in progress.

There were 779 infants enrolled between 1989 and 1990. Thirty-nine met exclusion criteria. Median maternal hair mercury was 6.9 ppm. The median gestational age was 39. Except for the 12 fish meals a week, the median values are pretty standard. In Seychelles, over half the women were still breastfeeding their children at 6 months of age. In fact, there's a great encouragement of breastfeeding in Seychelles.

The results from 6.5 months showed a small number of abnormal or questionable scores on the Denver, and we really could not do an analysis of that. There were also a small number of abnormal scores on the neurological exam and there was no analysis possible. Remember we had excluded all the severe children up front, which probably accounts for at least part of that.

We analyzed changes in the deep tendon reflexes, something associated with mercury exposure in Iraq and Canada. We found no association with mercury in the Seychelles study. We also found no association with limb tone and mercury. The more sensitive test at 6.5 months was the Fagen test of visual recognition memory. It also showed a normal distribution for the scores, showed appropriate associations, and had no association with mercury. The same was true for visual attention which showed no association with mercury. So at 6.5 months, we really found no association with mercury. Quite frankly, Dr. Marsh and I both thought we'd find something at 6.5 months.

At 19 and 29 months, we looked at the MDI, the PDI, and at 29 months the infant behavior record. There was no association with mercury for either the MDI or the PDI at either age. We had six items on the infant behavior record. Only one of those items, the activity level in children, was associated with mercury exposure. The activity level in the children went down as mercury exposure went up. It is not clear to us if that is an improvement or a worsening. We're not able at this point to interpret the change in activity level. It is a subjective evaluation done after an hour's evaluation by an examiner. We feel it is one of the weakest endpoints we've used.

Partial residuals plots for the mental developmental index had flat lines indicating no association with mercury. For activity level for males, the line trends downwards, a significant finding. Its interpretation is complicated, though, and we're not sure how to interpret it.

We looked at developmental milestones, the other endpoint that had been used in Iraq. In Iraq, the endpoints were walking before or after 18 months and talking before or after 24 months of age. In Seychelles, we had actual data on when the children walked and talked. In fact, the children in Seychelles all walked earlier, with average walking age earlier than what we find in the U.S.

We found a minimal association with mercury in males. The P value on the reduced model without outliers was 0.043, and that was dependent on a few statistical outliers. We were not able to find an association with mercury and the age at which the children first talked. Partial residual plots of age at walking show a slight trend up. There is very little difference plotted with or without outliers, only a marginal change. For females it was flat. We plotted the Seychelles data for walking the same way we did it in Iraq, but we did not observe similar findings.

At 66 months of age, we found no association with mercury for any endpoints, plotted both with and without outliers. We divided the 66-month measures into neuropsychological functions. Each one of these tests has multiple subscales, and they measure multiple things. So you can look at the subscales and organize them in different ways, so that instead of coming up with an overall score, you come up with a score for some function. In this case, these are the functions that we looked at: attention, executive functions, expressive language, etc. We were unable to find any association with mercury when we categorized them by these functional areas as well.

So after 66 months of looking at children in Seychelles whose mothers have a very high intake of fish, we found one of 36 endpoints that showed an association with mercury exposure. At 29 months, the activity level from the Bayley scales showed a decreased activity level as mercury increased, only in males. We're not sure if that's an improvement or a worsening, since, as many of you know, about 10 percent of children here in this country are on dexadrine and Ritalin because they're too active. In summary, through 66 months of age, 35 out of the 36 endpoints did not show an association of adverse effects with mercury exposure.

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY DRAFT MERCURY REPORT

Dr. Christopher DeRosa
Agency for Toxic Substances and Disease Registry

I'd like to thank the organizers of the conference for taking this opportunity to promote a dialogue on a topic that's generated a lot of interest, sometimes more heat than light in the last few years, in terms of the health guidance values for mercury. We've talked a lot about risk assessment, public health practice, and public health service the last few days. I think it's important to view risk analysis as part of what we're dealing with right now in this forum and other forums like it. We're attempting to place an overlay of biomedical judgment on the numerical conclusions of risk assessment that are often interpreted with an artificial sense of precision. So a key message is the value of biomedical judgment as a reality check as we employ a very useful tool called risk assessment.

One of the key points in the mission statement of our agency is the concept of prevention, not only of exposure and adverse health effects, but also diminished quality of life sometimes associated with loss of a resource. We need to look at risk in perspective and carefully evaluate whether we're overstating or understating risk, because there is a corresponding loss of resource if we overstate risk.

Today I'd like to address several questions related to the ATSDR mercury profile document. I'd like to point out another key message, which is that we need to articulate that fish is good, mercury is bad. Because mercury is bad, and fish are sometimes caught from mercury-polluted waters, some public health concerns may have to be addressed if you frequently eat a large number of those fish at critical periods in your life.

ATSDR has developed a toxicological profile on mercury because of our Superfund or Comprehensive Environmental Response, Compensation, and Liability Act of 1980 mandate. That mandate, among other things, charges us with the development of toxicological profiles for priority substances that we list in cooperation with USEPA on a biannual basis. Mercury is number three on that list. We have also initiated research to fill critical data needs for about 50 substances high on that list. About 200 priority data needs are being pursued with USEPA and the National Institute of Health Sciences. We also use that information to prepare public health assessments for each of the sites on the National Priorities List. We're required by law to do that within one year of listing of those sites. Because information is the basis for correct decisions, I think this legislation shows the wisdom of Congress. But it is also because of the wisdom of Congress that we

are required to update these profiles on a regular basis, not less than every three years. We first published a profile on mercury in 1989. We have subsequently published an update of that profile, and the current draft update is out for public comment.

We know we have completed exposure pathways at 40 percent of the 1,300 sites our agency has evaluated, and that groundwater is the primary pathway of exposure in 91 percent of the sites that have completed exposure pathways. Another 46 percent of those sites have completed exposure pathways through soil. Relevant to our discussion today, exposure through contaminated biota accounts for 14 percent of those completed exposure pathways, approximately 10 percent of that from fish. So this is an issue of concern to our agency.

By way of background, I'd like to point out that in 1993 we published a profile based on the Iraqi study in terms of the MRL, which is analogous to USEPA's RfD. Again, this was on the neurodevelopmental endpoint that has been described. Using those data we arrived at a numerical conclusion identical to USEPA's in their recent assessment, an MRL of 0.01 μg/kg/day.

We arranged a series of peer panel meetings in Atlanta, Georgia to review the direction we should take in the update effort. We were cognizant of a number of ongoing studies. We've supported the analytical work of the Faroe Islands study and were aware of the Seychelles work described this morning. We wanted to address how to proceed up front with the scientific community, so we arranged a pair of peer panel meetings in 1994, and again in 1995. The direction that we were given was to await the development of the Seychelles data set to use as a key point in our reassessment efforts. So we continued with our effort, recognizing in 1996 the publication of the 29-month data from the Seychelles from December of 1995. We decided to go forward with the development of our draft profile in 1997, and it is now out for public comment.

I'd like to talk about process, which is very important in terms of credibility in the public's mind. A key issue in good documentation practice, true for our MRLs as well as our toxicological profiles, is the value of external peer review. We also have some internal review efforts underway with the MRL work group; an interagency work group with representatives from USEPA and the National Institute of Health Sciences; and a public comment period to cast the net further for information relevant to our assessment efforts.

We are now midway through this public comment period. The profile is a work in progress, and we advise that it would be premature to predicate any risk management decisions on information in a draft document. That needs to await the finalization of the profile and sorting out issues that have been discussed here this morning.

In those peer panel meetings we looked at the Iraqi data and considered using the benchmark dose approach. We looked at the fact that this is a one-time acute episode, a single incident. It's a retrospective recall. Their range of exposure was from 10 to several hundred ppm. There were very few low-level exposures. The medium of exposure was via contaminated grain as opposed to fish. There were only 80 mother-infant pairs, very few of those again at the low range of exposure. The scalp as well as non-scalp hair was used in that analysis. The neurobehavioral data were obtained through family recall, which involves a societal issue because birthdays are not a big deal in Iraq. Asking mothers to recall the date their children first walked is subject to possible significant confounding bias.

Another point is that we tend to be very critical of studies, and find fault in the confounders that weren't controlled for. But it's important to view epidemiologic studies as lenses of a microscope which, for a range of different reasons, vary in their power and discriminating ability. They are focused on different slides or different populations. We need to recognize that when we see convergence in the data, it's a very compelling case, as for mercury. We can talk about differences in interpretations, but I see a very strong data set emerging from the aggregate of these different studies.

To summarize, the issues with the Iraqi study, from our review, were the magnitude of the exposure; the acute duration of the exposure; the vehicle of exposure being grain rather than fish; the presence of potential confounding factors; and the collection of data years after the episode.

Fast forwarding to the Seychelles study, we have a rather large sample size of 779 mother-infant pairs before the application of the exclusion criteria. The goal was stated prospectively. There were no associations to mercury found in neurodevelopment at different age milestones. There is an inverse relationship only in boys in terms of activity level, as judged by the examiner. We are awaiting the publication of the 66-month data. But as Dr. Myers indicated, these patterns seem to persist. As we looked at the Seychelles study, this is what we saw and this is what our peer review panels saw. The advice they shared with us is to use this as the basis for our reassessment, looking again at all available mercury data.

The tyranny of numbers; this is the MRL. It's a rather straightforward algorithm. It's very analogous to what USEPA and FDA do for the RfD and acceptable daily intake, respectively. You have a benchmark of toxicity and no observed adverse effect level (NOAEL), or some other surrogate for that, and an uncertainty factor. The magnitude of the uncertainty factor reflects the degree of available data. The higher the uncertainty factor, the lower the overall quality of the data set. The higher the quality of the data set, the lower the uncertainty factor. That is a key point.

The operational derivation of an MRL is very straightforward, but the judgmental aspects of that are much more involved. In the case of mercury, we must consider the fact that mercury is ingested by mothers, yet we know the fetus is the group of concern. The mercury concentrations are measured in the mothers' hair, but we're really concerned about the cord blood mercury concentration. So we have to convert the maternal hair mercury concentration to a cord blood mercury concentration, and subsequently convert that cord blood mercury concentration to a daily intake.

In addition, we have the issue of uncertainty. We have four general areas of uncertainty: cross-species extrapolation, 1 to 10; intra-species variability, 1 to 10; the use of an adverse effect level as opposed to a non-adverse effect level, 1 to 10; and a factor to account for the quality or sufficiency of the overall database, 1 to 10, sometimes referred to as a modifying factor.

We looked at uncertainty and the available mercury data. We have the most sensitive population, in terms of the developing fetus. We have an appropriate route of exposure, fish as opposed to grain or some other route of exposure. We have identified a NOAEL in the most sensitive subpopulation, and we see an absence of any neurodevelopmental deficits at similar exposure levels in other populations. That led us to select an uncertainty factor of 1. The methylmercury MRL is 0.5 μg/kg/day based on that analysis. I want to point out that we also present MRLs for both elemental mercury and mercury salts in the document.

We have worked with USEPA in developing health alerts regarding the concerns about mercury. We have an emergency response function in my division. Four times a year, on average, we're called to schools because kids broke sphignomometers or thermometers or used mercury in an inappropriate way. It's also a problem in hospitals. So we issued a mercury alert in cooperation with USEPA.

To summarize, the profile contains MRLs for three forms of mercury. We developed the selection of the critical study based on consideration of five factors. We think that the Seychelles data set is a gold mine because of the absence of confounding factors that we typically encounter in other studies.

Tobacco use, prenatal health care, alcohol use, and PCBs have also been associated with very subtle neurodevelopmental deficits. The work of the Jacobsons, and more recently of Helen Daily and her colleagues at the University of Buffalo, University of New York at Oswego, underscores the fact that the PCB story may be a recurrence of the lead story by showing subtle neurodevelopmental deficits at relatively low levels of exposure. Those results have societal implications. A 5-point shift in IQ means a doubling of intellectually

challenged people in our population and a reduction by one-half of intellectually gifted people.

We also have an uncertainty factor of 1 based on the NOAEL, again on the most sensitive subgroup of the multi-generational exposed study.

The bottom line is that we feel fish consumption does not represent an issue except when the fish consumed are taken from waters heavily polluted with mercury; then it becomes an issue, particularly for groups such as subsistence anglers, sports fishermen, and their families, and particularly women of childbearing age and the developing fetus. But we're not pretending to have a monopoly on science or truth in environmental health. That's why the document is out for public comment. Please provide us with those comments in writing. We will provide a formal disposition of comments we receive as part of the profile development process, and that will be a part of the administrative record for this effort.

Open Discussion

Dr. Ellis: We're going to get started on the open-mike session. I'd like to recap the regulatory issues, lead off with one question, and then open it up for questions.

To recap from the standpoint of the regulatory issues, USEPA is currently supporting a RfD for methylmercury of 0.1 μg/kg/day. This number was developed based on the Iraqi study that you heard about, and employs the use of an uncertainty factor. The draft MRL by ATSDR is based on the Seychelles study. It's five times higher, 0.5 μg/kg/day, and was developed without the use of an uncertainty factor. The data from the Faroe Islands study has not currently been used by either agency in the development of an RfD or MRL.

That leads to my first question for Dr. DeRosa. We heard about the consideration of the Iraqi data and the Seychelles data in the development of the draft MRL. Were the Faroe Islands data considered as part of that process?

Dr. DeRosa: The timing issue drove our evaluation. Our profile was released for public comment in October of this past year. Consequently, the Faroe Islands data were not included because they were not published until December. We were aware of the results, having in part sponsored the study, but by mandate are not allowed to use interim findings that have not been published.

Dr. Ellis: Thank you. At this point, I'll open it up to general questions.

Dr. Gale Carlson, Missouri Department of Health: As a follow-up to that, is it a possibility you will look at the Faroe Islands study if the public comment requests it, since the comment period is not yet over?

Dr. DeRosa: I would describe it as a certainty because the paper is now published, and we would use that as an important part of the picture.

Mr. Mike Dourson, Toxicology Excellence for Risk Assessment: Dr. Mahaffey, how have these new studies we've talked about this morning, and that you've looked at in relationship to the previous RfD, affected your judgment on the threefold part of the uncertainty factor for the lack of the two-generation reproductive study in potential long-term sequelae?

Dr. Mahaffey: There has been a subcommittee of federal agencies reviewing this and we've talked about these uncertainty factors. It is my understanding that, while people may wish to describe these as three separate components, it is in fact a composite uncertainty factor of which these are components.

