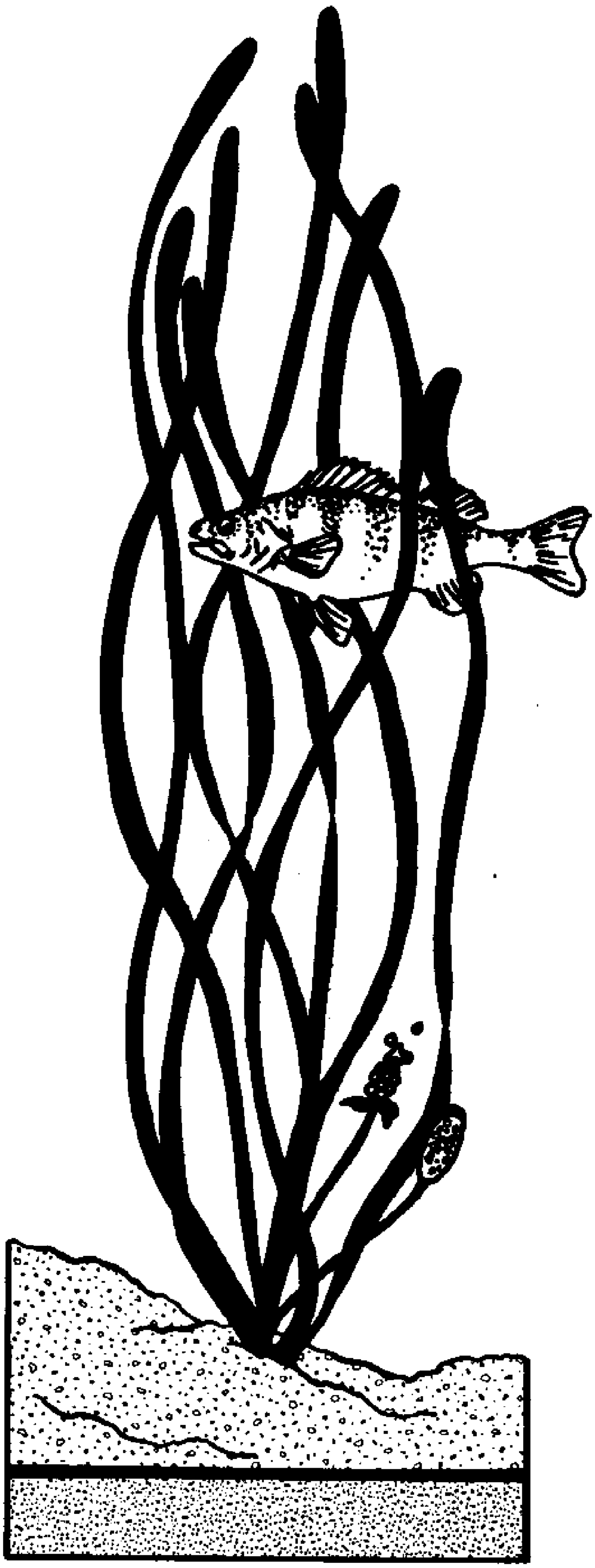
[redacted]



The Proceedings of the 1986 Green Bay/Fox River Research Symposium

March 24–25, 1986

Jointly published by the University of Wisconsin Sea Grant Institute and the Wisconsin Department of Natural Resources

Symposium Sponsors:
University of Wisconsin Sea Grant Institute
Wisconsin Department of Natural Resources
Brown County Neville Public Museum

Symposium Organizers:
H.J. Harris
Dennis Weisensel

Publication Coordinators:
Clifford Kraft
Lynn Persson
Peyton Smith

Format/Copy Editor:
Stephen Wittman

Cover Design:
Wendy Schorr

Illustration:
Christine Kohler

This report was jointly published by...

...the University of Wisconsin Sea Grant Institute under grants from the National Sea Grant College Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and from the State of Wisconsin. Federal Grant No. NA84AA-D-00065, Projects R/GB-5 and A/AS-2. UW Sea Grant Publication No. WIS-SG-86-243.

...and the Lake Michigan District and Bureau of Water Quality Resource Management, Wisconsin Department of Natural Resources, partially funded under a grant from the U.S. Environmental Protection Agency. Federal Grant No. R005865-01. DNR Publication No. PUBL-WR-138-86.

First Printing: July 1986

THE PROCEEDINGS OF THE 1986
GREEN BAY/FOX RIVER RESEARCH SYMPOSIUM

March 24-25, 1986

Green Bay, Wisconsin

Sponsored by the

University of Wisconsin Sea Grant Institute

Wisconsin Department of Natural Resources

and

Brown County Neville Public Museum

The Proceedings of the
1986 Green Bay/Fox River Research Symposium

Preface v

Welcome and Introductory Remarks

"Asking the Right Questions"
Robert A. Ragotzkie, Director, Sea Grant Institute,
University of Wisconsin-Madison 1

"A New Commitment to the Bay"
Charles Higgs, Director, Lake Michigan District,
Wisconsin Department of Natural Resources 3

Toxic Substances and the Green Bay/Fox River System
Session Chairman -- H.J. Harris

"The Persistence of Pollutants in Sediments of Green Bay"
David Edgington, University of Wisconsin-Milwaukee 7

"Tumors and Chemical Body Burdens in Fish from the Green Bay Watershed"
Michael Mac, U.S. Fish and Wildlife Service, Ann Arbor 8

"Sediment Characterization -- Fox River and Green Bay"
Timothy Kubiak, U.S. Fish and Wildlife Service, Green Bay 9

"A Toxicity Evaluation of Lower Fox River Water and Sediments"*
K. Biesinger, U.S. Environmental Protection Agency, Duluth 11

"Ecological Assessment of Factors Affecting Walleye Ova Survival
in the Lower Fox River"
M.D. Balcer and D.J. McCauley, University of Wisconsin-Superior 12

"The Control of Chemical Contaminants in Wisconsin's Aquatic Environment"
John Sullivan, Wisconsin Department of Natural Resources 13

Nutrients and Trophic Dynamics
Session Chairman -- Dennis Weisensel

"Update on Trophic Status of the Bay -- Trends, 1970-85"
Paul Sager, University of Wisconsin-Green Bay 15

*Paper submitted, not presented

"Implications of Trophic Gradients in Green Bay with Respect to Food Chain Dynamics"
Sumner Richman, Lawrence University, Appleton 16

"Ammonia Levels in the Fox River, Green Bay and East River"
H.J. Harris, University of Wisconsin-Green Bay 17

"Chemical and Biological Dynamics of Benthic Boundary Layer"
J. Val Klump, University of Wisconsin-Milwaukee 18

"East River Project"
Tim Rasman, Wisconsin Department of Natural Resources 19

"Nutrients and Eutrophication Panel Discussion Summary"
Discussion Leader: Victoria Harris, Wisconsin Department of Natural Resources 21

Fishery Resources
Session Chairman -- James Moore

"Yellow Perch Management of Green Bay"
Brian Belonger, Wisconsin Department of Natural Resources 25

"Drop Net Fishery and Effects on Yellow Perch Yields"
Clifford Kraft, University of Wisconsin Sea Grant Institute 27

"Fish Models for Green Bay"
Barry Johnson, University of Wisconsin-Madison 28

"Economic Analysis for the Wisconsin Yellow Perch Fishery of Green Bay, Lake Michigan"
Richard Bishop, University of Wisconsin-Madison. 29

"Green Bay Walleye Population -- Status and Future Outlook"
Terrence Lychwick, Wisconsin Department of Natural Resources 31

"Population Modeling of Lake Whitefish in Green Bay"
Frederick Copes, University of Wisconsin-Stevens Point 32

"Fishery Achievements and Challenges Panel Discussion Summary"
Discussion Leader: Lee Meyers, Wisconsin Department of Natural Resources 34

Luncheon Address

"Planning for Green Bay"
Lyman Wible, Division Administrator, Environmental Standards, Wisconsin Department of Natural Resources 37

Appendix

List of Attendees 45

Preface

This document serves as a record of the 1986 Green Bay/Fox River Research Symposium, sponsored by the University of Wisconsin Sea Grant Institute, the Wisconsin Department of Natural Resources and Brown County's Neville Public Museum. The purpose of the symposium was to share information from recently completed or ongoing studies on the Fox River/Green Bay system that had not yet been widely disseminated. The symposium also served as a springboard for the initiation of planning activities for Green Bay, identified as the Green Bay Remedial Action Plan.

The abstracts contained in this proceedings, as submitted by the authors of papers presented, portray the active nature of research and monitoring activities being conducted on the Fox River and Green Bay by a variety of agencies.

The symposium was organized around three recognized problem areas: Toxic Substances, Nutrient and Trophic Dynamics, and Fishery Resources. Panel discussions were conducted in conjunction with each of these three sessions. Each discussion session was structured around four questions:

* What improvements have occurred?
* What problems remain?
* What do we need to take into account when we try to solve/mitigate these problems?
* What are some of the management options? (Summaries of two of the panel discussions are contained in this proceedings.)

The introductory remarks by Robert Ragotzkie, director of the University of Wisconsin Sea Grant Institute, and Charles Higgs, director of the Lake Michigan District of the Wisconsin Department of Natural Resources, provide perspectives on past, present and future activities directed toward the restoration of beneficial uses of the Fox River and Green Bay.

The narrative of a luncheon address by Lyman Wible, administrator of the DNR's Division of Environmental Standards, outlining the whys, wherefores and expectations of the Lower Green Bay and Fox River Remedial Action Plan is contained in an appendix to the proceedings.

Nearly a hundred people registered for the symposium, with broad representation from both the public and private sectors. Based on the level of interest and participation, the significance of the information presented, and the spirit of open exchange and collegiality that pervaded the two-day sessions, we judge the symposium a success. We suggest that an annual symposium of this nature would go a long way toward helping all those concerned about this unique resource -- managers, researchers, regulators, decision-makers and users -- gain a better perspective for both the problems and potentials of the Fox River/Green Bay system in the future.

H.J. Harris
Symposium Organizer

Dennis Weisensel
Symposium Organizer

Asking the Right Questions

Robert A. Ragotzkie
Director, Sea Grant Institute
University of Wisconsin-Madison

Welcome to the Green Bay/Fox River Research Symposium.

It is particularly fitting that the University of Wisconsin Sea Grant Institute has joined the Wisconsin Department of Natural Resources (DNR) and the Brown County Neville Public Museum in sponsoring this conference. As you know, Green Bay and the lower Fox River has been designated an "area of concern" by the Water Quality Board of the International Joint Commission (IJC). As such, it requires a Remedial Action Plan.

Actually, the lower bay has been designated a problem area by the IJC since 1974, and five years before that, in 1969, the Wisconsin Sea Grant Program began its coherent research program on Green Bay.

In 1976, we published a summary of that program and other research in a book entitled The Green Bay Watershed: Past/Present/Future. That report set the stage for a second major Sea Grant research effort under the leadership of H.J. "Bud" Harris. We also added an outreach dimension to the program. In this conference, you will be hearing a good deal about the results of this program and also about the work of other agencies, like the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency (EPA) and, of course, the DNR.

What have we accomplished? Quite a bit, I believe. In fact, it's probably fair to say that we have more information about this bay and understand it better than any other comparable region of the Great Lakes.

Given this massive amount of information, it might seem to be relatively easy to identify and assess the problems and conditions of the bay and from that base to devise a rational management scheme to correct, rehabilitate and maintain the bay in a form satisfactory to the local community and society in general.

Of course, if it were that easy, we would not be here today. Despite years of research, we are only now approaching a general understanding of how this Great Lakes estuary works. There is an age-old saw that says that the most difficult step in research is to ask the right questions. We are clearly at that stage now.

In the next two days, you will hear about many of these research findings. You will also hear about the key questions -- questions about nutrients, about toxics, about fish, about birds and people, and, most of all, about the bay ecosystem. It is these questions as well as past research results that will provide the foundation for a sound management plan.

But the purpose of this conference is not simply to review past and present research; rather, its purpose is to use the research base as a point of departure for devising a rational and effective management plan for the bay and river -- to take the first step toward the creation of what the IJC and EPA call a Remedial Action Plan.

