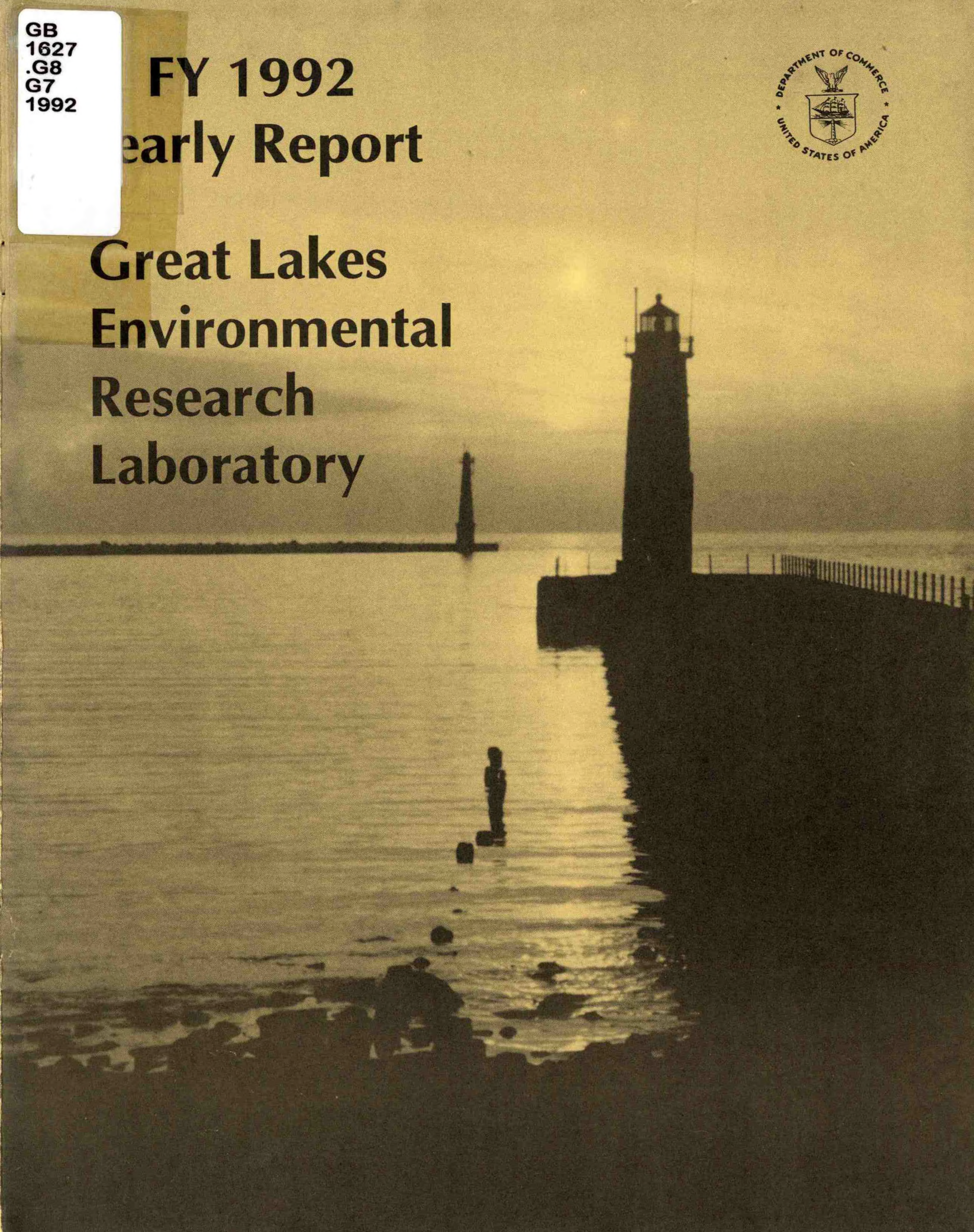
FY 1992
early Report

Great Lakes Environmental Research Laboratory




The Laurentian Great Lakes
ONTARIO
Great Lakes Drainage Basin Limit
CANADA
U.S.A.
MINNESOTA
LAKE SUPERIOR
Duluth
ONTARIO
Sault Ste. Marie
MICHIGAN
Georgian Bay
St. Lawrence River
WISCONSIN
Green Bay
LAKE HURON
Kingston
Traverse City
LAKE MICHIGAN
Toronto
LAKE ONTARIO
MICHIGAN
NEW YORK
N
Muskegon
Grand Haven
ONTARIO
Buffalo
Milwaukee
Lake St. Clair
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Ann Arbor
LAKE ERIE
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Kilometers
ILLINOIS
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INDIANA
Great Lakes Drainage Basin Limit

GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY

YEARLY REPORT FY 1992

Director

Alfred M. Beeton

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Design and electronic production by C.M. Darnell. This is GLERL Contribution No. 830

Cover photo: Muskegon Inner Pier Head Light adjacent to GLERL Muskegon Vessel Operations Facility. Photo courtesy of Mark Ford.

Contents

Introduction

The Great Lakes Environmental Research Laboratory (GLERL), located in Ann Arbor, Michigan, is 1 of 11 environmental laboratories operated by the National Oceanic and Atmospheric Administration (NOAA), Office of Oceanic and Atmospheric Research (OAR), through the Environmental Research Laboratories Directorate.

GLERL's mission is to conduct integrated interdisciplinary environmental research in support of resource management and environmental services in coastal and estuarine waters, with a special emphasis on the Great Lakes. GLERL's research focuses on investigations to improve our understanding of the biological, chemical, and physical processes occurring in natural ecosystems. These processes influence the fate and effects of pollutants, the cycling and through-put of nutrients and energy within the food chain, water quality, and water quantity (lake levels and the hydrologic cycle), or they pose a hazard to the human population who use the natural resources of the ecosystem. In addition, GLERL cooperates closely with other federal, state, and local agencies, private industry, academia, and the general public on major environmental projects in the Great Lakes.

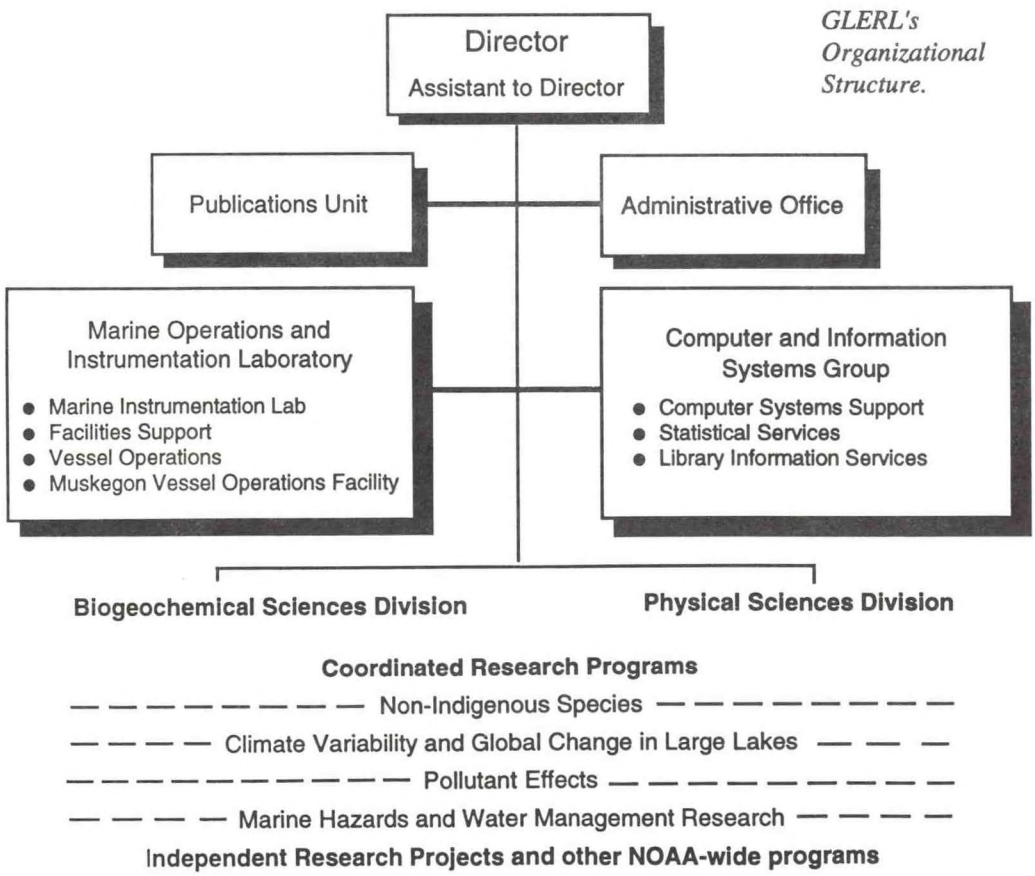
The products of GLERL's research are available as scientific publications, NOAA Technical Series reports, computer programs and computer-based models, brochures, posters, and presentations at scientific and public meetings. These products are used by government, educational, and private organizations for many different purposes ranging from informational to application and operational use. During FY 92, 54 scientific publications by GLERL authors were published, and 60 presentations were given by GLERL staff at scientific and public meetings and in schools.

This report describes the significant activities and accomplishments of GLERL staff during the period October 1, 1991 - September 30, 1992. For general information on how to obtain GLERL products, see the Facilities and Services section of this report.

GLERL's scientific programs are organized into four coordinated research programs considered critical to the NOAA mission and to Great Lakes problems (Marine Hazards and Water Management, Pollutant Effects, Non-Indigenous Species, Climate Variability and Global Change in Large Lakes) and several independent research projects. GLERL also participates in several scientific studies of NOAA's Coastal Ocean Program, such

as the Nutrient Enhanced Coastal Ocean Productivity (NECOP) and CoastWatch programs. In accomplishing this research, GLERL scientists are assisted by six support units which provide technical, operational, and administrative assistance to the scientific staff:

- the **Administrative Office** provides personnel, budget, purchasing, and facility information and management for the laboratory;
- the **Computer Systems Group** maintains GLERL's in-house computer network, the interface with off-site mainframe and super computers, and provides related user support to GLERL staff and others;
- the **Library** maintains a research collection tailored to GLERL staff needs and offers special retrieval services for materials not in the existing holdings;
- the **Marine Operations and Instrumentation Laboratory** designs, builds, and maintains instruments and systems for hands-on and automated field collection of data;
- the **Publications Unit** is responsible for providing editorial and publications support to GLERL staff, distributing GLERL publications, responding to related information requests, and designing and fabricating displays;
- the **R/V *Shenehon***, GLERL's research vessel, is the primary platform used by GLERL staff for field operations on the lakes.



GLERL's Organizational Structure.

Non-Indigenous Species

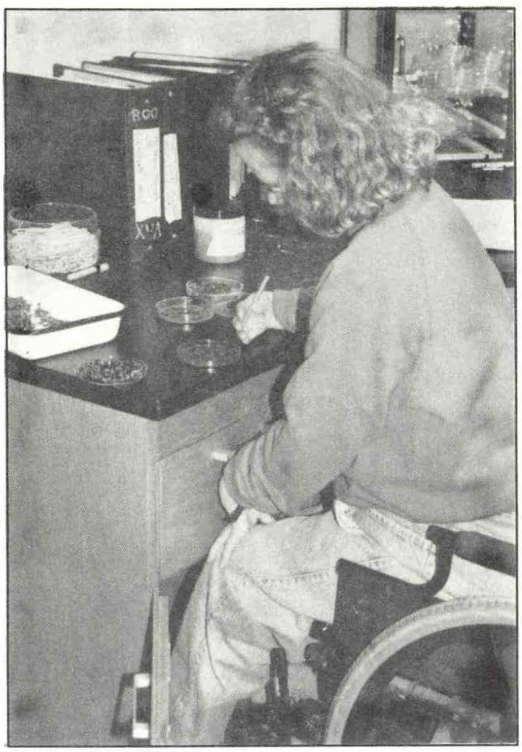
The goal of the Non-Indigenous Species Coordinated Research Program is to expand knowledge of the biology and the ecological effects of non-indigenous species in the Great Lakes.

One species, the zebra mussel (*Dreissena polymorpha*), introduced into the Great Lakes in 1988, has the potential to dramatically alter trophic relationships of the entire ecosystem. *Dreissena* is a small filter-feeding bivalve that attaches to any firm substrate. This organism is a prolific breeder and is capable of increasing in numbers very rapidly. For instance, in the summer of 1988, densities of 200 m^{-2} were reported in the intake canal of a power plant in western Lake Erie. By the summer of 1989, densities had increased to over 500,000 m^{-2}. It was first discovered in Lake St. Clair in late spring 1988 and by fall 1989 had spread throughout Lake Erie and into Lake Ontario. On the basis of numbers and filtering capabilities (up to 1 liter of water a day per mussel), this species will likely have a profound impact on the cycling of materials.

Effects of the Zebra Mussel, *Dreissena polymorpha*, on the Lower Food Web of Saginaw Bay. (Project Scientists: T.F. Nalepa, G.L. Fahnenstiel, and M.J. McCormick)

The objectives of this project are (1) to identify and understand changes in the abundance, biomass, and composition of the lower food web of Saginaw Bay that have resulted from the invasion of the zebra mussel, (2) to construct a model of carbon flow through the system and determine major changes in pathways, and (3) to monitor changes in the abundance and distribution of the zebra mussel in the bay.

In FY 92, samples were collected at 26 stations monthly beginning in April. In addition, zooplankton grazing rates were determined at six of the stations in June. Experiments to determine filtering rates of zebra mussels were conducted during each sampling period. Changes in carbon, chlorophyll, and dry weight of suspended particulates were measured over time. Abundance estimates of zebra mussels were obtained from the same locations as in 1991. All conductivity, temperature, and depth (CTD) data from the monitoring cruises were processed and archived. Ten global positioning system drifters were tested and used on Saginaw Bay. Each drifter internally records its position and temperature from seven thermistors at a user-selected time interval.



Scientist Marijo Wimmer works in the Benthos Laboratory processing zebra mussel samples collected for the Non-Indigenous Species Program.

Metabolic Physiology of the Zebra Mussel, *Dreissena polymorpha*. (Project Scientist: T.F. Nalepa)

This project seeks to seasonally determine oxygen consumption and nitrogen excretion of zebra mussels collected from Lake St. Clair, and lipid content and C:N ratios of soft tissue from zebra mussels.

In FY 92, mussels were collected monthly from April to November in Lake St. Clair and Saginaw Bay. Specimens were analyzed for lipid content, carbon content, nitrogen content, and ash-free dry weight.

Toxicokinetics and Bioaccumulation of Organic Contaminants by the Zebra Mussel. (Project Scientist: P.F. Landrum)

This project is assessing the impact of the zebra mussel on the distribution of contaminants in ecosystems dominated by these organisms. Selected contaminants are from two classes of compounds, the chlorinated hydrocarbons, primarily polychlorinated biphenyls (PCBs), and the polycyclic aromatic hydrocarbons (PAHs). These selected chemicals will be representative of both their class and the physical and chemical characteristics embodied in the chemicals as model compounds. Compounds from other chemical classes will be employed where specific characteristics will be helpful to determine specific processes or mechanisms of action.

In FY 92, work continued to examine the relationship between temperature and the accumulation of organic contaminants from water. Measurements of toxicokinetics of the organic contaminant pentachlorophenol were performed to increase the data base for toxicokinetics in the zebra mussel. Methods development continued to determine the appropriate experimental design to examine the accumulation of organic contaminants from ingested particles.

Direct Observations on the Trophic Ecology of *Dreissena* Early Life Stages: The Critical Planktonic Period. (Project Scientist: H.A. Vanderploeg)

This program is (1) observing feeding mechanisms, particle choice, and feeding rates of *Dreissena* larvae, (2) determining nutritional requirements of *Dreissena* larvae, and

(3) determining the vulnerability of *Dreissena* eggs and larvae to zooplankton.

In FY 92, we successfully maintained adult zebra mussels in the laboratory and have forced them to produce viable fertilized eggs that will survive with little mortality to the D-shell stage—the stage at which they first start feeding. We grew *Dreissena* larvae using static and continuous culture methods with different combinations of algae. We have a combination of algae that have allowed growth from 110 µm, a size approaching the post veliger D-stage, to 150 µm. The experimental results point to the nutritional quality of the algae as the limiting factor. Preliminary experiments which deal with the predation on *Dreissena* by various predators were completed.