I think there should have been some additional uncertainty factors considered, one of which would be generalizing from the subpopulation of one study to another.

In answer to your question: (a) it's my understanding it's a composite uncertainty factor; (b) I think that there should have been additional uncertainty factors used; and (c) while we described the results of these newer studies in the report to Congress, we have continued to base the RfD on the Iraqi data at the recommendation of the Science Advisory Board, and our own judgment.

Mr. Dourson: Yes, and I apologize for being so obtuse. My specific thought behind the question is that we have two long-term human exposure situations where there has been some study of the newborn and young child. Yet in that population, we have chronic exposure with the possibility of seeing evidence, or a lack of evidence, for long-term sequelae, and also the possibility of seeing evidence for whether reproduction has been affected over one or two generations.

Dr. Mahaffey: First of all, reproductive effects would include factors beyond the ability to produce living offspring, so simply being able to reproduce is not the full range of reproductive effects considered. So I don't find that a very compelling argument. Secondly, on long-term sequelae, while the Iraqi study may be described as an acute poisoning episode, it was clearly one that lasted long enough to produce the effects in the offspring. So are there additional effects that could have occurred with longer exposure?

The answer is very likely so. We can turn to Minamata as an example of additional effects that can happen to people with longer-term exposures.

Mr. Dourson: Thank you. I have one more question. Dr. Myers, you've had the opportunity to work through both of these studies. The RfD or MRL methodology in our current paradigm tends to focus on one study, although there may be a better way. Would you have a preference for one study over another as a basis of a RfD?

Dr. Myers: In Rochester we think that the Seychelles is the best study that we've done to date.

Mr. Dourson: Thank you.

Dr. Alan Stern, New Jersey Department of Environmental Protection: The two issues which I think are highly significant in terms of use of uncertainty factor adjustments for mercury are interindividual variability and the presence of sequelae. I think there is a misinterpretation of how interindividual variability needs to be addressed in respect to mercury. There are two aspects of interindividual variability. One aspect I would describe as the classic sense of interindividual variability related to toxicokinetics or toxic response across the population. If one chooses to use the Seychelles data, the question of whether or not one needs to adjust for uncertainty in interindividual variability is essentially a question of whether the extent of variability in toxicokinetic response in the Seychelles population is more or less the same as in the U.S. population. I would agree that arguably it is.

The other aspect is that of pharmacokinetic interindividual variability. Specifically with methylmercury, in terms of the studies we are discussing, we are measuring our metric of exposure at hair levels, but the metric of risk assessment is ingested dose. We use a pharmacokinetic model, the WHO one-compartment pharmacokinetic model, to calculate or to estimate the ingestion dose that corresponds to a hair level. That model requires several inputs which are distributed through the population, including blood volume, body weight, absorption, hair-to-blood ratio, and elimination rate constant. Each of those is distributed within any given human population, whether it's the Seychelles or the U.S. population.

There is an interindividual variability in estimating the ingestion dose that corresponds to a given hair dose. That model cannot legitimately be solved by point-value estimates; instead, each of those numbers is a distribution. From that standpoint, it's essential, even if one is calculating the ingestion dose that corresponds to a NOAEL hair level, to address the interindividual variability in that calculation. ATSDR did not do that. I call your attention to a paper of mine recently published in *Regulatory Toxicology and*

On the issue of sequelae, the work of Debra Rice of Health Canada with macaque monkeys showed very clear evidence that monkeys dosed either from *in utero* or immediately postnatally through childhood, who were asymptomatic through that entire period, became symptomatic with respect to tactile ability and essentially neurologic competency in middle age. Since the Seychelles study has not yet followed these children through middle age, clearly those data are in no position to address whether or not there are sequelae in adolescence, middle age, or later, resulting from *in utero* exposure. Data from the animal literature clearly suggest that as a possibility, so it is well within the process of risk assessment to include an additional uncertainty factor adjustment to address that.

Dr. DeRosa: Yes, you raise some very good points, and we recognize the issues with respect to interindividual variability. For example, in the WHO one-compartment model, we've looked at elimination constants from six different studies. We used the mean of those six different studies. Whether that's the reasonable approach to take is a question to debate, as is whether or not the assumed blood volume of 4.2 liters is appropriate. For example, we used 250 for the blood-to-hair ratio. We looked at about 14 different studies, identified a range of 140 to 370, and identified the fact that about eight or 10 of those studies point to around 250 as the point of central tendency. That's the basis for our using that factor.

The question of interindividual variability is also addressed in part by the large sample sizes. There are about 770 mother-infant pairs involved. So those are factors that led us to believe, given the rigorous nature of the study, that we had adequately accounted for that.

Dr. Stern: Not to belabor the point, but the question is not whether you chose an adequate mid-range value, but what the range of that value is within the population. This is not something that was measured in the Seychelles study, because it's not toxic response; it's pharmacokinetic variability in the use of the one-compartment pharmacokinetic model. In that respect, it doesn't matter how accurate the estimate of the mean is because it has no particular providence, nor does the 90th percentile or the 10th percentile. It's a distributional issue.

Dr. DeRosa: We look at the issue of interindividual variability in a somewhat different light. We feel we've looked at that when we select the most sensitive segment of the population. This is analogous to what USEPA has done in the case of fluorides. The RfD for fluorides, is based on a study illustrating NOAEL at 2 ppm and NOAEL at 1 ppm. The NOAEL at 1 ppm is adopted as the RfD for fluorides. If you have some sense of how that can be addressed, we'd be glad to hear from you and we'll look carefully at your point.

Pharmacology that suggests that, at a minimum, a factor of 3 is necessary to address the 5th to the 95th percentile of the population of women of childbearing age.

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1 ppm. The NOAEL at 1 ppm is adopted as the RfD for fluorides. If you have some sense of how that can be addressed, we'd be glad to hear from you and we'll look carefully at your point.

Dr. Stern: I intend to submit written comments, and I'll be glad to give you a copy of this paper. Any comment about the sequelae in terms of the monkey data?

Dr. DeRosa: Again, we feel the Seychelles is a long-term study that reflects multiple generations of exposure. We don't see any sequelae in that population. We have a fairly good health infrastructure in the Seychelles.

Dr. Stern: They didn't test adults in the Seychelles.

Dr. DeRosa: Again, I'm saying that surveillance is in place there in the Seychelles. It seems to me that if there were a profound effect there, it would have been picked up.

Dr. Stern: Well, we're probably not talking about a profound effect.

Dr. Henry Anderson from Wisconsin: Yesterday we spent a great deal of time talking about the benefits of fish consumption. In the Seychelles study, and to a lesser degree perhaps in the Faroe Islands study, we have the best risk to benefit ratio from a fish consumer's aspect, in that you have high fish consumption with very low mercury in the fish. It seems to be a potential confounder that will be hard to control for since the fish consumption is correlated with mercury. But when we then extrapolate that from a fish consumption study to methylmercury toxicity, we know there are different routes of exposure.

How confident are you that if you have low fish consumption of highly contaminated fish resulting in the same hair and blood levels, that you would see the same types of effects? In other words, would the potential growth and development benefit of the high fish diet be reduced? A number of different reproductive-outcome studies of high fish diets show a little longer gestational periods and higher birth weights. Do you have any thoughts on the role of the fish component, not the mercury component, in mitigating adverse effects?

Dr. DeRosa: The only data I'm aware of are from the 1995 study by Grangene, who looked at the effect of exposure to mercury through maternal milk. The results were suggestive of a precocious attainment of these different milestones which the author has attributed to the beneficial effects of the milk and the nursing itself.

Dr. Mahaffey: As I have endeavored to point out to others, the mercury study report to Congress is principally a report about reducing ambient emissions of mercury. We are

not endeavoring to comment about the risks or benefits of consuming fish per se, but instead are trying to inform people about sources, mercury levels in fish, and minimizing mercury intake while consuming fish.

Participant: I have a question about the application of the RfD to consumption. An RfD is a daily dose. Usually when we calculate exposure to methylmercury in fish, we calculate the range of what you would get in a week in a meal. The day you eat your meal of fish, you get higher than a daily RfD. But when it's evened out over the week, it will supposedly be lower. Occasionally someone brings up the question of the bolus dose effect, although I feel it's inapplicable in this situation. Is the USEPA advocating that the RfD be applied as a daily dose, or is the use of this in a dietary regimen over a week considered applicable?

Dr. Mahaffey: We looked at that question in the report and tried once again to provide a variety of ways of looking at this. It has been immensely valuable that the third NHANES included data on frequency of consumption of fish and shellfish by adults, so we are able to calculate month-long doses, as well as daily exposures to mercury that are part of making up these month-long doses. Exploration of the toxicokinetics of mercury is important because this intermittent, high dose—we know that it's highly absorbed, that it's a retained chemical. You've heard a lot about various estimates of the half-life of mercury, all of which can act to increase the body burden over time.

The RfD is intended to be a dose that can be consumed over the long-term. My interpretation of these intermittent, high exposures is that they are important. They're part of calculating this long-term dose. I don't think anybody eats mercury-contaminated fish just once. So you also need to know something about the frequency with which people eat these fish with higher concentrations of mercury, because some percent of that dose will be retained, and it's probably a pretty high percent. Certainly over 95 percent of it is absorbed.

Participant: I have a comment related to the macaque monkey data. The exposures used were so high they were comparable in range to exposures that were related to seizures in Iraq. Also, when some of the monkeys were followed over time, some of the results actually reversed themselves. The monkey data shouldn't be the focus. Instead, we need to be discussing the two very well-designed, excellently executed human studies in front of us.

I have a question for Dr. Gary Myers. Did I hear you correctly that increased methylmercury exposures were related to decreased hyperactivity? Would you repeat what you said?

Dr. Myers: On the infant behavior record, which is a part of the Bayley test, there are a series of questions that the examiner answers at the end of the examination. For example, how does the mother interact with the child. One question is whether the examiner felt that the child's activity level was more, less, or similar to other children. Of course, the examiners have been examining the same-age children over and over. For that single question on activity level there was a significant decrease in activity level in males.

Participant: You mentioned the prevalence of Ritalin among children. We know that omega-3s accumulate in our brain and are present on neurosynapses. It would be interesting to explore whether increased mercury exposure is a marker of increased omega-3s, and the role of omega-3s in hyperactivity.

Dr. Mahaffey: Could I offer a comment on one of your other comments? With respect to using the animal data, the Science Advisory Board advises us to use the animal data to better understand some of the underlying mechanisms of the neurotoxicity of mercury. No one assumes that you can compare the doses across species directly. We know from experience with lead that nothing is as sensitive to lead as a human. Doses of lead you can give to monkeys could kill infants and young children. Nobody is implying that you can take these animal data, even on primates, and apply them directly to people. I want to be clear on that point.

Mr. Arnold Kuzmack, USEPA Office of Water: Dr. White, you mentioned that you have done extensive analyses of the lack of confounding as a result of PCB exposures, but that was a very brief part of the published article. Could you expand on that?

Dr. White: From the cord blood samples, PCB analyses were done on the children, and we looked at the relationship between PCB levels and neurobehavioral performance. We saw only one significant relationship involving the naming test, and it was a much smaller effect than we saw with mercury. It was our conclusion that our results were not explained by PCB exposure. I should also say as background, that people eat both blubber and meat of pilot whales. The blubber contains high levels of PCBs, and the meat has higher methylmercury. So it's not highly correlated in individuals, because some people seem to eat more blubber, and some people seem to eat more meat. We have also started a PCB study in the Faroe Islands examining children at birth longitudinally to look at this in more detail. But our evaluation of this 7.5-year data is that the methylmercury effect overrides the PCB effect.

Mr. Kuzmack: My second question is for Dr. Myers, perhaps for Dr. DeRosa. I would like to question the basic assumption that the Seychelles data is a negative study. I would point to two things in addition to the issue of activity level in males. One is that there were results in the pilot study which we can't ignore. Particularly, the conditions were

not comparable in the two studies, as you mentioned. In fact, in the pilot study, the children were under more stress and had a harder task to do. In that case, you saw some items that—at least there were some suggestions of a relationship to mercury. Second, the results from brain autopsies also hinted at observable differences in the brains as a result of mercury levels.

Dr. Myers: Let me address the issue of the pilot study and the main study, because that's a little bit complex. We've carried out two studies in Seychelles. The first was what we called the pilot study, in 1987 and 1988. In the pilot study, we had clinically just arrived in Seychelles, although we had previously been there measuring hair mercury. I went around to all of the islands, of which there are three major ones, and did a series of evaluations in the local health clinics. We had hair mercurys on everybody, and it was all double-blind.

The data showed an association between the results on the Denver test and mercury, but only when you used the test in a way that most psychologists cringe at; that is, by grouping together the abnormal and the questionable results. Questionable, in the Denver test, means the child ought to be tested again because a significant number of those children turn out to be normal in most studies. So we found one positive effect when we looked at the data in the same way as was done in New Zealand where an association to mercury was found.

Then we looked at a subset of the pilot children, 217 of the total 700-plus children, at 5.5 years of age and found four associations, three of which were dependent on statistical outliers. So there were two associations from the pilot study between outcomes and mercury.

The main study, initiated a year after the pilot study, was modified to correct problems in the pilot study. One correction was the site at which the children were examined, because in the pilot study they were examined at health clinics that weren't set up for careful examinations. In the main study, all the children were evaluated in the main hospital in a suite of rooms used solely for evaluations. We looked at the exclusion factors more carefully than we had in the pilot study and there were a number of other differences. In our opinion, the main study is the one that should carry the most weight because it was more carefully done, looks at many more of the exclusion factors, and many more covariates. It was done under much more controlled circumstances.

Mr. Kuzmack: That addresses the question. I'm not sure I agree, but I don't want to get into a debate at this point.

Dr. Myers: To address the second question, the highest level of brain mercury in Seychelles is just right around 300 ppb, which is significantly higher than what's found here in America, although we found one child in Rochester with a fairly elevated level of mercury in the brain. There was no association with the neuropathological changes. We don't have clinical data on those children because that study looked at brains of children who died of natural causes in Seychelles.

Ms. Katie McKerney, Water Quality Standards Coordinator for the State of Alaska: Dr. DeRosa mentioned that groundwater is a primary exposure pathway for mercury, and that fish consumption is approximately 14 percent or less on a comparative basis. Is that correct?

Dr. DeRosa: I believe we said that 40 percent of the National Priorities List sites have completed exposure pathways. Of those 40 percent, 91 percent of the completed exposure pathways are via the groundwater.