Certainly, it is essential that any plan for rehabilitating the lower bay and river be based on the best available research. This conference is an important step in that direction.

It is equally important that the plan have the participation and support of all elements of the community, all the bay's users, as well as the resource management agencies. I am confident that the DNR will ensure that this broad participation occurs.

One further element is that the plan must be dynamic and ongoing -- it must raise new questions, which will require further research, and the plan itself must be adaptable to the findings of future research.

Given these three elements -- a sound research base, broad community participation and a dynamic plan -- the chances for success are excellent.

Again, I welcome you, and I wish you well in your task.

A New Commitment to the Bay

Charles Higgs
Director, Lake Michigan District
Wisconsin Department of Natural Resources

I have the pleasant task of welcoming you all to this symposium and workshop on behalf of the Department of Natural Resources. It's certainly encouraging to take a look at the program for the symposium and see not only the high quality of the writers and speakers who will be taking part, but also the variety of organizations they represent.

The fact that all these individuals have contributions to make to the restoration of Green Bay and the lower Fox reminds us of a few things: first, that Great Lakes water quality is in fact an international, interstate and interagency concern; second, that we all have a shared responsibility to maintain and improve these waters; and, finally, that what we manage to do with the lower Fox River and lower Green Bay will have regional, national and international impact. This all boils down to a splendid opportunity.

This symposium, and the remedial action process that has just begun, give us an opportunity to begin a new era of environmental reform and restoration for the Great Lakes, and for the lower Fox and lower Green Bay in particular. You'll hear more about the Green Bay Remedial Action Plan from Lyman Wible at lunch today. If those of us who care about the future of these waters create intelligent goals and then work with foresight and determination, we will lead by example, because leading, in the sense of taking on a new commitment, will be psychologically important to us, and to the people we serve -- just as important as the physical removal of pollutants has been to the bay and the river. As far as I'm concerned, there isn't any other practical alternative -- and as we'll see during the symposium, restoring and improving these waters is really a matter of the most obvious practicality and common sense.

This symposium and workshop has several purposes: One is to discuss and share what we already know about the bay; another is to talk about the research that will be done within the next few years, and yet another is to pool our knowledge and begin to plan future research needs.

Each of these is an important goal. But I would like to see us accomplish one more thing: With luck, this symposium could mark the beginning of a new commitment to the bay and the river -- a new commitment to quality; a new commitment to its resident wildlife and fish, its human users and, most important of all, to the future. The bay and the lower river are assets; it's up to us to maximize their value by making them as healthy and useful as we can.

If a new commitment is needed, it's not because what we have been doing over the last few years is wrong -- quite the contrary! I think we should set a new goal for the river and bay because what we have done so far to improve them really marks the end of an era. I believe we should start today to turn that ending into a beginning.

To understand what a new commitment might mean, we should take a look at the interactions of people, the river and the bay over time. I think we can divide them into four stages.

Last year, Green Bay celebrated the 300th anniversary of the arrival of the first white missionaries and explorers, who landed, according to the legends, somewhere near Red Banks. It wasn't long before Green Bay became one of the first white settlements in the middle of the continent.

Back then, the lower bay and the lower Fox River were functioning natural systems that had obvious benefits for both the original residents and the newcomers.

That was the first stage in the historical process -- the wilderness stage. The bay and the river were wild natural resources that provided fish and waterfowl for food and also were a hub in the canoe route from the lower Great Lakes to the Mississippi River. At that time and for a long time afterward, people received much from the bay and river, but had little impact on them.

The second stage -- that we might call a stage of transition -- began sometime in the 1800s. The population of the area had grown, and pollution -- from sewage, runoff, sawmills and the like -- became evident. The wilderness was gone, but the river and bay were still valuable as natural resources and transportation routes. The city of Green Bay became moderately important as a shallow-draft port, and excursion boats carried people on day trips around the bay and up the Fox through the new lock-and-dam system. During this transitional stage, the lower bay and river still provided many beneficial uses. The system had become a somewhat limited resource -- modified and damaged by people, but still valuable for recreation, sport and commercial fishing, waterfowl and transportation.

This transitional stage lasted until about the turn of the century, but by then many changes were evident. The population, industry and wealth of the area were growing, and our uses of the river and bay were changing. The third stage -- I call it "the assimilative stage" -- began. During this stage, the river and lower bay were used largely for the dilution and assimilation of human and industrial wastes. Boating, swimming, sport and commercial fishing, hunting and the other uses of the transitional stage suffered accordingly. Later in the assimilative stage, during the '50s and '60s, the river in particular could hardly be called a natural resource at all. It had immense value as a sink for wastes, but that was all. Game fish largely left the area, fish kills were almost annual events, and the river and bay went anaerobic from time to time.

The fourth historical stage, what I call "the recovery stage," began with this legal and policy shift in 1972. Since then, as a result of enforcement and the expenditure of plenty of public and private money, the river and lower bay have partially recovered. Game fish have returned, recreation has returned and property values along the Fox are improving.

The recovery is a testament to a lot of work and expense, but, as we all know, it is neither perfect nor complete. While we were removing the gross and visible pollutants, invisible toxic substances were accumulating in the sediments -- and in the fish and birds, as well. They have taken the bloom off the water quality improvements of the last decade. In part, those toxic pollutants -- PCBs, dioxins, furans and others -- are the reason for this symposium. The toxics are impossible to see and difficult to trace and have created an obvious need for further research and, eventually, further controls. We are still in the recovery stage, and we'll stay in it as long as toxic discharges remain.

I believe there can be a fifth stage. The lower Fox and lower bay can move into a new stage, of "stewardship" -- modified by people, not pristine, but at the same time productive and well-managed, offering beneficial uses of many kinds.

There could not, of course, be an abrupt shift to the stage of stewardship. Recovery and pollution control will have to continue, but, eventually, by taking positive steps, we can improve conditions and beneficial uses and reach a stage of stability and conscious control.

I said that the problem of toxics was holding the river and bay in the recovery stage, and it is -- but there is another factor that is just as important in its way, and that is the problem of attitude.

Back when the Fox was little more than a waste ditch, we lost track of it as a resource -- we quit thinking of it as a river. Now that attitude is changing, and it must continue to change. The day when we could "write off" parts of our state's waters as waste assimilators is over.

Progress toward stewardship will require research, controls and a further shift in attitude. It is also a matter of rights and responsibility.

The residents of this area have a right to a river and bay that are suitable for recreation. They have a right to fish that are safe to eat, with no qualifications or advisories. They have a right to waters that are safe to touch and swim in. On that I think we all can agree.

Finally, to attain stewardship, we have to learn to share the responsibility, and the sharing must extend beyond government and the universities. It must include everyone: business, industry and the public at large.

When the environmental movement began in the late 1960s, it consisted of a few legislators, some well-known authors and scientists, and a lot of concerned citizens. But as a few years went by and we geared up to solve the problems, the movement became partially "institutionalized" within the state and federal governments. The institutionalization was necessary, but it had an unfortunate effect: It created the notion that the government alone was responsible for the quality of the environment.

As a result, some people believe today that the DNR and the EPA are solely responsible for cleaning up the environment and that the private sector is responsible only for its own financial success. This notion turns environmental protection into a children's game of chases and evasions, which wastes public funds and everybody's time.

The responsibility must be shared. Governments and their agencies must enforce the laws, but they must also move at a pace that is compatible with economic reality. The right of business and industry to earn a return on their investments must be respected, but they, on the other hand, must anticipate and prevent environmental problems.

The final measure of responsibility must be accepted by the public, who will decide where the environment/economy balance should be struck.

I've said that we should form a new commitment of stewardship for the lower Fox and the lower bay. I've said we should try to move the management of these resources into a positive and creative stage. And I've said that the responsibility for all this must be shared and not turned into a game of tag.

You have a right to ask, why?

I think there are three reasons: (1) because a restoration of the beneficial uses of the river and bay will make good economic sense in the long run; (2) because a further restoration could result in a fair, just distribution of the beneficial uses of their resources; and (3) because it ought to be a matter of pride.

I'm not an economist, but, like most of us, I was given an average share of common sense. It seems to me that the recovery we've seen so far makes excellent sense. When I see fishermen on the Fox, boaters, water skiers, crowded boat landings -- that makes good sense to me. A recovering commercial perch fishery makes sense to me. When I see expensive private homes, condos and apartment buildings being built along the Fox -- that makes good sense as well. The river and bay are capable of much more than waste assimilation.

The second reason for a new commitment is the question of fairness. When the first missionaries landed, the waters were open to all. The Northwest Ordinance declared them "forever free." Later, Wisconsin doctrine established them as the property of the state, to be held in trust for the people. Yet for a time, during the assimilative stage, the Fox and lower bay changed hands and became in practice the property of the municipal and industrial waste dischargers. The use of these waters as waste dumps so altered them that other possible uses became impossible or irrelevant. That was unjust, and the injustice is being redressed today. The process of distributing these uses justly must not stop.

Third, I said that a new commitment should be a matter of pride. Wisconsin citizens are entitled to the best possible resource management and environmental quality. Recently, I read in the newspaper that an official of one of our largest industries, commenting on Wisconsin's leadership in social and environmental matters, asked this question, and I quote: "Why does Wisconsin always have to be first?"

Apparently, the reference was to the Wisconsin tradition of reform and innovation. That tradition goes back to the Wisconsin Progressives of the early years of this century, and by and large it has served us well. We are used to setting trends, to being first or among the first, certainly to being among the best. I'm proud of that tradition, and I think we should all want to be proud of the river and bay as well.

In conclusion, I hope the symposium is a success, and I also hope that, along with the discussion of research, you give some thought to the stage of progress that is ending, the new stage that could begin, and of the commitment it will take to get there. As the early settlers discovered, these are indeed "bountiful waters." If the people who care for them have the will, they can only become more bountiful for all of us.

The Persistence of Pollutants in Sediments of Green Bay

David Edgington
University of Wisconsin-Milwaukee

Many of the pollutants that have been discharged into Green Bay through its various tributaries or deposited directly onto the water surface have become more or less strongly associated with the sediments, depending upon their chemical properties. While it can be shown that the interaction of pollutants with sedimentary particles can significantly decrease the concentration in water and therefore the magnitude of bioaccumulation in organisms, as we further control new inputs to the system, the sediments themselves can become a significant source of pollution, apparently negating the cleanup process. Only when the contaminated particles are buried below the depths where benthic organisms or physical resuspension can rework sediments, will the sediments become a permanent sink for pollutants.

Detailed studies have been made of the distribution of sediments, sedimentation rates, and mixing depths in Green Bay. The results show that there is very little accumulation of sediment north of Chambers Island or south of Long Tail Point. The maximum deposition appears to be occurring in deeper water due west of Sturgeon Bay as a result of the effect of the Peshtigo reef on the generally counterclockwise current pattern in the bay. This distribution of sediments, and associated pollutants, indicates that the pollutant load from the Fox River is largely concentrated in the middle bay. Using average values of the sedimentation and mixing depth calculated from measurements of radionuclides in sediment cores, it may be predicted that the time needed for the concentration of certain pollutants such as PCBs, that are strongly absorbed to sediments, to decrease by a factor of two could be as long as 20 years.

Tumors and Chemical Body Burdens in Fish from the Green Bay Watershed

Michael J. Mac
U.S. Fish and Wildlife Service, Ann Arbor

Beginning in 1984, the Great Lakes Fishery Laboratory and the Columbia National Fisheries Research Laboratory of the U.S. Fish and Wildlife Service initiated a joint effort to determine the incidence of tumors in various nearshore fish populations in the Great Lakes. Two of the sites selected for study were the Fox and Menominee Rivers, tributaries of Green Bay. At each site, we collected walleyes and bullheads for gross pathological examination, histological analysis, and residue analysis of polynuclear aromatic hydrocarbons, metals, chlorinated pesticides, dioxins, polychlorinated biphenyls (PCBs) and furans. Sediment samples were also collected for chemical analysis and for use in mutagenicity bioassays.

