INTERNATIONAL ASSOCIATION FOR GREAT LAKES RESEARCH

PROGRAM AND ABSTRACTS

34TH CONFERENCE ON GREAT LAKES RESEARCH

JUNE 2-6, 1991

UNIVERSITY AT BUFFALO STATE UNIVERSITY OF NEW YORK

GREAT LAKES PROGRAM

IAGLR '91 - SCHEDULE

SUNDAY, JUNE 2

1:00 - 9:00 PM

Registration - Center for Tomorrow

3:00 - 6:00 PM

IAGLR Board Meeting - Center for Tomorrow

7:00 - 10:00 PM

Icebreaker - Center for Tomorrow

MONDAY, JUNE 3

7:30 - 8:30 AM

Continental Breakfast - Knox Rotunda area

7:30 AM - 5:00 PM

Registration/Information Desk - Knox Rotunda area

Exhibitors - Knox Rotunda area

9:00 AM - 12:00 PM

Plenary Session - Slee Hall

"Integrating Research and Management in the Great Lakes"

12:00 - 2:00 PM

Lunch/Annual Business Meeting - Talbert Dining Hall

2:00 - 5:20 PM

Technical Sessions

◊ 1A Progress on the Green Bay Mass Balance Study (I)
20 Knox Hall

◊ 1B Interactions Among Various Great Lakes Management Strategies
109 Knox Hall

◊ 1C Ecological, Epidemiological and Neurotoxicological Assessment of Great Lakes contaminants (I)
110 Knox Hall

◊ 1D Contaminant Bioavailability and Bioaccumulation
14 Knox Hall

◊ 1E Forecast and Prediction Systems (I)
4 Knox Hall

Dinner (on your own)

7:00 - 9:00 PM

Poster Session - Norton Hall (Carpenter Room)

TUESDAY, JUNE 4

7:30 - 8:30 AM

Continental Breakfast - Knox Rotunda area

7:30 AM- 5:00 PM

Registration/Information Desk - Knox Rotunda area

Exhibitors - Knox Rotunda Area

8:30 AM - 12:10 PM

Technical Sessions

◊ 2A Progress on the Green Bay Mass Balance Study (II)
20 Knox Hall

◊ 2B Lake Ontario Ecosystem: Past, Present and Future (I)
109 Knox Hall

◊ 2C Ecological, Epidemiological and Neurotoxicological Assessment of Great Lakes Contaminants (II)
110 Knox Hall

◊ 2D Fish and Fisheries Ecology in the Great Lakes
14 Knox Hall

◊ 2E Forecast and Prediction Systems (II) & Lake Levels and Coastal Stability: Geologic Implications and Historical Perspectives (I)

12:00 - 1:30 PM

Lunch - Talbert Hall

1:40 PM - 5:00 PM

Technical Sessions

◊ 3A Progress on the Green Bay Mass Balance Study (III)
20 Knox Hall

◊ 3B Lake Ontario Ecosystem: Past, Present and Future (II)
109 Knox Hall

◊ 3C Progress in the Assessment and Remediation of Contaminated Sediments (ARCS) Program (I)
110 Knox Hall

◊ 3D Research and Management of Wetlands in the Great Lakes
14 Knox Hall

◊ 3E Lake Levels and Coastal Stability: Geologic Implications and Historical Perspectives (II)
4 Knox Hall

6:00 PM - 10:00 PM

Banquet - Marriott Hotel

WEDNESDAY, JUNE 5

7:30 AM - 8:30 AM

Continental Breakfast - Knox Rotunda Area

8:30 AM - 12:10 PM

Technical Sessions

◊ 4A Progress in Zebra Mussel Research in the Great Lakes Basin (I)
20 Knox Hall

◊ 4B Lake Ontario Ecosystem: Past, Present and Future (III)
109 Knox Hall

◊ 4C Progress in the Assessment and Remediation of Contaminated Sediments (ARCS) Program (II)
110 Knox Hall

◊ 4D Bioindicators of Ecosystem Health in Great Lakes (I)
14 Knox Hall

◊ 4E Transport of Particle-Associated Contaminants in Large Surface Water Bodies
4 Knox Hall

12:00 PM - 1:00 PM

Lunch - Talbert Hall

12:15 - 3:15 PM

Tours

1:00 PM - 3:00 PM

Poster Session - Norton Hall (Carpenter Room)

Technical Sessions

3:20 PM - 5:20 PM

◊ 5A Progress in Zebra Mussell Research in the Great Lakes Basin (II)
20 Knox Hall

◊ 5B Implementing Sustainable Development and the Ecosystem Approach in Great Lakes Decision-Making (I)
109 Knox Hall

◊ 5C Progress in the Assessment and Remediation of Contaminated Sediments (ARCS) Program (III)
110 Knox Hall

◊ 5D Bioindicators of Ecosystem Health in Great Lakes (II)
14 Knox Hall

◊ 5E Evidence for the Restoration of Lake Erie (I)
4 Knox Hall

7:00 PM - 9:00 PM

Public Forum - 20 Knox Hall

THURSDAY, JUNE 6

7:30 AM - 8:30 AM

Continental Breakfast - Knox Rotunda Area

8:30 AM - 12:10 PM

Technical Sessions

EMAP Panel Discussion (8:30 AM - 10:10 AM)

"EPA's Environmental Monitoring and Assessment Program (EMAP): Implications for Great Lakes Surveillance and Monitoring"

◊ 6A General Limnology
20 Knox Hall

◊ 6B Implementing Sustainable Development and the Ecosystem Approach in Great Lakes Decision Making (II)
109 Knox Hall

◊ 6C Contaminated Sediments
110 Knox Hall

◊ 6D Towards an Appreciation of the Current Status of Rainbow Smelt in Lake Erie
14 Knox Hall

◊ 6E Evidence for the Restoration of Lake Erie (II) & Atmospheric Processes
4 Knox Hall

12:00 PM - 1:30 PM

Lunch - Talbert Hall

ADJOURN

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THE 34TH CONFERENCE OF

THE INTERNATIONAL ASSOCIATION FOR GREAT LAKES RESEARCH

JUNE 2 - 6, 1991

HOSTED BY

Great Lakes Program
State University of New York at Buffalo
207 Jarvis Hall
Buffalo, New York 14260

CO-HOSTED BY

New York Great Lakes Research Consortium

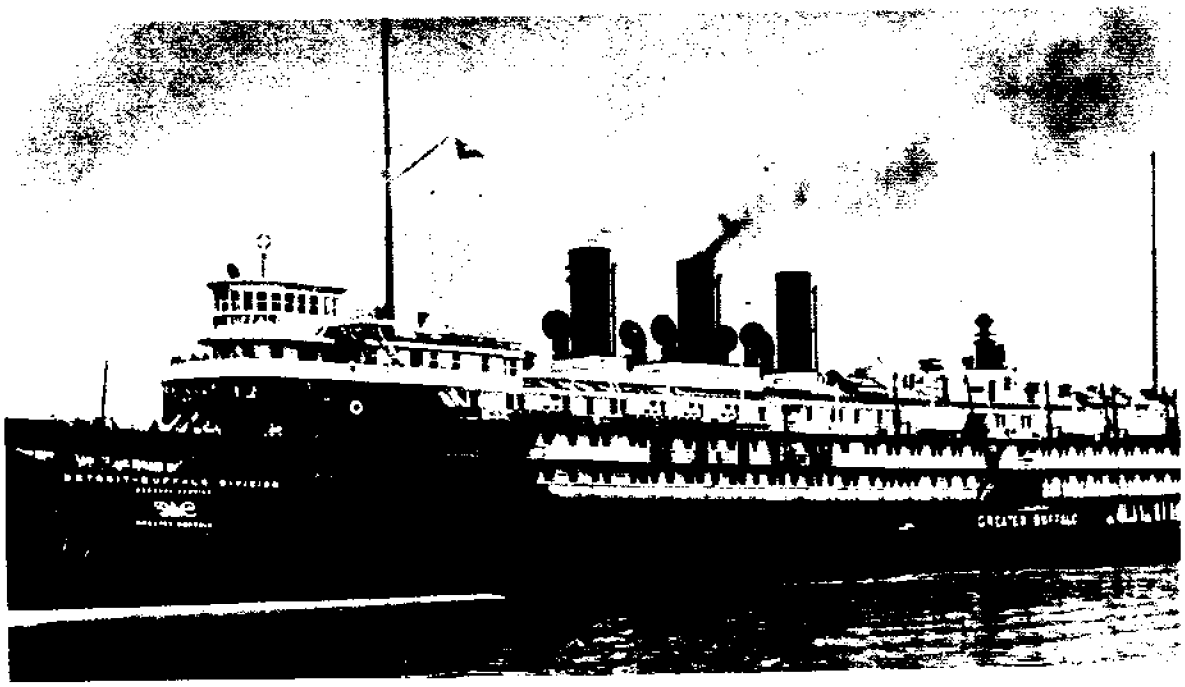
PATRONS

U.S. EPA - Great Lakes National Program Office
New York Sea Grant Institute
Ecology & Environment, Inc.

Acknowledgements

The Great Lakes Program of the State University of New York at Buffalo is grateful to the following for their assistance on the 34th Annual Conference on Great Lakes Research:

- ∇ *University at Buffalo News Bureau* - ***Publicity and Media Relations***
- ∇ *University at Buffalo Office of Publications* - ***Abstract Cover Design***
- ∇ *University at Buffalo Central Duplicating* - ***Printing Abstract Book***
- ∇ *Lower Lakes Marine Historical Society, P.O. Box 59, Buffalo, New York 14215* - ***Historical photos***



Great Buffalo Passenger Steamer later converted to an aircraft carrier (George Bush learned to fly off of) 1939.

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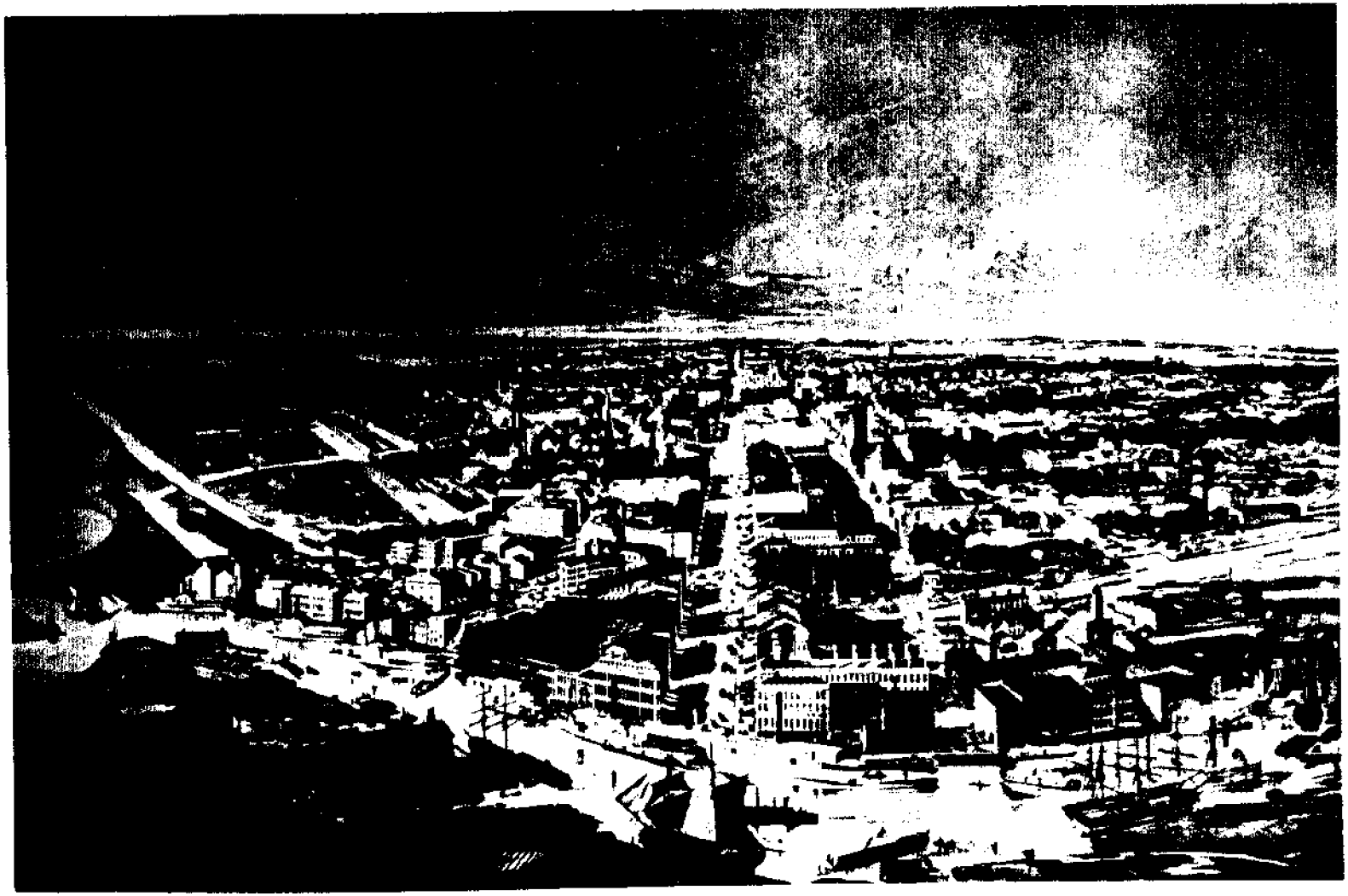


A view of Buffalo - 1853.

34th CONFERENCE
LOCAL PLANNING COMMITTEE

Conference Chairman: **Joseph V. DePinto**

Co-Chairman: **Ralph R. Rumer**

Planning Committee:

Joseph V. DePinto
Director
Great Lakes Program
University at Buffalo
- Technical Program, Budget

Ralph R. Rumer
Executive Director
New York State Center for Hazardous Waste Management,
University at Buffalo
- Budget, Campus Arrangements, Publicity

Jack Manno
Associate Director
Great Lakes Research Consortium
SUNY College of Environmental Science & Forestry
- Plenary session, Public Forum

Kenton M. Stewart
Biological Sciences
University at Buffalo
- Plenary Session, Awards

Robert A. Sweeney
Ecology & Environment, Inc.
- Exhibitions, Reception

Brian Shero
Department of Biology
Medaille College
- Public Forum

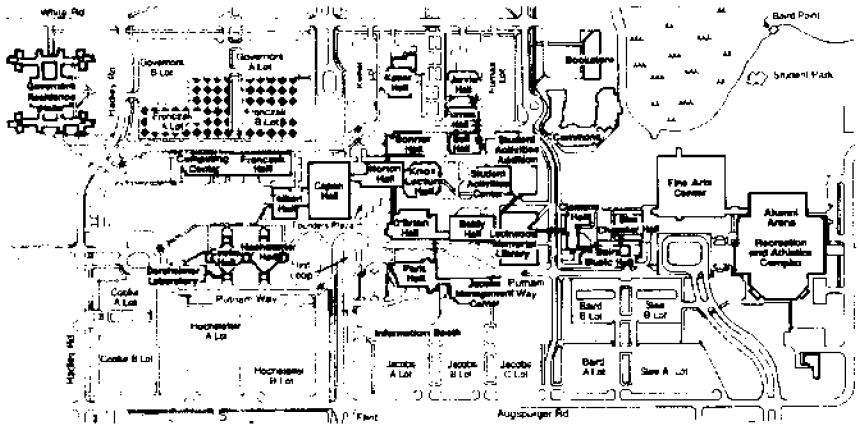
Judith Zuckerman
Director

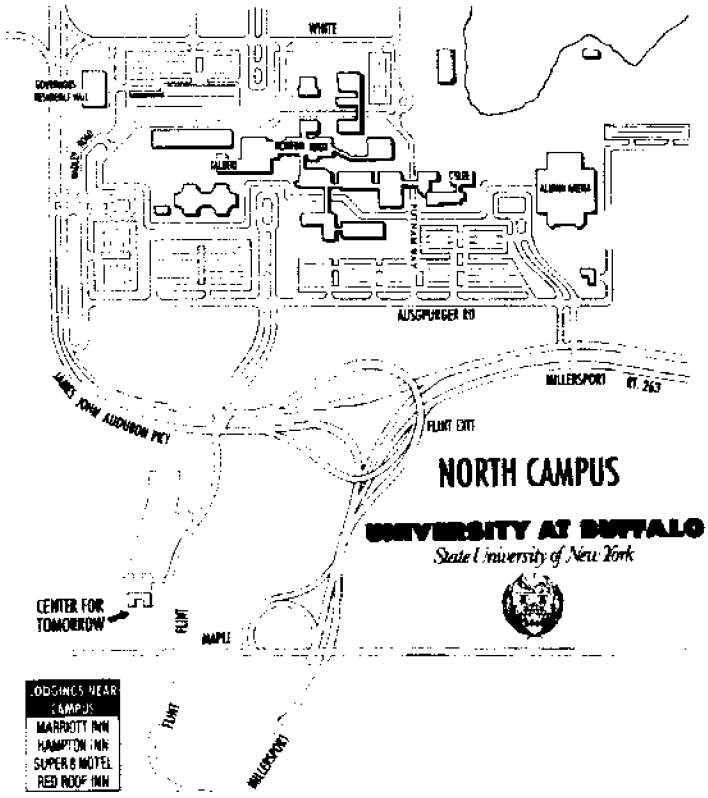
William Regan
Associate Director
Offices of Conferences and Special Events
University at Buffalo
- Special Events, Local arrangements, Registration, Contractual Services

Monica Moshenko
Administrative Assistant
Great Lakes Program
University at Buffalo
- Committee Secretary, Local Arrangements, Publications

CAMPUS MAPS

North Campus Spine





CAMPUS INFORMATION

Great Lakes Program
207 Jarvis Hall
Amherst Campus
- (716) 636-2088
- FAX (716) 636-3667

Office of Conferences and Special Events
526 Capen Hall
Amherst Campus
- (716) 636-3705

Department of Public Safety
Bissell Hall
- Emergency - (716) 636-2222
- Lost and Found - (716) 636-2227
- Parking Violations - (716) 831-2886

Governors Residence Hall
- Reception Desk (716) 636-2135

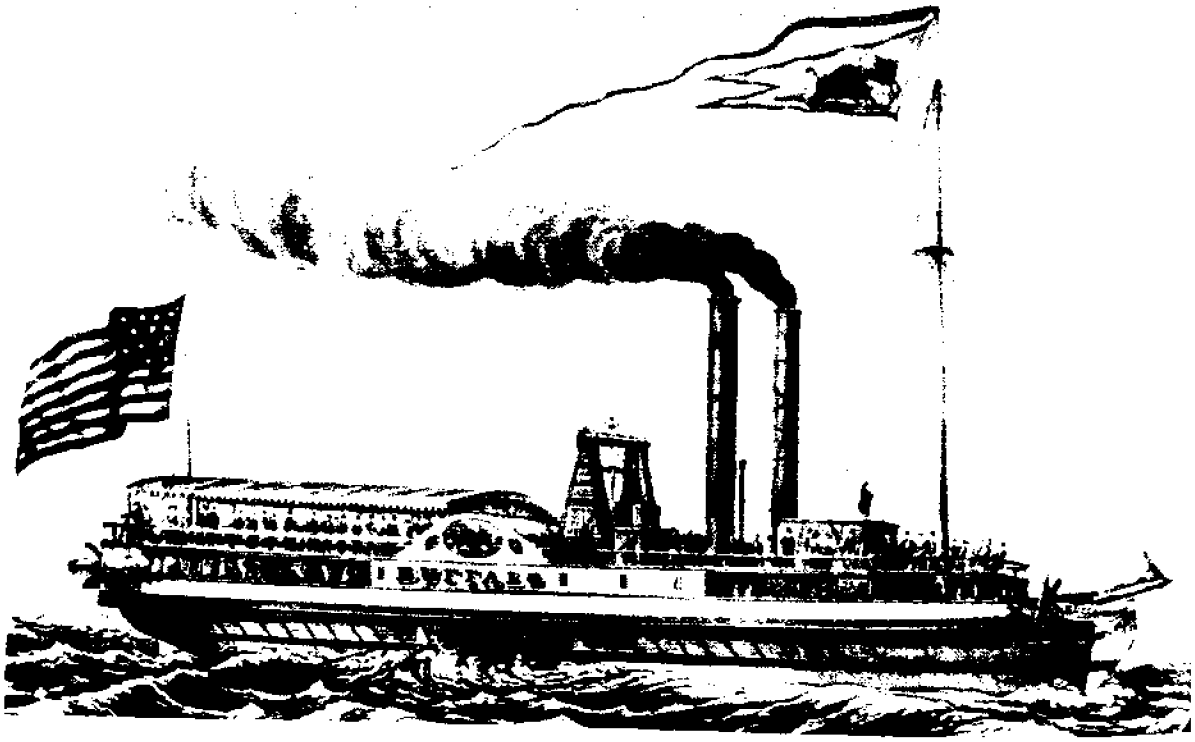
Center for Tomorrow
- (716) 636-2018

Slee Hall
- (716) 636-2921

Central Receiving - Campus Services
131 Helm Building
- (716) 636-3528

Handicapped Services
- (716) 636-2608

The "Walk-in-the-Water"
From "Niagara Journal," May 11, 1819



Side paddle wheel steamer "Buffalo" - 1847.

SCHEDULE OVERVIEW

SUNDAY, JUNE 2

3:00 - 6:00 PM	BOARD MEETING - *Center for Tomorrow*
1:00 - 9:00 PM	REGISTRATION - *Center for Tomorrow*
7:00 PM - 10:00 PM	ICE BREAKER - *Center for Tomorrow*

MONDAY, JUNE 3

7:30 - 8:30 AM	CONTINENTAL BREAKFAST - *Knox Rotunda Area*
7:30 AM - 4:00 PM	REGISTRATION - *Knox Rotunda Area*
9:00 AM - 12:00 PM	PLENARY SESSION - *Slee Hall*
12:00 - 2:00 PM	LUNCH/ANNUAL BUSINESS MEETING - *Talbert Hall*
2:00 - 5:20 PM	CONCURRENT SESSIONS - *Knox Hall*
7:00 - 9:00 PM	POSTER SESSION - *Norton Hall (Carpenter Room)*

TUESDAY, JUNE 4

7:30 - 8:30 AM	CONTINENTAL BREAKFAST - *Knox Rotunda Area*
7:30 AM - 4:00 PM	REGISTRATION - *Knox Rotunda Area*
8:30 - 12:10 PM	CONCURRENT SESSIONS - *Knox Hall*
12:00 - 1:30 PM	LUNCH - *Talbert Hall*
1:40 - 5:00 PM	CONCURRENT SESSIONS - *Knox Hall*
6:30 - 10:00 PM	BANQUET - *Marriott Hotel*

WEDNESDAY, JUNE 5

7:30 - 8:30 AM	CONTINENTAL BREAKFAST - *Knox Rotunda Area*
7:30 - 2:00 PM	REGISTRATION - *Knox Rotunda Area*
8:30 - 12:10 PM	CONCURRENT SESSIONS - *Knox Hall*
12:00 - 1:30 PM	LUNCH - *Talbert Hall*
1:00 - 3:00 PM	POSTER SESSION - *Norton Hall (Carpenter Room)*
12:15 - 3:15 PM	TOURS
3:20 - 5:20 PM	CONCURRENT SESSIONS - *Knox Hall*
7:00 - 9:30 PM	PUBLIC FORUM - *20 Knox Hall*

THURSDAY, JUNE 6

7:30 - 8:30 AM	CONTINENTAL BREAKFAST - *Knox Rotunda Area*
8:30 AM - 12:10 PM	CONCURRENT SESSIONS - *Knox Hall*
12:00 PM - 1:30 PM	LUNCH - *Talbert Hall*

SPECIAL EVENTS

Icebreaker

An "Icebreaker" will be held at the *Center for Tomorrow* on Sunday, June 2, 1991 from 7:00 - 10:00 PM featuring some of Buffalo's well known dishes, chicken wings, roast beef on kimmelweck with assorted snacks and beverages.

Banquet

On Tuesday evening, June 4, 1991 the Annual Banquet and Awards Ceremony will be held at the *Marriott Hotel.* **Dr. Farrell Boyce** of the National Water Research Institute, Environment Canada will be the guest speaker. A cash bar will be available.

Tours

Three off-campus and two on-campus tours are being offered to this year's conference attendees. Off-campus tour choices include the Niagara Power Project on the Niagara River, one of the world's largest hydroelectric plants; a boat tour of the Buffalo River and the City of Buffalo's Water Intake. On-campus tours include the Earthquake Center and Environmental Fluid Mechanics Lab featuring a rotating lab with scale model of Lake Ontario.

Baseball

On Thursday, June 6, 1991 the **Buffalo Bisons AAA** baseball team will be playing Rochester at 7:05 PM at *Pilot Field.* Tickets are available by contacting Monica at the Great Lakes Program office (716) 636-2088.

Recreation

Persons attending the conference may use the athletic facilities in the Alumni Arena, which include: pool (bring your own towel and lock), indoor jogging track, weight room, squash and racquetball courts. A **$2.00 usage fee** will be charged. Equipment such as racquets, volleyballs and basketballs is also available. For General information contact 636-3141; Recreation hotline number is 636-3147.

EXHIBITORS

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BOULDER, CO 80303

NOTE: The above names are a partial list of exhibitors confirmed at the time of printing. We anticipate several more additions to the list at the time of the Conference.

34th Annual Membership Meeting

INTERNATIONAL ASSOCIATION FOR GREAT LAKES RESEARCH

Great Lakes Program
State University of New York at Buffalo
June 3, 1991

1. Call to Order; 12:30 PM - (Talbert Hall)
2. Approval of Agenda
3. Approval of the 1990 Annual Membership Meeting Minutes
4. President's Report - Tom Nalepa
5. Treasurer's Report - Barry Lesht
6. Auditor's Report - Joe Leach
7. Editor's Report - Bill Sonzogni
8. Business Office report - Barry Lesht
9. Committee Reports
   a. *Publications - Keith Bedford*
   b. *Awards - Deb Swackhamer*
   c. *Membership - Mike Quigley*
   d. *Conference - Doug Haffner*
   e. *Technical Advisory - John Gannon*
   f. *Mott Fellowship - John Krezoski*
   g. *Nominations - Mike Whittle*
10. Other business from the floor
11. Motion of Responsibility
12. Recognition of Outgoing Members
13. Announcement of New Board Members
14. Transfer of the Chair
15. Adjournment

OPENING PLENARY SESSION

Monday, June 3, 1991
9:00 AM - Noon
Slee Hall

The conference will open Monday morning with welcoming remarks by **Dr. Donald Rennie,** Vice Provost for Research and Graduate Education; a keynote address by **Congressman Henry J. Nowak,** 33rd District of the State of New York. Following the keynote, a panel will address the conference theme of *"Integrating Research and Management in the Great Lakes"*. Leaders from several agencies involved with management responsibilities in the Great Lakes will discuss their experiences integrating research and management. **Dr. H. Lorraine Oak,** Associate for Program Development, Office of Vice Provost for Research and Graduate Education of the State University of New York at Buffalo will be the moderator.

Panel members include:

- Dr. Al Beeton of NOAA's Great Lakes Environmental Research Lab;
- Dr. Ralph Daly, Director of the Canada Centre for Inland Waters;
- Dr. Phillip Cook, a researcher and administrator at the U.S. EPA's Environmental Research Lab-Duluth;
- Mr. Roy Hickman, Director of Health & Welfare Canada's Environmental Health Centre and Co-Chair of the IJC's Council of Great Lakes Research Managers; and
- Dr. Jon G. Stanley, Director, National Fisheries Research Center- Great Lakes, U.S. Co-Chair, Council of Great Lakes Research Managers.

Panel members will discuss the ways they integrate research funding and results with management strategies and will address such questions as:

Are up-to-date research results available to resource managers when decisions are being made? If not, what are the major obstacles to this information flow?

Should management needs and management-identified information gaps drive the sponsored research agenda? If it does, how can researchers be protected from the rapid realignment of priorities prompted by shifting political fashions?

How can research hypotheses that contradict current management assumptions receive management attention?

An additional perspective will be provided by **Dr. Ulf Ehlin** of the *Swedish Meteorological and Hydrological Institute* who will discuss how these types of questions have been addressed in planning and implementing the international programme for the Gulf of Bothnia Year 1991.

INTEGRATING GREAT LAKES RESEARCH AND PUBLIC INTEREST

What questions should Great Lakes researchers be asking?
What do you want to know?

A PUBLIC FORUM

as part of the
ANNUAL CONFERENCE OF THE INTERNATIONAL ASSOCIATION FOR GREAT LAKES RESEARCH

Wedesday, June 5
7:00 - 9:30 PM
Knox Hall - Room 20
University at Buffalo, Amherst Campus

FREE AND OPEN TO THE PUBLIC

What's happening in Great Lakes research in 1991? What isn't happening? How can the public influence the research agenda?

A panel of leading scientists who are moderating several of the technical sessions of the Great Lakes research conference will meet a panel of representatives of various public interests as both sides consider these questions as they relate to:

- computer modeling
- contaminated sediments
- toxic chemicals and human health
- indicators of ecosystem well-being
- zebra mussels
- Great Lakes fish

The panel of public representatives include:

- **Dr. Fred Brown**, past-president of Great Lakes United and a member of the State of Michigan Water Quality Commission;
- **Senator John B. Sheffer II**, New York State Senate;
- **Grace Wever**, Program Manager for Eastman-Kodak's Division of Environmental Affairs;
- **George H. Musgrove**, Head of Mission and Senior Trade Commissioner of the Canadian Consulate in Buffalo.
- **Dr. Adeline Levine**, Department of Sociology, University at Buffalo

The representatives from the Technical Sessions are:

Dr. Joseph DePinto, IAGLR Conference Chairman
Director, Great Lakes Program of the University at Buffalo;
"Progress on the Green Bay Mass Balance Study"

Dr. Paul Bertram, U.S. EPA - Great Lakes National Program Office;
"Bioindicators of ecosystem health in Great Lakes"

Dr. James Olson, Department of Pharmacology, University at Buffalo;
"Ecological, epidemiological and neurotoxicological assessment of Great Lakes contaminants"

Dr. Charles O'Neill, New York Sea Grant Extension Specialist, SUNY-Brockport;
Zebra Mussel Information Clearinghouse;
"Progress in Zebra Mussel research in the Great Lakes Basin"

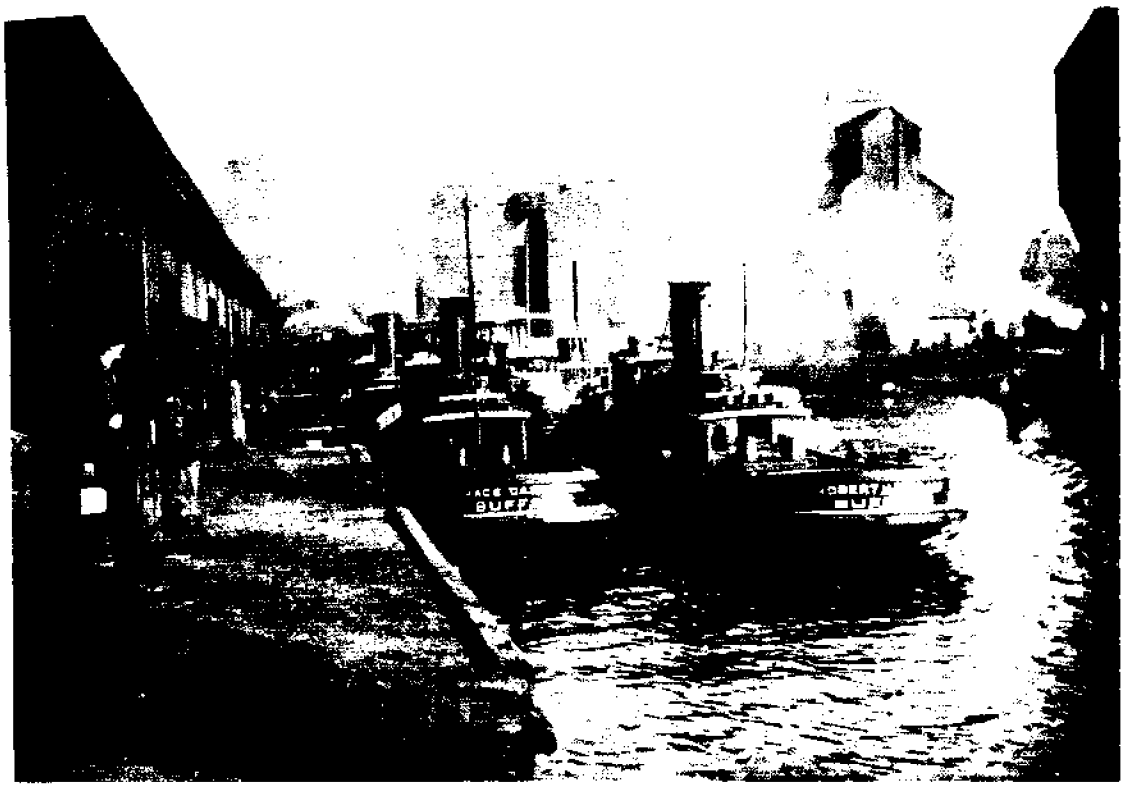
Dr. Mohiuddin Munawar, National Water Research Institute
Canada Centre for Inland Waters;
"Lake Ontario ecosystem: Past, present and future"

Dr. Dave Cowgill, U.S. EPA, Great Lakes National Program Office;
"Progress in the assessment and remediation of contaminated sediments (ARCS) program"

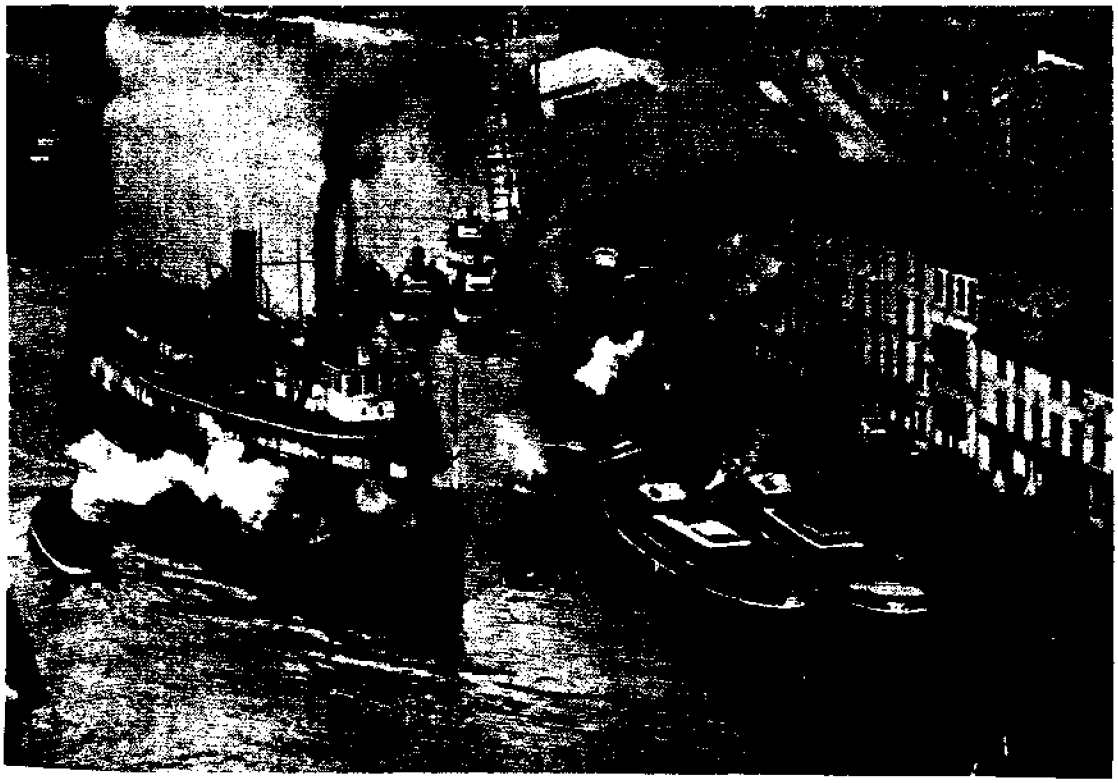
Dr. James Haynes, Department of Biological Sciences, SUNY Brockport;
"Fish and fisheries ecology in the Great Lakes"

Mr. Barry Boyer, Director, Baldy Center, School of Law;
"Implementing Sustainable Development and the ecosystem approach in Great Lakes decision-making"

The panel discussions will be followed by written questions from the audience. The forum will be moderated by **Jack Manno,** *Associate Director* of the New York Great Lakes Research Consortium.



Tugs docked at the foot of Main Street - 1890's.



Foot of Main Street; Large vessel "State of Ohio" - 1890

Monday, June 3

PLENARY SESSION – "INTEGRATING RESEARCH AND MANAGEMENT IN THE GREAT LAKES"

SLEEHALL

9:00 Welcome – DR. DONALD RENNIE, Vice Provost for Research and Graduate Education, University at Buffalo
9:15 Keynote Address – HONORABLE HENRY J. NOWAK, U.S. Representative 32nd District, New York State
10:00 BREAK
10:30 PANEL DISCUSSION
DR. H. LORRAINE OAK, Moderator, Office of Vice Provost for Research and Graduate Education, University at Buffalo
DR. AL BEETON, Director, NOAA, Great Lakes Environmental Research Lab, Ann Arbor
DR. PHILIP COOK, U.S. EPA, ERL-Duluth
DR. RALPH DALY, Director, Canada Centre for Inland Waters
DR. ULF EHLIN, Director, Hydrological/Oceanographical Div., Swedish Meteorological & Hydrological Institute
MR. ROY HICKMAN, Director, Health & Welfare, Canada's Environmental Health Centre
DR. JOHN TURNER, Director, U.S. Fish & Wildlife Service

SESSION 1A – SYMPOSIUM: "PROGRESS ON THE GREEN BAY MASS BALANCE STUDY" (I)

ROOM 20 KNOX HALL

CONVENORS: *VICTOR J. BIERMAN, JR.*, University of Notre Dame, *JOSEPH V. DEPINTO*, University at Buffalo, *DAVID F. DEVAULT*, U.S. EPA, GLNPO, *DEBORAH SWACKHAMER*, University of Minnesota

MODERATOR: VICTOR J. BIERMAN, JR

1:50 VICTOR J. BIERMAN, Jr. - Introductory Remarks
2:00 **WILFORD, WAYNE A.** Overview of Green Bay Mass Balance Project.
2:20 **EHLIN, ULF.** Overview of Gulf of Bothnia project.
2:40 **KENNEDY, JOHN A.** Long-term water quality monitoring of the Lower Fox River and Green Bay: the first five years.
3:00 **WARREN, GLENN J., D. C. ROCKWELL.** Surface water nutrient distribution in Green Bay during the Green Bay mass balance study: historical comparisons and water mass relationships.
3:20 BREAK
3:40 **McALLISTER, LYNNE, H. J. HARRIS.** Factors influencing the distribution of submerged macrophytes in Green Bay, Lake Michigan; a focus on light attentuation and vallisneria americana.
4:00 **HORNBUCKLE, K. C., S. J. EISENREICH, R. HOFF.** Atmospheric PCBs over Green Bay, 1989.
4:20 **MURPHY, THOMAS J., C. W. SWEET, C. A. KELSEY, J. HONG, J. H. BANNASCH.** Atmospheric deposition of PCB's and dieldrin to Green Bay.
4:40 **EISENREICH, S. J., D. ACHMAN, K. C. HORNBUCKLE.** PCB volatilization from Green Bay, Lake Michigan.
5:00 **FRANZ, T. P., S. J. EISENREICH.** Wet deposition of PCBs to Green Bay, Lake Michigan.

SESSION 1B – SYMPOSIUM: "INTERACTIONS AMONG VARIOUS GREAT LAKES MANAGEMENT STRATEGIES"

ROOM 109 KNOX HALL

CONVENOR: *JOHN CAREY*, National Water Research Institute, CCIW

MODERATOR: JOHN CAREY

1:50 JOHN CAREY - Introductory Remarks.
2:00 **WILLIAMS, D. J., T. BARTISH.** The Great Lakes international surveillance plan (GLISP): an introduction.
2:20 **MACKAY, DONALD, M. DIAMOND.** The role of mass balancing in Great Lakes management of toxicchemicals.
2:40 **TAYLOR, W. D., J. H. CAREY, D.R.S. LEAN, D. J. MCQUEEN.** Organochlorine concentrations in the plankton of lakes in southern Ontario and their relationship to plankton biomass.
3:00 **LEAN, D. R. S., M. A. NEILSON, A. MAZUMDER.** Response of Lake Ontario to reduced phosphorus loading.
3:20 BREAK
3:40 **POULTON, DONALD.** Heavy metals and toxic organic contaminants in water and sediments of the Bay of Quinte, Lake Ontario.
4:00 **DIAMOND, M. L., D. MACKAY, D. POULTON, F. STRIDE.** Modelling organic and inorganic chemicals in the Bay of Quinte.
4:20 **SIMMERS, JOHN W., L. F. BRYNIARSKI.** Assessment of an avian botulism control pilot project at the dike 14 confined dredged material disposal facility, Cleveland, Ohio.
4:40 **HARTIG, JOHN H.** Revised listing/delisting guidelines for Great Lakes areas of concern.
5:00 **EDER, TIM.**

SESSION 1C – SYMPOSIUM: "ECOLOGICAL, EPIDEMIOLOGICAL AND NEUROTOXICOLOGICAL ASSESSMENT OF GREAT LAKES CONTAMINANTS"(I)

ROOM 110 KNOX HALL

CONVENORS: *PAUL KOSTYNIAK*, Toxicology Research Center, University at Buffalo, *JAMES OLSON*, Dept. of Pharmacology & Therapeutics, University at Buffalo, and *RICHARD SEEGAL*, SUNY Albany Graduate School of Public Health, NYS DOH

MODERATOR: JAMES OLSON

1:50 JAMES OLSON - Introductory Remarks
2:00 **HUMPHREY, HAROLD E. B.** The human population - a receptor for aquatic contaminants.
2:20 **VENA, JOHN E.** The consumption of contaminated fish and perception of risk among New York fishermen.
2:40 **FITZGERALD, E.** Dietary exposure to PCBs from hazardous waste.
3:00 **HESSELBERG, R. J., L. J. SCHMIDT, J. D. BOWKER.** Comparative trends of selected AHH-active PCB congeners and pesticides in lake trout from Lakes Michigan and Ontario, 1977-1988.
3:20 BREAK

Continued on page 9

Monday, June 3

3:40 **FIORELLA, D., P. KOSTYNIAK, J. McREYNOLDS, J. OLSON, D. LIMPENSEL.** Quantitative determination of tri-fluoromethyl PCB's in Lake Ontario fish.

4:00 **MASLANKA, R., R. A. STEWARD, J. PANGREGAR, H.C. SIKKA.** Disposition of 2,3,7,8-Tetrachlorodibenzofuran (TCDF) in rainbow trout (*oncorhyncus mykiss*).

4:20 **DICKMAN, M., I. BRINDLE, N. GHAZI, G. RYGIEL.** The presence of contaminated sediments in the Niagara River watershed as indicated by invertebrates with deformities.

4:40 **WALKER, MARY K., R.E. PETERSON.** Toxic potencies of polychlorinated dibenzo-p-dioxins, dibenzofurans and biphenyls during rainbow trout early development using a microinjection method.

5:00 **WILLIAMS, LISA L., J. P. GIESY.** Coplanar polychlorinated biphenyl (PCB) congeners and TCDD-equivalents in fillets of Lake Michigan chinook salmon: implications for fish consumption advisories.

7:00 **POSTER SESSION** - Norton Hall (Carpenter Room). See page 16 for the participants.

SESSION 1D – "CONTAMINANT BIOAVAILABILITY AND BIOACCUMULATION"

ROOM 14 KNOX HALL

MODERATOR: HARISH SIKKA

2:00 **SANTIAGO, S., F. A. FOREL, R. L. THOMAS.** Bioavailability of suspended sediment bound phosphorus in some rivers tributary to Lake Geneva.

2:20 **COTTER, A. M., E. N. LEONARD, P. A. KOSIAN, G. T. ANKLEY.** Acid volatile sulfide measurement, a major indicator for determining metal bioavailability in sediments.

2:40 **SIMMERS, JOHN W., D. L. BRANDON, R. P. LEONARD.** Distribution of PCB contaminants in the vicinity of the Times Beach confined disposal facility, Buffalo, New York.

3:00 **HAFFNER, G. D., F. A. P. C. GOBAS, R. LAZAR.** Quantification of biomagnification and predator - prey interactions in the Great Lakes.

3:20 **BREAK**

3:40 **RUSSELL, R. W., F. A. P. C. GOBAS, G. D. HAFFNER.** Bioconcentration of chlorinated benzenes and biphenyls in field exposed fish.

4:00 **NOGUCHI, GEORGE E., L. J. SCHMIDT, M. J. MAC.** Tissue distribution of PCB congeners in Lake Michigan lake trout.

4:20 **BOWKER, JAMES D., L. J. SCHMIDT.** Bioaccumulation potential of selected PCB congeners from Saginaw River sediment during 10- and 28-day bio-exposure studies.

4:40 **LICK, WILBERT.** Physical parameters and the solids concentration effect in the sorption of hydrophobic chemicals from water.

7:00 **POSTER SESSION** - Norton Hall (Carpenter Room). See page 16 for the participants.

SESSION 1E – SYMPOSIUM: "FORECAST AND PREDICTIONS SYSTEMS"

ROOM 4 KNOX HALL

CONVENORS: *KEITH W. BEDFORD* and *CAROLYN J. MERRY*, Department of Civil Engineering, Ohio State University

MODERATORS: KEITH BEDFORD and CAROLYN MERRY

1:50 KEITH BEDFORD - Introductory Remarks

2:00 **BOYCE, DARON** Marine weather services on the Great Lakes.

2:20 **SCHWAB, DAVID J., G. A. LESHKEVICH.** Great Lakes coastwatch and NOAA Ocean Communications Network.

2:40 **BEDFORD, KEITH W., D. J. SCHWAB.** The Great Lakes forecasting system - Lake Erie nowcasts.

3:00 **MERRY, CAROLYN J., D. WELSH, Y. CHU, K. W. BEDFORD, D. SCHWAB, M. J. McCORMICK.** Using AVHRR and in-situ temperature data in a surface heat flux model for Lake Erie.

3:20 **BREAK**

3:40 **CLODMAN, S.** Lake wind wave forecasting at the Atmospheric Environment Service.

4:00 **BRISSETTE, F. P., I. K. TSANIS.** Wave directional spectra in Lake Ontario and Lake St. Clair.

4:20 **YOUNG, SHAROLYN R.** Long range ice forecasting in the Great Lakes.

4:40 **CRISSMAN, RANDY D.** An on-line early warning system for ice jams and ice stoppages on the upper Niagara River.

5:00 **PECK, EUGENE L.** Evaluation of ground and airborne data for snowmelt forecasting for Lake Ontario basin.

7:00 POSTER SESSION - Norton Hall (Carpenter Room)

Poster Session, continued from page 16

PATTERSON, DALE, J. STEUER, J. BHATTACHARYYA. Concentrations of polychlorinated biphenyls in bottom sediments of the lower Fox River, Wisconsin.

QUIGLEY, M. A., G. A. LANG, W. M. GORDON. Year-to-year variability in production of the Great Lakes Amphipod, Diporeia sp. in southeastern Lake Michigan.

REMNANT, RICHARD A., W. G. FRANZIN. An assessment of the impact of the Rainbow Smelt on the fishery resources of Lake Winnipeg.

ROOD, STEPHEN. Geographical information system (GIS)/Global Positioning System (GPS) support for assessment of contaminated sediments in the Buffalo River.

ROSA, FERNANDO Sediment translocation in Lake Erie during winter.

RUKAVINA, N. A. Future bedrock shoreline of the Great Lakes.

SAMSON, PERRY J., GUY A. MEADOWS, LORELLE A. MEADOWS. The depositional fate of airborne toxic contaminants in the Great Lakes.

SINGER, J. K. ROV operations in the Buffalo River.

TATEM, HENRY S. Information summaries for five Great Lakes areas of concern.

WALTON, T. L. Great Lakes water level forecasting and simulation.

Tuesday, June 4

SESSION 2A – SYMPOSIUM: "PROGRESS ON THE GREEN BAY MASS BALANCE STUDY" (II)

ROOM 20 KNOX HALL

CONVENORS: *VICTOR J. BIERMAN, JR., JOSEPH V. DEPINTO, DAVID F. DEVAULT,* and *DEBORAH L. SWACKHAMER*

MODERATOR: DAVID F. DEVAULT

8:30 **GOTTLIEB, ERIK S.,** J. H. SAYLOR, G. S. MILLER. Variability of the currents and temperatures in the passages connecting Green Bay and Lake Michigan.

8:50 **SAYLOR, J. H.,** G. S. MILLER, E. S. GOTTLIEB. Near-resonant wind forcing of internal seiches in Green Bay.

9:10 **ROSSMANN, RONALD,** J. A. BARRES, D. FRANCIS. Dissolved lead and cadmium distribution patterns in Green Bay, Lake Michgian.

9:30 EDSTROM, R. D., T. P. MARKEE, P. M. COOK. Analytical protocol and prelimary results for organic analytes in dissolved and particulate fractions in the Green Bay mass balance study water samples.

9:50 **CRANE, J. L.,** W. C. SONZOGNI. Water-particle partitioning of PCB congeners in Little Lake butte des Morts, Wisconsin.

10:10 BREAK

10:30 **SKOGLUND, ROBERT S.,** D. L. SWACKHAMER. Spatial and seasonal variations in the bioaccumulation of PCBs by phytoplankton in Green Bay, Lake Michigan.

10:50 **MANCHESTER, J. N.,** A. W. ANDREN. Comparison of PCB congener sediment- pore water distribution coefficients observed in two Green Bay sediment cores.

11:10 **EDGINGTON, DAVID N.,** J. V. KLUMP, A. A. ANDREN. Sediment desposition in Green Bay.

11:30 **KLUMP, J. VAL.** Sedimentary nutrient cycling and a nutrient budget for Green Bay.

11:50 **LESHT, B. M.,** N. HAWLEY. Wave-induced sediment resuspension in shallow water: comparison of field observations from Lake St. Clair and southern Green Bay.

12:10 LUNCH - Talbert Hall

SESSION 3A – SYMPOSIUM: "PROGRESS ON THE GREEN BAY MASS BALANCE STUDY" (III)

MODERATOR: DEBORAH L. SWACKHAMER

1:40 **KLUMP, J. VAL.** Short term particle transport in Green Bay.

2:00 **PATTERSON, D., STEUER, JEFFREY.** Polychlorinated biphenyl transport model for the Fox River.

2:20 **GAILANI, J.,** C. K. ZIEGLER, W. LICK, J. STEUER. The transport of sediments in the Fox River.

2:40 **VELLEUX, M.,** D. ENDICOTT, J. V. DEPINTO. A mass balance analysis of contaminant transport and fate in the lower Fox River.

3:00 BREAK

3:20 **SWEET, C. W.,** T. J. MURPHY. The role of the atmosphere in the mass balance of PCBs in Green Bay.

3:40 **WANG, PEI-FANG,** M. ZAKIKHANI, S. MCCUTCHEON. Hydrodynamic transport modeling of Green Bay, WI - two and three dimensional simulations.

4:00 **DEPINTO, J. V.,** R. K. RAGHUNATHAN, V. J. BIERMAN, JR., P.W. RODGERS, S. C. HINZ, T. C. YOUNG. Development and calibration of an organic carbon-based sorbent model for toxic chemicals in Green Bay.

4:20 **CONNOLLY, J. R.,** T. F. PARKERTON, S. TAYLOR, R. G. KREIS, JR. PCBs in Green Bay fish: the importance of diet and migration to observed concentrations.

4:40 **ENDICOTT, D. D.,** D. J. KANDT, W. L. RICHARDSON. Looking back to Saginaw Bay: post-audit verification of a PCB mass balance model.

6:00 BANQUET - Marriott Hotel

SESSION 2B – SYMPOSIUM: "LAKE ONTARIO ECOSYTEM: PAST, PRESENT, AND FUTURE" (I)

ROOM 109 KNOX HALL

CONVENORS: *MOHIUDDIN MUNAWAR,* Fisheries and Oceans Canada, CCIW, *STEPHEN BRANDT, W. GARY SPRULES,* University of Toronto and *DONALD STEWART,* SUNY-CESF, Syracuse

MODERATORS: MOHIUDDIN MUNAWAR and STEPHEN BRANDT

8:20 **MUNAWAR, M.** - Introductory Remarks

8:30 **SLY, PETER G.** Man's impact on the Lake Ontario ecosystem since 1750.

8:50 **AEL-SHAARAWI, A. H.** Recent trends in input loads from the Niagara River into Lake Ontario.

9:10 NIELSEN, M. Trends in nutrients of Lake Ontario.

9:30 **MUNAWAR, M.,** I. F. MUNAWAR. Is community structure of Lake Ontario phytoplankton changing?

9:50 **RALPH, K. M.,** O. E. JOHANNSSON, E. S. MILLARD, D. D. MYLES. Changes in the planktonic community and environment of Lake Ontario during the 1980's.

10:10 BREAK

10:30 **LEAN, D.** Phosphorus dynamics in the Lake Ontario ecosystem.

10:50 **DERMOTT, R.** Overview of the bottom fauna in Lake Ontario.

11:10 **WHITTLE, D. M.,** M. J. KEIR, W. H. HYATT. Temporal trends in contaminant levels for the Lake Ontario fish community (1977-1989).

11:30 **RANG, SARAH,** S. SLOTS, J. HOLMES, E. NIEBOER, H. REGIER. The impairment of beneficial uses in Lake Ontario.

12:00 LUNCH - Talbert Hall

SESSION 3B – SYMPOSIUM: "LAKE ONTARIO ECOSYSTEM: PAST, PRESENT, AND FUTURE" (II)

ROOM 109 KNOX HALL

CONVENORS: *MOHIUDDIN MUNAWAR, STEPHEN BRANDT, W. GARY SPRULES,* and *DONALD STEWART*

MODERATORS: GARY SPRULES andDONALD STEWART

1:40 **MUNAWAR, M.,** S. BRANDT, W. G. SPRULES, D. STEWART. Lake Ontario trophic transfer (LOTT) study: a new multidisciplinary and multitrophic approach.

2:00 **MUNAWAR, M., M. LEGNER, D. H. LYNN, I. F.** MUNAWAR, T. WEISSE. Microbial interactions in Lake Ontario.

2:20 **LYNN, D. H.,** M. MUNAWAR, M. LEGNER. Ciliates of Lake Ontario; distribution, abundance and composition.

2:40 **MILLARD, E. S.,** D. M. MYLES, O. JOHANNSSON. Primary production and phosphorus demand in Lake Ontario - whole lake assessment.

3:00 BREAK

3:20 **BAKER, J. E.,** R. DAWSON, P. SAWANGWONG. Plant pigment stratigraphy in Lake Ontario: tracking the deep-water flux of algal carbon to the sediment record.

3:40 **JOHANNSSON, O. E.,** K M. RALPH, D. D. MYLES. Mysis relicta distribution, abundance, and production in Lake Ontario.

4:00 **JIN, E. H.,** W. G. SPRULES. An optical plankton counter for continuous monitoring in large lakes.

4:20 **SPRULES, W. G.,** E. H. JIN. Large-scale patterns in zooplankton size and density in Lake Ontario.