Long Term Changes in the Resuspendable Sediments of Saginaw Bay. (Project Scientists: B.J. Eadie, and G.L. Bell)

In shallow systems, the behavior of particle-associated constituents are strongly mediated by the sediment/water exchange. The influence of this coupling on the concentrations, transport, and residence times of these constituents is a function of the extent of bioturbation and the rate of resuspension of these materials back into the water column. The introduction of zebra mussels into this system will likely modify the sediment/water exchange rate either by (1) changing the repackaging of particulate matter resulting in changes in sediment cohesion and resuspendibility, (2) influencing the development of increased macrophyte populations, or (3) changing the density/distribution of benthos and thereby the rate and extent of bioturbation.

In FY 92, we recovered the first trap deployment, analyzed ten 7-day interval mass and carbon fluxes, redeployed both traps, and collected biota for isotope analysis.

Effects of the Zebra Mussel on Nutrient Cycling and Lower Food Web Dynamics in Saginaw Bay, Lake Huron. (Project Scientist: W.S. Gardner)

This task is (1) determining the direct and indirect effects of the zebra mussel on nutrient regeneration and uptake by various trophic components in the lower food web, (2) determining the effects of the zebra mussel on bacteria standing crop, cell size, and growth rates, (3) determining how the sources, cycling rates, and fate of labile dissolved organic matter are affected by the presence of the zebra mussel, (4) collecting and determining the "nutritional composition" of feces/pseudofeces produced by the zebra mussel, and (5) comparing field observations of standing stocks and process rates with those predicted from bottle and mesocosm experiments.

In FY 92, a series of bottle experiments and one large mesocosm experiment were conducted to examine the effects of the zebra mussel on nutrient cycling and microbial dynamics in Saginaw Bay. Although the measurements and data handling are not yet complete, the following observations were made: the zebra mussel often quantitatively removes chlorophyll and other particles from the water, but the degree of particle

removal appears to vary seasonally and to depend on the composition of the phytoplankton in the water. In zebra mussel infested areas, zebra mussel excretion appears to be an important process that affects community nutrient regeneration rates. Regeneration rates for both ammonium and phosphate are directly increased in the presence of the zebra mussel. The presence of zebra mussels changes the abundance, size, and activity of bacteria in the water. Bacterial-sized particles were removed more rapidly from the water column in the presence of zebra mussels than in their absence, but at this time, we do not know whether the effect is direct or indirect. Zebra mussels affect the ability of the microbial community to take up and regenerate phosphorus, but the magnitude of this effect is dependent on how the zebra mussel responds to the existing phytoplankton communities.

Ecology of an Invader: the Physiological Ecology of *Bythotrephes* and its Direct Effect on Food Web Structure in the Great Lakes. (Project Scientist: H.A. Vanderploeg)

Objectives of the program are to (1) determine *in situ* selectivity and predation rates of *Bythotrephes cederstroemi* on zooplankton in the Great Lakes and examine the effect of *Bythotrephes* on food web structure, (2) determine spatial distribution of *Bythotrephes* and its prey, and relate vertical distribution to light climate, (3) directly observe predation mechanisms of *Bythotrephes* using Schlieren videography to observe swimming and attacks and use high-speed videography to observe prey handling of tethered animals, (4) determine nitrogen excretion, lipid content, respiration, and reproductive condition of *Bythotrephes* to understand its bioenergetics, life-cycle strategy, and ability to survive in the Great Lakes, and (5) develop a model of selective predation by *Bythotrephes* to predict its impact on Great Lakes community structure.

In FY 92, partial results of *Bythotrephes* predation were completed and some analysis of population data collected in FY 90 and 91 were completed. This program will be terminated in FY 93 due to lack of funds.

Zooplankton Grazing vs. Zebra Mussel Filtering in Saginaw Bay. (Project Scientists: H.A. Vanderploeg, and G.A. Lang)

This project, initiated this year, will (1) determine zooplankton grazing at Saginaw Bay master stations at monthly intervals from spring to fall, (2) build a model to predict zooplankton grazing and production from zooplankton data collected in this study and in the Saginaw Bay monitoring study, and (3) build a model to predict zebra mussel filtering rates from biomass data collected in the Saginaw Bay monitoring study and compare them with zooplankton grazing results. In FY 93, it is anticipated that field data on zooplankton and *Dreissena* abundance will be examined, and development of a model to predict grazing will be initiated.

Climate Variability and Global Change in Large Lakes

The Great Lakes are an excellent sites for climate change research due to the existence of both physical and biological/chemical measurable signals, existence of long-term records, ongoing physical process studies, and the importance of resources (a multi-billion dollar sport and commercial fishery, fresh drinking water for a large segment of the U.S. population, a multi-billion dollar commercial transportation waterway, etc.). Large lakes, including the Laurentian Great Lakes, are "closed systems" with boundaries on spatial scales and with processes that make them more tractable for study than the oceans. Many of the environmental situations which make some of the oceanic systems desirable for study of climate change are also present in the Great Lakes and can be studied with smaller logistical budgets. Comparative studies of long-term changes between the Great Lakes and other lakes of the world may be possible and would strengthen assessment of global change patterns. The goal of this program is to develop a comprehensive, integrated, interdisciplinary research program on climate change/variability in large lakes.

North American Temperature Characteristics. (Project Scientist: S.J. Bolsenga)

The objective of this new program is to (1) present the temperature patterns over the North American continent and particularly the Great Lakes for 10-year periods in the form of isoline charts, compute differences between the periods, and analyze changes/trends in the patterns, and (2) conduct a program of collaborative research with the National Climatic Data Center to determine temperature trends.

In FY 92, monthly temperature data for the U.S., Canada, and Mexico were obtained. The data sets were processed to computer files, ordered by year, and then combined into a master North American set. A first cut of grid processing was established to translate these station data to monthly gridded data. Annual, 5-year, 10-year, and 1901-1987 averages were computed. Software to produce temperature maps for North America was written and used to generate numerous draft charts. An informal agreement with the National Climatic Data Center was drafted.

Snow Mapping and Characteristics. (Project Scientist: S.J. Bolsenga)

The objectives of this program are to (1) compile monthly, yearly, and period of record snowfall maps for the Great Lakes basin and other areas of the world (Figure 1),

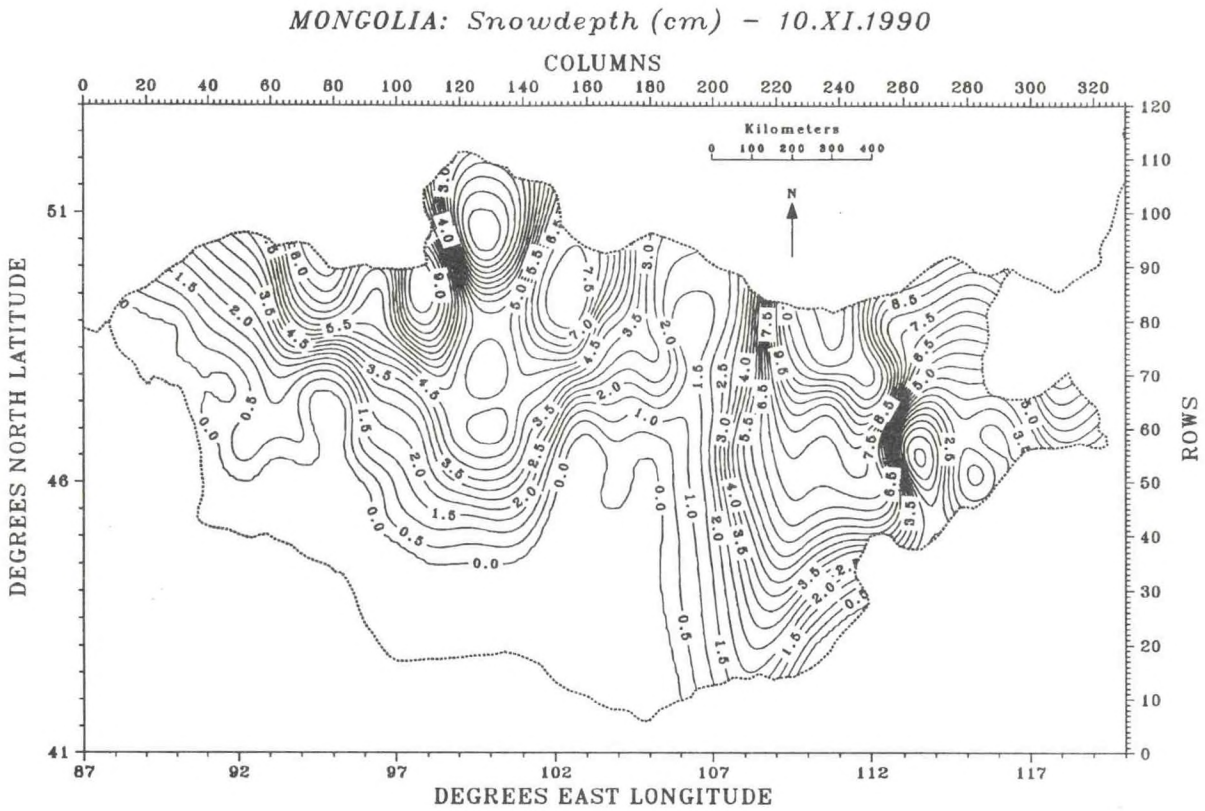


Figure 1. Preliminary snowdepth chart for the Republic of Mongolia. Chart is machine-calculated from Mongolian data. Paucity of data in the mountainous areas (middle Northern portion) produced contours that must be corrected during another phase of this research.

(2) analyze the spatial and temporal variation of the snowfall, and (3) develop quantitative relationships between northern hemisphere circulation patterns and Great Lakes snowfall/snow cover.

In FY 92, final Great Lakes basin snowfall maps were produced for publication. Snow depth data were obtained for the Republic of Mongolia, and snow depth maps were produced. A snow mapping system is being transferred to scientists in that country.

Effect of Climate Change on Large-Lake Ice Cycles. (Project Scientists: R.A. Assel, and D.M. Robertson)

The duration and extent of ice cover on the Great Lakes have a major impact on the economy of the region by impeding commercial navigation, interfering with hydropower production and cooling water intakes, and damaging shore structures. The ice cover also impacts the water balance of the lake by affecting lake evaporation and other heat and momentum transfers. The biology and chemistry of the lakes are also affected by the length and extent of ice cover. Climate change associated with global warming will significantly affect the ice cover which, in turn, will affect other physical, chemical, and biological processes.

In FY 92, a conceptual lake-averaged thermodynamics ice cover model was linked with GLERL's lake evaporation model and calibrated using observed ice cover data for Lakes Erie, Superior, Michigan, Huron, and Ontario.

Preliminary analysis of trends in freeze-up/break-up dates for Grand Traverse Bay starting in 1851 were made as part of a collaborative project with the University of Wisconsin to make a retrospective analysis of a large lake ecosystem. Long-term trends were compared with trends for ice event dates for Lake Mendota. Freeze-up and break-up dates are an index of integrated air temperatures prior to each event date. Air temperature ice event date models were constructed and used to estimate average seasonal air temperature for periods when mean freeze-up and mean break-up dates changed.

Thermal Structure Monitoring for Climate Change. (Project Scientist: M.J. McCormick)

The main objectives of this project are (1) to develop improved climatological information (via observations, new instrumentation, and improved analysis) on the distribution and variability of coastal and offshore temperatures and to study their dependence on meteorological and hydrological forces with emphasis on potential changes in climate, and (2) to concurrently provide data for improving numerical models that can simulate and predict the thermal structure in the lakes.

In FY 92, all subsurface moorings were successfully retrieved and the data were recovered. A new surface thermistor string mooring is being tried at the Lake Michigan site. All thermistor chain data were archived.

Current Velocity Profile Measurements in the Straits of Mackinac Using Acoustic Doppler Current Profilers. (Project Scientist: G.S. Miller)

This program is (1) measuring current profiles in strongly stratified shear flow, (2) relating these data to the numerous bi-lake hydraulic and hydrodynamic forcing processes, and (3) providing the framework for a future expanded study of the water volume transport process through the straits.

In FY 92, initial monthly and 136-day net volume flow estimates were computed, and an expanded program was developed to study strait dynamics and the physical, chemical, and biological interactions with Lakes Michigan and Huron.

Winter Ecology in Lakes. (Project Scientists: H.A. Vanderploeg, and S.J. Bolsenga)

This program involves laboratory and field studies to determine the effects of ice cover on ecological and related processes for selected sites on Great Slave Lake in the Canadian Northwest Territories (Figure 2) (in collaboration with the Canadian National

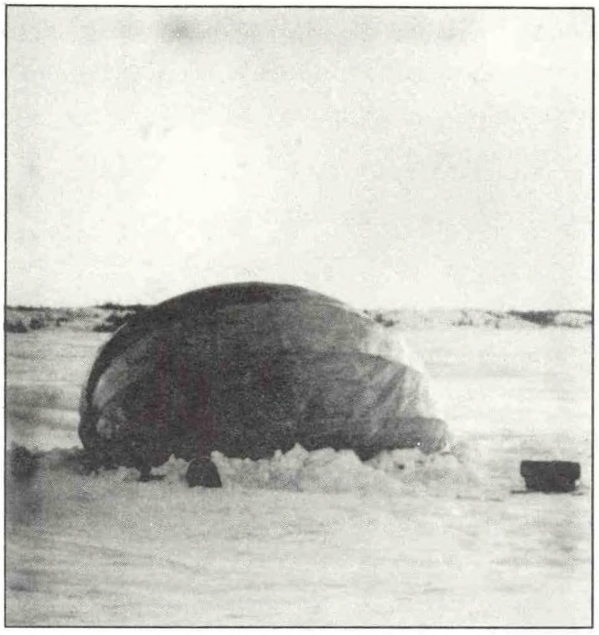


Figure 2. Tent used for biological sampling during -50°F conditions in a joint Canadian/U.S. under-ice ecolgy program on Great Slave Lake in the Canadian Northwest Territories.

Hydrology Research Institute), on Laurentian Great Lakes, on the Mongolian large lakes, and on certain small lakes to contrast impacts. We have thus far completed a 1-week pilot sampling and a 3-week field study. Data analysis is underway.

Impacts of Climate Change on the Hydrology of the North American Great Lakes. (Project Scientist: T.E. Croley II)

The primary goal of this task is to determine potential impacts of future climate change on the hydrology of the Great Lakes basin, and specifically on net basin supplies. Of particular concern is how various climate regimes may affect variability from year to year in net basin supplies and in lake levels.

In FY 92, two geographic areas, representing potential future climates in the Great Lakes basin, were chosen. They represent "hot and dry" and "hot and wet" possibilities for the Great Lakes. The density of meteorological stations needed for the hydrologic modeling effort and the data format and media for data transfer were identified.

Coupled Hydrosphere Atmosphere Research Model. (Project Scientist: T.E. Croley II)

This new research project will assess climate change impacts within the Great Lakes basin by (1) developing a Coupled Hydrologic Atmospheric Research Model (CHARM) from existing atmospheric and hydrologic models, utilizing two-way dynamic interactive feedbacks, and estimation of large-scale parameter impacts of climate change, (2) enhancing CHARM and fine-scale climate change impact estimates with second-generation, two-dimensional hydrologic models of lake thermal flux (and later, land surface parameterizations for runoff), and (3) refining climate-change estimates from other mesoscale modeling efforts by developing one-way linkages between them and existing Great Lakes hydrology models. A major focus in FY 93 will be to couple existing large-scale basin hydrology and lake evaporation models with an atmospheric model developed at the Air Resources Laboratory.

Climate Impacts on Large Lake Hydrology. (Project Scientist: T.E. Croley II)

In this program, which ended in FY 92 and has been reorganized into different tasks, accomplishments include compiling Soviet data for the Caspian Sea Basin, collecting General Circulation Model (GCM) climate-warming scenarios over the U.S. and Russia, and assessing GCM simulations to jointly study the hydrological aspects of climatic change over Russia. Other accomplishments are described under the "CHARM" task (above).

Climate Variability Using Chaotic Dynamics. (Project Scientist: P.C. Liu)

The objective of this study is to explore the applicability of chaotic dynamics for the analysis of Great Lakes climate changes as well as other physical and biogeochemical processes.

In FY 92, we developed an analysis program based on the widely used "embedding" method for calculating basic and generalized correlation dimensions to assess the chaotic characteristics of given time series. We also applied the preliminary analysis techniques to the study of Great Lakes monthly water level data as well as wind-wave time series.

Ecological Modeling. (Project Scientist: G.L. Pernie)

Collection of a detailed data set capable of separating normal seasonal dynamics and year-to-year variability from long-term changes will be necessary to detect climate-driven effects. This data set will also be useful in detecting long-term changes due to nutrient loadings, exotic species invasions, fish management, and other general ecological events.