Not all results are available as yet, but histopathology on walleyes from the two Green Bay sites is complete. Gross pathological examination of 40 walleyes from the Fox and 41 from the Menominee revealed no visible dermal or internal tumors. Histopathological evaluation of 10 apparently normal livers from each site indicated, however, that one from the Fox had neoplastic nodules and two in the Menominee had subtle alterations suggesting an early stage of tumor formation. Of 53 bullhead collected in the Fox, three had oral tumors, but no liver tumors were found. Of 47 bullhead collected in the Menominee, no gross tumors were found; however, histological analysis is not complete.

The mutagenicity of chemical extracts of Fox River sediments was tested with the Chinese hamster ovary test, a mammalian-cell bioassay. Results of this test showed a positive dose-response with increasing concentrations of extract causing higher mutation rates in cells. This test demonstrated that chemical extracts of Fox River sediments contained mutagens at concentrations much higher than those found in sediments from a reference site. However, the biological availability of these mutagens and the relevance of such tests to the presence of tumors in fish is not yet understood.

Preliminary results of contaminant analysis revealed PCB concentrations were higher in walleye from the Fox (mean, 15.7 ug/g; range, 2.3-54.5) than in walleye from the Menominee (mean, 3.0; range, 0.7-9.9). Bullheads showed a similar pattern averaging 1.8 ug/g in the Fox (range, 0.1-4.3) and 0.75 ug/g in the Menominee (range, 0.1-2.3). Metal analysis indicated whole-body residues of arsenic were elevated in Menominee River walleye (0.31 ug/g) and bullhead (0.16 ug/g). Concentrations of lead (0.34 ug/g) and nickel (0.82 ug/g) in bullhead from the Menominee were also high in comparison to values from other sites. Walleye and bullhead from the Fox had total chlorinated dioxin concentrations of 25 and 30 ug/g, respectively. In the Menominee these levels were 12 and 13 pg/g for walleye and bullhead, respectively. Furan concentrations varied more between species than by site, with walleye containing 67 and 52 pg/g in the Fox and Menominee, respectively, and bullheads from both rivers containing furan concentrations of 13 pg/g.

Possible correlations between tumor incidence in the field and the presence of specific contaminants will be made when complete data are available from all sites.

Sediment Characterization -- Fox River and Green Bay

Timothy J. Kubiak
U.S. Fish and Wildlife Service, Green Bay

Sediment samples from the lower Fox River and southern Green Bay were collected in 1984 and 1985 to determine the presence of polychlorinated dioxins (PCDDs), furans (PCDFs) and ortho-unsubstituted biphenyls (PCBs). These samples were collected for studies involving a survey of tumors in fish (Fox River) and bioavailability of contaminants in sediments (Green Bay). These pollutants were in need of characterization because many exhibit a high degree of toxicity in certain test species.

Analytical results confirmed the presence of these chlorinated aromatic hydrocarbon compounds. These results have been previously presented by Dr. Larry Smith of the U.S. Fish and Wildlife Service's Columbia National Fisheries Research Laboratory at the American Chemical Society annual meeting in Chicago in 1985. Congener specific analyses for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) confirmed each compound to be present in all sediment samples. The highest concentrations were 14 pg/g and 98 pg/g, respectively. Concentrations of specific congener groups generally were found to increase relative to the degree of chlorination of the dioxins and furans (i.e., $Cl_4 < Cl_5 < Cl_6 < Cl_7 < Cl_8$). The exception to this relationship was a lower concentration of octachlorofuran than for the heptachlorofurans. These findings parallel the relative concentrations of these congener groups in Great Lakes sediments, including sediment from Lake Siskiwit on Isle Royale, Lake Superior. Concentrations within each congener group from the Fox River and Green Bay are elevated by approximately two orders of magnitude compared to control sediments from Munuscong Bay, St. Marys River and those reported values from Lake Siskiwit sediment.

Two ortho-unsubstituted PCB congeners have been detected in Fox River/Green Bay sediments. These PCB congeners -- 3,4,3',4'-tetrachloro-biphenyl and 3,4,5,3',4'-pentachlorobiphenyl -- are two of the most bothersome of the 209 PCBs because their structure-activity relationship resembles that of 2,3,7,8-TCDD. Another ortho-unsubstituted PCB congener, 3,4,5,3',4',5'-hexachlorobiphenyl was not detected in any Fox River/Green Bay sediment despite being present in all fish samples.

Analyses of fish, birds (fish-eating) and bird eggs from the lower Fox River and Green Bay have also documented the presence of these compounds. In general, the following can be stated relative to these compounds in environmental samples:

1. Residues of PCDDs and PCDFs in sediments are more complex than those of fish from the area;
2. Fish accumulate 2,3,7,8-TCDD and 2,3,7,8-TCDF in this system but to a slightly lower wet weight concentration (whole fish) than the respective dry weight sediment concentration;
3. Ortho-unsubstituted PCBs are available to fish and occur in detectable concentrations;
4. Birds and bird eggs accumulate higher concentrations of 2,3,7,8-TCDD than fish, but lower concentrations of 2,3,7,8-TCDF;

5. Birds show higher concentrations of 3,4,5,3',4'-pentachlorobiphenyl and 3,4,5,3',4',5'-hexachlorobiphenyl relative to fish;
6. Bird eggs show an increased tendency for further accumulation of the 3,4,5,3',4'- and 3,4,5,3',4',5'-chlorinated biphenyls; and,
7. Fish, birds and bird eggs show preferential accumulation of the most toxic PCDD congeners, those that are 2,3,7,8-substituted.

The recently completed interagency investigation of the reproductive outcome of the Forster's tern on Green Bay has determined that some of the reproductive problems in this fish-eating bird species are consistent with the known effects of these compounds. The Fish and Wildlife Service is presently performing additional analyses on many of the existing environmental samples we now possess from Green Bay to identify additional, individual PCB congeners. This should improve our understanding of their presence, fate and potential effects on this ecosystem. What is less clear at the present time are the effects of these compounds regarding benthic invertebrates, plankton and fish. Any effects may well be obscured by other pollutants known to be present or yet to be found. As an example, PCB-substitute compounds have been documented as being used in the Fox River basin and have been found in limited samples from the Fox River/Green Bay. These compounds are neither well understood nor well researched relative to their potential environmental significance. The message this brings is that we must focus additional attention on compounds we know relatively little about in addition to those compounds for which we have much better understanding.

A Toxicity Evaluation of Lower Fox River Water and Sediments*

K. Biesinger
U.S. Environmental Protection Agency, Duluth

Physical and inorganic chemical measurements made on lower Fox River water show few abnormal values. Un-ionized ammonia (NH_3-N) levels were higher in April due to the influence of an increase in pH during that period on the relative percentage of un-ionized to total ammonia. Nitrate concentrations were elevated in March compared to the January or April study periods. Conductivity, ammonia, chloride, and sulfate values all measured higher at Station A compared to the other stations. Dissolved oxygen measurements obtained from the Wisconsin Department of Natural Resources for the lower Fox River range from 12.0 - 17.9 mg/L for January, 12.7 - 18.0 mg/L for February, 9.9 - 17.4 mg/L for March, and 7.5 - 17.9 mg/L for April 1985.

Results from the present study of lower Fox River water indicate a general absence of lethal effects as defined by the bioassays used and within the temporal and spatial framework of the study. Significant sublethal effects resulting from exposure to lower Fox River water included reduced growth of fathead minnows for Station D in January and fewer *Ceriodaphnia* progeny for stations A-K in March.

The liquid phase elutriate test showed few lethal effects with the exception of total mortality of *Daphnia magna* in two of three replicates for Station K in April; the third had 100 percent survival. Production of young *Daphnia* varied greatly in the elutriate test with two stations (G in March and K in April) producing significantly fewer young than the reference station (L) and three stations (A and D in January and D in March) producing significantly more young than the reference station.

Survival and reproduction of *Daphnia magna* in the solid phase test was often less for the reference stations than for the other stations. The solid phase was not toxic to *Hyalella* in the 10-day tests. *Ephemerella* were not well suited for the static environment of the solid phase test.

*Paper submitted, not presented.

Ecological Assessment of Factors Affecting Walleye Ova Survival in the Lower Fox River

M.D. Balcer and D.J. McCauley
University of Wisconsin-Superior

In response to improvements in the water quality of the lower Fox River, adult walleye now congregate below the DePere Dam during the spawning season. This study was designed to investigate the factors that might affect the reproductive success of this population.

Preliminary results indicate that suitable spawning substrates (i.e., rock and gravel areas) are present along the eastern shore of the river near the DePere Dam. Female walleye captured near the spawning grounds had an average condition factor of 1.03 and contained an average of 51,500 ova$\cdot$kg^{-1} body weight; comparing favorably with other Wisconsin populations. Fertilized walleye ova and newly hatched fry were captured by a variety of techniques and indicated that some recruitment was occurring at sites near the DePere Dam.

In order to determine hatching success, walleye ova were fertilized and incubated in situ at two sites that appeared to possess favorable conditions. A variety of ova incubators were employed, with average ova survival ranging from 20 to 37 percent by Day 8 when hatching occurred. These survival rates are similar to those obtained under laboratory conditions.

Throughout the study, water temperature, current velocity, dissolved oxygen, hydrogen, sulfide, nitrite, alkalinity, hardness and pH values at the sediment-water interface at the study sites were within recommended ranges for ova survival. On two occasions, ammonia-nitrogen levels exceeded recommended levels.

Work is continuing to determine what proportion of the lower Fox River contains areas with physical and chemical conditions that will promote the survival of walleye ova.

The Control of Chemical Contaminants in Wisconsin's Aquatic Environment

John Sullivan
Wisconsin Department of Natural Resources

With the passage of major federal environmental legislation in the last fifteen years, the nation has made great strides in controlling environmental pollution. In most cases the control of "conventional pollutants" has been realized, and in most instances these control programs have also eliminated the majority of acute toxicity problems that existed in our nation's waterways. We are now, however, at the threshold of a new phase in water pollution control. The baseline program now in place must be expanded to give additional consideration to all types of toxicity.

The control of toxic pollutants -- often coined "regulation at the edge of science" -- will not be simple. Regulatory programs must be carefully thought out and realistically balance environmental risk and economic reasonability. The affects we must eliminate are often very difficult to define or see in the environment. Changes over time may be very subtle and their elimination elusive, yet we must begin to control chemical compounds that pose teratogenic, mutagenic and carcinogenic threats to the aquatic, terrestrial and human environments.

The federal attempt at controlling toxic substances has grown out of the 1976 Flannery decision or Consent Decree. The goal is to regulate 129 "priority pollutants" for 21 industrial subcategories. The program has been slow and bogged down for a variety of reasons and has lost the support of many state environmental agencies. It has, however, served a variety of essential purposes. The program has acted as a catalyst for enhancing the level of technical sophistication of many labs as well as regulatory agencies and has provided a chemical screening of both industries and municipalities on a national basis. We now know that BPT for industries and secondary treatment for municipalities do remove priority pollutants and mitigate some toxicity problems. It has also given us a realization of the great number of chemicals that may be discharged from any given facility.

The large universe of chemicals that may cause toxicity problems underlies the major shortcoming of the Federal approach. This approach, often defined as regulation on a chemical-by-chemical basis, has the tendency to very easily slip into the "treatment for treatment's sake" analogy. Control programs can easily be misdirected and result in resource commitments in both monitoring and treatment with no attendant improvement in the environment.

A strategy has been developed by the State of Wisconsin to deal with the large universe of chemicals used in today's industrial society. The ultimate goal is the elimination of toxicity in State waters. A phased approach, combining the existing chemical-by-chemical approach with a biological testing component, is the heart of the new program. Out of necessity it must treat industries and municipalities equally. It is designed to address both acute and chronic toxicity and strive to assure aquatic, terrestrial and human health.

Update on Trophic Status of the Bay -- Trends, 1970-85

Paul Sager
University of Wisconsin-Green Bay

The spatial variation in trophic conditions in Green Bay, referred to frequently as the trophic gradient, has been described and analyzed mostly in terms of the longitudinal dimension of the bay. Hence, a south-to-north variation in physical-chemical features, such as light extinction or Secchi disc transparency, is apparent. Secchi values in the southern bay are as low as 0.5 meters and range as high as 6 meters in the northern waters. A major influence on light extinction is the abundance of phytoplankton, which also varies along this longitudinal axis. In the southern bay, chlorophyll _a_ levels in summer are often as high as 100 ug/L. In the northern bay, chlorophyll _a_ levels of 1-2 ug/L indicate the oligotrophic nature of this part of the bay. Concentrations of total phosphorus (TP) may similarly vary from summer averages of 190 ug/L to 10-20 ug/L from south to north.