6:00 BANQUET - Marriott Hotel

Tuesday, June 4

SESSION 2C – SYMPOSIUM: "ECOLOGICAL, EPIDEMIOLOGICAL AND NEUROTOXICOLOGICAL ASSESSMENT OF GREAT LAKES CONTAMINANTS" (II)

ROOM 110 KNOX HALL

CONVENORS: *PAUL KOSTYNIAK, JAMES OLSON* and *RICHARD SEEGAL*

MODERATOR: RICHARD SEEGAL

8:30 **JACOBSON, J.L., S. W. JACOBSON.** Effects of prenatal PCB exposure on central nervous system function.
8:50 **SCHANTZ, S. L., E. D. LEVIN, S. A. FERGUSON, R. E. BOWMAN.** Comparison of PCB and TCDD effects on behavior in monkeys.
9:10 **SHAIN, W., B. BUSH, R. SEEGAL.** In-vitro toxicity testing of polychlorinated biphenyls (PCBs).
9:30 **CARPENTER, D. O., M. L. EVANS, D. BUSSELBERG.** Pb2+ is a potent blocker of voltage-dependent calcium channels in both invertebrate and mammalian neurons.
9:50 **ASCHNER, M., H. K. KIMELBERG.** Methylmercury (MeHg) uptake and efflux from astrocyte cultures.
10:10 BREAK
10:30 **BURBACHER, T. M., N. K. MOTTET.** The developmental neurotoxicity of methylmercury in nonhuman primates.
10:50 **MILLER, D. B., J. P. O'CALLAGHAN.** Neurotoxicity assessment - the organotins as a case study.
11:10 **MCLACHAN, D.** Aluminum neurotoxicity of drinking water.
11:30 **GILBERT, M. E.** Do environmental toxicants promote a predisposition to seizure disorders?
12:00 LUNCH - Talbert Hall

SESSION 3C – SYMPOSIUM: "PROGRESS IN THE ASSESSMENT AND REMEDIATION OF CONTAMINATED SEDIMENTS (ARCS) PROGRAM" (I)

CONVENORS: *JOSEPH ATKINSON* and *STEWART TAYLOR*, Department of Civil Engineering State University of New York at Buffalo

MODERATOR: PHILLIPE ROSS

1:40 **HORVATIN, P. J., D. C. COWGILL, K. L. SCHROER, R. G. FOX, J. W. PIPER.** An overview of the assessment and remediation of contaminated sediments (ARCS) Program.
2:00 **BURTON, G. A., JR., C. INGERSOLL, P. ROSS, L. BURNETT, M. HENRY, S. KLAINE, P. LANDRUM, M. SWIFT, M. TUCHMAN.** Sediment toxicity assessments: optimal design considerations.
2:20 **INGERSOLL, C. G., G. A. BURTON, JR., L. CLEVELAND, J. J. COYLE, M. K. NELSON.** The acute and chronic effects of contaminated Great Lakes sediment on the amphipod *hyalella azteca* and the midges *chironomus riparius* and *chironomus tentans*.
2:40 **LANCASTER, E. K. VARGO, M. TRACY, J. TRACY, J. RATHBUN, C. INGERSOLL, A. BURTON, M. HENRY, P. LANDRUM.** Predicting sediment toxicity in the Buffalo River from "indicator" analyses.
3:00 BREAK
3:20 **MUELLER, MARY ELLEN.** Progress report of tumor surveys conducted at three ARCS sites.
3:40 **PAPOULIAS, D., D. BUCKLER, D. TILLITT.** Mutagenic assessment of contaminated Great Lakes sediments for the ARCS program.
4:00 **HOKE, R. A., J. P. GIESY, A. E. MacCUBBIN, J. TUNG.** Mutagenicity of sediments from the Grand Calumet River, IN: Comparison of mutatox and Ames assays.
4:20 **SWIFT, M. C., T. J. CANFIELD, T. W. LAPOINT, G. A. BURTON.** Evaluating benthic macroinvertebrate community structure using artificial colonization substrates and ponar grab samples.

SESSION 2D – SYMPOSIUM: "FISH AND FISHERIES ECOLOGY IN THE GREAT LAKES"

ROOM 14 KNOX HALL

CONVENOR: *JAMES HAYNES*, Biological Sciences, SUNY College at Brockport

MODERATORS: JAMES HAYNES and BETTY LOU BRETT

8:20 Introductory Remarks
8:30 **BRETT, BETTY LOU.** Low genetic variability in Great Lakes species of fish.
8:50 **DEXTER, PATRICIA A., R. G. WERNER.** Energetics of larval rainbow smelt.
9:10 **MUNKITTRICK, K. R.** Impacts of secondary treatment and mill shutdown on mitigating impacts of bleached kraft mill effluent on MFO activity and serum steroids in fish.
9:30 **SAVITZ, J., L. G. BARDYGULA, A. FELDMAN.** Bases for prey fish species selection by chinook salmon, coho salmon, and lake trout.
9:50 **AULTMAN, D. C., J. M. HAYNES.** Salmonine catches in Lake Ontario are higher at thermal fronts in the Spring: Experimental verification.
10:10 BREAK
10:30 **SAVITZ, J., L. G. BARDYGULA.** Homing of salmonids to Illinois harbors: Influence of caging parred salmon.
10:50 **MANDRAK, N. E., E. J. CROSSMAN.** A review of introduced fishes in the Canadian waters of the Great Lakes.
11:10 **RECKAHN, JAMES A.** Verification of index fishing as an accurate measure of year-class strength for lake whitefish coregonus clupeaformis.
11:30 **BUCHANAN, IAN D.** Lake Ontario, Toronto waterfront fish community and habitat assessment 1989.
12:00 LUNCH - Talbert Hall

SESSION 3D – SYMPOSIUM: "RESEARCH AND MANAGEMENT OF WETLANDS IN THE GREAT LAKES"

CONVENORS: *RICHARD C. SMARDON*, SUNY College of Environmental Science and Forestry and *DAN RAY*, The Center for the Great Lakes

MODERATOR: RICHARD C. SMARDON

1:40 **BUSCH, WOLF-DIETER N.** A macro approach to the identification of desired long-term water-level fluctuation in the Great Lakes using wetland dynamics.
2:00 **WISHEU, I. C., P. A. KEDDY, Q. WU, D. R. J. MOORE.** The importance of fertility and fluctuating water levels in the establishment and maintenance of wetland vegetation: results of a four year mesocosm experiment.
2:20 **McALLISTER, LYNNE, H. J. HARRIS.** Factors influencing the distribution of submerged macrophytes in Green Bay, Lake Michigan - A focus on light attenuation and *vallisneria americanca*.
2:40 **REEDER, BRIAN C., W. J. MITSCH.** Historical biogeochemistry of Old Woman Creek wetland, Lake Erie, U.S.A.
3:00 BREAK
3:20 **WILLARD, DANIEL E.** The upper Pere Marquette watershed: aquatic system restoration by benign neglect.
3:40 **FRANCIS, DONNA, D. J. JUDE, R. ROSSMANN, J. BARRES.** Mercury in a Great Lakes estuary: Old Woman Creek, Ohio.
4:00 **GLOOSCHENKO, V., T. KAVANAGH, N. ROULET.** Great Lakes coastal wetlands - increased provincial recognition of fisheries and hydrological values for protection purposes.
4:20 **WELLER, P., D. RAY, S. CONNELL.** Protecting Great Lakes wetlands through the use of international agreements.
4:40 **SELLINGER, CYNTHIA E.** Great Lakes hydromet database directory.

Tuesday, June 4

SESSION 2E – SYMPOSIUM: "FORECAST AND PREDICTION SYSTEMS"

ROOM 4 KNOX HALL

CONVENORS: *KEITH W. BEDFORD* and *CAROLYN J. MERRY*, Dep.t of Civil Engineering, Ohio State Univ.

MODERATOR: KEITH BEDFORD

8:30 **CARROLL, THOMAS R.** Airborne and satellite snow cover data used in operational and research hydrology programs for Lake Superior and Lake Ontario.

8:50 **LEE, DEBORAH H.,** T. E. CROLEY II, C. F. SOUTHAM. A comparison of Great Lakes water supply forecast methods.

9:10 **BUCHBERGER, STEVEN G.** Forecasting annual extreme lake levels to assist lake shore management.

9:30 **SOUTHAM, CHARLES F.** Forecasting water levels in the Great Lakes: Environment Canada's probabilistic approach.

9:50 **THIEME-JANISH, CHERYL K.,** D. H. LEE. Incorporation of storm rise frequencies to six month forecasts.

10:10 BREAK

SESSION 2E – SYMPOSIUM: "LAKE LEVELS AND COASTAL STABILITY: GEOLOGIC IMPLICATIONS AND HISTORICAL PERSPECTIVES" (I)

CONVENORS: *PETER BARNES*, U.S. Geol. Survey, Branch of Pacific Marine Geology and *MICHAEL CHRZASTOWSKI*, Illinois State Geological Survey

MODERATOR: MICHAEL CHRZASTOWSKI

10:30 **FOSTER, D. S.,** S. M. COLMAN. The Chippewa low-lake phase and the pre-Nipissing transgression of Lake Michigan: evidence from high-resolution seismic stratigraphy.

10:50 **THOMPSON, TODD A.** Lake-level behavior during the past 4,000 years in the southern part of the Lake Michigan basin.

11:10 **JIBSON, RANDALL W.,** JOHN-MARK STAUDE. Rates of bluff recession along the Lake Michigan shoreline in Illinois.

11:30 **JOHNSON, BETH L.,** CAROL A. JOHNSTON. Coastal erosion in relation to geology in the western end of Lake Superior.

11:50 **HUNTER, RALPH E.,** T. E. REISS, J. L. CHIN. Coastal depositional and erosional effects of 1985-1987 high water levels in Lake Michigan.

12:10 LUNCH - Talbert Hall

MODERATOR: PETER BARNES

1:40 **BURMEISTER, JEFFREY A. V.,** C. A. JOHNSTON, J. P. BONDE. Effects of wave energy on coastal recession.

2:00 **FOLGER, D. W.,** L. M. MAIZLISH, C. F. POLLONI, D. S. FOSTER, C. L. BROWN, B. A. SEEKINS. Bottom sediment texture determined with sidescan sonar, southern Lake Michigan.

2:20 **BOOTH, JAMES S.,** W. J. WINTERS. Possible wave-induced changes in Lake Michigan nearshore lakebed properties, Illinois Beach State Park.

2:40 **KEMPEMA, E. W.,** J. W. HAINES. Sediment transport by anchor ice in southern Lake Michigan.

3:00 BREAK

3:20 **REIMNITZ, ERIK, BARNES P. W.,** M. McCORMICK. Offshore ice transport of coastal sediment in Lake Michigan.

3:40 **REINHARD, R. D.,** D. B. DRIVER, H. M. HUBERTZ. Cross-shore wave energy flux and persistence as related to erosion on the southern shore of Lake Michigan.

4:00 **WOOD, WILLIAM L.** Modeling beach and nearshore profile response to lake level change.

4:20 **TERPSTRA, P. D.,** M. J. CHRZASTOWSKI. Summary of lake bottom changes at north point marina vicinity between 1988 and 1990.

4:40 **SHABICA, CHARLES W.,** F. A. PRANSCHKE, M. J. CHRZASTOWSKI. Sediment entrapment by coastal structures along the Illinois shore of Lake Michigan.

5:00 **JOHNSON, CHARLES N.** Mitigation of harbor-caused shore erosion with beach nourishment: two case studies on clay shorelines. II. Delayed mitigation, St. Joseph MI.

Wednesday, June 5

SESSION 4A – SYMPOSIUM: "PROGRESS IN ZEBRA MUSSEL RESEARCH IN THE GREAT LAKES BASIN" (I)

ROOM 20 KNOX HALL

CONVENORS: *CHARLES O'NEILL* and *DAVID MACNEILL*, New York Sea Grant Extension, SUNY-Brockport

MODERATOR: CHARLES O'NEILL

8:20 Introductory Remarks

8:30 **KLERKS, P. L.,** P. C. FRALEIGH. Zebra mussel veliger dynamics in westernLake Erie near Maumee Bay during 1990, and zebra mussel control in waterintakes by oxidant addition.

8:50 **NICHOLS, S. J.,** B. KOLLAR. Reproductive cycle of zebra mussels (*Dreissena polymorpha*) in western Lake Erie at Monroe, Michigan.

9:10 **FITZSIMONS, J. D.,** J. LEACH, S. NEPZY, V. W. CAIRNS. Effects of zebra mussels on walleye reproduction in western Lake Erie.

9:30 **CAVALETTO, JOANN F.,** T. F. NALEPA, M A. FORD, K .D MCELROY. Zebra mussel fitness in Lake St. Clair: a comparison at two sites.

9:50 **MacISAAC, HUGH J.,** W. G. SPRULES. Modelling the dynamics of zebra mussel populations in the Great Lakes: How important are biotic processes?

10:10 BREAK

10:30 **RAMCHARAN, CHARLES W.,** D. K. PADILLA, S. I. DODSON. Analysis of Dreissena population dynamics in Europe and predictions for North America.

10:50 **PARE, S. M.,** H. P. RIESSEN. Impact of fish predation on zebra mussel populations.

11:10 **KREIS, R. G. JR.,** M. D. MULLIN, R. ROSSMAN, J. L. UTZ, J. E. REIDY, K. A. VARGO, K. T. SMITH. Contaminant concentrations in zebra mussel tissue from western Lake Erie, Monroe, Michigan.

11:30 DONAHUE, M. J., C. A. RATZA. Policy and process: Implementing the "nonindigenous aquatic nuisance prevention and control act of 1990"

11:50 **LICHTKOPPLER, FRANK R.,** D. O. KELCH. Recreational resource user attitudes concerning the zebra mussel (*Dreissena polymorpha*), and other Great Lakes issues.

12:10 LUNCH - Talbert Hall

12:15 TOURS

1:00 POSTER SESSION - Norton Hall (Carpenter Room). See page 16.

SESSION 5A – SYMPOSIUM: "PROGRESS IN ZEBRA MUSSEL RESEARCH IN THE GREAT LAKES BASIN" (II)

MODERATOR: CHARLES O'NEILL

3:20 **MacNEILL, D. B.** Physiological and morphological comparisons of *Dreissena polymorpha* and *Mytilopsis leucophaeta* (Bivalvia: Dreissenidae).

3:40 **MATISOFF, G.,** A. GREENBERG, G. GUBANICH, P. L. McCALL. Effects of ammonia, chloramine, and chlorine dioxide on zebra mussel veliger mortality.

4:00 **SPENCER, F. S.** Alternatives to chlorination for control of zebra mussels.

4:20 **BAIER, ROBERT E.** Control and mitigation of zebra mussel attachment by use of nonpolluting, fouling-release coatings.

4:40 **SNYDER, FRED. L.,** S. W. FISHER, D. O. KELCH, F. R. LICHTKOPPLER. Developing strategies for chemical applications to impede zebra mussel movement to inland waters.

5:00 **KEILLOR, PHILIP.** Sand filter intakes for the prevention of zebra mussel infestation in large and small water supply systems.

7:00 PUBLIC FORUM - Knox Hall

Wednesday, June 5

SESSION 4B – SYMPOSIUM: "LAKE ONTARIO ECOSYSTEM: PAST, PRESENT, AND FUTURE" (III)

ROOM 109 KNOX HALL

CONVENORS: *MOHIUDDIN MUNAWAR, STEPHEN BRANDT, W. GARY SPRULES* and *DONALD STEWART*

MODERATORS: JACK CHRISTIE and MOHIUDDIN MUNAWAR

8:30 **ROSS, P. E., M. MUNAWAR.** Zooplankton feeding studies during the LOTT program.

8:50 **MILLS, E. L., R. O'GORMAN, J. DEGISI.** Zooplanktivory by alewives in Lake Ontario: seasonal, spatial, and age specific patterns.

9:10 **BRANDT, STEPHEN B., D. M. MASON, A. P. GOYKE.** Tropic supply and demand in Lake Ontario: system perspectives.

9:30 **GOYKE, ANDREW P., S. B. BRANDT, D. M. MASON.** Tropic supply and demand in Lake Ontario: distribution and abundance of pelagic planktivores.

9:50 **MASON, D. M., S. B. BRANDT, A. GOYKE, V. PATRICK, W. G. SPRULES.** Tropic supply and demand in Lake Ontario: the zooplankton - planktivore linkage.

10:10 BREAK

10:30 **BRANDT, STEPHEN B., D. M. MASON, A. P. GOYKE, E. V. PATRICK, D. J. STEWART.** Trophic supply and demand in Lake Ontario: the planktivore - piscivore linkage.

10:50 **RAND, PETER, D. STEWART, P. SEELBACH, M. JONES, L. WEDGE.** Modeling steelhead trout energetics in Lakes Michigan and Ontario.

11:10 **STEWART, D., P. RAND, S. BRANDT, J. HAYNES.** Dynamics of salmonine predation in New York waters of Lake Ontario.

11:30 **LANTRY, B., D. STEWART.** Ecological energetics of rainbow smelt in the laurentian Great Lakes.

11:50 **CHRISTIE, W. J.** Thoughts about past events and future prospects for the biotic system of Lake Ontario.

12:10 LUNCH - Talbert Hall

12:15 TOURS

1:00 POSTER SESSION - Norton Hall (Carpenter Room). See page 16.

SESSION 5B – SYMPOSIUM: "IMPLEMENTING SUSTAINABLE DEVELOPMENT AND THE ECOSYSTEM APPROACH IN GREAT LAKES DECISION-MAKING" (I)

CONVENORS: *BARRY BOYER*, Faculty of Law and Jurisprudence, University at Buffalo and *TOM MUIR*, Inland Waters Directorate, Environment Canada

MODERATOR: TOM MUIR

3:10 TOM MUIR - Introductory Remarks

3:20 **MUIR, TOM.** Development, growth and sustainability.

3:40 **SHIMIZU, RONALD, H. REGIER.** Towards green governance.

4:00 **RIVERS, RAY, LESTER MILBRATH.** Learning sustainable development.

4:20 **WESTRA, LAURA.** Sustainable development and the ecosystem approach: is there a conflict?

4:40 **KELLOGG, WENDY A.** Remedial action plans: water quality or ecosystem planning?

5:00 **WELLER, PHILIP, SEAN ENRIGHT.** Implementing an ecosystem approach.

5:20 **HUNT, CONSTANCE E.** Lake Michigan lakewide management plan for critical pollutants.

7:00 PUBLIC FORUM - Knox Hall, Room 14

SESSION 4C – SYMPOSIUM: "PROGRESS IN THE ASSESSMENT AND REMEDIATON OF CONTAMINATED SEDIMENTS (ARCS) PROGRAM" (II)

ROOM 110 KNOX HALL

CONVENORS: *STEWART TAYLOR* and *JOSEPH ATKINSON*

MODERATORS: MARC TUCKMAN

8:30 **MARTIN, J. L., W. L. RICHARDSON.** Mass balance modeling of selected Great Lakes areas of concern: an overview.

8:50 **WANG PEI-FANG, J. MARTIN.** Mass balance modeling of the Buffalo River, New York: hydrodynamics and transport.

9:10 **IRVINE, K. N., B. G. LOGANATHAN, J. R. RUTKOWSKI, S. KUMAR, H. C. SIKKA.** Methodology to determine pollutant loadings from combined sewer overflows to the Buffalo River.

9:30 **HAYASHIDA, T., S. W. TAYLOR.** Non-point source contaminant loading to the Buffalo River from contaminated groundwater.

9:50 **PASSINO-READER, DORA R., P. L. HUDSON, J. P. HICKEY.** Baseline hazard evaluation for aquatic life of priority consideration areas under the assessment and remediation of contaminated sediments (ARCS) program: Buffalo River.

10:10 BREAK

10:30 **LANIAK, G. L., W. W. SUTTON, J. L. CRANE.** Baseline human health risks in the Buffalo River, New York, area of concern.

10:50 **SMITH, V. E., J. E. RATHBUN, J. C. FILKINS.** Mapping contaminated sediments in Great Lakes areas of concern (AOC).

11:10 **HUELLMANTEL, LAURA L., J. E. REIDY, J. E. RATHBUN, J. C. FILKINS.** Horizontal and vertical distribution of contaminated sediment in the Buffalo River, New York.

11:30 **SINGER, J. K., P. MANLEY.** A side-scan sonar survey of the Buffalo River.

11:50 **SONZOGNI, W., L. MAACK, T. GIBSON, J. LAWRENCE.** Toxic PCB congeners in Sheboygan River (WI) sediments.

12:10 LUNCH - Talbert Hall

12:15 TOURS

1:00 POSTER SESSION - Norton Hall (Carpenter Room). See page 16.

SESSION 5C – SYMPOSIUM: "PROGRESS IN THE ASSESSMENT AND REMEDIATION OF CONTAMINATED SEDIMENTS (ARCS) PROGRAM" (III)

CONVENORS: *STEWART TAYLOR* and *JOSEPH ATKINSON*

MODERATOR: STEVE YAKSICH

3:20 **AVERETT, DANIEL E.** Review of removal, contaminant and treatment technologies for the assessment and remediation of contaminated sediment (ARCS) program.

3:40 **GARBACIAK, S., JR., D. TIMBERLAKE.** Bench scale testing of sediment remediation technologies.

4:00 **ALLEN, J. P., R. R. HALL.** Characterization and processing of contaminated sediment by mineral processing methods.

4:20 **FLEMING, ELIZABETH, C., D. E. AVERETT, M. G. CHANNEL.** An evaluation of solidification/stabilization technology for Buffalo River sediment.

4:40 **MILLER, JAN. A.** Sediment remediation: going from demonstrations to fullscale.

7:00 PUBLIC FORUM - Knox Hall Room 14

Wednesday, June 5

SESSION 4D – SYMPOSIUM: "BIOINDICATORS OF ECOSYSTEM HEALTH IN THE GREAT LAKES" (I)

ROOM 14 KNOX HALL

CONVENORS: *G-YULL RHEE*, SUNY Albany Graduate School of Public-Health, NYS DOH and *PAUL BERTRAM*, GLNPO, U.S. EPA

MODERATOR: Paul Bertram

8:20 Introductory Remarks

8:30 **KRANTZBERG, G., J. SMITH, T. REYNOLDSON.** Benthic indicators of ecosystem health.

8:50 **BRINKHURST, R.O.** A recent advance in the use of benthic communities as bioindicators of ecosystem health.

9:10 **WHITE, DAVID S.** Functional structure of large lake benthic communities from the shoreline outward.

9:30 **WARWICK, W. F.** Morphological deformities in chironomid larvae as measures of ecosystem health.

9:50 **DICKMAN, M. D., G. A. RYGIEL, N. GHAZI, T. D. DIGGINS, K. M. STEWART.** Deformities in chironomid larvae as an index of toxic sediments in the Niagara River watershed.

10:10 BREAK

10:30 **STOERMER, EUGENE F.** Algae as indicators of ecosystem health.

10:50 **HARRIS, H. J., T. C. ERDMAN, K. B. LODGE, G. T. ANKLEY.** Measures of reproductive success and contaminant concentration in Forster's Tern on Green Bay, Lake Michigan.

11:10 **STARK, ALICE D., B. T. KAGEY.** Maternal residence in the Great Lakes drainage basin and adverse reproductive outcomes.

11:30 **HOPPES, WILLIAM G.** Responsible stewardship of the Lake Ontario ecosystem: quantitative indicators to monitor binational efforts.

12:10 LUNCH - Talbert Hall

12:15 TOURS

1:00 POSTER SESSION - Norton Hall (Carpenter Room). See list of participants on page 16.

SESSION 5D – SYMPOSIUM: "BIOINDICATORS OF ECOSYSTEM HEALTH IN GREAT LAKES" (II)

CONVENORS: *G-YULL RHEE* and *PAUL BERTRAM*

MODERATOR: G-YULL RHEE

3:20 **THOMPSON, PATSY A., R. CHASSE, P. COUTURE.** Eco-physiological indicators of contaminant effects on microalgal communities.

3:40 **McNAUGHT, D. C.** Behavioral assays for detection of sublethal effects from complex effluents and pore waters.

4:00 **EDSALL, CAROL COTANT, MICHAEL J. MAC.** Use of clinical blood chemistry to assess health of laboratory-reared and field-sampled Lake Trout.

4:20 **NEWSTED, J. L., J. P. GIESY, P.D. JONES, R. CRAWFORD, J. GOOCH.** Development of toxic equivalency factors for planar halogenated hydrocarbons in rainbow trout (*oncorhynchus mykiss*)

7:00 PUBLIC FORUM - Knox Hall Room 14

SESSION 4E – SYMPOSIUM: "TRANSPORT OF PARTICLE-ASSOCIATED CONTAMINANTS IN LARGE SURFACE WATER BODIES"

ROOM 4 KNOX HALL

CONVENOR: *JAMES BONNER*, Department of Civil Engineering, Texas A & M University

MODERATOR: JAMES BONNER

8:20 Introductory Remarks

8:30 **LOGAN, BRUCE, E.** Fractal dimensions of aggregates formed in natural systems.

8:50 **GUO, J., J. R. KRAMER.** Double layer interaction model and particle concentration effect in water.

9:10 **STANGE, KARI, D. L. SWACKHAMER.** Uptake of hydrophobic organic compounds (HOCs) by phytoplankton: a species comparison.

9:30 **BURNS, S.E., J. P. HASSETT.** Mirex contamination and transport in the Oswego River.

9:50 **OLSON, DANIEL G., D. L. SWACKHAMER.** Microbial cycling of hydrophobic organic compounds in bottom waters of the Great Lakes.

10:10 BREAK

10:30 **SHENG, Y. PETER.** Transport of fine sediments and nutrients in Lake Okeechobee.

10:50 **LICK, W., J. LICK, C. K. ZIEGLER.** The resuspension and transport of fine-grained sediments in Lake Erie.

11:10 **KO, FUNG-CHI, J. E. BAKER.** Particle-mediated transport of hydrophobic organic contaminants in Chesapeake Bay.

11:30 **COOK, PHILIP M.** Unique opportunities for study of particle-associated contaminant transport and fate in Lake Superior using the exogenous mineral cummingtonite-grunerite.

11:50 **CARTER, DONNA S., R. A. HITES.** Fate and transport of Detroit River derived pollutants throughout Lake Erie.

12:00 LUNCH - Talbert Hall

12:15 TOURS

1:00 POSTER SESSION - Norton Hall (Carpenter Room)

SESSION 5E – SYMPOSIUM: "EVIDENCE FOR THE RESTORATION OF LAKE ERIE" (I)

CONVENOR: *JOSEPH MAKAREWICZ*, Dept. of Biological Sciences, SUNY College at Brockport

MODERATOR: JOSEPH MAKAREWICZ

3:20 **RICHARDS, R. PETER, DAVID B. BAKER.** Nutrient trends in selected Lake Erie Tributaries, 1975-1990.

3:40 **DOLAN, DAVID M.** Changes in point source loadings of phosphorus to Lake Erie.

4:00 **BERTRAM, PAUL E.** Spring total phosphorus and summer dissolved oxygen trends in the Central Basin of Lake Erie, 1970-1989.

4:20 **CHARLTON, MURRAY N.** Lake Erie water quality in 1990: restoration or resilience?

4:40 **DOLAN, DAVID M., LAURA FAY, DAVID E. RATHKE.** Analysis of water quality trends in the Western basin of Lake Erie.

5:00 **DRISCOLL, MARK S., JOHN P. HASSETT, SIMON LITTON.** Heterogeneous distribution of organochlorine compounds in eastern Lake Erie water.

7:00 PUBLIC FORUM - Knox Hall Room 14

Thursday, June 6

DISCUSSION SESSION: EPA's ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM (EMAP): IMPLICATIONS FOR GREAT LAKES SURVEILLANCE AND MONITORING
ROOM 20 KNOX HALL

MODERATOR: DAVID DOLAN, Great Lakes Regional Office, IJC

8:30 AM - 10:10 AM

STEVE HEDKE, Overview of EMAP Technical Director, EMAP-Great Lakes EPA-Duluth

Discussants:

MARY HENRY, Dept. of Fisheries and Wildlife, University of Wisconsin

ABDEL EL-SHAARAWI, National Water Research Institute, Environment-Canada

DON WILLIAMS, Inland Water Directorate, Environment Canada

10:10 BREAK

SESSION 6A – "GENERAL LIMNOLOGY"

10:30 **EDGINGTON, DAVID N., A. S. BROOKS.** Nutrient cycling in Lake Michigan.

10:50 **AXLER, R., C. LARSEN, C. OWEN, C. ROSE.** Primary productivity in western Lake Superior.

11:10 **HICKS, RANDALL E., PETER AAS, CHRISTINE JANKOVICH.** Seasonal and wind-induced changes in bacterioplankton densities and production in Lake Superior.

11:30 **VANDERPLOEG, H. A., T. F. NALEPA, J. R. LIEBIG.** Filtration rate and particle retention efficiency of *lampsilis radiata siliquoidea* on artificial particles and natural seston of Lake St. Clair.

11:50 **WU, J. J., I. K. TSANIS.** A circulation model for the nearshore areas of the Great Lakes.

SESSION 6B – SYMPOSIUM: "IMPLEMENTING SUSTAINABLE DEVELOPMENT AND THE ECOSYSTEM APPROACH IN GREAT LAKES DECISION-MAKING" (II)
ROOM 109 KNOX HALL

MODERATOR: TOM MUIR

8:30 **LOUCKS, ORIE L., W. RENWICK, H. EREKSON.** Assessing the industry-environment partnerships in pursuit of sustainability at RAP sites.

8:50 **RIVERS, RAY., J. F. RYAN.** Sustainable development for the City of Burlington.

9:10 **BROOKS, ANN DEWITT.** Sustaining the Chesapeake Bay: managing population growth and development.

9:30 **FINDLAY, RICHARD.** Implementing sustainable development in Ontario.

9:50 **SERAFIN, RAFAL.** Assessing institutions for sustainable development: lessons from Great Lakes management.

10:10 BREAK

10:30 **SLOCOMBE, D. SCOTT.** Integrating ecosystem dimensions for indicators of sustainability.

10:50 **BOYER, BARRY.** Building legal and institutional frameworks for sustainability.

11:10 **MULDOON, PAUL.** Sunset chemicals: implementing the concept of zero discharge through pollution prevention.

11:30 **AMES, ERIE., T. CRANE, M. J. DONAHUE.** Promoting consistency in water toxics regulation for protection of the Great Lakes.

11:50 **KALINAUSKAS, R., L. BOGGS.** Bridging the gap - linking research to decision-making in the implementation of agricultural non-point source programs.

12:10 **DONALDSON, C., M. WEBB.** Pollution prevention - a societal affair.

12:30 LUNCH - Talbert Hall

SESSION 6C – "CONTAMINATED SEDIMENTS"
ROOM 110 KNOX HALL

MODERATOR: H. C. SIKKA

8:30 **POULTON, DONALD, J. PAWLOWSKI, M. GRIFFITHS.** Mapping of contaminated sediments using the electromagnetic (inductive) method.

8:50 **RUKAVINA, N. A.** Variability of the physical properties of Hamilton Harbour bottom sediments.

9:10 **VERSTEEG, K., W. MORRIS, N. A. RUKAVINA.** Mapping contaminated-sediment thickness with magnetic susceptibility.

9:30 **MOREHEAD, N. R., J. A. ROBBINS, A. MUDROCK.** Anthropogenic alteration of carbon, nitrogen, and biogenic silica deposition in Lake George (St. Mary's River) since 1820.

9:50 **COAKLEY, J. P., D. J. POULTON.** Source-related classification of St. Lawrence estuary sediments.

10:10 BREAK

10:30 **SIDDIQI, MUHAMMAD A., H. C. SIKKA.** Microbial degradation of benzo[a]pyrene [BaP] in the soil at the Times Beach confined disposal site.

11:50 **BALCH, G. C., C. D. METCALFE.** Characterization of chemical carcinogens within sediments of Hamilton Harbour, Ontario.

11:10 **COMBA, M. E., C. MACDONALD, D. G. NOBLE, M. M. GAGNON, J. J. DODSON, R. J. NORSTROM, K. L. E. KAISER.** A Lake Ontario – Gulf of St. Lawrence mass balance for mirex.

11:30 **CHANG, C., J. KENDER, T. TISUE** ^{113m}Cd in Lake Tahoe.

11:50 **ZEMAN, A. J.** Consolidation of very soft sediments due to subaqueous capping.

12:00 LUNCH - Talbert Hall

SESSION 6D – SYMPOSIUM: "TOWARDS AN APPRECIATION OF THE CURRENT STATUS OF RAINBOW SMELT IN LAKE ERIE"
ROOM 14 KNOX HALL

CONVENORS: *STEPHEN J. NEPSZY*, Lake Erie Fisheries Station, Ministry of Natural Resources and *LARRY D. WITZEL*, Lake Erie Fisheries Assessment Unit

MODERATOR: LARRY WITZEL and STEPHEN NEPSZY

8:20 LARRY WITZEL and STEPHEN NEPSZY - Introductory Remarks

Thursday, June 6

8:30 **DIETZ, PAULINE A. (MONCK), D. N. HUGHES.** A review of the ecology of rainbow smelt in Lake Erie.
8:50 **PAINE, JERRY R., E. T. COX.** The trawl fishery for rainbow smelt on Lake Erie.
9:10 **WOLFERT, DAVID R.** Rainbow smelt abundance in U.S. waters of central and eastern Lake Erie, 1978-1980.
9:30 **EINHOUSE, DONALD.** The status of rainbow smelt in New York waters of Lake Erie.
9:50 BREAK
10:10 **WITZEL, LARRY D.** Year-class recruitment indices of rainbow smelt derived from bottom trawl surveys in Long Point Bay, and projections of commercial smelt harvests by the Ontario trawl fishery in eastern Lake Erie.
10:30 **ORSATTI, S.** Catch at age analysis to reconstruct the characteristics of a population of rainbow smelt (*Osmerus mordax*) from commercial trawl harvest data.
10:50 **RYAN, P. A.** Application of surplus production models to the commercial trawl fishery for rainbow smelt (*Osmerus mordax*) in eastern Lake Erie.
11:10 **OWENS, R. W., T. H. ECKERT, R. O'GORMAN.** Response of rainbow smelt to the changing fish community in Lake Ontario 1978-90.
11:30 **RITCHIE, BEVERLEE J.** Dynamics of introduced rainbow smelt (*Osmerus mordax*) in Lake Nipigon, Ontario and assessment of potential impacts on indigenous fish species.
11:50 **REMNANT, RICHARD A., WILLIAM G. FRANZIN.** An assessment of the impact of the rainbow smelt on the fishery resources of Lake Winnipeg.

SESSION 6E – SYMPOSIUM: "EVIDENCE FOR THE RESTORATION OF LAKE ERIE" (II)

ROOM 4 KNOX HALL

CONVENOR: *JOSEPH MAKAREWICZ*

MODERATOR: JOE MAKAREWICZ

8:30 **REYNOLDSON, TREFOR B.** Evidence on the former state and recovery of the benthos of Lake Erie.
8:50 **MAKAREWICZ, JOSEPH, T. LEWIS.** Long term changes in phytoplankton and zooplankton in Lake Erie.
9:10 **KNIGHT R. L., B. VONDRACEK.** Changes in the forage fish community of Lake Erie, 1969-88: Effects of Predation?
9:30 **CORNELIUS, FLOYD C.** The status of salmonine stocks in Lake Erie.
9:50 **HENDERSON. BRIAN A., S.J. NEPSZY.** Walleye stocks and dynamics in relation to fisheries management in Lake Erie.
10:10 BREAK
10:30 **LICHTKOPPLER, FRANK R.** Ohio's Lake Erie charter boat industry in 1990.
10:50 **JUDE, DAVID A.** First evidence of gobiidae in the Great Lakes Basin.

"ATMOSPHERIC PROCESSES"

11:10 **HERMANSON, MARK.** PCBs and organochlorine pesticides and fungicides in atmospheric samples from Lakes Superior, Michigan and Huron.
11:30 **RECTOR, D., R. KUMMLER, W. PORT, E. PICHE, C. FRANKLIN, K. SHIKAZE, R. TOOLEY.** The status of air toxics in the Detroit-Windsor/Port Huron Sarnia region: a report of the International Joint Commission's Air Pollution Advisory Board.
11:50 **HOLSEN, THOMAS M., K. E. NOLL, S. P. LIU, W. J. LEE.** The fate of airborne PCBs and PAHs in the Great Lakes region.

POSTER SESSIONS

Norton Hall (Carpenter Room)

Monday, 7-9 PM

Wednesday 1-3 PM

BARNES, PETER, ERIC REIMNITZ, EDWARD KEMPEMA. Ice rafting and ice-induced profile modification: winter coastal erosion in southern Lake Michigan.

BARNHART, MICHAEL J., JULIAN M. MYERS. Pilot bioremediation of petroleum contaminated soil.

BROWN, RUSSELL W., W. W. TAYLOR. Effects of egg composition and prey density on the larval growth and survival of lake whitefish.

CAP, ROBERTA, C. LANGE. Zooplankton in the New York State canal system.

DICKMAN, M., I. BRINDLE, N. GHAZI, G. RYGIEL. The presence of contaminated sediments in the Niagara River watershed as indicated by invertebrates with deformities.

ERNEST A., J. BONNER, R. AUTENRIETH. Effect of particle size distribution descretization on estimated particle aggregation efficiencies.

FINK, LARRY E., MICHAEL PENN. A spreadsheet toxic substances model for the Great Lakes.

FULLER, JONATHAN A. Sand resources of the outer lorain pumping grounds on the Lorain-Vermilion Moraine, Lake Erie.

HAYES, JOSHUA A., O. L. LOUCKS, G. E. GLASS, J. A. SORENSEN, G. RAPP JR. Increasing importance of nitrate in acidification of upper midwest seepage lakes.

HOKE, R. A., G. T. ANKLEY, M. K. SCHUBAUER-BERIGAN, P. A. KOSIAN, G. L. PHIPPS. An overview of U.S. EPA, ERL-Duluth sediment research - preliminary results.

HORGAN, M., M. LUTTENTON. Genetic identity of Little Bay de Noc and Grand River Walleye populations.

JAHAN-PARWAR, J. A model system for neurobehavioral toxicology of polychlorinated biphenyls.

JOHNSON, CHARLES N. Structural shore protection in the Great Lakes: a costly myth.

JOHNSON, CHARLES N. A remarkable fit of the longinov-type profile with bar-troughs.

JOHNSON, CHARLES N. Behavior of the toe of a glacial till bluff in response to varying water levels, Glenn, MI, on Lake Michigan, 1973-1990.

JOHNSON, CHARLES N. Mitigation of harbor-caused shore erosion with beach nourishment: two case studies on clay shorelines. I. Immediate mitigation, New Buffalo, MI.

KOCIK, JOHN F., W. W. TAYLOR. Anadromous steelhead and resident brown trout competition in a Great Lakes tributary.

LESHT, BARRY M. Design of a limnological sampling network based on combinational optimization.

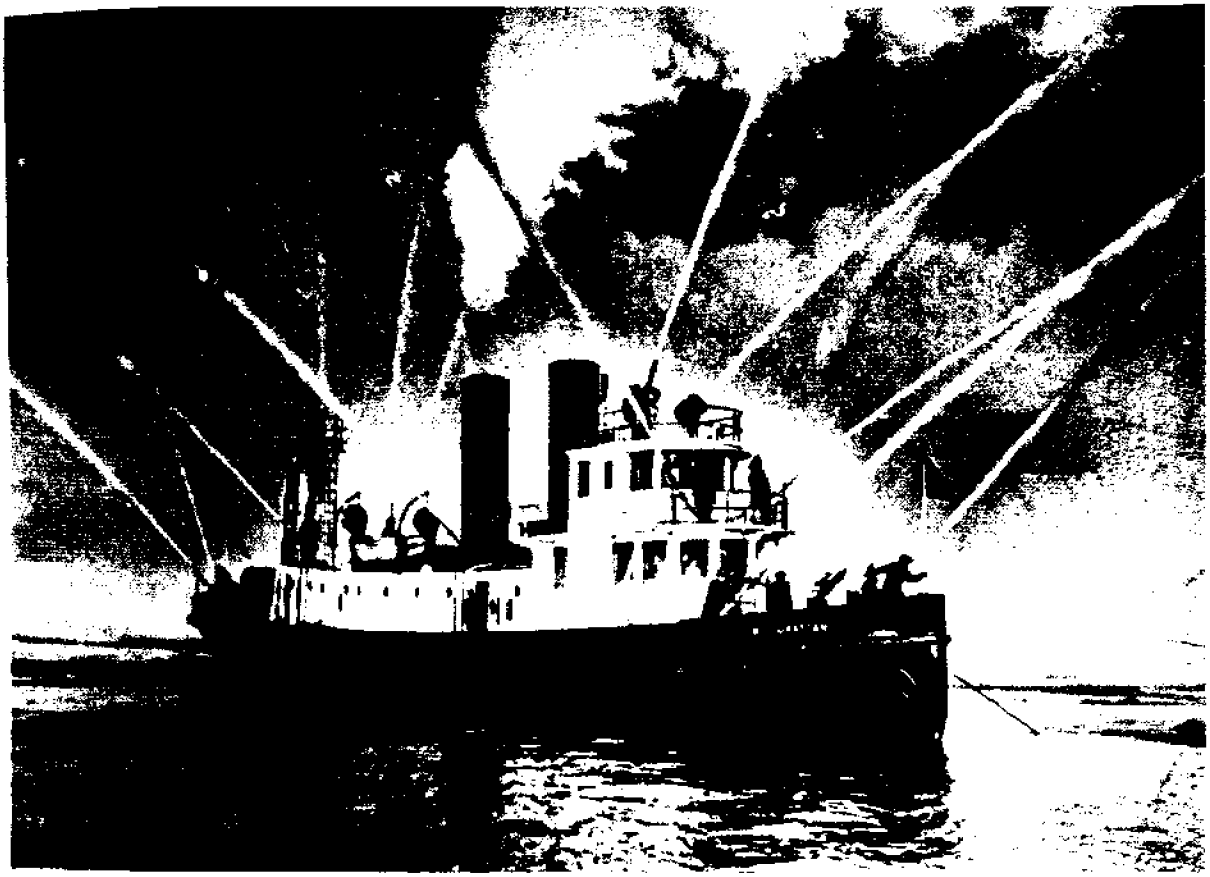
R. O'GORMAN, E. L. MILLS, J. DEGISIS. Use of zooplankton to assess forage distribution and movement in the Great Lakes.

O'NEILL, C.R. JR. Introduction and dispersal of the zebra mussel, *Dreissena polymorpha*, in Lake Ontario, 1989 - 1991.

Continued on page 9

Foot of Main Street; "G. W. Gardner" of the Hard Tug Line - 1867.

ABSTRACTS



Fire boat "Grattan" in Buffalo Harbor, now "Cotter" - 1920's

PROGRESS ON THE GREEN BAY MASS BALANCE STUDY

Convenors: Joseph V. DePinto, Victor J. Bierman, Jr., Deborah Swackhammer and Dave Devault

Session 1A - Monday, June 3, 1991
2:00 - 5:20 PM

Session 2A - Tuesday, June 4, 1991
8:30 AM - 12:10 PM

Session 3A - Tuesday, June 4, 1991
1:40 - 5:00 PM

20 Knox Hall

KENNEDY, JOHN A., Green Bay Metropolitan Sewerage District, P.O. Box 19015, Green Bay, WI 54307-9015. **LONG-TERM WATER QUALITY MONITORING OF THE LOWER FOX RIVER AND GREEN BAY: THE FIRST FIVE YEARS.**

The Green Bay Metropolitan Sewerage District initiated an on-going water quality monitoring program of the lower Fox River and Green Bay in 1986. Data collected helps the District assess the impact of its discharge on the receiving waters. The program also provides data for overall system tracking, such as the Green Bay Remedial Action Plan (GBRAP) effort which is currently in the implementation stage. The fiveyear period in question showed extreme variation in rainfall, including record river flow and stage levels in 1986 and drought conditions in 1988. Of the conventional parameters, only ammonia and TKN showed significant annual variation. Spatial trends were evident for most parameters, due to high loadings to the lower Fox River which are subsequently diluted in Green Bay. Unionized ammonia concentrations above the 0.04 mg/L EPA criterion were frequently observed. Average total phosphorus concentrations observed in the AOC during the 1986-1990 period ranged from 0.112 to 0.179 mg/L, which exceeds the GBRAP recommendation of 0.100 to 0.125 mg/L. Other specific findings of interest include: occasional dissolved oxygen depletions in the river and bay; hypolimnetic water mass movement in the lower bay; and elevated levels of PCBs and heavy metals in sediment cores.

WARREN, GLENN J., and, ROCKWELL, DAVID C. U.S. Environmental Protection Agency, Great Lakes National Program Office, 230 S. Dearborn St., Chicago, IL 60604. Surface Water Nutrient Distribution in Green Bay During the Green Bay Mass Balance Study: Historical Comparisons and Water Mass Relationships.

Green Bay is a system heavily influenced by nutrient and suspended solids loadings. Data on nutrients and other water chemistry of the waters of Green Bay were collected during nine surveys, two during ice-covered conditions, as part of the Green Bay Mass Balance Study. The data provide information on nutrient distribution in the Bay, and will be compared with historical limnological data. Seasonal changes in nutrient concentrations and nutrient ratios will be discussed, particularly changes in nitrogen:phosphorus ratios favoring cyanobacteria. Nutrient/particle relationships within the Bay will be addressed.

McALLISTER, LYNNE and H. J. HARRIS. NSI Technology, Inc., Corvallis, Oregon and University of Wisconsin-Green Bay.—Factors influencing the distribution of submerged macrophytes in Green Bay, Lake Michigan—A focus on light attenuation and *Vallisneria Americana*.

This study focused on the importance of light as a factor limiting depth distribution and abundance of *Vallisneria americana* along the west shore of Green Bay from Duck Creek to the Pensaukee River. Light penetration parameters were assessed weekly at 5 study sites, lying along the bay's north-south trophic gradient, from June to August in 1989 and 1990. Sampling was also done at each site for end-of-season submerged macrophyte density and biomass. In addition, a model was developed which predicts potential increases in depth distribution of *Vallisneria* for improvements in water clarity as remedial action progresses. The maximum depth of *Vallisneria* growth and persistence Z_c was 30–38 uE/m_2/s, which represented 2.4–3.7% of the light intensity at Z_o. The compensation light intensity of *Vallisneria* was experimentally determined as 18 uE/m^2/s using an oxygen production method. *Vallisneria* depth distribution is probably limited by light availability in some areas. Based on predictions of the model, it appears that the scarcity of *Vallisneria* in the area south of Long Tail Point is due to light limitation. It is also probable that other factors – e.g. wave action, substrate composition, nutrient availability – interact with light to influence macrophyte production and depth distribution in some places.

HORNBUCKLE, K.C.; EISENREICH, S.J.; HOFF, R. Gray Freshwater Biological Institute, P.O. Box 100, University of Minnesota, Navarre, MN 55392. **ATMOSPHERIC PCBs OVER GREEN BAY, 1989.**

The atmospheric concentrations of PCBs were measured in 1989 over Green Bay as part of the Green Bay PCB Mass Balance Study. Air samples were collected using a Hi-Vol and a glass-fibre filter backed by a polyurethane foam (PUF) adsorbent trap at flow rates of ~0.6 m^3/min for 6 to 12 hours. Samples were collected in June, July, and October over the bay aboard the RV Bluewater. Analyses were conducted on ~20 gas-phase (PUF) samples by GC-ECD following alumina-silica cleanup. Atmospheric PCB concentrations ranged from 0.1 to 2.0 ng/m^3, with concentrations generally higher in the southern bay compared to the northern bay. Congener distributions were not significantly different over space and time, favored the 2,3, and 4 chlorine-substituted PCBs, and were similar to the dissolved-phase (filtration) PCBs. Back-trajectory analysis of discrete air samples were generally correlated with atmospheric PCB concentrations.

MURPHY, THOMAS J., SWEET*, CLYDE W., KELSEY, CYNTHIA A., HONG, JOHN, and BANNASCH, JAMES H. DePaul University, Chemistry Department, 25 E. Jackson Blvd., Chicago, IL 60604 and *Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820. **Atmospheric Deposition of PCBs and Dieldrin to Green Bay.**

In conjunction with the Green Bay Mass Balance Project, air and precipitation samples were collected at three sites along Green Bay to allow the estimation of atmospheric inputs and losses from the Bay. Because of lower than expected sample values, and unexpected contamination problems with the sampler and XAD-2 resin, the PCB and Dieldrin concentrations in precipitation were below a LOD based on field blanks. Based on the blanks, [PCB] in precipitation were <4 ng/l and precipitation inputs of PCBs to the Bay would be <3 g/km^2/yr or <14 kg/yr to the Bay.

Air samples were collected at the three sites when the wind was blowing from particular sectors. Samples were collected for a two week period, and volumes ranged from 200 to 8000 m^3 with an average of 2450 m^3 (0.55 m^3/min sampling rate). In an average sample 62 congeners were detected. Of these, 43 (92% of the mass) were above the LOD, and 21 (80% of the mass) were above the LOQ. The average PCB concentrations found were lower than anticipated: 0.31 ng/m^3 in Green Bay, 0.21 ng/m^3 at Peninsula State Park and 0.085 ng/m^3 at Fayette State Park. An input of 5.5 kg/yr of vapor to the Bay during an 8 month ice-free season can be calculated using meteorological information collected at the sites and an air/water exchange model.

EISENREICH, S.J.; ACHMAN, D.; HORNBUCKLE, K.C. Gray Freshwater Biological Institute, P.O. Box 100, University of Minnesota, Navarre, MN 55392. **PCB VOLATILIZATION FROM GREEN BAY, LAKE MICHIGAN.**

The volatilization of polychlorobiphenyls (PCBs) from Green Bay was estimated as part of the Green Bay Mass Balance Study in 1989. The strategy employed was to simultaneously collect air and water samples above and below the air-water interface, analyze the atmospheric gas phase and the water column dissolved phase for ~70 PCB congeners, and calculate the direction of flux for each congener using Henry's Law, and meterological and hydrological parameters. Sampling covered the period May through October, 1989. Atmospheric PCB concentrations ranged from 0.1 to 2.0 ng/m^3, and dissolved PCB levels ranged from 0.6 to 6.1 ng/L. At ambient wind speeds during sampling of 2 to 8 m/s, and surface water temperatures of 5 to 22°C, PCB volatilization fluxes were ~25 to 40 ng/m^2 · day in the northern two-thirds of the bay, and 100 to 350 ng/m^2

FRANZ, T.P. and EISENREICH, S.J. Gray Freshwater Biological Institute, P.O. Box 100, University of Minnesota, Navarre, MN 55392. **WET DEPOSITION OF PCBs TO GREEN BAY, LAKE MICHIGAN.**

The wet deposition of polychlorinated biphenyls (PCBs) to Green Bay was measured from April, 1989 to May, 1990 as part of the Green Bay PCB Mass Balance Study. Integrated precipitation samples were collected over two-week intervals using wet-only samplers constructed by M.I.C. Co. (Thornbill, Ontario). Sampling was conducted at Fayette State Park in the upper peninsula of Michigan, at Peninsula State Park in Door Co., Wisconsin, and at the University of Wisconsin-Green Bay. No differences in rain concentration were evident among the sites. PCB concentrations in precipitation at all sites ranged from 0.8 to 5.9 ng/L, with an average concentration of 1.5 ng/L. This average concentration results in an annual flux of PCBs to the bay of approximately 1.0 to 1.5 ug/m^2-yr or an annual wet deposition input of 4 to 7 kg/yr.

GOTTLIEB, Erik S., SAYLOR, James H. and MILLER, Gerald S., NOAA / GLERL, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593. **VARIABILITY OF THE CURRENTS AND TEMPERATURES IN THE PASSAGES CONNECTING GREEN BAY AND LAKE MICHIGAN.**

Green Bay is a large shallow embayment connected to Lake Michigan. Discharges of inadequately treated industrial and municipal wastes have adversely affected water quality in the bays' southern end. Flushing of the bay is controlled by exchange of water with Lake Michigan. The exchange occurs primarily through the four main passages located at the bays' northeastern end. In order to help identify the important exchange processes and estimate the magnitude of the exchange, the passages were instrumented in 1977-1978 and again in 1988-1989. Current velocity and water temperature data thus collected is presented, analyzed, and used to compute the volume transport into the bay. Fluctuations in the currents and temperatures occur at tidal and longer periods. Winter currents are almost entirely barotropic and of moderate strength, even under the ice. Summer currents are affected by the thermal stratification, becoming sheared and even two-layered (bi-directional) at times. The two-layered flow should be simply related to the internal thermal structure, but thermistor chain data show that the relationship is more complex. A strong, persistent, eight-day oscillation, indicating seiching of the thermocline in Green Bay, resulted in very enhanced lower-layer inflow through all passages. An attempt is made to explain the observed currents through use of a simple conceptual model. Strategies for future observation programs also will be discussed.

SAYLOR, J.H., MILLER, G.S., and GOTTLIEB, E.S., NOAA/GLERL, 2205 Commonwealth Blvd., Ann Arbor, Michigan 48105. **NEAR-RESONANT WIND FORCING OF INTERNAL SEICHES IN GREEN BAY**

Currents and water temperature distributions were measured at a dense network of stations within Green Bay in 1989. During the summer months of intense water density stratification, exaggerated responses of thermocline displacement and associated currents occurred with wind forcing at periods close to the bay's free internal seiche period. The internal waves generated propagate similarly to those observed in smaller, narrow lake basins where the effects of the earth's rotation can be accounted for by assuming geostrophy between currents and thermocline incline. The seiches were strong enough to to be important contributors to volume fluxes between the north and south halves of the bay past the Chambers Island constriction.

ROSSMANN, RONALD, JAMES A. BARRES, AND DONNA FRANCIS. Center for Great Lakes and Aquatic Sciences, The University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109
Dissolved Lead and Cadmium Distribution Patterns in Green Bay, Lake Michigan

During 1989 and 1990, Green Bay waters were sampled for dissolved lead and cadmium. All samples were processed in a shipboard clean room and filtered through 0.5 μm pore-sized filters. For the two cruises (April 30 - May 7, 1989 and June 6 - June 13, 1989) of samples analyzed at this time, lead distribution patterns were very similar. Highest concentrations were found at the south end of the bay near the mouth of the Fox River and along the eastern shore of the bay. With the Fox River serving as a point source for lead (410 - 450 ng/L) and the generally counterclockwise circulation pattern in the bay, this is the dissolved lead distribution pattern expected . The mean dissolved lead concentrations for cruises 1 and 2 were 76 and 120 ng/L, respectively. During cruise 1, inputs of lead by the Menominee River elevated lead concentrations in the bay adjacent to the mouth of the river. Because lead concentrations were higher in the bay during cruise 2, the impact of the Menominee River on bay lead concentrations was not observed. Dissolved cadmium concentrations in the bay were similar to one another for cruises 1 and 2 (2.2 and 2.7 ng/L, respectively). Dissolved cadmium concentrations in the Fox River for cruises 1 and 2 were 4.7 and 2.6 ng/L, respectively. Because of the small observed range of cadmium concentrations in the bay and the similarity of Fox River and bay cadmium concentrations, no horizontal cadmium distribution pattern was found for either cruise.

EDSTROM, R.D., AScI Corporation, Duluth, MN 55805, MARKEE, T.P., Center for Lake Superior Environmental Studies, Superior, WI 54880 and COOK, Philip M., Environmental Research Laboratory (USEPA), 6201 Congdon Boulevard, Duluth, Minnesota 55804. **Analytical Protocol and Preliminary Results for Organic Analytes in Dissolved and Particulate Fractions in the Green Bay Mass Balance Study Water Samples.**

During the fall of 1988, water column sampling for the Green Bay Mass Balance Study was initiated. Preliminary results from PCB congener analyses of these samples indicated spatial, temporal and partitioning differences in total PCB concentrations and homolog distributions. For example, dissolved fraction congener distributions in the lower Fox River samples from April '89 showed abundances of dichloro, trichloro, tetrachloro and pentachlorobiphenyls in approximate ratios of 2:8:4:1. The same homolog ratio for corresponding filtered solids samples was approximately 1:5:5:1. Dieldrin analyses, using HRGC/ECD, provided erroneous results. HRGC/HRMS analysis of selected samples indicated significantly lower analyte concentrations. Analytical methodology, preliminary results and estimated partitioning characteristics of the study analytes will be discussed.