Ms. McKerney: Based on that understanding, was any drinking water tested of the study groups, Faroe Islands, Seychelles, or Iraq, to rule out the potential exposure effects on the study groups of ambient levels of mercury in the water?

Dr. DeRosa: I'm not aware of any. But the issue with respect to methylmercury is that 95 percent of the exposure is via contaminated fish in the diet.

Ms. McKerney: Thank you.

Mr. Bob Vanderslice, Rhode Island Department of Health: Most of us would agree that what makes this debate interesting is the fact that if one chooses 0.1 or 0.5 μ/kg/day, there are dramatic impacts on fish advisories. We're debating the science in this room, but there are other forums that are important in making the ultimate decisions, formulating final documents, and arriving at a consensus. We talked yesterday about doing a risk-benefit analysis. Our calculations for RfDs do not include a factor for benefits. In fact, they don't include a factor for political ramifications. How should we go forward? Certainly debating the science is interesting, and I just don't want to close my eyes. Are there important political processes that I should be aware of to figure out how to proceed given this difference in advice from different federal agencies?

Dr. Mahaffey: Part of what Dr. DeRosa was saying, correct me if I misunderstood, is that because the ATSDR document is at this stage a draft statement, it is recommended that the USEPA's RfD be used.

Dr. DeRosa: I think that was a restatement of my point. I was ready to jump in on a response until you mentioned the political issues. The points that you raise are very valid. The first point is that we are talking the science here and trying to understand where it is leading us. Once we have articulated the case based on the science, then we get into the risk management end of the scenario. As I mentioned, it would be premature to use our document as a basis for risk management decisions at this point in time, because it's a work in progress. There are a number of people we wish to hear from through the public comment process, and we will be reconvening a peer review process following the revision of the draft in response to those public comments. So this is still part of a deliberative process. I don't want to pre-judge the science. We need a forum where we can lay out the information and have an informed dialogue. But again, our bottom line is that the fish are good, the mercury is bad. Fish advisories are essential because we know that if fish are taken from mercury-polluted waters, it has health implications for certain segments of the population.

Participant: This meeting is a great opportunity for the Seychelles and Faroe Island researchers. In one study we have an apparent NOAEL on the order of 5 ppm mercury in hair. In another study we're getting what looks like effects at between 3 and 10 ppm mercury in hair. So we're seeing a large discordance in studies with somewhat similar design. It would be very interesting to hear the panel's description of what may be some of the fundamental reasons for those differences. I've been curious about the exposure levels; how high would the mercury concentrations be in the whale meat from Faroe relative to how high the concentrations were in Seychelles.

Also along those lines, selenium has been brought up as a mitigating factor, and selenium does concentrate in fish. Does anybody have a handle on the ratio of mercury to selenium in one study population versus the other study population? Also, is the extrapolation from the fairly homogenous population in the Seychelles to the U.S. population a fair one to make, given all the nutritional and genetic differences in our makeup.

Dr. DeRosa: Let me try the last question first. The issue of generalizability is a good point, but we should recognize that we've got a number of studies here from a number of different populations that reflect heterogeneity—I'm referencing the studies in New Zealand, Peru, and the Faroe Islands, among others. These are in the mercury report, and one of the interesting exercises in that report was a benchmark dose comparison of those different studies. The benchmark dose that was derived based on those different data sets was between 10 and 13 ppm maternal hair mercury. That suggests there is a good case to be made that the results from the Seychelles are generalizable to other populations, again based on this comparison of the studies using the benchmark dose approach.

Regarding the first question about what might account for some of the differences we see between the Faroe Islands and the Seychelles, I would focus on the concomitant exposure to PCBs and the fact that exposure is via blubber versus fish. There are those who have proposed that there are some neutral amino acids in fish that convey a protection against the uptake of methylmercury into the central nervous system. Also, maternal use of alcohol was a factor in the Faroe Islands, but did not seem to be as great a factor in the Seychelles. I think these are things we would focus on in our reassessment this coming fall.

The other point regarding the Faroe Islands was that the range was rather large, from 3 up to just less than 10 ppm maternal hair mercury. Which portions of the study group are exhibiting those effects? We have a body of information that's emerging. The pilot study from the Seychelles reported some results, although they have been set aside, at around 7.1 ppm maternal hair mercury, I believe. I'm suggesting that we're very close to pinning down a threshold for mercury, between perhaps 7 and 10 ppm. I think we've got a very robust database, and that's what I see emerging from that database at this point. There are a number of reasons to suggest that there may be, in fact, a threshold for mercury because of the interhepatic cycling of the consumed fish. Once mercury has returned to the gut, the organic mercury is converted to inorganic mercury, which is then eliminated. There is a physiologic premise for suspecting we may be very close to identifying the fact that a threshold is somewhere at these levels of exposure.

Dr. Mahaffey: It's unfortunate Roberta White just left, because she can more clearly respond to the interpretation of the Faroe data. But on the other hand, I was at the Faroe meeting this summer, and I have read the reports carefully, so I think I can be helpful. First of all, Roberta just indicated that they looked for the effects of PCBs as confounders and did not consider that the effects they reported in their paper were influenced by PCBs. Secondly, they have dealt with alcohol as an issue in the paper.

Generalizability across populations is clearly an issue. Something we learned in the years of debate about lead was that not all the populations showed effects. We spent a lot of time and energy trying to figure out why some studies showed positive effects and others did not. The reality is that when you are on the border of where effects start to occur, some of the covariables start to seem very important.

Another big factor is that they are going back into the Seychelles study and using the same testing paradigms, broadly speaking, that were used in the Faroe Islands. Only when we have the results from those testing protocols do we have a direct comparison between the results from the Faroes and the results from the Seychelles. At this point, we're comparing different endpoints measured in these two populations. Is one better

and one worse? I don't think that's really the issue we're here to discuss this morning. But are they different? They do seem to be different.

Finally, with regard to selenium, there is evidence that selenium is protective against renal toxicity and toxicity of methylmercury to the liver. There is not compelling evidence that selenium is protective against neurotoxicity of methylmercury. In fact, there are several papers, but I'm thinking in particular of a study on development of overt neurotoxicity in cats resulting from exposure to methylmercury through fish consumption. The study determined that the animals had both the same time to onset and the same severity of neurotoxic symptoms as they did when exposed to methylmercury through non-fish sources, and that there was no benefit derived from having that methylmercury come from fish. There also are additional papers that show no protective benefit of selenium against neurotoxicity of methylmercury.

Last but not least, on the issue of renohepatic recirculation and whether or not the gut demethylates enough methylmercury to contribute significantly to producing less-bioavailable inorganic mercury—I don't know that there are quantitative figures that deal adequately with the toxicokinetics of that mechanism as applied to methylmercury intakes in humans at the kinds of levels that we see in the diet. It's something that should be explored in some real depth if we're going to assert it as a protective mechanism.

Participant: (Inaudible.)

Dr. Mahaffey: I'm sitting here trying to remember.

Participant: It's 3 ppm.

Dr. Mahaffey: Is it 3 ppm? There are fish...

Participant: But the fish is cod, and it's relatively low. So they are a high fish consuming population. But the fish and the pilot whales are a less frequent source of protein. But it is more the culture that dictates that the pilot whales are caught meat, and blubber and meat are both shared. So it's a consistent way of exposure.

Dr. Mahaffey: So if it's 3 ppm, while it's certainly higher than fish, we've got to remember that even in the commercial food supply, there are some fish approaching 1 ppm. So we're not talking about vast differences. Now, fish that approach 1 ppm are certainly a very small part of the commercial food supply. The comparatively low level of mercury concentrations of fish in the commercial food supply support the kind of exposures to mercury we see in the general population in the U.S.

Dr. Ellis: Among the differences of the Seychelles and Faroe studies is the battery of tests used. It sounds like the battery of tests that were used at the Faroe Islands are going to be used at the Seychelles. Can we say anything at this point in time about the comparability of those two batteries of tests if they are applied to the Seychelles? Has there been any comparison in any other study? Also, if this new battery of tests is used at the Seychelles, can we put a time estimate on when that information might be available for use in developing an MRL or an RfD?

Dr. Myers: Everyone was waiting for the 66-month data, and now we have that, so now we're waiting on the 96-month data. First let me address the issue of the comparability of the two studies. I visited both Seychelles and Faroes, and I think the populations are very similar. They are both very Westernized, and they both speak English. There are big weather differences, and there are obvious genetic differences in the populations. The Seychelles population is primarily African in origin. The Faroes population is primarily Scandinavian in origin.

After I came back from the Faroes meeting, I drew up a list of the differences between the two studies, and really, they are enormous. The diets are different. There are differences in the fish that are eaten and where they get the mercury from. Omega-3s are either higher or lower in cold water—I always get this backwards—and they are almost nonexistent in farm fish. In the Faroes, they farm salmon, although I don't know if much of that is eaten locally. The details of the study designs and approach are very different, the way we've both approached things. We have taken an approach to look at very early ages. In the Faroes they examined the children at seven years of age in enormous detail with a sophisticated battery of neuropsychological tests. It was very impressive. In Seychelles, the kids are not used to sitting still, so we've limited our test battery to two hours. In the Faroes, their batteries were four hours. The kids oftentimes came from further away.

I'm only pointing out that there were a lot of differences in the designs of the study. They did not really do the exclusions, as best I could tell, except for a few kids who had seizures. It was not clear to me if they excluded them from all their analyses or just some of their analyses. They took a different approach to covariates than we did. We included all the covariates in the full model, and a reduced number in the reduced model, because all of those covariates are known to affect child development.

The battery of tests they used are different. They did some neurophysiological tests that we have not done. The major thing about neuropsychological testing is not so much the test, because there are lots of overlap in these tests. These tests from early ages measure similar sorts of domains and functions. If there are functions or domains that are affected, they ought to be affected at earlier ages too. We have not been able to find any

association yet, looking at this in the functional way that neuropsychologists do. One important thing to keep in mind is that we are looking for associations. We have no assurance that this is causative, but are simply looking for an association. The second thing to keep in mind is that if you establish a level of 0.05, that means that one out of every 20 tests ought to be positive, just by chance.

Dr. Mahaffey: Could I offer just one other comment? Association in epidemiology is certainly always a limitation, which is again one of the reasons why the science advisory board directed USEPA to go back and use the laboratory-based testing of non-human primates in interpreting the findings of the epidemiological studies. It strengthens your interpretation of the associations if the effects are happening in areas where the animal testing has shown that effects occur. The other way of strengthening the epidemiological data is to draw on the wealth of information from clinical studies of severe human poisoning that tells us which domains are affected. So it's not as though we have the epidemiological findings in a vacuum and we're trying to interpret those. There is additional information that strengthens these interpretations.

Dr. Myers: What Kate says is absolutely correct. On the other hand, one of the interesting things that comes out of Japan is that nobody has ever done a study of low-level effects in Japan. There have been no mild cases of mercury poisoning from Japan or really anyplace in the world. If you look at the congenital cases out of Japan, every one of them was severe.

Dr. Mahaffey: Gary, how would you then interpret the Amazonian findings now underway?

Dr. Myers: The Amazon is an interesting place. Dealing with all of the covariates in studies that are epidemiological in nature is really very difficult, and sorting them out when you have multiple things which might influence these same functions is very hard. I'm not positive at this point that they have controlled for all the positive confounders and covariates in a primitive society. When you leave civilization, it becomes extremely difficult to control for all the confounders.

Dr. Mahaffey: This brings back some of the thoughts I've had about generalizability from one study across multiple populations. I think that's something that we need to bear in mind.

Dr. Sara Chasis, Natural Resources Defense Council: Dr. DeRosa, I thought it was notable in your discussion that you made no reference to the Faroe Islands study in terms of ATSDR's recommendation. Was that because of the timing of the release of those

findings or concerns about the study? Do you intend to factor that in as you conclude your analysis and recommendations?

Dr. DeRosa: Yes. Our mandate restricts us from using unpublished information. We were not able to use the Grangene paper because it was released in December, and our report was released in October. But we will certainly be drawing upon that and any other information that comes to us before we finalize the document.

Dr. Tom Hornshaw, Illinois Environmental Protection Agency: I have two concerns about an uncertainty factor of one for intra-species variability. I'm concerned first of all by the Iraqi study, which of course has some problems. But there are some hair mercury levels from the Seychelles study that overlap with the Iraqi study, and you don't see the same effects, on age to walking, for instance. It seems like the Seychelles population is a very good sensitive population because it is well-fed, has free health care, has 95 percent prenatal care, etc., versus the Iraqi population, which, as I recall, is probably, if not malnourished, at least under-nourished, so that you're not comparing the same populations. I would think that, within the whole U.S. population, our sensitive population falls somewhere between the two. So I don't feel comfortable about an uncertainty factor of 1.

The other thing that gives me some discomfort is that I've heard several instances of effects being discounted because they are outliers. Based on what we learned with lead, the major effects at a population level are at the "outliers" at either end of the distribution tail. For those two reasons, I am concerned about an uncertainty factor of 1.

Dr. DeRosa: This is part of the issue that we'll be trying to wrestle with as we go forward with the final version of the document. We will be specifically addressing some of the concerns that have been brought up here.

Dr. Andrew Smith, Maine Bureau of Health: The overheads from Dr. White's report showed they saw a correlation between cord blood mercury and maternal hair mercury of about 0.8. You're explaining about 64 percent of the variants, roughly. It was also interesting to note that the regression coefficients using maternal hair as a predictor were lower compared to cord blood, somewhat consistent with my recollection of epidemiology: if you have any sort of misclassification of exposure, you'll have a bias towards null. I'm curious as to whether or not you've done any work on looking at cord blood, or have any comments about to what extent using maternal hair may be an inferior measure of exposure compared to cord blood.

Dr. Myers: We've discussed this issue at length in Rochester. We have not measured mercury in cord blood at Seychelles. Of all of the studies on methylmercury, the only one

that has used cord blood is the Faroes. The cord blood measures whatever the recent exposure is. If you assume that the highest exposure is the one that has the most effect, and it happens to be near the end of pregnancy, then that's probably your best measure. We have chosen hair because you can recapitulate the exposure during the entire pregnancy, and that's what most people have done in other studies. In Iraq, if you used cord blood, you would have missed the peaks, because those were acute exposures that took place any time during pregnancy. If they took place in early or middle, or even the first part of the last trimester, they would all be washed down to a much lower value at the time the children were born. So we have opted for measuring the longitudinal exposure because there are not significant peaks. We have looked at the hair mercury longitudinally in Seychelles, as well as we did interact—it's a different situation. It's a fairly elevated level that goes on pretty much the same with only minor peaks, changes of only 1 or 2 or 3 ppm over the course of the entire nine months.