The primary objective of this project is to monitor plankton dynamics to recognize changes due to climate change caused by increasing atmospheric CO_2. Increases in atmospheric CO_2 may lead to changes in temperature, the onset and duration of thermal stratifications, and critical inorganic carbon dynamics—all of which are important ecological functions and could lead to substantial changes in Great Lakes ecology. We have been routinely monitoring several critical biological, chemical, and physical parameters. Sampling is done so that detailed seasonal and vertical variations will be detected. Special attention is given to frontal formations, since the major impacts due to temperature change will most likely occur during this time. We will also develop a computer data base capable of compiling and presenting the monitoring data in a manner that will be accessible to interested scientists and agencies.

Pollutant Effects

This program pursues research to increase our understanding of the dynamics and effects of contaminants in the ecosystem. The conceptual framework for this research will be the basic toxicological concept that effects are related to the attainment of a critical dose of contaminant for a specific duration. This research will strive for a generic understanding of contaminant dynamics and effects that can be applied to many different systems using sites and processes from the Great Lakes as specific examples. The research effort will combine process studies and mathematical modeling to improve our understanding and ability to predict contaminant fate and effects in the Great Lakes. The program focuses on toxic organic contaminants with primary emphasis on exposure and effects and a lesser emphasis on fate and assessment. Since the role of contaminated sediments remains among the least well understood, but probably among the most important of the exposure pathways, much of the current research is focused on sediment-associated contaminants and exposure to benthos.

Contaminant Effects and the Relationship to Exposure. (Project Scientist: P.F. Landrum)

This project will focus on developing the relationship between contaminant exposure and contaminant effects on biota. To accomplish this goal, new bioassays will be developed, and the body burdens required to elicit the effects of these contaminants will be studied.

In FY 92, *Diporeia* spp. were exposed to pyrene contaminated sediments, and both mortality and pyrene accumulation were followed. The lethal body burden for *Diporeia* was 9.4 µmol/g. A similar experiment was performed with *Lumbriculus variegatus*, however, the doses were not enough to produce sufficient mortality to determine an LD50 (dose required to produce 50% mortality). Mortality and avoidance bioassay data using Saginaw Bay and Saginaw River sediments were combined and analyzed as a preliminary assessment of sediment contamination in this system. Solid phase bioassays using *Diporeia* spp. were performed on sediments from the Raritan Estuary to evaluate the utility of this assay for estuarine environments and from the Saginaw River to evaluate the extent of toxicity reduction achieved by one treatment technique under evaluation. Raritan Estuary sediments were collected as

part of the National Status and Trends Program; Saginaw River sediments were provided by the Corps of Engineers as part of the U.S. EPA's Assessment and Remediation of Contaminated Sediments Program.

Physical and Biological Diagenetic Processes in Sediments. (Project Scientist: P.F. Landrum)

This research examined feeding, burrowing, and other locomotive activities of benthic invertebrates which contribute to sediment bioturbation and the effect of contaminants on these processes. The effect of bioturbation processes on porosity, particle size distribution, and distribution of organic matter including contaminants is also examined.

In FY 92, the reworking rates, an estimate of the rate of bioturbation, for several marine invertebrates were determined. Further, the reworking rates for selected marine benthic assemblages were investigated using intact cores collected from Tampa Bay, Florida. Bioturbation rates were greatest for sediments containing the more diverse assemblages and for sandier sediments. A range finding study of the effect of DDT on *Heteromastus filiformis* feeding was performed in preparation for the examination of the effect of DDT on bioturbation rate.

Particle Transport and Contaminant Cycling in the Upper Great Lakes. (Project Scientist: B.J. Eadie)

The objectives of this program are (1) to collect settling material in Lakes Michigan, Huron, and Superior, (2) to estimate mass and organic carbon fluxes from these trap samples, (3) to measure the decomposition rate of substrate organic matter, and (4) to measure a suite of hydrophobic organic compounds (HOCs) and estimate fluxes and recycling rates.

In FY 92, samples were analyzed and mass fluxes calculated. Carbon has been analyzed on some samples.

Long-Term Trends in Benthic Populations. (Project Scientist: T.F. Nalepa)

The objectives of this project are to first determine trends in benthic populations in selected areas of the Great Lakes, and, if trends are detected, to determine the most probable reasons for the changes observed.

In FY 92, all samples collected in Saginaw Bay in 1987-88 were processed. This includes the identification and length measurements of all oligochaetes. Length measurements of *Diporeia* in samples collected in southern Lake Michigan in 1986-87 were initiated. Samples were collected in spring, summer, and fall at 40 stations in southern Lake Michigan. In addition, 3 extra samples were collected at 10 stations on each sampling date. These samples will be given to personnel from the Canadian Center for Inland Waters for processing as part of the EPA Mapping Program (E-Map) agreement.

Bioavailability of Sediment-Associated Toxic Organic Contaminants. (Project Scientist: P.F. Landrum)

This program seeks to (1) determine the assimilation efficiency of *Diporeia* sp. for ingested sediment-associated organic pollutants, (2) continue to develop the data required to improve the parameterization of a mechanistic bioaccumulation model, (3) validate the kinetics data obtained with laboratory-manipulated sediments by exposing *Diporeia* sp. to field-collected sediments containing similar contaminants, and (4) continue to develop simulation models for sediment-associated toxicants to better understand the bioavailable sources within the sediments and determine if transfer of sediment-associated toxicants to the food chain is significant.

In FY 92, methodology to measure the assimilation efficiency of organic contaminants from ingested sediment was investigated. Examination of the extent of exposure for benthic organisms *Chironomus riparius, Lumbricuus variegatus,* and *Diporeia* exposed to differing representations of sediment; whole sediment, interstitial water, and elutriates (prepared as a 4:1 water to sediment ratio) suggests that the organisms in the whole sediment accumulate more compound (Figure 3), and the contaminant in the sediments is much more available. The potential use of polydimethylsiloxane (PDMS) as a tracer of contaminant assimilation is under investigation. This material may be a better tracer than ^{51}Cr for the organic contaminants. The importance of organic carbon as a tracer of contaminants in sediments was examined by exposing *Diporeia* to sediments collected from several sites in Lake Michigan.

Figure 3a. Accumulation of BaP after 96 hour exposures.

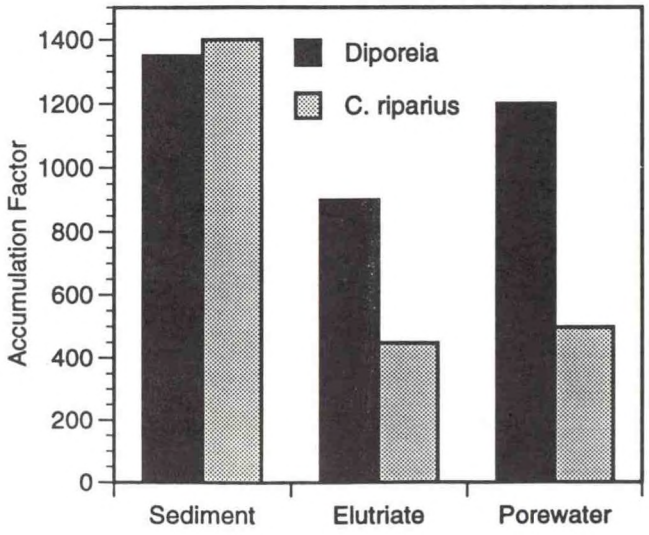
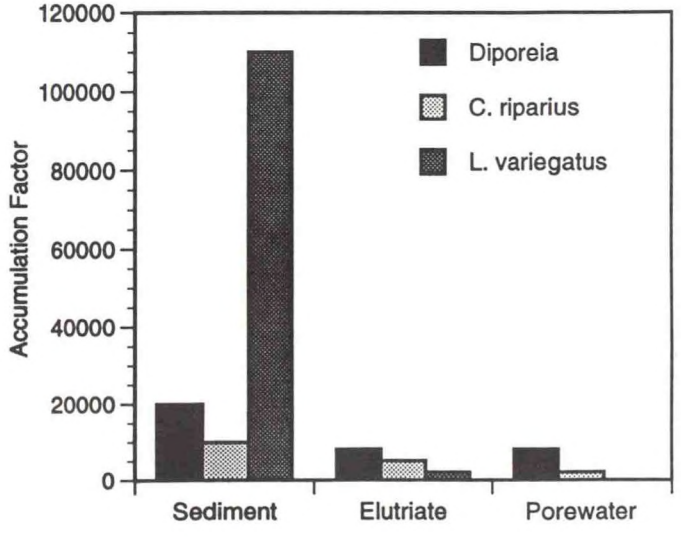


Figure 3b. Accumulation of trans-Chlordane after 96 hour exposures.



Assessment of Chemical Extractability and Bioavailability of Sediment-Associated Pollutants. (Project Scientist: P.L. Van Hoof)

This project will assess the importance of environmental factors such as contact time and weathering on HOC sorption to sediment and bioaccumulation by the benthic organism *Diporeia* sp. Currently, a major topic of interest in assessing the exposure of persistent HOCs to benthic organisms is the relative importance of uptake via the bulk overlying water, interstitial porewater, or ingestion of sediment. Two factors often neglected in laboratory studies which may significantly influence the extent of sorption are pollutant-sediment contact time and physicochemical processes involved with environmental weathering. There is a significant need to compare benthic organisms accumulation of HOCs from laboratory-dosed sediment exposure to accumulation obtained from field-contaminated sediments. The use of chemical extraction kinetics to assess bioavailability will also be explored. This project has just recently begun; plans for FY 93 include methodology development, time course extraction examinations, design and construction of new equipment, and comparison of uptake rates between field-contaminated sediments and laboratory-dosed sediments for *Diporeia* sp.

Bioenergetics of the Great Lakes Amphipod *Diporeia* sp. (Project Scientist: M.A. Quigley)

The overall project objective is to obtain a detailed energy (carbon flow) budget in *Diporeia* sp.

In FY 92, estimates of the annual and seasonal carbon budgets for *Diporeia* in Lake Michigan were completed. Work continued on the parameterization of the amphipod bioenergetics model using the available literature and the results of the long-term trends and carbon budget analyses.

Marine Hazards and Water Management Research

Great Lakes water is used for drinking, power generation, commercial shipping, recreation, and supports an extensive commercial and sport fishery. Both natural (evaporation) and anthropogenic (diversions, consumptive use) influences threaten this valuable resource. Astute water management must be practiced to preserve the Great Lakes water supply. Portions of this program, currently and in the past, have related to prediction, climatology, statistics for decision making, process studies, and interfaces with policy and decision makers. Marine hazards are a result of a variety of environmental phenomena. These hazards can threaten loss of lives or property and cause social or economic disruption. Large waves, high and low lake levels, heavy snowfalls, ice, and erosion are significant hazards in the Great Lakes system and (with the exception of low lake levels) in other coastal areas as well. Human-caused hazards also pose serious threats, especially spills of petroleum products and chemicals. This program is providing models and other service products to assist in marine hazard prediction, emergency response, damage prevention and reduction, and more effective management of water resources.

Great Lakes Evaporation and Heat Storage. (Project Scientist: T.E. Croley II)

This program seeks to (1) derive lake surface temperature and cloud cover models using NOAA and Geostationary Observational Environmental Satellite (GOES) data, (2) classify and interpret lake surface temperature patterns with special respect to weather situations, (3) develop a lake surface temperature model on the basis of NOAA satellite data to derive surface temperature patterns when no satellite data are available, and (4) develop and refine spatially distributed models of the heat fluxes at the lake surface by using satellite and meteorological data, including a model, to determine lake evaporation (Figure 4).

In FY 92, new cloud-testing algorithms were under development to enable automatic cloud masking of the available NOAA CoastWatch data. Algorithms were developed to correlate temperature images from different dates and to correlate temperature images with other spatial data sets (bathymetry, for instance).

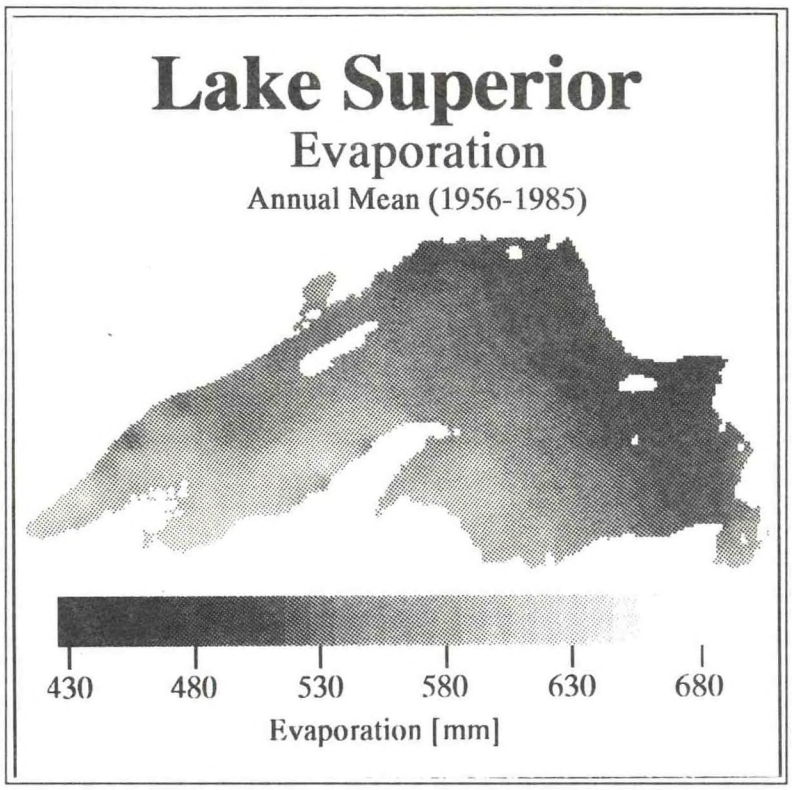


Figure 4. Mean annual evaporation patterns for Lake Superior. The spatial average was 552 mm. Evaporation reaches values of 600 mm in the southwestern part of the lake, while in the eastern lake area, evaporation is mostly under 500 mm.

Great Lakes Hydrology and Ice Databases. (Project Scientists: R.A. Assel, and D.H. Lee)

This program develops and maintains historical Great Lakes hydrology and ice cover data bases. It develops and maintains geographic information data bases of the Great Lakes basin and links the hydrology and ice cover data bases with the geographic data bases for spatial analysis.

In FY 92, we began digitizing historical pre-1948 monthly precipitation data for the Great Lakes states, established Internet computer communications for more efficient communication and transfer of hydrometeorological/ ecological data with outside agencies, completed and distributed an International Great Lakes datum brochure, and collected and archived historical Great Lakes ice charts from the NOAA/Navy Joint Ice Center for the winter of 1991-1992.

Lake Circulation and Thermal Structure Modeling. (Project Scientists: D.J. Schwab, M.J. McCormick, and W.P. O'Connor)

The objectives of this project are (1) to develop and test improved hydrodynamic models that can simulate and predict the three-dimensional structure of currents and temperatures in the Great Lakes, and (2) to extend the models to simulate and predict the transport and diffusion of pollutants and nutrients, and participate in coupling these models to aquatic ecology and water quality models.

In FY 92, routine operation of the Great Lakes Forecasting System at Ohio State University was accomplished and techniques developed for analysis of marine winds, Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) data, and water level data were all incorporated into the prototype Great Lakes Forecasting System.

Great Lakes Water Level Statistics for Decision Making. (Project Scientists: F.H. Quinn, and L.R. Herche)

The long-term objective of this project is to develop improved water level statistics that reflect (1) existing hydrologic and hydraulic conditions, (2) the long lag response of the lakes to meteorologic variability, (3) secular changes in climatic regimes, and (4) the needs of diverse Great Lakes decision makers.

In FY 92, progress was made by (1) evaluating appropriate time series models of net basin supplies and exploring the properties of the historical data, (2) developing a stochastic evaporation time series model, (3) creating a regulations and routing model capable of simulation of long-series of water levels, and (4) assessing water level information needs, developing decision-making techniques, and identifying future statistical products.

Objective Analysis of Great Lakes Marine Meteorological Observations. (Project Scientist: D.J. Schwab)

The main objective of this project is to develop and test improved techniques for objective analysis of overwater meteorological fields and to apply these techniques to practical problems of hindcasting and forecasting winds, waves, storm surges, and lake circulation.

In FY 92, Fleet Numerical Oceanographic Center (FNOC) Field by Information Blending and Smoothing (FIBS) winds were compared to wind fields analyzed by nearest-neighbor and inverse distance weighting schemes. When used to drive a Lake Erie storm surge model, smoothed nearest neighbor wind fields appeared to provide the most realistic storm surge simulations (Figure 5).