A major factor in this trophic gradient in Green Bay is the phosphorus load of the Fox River, greater than any of the other major tributaries to Green Bay. Entering as it does at the head of the bay, dispersion of this water and associated substances has much to do with the water quality of large areas of the bay. In the extreme southern bay, average summer concentration of TP have been observed to decrease since the early 1970s by 25-40 percent. In the same period, effluent discharges of TP by sewage treatment plants along the lower Fox River have decreased by almost 90 percent, a figure considerably larger than the reduction observed in the bay. Apparently, other TP sources continue to contribute significant amounts of phosphorus to the bay waters. Indeed, TP levels in summer 1985 averaged 185 ug/L in the southern bay, up 20 percent from those observed in summer 1984.

A modification of our current perception of the influence of the Fox River on Green Bay may be in order, based on recent indications from Landsat 5 satellite imagery. An image created from data accumulated in July 1984 shows a continuity of the Fox River/lower bay water mass features (turbidity and chlorophyll _a_) extending almost as far as Sturgeon Bay tightly along the east shore. The implications are great if this is a persistent pattern, for the effects of Fox River loadings more directly on the middle bay region. For example, small changes in TP loadings may have only a small effect on chlorophyll _a_ levels in the southern bay where hypereutrophic conditions persist. But in the middle bay region, a small phosphorus change (in loading) could have a more dramatic effect simply because of greater nutrient sensitivity of the system. Additional satellite images are expected to clarify this new dimension in our understanding of the trophic conditions in Green Bay.

Implications of Trophic Gradients in Green Bay
With Respect to Food Chain Dynamics

Sumner Richman
Lawrence University, Appleton

A distinct feature of Green Bay is a south-to-north gradient evident in increases in mean depth, water volume and light penetration, and decreases in nutrient concentration and specific conductance. These physico-chemical gradients correlate well with gradients in standing stock distributions of phytoplankton in terms of numerical density, biovolume concentration, chlorophyll a concentration and species composition, and with primary productivity. These parameters are closely correlated with one another and clearly establish spatial variations in trophic conditions oriented along the longitudinal axis of the bay from very high hypereutrophic conditions in the extreme southern end (corresponding to average primary productivity = 586 mg C m^{-3} day^{-1}, chlorophyll a = 49.8 mg L^{-1}, phytoplankton biovolume = 12 parts per million [ppm] and phytoplankton density = 15,000 particles ml^{-1}), to sharp declines to mesoeutrophic/oligotrophic status in the northern bay (corresponding to primary productivity = 20.6 mg C m^{-3} day^{-1}, chlorophyll a = 2.1 mg L^{-1}, phytoplankton biovolume = 0.8 ppm and phytoplankton density = 1,500 particles ml^{-1}). In terms of species composition, similar sharp decreases were noted, especially in species of blue-green and green algae.

Total zooplankton biovolume concentrations drop from average summer values of 1.4 ppm in the extreme southern region, where nutrient loadings and their dispersion have a major influence, to 0.2 ppm by volume in the northern bay waters, where exchanges with Lake Michigan commonly occur. These changes are due to both rotifer and microcrustacea distributional shifts and are related to the influence of nutrient loadings and their transport and dispersion on the food quality of the phytoplankton community. In numerical terms, rotifers, especially *Polyarthra* and *Keratella* genera, are major contributors to the observed decreasing south to north pattern and comprise over 80 percent of the zooplankton community throughout the bay. The microcrustacea, on the other hand, make up almost as great a percentage of the zooplankton biovolume throughout the bay and show interesting compositional shifts in the Cladocera, Calanoid and Cyclopoid plankton community that are related to feeding-niche considerations with respect to food quality. Specifically, increases in blue-green algae results in a shift from Cladocera to copepods, which have a more selective feeding behavior.

Estimates of carbon transfer between algae, zooplankton and fish show low efficiencies in the lower bay due to an overabundance of inedible blue-green algae as compared to mid-bay regions. The picture in the upper bay is one of high efficiency for zooplankton conversion and low efficiency for fish. The latter value, however, may be the result of the difficulty in estimating the standing stocks of migrating fish populations.

Ammonia Levels in the Fox River, Green Bay and East River

H.J. Harris
University of Wisconsin-Green Bay

An investigation of ammonia concentrations commissioned by the Green Bay Metropolitan Sewerage District (GBMSD) was initiated in Spring 1985. Sampling was conducted on a weekly basis from June 20th to August 26th at 11 stations in the Fox River and lower Green Bay. Diurnal sampling was conducted during three 24-hour periods at seven stations, which included two stations on the East River. Dissolved oxygen, pH and temperature measurements were taken with each water sample. Dissolved oxygen levels dropped below 5 parts per million (ppm) at the Fox River mouth stations and East River stations only. Oxygen levels were not observed to fall below 4 ppm. No seasonal trends in either total NH_3 or un-ionized ammonia were found. Ammonia concentrations did not vary significantly with depth but did vary appreciably between sites. Both pH and temperature varied in a quadratic fashion from June to August and reached seasonal peaks in mid-July. The mean un-ionized ammonia value for the station below the DePere Dam (background value) was as high or higher than for most other river and bay stations. The stations northwest of Kidney Island (4.5) and at the Chicago and Northwestern Railroad bridge (R1) had the highest mean un-ionized ammonia values. These values are 0.109 and 0.034 mg/L, respectively. Cluster analysis using un-ionized ammonia concentrations separated stations into two groups. One group consists of six stations near the mouth of the Fox River (Group 1) and the other consists of 12 stations existing further out in the bay (Group 2). Eleven percent of all samples taken (28/243) exceeded the 0.04 mg/L chronic toxicity level. Group 1 stations accounted for 46 percent of all samples that exceeded the un-ionized ammonia standard of 0.04 mg/L. These data reveal that the waters of the Fox River from below the DePere Dam to the mouth of the river and an area of waters in the bay east of the ship channel and north to Point au Sable periodically have levels of un-ionized ammonia considered to be chronically toxic. However, only one station on one sampling date exceeded levels for acute ammonia toxicity. The data strongly implicate the GBMSD effluent as a major factor contributing to the ammonia levels found in lower Green Bay.

Chemical and Biological Dynamics of Benthic Boundary Layer

J. Val Klump
University of Wisconsin-Milwaukee

The sediments of Green Bay are both the major sink for nutrient inputs and an important site of nutrient recycling within the bay. Because of high productivity and the relatively shallowness of the overlying waters, Green Bay sediments receive high inputs of organic matter with concentrations of organic carbon ranging from 5 to 10 percent in those areas where significant sediment deposition is presently occurring. A rough depositional gradient extends south to north from 10 to 30 meters water depth where sedimentation rates range from < 30 to > 200 $mg \cdot cm^{-2} \cdot y^{-1}$. Across this gradient, annual organic carbon and nitrogen inputs increase approximately fivefold as a result of both increased organic matter content and increased sediment deposition. Fluxes to the sediment reach a high of approximately 15 $mol \cdot m^{-2} \cdot y^{-1}$ for organic carbon and 1.5 $mol \cdot m^{-2} \cdot y^{-1}$ for nitrogen. At each point along this gradient, profiles in the sediment column show decreasing organic carbon and nitrogen content with depth in the upper 30 cm or more of the sediment. This change in concentration results from two major processes: (1) increased burial rates of carbon and nitrogen as a result of increased loading through time and (2) the regeneration of "metabolizable" or recyclable carbon and nitrogen from the sediments back into the overlying water. Preliminary estimates of the fraction of incoming organic matter actually recycled range from 10 to 40 percent. The residence time for this recycled fraction in the sediment is estimated to be on the order of months to years and indicates the time scale over which the benthic system would respond to changes in organic matter loading.

East River Project

Tim Rasman
Wisconsin Department of Natural Resources

The East River is approximately 140 square miles in area. It originates in Calumet and drains north through Brown County entering the Fox River approximately 2 miles above the mouth. It is 33 miles long with two named tributaries: Bairds Creek, 4 miles long, and Bower Creek, 3 miles long. There are numerous unnamed tributaries.

Since 1967, Brown County has been active trying to attract interest in cleaning up the East River. Historical information is somewhat limited on the river. The Green Bay Metropolitan Sewerage District, City of Green Bay, U.S. Fish and Wildlife Service, UW System, Fox Valley Water Quality Planning Agency, county and DNR have been involved answering complaints and collecting some data. Numerous complaints regarding odors, discharges of animal waste along with similar complaints have been investigated. The city has collected bacterial data over a number of years. Fecal counts have continually been above the 200/100 ml for human contact. FC/FS ratios have indicated animal waste as a primary source.

The DNR collected invertebrates and applied Hilsenhoff's Index at 6 sites in 1979. Water quality was determined to be poor to very poor.

U.S. Geological Survey and FVWQPA began a monitoring program in April 1985 collecting hydrological and chemical data at four sites in the watershed. Sediment and phosphorus yields were calculated at two sites: The East River at Monroe Street and Bower Creek at Sunnyview Road. Peter Hughes, a hydrologist responsible in part for the project plotted the total phosphorus/suspended solid unit area loads on a regression equation to compare similar stations monitored throughout the State. Bower Creek had extremely high yields and the East River wasn't far behind. A preliminary summary Peter reached was that the East River between April and November 1985 was contributing 21 percent of the sediment yield at the mouth of the Fox River. He is continuing his monitoring this year and hopefully will be able to get the spring flush he missed in 1985. We are fortunate to have the efforts of Peter and David Wentland from FVWQPA and their data.

A fishery study completed by Lee Meyers from DNR in 1985 identified 35 species of fish in the entire East River drainage area. High points Lee pointed out in his study included the possibility of game fish spawning in the lower reaches of the system. The upper reaches contain mostly forage fish. The heavy sediment yields in the upper reaches produce little if any spawning. Carp are primarily a problem in the lower reaches and are responsible for resuspending a lot of the fine clay particles in the river. One red-sided dace, a species on Wisconsin's watch list, was captured in Bower Creek.

Lee's report included a description of the physical features in the drainage area. Bairds Creek had the best water clarity with some bottom areas dominated by rock and rubble -- good fish habitat. He concluded by saying, "If water quality was improved, the Upper East main stem would probably lend itself to a limited warmwater fishery, such as smallmouth bass, rockbass, with some northern. The lower reaches would probably be capable of producing a warmwater fishery of northern pike, yellow perch and crappie along with limited numbers of walleye, catfish and white bass."

An appraisal monitoring group made up of industry and various agency people has assembled to look at historical data and the efforts of USGS and FVWQPA. The purpose of the committee is to establish a list of water quality objectives that we might achieve through a state-funded NPS watershed project.

Nutrients and Eutrophication Panel Discussion Summary

Discussion Leader: Victoria Harris
Wisconsin Department of Natural Resources

Panelists: H.J. Harris, UW-Green Bay; J. Val Klump, UW-Milwaukee; Sumner Richman, Lawrence University; and Paul Sager, UW-Green Bay.
Recorder: Paul Rome, UW Sea Grant

What improvements have occurred?

There have been major reductions in point-source nutrient loadings to the Fox River. A 90 percent reduction in phosphorus loading from municipal point sources occurred from 1972 to 1985. Reductions are attributed to construction of secondary wastewater treatment facilities, a 1 mg/L phosphorus limit for municipal dischargers over 2,500 in population equivalent, and to state law which controls the amount of phosphorus allowed in household detergents. Loadings of BOD have also been reduced by over 90 percent through regulation of municipal and industrial discharges.

Although "improvement" may be too presumptive a term, phosphorus load reductions have lowered average summer phosphorus concentrations in the inner bay area by 40 percent. However, this has not resulted in an observable change in average chlorophyll a concentrations since 1976 or phytoplankton species composition. Average summer chlorophyll a values are not available prior to 1976.