Participant: As a public health advocate, I agree with ATSDR's MRL for fish consumption advisories based on the Seychelles data, because I think the Seychelles data are the most relevant human data available that we have, and because of the benefits of fish consumption. However, ATSDR deals with contaminated sites, with the majority of problems related to groundwater contamination, so I would tend to lean towards USEPA's RfD, which is more conservative and strict. Can we have an RfD that is conservative in terms of regulating industrial emissions and clean-up standards, and a slightly different standard when we apply it to food consumption and fish consumption advisories?

Dr. DeRosa: Just a quick comment. You mentioned groundwater as the primary source of exposure for completed exposure pathways, and that is true. But also, 10 percent of our completed exposure pathways are via fish. In terms of having two different values, the issue to keep in mind, from a public health perspective at least, is to lead with the science as opposed to aiming for a particular regulatory position. To assume a regulatory position and then to cast about for the science to support it is risky business. I think what we want to do as a government and as a society, is to get the best version of facts that we can and base our decisions on that.

I was involved in USEPA's ambient water quality criteria document development process in 1980 and we were developing water quality criteria for mercury. It turned out that the algorithm that we used resulted in a water quality criteria that would have been in excess of the levels at Minamata. Based on that, my co-author at the University of Rochester, Tom Clarkson, said there comes a time when you have to just throw out the algorithm or revisit what you're doing if it doesn't pass a certain common reality check. I think we continue to wrestle with what the science tells us. Then we have to go beyond just the numerical number crunching of risk assessment and apply some biomedical judgment in

the interpretation and application of these values. I don't know how to say it any more artfully than that. But perhaps Kate might comment?

Dr. Mahaffey: It's hard to argue against seeking the best science. We find ourselves at this point with important studies with strong designs underway and there is a federal commitment to revisit these studies. We eagerly await the opportunity to fully assess the results. We hope to be visiting the later results of these studies and appreciate the opportunity to do so.

Dr. Ellis: I'd like to thank the speakers and those of you who have asked questions. This concludes this session. Thank you very much.

MERCURY SOURCES AND MITIGATION

Dr. Tom Armitage, Moderator
U.S. Environmental Protection Agency

We've heard from our last panel of experts about the health effects of exposure to mercury through consumption of fish. I think those presentations lead us naturally to a number of questions concerning the sources of mercury in fish tissue and what can be done to actually reduce the levels of mercury in fish.

I think, as a number of speakers have already mentioned at this conference, our long-term public health protection objectives should include not only providing protection through the issuance of fish advisories, but also efforts to reduce levels of contaminants in fish through source control and mitigation.

The mercury cycle in the environment is complex. Mercury is released to the atmosphere and surface waters from a number of different sources. So source control and mitigation present us with particularly challenging problems. Our next three speakers are going to address some of these source control and mitigation issues.

MERCURY IN FRESHWATER ECOSYSTEMS IN FISHES

Dr. Jim Wiener
U.S. Geological Survey

I'd like to take the discussion back into the environment and revisit a history of fish contamination. I think there was a time when people thought this issue had been largely resolved. The contamination problems associated with acute poisonings at Minamata Bay led to an understanding that industrial releases, direct releases of mercury into surface waters, could be a problem as far as contamination of aquatic food chains was concerned.

Considerable effort was made to evaluate the state of the problem and to reduce direct point source discharges of mercury into surface waters. Then, around the early 1980s or so, investigations associated with acid rain and other studies led us to discover the presence of mercury-contaminated fish in inland waters that do not receive direct discharges of mercury from municipal or industrial sources. At that time, I think we became aware that a water body's remoteness does not ensure its freedom from mercury contamination.

So what I'd like to do today is focus on mercury-sensitive ecosystems as problem areas. I think if we look at the current situation with regard to fish consumption advisories, we find that in most cases the waters we're concerned about are lightly contaminated, at least relative to the days of gross contamination and point source discharges. Those waters can be categorized in a number of ways, but this simplistic approach catches many of them—low-alkalinity lakes, acidified lakes, newly-flooded reservoirs, and wetland ecosystems. There are also water systems that don't fit into this very simplistic categorization scheme that do not receive direct discharges of mercury and are under fish consumption advisories.

Now, we know that we have some waters with high inventories of mercury in sediments and low concentrations of mercury in fish. Conversely, we know that there are other waters that have very low inventories of inorganic mercury in sediments and high concentrations in fish. What all of this points to is the importance of methylmercury production within the ecosystem as a factor influencing mercury levels in biota.

How contaminated are fish in some of these lightly-contaminated systems? A point that I would make is that we find our sample —a sample being a group of fish from a given area, a lake, a reservoir, or a site in the Everglades for example—our sample mean

mercury concentrations and maximum mercury concentrations in fish flesh are actually falling into the range that we saw back when we had fairly gross point source contamination. So these lightly contaminated sites can result in significant contamination of our fishery resources.

During the recent decades, there have been major methodological advances that have greatly improved our ability to quantify mercury species and fluxes in the environment. That work is largely a result of Bill Fitzgerald and his students, who developed clean techniques and sensitive analytical techniques for total unreactive mercury, and of Nick Bloom, who developed techniques for direct measurement of methylmercury in dilute media.

Basically what we see is nanograms of mercury per liter, or parts per trillion, in lightly contaminated systems—contaminated but, certainly relative to the point source situation, lightly contaminated. There are probably no uncontaminated systems anywhere, globally, as a result of airborne transport. Total concentrations of mercury in these lightly contaminated waters generally range from less than a nanogram per liter to 4 nanograms per liter or so.

One cautionary note is that if you look at the historical literature in peer reviewed journals, you have to do so with a bit of awareness and caution. For several decades people were struggling to quantify mercury in dilute media and were, in fact, significantly contaminating their samples during the process of collection, handling, storage, and analysis. From 1970 to 1990, there was a decline in the estimated values of mercury concentrations in surface waters reported in the literature. That's not due to environmental improvement. That's due to the ability of scientists to collect and handle samples without introducing contamination. Clean techniques have been a central part of that effort.

As a result of this new information, the way in which we view mercury accumulation in organisms and transfer through food chains has changed. We now recognize that dietary uptake is the primary source of mercury accumulation in fish, and in aquatic animals in general. There are multiple lines of evidence for this.

If we look at the patterns of mercury concentrations in food webs, there is actually a great deal of similarity between food webs in very dissimilar systems. For example, compare data for an Australian marine bay, and a Northern Wisconsin lake. The pattern in both systems is one of increasing methylmercury as a percent of total mercury as you move up the food chain. Once you get to the fish, you're dealing almost entirely with methylmercury. There is also a pattern of increasing concentrations of total mercury as

you move up the food web through higher trophic levels. It is methylmercury that biomagnifies in food webs, not inorganic mercury.

We've learned that fish in lakes receiving similar loadings, lakes with similar chemistries, can actually differ quite substantially. An example of this is Marty Rask's work with northern pike in two very similar Finnish forest lakes. Pike from the lake with forage fish have mercury concentrations sufficient to trigger advisories, concentrations significantly greater than pike from the nearby lake without forage fish.

We've also learned that the structure of aquatic food webs significantly influences the concentration of mercury that we find in fish. In work by Cabana, et al., lake class can basically be translated to number of trophic levels above small zooplankton. So lake trout that are feeding largely on zooplankton have low geometric mean mercury concentrations; lake trout feeding on forage fish have higher mercury concentrations, and lake trout feeding on opossum shrimp and forage fish have higher mercury concentrations still.

My two initial points thus far in the presentation are 1) the inventories or inputs of mercury in an aquatic system can cause significant contamination of biological resources, and 2) the trophic structure in aquatic food webs can greatly influence mercury concentrations in predatory fishes in upper trophic levels.

I'd like to revisit the issue of mercury-sensitive ecosystems as one way of viewing this problem. We have systems that I would classify as mercury-sensitive receptor areas, in which small quantities of inorganic mercury, through efficient formation of methylmercury and entry of methylmercury into food webs, can cause serious contamination. A point I would like to make is that factors other than the entry of mercury into the system can greatly influence the mercury levels in fish.

I'd like to talk about a particular flooding study that was done in Canada. They took a worst-case approach and flooded a small lake and adjacent wetlands, and looked at the bio-geochemistry of mercury and subsequent contamination of water, food chain organisms, and fish (Kelly et al. 1997, *Environmental Science and Technology*). The experimental lake in Ontario was 3 hectares in size before flooding. After flooding, the water level was increased by 1.3 m, and the area of the lake increased from 3 to 14 hectares. The lake was drawn down in October of each year to simulate a managed system in which water levels are drawn down in the fall. We see very, very dramatic increases in methylmercury concentrations in water and zooplankton as a result of flooding. We also see a bit of a seasonal cycle. I think that's probably in part due to microbial activity. The methylation of inorganic mercury is largely a microbial process, and it's very closely linked to temperature, as microbial activity is closely linked to

temperature. The mercury concentrations in fine-scale bass that were held in cages in the lake increased by about tenfold as a result of flooding.

So what we see here is a situation in which we have greatly increased potential methylmercury exposure as a result of land use. No mercury was added to this system. This is mercury that was existing in the system prior to the flooding experiment.

Now, a number of prior speakers have mentioned the issue of sediments as part of this problem. I think a good question is, to what extent are contaminated sediments a problem? The old sins are out there in the sediments.

Looking at a sediment core from lower Lake Pepin on the Mississippi River dated with lead 210 dating techniques and census data from the Minneapolis-St. Paul metro area, it is apparent that the contamination of the sediments follows quite closely the human development of the basin.

What does this mean, and how can we resolve the issue? The issue of sediment geochemistry of mercury and methylmercury is a complex one, but all I would like to offer here is that the issue is not simply a function of mercury levels in sediment. We studied an array of sites on the Sudbury River Basin in Eastern Massachusetts, a Superfund site, where there was significant mercury contamination. Concentrations of total mercury in bulk sediments ranged from 0.1 ppm to about 20 ppm on the extreme end. We took those sediments into the lab and did bioassays looking at methylmercury production, methylmercury in water, and methylmercury accumulation in mayflies.

The water and the mayfly data were quite similar, showing us that the wetland sediments, which were lightly contaminated relative to, say, the reservoir sediments, produced significantly more methylmercury, which led to far more mercury contamination in the mayflies. This work has recently been submitted to the *Canadian Journal of Fisheries and Aquatic Sciences.* But basically what it points to, I think, is system-specific factors that influence the extent to which mercury is a problem.

Now, I would like to end my presentation with some comments about information on effects of methylmercury on fish-eating wildlife. The common loon is an occupant of many of our lakes in north central and northeastern U.S. and in Canada. Initial work suggests considerable sensitivity of this fish-eating organism to methylmercury. The loon is an almost exclusively fish-eating bird, and it has basically few dietary alternatives to fish consumption. The information that's been collected by Mike Myers suggests that the reproductive success of loons, as far as the developing young are concerned, is adversely affected by methylmercury exposure in some systems.

We've invested quite a bit of effort in looking at the bio-geochemistry of mercury in some of the lakes in this same area that Mike is working in. We see tenfold increases in mercury concentrations in whole yellow perch, the primary prey of loons. Most of the prey are fish that weigh less than 100 g. The loons will occasionally take prey up to 250 g in total weight. In terms of a loon chick being fed perch from nearby lakes, there can be enormous variation in dietary exposure as a result of differences in mercury concentrations among lakes and fish.

We think, in large part, these are forested lakes, seepage lakes that are contaminated through atmospheric deposition. We can account for all the mercury in fish as a result of atmospheric inputs. We think that the differences in mercury concentrations among lakes are due to differences in in-lake mercury processing. Methylation, of course, is a key factor. There are variations in methylation effectiveness among these lakes.

What Mike has shown is that there is in fact an inverse relationship between pH and mercury—young loons nesting on low pH lakes containing fish with high mercury concentrations have much higher mercury levels in their blood.

What's interesting is the potential effect of methylmercury exposure on the reproduction of loons. The loons are very territorial and defend their nesting territories rigorously. We see that loons that have blood mercury concentrations exceeding 0.3 μg/L have much lower reproduction levels as far as hatching rates and fledgling rates are concerned.

My final point today is that fish-eating wildlife may be adversely affected by dietary methylmercury in ecosystems with mercury-contaminated fish. I would generate a plea for assessments related to the costs of methylmercury exposure.

Open Discussion

Participant: Jim, there has been a lot of attention recently looking at dissolved organic carbon and pH in lakes. Can you comment on that? It also seems to be a really important factor.

Dr. Wiener: I think dissolved organic carbon certainly is an important factor. I hesitate to say too much based on a lot of the work that's been done, which is simply correlational in nature. I think perhaps one of the best ways to look at that is through some of the manipulative experiments that have been done, where pH has been varied experimentally in whole-lake manipulations, in mesocosms, and in microcosms. There I would point to the fact that we see significant variations in net methylmercury production as a function of pH. I think dissolved organic carbon is probably an important variable influencing

transport and bioavailability of the mercury. I think pH is also probably a significant factor.

Mr. Larry Schwarzkopf, Fond du Lac Reservation: We conducted some studies of wildlife and mercury levels in reservoirs that fluctuated annually. Up in our region, we found what seemed to be a higher level of mercury than we would otherwise see. The question I have, though, is, do you see a large effect of wetlands on mercury concentrations in lakes, even where there are no direct anthropogenic sources? Also, perhaps land use effects could factor into the flow of water through wetlands?

Dr. Wiener: I think work that has been done by investigators in Winnipeg and by Jim Hurley in the upper midwest shows that the total area of wetlands in a watershed certainly affects methylmercury export from the watershed. Wetlands are active sites of methylmercury production.

It's very clear that there is very significant production of methylmercury in wetlands from inorganic mercury present. We don't really understand all of the reasons for that, but certainly I think wetlands offer environments with the right redux conditions, a lot of organic carbon, and a supply of inorganic mercury. You don't need much, obviously, to provide a very conducive environment for production of methylmercury.

Mr. Schwarzkopf: In conjunction with that, do you see an improvement in, or protection of the quality of water bodies through changes in land use practices, such as in riparian zones and buffer zones?