Assessment of Shallow-Water Effects on Wind Waves. (Project Scientists: P.C. Liu, and D.J. Schwab)

Using field measurements, data analyses, analytical techniques, and numerical models, this program seeks to (1) quantitatively assess the importance of shallow water effects on wind waves in the Great Lakes, (2) identify as well as quantify the circumstances and locations in which shallow water effects have a significant impact on deep water waves, and (3) improve understanding and prediction techniques of shallow water waves.

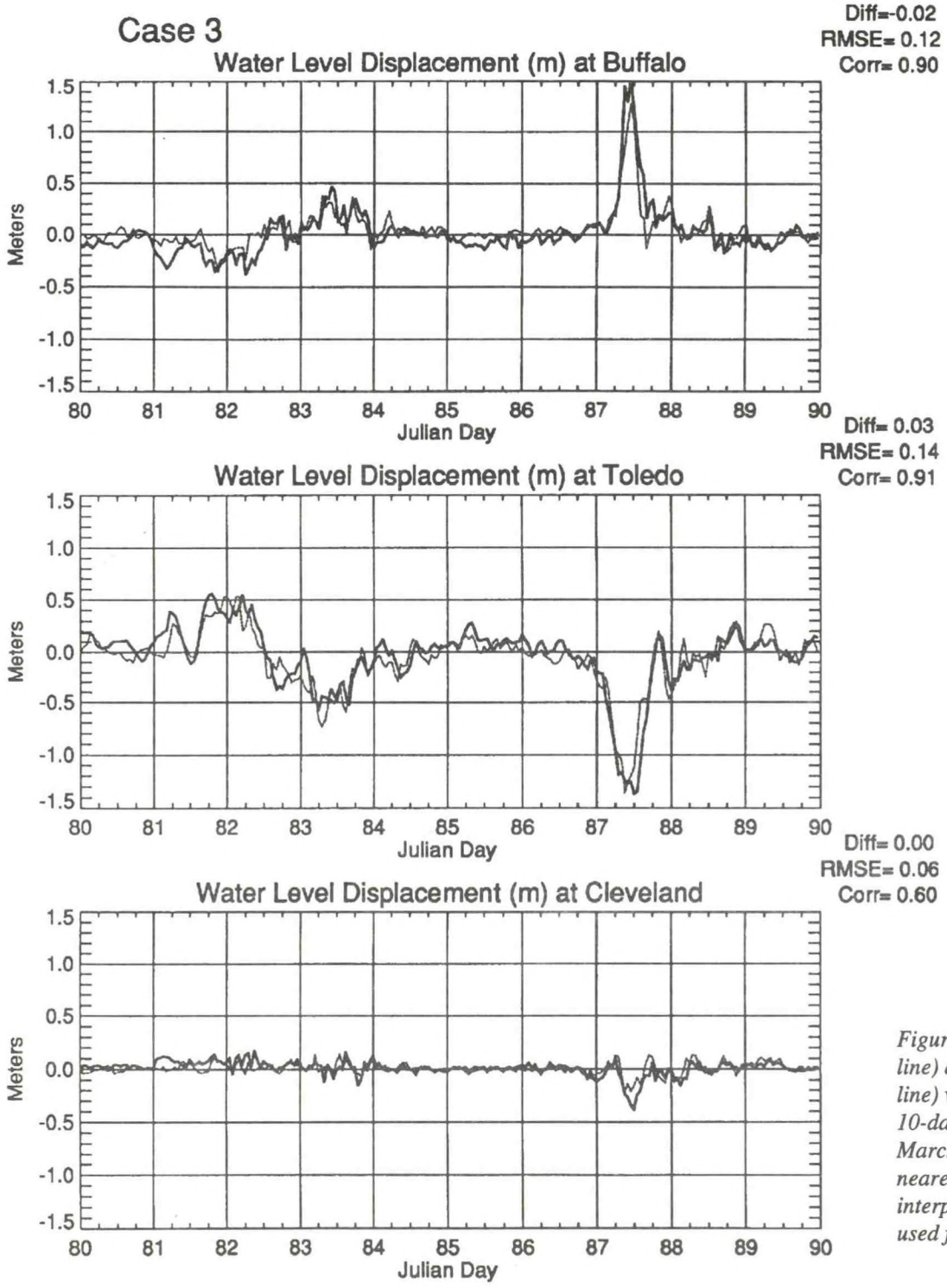


Figure 5. Observed (heavy line) and calculated (dashed line) water levels during a 10-day storm episode in March 1991. Smoothed, nearest-neighbor interpolated wind fields were used for the calculations.

In FY 92, we successfully developed preliminary wavelet transform data analysis programs.

Analysis and Forecasting of Great Lakes Wind Fields. (Project Scientists: D.J. Schwab, and W.P. O'Connor)

The primary objectives of this recently initiated study are to test, evaluate, and refine marine boundary layer physics in the mesoscale models for wind predictions over the

Great Lakes. Specifically, the focus will be on testing Eta-coordinate model performance over the Great Lakes region, looking for necessary changes in the grid representation of the coast line geometry and topography, and modifying the boundary layer physics to improve the model's performance. Also, improved coastal wind analysis techniques will be developed using the better coverage of wind measurements provided by the deployment of future satellites, aircraft winds, and the National Weather Service's (NWS) Next Generation Doppler Radar network.

In FY 93, we will participate in the evaluation of regional coastal meteorological forecasts for the Great Lakes based on a National Marine Center (NMC) model. NMC regional forecasts will also be tested for application to the operational Great Lakes wind wave forecast program at Cleveland and for use in the Great Lakes Forecasting system in collaboration with Ohio State University.

Next Generation Runoff Models. (Project Scientist: D.H. Lee)

This new project will develop next generation runoff models with gridded land surface parameterizations at scales from 1 to 30 km, which can be incorporated into mesoscale atmospheric models and water supply simulation and forecasting packages, and implement the improved models at agencies responsible for water resources forecasting and management.

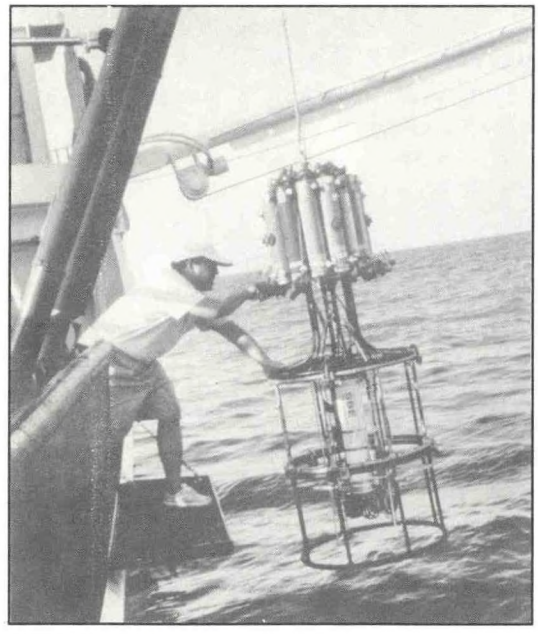
In FY 93, we will survey the literature to assess state-of-the-art runoff modeling, define land surface parameterizations of the next generation runoff model, and acquire land surface spatial data.

Great Lakes Evaporation, Forecasting, and Simulation. (Project Scientist: T.E. Croley II)

In this program, which ended in FY 92 and has been reorganized into different tasks, accomplishments include the following: compared GLERL and Corps of Engineers net water supply forecasts, determined probabilistic outlook methodology for Great Lakes hydrology, integrated one-dimensional flow routing models for the St. Lawrence River, continued improving the quality of the hydrometeorological data base and finished building the hydrometeorological station data base, completed Great Lakes response simulations to extreme climate scenarios, developed and distributed a set of lake levels and flows which reflect a consistent hydraulic regime in the Great Lakes-St. Lawrence River system, developed estimates of present consumption of Great Lakes water based on data collected by the Great Lakes Commission and U.S. Geological Survey, and investigated the pre-1900 St. Clair River flow regime by using measurements and data from dredging between 1860 and 1902.

NECOP

NECOP is one of a series of NOAA-wide programs dealing with major problems in the coastal ocean. The central hypothesis is that increased nutrient input from the Mississippi River has led to increased productivity, with undesirable consequences. GLERL is involved in several studies that have been underway for 2 years.



GLERL scientist Dale Dong assists in the deployment of the conductivity/ temperature/depth (CTD) sampler into the Gulf of Mexico aboard the R/V Longhorn.

The Fate and Effects of Riverine (and Shelf-Derived) Dissolved Organic Carbon and Nitrogen on Mississippi River Plume/Gulf Shelf Processes.

(Project Scientists: W.S. Gardner, and B.J. Eadie)

The objectives of this study are to define the chemical and isotopic composition of riverine and Mississippi River Plume/Gulf Shelf (MRP/GS) dissolved organic nitrogen (DON) and determine the biological reactivity of dissolved organic carbon (DOC) and DON.

In FY 92, our high performance liquid chromatography (HPLC) method to determine ratio of $^{15}NH_4$ to total NH_4 was automated and improved to make it a practical and precise method for isotope dilution experiments being conducted in the Gulf of Mexico. Ammonium regeneration rates were higher in the summer than in the winter. They were also higher in surface waters near the Mississippi River outflow than at stations farther offshore in the plume or in the river. In the productive regions, ammonium regeneration rates were higher in the upper portion of the water column than in regions below the euphotic zone. Methods were developed to concentrate and manipulate bacteria from seawater to assess their importance in regenerating ammonium relative to other heterotrophic organisms. Measurement of ammonium regeneration

rates, in conjunction with manipulation of microbial biomass, indicated that heterotrophic bacteria regenerated a significant portion (50%) of the Mississippi River plume (MRP) but were responsible for a smaller fraction of total regeneration at other sites.

Retrospective Analysis of Nutrient-Enhanced Coastal Ocean Productivity in Sediments from the Louisiana Continental Shelf. (Project Scientists: B.J. Eadie, and J.A. Robbins)

The objectives of this program are to (1) identify areas in the coastal region where sediments with coherent geochronologies of approximately 200 years can be collected, and (2) examine the selected cores for tracers of past water and ecosystem conditions (e.g. carbon, nitrogen, diatom frustules, and stable isotopes).

In FY 92, we completed analysis of 1990-91 cores for lipids and lignins. These results confirmed our stable isotope results showing the presence of increased levels of coastal production in recent sediments. We also participated in a major sediment cruise in April 1992. Cores were collected to extend our program into pore water and diagenesis work. These data are partially analyzed.

Buoyancy and Nutrient Exchange in the Mississippi River Outflow Region. (Project Scientists: A.M. Bratkovich, and S.P. Dinnel)

The primary objectives of this study are to establish a historical relationship between buoyancy and nutrient fluxes for the Mississippi Atchafalaya River (MAR) system and to quantitatively determine the scales of variability for buoyancy and nutrient fields in a shelf region dominated by riverine sources.

In FY 92, we continued field work and analysis of both the historical data base and new data. We processed cruise CTD data for May 1992 and submitted it to the NECOP data base.

Primary Production and Vertical Flux of Organic Carbon. (Project Scientists: G.L. Fahnenstiel, D.G. Redalje, and S.E. Lohrenz)

This research is addressing the following objectives: (1) characterize photoautotrophic community dynamics in relation to optical conditions, nutrient inputs, and other aspects of the physical and chemical environment, (2) examine the relationship between phytoplankton production, growth, and biomass, and the vertical export of fixed carbon from the surface waters of the MRP/IGS (Inner Gulf Shelf), and (3) develop conceptual and predictive models which describe the production and fate of fixed carbon as a function of optical conditions, nutrient inputs, and other environmental variables.

In FY 92, we completed two research cruises and continued development and implementation of the production model.

Suspended Sediment on the Louisiana Continental Shelf: Concentrations, Compositions, and Transport Pathways. (Project Scientist: N. Hawley)

This completed study had three major objectives: (1) to map the spatial distribution and, to the extent possible, the temporal variations of suspended particulate material (SPM) concentrations and composition in the MRP and adjacent shelf water, (2) to determine, within the limits imposed by the budget, the importance of lateral transport of SPM in the study region, and (3) to determine the relationships between the existence and extent of nepheloid layers and other characteristics of the water column such as vertical temperature and salinity structure, ambient current velocity, wave activity, and river discharge.

In FY 92, all available data were processed and plotted. Only one resuspension event occurred during the second cruise at station 1.

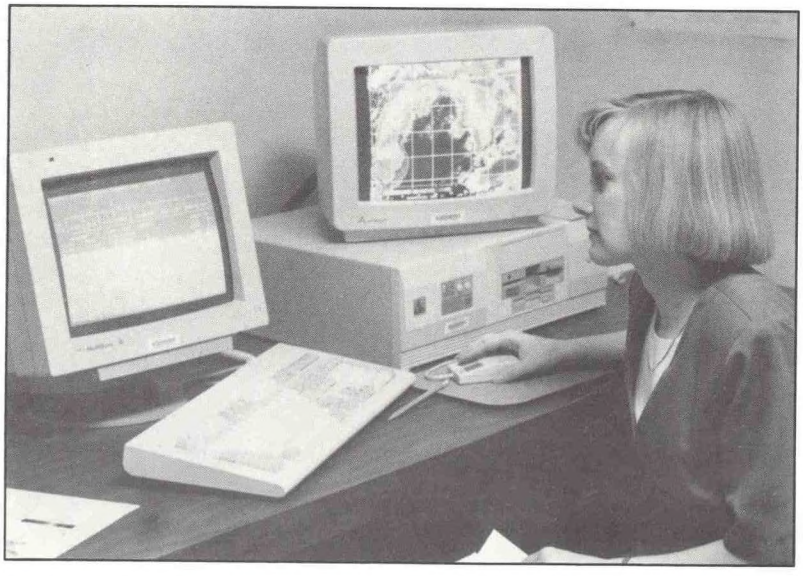
CoastWatch

CoastWatch is a NOAA-wide program within the Coastal Ocean Program. As a CoastWatch Regional Site, GLERL is establishing operations of the Great Lakes Regional National Ocean Communications Network (NOCN) Node (RNN), identifying regional CoastWatch users and their NOAA data needs, and supplying useful products to participants in the Great Lakes CoastWatch Program.

Great Lakes CoastWatch Product Development and Research. (Project Scientist: G.A. Leshkevich)

The objectives of this task are to evaluate and help validate Great Lakes CoastWatch products, provide input to the National Environmental Satellite Data Information Service (NESDIS) for product needs and development, and research and develop products and uses specific to the Great Lakes region using CoastWatch data.

In FY 92, we (1) participated in verification of new Sea Surface Temperature (SST) algorithms for the Great Lakes, (2) began receiving Synthetic Aperture Radar (SAR) workstation hardware and software and some Earth Resources Satellite (ERS)-1 SAR data, (3) completed preliminary evaluation of a Landsat Thematic Mapper (TM) scene for use in chlorophyll mapping, and (4) incorporated 15 federal, state, and local agencies and academic institutions into the program as local CoastWatch sites.



Hydrologist Debra Lee examines CoastWatch products in the Image Processing Laboratory.

Independent Research Projects

Several independent research projects are also included in the GLERL research program. These projects are considered important to the GLERL mission, but do not currently integrate into one of the coordinated research programs.

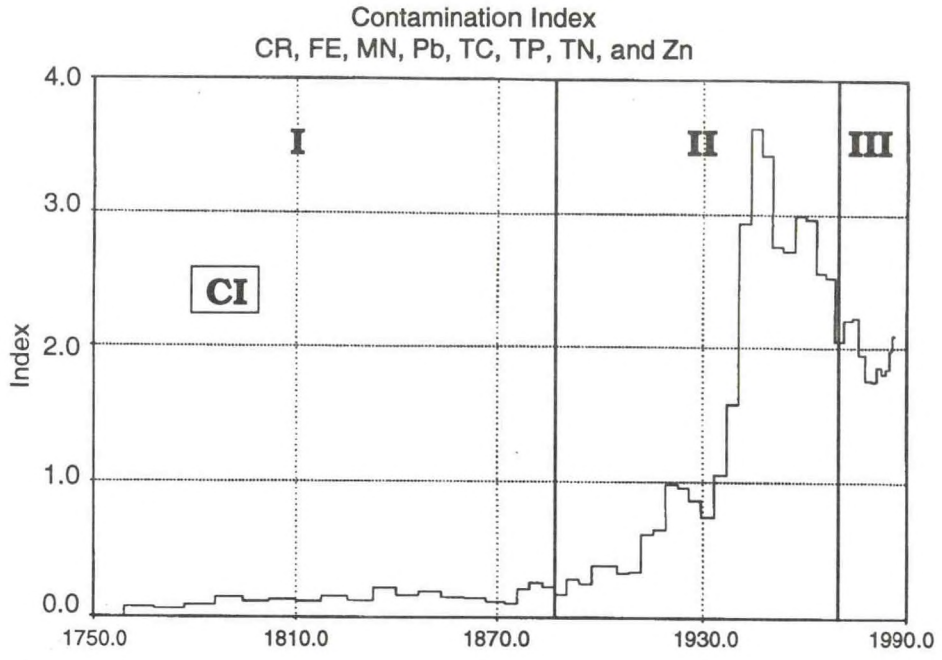
Environmental Radiotracers. (Project Scientist: J.A. Robbins)

This project encompasses studies of diverse aquatic systems and emphasizes the use of radiotracers to identify and model fundamental lake/watershed transport processes. Objectives of the program are (1) to identify principal transport mechanisms in aquatic systems and determine associated space-time scales and rates, (2) to investigate and quantify sediment depositional and geochemical processes, (3) to develop geochronological information from sediment radionuclide profiles for paleolimnological studies, (4) to determine and account for relationships between system loadings and sedimentary records of tracers, contaminants, and other constituents, and (5) to apply techniques, insights, and models arising from radiotracer studies to specific problems of ecosystem dynamics, environmental contamination, and regional effects of climate change.