Average summer dissolved oxygen concentrations in the inner bay area have improved. This is largely due to reduced BOD discharges.

The relationship of algal growth (primary production) to the rate at which this food source is transferred to higher trophic levels (fish production) has been measured too recently to establish trends in improvement.

What problems remain?

Remaining high phosphorus concentrations in the inner bay cause hypereutrophic conditions including predominance of blue-green algae species in late summer, lowered food quality for zooplankton, turbidity, lowered dissolved oxygen and aesthetic problems.

There is an "imbalance" in trophic dynamics in the lower bay which is manifested by reduced carbon transfer efficiencies to higher trophic levels. The high biomass of large-sized blue-green algae is not effectively utilized by zooplankton or fish. This unused biomass contributes to higher organic carbon and nutrient deposition and to hypolimnetic oxygen depletion in mid-regions of the bay.

Although point-source loadings of phosphorus have been greatly reduced, nonpoint-source loadings from poor agricultural and urban land use practices remain high. Preliminary East River study data show the magnitude of the nonpoint-source problem. "Ambient" water quality data from the Department of Natural Resources also show that nutrient outputs from Lake Winnebago to the lower Fox River remain substantial.

What do we need to take into account when we try to solve/mitigate these problems?

We need better assessments of nutrient and sediment loadings to Green Bay. It is difficult to measure Fox River flow and water quality at the mouth due to seiche and mixing with Green Bay water. There are about 12-15 years of ambient water quality data from the DePere Dam. But these data are collected monthly and do not take runoff events into account nor include downstream tributary loadings which may be more significant than previously thought.

We need better estimates of nutrient and sediment loadings from upstream tributaries and Lake Winnebago. Tributary watersheds should be evaluated to determine how much phosphorus loading is from controllable nonpoint sources.

We also need to establish an acceptable target load for phosphorus to Green Bay from the Fox River. This could be based upon average phosphorus concentrations in regions of the bay which demonstrate desirable trophic conditions and upon the level of point- and nonpoint-source phosphorus control which is believed to be achievable.

There appears to be little sediment, nutrient and organic carbon deposition in northern and southern bay regions. Organic matter content and sediment deposition are greatest in the middle bay and exhibit a rough gradient from south to north in depths of 10 to 30 meters. This may be due to a combination of greater water depth and large scale circulation patterns which retard mass transport of materials beyond Chambers Island.

Organic sediments have little residence time in the lower bay. Sediments appear to be well oxidized and/or rapidly flushed from the area. Therefore, phosphorus input from the Fox River may be the most important factor controlling algae production in the lower bay; whereas nutrient regeneration from organic sediments may be a more important factor in primary production of the middle bay.

Algae production in the southern bay is not being processed effectively through the food chain to higher trophic levels. Most algae end up in the detrital food chain. Algae are rapidly recycled, eventually transported north and settle out in the middle bay area. Future reductions in phosphorus in the southern bay could result in greater benefits for the middle bay including less organic deposition, reduced hypolimnetic oxygen deficit, reduced nutrient regeneration and recycling, and reduced algae production. It would take substantial phosphorus reductions to change the trophic status of the inner bay.

Phosphorus is the most rapidly recycled nutrient in the system. Available phosphorus is readily taken from the water column by phytoplankton. By the time phosphorus reaches sediment sinks, it has been reused many times and may be in a less available form for regeneration or plant uptake.

We have little information about nutrient outputs to Lake Michigan from the bay but it appears to be minor at least during summer periods. It is possible that pulses due to storm events or spring flush are transporting nutrients out of the bay; but there are no supporting data. This raises questions about the nutrient budget for the bay. Green Bay may be more of a closed system for nutrients, sediments and other materials than previously thought. One possible output of phosphorus may be tied to the substantial biomass of alewives that migrate from Green Bay to Lake Michigan in winter. Some alewives also return in spring but many are consumed by Lake Michigan salmonids.

To manage algae populations of the lower bay, we must consider the availability of other nutrients like nitrogen and silica. The N/P ratio is an important determinant in the selection of green algae over blue-greens. The

Si/P ratio will determine the production of diatoms. Therefore, we need to consider other nutrient inputs, outputs and regeneration rates in selecting for desirable phytoplankton communities. However, the consensus of the panel was that phosphorus input from the Fox River to the bay is the most critical factor controlling algae production and trophic dynamics in the inner and middle bay regions.

Economic assessments have tended to dwell on the costs of nonpoint-source management. We also need to address the economic benefits of improved trophic balance in the bay, including improved recreation and fish production.

It will be difficult to predict the impacts that problems in farm economy will have on nonpoint-source contributions to the bay. For example, fewer farmers may be willing to invest in nonpoint-source management practices; but as less viable farms fail, more land may be reverted to less intensive uses.

What are some of the management options?

Management must focus on means to reduce nonpoint sources of phosphorus from upstream tributaries. We should target our traditional nonpoint-source control programs at critical watersheds. We do have estimates of phosphorus, sediment and COD loadings from tributaries to the Fox River. Estimates were based on generalized land uses and a modified soil loss equation. While the estimates may not be accurate in an absolute sense, they do provide relative comparisons of areal loadings from which we could identify watersheds with the greatest management needs. This approach is a first cut for selecting watersheds for nonpoint-source management. Other methods may also be used to generate better loading estimates.

Urban areas were also identified as significant nonpoint sources. Rural land uses are not the only problem. However, in older established urban areas it may be more difficult to control nonpoint sources.

Agricultural agencies should consider water quality impacts when making decisions about which lands to take out of production for soil erosion control or which farms to consider for total herd buyout. Farm subsidy programs should also require "cross compliance" with water quality programs. Eligibility for subsidies should depend upon meeting nonpoint-source management needs.

Another management technique to control algae and improve trophic dynamics is "top-down management." This involves stocking large predatory fish (preferably native) to reduce the numbers of planktivorous fish and thereby increase the numbers of large-sized zooplankton that can feed upon algae. Currently the technique may be more effective in managing green algae in the middle bay. The inner bay has high concentrations of blue-green algae which are often too large and less palatable for zooplankton. Control of blue-green algae will require management of N/P ratios. As populations shift from blue-green to green algae, "top-down management" may become more effective in the inner bay.

Perhaps one of the greatest challenges will be to integrate management options for nutrients and eutrophication with management of toxics, biota and habitat. It is uncertain how improved trophic dynamics will affect the bioaccumulation of persistent toxics in fish or how sediment management will affect the fate of in-place pollutants. In the long term, however, reduced sediment and nutrient loadings to Green Bay should benefit the entire system.

Yellow Perch Management of Green Bay

Brian Belonger
Wisconsin Department of Natural Resources

Reported commercial yellow perch catches averaged approximately a million pounds annually from 1914 through 1964 in southern Green Bay. In 1965, the catch declined dramatically to 238,000 pounds from 1,090,000 pounds in 1964. From 1965 through 1982, the catch averaged 421,000 pounds. The decline occurred lakewide and thus was related to a lakewide phenomenon: the rapid increase in alewife abundance. Wells (1977) stated, "Circumstantial evidence suggests that the nonnative alewife (*Alosa pseudoharengus*), by interfering with perch reproduction, was the primary cause of the decline." It is now suggested that there may have been predation on perch fry as well as direct competition for food.

Wells also stated "an intensive fishery hastened the decline of perch." Along with the population crash came increased growth rates. These fast growth rates coupled with a high exploitation rate resulted in a continually young population with harvest fluctuating annually dependent on the year-class strength of two-year-olds.

In 1981, yellow perch catch rates bottomed out at 9.93 pounds per 1,000 feet for gill nets and 8.08 pounds per drop net lift.

In 1982, management goals were established for yellow perch in Green Bay. They were (1) to increase abundance by reducing mortality rates, thus improve the age structure and stability of the population and (2) to more equitably allocate the harvest between sport and commercial fishers.

Direct causes of yellow perch mortality which we could influence to give the population more protection were identified; namely, impingement at the Pulliam Power Plant, and sport and commercial fishing. As water quality improved in the Fox River, impingement of walleyes and yellow perch increased at the Pulliam Power Plant. As a result, Wisconsin Public Service installed a barrier net system which substantially reduced impingement.

In 1983, several steps were taken to reduce the commercial and sport fishing impact on the perch population. Since approximately 85 percent of the harvest mortality was induced by commercial fishing, most of the protective measures were aimed at that segment. Steps taken involving the commercial fishery were: (1) establishment of an annual harvest quota, (2) retarding the season opening for drop nets to reduce the mortality associated with handling sublegal perch, (3) creating an east shore closed area, and (4) limiting fishing from January 1 through April 9 to ice fishing only.

The only step taken with regard to the sport fishery was to reduce the daily bag limit to 25 perch per day. The bag limit was reduced from 50 during the spawning season (April 9-May 20) and no bag limit during the remainder of the year. In 1985, the bag limit was increased to 50 year-round.

The commercial quota for 1983-84 was 200,000 pounds (175,222 pounds reported caught); 350,000 pounds in 1984-85 (320,233 pounds reported caught); and 350,000 pounds in 1985-86 (322,317 pounds reported caught to date). The proposed quota for 1986-87 is 400,000 pounds.

Both sport and commercial catch information is in the process of being key punched. Catch rates for both drop nets and gill nets are expected to be up substantially in 1985.

In the past two years a major additional sport fishery has developed on the east shore of Green Bay. Longhand expansion of information from a section of the east shore for June and July 1985 indicated more than 400,000 perch were harvested from Red River to Little Sturgeon during that period.

As a measure of the initial success of the management program, index station trawling has indicated that the age III+ perch were approximately 10 times more abundant in 1985 (568 per trawl hour) than any year since trawling began in 1978. While this is partially due to the strength of the 1982 year class, the strong 1977 year class was poorly represented by the time they reached age III+ (58 per trawl hour).

Nineteen eighty-five index station trawling also indicated a very weak 1983 year class, a moderate 1984 year class and a strong 1985 year class.

While steps have been taken to maintain higher abundance and a more stable population, which should benefit both sport and commercial fishers, and initial results are encouraging, the challenge remains whether higher abundance, a better age structure and more equitable distribution of the resource can be maintained.

Reference

Wells, LaRue. 1977. Changes in Yellow Perch (*Perca flavescens*) Populations of Lake Michigan, 1954-1975. *Journal of the Fishery Research Board of Canada*, 34(10):1821-1829.

Drop Net Fishery and Effects on Yellow Perch Yields

Clifford Kraft
University of Wisconsin Sea Grant Institute

The waters of southern Green Bay support a substantial yellow perch (*Perca flavescens*) commercial fishery. The perch are captured in either of two gear types: gill nets or drop nets. It has been estimated that 34 percent of the sublegal perch that are released from drop nets die within 24 hours. Many of the sublegal perch returned to the water from drop nets are also eaten by gulls before they have a chance to recover.

The purpose of this project was to test alternative mesh sizes which would allow more sublegal perch to escape from drop nets while retaining enough legal-sized perch to sustain a commercial drop net fishery. In 1981 the Wisconsin DNR initiated work on modifying drop nets to reduce sublegal perch mortality. UW Sea Grant subsequently funded a study of the drop net fishery and its effect on yellow perch yields. As a result of that study field trials were conducted during the summer of 1985 using five alternative mesh sizes from 2 1/8 to 2 5/16 inches. These test nets were fished along with control nets constructed from the mesh size used by most commercial fishermen (about 1 7/8 inches).

Two groups of fishermen participated in the field trials. For both groups the test nets caught significantly greater percentages of legal perch than the control nets ($p < 0.05$). Catch per unit effort (CPUE) of legal perch was not significantly different between test and control nets for one group of fishermen; for the other group the control nets had a significantly higher CPUE ($p < 0.05$). It was also determined that mesh size varied according to handling conditions.

These data indicated that nets with a 2 1/4-inch mesh size would exhibit the most efficient combination of size selectivity while maintaining a reasonable CPUE. Given this summer's conditions, this mesh would require no loss of CPUE for one family of fishermen participating in the trials, and only a modest loss of CPUE for the second group of fishermen. Where there are great concentrations of perch, this modest loss of CPUE is outweighed by the efficiency gained in lifting nets with larger fish and thereby spending less time sorting fish.