Dr. Wiener: Well, a point I want to make is that land use manipulation is certainly a significant factor influencing exposure of populations. I think the Canadian reservoirs are a good example. You flood an impoundment and for two decades you get a tenfold increase or so in mercury levels in predatory fish. We could work awfully, awfully hard at reducing emissions to get mercury levels in fish down by half, if that were even possible.

So I think it's important to consider some of these other processes that can greatly influence methylmercury production and exposure of populations.

U.S. ENVIRONMENTAL PROTECTION AGENCY REPORT TO CONGRESS

Ms. Martha Keating
U.S. Environmental Protection Agency

I am going to limit my discussion this morning to mercury emissions. The USEPA Report to Congress covers a large number of areas, including modeling and deposition modeling, as well as health effects. But I will limit myself to the data that we will be presenting in the final draft of the report.

The Clean Air Act mandate states, "The administrator shall conduct a study of mercury emissions from electric utility steam generating units, municipal waste combustion, and other sources including area sources." We should include the rate and mass of such emissions, and then these other things that really form the rest of the study—the health and environmental effects of such emissions, technologies that are available to control such emissions, and the cost of these technologies.

Effectively, the mercury emissions inventory that we present in the report was the first activity that we started on in 1992 and has since been updated at least twice, including this most recent time, to try and get the best data available from as many sources as we could.

For the mercury emissions inventory, we used an emissions-factor-based approach for most source categories. The quality of these emissions factors is going to vary. Basically, as we go through the regulatory process for several source categories under the Clean Air Act, we're able to collect new data, and as a result we have better information, more recent information on these sources. Over the course of this study, we have been able to update important mercury emissions data for some very important source categories, principally the municipal waste and medical waste incinerators.

We also have a number of uncertainties from the emissions-factor-based approach in terms of estimating how much control of mercury we'll get from conventional control technologies. I'm sure you're probably all aware that mercury, although it's a metal, is emitted as a gas and is not effectively captured by conventional control techniques that might be used for particulate matter or other pollutants. So there is some uncertainty here in figuring out how much mercury these technologies would capture.

"Activity levels" refers primarily to production rates and things like that. When we're talking about, for example, municipal waste combustion and we look at an emission factor based on tons of waste burned, that would be the activity factor. For our most recent inventory, we updated to about the 1994-1995 timeframe. We used 1994 data for fuel usage such as coal, oil, and gas, because it is the most recent data available from the DOE for these types of sources.

Speciation of mercury has turned out to be a critical component of the modeling exercises. Whether mercury is emitted in its elemental form or its inorganic form, and whether or not it's bound to particulates is really critical to assessing deposition from these types of sources. Speciation test data are extremely limited, and this is a research need that we elaborate on in many places. We did have, at the end, speciated data from medical waste incinerators from recent tests down in Florida. There is some data on utility boilers as well, and on municipal waste combusters. So those kind of data are filtering in.

Major contributors to the mercury emissions inventory include the coal-fired utility boilers (not oil or gas), coal-fired commercial and industrial boilers, medical and municipal waste combusters, chlor-alkali plants (chlorine manufacturers using the mercury cell process), and cement manufacturers.

A best estimate of total mercury emissions inventory is 159 tons per year. We have the area source category contributing only 3.4 tons per year. Combustion contributes 138 tons per year; manufacturing 16.5 tons per year, and a lot of that is from Portland Cement and chlor-alkali plants; and geothermal power plants contribute the remaining 1.1 tons per year.

Under combustion (138 tons), about 52 tons are from utility boilers, 29 tons are from municipal waste combusters, 16 tons are from medical waste, and about 7 tons are from hazardous waste combusters. I should note that the 1994-1995 numbers for the municipal waste and the medical waste source categories do not include reductions that we expect to see from these source categories when the emission guidelines are fully implemented in a couple of years, I guess by the year 2000 or so.

The mercury emissions inventory is always a moving target, as any emissions inventory is. We do have a number of categories that we could not make estimates for, which we think could be important. Petroleum refineries, coke ovens, iron and steel—we didn't have any mercury test data for those.

We have existing mercury emissions information from a lot of source categories where, again, the data could be improved, including secondary mercury recycling. These are the

places that take mercury waste such as fluorescent lamps and batteries, and recycle it. We have an estimate that is highly uncertain for those. Recycling is actually a source where we will expect to see an increase as more recycling happens nationally, especially on account of state regulations on mercury products recycling.

Commercial and industrial boilers—these are being evaluated now under our integrated combustion rule. Again, we need to improve those numbers, especially the coal numbers.

Lamp breakage pretty much refers to fluorescent lamps. This is an issue for our Office of Solid Waste at this time, and for states who are looking at mandatory recycling for fluorescent lamps. As I said, we need those speciated data for all these sources. Another thing that we could look at is whether there is variability over time or season for some of these types of source categories.

The use of mercury in industrial products peaked in 1964. This data is taken from the Bureau of Mines data, which tracks all of this. Between 1980 and 1993, demand fell off by 74 percent, and by more than 50 percent since 1988.

The industrial manufacturers are shifting away from mercury use, except where essential. It's still essential in fluorescent lights and in some of the mercuric oxide batteries, especially for medical uses. We attribute most of these declines to the federal bans on mercury additives in paint and fungicides. Paint used to be a huge source category.

The battery industry has made significant efforts to remove mercury from batteries. Now there is federal legislation on batteries. But a lot of the reductions in terms of manufacturing have already taken place. The states have played an incredible role in looking at products and regulating mercury emission sources within their own states.

So what do we predict in terms of mercury emissions? We will still see significant decreases from municipal waste and medical waste incinerators, probably at least 95 percent reductions from those source categories. I think medical waste will be expected to drop down to about 1 ton per year, and municipal down to about 6 tons per year.

We had a lot of plant closures in medical waste incinerators over the last few years, like 2,000 or so plant closures. The small ones are consolidating, going to commercial incinerators. Hospitals are finding it easier to ship their waste off-site than burn it themselves. So we had lots of small plants close.

Manufacturing use will probably continue to decline. However, the chlor-alkali plants, there's 14 of them now, are very old. Some of them have been operating since the 1940s,

some earlier than that. Those manufacturers really don't expect to shift much production away from these plants unless their clientele changes and they need to change for economic reasons. It's a very expensive process to change. One plant is in the process of shifting away from the mercury process.

Mercury emissions from utility boilers are always of great interest. We think that these emissions are going to be dependent on a lot of things, including the future energy needs of the country. We are continuing to increase our energy usage. But we have a lot of other things happening now with utility boilers, particularly impacts of other Clean Air Act authorities, like the acid rain program. Now we have the new ozone standard, of course, the new particulate matter standard. We think we'll get some co-control benefits from those. Then just this week at the Kyoto conference, we found out we probably will be getting some reductions in greenhouse gases, which should impact mercury emissions as well, depending on the extent of fuel switching or other kinds of measures the utilities take.

On the other hand, we also have restructuring issues, where the utilities will be going into a free market system. Lots of analyses have been done on whether coal use will actually increase or decrease under various types of restructuring scenarios, when folks can pick their utility company.

The mercury emissions inventory was ultimately used in the report to do a long-range transport analysis of wet and dry mercury deposition nationally. Deposition appears to be ubiquitous across the United States. We see more of it in the eastern part of the country where the weather patterns affect deposition and where these sources are located.

What affects the deposition the most is where these sources are located, because this is not just a global problem, although we do certainly have global circulation of mercury. The species of mercury emitted affects whether the mercury will be deposited near the source, go into the global pool, or become more of a regional problem. Sources that emit more divalent or particulate mercury are more likely to have deposition closer to the source.

We see most of the mercury being deposited through wet deposition, which means in a rain or snow event. This is primarily, again, the divalent form of mercury. So the climate and the weather patterns factor in here a great deal. We also have U.S. sources contributing to the global pool. A lot of this is attributable to utility boilers, where we see the split between divalent and elemental mercury, leaning more towards the elemental side, which is more likely to be transported long distances.

We have areas of high deposition on the East Coast, from say Washington, DC on up through southern Maine, particularly in highly urbanized areas. The southern Great Lakes region and regions in Florida also have higher deposition than the rest of the country. A lot of that has to do with the large number of sources in those areas. In the western part of the country we don't see the higher deposition; a lot of that has to do with the dry climate.

When you come out with a regulation, you generally have to prove that there is a benefit to requiring such regulation, at least on the federal level. The benefits assessment for mercury regulation, which we haven't done, although we have developed a framework for doing it, is confounded by this whole issue of global mercury emissions and how much global transport impacts mercury deposition in the U.S., as well as how much mercury contamination has been caused by natural sources. Another confounding issue is past uses of mercury, historic deposition from uses such as mining and paint production, where the mercury was previously deposited by sources that are no longer there and is then re-emitted and re-deposited.

So basically when we try to look at it on a source category by source category basis, not only is it impossible at this point to quantify how much mercury in fish is due to a particular source category, we also have to account for these other types of sources. I think Carol Andrews is going to talk about the reduction program in Minnesota, where they have recognized this problem and are looking at a more holistic approach and at the least-cost approach, rather than looking at it on a source category by source category basis. USEPA will be moving in that direction as well.

The second thing is that a lot of the impacts that we see from mercury contamination are not easily expressed in dollars. Some of these have to do with cultural values of subsistence people, native people, the fact that fishing is part of their culture, the fact that people may not have free choice of food supply due to contamination. These things are certainly not easy to put a dollar value on.

Third, we have to consider total mass loading, because the impacts from any single source, or even a source category, are likely to be small if we use our traditional approaches of running an exposure analysis and just looking around a single source plant. What we need to be looking at is the total mass loading. Again, the traditional approach of end-of-pipe controls is not conducive to this type of analysis, and we need to start moving toward looking at a more holistic approach.

Next, controlling mercury emissions can be difficult and costly, particularly when mercury is a trace contaminant of fuel. That's a real issue, particularly with the utility boilers. We have pilot scale data from this source category, and we know that the costs of

reducing mercury emissions from utility boilers are extremely high. So looking for cost-effective approaches and, as Carol is going to talk about, the least-cost approach, is a real need in the future.

Then we have the scientific uncertainties. The gentleman, I think, from Vermont brought up the political realities of folks setting fish advisory limits. Basically, the RfD, hopefully, and the MRL—those are scientific processes removed from any politics. But then the decision-makers weigh in, and politics become a reality. They are the ones who must weigh the scientific uncertainties and look at the cost benefit and the feasibility of controls and other kinds of economic factors before these types of decisions are made.

Just as a closing, I'm always pleased to address the state agencies. I think most of you may be public health people, and I just wanted to tell you, for those that aren't familiar with it, that the Northeast states have recently completed a study that's out for peer review. They came together as a group of eight states to look at the emissions inventories for those states, to compile their fish data, compile their monitoring data, and pull this all together to try to work collaboratively as a region to address some of these problems. I think you'll find it interesting when they release that report in February. They have looked at some of the water quality parameters and identified those as areas for future work. They're working on their action plan.

I know North Carolina is trying to integrate their water, waste, air, and public health people into a task force to look at this problem across all of those media, and across what certainly in USEPA are organizational impediments. But I would encourage you to do that. New York is now active, and Arkansas. So I hope that you will use this forum to get to know each other and work on this regionally and collaboratively.

Open Discussion

Ms. Luanne Williams, state toxicologist from North Carolina: I am asking for your help, your assistance, from any of the states where you have listed the major sources for your state, or identified the major sources in your state and applied that to areas where you have issued fish consumption advisories; that's what we're currently doing.

We'd like to know, what are our major sources of mercury? Are they in areas where we have actually issued fish consumption advisories? Is there a pattern? What can we do, not only as representatives of the health agency, but also working with environmental remediation programs, what can we do to minimize the release of mercury and prevent our fish industries from disappearing?

It's getting worse and worse each year. We just recently issued a statewide advisory, and it's really sad. So if any of you all have done this, if you would like to share your ideas with me, I'll be back here after this session. I'm very interested in what you have to say. Also, you mentioned the major sources of mercury were coal-fired power plants, commercial and industrial coal-fired plants, municipal solid waste, medical waste incinerators, and . . .

Ms. Keating: The chlorine manufacturers, which you have down in Wilmington.

Ms. Williams: Okay. Well, I might have missed that. Thank you very much.

Mr. Gary Ginsberg: Can you just briefly comment on the importance of ozone in mercury deposition and whether or not we'd expect to see a significant drop in mercury deposition if the ozone problem was addressed in a more productive way?

Ms. Keating: Yes. Actually, when Russ Bullock, one of our colleagues at the Office of Research and Development who did the long-range transport analysis, looked at this issue for the Northeast states, he took a variety of scenarios. First of all, it's only going to affect elemental mercury, because it has to be oxidized into its divalent form before it can be precipitated out by rainfall.

Russ looked at the elemental concentrations over the NESCOM region and then ran a series of what-if scenarios in regard to the ozone levels and didn't see a lot of difference at this point. He had some interesting theories about that; that is, there is a lot more than ozone out there as an oxidizing agent. That's an area for future research.

But what if, down the road, we reduced a lot of emissions from municipal waste and medical waste incinerators, and so you have this global pool of primarily elemental mercury? What will happen is most of the mercury deposition will then be coming from the global pool, which is elemental. So ozone may become a factor in the future in areas where there are high ozone concentrations, which would not only affect how much mercury was being deposited, but where. So you'd probably see your urban areas being affected more strongly by deposition. The analysis didn't show enough to even really mention, but we did look at it.

Ms. Sarah Chasis, NRDC: Did you expand your analysis of measures that could be taken to address coal-fired plants to look at some of the less costly alternatives, such as treating the coal before it's used, or focusing on sources of coal that have lower levels of mercury initially?

Ms. Keating: Yes and no. We certainly expanded the discussion to look at other, less traditional approaches, I think we called them, such as emissions cap and trade, co-control, looking at other pollutants and controls for those pollutants. We didn't cost those out because it would be another eight-volume report in itself. However, on the coal-cleaning side, I think there is a misconception, first of all, that there exists a low-mercury coal. It's not like sulphur in coal, where you can look at different seams. The range of mercury in coal, the variability is actually quite small. So it's not like you can switch to another coal, except in the case of lignite, where the British thermal unit value is such that you have to burn twice as much. So it's kind of a wash there.