CRANE, JUDY L.* and WILLIAM C. SONZOGNI, Water Chemistry Program, University of Wisconsin, Madison, WI 53706. (* Current Address: AScI Corporation, c/o USEPA ERL, College Station Road, Athens, GA 30613). **Water-particle Partitioning of PCB Congeners in Little Lake Butte des Morts, Wisconsin.**

Little Lake Butte des Morts forms an 8 km reach of the Lower Fox River, the major tributary entering Lake Michigan's Green Bay. The results of an intensive two year field study on this lake demonstrates that the fractionation of PCB congeners in the water column appears to be controlled by equilibrium partitioning between aqueous and sorbed states. Total and congener distribution coefficients (K_ds) varied seasonally, with the highest values occurring during ice-cover periods (log K_d = 5.63 for total PCBs); the lowest values occurred during summertime (log K_d = 4.74 for total PCBs). Partitioning was related to the physical-chemical properties of congeners and to the fraction of organic carbon (f_{oc}) contained within suspended particulate matter. The partitioning of 7 PCB congeners normalized for f_{oc} (i.e., K_{oc}) was strongly correlated to their octanol-water partition coefficients (K_{ow}s) (i.e., log K_{oc} = 1.07(log K_{ow}) - 0.41, r^2 = 0.985). The slope of ~1 suggests that congener hydrophobicity is an important factor controlling K_{oc}. This relationship was similar to the empirical models of Rao and Davidson (1980) and Karickhoff et al. (1979). Thus, this is the first field investigation to confirm laboratory derived water-particle partitioning relationships for hydrophobic organic compounds.

SKOGLUND, Robert S., and SWACKHAMER, Deborah L. Environmental and Occupational Health, School of Public Health, Box 197 UMHC, University of Minnesota, Minneapolis, MN 55455. **Spatial and Seasonal Variations in the Bioaccumulation of PCBs by Phytoplankton in Green Bay, Lake Michigan.**

The uptake of hydrophobic organic compounds by phytoplankton and their subsequent transfer to predators is a significant route by which contaminants enter the food web. Between April, 1989 and February, 1990, the phytoplankton and zooplankton of Green Bay, Lake Michigan were sampled six times by size fractionation. After congener specific analysis of both the dissolved and particulate phase PCBs, bioaccumulation factors (BAFs) were determined for approximately 65 congeners. Spatial variations in the BAFs were minimal despite the significant PCB concentration gradient in the bay. However, significant seasonal differences in the BAFs were observed. Winter BAFs were consistently larger than summer BAFs for congeners with five or more chlorines. These data are consistent with predictions based on laboratory studies which have demonstrated that growth status of phytoplankton affects the partitioning of PCBs between the dissolved and particulate phases. It is hypothesized that growth and related processes such as release of organic material prevent accumulation from reaching its thermodynamically predicted level. As a result, when these processes are minimized during the winter months, accumulation is more likely to reach levels predicted for steady-state equilibrium, while during summer months the accumulation is significantly less.

MANCHESTER, J.N.; ANDREN, A.W. Water Chemistry Program, University of Wisconsin, 660 N. Park St., Madison, WI 53706. **COMPARISON OF PCB CONGENER SEDIMENT-PORE WATER DISTRIBUTION COEFFICIENTS OBSERVED IN TWO GREEN BAY SEDIMENT CORES.**

Sediments containing contaminants such as PCBs may act as capacitor-like sources of these compounds to overlying waters. The extent to which in-place pollutants contribute to their water-column concentrations depends in part on partitioning of pollutant between sediment particles and pore water. Distribution coefficients, K_D, are used to quantify the partitioning process. Pore water concentrations of PCBs measured at several sediment depths at two locations in Green Bay (using low-pressure whole core squeezing) were combined with solid phase data at these locations (obtained by sonication solvent extraction of 1 cm slices) to determine distribution coefficients for about forty congeners. The K_D for total PCB was about 50,000 L/Kg and congener K_D's range between 2000 for dichlorobiphenyls and 300,000 L/Kg for heptachlorobiphenyls and these values were correlated with congener K_{ow} values. Differences in K_D values were also correlated with depth and location. Statistical techniques were used to examine these correlations for evidence of weathering and/or remobilization of sediment-associated PCB.

EDGINGTON, DAVID N. and KLUMP, J. VAL, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee WI 53201 and ANDREN, ANDERS A. Water Chemistry Laboratory, University of Wisconsin, Madison, WI 53706. **Sediment Deposition in Green Bay**

Sediments represent the long-term repository of hydrophobic contaminants and it has already been shown that, for certain inorganic particle-reactive contaminants such as Pu-239 and Cs-137, over 95% of the total inputs are in the sediments while the continued decrease in concentration in the water is controlled largely by loss from the surface mixed to undisturbed historical layers of the sediment record. Over the last four years sediment samples have been collected from over 120 stations as part of the joint Wisconsin Sea Grant - U.S.E.P.A. program. These samples have been analyzed for Cs-137 and Pb-210 and the data have been used to estimate sediment accumulation rates and mixing depth using a variety of models. These results will be examined in terms of: the areal variations in distribution and accumulation rate; the time-scale for the loss of contaminants from the mixed layer; evidence for longer-term sediment (and contaminant transport), particularly between the south and north parts of the bay; and the extent and time-scale of long-term sediment transport.

KLUMP, J. VAL, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee WI 53201. **Sedimentary nutrient cycling and a nutrient budget for Green Bay**

Using direct measurements of sediment accumulation rates and the carbon, nitrogen and phosphorus content of the sediments in Green Bay, a mass balance for nutrient flow in the system is constructed. The major terms in the budget include phosphorus inputs and net primary production, CNP deposition, burial, and export. The principle uncertainties in these budgets arise from uncertainties in phosphorus loading, in the stoichiometry of carbon fixation driven by phosphorus, and in sediment recycling efficiencies. Direct measurements of sediment-water exchange and nutrient remineralization in sediments serve as a check on the latter. Assuming that all phosphorus entering the system supports carbon fixation according to a Redfield ratio, mass balance requires that ~50-60% of the net primary production is exported from southern Green Bay with the remainder buried in the sediments -- a sink equivalent to 135, 13 and 1.1 x 10^7 moles of C,N,P per year, respectively. This is likely a maximum percentage, since both less efficient P utilization and more efficient burial will drive export terms lower. The kinetics of sediment nutrient cycling indicate that the response time of the Green Bay system to changes in inputs is on the order of years.

LESHT, Barry M., Environmental Research Division, Argonne National Laboratory, Argonne, Illinois, 60439, and HAWLEY, Nathan, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, 48105. **WAVE-INDUCED SEDIMENT RESUSPENSION IN SHALLOW WATER: COMPARISON OF FIELD OBSERVATIONS FROM LAKE ST. CLAIR AND SOUTHERN GREEN BAY.**

Mass balance models of particle-associated contaminants require some estimation of the importance of local sediment resuspension in order to properly account for internal sources of particles. Estimates of the horizontal transport of suspended sediment between model segments also are important in models that have spatial segmentation. While laboratory results relating the erosional behavior of sediments to an imposed shear stress may be applicable in some situations, uncertainties in the characterizations of natural sediments and in the calculation of shear stress in complicated flows make generalization to many field cases problematic. Our recent work in Lake St. Clair (6.5 m deep) has shown that local sediment resuspension due to surface waves can be successfully modeled by using empirical relationships derived from field observations of near-bottom currents and water transparency. Similar observations made during 1989 at slightly greater depth (9.5 m) in southern Green Bay, however, do not exhibit either the variability in suspended sediment concentrations found in Lake St. Clair, nor the consistent correlation between changes in suspended sediment concentration and wave orbital velocity indicative of local resuspension. Analysis of meteorological and wave records shows that the difference can be accounted for by differences in the wave climatologies of the two regions

KLUMP, J. VAL, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee WI 53201. **Short term particle transport in Green Bay**

Time series measurements of Be-7 (half life 53 d), a cosmogenic, particle reactive radionuclide, in suspended particulates and surface sediments throughout the southern half of Green Bay provide estimates of the time scales of particle settling, sediment mixing, and horizontal sediment mobility. Deposition of particles to the sediment surface is rapid with particle residence times in the water column on the order of days. Comparison of time-dependent Be-7 inventories in sediments, corrected for decay, indicate sediment remobilization and transport on time scales of weeks to months. Focusing occurs on longer time scales as a result of resuspension and redeposition events coupled with sediment particle size sorting.

PATTERSON, Dale, Wisconsin Department of Natural Resources, Madison, Wisconsin, 53707.
STEUER, Jeffrey, United States Geological Survey, Madison, Wisconsin, 53719. POLYCHLORINATED BIPHENYL TRANSPORT MODEL FOR THE FOX RIVER

The Wisconsin Department of Natural Resources, in cooperation with the U.S. Geological Survey, is calibrating and testing a deterministic polychlorinated-biphenyl (PCB) transport model (WASP4) for the lower Fox River between Lake Winnebago and DePere. This study effort is part of the Green Bay/Fox River Mass Balance Project. Hydrologic data, and bottom sediment and water column PCB concentrations were collected from April 1989 through March 1990 for use with the model. Gravity cores were collected at more than 275 sites and analyzed for PCB and organic carbon concentrations, particle size distribution, and moisture content. Most of the cores were collected in soft sediments upstream of the DePere dam. Concentrations of PCBs as high as 210 milligrams per kilogram were found in the sediment. PCB concentration and congener composition changed with depth. Estimates were made of the total volume of contaminated sediment and the quantity of PCB in the sediment. PCB loads to the water column from ground water, point discharges and bottom sediments have been calculated. Model runs were made to predict the effects of removing major deposits of contaminated sediments on PCB concentrations in the waste column. Model runs were made for total PCBs and for selected PCB congeners.

GAILANI, J., ZIEGLER, C.K., LICK, W., Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106, and STEUER, J., Wisconsin Department of Natural Resources, Madison, WI 53707. **THE TRANSPORT OF SEDIMENTS IN THE FOX RIVER**

A numerical model of the transport and fate of sediments in the lower Fox River has been developed and verified. The model consists of a two-dimensional, vertically-integrated, time-dependent hydrodynamic and transport model coupled with a three-dimensional, time-dependent model of the sediment bed and its properties. Settling speeds and sediment resuspension parameters needed in the model were determined from laboratory and field tests. Calculations were made for steady flows at high, medium, and low flow rates as well as for real, time-varying flow events. In particular, two flow events were modeled in detail, the first from May 22, 1989 to June 20, 1989 (this included a once in five year high flow as well as moderate to low flows) and the second from March 24, 1989 to April 10, 1989. For these events, calculated sediment concentrations at the river mouth were compared with observations. Good agreement between the calculations and observations was obtained, thereby validating the model and the description of the physical processes implied in the modeling. In particular, the presence and effect of an easily resuspendable surficial layer was demonstrated. In addition, statistical calculations, coupled with real, time-varying calculations of major flow events were made for a period from October 1989 to September 1990. Comparison between calculated erosion and deposition and field measurements of river bed changes during the same period showed qualitative agreement.

VELLEUX, Mark, Department of Civil Engineering, State University of New York at Buffalo, Buffalo, New York
ENDICOTT, Douglas, U.S. Environmental Protection Agency, Large Lakes Research Station, Grosse Ile, Michigan
DEPINTO, Joseph, Department of Civil Engineering, State University of New York at Buffalo, Buffalo, New York

A Mass Balance Analysis of Contaminant Transport and Fate in the lower Fox River.

A mass balance approach was used to develop a mathematical model describing the temporal dynamics of contaminant transport and fate in the water column and sediments of the lower Fox River, Wisconsin. Field observations of flow, chlorides, total suspended solids, and PCBs for the period October, 1988, to December, 1989, collected as part of USEPA's Green Bay Mass Balance Survey Project, supplemented by additional field and laboratory data, were used to develop and calibrate the hydraulic, sediment, and contaminant transport characteristics of the model. The model was used to assess 1) the relative importance of upstream, point, and in-place contaminant sources to the total loads to the river, 2) the magnitude of contaminant export from the river to Green Bay for the period of observation, and 3) the projected magnitude of future contaminant export to the bay. For chlorides, upstream sources contributed 64% and point sources 36% of the total chloride loadings to the lower Fox River over the period of observation. Of the seven major industrial and municipal point sources, only two were significant. For suspended solids, upstream sources contributed 45% and point sources 55% of the total solids loadings to the lower Fox River over the period of observation. Of the seven major industrial and municipal point sources, the Fort Howard Paper Company discharge was the most significant.

SWEET, CLYDE W., and MURPHY*, THOMAS J. Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820 and *DePaul University, Chemistry Department, 25 E. Jackson Blvd., Chicago, IL 60604. **The Role of the Atmosphere in the Mass Balance of PCBs in Green Bay.**

As part of an overall mass balance study of PCBs in Green Bay, exchanges of PCBs between the atmosphere and the bay were evaluated. PCB congener-specific analyses of airborne vapor and particles were carried out on samples collected at three sites on the eastern shore of the bay. Preliminary mass balance calculations indicate that inputs of PCBs from the atmosphere to Green Bay make up less than 10% of total PCB inputs. These calculations also indicate that large amounts of PCBs volatilize from the bay to the atmosphere. Wind sector sampling, seasonal variations in PCB concentrations and the congener pattern found in airborne PCBs all confirm that southern Green Bay contributes a measurable amount of PCBs to the atmosphere.

WANG, PEI-FANG and ZAKIKHANI, MANSOUR; ASci Corporation, c/o USEPA, Athens, GA 30613, McCUTCHEON, STEVE; Environmental Research Laboratory, USEPA, Athens, GA 30613
Hydrodynamic Transport Modeling of Green Bay, WI - Two and Three Dimensional Simulations

A 3-dimensional hydrodynamic model is used to investigate the transport processes of Green Bay, WI, in response to wind, tide and temperature variations. The capabilities of the model in describing the 3-dimensional characteristics of water transport are demonstrated by comparing the model results with the results of some previous modeling work. Water surface elevations from the simulations were compared with the measurements and the results obtained by other investigators, in which 2-dimensional models were used. The results from the present model application are, generally, in agreement with the measurements. Sensitivity analysis are conducted to verify the speculations, previously made by other investigators, for the discrepancies between the model results and measurements. Simulations of bay currents are also compared with field data. The simulated results of currents exhibit the predictive capability of the model in describing the multidimensional flows in the bay. The feasibility of using the hydrodynamic model in providing transport information to the water quality model is also demonstrated in a study of chloride transport.

DEPINTO, J.V., RAGHUNATHAN, R.K., Civil Eng. Dept., State University of New York at Buffalo, Buffalo, NY 14260; BIERMAN, V.J., Jr., University of Notre Dame; RODGERS, P.W., HINZ, S.C., Limno-Tech, Inc.; YOUNG, T.C., Clarkson University. **DEVELOPMENT AND CALIBRATION OF AN ORGANIC CARBON-BASED SORBENT MODEL FOR TOXIC CHEMICALS IN GREEN BAY.**

Accurate computation of the characteristics and fate/transport dynamics of toxic chemical sorbents is crucial to development of an integrated exposure model. Such an effort has been undertaken as part of the Green Bay Mass Balance Study. This sorbent dynamics model is distinguished from previous efforts in that the three sorbent state variables (biotic solids, abiotic solids, and "dissolved" organic carbon (DOC)) are represented on the basis of their organic carbon concentrations. In addition to the conventional transport dynamics (advection, dispersion, settling, resuspension, diffusion), this model includes both allochthonous and autochthonous inputs of organic carbon sorbents as well as various transformation and decay pathways among these sorbent compartments. The model was developed by modifying WASP4 to include the above kinetics and has been calibrated to available Green Bay field data from 1982. Approximately two-thirds of the pool of organic carbon sorbents comes from gross primary production. Transformations of biotic carbon to abiotic carbon and DOC are essential to an accurate calibration.

CONNOLLY[1], John P., PARKERTON[1], Thomas F., TAYLOR[1], Scott and KREIS[2], Russell G. Jr.
[1]Environmental Engineering & Science Program, Manhattan College, Riverdale, NY 10471;
[2]USEPA, Large Lakes Research Station, Grosse Ile, MI 48138. **PCBs in Green Bay Fish: The Importance of Diet and Migration to Observed Concentrations.**

Because the dominant PCB source to Green Bay is the Fox River, significant north-south water column and sediment PCB concentration gradients exist within the Bay. Observed PCB concentrations in alewife and walleye indicate a north-south gradient that is less steep than that of water column and sediment PCB, presumably because their movements within the Bay result in an averaging across the water column and sediment gradients. In contrast, the non-migratory carp exhibit a higher north-south gradient than the walleye and alewife.

Preliminary application of a PCB bioaccumulation model to the walleye, brown trout, carp and their food webs indicates that migration is a dominant process controlling PCB concentrations in the fish, particularly in the Fox River and the southern portion of the Bay. Assumptions regarding alewife and walleye movements into and out of the river greatly affect concentrations. The modelling suggests that the observed PCB concentrations in these migratory species are significantly less than what they would achieve if they were fully resident in the river. Thus migration mitigates the PCB problem in the species of interest. However, because significant uncertainty exists about the migration patterns of fish within the Green Bay system, the extent of this mitigation is not well defined. Accurate calibration of the model requires more definitive information on fish movement.

Differences in the diets of the various fish also seem to be important in controlling concentrations. Carp have the highest concentrations of the species studied. The model indicates that this occurs because the carp are exposed to higher dietary PCB concentrations because they consume benthic animals and sediment that have higher PCB concentrations than the water column animals that form the diet of the other fish.

ENDICOTT, D.D., KANDT, D.J. and RICHARDSON, W.L., EPA Large Lakes Research Station, 9311 Groh Road, Grosse Ile, Michigan 48138. **Looking Back to Saginaw Bay: Post-Audit Verification of a PCB Mass Balance Model.**

Predictions of a water quality model for polychlorinated biphenyls (PCBs) in Saginaw Bay, Lake Huron have been verified by comparison to contemporary PCB concentration data. Data were available for Saginaw Bay water in 1986 through 1989 and for sediment in 1987 and 1988. The predictions of PCB water and sediment concentrations were found to be remarkably accurate. The ten years between model development and verification corresponds to a period during which PCB inputs to Saginaw Bay have substantially declined. The success of the model in predicting the water quality response to this change in inputs lends credence to the mass balance approach for modeling toxic contaminants.

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INTERACTIONS AMONG VARIOUS GREAT LAKES MANAGEMENT STRATEGIES

Convenor: John Carey

Session 1B - Monday, June 3, 1991
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WILLIAMS, D.J., Inland Waters Directorate, Environment Canada, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, and BARTISH, I., International Joint Commission, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3. **The Great Lakes International Surveillance Plan (GLISP): An Introduction.**

The Great Lakes International Surveillance Plan (GLISP) sets out the goals and rationale for surveillance programs responsive to the needs of the Great Lakes Water Quality Agreement. Development of the Plan began in 1974 under the aegis of the International Joint Commission (IJC) in recognition of the need to better coordinate the plethora of individual surveillance activities being conducted by various government and academic agencies in both Canada and the United States. Many individuals in the Great Lakes Basin may know of the Plan; yet, despite its existence for almost 16 years few know its rationale or content. The GLISP has been the major driving force behind the collection of long-term data sets for phosphorus and toxic substances in the Basin. These data sets have been invaluable in calibrating and verifying management models. Unfortunately, there is still the perception that GLISP activities do not relate to "real" or "meaningful" studies. This paper attempts to correct this misconception. The rationale and goals behind the development of GLISP are discussed along with our perceptions of some of the strengths and weaknesses of both the Plan and the development process.

MACKAY, DONALD and DIAMOND, MIRIAM. Institute for Environmental Studies, University of Toronto, Toronto, Ontario M5S 1A4. The Role of Mass Balancing in Great Lakes Management of Toxic Chemicals.

A major preoccupation of the Great Lakes scientific, regulatory and public communities is defining a strategy for achieving "Virtual Elimination" of toxic chemicals from the Basin. Whereas there was considerable progress in reducing contaminant levels in the 1970s, progress in the 1980s has been disappointing. It is suggested that a useful contribution to this strategy would be the availability of a generally accepted, simple mass balance model for each Lake for the critical contaminants which can be used to relate total loadings to prevailing concentrations in water, sediments and in selected organisms comprising a simple food chain. The "Great Lakes Mass Balance Project" which has this aim is described. The current status of the project and plans for the future are outlined.

TAYLOR, W.D[1]., CAREY, J.H.[2], LEAN, D.R.S.[2], and McQUEEN, D.J.[3] University of Waterloo[1], National Water Research Institute[2], York University[3]. **Organochlorine concentrations in the plankton of lakes in southern Ontario and their relationship to plankton biomass.**

Concentrations of 12 hydrophobic organochlorine contaminants were surveyed in net plankton from 33 lakes in southern Ontario at fall overturn. Organochlorines were detected in all lakes. Relative concentrations of the various organochlorines suggest that they all derive from a common source, probably atmospheric transport. Variability in relative abundances of the contaminants increased with contaminant concentration. Lakes with low plankton biomass had high organochlorine concentrations in that biomass, indicating that volumetric concentrations are relatively uniform and that a large portion of the variation among lakes in the concentration in plankton can be ascribed to variable planktonic biomass. Among the compounds we assayed, this biomass dilution effect was strongest for the more hydrophobic and refractory compounds.

LEAN, D.R.S.[1], M.A. NEILSON[2], and A. Mazumder[3]. Lakes Research Branch, National Water Research Institute[1], Box 5050, Burlington, Ontario L7R 4A6; Water Quality Branch, Ontario Region, Inland Waters Directorate[2]; and University of Montreal[3]. **Response of Lake Ontario to Reduced Phosphorus Loading**

Phosphorus loading to Lake Ontario has been reduced from 14600 t y^{-1} in 1969 to present levels which range between 6700 and 8000 t y^{-1}. Midlake spring TP showed a 90 % response within four years and after an eight year lag chlorophyll a levels were also less but particulate carbon and nitrogen concentrations have not changed. Evidence is presented to show that Lake Ontario was likely nitrogen deficient in 1972, but due to the spring nitrate increase of 9.5 ug L^{-1} y^{-1} since 1969, became P deficient soon thereafter. We predict that if no phosphorus controls were initiated, the increased nitrate loadings would have resulted in a chlorophyll increase in excess of 4 times the maximum concentrations ever observed in the last 20 years. Physical control of phytoplankton biomass and top-down control by the cascade effect of increased levels of large fish on planktivores and their influence on abundance and size structure of the zooplankton and phytoplankton community is discussed. Such information is a prequisite for reliable nutrient-contaminant management strategies.

POULTON, Donald, Water Resources Branch, Ministry of the Environment, 135 St. Clair A. W., Toronto, ON M4V 1P5. **Heavy metals and toxic organic contaminants in water and sediments of the Bay of Quinte, Lake Ontario.**

In 1988, water and sediment samples were collected from 15 locations in the Bay of Quinte, and analyzed for trace contaminants (inorganic and organic). Similar samples were also collected at point sources and tributary mouths. In the water, Provincial Water Quality Objectives (PWQO) were exceeded only on a small portion of samples for copper, cadmium, iron, zinc and phenols. Point source sampling showed that Domtar Wood Preserving at Trenton was a major contributor of chlorinated phenols; several sewage treatment plants were significant sources of heavy metals, but tributary metal loadings were generally higher than sewage treatment plant loadings. Heavy metal levels in sediments were generally found to exceed Ministry dredge spoil disposal guidelines. Compared to 1982, slight decreases in sediment concentrations of mercury, lead and zinc were found; other metal levels were similar. Detectable levels of many PAHs were found in the sediments, with the highest concentrations at the mouth of the Trent and Moira rivers. Other organic contaminants were seldom, if ever, found in the sediments.

DIAMOND, M.L.[1], MACKAY, D.[1], POULTON, D.[2] and STRIDE, F.[3], 1 Institute for Environmental Studies, University of Toronto, Toronto, Ontario M5S 1A4, 2 Great Lakes Section, Water Resources Branch, Ontario Ministry of the Environment, 135 St. Clair Ave. W., Toronto, Ontario M4V 1P5, 3 Southeastern Region, Ontario Ministry of the Environment, P.O. Box 820, Kingston, Ontario K7L 4X6. **Modelling organic and inorganic chemicals in the Bay of Quinte.**

A toxic chemical model for the Bay of Quinte has been developed based on the fugacity/aquivalence approach of Mackay and co-workers. The mass balance model estimates the fate and transport of dissolved and particle-sorbed chemical in 7 water and 5 sediment compartments, and through 7 trophic levels of a food web. The model has been tested against measured concentrations of arsenic (As) and pentachlorophenol (PCP) in water and sediments. The steady-state model, together with the Linear Additivity Principle of Stiver and Mackay (1990), has been used to estimate contributions from sources to the amount and concentration of chemicals in the Bay. The major source of As to the Bay is the Moira River and for PCP, an industrial source in the Upper Bay. Back-calculating from measured concentrations in fish, it is estimated that 78 kg of PCBs enter the Bay annually. Illustrative models of an additional 3 inorganic and 11 organic chemicals clearly illustrate their various behaviours which follow from their physical/chemical properties.

SIMMERS, John W. USAE Waterways Experiment Station, Vicksburg, MS and Bryniarski, Len F. USAE Buffalo District, Buffalo, NY **ASSESSMENT OF AN AVIAN BOTULISM CONTROL PILOT PROJECT AT THE DIKE 14 CONFINED DREDGED MATERIAL DISPOSAL FACILITY, CLEVELAND, OHIO**

The Dike 14 Confined Dredged Material Disposal Facility (CDF) at Cleveland, OH was the site of an avian botulism outbreak in 1986. At that time the use of noise-making devices was not successful in preventing the use of the CDF by shorebirds, wading birds, and waterfowl susceptible to botulism. The Buffalo District identified the problem as one requiring a generic solution that could be applied at other operational CDFs. In a pilot project, plant propagules were planted at the CDF prior to the disposal operations so that a vegetative cover would rapidly appear as the CDF dewatered after disposal. The vegetation on the dewatering dredged material was expected to make the CDF unattractive to shorebirds, wading birds, and waterfowl. The pilot project was a qualified success in the prevention of a 1987 outbreak of avian botulism. The duration of the disposal operation and the depth of the dredged material placed in the CDF limited the anticipated vegetation establishment.

HARTIG, JOHN H. International Joint Commission (IJC), 100 Ouellette Ave., Windsor, Ontario N9A 6T3. **Revised Listing/Delisting Guidelines for Great Lakes Areas of Concern.**

In 1987, the Great Lakes Water Quality Board (WQB) of the International Joint Commission (IJC) recommended that a common set of criteria be developed to determine when ecosystem conditions have been impacted enough to warrant designation of an Area of Concern, and when ecosystem conditions have sufficiently improved to delist an Area of Concern. Based on scientific input from a 1988 International Association for Great Lakes Research Symposium the WQB developed and reached agreement, in principle, on a set of Listing/Delisting Criteria for Areas of Concern. The WQB and the IJC also recognized that these criteria could be improved and immediately, upon adoption of the criteria, published them in IJC's newsletter Focus in 1989 in an effort to obtain widespread scientific and public comment. Based on all input received, a revised set of listing/delisting guidelines for Areas of Concern has been developed based on the 14 use impairments identified in Annex 2 of the Great Lakes Water Quality Agreement. The intent of the listing/delisting guidelines is to assist the IJC and its Boards in: 1) making recommendations for new Areas of Concern; and 2) reviewing all stages of remedial action plans (RAPs).

EDER, Tim, Project Manager, National Wildlife Federation, 802 Monroe, Ann Arbor, MI. 48118. **A Prescription For Healthy Great Lakes.**

In February of 1991, NWF and the Canadian Institute For Environmental Law and Policy released the **Prescription.** The study summarizes a two-year research effort and recommends needed reforms in government programs and regulations to achieve the goal of zero discharge. The strategy for achieving this objective includes three preventative steps: 1) A Toxics Freeze; 2) Sunsetting (or Banning) the 60-70 most harmful toxic substances, and 3) Reducing the use of all toxic chemicals by 50% by 1995 and 75% by 2000. In addition, the strategy includes three clean-up steps: 1) New water quality standards to protect women, their infants, wildlife and frequent fish consumers from all toxic effects, including reproductive and developmental effects; 2) Prohibit dilution and protect high quality waters, and 3) Adopt comprehensive Lakewide clean-up strategies. We propose the use of a mass balance fate and transport model in development of the comprehensive Lakewide clean-up strategies.

ECOLOGICAL, EPIDEMIOLOGICAL AND NEUROTOXICOLOGICAL ASSESSMENT OF GREAT LAKES CONTAMINANTS

Convenors: Paul J. Kostyniak, James Olson and Richard Seegal

Session 1C - Monday, June 3, 1991
2:00 - 5:20 PM

Session 2C - Tuesday, June 4, 1991
8:30 AM - 12:10 PM

110 Knox Hall

HUMPHREY, HAROLD E.B., Michigan Department of Public Health, Lansing, Michigan. **The Human Population - A Receptor for Aquatic Contaminants.**

Humans who eat sport caught fish are exposed to a variety of chemical contaminants found in the aquatic environment. Regular consumption can result in elevated human body burdens of these contaminants and accordingly, possible toxicological risks. Beginning with a Lake St. Clair mercury exposure study in 1970 public health officials in Michigan have developed and sustained epidemiological cohort studies in order to monitor human exposure and evaluate potential health outcomes from such exposures. These studies have served as the basis for innovative collaborative research aimed at exploring subtle as well as obvious toxic effects. Work with experts in psychology, immunology and enzymology is breaking new ground in our understanding of contaminant manifested biological differences between exposed populations and unexposed populations.

VENA, JOHN E., Dept. of Social and Preventive Medicine, SUNY at Buffalo, Buffalo, New York, 14214. **The Consumption of Contaminated Fish and Perception of Risk Among New York Fishermen.**

Sport fish in Lake Ontario and other New York (NY) waters bioaccumulate toxic chemicals above Food and Drug Administration tolerance levels. Very little is known about the amount and type of fish caught and consumed by anglers. The effectiveness of advisories in NY warning against eating fish has not been studied. A study was conducted to determine fish consumption histories, knowledge of the advisory, and the perception of risk associated with consumption of sport fish. A random sample of fishing license holders and members of the lake Ontario Trout and Salmon Association (L.O.T.S.A.) (200 of each) were mailed a standardized self-administered questionnaire. After only one mailing, the response rates were 53% for L.O.T.S.A. members and 33% for license holders. A total of 170 households responded with 245 individuals completing a survey. At least one sport caught fish meal in the past year was consumed by 60% of the respondents. Consumption of at least one sport fish meal per week of any species was reported by 22%. Consumption of at least one meal of contaminated fish from Lake Ontario varied by species (any species 27%, Chinook Salmon 22%, Lake Trout 15%, and Coho Salmon 15%). Ninety-one percent of the respondents were aware of the advisory and amoung those 80% had read it and 85% had learned of it through the news. When respondents ranked various risks, illegal drugs, smoking and pesticides were considered riskiest, but eating sport fish received the lowest risk rating, lower than air and/or water pollution. The conduct and results of this pilot survey and their impact on the design of a large population-based survey, investigating the relationship between fish consumption, body burdens and adverse health outcomes will be discussed. Specific aims and objectives of the cohort study and preliminary response rates will be presented.

FITZGERALD, E., BUSH, B., HWANG, S., BRIX, K., QUINN, J. and COOK, K. (State University of New York, Albany, NY 12203).
Dietary Exposure to PCBS from Hazardous Waste.

To test if dietary exposure to PCBs from a nearby Superfund site is elevating body burdens, the authors are studying nursing Mohawk mothers and their infants at Akwesasne, a Native American community along the St. Lawrence River. Mohawk and control women are interviewed at 1 and 3 months post-partum, and asked to provide breast milk and maternal and infant urine samples for the analysis of 73 PCB congeners. Preliminary results indicate that the mean for total PCB among Mohawk women who ate local fish at least once a month was 0.809 ppm, compared to 0.530 ppm for the controls ($p=0.030$). A statistical technique based on summary scores demonstrates that the congener pattern in Mohawk breast milk more closely approximated that in fish samples collected near the waste site than did the controls ($p=0.024$). Future efforts will focus upon the effects of PCB exposure in this population, including neurobehavioral outcomes.

HESSELBERG, Robert J., Larry J. Schmidt, and James D. Bowker. U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes, 1451 Green Road, Ann Arbor, MI 48105. **COMPARATIVE TRENDS OF SELECTED AHH-ACTIVE PCB CONGENERS AND PESTICIDES IN LAKE TROUT FROM LAKES MICHIGAN AND ONTARIO, 1977 - 1988.**

PCB congeners (# 77, 105, 126, etc.) that induce the activity of the enzyme aryl hydrocarbon hydroxylase (AHH) have greater toxicity to mammals and possibly fish. Several investigators have theorized that some of the AHH-active congeners in the Great Lakes are declining at a much slower rate than non AHH-active congeners. To test this theory we analyzed 1977 - 1988 archived samples from Lakes Michigan and Ontario. From each homogenized whole lake trout sample two grams of tissue was extracted for PCBs and pesticides, lipids were removed from the extract by GPC, the extract containing PCBs and pesticides was concentrated to 5 ml and then quantitated by GC/MS. The GC/MS was operated in the negative chemical ionization and selective ion monitoring mode using methane reagent gas. We determined some AHH-active PCB congeners declined at a slower rate than total PCBs. However, the decline was inconsistent for a given congener between lakes. For example, PCB congener #77 declined only about 8% over 11 years in Lake Michigan but 60% in Lake Ontario. During the same period total PCBs in lake trout declined 70 in Lake Michigan and 60% in Lake Ontario.

FIORELLA, David, KOSTYNIAK, Paul., McREYNOLDS, James., OLSON, James., LIMPENSEL, Douglas., Toxicology Research Center, University of Buffalo, Buffalo, New York, 14214, **Quantitative Determination of Tri-fluoromethyl- PCB's in Lake Ontario Fish.**

Tri-fluoromethyl PCB's (TFBP) have been identified as environmental contaminants unique to the Hyde Park land fill in Niagara Falls, N.Y. The tri-fluoromethyl substituant confers both increased longevity and lipid solubility on these compounds, making them specific biomarkers for the distribution of leachate from the Hyde Park dump into the Lake Ontario ecosystem. Measuring the concentrations of specific isomers in sediments and fish will provide meaningful quantitative data pertaining to the distribution of aromatic halides and like compounds in the biosphere. Three TFBP isomers of analytical purity have been synthesized for use as GC/MS and GC standards. Methods for GC/NCI-MS, GC/EI-MS and EC-GC sample analysis have been developed using these standards. A novel steam distillation method (employing the Neilson-Krieger apparatus) is presently being standardized for the extraction of these organic substances. The apparatus performs continuous steam distillation on a 50 gram fish tissue sample into 10 mls of organic solvent for a 24 hour period. The collected organic solvent is ready for direct analysis with only minor work up and no further concentration.

MASLANKA, Robert. STEWARD, A.Ruth., PANGREGAR, Jyotsna. and SIKKA, Harish.C. Division of Environmental Toxicology and Chemistry, Center for Environmental Research, State University of New York College at Buffalo, Buffalo, NY 14222 **Disposition of 2,3,7,8-Tetrachlorodibenzofuran (TCDF) in Rainbow Trout (Oncorhyncus mykiss)**

TCDF is an extremely toxic environmental contaminant which is biomagnified by the food web and has been found in fish in the Great Lakes. To better assess the ecological and health risks posed by TCDF, we determined its whole body half life and tissue distribution in trout dosed orally with 1 ppb [^{3}H]TCDF. Half-life data revealed a rapid initial phase of 3 days during which the whole body level was reduced to 40% of the administered dose, followed by a much slower phase of excretion (half-life, 17 days). Maximum concentrations of TCDF-derived radioactivity in the blood, liver and kidney occurred at 8-24 hr, followed by biphasic elimination from these tissues, in parallel with the total loss of from the fish. Maximum concentrations in bile, muscle and adipose tissue occurred at 72 hr. Thereafter the concentration in muscle decreased and was similar to that in liver at these time points. The concentration in adipose tissue, however, remained constant until 14 days and then increased. The largest amount of TCDF equivalents occurred in muscle. These data indicate that maximum absorption of TCDF from the gut occurs between 8 and 24 hr after exposure, with subsequent distribution to tissues, followed by metabolism by the liver and excretion via the bile, with possible long-term storage in adipose tissue. (Supported by NY Sea Grant Institute)

WALKER, Mary K., PETERSON, Richard E., University of Wisconsin, Madison, WI. **Toxic Potencies of Polychlorinated Dibenzo-p-dioxins, Dibenzofurans and Biphenyls During Rainbow Trout Early Development Using a Microinjection Method.**

Since polychlorinated dibenzo-p-dioxin, dibenzofuran, and biphenyl congeners occur as mixtures in Great Lakes fish, predicting their combined toxicity is difficult. Often, toxicity of mixtures can be predicted from the toxic potencies, or toxic equivalency factors (TEFs), of individual components, assuming they interact additively. TEFs of selected congeners have been determined, relative to the potency of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), in causing rainbow trout (Onchorynchus mykiss) embryo mortality. Rainbow trout eggs were microinjected with either vehicle control or one of 7 graded doses of TCDD, or an individual dioxin, furan, or biphenyl congener. Cumulative mortality to swim-up was determined, and LD_{50}s calculated. A TEF was calculated by dividing the LD_{50} for TCDD (250 ppt in the egg) by the LD_{50} for the dioxin, furan, or biphenyl congener. TEFs (95% C.I.) for 4 furan congeners were: 2,3,7,8-TCDF, 0.027 (0.015-0.043); 2,3,4,7,8-PCDF, 0.491 (0.278-1.29); 1,2,3,7,8-PCDF, 0.033 (0.016-0.095); and 1,2,3,4,7,8-HCDF, 0.383 (0.219-0.688). Structure-toxicity relationship of these furan congeners is comparable to that for mammalian and avian species. (Supported by C.S. Mott Foundation fellowship, and UW Sea Grant R/MW-40).

WILLIAMS, Lisa L. and GIESY, John P., Department of Fisheries and Wildlife, Pesticide Research Center and Institute for Environmental Toxicology, Michigan State University, East Lansing, MI 48824. **Coplanar Polychlorinated Biphenyl (PCB) Congeners and TCDD-Equivalents in Fillets of Lake Michigan Chinook Salmon: Implications for Fish Consumption Advisories**

Concentrations of PCBs often drive risk assessments for fish consumption advisories, yet concentrations of total PCBs may not be accurate representations of toxicity. Coplanar congeners are the most toxic of the mixture of more than 100 congeners detected in fish. The objectives of this study were to determine the relationships among concentrations of coplanar PCB congeners, total PCBs and fish size in trimmed fillets of chinook salmon from Lake Michigan. Concentrations of total PCBs were measured in 81 fillets. Coplanar PCBs in 17 fillets were analyzed following carbon column fractionation. Concentrations of total PCBs ranged from 0.14 to 2.1 ug/g. Regression of total PCB concentration against fish length explained 48% of the variability in PCB concentration. Concentrations of coplanar congeners #77, #105 and #126 (IUPAC nomenclature) ranged from 0.3 to 4.0 ng/g, 3.9 to 36.2 ng/g and 0.04 to 0.48 ng/g, respectively. Concentrations of these congeners and 7 others were used to calculate equipotent concentrations of 2,3,7,8-TCDD (TCDD-EQ) in each fillet. Concentrations of TCDD-EQ ranged from 26 to 204 pg TCDD/g. The 95% confidence interval for predicting TCDD-EQ from concentrations of total PCBs and fish length spanned 123 pg/g.

JACOBSON, J.L. and JACOBSON, S.W., Department of Psychology, Wayne State University, Detroit, MI. **Effects of Prenatal PCB Exposure on Central Nervous System Function in Young Children.**

236 children, recruited at birth on the basis of maternal consumption of Lake Michigan fish, participated in a longitudinal study of the neurotoxicity of polychlorinated biphenyls (PCBs) and related contaminants. Prenatal exposure (indicated by umbilical cord serum PCB level) predicted poorer short-term memory function in four assessments: visual recognition memory at 7 months and verbal, quantitative, and pictorial memory at 4 years. Contemporary body burden (assessed by 4-year serum PCB level) was associated with reduced activity level. These effects cannot be attributed to a broad range of confounding variables, the impact of which was evaluated statistically. Although much larger quantities of PCBs are transferred postnatally via lactation than prenatally across the placenta, exposure from nursing was unrelated to cognitive function. These deficits, although subtle, could have a significant impact on acquisition of reading and arithmetic skills in later childhood.

SCHANTZ, S.L.[1], LEVIN, E.D.[2], FERGUSON, S.A.[3] AND BOWMAN, R.E.[4] [1]Institute for Environmental Studies, University of Illinois, Urbana, IL; [2]Department of Psychiatry, Duke University School of Medicine, Durham, NC; [3]National Center for Toxicological Research, Jefferson, AR and [4]Harlow Primate Lab, University of Wisconsin, Madison, WI. **Comparison of PCB and TCDD effects on behavior in monkeys.**

Many of the toxic effects of PCB mixtures are qualitatively similar to those of TCDD and are believed to be mediated through the binding of coplanar PCB congeners to the Ah-receptor. In our laboratory, monkeys exposed to commercial PCB mixtures (Aroclor 1016 or Aroclor 1248) or to TCDD during gestation and lactation were later tested for effects on locomotor activity, reversal learning and delayed spatial alternation. Interestingly, the pattern of behavioral effects following early PCB exposure differed from that following TCDD exposure. Both Aroclor 1016 and Aroclor 1248-exposed monkeys were hyperactive with respect to age-matched controls; whereas TCDD-exposed monkeys showed no consistent changes in locomotor activity. PCB-exposed monkeys were impaired on spatial reversal learning and delayed spatial alternation, but showed facilitated performance on object quality reversal learning. In contrast, TCDD-exposed monkeys were somewhat facilitated on spatial reversal learning and delayed spatial alternation and showed impaired performance on object quality reversal learning. In summary, the neurobehavioral effects of complex PCB mixtures appear to be qualitatively different from those of TCDD and may be mediated at least partially through mechanisms other than binding to the Ah-receptor.

SHAIN, W., BUSH, B., and SEEGAL, R. Division of Environmental Sciences, Wadsworth Center for and Department of Environmental Health and Toxicology, School of Public Health, SUNYA, Empire State Plaza, Albany, NY 12201-0509, ***In vitro*** **Toxicity Testing of Polychlorinated Biphenyls (PCBs)**

Epidemiological and animal studies indicate that consumption of PCB-contaminated food results in neurological deficits. Several of these deficits may occur because of changes in catecholamine metabolism. When non-human primates or rats are exposed to different commercial mixtures of PCBs changes in catecholamines metabolism have been observed, e.g. decreases in dopamine content. We have developed a sensitive alternative to animal testing for studying PCB toxicity testing using PC12 cells that metabolize and release dopamine. We have used commercial mixtures of PCBs to demonstrate that PCBs cause a decrease in cell dopamine content. We have used individual PCB congeners to describe the structure-activity relationship for PCBs and decreases in cell dopamine content and to initiate experiments that indicate PCB congeners decrease dopamine content by inhibiting dopamine synthesis. We have now used this assay method to demonstrate that hexane extracts of Coho salmon from Lake Ontario cause decreases in cell dopamine content. Analytical analysis indicates that these extracts contain PCBs suggesting that PCBs in these fish may be responsible for the observed neurological deficits observed in epidemiological and laboratory studies.

CARPENTER, D.O., EVANS, M.L. and BÜSSELBERG, D.; Wadsworth Laboratories, NYS Dept. of Health and School of Public Health, Albany, NY 12201; **Pb^{2+} is a potent blocker of voltage-dependent calcium channels in both invertebrate and mammalian neurons.**

Lead, at remarkably low concentrations, causes a permanent reduction in cognitive ability as well as behavioral abnormalities in children. The exact mechanism and site(s) of action responsible for this effect is unknown. One possible site of action is voltage-dependent calcium channels, which have essential functions in all neurons. We have investigated the effects of Pb^{2+} on currents through voltage-dependent calcium channels in isolated neurons of the marine mollusc, Aplysia, and in cultured rat dorsal root ganglion neurons. Aplysia neurons were recorded with standard two-electrode voltage clamp techniques, while dorsal root ganglion neurons were recorded in a whole-cell patch configuration. Calcium currents were isolated by pharmacologic blockade of sodium and potassium currents. Pb^{2+} reversibly blocked calcium currents in both preparations at concentrations which did not significantly affect potassium and sodium currents. In Aplysia the block was concentration dependent, and the percentage blockade was reduced in elevated Ca^{2+}. The threshold Pb^{2+} concentration for blockade was about 1 μM, with an IC_{50} of about 50 μM. The blockade was very voltage dependent, increasing with depolarization. With addition of Pb^{2+} the voltage at which peak calcium current was generated shifted to hyperpolarized potentials. Three calcium currents could be isolated in the dorsal root ganglion neurons by use of different holding potentials and voltage jumps, and all were blocked by Pb^{2+} with IC_{50}s of between 0.64 and 6 μM. This suggests Pb^{2+} is a competitive antagonist of voltage dependent calcium channels. Since calcium entry into neurons is important in plasticity of the nervous system, blockade of that process by lead at very low concentrations may be important as a mechanism of lead toxicity.

#ASCHNER, M., and *KIMELBERG, H. K. #Department of Pharmacology and Toxicology, *Division of Neurosurgery, Albany Medical College, Albany, NY, 12208. **Methylmercury (MeHg) uptake and efflux from astrocyte cultures.**

To delineate the potential relationship between astrocytes and MeHg neurotoxicity, MeHg uptake and efflux were studied in rat astrocyte cultures. MeHg uptake exhibited the kinetic criteria of a specific transport system when added to the media as the L-cysteine adduct. Cysteine-mediated uptake of MeHg was inhibited by L-methionine, and 2-aminobicyclo-[2,2,1]-heptane-2-carboxylic acid (BCH). 2-methyl-aminoisobutyric acid (MeAIB) was ineffective in inhibiting the uptake of MeHg-cysteine adducts. Astrocytic loading with L-glutamate was moderately effective in trans-stimulating the uptake of MeHg-cysteine adducts; in the absence of cysteine, uptake of MeHg in L-glutamate loaded cells was unchanged, suggesting trans-stimulation of MeHg-cysteine uptake in exchange for intracellular L-glutamate. Net efflux of MeHg was most rapid during the first 5 min. The percentage of MeHg retained was independent of the loading period, but the total amount of intracellular MeHg that was available for efflux gradually decreased as the loading period increased. Hence, MeHg removal from diffusible -SH containing ligands may represent the principal mechanism for concentrating MeHg within the astrocytes. Trans-stimulation of MeHg efflux was detected when astrocytes were incubated with "cold" MeHg and graded cysteine concentrations. In conclusion, MeHg influx and efflux in astrocytes appear to be specific for the MeHg-cysteine conjugate and represent transport by the neutral amino acid System L. (Supported by NIH ES0 5223 awarded to MA, and NS 23750 awarded to HKK).

BURBACHER, T.M. and MOTTET, N.K., Departments of Environmental Health and Pathology, University of Washington (Seattle). **The Developmental Neurotoxicity of Methylmercury in Nonhuman Primates.**

To investigate the toxic, reproductive, and developmental effects of *in utero* methylmercury (MeHg) exposure, 30 adult female Macaca fascicularis monkeys were orally-exposed to MeHg prior to and throughout pregnancy. Infants were separated from their mothers at delivery and tests of neurobehavioral and physical development have been ongoing for over 8 years. MeHg exposure did not affect maternal menstrual cycle length but did significantly reduce the number of liveborn infants. Exposed infants were normal in size at birth, although male exposed offspring exhibited growth retardation at puberty. MeHg induced delays in the development of object permanence and deficits on tests of early visual memory. In addition, exposed infants exhibited decreased social play behavior and increased nonsocial passive behavior. The overall results from this study suggest that MeHg exposure can produce subtle central nervous system effects in offspring at levels that do not result in overt signs of maternal or infant toxicity.

MILLER, D. B. & O'CALLAGHAN, J. P. U.S. Environmental Protection Agency, Neurotoxicology Division, RTP, NC 27711. **Neurotoxicity Assessment - The Organotins as a Case Study.**

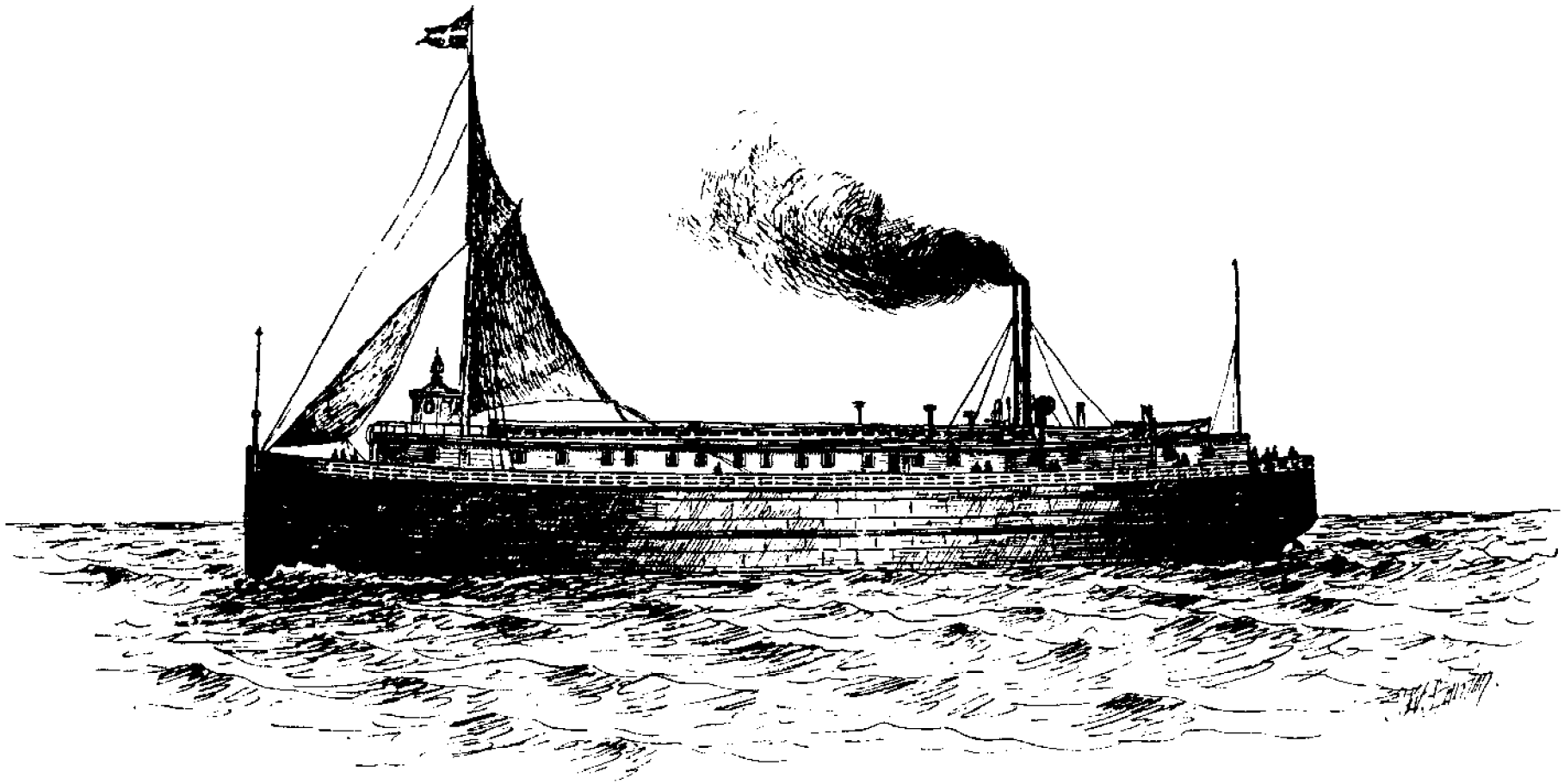
Organometallic compounds, including the organotins, are persistent in aquatic systems and sediments of the Great Lakes and a question of great concern is their neurotoxic potential. Predicting neurotoxicity is difficult because specific brain regions are often selectively vulnerable to the effects of a given chemical. Thus, a common dilemma is deciding where to look. Given the extreme cellular and molecular heterogeneity of the brain it is not unexpected that different brain regions and cell types are differentially sensitive to chemical alteration. However, the differences between nervous system cell types can be distinguished on the basis of specific neuronal and glial proteins. The development of radioimmunoassays for these proteins allows their use in the detection and characterization of cell-type-specific responses to chemically-induced alterations in the CNS. We will present data demonstrating the utility of this approach in determining the differential neurotoxicity of the structurally related organotins, triethyltin (TET), trimethyltin (TMT) and tributyltin (TBT). All three organotins, although TBT to a much lesser extent, produce characteristic regional and cellular alterations after a single exposure in the adult and developing rodent. The hippocampus is a particular regional target of both TET and TMT. Thus, neuron- and glial-localized proteins can be used as biochemical indicators of neurotoxicity and are applicable regardless of the information available on the chemical in question. When these assays are combined with functional evaluations a complete characterization of neurotoxicity can be provided.

MCLACHLAN, D.R., Centre for Research in Neurodegenerative Diseases, Tanz Neuroscience Building, University of Toronto, Toronto, Canada. M5S 1A8
Aluminum Neurotoxicity of Drinking Water

Recent research has raised the question of whether excess amounts of aluminum used in the treatment of drinking water obtained from the Great Lakes poses a risk to public health. Elevated concentrations of aluminum in the brain are known to be neurotoxic. Normal bulk brain aluminum concentration ranges between 1 and 2 µg/g dry weight. In aluminum sensitive species such as cat and rabbit, brain concentrations between 5 and 6 µg/g dry weight are lethal within twenty-eight days. Concentrations approaching the lethal range are found in a number of neurodegenerative diseases including the most common form of senile dementia, Alzheimer's disease. The Parkinson dementia/Amyotrophic Lateral Sclerosis syndromes of Guam also contain elevated concentrations of aluminum. In addition to a large body of knowledge concerning the cytoplasmic and nuclear toxic effects of aluminum, there are six epidemiological studies which indicate the incidence of Alzheimer's disease exhibits a positive correlation with the amount of aluminum in the drinking water. Aluminum dust in the work place may also represent a risk for altered cognitive function. Excess aluminum may represent a potential public health risk.

GILBERT, M.E., MANTECH ENVIRONMENTAL TECHNOLOGY INC., Research Triangle Park, NC, 27709.
DO ENVIRONMENTAL TOXICANTS PROMOTE A PREDISPOSITION TO SEIZURE DISORDERS?

Kindling is a model of epilepsy whereby seizures are gradually induced by daily delivery of brief, low intensity trains of electrical stimulation to limbic brain regions. Repeated administration of low doses of some chemicals can substitute for electrical stimulation to induce a permanent predisposition to develop seizures. Many neurotoxicants produce convulsions in humans and laboratory animals following acute high dose exposure. We hypothesized that repeated exposure to subconvulsive doses of the pesticide endosulfan may gradually induce behavioral seizures via a kindling mechanism. Male Long Evans rats were administered endosulfan (0, 5, 10 mg/kg in corn oil) for 10-21 days and observed 1 hr after each treatment. Behavioral signs of seizure activity developed which increased in severity with repeated dosing (facial twitching, myoclonic jerks, clonic seizure activity). Two to four weeks after the last dosage, animals were prepared with stimulating/recording electrodes in the amygdala and stimulated once daily in a standard electrical kindling paradigm. In the absence of further endosulfan treatment, animals were found to be significantly more susceptible to the development of limbic kindling than controls. It was concluded that repeated low level exposure 'chemically kindled' the animals and subsequently enhanced the proclivity for induction of limbic seizures.