The ultimate question is how the fishery would respond to changes in drop net mesh size over an extended period of time. A computer simulation of the Green Bay yellow perch fishery was conducted in which drop nets of different mesh sizes were substituted for standard drop net mesh sizes. According to the model, a substantial increase in the perch harvest over a 20-year period would result from a drop net mesh size increase to 2 1/4 inches.

Fish Models for Green Bay

Barry Johnson
University of Wisconsin-Madison

Modeling can help managers predict future effects of management actions, determine important interactions within the system, and address questions which cannot be easily answered empirically. Our current work involves mathematical modeling of energetics of forage fishes and dynamics of the yellow perch fishery. Energetics modeling is an accounting of energy flow and storage in fish. We have used this approach to estimate food requirements of alewives and yellow perch and to investigate possible predator-prey interactions between them.

Model results indicate that alewives consume much more zooplankton than do perch and that competition for food between alewives and juvenile perch may be severe. Also, the potential exists for high predatory mortality on larval perch by alewives. Future work will concentrate on quantifying these interactions.

The perch fishery model is designed to evaluate the effects of different management policies on population dynamics and harvest. The model includes specific selectivity curves for the two major commercial gears and variability in perch recruitment as measured in the bay. Preliminary results indicate that various policies could increase perch population size and that increases in both commercial and sport catch appear possible, although increases for gill netters will probably be larger than for drop netters. Future work will concentrate on expanding the sport fishery component, adding economics to the model, and developing a method of optimizing the variable commercial quota.

Economic Analysis for the Wisconsin Yellow Perch Fishery of Green Bay, Lake Michigan

Richard C. Bishop
University of Wisconsin-Madison

Effective fishery management requires two information sets: biological and socio-economic. The first set predicts biotic impacts arising from management actions -- but biotic predictions alone cannot pinpoint which management policy is "optimal." Rather, optimality is determined by the degree to which a policy, via its biotic impact, advances important socio-economic objectives, such as enhanced economic welfare, greater cultural opportunities and species preservation.

This presentation, then, focuses on the socio-economic impacts of the 1983 Wisconsin DNR quota scheme for the Green Bay, Lake Michigan, yellow perch fishery. Specifically, estimates of changes in fishing income for commercial perch fishers due to the quota scheme are presented. Possible sport fishing benefits generated by the quota plan are also discussed qualitatively.

The DNR has provided estimates of eventual commercial harvest and fishing gear productivities to be attained from the quota plan. These data are combined with fishing cost estimates and price forecasts to compute, in present value terms, the commercial fishing income earned under the quota scheme. This income figure is then compared to the "baseline" income which the fishers would have earned in the absence of the quota scheme. The results:

1. Commercial fishers break even or make slight gains if the DNR harvest and gear productivity goals are fully reached.

2. Fishers lose income if these goals are partially met, but losses may be relatively modest.

3. Fishers lose a large amount of money if the DNR goals are not achieved at all.

Since sport anglers experience large gains if the DNR goals are either fully or partially met, it is concluded that total economic gains (sport plus commercial) are large if the DNR goals are fully met, the gains may still be positive if such goals are partially met, but they are probably negative if the goals are not achieved at all. Thus, if the odds of total policy failure are low, the DNR quota plan appears to be a good economic gamble.

Several additional policy issues are raised. If the quota does enhance perch abundance, then the DNR will face pressure from both sport and commercial fishers to increase their respective shares of the total harvest. How should total harvests be allocated between the two groups?

Also, under the quota plan, the major risk bearers are the commercial fishers, for if the plan does not work, they will lose at least some money. (In contrast, the major beneficiaries of the plan, sport anglers, lose nothing if the plan does not work.) Should the commercial fishers receive any compensation if they lose money? Economic analysis may aid the DNR in resolving both of these issues.

Finally, some tentative economic results are presented for several policy options from B. Johnson's "bioeconomic" model of the Green Bay perch fishery. Net gains from regulation appear to be substantial for commercial fishers under policies which either restrict fishing effort, increase drop net mesh size, or do both. The potential usefulness of this bioeconomic model for making policy choice for this fishery is stressed.

Green Bay Walleye Population -- Status and Future Outlook

Terrence Lychwick
Wisconsin Department of Natural Resources

Between the early 1930s and mid 1970s, the population of desirable fish species and other aquatic organisms in the Fox River ecosystem was poor. During this time, dissolved oxygen (DO) concentrations grew worse as a consequence of increasing biological oxygen demand (BOD) discharges to the river. Often DOs were 2 mg/L or less, especially near the mouth of the river and in the lower bay. These conditions limited the variety of desirable fish species and their total abundance.

As a result of the Federal Clean Water Act, improved waste treatment facilities began operation in the early 1970s. Greatly reduced BOD discharges resulted from the implementation of this Act. Since 1977, DOs have generally exceeded 5 mg/L which has allowed for active management toward the rehabilitation of walleye stocks in the Fox River and lower Green Bay.

Since the initial introduction of 59,000 fingerling walleye to the Fox River during 1977, 58.4 million walleye fry have been released into the Fox River below the DePere Dam by the Wisconsin Department of Natural Resources (DNR). An additional 825,000 fingerling walleye have been stocked in the lower bay since 1980. Survival of stocked walleye has led to the development of an active sport fishery on the river and an expanding walleye sport fishery in the lower bay as well as increasing stock size to levels consistent with successful natural reproduction.

Independent studies conducted during 1985 by the DNR and UW-Superior showed natural walleye recruitment of the 1985 year class to the fall fingerling stage. Optimum water temperatures during incubation appeared to significantly affect survival. Other factors which may suppress walleye reproduction are available spawning habitat, toxic chemicals, ammonia levels, sediments and other abiotic factors. Within a given year, any of these factors, as well as DO levels, temperatures or reduction in spawning stock size, can exclusively limit reproductive success or they may act synergistically. The future of walleye rehabilitation and the rehabilitation of other fish species depends on ensuring that the effects of these factors are minimized.

Population Modeling of Lake Whitefish in Green Bay

Frederick Copes
University of Wisconsin-Stevens Point

Lake whitefish (Coregonus clupeaformis) were studied in Green Bay and Lake Michigan waters east of Door County, Wisconsin, to obtain information for the management of the species. Primary objectives were to determine the discreteness of the lake whitefish stocks, biological statistics and equilibrium yield and to suggest management consideration. The study area has been divided into statistical districts.

Five stocks of lake whitefish have been identified for Lake Michigan. Discrete stocks of lake whitefish were associated with spawning grounds at Big Bay de Noc (BBN), Michigan, and North and Moonlight Bays (NMB), Wisconsin. The fish from BBN were sedentary, whereas fish from the NMB stock were migratory.

Lake whitefish were tagged (25,000+) at NMB and BBN and commercial catches were sampled in 1975 through 1985. Age III whitefish dominated the commercial harvest from the BBN stock, but ages III-V comprised the majority of the harvest (84 percent) from the NMB stock. The 1972, 1975, 1978 and 1980 year classes were more abundant than other year classes in the harvest from the NMB stock, whereas the 1976 and 1979 year classes were more abundant in the harvest from the BBN stock. Tag returns indicate that NMB stock made up 90 percent of the Wisconsin lake whitefish harvest from Green Bay, 98 percent of the whitefish harvest from Wisconsin waters from Lake Michigan, 76 percent of the Michigan harvest off Bark and Cedar rivers, and 33 percent of all Michigan's lake whitefish harvest from northern Green Bay (MMI). Fifty percent of the tag returns from fish tagged at North and Moonlight bays were from Green Bay. Age VII and older whitefish made up 10 percent of Wisconsin's catch from 1975 to 1979, but contribute only 2 to 4 percent to the current catch.

Lake whitefish from NMB stock of age VII and older experienced a lower mortality rate (38 percent) than younger ages (65 percent). Estimates of mortality were higher for fish from the BBN stock (84 percent) than for fish from the NMB stock. Fishing was a larger proportion of the total mortality in the BBN stock than in the NMB stock. The exportation rate of age III fish from the NMB stock has increased from 10-15 percent during the 1975-1979 period to greater than 30 percent in 1983 and 1984. Trap net effort for lake whitefish has continued to increase, whereas gill net and pound net effort has continued to decrease.

Estimated mean biomass for both stocks peaked in 1976 and the NMB stock has averaged 3-8 times larger than the BBN stock. The biomass of age III+ lake whitefish has averaged 4.3 million pounds (range of 2.8-8.4 million pounds) for the NMB stock. Estimated yield-per-recruit was greater for the BBN stock (116 kg/1,000 kg of age II lake whitefish) than for the NMB stock (816 kg/2,000 kg of age II lake whitefish). Model simulations indicated that increasing the minimum size limit would reduce yield per recruit for both stocks, but would increase the biomass of spawners and spawning frequency, substantially so in BBN. Management steps to delay age at recruitment to the fishery and increase biomass would benefit the BBN stock but not the NMB stock. Increased fishing effort on either stock would not be beneficial. Strict enforcement of the 432mm minimum size limit by the State of Michigan would reduce the reported yield 5 to 8 percent in MMI but would increase the spawning stock biomass by 30 to 40 percent in a two- or three-year period. Management methods for lake whitefish should be similar and consistent between the states of Wisconsin and Michigan.

Fishery Achievements and Challenges Panel Discussion Summary

Discussion Leader: Lee Meyers
Wisconsin Department of Natural Resources

Panelists: Brian Belonger, DNR; Frederick Copes, UW-Stevens Point; Barry Johnson, UW-Madison; Clifford Kraft, UW Sea Grant; Terrence Lychwick, DNR; and Scott Milliman, UW-Madison.

In recent years major improvements have occurred in the fishery of the lower Fox River, mainly as a result of better water quality. Over 50 fish species have been identified during surveys since 1973. Greater species diversity has been complemented by increases in abundance of desirable fish such as walleye and yellow perch with a corresponding decrease in such species as bullhead. The reestablishment of the fishery (particularly walleye) has been translated into thousands of fishing opportunities which could not be enjoyed 15 years ago.

Other achievements include the initiation of sound baseline monitoring programs, such as the fall trawl hauls to assess yellow perch year-class strength in the bay. The annual transects also provide valuable data on the relative abundance of other species. Monitoring programs can provide information on population trends necessary to make good management decisions.

University of Wisconsin Sea Grant studies in recent years have provided insight to specific population dynamics and have provided solutions to various problems, such as improved net design to reduce incidental yellow perch mortality. The whitefish study identified separate stocks with different mortality rates, pointing out management problems that both Wisconsin and Michigan must deal with. Computer models have been utilized to evaluate management options for the yellow perch population: not only the population dynamics but, more importantly to commercial fishermen, the economic impacts of the options. Models help managers choose the best option and provide information which develops a better understanding of the situation for both commercial and sport fishermen.

However, problems still remain with the fishery resource. There is a need to better understand the interrelationship of all species at all trophic levels. How do yellow perch and alewife interact, and how does this effect zooplankton? The fish community appears to be out of balance at present, with not enough top predators such as walleye and northern pike and too many exotics such as carp.

Contaminants are present at levels which warrant human consumption advisories on various fish species. The contaminants not only have the potential to impact human health but also have a negative economic impact in the area such as resulted from the closing of the commercial carp fishery in 1984. Acute and chronic effects of contaminants on fish and other biota are still relatively unknown.

While major improvements in water quality have occurred over the last 15 years, there still appear to be some problems. There is a concern over periodic low dissolved oxygen levels in the lower bay, which may impact fish populations. Suspended solids including blue-green algae may be limiting desirable food sources along with degrading critical spawning and rearing areas for certain fish species. Benthos in the lower bay and Fox River are not present in desirable quality or quantity. Along with water quality improvement, wetland protection and enhancement is needed.

Although some desirable species are on the increase, fish production levels are not at the maximum. The commercial harvest of northern pike has declined in recent years, hinting at possible problems with that population.

The fish community of the bay is very dynamic as illustrated by yellow perch year classes, which have varied by 25-fold in recent years. Thus management must be flexible, able to be adjusted as fish populations fluctuate.