Most utilities already burn washed coal. We estimated that you would get about a 20 percent reduction; looked at what coals people were buying, what seam they got them from, how much mercury was in those seams, and so on. Electric Power Research Institute estimates a higher amount of coal washing. The DOE has been doing a lot of research on advanced coal washing which they haven't costed out yet, so we weren't able to cost that out. But they said it was extremely expensive. I don't have any more information on that.

MINNESOTA MERCURY REDUCTION PROGRAM

Ms. Carol Andrews
Minnesota Pollution Control Agency

Although we have evidence that actions taken to reduce mercury use and release are having impacts on environmental deposition rates, which is good news, a state such as Minnesota acting alone will have very limited ability to reduce the concentration of mercury in our lakes by reducing emissions from our sources alone. There's a real need for national and international cooperation to reduce mercury emissions. I think forums such as this are really useful.

I'm going to quickly touch on three things today. Before I talk about our initiative, I want to mention some research that's been going on in Minnesota on sediment cores, talk a little bit about what has been done, and then get into the initiative and what we hope to do next.

We looked at sediment cores collected in lakes. What we see for mercury deposition in Minnesota is a rapid increase, especially in the early to mid-1900s, peaking in the 1960s and 1970s, and then decreasing. What I'm saying, number one, is good news, that I think it's nice to see an environmental indicator such as this show a payoff for actions taken to reduce emissions. The bad news is that global mercury levels, or the estimated global deposition has continued to increase pretty steadily. That gets back to the point that I made before, that even if we get rid of our regional sources, if the amount of mercury circulating continues to go up globally, we're going to hit a point where we can't do anything locally anymore, yet we'll still have a problem.

There are two main causes for the decrease in mercury deposition in Minnesota. First is the actual decrease in the mercury emissions themselves resulting from decreased industrial use, incidental capture by control equipment, and a couple of other reasons, including the cessation of uncontrolled waste incineration.

The second is a shift from regional to global impacts from the mercury that is released. For example, the average stack height of a coal-combusting boiler has increased tremendously. So you're going to get much more long-distance transport. Also, the mercury that is captured incidentally in the control equipment installed to collect particulate matter will tend to be the ionic mercury which is what would otherwise be deposited locally. It's water-soluble and typically associated with a particulate. The more difficult to capture mercury, the elemental mercury, is going to move globally.

Ed Swain did a little estimate of where the mercury in Minnesota is coming from. Where are the sources located? Thirty percent of the mercury comes from natural sources such as volcanoes. Only about 10 percent is estimated to be from sources within the State of Minnesota, and only a quarter from sources within the Midwest. So this gets back to my point about our limited ability to impact mercury deposition as one state acting alone.

Minnesota has a host of laws pertaining to mercury that have mostly been really effective, including laws on mercury content of batteries and outright prohibition on use of mercury in things like toys, games, and apparel.

Product stewardship refers to programs like the one at Honeywell, a manufacturer of thermostats with mercury in them. They use labeling and have a take-back program to ensure that the mercury is properly managed.

As a result of these programs, mercury is no longer used in most batteries and the incinerator emissions in the state have been reduced from around 1,500 pounds a year in 1990 to less than 500 pounds a year in 1995. Most of that is due to getting the mercury out of the products and to added controls on our largest, 1,000 ton-a-day, incinerator in Minneapolis; that was responsible for a reduction of about 300 pounds a year, I think. A medical waste incinerator shutdown has also had a big impact. So if you look, there has been a huge decrease in the intentional use of mercury over the last five years, while energy production has stayed about the same. The five major areas in which mercury emissions were reduced over the last five years were mercury use in latex paint, which has been just eliminated; medical waste incineration; fluorescent lamp breakage; fungicide volatilization; and incineration.

If we look at the remaining sources in 1995, we could make a reduction of maybe another third by going after intentional use, the easiest and lowest-cost target. A lot of people are saying this doesn't seem too fair, and what if this isn't enough just to get rid of intentional use?

So we have an initiative. Which sources should be targeted to reduce mercury emissions at the lowest cost with the greatest effect? The cost/benefit analysis is really difficult. How should emissions be reduced? Who should pay for it? That's always a really good debate, too. So the goals of the Mercury Contamination Reduction Initiative, which is funded by a USEPA grant, include three things. The main thing is to achieve significant reductions in mercury contamination. We intentionally chose the word contamination here, and not just releases, because the idea is to get rid of the need for fish consumption advisories altogether.

What we're aiming for one year from now is a report where we've looked at all the sources and what they are doing to reduce mercury emissions. What will they be doing in the next five years, and what should they be doing off into the future?

There are three groups that we're working with. The main one right now has been an advisory council of 30 stakeholders, including Larry Schwarzkopf from the Fond du Lac Reservation, four or five representatives from the utility industry, representatives from other sources, other environmental groups, and also state agencies, including our Minnesota Department of Health.

We're trying to get everybody educated and get all the facts on the table, and then plan our recommendations and develop a program that has support from the stakeholders, as opposed to trying to come up with our own program and then go to the legislature and argue there; that usually doesn't work.

Also, we have a conference call once a month with nine states and Ontario to learn from the other states, and try to ensure that what we come up with is useful to the other states. We hope to start something called the Correspondence Council. This is our effort at reducing your time spent in meetings but letting you participate using e-mail, some written communication, and a Web site to make our plans available to the public for comment.

Fall 1998 is when we hope to come up with a draft report. I think we'll try to be finished by the end of 1998.

I have two conclusions, one aimed at the people who are wondering if this is going to be something you're doing the rest of your life. Will your offspring be doing this, too? I can say that there really is a lot of work being done to reduce mercury releases. But as you've heard, how long it will take to see results of that in the environment is an open question.

For those of you that are wondering what message should I be taking back, for example, to my tribal council, mercury is not a nutrient. It would be best if everyone could eat more fish that contained less mercury. So that's what we're working toward.

Open Discussion

Mr. John Persell, Minnesota Chippewa Tribe: I just wanted to comment here. I think it's interesting to note that Minnesota—and we're fortunate as a tribe to be in Minnesota. We do have our differences, of course, but it should be noted that Minnesota is leading the way. We're one of the most regulated states in the country, I believe, and one of the most taxed, too, as they say. But the economy in Minnesota is also one of the highest,

one of the best. The bond rating has certainly been right up there. I just think it's important to note that we can regulate, and a clean environment does in fact promote a clean economy, or a good economy.

METHODS FOR DEVELOPING AND COMMUNICATING MERCURY ADVISORIES

Mr. Jim Amrhein, Moderator
Wisconsin Department of Natural Resources

I think Dr. Anderson hit it on the head yesterday when he said the best risk assessment in the world isn't going to do you any good if you can't take that information, summarize it in some way, and get it out to the public in a way that is very understandable for them. It's just not going to do any good whether the number is 0.5 or 0.1, or whether it's PCBs or mercury. We need to have programs where we can take the fish contaminant information, decide what the contaminant levels are and how they relate to the fish and the fish consumption, and then put it into an easily understandable format.

We're going to have five speakers today that are going to go over their various programs and explain how they come up with fish advisories, put them into some type of format, and get them out to the public.

Dr. Gary Ginsberg
Connecticut Department of Public Health

Based on the December 1994 target date of the mercury report to Congress, and looking at the fact that mercury concentrations in lakes and ponds from New Jersey all the way up through Maine were fairly high compared to what we were seeing in rivers and streams, we felt that we needed to have a focused monitoring program on Connecticut lakes.

So in 1995, 52 of the state's lakes and 2 rivers were sampled primarily for largemouth bass and some panfish. Tissues were analyzed for mercury. The 52 lakes represent the majority of the state's public access, large, fished lakes. Certainly there are lots of other lakes that weren't sampled, but we were looking at this as somewhat representative, at least of our larger water bodies.

In 1996, based on the results from 1995, we went after 6 additional lakes that we thought might have high mercury concentrations, and we expanded the sampling to include not only bass, but pickerel, and, again, panfish. We also looked at some seasonal issues, because you won't necessarily get the same results from fish sampling in the spring,

summer, and fall. This appeared consistent with the literature. So we looked at that, and also conducted biomagnification studies in two ponds.

Our results overall showed that the statewide average mercury concentration in fish tissue ranged from 0.2 to 1.2 ppm. The maximum detection for a single fish was 2.6 ppm. We had four lakes that sort of stood apart from the others, where the mean bass mercury concentrations were greater than or equal to 1 ppm. By and large, the others were well below that. Regarding differences between trophic levels, mercury in panfish tended to be lower. By that I mean perch and suckers and some of the smaller fish had lower mercury concentrations by a factor of roughly 2 or 3. Seasonal differences were also found.

The state was divided up into five eco-regions—Southeast, Northeast, Northwest, Southwest, and Central Lowlands. There were statistical differences between the eco-regions in terms of mercury concentrations in the bass and there was a very strong correlation with pH. Actually, it exactly matches the pH profile, with the lowest pH being in the Southeast and the highest in the Central Lowlands.

We did a focus study on two lakes to determine the seasonality of mercury concentrations in bass. Both for Lake Lillinonah and for Pickerel Lake the concentrations ran 35 percent higher in the spring sampling than in the summer or fall sampling.

Over winter, the fish are not feeding and they are losing fat mass. So in the springtime they will have a higher protein-to-bodyweight ratio, and so a higher mercury concentration. This brings up some obvious sampling issues. It also brings up questions such as when are people fishing in our waters? When are they catching fish? Is the 0.69 ppm mercury concentration in fish at Lake Lillinonah more relevant to our fish eaters, or the 0.5 ppm measurement?

A lot of fishing does happen in the spring, so we are concerned about that. We're looking at the lakes that were somewhat borderline and going back and considering resampling in the spring.

Being a toxicologist, I'm going to focus a little on how the risk assessment process led us to our fish consumption advisories. I'll give you the bottom line now—a statewide advisory for mercury for all fish in the state. We recommended that the high-risk groups—pregnant women, women planning pregnancy within one year, children under the age of six—eat no more than one meal per month of the state's freshwater fish. For everyone else, no more than one meal per week.

Here's how we got there. The Iraq studies have already been discussed. We relied on the USEPA RfD of 0.1 μg/kg/day as a developmental RfD, and the adult RfD for non-high-risk groups of 0.3 μg/kg/day. We used that threefold difference as a key to distinguish between the amount of fish that could be consumed by the general population versus the high-risk group.

We spent more of our time in the risk assessment process looking at the animal toxicology literature. Given that there was controversy over some of the newer epidemiology studies and some of the limitations of the Iraq data, we just wanted to see whether or not the animal data were supportive, or if they took us in a different direction relative to the RfD.

We looked at the data for monkeys. Pregnant monkeys got 50 μg/kg/day and more of methylmercury in apple juice. There were clear-cut neurological effects in the offspring at a level of 50 μg/kg/day, things like impaired memory, visual and auditory functional changes, and behavioral changes. No NOAEL was established in these monkey studies, probably because they didn't test at low enough concentrations. There was a suggestion of an effect at 10 μg/kg/day but there wasn't enough data to really call that an effect level or a no-effect level.

The reason I'm focusing on these monkey studies is because these are not high-dose, acute studies. These are fairly low-dose product studies that are very relevant to a reproductive endpoint. When you have an RfD of 0.1 μg/kg/day, and a clear-cut effect level at 50 μg/kg/day, it's not a far stretch between where the animal studies were dosing and where USEPA's RfD is.

Also, rats were dosed during gestation and had poor performance. The offspring had poor performance on a lever press/reward system, with a NOAEL of 5 μg/kg/day. The effect level was 10 μg/kg/day.

So there is some convergence there between the monkey study and the rat study, at least in our eyes, that there are reproductive effects in animals down in the 50 μg/kg/day range, perhaps somewhat lower, with a NOAEL level of 5 μg/kg/day. The USEPA RfD is about 50 times below the animal NOAEL. A typical safety factor to put on an animal NOAEL in deriving the safe level that you'd be willing to expose people to on a day-in and day-out basis would be about 100-fold, although that can vary.

So at 50-fold, we felt fairly comfortable that the animal data supported an RfD at least as low as 0.1 μg/kg/day. On that basis, we moved forward. We were aware of other epidemiology studies from the Cree Indians in Quebec and the New Zealand study, which

had numerous limitations and uncertainties, but overall were supportive of a neurological effect in offspring with a threshold of about 10 μg/kg/day.

How did we go through the process of going from an RfD to developing a fish consumption advisory for methylmercury? Our approach was pretty standard, but keep in mind we have two different RfDs working, a developmental RfD and an adult RfD based on paresthesias. We assumed a 227-gram fish meal size. Our approach was to limit meal frequency based on fish tissue mercury concentrations rather than trying to do a risk assessment based on a fish consumption survey. We assumed we didn't know how much fish people were eating. Our approach was to ask what would be an appropriate consumption frequency of a given fish meal size at the current mercury concentrations found in our fish.

As I said, we decided to provide two sets of advice. We thought that there was enough difference in the effects to separate the high-risk group from the general population. Here we departed from other states.

We wanted to keep our advisory simple for the sake of risk communication. We had four categories of consumption—no fish meals, one meal a week, one meal a month, and unlimited consumption. Certainly there are many other gradations, but what this allowed us to do was to make our advisory very simple; it fits on one page. It allows water bodies and fish species to be organized into a few broad categories.

The overall result is that we have a statewide advisory covering all freshwater bodies and species of fish, with two important exceptions. One exception is four water bodies where we found exceptionally high levels of mercury; we're calling these outlier lakes and we have more restrictive advisories on them. The other exception is trout. Since trout are stocked, most of them are consumed before they have much chance for bioaccumulation. The advisory says unlimited trout can be eaten if they are less than 15 in. long. A fisheries biologist thought that 15 in. was a good cutoff length based on an estimate of how long a 15 in. trout would be in the water, but this is not based on hard data. We would love to get some data to support that. Right now, that's one of our uncertainties.

Here are our four categories, "Do not eat" down to "Unrestricted." The range of fish concentrations is pretty broad in the "May eat once a month" category. We have a range of mercury concentrations from 0.2 to 0.9 ppm in fish under the "May eat once a month" category. Obviously, you can eat fish with a 0.2 ppm mercury concentration more than once a month, but less than once a week. If you can eat the fish less than once a week—in other words, two or three times a month—we lump those fish into the once-a-month category, being overly conservative or overly protective in regard to some of the

smaller panfish species that would have mercury concentration in the 0.2 to 0.3 ppm range.

But from a risk communication point of view, we really try to give people some advice in terms of which species to eat, which species are more of a concern for mercury, and which water bodies have somewhat lower mercury concentration. So if somebody is fishing at one of the lakes with higher mercury concentrations, we may tell them to fish at one of the lakes with lower mercury concentrations. We also provide people with information about alternative sources of protein.