"Merchant" - 1862
First iron propeller on the Great Lakes, built at Buffalo, New York., 861 tons, by David Bell, for J. C. and E. T. Evans, Buffalo and Chicago route. Wrecked on Racine Reef, Lake Michigan, 1875.

CONTAMINANT BIOAVAILABILITY AND BIOACCUMULATION

Session 1D - Monday, June 3, 1991

2:00 - 5:20 PM

14 Knox Hall

Santiago, S, Institute F.A. Forel, University of Geneva, 10, route de Suisse 1290 Versoix (Switzerland). Thomas, R.L., NWRI Box 5050, Burlington, Ont. BIOAVAILABILITY OF SUSPENDED SEDIMENT BOUND PHOSPHORUS IN SOME RIVERS TRIBUTARY TO LAKE GENEVA.

Suspended sediment samples were recovered by continuous flow centrifugation of water samples taken at the mouths of the Rhone, Venoge, Dranse and Aubonne rivers draining into Lake Geneva in 1988 and 1989. In addition the effluent of the sewage treatment plant at Vidy (Lausanne) was sampled in each of the two years. Samples were analyzed for the forms of phosphorous (Total-P, Organic-P, Apatite-P and Non-Apatite Morganic-P). Sediment was used in an algal fractionation bioassay test. This involved a four hour incubation of natural phytoplankton in direct contact with sediment. Change in growth rate was measured by C^{14} uptake as compared to a lake water control. C^{14} was measured in the >20 and <20 size fractions following filtration and DSMO extraction. Results showed that the sediment generated growth of cells relates well to sediment bound phosphorus added and that growth varies with river and the limnological conditions in the lake. No growth was observed from Rhone River sediment due to low concentrations of NAIP whilst no growth from the sewage treatment plant is believed to be due to toxicity.

COTTER, A.M.[1], LEONARD, E.N.[2], KOSIAN, P.A.[1], ANKLEY,G.T.[2]; [1]ASCI Corporation Inc., Duluth,MN, [2]U.S. EPA, ERL-D, Duluth,MN; **ACID VOLATILE SULFIDE MEASUREMENT, A MAJOR INDICATOR FOR DETERMINING METAL BIOAVAILABILITY IN SEDIMENTS**

Acid volatile sulfide (AVS), (that fraction of solid phase sulfide soluble in cold acid,) has been demonstrated to be important in determining the bioavailability and thus toxicity of cationic metals such as cadmium and nickel, in freshwater sediments. A number of exposures have been conducted at the U.S. EPA laboratory in Duluth,MN to evaluate the degree to which AVS concentrations can be used to predict metal bioavailability in sediments. In this presentation we will describe in detail techniques used to analyze AVS and metals in these studies. We also will present results of an ongoing study which shows how AVS concentrations vary seasonally and spatially in three northern Minnesota lakes. These data will help to determine potential metal bioavailability throughout the year.

SIMMERS, John W., BRANDON, Dennis L. USAE Waterways Experiment Station, Vicksburg, MS and LEONARD, Richard P. USAE Buffalo District, Buffalo, NY **DISTRIBUTION OF PCB CONTAMINANTS IN THE VICINITY OF THE TIMES BEACH CONFINED DISPOSAL FACILITY, BUFFALO, NEW YORK**

Mussels, *Elliptio dilatata*, were collected from a pristine lake and exposed as biomonitors in Lake Erie, and inside the Times Beach confined dredged material disposal facility. The mussels were allowed time to burrow either in the sediment or between stones for 35 days and then collected and analyzed for polychlorinated biphenyls (PCBs). After 35 days exposure in the Times Beach CDF, mussels accumulated PCB congeners 28, 44, 49, 52, 70, 87 and 101 to levels above those of mussels exposed on the outside of the disposal facility dike in Lake Erie. The concentrations of higher-chlorinated PCBs (138 and 153) were found to be higher in the biomonitors outside the dike.

HAFFNER, G. D., GOBAS, F.A.P.C. AND LAZAR, R. Great Lakes Institute, Department of Biological Sciences, University of Windsor. Quantification of biomagnification and predator - prey interactions in the Great Lakes.

Food webs were sampled in five different habitats in the Great Lakes, and contaminant distributions measured. The importance of bioamagnification in regulating levels and distribution of organic chemicals was assessed by comparing predator/prey chemical ratios with similar ratios of organism/water and organism/sediment. Biomagnification factors were low, and only slightly greater than 1. It was observed that BMF was dependent on feeding strategies (generalist versus specialist), and that the distribution of chemicals with a Log Kow > 6.0 was regulated by food web processes.

RUSSELL, R.W., GOBAS, F.A.P.C. and HAFFNER G.D., University of Windsor, Simon Fraser University, Great Lakes Institute. **Bioconcentration of chlorinated benzenes and biphenyls in field exposed fish.**

It has been shown that organic substances in water can be partially or completely unavailable for uptake and bioconcentration in fish. This study investigates the role of particulate and dissolved organic matter on the bioavailability of hydrophobic organic chemicals under field conditions. The truly dissolved or bioavailable chemical concentration was determined by a novel continuous flow gas sparging technique designed for application in the field. Fish were exposed for 42 days in Little River, Ont. The results indicate that BCF's calculated using the bioavailable chemical concentration follow a relationship predicted by the K_{ow} of the chemical. Models for field bioconcentration are discussed.

NOGUCHI, George E., Schmidt, Larry J., and Mac, Michael J. U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes, 1451 Green Rd, Ann Arbor, MI 48105. **TISSUE DISTRIBUTION OF PCB CONGENERS IN LAKE MICHIGAN LAKE TROUT.**

Concentrations of polychlorinated biphenyl (PCB) congeners were measured in lake trout tissues to determine whether chlorine content or substitution pattern within individual congeners influence the internal distribution of accumulated PCBs. The liver, gonad, fillet, visceral fat and carcass of mature lake trout collected from southeastern Lake Michigan were analyzed for total PCBs, 24 individual PCB congeners, total lipid content and lipid class composition. Much of the variability in congener concentrations between tissues could be accounted for by differences in neutral lipid content. The composition of PCB congeners relative to total PCB content in visceral fat, carcass and fillet were similar. Compared to these three tissues, female gonads (eggs) were enriched in lower chlorinated congeners. Overall, the concentration of PCB congeners in eggs relative to concentrations in visceral fat, carcass and fillet was negatively related to the octanol-water partition coefficient of the individual congeners, including those with non-ortho (77 and 126) and mono-ortho (105, 114, 118, 156, 157 and 189) substitution patterns.

BOWKER, James D. and Larry J. Schmidt, U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes, 1451 Green Road, Ann Arbor, MI 48105.
BIOACCUMULATION POTENTIAL OF SELECTED PCB CONGENERS FROM SAGINAW RIVER SEDIMENT DURING 10- AND 28-DAY BIO-EXPOSURE STUDIES.

Increased attention is being given to the study of individual PCB congeners which induce aryl hydrocarbon hydroxylase (AHH) activity. Laboratory sediment exposure studies determine whether organisms accumulate significant levels of these individual congeners. However, the appropriate duration of these bio-exposure studies is a matter of contention. In this study, fathead minnows were exposed to either PCB-contaminated sediment or control sediment for 10 and 28 days. From each sample composite, two grams of tissue was extracted for PCBs, the lipid was removed from the extract by GPC, and the PCB congeners quantified by GC/MS using negative selective ion monitoring. Ten day test was an inadequate length of time for significant bioaccumulation, and may lead to false negative results. Fish in the 28 day test accumulated levels of PCBs significantly higher than pre-exposure levels and those from control sediment for all congeners analyzed. Fish exposed to river sediment lost significant weight and lipid. Correlation was significant between log K_{ow} and the ratio for each PCB congener concentration in fish and in sediment.

LICK, W., Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106. **PHYSICAL PARAMETERS AND THE SOLIDS CONCENTRATION EFFECT IN THE SORPTION OF HYDROPHOBIC CHEMICALS FROM WATER**

Many organic chemicals are hydrophobic and readily sorb to solid particles in water. Recent experimental work has attempted to determine the extent of this sorption (the equilibrium partition coefficient K_p) and the rate at which this sorption occurs. However, these processes are not yet well understood. In order to obtain a better understanding of these processes and the parameters on which they depend, the effects on sorption of mass transfer by combined convection and diffusion, dynamic aggregation and disaggregation, and time-dependent internal diffusion both for a single-size particle and as affected by particle size distribution have been investigated, quantified as much as possible on the basis of existing data, and related to recent batch and purge experiments on sorption. From this, an improved understanding of the general characteristics of the sorption of hydrophobic organic chemicals is obtained. It is also demonstrated that the basic reason for the solids concentration effect is that the chemical mass transfer rate from the solution to the solids for small time is dependent on the solids concentration.

DID YOU KNOW

That at the Battle of Lake Erie, September, 1813, two vessels of Perry's squadron were built at Black Rock and another vessel outfitted there. Also, one vessel in the British fleet, LITTLE BELT, was built there.

FORECAST AND PREDICTION SYSTEMS

Convenors: Keith W. Bedford and Carolyn J. Merry

Session 1E - Monday, June 3, 1991
2:00 - 5:20 PM

Session 2E - Tuesday, June 4, 1991
8:30 AM - 10:10 AM

4 Knox Hall

BOYCE, Daron E., National Weather Service, Cleveland, Ohio, **Marine Weather Services on the Great Lakes.**

A summary of the various Marine Weather Services provided by the National Weather Service to Great Lakes users will be made. Basic services include wind, wave and weather forecasts; ice forecasts and observational weather summaries. Warning services will also be described. Sample Weather Service products will be presented and the activities of the specialized marine weather forecasting staff at the Cleveland Forecast Office will be listed.

SCHWAB, David J. and LESHKEVICH, George A. Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan. **Great Lakes CoastWatch and NOAA Ocean Communications Network**

CoastWatch is a NOAA-wide program designed to focus on specific regional and national priorities in the coastal environment. The objectives of CoastWatch are: 1) to provide access to near real-time and retrospective satellite and aircraft observations for the coastal ocean of the US for federal, state, and local decision making, 2) to develop workstations and associated software systems for integrated analyses of environmental quality, coastal hazards, and wetlands change, 3) to develop a communications system supporting distribution of near real-time and historical satellite and in situ observations to national and regional coastal users, and 4) to develop and implement a data base management and display system(s) supporting integrated coastal ocean applications. NOAA CoastWatch directly supports agency statutory responsibilities in estuarine and marine science, living marine resource protection, and ecosystem monitoring and management contained in several federal environmental statutes including the Great Lakes Water Quality Agreement. As the CoastWatch Regional Site for the Great Lakes, GLERL will establish operations of the Great Lakes Regional NOAA Ocean Communications Network (NOCN) Node, identify regional CoastWatch users and their NOAA data needs, and supply useful products to participants in the Great Lakes CoastWatch Program. The first CoastWatch products for the Great Lakes will be digital images of lake surface temperature derived from NOAA AVHRR thermal infrared satellite imagery at resolutions of 1.3 and 2.6 km. Several of these images per week have been received at GLERL on an experimental basis since April, 1990. Preliminary analysis shows good correlation of satellite-derived temperatures with in situ measurements at mid-lake weather buoys. Other CoastWatch products are planned including turbidity, ocean color, ice mapping etc., many using new satellite sensors such as SeaWiFs and Synthetic Aperture Radar (SAR).

BEDFORD, Keith W. and SCHWAB, David J., Ohio State University, Columbus, Ohio and Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, **The Great Lakes Forecasting System - Lake Erie Nowcasts.**

The Lake Erie Information Forecasting System (LEIFS) is the first of the five forecasting systems comprising the Great Lakes Forecasting System. Designed to make real-time predictions of the physical status of each Lake, the initial forecasts consist of three-dimensional velocity and temperature fields as well as the wind wave and water level distributions. The prediction template consists of a nowcast, or estimate of present conditions, followed by the forecast for a one- or two-day time period. This presentation details the nowcast procedure for LEIFS and offers examples from nowcasts made since April 1991. The nowcast differs from the forecast in that observed data from the prior 24-hour period are used to estimate the present conditions. The required model data consists of surface wind shear and heat flux distributions. A skill test evaluated nowcast for the prior day serves as the initial condition. The wind field observations are obtained from the FIB analyses at the joint Navy-NOAA Forecasting Center in Monterey, California. The additional data required for the heat flux calculation are obtained from the Cleveland NWS Marine Forecast Center. Nowcast evaluations are performed with AVHRR data from Coastwatch, the NOS measured water levels and auxiliary data from the Marine Forecast Center.

MERRY, Carolyn J., WELSH, David, CHU, Yi-Fei, BEDFORD, Keith W., Dept. of Civil Engineering, The Ohio State University, 2070 Neil Ave., Columbus, OH 43210 and SCHWAB, David and McCORMICK, Michael J., NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI 48105

Using AVHRR and In-Situ Temperature Data in a Surface Heat Flux Model for Lake Erie

A real-time three-dimensional system for forecasting the currents and temperatures in the Great Lakes, called the Great Lakes Forecasting System (GLFS), is being developed at OSU. One of the key components in the Lake Erie Forecasting System is estimating the surface heat flux information required for the temperature calculations. Real-time acquisition of temperature measurements is being configured for the following types of data: the NOAA AVHRR satellite image data, a network of 20 in-situ temperature measurements taken by electric and water utilities, and the NDBC buoy in the center of Lake Erie. Data on air temperature, wind speed, dew point or vapor pressure, water temperature, air-sea drag coefficients, cloud cover and Julian date serve as input to the surface heat flux model. AVHRR images are being integrated into the system using high-speed communications with GLERL with follow-on processing using the NASA Land Analysis System (LAS). Procedures to extract, correct and match the image with the model grid are being developed and automated. Preliminary results are being developed to test the spatial and temporal correlations between the satellite and in-situ temperature measurements in the surface heat flux model of Lake Erie.

CLODMAN, Stephen, Atmospheric Environment Service, 4905 Dufferin St., Downsview, Ont., Canada, **Lake wind wave forecasting at the Atmospheric Environment Service.**

Wind wave modeling research is being done to support Canadian weather forecasting. The parametric model originally by Donelan and Schwab computes wave momentum at gridpoints by timesteps. After some tuning changes, extensive buoy data hindcasts showed generally accurate wave heights. Some remaining systematic errors were found, especially in the wave decay and in the wave period. The wave decay procedure has been refined. A better wave spectrum was needed to improve the wave period. Therefore the model has been generalized to allow different read-in choices of spectrum and forcing function. These values can be output dependent. The model equations are analytically solved for simple cases. A shallow water compensation has been introduced. Also the computer program code has been reorganized. These changes make the model more accurate and flexible while retaining its relative simplicity and economy. An old version of the model is now being run by forecast offices for mid-lake forecasts. A new version should be implemented soon on the new AES workstation system. For near shore and smaller lakes, a routine is proposed based on simple empirical equations for onshore and offshore winds. Finally, better lake wind modeling is needed for the wave forecasts; work on this is in progress.

BRISSETTE F.P. and TSANIS I.K.
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Hamilton, Ontario, Canada, L8S 4L7

Wave Directional Spectra in Lake Ontario and Lake St.Clair

An accurate description of a sea state is essential to many ocean and engineering applications such as: wave forecasting, satellite surveillance, shore protection, upper mixed layer dynamics, environmental hazards and design of marine structures and vehicles. Such a description requires information not only in the frequency domain (frequency spectrum), but also on the directional spreading of a given sea. Wave data was obtained from a symmetrical six wave gage array at the National Water Research Institute's waves Tower on Lake Ontario and from a three wave staff array mounted on a temporary waves Tower on Lake St.Clair. High resolution directional spectral estimates were obtained from both lakes using a number of computational techniques. Results show the occasional occurence of bimodal seas in Lake Ontario in which a wind sea propagates counter to a residual swell. An interesting phenomenon is observed in Lake St.Clair where waves generated by westerly winds are found to propagate at a significant angle (up to 90°) to the wind direction. Preliminary findings suggest that a strong wave-current interaction is responsible for this behavior.

YOUNG, Sharolyn R., **NAVY/NOAA Joint Ice Center, 4301 Suitland Rd., Federal Bldg. #4, Rm. 2306, Washington, D.C. 20395-5180. Long Range Ice Forecasting in the Great Lakes.**

In-depth research and development is required in order to improve ice forecasting accuracy for the Great Lakes. In addition to the Monthly and Seasonal Weather Outlook, a relatively new data base of Freezing Degree Days (FDD) is used to forecast Great Lakes ice conditions. The weather outlook is correlated with present FDD totals and air temperature data, resulting in a projected FDD accumulation total. The FDD is used as an indication of winter severity based on the concept that air temperature is the most important factor influencing ice growth. The FDD projection for each lake is then compared to analogous FDD years observed from the historical FDD data base. Analyses for the corresponding years are then used as a basis for the projection. Additionally, the Great Lakes Ice Climatology Atlas is consulted as a guide in forecasting extreme minimum or severe ice seasons. This method, developed in the early 1970s, has proven useful, considering the limitations of the data base. By updating the expanding FDD data base over the upcoming years, this statistical method of ice forecasting should also improve.

CRISSMAN, Randy D.
New York Power Authority
P. O. Box 277
Niagara Falls, New York 14302

An On-Line Early Warning System for Ice Jams and Ice Stoppages on the Upper Niagara River

Ice stoppages and/or ice jams in the upper Niagara River can cause reductions in hydroelectric power generation at the plants operating on the river. A method for predicting the potential occurrence of ice stoppages and/or ice jams was developed and incorporated into a computerized, on-line early warning system for use by the operators of the generating facilities. The method was derived from analyses of historical ice-affected flows, from which early warning indicators for the occurrence of ice stoppages and ice jams were derived. Hydraulic conditions, particularly water levels, on the river are monitored and computations are performed in real-time to determine when conditions arise that might lead to the occurrence of an ice stoppage or ice jam. Warnings are issued to the operators by the computer, if the thresholds for the indicators are exceeded or elevations at the water level gauges exceed zero damage elevations established by the U. S. Army Corps of Engineers.

PECK, Eugene L.; Hydex Corporation, 2203 Lydia Place, Vienna, Virginia 22181.
Evaluation of Ground and Airborne Data for Snowmelt Forecasting for Lake Ontario Basin.

Hydrometeorological measurements have been made for many years in the Lake Ontario drainage basin. More recently, airborne measurement of the water equivalent of the snow cover are being collected. There are many inaccuracies and inconsistencies in these data that limits their usefulness for operational snowmelt forecasting. This is especially true for precipitation. The monthly amount of precipitation reported, especially for snowfall, may be 10 to 30 percent less than the actual precipitation that occurred at the measurement site. A selection of the available data base for the Lake Ontario Basin (Canadian and United States) is evaluated. The records are checked for consistency and precipitation records adjusted for errors in gage measurements, primarily due to wind effects. A method to combine the adjusted ground measurements with the airborne data to obtain areal averages of the water equivalent of the snow cover for forecasting snowmelt runoff is demonstrated.

CARROLL, THOMAS R.; National Operational Hydrologic Remote Sensing Center; National Weather Service, NOAA; 6301-34th Avenue South; Minneapolis, Minnesota 55450. **Airborne and satellite snow cover data used in operational and research hydrology programs for Lake Superior and Lake Ontario.**

Airborne snow water equivalent data have routinely been collected by the National Weather Service (NWS) over the Lake Superior basin since the early 1980s and used by the U.S. Army Corps of Engineers (COE) in operational lake level regulation activities. The NWS and the COE have established airborne data collection networks consisting of 85 flight lines and 42 flight lines around Lake Superior and Lake Ontario, respectively. Both airborne snow water equivalent data and satellite areal extent of snow cover data are being collected over the Lake Ontario basin for use in a multi-agency research project to enhance the use of remotely sensed hydrology data for Great Lakes forecasting. Airborne snow water equivalent data are collected, analyzed, and distributed in real-time to NWS and COE hydrologists. Advanced Very High Resolution Radiometer data are used to map areal extent of snow cover, in real-time, over all of the Great Lakes basins as frequently as cloud cover conditions permit. Airborne snow water equivalent data are combined with satellite areal extent of snow cover data to generate mean areal snow water equivalents, by sub-basin, in the Lake Ontario watershed.

LEE, Deborah H.; CROLEY II, Dr. Thomas E., Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, Michigan, 48105; SOUTHAM, Charles F., Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, Ontario L7R 4A6. **A Comparison of Great Lakes Water Supply Forecast Methods.**

Three methods for forecasting Great Lakes water supplies have been developed by Environment Canada, the U.S. Army Corps of Engineers, and the Great Lakes Environmental Research Laboratory. The methods employed by the U.S. Army Corps of Engineers and Environment Canada are based on statistical models, while that of the Great Lakes Environmental Research Laboratory is based upon a deterministic hydrologic model. The models' forecasted supplies are compared to actual supplies experienced during August 1982 through December 1988 - a period which encompassed persistent above average precipitation followed by severe drought. The accuracies of the forecasts produced by each method are similar when averaged over the evaluation time frame. The forecast errors, relative to the actual supplies indicate the potential for improvements in forecasting supplies. However, the similar accuracies of the three state-of-the-art methods suggest that more accurate forecasts are not only dependent on model improvements, but on improvements in associated inputs to the models, such as long-range weather forecasting.

BUCHBERGER, Steven Gene, Department of Civil and Environmental Engineering, University of Cincinnati, Cincinnati, Ohio 45221-0071

Forecasting Annual Extreme Lake Levels to Assist Lake Shore Management

Lake shore flooding behaves differently than does riverine flooding. In contrast to annual peak river flows which are independent over time, annual maximum lake levels exhibit significant autocorrelation. Current strategies for managing lake shore floodplains, however, still mimic policies developed for riverine environments. This regulatory posture provides only a static glimpse of a dynamic process. It is argued that, in the presence of autocorrelated flooding events, prudent management of lake shore floodplains should be based on current lake conditions rather than on long-term steady-state water levels. To illustrate this new approach, a time series model is introduced to generate conditional forecasts of annual extreme lake levels. Application of the forecasting model to three sites on Lake Erie shows that initial lake levels are the most important factor in estimating the magnitude and frequency of imminent lake shore flooding.

SOUTHAM, CHARLES F., Environment Canada, IWD-OR, WPM, P.O. BOX 5050 Burlington, Ontario L7R 4A6 CANADA. **FORECASTING WATER LEVELS IN THE GREAT LAKES: ENVIRONMENT CANADA'S PROBABILISTIC APPROACH.**

Each month Environment Canada prepares a six-month forecast of Great Lakes water levels and outflows. The approach uses probabilistic net basin supplies and does not require extensive data preparation through sophisticated hydrologic modelling. The discussion focuses on the forecast methodology, data and computing system requirements, as well as, an evaluation of the successes and limits of the predictions. The evaluation shows that when the Basin experiences extreme wet or dry conditions the actual water levels may fall outside the band of forecasted levels. Nevertheless, the user public is provided with a useful outlook of lake levels for the next one to six months.

THIEME-JANISH, Cheryl K., U.S. Army Corps of Engineers, P.O. Box 1027, Detroit, Michigan, 48231; LEE, Deborah H., Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, Michigan, 48105. **Incorporation of Storm Rise Frequencies to Six Month Forecasts.**

The U.S. Army Corps of Engineers, Detroit District, publishes a six month forecast of Great Lakes water levels under the auspices of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. This forecast projects probable still water levels which reflect the seasonal fluctuations of the Great Lakes. A need exists, however, to incorporate information regarding storm events which can cause short-term, site-specific rises in levels. These storm rises can cause severe damage to shoreline property, but are not often considered by riparians in planning shoreline development. A booklet to inform the general public on the Great Lakes System, and how to interpret the published six month forecast, has been designed which includes information on storm rise frequencies. This aspect of the booklet is presented and discussed.

DID YOU KNOW

The year 1924 saw 10,000 boats enter and leave Buffalo harbor, 1987 saw 29 commercial boats.

LAKE ONTARIO ECOSYSTEM: PAST PRESENT AND FUTURE

Convenors: Dr. Mohiuddin Munawar, Stephen Brandt and Gary Sprules

Session 2B - Tuesday, June 4, 1991
8:30 AM - 12:10 PM

Session 3B - Tuesday, June 4, 1991
1:40 - 5:00 PM

Session 4B - Wednesday, June 5, 1991
8:30 AM - 12:10 PM

109 Knox Hall

SLY, PETER, G. Rawson Academy, Suite 404, 1 Nicholas Street, Ottawa, Ont. K1N 7B7. Man's Impact on the Lake Ontario Ecosystem Since 1750.

European settlement in the Lake Ontario basin began about the middle of the 18th Century; in less than 250 years, the lake and its watershed have been subjected to almost every human-induced stress that can be imposed on a lake. This synthesis and summary of causes and effects looks at the impacts caused by deforestation, canal construction, the building of dams and mills, changes in fishing practices and technology, agricultural development, range extension and the introduction of exotic species, nutrient and toxic contaminant loadings, urban development, and lake level regulation. It looks at responses in terms of ecosystem health including species shifts and extirpations, changes in food web structures and yield, habitat loss and change, and animal and human health.

Since the early 1970s, a wide range of remedial actions have greatly improved water quality and the fishery of Lake Ontario, and recent initiatives seek to redress habitat loss. Ahead, what should we expect from the RAPs, what's special about managing oligotrophic lake systems, what might be the implications of climate change; are we heading towards environmentally sustainable development in the basin?

EL-SHAARAWI, A.H. National Water Research Institute. **Recent Trends in Input Loads from the Niagara River into Lake Ontario.**

Statistical methods for estimating the input loads from the Niagara River to Lake Ontario and for evaluating the year to year variability in these estimates are discussed. The utilities of these methods are illustrated using both nutrients and contaminants data which are routinely collected by Environment Canada since 1975. The results indicate major reductions of the Niagara River load to the Lake.

NEILSON, M.A., Water Quality Branch, Ontario Region, Inland Waters Directorate, Burlington, Ontario, L7R 4A6, Canada. **NUTRIENT TRENDS IN LAKE ONTARIO.**

The water quality of Lake Ontario has been monitored on a continuous basis by the Water Quality Branch-Ontario Region of Environment Canada since 1968. Annual spring lakewide cruise data have shown that total phosphorus concentrations have declined, in response to phosphorus control measures, to achieve the acceptable inlake concentration of 10ugP/L, as recommended by the Phosphorus Management Strategies Task Force (1980). Annual summer cruise data indicate that chlorophyll a concentrations have finally responded to the reduced P levels. The long-term increasing filtered nitrate-plus-nitrite trends which have consistently been reported in each of the Great Lakes, have shown deviations in recent years, parallelling changes observed in the Niagara River.

Munawar, M. & Munawar, I.F. Fisheries & Oceans Canada, Burlington, Ontario, **Is community structure of Lake Ontario phytoplankton changing ?**

Since 1970 Fisheries & Oceans Canada has been monitoring long- term changes of the community structure of Lake Ontario phytoplankton. Lakewide surveys conducted during 1970 and 1978 were compared for species and size composition. Lakewide evaluation revealed significant reductions of several taxonomic groups of phytoplankton such as Cyanophyta, Chlorophyta, Chrysophyceae, and Cryptophyceae. Similarly long-term assessment of community structure was carried out at a Midlake/pelagial station from 1970 to 1987. The results indicated that most of the statistically significant changes were due to Fluctuations of Chlorophyta and Cyanophyta. The size structure data showed an increase of μ-algae (<5 μm) during the spring season where as ultraplankton (5-20 μm) and microplankton (20-64 μm) fluctuated significantly during the summer season. Possible ecological implications of the long-term structural changes of Lake Ontario phytoplankton will be discussed.

RALPH, K.M., O.E. JOHANNSSON, E.S. MILLARD, and D.D. MYLES. Great Lakes Lab for Fisheries and Aquatic Science. Dept. Fisheries and Oceans. Canada Centre for Inland Waters. Burlington, Ontario, Canada. **Changes in the Planktonic Community and Environment of Lake Ontario during the 1980's.**

The Lake Ontario Biomonitoring Program has conducted weekly sampling at two open lake stations since 1981. Chemical, physical and biological variables were measured with most emphasis on epilimnetic or surface water conditions. During the 1980's we have observed significant decreases in both nutrient (TP) and biological (PON, POC, Chlorophyll a, phytoplankton biomass, zooplankton abundance) variables, particularly in the latter years. We have examined the seasonal aspect of these changes, and most have occurred during the stratified period. The composition of the phytoplankton has shifted slightly, but zooplankton composition has not changed significantly.

LEAN, DAVID. National Water Research Institute, Lakes Research Branch, Box 5050, Burlington, Ontario, Canada L7R 4A6.
PHOSPHORUS DYNAMICS IN THE LAKE ONTARIO ECOSYSTEM.

Historically, research has focused on quantifying quantities of phosphorus in certain operationally defined compartments (particulate phosphorus, soluble reactive phosphorus etc.) but the rates of transport between compartments is still in the early phase of development. Here data from the Lake Ontario Nutrient Assessment Study (LONAS), see Can. J. Fish. Aquat. Sci. 44, No 12 1987 were synthesized to illustrate the overall pattern between trophic levels, exchange rates between bacteria and heterotrophic microflagellates, meso- and microzooplankton grazing, and losses due to sedimentation. While problems still exist in estimating nutrient assimilation and regeneration rates, the quantity of P required to support the plankton community during summer stratification will be calculated and related to overall loading estimates.

DERMOTT R. Fisheries and Oceans, Canada Centre for Inland Waters, Burlington, Ontario, Canada.
Overview of the Bottom Fauna in Lake Ontario.

First examined in 1924, the bottom fauna of open Lake Ontario was examined during several whole lake suveys conducted between 1965 and 1977. The deep water community has been well described and is dominated by a few oligotrophic species, but lacks both many of the oligotrophic indicator species or dominate mesotrophic indicators. The steep slope and large areas of upwelling along the shore limit the diverse communities to a thin band about 5 miles in width around the lake. The shallow harbour areas now support only pollution tolerant communities. Offshore, the populations of the dominant amphipod, oligochaetes and sphaerids show large swings in annual abundance. Inshore, above the thermocline, a number of Palearctic invertebrates, particularly molluscs are now key organisms in the community.

WHITTLE, D.M., KEIR, M.J. & HYATT, W.H. Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries & Aquatic Sciences, Burlington, Ontario, L7R 4A6. **Temporal Trends in Contaminant Levels For The Lake Ontario Fish Community (1977-1989).**

As part of the IJC Open Lake Surveillance Program, the Department of Fisheries and Oceans has conducted an annual survey on Lake Ontario since 1977 to measure whole fish levels of a range of trace metals and organic contaminants. Lake trout (Salvelinus namaycush) and rainbow smelt (Osmerus mordax) have been the principle monitoring species. The program has recently been expanded to include the analysis of both alewife (Alsoa pseudoharengus) and sculpin (Cottus sp.). After an initial rapid decline, concentrations of some organic contaminants levelled off and oscillated around a baseline level 2 to 3 times lower than recorded a decade earlier. Most recently there has been evidence that the measured levels of some organic contaminants, whose use has been restricted for more than 10 years, are increasing, particularly in forage fish collections. Factors such as changes in lipid concentrations and diet composition are partially responsible for this apparent reversal of contaminant trends in the Lake Ontario fish community.

RANG, S., SLOTA, S., HOLMES, J., NEIBOER, E., & REIGER H. Institute of Environment and Health, University of Toronto and McMaster University.
The impairment of beneficial uses in Lake Ontario.

Annex 2 of the Great Lakes Water Quality Agreement requires the development of Lakewide Management Plans. The first of these plans is being developed by the four parties for Lake Ontario, using the information gathered in the Lake Ontario Toxics Management Plan. As Part of this exercise, an inventory of impairments of beneficial uses in Lake Ontario and the casual pollutants responsible for the impairment has been compiled. The impairment of beneficial uses is broadly based, including degradation of aesthetics, beach closures and drinking water consumption restrictions. The guidelines used to select information for this inventory, clarification of the cause-effect linkage, and the draft list of casual pollutants for Lake Ontario will be presented.

MUNAWAR, M., BRANDT, S., SPRULES, G., & STEWART, D. Fisheries & Oceans, Chesapeake Biological Station, University of Toronto, & SUNY College of Environmental Science & Forestry, Syracuse. **Lake Ontario Trophic Transfer (LOTT) Study: A new multidisciplinary and multi-trophic approach.**

The Lake Ontario ecosystem has been experiencing considerable abiotic and biotic changes during the past quarter of a century. It is the recipient of nutrients and contaminants from municipal, industrial and atmospheric inputs. The changes include the heavy stocking of salmonoids and the invasion of zebra mussel. Very little is known about the impact of these perturbations on the food web dynamics. Consequently an international and multi-agency project- LOTT was initiated on a lakewide basis during 1990. LOTT s' mandate included: a) simultaneous measurement of food web parameters, b) application of new acoustical, optical survey technologies and bioenergetic models, and c) evaluation and management of impact of nutrient and contaminants, piscivore stocking and introduction of exotic species on the food web structure and production in the Great Lakes.

MUNAWAR, M., LEGNER, M., LEPPARD, G., LYNN, D.H., MUNAWAR, I.F. & WEISSE, T. Fisheries & Oceans Canada, Environment Canada, University of Guelph & University of Konstanz. **Microbial interactions in Lake Ontario.**

Integrated water samples were collected during 1988-1990 for the identification and enumeration of bacteria, autotrophic picoplankton, ultraplankton, microplankton and netplankton, heterotrophic nannoflagellates and ciliates. Analyses by epifluorescence microscopy, Utermohl technique or Quantitative Protargol Staining method was done. Determined primarily by their oral morphology and body size, different ciliate groups greatly differ in their way of tapping food resources. The methods of food capture range from encounter feeding on larger mobile organisms to filtering particles through oral membranes of various "mesh" size. Ciliates were grouped as bacterivorous and planktivorous (either eating heterotrophic or autotrophic plankton). Species considered to consume other eucaryotes, especially heterotrophic ones prevailed in spring (nearshore stations) and summer (offshore stations) whereas species which consumed primarily, autotrophic picoplankton dominated in the fall (offshore samples). This is the first time such a study has been attempted which suggests need of experimental research to assess trophic interactions.

LYNN, D.H., MUNAWAR, M. & LEGNER, M. University of Guelph, Fisheries & Oceans Canada. **Ciliates of Lake Ontario: Distribution, abundance and composition.**

As part of a lake-wide survey to examine the components of, and importance of the microbial loop, ciliates were collected from 30 stations along eastern, mid-lake, and western transects. Lugol preserved integrated samples from 0-20 m were analyzed using Utermohl technique while others were post-fixed with Bouin's fixative and stained by the Quantitative Protargol Staining technique.

The ciliates were classified into the following conspicuous taxonomic groups: the hypotrichs; the oligotrichs (Halteria, Strombidium, Strobilidium), and tintinnids; the peritrichs (Vorticella); the prostomes (Urotricha); the litostomes (Askenasia and Mesodinium); and a miscellaneous category which included minor genera or unidentifiable taxa. A more complete analysis of the detailed data set will provide further insights into the role and function of ciliates in the Lake Ontario ecosystem.

MILLARD, E.S., D.M. MYLES and O. JOHANNSSON. Great Lakes Lab for Fisheries and Aquatic Science. Dept. Fisheries and Oceans. Canada Centre for Inland Waters. Burlington, Ontario, Canada. **Primary production and phosphorus demand in Lake Ontario - whole lake assessment.**

Primary production and P demand have been measured for several years at selected stations as part of the Lake Ontario Biomonitoring Project. How well these stations represent major portions of the lake can be assessed from the lake-wide approach taken in the Lake Ontario Trophic Transfer Project (LOTT 1990). Total primary production for the whole lake and various zones has been estimated. The seasonal and lake-wide variability in factors determining integral production such as photosynthetic parameters and light extinction will be presented. Measurements of phosphorus demand using $^{32}PO_4$ were made on a lake-wide basis in spring, summer and fall. Inshore-offshore gradients in P demand in May shows that there is a lake-wide shift from light to phosphorus limitation of phytoplankton growth that is dependant on depth but modified by P supply in some inshore areas. Spatial analysis done with GIS (SPANS) software will be presented.

BAKER, JOEL E.; R. DAWSON, and P. SAWANGWONG Chesapeake Biological Laboratory, CEES, University of Maryland, Solomons, MD 20688. **Plant pigment stratigraphy in Lake Ontario: tracking the deep-water flux of algal carbon to the sediment record.**

To investigate the cycling of algal carbon in the Great Lakes, samples of water column, benthic nepheloid layer, and sediment particulate matter were collected with the submersible Johnson Sea Link from stations in Lake Ontario during summer 1990. HPLC pigment analyses revealed highly stratified populations of chlorophytes, cryptomonads, and cyanophytes with lesser contributions of dinoflagellates and diatoms focussed around the thermocline. The deep-water chlorophyll maximum, 150 m below the thermocline, consisted almost entirely of diatoms, with a remarkably well-preserved signature of the settled spring diatom bloom. Estimates of the flux of algal carbon were made on the basis of carotenoid and chlorophyll ratios and compared with typical carbon sinking fluxes.

JOHANNSSON, O.E., K.M. RALPH, and D.D. MYLES. Great Lakes Lab for Fisheries and Aquatic Science. Dept. Fisheries and Oceans. Canada Centre for Inland Waters. Burlington, Ontario, Canada. **Mysis relicta distribution, abundance, and production in Lake Ontario.**

Mysis relicta abundance and growth rates have been monitored at a mid-lake station since 1984 as part of the Lake Ontario Biomonitoring Program. Production has also been calculated when possible. However, in some years significant immigration/emmigration in the region of the sampling station has prohibited these calculations. The Lake Ontario Trophic Transfer study has provided the opportunity to examine factors, such as depth and position in the lake relative to the dominant wind patterns, on the abundance and local size structure of the population. Through the use of GIS (SPANS) software, regional and whole lake abundances and size-frequency distributions have been assessed.

JIN, EDDY H. and W. GARY SPRULES. Dept. Zoology, Erindale College, University of Toronto, Mississauga, Ontario, L5L 1C6, Canada. **AN OPTICAL PLANKTON COUNTER FOR CONTINUOUS MONITORING IN LARGE LAKES**

A towed underwater sampling device comprising an optical plankton counter, fluorometer, transmissometer, thermistor, and depth sensor was tested for the first time in freshwater. These instruments, fixed to a hydrodynamic wing or tow body, are linked via cable to shipboard computers for data logging. The optical plankton counter, as configured for our purposes, can sample organisms between 250 μm and 4 mm at rates as high as 150 per second. We operated the instrument cluster continuously along a transect in Lake Ontario from nearshore at Ashbridge's Bay, Toronto (depth 5.5 m) to mid-lake 22 km offshore (depth 137 m) at an average speed of 9.3 km/h. For parts of the transect the instruments were towed at constant depth, and for other parts they were towed in a sinusoidal pattern between depths of 5 and 50 m. Periodic net samples were taken along the 22 km transect for ground-truthing. Data collected are presented to illustrate the utility of the system in providing continuous biological and physical information over large spatial scales.

SPRULES, W. GARY & EDDY H. JIN. Dept. Zoology, Erindale College, University of Toronto, Mississauga, Ont. L5L 1C6. **Large-scale patterns in zooplankton size and density in Lake Ontario.**

During the fall of 1990 we used a towed, Optical Plankton Counter (OPC) to continuously sample zooplankton along three north-south cross-lake transects in the western, central and eastern portions of Lake Ontario. The OPC, which was towed either at constant depth or in a sigmoidal pattern from near surface to depth, detects animals from roughly 250 μm to 4 mm equivalent spherical diameter. We noted sharp changes in zooplankton size and density at the thermocline, and have some evidence for similar changes as we towed the OPC across a horizontal thermal bar. We present analyses of the variance and mean in body size and density at scales ranging from meters to kilometers in order to elucidate patterns in spatial heterogenity.

ROSS, P. E., Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL, USA, and MUNAWAR, M., Fisheries and Oceans Canada, Box 5050, Burlington, ON, Canada L7R 4A6. **Zooplankton feeding studies during the LOTT program.**

This paper presents results of zooplankton community filtration rate experiments performed during the July-August 1990 cruise of the Lake Ontario Trophic Transfer (LOTT) initiative. Fifteen experiments were done at ten stations on two north-south transects, one in central Lake Ontario and one in the western part of the lake. Both day and night experiments were done at five stations. The feeding rates were measured on radioactively-labeled natural algal food in a modified Gliwicz-Haney grazing chamber at 5 m depth. Community filtration rates were generally much higher at night than during the day, with the exception of one station in the western transect where night filtrations rates were only slightly higher than daytime values. Using phytoplankton biomass and production rates from the same LOTT cruise, estimates of community feeding rates (biomass) and cropping rates (fraction of primary production) are calculated.

E.L. MILLS[1], R. O'GORMAN[2], AND J. DEGISI[1]. [1]Department of Natural Resources, Cornell University, Ithaca, New York 14853 and [2]U.S. Fish and Wildlife Service, Oswego Biological Field Station, 17 Lake Street, Oswego, New York 13126. **ZOOPLANKTIVORY BY ALEWIVES IN LAKE ONTARIO: SEASONAL, SPATIAL, AND AGE SPECIFIC PATTERNS.**

Our objective was to examine the food habits of alewives, *Alosa pseudoharengus*, in the southern waters of Lake Ontario after (1988) the invasion of the exotic cladoceran, *Bythotrephes cederstroemi*. *Bythotrephes* was important in the stomach contents of alewives (>90 mm total length) at all depths where alewives were collected. Typically, tail spines were the only body part of *Bythotrephes* found in alewife stomachs. Adult alewives (>107.5 mm) ate mostly microzooplankton (numbers and biomass) when the lake was thermally stratified, but during the spring and fall when waters were homothermous or weakly stratified, alewives supplemented their diet of zooplankton with *Mysis relicta* and amphipods. Because of the strong dependence of alewives on microzooplankton for food in Lake Ontario, we conclude that any changes in the production of microzooplankton will affect both the alewife community and the salmonine population it supports.

BRANDT, Stephen B., MASON, Doran M., and Goyke, Andrew P., University of Maryland System, Chesapeake Biological Laboratory, Solomons, MD 20688-0038, **Trophic Supply and Demand in Lake Ontario: System Perspectives.**

Fish production and, ultimately, yield are governed by the laws of trophic supply and demand (Ney 1990). The relationship between the availability of prey resources (supply) and the amount of prey a particular predator needs to consume (demand) will determine the extent to which the biomass and production of fishes is limited by the food supply and the extent to which the predators can exert control over lower trophic levels. Supply and demand are difficult parameters to quantify, but recent developments in bioacoustics and bioenergetics have significantly advanced our ability to measure prey abundance and predator energetic requirements. Our research is designed to assess the supply and demand of the pelagic piscivores and planktivores in the Great Lakes and to define their interrelationships with lower trophic levels. For each trophic level we combine high-resolution spatial data on prey abundances and sizes, water temperature, and the physiological requirements of the predator to produce detailed cross-lake maps of predator growth potentials. Such spatial compartmentalization of predator-prey models allows us to evaluate how spatial changes in thermal structure, prey distributions and predator behavior will affect predator production.

GOYKE, Andrew P., BRANDT, Stephen B., and MASON, Doran M., (University of Maryland System, Chesapeake Biological Laboratory, Solomons, MD 20688-0038) **Trophic Supply and Demand in Lake Ontario: Distribution and Abundance of Pelagic Planktivores.**

We used a 120 kHz acoustic system to measure the abundance and distribution of pelagic planktivores in Lake Ontario during the summer and fall of 1990. Fish density (number$\cdot m^{-3}$) was determined using echo integration, whereas size of fish (mm) was determined using dual-beam analyses. Since interpretation of acoustic information depends on the scale of observation, fish density was partitioned into 1m depth bins and less than 80m horizontal bins during processing to examine fine-scale changes in distribution. To determine the temporal changes in fish distribution, patterns were compared on hourly, daily, monthly, and seasonal basis. Preliminary partitioning of echoes to species (either alewife, Alosa pseudoherangus, or rainbow smelt, Osmerus mordax) was based on fish catches in aimed midwater trawls. The distribution of planktivores was dynamic on both temporal and spatial scales, and was closely related to the thermal structure of the lake. Acoustical measures of fish abundance and distribution were used for high-resolution compartmentalization of supply-demand assessment.

MASON, Doran M., BRANDT, Stephen B., GOYKE, Andrew, PATRICK, Vincent, (University of Maryland System, Chesapeake Biological Laboratory, Solomons MD 20688-0038), and SPRULES, W.G., (Erindale College, Dept. of Zoology, 3359 Mississauga Rd., Mississauga, Ontario, Canada L5L 1C6).
Trophic Supply and Demand in Lake Ontario: The Zooplankton - Planktivore Linkage.

Quantitative spatial distribution of pelagic fishes can be accurately mapped with acoustics. However, this does little to increase our understanding of the processes governing the observed distributions. In an attempt to understand the regulating mechanisms, we integrated food supply, thermal habitat and physiological rates of the planktivores into one unifying theme, supply and demand. We used bioenergetic simulations of alewife to determine planktivore demand and an optical plankton counter to determine zooplankton abundance and distribution (supply). Demand and supply were combined to generate a detailed cross-lake map of the potential growth field for planktivores. The predicted potential growth field varied in response to both the thermal habitat occupied and the spatially variable prey distribution. The greatest planktivore concentrations were assumed to occur in the regions of greatest potential growth. The predicted planktivore distribution was then compared to that observed acoustically from the field. To evaluate the potential intensity of the predator-prey interaction, we used field measured distribution of planktivores and expanded the individual demand to the population. The ratio of demand to supply was used as an index of the intensity of the interaction.

BRANDT, Stephen B., MASON, Doran M., GOYKE, Andrew P., PATRICK, E. Vincent, (University of Maryland System, Chesapeake Biological Laboratory, Solomons, MD 20688-00380 and STEWART, Donald J. (State Univ. of New York, CESF, Syracuse, NY 13120).
Trophic Supply and Demand in Lake Ontario: The Planktivore - Piscivore Linkage.

We generated detailed cross-lake maps of piscivore (salmonine) growth potential based on bioenergetic simulations of field measures of piscivore diets, thermal structure and prey availability. Prey availability was estimated with high spatial resolution acoustic measures of planktivore abundances and sizes. Prey availability was spatially complex and changed dielly and seasonally, producing a spatially variable field of piscivore growth potential. Estimates of piscivore production were dependent on whether piscivores were assumed to be occupying preferred temperatures, foraging optimally or exhibiting other types of behavior. Overall, fine-scale compartmentalization of predator-prey interactions demonstrates that the spatial linkages of prey abundances, thermal structure and predator behavior can significantly affect lakewide piscivore production and may partially explain the apparent dichotomy in the predator-prey production ratios of Lake Michigan and Lake Ontario.

RAND, Peter, STEWART, Donald [SUNY-CESF, Syracuse, NY, 13210; and SUNY College at Oswego, Oswego, NY 13126], SEELBACH, Paul [Michigan DNR, Ann Arbor, MI 48109], JONES, Mike [Ontario MNR, Maple, ONT L6A 1S9], WEDGE, Les [New York DEC, Cortland, NY 13045].
MODELING STEELHEAD TROUT ENERGETICS IN LAKES MICHIGAN AND ONTARIO

We synthesized available data on physiology and life history characteristics of the steelhead trout (*Onchorynchus mykiss*) in Lakes Michigan and Ontario to construct a bioenergetics model to estimate lake-wide production and prey consumption. We analyzed diet data for sport-caught steelhead from western Lake Michigan (1982-88), southeastern Lake Michigan (1973-82), and New York waters of Lake Ontario (1983-88). We derived life history parameters for wild steelhead in Lake Michigan from data on the Little Manistee River population in northern Michigan, and from NYDEC creel-census data for Lake Ontario. A size-dependent relationship for survival was applied to historical steelhead stocking data to estimate "smolt-equivalents". From an analysis of 571 scales from sport-caught steelhead in Lake Michigan, estimates of the percentage of stocked fish increased from 65% in 1985 to 85% in 1990, reflecting improvements in stocking procedures. Estimates will be presented for lake-wide production and prey consumption by wild and hatchery-reared steelhead trout derived from simulations for both lakes.

STEWART, Donald, RAND, Peter [SUNY-CESF, Syracuse, NY, 13210; and SUNY College at Oswego, Oswego, NY 13126], BRANDT, Stephen [Univ. Maryland, CBL, Solomons, MD 20688], AND HAYNES, Jim [SUNY College at Brockport, Brockport, NY 14420].
DYNAMICS OF SALMONINE PREDATION IN NEW YORK WATERS OF LAKE ONTARIO.

We examined stomach contents of 5,800 sport-caught salmonine fishes from New York waters of Lake Ontario form 1983-88 and compared these to similar samples from Lake Michigan. Average weight, condition, and stomach fullness were also evaluated as indices of feeding success. For example, average weight of fall-caught chinook salmon in Lake Ontario remained stable over the study period and was almost double that of sport-caught chinooks from Lake Michigan during the same years. In contrast, condition of chinooks in both lakes appeared to vary among years in parallel, perhaps reflecting prey-fish dynamics. Throughout, alewives dominated diets in both lakes with rainbow smelt of secondary importance. We report on interannual, seasonal and geographic trends in these parameters for chinook, coho, lake trout and brown trout, and extend the analyses to preliminary modeling estimates of lake-wide salmonine predation.

LANTRY, Brian, AND STEWART, Donald [State University of New York CESF, Syracuse, NY 13210; and SUNY College at Oswego, Oswego, NY 13126].
ECOLOGICAL ENERGETICS OF RAINBOW SMELT IN THE LAURENTIAN GREAT LAKES.

We developed a bioenergetics model for rainbow smelt (*Osmerus mordax*) to evaluate their predation and production dynamics in the Great Lakes. This model is based on new field observations on temporal and spatial patterns of abundance, diet, energy density cycles, and laboratory estimates of weight and temperature dependence of routine metabolism. A literature synthesis provided necessary estimates of growth, mortality, fecundity, evacuation rate, temperature preference, prey energy density, and egestion. Modeling results for the Lake Michigan population indicate that for a population biomass of 34,700 t of smelt (Aug. 1987 estimate), total annual gross production was 53,100 t (= 0.94 g/m^2; P:B ratio = 1.53). Total annual consumption of all prey types was 293,400 t, giving a gross conversion efficiency of about 17% for wet biomass. Modeling comparisons are developed between smelt populations in Lakes Michigan and Ontario.

CHRISTIE, W.J. R.R. #4, Picton Ontario, K0K 2T0.
Thoughts about past events and future prospects for the biotic system of Lake Ontario.

Two perspectives have been published on the ecological history of Lake Ontario. One argues that the system has been so damaged that fish yields can only be maintained through extensive management interventions. The other is more optimistic about the naturalistic resilience of the ecosystem, and offers the possibility of return to something like former equilibrium conditions, after relaxation of the major cultural stresses. These interpretations lead to different water quality and fishery management strategies, and more important, affect development of aggregated measures of ecosystem health needed to evaluate progress towards Sustainable Development. The longterm sequence of fish community changes is used to illustrate the discussion of the emergence, and consequences of this dichotomy.

FISH AND FISHERIES ECOLOGY IN THE GREAT LAKES

Convenor: James Haynes

Session 2D - Tuesday, June 4, 1991
8:30 AM - 12:00 PM

14 Knox Hall

BRETT, Betty Lou, Nazareth College of Rochester and S.U.N.Y. Brockport

Low Genetic Variability in Great Lakes Species of Fish

Evidence suggests that fish which inhabit previously glaciated areas have extremely low levels of genetic variability. Populations of *Etheostoma, Rhinichthys, Micropterus* and *Stizostedion* from the Great Lakes are compared with fish from non-glaciated areas. The neutral theory predicts that random mutations with no selective effect can be incorporated into the genome, however, northern populations of vertebrates have undergone 3-6 thousand generations without incorporating significant genetic changes into the genome. These low levels can in part be explained by low numbers of founders after the glacial retreat and possibly by stabilizing selection. However, the low levels of heterozygosity, that are found in the Great Lakes drainages cannot be explained within the context of the neutral theory. Other studies show that heavy metals present in streams also reduce the genetic variability of the fish populations. The implications of low heterozygosity to fisheries management is profound as populations with little or no genetic variation may be more susceptible to disease or extinction from pond culture, environmental changes or pollution.

DEXTER, PATRICIA A., WERNER, ROBERT G. [State University of New York - CESF Syracuse, NY 13210]. ENERGETICS OF LARVAL RAINBOW SMELT.

Rainbow smelt (*Osmerus mordax*) is the only species of fish in the Laurentian Great Lakes that is presently a dominant component of the fish community in all five lakes. In the Great Lakes, they have shown wide oscillations in abundance that may be related in part to variation in survival/recruitment of early life history stages.

Routine metabolism, a critical component of an energy budget, was estimated for the average individual rainbow smelt larvae from measurements of oxygen consumption in closed respirometry chambers. We conducted experiments at 8, 12, and 16°C representing the range of temperatures normally experienced by larval smelt in the Great Lakes. The values for larval smelt metabolism were 21.8, 36.1, and 49.5 cal · g wet $wt^{-1} \cdot d^{-1}$ at 8, 12, and 16°C, respectively. The Q_{10} for metabolic rate in larvae was 2.8, a value noticeably higher than that for adult smelt, but similar to that of many other larval fishes. Average metabolism of first-feeding larvae is also much lower than would be predicted from back-projection of the metabolism-weight relationship for adult smelt. We use these metabolic observations together with other available information to analyze larval smelt energetics, providing an improved, quantitative perspective on mechanisms possibly influencing population dynamics of these fishes.

MUNKITTRICK, K.R., GLLFAS, Dept. of Fisheries & Oceans, Burlington, Ontario L7R 4A6; G.J. VAN DER KRAAK, Dept. of Zoology, University of Guelph, Ontario N1G 2W1; M.E. McMASTER, Dept. of Biology, University of Waterloo, Ontario N2L 3G1; and C. PORTT, C. Portt & Associates, Guelph, Ontario N1H 3H5. **Impacts of secondary treatment and mill shutdown on mitigating impacts of bleached kraft mill effluent on MFO activity and serum steroids in fish.**

Up until the initiation of secondary treatment in September of 1989, Jackfish Bay, Lake Superior, had received the primary-treated effluent from a bleached kraft pulp mill (BKME) for several decades. August 1990 collections found similar MFO activity as during August 1988 and 1989, despite the initiation of secondary treatment. However, samples collected two weeks after a planned mill maintenance shutdown during September 1990 showed no EROD induction in longnose sucker, and a reduced impact zone for lake whitefish. Secondary treatment has been successful at removing problems associated with BOD, suspended solids, temperature and acute fish lethality, but secondary treatment has not been successful in eliminating BKME impacts on MFO activity and serum steroids in white sucker, lake whitefish or longnose sucker living in Lake Superior. The short duration of MFO induction after mill shutdown indicates that changes are not related to contamination by dioxin-like compounds, and that the persistence of EROD induction in these species is not related to food chain contamination. Impacts on steroid levels persisted during September, suggesting that the absence of EROD induction was not due to migration of new fish into the area, that steroid changes are more sensitive and persistent than MFO induction, and that steroid reductions and MFO induction are not causally related.