Solutions to the problems will not be easy quick-fixes, due to the size and complexity of the system. Various management techniques may have to be implemented such as biomanipulation of forage stocks to promote desirable zooplankton. The solution to nonpoint-source pollution may involve extensive changes in land use practices. As for the fishery of the lower bay and Fox River, similar waters such as western Lake Erie may be useful as a guide to future fish community structure. Future management decisions on stocking, harvest regulation and habitat protection and enhancement will be best accomplished with the use of predictive models in order to select the best management route for this complex system.

The main key to reaching a desired fishery for the lower bay and Fox River will necessitate cooperation and interaction among various agencies and functions within agencies. It is obvious there is still much to learn about various interactions within this system and it will take the coordinated effort of many people to formulate wise management decisions in order to properly manage this valuable resource.

Planning for Green Bay

Lyman Wible
Division Administrator, Environmental Standards
Wisconsin Department of Natural Resources

Good afternoon, ladies and gentlemen. This is a wonderful opportunity for me to be here with you today and offer my comments on the Fox River and Green Bay and, more specifically, on some planning activities which we think are of great importance. The symposium presents a really remarkable array of impressive technical studies. We are hearing the results of world-class research efforts. I think it is particularly important to have such a symposium as a step in closer relationships among all of the parties involved, especially between the Department of Natural Resources and the university. As indicated by this morning's talks on toxics and later talks on eutrophication and the fishery, we face difficult management questions. The interchange of ideas and information at this symposium is quite critical. I notice it's becoming a tradition here in the Green Bay area, thanks to the persistent efforts of the University of Wisconsin people and also our district staff.

My knowledge of many of the detailed technical topics is rather limited. I know just enough to be dangerous, so I will focus instead on a planning effort. Of course, that's why I was asked to participate and to share with you our views on a plan that is an administrative issue rather than a technical issue. It is a plan that I hope will provide a continuation of this exchange of information and ideas. It is:

* a plan that will build on past research by Sea Grant and others;
* a plan that will build on previous planning studies;
* a plan that will build on the more than $300 million commitment that the Fox River communities and industries have made to clean water while keeping the jobs that are so important to Green Bay;
* a plan that will describe Wisconsin's strategy for protecting our accomplishments;
* a plan for fully restoring the beneficial uses of the lower Green Bay and adjacent Fox River through the year 2000.

The Lower Green Bay and Fox River Remedial Action Plan is the focus of my discussion, and I will comment on: Why would one want to do a remedial action plan? What is the character and scope of a remedial action plan? What are the expectations of DNR from such a plan? And along the way I hope to impress upon you six basic messages. If I have been overly ambitious and run out of time, I would like to say these six major points right now:

1. There are major water use problems in the study area -- you already know this. The international community and the local community seem to agree on this point.
2. The time has come to deal with these problems and to deal with them through the use of an "ecosystems approach."
3. A remedial action plan is not the first, nor is it the last, step, but it is a midcourse coordination activity in the continuing management of water resources in this area.

4. The remedial action plan we are talking about today has a dangerously abbreviated schedule.
5. The remedial action plan must be Wisconsin's plan, your plan, and the citizens' plan. It must be a community product if we are to advance at all on the problems of water resources and related management in the Fox River and Green Bay area.
6. Problems exist, and they are challenging ones. People with knowledge also exist, and they can contribute significantly to the resolution of these problems. The remedial action plan must match them up. That is my sixth point.

Why do a remedial action plan? Well, generally speaking there are really two reasons:

1. There are resource problems to be resolved.
2. It's clear that these interrelated problems will not be addressed properly unless some form of coordination is provided.

There are resource problems. At its first meeting, the Citizens Advisory Committee, which is part of our remedial action plan effort, identified and ranked problems of the bay that they hope the plan will address. In order of priority ranking, these are the problems that the committee gave us:

1. Toxics.
2. Dredging and spoils disposal.
3. Habitat loss.

These were followed by: conflicting uses; sedimentation; nutrients and habitat loss, eutrophication, nonpoint sources of pollution; high and low water levels; should dredging continue; and shoreland use.

These sorts of water resource problems are not unique to lower Green Bay or the Fox River. I serve on the Great Lakes Water Quality Board as Wisconsin's representative. This board was established in 1972 as part of the 1972 Water Quality Agreement to advise the International Joint Commission, an international body established under the U.S. and Canadian Boundary Waters Treaty. The participants on the Water Quality Board include Wisconsin, the other Great Lakes states, the U.S. Environmental Protection Agency, the Canadian provinces, and the Canadian federal government.

There have been major achievements through the Water Quality Board: reductions in phosphorous loadings to the Great Lakes, improvements in Lake Erie, and, of course, the dramatic cleanup of traditional pollutants in the lower Fox River and Green Bay area. Many of the people in this room can take great pride in this accomplishment, as the community in general does. We can see the results of these past efforts. Walleye and perch have returned. Walleyes are spawning below the DePere Dam. The dissolved oxygen levels have improved. There are new buildings and developments overlooking the river and the bay: the Neville Public Museum, a convention center and the mall. People are using the lower Fox River and the bay itself more: waterskiing at Ashwaubanay Park, ice fishing, excursions on the RIVER QUEEN and the Dutchman's landing and amusement park.

All of these reflect the community's embracing of the water resources accomplishments. But, as I noted, there are problems in the bay and the river. Not all of the fish are safe to eat. Deformities occur in wildlife. Of course we are not certain, but we believe they are related to toxics. We are seeing a decline in fall migrating waterfowl, probably a result of habitat loss. Water quality continues to limit recreation. No public swimming beaches have replaced Bay Beach. Toxics problems hinder what should be routine navigational maintenance. So, these are the problems of remedial action we will need to address.

More recently, international attention has focused on the major bays and estuaries of the Great Lakes. The Water Quality Board has designated 42 areas of concern. These have been listed and worked on for more than a decade. In general, these are areas where there have been major efforts to improve water quality and control pollution and where some major accomplishments -- such as in the Fox River -- have been achieved. But problems remain -- usually related to toxics. In Wisconsin, there are four areas of concern: the Fox River and Lower Green Bay, Sheboygan Harbor, the Menominee River and the Milwaukee River estuary.

We Water Quality Board members asked ourselves, "What will we do to restore these uses?" In order to solve these problems and as part of the international commitment to the Great Lakes, Wisconsin and other Great Lakes states, as well as EPA and the provinces, have agreed to prepare remedial action plans for these areas of concern.

Lower Green Bay is the first remedial action plan being prepared in Wisconsin. It will be a model for others prepared in the state and the Great Lakes area.

Just one footnote here. The contaminated sediment problem really constitutes a major omission in the United States' pollution control and environmental quality programs -- and similarly in Canada. The Clean Water Act does not deal with it. Federal dredging support programs are primarily navigational; they do not deal with it directly. The Superfund program exists, but only grudgingly and in extreme cases does EPA support addressing some of this problem. The Hazardous Waste Act does not address contaminated sediment. The Toxic Substances Control Act does not address it, and the Fish and Wildlife Service's programs are not remedial in nature. So the proper federal statutory fix and resolution are several years away at the least and likely longer than that. This is where the Lower Green Bay and Fox River Remedial Action Plan will be important as an example of how we can use an ecosystem approach to deal with contaminated sediment.

We have discussed why we should do a remedial action plan. Let's talk about what it is. We should also talk about the who, when and how. The plan is an identification of water use objectives and the means or the steps to be taken to restore or protect those uses for the water resources between the DePere Dam, Point au Sable and Long Tail Point through the year 2000. The plan is our effort to apply ecosystems analysis to this problem. The plan is a new process for us at the DNR. The plan is <u>not</u> several things:

* The plan is not the start of all planning and study;
* The plan is not the end of all planning and study;
* The plan is not a panacea;
* The plan is not self-implementing; and
* The plan is not perfect. (I know that planners -- and I have worked as one -- think it is important to do everything perfectly. But practical planners, applied planners, effective planners -- and I would even say some of us in engineering -- know it is more important to do something, even if it is imperfect.
* Above all, we think that the plan is not just a DNR plan, and we hope it will not be just a DNR plan.

What are the objectives of the plan?

The scope of the study for the plan is being finalized. But the draft document says that the plan should address the following resource-based objectives:

1. Reduce toxics from all significant sources to levels that protect human health from unacceptable risks and avoid ecological harm.

2. Reduce the point and nonpoint nutrient loadings to the river and lower bay.
3. Protect, improve and rehabilitate wetlands, shorelands, reefs and islands.
4. Provide a framework for developing a long-term, 25-year dredge and dredge-spoil disposal plan that is reviewed every 10 years.
5. Protect spawning areas and reestablish bottom-rooted plants by reducing sedimentation.
6. Improve land management, including aesthetic considerations, public access, sensitive areas and other public concerns.
7. Establish and maintain a self-sustaining, edible, well-balanced fishery.
8. Increase public awareness of the bay's potential.
9. Track and evaluate changes in the lower bay and adjacent Fox River ecosystem.
10. Restore recreational uses.

What will be the basis for this plan? Clearly, the plan will use available studies as a point of departure. These include Sea Grant research; Fish and Wildlife Service studies; the Great Lakes Fisheries Commission's ecosystem rehabilitation reports; the products of the Future of the Bay, including the dredge management plan; the Fox Valley Water Quality Planning Agency's work; Brown County's planning; the "Fox Tox Report," as we call the DNR's Fox River Toxics Report; the wasteload assimilation studies, and others. All of these and every other bit of information we can bring to bear will be used as a basis for the plan.

How will the remedial action plan be prepared? I've talked about what, where, why. Let's talk about how. As many of these efforts have recommended, an "ecosystem approach" will be used to prepare the remedial action plan. The ecosystem approach should address:

* All sources that affect the bay -- air pollution deposition, nonpoint sources, point sources, in-place pollutants, and so forth;
* All aspects of resource management in the lower bay and Fox River (fishery, wildlife, endangered species, recreation, etc.).

Within the DNR, this ecosystem approach provides an opportunity to coordinate and integrate our programs.

The plan will be prepared through a cooperative effort. That's how the plan will be prepared: though a cooperative effort. So, through the Lower Green Bay Citizens Advisory Committee, our local leaders will be asked to help identify the beneficial uses involved and evaluate different strategies.

There will be four technical advisory committees, which will assist this Citizens Advisory Committee. These four will deal with: (1) toxics, (2) biota and habitat, (3) eutrophication and nutrients, and (4) institutional issues.

These technical committees, made up of resource managers and university and local experts, will provide a forum for further exchange of ideas and information begun at this symposium.

This is Wisconsin's remedial action plan. Again, it means not just the DNR, but citizens, local involvement and business. The alternatives prepared by the Technical Advisory Committee will be reviewed by the Citizens Advisory Committee and DNR program managers. Based on this evaluation, a draft plan will be prepared for public review. After we address comments on the draft plan, a public hearing will be held, and after modifications the Secretary will be asked to review and approve the plan. It will then be submitted to the International Joint Commission's Water Quality Board.

There is a very short time frame. I have called it dangerously abbreviated. The October 1986 deadline will be quite difficult for such technical and complex work to be completed, but it is when the final draft is supposed to be available for public review. The planning horizon for the plan, as I mentioned before, is for year 2000 and beyond.

I would like to highlight some of DNR's current activities that will help address these problems and what the remedial action plan can provide.

At the current time, with regard to toxics, we are reviewing many of the discharge permits for reissuance. Requirements for biomonitoring -- including toxicity to fish and other aquatic life as well as carcinogenicity -- are being considered. Fish monitoring is continuing to establish fish consumption advisories. There is a major study of in-place pollutants starting in Little Lake Buttes des Mortes, and the remedial action plan should add to this.

We cannot wait until we know everything about toxics before we act, but we must continue to seek answers to many questions. Remedial action plans should initiate development of a strategy for dealing with in-place pollutants. This omission I have talked about a moment ago.

The plans should look at the big picture of ultimate toxic waste disposal. What is environmentally the best solution? Rather than push pollutants from the surface water to the air to land disposal and back again -- I mean recycling is all right, but we think this would be carrying it too far -- instead, alternate substances that are less toxic to the environment might be considered. Recycling of materials within a production facility must also be considered. We should recognize there still will be waste we must dispose of. The plan should also identify priority areas to devote our limited resources to in order to solve the toxics problems of the bay and the river.