Some of the accomplishments for FY 92 in this project include (1) analysis of cores from two reference sites for gamma emitters, (2) analysis of samples from 1991 collections in Lake Erie for lead-210 dating and BSi analysis, (3) completion of additional work on geochronological and transport modeling of contaminants in Lake George sediments (Figure 5), (4) development of proper error propagation calculations for widely used geochronological point transformations, (5) currently analyzing cores collected in the Lake Ontario Comprehensive Study, (6) analyzed cores from lakes in Michigan's Upper Peninsula to determine the extent of contamination by copper mining, and (7) processed cores from Great Slave Lake, Northwest Territories for gamma radionuclides to determine feasibility of a more extended project on the lake's history.

Exchange Processes in Coastal Environments. (Project Scientist: A.W. Bratkovich)

This project seeks to observe, analyze, and quantitatively characterize exchange processes impacting variable fields of environmental concern. An essential first step in this sequence is to measure (observe) a range of physical, biological, or chemical fields



Lake George Monitoring Site - LG86

Figure 6. Contamination index versus time in a dated sediment core from Lake George. The index measures the impact of a suite of contaminants on benthic animals relative to background. Little change occurred during the period of early settlement and forest clearance (I: 1750-1900). With industrialization and urban development (II: 1900-1960), impacts increased rapidly to values far exceeding those expected to make sediments largely uninhabitable During the period of industrial decline and environmental remediation (III: 1960-present), the index has decreased, but surface sediments remain significantly impaired, and highest levels of contamination are probably still within reach of some organisms potentially recolonizing sediments.

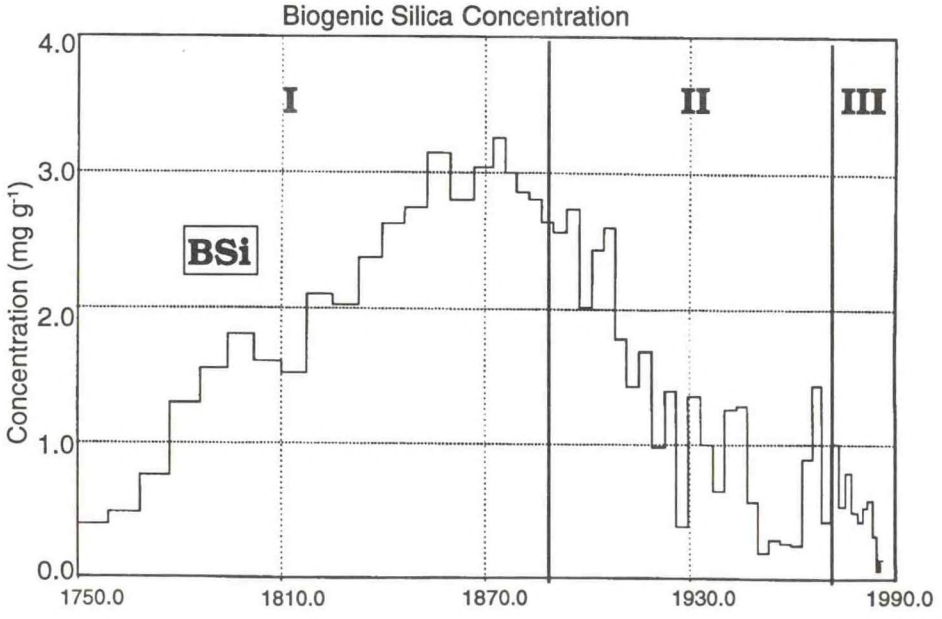


Figure 6 (cont). Concentration of Bsi measures amounts of diatom exoskeletons in sediments and thus, mirrors the impact of contaminants on their abundance in the water. During period I, diatom abundance increased, presumably as a result of addition of nutrients. Urban/industrial activities during period II appear to have significantly impaired diatom production even though nutrient loadings continued to increase. During period III, diatom biomass may have started to rise again.

which affect or characterize the variability of the target field (usually horizontal current components, water density or temperature, impacting critical biological or chemical fields). The objectives are (1) to evaluate the relative importance of advective exchange mechanisms, (2) to identify and investigate the dominant intervariable relationships which form the linkage of these exchange mechanisms, and (3) to develop realistic conceptual, statistical, and analytical models of specific exchange processes which affect variability in fields of environmental concern.

In FY 92, we successfully conducted spring field measurements including near-surface current and thermistor chain measurements, full-water-column moored current profiler measurements, and seven ship surveys of biological/physical variable fields in the vicinity of the frontal zone. Preliminary analysis indicates that these data are of high quality.

Carbon Biogeochemistry in Lakes and Coastal Ecosystems. (Project Scientist: B.J. Eadie)

Great Lakes and coastal ecosystems are continually subject to a series of stressors that are transient in nature. These lead to issues such as the biogeochemical response of systems to increased or decreased nutrient loads, man-induced changes in the carbon cycle and climate, and the introduction of toxic contaminants and their effects. This project focuses on these issues through research on processes regulating the major biogeochemical cycles and fluxes with an emphasis on carbon. The long-term goal of this research is the development of a hierarchy of calibrated numerical models of processes regulating the biogeochemical cycle of carbon in the Great Lakes with subsequent applications to coastal ecosystems. In order to accomplish this, a series of tasks need to be undertaken to provide insight into, and rates for, important processes including CO_2 gas exchange, remineralization of organic carbon (primary production is assumed known from published data, but this parameter is very weak), formation of $CaCO_3$, vertical flux of carbon species, dissolution rate of $CaCO_3$, and remineralization of carbon in sediments and transport across the sediment water interface.

Isotopic analyses of sediments from Lakes Erie, Ontario, and Michigan were completed and data analysis has begun. Autosequencing traps were deployed in Lake Michigan. The E-Map program provided some funding to cover expenses relating to retrieval of these traps and sample splitting with Dr. Eugene Stoermer of the University of Michigan. Samples were collected from Yellowstone Lake for H and O stable isotope analysis. Initial testing of procedures was completed.

Lake Circulation and Bottom Boundary Layer Studies. (Project Scientist: J.H. Saylor, and G.S. Miller)

The existence of a persistent benthic boundary layer has been documented in the offshore regions of all of the Great Lakes. Although the layer contains only a small proportion of the total suspended material found in the lakes, sediment trap studies

have shown that the bulk of the mass flux occurs within the bottom 25 m. This study will quantify the distribution of bottom current intensities as functions of space and time in order to parameterize the distribution and frequency of resuspension events.

In FY 92, we completed a year-long observational study of currents, water temperature distributions, and suspended and bottom sediments in Lake Champlain. We also participated with the Canada Centre for Inland Waters (CCIW) in boundary layer experiments in Lake Ontario during the summer of 1992.

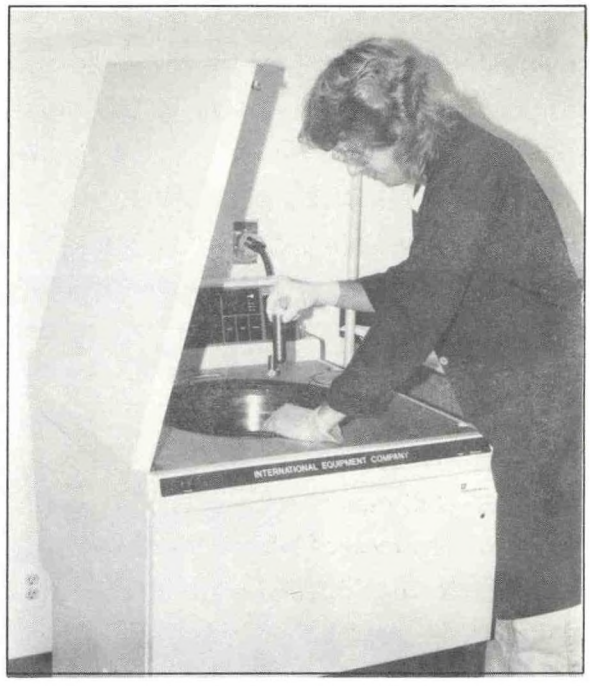
Nitrogen Dynamics. (Project Scientist: W.S. Gardner)

This study is providing (1) improved methodologies to measure fluxes of important nitrogen compounds that reflect nitrogen dynamics in lakes, wetlands, or marine coastal regions, (2) identify, quantify, and compare major processes controlling nitrogen regeneration from lake and marine coastal sediments, and (3) identify and quantify major nitrogen regeneration processes in lake and/or marine pelagic waters.

In FY 92, our HPLC method for $^{15}NH_4$:Total NH_4 ratio determination was automated and improved to make it a practical and precise method for isotope dilution experiments. Literature research was done to examine the potential applicability of capillary zone electrophoresis (CZE) as an improved rapid method for $^{15}NH_4$:Total NH_4 ratio determinations. Dr. Janusz Tomaszek, a visiting scientist from Poland, was at GLERL for 3 months during this fiscal year doing cooperative research on nitrogen dynamics in Old Woman Creek, Lake Erie.

Facilities and Services

GLERL's research facility contains 17 laboratories equipped with general laboratory equipment. In addition, GLERL has a stable isotope mass spectrometer (SIMS), several gas chromatographs and liquid scintillation counters, a high pressure liquid chromatography system, a multi-channel Coulter Counter, growth chambers and incubators, stereo and inverted microscopes, and a fully equipped multi-purpose epifluorescence microscope. GLERL also has high speed microcinematography equipment located in a temperature-controlled environmental chamber which is maintained for conducting experiments and growing biological cultures at low temperatures.



Laboratories contain many different types of equipment. Scientist Duane Gossiaux uses a refrigerated centrifuge in the contaminants laboratory.

Computer Facility

The GLERL computer facility can be best characterized as a Local Area Network (LAN) of distributed computing resources. This network currently consists of 8 VAXs, 5 UNIX/RISC workstations, 15 PCs which are connected by an ethernet, and approximately 80 additional PCs able to access the network via a communications switch. The LAN is connected to the Internet via a router to MichNet.

A variety of scientific applications, including real-time and near real-time data acquisition, data reduction, graphics, large scale modeling, statistical and mathematical analysis, electronic mail, and remote file transfer are accessed by GLERL personnel and collaborators.

Library

The GLERL library has a program-oriented research collection maintained in support of the laboratory's research activities. The collection reflects an emphasis upon freshwater studies, particularly in the Great Lakes basin. Current holdings include 5,452 unbound periodical volumes and 7,787 books/technical reports in the program subject areas of climatology, contaminant organics, hydraulics, hydrology, ice, limnology, mathematical models, meteorology, nutrients, oceanography, sediments, and wave motion. The library currently receives 220 periodical subscriptions. Virtually all GLERL books dating 1980 onward, as well as a large number of earlier books, are now accessible through the On-line Computer Library Center (OCLC) catalog. These books are reflected in the CD-ROM (Compact disk-Read Only Memory) based, computerized NOAA Library Catalog available in the library. Records are shared with EPA and other NOAA Libraries in this union catalog of library holdings. The records can be interactively searched using Boolean search options and displayed in various formats including a full Machine-Readable Cataloging (MARC) record. Library facilities are open to the public for reference use during normal business hours.

Library staff maintain the collection and provide library and information retrieval services in support of laboratory researchers, laboratory-affiliated personnel, and visiting scientists. Special retrieval services are provided when the collection does not meet the needs of individual scientists. Library services include acquisition, circulation, document delivery, interlibrary loan, reference, and online information retrieval.

During FY 92, the library added a public access workstation with four CD-ROM and diskette based databases. The GLERL Library Online Menu was enhanced to provide simplified, internet access to several university library catalogs and information resources within Michigan. The third highest number of interlibrary loan requests were processed, and ongoing efforts were continued to put the complete library holdings into machine readable format to facilitate catalog record searching by library users.

The GLERL library is a member of the Michigan Library Consortium (MLC), Washtenaw-Livingston Library Network (WLLN), Federal Library and Information Network (FEDLINK), NOAA Library and Information Network (NLIN), and the OCLC.

Information Services - Publications Unit

The Publications Unit staff are responsible for providing editorial and publications support to the scientific staff, for preparing and distributing GLERL publications, and for responding to publications and information requests from the public. They also produce and update reports, brochures, and displays concerning GLERL's work.

Research products generated during FY 92 include 54 scientific articles, reports, and books and 60 formal presentations. There were 2,324 documented requests for GLERL information, with 4,868 items mailed in response to those requests.

The Publications Unit maintains a mailing list for distribution of GLERL publications. NOAA-series publications are automatically distributed according to this mailing list as is the six-month update and the yearly report. All new publications, including journal articles and books, are added to our six-month update listing of new publications, to keep our users informed of GLERL's latest product releases. If you would like to be added to GLERL's mailing list, or would like additional information on GLERL's research activities, please write to:

Publications Office
NOAA/Great Lakes Environmental Research Lab
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-1593.

Vessel Operations

- **Muskegon Vessel Operations Facility**

The GLERL Vessel Operations Facility is located in Muskegon, MI in a former Coast Guard Base which includes three buildings and research vessel dockage.

This facility has great potential for the establishment of a lake-side laboratory which has a continuous supply of lake water and will allow some studies to be conducted that are not feasible at the laboratory in Ann Arbor. At present, samples must be transported to Ann Arbor for analysis. A separate garage building is being used for a crew office, a workshop, and for storage of ship supplies and equipment. The third GLERL building is used for storage of research equipment. It is being renovated to include a new chemical laboratory. Equipment installation is planned for June 1993.

There is dockage for the R/V *Shenehon* and one of the smaller research launches in the Coast Guard mooring basin adjacent to the main building. There is an additional 100 feet of dockage in the Government mooring basin currently being leased from the Corps of Engineers and located approximately 0.3 mile from the main building.

- **Research Vessels**

The *Shenehon* is owned and operated by GLERL. The *Shenehon* is based at the Vessel Operations Facility, Muskegon, MI and is the primary platform used in support of GLERL's open lake field investigations. The vessel is 65.6 feet long, with a 6.5-foot mean draft, a 700-nautical-mile cruising range, and a 10-knot cruising speed. Navigation equipment include a Sperry Gyrocompass, Raytheon Radar, two

Sample collection aboard the R/V Shenehon.

The *Shenehon* is owned and operated by GLERL. The *Shenehon* is based at the Vessel Operations Facility, Muskegon, MI and is the primary platform used in support of GLERL's open lake field investigations. The vessel is 65.6 feet long, with a 6.5-foot mean draft, a 700-nautical-mile cruising range, and a 10-knot cruising speed. Navigation equipment include a Sperry Gyrocompass, Raytheon Radar, two LORAN-C (Location Radio Navigation-Coordinates) units, Sperry Auto Pilot and a Raytheon Depth Sounder. A 55-channel radiotelephone is available for ship to shore communication. Electrical power is provided by a modern 20-kW, 3-phase Onan generator, and a 30-kW, 3-phase diesel generator which is original equipment. An electro-hydraulic articulated crane is used for deployment and retrieval of water and bottom sediment samplers and heavy instrument moorings. Electrohydraulic winches handle hydrographic wire and multiconductor cable for sample casts and *in situ* measurements of water variables. An on-board wet laboratory is available for onsite experiments and sample processing. Scientific equipment includes various sizes of Niskin samplers, reversing thermometers, and bottom samplers including a small box corer.

The *Shenehon* is a designated NOAA weather reporting station, and has a Shipboard Environmental (Data) Acquisition System (SEAS) installed by the National Ocean Service. This system provides increased capability to collect and transmit weather data using satellite communications.

A data acquisition system of GLERL design, separate from the SEAS system, records and plots data from a Sea Tech transmissometer which is coupled to an electronic bathythermograph. The system includes equipment to record, process, and plot water temperature data collected using Sippican Expendable Bathythermograph (XBT) probes.