SAVITZ, J., L.G. Bardygula, and A. Feldman. Biology Department, Loyola University of Chicago, 6525 N. Sheridan Road, Chicago, Illinois 60626. Bases for Prey Fish Species Selection by Chinook Salmon, Coho Salmon, and Lake Trout.

We examined foraging behavior by three salmonid predators, chinook salmon, coho salmon, and lake trout, on various prey species under laboratory conditions. Salmonids were introduced to two and three prey species in varying proportions in order to determine which of the prey species was preferred by the predators. Coho salmon were introduced to bloaters and yellow perch. They chose bloaters to yellow perch. Lake trout were allowed to forage on species combinations which included alewives, bloaters, and yellow perch. Lake trout foraged on alewives in preference to the other species. Alewives generally remained in the pelagic and could easily be attacked.

AULTMAN, D.C. & HAYNES, J.M., SUNY College at Brockport, Biological Sciences, Brockport, New York 14420. **Salmonine Catches in Lake Ontario are Higher at Thermal Fronts in the Spring: Experimental Verification.**

Haynes et al. (1986) hypothesized that radiotagged rainbow trout (***Oncorhynchus mykiss***) moved offshore in Lake Ontario with thermal fronts in spring and early summer. In 1990 we tested this hypothesis for salmonines generally by comparing catches in non-frontal waters and three types of fronts (thermal bar, 4 C; spring thermocline, 6-8 C; thermal break, ≥ 9 C). A thermal front in the spring on Lake Ontario is a rapid temperature cline across the surface of the lake (> 0.15 C/min at standard trolling speed) parallel to shore that extends obliquely toward shore and the bottom. Surface temperature was recorded every 2 min during 44 hours of experimental fishing. Only 20% of the time was spent fishing thermal fronts where 35% of the 88 fish were caught. CPUE at thermal fronts was significantly greater than non-frontal CPUE on all 11 sampling dates ($p < 0.001$). The data suggests that CPUE is greater for warmer thermal fronts (thermal break CPUE > spring thermocline CPUE > thermal bar CPUE; $p = 0.09$) and that there is a relationship between species distributions and thermal fronts. Relative to non-thermal water, coho salmon CPUE was higher in the spring thermocline ($p < 0.05$); rainbow trout and lake trout CPUE's were higher in thermal breaks ($p < 0.05$). For species where comparisons were nonsignificant, the trend was for thermal CPUE's to exceed non-thermal CPUE's. It appears that anglers can effectively target salmonine catches by fishing specific thermal structures. These results likely are applicable to other pelagic habitats utilized by salmonines.

SAVITZ, J. and L.G. Bardygula. Biology Department, Loyola University of Chicago, 6525 N. Sheridan Road, Chicago, Illinois 60626. Homing of Salmonids to Illinois Harbors: Influence of Caging Parred Salmon.

The purpose was to enhance the homing of chinook and coho salmon to the harbors where they were stocked along the Illinois shoreline of Lake Michigan. It was hope that these enhanced returns would provide the basis for the development of a fall salmonid fishery. The basic design of the study was to place parred fish in cages and release them after they had smolted and imprinted the odors of the harbors. Fish were sampled by D.C. electrofishing during the fall months of 1988, 1989, and 1990. Homing generally occurred among caged and non-caged control salmon. The low returns of salmon in the fall months were probably caused by the small number of surviving salmon.

MANDRAK, N.E. and CROSSMAN, E.J. Department of Ichthyology and Herpetology, Royal Ontario Museum, Toronto, Ontario M5S 2C6.

A Review of Introduced Fishes in the Canadian Waters of the Great Lakes.

The introduction of 39 species and two hybrids into the Canadian waters of the Great Lakes has been documented. Twenty-two of these 41 introductions have established self-reproducing populations. The intentional introduction of 12 species and two hybrids has been authorized. Three vectors are responsible for the unintentional introduction of 25 species. Nine have naturally expanded their ranges into the Canadian waters of lakes Erie, St. Clair and Huron. Eleven species have been introduced as a consequence of man's activities: six of these artificially invasive species have expanded their ranges as a result of canal building; and, five species have become established by accidental release and subsequent expansion of range. Ballast water is responsible for the introduction of three foreign species, and extending the ranges of two native species. Five species have been introduced as a result of release from aquaria, and two species exhibit disjunct range extensions that may have resulted from bait-bucket transfer.

JAMES A. RECKAHN, ONTARIO MINISTRY OF NATURAL RESOURCES, FISHERIES BRANCH, RESEARCH SECTION, P.O. BOX 5000, MAPLE, ONTARIO L6A 1S9

VERIFICATION OF INDEX FISHING AS AN ACCURATE MEASURE OF YEAR-CLASS STRENGTH FOR LAKE WHITEFISH *Coregonus clupeaformis*.

This paper describes calibration of sampling gear and sampling designs used to measure changes in year-class strength of lake whitefish *Coregonus clupeaformis* in a small bay (7320 ha) in northern Lake Huron. Tag:recapture population estimates of adult male whitefish were used as final measures of actual abundance against which to compare catch/unit effort (CUE) indices of relative abundance obtained at several life history stages (larval, fingerling, juvenile, and adult). An "index" approach to obtaining CUE estimates was used. Index fishing is defined as a deliberately biased two stage sampling approach where, after the initial, first stage of completely randomized sampling efforts demonstrated where and when the target species life history stage could consistently be sampled, then in the second stage, only those few productive strata were sampled repeatedly. A large array of unproductive sampling sites were excluded. The concept is based on the fact that fish and their preferred habitats are non-randomly distributed in clumped or contagious distributions both spatially, bathymetrically, and temporally.

BUCHANAN, IAN D. Ontario Ministry of Natural Resources, 10401 Dufferin Street, Box 7400, Maple, Ontario, Canada L6A 1S9. Lake Ontario, Toronto Waterfront Fish Community and Habitat Assessment 1989.

As part of the Toronto Waterfront Remedial Action Plan a fisheries community and habitat survey was conducted in 1989. Fish community dynamics including biological integrity, presence, absence, abundance, reproductive success and species interactions were investigated. Critical habitats were mapped, and the significance of physical habitat was identified. This study provides data which indicates that physical habitat rehabilitation in conjunction with water quality initiatives will provide an optimal cohabilitative strategy for this sensitive area.

LAKE LEVELS AND COASTAL STABILITY: GEOLOGIC IMPLICATIONS AND HISTORICAL PERSPECTIVES

Convenors: Peter Barnes, Eric Remnitz, and Michael Chrzastowski

Session 2E - Tuesday, June 4
10:30 AM - 12:10 PM

Session 3E - Tuesday, June 4
1:40 - 5:00 PM

4 Knox Hall

Foster, D.S., and Colman, S.M., U.S. Geological Survey, Woods Hole, MA 02543. **THE CHIPPEWA LOW-LAKE PHASE AND THE PRE-NIPISSING TRANSGRESSION OF LAKE MICHIGAN: EVIDENCE FROM HIGH-RESOLUTION SEISMIC STRATIGRAPHY**

Seismic-reflection profiles collected in the southern two-thirds of Lake Michigan show a basinwide seismic reflector within lacustrine sediments. This reflector is time-transgressive and represents the extreme low-lake level of the Chippewa phase (10 ka) and the subsequent Chippewa-Nipissing transgression (10-5 ka). A conformable horizon in the deep basins, which correlates with a gradational change from red glaciolacustrine to gray postglacial clay, is equivalent to the erosional surface of the Chippewa unconformity. The planar character of the reflector and the absence of erosional channels at the unconformity suggest that erosion occurred subaqueously during the Chippewa-Nipissing transgression. Most strandline and relict nearshore features, as well as preexisting regressive and subaerial features, were apparently destroyed during the transgression. Paleochannels, beach deposits, wave-cut scarps, and other relict nearshore features occur locally at a variety of depths and cannot be mapped at the spacing of our seismic profiles. Strandline deposits of the maximum Chippewa lowstand are generally not preserved. Instead, cores show that a sand, pebble, and shell layer only a few centimeters thick occurs immediately above the Chippewa unconformity. Seismic profiles show a lenslike unit locally within postglacial deposits, between 42 and 94 m below present lake level, just above the Chippewa unconformity. The upper surface of the unit appears to mark a facies change from relatively high-energy to low-energy deposition, which occurred as lake level rose to the Nipissing high stage. The maximum lowstand of the Chippewa low stage may be derived from the maximum depth of the Chippewa unconformity and an assumed depth of wave base, but the latter assumption creates large uncertainties. We have been unable to map the shorelines of the Chippewa and later lake stages because of the poorly preserved strandline features and subsequent isostatic deformation.

THOMPSON, Todd A., Ind. Geol. Survey, Bloomington, IN 47405, **LAKE-LEVEL BEHAVIOR DURING THE PAST 4,000 YEARS IN THE SOUTHERN PART OF THE LAKE MICHIGAN BASIN**

The historic record is the primary source of information on modern lake levels throughout the Great Lakes. Although it can be semi-quantitatively extended into the late 1700's, the historic record is too short to recognize long-term patterns of lake-level behavior. To extend the historic record, information must be obtained from the Great Lakes's geologic record. Such information includes the altitude and age of geomorphic features and stratigraphic sequences. One of the longest records of lake-level variation is preserved in a beach ridge complex along the southern shore of Lake Michigan. This strandplain contains more than 150 beach ridges that arc across northwestern Indiana and fan out into northeastern Illinois. The ridges were formed during the fall from high stands in lake level, and the altitudes of their foreshore deposits provide information on the upper physical limit of lake level over the past 4,000 years. An increase in the rate of shoreline progradation from east to west across Indiana's shoreline causes differential preservation of lake-level fluctuations. That is, groups of 4 to 6 ridges in the western part of the strandplain that formed in response to small-scale fluctuations combine eastward into single ridges and groups of ridges representing larger-scale fluctuations. Three scales of quasi-periodic lake-level variation were determined by radiocarbon dating basal peats of wetlands between the ridges and by measuring the altitude of foreshore (swash) deposits within ridges: (1) a short-term and small-scale fluctuation of 25 to 30 years with a range of about 0.5 m; (2) an intermediate-term and meso-scale fluctuation of 150 to 160 years and a range of about 1 m; and (3) a long-term and large-scale fluctuation of about 600 years and a range of 2 to 4 m. The short-term and intermediate-term fluctuations are reflected in the historic record.

JIBSON, RANDALL W., and STAUDE, JOHN-MARK, U.S. Geological Survey, Box 25046, MS 966, Denver Federal Center, Denver, Colorado 80225

Rates of bluff recession along the Lake Michigan shoreline in Illinois

Using airphotos and maps, we measured bluff-top retreat at 300 locations along 30 km of shoreline from Wilmette to Waukegan, Ill. Over two time periods, 1872 to 1937 and 1937 to 1987, rates of retreat varied from 10 to 75 cm/yr between discrete segments of bluffs (defined by lithology) and between the two time periods for a given bluff segment. The average rate for the entire area, however, did not vary significantly between the two time periods and was approximately 20 to 25 cm/yr. Mean and maximum lake levels and rainfall for the two periods did not vary significantly, so local temporal variations in retreat rate cannot be attributed to these factors. Beach width and groin construction did vary between time periods but showed no effect on retreat rates. Local rate variations correlate closely with variations in the lithology of the glacial materials exposed in the bluff, which consist of clay tills and outwash silts, sands, and gravels. However, both the temporally constant regional retreat rates in the area and the regular shape of the local shoreline indicate that a uniform rate of retreat prevailed and that local variations in retreat rates balance out through time to produce long-term parallel bluff retreat in the area.

JOHNSON, Beth L., and JOHNSTON, Carol A., Natural Resources Research Institute, University of Minnesota, Duluth, MN 55812. **COASTAL EROSION IN RELATION TO GEOLOGY IN THE WESTERN END OF LAKE SUPERIOR.**

Recession rates for the Lake Superior shoreline in Wisconsin and Minnesota were compared by geologic type. Recession measurements were obtained from previous studies that used historical aerial photos taken in the 1930s and 1960s, and geologic types were determined from Pleistocene geology maps and field verification. Average shoreline erosion rates for clay deposits (glacio-lacustrine clays and clay tills) were 3.5 times higher in Wisconsin (0.52 m/yr) than in Minnesota (0.15 m/yr). Coastal sand and gravel deposits eroded at comparable rates in both Wisconsin (0.14 m/yr) and Minnesota (0.16 m/yr). Peat deposits along the Wisconsin shoreline eroded faster than any other geologic type, 4.48 m/yr. Peat deposits along the Minnesota shoreline were protected by sand bars, and were not eroding. The higher erosion rates for the Wisconsin shoreline are probably due to the lack of bedrock headlands, which protect much of the Minnesota coast.

HUNTER, Ralph E., Reiss, Thomas E., and Chin, John L., U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025, **COASTAL DEPOSITIONAL AND EROSIONAL EFFECTS OF 1985-1987 HIGH WATER LEVELS IN LAKE MICHIGAN**

Beach ridges and scarps that formed during storms accompanying the 1985-87 period of near-record-high lake levels were surveyed and trenched at 17 sites in areas of long-term deposition around Lake Michigan. Beach ridges were formed where the beach was backed by low, flat land or where the beach material was gravel, whereas scarps were formed where the beach was backed by a bluff or high dune ridge. The beach ridge crests and scarp bases were, respectively, 0.5-2.4 m and 0.2-1.2 m higher than the highest monthly level reached by the lake during the 1985-87 period (177.28 m above IGLD in October, 1986, compared to the 1860-1986 mean of 176.42 m). The elevations of the beach-ridge crests are probably close to the elevations of wave runup at the time of beach-ridge formation. Variations in crest elevation can be explained by variations in storm-wave height around the lake.

BURMEISTER, Jeffrey A.V., JOHNSTON, Carol A., BONDE, John P., University of Minnesota-Duluth, Duluth MN 55812, USA. **EFFECTS OF WAVE ENERGY ON COASTAL RECESSION.**

This is part of a three year ongoing project to study soil erosion hazards on the Minnesota North shore of Lake Superior. This section of the project evaluates the effect of wave action on shoreline recession rates. The annual erosion rates for a given site were compared to the wave run-up (energy), as computed using the U.S. Army Corps of Engineers' Wave Run-up program. This application uses a variation of the JONSWAP equation to compute the energy of a wave. This is the translated into the height above the undisturbed water level. Preliminary results indicate an inverse relationship between annual erosion rates and wave run-up. This is due to the loss of energy through wave overtopping as a wave reaches shallow water with a low nearshore slope (ie. beach). Waves do not lose energy as rapidly in areas having steep nearshore slopes (ie. cliffs), and thus have higher run-ups.

Folger, D. W., Maizlish, L. M., Polloni, C. F., Foster, D. S., Brown, C. L., Seekins, B. A., U.S. Geological Survey, Woods Hole, MA 02543, **BOTTOM SEDIMENT TEXTURE DETERMINED WITH SIDESCAN SONAR, SOUTHERN LAKE MICHIGAN**

An attempt to map the complex distribution of bottom sediment along the Illinois and Indiana shoreline with 20 widely spaced (5-10 km) sidescan sonar profiles, limited samples, and a few direct observations outlined the predominant surficial sediment types. Detailed variations, however, could be mapped only in areas where sidescan sonar lines were closely spaced (100-150 m) and mosaics could be constructed. Between Waukegan, IL and Indiana Harbor, IN and from 1 to 2 km to about 15 km offshore, little net deposition is taking place; the bottom is, for the most part, floored by gravelly sand, sandy gravel, and exposed till. Gravel, cobbles, and boulders occur as lag deposits over till. North of Waukegan and east of Indiana Shoals, finer textured sediment, mainly silty sand, (in part the Lake Michigan Fm.) has accumulated. South of Waukegan, a discontinuous ribbon of sand about 1 km wide thins from the shore lakeward to a patchy veneer. A sidescan sonar mosaic of the Indiana Shoals area shows that sediment texture varies over short distances in patterns that apparently are unrelated to bathymetry. Strong acoustic reflections on the sonar images are produced by coarse sand, gravel, and cobbles in fields of megaripples that appear to form during winter storms and are stable the rest of the year. The southwestern Lake Michigan nearshore area is a dynamic environment; storm-driven currents transport sediment that periodically covers and uncovers the till-gravel pavement. It is, therefore, likely that detailed maps of bottom-sediment texture will differ significantly from year to year.

BOOTH, James S., and WINTERS, William J., U.S. Geological Survey, Woods Hole, MA 02543
Possible Wave-Induced Changes in Lake Michigan Nearshore Lakebed Properties, Illinois Beach State Park

The fortuitous interruption of sampling activity by a summer storm provided an opportunity to examine the effects of storm waves on lakebed morphology, near-surface sediment density, and penetration resistance in a nearshore zone off Illinois Beach State Park. Special sampling equipment and methods to measure in-situ density, and an in-situ penetrometer were used by SCUBA divers on two, shore-normal sampling transects consisting of stations at 4, 6, 8, and 10 m water depths. The transects were spaced about 200 m apart. Collection of the data from the three shallower stations of each transect was separated by the storm, which generated waves having heights up to 2 m and periods of about 7 s. Within the study area, the bathymetric contours are generally smooth, evenly-spaced, and shore-parallel, whereas the sediment grain size gradually decreases offshore from fine sand at 4 m water depth to very fine sand at a depth of 10 m.

Ripples, not present in the sand during the pre-storm sampling, were present on the post-storm lakebed. Moreover, preliminary results suggest that the thickness of the sand lens in the innermost part of the study area may have been slightly reduced: the in-situ penetrometer encountered a much more resistant lakebed beneath the shallower two stations after the storm. The relative density of the uppermost sediment at the 4-m station was considerably reduced after the storm, suggesting that wave-generated oscillatory currents (bottom velocities > 100 cm/sec) may have, whether or not there was net erosion, entrained or otherwise reworked the sand to a depth of 10 cm or more. This looser, more porous lakebed may be more susceptible to erosion than the pre-storm bed. Experimental studies using an oscillatory water tunnel are underway to determine if the density of the sand influences its susceptibility to changes by wave-induced currents.

KEMPEMA, E.W., University of Washington, School of Oceanography, Seattle, WA, 98195; and Haines, J.W., U.S. Geological Survey, St. Petersburg, FL 33701. **SEDIMENT TRANSPORT BY ANCHOR ICE IN SOUTHERN LAKE MICHIGAN**

Part of a federal - state cooperative program on southern Lake Michigan coastal erosion studied the influence of ice at Gillson Beach, Illinois during January 1991. One aspect of this study focused on the potential of anchor ice to enhance sediment transport using meteorological data and diver surveys. Ice attached or anchored to the lake bed formed underwater during cold nights with low wave energy conditions. Morning wading and diver surveys showed widespread evidence of anchor ice formation from the outer edge of the nearshore ice complex to several hundred meters offshore. Anchor ice consisted of individual ice crystals attached to the lake bed or of platy masses of ice crystals that covered up to several square meters of the bottom. Anchor ice crystals were about one millimeter thick but averaged 50 to 100 mm in diameter (max. 400 mm). Anchor ice was found attached to a variety of substrates, including sand, gravel, and boulders in a glacial till. On mornings following its formation, anchor ice, often with pieces of attached substrate, rose to the surface and was advected offshore and alongshore. Comparison of the ice samples to water samples collected at the same time show that the anchor ice had substantially higher sediment concentrations with a larger mean grain size. The formation and release of anchor ice provides a vehicle for suspension and transport of bottom sediments during periods when hydraulic conditions limit water-borne sediment transport.

REIMNITZ, Erk , BARNES, Peter W. , and MCCORMICK, Michael, U.S. Geological Survey, 345 Middlefield Road (MS-999), Menlo Park, CA 94025, **OFFSHORE ICE TRANSPORT OF COASTAL SEDIMENT IN LAKE MICHIGAN**

Measurements of sediment content in drifting coastal ice, in combination with aerial observations, shipboard ice sampling, and study of LANDSAT images, show that ice rafting of sand is an important mechanism of coastal erosion and sedimentation in southern Lake Michigan. During winter, the central part of the lake generally remains open, while coastal, sand-charged ice is displaced lakeward from the west shore in long, sinuous bands by offshore winds. Under some conditions, these ice streamers are dissipated within 2 to 20 km from the coast. The existence of such streamers during offshore collection of ice-rafted sand and gravel demonstrated a net loss of beach sand from the windward shore to deep water. Under other conditions, ice streamers can cross the entire lake, leading to ice accumulations on the southeast, downwind shore. Northwesterly winds dominate winter weather, and so accumulations of floating ice form mainly at the southeast end of the lake, where they ultimately melt. Thus, ice rafting may be partly responsible for net sediment accretion along this downwind shore during the past few thousand years, and it clearly is responsible for the sprinkling of coarse clasts found in deep basin mud.

REINHARD, R. D., DRIVER, D. B., and HUBERTZ, J. M.
USAE Waterways Experiment Station
Coastal Engineering Research Center
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Cross-shore Wave Energy Flux and Persistence as Related to Erosion on the Southern Shore of Lake Michigan

The Wave Information Study at the U. S. Army Engineer Waterways Experiment Station's Coastal Engineering Research Center has completed a 32 year hindcast of wind and wave conditions on the Great Lakes. The goal of the study was to provide an accurate representation of the climatology of winds and waves over the lakes. Directional wave spectra, as well as wind speed and direction, are available every three hours for the period 1956-1987 at stations 10 miles apart along both United States and Canadian shorelines and selected midlake locations. Hindcast results were verified against data from eight buoys. Biases in wave height and peak period were approximately zero. Root mean square errors were less than 0.5 meters and 1.2 seconds, respectively. Results are summarized in reports for each lake and are available from a database. Procedures used to produce this information are discussed and an example application as related to erosion on southern Lake Michigan is presented. The mean monthly energy flux toward shore is calculated at nine stations along the southern Lake Michigan shore. Wave persistence for storm conditions is also calculated at these stations. These parameters are then related to the potential for erosion due to wave energy in this location.

WOOD, William L., Great Lakes Coastal Research Laboratory, School of Civil Engineering, Purdue University, West Lafayette, IN 47907.
MODELING BEACH AND NEARSHORE PROFILE RESPONSE TO LAKE LEVEL CHANGE

Results of this study have shown that the nearshore profile form found by Dean(1977) $h(x) = Ax^m$, is appropriate for use in describing the "average" or characteristic nearshore profile found on the Great Lakes. Results fail to support the argument that the shape factor A is dependent on mean sediment size, as suggested by Moore(1982). Response of nearshore profiles to an equilibrium profile form is much longer than the time scale of mean annual water level change. These results are similar to those of Hands(1980) in as much as the profile response appears to be "out-of-phase" or lagging behind that of water level change. Significant profile response to lake level variation could only be established for "inner sections" of the total profile(depth less than 2m). At greater depths no significant relation could be established between lake level change and profile response. The effect of falling water level on nearshore profile adjustment could not be determined due to the slower than expected response of the profiles. Application of the equilibrium concept through a modified version of Dean's(1983) shoreline extension model shows good agreement between predicted and observed shoreline positions.

Terpstra, P.D., and Chrzastowski, M.J., Illinois State Geological Survey, 615 E. Peabody Drive, Champaign, IL 61820; **SUMMARY OF LAKE BOTTOM CHANGES AT NORTH POINT MARINA VICINITY BETWEEN 1988 AND 1990.**

Lake-bottom changes near North Point Marina on the Illinois Lake Michigan shore have been mapped for the first two years following marina construction. Overall, the area shows net accretion updrift of the marina and in the marina entrance, and net erosion downdrift of the marina for at least 1.2 km. In the first year (1988-1989), a fan delta of dredged sand and gravel was the source of accreted sediments. Estimated net accretion of 100,000 m^3 occurred that year, most of it downdrift from the fan delta and in the marina-entrance area. The updrift area had no significant accumulation. The following year saw a reversal of these trends. Much of the accumulated sediment in the downdrift area was removed by littoral transport. Updrift, 20,000 m^3 of accretion formed as an outer bar extending from the Illinois-Wisconsin state line to the distal end of the north breakwater. This bar terminates as a submerged spit extending into the marina entrance, indicating that littoral sediment from Wisconsin is bypassing the north breakwater. Possibly, bidirectional currents through the marina entrance are influential in transferring sediment from the submerged spit to an accretionary wedge along the south breakwater, maintaining the continuity of the littoral-transport stream.

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SEDIMENT ENTRAPMENT BY COASTAL STRUCTURES ALONG THE ILLINOIS SHORE OF LAKE MICHIGAN

Sand diversion and entrapment by harbors and lakefills are acknowledged to be important causes for depletion of the littoral stream sands along the Illinois shore of Lake Michigan north of Chicago. Until now estimates of material trapped as sand fillets by structural barriers has been based mainly on maps and air photos. Only a small amount of core or drill data, necessary for detailed estimates, is available.

In a preliminary survey sponsored by Illinois/Indiana Sea Grant and Northeastern Illinois University, beach and lake bottom sands adjacent to structural barriers were measured using a hydraulic probe. Locations include Waukegan Harbor, Great Lakes Naval Training Center, Forest Park Beach in Lake Forest, Highland Park Waterworks, Winnetka Waterworks, Wilmette Harbor and Northwestern University Lakefill.

Results show the Waukegan Harbor sand fillet to contain more than 6,000,000 cubic yards of sand. Substantially lesser amounts were found at the remaining barriers, all of which are downdrift from Waukegan Harbor.

JOHNSON,Charles N, US Army Corps of Engineers, Chicago, IL. MITIGATION OF HARBOR-CAUSED SHORE EROSION WITH BEACH NOURISHMENT: TWO CASE STUDIES ON CLAY SHORELINES. II. DELAYED MITIGATION, ST JOSEPHMI

The ST Joseph Harbor jetties were extended to their present lengths in the 1920's. By 1970 the clay-bluff toes and beach benches downdrift from the harbor looked much different from those updrift. The updrift bluffs have wide clay benches, often with partial cobble and gravel cover, at their toes. Downdrift efforts to retard erosion with seawalls have led to much lower elevations for whatever such benches as may exist, with no apparent cobble cover. Mitigation began with 350,000 cy fine sand in 1976. The first use of trucked-in gravel was in early 1986 (about 90,000 tons). A transient fine-sand beach has been passing Glenlord Road, 5 miles south, since early 1988. The leading edge of the gravel is still within one mile of the nourishment site, building an almost continuous beach along a railroad seawall. The qualitative differences between the movement of the fine sand versus that of the gravel raise the question of just what is meant by the term "mitigation". Also, it appears that shore damage due to this harbor is much greater than has been previously estimated.

PROGRESS IN THE ASSESSMENT AND REMEDIATION OF CONTAMINATED SEDIMENTS (ARCS) PROGRAM

Convenors: Stewart Taylor and Joseph Atkinson

Session 3C - Tuesday, June 4
1:40 - 5:00 PM

Session 4C - Wednesday, June 5
8:30 AM - 12:10 PM

Session 5C - Wednesday, June 5
3:20 - 5:20 PM

110 Knox Hall

HORVATIN, P.J., COWGILL, D.C., SCHROER, K.L., FOX, R.G., and PIPER, J.W., U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL 60604. **An Overview of the Assessment and Remediation of Contaminated Sediments (ARCS) Program.**

The 1987 amendments to the Clean Water Act, in Section 118(c)(3), authorize the USEPA's Great Lakes National Program Office (GLNPO) to conduct a 5-year study and demonstration project relating to the control and removal of toxic pollutants in the Great Lakes, with emphasis on removal of toxic pollutants from bottom sediments. Five areas were specified in the authorization as requiring priority consideration in locating and conducting demonstration projects: Saginaw Bay, Michigan; Sheboygan Harbor, Wisconsin; Grand Calumet River, Indiana; Ashtabula River, Ohio; and Buffalo River, New York. In response, GLNPO has initiated the Assessment and Remediation of Contaminated Sediments (ARCS) Program. ARCS is an integrated program for the development and testing of assessment and remedial action alternatives for contaminated sediments. The Program has received in excess of twelve million dollars from 1988 through 1991. A summary of the structure of the Program and the tools to be developed to address critical management questions common to many Great Lakes Areas of Concern will be presented.

BURTON, G.A., Jr.[1], INGERSOLL, C., ROSS, P., BURNETT, L., HENRY, M., KLAINE, S., LANDRUM, P., SWIFT, M.[1], TUCHMAN, M. [1]Wright State University, Dayton, Ohio 45435. **Sediment Toxicity Assessments: Optimal Design Considerations.**

Thorough assessments of aquatic ecosystem degradation often consist of surrogate toxicity testing, community indices, and chemical analyses. While this "triad" approach is well accepted, it is very general in nature and must be tailored to efficiently meet study objectives. A comprehensive evaluation of sediment assessment procedures was conducted through the USEPA ARCS Program at three Great Lakes "Areas of Concern." Results have shown the optimal assessment tools to vary with the test site; however, techniques can be ranked based on apparent usefulness in the ARCS studies. Ranking criteria may include: sensitivity, response range, discriminatory ability, assay variance, interstudy consistency, resource requirements, ecological relevance, environmental realism (e.g., test conditions, lab vs. field). The importance of the various ranking criteria varies with the study objectives, the ecosystem, and contaminants of concern.

INGERSOLL, C.G.[1], BURTON, G.A., Jr.[2], CLEVELAND, L.[1], COYLE, J.J.[1], AND NELSON, M.K.[1] [1]National Fisheries Contaminant Research Center, Columbia, MO and [2]Wright State University, Dayton, OH. **The Acute and Chronic Effects of Contaminated Great Lakes Sediment on the Amphipod *Hyalella azteca* and the Midges *Chironomus riparius* and *Chironomus tentans*.**

Amphipods and midges were exposed for 2 to 28 days to contaminated sediment collected from Indiana Harbor, Buffalo River, Saginaw River, and Waukegan Harbor. Amphipod tests started with juvenile animals and were conducted for up to four weeks until reproductive maturation. Toxicity endpoints measured in the amphipod tests included survival, growth, and reproductive maturation. Midge tests started with either first (*C. riparius*) or second (*C. tentans*) instar animals and continued until the forth instar. Toxicity endpoints measured in the midge tests included survival and growth. Effects on amphipod survival after 7, 14, and 28 days of exposure were similar, however sediments were not toxic to amphipods after 2 day exposures. Effects on amphipod and midge growth were only observed in exposures to sediment that reduced survival. Identification of marginally contaminated sediments requires measurement of chronic toxicity endpoints.

LANCASTER, E.[1], VARGO, K.[1], TRACY, M.[1], TRACY, J.[1], RATHBUN, J.[1], INGERSOLL, C.[2], BURTON, A.[3], HENRY, M.[3], and LANDRUM, P. [1]ASci Corp., Grosse Ile, MI; [2]USFWS-NFCRC, Columbia, MO; [3]Wright State Univ., Dayton, OH.
Predicting Sediment Toxicity in the Buffalo River From "Indicator" Analyses.

Two data sets; 9 bioassays, and 19 simple chemical analyses plus Microtox; derived from 10 surficial sediment samples were compared via linear and stepwise regression analysis to produce correlative equations for the bioassays. The equations were then used to predict toxicity at 124 levels in 40 cores where the bioassays were not performed. Linear regression between Microtox and the other bioassays showed weak correlations (r^2 = 0.001 - 0.64). Stepwise regression, using all of the indicator analyses, resulted in stronger correlative equations (r^2 > 0.97). Common correlates in these equations were ammonia, conductivity, Cu, Ni, pH, and volatile solids. Results of these analyses indicate the existence of toxic sediment deposits up to 13 ft. below the surface of the sediment. This may influence future remedial action decisions for the Buffalo River.

MUELLER, Mary Ellen U.S. Fish and Wildlife Service, Ann Arbor, MI. **Progress Report of Tumor Surveys Conducted at Three ARCS Sites.**

The U.S. EPA's Great Lakes National Program Office is conducting a 5-year study and demonstration project on the assessment and remediation of contaminated sediments at 5 Great Lakes Areas of Concern. Three of these areas (Saginaw River, MI; Grand Calumet River, IN; Ashtabula River, OH) were selected by the Toxicity/Chemistry work group for fish tumor surveys. Indiana Harbor and the Grand Calumet River as well as the Saginaw River were electroshocked during the summer of 1990 but produced no suitable species known to be sensitive to tumors. These sites have therefore been rejected for further effort. However, previous data from the Saginaw River collected in 1984-1985 revealed no hepatocellular carcinomas in livers from either walleye or brown bullhead taken from this area. In July 1990, 98 brown bullhead were collected from the Ashtabula River. All fish were examined for any external abnormalities. Livers were taken from each fish for histological analysis. Preliminary findings from these fish show 14 with lip papillomas, 36 with stubbed barbels, 42 with skin discolorations (presumed melanomas, to be confirmed by histological analyses), 3 appeared blind in one eye, and 3 showed external skin tumors. Two excised livers showed obvious tumors.

PAPOULIAS, D., BUCKLER, D., AND TILLITT, D. National Fisheries Contaminant Research Center, Columbia, MO. **Mutagenic Assessment of Contaminated Great Lakes Sediments for the ARCS Program.**

The Ames/salmonella assay was used to assess the mutagenic potential of contaminated sediments collected from the Saginaw River, the Buffalo River, and Indiana Harbor as part of the USEPA/GLNPO ARCS Program. Pre-treatment of sediment extracts, selection of appropriate test parameters, and confirmation of revertant colonies was necessary to optimize sensitivity and identify false-positive mutagenic responses. Gel permeation chromatography was used to remove biogenic macromolecules from methylene chloride extracts before transfer to DMSO for Ames testing. Most samples prepared in this manner remained toxic to the bacteria, masking the ability of the test to detect a mutagenic response. Serial dilution to mitigate cytotoxicity co-diluted mutagenic constituents of the sediment extracts, again limiting the sensitivity of the test. However, increasing metabolic activity, over a range of S9 concentrations up to 30% coupled with serial dilution, optimized the expression of mutagenic potential. Finally, a replicate transfer plating technique was used to help discriminate between revertant and non-revertant colonies.

HOKE, R.A.[1], GIESY, J.P.[1], MACCUBBIN, A.E.[2], TUNG, J.[3] [1]Michigan State University, Pesticide Research Center, E. Lansing, MI, [2]Grace Cancer Drug Center, Roswell Park Cancer Institute, Buffalo, NY, [3]Microbics Corp., Carlsbad, CA. **Mutagenicity of Sediments from the Grand Calumet River, IN: Comparison of Mutatox and Ames Assays.**

Ames and Mutatox assays were conducted on sediments from the Grand Calumet River, IN to assess the mutagenic potential of organic extracts of sediments from an IJC "Area of Concern" and to compare the results of the mutagenicity assays when used to test environmental samples. Sediments were Soxhlet extracted for 24 h in isopropanol followed by 24 h in methylene chloride. Extract volumes were reduced, combined and exchanged into DMSO. Ames assays were conducted using two tester strains while Mutatox assays were conducted using a dark mutant of the marine bacterium, Photobacterium phosphoreum. With S9 activation, all samples were identified as mutagenic in both assays. Without activation, one sample was identified as mutagenic in both assays while a second and third sample were mutagenic in only one assay.

Swift, M.C.[1], CANFIELD, T.J.[2], LA POINT, T.W.[2], and BURTON, G.A.[1]. [1]Department of Biological Sciences, Wright State University, Dayton, OH and [2]National Fisheries Contaminant Research Center, Columbia, MO. **Evaluating benthic macroinvertebrate community structure using artificial colonization substrates and ponar grab samples.**

Artificial colonization substrates and ponar grab samples at the same sites in the lower Saginaw River sampled benthic macroinvertebrate communities with proportionally different numbers. Artificial substrates (3M mesh in wire baskets) (n=18) were incubated in the river for 28 d. The substrates were colonized by large numbers of animals--predominantly Gammarus sp., Hydra sp., and chironomids. These animals constituted between 75-98% (by number) of the organisms collected in the samples. Oligochaetes were only abundant (21%) at one site. In contrast ponar grab samples (n=69) (3L volume) collected predominantly oligochaetes, chironomids, and molluscs. Oligochaetes constituted between 75-100% of the animals (by number) at all sites. Assessment of sediment contamination on benthic macroinvertebrate communities may require incorporation of both grab and colonization samples into future studies.

MARTIN, J.L.[1], RICHARDSON, W.L.[2] [1]AScI Corporation, Athens, GA, [2] USEPA Large Lakes Research Station, Grosse Ile, MI. **Mass Balance Modeling of Selected Great Lakes Areas of Concern: An Overview.**

As part of the Assessment and Remediation of Contaminated Sediments (ARCS) program, mass balance modeling studies are being conducted at two Great Lakes Areas of Concern: Buffalo and Saginaw Rivers. Primary objectives of these studies include the demonstration of available modeling techniques and how they may be used as an aid in addressing management questions concerning the remediation of contaminated sediments. Using information provided from other ARCS projects and field studies, modeling studies will estimate contaminant concentrations in both the rivers and their receiving waterbodies (Lake Ontario and Saginaw Bay) under different management scenarios. Components of the Buffalo and Saginaw River modeling studies include hydrodynamic, sediment transport, and contaminant models. Loading estimates from the rivers will be used to predict responses in Lake Ontario and Saginaw Bay. Estimated contaminant concentrations from these modeling studies will provide input to ARCS comparative risk assessment studies.

WANG PEI-FANG and MARTIN, JAMES; ASci Corporation, c/o USEPA, Athens, GA 30613, **Mass-Balance Modeling of the Buffalo River, NY : Hydrodynamics and Transport**

A hydrodynamic and water quality transport study of the Buffalo River, NY, has been conducted. Using a two-dimensional laterally averaged model, the transport of river water temperature and conductivity has been successfully simulated for the period of June-August, 1988. The temperature-induced gravity flow intrusions between the river water and lake (Erie) water are described by the model and confirmed by the measurements during the period. An equilibrium temperature approach was used in the prediction of temperature variations over the stratification period. The simulated conductivity compares well with the measurements for most situations but underestimates in regions close to the mouth. Such discrepancies are attributed to the fact that point and non-point source loadings are neglected in simulation. The accurate estimate of the hydrodynamic transport of the river water is ensured by the agreement of temperature and conductivity between the model results and measurements. The predicted river transport is then processed and linked into a water quality mass balance model (WASP4). The successful linkage between those two models is demonstrated by reproducing the simulated conductivity from WASP4.

IRVINE, K.N. Dept. of Geography/Planning, SUNY College at Buffalo, LOGANATHAN, B.G., RUTKOWSKI, J.R., KUMAR, S., and SIKKA, H.C., Center for Environmental Research, Buffalo, NY 14222. **Methodology to Determine Pollutant Loadings from Combined Sewer Overflows to the Buffalo River**

The Buffalo River is an International Joint Commission Area of Concern (AOC) that experiences pollutant contributions from a variety of sources, including direct input from 39 combined sewer outfalls. An automated sampling site was established in the summer of 1990 to provide flow-proportioned samples for one of the major outfalls. The site consists of a recording flow measurement device that signals a pump sampler to begin sample collection once a combined sewer overflow (CSO) is detected. A total of 7 overflow events were observed between June 25 and December 3, the overflow volumes ranging between 815 and 11817 m^3 (mean of 3696 m^3) and the durations ranging between 1.2 and 10.5 hours (mean of 3.6 hours). The rainfall-runoff relationship for the events is examined and a personal computer version of the Stormwater Management Model (PCSWMM) is used to model the overflows at the automated site. Trace element and PCB levels associated with the solid and dissolved phases of the CSO samples have been quantified. Trace element concentrations were determined using Instrumental Neutron Activation Anlaysis. PCB residues associated with water (dissolved fraction) and suspended matter were determined by liquid/liquid extraction using methylene chloride and soxhlet extraction methods, respectively. Quantification of total PCBs was done using GC-ECD. Trace element concentrations, PCB residue levels and their possible sources are discussed. Grab samples and volume measurements will be taken during overflows at 9 additional sites in the spring of 1991. The ultimate goal of the ongoing project is to apply the PCSWMM model to the entire system. The overflow volume estimates will be combined with "representative" pollutant concentrations determined from the 10 sample sites to provide planning level loading estimates to the AOC.

Non-Point Source Contaminant Loading to the Buffalo River from Contaminated Groundwater

T. Hayashida and S. W. Taylor, Department of Civil Engineering, State university of New York at Buffalo, Buffalo, NY 14260.

Groundwater modeling studies were conducted to predict the amount of the contaminant discharged into the Buffalo River. Two-dimensional (depth-averaged) models were constructed for several inactive hazardous waste sites adjacent to the Buffalo River. Groundwater flow and contaminant transport were modeled on regional and site-specific spatial scales.

For the calculation of flow, a sensitivity analysis was carried out by changing aquifer characteristics to improve the reliability of these models. Using results of sensitivity analysis, contaminant transport simulations were conducted, and the pattern of mitigation of contaminant plume and the time variation of contaminant discharged into the Buffalo River were studied. The difference and relationship between the results of these simulations at two different space scales are discussed.

Passino-Reader, Dora R.; Hudson, Patrick L.; Hickey, James P. U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes, 1451 Green Road, Ann Arbor, MI 48105. **Baseline Hazard Evaluation for Aquatic Life of Priority Consideration Areas Under the Assessment and Remediation of Contaminated Sediments (ARCS) Program: Buffalo River.**

The U.S. Environmental Protection Agency's Great Lakes National Program Office has designated the Buffalo River as a priority consideration area for control and removal of toxic pollutants, especially those in bottom sediments. We have provided a generic risk assessment approach to be used in the ARCS Program to describe hazards of contaminated sediments to aquatic life. We evaluated data on residues in sediment, biota, and water to identify certain PCBs, PAHs, pesticides, and heavy metals as potential chemicals of concern for fish and benthic invertebrates. An exposure assessment and toxicity assessment were utilized in the risk characterization, as well as data on Apparent Effects Threshold and Equilibrium Partitioning. Toxicological information, including dose-response relationships, were provided for use in predicting impacts on aquatic life from various remedial alternatives.

LANIAK, G.L.[1], SUTTON, W.W.[1], CRANE, J.L.[2]. [1] USEPA Environmental Research Laboratory (ERL), Athens, GA 30613. [2] ASci Corporation, c/o USEPA ERL, Athens, GA 30613. **Baseline Human Health Risks in the Buffalo River, NY, Area of Concern.**

A baseline human health risk assessment for an 8 km long, heavily industrialized section of the Buffalo River, NY, was performed as part of the Assessment and Remediation of Contaminated Sediments Program. Both cancer risks and non-cancer hazards, resulting from direct and indirect exposure to contaminated sediments, were evaluated for "typical" and "worst case" exposure scenarios. Historical data (1984-1989) for environmental concentrations of heavy metals, PAHs, PCBs, and pesticides collected from river water, sediments, and fish were used to develop conservative estimates of risk from four exposure pathways: 1) incidental ingestion of surface water while swimming, 2) dermal contact with surface water while swimming, 3) dermal contact with sediments while swimming, and 4) consumption of Buffalo River fish. The general framework for constructing and analyzing exposure related to sediment contamination was amended from U.S. EPA Superfund guidance. The greatest potential for carcinogenic and non-carcinogenic risk apparently results from the consumption of contaminated fish. The results of this baseline risk assessment will be used in a future comparative risk assessment to estimate reductions in human health risk that would result from the implementation of various remedial alternatives.

SMITH, V.E., RATHBUN, J.E., ASCI Corp., and FILKINS, J.C., USEPA, Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI 48138. **Mapping Contaminated Sediments in Great Lakes Areas of Concern (AOC).**

A capability for mapping polluted sediments was developed and demonstrated in support of the USEPA program, Assessment and Remediation of Contaminated Sediments (ARCS). The design goal was to locate and map deposits of bottom contamination in Great Lakes AOC, generally harbors and rivers. The strategy involved measuring and mapping certain "indicators" of sediment quality at numerous "recon" stations; these data were correlated with contaminant and toxicity values measured at a sub-set of "master" stations. From these relationships other contaminant-toxicity distributions were modeled throughout the study area. Work stages in sequence were: (1) remote sensing to locate soft bottom areas; (2) core sampling and characterization; (3) indicator, contaminant and toxicity analysis; (4) correlation analysis and parameter mapping; (5) follow-up sampling, analysis and mapping. Supporting technologies in the field were deployed from a specially built 10 m survey vessel. During 1990 this capability was demonstrated in three AOC areas: Saginaw River, MI; Buffalo River, NY; and Indiana Harbor, IN.

HUELLMANTEL, LAURA L., REIDY, JOSEPH E., and RATHBUN, JOSEPH E., AScI Corporation, Grosse Ile, MI; and FILKINS, JOHN C., USEPA/Large Lakes Research Station, Grosse Ile, MI. **Horizontal and Vertical Distribution of Contaminated Sediment in the Buffalo River, New York.**

Forty sediment cores, up to 14.8 ft. long were collected from the lower 5.6 miles of the Buffalo River and the Buffalo Ship Canal in 1990. Selected layers were analyzed for a number of parameters, including Microtox toxicity, metals, grain size, and extractable residue. Core layers up to 13 ft. beneath the surface of the sediment exceeded EPA dredging guidelines for a number of parameters, including metals and volatile solids. Fifty percent of the cores ended in what was visually characterized as black, oily silt. This material contained elevated concentrations of volatile solids (up to 19.8% DW), extractable residue (up to 27,295 ug/g DW), metals (Pb up to 1586 ug/g DW; Cu up to 951 ug/g DW) and Microtox toxicity (50% = EC50 < 50%). These results may influence future remedial action decisions for the Buffalo River.

SINGER, J.K., State University College at Buffalo, Department of Earth Sciences, 1300 Elmwood Avenue, Buffalo NY 14222 and MANLEY, P., Middlebury College, Department of Geology, Middlebury VT 05753. **A Side-Scan Sonar Survey of the Buffalo River**

The lower 9.2km of the Buffalo River has been designated as an Area of Concern (AOC) by the IJC because of its impaired water quality and contaminated sediments. A goal of the EPA Assessment and Remediation of Contaminated Sediments Program of modeling sediment dynamics in the Buffalo River is the identification of portions of the river where sediment erosion and sediment accumulation are occurring. This information will be used in developing sediment remediation strategies for the Buffalo River. In order to define portions of the river where sediment erosion is occurring, an underwater mapping survey was conducted within the Buffalo River AOC in June 1990. This survey used a Klein dual frequency (100 kHz and 500 kHz) digital sonar system. These frequencies provided high resolution images of the bottom. The swath width of the maps ranged from 25m to 125m, providing complete coverage of the river bottom. Based on the acoustic properties of the sediment, much of the lower 9km of the Buffalo River appears to be covered by sediment of rather uniform texture. Some portions of the river show evidence of current scour, including "tailings" behind objects, lineations, and exposed bedrock. Approximately 3km upstream from the mouth of the river, longitudinal furrows were identified. The furrows are continuous for nearly 1000m and parallel the bank; the spacing between furrows is several meters. The furrows do not cut across each other and appear to be current-derived features, rather than scour from propellers of lake freighters.

SONZOGNI, W., MAACK, L., GIBSON, T., and LAWRENCE, J., Laboratory of Hygiene and Water Chemistry Program, University of Wisconsin, Madison, WI 53706. **TOXIC PCB CONGENERS IN SHEBOYGAN RIVER (WI) SEDIMENTS**

Many of the polychlorinated biphenyl (PCB) congeners that are currently thought to be most toxic are not resolved by single column high resolution gas chromatography. A multidimensional gas chromatograph, employing two capillary columns in series, was used to resolve and quantify eight toxic congeners in river sediment. Sediment was analyzed from the Sheboygan River, a tributary to Lake Michigan that is contaminated with PCBs. Congeners 118 (245-34), 105 (234-34) and 77 (34-34) were found in all samples. Other toxic congeners, 167 (245-345), 114 (2345-4), 126 (345-34), 169 (345-345) and 81 (345-4) were found, but less frequently. Weight percents of the toxic congeners were less than found in Aroclor 1248, the principal PCB mixture released to the river. Congener 118 was found in the sediment in the highest weight percent (0.07 to 0.33%) of any of the toxic congeners. Overall, the eight toxic congeners were found in low concentrations in Sheboygan sediment relative to total PCBs or other more abundant (but presumedly less toxic) congeners.

AVERETT, Daniel E., U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. **"Review of Removal, Containment and Treatment Technologies for the Assessment and Remediation of Contaminated Sediment (ARCS) Program."**

This study identified technologies that may be feasible for remediating Great Lakes contaminated sediment and that should be considered for demonstrations under the ARCS program. The review is organized by components or stages of a remedial action, technology types for each component, and process options for each technology type. The removal component includes hydraulic dredges, mechanical dredges, turbidity containment, and operational controls. Dredged material may be transported to a treatment or disposal site by barges/scows, hopper dredges, pipelines, rail, or truck. Pre-treatment may consist of dewatering, particle separation, or slurry injection. Technology types for the treatment component include biological, chemical, extraction, immobilization, radiant energy, and thermal processes. Disposal options for containment of contaminated sediment or treated residuals are categorized into confined disposal, beneficial use, or open water disposal. Effluent treatment following pre-treatment, treatment, or disposal may also be an important component of a remedial action. Nonremoval alternatives for contaminated sediment include in situ treatment or containment. Key factors for evaluation of various options are effectiveness, implementability, and cost.

GARBACIAK, Stephen (Jr) and TIMBERLAKE, Dennis, U.S. Army Engineer District, Chicago, 111 N. Canal St., Suite 600, Chicago, IL, 60606-7206 and USEPA Office of Research and Development, 26 W. Martin Luther King Dr., Cincinnati, OH, 45268, **Bench Scale Testing of Sediment Remediation Technologies.**

The ARCS Program has identified 18 technologies that show promise for treating contaminated sediments. In order to assess the efficiency, effectiveness, and feasibility of using these technologies, laboratory tests were conducted on sediment samples collected from five Areas of Concern in the Great Lakes (Buffalo River, Saginaw River, Grand Calumet River, Sheboygan River, and Ashtabula River). Technologies tested included solvent extraction, low temperature thermal stripping, wet air oxidation, thermal destruction, biodegredation, and solidification. Bench-scale tests were conducted on samples ranging in size from 1 to 300 kilograms. Results are presented showing destruction and extraction efficiencies, residue contaminant concentrations, and cost estimates for full-scale technology applications.

ALLEN, J. P. and HALL, R. R., U.S. Bureau of Mines, Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, UT 84108, USA. **Characterization and Processing of Contaminated Sediment by Mineral Processing Methods**

The Bureau of Mines, U.S. Department of the Interior, in cooperation with the Great Lakes National Program Office, U.S. Environmental Protection Agency, is investigating the application of methods commonly used in mineral processing for removal of pollutants from contaminated sediment. Mineral processing techniques perform particle-particle separations rather than chemical dissolution or leaching of the metals from the particles as is done with extractive metallurgical techniques. Sediments from Buffalo River, NY, Indiana Harbor-Grand Calumet River, IN, and Saginaw River, MI, have been characterized according to mineralogy, grain size, and other physical properties important to selection of mineral processsing options. Many of the heavy metal contaminants are found to be distributed toward the fines, suggesting that a size-separation technique, such as hydrocycloning, may be useful on certain sediments. Other techniques such as magnetic separation, gravity separation, and froth flotation have been investigated and found to have applications under some conditions.

FLEMING, Elizabeth C., AVERETT, Daniel E., and CHANNEL, Michael G. U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. **"An Evaluation of Solidification/Stabilization Technology for Buffalo River Sediment."**

Under the Assessment and Remediation of Contaminated Sediments Program, the U.S. Environmental Protection Agency Great Lakes National Program Office asked the U.S. Army Corps of Engineers to evaluate solidification (S/S) as a treatment technology for contaminated sediments from the Buffalo River. Cement, kiln dust, and lime/fly ash were evaluated as binders for S/S of the sediment. Physical tests used in the evaluation included unconfined compressive strength (UCS) tests and wet/dry and freeze/thaw durability tests. The toxicity characteristic leaching procedure (TCLP) and a serial leaching test (SLT) using distilled water were performed to compare contaminant releases for the sediment to releases from crushed S/S specimens. Based on TCLP results, the cement and kiln dust binders were effective in reducing the leachability of lead, nickel, and zinc, compared to untreated sediment. However, all binders increased the leachability of chromium and copper. SLT leachates for both untreated sediment and cement-treated sediment met primary and secondary drinking water criteria for the five metals tested. Specimens solidified with cement passed all durability tests and provided the highest UCS values.

MILLER, Jan A., US Army Corps of Engineers, North Central Division, " Sediment Remediation: Going from Demonstrations to Full-Scale."

The ARCS program will evaluate available technologies for remediation of contaminated sediments and perform demonstrations of selected technologies at bench- and pilot-scales. Conceptual plans for full-scale remediation are being developed for ARCS. The application of ARCS guidance to full-scale sediment remediation will require consideration of funding and regulatory constraints that have been tested only recently. The regulation of sediment remediation could potentially involve a variety of Federal and state environmental laws (CWA, TSCA, RCRA, NEPA, and others). Funding mechanisms for sediment remediation include enforcement actions (under Superfund, Clean Water Act, and other laws), project-specific Federal or state legislation, and existing Federal legislation (Section 115 of CWA and Section 312 of WRDA).

DID YOU KNOW

The first inland English Naval fleet was constructed at Navy Island, Niagara River, 1761.

RESEARCH AND MANAGEMENT OF WETLANDS IN THE GREAT LAKES

Convenors: Richard Smardon and Dan Ray

Session 3D - Tuesday, June 4
1:40 - 5:00 PM

14 Knox Hall

BUSCH, WOLF-DIETER N. U.S. FISH AND WILDLIFE SERVICE, CORTLAND, NEW YORK. **A MACRO APPROACH TO THE IDENTIFICATION OF DESIRED LONG-TERM WATER LEVEL FLUCTUATIONS IN THE GREAT LAKES, USING WETLAND DYNAMICS.**

Agencies regulating water levels, need numerical information as to the water levels required by the biological resources. An approach was developed to deal with the difficulty in quantitatively evaluating changes in wetlands caused by water-level regulations and providing the information in a form usable by the regulators. This approach includes identifying the biological significant range of needed long-term fluctuations, within long-term minimum and maximum seasonal curves, and identifying the numerical setting of the curve, for the coming year's levels, based on the past year's water supply and predicted precipitation rates. The seasonal curve follows the shape of the historic median curve, although the actual numbers used for the y-axis are calculated each year while the x-axis remains constant.

WISHEU, I.C. KEDDY, P.A., WU, Q. AND MOORE, D.R.J. DEPT OF BIOLOGY, UNIVERSITY OF OTTAWA, ONTARIO, CANADA, K1N 6N5. **THE IMPORTANCE OF FERTILITY AND FLUCTUATING WATER LEVELS IN THE ESTABLISHMENT AND MAINTENANCE OF WETLAND VEGETATION: RESULTS OF A FOUR YEAR MESOCOSM EXPERIMENT.**

To determine how different environmental factors affect the establishment and maintenance of wetland vegetation, we created 120 artificial wetland habitats (mesocosms) and monitored the establishment and development of vegetation over a 4 year period. Each mesocosm was initially sown with an identical seed mix (20 species) then manipulated with regard to one of the following variables: fertility, water depth, fluctuations of water depth, soil texture, litter load, length of growing season and invasion by Typha. The first 5 variables were all capable of influencing species composition, especially fertility, which increased total cover ($p > .005$ for all habitats) and decreased species richness ($p < .500$ for 2/3 of habitats). Small, rare species were absent from fertile treatments. Species richness was also significantly affected by relatively small differences in water depth. Deep water treatments had fewer species but greater abundances of Bidens cernua. Small, rare species were never abundant even though we sowed their seeds and tried to duplicate their habitat. We therefore suggest a priority be put on conserving rather than reconstructing rare plant habitat.