With regard to dredging and disposal of dredged spoils, it is obviously an ongoing problem. The recently completed in-place pollutant effort of the Department of Natural Resources (an in-house task force) will result in revised rules and a program for managing in-place pollutants. One of the questions is how this program, which is a long-term program, should be applied to the more immediate problems of Green Bay. This the remedial action plan will consider.

The in-place pollutant task force report I have just mentioned would provide new guidelines for spoils disposal. It recommends that the type of disposal to be required would depend on the type of contamination found. It raises the possibility of a change in the law to allow 10-year dredge disposal plans and consolidated permitting for those dredging activities which follow an approved plan.

We must find the most environmentally sound management approach, since any alternative will cause some problems. The question is: What is the most environmentally sound management approach? -- What is the scope of that approach? Is it project by project? Is it one element of the ecosystem materials flow, or is it the overall system?

The remedial action plan can provide some guidance so that in the future we avoid the current situation. However, the remedial action plan will not be a dredge spoil disposal plan for several reasons. Among those the two short-term plans are already in hand. Also, such planning is a local responsibility, or at most the Corps of Engineers' responsibility.

The Department of Natural Resources staff (I know Buzz Besadny and I) believe that the possibility of continued dredging has to be assumed by the department. Until somebody tells us otherwise, we believe that dredging is generally in the interest of the economics of the Green Bay area in order to provide the potential for further growth and create more jobs, and we will not assume otherwise until some local studies or state energy studies tell us otherwise.

The remedial action plan can guide the future efforts for dealing with the problem of dredging and integrate it with other efforts like air deposition or point-source discharge of pollutants into the system. The remedial action plan can also help to define critical environmental concerns that should be addressed in any dredging plan, like toxics hot spots, or critical habitat and sensitive areas to be protected. The sediment loading reductions recommended by the plan may help to reduce the amount of dredging needed or the frequency of dredging, but we would certainly not expect too eliminate the need to dredge.

With regard to eutrophication and nutrients, sediments and nonpoint sources, I will briefly cover all of these together. Current activities include point-source phosphorous control requirements, which are being met. Wisconsin has reestablished its phosphate ban. The department's Nonpoint Source Priority Watershed Program is providing cost-sharing to many watersheds in the state. Local interest has been reflected in the East River area. The remedial action should contribute further to these sorts of efforts:

* It should develop a phosphorous and sediment loading objective or goal for the lower bay.
* It should identify the worst sources, so that we can direct nonpoint-source management activities there first.
* Finally, the remedial action plan should, of course, look at other problems. I have emphasized toxics a bit, but the fishery is returning. However, it is a limited resource. There will be others to speak more about that -- as well as habitat loss, wildlife and endangered species in the coming presentations.

For the DNR, what are expectations for the remedial action plan today? In other words, how will we evaluate its degree of success?

First, we will wonder if it addresses the goals we held: Does it contribute to coordination? Does it contribute to coordination? Does it contribute to improved communications and improved cooperation? Does it meet our obligations to the International Joint Commission and Water Quality Board? And does it lay the groundwork for more specific future actions?

Second, does it address those objectives which are explicitly stated as the objectives of the plan? These objectives deal with toxics, nutrients, habitat and balanced fishery, dredging, land management, water resources access, recreation, public interest and awareness, and others.

Third, does it provide a framework -- a logical step-wise proposal for action -- based on the information we know today? These will not necessarily be specific recommendations for physical change or physical management actions. These will more likely be, to a degree, procedural steps which are included in the plan rather than substantive technical points.

The remedial action plan presents a major challenge to all of us here in 1986. It is a challenge to develop an ecosystems approach as a means of integrating problems and integrating solutions. It is a challenge to develop an ecosystems approach to achieve these multiple and sometimes competing uses. We have the problems of a river with multiple uses, feeding a bay with multiple uses, part of a lake and a Great Lakes system with multiple uses. This layering of uses must be done properly and sensitively if we are to achieve the maximum quality of life including jobs, navigation, industrial activity, as well as recreation. All depend vitally upon these water resources.

These goals and objectives provide a challenge to apply the best science, which is at hand. Not to stop research -- we are not saying that's the end of all research -- but at least to apply the research we have now and translate it into action.

This is a challenge to build on our strengths, our advantages. This problem is a very important one: It is economically important; it is physically important to the quality of life; it is environmentally important; and it is socially important, because the bay provides such an essential identification for the Green Bay area. We have an important problem of international interest.

However, the planning area includes only a single state and a few local governments, so again we have an advantage in developing this plan. Another advantage is that there is strong public interest and support. There is also a very strong record of positive achievement and success: Fish have returned to the lower Fox River and lower Green Bay. Finally, the timing is fortuitous: We think the technology for evaluation is at hand; we think the point-source control is well advanced; nonpoint-source control is coming of age; navigation on the Great Lakes, of course, is getting increased attention and will get dramatically increased attention if and when (I should say sometimes we wonder if) the lake levels ever go down.

The plan, however, presents a challenge to overcome some negative factors. The importance of the problem is positive, but it is also a negative factor in a sense that it creates urgency and pressure. That's okay: It makes our work important. It's technically complex -- in some ways, that's a negative factor. It's the state-of-the-art, the problems we face here. Resolution then will be expensive, the planning will be expensive, but it's cheaper than not coordinating in any case. Development of this plan and the implementation will be slow. It takes more time than any of us want it to. The problems we face are dynamic; they will not hold still for resolution, for, we have all seen, this whole processes circumstances keep changing.

So it really boils down to this: We have tremendous resource problems and potential. We have tremendous people resources and skills: The university, the industries, the environmental groups, and the general community, as well as the DNR staff, all have great skills and knowledge to bring to this process. The challenge is really managerial and cooperative to a great degree. Can we match the assets, the people and the knowledge to the problems of the resource? Can we apply the people and the knowledge to these technical problems? That is the real challenge. If we cannot do this we will have to try again and again. If we can do this, then the wheels of society will move forward, they will find traction. We will have progress, and we all will be better off -- the people, the industry, the economy, the fish and the critters, and the potential for future jobs. The world we leave our children will be improved.

In closing let me summarize. I tried to address:

* Why is a remedial action plan needed? -- It is needed to address very real water resources problems, and the timing is right for doing this.
* What is the remedial action plan? -- It is a set of steps to achieve water uses through the year 2000, applying an ecosystems approach.
* Who will do the remedial action plan? -- It is broadly based to be Wisconsin's plan -- not just the DNR's.
* How and when will it be done? -- The plan will be prepared by committees and include public reviews, hearings and public input. We are aiming at having a draft available for public comment by the end of October 1986.
* What will be the importance of the plan? -- It will build on past work. It will lay out future steps. And it will assure protection of water uses. That is the importance of the plan.

With your help and support, working together, we at the DNR believe we can all match our tremendous knowledge base and the resources available in the Green Bay area to the imposing technical challenge we face. We can find a way to assure that this and future generations will have the quality and safety of the environment and the employment potential that will serve Green Bay as a great place to live and work. I think we will all have a chance to be a part of this very important work.

Thank you very much for your attention.

List of Attendees

Anders Andren, UW-Madison, Sea Grant Institute
Mary Balcer, UW-Superior
Tom Bathi, DNR
Jim Baumann, DNR, Bureau of Water Resources
Brian Belonger, DNR
Ralph Bergman, Bay Lake Regional Planning Commission
Richard C. Bishop, UW-Madison
R. Bishop's son
Larry F. Boyer, UW-Milwaukee, Center for Great Lakes Studies
Larry Brooke, UW-Superior
Bob Bues, Green Bay Metropolitan Sewerage District
Jeanne Christie, DNR, Bureau of Water Resources
Dan Coble, UW-Stevens Point
Phil Cochran, St. Norbert College
Kevin Colson, DNR
Tom Cooper, Green Bay Metropolitan Sewerage District
Fred Copes, UW-Stevens Point
Harold J. Day, UW-Green Bay
Pete de Arteaga, UW-Green Bay graduate student
David Devault, U.S. EPA
Tim Doelger, DNR
Charles Druckrey
David Edgington, UW-Milwaukee
Ron Fassbender, DNR
Joanne Finnell, UW-Green Bay student
Lynn Frederick, UW-Madison, Sea Grant Institute
Kent Fuller, U.S. EPA, Great Lakes Office
Samuel Halloin, Mayor of Green Bay
Mike Hammers, DNR
H.J. Harris, UW-Green Bay
Victoria Harris, DNR
Scott Hausmann, DNR

Michael Hawley, DNR
Steve Hewett, UW-Madison, Center for Limnology
Charles Higgs, DNR
David Hildreth, DNR
Marc Hudson, Audubon Magazine
Lori C. Hutts, DNR
Barry Johnson, UW-Madison
John Kennedy, Green Bay Metropolitan Sewerage District
George Kipphut, University of Alaska, Marine Science
Val Klump, UW-Milwaukee
Clifford Kraft, UW-Madison, Sea Grant Institute
John R. Krezoski, UW-Milwaukee, Center for Great Lakes Studies
Timothy Kubiak, U.S. Fish and Wildlife Service
Amy Kuras, Lake Michigan Federation
Rebecca Leighton, Lake Michigan Federation
Mary Ann Lownders, DNR
Terrence Lychwick, DNR
Michael Mac, U.S. Fish and Wildlife Service, Ann Arbor
Bob Martini, DNR
Dennis J. McCauley, UW-Superior, Lake Superior Environmental Studies
Tom McIntosh, UW-Green Bay
Douglas B. McLaughlin, Fort Howard Paper Co.
Rob McLennon, DNR, Lake Michigan District
Tom Meinz, Wisconsin Public Service Corp.
Lee Meyers, DNR
James Moore, DNR
Walter D. Naab, DNR, Oshkosh
Bobette Nelson, UW-Green Bay student
W.R. Nelson, Green Bay Packaging
David Nennig, Assistant to Mayor of Green Bay
Ed Newman, Wisconsin Public Service Corp.
Randy Oswald, Wisconsin Public Service Corp.
Robert J. Overly, Fort Howard Paper Co.
David F. Pagel, Fort Howard Paper Co.
Dale Patterson, DNR, Bureau of Water Resources
Lynn Persson, DNR, Bureau of Water Resources
David Rades, Institute of Paper Chemistry

Bob Ragotzkie, UW-Madison, Sea Grant Institute

Tim Rasman, DNR

David Reinke, Green Bay Metropolitan Sewerage District

Sumner Richman, Lawrence University, Appleton

Bruce Robertson, James River Corp.

David Rockwell, U.S. EPA

Paul Rome, UW-Madison, Sea Grant Institute

Richard Rost, DNR

Paul Sager, UW-Green Bay

Donald J. Schneider, Fort Howard Paper Co.

Todd Schneider, DNR

Leander J. Schwartz, UW-Green Bay

David Smith, UW-Madison, Center for Limnology

Peyton Smith, UW-Madison, Sea Grant Institute

Ted Smith, DNR, Spooner

Elmer Smits, S.U.W.Q.A.

Ken Stromborg, U.S. Fish and Wildlife Service

Jack Sullivan, DNR, Bureau of Water Resources

John Sullivan, DNR, LaCrosse

Gus Swoboda, Wisconsin Public Service Corp.

Linda Talbot, DNR, Bureau of Water Resources

Paul Thormodsgard, Green Bay Metropolitan Sewerage District

Patrick Vaile, Brown County Planners

Bernie Van Camp, Recycle Techn., Inc.

Dennis C. Weisensel, DNR

Douglas Welch, DNR

David A. Wentland, Fox Valley Water Quality Agency

Lyman Wible, DNR

Additional copies of this publication are available from:

Lake Michigan District Office
Wisconsin Department of
Natural Resources
P.O. Box 10448
Green Bay, WI 54307-0448

Public Information Office
Wisconsin Department of
Natural Resources
101 S. Webster St.
Madison, WI 53702

Communications Office
University of Wisconsin
Sea Grant Institute
1800 University Avenue
Madison, WI 53705