A SeaArk workboat, 28.5 feet in length, including a 2.5 foot deck extension, is

deployment and retrieval of sampling equipment. Safety equipment includes an inflatable life raft and an EPIRB (emergency transmitter).

Two small surplus boats are used as auxiliary research platforms, and a 23-foot Monark workboat, obtained from the Corps of Engineers, was outfitted as a research launch with an electric winch and crane.

- **Research Support**

The majority of the work supported by the *Shenehon,* the 28-foot, and the 23-foot launch was connected with biological studies in Lake Michigan and in Saginaw Bay. These studies included benthic, planktonic, and bacterial experiments relating to algal growth, zooplankton grazing, food chain transport in the aquatic environment, fate and effects of sediment-associated toxic organics, and long-term trends of benthic fauna. Exotic species, such as the zebra mussel and *Bythotrephes* continue to be a very important part of the studies.

During FY 1992, numerous cruises were made by the *Shenehon* in Lake Michigan, and one cruise was made into Lakes Huron and Superior, Straits of Mackinac, Saginaw Bay, and into Green Bay.

The 100-meter station off Grand Haven, MI continued to be the site monitored using sediment traps and periodic water and plankton samplings to study the temporal variations in water quality, and the vertical mass and chemical flux as determined by samples from the traps. Particular emphasis was placed on carbon pools and the rates of transfer. Several cruises were made during the spring using the *Shenehon* along traverses in the vicinity of Grand Haven and Muskegon, MI in connection with studies of frontal processes and thermal bar development and decay.

Sediment traps were deployed at one station in Lake Michigan and at two stations in Saginaw Bay to monitor the vertical mass and chemical flux. Current and temperature sensors were deployed in the center of the southern basin of Lake Michigan.

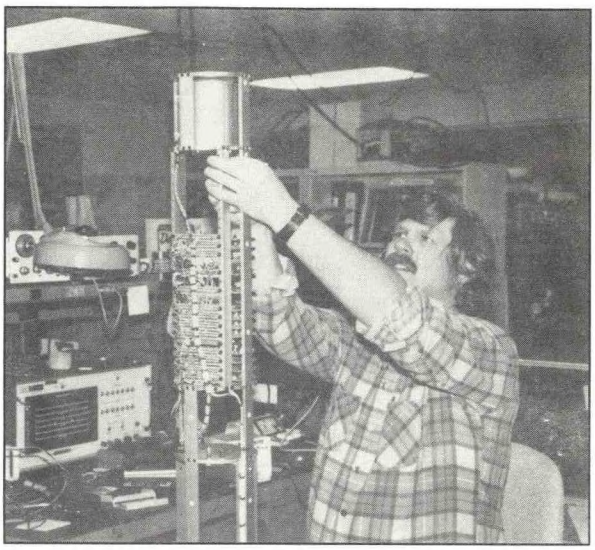
Seven GLERL-designed sequential sediment traps were deployed over the winter of 1991-1992 in Lake Michigan. All were recovered in October 1992 and excellent data were obtained. A portion of these samples will be analyzed by the University of Michigan.

The wire line sweep technique developed by GLERL was successfully used again to recover sediment trap and current meter moorings from submerged positions in Lakes Michigan and Superior. The technique continues to pay dividends due to a rapid and inexpensive recovery of lost equipment.

The R/V *Shenehon* continues to attract attention as she cruises the lakes. Vessel operations supported a GLERL-Muskegon school project to monitor the population

to recover sediment trap and current meter moorings from submerged positions in Lakes Michigan and Superior. The technique continues to pay dividends due to a rapid and inexpensive recovery of lost equipment.

The R/V *Shenehon* continues to attract attention as she cruises the lakes. Vessel operations supported a GLERL-Muskegon school project to monitor the population and growth of zebra mussels in Muskegon Lake. Several newspaper articles were written during the year covering research efforts supported by the *Shenehon*.



Electronics Technician John Lane repairs a current meter in the MOIL.

Marine Operations and Instrumentation Laboratory

The Marine Operations and Instrumentation Laboratory (MOIL) staff select, calibrate, repair, and, when necessary, adapt or design instruments to collect data in the lakes and their environs. Engineers and technicians in this unit work closely with GLERL researchers to ensure that instruments are compatible with their needs. They also participate in field experiments by providing support for the deployment and retrieval of field equipment, assistance with the collection of samples and data, and in-field maintenance or repair of equipment. GLERL's data collection equipment includes 43 AMF Vector Averaging Current Meters, 14 AMF Acoustical Releases, 7 Mini-TOD Drifter Buoys, 1 Adamo-Rupp Waverider WRIPS Buoy, 5 Aanderaa Thermistor String Recorders, 5 Marsh McBirney 585 Current Meters, 1 RD Instrument Co. RDDR-1200 Acoustical Doppler Current Profiler (ADCP), 2 RDSC-600 ADCPs, 1 RDSC broad band ADCP, and 7 sequential sediment samplers.

In FY 92, MOIL staff successfully completed the design and development of a new Global Positioning System (GPS) drifting buoy. These units use the GPS satellite system in a differential mode to track lagrangian water flow while measuring water temperature profiles. They also incorporate the ARGOS satellite system to aid in retrieval and real-time data analysis. Eleven units were constructed and deployed in a prototype experiment in Saginaw Bay.

Other developments include an MOIL-designed temperature profiler that was deployed in southern Lake Michigan that uses the ARGOS satellite system to provide real-time data analysis. Also, a prototype GOES satellite data link was developed to allow real-time data analysis from electromagnetic current meter and multisensor

A new photosynthetron was constructed to measure photosynthesis irradiance curves for use in primary production studies and resulted in a number of inquiries from academia. A refined design was constructed through Great Lakes Engineering Company who plans to build and supply these as a commercial item.

Outreach

The GLERL mission includes the development of environmental information, data, and service tools for users in government and private organizations. Staff participation on boards, commissions, task forces, and committees helps to identify environmental information needed by our users and to guide our research focus and the development of usable products. Participation also helps to maintain staff involvement in programs concerned with environmental problems and issues of water- and land-oriented resource development and management issues. The Publications Unit plays an important role by making GLERL's products available to those who need them, answering information requests, and creating displays and literature concerning GLERL's products and work.

During FY 92, GLERL staff participated as members of the following boards, committees, and task forces:

International Joint Commission

- Council of Great Lakes Research Managers (A. Beeton, member)
- Great Lakes Water Quality Board, Surveillance Work Group
  - Lake Erie Task Force (J. Robbins)
- Great Lakes Water Levels Reference
  - Working Committee 3: Existing Regulation, System-wide Regulation, and Crises Conditions (F. Quinn)
  - Working Committee 3, Task Group 1: Regulation Studies (D. Lee)
  - Working Committee 3, Task Group 2: Support Studies (U.S. Co-chair, F. Quinn, D. Lee)
  - Working Committee 3, Task Group 3: Crises Conditions (D. Lee).
- Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data
  - Hydrometeorology and Modeling Subcommittee (T. Croley II, D. Lee)
  - River Flow Subcommittee (F. Quinn)
- International Great Lakes Levels and Flows Advisory Board (F. Quinn, U.S. Co-chair)

Other interagency, professional society, and international activities:

- American Society for Testing and Materials Sediment Toxicity Subcommittee (P. Landrum)
- American Society for Limnology & Oceanography

- Editorial Board (H. Vanderploeg)
- American Water Resources Association
  - Michigan State Section Steering Committee (D. Lee)
- Assessment and Remediation of Contaminated Sediments (ARCS, USEPA)
  - Toxicity/Chemistry Work Group (P. Landrum)
  - Management Advisory Committee (D. Reid)
- *Chemosphere*, Board of Editors (P. Landrum)
- Critical Reviews in Environmental Science and Technology, Editorial Board (P. Landrum)
- Eastern Snow Conference Research Committee (D. Norton)
- Great Lakes Commission
  - Drought Management and Great Lakes Water Levels Task Force (F. Quinn)
  - Great Lakes Panel on Non-Indigenous Species (T. Nalepa, V. Chair; A. Beeton)
  - Great Lakes Speakers Bureau Directory (G. Laird Pernie, F. Quinn)
  - Task Force on Emergency Preparedness (D. Reid)
  - Observer delegate (A. Beeton)
- Great Lakes GIS Coordinating Committee (G. Leshkevich)
- Great Lakes Protection Fund
  - Technical Advisory Committee (A. Beeton)
- *Handbook of Environmental Chemistry*, Advisory Board (P. Landrum)
- *Hydrobiologia*, Special Issue
  - Associate Editor (B. Eadie)
- International Association for Great Lakes Research
  - Board of Directors (T. Nalepa, M. Quigley, G. Fahnenstiel)
  - IAGLR Membership and Endowment Committee (M. Quigley, Chair; B. Eadie, Liaison with SIL)
  - *Journal of Great Lakes Research* (F. Quinn, D. Schwab, T. Nalepa, P. Landrum, Associate Editors)
- International Association of Theoretical and Applied Limnology (A. Beeton, U.S. Representative)
- International Great Lakes - St. Lawrence Ice Information Working Group (R. Assel, U.S. Co-chair; S. Bolsenga, D. Norton, G. Leshkevich)
- Interagency Non-Indigenous Species Research Protocol Committee (D. Reid, Member)
- International Mathematics and Statistical Library (IMSL) North American Users Group (L. Herche, Chair)
- Michigan Sea Grant Research Advisory Committee (J. Saylor, A. Bratkovich)
- Midwestern Climate Center
  - External Advisory Panel (T. Croley II)
  - Research Review Committee (T. Croley II)
- Mississippi-Alabama Sea Grant Program reviewer (A. Beeton)

- National Research Council
  - Postdoctoral Program (A. Beeton, W. Gardner, H. Vanderploeg, P. Landrum, A. Bratkovich, D. Schwab)
- National Sea Grant Zebra Mussel Review Panel (T. Nalepa)
- NOAA Climate and Global Change Program
  - Technical Advisory Committee (H. Vanderploeg)
- NOAA Coastal Ocean Program
  - Coastal Fisheries Ecosystem Technical Advisory Committee (D. Reid)
  - Great Lakes Forecasting System (D. Schwab, M. McCormick)
  - Coastal Hazards Component (D. Schwab)
  - NOAA/ERL Satellite Requirements Committee (S. Bolsenga, G. Leshkevich)
  - NOAA Mississippi River Plume/Gulf Shelf Region Research Planning Workshop (W. Gardner, G. Fahnenstiel)
  - NOAA NECOP Technical Advisory Committee (B. Eadie, W. Gardner)
  - CoastWatch Program (G. Leshkevich, D. Schwab, G. Spalding)
- NOAA Measurement Technique Development/Ocean Acoustic Techniques and Climate Change Committee Member (M. McCormick)
- NOAA/NURP University of Connecticut/Avery Pt. Center
  - Proposal Review Panel (D. Reid)
- NOAA/SABRE Technical Advisory Committee (A. Bratkovich)
- NOAA Technical Subcommittee, New Bedford Superfund Action (B. Eadie)
- NSF Long-Term Ecological Research Network (S. Bolsenga)
- Ohio Sea Grant
  - Zebra Mussel Project (A. Beeton, T. Nalepa, W. Gardner)
  - Ph.D. Committees (D. Schwab)
  - Research program participation (S. Bolsenga)
- Regional Response Team (RRT), Region V
  - Department of Commerce Representative (D. Reid)
- State of Michigan, Department of Natural Resources
  - Great Lakes Information System Technical Advisory Committee (A. Beeton)
  - Michigan Great Lakes Fund (A. Beeton, S. Bolsenga)
- State University of New York (SUNY) Buffalo, Great Lakes Programs
  - Advisory Board (F. Quinn)
- The University of Michigan
  - Cooperative Institute for Limnology and Ecosystems Research (CILER) Board of Directors; Council of Fellows (A. Beeton, S. Bolsenga, B. Eadie, T. Nalepa, F. Quinn, D. Reid, D. Schwab, A. Bratkovich)
  - Biological Station Executive Committee (A. Beeton)
  - Ph.D Committees (A. Beeton, A. Bratkovich, G. Fahnenstiel, J. Saylor, B. Eadie, H. Vanderploeg)
  - Task Force on Environmental Studies (A. Beeton)

- Thurston Nature Center Advisory Committee (A. Bratkovich)
- U.S.-Canada Ice Information Working Group
  - Great Lakes Ice Issues Subcommittee (R. Assel, U.S. Co-chair)
- U.S. Department of Commerce Consolidated Scientific Computing System Technical Committee (G. Spalding)
- U.S. Department of Energy, Ocean Margins Program
  - Review Panel (B. Eadie)
- U.S. Department of State
  - Cooperative Study on Chernobyl Fallout in Masurian Lakes, Poland (J. Robbins)
  - Mongolian Cooperative Research Program (S. Bolsenga)
  - Russian cooperative research programs (A. Beeton, S. Bolsenga)
- U.S. Environmental Protection Agency
  - Policy Committee (A. Beeton; S. Bolsenga, Alternate)
  - State of the Lakes Ecosystem Conference Steering Committee (H. Vanderploeg)
- U.S. Soil Conservation Service (A. Beeton, Technical Advisor)
- University of Wisconsin Sea Grant Institute (A. Beeton, Site Team Member)
- Wayne County Community College
  - Technical Advisory Committee (H. Booker)
- Zebra Mussel Coordination Committee (A. Beeton, Chair)

Cooperative Research was performed with the following organizations:

- Canadian Climate Center
- Canada Hydrographic Service
- Canadian National Hydrology Research Institute
- Center of Limnology, University of Wisconsin, Madison
- Memorial University, Newfoundland, Canada
- Michigan State University
- Middlebury College and Lamont-Doherty
- NASA/Goddard
- Naval Ocean and Atmospheric Research Lab (NOARL)
- NOAA ERL Air Resources Laboratory, Silver Spring, MD
- NOAA National Geophysical Data Center
- Ohio State University
- Stockholm University, Sweden
- USSR Academy of Sciences
- U.S. Fish and Wildlife Service
- U.S. Geological Survey, Water Resources Division, Madison, WI
- University of Waterloo, Ontario, Canada
- University of Wisconsin-Milwaukee on Yellowstone Lake
- Weber State University

GLERL scientists also:

- Convened and chaired a committee to develop zebra mussel specific research protocols.

- Provided statistical consulting to scientists from The University of Michigan and The University of British Columbia.

- Continued coordination with the Midwestern Climate Center and the Illinois State Water Survey to develop a Midwestern Climate Information System (MICIS).

- In cooperation with researchers from Ohio State University, NOAA Center for Ocean Analysis and Prediction (COAP), and the National Weather Service, developed the Great Lakes Forecasting System, a prototype coastal ocean prediction system for the Great Lakes.

- Provided hydrologic consulting to Hydro-Quebec for their Beauharnois-Les Cedres Extreme Flood Study.

- Serve as adjunct professors at The University of Michigan.

- Serve as adjunct professors at The Ohio State University.

- Served on a review panel for the Department of Interior's Natural Resource Damage Assessment Model for the Great Lakes, a 2-year effort to develop a computer program for assessing financial damages for environmental accidents on the Great Lakes.

- Participated in Cooperative Student Programs with The University of Michigan and Eastern Michigan University.

- Guided students on tours of our facility and gave briefings of GLERL activities.

Meetings and Presentations

An integral part of the scientific development of GLERL staff is attendance and participation in scientific and technical meetings. During FY 92, GLERL sponsored 24 in-house seminars as part of the GLERL Informal Seminar Series. Our staff made 60 presentations concerning GLERL's work at public and professional meetings.