MCALLISTER, LYNNE AND H. J. HARRIS. NSI TECHNOLOGY, INC., CORVALLIS, OREGON AND UNIVERSITY OF WISCONSIN-GREEN WAY. **FACTORS INFLUENCING THE DISTRIBUTION OF SUBMERGED MACROPHYTES IN GREEN BAY, LAKE MICHIGAN - A FOCUS ON LIGHT ATTENUATION AND VALLISNERIA AMERICANA.**

This study focused on the importance of light as a factor limiting depth distribution and abundance of *Vallisneria americana* long the west shore of Green Bay from Duck Creek to the Pensaukee River. Light penetration parameters were assessed weekly at 5 study sites, lying along the bay's north-south tropic gradient, from June to August in 1989 and 1990. Sampling was also done at each site for end-of-season submerged macrophyte density and distribution of *Vallisneria* for improvements in water clarity as remedial action progresses. The maximum depth of *Vallisneria* growth and persistence Z_c was 30-38 uE/m_2/s, which represented 2.4-3.7% of the light intensity at Z_o. The compensation light intensity of *Vallisneria* was experimentally determined as 18 uE/m_2/s using an oxygen production method. *Vallisneria* depth distribution is probably limited by light availability in some areas. Based on predictions of the model, it appears that the scarcity of *Vallisneria* in the area south of Long Tail Point is due to light limitation. It is also probable that others factors - e.g. wave action, substrate composition, nutrient availability - interact with light to influence macrophyte production and depth distribution in some places.

REEDER, BRIAN C. AND MITSCH, WILLIAM J1 DEPARTMENT OF BIOLOGICAL AND ENVIRONMENTAL SCIENCES, MOREHEAD STATE UNIVERSITY, MOREHEAD, KENTUCKY AND1 SCHOOL OF NATURAL RESOURCES, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO. **HISTORICAL BIOGEOCHEMISTY OF OLD WOMAN CREEK WETLAND, LAKE ERIE, U.S.A.**

The Great Black Swamp that once surrounded the western basin of Lake Erie (USA) has been almost entirely drained for agricultural use. Had some of these wetlands remained intact, they may have helped halt the cultural eutrophication of Lake Erie. Little is known about the current or historic functions of these wetlands. Changes in ecosystem function and watershed characteristics following the retreat of the Wisconsin Glacier were determined in a remnant of these pre-settlement wetlands: Old Woman Creek National Estuarine Research Reserve. Wetland dynamics over the past 10,000 years were determined by analysis of a 5.7 meter sediment core. Abundance and distribution of pollen, phosphorus, sedimentary chlorophyllous degradation products, organic matter, iron, and manganese were analyzed to determine the effects of a changing landscape on the wetland. Water level fluctuations in Lake Erie did not change ecosystem structure and function to as great an extent as watershed deforestation. An increase in *Ambrosia* pollen (denoting watershed for deforestation and European habitation) coincided with increased sedimentation and order of magnitude (0.73 cm y^{-1}), decreased percentage of organic phosphorus. Pollen and sediment analyses suggests that the area has been a wetland since glaciation, and has retained it integrity as a shallow water system throughout the Lake Erie water level fluctuations. Simulation models based on core and field data predict that Old Woman Creek wetland may prevent more than 50% of inflowing phosphorus from reaching Lake Erie.

DANIEL E. WILLARD, SCHOOL OF PUBLIC AND ENVIRONMENTAL AFFAIRS, INDIANA UNIVERSITY, BLOOMINGTON, INDIANA 47405. **THE UPPER PERE MARQUETTE WATERSHED: AQUATIC SYSTEM RESTORATION BY BENIGN NEGLECT.**

The upper Pere Marquette River is now a nationally known recreational boating and fishing stream. Wildlife and fishes abound in its waters. Yet newspapers reports of eighty years ago considered it a dead river. Logging had removed the vegetation of the watershed and decaying logs had reduced the available oxygen of the river practically to zero. We examine the invertebrate populations, fish diversity, and vegetation of the river corridor and show the connections between the conditions of the present day river, wetlands and land use to the regional hydrology and economics in the watershed. Ultimately, we hope to show the potential outcome of global climate change scenarios on the aquatic systems of the river.

FRANCIS, DONNA, JUDE, DAVID, J., ROSSMAN, RONALD AND BARRES, JAMES A. CENTER FOR GREAT LAKES AND AQUATIC SCIENCES, UNIVERSITY OF MICHIGAN, 2200 BONISTEEL BOULEVARD, ANN ARBOR, MI 48109. **MERCURY IN A GREAT LAKES ESTUARY: OLD WOMAN CREEK, OH.**

Disappearance of Great Lakes wetlands and effective management of remaining areas prompted this investigation of toxic Hg compounds in the Old Woman Creek estuary ecosystem, with emphasis on transport pathways through the pelagic and benthic food chains. Samples of water, sediment, benthos, zooplankton, fish and macrophytes were collected in 1989. Hg concentrations were determined by cold vapor flameless atomic absorption. Concentrations were non-detectable in water (<21 ng/L) and low in the top 10 cm of sediment (0.10 ug Hg/g). Mean concentrations in organism ranged from <0.01 ug Hg/g in benthos and zooplankton to 0.64 ug Hg/g in fish (bowfin)). One Great Blue Heron was also analyzed and found to have the highest level (1.62 ug Hg/g). The data indicate that Hg bioaccumulates and biomagnifies in this ecosystem. In common carp and channel catfish, the older (larger) fish had higher levels of mercury in muscle tissue than did the younger (smaller) fish. In both benthic and pelagic food chains, Hg levels were low at lower tropic levels, but elevated concentrations occurred intop predators. it may be important in wetland management to recognize that even in areas with relatively uncontaminated water and sediment, there is still potential for accumulation of Hg in top predators.

GLOOSCHENKO, V., KAVANAGH, T. AND N. ROULET. ONTARIO MINISTRY OF NATURAL RESOURCES, QUEEN'S PARK, TORONTO, ONTARIO AND YORK UNIVERSITY, TORONTO, ONTARIO. **GREAT LAKES COASTAL WETLANDS - INCREASED PROVINCIAL RECOGNITION OF FISHERIES AND HYDROLOGICAL VALUES FOR PROTECTION PURPOSES.**

A planning policy document or legislation will be used to protect Ontario's wetland resources in the near future. Recommendations for wetland protection will be based on a data bank quantifying biological, social, hydrological and special features values for over 1900 Ontario wetlands, including 64 Great Lakes coastal wetlands. Due to increased knowledge of southern Ontario wetland communities in the past several years, certain aspects of Ontario's wetland assessment program are being strengthened. These include recognition of fisheries and hydrological values, particularly for Great Lakes shoreline wetlands. The use of coastal wetland habitat by fish for various aspects of reproduction (spawning, rearing) is more important than previously noted. Extended field data on fisheries habitat and submergent vegetation communities will be sought for shallow water wetlands. The role of lakeshore marshes and swamps in reduction of shoreline erosion and improvement of water quality impacted by agriculture and urban runoff will also be quantified. These measures will increase the scope of provincial protection to a greater percentage of Great Lakes wetlands.

PHILIP WELLER (GREAT LAKES UNITED) DAN RAY (CENTRE FOR THE GREAT LAKES) SANDY CONNELL (ONTARIO MINISTRY OF THE NATURAL RESOURCES). **PROTECTING GREAT LAKES WETLANDS THROUGH THE USE OF INTERNATIONAL AGREEMENTS. PRESENTED TO THE INTERNATIONAL ASSOCIATION FOR GREAT LAKES RESEARCH.**

Abstract - Wetland quantity and quality has dramatically declined in the Great Lakes Basin since the arrival of European settlers in the Great Lakes region in the late 1700s. The full extent of wetland losses in the region are now known but estimates are that between 60-80 percent of the pre-settlement wetlands have been lost. In recent years there has been a growing awareness of the need to protect and preserve the remaining wetlands. This awareness has resulted in commitments at a national, state and provincial, and local levels to greater protection of wetlands. To ensure consistency, adequacy and comprehensiveness in the efforts to protect wetlands within the Great Lakes Basin it is essential that there be greater international cooperation and coordination of wetland protection efforts. This paper suggests a number of opportunities for expanded and better coordinated international wetlands protection. In particular , the wetlands protection programs of agencies and organizations responsible for the Great Lakes Water Quality Agreement, the Great Lakes Fishery Convention, the Migratory Birds Convention, and Great Lakes Water Level Control are analyzed and recommendations are provided on expanding cooperation and integration of these efforts. A separate Annex of the Great Lakes Water Quality Agreement dealing specifically with wetlands is proposed and discussed.

SELLINGER, Cynthia E., Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, Michigan 48105-1593. **GREAT LAKES HYDROMET DATABASE DIRECTORY.**

In November 1988 the Coordinating Committee on the Great Lakes Basic Hydraulic and Hydrologic Data established the Hydrometeorology and Modeling Subcommittee to assist with hydrometeorologic data collection and hydrologic modeling. Upon establishment, the subcommittee agreed that there was a need to update the Great Lakes Hydrometeorological Station Directory. The 1983 report listed hydrometeorological data available to Great Lakes researchers, data collection agencies, and station information. The Hydromet Database Directory replaces the 1983 information with a menu-driven, computerized depository of data information that consists of 29,063 hydrometeorological stations compared with the 6600 stations of the previous directory. This directory contains eight databases from seven data collecting agencies, station information about twenty-one data types, and addresses and phone numbers of these agencies.

PROGRESS IN ZEBRA MUSSEL RESEARCH IN THE GREAT LAKES BASIN

Convenors: Charles O'Neill and David MacNeill

Session 4A - Wednesday, June 5
8:30 AM - 12:10 PM

Session 5A - Wednesday, June 5
3:20 - 5:20 PM

20 Knox Hall

KLERKS, P.L. and FRALEIGH, P.C. Department of Biology, The University of Toledo, Toledo, Ohio 43606. **Zebra mussel veliger dynamics in western Lake Erie near Maumee Bay during 1990, and zebra mussel control in water intakes by oxidant addition.**

This research investigated zebra mussel veliger occurrence and settlement in western Lake Erie near the Toledo Water Intake and at the Toledo Low Service Pump Station (at the end of a three-mile pipe carrying water from the intake). We also addressed the possibility of controlling zebra mussels in water intake systems with various oxidants. Weekly plankton sampling in Lake Erie first showed veligers on May 31. Veliger densities peaked in June and again in late July / early August, while veligers were last found on October 20. The maximum density encountered was 360/L. Veliger settlement was assessed by weekly inspection of substrates placed near the water intake. Settlement of veligers was first observed on July 16, and was heaviest in August (maximum settling rate: 5600/m^2/week). Veliger abundances at the pump station were about 80% lower than near the water intake. Filtering by adult mussels may have been contributory to this; plankton at the pump station consisted mainly of detritus (pseudofaeces ?). To assess control possibilities, veligers and adults were exposed to oxidants in static and flow-through systems. Both sodium hypochlorite and potassium permanganate appeared effective, especially when treatment was continuous rather than intermittent. In contrast, the combination of hydrogen peroxide and iron appeared ineffective. Increased treatment duration and elevated water temperatures increased the effectiveness of chlorine and permanganate treatments.

NICHOLS, S. J. National Fisheries Research Center-Great Lakes, 1451 Green Road, Ann Arbor, MI 48105. Kollar, B. Detroit Edison, 2000 Second Ave., Detroit, MI 48226. **Reproductive Cycle of Zebra Mussels (Dreissena polymorpha) in western Lake Erie at Monroe, Michigan.**

The reproductive cycle of zebra mussels was investigated at the Detroit Edison plant in Monroe, Michigan, weekly since May 1990. Zebra mussels showed seasonal variation in sex ratios and size at sexual maturity. Mussels carried ripe gametes for eight months, although veligers were produced for only five months. Veligers first appeared May 30 at densities of 75/L, peaked July 26 at 187/L, and were last found October 3, at 4/L. However, at least 50% of the mussels examined contained ripe gametes from May 1 through December 28. Gametes were then resorbed, and by January 15, less than 2% of the mussels contained ripe gametes. From May through December, the proportion of females in the population increased and the size at sexual maturity decreased. These seasonal changes indicate that the reproductive cycle of the zebra mussel is very flexible and can alter to take advantage of local environmental conditions.

FITZSIMONS, J.D.[1], LEACH, J.[2], NEPZY, S.[2], and CAIRNS, V.W.[1]. [1]Department of Fisheries and Oceans, Burlington, Ontario. [2]Ontario Ministry of Natural Resources, Wheatley, Ontario. *Effects of zebra mussels on walleye reproduction in western Lake Erie.*

With the rapid colonization by zebra mussels of walleye spawning shoals in western Lake Erie there is concern for their continued successful use. This work looked at effects on spawning use, viability of eggs and dissolved oxygen within interstitial spaces at one shoal in western Lake Erie. Despite high numbers of mussels, averaging 147,000/m^2, walleye continued to use the shoal with no apparent effect on numbers or viability of eggs. Dissolved oxygen was close to saturation. Preliminary observations indicate that egg deposition is occurring randomly irrespective of large ice-scoured mussel-free areas.

CAVALETTO, JOANN F.; NALEPA, THOMAS F., FORD, MARK A., MCELROY, KATHLEEN D.; **NOAA/GLERL 2205 Commonwealth Blvd. Ann Arbor, MI 48105.** **Zebra mussel fitness in Lake St. Clair : a comparison at two sites.**

Zebra mussels (Dreissena polymorpha) were collected at two sites in Lake St. Clair on a monthly basis from April to November 1990. The sites varied both in terms of substrate and zebra mussel abundances; one site had a gravel/hard bottom and high densities while the other site had a silt bottom and low densities. The following variables were measured each month: shell length (SL), shell weight (SW), tissue dry weight (TDW), tissue ash-free dry weight (TAFDW), total lipids, lipid classes, and lake surface chlorophyll. The mean TAFDW:TDW ratio was 0.88. This ratio did not vary significantly between sites or sampling dates. However, the TDW:SW ratio was significantly higher in the months prior to spawning (April, May) than in the months during and after spawning. Linear regressions between TDW and SL at the two sites were significantly different; greater dry weights (per unit length) were found at the silty site. Total lipids ranged from 6-20% of dry weight. Highest lipid levels occurred during the spring, and overall, greater percentages occurred in individuals from the silt-bottom site. In the spring, chlorophyll concentrations were higher at this site as compared to the hard-bottom site (5.7 and 2.2 mg/m^3 respectively). We conclude that the relative fitness of zebra mussels in Lake St. Clair is site specific.

MACISAAC, Hugh J. and SPRULES, W. Gary. Zoology Department, University of Toronto, Mississauga, Ontario. **Modelling the dynamics of zebra mussel populations in the Great Lakes: How important are biotic processes?**

Populations of zebra mussels may be characterized by three distinct subgroups: planktonic veliger larvae, settled subadults, and adults. European workers have suggested that mortality between the larval and adult stages, which frequently exceeds 99%, results from lack of appropriate substrate or from variations in water temperature or water chemistry encountered by settling veligers. It is unlikely that mussel recruitment patterns in western Lake Erie have been determined by these abiotic factors alone, because current population densities could not have been as high as they are under such a schedule of larval mortality. We have conducted experiments to determine the vulnerability of Great Lakes zooplankton to predation by adult (2.2 cm) mussels; small-bodied, weak-swimming species (rotifers and mussel veligers) were particularly vulnerable to predation, while larger-bodied species (ie. Cladocera) were much less susceptible.

We utilized STELLA-software to develop a model which incorporates moderate (~ 60%) abiotic larval mortality, and density-dependent subadult and adult predation on planktonic and settling larvae. Larval survival and recruitment rates were inversely related to the population density of predaceous adults. Our model is consistent with recent recruitment patterns in western Lake Erie and Lake St. Clair. We predict that recruitment dynamics are determined by a combination of abiotic and biotic factors in shallow well-mixed basins, and by abiotic factors in deep, stratified basins where benthic adult mussels are disassociated from pelagic food webs.

RAMCHARAN, Charles, W., PADILLA, Dianna K., and DODSON, Stanley I. Department of Zoology, Birge Hall, University of Wisconsin, Madison, Wisconsin, 53706.
ANALYSIS OF *DREISSENA* POPULATION DYNAMICS IN EUROPE AND PREDICTIONS FOR NORTH AMERICA.

In some European lakes abundance of *Dreissena* is fairly constant over time periods of 10-30 years, while in other lakes populations show interannual fluctuations of more than an order of magnitude. If populations in the Great Lakes fluctuate, then the problems caused by *Dreissena* may be most severe during years of population peaks. Long-term population averages may be lower than are now found in lakes Erie and St. Clair. The range over which populations might fluctuate from year to year, will affect predictions of the ecological role of *Dreissena* in the Great Lakes. We predict the potential population dynamics of *Dreissena* in the Great Lakes using a multivariate model developed from published European data. Using Discriminant Function Analysis we analyze data on the morphometric, physical, and chemical environments of lakes with either variable or constant populations of *Dreissena* (classified by analysis of coefficients of interannual variation). We find that lakes with variable populations tend to be deep with small surface areas and high flushing rates. Larger, shallower basins with low flushing rates tend to have more constant populations. Our model suggests that populations would be most variable in areas of the Great Lakes that have high flushing rates.

PARE, S.M., and RIESSEN, H.P., Department of Biology, SUNY College at Buffalo, Buffalo, NY 14222. IMPACT OF FISH PREDATION ON ZEBRA MUSSEL POPULATIONS.

The zebra mussel population in Lake Erie has increased dramatically since its discovery in the western basin in 1988. This rapid population increase suggests that natural control mechanisms, such as predators, may be lacking in the Great Lakes. Analysis of the gut contents of Lake Erie fish, however, suggests that several species may serve as potential predators. We performed a field exclosure experiment over a 5-week period during summer 1990 in the Bass Island region of western Lake Erie to investigate the impact of fish predation on the zebra mussel population. 0.1-m^2 plots of lake bottom, which supported high densities of zebra mussels, were either enclosed with wire mesh to exclude predators (treatments, n=30) or left subject to the natural levels of fish predation present in the lake (controls, n=30). Differences in mussel population density and size distribution between control and treatment areas, and an analysis of gut contents of fish collected from the test area are used to estimate the effects of fish predation on this recently introduced exotic species.

KREIS, R.G., Jr.[1,3], MULLIN, M.D.[1], ROSSMANN, R.[2], UTZ, J.L.[3], REIDY, J.E.[3], VARGO, K.A.[3], and SMITH, K.T.[1]. [1]USEPA, LLRS/ERL-Duluth, 9311 Groh Rd., Grosse Ile, MI 48138; [2]CGLAS, Univ. Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109; [3]AScI Corp., 9311 Groh Rd., Grosse Ile, MI 48138. Contaminant Concentrations in Zebra Mussel Tissue from Western Lake Erie, Monroe, Michigan.

Zebra mussels were collected from a nearshore area of western Lake Erie at Sterling State Park, Monroe, Michigan, and soft tissues were analyzed for organic contaminants and heavy metals. Lipid, moisture, and total carbon averaged 1.5%, 87%, and 42%, respectively. Total PCB concentrations averaged 520 ug/kg wet weight. Distributions of PCB homologs and congeners were very similar in all tissue samples. Prevalent homologs were tetra-, penta-, and hexachlorobiphenyls. PCB congeners 52 and 66 were dominant, each contributing over 5% of the total concentrations. Sum of DDT analogs, chlordane components, and HCB averaged 23, 14, and 0.83 ug/kg, respectively. Heavy metal concentrations were near or below the limit of detection using ICP-AES; additional AA graphite furnace analyses are being conducted for confirmation. As additional contaminant concentrations in zebra mussels from different areas in the Great Lakes become available, they will begin to provide some insight into the role of zebra mussels regarding contaminant cycling, bioaccumulation in food chains, and their use for biomonitoring.

DONAHUE, Michael J., RATZA, Carol A. Great Lakes Commission, 400 Fourth Street, Ann Arbor, MI 48103-4816. **POLICY AND PROCESS: IMPLEMENTING THE "NONINDIGENOUS AQUATIC NUISANCE PREVENTION AND CONTROL ACT OF 1990"**

Zebra mussels respect no political boundary, a fact which presents a challenge in implementing present and prospective laws and policies in the Great Lakes Basin. The existing Great Lakes institutional framework is challenged by the immediate need for sound policy to meet this rapidly advancing problem. The policy process at the federal, state and provincial levels is developing rapidly in the United States and Canada to provide a framework to fund research and control, encourage cooperative management efforts, begin information dissemination and public education, and protect against future introductions of other unwanted exotic species. The institutional management framework in the international Great Lakes Basin is forming to ensure concerted attention to this issue. The new U.S. law and related initiatives recognize the binational Great Lakes Basin's unique management requirements and available expertise. This paper will examine all aspects of the recently enacted U.S. "Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990" with a special focus on: the Great Lakes Commission role as the convener of a regional panel to identify priorities for the Great Lakes; intergovernmental coordination challenges and the array of related Basin initiatives at the various levels of government.

LICHTKOPPLER, FRANK R. and KELCH, DAVID O., The Ohio State University, 99 East Erie Street, Painesville, OH 44077; Recreational resource user attitudes concerning the Zebra Mussel (Dreissena polymorpha), and other Great Lakes issues.

Because public opinion influences the allocation of resources needed to manage the Great Lakes it is important to quantify the attitudes of Great Lakes resource users. Six hundred randomly selected patrons of the 1990 Mid-America Boat Show were surveyed by mail in February and March of 1990 on Great Lakes issues including the invasion of the zebra mussel, with a response rate of 85%. The average respondent was 43.25 years old, male, employed in professional, highly skilled or managerial positions, with household incomes in excess of $30,000. Almost 78% were boat owners. The zebra mussel was viewed as a threat to the Lake Erie boating and sportfishing industry by over 65% of respondents. Public funding for research on zebra mussels was believed to be a wise investment by 71% of respondents. Almost 91% of respondents felt that pollution by individuals does have an affect on the Great Lakes and that government should be doing more to clean up Lake Erie. Over 85% felt that citizens should be involved in the management of the Lakes. Quantifying public opinion concerning Great Lakes natural resource issues will help stimulate debate concerning the allocation of scarce resources to study, monitor and manage the Great Lakes.

MACNEILL, D.B. Regional Extension Specialist, New York Sea Grant Extension Program, 248 Hartwell Hall, SUNY College at Brockport, Brockport, NY 14420. Physiological and Morphological Comparisons of *Dreissena polymorpha* and *Mytilopsis leucophaeta* (Bivalvia:Dreissenidae).

The introduction of the zebra mussel, *Dreissena polymorpha* into North America may have serious economic and ecological ramifications. Within the next ten years, *Dreissena* is predicted to spread into several estuarine areas along the eastern seaboard of the U.S., potentially resulting in a range overlap with the dark false mussel, *Mytilopsis leucophaeta*, a euryhaline dreissenid native to North America. Like other dreissenids, *Mytilopsis leucophaeta* has biofouling tendencies, although believed to be of lesser consequence than *Dreissena*. Results of a literature review indicate partially overlapping salinity tolerances and habitats of *Dreissena* and *Mytilopsis* in Europe. Because of their related phylogenies, these two bivalve species display close morphological similarities, particularly as juveniles, leading to probable field misidentification as their populations become sympatric. This presentation reviews physiological and morphological descriptions of *Dreissena polymorpha* and *Mytilopsis leucophaeta* and provides an abbreviated guideline for their definitive identification.

MATISOFF, G.[1], GREENBERG, A.[2], GUBANICH, G.[2] and McCALL, P.L.[1]
[1]Department of Geological Sciences, Case Western Reserve University, Cleveland, OH 44106.
[2]Cleveland Division of Water, 1201 Lakeside, Cleveland, OH 44114. **Effects of Ammonia, Chloramine, and Chlorine Dioxide on Zebra Mussel Veliger Mortality.**

Chemical dose/response studies of zebra mussel veligers in static systems and in flow-through aquaria were conducted to evaluate the effectiveness of chlorine dioxide, chloramine, and ammonia on veliger mortality in water intake pipes. Ammonia had little effect at the 1 ppm level and about 40% mortality was induced at 10 ppm. Chlorine dioxide treatment resulted in mortalities of about 30-80% at the 2-5 ppm level, with values obtained in the flow-through experiments slightly higher than those obtained from static studies. The LC50 following a single dose administration of chloramine is 2 to 3 ppm. When the chloramine data were corrected for high mortality in the controls, the mortalities ranged from 49% at 0.1 ppm to 100% at 5 ppm yielding an LC50 less than 1 ppm. Thus, chloramine appears to be the most effective of the tested chemicals. The general agreement between the results obtained in static and flow-through experiments indicates that static testing is a cost-effective method that is useful for screening the effectiveness of various chemicals for control of zebra mussel veligers.

SPENCER, F. S., Ontario Hydro, Research Division, 800 Kipling Ave, Toronto, ON, M8Z 5S4, Alternatives to Chlorination for Control of Zebra Mussels

Ontario Hydro provides over 95% of the province's electricity from hydraulic, fossil and nuclear plants located on the Great Lakes, their interconnecting waterways and various inland rivers. As one of the largest Canadian users of raw water Hydro has been seriously affected by the zebra mussel invasion of service and cooling water systems at facilities on Lake Erie, western Lake Ontario and the Niagara River. Infestation of remaining Great Lakes facilities is expected 1991. Hydro is currently relying on the intermittent (2 ppm for 30 mins every 12h) or continuous (0.5 ppm) use of sodium hypochlorite in service water systems for control of zebra mussels throughout their breeding season. Untreated condenser cooling water systems require mechanical cleaning. In the longer term, the development of alternative chemical and non-chemical control measures for specific service water subsystems may offer more economical and environmentally acceptable approaches. The research to define these alternatives is directed primarily at preventing colonization by zebra mussel larvae. These measures include alternative chemicals (ozone) and physical measures, such as coatings, pressure, UV and gamma irradiation, acoustics and electroshock. To control adult mussels time-temperature regimes have been established for thermal backwashing. Potential enhancement of metal corrosion by NaOCl use in service water systems is being evaluated by sensitive electro- chemical instrumentation. Control measure development is supported by a multi-celled flow test rig in the field and attempts are underway to culture veligers to enable laboratory experimentation outside the normal breeding season.

BAIER, Robert E., Industry/University Center for Biosurfaces, State University of New York at Buffalo, 110 Parker Hall, Buffalo, NY 14214. Control and Mitigation of Zebra Mussel Attachment by Use of Nonpolluting, Fouling-Release Coatings.

Significant promise is shown for the manipulation of zebra mussel habitat by use of surface physical/chemical techniques that add no foreign substances or extra heat to the ecosystem. In particular, provision of low-surface-energy coatings as easy-release layers minimizes the strength of attachment of the mussel byssus structures to otherwise suitable substrata. This results from inability of the biological cements to develop adequate anchorage to surfaces exposing only closely packed molecular arrays that can not enter into polar or hydrogen bonds, or induce biospecific interactions. The consequence is that hydrodynamic control alone, such as increased shear rates, may suffice to prevent or remove fouling colonies at walls, and this release process should occur at small enough cluster sizes to allow trouble-free passage through the remainder of the flow path. Over the near term, use of such fouling-release approaches together with minimal doses of biocides will be helpful since chemical control agents work much more effectively against detached and suspended organisms than those strongly surface-attached. Coatings dominated by polydimethylsiloxane at their outermost faces perform best.

SNYDER, Fred L., FISHER, Susan W.[1], KELCH, David O., and LICHTKOPPLER, Frank R., Ohio Sea Grant College Program; [1]Department of Entomology, The Ohio State University, Columbus, Ohio, 43210.

Developing Strategies for Chemical Applications to Impede Zebra Mussel Movement to Inland Waters.

The anticipated, and recently observed, movement of zebra mussels from the Great Lakes into inland waters has caused management responses ranging from the closure of reservoirs to boating to the issuance of government guidelines for transporting boats, equipment, live bait and commercial fish. Investigations have found potassium phosphate and potassium chloride to kill zebra mussels at relatively low concentrations without affecting nontarget organisms. Current investigations are underway to identify the minimum concentrations needed to kill veligers. Evaluations were conducted of commercial antifouling paints containing copper and tributyltin to determine their effectiveness in preventing the attachment of settling veligers. The results of these studies can lead to new strategies for avoiding zebra mussel transfer among water bodies by boaters, fish transporters and marine equipment users.

KEILLOR, PHILIP, University of Wisconsin Sea Grant Institute, 1800 University Avenue, Madison, Wisconsin 53705. **Sand Filter Intakes for the Prevention of Zebra Mussel Infestation in Large and Small Water Supply Systems**

Zebra mussels have seriously impaired flow in water intakes in the eastern Great Lakes and are expected to cause similar problems as this exotic organism spreads through the rest of the Great Lakes and the rivers of North America. Filtration has been effective in excluding zebra mussels from portions of water systems in Europe. Sand filter intakes have been used for small municipal water supplies in the western Great Lakes. Can sand filter intakes be used to exclude zebra mussels from entire water systems? The author describes the pros and cons of sand filter intakes with examples of design types and operational experience. In the past, such intakes were briefly considered by the electric power industry because of concern for the exclusion of larval aquatic organisms. The new threat of zebra mussel infestation to plant system operations justifies a new look at sand filter intakes.

Junction of City Ship Canal and Buffalo River - 1890.

BIOINDICATORS OF ECOSYSTEM HEALTH IN GREAT LAKES

Convenors: G-Yull Rhee and Paul Bertram

Session 4D - Wednesday, June 5
8:30 AM - 12:10 PM

Session 5D - Wednesday, June 5
3:20 - 5:20 PM

14 Knox Hall

KRANTZBERG, G.[1], SMITH, J. & REYNOLDSON, T[2], [1]ENVIRONMENT ONTARIO, WATER RESOURCES BRANCH, 1 ST. CLAIR AVE. W., TORONTO, ONTARIO M4V 1K6, [2]CANADA CENTRE FOR INLAND WATERS, 867 LAKESHORE RD. PO BOX 5050, BURLINGTON, ONTARIO L7R 4A6.
BENTHIC INDICATORS OF ECOSYSTEM HEALTH.

In recognition of the need for an ecosystem approach to the restoration of the Great Lakes, the 1987 revision of the Great Lakes Water Quality Agreement stipulates development of ecosystem objectives. The Ecosystem Objectives Work Group (EOWG) was established and recommended that the presence of diverse healthy reproducing communities unimpaired by contaminants in the ecosystem be a primary objective. Specific measurable indicators of the achievement of this and other objectives are currently being appraised. Due, in part, to their importance in food web processes and contaminant dynamics, the benthic community is one of several ecosystem components being considered for the derivation of functional and structural indicators. The selection of benthic indicators will be based on the identification of reference communities and species representative of those communities, complemented by aspects of organism health based on ecotoxicological principles. These indicators can be used to identify restoration of degraded areas of the Great Lakes.

BRINKHURST, R.O., Aquatic Resources Center, Box 808, Franklin, TN, 37065-0808
A recent advance in the use of benthic communities as bioindicators of ecosystem health.

Tables of data derived from quantitative samples of the benthos are difficult to interpret. Attempts at clarification for non biologists have progressed from the indicator species concept, through point-scores for pollution tolerance summed to create indices, to statistical methods. Increasing taxonomic, ecological and toxicological knowledge showed the indicator species concept to be naive. Indices usually assume equal tolerances to all possible contaminants. Diversity indices ignore taxonomic differences between sites. The data do not meet the requirements for parametric statistics. Multivariate, non-parametric statistics utilize all of the data, but the identification of clusters is subjective. One new alternative is to identify statistically significant clusters, and to test for significant differences between clusters with a combination of the Fowlkes-Mallows statistic and the bootstrap procedure. Examples of the sensitivity of this method will be given.

WHITE, David S. Hancock Biological Station, Murray State University, Murray, Kentucky 42071, U.S.A.
Functional structure of large lake benthic communities from the shoreline outward.

Theoretical benthic community structures for large lakes were developed based on feeding mechanisms, habits, distributions of substrata and organic matter, and selected limnological features. Primary physical factors are substratum type and frequency of resuspension, depth of light penetration, and depth of the thermocline; feeding categories are predators, surface algae grazers, suspension filterers, and both surface and subsurface deposit gatherers; habits are surface dwellers, and near-surface and subsurface burrowers. Six unconsolidated substrata zones and their major components were identified from the shoreline outward: 1) high energy zone (resuspension >>deposition, coarse sand & gravel, subsurface deposit gatherers, burrowers); 2) intermediate energy zone (resuspension>deposition; sand & organic patches, burrowers; 3) low energy zone (resuspension≈deposition, sand mixed with organic matter, benthic algae population if light penetration, maximum diversity, all feeding mechanisms and habits present; 4) infrequent energy zone above the thermocline (resuspension<deposition, organic matter mixed with sand, suspension filterers and deposit gatherers, surface dwellers and burrowers, maximum density); 5) infrequent energy zone below the thermocline, (resuspension<deposition, organic matter mixed with sand, subsurface deposit gatherers, burrowers); 6) deep benthic zone (resuspension<<depostition, fine organic matter, subsurface deposit gatherers, burrowers). Distributions of most macrobenthic species were limited to one or two zones. The data show promise in assessment of benthos that should be present at any large lake site given physical conditions.

WARWICK, W. F. National Hydrology Research Institute, 11 Innovation Blvd., Saskatoon, Saskatchewan, Canada. S7N 3H5 **Morphological deformities in chironomid larvae as measures of ecosystem health.**

Chironomids possess a number of advantages for accessing the complex and dynamic world of freshwater ecosystems. As a family, they integrate the key features of almost every type of aquatic habitat. While their biomonitoring capabilities have already been demonstrated in the Lake Classification System, morphological analyses extend these capabilities, but focus on contaminant rather than trophic effects and operate at greater levels of discrimination, ie. at individual rather than population or community levels of organization. Lac St. Louis, a river-lake on the St. Lawrence River, represents a case study where assessment of deformities in the ligula and antennae of *Procladius*, the dominant surviving component of the benthic community, clearly identified one of the source areas of contamination. The index of Chironomid Community Response rose dramatically from 0.263 at a site some 7 km away to 1.359 at a site immediately offshore from the industrial complex at Beauharnois, Quebec. Analysis of head capsule remains in the latter area revealed that many former components of the chironomid community had already been eliminated. Efforts to automate morphological analysis using Artificial Intelligence techniques are being undertaken to improve uniformity of assessment and accessibility to user groups.

DICKMAN, M.D., RYGIEL, G.A., GHAZI, N. Biological Sci. Dept., Brock University, St. Catharines, Ontario L2S 3A1, and DIGGINS, T.D., and STEWART, K.M., Dept. Biological Sci., SUNY/Buffalo, NY 14260. **DEFORMITIES IN CHIRONOMID LARVAE AS AN INDEX OF TOXIC SEDIMENTS IN THE NIAGARA RIVER WATERSHED.**

Chironomid larvae may serve as ecological indicators of contaminated sediments by their reduction in numbers and extent of deformities (particularly their deformed menta/teeth). Results to date, from an examination of chironomids from various locations in the Niagara River Watershed, revealed the following. At a coal tar contaminated site in the Chippawa Creek (Ontario) sediments, 8.5-14% of the chironomids were deformed. About 22% of the chironomids from the Welland River (Ontario) sediments, near a discharge from a PVC manufacturer, were deformed. Downstream of a steel plant in the latter river, where sediments were contaminated with oils and heavy metals, 27% of the chironomids were deformed. In portions of the Buffalo River (New York), an IJC designated area of concern (AOC), the extent of toxicity was such that numerous dredge samples were required to obtain even a few chironomids. A recent sampling of the Buffalo River showed an inverse relationship between chironomids and oligochaetes in that the highly polluted middle portion of the river had low numbers of chironomids - but surprisingly high numbers of oligochaetes.

STOERMER, EUGENE F., Center for Great Lakes, University of Michigan, Ann Arbor, MI.
Algae as Indicators of Ecosystem Health.

Algal species or communities provide useful indications of ecological perturbation over a wide range of time/space scales. The Great Lakes, because they contain very large and steep time/space gradients related to anthropogenic perturbation, provide particularly interesting and instructive examples. Many species show very rapid (sec - day) direct cellular level responses to toxic chemicals. Such responses are detectable in mixing zones near river mouths and other influents. Direct growth responses, both enhancement and inhibition, occur on longer time scales (hrs - weeks) and can be mapped on regional scales. Integrated successional effects occur on longer (days - yrs) time scales and can be mapped on regional or whole-lake scales. In theory, properly implemented systematic sampling programs could extend time scales to the future at any degree of temporal or spatial resolution desired. For certain algal groups, successional records can be extended historically on annual to millennial time scales through paleolimnological studies. In particular, the very abundant and diverse diatom assemblages found in Great Lakes sediments provide a sensitive integrative index of ecological change, and the causes thereof, during the past two centuries. This approach is particularly useful for detecting subtle, long-term effects. Recent studies also suggest that, due to temporal and spatial integration obtained in paleolimnological samples, sedimentary diatom assemblages can provide a more sensitive index of recent perturbation than comprehensive monitoring using neolimnological methods.

HARRIS, H. J., ERDMAN, T. C., LODGE, K. B. and ANKLEY, G. T. University of Wisconsin-Green Bay and EPA Environmental Research Laboratory, Duluth, Minnesota. Measures of Reproductive Success and contaminant concentration in Forster's Tern on Green Bay, Lake Michigan.

A study of Forster's Terns in 1988 on lower Green Bay revealed improved reproductive performance when compared to a similar study conducted in 1983. Length of the incubation period, hatchability and number of young produced per pair were indistinguishable from values observed on a "clean" reference colony. Total median PCB concentration in eggs from 1988 was 66 percent lower than the 1983 level (22.2 ug/g). 3,3',4,4',5-PCB was 30 percent lower in 1988, and total TCDDeq was 14% lower than 1983 values. We estimated tern chicks would need to ingest PCB at the average rate of 18 ug/day to acquire the concentrations observed during growth. Some chicks appeared to suffer from "wasting" syndrome.

STARK, ALICE D., Director, Bureau of Environmental and Occupational Epidemiology, NYS Department of Health and KAGEY, BETSY T. **MATERNAL RESIDENCE IN THE GREAT LAKES DRAINAGE BASIN AND ADVERSE REPRODUCTIVE OUTCOMES**

This paper examines indicators of human reproductive health of the population residing within the hydrogeologic area known as the Great Lakes Drainage Basin (GLDB). To study the health impact of residence within the GLDB on reproductive outcomes as well as providing baseline data on the reproductive health of the entire GLDB population, an ecological epidemiologic study of that portion of the GLDB that lies within New York State was conducted. The specific objective of this study was to determine if women residing within the GLDB during the time period of 1968-1987, were at greater risk of having lower birth weight infants when compared to those infants born in New York State outside of the GLDB, (excluding NYC). Utilizing birth certificate data, birth weight and gestational age were studied. The protocol for this study has been developed so that each of the additional 7 states which border the Great Lakes in the U.S. could replicate this study. Ultimately, information from all of these studies could be combined to provide the first human health study of the entire Great Lakes Basin within the United States. It also may be possible to adapt this protocol to the existing Canadian data bases.

HOPPES, William G. Niagara Frontier Program Office, Region II EPA 26 Federal Plaza, New York, NY 10278. **Responsible stewardship of the Lake Ontario ecosystem: quantitative indicators to monitor binational efforts.**

As part of an effort to monitor the health of the Lake Ontario ecosystem, a binational technical committee is developing quantitative indicators to measure the following objective for responsible stewardship of the Lake Ontario ecosystem: human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship. A summary of the initial efforts of the committee is presented, focussing on 1) the features comprising "responsible stewardship" of the Lake Ontario ecosystem 2) the "state" of those features that constitutes "responsible stewardship", 3) the degree current lake stewardship deviates from the "preferred state" 4) appropriate, quantifiable measures to track changes in the state of those features.

THOMPSON[1,2], Patsy-A., R. Chasse[1] and P. Couture[1]. [1]Institut National de la Recherche Scientifique (INRS-Eau) C.P. 7500 Sainte-Foy, Qc, Canada, G1V 4C7. [2]Present address: Wadsworth Laboratories, New York State Dept. of Health, Empire State Plaza, Albany, NY, 12201-0509. **Eco-physiological indicators of contaminant effects on microalgal communities.**

The standard Selenastrum capricornutum toxicity test measuring a percent reduction in cell density is routinely used as a screening tool to assess the effects of pure chemicals and complex effluents on microalgal communities. However, reliable predictions concerning the health of phytoplankton and periphyton communities exposed to these toxic effluents are not easily obtained from extrapolations of these toxicity test results. Difficulties arise more particularly in predicting the potential recovery of lotic phytoplankton communities exposed to these toxic effluents for short periods. Assessing the potential impacts of complex effluents containing both growth inhibiting and growth stimulating substances also poses problems. In this context, our laboratory is attempting to develop routine ecophysiological indicators of growth recovery and altered autotrophic metabolism. The ATP/ADP and Protein/Lipid ratios have been shown to be good indicators of growth recovery in S. capricornutum populations exposed to Cd and to a complex industrial effluent. The heterotrophic index (photosynthetic C assimilation / heterotrophic C assimilation) reveals changes in the metabolism of periphytic communities receiving effluents from a pulp and paper mill. Data on community structure modifications responsible for this metabolic shift will be presented.

McNaught, D.C. Dept. of Ecology, Evolution and Behavior, University of Minnesota, Minneapolis, MN 55455. *Behavioral Assays for Detection of Sublethal Effects from Complex Effluents and Pore Waters.*

Behavioral modifications have resulted from sublethal chronic exposure to toxic contaminants introduced into Great Lakes ecosystems. Such modifications threaten ecosystem integrity. Behavioral changes have been documented in the herring gull, as well as in infants of human mothers, with fish consumption involved in both cases. Yet ecotoxicologists have not performed such assays with zooplankton, which have the advantages of ease of culture, short generation times, and high fecundity. This must be done, because while high-level exposure of crustaceans has led to mortality or gross physiological changes, the subtler behavioral changes associated with low-level exposure to these same chemicals may be much more common. Previously we proposed four bioassays, all based on dominant behaviors of cladocerans which undertake diel vertical migrations. They involved: 1) modification of the timing and extent of vertical migration; 2) the response of populations to the angular light distribution characteristic of all waters; 3) the response of populations to polarized light, and 4) certain behavioral characteristics of the cladoceran compound eye. Three of these assays have been tried and results will be presented and discussed. Recommendations will be made relative to their potential for widespread application.

EDSALL, Carol Cotant and Mac, Michael J. U. S. Fish and Wildlife Service, Ann Arbor, MI. Use of Clinical Blood Chemistry to Assess Health of Laboratory-Reared and Field-Sampled Lake Trout

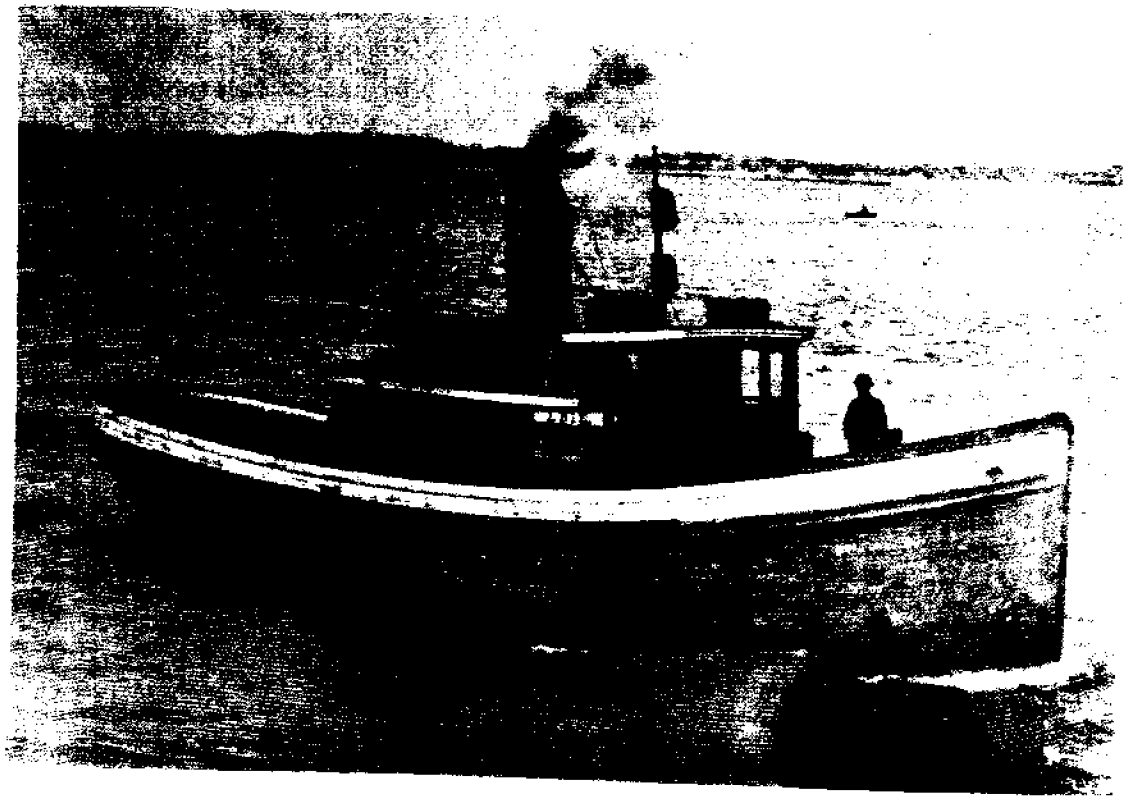
Knowledge of blood chemistry and its diagnostic utility in feral fish is greatly limited. Normal ranges of several clinical blood parameters (glucose, total protein, amylase, alkaline phosphatase, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) have been established for laboratory-reared lake trout (Salvelinus namaycush). Measurements were made accurately and rapidly using a Kodak Ektachem DT60 Analyzer and the Ektachem DTSC Module. Adult lake trout in spawning condition were sampled from northwestern Lake Michigan; eggs from individual females were fertilized and returned to the laboratory for incubation. In addition, blood samples were taken from each lake trout. Ranges of above-mentioned parameters will be compared to the ranges found in the field-sampled trout. Survival to hatch and survival of normal fry will be monitored and correlated with the blood analysis of the parent trout. Establishment of normal ranges for these blood parameters in laboratory-reared fish is important for comparison with field-sampled fish to evaluate clinical blood chemistry as a tool for monitoring fish health.

NEWSTED, J.L., GIESY, J.P., JONES. P.D., CRAWFORD, R., [1]GOOCH, J., Department of Fisheries and Wildlife, Pesticide Research Center, Institute of Environmental Research, Michigan State University, East Lansing, MI., [1]University of Maryland-CEES, Solomons, MD.
Development of Toxic Equivalency Factors for Planar Halogenated Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss).

Planar halogenated hydrocarbons are a group of environmental contaminants which consist of polyhalogenated biphenyls, dioxins and furans. Toxic effects include immunotoxicity, hepatotoxicity and reproduction dysfunction. It is believed that all PHHs act via a common mode of toxic action that is mediated by the aryl hydrocarbon (Ah) receptor. Due to PHHs common mode of action, it is possible to calculate relative potency factors of individual PHHs and mixtures by expressing their toxicity relative to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for endpoints such as cytochrome P-450 and aryl hydrocarbon hydroxylase (AHH). This approach has been adapted to determine the contribution of PHHs to observed environmental effects. However, preliminary studies have indicated that TEFs developed in mammals may not be appropriate for assessing the effects of PHHs in salmonids. Here we report the results of a study that was conducted to develop TEF for PHHs in rainbow trout using the AHH induction, cytochrome P-450E and cytochrome P-450 mRNA as endpoints. The results of this study show that rainbow trout derived TEFs significantly differ from mammalian values. As a result, specific TEFs should be developed before this approach can be used to assess the effects of PHHS to other species.

DID YOU KNOW

Buffalo had the worlds longest breakwall in 1897.



Buffalo Harbor - 1900's.

TRANSPORT OF PARTICLE-ASSOCIATED CONTAMINANTS IN LARGE SURFACE WATER BODIES

Convenor: James Bonner

Session 4E - Wednesday, June 5
8:30 AM - 12:00 PM

4 Knox Hall

LOGAN, BRUCE E., Environmental Engineering Program, Department of Civil Engineering, University of Arizona, Tucson, AZ 85721, **"Fractal dimensions of aggregates formed in natural systems".**

Aggregates in lakes, rivers and oceans have fractal, and not Euclidean, geometries. Fractal dimensions of marine snow aggregates, obtained from settling velocity and porosity data, are 1.26 and 1.39-1.52, respectively. Lacustrine aggregates span a similar range of fractal dimensions of 1.39-1.69. These values are lower than fractal dimensions of 1.8-2.2 obtained for laboratory-generated inorganic aggregates. Aggregates are formed by physical coagulation mechanisms of Brownian motion, shear, and differential sedimentation. We have derived a set of collision functions containing a fractal dimension for use in a general coagulation equation. These collision functions predict greater collision frequencies than models based on spherical particles with Euclidean properties. Assuming only one mechanism of aggregate formation is dominant for a range of particle sizes, we also incorporated a fractal dimension in a dimensional analysis of steady-state particle size distributions. Using particle-size distributions observed in marine systems, we calculated that aggregates formed by shear coagulation had fractal dimensions greater than 2.4, whereas aggregates formed from differential sedimentation had lower fractal dimensions in the range of 1.61-2.31. These values are slightly larger than fractal dimensions obtained using other techniques. Overall, fractal dimensions for many biological aggregates from natural systems and engineered reactors are in the range expected for formation by differential sedimentation. Fractal dimensions of inorganic colloidal aggregates are in the range calculated for aggregation by Brownian motion and shear coagulation.

GUO, J. and KRAMER, J.R.
Dept. of Geology, McMaster University, Hamilton, Ontario, Canada, L8S 4M1
DOUBLE LAYER INTERACTION MODEL AND PARTICLE CONCENTRATION EFFECT IN WATER

A double layer interaction model was developed in the study of the particle concentration effect on adsorption. The hypothesis is: At high particle concentration and low ionic strength, double layers of sorbent particles overlap to a significant extent. This interaction counteracts columbic adsorption and consequently reduces the partition coefficient. Experimental observations support the model prediction. The sorbent for the preliminary demonstration of the particle concentration effect was kaolinite. Later, glass beads were employed to minimize possible interference from other mechanisms as well as to provide precise information for model calibration. On equilibration of the adsorption system, particles were separated from solution by both filtration and centrifugation. In other experiments, a Couette device was also constructed to examine the impact of collision on adsorption. The model (with experimental confirmations) gives limits for the particle concentration effect.

STANGE, Kari and SWACKHAMER, Deborah L. Environmental and Occupational Health, School of Public Health, Box 197 UMHC, University of Minnesota, Minneapolis, MN 55455. **Uptake of Hydrophobic Organic Compounds (HOCs) by Phytoplankton: A Species Comparison.**

The concentration of HOCs in phytoplankton at equilibrium with the surrounding water can be described by the bioaccumulation factor (BAF). The BAF for lipophilic compounds has been correlated to the octanol-water partitioning coefficient (Kow). Equilibrium between phytoplankton and HOCs is commonly reported to be reached within the range from 1 hour to 3 days in laboratory experiments. However, earlier studies in this laboratory have shown that the partitioning of HOCs between water and the green algae *Scenedesmus sp.* require weeks to months to reach equilibrium. This study examined species differences in the uptake of HOCs by comparing rates of uptake, and whether differences in BAF among species could be explained by differences in algal lipid content. We investigated partitioning of 40 PCB congeners in unialgal batch cultures over 2-5 weeks. Correlation of Kows and lipid normalized BAFs at chosen time points were compared between a green algae, a blue green algae and a diatom. Cultures were incubated at sub-optimal temperature conditions to limit growth and its effect on equilibrium.

BURNS, S.E., HASSETT, J.P. Dept. of Chemistry, State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210. **Mirex Contamination and Transport in the Oswego River.**

The Oswego River has been a source of mirex loading to Lake Ontario since the 1960's. In this study, water samples and sediment cores were collected from the Oswego River to determine the present extent and distribution of mirex contamination in river sediments and to determine the mechanism and magnitude of mirex transport by the river. Detected mirex concentrations in whole water samples taken from the river on 12 occasions between December, 1989 and June, 1990 ranged from 35 to 1156 pg/L. The calculated average loading of mirex to Lake Ontario based on these whole water concentrations is 2 kg/yr. Separate analyses of particulate and dissolved mirex fractions were performed on a smaller series of water samples. The results of these analyses suggest that the dominant transport mechanism in the river is particulate. Analysis of sediment cores is ongoing. To date, mirex concentrations in cores taken at 11 sites from 0.7 to 14.6 km upstream of Lake Ontario range from 0.1 to 564 ng/g, with the highest concentrations occurring in sediments behind a dam 0.7 km upstream from the mouth of the river.

OLSON, Daniel G. and SWACKHAMER, Deborah L. Environmental and Occupational Health, School of Public Health, Box 197 UMHC, University of Minnesota, Minneapolis, MN 55455. **Microbial Cycling of Hydrophobic Organic Compounds in Bottom Waters of the Great Lakes.**

Recent evidence indicates that a substantial amount of particulate-associated hydrophobic organic contaminants (HOCs) leaving the water column by sedimentation are not incorporated into the sediments but are recycled back into the water column in the dissolved phase. We hypothesize that particulate associated HOCs are released from particles in bottom waters by heterotrophic bacteria during the normal course of mineralization of natural organic matter. Experiments with water collected from several depths in Lakes Ontario and Superior incubated with ^{14}C-2,2',4,4',5,5'-hexachlorobiphenyl-labeled detritus showed the removal of the ^{14}C-HCB from the detritus during decomposition. The results suggest a linkage between natural carbon cycling and HOC recycling. Such a linkage implies that permanent burial of HOCs into the sediment will be delayed and will be accompanied by an increase in water column residence times. Thus, the exposure time of HOCs to the aquatic foodweb may be increased.

SHENG, Y. PETER
COASTAL & OCEANOGRAPHIC ENGINEERING DEPARTMENT
UNIVERSITY OF FLORIDA, GAINESVILLE, FL 32611
TRANSPORT OF FINE SEDIMENTS AND NUTRIENTS IN LAKE OKEECHOBEE

This paper presents a study on the transport of fine sediments and nutrients in Lake Okeechobee during spring 1989. Intensive field surveys were conducted to measure wind, current, temperature, suspended sediment concentration, and concentrations of various phosphorus components. Laboratory and field experiments on sediment properties were also conducted. Based on the comprehensive data, resuspension rate of fine sediments was determined and found to be an order of magnitude larger than that determined in the laboratory, due to the strong influence of waves in the field. Resuspension rate of phosphorus was found to be typically two orders of magnitude larger than the diffusive flux of phosphorus. A three-dimensional hydrodynamic and sediment transport model successfully simulated the wind-driven currents and sediment transport during a 4-week period. The phosphorus model also reproduced some features of field data. A video tape showing the computer animation of the simulation results will be presented.

LICK, W., LICK, J., and ZIEGLER, C.K., Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106. **THE RESUSPENSION AND TRANSPORT OF FINE-GRAINED SEDIMENTS IN LAKE ERIE.**

The resuspension and transport of fine-grained sediments in Lake Erie has been modeled. The emphasis was on the effects of major storms. Calculations were made for a variety of constant wind speeds and wind directions and also for major storms including the November 1940 storm, one of the largest in the last century. It is shown that major storms, despite their infrequent occurrence, are responsible for most of the transport of fine-grained sediments in Lake Erie, especially in the deeper parts of the lake. The results of the calculations are used to more quantitatively interpret geochronological data from Lake Erie.