One thing that we think is somewhat unique or different about Connecticut is that we have an acute single meal advisory; that is, if any fish from a given lake has a mercury concentration of 1.5 ppm or higher, we advise against consuming any fish from that lake.

Our advisory—all of our water bodies and all of our consumption advice—fits on one page, and we're fairly proud of that. We have general advice about mercury. We have advice about PCBs and chlordane for some other specific water bodies. At the top of the advisory are the four water bodies that had particularly high mercury levels, and there is specific advice about them.

Risk communication—we created a pamphlet and mailed it to local health directors, tackle shops, and the National Association of Women, Infants, and Children (WIC) clinics. We posted warnings about mercury contamination in the fish at public access lakes and rivers across the state. The signs and pamphlets have been translated into Spanish and Southeast Asian languages. We're developing a fish consumption video targeted at Southeast Asian immigrants. We issue a press release in the spring, and our advisory appears in the annual fishing guide.

To conclude, I would like to comment on our acute single fish meal advisory. If one fish in a lake has a mercury concentration of 1.5 ppm, it's a concern to us. This is based on a pharmacokinetic model that we developed that looks at mercury concentrations in maternal hair over time after consumption of a single fish meal.

The model shows that a woman who consumes a single fish meal with a mercury concentration of 1.5 ppm will have a hair mercury concentration just at or below 1.1 ppm, which is the risk goal for hair concentration during pregnancy. As soon as you get a mercury concentration above 1.5 ppm in fish meal, pregnant woman would theoretically have a hair mercury concentration above 1.1 ppm for close to 30 days. So if you buy into the concept that it's important to keep the maternal hair mercury concentration at the benchmark threshold level of 1.1 ppm, then you can see that the pharmacokinetic model predicts 1.5 ppm as a reasonable cutoff concentration for one fish meal.

Dr. Andrew Smith
Maine Bureau of Health

What I'm going to do is quickly run through the fish consumption advisory program in Maine. It's a new program. We've really only been at it since 1993, when we started to get some data. I'll just touch briefly on what the current advisory is in Maine and then explain how we actually derived it, what sort of fish tissue data we're relying on, how we communicate the advisories, and a little on what we know about the effectiveness of the advisories.

The advisory in Maine states, "Pregnant women, nursing mothers, women who may become pregnant, and children less than eight should not eat any warm water fish species caught in any of the inland waters in Maine. Consumption of cold water species should be limited to a meal per month." Warm water species include bass, pickerel, perch, sunfish, and crappie. Cold water species include trout, salmon, smelt, and cusk. It's a very restrictive advisory for our sensitive population.

The general population, meaning everybody else, should limit consumption of warm water fish species to two to three meals a month. That's not much of a limit on behavior. For cold water species, there are no consumption limits.

Now I'll explain how we derived the advisory. We followed standard USEPA guidance for coming up with our detection levels and for issuing advisories, focusing on number of meals per month. We are using the current USEPA RfD of 0.1 μg/kg/day of mercury for sensitive individuals. We also use the old USEPA Integrated Risk Information System RfD of 0.3 μg/kg/day of mercury for the general population.

So again, we do one analysis for our sensitive group and another analysis for the general population. Our database contains composite average concentrations, so we're looking at average mercury concentrations in fish. Using an eight-ounce meal as a standard, we determined how many fish meals someone can safely eat per month.

We determined that our sensitive population could safely eat one meal per week of fish with average mercury concentrations up to 0.2 ppm and one meal per month of fish with average mercury concentrations up to 0.8 ppm.

We then make a policy distinction. If we determine that a person can safely eat at least one fish meal per week, then we don't feel a need to issue any sort of advisory. On the other hand, if we determine that a person cannot safely eat at least one meal per month,

we recommend no consumption. For the general population, we would start to advise no consumption at fish tissue mercury concentrations of 2.6 ppm.

There are about 5,900 lakes and ponds in Maine and about 2,000 have been surveyed. We based the advisories on a random sample of the data from the 2,000 lakes that have been surveyed.

There is no pattern of mercury contamination in fish in the lakes and ponds of Maine. An example is Acadia National Park. We have two lakes right next to each other, and in one lake the fish are so highly contaminated with mercury we would advise no consumption, and in the other lake there's no need for an advisory at all. This made us feel very uncomfortable about trying to do anything other than make a general statistical statement for the state.

If you split the fish into warm water species and cold water species, you see a significant difference. Warm water fish tend to have higher concentrations of mercury than the cold water species. A considerable fraction of the warm water fish species had mercury concentrations above the level at which we would advise no consumption for the sensitive population.

We don't know why there's this difference between warm water and cold water fish species, but our guess is that it's an age distribution issue. In Maine, the most popular species are cold water fish, and they are harvested extensively. We stock about 1.2 million cold water fish a year including landlocked salmon, brook trout, brown trout, and a couple of other species. Most of those fish are caught within one or two years. The warm water species are older fish that have been in the waters longer than the cold water fish species, and therefore have higher mercury burdens.

What drove the advisory? Twenty-three percent of the lakes had warm water species with mercury concentrations that warranted a consumption advisory. But we can't identify which lakes these are. On average, anglers have a one-in-four chance of choosing a lake containing warm water fish with high mercury concentrations. We made a very conservative public health decision to extend the no-consumption advisory to all warm water species.

The driving factor for the cold water fish advisory was that only 3 percent of the lakes surveyed had cold water species with mercury concentrations that warranted a fish advisory for the sensitive population. Very few lakes warranted any sort of cold water fish consumption advisory for the general population and those that did were very close to allowing the upper limit of three meals a month or so. That's why we have no advisory on cold water fish species for the general population.

What have we done to get the message out? Our philosophy is to send the message through multiple channels. In 1994, we mailed out brochures to all fish-license dealers and asked them to distribute them. We include the advisory on the first page of the fishing rule book. We include the advisory for mercury, and any other advisories we have as well. Maine has dioxin and PCB advisories, too. We make up brochures or pamphlets and give them out at conferences and sportsmen shows, like the major Maine sportsmen show where we gave out 10,000 copies. We make as much use as we can of newsletters. The Department of Marine Resources and Inland Fish and Wildlife have major newsletters that post the advisories. We also publish them in magazines. We issue press releases. This year we are also doing the talk show circuit. We take advantage of every opportunity we can to get out and speak about the advisories. We post them on our Web page as well. Again, we're trying to get the message out as many different ways as we can, on a very limited budget.

Does it work? We don't have very much data on whether or not it works. We did put a module into the Behavioral Risk Factor Surveillance System survey, and we're still waiting to get the results back.

There was a survey done in Maine in 1995, immediately after we issued the first advisory in 1994. The advisory was issued in brochures. From that survey, we found that about 70 percent of resident anglers were aware of the advisory. But only 33 percent of nonresident anglers were aware of the advisory. So clearly, we have two different populations we need to reach.

Female anglers were less aware of the advisory than male anglers. Only about 56 percent of female anglers were aware of the advisory. Of those that were aware, only about 22 percent said they actually changed their behavior in response to the mercury advisories. But if you look at their estimates of fish consumption, most of them were following the recommendations of the advisory anyway.

Open Discussion

Mr. Randy Christensen, Aleut Tribe from Kodiak Island, Alaska: The last comment you made brought up a point that I was thinking about this morning, that females are less aware of the advisories. What do you attribute that to?

Dr. Smith: If you get the message to the angler, is the information getting to the woman in the home if the woman is not the angler?

Dr. Barbara Knuth, Cornell University: We've seen that result in many studies, where the female anglers are less aware of the advisories than male anglers. Just anecdotally,

we find that often the male actually purchases the licenses and therefore also picks up the regulations guide. So maybe it's just a result of common male/female behavior, where the man is more likely to purchase the licenses and get the information than the woman. Again, that's just anecdotally. But that does merit more attention.

Participant: How do you come up with an appropriate sample to analyze for mercury?

Dr. Smith: The sampling was done by the Department of Environmental Protection. I believe they would go to a lake and collect four to five, sometimes as many as 10 individual fish. Those would then be composited, into a single sample.

Participant: So I guess they try to collect fish over the full-size range, because there's quite a difference in contaminant levels between the smaller fish and the larger fish.

Dr. Smith: That's an interesting comment. We've looked at that with our white perch data because it's the only data where we have information on 10 or more individual fish per lake. In some lakes we have an absolutely beautiful relationship between length and mercury concentration. In other lakes we don't have any relationship at all. So the relationship between fish length and mercury contamination is very lake-specific.

Ms. Pat McCann
Minnesota Department of Public Health

Minnesota has a long history of giving fish consumption advice. We've been giving fish consumption advice based on concentrations of mercury in fish for at least 20 years. We definitely don't want our advice to discourage people from eating fish altogether. What we'd like to do is give people information to help them choose which fish they eat, from which bodies of water, and how often they eat fish.

We give advice based on both mercury and PCBs, but the majority of the advice for lakes is based on mercury. The PCB advice that we give is based on the uniform protocol for the Great Lakes. There are about 700 lakes that we've sampled. About 687 lakes are in the fish consumption advisory in 1997.

Minnesota has the greatest number of advisories, but that's because of the amount of sampling that we've done, not because we have more pollution than other states. It's just that we've gone out and looked for it, and it's there, and then we give advice.

It's also true that just because a certain lake doesn't have advice, that doesn't mean it's okay or clean or doesn't have mercury. It may just mean that it hasn't been sampled.

In May every year, we release the new advisory booklet, and that corresponds with the wildlife fishing opener in Minnesota, which is a time when most Minnesotans are really excited about fishing. We actually try to get as much press as we can. This year one of the items we stressed was that we had similar advice to Wisconsin, at least on border waters.

There are 2.1 million licensed anglers in Minnesota. We distribute about 30,000 fish consumption advisories. We have a public database and we send out fish advisories to the public on request. We have distributors that help do this—the Minnesota Department of Natural Resources (DNR), state parks, resorts, all kinds of people distribute the advisories.

We also have a number of fact sheets that cover specific populations or at-risk groups. One of these is *The Expectant Mother's Guide to Eating Fish: What you should know if you are pregnant, planning to be pregnant, or nursing a baby.* This brochure is very popular. A lot of states and other groups have expressed interest in copying this brochure. We give this out through WIC groups, and we also try to network with physicians and HMOs to get this brochure out.

We have a fact sheet that gives general advice about eating fish, how to clean fish, and which fish to eat. We recommend eating panfish or smaller predator fish. In Minnesota we have a pretty large community of Southeast Asians, so the fact sheet is available in five different Southeast Asian languages. We have two fact sheets on mercury, one about mercury and the environment, and one about methylmercury in fish.

Beginning this year, we also worked with the fisheries group at DNR to get our information into their public lakes reports. These reports are specific for lakes, and they have lake reports for about 5,000 lakes in Minnesota. These reports cover things like populations of fish, access to the lake, aquatic life, and other lake characteristics, so they are really popular with the anglers in the state. About 40,000 of the lake reports are distributed annually. They are also available on the DNR Web site.

We use a risk assessment method in our advisory program. We use the USEPA-based questions, using the standard 227-gram meal size per 70 kg body weight. We use two different RfDs, one for the general population and one for the sensitive population.

We also give advice for short-term consumption based on consumption during a vacation or during a season. This allows people who only eat fish during specific time periods to consume fish at a higher rate than people who eat fish year-round.

The RfD that we use for the general population is based on the 1990 RfD from the Integrated Risk Information System. Our risk assessment was developed in 1989 to 1991 and we haven't changed it since then. So the RfD for the general population is 0.3 μg/kg/day, and the RfD for the sensitive population is 0.07 μg/kg/day.

The mercury concentration in fish is calculated using USEPA methods. We then calculate the number of meals per month or meals per week that can be eaten by the sensitive or general population. We also have a break down for the vacation and season categories. Our advice is lake or river specific. We give it by species and length. Most annual advisories for the predator fish species fall into the once-a-week category for the general population, and the once-a-month category for the sensitive population.

One big data gap is that we don't know who's eating fish and how much they're eating. We'd like to work on outreach programs for the sensitive population. We'd also like to have the Great Lakes states develop a uniform protocol for giving mercury advice.

Open Discussion

Ms. Rosanna Kroll, Maryland Department of the Environment: I am fascinated by the idea of issuing advisories for vacationers using shorter-term exposure assumptions, etc. I was just wondering, do you still use chronic benchmarks such as the RfD, or are you using acute or subchronic toxicological information for that? The other question is, do you account for the fact that those anglers may go back to their own states and get mercury from other sources of fish?

Ms. McCann: The advice is based on the one-compartment, first-order model that was discussed earlier. It's not a chronic RfD. It would be considered more acute or subacute. They are subchronic RfD.

In the consumption advisory book, we state that if you follow the vacation advice, you can only eat fish from one to three weeks out of the entire year, and for a season it would be up to three months out of the year.

Dr. Andrew Smith, Maine Bureau of Health: I'm very fascinated by the booklet you had for pregnant women. What's the reaction from the doctors on that? Are you actually getting it into their offices and do they have any response to it?

Ms. McCann: The responses I have heard have been very good. Recently, I was called by a nurse whose physician had asked to get more of the brochures. So I think they do really like it.

Dr. Smith: Do you have direct outreach to the physicians or are you mailing information to them? How do you actually communicate with them?

Ms. McCann: We try to network through the family health division in the Department of Health. They already network with these physicians. So we try to get lists of those physicians and contact them, send them letters, and offer them our materials.

Mr. Alan Hayton
Ministry of Environment, Ontario, Canada

In Ontario our sport fish contaminant monitoring program was started in about 1968 or 1969. Initially, we issued a brochure that listed some of the lakes we had tested, predominantly for mercury, and people were asked to write in or call us if they were interested in information on a specific lake. We would then send out a page of information on that specific lake.

The first year in which we produced a formal guide was 1978, and the guide has been getting larger and larger since then. Our last guide has information on over 1,700 locations. We have sampled at approximately 2,200 locations in Ontario.

We have some fairly complex problems in Ontario. About 99 percent of the inland advisories that we issue are for mercury. Very few of them are for other contaminants. However, in some of our other water bodies, the Great Lakes in particular, we have a number of problems. In Lake Superior, we have problems with toxaphene and dioxins, as well as mercury. In Lake Huron, we have problems with dioxins and PCBs, as well as mercury. Lake Erie has a problem with mercury and PCBs. We have the most problems in Lake Ontario—dioxins, mirex, and PCBs, as well as mercury.