Technology Transfers

GLERL staff responded to 2,324 requests for information during FY 92 and provided more than 4,868 items to service those requests. Many of the products that GLERL produces and distributes involve a transfer of both technology and data. During FY 92, GLERL's outreach of this nature involved the transfer of the following:

Great Lakes Freezing Degree Day Ice Cover Model

- Canadian Climate Center

Great Lakes CoastWatch Data

- Argonne National Laboratory
- Bloom Trail High School
- Center for Great Lakes Studies, University of Wisconsin-Milwaukee
- Department of Civil Engineering, Ohio State University
- Eastern Michigan University
- Illinois-Indiana Sea Grant Program
- Lake Superior Center, Duluth, MN
- Michigan DNR Forest Management Division
- Michigan State University
- Michigan Technological University
- U.S. EPA, Environmental Monitoring Systems Lab
- U.S. EPA, Great Lakes National Program Office
- U.S. Department of Interior, Hammond Bay Biological Station
- U.S. Department of Interior, National Fisheries Research Center, Great Lakes
- U.S. Department of Interior, Water Resources Division
- University of Wisconsin-Madison

Hydrologic Response Model

- Ohio State University

Net Basin Supply Forecast Package

- U.S. Army Corps of Engineers, Detroit District

Water Resources Simulation Package

- Harvard University
- Atmospheric Environment Service (Canada)

Wave Forecast Model

- National Weather Service, Cleveland, OH

"Pathfinder" Trajectory Prediction System

- U.S. Department of the Interior
- U.S. Coast Guard
- McMaster University

Thiessen Weighting Package

- Atmospheric Environment Service (Canada)

Satellite Drifter Programs

- Scripps Institution of Oceanography

Evaporation and Other Data

- National Weather Service
- University of Wisconsin

GLERL's data gathering equipment was shared with:

- The University of Michigan (Center for Great Lakes and Aquatic Sciences; College of Engineering)
- U.S. Army Corps of Engineers
- U.S. Department of the Interior, Fish and Wildlife Service
- Canadian Centre for Inland Waters
- University of Wisconsin
- University of S. Mississippi
- Middlebury College
- U.S. EPA, Environmental Monitoring Systems Laboratory, SUNY Stony Brook

Plans for construction of sediment traps were shared with:

- Ocean Sciences Centre, Newfoundland, Canada
- University of Stockholm, Sweden
- Great Lakes Engineering Company
- University of Michigan
- University of Florida
- University of North Carolina
- University of Minnesota
- Duke University

Other:

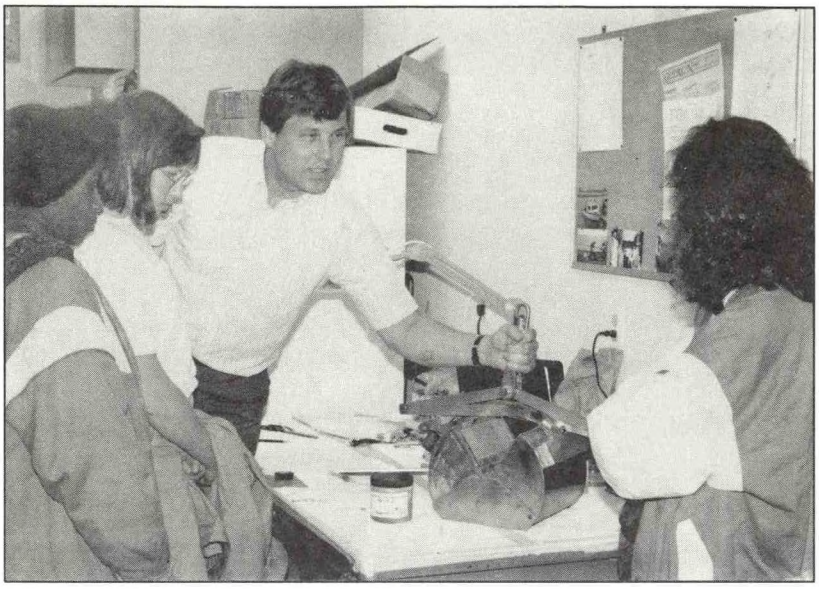
- Filtration device developed at GLERL is being marketed by a small business (St. John Associates).
- Great Lakes Engineering Co. is using plans developed at GLERL to build and market a photosynthetron.

GLERL and Great Lakes Education

Partners for Excellence

In conjunction with NOAA's desire to better inform the public of its research activities, GLERL is involved in a number of Great Lakes community education programs.

In FY 92, GLERL continued its involvement with the Science Department of the Ann Arbor Public Schools' Partners for Excellence Program (T. Nalepa, GLERL Coordinator). The partnership seeks to enrich the schools' curriculum in the area of environmental science, particularly with respect to the Great Lakes and aquatic sciences. Designated partnership activities include:



Biologist, and Partners for Excellence Coordinator, Tom Nalepa explains the use of sediment traps to a group of visiting students.

- Providing mentors to help students with science fair projects.
- Providing practical "hands-on" experience to promising science-oriented students via participation in a Student Volunteer Program.
- Providing information on careers in environmental science and acting as consultants for the science curriculum.
- Inviting science teachers to laboratory-sponsored seminars.

In addition, GLERL staff have made presentations concerning GLERL programs at area schools and have given several tours of our facility to interested students and teachers.

Great Lakes Education Kit

The Publications Unit has compiled and is continually updating a kit composed of materials for teachers who wish to integrate Great Lakes education into their curriculum. The kit is available on a loan basis. Contact the Publications Unit for more information.

Southeast Michigan Science Fair

In conjunction with the 34th Annual Southeast Michigan Regional Science Fair, GLERL sponsored awards for outstanding projects in aquatic science in each of the Science Fair divisions: Senior Projects, Junior Projects, and Junior Models and Collections. GLERL staff (T. Croley, D. Schwab, H. Vanderploeg, J. Saylor, A. Beeton, and J. Cotner) acted as general science fair judges and also as judges for the GLERL award in the Southeast Michigan and local junior high science fairs.

Student Volunteer Program

GLERL and the Ann Arbor Public Schools established a Student Volunteer Program authorized by the Civil Service Reform Act of 1978 (Public Law 95-454). This program provides selected high school students with the opportunity to perform volunteer work at GLERL after school.

ERL Equal Employment Opportunity (EEO) Outreach

In FY 92, GLERL hosted a 16-year-old high school student from Bay City/Saginaw, MI for a 6-week summer internship in cooperation with the ERL/EEO Minority Outreach Program.

Seminars

The following seminars were held at GLERL during FY 92:

Water-particle partitioning of PCB congeners in Little Lake Butte-Des-Morts, WI. J. Crane, ASCI Corp., Athens, GA. October 7, 1991.

Analytical chemistry support of a preliminary investigation of chemical contamination at McMurdo Station, Antarctica. K. Picel, Argonne National Laboratory, Argonne, IL. October 8, 1991.

Influence of nonionic surfactants on the biodegradation of hexachlorobenzene anaerobic sediments. P.L. VanHoof, U.S. EPA, Athens, GA. October 10, 1991.

Dissolved organic matter in natural waters affects the bioavailability of organic xenobiotics. Jussi Kukkonen, University of Finland. October 31, 1991.

Behavioral biomarkers indicative of sublethal stress in Daphnia: effects of NaBr. D.C. McNaught, Director, University of Minnesota Sea Grant Program. November 13, 1991.

GLERL/CILER research possibilities in outer Mongolia. S.J. Bolsenga, GLERL. November 26, 1991.

Career awareness seminar. A. Hicks, Personnel Management Specialist, CASC, Kansas City, MO. December 4, 1991.

Overview of the regional atmospheric modeling system with applications to the Kuwait oil fires. J. McQueen, Air Resources Laboratory, Boulder, CO. February 5, 1992.

Ecotourism, Ecotoxicology, and Endoparasites in Nepal, or Rhinos always get "cuts" in the line for the latrine. J. Rathbun, ASCI Corporation, U.S. EPA Large Lake Research Station, Grosse Ile, MI. February 20, 1992.

Pre-retirement seminar. M. Christenson, CASC Personnel, Kansas City, MO. March 3-4, 1992.

Nutrients/chlorophyll distributions in southeastern shelf waters during winter. L. Atkinson, Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA. March 11, 1992.

The Arctic mixed layer. J. Pazdalski, GLERL. March 19, 1992.

Water resource issues in China. B. Chang, Division of International Programs, National Science Foundation, Washington, DC. March 26, 1992.

A demonstration of ARC/INFO, a geographic information system. A. Bieber, Environmental Systems Research Institute, Redlands, CA. April 8, 1992.

Circulation modeling and new techniques for calculating wave directional spectra. I.K. Tsanis, and F.P. Brissette, McMaster University, Hamilton, Ontario, Canada. May 5, 1992.

Results of the 1991 Survey "Characterization of your work and work conditions." E. Lashbrook, Federal Women's Program Manager, GLERL. June 10, 1992.

Tides and storm surges in the Rio de la Plata estuary. W.P. O'Connor, Institute for Naval Oceanography, Stennis Space Center, MS. June 11, 1992.

Frontogenesis processes in the troposphere. K.M. Hines, UCLA, Los Angeles, CA. June 23, 1992.

Sensitivity of climate and soil moisture to land surface conditions. B.M. Lofgren, Geophysical Fluid Dynamics Lab, Princeton, NJ. June 24, 1992.

Zooplankton community structure and bactovory: a comparison of Sandusky Bay and nearshore Lake Erie. S.-J. Hwang, Dept. of Biological Sciences, Kent State University, Kent, OH. July 17, 1992.

Spatially explicit models of pelagic fish growth: functional linkages between physical and biological structures. S. Brandt, Chesapeake Biological Laboratory, University of Maryland. July 23, 1992

Persons with disabilities: affirmative action and the Americans with disabilities act (ADA). K. Peterson, The Center for Independent Living, Ann Arbor, MI. August 6, 1992.

Precipitation metadata: Why we need them. P.Y. Groisman, State Hydrological Institute, St. Petersburg, Russia. September 8, 1992.

Production of pseudofeces by zebra mussels: costs and benefits. D. McNaught, University of Michigan, CILER, Ann Arbor, MI. September 10, 1992.

FY 92 Staff

Office of the Director

Beeton, A.M. - Director
Noble, P.E. - Secretary
Bolsenga, S.J. - Asst. to Director
Kulpanowski, K.A.- Certified Industrial Hygienist

Administrative Services

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Lashbrook, E.K.
Mull, R.C.

Publications Unit

Darnell, C.M. - Head
Sparks, K.J.

Computer and Information Systems Group

Spalding, G.E. - Head
Lojewski, N.L. - Secretary
Del Proposto, D.J.
Fenton, J.F.
Herche, L.R.
Lefevre, J.T.
Shrum, A.F.

Library Facility

Carrick, B.J. - Librarian
Threm, S.M.

Marine Operations and Instrumentation Laboratory

Soo H.K. - Head
Lojewski, N.L. - Secretary
Bell, G.L.
Booker, H.L.
James, C.*
Kistler, R.D.
Lane, J.C.
Lee, J.P.
Miller, T.C.
Muzzi, R.W.

R/V *Shenehon*

Morse, D.V. - Ship Operator
Burns, W.R.
Grimes, J.E.
Marquardt, J.W.*

Biogeochemical Sciences Division

Reid, D.F. - Head
Williams, R.S. - Secretary

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Calhoun, C.C.=
Cavaletto, J.F.
Cotner, J.B.[C]
Eadie, B.J.
Fahnenstiel, G.L.
Fanslow, D.L.
Faust, W.R.
Gardner, W.S.
Gordon, W.M.=
Gossiaux, D.C.
Gostenik, G.W.*
Gluck, A.A.=
Harkey, G.A.[C]
Johengen, T.H.[C]
Johnson, J.R.[C]
Landrum, P.F.
Lansing, M.B.
Lang, G.A.
Liebig, J.R.
Marcovitz, M.[N]
Morehead, N.R.
Nalepa, T.F.
Nelson, A.S.*
Pernie, G.L.
Quigley, M.A.
Robbins, J.A.
Rood, R.W.[C]
St. Pierre, L.M.=
Thoms, S.R.[N]
Vanderploeg, H.A.
VanHoof, P.A.
Wagoner, B.B.
Wimmer, M.=
Wojcik, J.A.[C]

Physical Sciences Division

Quinn, F.H. - Head
Lawton, B.J. - Secretary

Assel, R.A.
Blythe, K.L.=
Bratkovich, A.W.
Carter, B.S.=
Carver, Y.M.=
Clites, A.H.
Conklin, P.A.=
Croley, T.E., II
Dong, D.Y.[C]
Gottlieb, E.S.*
Hawley, N.
Hunter, T.S.
Jones, B.H.[N]
Kulaszewski, M.=
Lee, D.H.
Leshkevich, G.A.
Lilley, K.=
Liu, P.C.
McCormick, M.J.
Meyer, D.E.
Miller, G.S.
Muhr, G.C.
Nicolini, S.=
Norton, D.C.
O'Connor, W.P.[C]
Pazdalski, J.*
Presley, J.W.=
Ridley, A.[C]
Saylor, J.H.
Schneider, K.[N]
Schwab, D.J.
Sellinger, C.E.

* - Indicates WAE Employee
= - Indicates Co-op Employee
[N] - Indicates NRC Fellow
[C] - Indicates CILER Employee

Visiting Scientists

Dr. Robert Heath
Kent State University, Kent, OH.
Dr. Heath began his 1-year sabbatical starting in August 1991. He collaborated with Dr. Wayne Gardner and others on the Saginaw Bay zebra mussel project. His interests are with carbon and phosphorus cycling and the lower food web.

Dr. Ladd Johnson
Williams College, Mystic, CT
Dr. Johnson is conducting post-doctoral research on zebra mussel distribution. He began his work here in December 1991.

Dr. Jussi Kukkonen
Academy of Finland.
His research focuses on the fate, bioavailability, and toxicity of organic pollutants in fresh-water sediments. Dr. Kukkonen is performing collaborative research with Dr. Peter Landrum from February 92 - July 93.

Dr. Peter McCall
Case Western Reserve University, Cleveland, OH.
Dr. McCall spent 5 months at GLERL as a visiting scientist working with Dr. Peter Landrum and Dr. John Robbins on an EPA-funded project titled "Laboratory Radiotracer Studies of Biological Mixing in Shallow Marine Sediments."

Dr. Don McNaught
University of Minnesota, Minneapolis, MN.
In September 1991, Dr. McNaught began a 1-year sabbatical to work with various GLERL and U.S. Fish and Wildlife Service scientists on the zebra mussel problem.

Dr. Sandor Mulsow
Case Western Reserve University
Dr. Mulsow is working on an EPA project investigating bioturbation with Dr. Peter Landrum and Dr. John Robbins from January 1992 - January 1993.

Dr. Jerome Nriagu
Canada Centre for Inland Waters, Burlington, Ontario, Canada
During his six month sabbatical, Dr. Nriagu divided his time between teaching and research at the University of Michigan School of Public Health and collaborating with Dr. John Robbins on the use of stable lead isotopes to trace sources of lead contamination in the Great Lakes.

Mr. Nathanial Ostrum
Memorial University, St. Johns, Newfoundland.
Mr. Ostrum, a Ph.D. student, was at GLERL for 6 months working with Dr. Brian Eadie to customize a sample preparation system and to calibrate our instrument for nitrogen isotopes.

Dr. Walter Pfeiffer
University of Constance, Constance, Germany.
Dr. Pfeiffer began working with Dr. John Robbins in August 1991. During his 2 month stay at GLERL, his work focused on radiotracers in sediments.

Mr. Gerhard Rappold
Albert Ludwig's University, Freiburg, Germany.
Mr. Rappold worked with George Leshkevich on remote sensing from July - September 1992.

Dr. Janusz Tomazek
International Research and Exchanges Board, Inc., Rzeszo'w University of Technology, Rzeszo'w, Poland.
From September - December 1992, Dr. Tomazek conducted research on denitrification in Old Woman Creek with Dr. Wayne Gardner.

Dr. Paul Walline
Lake Kinneret Limnological Laboratory, Israel.
Dr. Walline began his 14-month sabbatical at GLERL in June 1991. Worked with various GLERL and outside scientists on ecosystem and fisheries related activities.

FY 92 Publications

ASSEL, R.A. A computer tutorial for Great Lakes ice cover climatology. Proceedings, 18th Annual Meeting of the Eastern Snow Conference, Guelph, Ontario, Canada, June 5-7, 1991. 267-272 (1992).

ASSEL, R.A. Great Lakes winter weather 700-hPa PNA teleconnections. *Monthly Weather Review* 120(9):2156-2163 (1992).

ASSEL, R.A., and J.M. RATKOS. A computer tutorial and animation of the normal ice cycle of the Laurentian Great Lakes of North America for 1960-1979. NOAA TM ERL GLERL-76 (PB92-129949/XAB), 31 pp. (1991).

ASSEL, R.A., and D.M. Robertson. Climatic changes near the Great Lakes inferred from 141 year ice records. Proceedings, 5th International Meeting on Statistical Climatology, Toronto, Ontario, Canada, June 22-26, 1992. Environment Canada, Toronto, 81-85 (1992).

Benner, R., G. Chin-Leo, W.S. GARDNER, B.J. EADIE, and J.B. COTNER, Jr. The fates and effects of riverine and shelf-derived DOM on Mississippi River plume/Gulf shelf processes. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 84-94 (1992).

BOLSENGA, S.J. A review of Great Lakes ice research. *Journal of Great Lakes Research* 18(1):169-189 (1992).

BOLSENGA, S.J., and D.C. NORTON. Maximum snowfall at long-term stations in the U.S./Canadian Great Lakes. *Natural Hazards* 5:221-232 (1992).

BOLSENGA, S.J., C.E. Herdendorf, and D.C. NORTON. Spectral transmittance of lake ice from 400-850 nm. *Hydrobiologia* 218:15-25 (1991).