KO, FUNG-CHI and BAKER, JOEL E. Chesapeake Biological Laboratory, University of Maryland System, P.O. Box 38, Solomons, MD 20688 **Particle-mediated transport of hydrophobic organic contaminants in Chesapeake Bay.**

Estuaries are among the most productive natural habitats in the world. The cycling of particles and organic matter in estuaries is controlled by highly variable physical, chemical and biological processes. Since hydrophobic organic contaminants (HOCs) associate with solids, their transport is controlled by the dynamics of particle formation and movement. We hypothesize that sediment transport (resuspension) and biological activity (primary production, degradation and zooplankton grazing) control the transport and residence times of particles and HOCs in Chesapeake Bay. We are currently investigating these processes in Chesapeake Bay using sediment traps, sediment coring, and high volume, size-specific filtration at a mesohaline station. These samples are being analyzed for a variety of HOCs, including PCBs and PAHs, to obtain contaminant inventories, settling fluxes, and recycling rates. Initial results suggest that intense sediment resuspension events introduce large quantities of sediments and HOCs into the overlying water.

COOK, Philip M., Environmental Research Laboratory (USEPA), 6201 Congdon Boulevard, Duluth, Minnesota 55804. **Unique Opportunities for Study of Particle-Associated Contaminant Transport and Fate in Lake Superior Using the Exogenous Mineral Cummingtonite-Grunerite.**

Cummingtonite-grunerite, an iron magnesium silicate of the amphibole group, was discharged into Lake Superior with 5×10^{11} Kg of finely crushed rock (taconite tailings) during the period of 1956-1980. Since this mineral is very rare in the Lake Superior watershed, its concentration, as measured by x-ray diffraction for Lake Superior sediment samples, provides a good indication of how fine particles from a point source discharge to the open lake are transported and sorted over many years of residence in the lake. The historical record and the present distribution of this large volume of unique tracer particles could be utilized to study how hydrophobic organic contaminants adsorbed to inorganic particles in an effluent or tributary would distribute in sediments of a dynamic large lake system. Also, at some locations in western Lake Superior undisturbed recent sediment deposits contain distinct annual varves due to the influence of tailings on sedimentation. The year of each varve can be identified from the tailings discharge record so that concentrations of PCBs and other persistent organic chemicals may be measured and relative annual contaminant loading factors to the lake determined.

CARTER, DONNA S. and HITES, RONALD A., School of Public and Environmental Affairs and Department of Chemistry, Indiana University, Bloomington, IN 47405 USA. **FATE AND TRANSPORT OF DETROIT RIVER DERIVED POLLUTANTS THROUGHOUT LAKE ERIE.**

The influx of persistent, toxic pollutants is one of the foremost problems affecting Lake Erie. The majority of these contaminants come from the Detroit River; thus, the transport and fate of Detroit River derived pollutants are major environmental concerns. We have found that a series of structurally unusual alkyl phenols, originating from a single point source in the Trenton Channel of the Detroit River, are useful as specific chemical markers for studying the fate and transport of Detroit River derived, sediment-bound pollutants. Gas chromatographic mass spectrometry has been used to determine 2,4-di-*tert*-pentylphenol (24DP), the most abundant of the marker compounds, in Lake Erie sediment cores. Since the source of 24DP is known, its measurement throughout the Lake unambiguously establishes a source-sink relationship for all Detroit River derived pollutants, providing that 24DP can accurately represent them. Using measured 24DP concentrations and a simple compartmentalized model of the Lake Erie basins, relative pollutant loads within each of the basins and interbasin transport rates have been estimated.

1897 view of area East of Main Street Buffalo.

IMPLEMENTING SUSTAINABLE DEVELOPMENT AND THE ECOSYSTEM APPROACH IN GREAT LAKES DECISION-MAKING

Convenors: Tom Muir and Barry Boyer

Session 5B - Wednesday, June 5
3:20 - 5:20 PM

Session 6B - Thursday, June 6
8:30 AM - 12:10 PM

109 Knox Hall

MUIR, TOM, Environment Canada, Ontario Region, Canada Centre for Inland Waters, P.O. Box 5050, Burlington, Ontario L7R 4A6
Development, Growth and Sustainability

The major obstacle to achieving sustainable development is the view in which unconstrained exploitation, and expansionary population and economic growth are desirable and even necessary. This view of economy, the paradigm of "growth," is still praticed and planned for at the local level by many, if not most, Great Lakes communities. As a general strategy, this works only so long as the surroundings can stand the changes involved, and if the marginal costs of growth are declining or constant. Case studies of several communities in the Lake Ontario basin are examined from the perspective of the economic and environmental sustainability of their official development plans. It was found that the environmental and economic impacts of population growth, and city form are not adequately recognized. Suburban sprawl, the most taxpayer subsidized, and environmentally damaging form of development, is still favoured. This is a major cause of inflation in tax rates, land prices, rents, infrastructure costs, and the general cost of living and doing business. As well, plans include an acceleration in the growth that is beneficial. One form is called "intensification," and it is shown how this can be complementary to Remedial Action Plans.

SHIMIZU, RONALD and REGIER, HENRY A., Institute for Environmental Studies, University of Toronto, Toronto, Ontario M5S 1A4
Towards Green Governance

Two very significant themes have emerged in Canadian society during the past two decades: concern for the environment, and the call for public participation. In Canada, we note the renaissance of French Canadian nationalism, the empowerment of the Canadian indigenous peoples, and the rise of feminism. These social forces, along with the environmental movement, have changed the cultural, social and political landscape of Canada. These forces are affecting the values, beliefs, attitudes and actions of Canadians. A common factor is the call for participation. Concern for the environment challenges the basic North American belief in technological progress, and the demand for participation challenges the legitimacy of existing decisionmaking processes. Concern for the environment appears to be taking a more prominent position in the values of the individual and of the citizenry, displacing, modifying, or replacing other values. We will describe a view of environmentalism grounded in the concept of ecosystem integrity which both reflects and nurtures this shift in values. Also, we will explore the implications for governance in the Great Lakes Basin Ecosystem.

RIVERS, RAY and MILBRATH, LESTER, Environment Canada, Ontario Region, Canada Centre for Inland Waters, Burlington, Ontario and State University of New York at Buffalo, Department of Political Science, Buffalo, New York
Learning Sustainable Development

Attitudes towards development have been fashioned by a cultural heritage in which the planet is portrayed as a frontier with largely unlimited resources and with humans in the centre. This egocentric perspective of the global ecosystem has led to the kinds of human intervention where the long term existence of this planet is threatened. The publication of "Our Common Future" by the World Commission on Environment and Development was the first significant world-wide effort to change the way that human society views itself in relation to everything else in the global biosphere. It is clear that, if the issues raised in the report are to be addressed, society must change its attitude to the environment and to the nature of human activity in the ecosystem. While formal education, at the elementary levels, is crucial for this attitude change to come about, that clearly will not be enough. Churches, universities and the information media must become a greater part of the reformation process, and accept a greater share of the responsibility for the conditioning of society to environmental ethics. Professional training at trade schools and within universities must challenge the conventional wisdom and consider the impact of these activities by professions on long term survival of the ecosystem. It is only in this way that society can hope to become sustainable.

WESTRA, LAURA, Ph.D., Department of Philosophy, University of Windsor, Windsor, Ontario N9B 3P4
Sustainable Development and the Ecosystem Approach: Is There a Conflict?

While the "ecosystem approach" and the call to "integrity" are fairly recent developments in both planning and theory, the concept of "sustainable development" is a well-established one, supported--in a rare unity of aims and purposes--by scientists, religious leaders and people in grass-roots movements alike. Yet for all their apparent similarities, there are great differences between "sustainability" and "integrity." International agencies concerned with sustainable development are intent upon fostering policies and practices that will feed the world's starving people, on a continuing basis, globally. Their primary concern is with human suffering and hunger, not with instilling respect for non-human entities. Yet they are also concerned with altering a mind-set that dictates practices and regulations which are divisive, limited in scope as well as geographically, and entirely profit-oriented. I propose an analysis of the two concepts, that is of "sustainable development" and "integrity" which helps to understand how they relate to one another, and how the two could be best utilized in policy-making.

KELLOGG, WENDAY A., Dept. of City & Regional Planning, Cornell University; 17 St. John's Place, Buffalo, NY 14201
Remedial Action Plans: Water Quality or Ecosystem Planning?

To what extent do Remedial Action Plans developed for Areas of Concern embody an "ecosystem approach" as a planning framework and foster sustainable development in their recommendations? The paper presents results from a study of the role of public advisory committees in five Areas of Concern in New York and Ontario. Methods consist of interviews with members of advisory committees and lead agency staff, observation of public meetings, and content analysis of planning documents. Data suggest a tension between the advisory committees and lead agencies in their conception of what constitutes an "ecosystem approach"--both in terms of scientific indicators and institutional arrangements--and the appropriate integration of sustainable development goals into the RAP itself. Resolution of these differences will likely prove critical for increasing community support for implementation of the RAP and the long-term efficacy of the RAPs for guiding environmental and economic planning and policy decisions in the Area of Concern.

WELLER, PHILIP and ENRIGHT, SEAN, Great Lakes United, SUC/Buffalo, Cassety Hall, 1300 Elmwood Avenue, Buffalo, New York 14222
Implementing an Ecosystem Approach

Remedial Action Plans in the Great Lakes-St. Lawrence River system offer a significant opportunity to put into practice the ideal of managing the Great Lakes as an ecosystem. While much rhetoric about the need for an ecosystem approach has been articulated since the concept was first written into the Great Lakes Water Quality Agreement there has been few practical attempts to implement such an approach. An ecosystem approach needs to be applied throughout the Great Lakes basin and in site specific locales. This presentation will review the experience of incorporating ecosystem management in Remedial Action Plans and present views on how "an ecosystem approach" can be fully adapted in these areas of concern. Principles for "ecosystem approaches" in Remedial Action Plans will be presented.

HUNT, CONSTANCE E., Special Assistant, Lakewide Management Plans, U.S. EPA, Region V 230 S. Dearborn, 5-WQS-TUB-8, Chicago, IL 60604
Lake Michigan Lakewide Management Plan for Critical Pollutants

Annex 2 of the Great Lakes Water Quality Agreement, as amended in 1987, requires Canada and the U.S. to formulate Lakewide Management Plans for Critical Pollutants (LaMPs) for each of the Great Lakes. The Water Division within Region V of the U.S. EPA has the lead responsibility for development and implementation of LaMPs for Lakes Michigan, Erie, Huron and Superior. The Lake Michigan LaMP, a multi-media, interagency process to identify ecological impairments and the pollutants responsible for those impairments, locate pollutant sources, quantify and reduce pollutant loads, and monitor the environmental results, is currently underway.

LOUCKS, ORIE, RENWICK, WILLIAM, and EREKSON, HOMER, Miami University, Oxford, Ohio
Assessing the Industry-Environment Partnerships in Pursuit of Sustainability at RAP Sites

The widespread acceptance of "sustainable development" as a paradigm presumed to offer a strategy for compatible long-term multiple use of resources such as those of the Great Lakes is being challenged by a view that the concept is a contradiction in terms (by definition) and only a license to continue incompatible exploitation, albeit more subtly than in the past. The "Sustainability Perceptions Project" at Miami University, Ohio, represents an initiative by Business School faculty in finance, marketing and economics collaborating with natural scientists in geography, geology, biology and environmental science. The goal is to explore the common ground of sustainability issues and evaluate various approaches to the fostering of sustainable relationships between business, resources and the environment. A critical step is consensus on system endpoints or other measures against which success in the use of resources in a sustainable relationship is to be measured. Results on definition of these measures will be presented, using the contributions of local industries to work underway at selected Remedial Action Plan sites.

RIVERS, RAY and RYAN, J.F., Environment Canada, Water Planning and Management Branch, Ontario Region, Canada Centre for Inland Waters, Burlington, Ontario
Sustainable Development for the City of Burlington

Following the recommendations of the National Task Force on Environment and Economy by the Canadian Council of Resource and Environment Ministers for the creation of federal and provincial Roundtables on Environment and Economy, several municipalities went a step further and set up sustainable development committees to advise on planning and resource decisions at the municipal level. The City of Burlington, Ontario was one of the first municipalities in Ontario to set up a Sustainable Development Committee reporting to City Council and with a key role in advising on the official planning process for the City. The approach adopted and the successes and failures in promoting a more sustainable development at the municipal level are discussed in this paper.

BROOKS, ANN DEWITT, Commonwealth of Virginia,Council on the Environment, 903 Ninth Street Office Building, Richmond, VA 23219
Sustaining the Chesapeake Bay: Managing Population Growth and Development

While siltation, overharvesting, and toxic chemicals all are causing the decline of the Chesapeake Bay, nutrient enrichment is the major problem to be managed if the Bay is to be revitalized. The 1987 Chesapeake Bay Agreement committed its signatories to achieve a 40 percent reduction of nitrogen and phosphorus loadings entering the main stem of the Chesapeake Bay by the year 2000. To meet this commitment, the Bay states are: improving their sewage treatment facilities; changing their forestry and agricultural practices; improving their erosion and stormwater management; eliminating phosphates from their detergents; and trying to contemplate what it means to reduce nutrients by 40% in the face of tremendous growth pressures. The Chesapeake Bay Program has caused the Bay community to face for the first time the consequences of "business as usual" growth and development. Each jurisdiction has responded differently and a number of creative programs have been developed. The paper will discuss the management of population growth and development in the Bay area. While "sustainable development" has not been a byword of the program, that is what we are tyring to accomplish. Whether we will succeed is as yet unkown.

FINDLAY, RICHARD, Ontario Round Table on Environment and Economy, 790 Bay Street, Suite 1003, Toronto, Ontario M7A 1Y7
Implementing Sustaintable Development in Ontario

We are beginning to discuss the answers to some very important questions: What sort of legacy will we be leaving future generations? Will it be a legacy of polluted air and water and depleted resources? Or can we shape the future so that our actions lead to the long-term management of resources in such a way as to ensure the environment is protected? The general response to these questions is that society must move quickly to adopt a strategy for sustainable development. The challenge is to develop a strategy that brings environmental considerations more into the mainstream of economic decision making. In Ontario, to provide leadership and direction in meeting the challenge, the Ontario government established the Round Table on Environment and Economy. Representing environmental organizations, industry, labour, agriculture, aboriginal peoples, academia and government, the 21 members of the Round Table reflect the need to involve all sectors of society in integrating environmental planning with economic planning. The release of the Round Table's Challenge Paper is the first important step in preparation of Ontario's strategy for sustainable development. It explores the environmental and economic issues that must be addressed and presents six principles which will be used to guide and implement sustainable development.

SERAFIN, RAFAL, Heritage Resources Centre, University of Waterloo, Waterloo, Ontario N2L 3G1
Assessing Institutions for Sustainable Development: Lessons From Great Lakes Management

Efforts to manage Great Lakes water quality can be traced back to the late nineteenth century. Four historical periods can be identified in the search for sustainable development: (1) "Early conservation," c1870-1914; (2) "Crass exploitation," c1915-1955; (3) "Ecodevelopment," c1955-1975; (4) "Towards ecosystem integrity," c1975-present. Each one of these historical periods has been associated with a distinctive set of institutional arrangements which can be characterized in terms of distinctive information systems and communication strategies. The argument of the paper is not that the most recent historical period is somehow "best" or most evolved, but that it is part of an historical process. Taking an historical perspective on the strengths and weaknesses of past experiences provides the opportunity not only for assessing the current practice of Great Lakes management, but also an opportunity for improving assessment methods in environmental management and planning more generally.

SLOCOMBE, D. SCOTT, Department of Geography, Wilfrid Laurier University, Waterloo, Ontario N2L 3C5
Integrating Ecosystem Dimensions for Indicators of Sustainability

The effort to prevent and remediate problems due to the interaction of human society and the natural environment in the Great Lakes Basin has been guided for more than ten years by the ecosystem approach. Today the concepts of sustainability and sustainable development are providing new goals to guide those efforts. The key to operationalizing sustainable development is devising measures of progress toward it--indicators. As the ecosystem approach seeks to integrate ecological, social, political, economic and ethical dimensions of the Basin, so must indicators of sustainability. Within a nonequilibrium systems theory framework concepts such as complexity, integrity, change, landscape, transformation, and catastrophe contribute to integrating insights from ecosystem science, landscape ecology, human ecology, thermodynamics and organization science in selection of indicators. Synthetic indicators, e.g., landscape heterogeneity, social/ecological feedbacks, and system dissipation, not only tell us where we are in relation to sustainability, but also give some indication of limits and alternatives to traditional development.

BOYER, BARRY, Director, Baldy Center for Law and Social Policy, State University of New York at Buffalo, Buffalo, New York 14260
Building Legal and Institutional Frameworks for Sustainability

While the U.S. has lagged behind Canada in adopting ecosystem protection and sustainable development as social goals, neither country has made great progress in modifying governmental policy or private behavior to achieve these goals. One reason may be the lack of an appropriate normative and organizational infrastructure. Based on experience with Remedial Action Plans, several dimensions of this infrastructure can be identified: (1) Further technical and policy development to translate the broad goals into relatively simple and understandable operational mandates; (2) Development of appropriate reality checks to avoid manipulative oversimplification of success measures; (3) Redesign of legal and regulatory mandates to move ecosystem restoration and sustainability concerns from a peripheral to a central position; (4) Popularization of appealing visions of desired future states, as well as negative stereotypes of environmentally destructive acts and values; and (5) Training and empowerment of intermediary persons and organizations to bridge the gap between technocratic scientific and policy elites and mass publics.

MULDOON, PAUL, Director of Programs and Counsel, Pollution Probe, 12 Madison, Toronto, Ontario M5R 2S1
SUNSET CHEMICALS: Implementing the Concept of Zero Discharge through Pollution Prevention

The goal of "zero discharge" of persistent toxic chemicals has been a vital component of the Great Lakes Water Quality Agreement for 13 years, but there is no systematic, comprehensive program to deal with the use, manufacture, generation and discharge of these substances. This paper reviews the weaknesses of ther existing regulatory approaches to toxic chemicals and then proposes reforms to further the goal of zero discharge. Two of these reforms are the "sunset chemicals" concept and "toxic use reduction" measures. The "sunset chemical" concept involves a process for the systematic banning and phase-out of various substances or categories of toxic chemicals. The first step is developing criteria for assessing actual or potential harm. Criteria are then applied to chemicals used or found in the Great Lakes, to determine which ones will be banned or phased-out. Finally, basin governments must implement the bans or phaseouts. The second reform is developing strategies to reduce the use of toxic chemicals. Several U.S. states have enacted such laws, which set numerical reduction goals and require users to develop plans for reaching them. Other practical reform measures for achieving zero discharge will also be discussed.

AMES, ERIE, CRANE, THOMAS and DONAHUE, MICHAEL J., Great Lakes Commission, 400 Fourth Street, Ann Arbor, MI 48103-4816
Promoting Consistency in Water Toxics Regulation for Protection of the Great Lakes

The Great Lakes Critical Programs Act of 1990 codified EPA Region V's ongoing collaboration with the eight Great Lakes states to develop uniform guidelines for calculating numeric toxicant criteria and effluent limits. This effort, the Great Lakes Initiative, seeks to address toxicant accumulation in the Great Lakes, rather than the traditional focus on stream sements. However, neither the Act nor the Initiative alter the process by which the Great Lakes states currently promulgate water quality criteria or application procedures. Consequently, the potential still exists for wide differences between the states in the scope and strength of their toxics control programs. This paper will discuss the causes for the lack of consistency, the environmental and economic consequences, the Initiative's role in promoting the objectives of U.S. law and international treaty, and the Commission's efforts to inform state legislators and the public of the need to participate in andsupport the process.

KALINAUSKAS, R. and BOGGS, L., Environment Canada, 867 Lakeshore Road, Burlington, Ontario L7R 4A6
"Bridging the Gap" -- Linking Research to Decision-Making in the Implementation of Agricultural Non-Point Source Programs

An ecosystem appraoch must be adopted to link research to decision-making in the implementation of agricultural non-point source programs. Preliminary findings indicate that SWEEP (Soil and Water Environmental Enhancement Program), a $30 million federal-provincial program to reduce phosphorus loadings to Lake Erie from agriculture, has failed. Although the program advocated an ecosystem approach, no new mechanisms were established to bring about change. Research findings were ignored and the program was implemented in the conventional manner. The Non-Point Source Overview Model "bridges the gap" between research and decision-making. The model is GIS (geographic information system) based. Its ability to store, manipulate, analyze and display spatial information on soils, land use, slopes, climate, and sediment delivery facilitates an ecosystem approach. The model is being used to identify priority management areas, evaluate existing agricultural practices/programs, and analyze the impact of different policy scenerios. GIS technology can link research to decision-making. By integrating data and research from a wide variety of sources, the model provides decision-makers with the information required to support environmental sustainability in agriculture.

DONALDSON, C. and WEBB, M., Environment Canada, C&P - Ontario Region
Pollution Prevention -- A Societal Affair

Sustainable development has become the operational byword for doing business in the Great Lakes Basin with little consideration given to practical frameworks for achieving success. This paper outlines one approach based on the sustainable development principle of anticipate and prevent, the cornerstone of which is pollution prevention at source, unlike traditional command and control techniques. The suggested approach is based on: active multistakeholder involvement; promotion of prevention technologies and techniques; and extensive community and local government participation. While rooted in anticpate and prevent, the approach incorporates: environment-economy integration; ecosystem integrity; conservation and efficiency of resource use; and public-private alliances.

Richards, R. Peter and Baker, David B. Water Quality Laboratory, Heidelberg College, Tiffin, Ohio 44883. **NUTRIENT TRENDS IN SELECTED LAKE ERIE TRIBUTARIES, 1975-1990.**

Total phosphorus, soluble phosphorus, and nitrate data with near-daily resolution will be aggregated into monthly and annual loads and time-weighted and flow-weighted average concentrations. Data is available for the major Ohio tributaries to Lake Erie, including the Maumee, Sandusky, and Cuyahoga Rivers. The derived time series will be analyzed for trends using simple regression approaches and more elaborate time-series models which will account for seasonality and possible autocorrelation, and using non-parametric trend tests such as the Kendall and Seasonal Kendall tests. Preliminary results indicate that trends for total phosphorus and soluble phosphorus are downward, but nitrate trends are upward.

DOLAN, David M., International Joint Commission, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3. **Changes in Point Source Loadings of Phosphorus to Lake Erie**

After the signing of the Great Lakes Water Quality Agreement in 1972, point source phosphorus control became a priority with all of the jurisdictions around Lake Erie. Implicit recognition of the requirements of the Agreement by stipulating a total phosphorus limit of 1 mg/l for major municipal sewage treatment plants resulted in significant decreases in phosphorus loadings to Lake Erie. Recent estimates of point source loadings from municipal and industrial sites in the Lake Erie basin demonstrate that these improvements have continued as smaller sources are providing treatment and larger sources are achieving better control. The potential for further reductions will be assessed and the status of compliance will be presented. The question of reduction of loadings of other chemicals, especially persistent toxics, is considerably less straightforward, and ambient data demonstrate that improvements similar to the phosphorus decreases are not occurring.

BERTRAM, PAUL E., U.S. Environmental Protection Agency, Great Lakes National Program Office, 230 S. Dearborn St., Chicago, IL 60604. **Spring Total Phosphorus and Summer Dissolved Oxygen Trends in the Central Basin of Lake Erie, 1970 - 1989.**

With annual loadings of total phosphorus (TP) to Lake Erie presently near the targeted 11,000 tonnes, elimination of anoxia in the hypolimnetic waters in the Central Basin is anticipated, coinciding with reductions in TP concentrations. Present monitoring programs emphasize between-year comparisons of TP concentrations during isothermal spring conditions to determine long-term trends, whereas results from multiple surveys per year were previously combined to provide a different annual TP estimator. The rate of reduction of TP concentrations in the Central Basin from 1970 to 1986 was calculated from both sets of estimators based on data in the STORET database from all stations within a defined polygon in the Central Basin for those years in which at least 4 surveys were conducted, including one under isothermal spring conditions. The annual spring-only estimators did not correlate well with the multiple survey estimators, (correlation coefficient = 0.07, p=0.83), but they did indicate a similar rate of decline in TP concentrations (0.28 ug TP/L/yr vs 0.24 ug TP/L/yr, respectively). Results of recent surveys under spring isothermal conditions are consistent with the long-term rate of decline in TP concentrations. Despite reductions in TP loadings to Lake Erie since 1970, the annual normalized rate of oxygen depletion in the hypolimnion of the Central Basin, did not consistently decline between 1970 and 1987. In 1988 and 1989, however, the depletion rates were lower than any reported during the previous 20 years.

CHARLTON, MURRAY N. National Water Research Institute, P.O. Box 5050, Burlington, Ontario, L7R4A6, Canada.

Lake Erie Water Quality in 1990: Restoration or Resilience?

A series of surveys were conducted on the west, central and east basins of Lake Erie 20 years after the landmark work of "Project Hypo". Electronic profiling apparatus was used to simultaneously measure oxygen, temperature, pH, turbidity, and conductivity. Chemical analyses were similar to those used in 1970. Water clarity was exemplary in the central basin as it has been for 11 years. Despite 20 years of phosphorus load reductions and Secchi clarity >8M, anoxic conditions developed in the relatively warm and thin hypolimnion. Phosphorus release from sediments occurred in 1990. These data are consistent with a lag response of the oxygen situation to P load and this challenges the idea that oxygen depletion ever fully responded to load increases. The apparent recalcitrancy of the oxygen depletion "problem" may be explained by resilience related to the scale of the lake and the locations of loadings.

DOLAN, David M., International Joint Commission, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3. FAY, Laura A., Ohio EPA, 1030 King Ave., Columbus, Ohio 43212. RATHKE, David E., U.S. EPA, Region VIII, 999 18th Street, Denver, Colorado 80202.

Analysis of Water Quality Trends in the Western Basin of Lake Erie

The extreme spatial variability in the Western Basin of Lake Erie has confounded attempts to detect trends in open water quality which may have resulted due to the remedial efforts of the past two decades. This problem is further complicated by inconsistencies in the parameters measured and the sampling locations visited. Using cluster analysis of data available from the U.S. EPA STORET data base, a representative region within the Western Basin was identified. Factors considered were season and sample depth and location. Trends in nutrients, ions and chlorophyll *a* were then analyzed for this region using non-parametric statistical methods. Chloride and total phosphorus exhibited the strongest trends decreased over a 25-year period. These declines are attributed primarily to decreases in loadings from the Detroit River.

DRISCOLL, MARK S.; HASSETT, JOHN P.; State University of New York, College of Environmental Science and Forestry, Syracuse, New York 13210; and LITTEN, SIMON; New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233:

HETEROGENEOUS DISTRIBUTION OF ORGANOCHLORINE COMPOUNDS IN EASTERN LAKE ERIE WATER.

Water samples collected from the mouth of the Niagara River at Fort Erie, Ontario, were compared to samples collected from Lake Erie at Sturgeon Point, New York. The samples were collected from 7/24/86 to 1/24/87. The concentration of p,p'-DDE was higher in the samples from the Niagara River. The average p,p'-DDE concentration was 0.531 ng/L in the Niagara River but only 0.276 ng/L in Lake Erie. While p,p'-DDE concentration was higher in the Niagara River PCBs were not. Four PCB congeners were studied and all were significantly higher in concentration in Lake Erie. The average difference in concentration was 11%. A transect of eastern Lake Erie was made on 9/15/86 from Sturgeon Point, New York to Point Abino, Ontario. PCB concentrations were as high as 792 ng/L and had a congener pattern similar to Aroclor 1262. These high PCB concentrations were also seen for two sampling dates at about the same time in the samples collected from the Niagara River. Using a simple model and average PCB concentrations reported by other researchers these high PCB concentrations could account for an increase in the PCB loading to the Niagara River from 82 to 225%.

REYNOLDSON, Trefor B., **NWRI, CCIW 867 Lakeshore Rd, Burlington, Ontario L7R 4A6.** **Evidence on the former state and recovery of the benthos of Lake Erie.**

Surveys of the benthos of L. Erie from 1929 to the present show major changes in the faunal composition, particularly in the western basin. This was a system that was dominated by the mayfly *Hexagenia limbata* from the first survey in 1929 until its disappearance, due to oxygen depletion from eutrophication, in the early 1950's. Since that time the benthic community of the western basin has been dominated by oligochaetes. However, recent data suggests that there is evidence of recovery of the western basin. The species composition of the oligochaete community has shifted to the point where the more eutrophic species, such as *Limnodrilus hoffmeisteri*, are reduced in number and the mesotrophic species, such as the *Aulodrilus* species assemblage, are more abundant. This is particularly marked off the Maumee and Raisin river mouths.

While there is less data available in the central and eastern basins evidence from *Hexagenia* remnants in sediment cores suggests this mayfly was also an important component of the community in much of the central basin, although the absence of tusks from the southwestern part of the central basin does indicate historical anoxia in the area off Sandusky. From the limited data available there does not appear to be an recovery of *Hexagenia* or the benthic community in central Lake Erie.

Makarewicz, J.C. and T. Lewis. SUNY Brockport. Long-term changes in phytoplankton and zooplankton in Lake Erie

The historically high productive Western basin has had a steady decrease in algal biomass from 1958 to 1985. Similarly, chlorophyll a levels have decreased in all basins, but most dramatically in the Western basin. Lakewide, the mean weighted algal biomass was 3.4, 1.5, 0.8 and 1.26 g/m^3 in 1970, 1983, 1984 and 1985, respectively. A 56 to 76% reduction in algal biomass has occurred in offshore waters of the lake from 1970 to 1983-85. A 96% reduction in the maximum biomass of the nuisance species Aphanizomenon flos-aquae has occurred since 1970.

A decrease in summer Cladocera and Copepoda abundance in the Western Basin is suggested from 1961 to 1985. The decreases in phytoplankton abundance, chlorophyll, total phosphorus and turbidity are consistent with expectations of long-term nutrient control. However, the significant changes in the composition of the zooplankton community with the appearance and establishment of the large cladoceran Daphnia pulicaria are attributed to a change in planktivory.

Knight, R.L., Ohio Div. Wildlife, 305 E. Shoreline Dr., Sandusky, OH 44870, and B. Vondracek, Ohio Coop. Fish and Wildlife Res. Unit, 1735 Neil Ave., Columbus, OH 43210. **Changes In The Forage Fish Community Of Lake Erie, 1969-88: Effects Of Predation?**

The effects of predation on the structure of aquatic communities have focused largely on interactions between planktivorous predators and their prey. Increased densities of piscivorous walleyes (Stizostedion vitreum) in Lake Erie over the past decade provide an opportunity to study the effects of piscivory on the fish community. We examined annual fish assessment data from bottom trawls in the western basin of Lake Erie to measure changes in relative abundance and size structure of prey fishes during a period of low walleye abundance (1969-77) and one of high abundance (1978-88). Significant declines in prey fish catch-per-unit-of-effort between periods may reflect increased walleye predation. Declines were most evident for shiners (Notropis spp.) and least for rarely eaten species. Length frequency distributions shifted toward large sizes for most prey species by the 1980's, possibly reflecting size-selective predation. These trends suggest walleyes are a major structuring force in the community. Thus, current fisheries management programs that focus on walleyes are indirectly affecting the entire fish community.

CORNELIUS, Floyd C., NYSDEC. 178 Point Drive North, Dunkirk, New York
The Status of Salmonine Stocks in Lake Erie

During the late sixties and early seventies, several state fisheries agencies having jurisdiction on Lake Erie implemented salmonid stocking policies to develop a sport fishery. These efforts were encouraged by the earlier successes of Lake Michigan's pacific salmon program. Recent annual plants of between 2 and 4 million fish have met with various degrees of success. Catch rates from several different sampling programs are presented. Stomach data is looked at as a cursory indicator of forage base impact. Rehabilitation of Lake Erie's once native lake trout (Salvelinus namaycush) population will dominate future management activities for hatchery-reared salmonids. Assessments to date indicate that the lake trout population is healthy and steadily progressing toward established rehabilitation goals. Prior to treatment of tributary streams in 1986, sea lamprey induced mortality was thought to be a major limiting factor to rehabilitation. Following treatments, lake trout and other salmonids are demonstrating favorable responses to reduced sea lamprey presence. Continued sea lamprey treatments appear to be necessary to allow population growth.

HENDERSON, Brian, A., S.J. Nepszy. Ontario Ministry of Natural Resources, Fisheries Research Section.
Walleye Stocks and Dynamics in Relation to Fisheries Management in Lake Erie

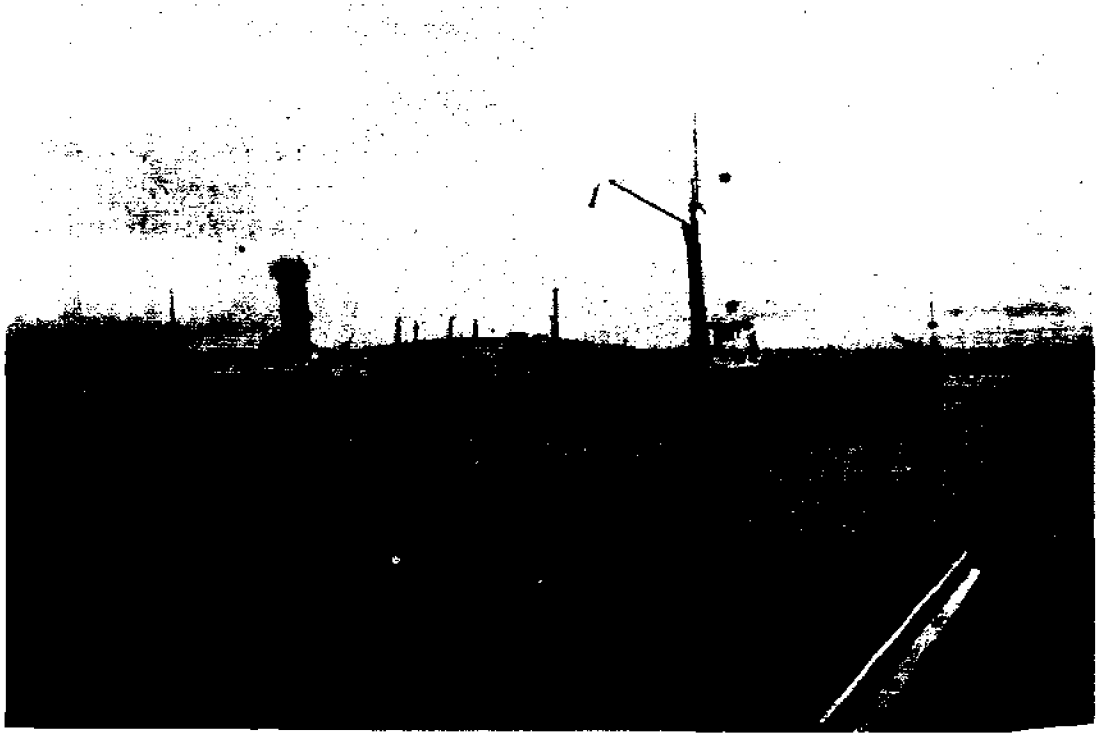
A successful fisheries management policy depends upon an appreciation of the temporal and spatial dynamics of stocks. We explore the evidence that there may be a behavioral and/or genetic differentiation of stocks in Lake Erie. These speculations are largely based on an analysis of the temporal and spatial distributions of commercial walleye catches in Ontario. Recruitment explains most of the variation in stock size and harvest. We considered three factors affecting recruitment: parental stock size, thermal conditions, and parental condition. Of these, only parental condition appears related to recruitment. Regulation of recruitment appears to be more related to the abundance of preceding cohorts than to parental stock size. A closely coupled regulation may appear chaotic.

Lichtkoppler, Frank R., The Ohio State University, 99 East Erie Street, Painesville, OH 44077; **Ohio's Lake Erie Charter Boat Industry In 1990.**

Reflecting the restoration of Lake Erie's walleye population, the Ohio Lake Erie charter industry has grown from 46 vessel captains in 1976 to 1,211 vessel captains in 1990. The number of charter boat angler hours has grown from 38,000 in 1976 to almost 1.5 million in 1989. However, 1990 was the first year since 1976 that the charter boat angler effort fell from the previous year. A 1990 survey of Ohio charter captains resulted in a return rate of 51 percent. The average number of charter trips fell from 43 in 1985 to 29 in 1990. The responding captains indicated that poor weather conditions and the impacts of exotic species concerned them most in 1990. Increasing the number of charter trips per captain was by far the most frequently planned change desired by the responding charter captains. The charter industry in the 1990's faces a number of problems including a reduction in the Ohio daily catch limit from 6 to 5 walleye, unknown impacts from the exotic zebra mussel, costly new safety regulations and increased competition for recreational dollars. These problems reflect the increased demands that have been made on the resource.

JUDE, David J., REIDER, Robert H., and SMITH, Gerald R. Center for Great Lakes and Aquatic Sciences, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109.
Technical and Engineering Services, Detroit Edison Company, Detroit, MI 48210,
and Museum of Zoology, Division of Fishes, University of Michigan, Ann Arbor, MI 48109.
First Evidence of Gobiidae in the Great Lakes Basin.

A tubenose goby (*Proterorhinus marmoratus*), a European endangered species native to the Black and Caspian Seas, was recovered on 11 April 1990 from the travelling screens of the Belle River Power Plant located on the St. Clair River, south of St. Clair, Michigan. Subsequently on 28 June, 18 July, and 23 September, a Canadian and two American anglers each caught a round goby (*Neogobius melanostomus*) in the St. Clair River near Sarnia, Ontario. Three tubenose gobies and four round gobies were impinged on the Belle River Power Plant screens in fall 1990, and 17 round gobies and 27 tubenose gobies were trawled from an area near the Belle River Power Plant intake structure on 30 November, and 12 and 17 December 1990. Length range of the round gobies was 29-118 mm total length, while tubenose gobies ranged from 45 to 87 mm. Nine of the round gobies (29-61 mm) are believed to be young of the year. These species are believed to have been transported to the Great Lakes in ballast water. It appears these two species may have successfully colonized the St. Clair River and will probably spread throughout the Great Lakes. They are expected to directly impact other benthic fishes, such as sculpins (*Cottus* spp.), darters (*Etheostoma* spp.), and logperch (*Percina caprodes*), and in turn act as prey for walleye (*Stizostedion vitreum*).



Steamer Buffalo - Black Rock Canal.

GENERAL LIMNOLOGY

Session 6A - Thursday, June 6
8:30 AM - 12:10 PM

20 Knox Hall

CONTAMINATED SEDIMENTS

Session 6C - Thursday, June 6
8:30 AM - 12:10 PM

110 Knox Hall

POULTON, Donald[1], PAWLOWSKI, Jerzy[2], and GRIFFITHS, Marta[2], 1 Ministry of the Environment, 135 St. Clair Av. W., Toronto, ON M4V 1P5, 2 Geomar Geophysics Ltd., 1744 Meyerside Dr., Suite 4, Mississauga, ON L5T 1A3. **Mapping of contaminated sediments using the electromagnetic (inductive) method.**

The electromagnetic method was used in 1989 to map the distribution of soft sediments in several areas of Lake Ontario in the Toronto and Kingston vicinity. The selected areas are affected by industrial and sewage treatment plant discharges, or active lakefilling. In the electromagnetic method, an alternating voltage applied to a transmitter coil on or near the sediment-water interface causes eddy currents to be induced in the sediment. These currents, in turn, generate a secondary magnetic field which is proportional to the sediment conductivity, and is measured by a receiving coil. This conductivity increases in areas of soft, contaminated sediments, and provides an estimate of the area of contamination. Contaminant levels in sediment samples collected during the surveys are used as a measure of "ground-truth". This method has proven to be a very efficient, fast and cost-effective tool in investigating spatial distributions of sediment physical and chemical properties, as well as a guiding tool for future survey programs.

RUKAVINA, N.A., National Water Research Institute, Burlington, Ontario, L7R 4A6.
Variability of the physical properties of Hamilton Harbour bottom sediments

Hamilton Harbour bottom sediments consist of soft, black, porous muds and sandy muds averaging 34 cm thick over a substrate of firm grey and grey-brown silty clays and sands. Pb210 data from sediment cores give sedimentation rates of 0.2-0.8 cm/yr and indicate that the black muds are industrial sediments deposited since the start of the steel industry in the harbour about 150 years ago, and that the substrate material predates industrial activity. Sediment properties are consistent with this origin. The underlying silts and clays are uniform in both plan and profile and appear to be natural bay sediments. The black muds show unsystematic vertical and areal variations in geotechnical and magnetic properties, particularly in the main central basin and in the small basin opposite Dofasco. This appears to be related to sediment disturbance by industrial activities in the harbour but may also be caused by degassing and mixing of core sediments during recovery. Whatever its origin, the sediment variability will affect chemical and biologic profiles of sediment cores and will have to be taken into account to ensure that trends in sediment quality are not misinterpreted.

VERSTEEG, K., MORRIS, W. AND RUKAVINA, N.A.Dept. of Geology, McMaster University, Hamilton, Ontario, National Water Research Institute, Burlington, Ontario; **Mapping contaminated-sediment thickness with magnetic susceptibility.**

Magnetic-susceptibility profiles of sediment cores from Hamilton Harbour show a pronounced drop at depths of about 50-60 cm which appears to correspond with the base of contaminated industrial sediment associated with the steel industry. Since susceptibility measurements can be taken quickly and non-destructively on unopened cores, they may be a useful first step in mapping the thickness of the contaminated-sediment layer in the harbour and in other areas, like tailings ponds, in which the contaminated sediment has a magnetic label. More detailed studies in progress are concerned with the effects of grain size and mineral composition on the profiles and with more subtle changes in profile structure which may represent disturbance of the sediments by dredging or dumping.

MOREHEAD, N.R., J.A. ROBBINS, and A. MUDROCK. Anthropogenic Alteration of Carbon, Nitrogen, and Biogenic Silica deposition in Lake George (St. Marys River) since 1820.

In 1986, sediment cores were taken by diver in Lake George, part of the St. Marys river system below the Sault Ste. Marie industrial region. Cores previously radiometrically dated and analyzed for contaminants (PAH, PCB, DDT, Cr, Fe, Mn, Pb and Zn) show organic carbon (OC), nitrogen (N), and biogenic silica (BSi) concentration increases that are well correlated from 1830 until they peak around 1910. Thereafter with increases in iron and manganese from steel production, these three constituents diminish until about 1940. After 1940, N and BSi decrease further, reaching a minimum in the early 1960's, while OC increases two-fold by the mid 1970's. An additional short term depression in BSi in the 1960's coincides with a sharp spike in the Cr concentration, probably due to tannery activities upstream, and with a broader spike in the Zn concentration of unknown origin. Of 38 constituents measured, elemental bromine is distinct in its high correlation with BSi (r=0·90;N=56). To investigate this correlation, the conventional NaOH extraction method was modified (by substituting LiOH) to allow neutron activation of the extractants.

COAKLEY, J.P., Lakes Research Branch, National Water Research Institute, Burlington, ON
POULTON, D.J., Water Resources Branch, Ontario Ministry of the Environment, Toronto, ON

Source-related classification of St. Lawrence Estuary sediments

Surficial sediment samples covering the shallow-water and intertidal zone of the St. Lawrence Upper Estuary (Ile d'Orleans to Saguenay River) were analyzed for grain-size and selected trace elements. The aim of the study was to identify integrated patterns of sediment transport in this dynamic body of water as an aid in resolving contaminant pathways. A modified cluster analysis of the sediment data (62 samples, 15 variables), using ratio matching and average linkage, revealed clustering of sample sites that can be interpreted in terms of two principal sediment sources. The largest cluster (49 samples) is associated with the main St. Lawrence discharge, while the smaller grouping, comprising 2 sub-clusters (1 containing 6, the other, 4 samples) is located in the eastern portion of the area, near the outfall of the Saguenay River. Research is continuing to resolve other source indicators in the estuary and to place these sources into an historical context.

SIDDIQI, Muhammad A., and SIKKA, Harish C., Division of Environmental Toxicology and Chemistry, Center for Environmental Research, State University of New York College at Buffalo, Buffalo, NY 14222
MICROBIAL DEGRADATION OF BENZO[a]PYRENE [BaP] IN THE SOIL AT THE TIMES BEACH CONFINED DISPOSAL SITE

The soil and sediment at the Times Beach Confined disposal site, Buffalo, NY are contaminated with polynuclear aromatic hydrocarbons (PAHs). In order to assess the environmental fate of high-molecular weight PAHs at this site, we have examined the microbial degradation of benzo(a)pyrene [BaP], a model carcinogen PAH, in surface and subsurface soil collected from the Times Beach site. The soil was incubated with 10 ppm ^{14}C-labelled BaP and microbial degradation was examined by assessing the evolution of $^{14}CO_2$ (mineralization) and the formation of BaP metabolites. After 144 days of incubation of ^{14}C-BaP in the soil with a moisture content of 38% at 28° C, 32% of the initial radioactivity was evolved as $^{14}CO_2$, indicating that the microorganisms in the soil have the ability to cause BaP ring cleavage at position 7 or 10, or both. The microorganisms in the surface soil rapidly degraded BaP without any lag time. In contrast, mineralization of BaP started after a lag period of 20 days in the subsurface soil. The degradation of BaP in the surface soil increased with an increase in soil moisture content and incubation temperature. Analysis of organic solvent-extractable residue from the soil by HPLC showed the presence of a single metabolite peak which accounted for nearly 5% of the total extractable radioactivity. To our knowledge, this is the first study to report a significant mineralization of BaP by soil microorganisms. (Supported by Buffalo District Army Corps of Engineers)

BALCH, G. and METCALFE, C.D., Trent University, Peterborough, Ontario

CHARACTERIZATION OF CHEMICAL CARCINOGENS WITHIN SEDIMENTS OF HAMILTON HARBOUR, ONTARIO.

Organic contaminants have been implicated as putative etiological agents responsible for the elevated occurence of neoplasia among feral fish inhabiting industrialized portions of the Great Lakes. In this study, organic compounds were extracted from the heavily contaminated sediments of Hamilton Harbour. Mutagenicity and carcinogenicity directed subfractionation was used to characterize the organic extract. Results from this study indicate that the 2nd and 3rd fractions, which contain PAH's, are both mutagenic in the identification of carcinogenic activity in the 4th and 5th fractions. These fractions do not contain PAH's, nor do they produce a mutagenic response in the Ames test when tester strains TA98 and TA100 are used. Japanese medaka are currently being exposed to Hamilton Harbour sediments in an attempt to assess the bio-availability of the carcinogenic agent(s). Results of the medaka assay will also be presented.

A LAKE ONTARIO - GULF OF ST. LAWRENCE MASS BALANCE FOR MIREX.

M.E. Comba[1], C. MacDonald[2], D.G. Noble[2], M.M. Gagnon[3], J.J. Dodson[3], R.J. Norstrom[2] and K.L.E. Kaiser[1].
[1] Nearshore-Offshore Interactions Project, Lakes Research Branch, Burlington, Ontario; [2] National Wildlife Research Centre, Canadian Wildlife Service, Ottawa, Ontario; [3] Biology Dep., Laval University, Ste-Foy, Quebec

Mirex, a flame retardant and pesticide is unique among the organochlorine contaminants in the Great Lakes as its occurrence is restricted to Lake Ontario due to its two sources at the Niagara and Oswego Rivers. Because of its high lipophilicity and extreme persistence, mirex has entered the entire Lake Ontario foodchain. It is being removed from Lake Ontario (exclusive of sedimentation and burial) primarily by outflowing water and migrating biota.

Mirex concentrations in water, suspended and bottom sediments in Lake Ontario and downstream thereof are useful indicators of its present and past movement in this system. We report here new data on mirex concentrations as far downstream as the Gulf of St. Lawrence and our use of such data to develop a mass balance for this compound. This mass balance incorporates results obtained from the herring gull and TOXFATE models and includes new data on the contaminant in the foodchain in the St. Lawrence estuary and its top predator, the beluga whale.

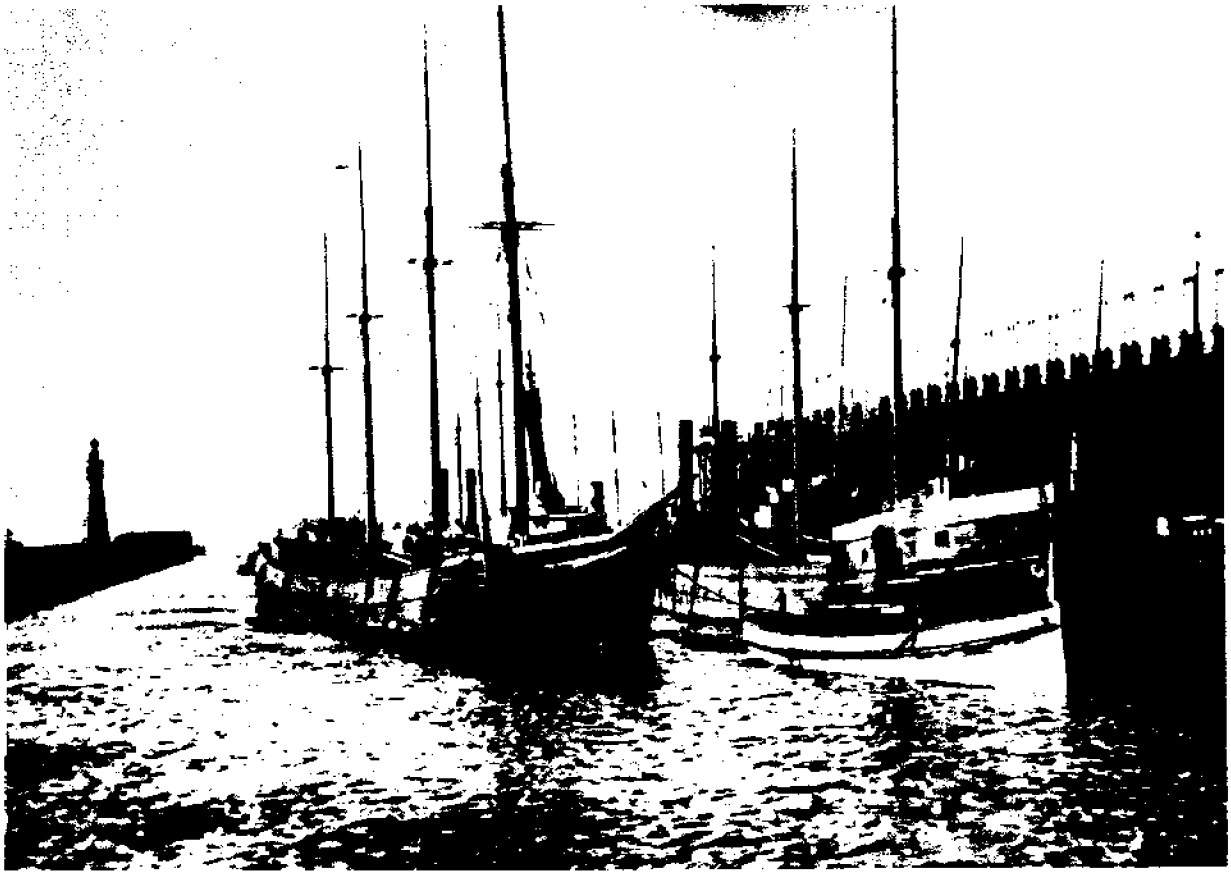
CHANG*, C., KENDER+, J., and TISUE+, T. *U. S. Geological Survey, Menlo Park, CA 94025; +Department of Chemistry, and Department of Earth Sciences, Clemson University, Clemson, SC 29634-1905.

^{113m}Cd in Lake Tahoe.

The fallout isotope ^{113m}Cd ($t_{1/2}$=14.6y,99% *beta*$^-$,E_{max} 0.59MeV) has been detected in preliminary studies of water and sediment from Lake Tahoe. A hollow fiber filtrator was used to dewater ca. 1 g of $Fe(OH)_3$ freshly precipitated from 750 L of lake water that had been amended with a stable Cd recovery tracer. ^{113m}Cd isolated on this precipitate was decontaminated from other *beta*$^-$ emitters using the procedure developed earlier, and determined using a "pancake" proportional counter. Duplicate samples averaged 500 +/- 210 x 10^{-6} Bq L^{-1}. Naturally-occurring Cd in the lake ranges around 20 pM, giving a mean specific activity of ~0.2 MBq g^{-1}. In sediment cores from near midlake, ^{113m}Cd activity exhibits a pronounced subsurface maximum between 2-3 cm, reaching about 17 mBq g^{-1} dry weight. ^{137}Cs shows a similar peak at about the same depth, indicating the year 1963, which corresponds to a surface sedimentation rate of about 1 mm y^{-1} for material with a porosity of 0.95. This value agrees well with the sedimentation rate derived from the unsupported ^{210}Pb profile.

ZEMAN, A. J., Lakes Research Branch, National Water Research Institute, Burlington, Ontario L7R 4A6. **Consolidation of very soft sediments due to subaqueous capping.**

Subaqueous capping has become an important concept for isolating contaminated fine-grained sediments from aquatic and terrestrial environment. The capping concept is being considered as a remedial measure for sediments with moderate toxicity in Hamilton Harbour. The primary geotechnical concern is time-dependent consolidation behaviour due to the load applied by the cap. The consolidation analysis was carried out for two sites in the harbour and, for comparative purposes, for one site in western Lake Ontario. Large oedometer tests with pore pressure measurements were used to define void ratio-effective stress and void ratio-permeability relationships. The settlements and rate of consolidation were computed using the classical (Terzaghi) analysis and the finite strain analysis. It is shown that the finite strain analysis predicts greater magnitudes of settlement and substantially faster rates of consolidation than those calculated by the classical theory of consolidation.



Four-masted schooner entering Buffalo Harbor under tow - 1897.

TOWARDS AN APPRECIATION OF THE CURRENT STATUS OF RAINBOW SMELT IN LAKE ERIE

Convenors: Stephen Nepszy and Larry Witzel

Session 6D - Thursday, June 6
8:30 AM - 12:10 PM

14 Knox Hall

DIETZ, PAULINE A. (MONCK), and DONALD N. HUGHES, Ont. Min. Natur. Resour., R.R. 2, Wheatley, Ontario N0P 2P0. **A review of the ecology of rainbow smelt in Lake Erie.**

Information on the biology of Lake Erie rainbow smelt was compiled from a variety of published and unpublished sources, as background material toward the synthesis of new science for managing Ontario's smelt fisheries. Earlier studies have documented the alternating year-class dominance (AYD) characteristic of smelt in Lake Erie, and have described the horizontal and depth distribution of smelt YOY, yearlings and adults. Changes observed in the smelt population include: declining size-at-age; increasing Glugea infection rate; disappearance (in the mid-1970s) and re-establishment (mid-1980s) of AYD; decreasing representation of smelt ≥3 yr in the trawl fishery since 1985; and a pronounced reduction in number of beach-spawning smelt at Point Pelee during the past decade. Concurrent changes in the Lake Erie environment and fauna are noted in regard to the above observations.

PAINE, JERRY R., and EDWARD T. COX, Ontario Ministry of Natural Resources, R.R. #2, Wheatley, Ontario, N0P 2P0, The trawl fishery for rainbow smelt on Lake Erie.

The history of the commercial trawl fishery in the Ontario waters of Lake Erie is traced from its inception in the 1950's to the present. Catch, effort and regulatory measures are chronicled. Modifications in technology associated with the fishery and the reporting systems used to monitor catch and effort are described.

WOLFERT, DAVID R. Sandusky Biological Station, 6100 Columbus Avenue, Sandusky, Ohio, Rainbow smelt abundance in U. S. waters of central and eastern Lake Erie, 1978-1980.

Eleven synoptic surveys using bottom trawls were conducted in the U. S. waters of the central and eastern basins of Lake Erie during 1978-1980 to determine if smelt (Osmerus mordax) stocks were sufficiently abundant to establish a commercial fishery. Smelt biomass estimates were made for all sampling periods, however only two were considered to be indicative of the population - central basin estimates in April and November 1978 of 47 and 18 million pounds respectively. A commercial fishery was not considered warranted as 60% of the catches amounted to 10 pounds or less. Only 5 tows produced quantities considered to be economically feasible. Five age classes were collected, however the spawning population was usually composed of age II and III fish. A large post-spawning mortality occurred in 1978 and 1979 but not in 1980. Associated species taken in trawls consisted mostly of spottail and emerald shiners, trout-perch, and yellow perch. Most of these species were taken at depths less than 50 feet while smelt catches were mainly from depths greater than 50 feet.