We use a standard approach for all our consumption advisories and all contaminants. Currently we analyze fish for up to 70 contaminants. Health Canada provides us with a tolerable daily intake, a uniform standard for Canada. They provide us with some advice on what proportion of the tolerable daily intake should be allocated to fish consumption. In most cases it's 100 percent, but for PCBs it's still 50 percent. We use a standard adult body weight of 60 kg, which is slightly lower than the 70 kg standard used in the U.S.

Our standard fish meal size is 227 g, taken from angler surveys. We make the assumption that meal size is proportional to body size. In our calculations we work on the assumption that sport fish anglers very rarely consume more than eight meals per month. It's clearly stated in the guide that the advice we provide is based on up to eight fish meals per month, and if they are consuming more fish than that, they should contact us directly and we will give them individual advice. For our calculations, we use one month as a standard time period.

So our objective is to protect all individuals. If your total tolerable monthly intake is not exceeded for any contaminant when eight fish meals per month are consumed, we indicate that intake is unlimited. The other extreme—if you will exceed your total tolerable monthly intake by consuming one fish meal in a month, then we recommend no consumption. In between these extremes, we provide advice on whether people can eat four meals, two meals, or one meal per month. So this is the extent of information we give, anywhere from unlimited consumption to no consumption. We provide advice on how people can calculate what they can eat. We have cutoffs for sensitive groups—women of childbearing age and children under age 15.

The specific method we use for mercury deviates slightly from the methods used for other contaminants. The tolerable daily intake that's provided by Health Canada is 0.47 μg/kg/day. We make the assumption that about 95 percent of the mercury in fish flesh is in the form of methylmercury. This has been confirmed in laboratory studies. We use the 227-gram meal, eight meals per month maximum, and 60 kg body weight. If the mercury concentration in fish is between 0 and 0.5 ppm, then the fish is listed as unrestricted consumption, up to eight meals per month. If the mercury concentration in the fish is between 0.5 and 1 ppm, we recommend eating no more than 4 meals per month of that fish. If the concentration is between 1 and 1.5 ppm, we recommend no more than 2 meals per month. Anything over 1.5 ppm we list as unacceptable for consumption.

We have an extensive sampling and analytical program. Every year we analyze at least 6,000 fish for mercury, and in addition we analyze approximately 1,500 to 1,700 for PCBs, organochlorine pesticides, toxaphene, and mirex, and anywhere between 200 and 250 for dioxins. We do the full range of 2,3,7,8 substituted dioxins and furans. Within a few months, we will be doing dioxin-like PCBs, and we will be including that in our dioxin scan.

When we go to any lake, we collect up to 20 fish of one species over the broad size range that's present. Usually we will collect anywhere from 12 to 15 fish; 20 is the maximum. We found that statistical results are not improved by collecting more than 20 fish. We use the skinless, boneless dorsal fillet because this part of the fish represents the worst

case. From the dorsal to the ventral part of the fish, mercury level declines, and people tend to like the dorsal portion. We sample individual fish.

We then provide consumption advice not for composites or for a species, but for a size range of each of the species that is present in the lake, for example 30 to 35 cm, 35 to 45 cm, and so forth. We provide advice only for the sizes of fish that we collect in a lake, so that if we've collected fish up to 45 or 50 cm, we don't provide any advice for larger fish. We do, however, do a little extrapolation to the ends of the length categories for which we have fish. For example, if we have a length category of 65 to 75 cm and we have collected fish that are up to, say, 67, 68, or 70 cm, we will predict the contaminant level up to 75 cm but not beyond that.

Generally, we provide advice on lakes that we have sampled at only one location. But when we looked at the Great Lakes, we found that we have to block the lake. We have divided Lake Ontario into 11 blocks and sub-blocks based on fish movement and on statistical interpretation of the information. If there were no major differences in contaminant levels within an area, then that area was considered to be one block. If there were minor differences within the block, we based our advice on the worst-case scenario for that block.

We distribute free copies of the guide at the Toronto Sportsman Show where we talk to about 10,000 people. It's also distributed through the Liquor Control Board of Ontario, government offices, and tourist information boards. If people write in, we send them a copy.

There is usually a press release associated with the guide, so it gets into a lot of the local newspapers. We get radio and TV interviews. We have a one-half page advertisement in the fishing regulations, which come out at the beginning of the year. The advertisement has a picture of the guide and information on when it will be available, where people can get it, and our phone number.

Health Canada has brochures in 17 languages that have been distributed at some of the areas of concern where ethnic communities tend to fish. The Chinese community in Toronto is very well-organized and usually advertises the guide in its community newspaper.

Ms. Maxine Cole
Assembly of First Nations

The Eagle Project is examining the effects of environmental change on aboriginal peoples in the Great Lakes basin. It's a community-based research project. Our goal has been to blend the traditional knowledge of aboriginal people with scientific information to assess the effects of environmental contaminants on all aspects of health and well-being of aboriginal people.

In the Eagle Project, we are collecting accurate baseline data on the environmental health of the First Nations and forming new partnerships, like the one we have with the Ministry of Environment (Ministry). Al Hayton is a member of our working group and science advisory group. The partnerships we're forming may be as important as the actual results.

The Assembly of First Nations is a national political organization within Canada with a membership of more than 600 First Nation communities. The Eagle Project is a regional project located in the Great Lakes basin. There are approximately 63 First Nation communities in the Great Lakes basin. In the Eagle Project, we deal with approximately 45 of these communities in some degree or another, whether we keep them up to date and aware of what's going on in the Eagle Project or actually work with them on fish consumption guidelines. Again, our partnership with the Ministry is appreciated.

Our research approach addresses three fundamental questions: Which contaminants are First Nations people exposed to? What are the levels of those contaminants? Are there any associated health effects?

Between 1990 and 1997, the Eagle Project developed a framework of six major research programs to address the above questions: the eating patterns survey, the freshwater fish and wild game program, contaminants in human tissue program, the health survey, the social-cultural program, and a geographic information system. It's the freshwater fish and wild game program and the eating pattern survey that helped us to develop the fish consumption guidelines.

The eating pattern survey documented for the first time that the aboriginal population is a high-risk group because of their consumption rate of fish and wild game. It was necessary to quantify this consumption rate. The results of the eating pattern surveys show that on the average, 19.78 g of fish per day are consumed. That's taken as an average for male and female. For the average male, it's 26 gpd and for the average female, approximately 14 gpd.

The top three fish species that the population was consuming were pike, white fish, and lake trout. The average meal weight was 261 g, with approximately 24 meals per year.

Once the rates were documented, it became necessary to develop fish consumption guidelines and determine if individuals were at risk. The background information that we used was from the Ministry's *Guide to Eating Ontario Sport Fish.* Again, the objective was to produce and provide fish consumption guidelines specifically for members of Eagle First Nation Communities, and give them the opportunity to decide whether or not they should follow those guidelines. I oppose the idea of telling people not to consume fish, because I think personally that the benefits of consuming fish, especially for aboriginal populations, far outweigh the risks. That's a personal opinion; it's not of the working group.

As we reviewed the database, we found that the guidelines were not necessarily relevant to First Nations people. The diet of First Nations people includes more species of fish than were documented in the guide. The physical characteristics of the population are different from the average Canadian population; the average body weight is larger. The average meal size is larger. Additional data were needed to recalculate the consumption advisories with variables relevant to Eagle First Nation Communities. Data on fishing locations within the communities were also needed.

We had 34 First Nation communities participate in an eating pattern survey. For each community participating we developed fish consumption guidelines. Lakes within a 20- to 50-km radius of the geographic center of each community were considered fishing locations for that community. If a lake overlapped two communities, we developed fish consumption guidelines for both communities.

Again, we used two data sources to prepare the guidelines, the Ministry's data, which was taken from nearly 500 lakes for 17 contaminants and 16 species of fish, and the eating pattern survey of the Eagle Project, which supplied relevant demographic variables. The demographic variables from the eating pattern survey of the Eagle Project included species of fish eaten, fishing locations, body weight, amount of fish eaten, meal frequency, and meal size.

Once we reviewed the Ministry's data and the Eagle Project's eating pattern survey, the two data sets were merged. Variables necessary for guideline calculations were retained, including species of fish, the date the sample was collected, the length and weight of the fish, the portion of the fish used for testing, the contaminant being tested for, the result of the test, and location of sampling site. The statistics group at Health Canada then contributed quite a bit of time to validate data and deal with missing values.

The advisories were computed for each contaminant and were specific for community, location, and species. Again, this was based on the contaminant level in the fish; the safe guidelines for contaminants or tolerable daily intake, also known as the RfD here in the States; the usual amount of fish consumed; and community body weights.

The statistics group developed a software program that calculates individual and community-specific fish consumption guidelines for 34 First Nation communities. The software produces guidelines based on species, location, and individual variables including gender, age, body weight, and meal size. The software and posters will be going out to communities in the very near future. That information will also go to our steering committee members, who are First Nations people, health technicians, environmental technicians, fishers and hunters and to other community organizations. The posters will be placed at lake sites.

The posters are in English, but they will also be translated into Ojibwa language. We will be on the Web site. We have mercury fact sheets, and also a video entitled *Alternative Protein Sources.* Alice spoke of this yesterday, and again, what do you tell people? Don't eat the fish? You have to give them something to replace that protein in their diet. The *Alternative Protein Sources* video is of a workshop with Tony Del Plato from Moosewood Restaurant in Ithaca, New York. He says that returning to the traditional diet of the Iroquois people, which includes corn, beans, and squash, for instance, would replace the protein loss from not consuming fish.

The are many benefits of having community people involved in the production of the fish consumption guidelines and in the Eagle Project. We have developed strong partnerships among the Eagle Project's communities, the Assembly of First Nations, Health Canada, and the Ministry. We have developed community-specific guidelines which are focused on and relevant to the aboriginal population. We have strong methodology, improved computerized analytical reporting processes, and a larger sampling base.

In conclusion, I would just like to say that part of our work on the Eagle Project has been to increase the awareness of this high-risk population and enable them to make informed decisions about whether or not they should stop eating fish. The guidelines alone do not solve the problem. But again, what do you tell people who consume a subsistence food source? That they are no longer able to do that? As I said earlier, I think the benefits of consuming that food source outweigh the risks. But there's a particular concern in aboriginal communities because females of childbearing age make up a large part of the population, which leads to concern for fetuses and for developing children. I agree, as John Persell said yesterday, that we need to strengthen our resolve in addressing the issue of contaminated fish and wild game.

Open Discussion

Participant: Thank you very much for a nice presentation, Ms. Cole. I was interested in your personal opinion that continuing to eat traditional diets might be more beneficial to the Native American population than avoiding the chemical contamination in fish. How did you balance that judgment? Was it based on something quantitative, or it was just sort of a gut feeling?

Ms. Cole: It's more than a gut feeling. Being aboriginal myself, I'm aware of the social-cultural impacts of fishing. The Shoshone, the community that I'm from, used to be a fishing society. They are also an agricultural society, historically. So when we could no longer fish, we went to farming the land.

Since fishing was taken away, there has been a loss of knowledge about where to find the fish, the different stocks, the different species, the quantities, and where their spawning beds are; the knowledge is not being passed on to younger family members. That's why it's very important in this project that we incorporate community-based knowledge also. Part of our work is to consider the social-cultural impacts; we have qualitative data to support the fact that there are effects there.

Participant: A follow-up question, if I may. So we have qualitative data to show impacts of fish consumption advisories, maybe from a way that we haven't traditionally looked at impacts. Have you tried to quantitate those qualitative observations yet?

Ms. Cole: I was just talking to Alice Tarbell about this because one thing we overlooked as we were doing our research was collecting information about historical consumption. As we look at our results today, we see that the random selection of individuals in our communities are on the high end of the fish consumption scale with other high fish-consumers throughout Canada and the Great Lakes. Historically, I'm sure fish consumption was even higher than it is now. So there are a couple of ideas floating around about trying to document historical consumption and determine the risk of mercury in relation to historical consumption rates.

CLOSING REMARKS

Dr. Betsy Southerland
U.S. Environmental Protection Agency

I want to repeat my request. If you have any specific ideas about the USEPA response to your action plan for requested technical assistance, please write to me and let me know.

I think we will definitely start quarterly conference calls with you on a regional basis. This way, I think we can have more substantive discussions on the action plan and respond appropriately to your needs. We can also get into detailed discussions on whether you need training workshops or prefer to have these once-a-year, technical forums. A number of states have talked to us about potentially co-hosting a training workshop or a technical forum in their state and sharing the expense with us.

I'd like to summarize what we've heard the last two days. I want to express my appreciation for the tribal representatives who spoke to us. That is a new perspective, certainly for me here in Washington, DC, and perhaps for other states. It is quite different than the concerns we have had, which are focused mostly on sports fishermen.

I appreciate the NRDC group for taking a critical look at the information we have available nationally on fish advisory programs in each of the states. They certainly brought up some things that we don't provide to the public, and it probably is important to make that kind of information accessible.

ATSDR also did a nice job. I thank Dr. Hicks for giving us an update on all the studies they are funding related to fish consumption and health. The next two sessions that we had yesterday were Dr. Anderson's advisory awareness program and Dr. Dourson's comparative risk project. Whether we have a big national training workshop or a national forum next year, we will definitely bring those people back to report on the results of those two important projects.

On our mercury discussion this morning, I want to encourage everybody to get your comments in on the ATSDR mercury profile document. This document is now out for public review with a due date in February. So please comment when you get a chance to look at it in detail.

I'd like to repeat that the current recommendation from both USEPA and ATSDR is that states and tribes continue to use USEPA's RfD in the risk assessments that they use to

support fish consumption advisories. Because of the draft nature of the ATSDR toxicity profile, both agencies agree that it would be premature to use that RfD in support of your fish advisory programs.

In some ways, the source control information about mercury that we heard today was very reassuring. I was glad to see that mercury emissions in this country are decreasing because a number of uses have changed and because there are emissions controls. The concern, of course, is that global emissions are of increasing importance. When our emissions come down to a point where we are dominated by global emissions, are we going to be stuck with a level of contamination that's coming from outside our country? I think that's a really important issue for further study.

Finally, I want to thank everyone who spoke on communicating fish advisories. Since that's the most important aspect of all of this, getting the word out when there is a public health risk, I really appreciate all of them for sharing their methods with us.