EINHOUSE, Donald, NYSDEC, 178 Point Drive North, Dunkirk, New York
The Status of Rainbow Smelt in New York Waters of Lake Erie

Rainbow smelt (Osmerus mordax) have long been a dominant member of the coldwater fish community in the New York waters of Lake Erie. This species is a major component of the diet of both warmwater and coldwater piscivores. Adult lake trout appear to consume rainbow smelt almost exclusively during the summer months. Walleye also make extensive use of rainbow smelt as prey. As such, the summer distribution of walleye in New York waters appears to be strongly influenced by the distribution of rainbow smelt. Neither commercial or sport fisheries targeting rainbow smelt have developed in New York waters.

The New York Department of Environmental Conservation only recently began an annual bottom trawling program to monitor smelt stocks in 1987. Results from this new assessment program suggest larger, and presumably older, rainbow smelt are scarce in the population. A spring sampling program to monitor ichthyoplankton indicates larval rainbow smelt occur in very low densities in New York waters. There is no other evidence available that currently identifies any significant smelt spawning areas within New York waters.

WITZEL, LARRY D., Ont. Ministry of Natural Resources, Port Dover, Ontario N0A 1N0.
Year-class recruitment indices of rainbow smelt derived from bottom trawl surveys in Long Point Bay, and projections of commercial smelt harvests by the Ontario trawl fishery in eastern Lake Erie.

Two bottom trawl surveys were conducted annually during September to October by the LEFAU in Long Pt. Bay, Lake Erie to estimate recruiting year-class strength and to predict commercial harvests of smelt by the Ontario trawl fishery in eastern Lake Erie. Standardized bottom trawls were fished weekly at fixed inshore (1.5-5.0 m depth) and offshore stations (9-21 m depth) since 1980 and 1984 respectively. Only the YOY of smelt were present in the inshore trawl catches. In the offshore survey, dominant year classes of smelt remained a significant component of the fall index trawl catches for up to two years of age despite an average annual commercial harvest of 9479 tonnes since 1981. Trends in year-class abundance, measured as geometric mean catch per trawl hour (CPTH), show an alternating year-class dominance until 1988 in both trawl surveys. A moderate, stronger than expected year class in 1989 was followed by another moderate year class in 1990. A strong linear relationship existed between YOY trawl indices and the total number of yearling smelt harvested in year + 1, and between yearling trawl indices and the number of two-year-olds commercially harvested in year + 1.

ORSATTI, S., Ont. Min. Natur. Resour., R.R. 2, Wheatley, Ontario N0P 2P0.
Catch at age analysis to reconstruct the characteristics of a population of rainbow smelt (*Osmerus mordax*) from commercial trawl harvest data.

The commercial fishery for rainbow smelt in eastern Lake Erie, operates year round, and the characteristics of the harvest vary seasonally. The sampled age composition has been biased by the selective loss of scales from small smelt during trawl harvest. Unbiased estimates of age composition were calculated by fitting a mixture of length distributions representative of particular age classes of smelt, to the overall length distribution for each harvest season. Smelt aged 1 and 2 dominate the commercial harvest. Strong year classes were produced in 1984 and 1986, weak year classes in 1985 and 1987, and intermediate sized year classes in 1988 and 1989, providing good contrast. Catch at age analysis was performed for the 1982-89 data using CAGEAN (Deriso et al 1985). The population has ranged between 3.7 and 12.5 million kg, or 1 to 1.4 billion fish. The biomass was greatest in the early years (>11 million kg), but dropped to <5 million kg in 1984 and 1986. The population has slowly increased in the later part of the decade, to 8 million kg in 1989. The alternate year dominant year class phenomenon began in 1984 after the population was drastically reduced by fishing.

RYAN, P.A., Ontario Ministry of Natural Resources, Box 429, Port Dover, Ontario. **Application of surplus production models to the commercial trawl fishery for rainbow smelt (*Osmerus mordax*) in eastern Lake Erie.**

Changes in the fishery over time (areas fished, duration of trawl drags, and the reduction in discard of small smelt) described by previous investigators led to restriction of the analysis to the 1980-90 period. Schaeffer (p=0.007) and Fox (p=.006) models were fitted by functional regressions of fishing success (CPUE, ln(CPUE) on effort (boat-days) to provide estimates of MSY (11650, 12700 tonnes) and optimal effort (5880, 8130 boat days) respectively. Fishing effort as trawl hours was recorded from 1985 to 1990. The bias in fishing effort measured by trawl days ranged between -19 and +19%, during this time. Schaeffer (p=0.135) and Fox models (p=.148) using effort measured as trawl hours provided lower estimates of MSY (8475 and 8825 tonnes; effort levels 9600, 8100 trawl hours respectively). Estimates of Z (used as a surrogate of F) indicated that the 1985-90 models were more accurate descriptions of the stock. The recent fishing effort is in excess of that required for MSY, and the stock is overfished.

OWENS[1], R. W., ECKERT[2], T. H. and O'GORMAN[1], R. 1. U. S. Fish & Wildlife Service, 17 Lake St, Oswego, NY 13126. 2. New York Department of Environmental Conservation, Cape Vincent Fisheries Station, Cape Vincent, NY 13618. **Response of Rainbow Smelt to the Changing Fish Community in Lake Ontario, 1978-90.**

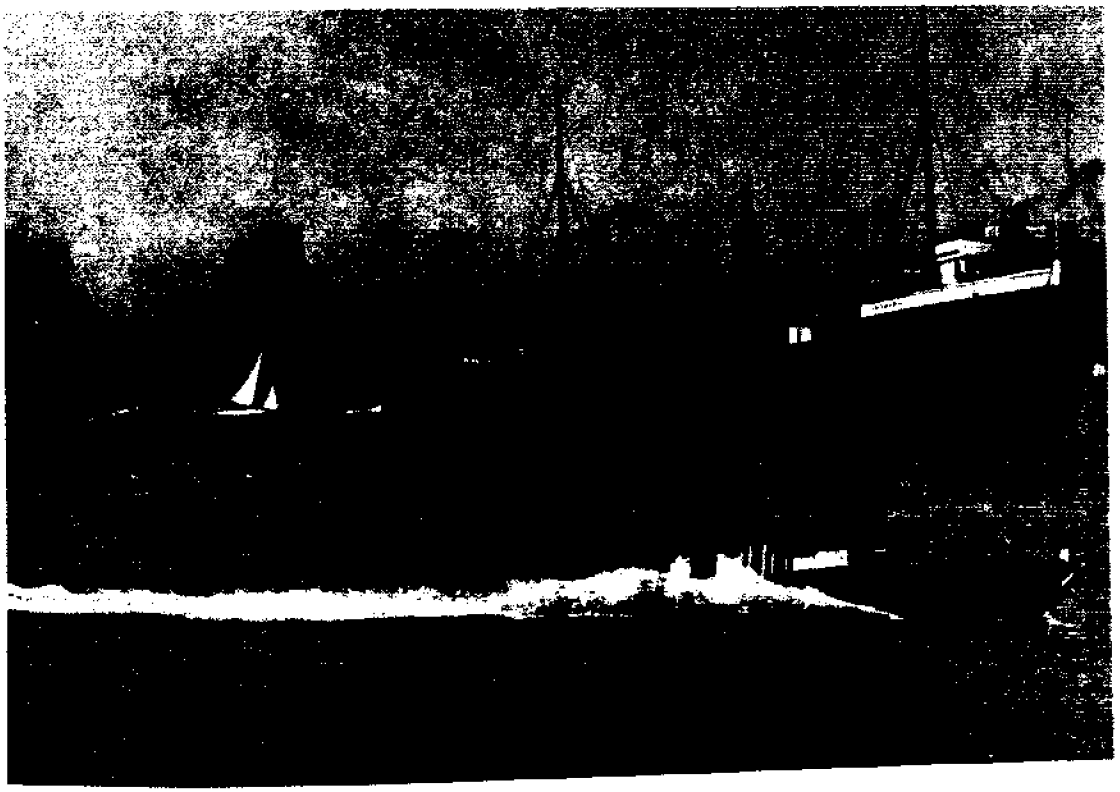
With alewives and piscivorous salmonines abundant, the fish community in Lake Ontario in the late 1980's was markedly different from that in the early 1980's (alewives were abundant and salmonines were rapidly becoming abundant) and from that in the late 1970's (alewives and salmonines were scarce). Throughout this period of change, we assessed rainbow smelt with bottom trawls in U.S. waters. Growth of young, planktivorous smelt declined as alewives increased and it remained slow during the 1980's despite a nearly 3-fold variation in alewife numbers. Size-at-age among older smelt declined initially due to slower growth in the first year of life and later due to size-selective predation (age-3 smelt averaged 158 mm in 1978-80, 136 mm in 1981-85, and 123 mm in 1986-90). Survival of smelt age-2 and older was positively correlated with alewife numbers (alewives apparently buffered smelt from predation) until predators became abundant in the late 1980's, then survival was consistently low. Intense predation reduced the numbers of smelt >149 mm -- mean catch fell from 134 in 1978-83 to 24 in 1984-90. Despite changes due to predation by salmonines and competition with alewives, there was no clear trend in smelt numbers during 1978-90 (smelt biomass, however, did trend downward after 1987). Cannibalism, the mechanism controlling year-class size, remains unchanged and strong year classes are still being produced.

RITCHIE, Beverlee J. **Ontario Ministry of Natural Resources, P.O. Box 5000, 435 James St. S., Thunder Bay, Ontario, P7C 5G6. Dynamics of Introduced Rainbow Smelt (Osmerus mordax) in Lake Nipigon, Ontario and Assessment of Potential Impacts on Indigenous Fish Species.**

The presence of smelt in Lake Nipigon was confirmed in 1976. Due to the potential impact on the highly valued lake whitefish fishery, (landed value of approximately $500,000), the Lake Nipigon Fisheries Assessment Unit has collected annual data on the Postagoni River spawning population since 1981. Assessment results include relative abundance, size and age structure and importance of smelt as forage by walleye. The lake's unexploited smelt population has experienced two major crashes following 2 to 3 years of gradual population increase since 1981. Smelt assessment along with annual index netting and commercial catch sampling of lake whitefish and walleye indicate that growth of walleye appears to increase and whitefish year-class strength appears to decrease with increased smelt abundance. Management implications, potential impacts on indigenous fish species, and recommendations for assessment are discussed.

REMNANT, Richard A., Natural Resources Institute, University of Manitoba, Winnipeg, MB R3T 2N2; FRANZIN, William G., Fisheries and Oceans, Winnipeg, MB R3T 2N6. **An Assessment of the Impact of the Rainbow Smelt on the Fishery Resources of Lake Winnipeg**

Rainbow smelt (Osmerus mordax) were collected from a number of discrete locations on the upper Winnipeg River system in 1989 field surveys. In 1990 three specimens of rainbow smelt were collected from Lake Winnipeg itself. Morphometric and fish community data from Lake Winnipeg were compared with lakes Erie and Simcoe, relatively similar smelt-impacted lakes. The degree of similarity was used as one tool of predicting the success of the rainbow smelt in Lake Winnipeg. Changes in community structure following the arrival of smelt in various lakes, including Erie and Simcoe, were examined for their relevance to the Lake Winnipeg situation. Management strategies from all provincial and state agencies dealing with rainbow smelt were reviewed for their pertinence. It is concluded that the rainbow smelt will become an important part of the Lake Winnipeg fish community, with the potential to at least partially replace existing populations of lake cisco (Coregonus artedii) and lake whitefish (C. clupeaformis).



ATMOSPHERIC PROCESSES

Session 6E - Thursday, June 6
11:10 AM - 12:30 PM

4 Knox Hall

HERMANSON, MARK; BASU, ILORA Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61821-7495 **PCBs and organochlorine pesticides and fungicides in atmospheric samples from Lakes Superior, Michigan and Huron.**

Air vapors and particles are collected using Hi-Vol samplers at three sites in Michigan on Lakes Superior (Sault Ste. Marie), Michigan (Grand Traverse Bay) and Huron (Saginaw Bay) for purposes of measuring ambient concentrations of organochlorine compounds (OCs) in the atmosphere and for future estimation of deposition of toxic organic compounds to these lakes. Target compounds include PCBs, dieldrin, hexachlorobenzene (HCB), and alpha and gamma hexachlorocyclohexane (a- and g-HCH). Vapor concentrations of dieldrin and a-HCH and g-HCH are more air temperature dependent than PCBs and HCB. Most vapor phase measurements are therefore lowest at Sault Ste. Marie and highest at Saginaw, respectively the most northern and southern sites. Wet deposition of particles may be a major pathway for flux of these compounds from the atmosphere to the lakes. However, during cold weather, HCB, a-HCH and g-HCH are not detectable on particles, while dieldrin and PCBs are from 5% to 25% as concentrated on particles as in vapors. Where measurable, particle concentrations are consistent among sampling sites, suggesting that wet deposition of particles is similar to these lakes.

RECTOR, D., U.S. CO-CHAIR, KUMMLER, R., PORTER, W., PICHE, E., CANADIAN CO-CHAIR, FRANKLIN, C., SHIKAZE, K., and TOOLEY, R., STAFF ASSISTANT

The Status of Air Toxics in the Detroit-Windsor/Port Huron-Sarnia Region: A Report of the I.J.C.'s Air Pollution Advisory Board

The Air Pollution Advisory Board undertook a study to provide an assessment of emissions, ambient air quality, and toxicity data, evaluate the hazards posed to human health and the environment from air borne toxic substances and assess the potential effects of emissions from incineration facilities in the Detroit-Windsor/Port Huron-Sarnia Region.

A list of 125 chemicals were identified which required more careful review. The Board estimated the extent of the exposure and summarized the toxicity of each air contaminant. Using a novel screening technique 20 pollutants were identified which are considered to be of the greatest concern. The Board also identified the principal regional incinerators.

Of the 125 compounds, 21 have been evaluated for carcinogenic potential. That is, ambient air monitoring data, a screening level and estimation of exposure existed for each of the 21 chemicals.

HOLSEN, Thomas M., NOLL, Kenneth E., LIU, Shi-Ping, and LEE, Wen-Jhy Pritzker Department of Environmental Engineering, Illinois Institute of Technology, Chicago, Illinois 60616 **The Fate of Airborne PCBs and PAHs in the Great Lakes Region**

The PCB and PAH dry deposition flux was measured in Chicago with a greased, Mylar covered smooth plate with a sharp leading edge pointed into the wind. The PCB data analyzed to date has shown that the dry deposition flux of PCBs in Chicago averaged 3.8 $\mu g/m^2$-day between May and November, 1989 and 6.0 $\mu g/m^2$-day for May and June 1990. A comparison of the PCB flux measured in Chicago to an estimated non-urban PCB flux shows that the flux of PCBs is up to 3 orders of magnitude higher in urban areas than in non-urban areas indicating that Chicago and other urban areas near the Great Lakes must be considered as major sources terms for deposition of PCBs into the lakes. The airborne PCB concentration as measured by the Noll Rotary Impactor (NRI) A stage (particles with aerodynamic diameters > 6.5 μm) was 0.94 ng/m^3 in Chicago and the mean particle phase PCB concentration was 47 $\mu g/g$. PCBs were found to be associated with all sizes of atmospheric particles however their particle mass normalized concentration decreased with increasing particle size. PCBs associated with particles, particularly coarse particles, represented a significant fraction of the total PCB dry deposition flux even though PCBs in the ambient air were present primarily in the gas phase.

BURNISTON, D. A., W. M. J. STRACHAN, National Water Research Institute, CCIW, Burlington, Ont., L7R 4A6 and R. A. HOFF, Atmospheric Environment Service, Downsview, Ont., M3H 5T4. **GLWQA Annex 15: Organics in 1989-1990 Precipitation at Point Petre, Lake Ontario.**

Annex 15 of the Great Lakes Waters Quality Agreement (1987 Protocol) requires the governments of Canada and the United States to determine the atmospheric loadings of toxic chemicals to each of the Great Lakes. An Integrated Atmospheric Deposition Network (IADN) is being developed to quantify these inputs of contaminants and compare them to other inputs. A "master" station has been constructed at Point Petre on Lake Ontario and presently forms the first Canadian station of the network. It has been operating for approximately two years.

Bi-weekly wetfall precipitation samples for organochlorine pesticides, PCBs and chlorobenzenes have been collected in replicate (3) from this site. Seasonal analytical results will be reported along with calculated loading rates extrapolated for the lake. Results will be compared with other Great Lakes and Canadian sites (non-IADN) and trends in the data will be discussed.

POSTER SESSIONS

Monday, June 3
7:00 - 9:00 PM

Wednesday, June 5
1:00 - 3:00 PM

Carpenter Room - Norton Hall

BARNES, Peter, REIMNITZ, Erk; U.S. Geological Survey, Menlo Park, CA, 94025, and KEMPEMA, Edward, Dept. of Oceanography, Univ. of Washington, Seattle, WA 98195, **ICE RAFTING AND ICE-INDUCED PROFILE MODIFICATION: WINTER COASTAL EROSION IN SOUTHERN LAKE MICHIGAN**

Winter fieldwork, undertaken in 1989, 1990, and 1991 at more than 20 sites along the shore of southern Lake Michigan, examined the role of lake ice in coastal erosion and sediment transport. During the formation of coastal lake ice, a *nearshore ice complex* (NIC) develops, consisting of an ice foot along the shoreline and a static lakeward sequence of wave-generated ice ridges with intervening shore-parallel lagoons. A ubiquitous belt of mobile brash and slush ice precedes and accompanies each stage, supplying the ice for construction. During a single winter, the NIC develops and partially or completely decays several times. Ice ridges are typically 1-2 m high but reach a maximum height of 7 m and commonly are situated on offshore bars. Coastal profiles illustrate both erosion and deposition, plus the consistent development of an erosional troughs along the outer edge of ice ridges. The bathymetric changes and the ice-ridge construction reflect offshore displacement of wave energy from the summer shoreface to the ice-ridge face. Sediment content of the NIC was highest in the ice foot and ice ridges, and lowest in the lagoonal and offshore ice, ranging from less than 0.1 to 866 g/L. Average sediment contents indicate that the static NIC contains 180 to 280 t (290 to 450 m^3) of sand per kilometer of coast. The NIC sediment load is nearly equivalent to the average amount of sand eroded from the bluffs and to the amount supplied to the deep lake basin by ice rafting each year. In addition, southward, longshore ice rafting by brash and slush was commonly at rates of 10-30 cm/s, suggesting that 0.35×10^3 to 2.75×10^3 t of sand per day could be transported along shore.

BROWN, RUSSELL W. and WILLIAM W. TAYLOR, Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824, 517-353-6697

Effects of Egg Composition and Prey Density on the Larval Growth and Survival of Lake Whitefish

Lake whitefish eggs were collected from two stocks of lake whitefish in Lakes Michigan and Huron to assess the effect of egg composition and prey density on larval growth and survival. Egg composition parameters including wet weight (g/egg), dry weight (g/egg), percent water, caloric content (cal/egg), caloric density (cal/gram), percent lipid content, and lipid content (g lipid/egg) were measured. Fish hatched from six parental females in each stock were fed one of four rations (0, 18, 24, 50 brine shrimp/larva/day) after yolk-sac absorption. Length at hatch, endogenous growth, exogenous growth, and survival were measured during a 42-day laboratory experiment. Length at hatch of larvae was positively related to egg caloric content (r^2 = 0.780), while endogenous growth was positively related to egg caloric density (r^2 = 0.896) and egg lipid content (r^2 = 0.876) of parental females. Exogenous growth and survival of larval lake whitefish was positively related to prey availability and growth was accurately modelled (r^2 = 0.973) using a threshold-corrected hyperbolic equation. These results indicate that egg composition has the potential to be an important influence on the growth and survival dynamics of larval lake whitefish.

CAP, Roberta and LANGE, Cameron Acres International Corporation
140 John James Audubon Parkway
Amherst, New York 14228

Zooplankton in the New York State Canal System

Water samples from 13 sites along the New York State Barge Canal system and its interconnecting waterways were analyzed for Crustacean zooplankton during April, June, August, October and December 1990. A total of 30 taxa were identified (21 Cladocera and 9 Copepoda). The highest number of organism (69,000/m^3) was seen near Waterloo, NY in October. The greatest number of taxa (12) occurred at Albion in June. Highest average number of organisms per month (22,930m^3) and taxa (7.2) were found in June, lowest number of organisms (2,872/m^3) and taxa (3) occurred in December. Organisms that dominated the populations were mucronate bosminids (probably Bosmina longirostris), copepod nauplii, immature cyclopoid copepodids and Chydorus sp. in order of percent occurrence. On average, high numbers of organisms and taxa were seen at the Baldwinsville, Montezuma, Danskammer and Waterloo, NY sites. Zooplankton populations followed expected seasonal trends. Zebra mussels (adult and/or veligers) occurred at three sites but their effect on the zooplankton populations was not apparent.

DICKMAN, M., Brindle, I.[1], Ghazi, N., and Rygiel, G., Biological Sciences Department, and Chemistry Department[1], Brock University, St. Catherines, Ontario, L2S 3A1 Canada. **The Presence of Contaminated Sediments in the Niagara River Watershed as Indicated by Invertebrates with Deformities.**

Polyvinylbutyral resin is used by the Ford Glass Co. in producing car window glass laminates. These resins and surfactants for cleaning glass are discharged into treatment systems which ultimately discharge to the Welland River, the major Canadian tributary to the Niagara River. Downstream of the Ford discharge, the frequency of chironomid larval abnormalities was elevated above the control site at King's Bridge Park. The park is located near the water intake of the City of Niagara Falls, Canada. A chironomid is a non-biting fly or midge. A deformity in the mentum of a chironomid was characterized by deformed "teeth", large irregularities in the shape of "teeth", or major "jaw" (mentum) asymmetries associated with more teeth on one side of the "jaw" (mentum) than on the other. Chemical analyses of the sediments using a GC/MS indicated the likely presence of 1 or 2 n-phenyl naphthylamine and 2,2' or 3,3'- bipyridine at elevated levels in the sediments from which the deformed benthic invertebrates had been taken. Among the 543 chironomids taken from the King's Bridge Park, 16 (3%) were deformed as indicated by the teeth. Among the 40 chironomids taken from the Ford Glass site, 3 (7.5%) were deformed as indicated by the teeth. A one tailed "t" test indicated that the probability of this difference occurring by chance alone was less than 0.05.

ERNEST, A., BONNER, J., and AUTENRIETH, R. **Effect of Particle Size Distribution Descretization on Estimated Particle Aggregation Efficiencies**

Models proposed for simulation of particle aggregation dynamics range from simple empirical models to applications of fractal geometry. Electronic particle counters used to measure particle size distributions provide histograms of particle numbers in descrete particle size categories. A flocculation model based on binary inter-particle collision frequencies was developed to simulate particle number dynamics in descretised particle size categories. A framework was developed in conjunction to synthesize experimental data with the predictive model into the unknown model parameters. The object of this study is to investigate the data needs for accurate estimation of particle collision efficiencies (α). Batch flocculation and vertical flocculent settling studies were conducted on aquatic sediment particles in the size range of 2 to 80μm in diameter to determine aggregation and settling rates. Using this algorithm, α was determined to vary from 0.002 to 0.4 with salinity and shear rate. Perceptible settling in the batch flocculation studies accounts for higher estimated values of α. Significant variability in estimated values of α was also noticed within individual experiments when the dynamic particle size distribution data were compressed from the instrument dependent 256 categories to coarser distributions. Using the initial 256 category size distributions from the batch experiments, the predictive model and a wide range of α values, dynamic particle size distribution data sets were generated and subsequently compressed into 128, 64, 32, 16 and 8 linearly and logarithmically varying particle size categories. Variability in the α values estimated from the compressed data sets indicates that it is not an artifact of the experimental data. The final residual function value after 20 estimation iterations increased with the descretization levels, indicating shallower residual function slopes. Studies are ongoing to quantify this phenomenon.

FINK, LARRY E. AND PENN, MICHAEL, SAIC, McLean, VA, and the University of Michigan, Ann Arbor, MI. **A SPREADSHEET TOXIC SUBSTANCES MODEL FOR THE GREAT LAKES.**

A time-dependent, two-compartment, mass balance model of the fate of hydrophobic toxic substances was developed in a spreadsheet framework for the calculation of load-concentration relationships to evaluate various load reduction and allocation strategies. This simplified model represents all significant fate processes in the Great Lakes with first-order kinetics expressions. The model was calibrated and validated for Total PCBs in Lake Ontario. The response of Lake Michigan was evaluated for various PCBs load reduction strategies. It is concluded that the time-dependent load-concentration relationship is most sensitive to the values of the PCBs air:water and the particle:water partition coefficients and the depth of the active sediment layer. The optimum load reduction strategy appears to require simultaneous reductions of PCBs in air and tributaries and the optimum rate of reduction is on the order of the sediment clearance rate.

FULLER, JONATHAN A., Ohio DNR Div. Geo. Survey, 1634 Sycamore Line, Sandusky, 44870. SAND RESOURCES OF THE OUTER LORAIN PUMPING GROUNDS ON THE LORAIN-VERMILION MORAINE, LAKE ERIE

For many years the 24 sq mi Lorain-Vermilion outer commercial pumping grounds have been dredged. The grounds' borders and early sand-resource reserve estimates were based on sparse data. Forty-four vibratory cores were taken within a 60 sq mi study area to look at the environmental setting and improve on reserve estimates. The study area straddles the crest of the Pelee-Lorain Moraine just south of the Canadian border. The east flank of the moraine is covered by muddy sand or by a sand lag. The cleanest and coarsest sand is on the crest of the moraine. On either side of the moraine the deeper-water lake bottom is made up of fluid mud. The distribution of the sand supports earlier interpretations that the complex is a stranded beach. A study of the inner pumping grounds suggests that the beach was built at the transgressing shoreline before the moraine was drowned by the re-establishment of the Upper Lake's drainage through the Lake Erie basin, about 2,600 YBP. The sand, which presumably came from winnowing of the moraine till, is therefore a relic deposit which is being kept clear of fluid mud because it is on a localized bathymetric high and it is within wavebase of the larger storm waves that sweep the area.

HAYES, Joshua A. and LOUCKS, Orie L. (Miami University, Oxford OH USA); GLASS, Gary E. (US EPA Environmental Research Laboratory, Duluth MN USA); SORENSEN, John A. and RAPP, George Jr. (University of Minnesota, Duluth MN USA). **Increasing Importance of Nitrate in Acidification of Upper Midwest Seepage Lakes.**

We have developed a two-stage model of the effects of acid deposition on internal generation of acid neutralizing capacity (ANC) in seepage lakes of Wisconsin and the Upper Peninsula of Michigan. The model uses direct measurements and multiple regression to estimate relevant parameters, and then extrapolates backward and forward in time using reasonable scenarios of past and future acid deposition patterns. We predict many lakes will undergo little change in acid-base chemistry in the near future, despite high rates of acid deposition, due to large increases in ANC produced by nitrate reduction; we predict the importance of sulfate reduction will diminish. Acid deposition is known to interfere with nitrogen cycling. Consequently, continuing acid deposition may lead to interruption of nitrate reduction pathways, thus producing large and rapid declines in ANC.

HOKE, R.A.[1], ANKLEY G.T.[2], SCHUBAUER-BERIGAN, M.K.[1], KOSIAN, P.A.[1] AND PHIPPS, G.L.[1] [1]AScI Corp. and [2]U.S. EPA, 6201 Congdon Blvd., Duluth, MN 55804. **An Overview of U.S. EPA, ERL-Duluth Sediment Research - Preliminary Results.**

U.S. EPA commitment to research on contaminants of sediments has grown recently and will continue to grow in the immediate future. ERL-Duluth maintains an integral role in sediment contaminant research at a variety of study sites throughout the U.S. including the Great Lakes. Current ERL-Duluth sediment research has three primary areas of focus; the evaluation of methods for the development of sediment quality criteria, the development of standard methods for acute sediment toxicity tests using benthic invertebrates and the development of acute toxicity identification evaluation methods for toxic sediments. Preliminary results from each of these areas have already contributed substantially to our knowledge of contaminated sediments as, for example, evidenced by the findings that acid volatile sulphide (AVS) plays a major role in determining the bioavailability of several metals in sediments porewaters and ammonia is an important contaminant in many sediments. Future research will continue in these areas and expand into new areas such as the development of food chain models for establishing sediment quality criteria.

HORGAN, M. and LUTTENTON, M. **Water Resources Institute, Grand Valley State University, Allendale, MI 49401.** **Genetic Identity of Little Bay de Noc and Grand River Walleye Populations.**

Allelic frequencies for three polymorphic loci (ADH, MDH, PROT-4) in muscle were determined for walleye populations from Little Bay de Noc (LBD) and the Grand River (GR). These populations differed at the MDH and PROT-4 loci, but not ADH. The LBD population was similar to Lake Huron and Muskegon River populations at all three loci. In contrast, MDH in the GR population differed from other populations, particularly from the Muskegon River. PROT-4 also differed between these two populations, but differences may be due to small sample size (GR n=5). The Grand River is heavily planted with Muskegon River stocks; the genetic difference between these two populations suggests the presence of strong selective pressure in the Grand River, or successful reproduction by wild stocks.

JAHAN-PARWAR, B. **SUNY School of Public Health and Wadsworth Center for Laboratories and Research, New York State Department of Health, Albany, New York.** **Neurobehavioral Indicators of Great Lakes Contaminant Toxicity in Mollusks and Fish.**

We have been studying the neurobehavioral effects of polychlorinated biphenyls (PCBs) in several fish and molluscan species with the aim of providing insight into general principles of PCB action on the nervous system and behavior. Results suggest that exposure to a broad spectrum PCB mixture causes similar neurological deficits, reflex retardation, in both *Aplysia* (a mollusc) and fish in a dose-dependent fashion. In *Aplysia*, we have also found that while PCB congeners are taken up indiscriminately from diet, they are distributed differentially to the internal organs. Only a few ortho-substituted non-coplanar congeners bioconcentrate in the nervous system. A single neurophilic ortho-congener (2,4,4'-Trichlorobiphenyl) can mimic the neurobehavioral deficits produced by the PCB mixtures. These findings together with recent evidence (Seegal *et al.*, this meeting) for the ortho-affinity of the mammalian nervous tissue suggest that the ortho substituted neurophilic congeners may be responsible for the neurobehavioral effects of PCBs.

JOHNSON, Charles N, US Army Corps of Engineers, Chicago, IL. STRUCTURAL SHORE PROTECTION IN THE GREAT LAKES: A COSTLY MYTH

One of the unfortunate consequences of past IJC shore-damage studies is the belief that, because shore erosion is hypothesized to be caused only by high water levels, it can be prevented simply by placing barriers to keep wave runup from reaching the bluff toe. Experience during the past two Great Lakes high-low water-level cycles provides many opportunities to test this belief. When water levels declined, beach accretion took place more slowly at seawalls and revetments than at nearby unprotected sites. The accreted beaches tend to be very flat, often with springs flowing from them. The springs indicate thin sand cover; the delayedbeach accretion indicates accelerated clay erosion near the structures. Engineered revetments do not tolerate undermining. Groins provide little protection wherever the nearshore profile is determined by clay. Durable stone is not easily available. Undermined, crumbling engineered revetments are usually succeeded by broken concrete. Quite likely, the ineffectiveness of engineered shore-protection structures explains the eager receptions given "magic" devices such as artificial seaweed.

JOHNSON, Charles N, US Army Corps of Engineers, Chicago, IL. THE HANDS PROFILES AT LITTLE SABLE POINT, MI: A REMARKABLE FIT OF THE LONGINOV-TYPE PROFILE WITH THE BAR-TROUGHS

The approximately 30 profiles surveyed periodically at Little Sable Point on Lake Michigan by E Hands 1967-1976 have been cited as an excellent example of the Bruun Rule for sand-beach profile response to rising water levels. However, the nearly continuous series of springs on the beaches of the north side of the peninsula as far south as the Silver Lake State Park boundary indicate that much of the peninsula is basically a clay feature. Indeed, Hands noted that the bar-troughs of his profiles were often covered with cobbles and gravel. Such particles often overlie till. The deepest troughs of the profiles show a remarkable fit with a type of equilibrium profile derived by V V Longinov for cohesive materials. This type of profile is logarithmic and convex-up.

JOHNSON, Charles N, US Army Corps of Engineers, Chicago, IL. BEHAVIOR OF THE TOE OF A GLACIAL TILL BLUFF IN RESPONSE TO VARYING WATER LEVELS, GLENN, MI, ON LAKE MICHIGAN, 1973-1990

Important assumptions of past IJC erosion-damage studies have been that the bluff-toe elevation is constant and that the recession rate is a function of wave energy reaching the bluff toe. For sand and gravel beaches this assumption is known to be incorrect. For glacial till shores the variability of the bluff-toe elevation with water level is less well established. A site at Glenn MI was surveyed monthly by RA Davis under Corps of Engineers sponsorship from July 1970 thru August 1973 and photographed by Corps of Engineers personnel at irregular intervals 1973-1990, at least once per year from 1984 onward. The bluff and lakebed are stiff till. The bluff-toe elevation appeared to vary directly with water level. This result casts doubt on the IJC study assumptions and therefore on the study conclusions.

JOHNSON, Charles N, US Army Corps of Engineers, Chicago, IL. MITIGATION OF HARBOR-CAUSED SHORE EROSION WITH BEACH NOURISHMENT: TWO CASE STUDIES ON CLAY SHORELINES. I. IMMEDIATE MITIGATION, NEW BUFFALO, MI

This harbor was built in 1974-75. A 275,000 cy dredged-sand mitigative feeder beach was placed downdrift of the harbor as part of the initial construction. Rapid depletion of this beach (gone by 1977-78 winter) led to specification of gravelly land-borrow material for a 1980-81 389,000-ton nourishment. This placement was not yet fully depleted when augmented in 1985 with 120,000 tons of similar material. The gravel was easily traced downdrift. During 1986-88 it began passing two small lakefront communities 3 to 4 miles downdrift. Back updrift at New Buffalo, nourishment of the 1985 type has not been repeated. As of 1990 a rapidly worsening erosion problem is developing in the first mile downdrift from the harbor.

KOCIK, JOHN F. and TAYLOR, WILLIAM W.
Department of Fisheries and Wildlife
Michigan State University
East Lansing, MI 48824

Anadromous steelhead and resident brown trout competition in a Great Lakes tributary

Steelhead have been viewed as potential competitors with resident brown trout in Great Lakes tributaries. We evaluated the degree of competition between these species, by introducing steelhead into an allopatric brown trout population. Prior to the introduction, we evaluated brown trout population characteristics in six discrete study sections of Gilchrist Creek. Assessments were conducted three times during the year using electrofishing. This stream contained a productive (approximately 7500 trout /ha), self-sustaining population of brown trout. Steelhead swim-up fry were introduced in June 1990 to the lower three study sections. We have not detected any differences in the growth or survival of brown trout in sympatry with steelhead. Steelhead YOY have successfully established themselves and exhibit typical growth and survival characteristics. As such, we feel that steelhead do not significantly influence brown trout production in Great Lakes tributaries during their first year.

LESHT, Barry M., Environmental Research Division, Argonne National Laboratory, Argonne, Illinois, 60439. **DESIGN OF A LIMNOLOGICAL SAMPLING NETWORK BASED ON COMBINATORIAL OPTIMIZATION.**

While nonparametric computer-intensive methods have been used to determine the number of sampling stations that would be required to meet specified criteria of accuracy and precision in the calculation of a spatial mean, the objective selection of *m* particular station locations from a larger set of *n* possible locations is a much more daunting computational task. This is because the required number of stations in the network may be determined statistically, but selection of an optimal network configuration of stations requires specification of a particular set. We have experimented with applying a statistical method of combinatorial optimization known as simulated annealing to the problem of designing an optimal sampling network for determining the spatially averaged turbidity in Green Bay. We find that although simulated annealing requires large amounts of computer time, it can provide reasonable solutions. Computational efficiency depends on the nature of the objective function used and on the method by which alternative network configurations are generated. Analysis of the solutions in terms of limnological features can be used to develop station siting criteria.

MYERS, JULIAN M WASTE STREAM TECHNOLOGY INC. 302 GROTE STREET, BUFFALO, NY 14207
PILOT BIOREMEDIATION OF PETROLEUM CONTAMINATED SOIL

Bioremediation of various petroleum hydrocarbons occurred during a four month period at the Port Stanley, Ontario site, 4,800 cubic meters of soil was treated in a two acre containment faciltiy.
The purpose of the pilot project was to demonstrate that: all emissions from the site could be controlled to acceptable levels; the PAH concentrations could be reduced to acceptable levels; bioremediation could be undertaken in a resonable time frame and in a cost effective manner.
Intensive biological and physical operations resulted in a decrease of BETX compounds by 73%; Total Polycyclic Aromatic Hydrocarbon compounds by 86%; and Benzo(a)pyrene by 60%. The four points presented in the purpose have been addressed and positive results indicated.
As a result of the success of the pilot project, the Client has received a Certificate of Approval for a Waste Disposal Site from the M.O.E. Full-scale bioremediation of the remaining volume of contaminated soil (approximately 40,000 cubic meters) has commenced.

O'NEILL, C.R., JR., New York Sea Grant Extension Program, 248 Hartwell Hall, State University of New York College, Brockport, NY 14420, **Introduction and Dispersal of the Zebra Mussel, *Dreissena polymorpha*, in Lake Ontario, 1989 - 1991.**

Since its discovery in Lake St. Claire in June 1988, the zebra mussel, *Dreissena polymorpha*, has spread rapidly throughout the Great Lakes. The first Lake Ontario sighting of the mussel was in Port Weller, at the mouth of the Welland Canal, in November 1989. In December 1989, the mussel was reported at several raw water intakes along the Niagara River. Several individuals were found attached to the hull of a navigation marker buoy in Lake Ontario approximately four miles off the Niagara Bar when buoys were pulled in December 1989 at the end of the commercial navigation season. By January 1990, zebra mussels were confirmed in several locations in the St. Lawrence River. Spring and Summer 1990 evidenced the mussel's rapid dispersal along the south shore of Lake Ontario, infesting waters from Burlington, Ontario, to Nine Mile Point, NY, and in several locations along the lake's northern shore, near Toronto, Picton, and Kingston, Ontario. While little definitive data exists to accurately determine the mechanisms at work in the rapid dispersal of the zebra mussel, several natural and human related vectors can be assumed. The potential further distribution of the zebra mussel during the 1991 spawning season can also be inferred from the experience of the past 14 months.

PATTERSON, Dale, Wisconsin Department of Natural Resources, Madison, Wisconsin, 53707.
STEUER, Jeffrey, United States Geological Survey, Madison, Wisconsin, 53719.
BHATTACHARYYA, Joydeb, Wisconsin Department of Natural Resources, Madison, Wisconsin, 53707. CONCENTRATIONS OF POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF THE LOWER FOX RIVER, WISCONSIN

The Wisconsin Department of Natural Resources, in cooperation with the U.S. Geological Survey, is calibrating and testing a polychlorinated-biphenyl (PCB) transport model for the lower Fox River between Lake Winnebago and DePere. This study effort is part of the Green Bay/Fox River Mass Balance Project. As part of this project, bottom-sediment samples were collected from more than 275 sites in a 30-mile reach of the river. Most of the samples were gravity cores of soft sediment deposits, but some samples were collected using a ponar dredge. Core samples were analyzed for PCB and organic-carbon concentrations, particle-size distribution, and moisture content. Most of the samples were analyzed only for total PCB concentration, but about 10 percent of the samples were also analyzed for concentrations of PCB congeners. Total PCB concentrations in the sediments ranged from less than the analytical detection limit (0.05 milligrams per kilogram) to 210 milligrams per kilogram.

Quigley, M.A., Lang, G.A., and Gordon, W.M. Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI 48105. **Year-to-Year Variability in Production of the Great Lakes Amphipod, *Diporeia* sp. in southeastern Lake Michigan.**

During 1984 to 1988, annual production of the Great Lakes Amphipod *Diporeia* sp. was estimated at a 45 m-deep station in southeastern Lake Michigan through PONAR grab samples obtained periodically from March to December for each year. Amphipods in grab samples were separated from sediment by elutriation (595 µm sieve) and subsequently preserved in 10% formalin solution. Individual total length (rostrum-telson) was later determined with a microscope-digitizer system. Since distinct cohorts could not be identified, production was estimated by a size-frequency method that accounted for size class abundance and individual dry weight derived from length-weight regressions. Production estimates ranged from 15.4 to 18.2 g dry weight $m^{-2}y^{-1}$ and were comparable to previously reported values. P/B ratios ranged from 2.2 to 2.6 and were similar to values expected for pontoporeiid populations inhabiting a 45 m depth interval. A regression analysis of production values over an 8-year period revealed that a significant ($p < 0.10$) decline occurred from 1981 to 1988. Actual factors effecting this decline are presently unknown, but previous evidence suggests that an increase in abundance of fish predators may be partially responsible.

ROOD, STEPHEN G., ASci Corp., Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI 48138. **Geographical Information System (GIS)/Global Positioning System (GPS) Support for Assessment of Contaminated Sediments in the Buffalo River.**

The Buffalo River was selected as one of three sites for study as part of the Assessment and Remediation of Contaminated Sediments (ARCS) Program. Sediment profiling was conducted and core samples were collected for contaminant analysis during 1990. Preliminary planning for the ARCS project determined that accurate locating of sample stations was critical for future spatial data analysis. A GPS using Navstar satellites was chosen to achieve the accuracy required. An example of LORAN versus GPS positioning accuracy is shown. GIS has been used to organize, analyze and display sediment quality information. A variety of GIS products were produced using ARC/INFO, ISM and Surfer. Products presented include: station location maps, contour maps of various chemical and biological parameters and volumetric calculation of contaminated sediments. This application of GIS/GPS demonstrates the ability of this technology to enhance the evaluation and interpretation of sediment quality data.

ROSA, Fernando, Environment Canada, Lakes Research Branch, National Water Research Institute, Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, Ontario L7R 4A6
SEDIMENT TRANSLOCATION IN LAKE ERIE DURING WINTER

Sediment trap moorings were deployed in the three basins of Lake Erie, to measure downflux of particulates and associated contaminants during the winter. The mean downflux of Total Trapped Matter (TTM) and the concentration of total PCBs in different types of sediments in each basin, were measured. The degree of recent contamination, due to contaminated sediments translocated from the West Basin, should be revealed by comparing PCB concentration between the trapped matter, the surficial sediments (0-2mm) which were probably deposited during the winter period, and the top 0-10mm, which in Lake Erie's Central Basin represents the accumulation rate over the past 2-3 years. The mean downflux of TTM, and the concentrations of PCBs in all sediment samples, decrease from west to east and the trap concentrations are equal to the surficial sediment concentrations. PCB concentrations in the trap are higher than in the bottom sediments (0-10mm) by about 33% in the Central and East Basin. These research results show that the Central and East Basin sediments continue to be laden with PCBs translocated from the West Basin, at a rate of 3.1 $\mu g \cdot m^{-2} d^{-1}$, during the winter months.

RUKAVINA, N.A., National Water Research Institute, Burlington, Ontario, L7R 4A6. KARROW, P.F., Department of Earth Sciences, University of Waterloo, Ontario, N2L 3G1
Future bedrock shorelines of the Great Lakes

Bedrock shorelines in the Great Lakes erode more slowly than shores of unconsolidated sediment and exert an important local control on the rate of shoreline recession. Exposed bedrock accounts for about 12 percent of the Canadian shore of the lower lakes and erodes at rates of 1 to 2 orders of magnitude less than those for unconsolidated sediment. To determine the future impact of bedrock on shoreline change in areas where it is not currently exposed, this study projected current lake-level elevations inland until they intersected the bedrock surface. In Lake Ontario, eastern Lake Erie and northern Lake Huron, the bedrock intercept is close enough to the current shoreline to have an influence on recession rates in the near future, and better data on erosion rates for various bedrock types are needed for use in erosion research and coastal-zone management. In most of central and western Lake Erie, Lake St. Clair and southern Lake Huron, the intercept is more than 3 km and as much as 50 km inland, and will not be an important factor in shoreline change. Shore-erosion research and management in these areas should be directed at the inshore changes in overburden stratigraphy and resistance to erosion.

SAMSON, PERRY J., MEADOWS, GUY A., MEADOWS, LORELLE A., Atmospheric, Oceanic and Space Science, Naval Architecture and Marine Engineering, The University of Michigan, Ann Arbor, MI 48109
THE DEPOSITIONAL FATE OF AIRBORNE TOXIC CONTAMINANTS IN THE GREAT LAKES

The Great Lakes region hosts a unique and accurate wind generated, time dependent, current prediction capability not available to most coastal regions. A mesoscale, photochemical, atmospheric transport model for the Great Lakes which predicts the surface deposition of industrial emissions has been recently developed. By coupling this mesoscale atmospheric transport model for the Great Lakes with the existing current prediction capability, the fate of toxic airborne contaminants can be predicted. A case study of the fate of Chicago emissions is investigated to demonstrate the potential depositional patterns in the Lake Michigan fluid body and bottom sediments. These patterns are examined in association with the dominant short term and long term wind climate of the region.

SINGER, J.K., State University College at Buffalo, Department of Earth Sciences, 1300 Elmwood Avenue, Buffalo NY 14222. **ROV Operations in the Buffalo River**

In September 1990, a Remotely Operated Vehicle (ROV) was used to document the bottom of the Buffalo River. Loan of the ROV *Phantom 300* and training in its use was provided by the National Undersea Research Center, Pt. Avery, Conn. The objective of the ROV dives in the Buffalo River was to verify features previously mapped using side-scan sonar. The high amount of sediment in the water column and the fixed focal length of the lens on the *Phantom 300* were two factors contributing to the limited resolution of bottom features. This prevented the observation of longitudinal furrows mapped in the side-scan sonar survey. Despite these limitations, small-scale bottom features were identified including gas escape holes and assorted pock marks. Numerous small fish were observed swimming just above the bottom. Footage documents the disturbance and resuspension of the bottom sediments both by these fish and by the horizontal thrusters on the ROV. A summary tape of ROV operations in the Buffalo River is available.

Topic No. 2, c, p

TATEM, Henry E., SIMMERS, J.W., LEE, C.R., BRANDON, D.L., SKOGERBOE, J.G., USAE Waterways Experiment Station ES-R 3909 Halls Ferry Road Vicksburg MS 39180
Information Summaries for Five Great Lakes Areas of Concern

Contaminated sediments are a problem at most of the Great Lakes Areas of Concern (AOCs). To begin the process of remediation at the AOCs there is a need to know what sediment studies, both published and unpublished, have been conducted and what the results were in relation to the location of contaminated deposits, the contaminants of concern, documented biological effects, and the volume of contaminated sediment at each AOC. State remedial action plans (RAPs) for five AOCs, in-house Corps of Engineer studies, and other literature were reviewed for the USEPA ARCS Program to provide the necessary information. State RAPs for Ashtabula, OH, Grand Calumet R., IN, Buffalo, NY, Saginaw R., MI, and Sheboygan R., WI were obtained and reviewed. Sediment sampling sites and bioassay/biological data at the AOCs are summarized in a subject-reference matrix.

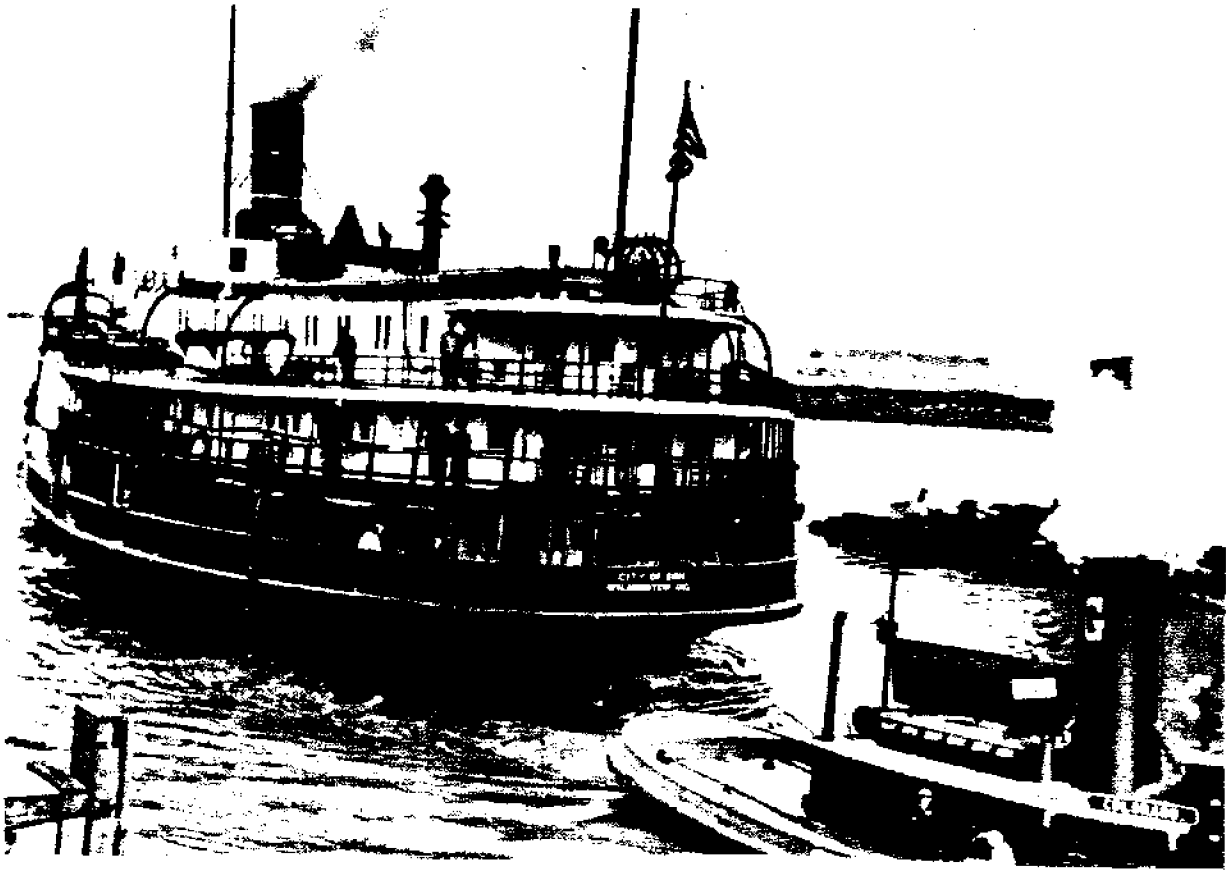
WALTON, T. L., USAE WATERWAYS EXPERIMENT STATION, COASTAL ENGINEERING RESEARCH CENTER, 3909 HALLS FERRY RD., VICKSBURG, MS 39180-6199.

GREAT LAKES WATER LEVEL FORECASTING AND SIMULATION

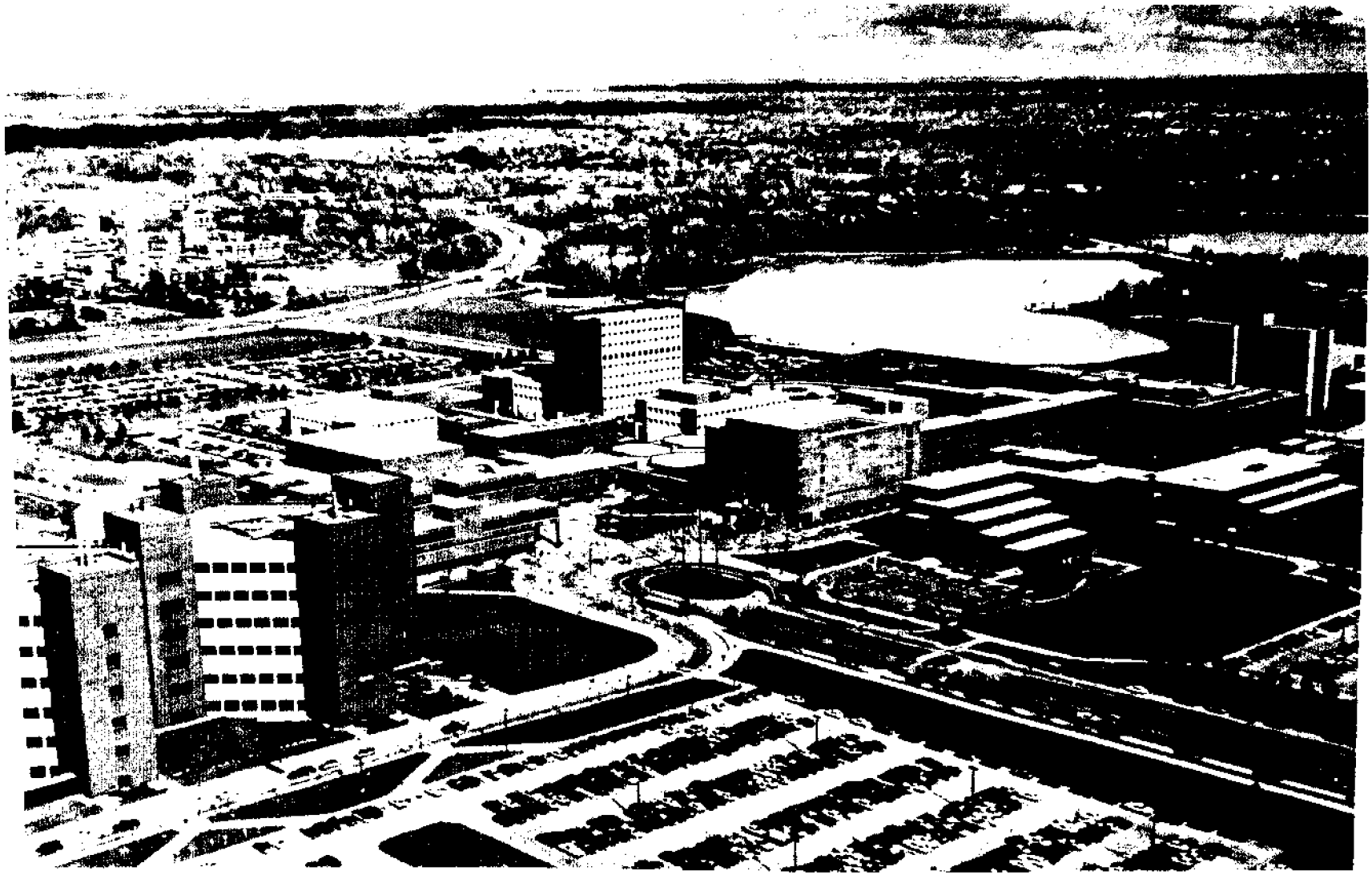
An ability to forecast future water levels would be useful for optimal control of lake stages, but it is also a necessary first step in simulating future water levels for prediction of potential beach erosion that might occur in a major storm. The present paper is an attempt to utilize recent digital signal processing techniques to forecast Great Lakes water levels by separating water level signal informational content from random noise in the time series. By reducing the water level time series to random uncorrelated noise, the potential for simulation of water levels containing the same statistical properties and correlation structure as the original series is realized. The methodology used to do the forecast is shown to provide a forecast horizon well beyond one year in the case of the lower Great Lakes.

DID YOU KNOW

The last passenger vessel built in Buffalo was the CANADIANA.



"City of Erie" passenger vessel being towed in 1939.



An aerial view of the North Campus of State University of New York at Buffalo, site host of the 34th Annual Conference on Great Lakes Research, June 2 - 6, 1991.