BRATKOVICH, A.W., and S.P. Dinnel. Lower Mississippi River historical nitrate flux and Mississippi River outflow buoyancy flux. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 37-42 (1992).

BRATKOVICH, A.W., R.L. Bernstein, D.B. Chelton, and P.M. Kosro. Central California coastal circulation study: Program overview and representative results. Proceedings, Southern California Bight Physical Oceanography Workshop, LaJolla, CA, November 1990. U.S. Department of the Interior, Minerals Management Service, 91-109 (1991).

*Capitalized names represent GLERL authors.

Burrows, W.R., and R.A. ASSEL. Use of CART for diagnostic and prediction problems in the atmospheric sciences. Proceedings, 12th Conference on Probability and Statistics in the Atmospheric Sciences, Toronto, Ontario, Canada, June 22-26, 1992. American Meteorological Society, Boston, 161-166 (1992).

CARRICK, H.J., G.L. FAHNENSTIEL, E.F. Stoermer, and R.G. Wetzel. The importance of zooplankton-protozoan trophic couplings in Lake Michigan. *Limnology and Oceanography* 36(7):1335-1345 (1991).

CLITES, A.H., T.D. FONTAINE, and J.R. WELLS. Distributed costs of environmental contamination. *Journal of Ecological Economics* 3:215-229 (1991).

COTNER, J.B., Jr., and R.G. Wetzel. Uptake of dissolved inorganic and organic phosphorus compounds by phytoplankton and bacterioplankton. *Limnology and Oceanography* 37(2):232-243 (1992).

CROLEY, T.E., II. Long-term heat storage in the Great Lakes. *Water Resources Research* 28(1):69-81 (1992).

EADIE, B.J., N.R. MOREHEAD, J. Val Klump, and P.F. LANDRUM. Distribution of hydrophobic organic compounds between dissolved and particulate organic matter in Green Bay waters. *Journal of Great Lakes Research* 18(1):91-97 (1992).

EADIE, B.J., G.L. BELL, and N. HAWLEY. Sediment trap study in the Green Bay mass balance program: Mass and organic carbon fluxes, resuspension, and particle settling velocities. NOAA TM ERL GLERL-75 (PB92-125293/XAB) 29 pp. (1991).

EADIE, B.J., J.A. ROBBINS, P. Blackwelder, S. Metz, J.H. Trefry, B. McKee, and T.A. Nelson. A retrospective analysis of nutrient enhanced coastal ocean productivity in sediments from the Louisiana continental shelf. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 7-14 (1992).

FAHNENSTIEL, G.L., and H.J. CARRICK. Phototrophic picoplankton in Lakes Huron and Michigan: Abundance, distribution, composition, and contribution to biomass and production. *Canadian Journal of Fisheries and Aquatic Science* 49:379-388 (1992).

FAHNENSTIEL, G.L., M.H. MARCOVITZ, M.J. McCORMICK, G.D. Redalje, S.E. Lohrenz, H.J. CARRICK, and M.J. Dagg. High growth and microzooplankton-grazing loss rates for phytoplankton populations from the Mississippi River plume region. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 111-116 (1992).

FONTAINE, T.D., and D.J. Stewart. Exploring the effects of multiple management objectives and exotic species on Great Lakes food webs and contaminant dynamics. *Environmental Management* 16(2):225-229 (1992).

GOTTLIEB, E.S. Variability of the stratified flow in the passages connecting Green Bay and Lake Michigan. Ph.D. dissertation, The University of Michigan, Ann Arbor, 94 pp. (1992).

GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY. Annual Report for the Great Lakes Environmental Research Laboratory, FY 91. Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 54 pp. (1992).

GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY. Publications by the staff of the Great Lakes Environmental Research Laboratory, 1974-1991. Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 83 pp. (1992).

HAWLEY, N. Preliminary observations of sediment erosion from a bottom resting flume. *Journal of Great Lakes Research* 17(3):361-367 (1991).

HERCHE, L.R., and H.C. HARTMANN. Estimation of Great Lakes water level statistics: conditioning via "the bootstrap." *Journal of Great Lakes Research* 18(1):218-228 (1992).

JOHENGEN, T.H., and A.M. BEETON. The effects of temporal and spatial variability on monitoring agricultural nonpoint source pollution. The National Rural Clean Water Program Symposium, EPA/625/R-92/006. U.S. EPA Office of Research and Development, Washington, DC, 89-95 (1992).

JOHENGEN, T.H., A.M. BEETON, and R. Holland. A final water quality monitoring report and evaluation of the Saline Valley rural clean water project. Contract Report, Michigan Department of Agriculture, Washtenaw County Board of Commissioners, the Monroe County Board of Commissioners, the Washtenaw County Soil Conservation District, and the Monroe County Soil and Water Conservation District, 136 pp. (1991).

LANDRUM, P.F., and W.R. FAUST. Effect of variation in sediment composition on the uptake rate coefficient for selected PCB and PAH congeners by the amphipod, *Diporeia* sp. In *Aquatic Toxicology and Risk Assessment: Fourteenth Volume*, ASTM STP 1124, M.A. Mayes, and M.B. Barron (eds.). American Society for Testing and Materials, Philadelphia, PA, 263-279 (1991).

LANDRUM, P.F., B.J. EADIE, and W.R. FAUST. Variation in the bioavailability of polycyclic aromatic hydrocarbons to the amphipod *Diporeia* (spp.) with sediment aging. *Environmental Toxicology and Chemistry* 11:1197-1208 (1992).

LANDRUM, P.F., W.A. Frez, and M.S. Simmons. Relationship of toxicokinetic parameters to respiration rates in *Mysis relicta*. *Journal of Great Lakes Research* 18(2):331-339 (1992).

LEE, D.H. Introduction to the special section on improving Great Lakes water level statistics. *Journal of Great Lakes Research* 18(1):199-201 (1992).

LIU, P.C. Chaotic dynamics and ocean wave statistics. Proceedings, Sixth IAHR International Symposium on Stochastic Hydraulics, Taipei, Taiwan, May 18-20, 1992. 345-352 (1992).

LIU, P.C. Extracting dynamics from ocean wave time series data. In *Mechanics Computing in 1990's and Beyond. Volume 1.* H. Adeli and R.L. Sierakowski (eds.). American Society of Civil Engineers, New York. 348-352 (1992).

Lohrenz, S.E., D.G. Redalje, G.L. FAHNENSTIEL, and G.A. LANG. Regulation and distribution of primary production in the northern Gulf of Mexico. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 95-104 (1992).

NALEPA, T.F., W.S. GARDNER, and J.M. MALCZYK. Phosphorus cycling by mussels (Unionidae:Bivalvia) in Lake St. Clair. *Hydrobiologia* 219:239-250 (1991).

NORTON, D.C. Digital Investigation of Great Lakes regional snowfall, 1951-1980. Proceedings, Eastern Snow Conference, Guelph, Ontario, Canada, June 5-7, 1991, 68-80 (1992).

PARRISH, C.C., B.J. EADIE, W.S. GARDNER, and J.F. CAVALETTO. Lipid class and alkane distribution in settling particles of the upper Laurentian Great Lakes. *Organic Geochemistry* 18(1):33-40 (1992).

PRIVALSKY, V. Statistical analysis and predictability of Lake Erie water level variations. *Journal of Great Lakes Research* 18(1):236-243 (1992).

PRIVALSKY, V., and T.E. CROLEY, II. Statistical validation of GCM-simulated climates for the U.S. Great Lakes and the C.I.S. Emba and Ural River basins. *Stochastic Hydrology and Hydraulics* 6:69-80 (1992).

QUIGLEY, M.A., and H.A. VANDERPLOEG. Ingestion of live filamentous diatoms by the Great Lakes amphipod *Diporeia* sp.: A case study of the limited value of gut contents analysis. *Hydrobiologia* 223:141-148 (1991).

QUINN, F.H. A regional precipitation index for Lake Michigan-Huron water level fluctuations. Preprints, Fifth Conference on Climate Variations, Denver, CO, October 14-18, 1991. American Meteorological Society, Boston, MA, 143-144 (1991).

QUINN, F.H. Effects of climate change on the water resources of the Great Lakes. Proceedings, Annual Meeting of the American Association for Advancement of Science, Chicago, IL, February 1992. Illinois State Water Survey, Champaign, IL, 10-16 (1992).

QUINN, F.H. Hydraulic residence times for the Laurentian Great Lakes. *Journal of Great Lakes Research* 18(1):22-28 (1992).

QUINN, F.H. Outlook for future water supplies to the Great Lakes. Proceedings, Water Pipelines and Diversions in the Great Lakes Basin, University of Waterloo, Waterloo, Ontario, Canada, March 12-13, 1991. 63-69 (1991).

Redalje, D.G., S.E. Lohrenz, and G.L. FAHNENSTIEL. The relationship between primary production and the export of POM from the photic zone in the Mississippi River Plume and inner Gulf of Mexico shelf regions. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 105-110 (1992).

REID, D.F., and A.M. BEETON. Large lakes of the world: A global science opportunity. *GeoJournal* 28.1:67-72 (1992).

ROBBINS, J.A., G. Lindner, W. Pfeiffer, J. Kleiner, H.H. Stabel, and P. Frenzel. Epilimnetic scavenging of Chernobyl radionuclides in Lake Constance. *Geochimica et Cosmochimica Acta* 56:2339-2361 (1992).

SAYLOR, J.H., and G.S. MILLER. Current flow through the Straits of Mackinac.. Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 5 pp. (1991).

Schulze, P.C., J.R. Strickler, B.I. Bergstrom, M.S. Berman, P. Donaghay, S. Gallager, J.F.Haney, B.R. Hargreaves, U. Kils, G.-A. Paffenhofer, S. Richman, H.A. VANDERPLOEG, W. Welsch, D. Wethey, and J. Yen. Video Systems for in situ studies of zooplankton. *Archives Hydrobiol. Beih. Ergebn. Limnol.* 36:1-21 (1992).

SCHWAB, D.J., G.A. LESHKEVICH, and G.C. MUHR. Satellite measurements of surface water temperature in the Great Lakes: Great Lakes CoastWatch. *Journal of Great Lakes Research* 18(2):247-258 (1992).

Trefry, J.H., R.P. Trocine, S. Metz, T.A. Nelsen, and N. HAWLEY. Suspended particulate matter on the Louisiana shelf: Concentrations, composition, and transport pathways. Proceedings, Nutrient Enhanced Coastal Ocean Productivity Workshop, Louisiana Universities Marine Consortium, New Orleans, LA, October 1-4, 1991. NOAA Coastal Ocean Program Office, 126-130 (1992).

VANDERPLOEG, H.A., W.S. GARDNER, C.C. PARRISH, J.R. LIEBIG, and J.F. CAVALETTO. Lipids and life-cycle strategy of a hypolimnetic copepod in Lake Michigan. *Limnology Oceanography* 37(2):413-424 (1992).

Washburn, L., B.H. Jones, A.W. BRATKOVICH, T.D. Dickey, and M.S. Chen. Mixing, dispersion, and resuspension in vicinity of an ocean wastewater plume. *Journal of Hydraulic Engineering* 118(1):38-58 (1992).

FY 92 Presentations

ASSEL, R.A. Impact of 2xCO2 global warming on Great Lakes ice cover. 6th Annual Meeting of U.S./Canada Joint Ice Working Group, Suitland, MD, May 5, 1992.

ASSEL, R.A. and D.M. Robertson. Climatic changes near the Great Lakes inferred from 140 year ice record. Fifth International Meeting on Statistical Climatology, American Meteorological Society/World Meteorological Organization, Toronto, Ontario, Canada, June 22, 1992.

Bedford, K.W. and D.J. SCHWAB. Nowcasting protocol for the Great Lakes forecasting system. Ocean Sciences Meeting, American Geophysical Union, New Orleans, LA, January 27, 1992.

BEETON, A.M. Non-indigenous species and major changes in large lake ecosystems. International Workshop on the Importance of External Perturbations for Short- and Long-term Changes in Large Lakes Systems, University of Konstanz, Konstanz, Germany, October 22, 1991.

BEETON, A.M. NOAA activities in the Great Lakes region: Response to the zebra mussel. 2nd International Zebra Mussel Conference, Toronto, Ontario, Canada, February 14, 1992.

BEETON, A.M., and J. Hageman, Jr. Impact of *Dreissena polymorpha* on the zooplankton community of western Lake Erie. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

BEETON, A.M. Development of a Great Lakes research strategy. Special Session - Council of Great Lakes Research Managers, 35th Annual Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

BELL, G.L., J.A. ROBBINS and B.J. EADIE. The use of geochemical markers in estimating sediment resuspension with sediment traps. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

BRATKOVICH, A.W. and S. Dinnel. Lower Mississippi River historical Nitrate flux and Mississippi River outflow buoyancy flux. Principal Investigators Meeting, NECOP Synthesis Meeting, Chauvin, LA, October 2, 1991.

BRATKOVICH, A.W., G. LESHKEVICH, G. MILLER, G. PERNIE, and J. SAYLOR. Vernal thermal fronts in the Great Lakes: A model for large scale forcing and ecosystem response. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Sante Fe, NM, February 7-14, 1992.

Buchberger, S.G., and D.H. LEE. Simulating Great Lakes monthly water levels with contemporaneous ARMA models. Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 11-15, 1992.

CAVALETTO, J.F. Comparison of chemical oxidation vs. high temperature direct combustion methods for the determination of dissolved organic carbon in the Great Lakes. 35th Annual Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

CROLEY, T.E., II. Climate change impacts on Great Lakes meteorology. 35th Annual Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

CROLEY, T.E., II. Climate change induced shifts in large lake heat storage. Proceedings, Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 13, 1992.

EADIE, B.J. A retrospective analysis of nutrient enhanced coastal ocean productivity in sediments from the Louisiana continental shelf. Nutrient Enhanced Coastal Ocean Productivity Review, Chauvin, LA, October 1991.

EADIE, B.J. and M.B. LANSING. Stable isotope shifts in POM and DOM across the salinity gradient off the Mississippi Delta. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Sante Fe, NM, February 7-14, 1992.

EADIE, B.J., G.L. BELL and J.A. ROBBINS. Development and testing of an autosequencing sediment trap for Great Lakes studies. Meeting of the American Chemical Society, Marquette University, Milwaukee, WI, June 2, 1992.

EADIE, B.J., J.A. ROBBINS, and P.F. LANDRUM. PAH in sediments and pore waters of the lower Great Lakes: Reconstruction of a regional source function. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Sante Fe, NM, February 7-14, 1992.

FAHNENSTIEL, G. and B. WAGONER. Phytoplankton growth rates from Lake Huron using the chlorophyll a labelling technique. 35th Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

GARDNER, W.S. Benthic pelagic energy coupling in Lake Michigan. University of Wisconsin, Milwaukee, WI, March 12-13, 1992.

GARDNER, W.S. Nitrogen remineralization in freshwater and coastal marine ecosystems. Memorial University of Newfoundland, St. Johns, Newfoundland, Canada, December 10, 1991.

GARDNER, W.S. Pelagic-benthic energy coupling between spring diatoms and benthic amphipod in Lake Michigan. Ocean Sciences Centre, Memorial University of Newfoundland, St. Johns, Newfoundland, Canada, December 9, 1991.

GARDNER, W.S., J.B. COTNER, Jr., and J.F. CAVALETTO. Effects of zebra mussel on bacterial dynamics and nitrogen cycling in Lake St. Clair. 35th Annual Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

GARDNER, W.S., J.B. COTNER, Jr., and J.F. CAVALETTO. Organic nitrogen mineralization in the Gulf of Mexico Mississippi River plume. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Santa Fe, NM, February 7-14, 1992.

HAWLEY, N. Lateral mass flux calculations for southern Green Bay. Fall Meeting, American Geophysical Union, San Francisco, CA, December, 1991.

HERCHE, L.R. Great Lakes research statistics. 3rd Environmetrics Conference, International Environmetrics Society, Madison, WI, October 7-10, 1991.

JOHENGEN, T.H., R. Moll, and G.L. PERNIE. Nutrient and plankton dynamics associated with thermal front formation in Lake Michigan. 35th Annual Conference on Great Lakes Research, International Association for Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

JOHENGEN, T.H., R. Moll, and G.L. PERNIE. Nutrient and plankton dynamics associated with thermal front formation in Lake Michigan. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Santa Fe, NM, February 7-14, 1992.

LANDRUM, P.F. Bioaccumulation of sediment-associated contaminants by benthic invertebrates: Factors controlling bioavailability. Assessing and Treating Contaminated Sediment, University of Wisconsin, Madison, WI, November 19, 1991.

LANDRUM, P.F. Bioavailability of sediment-associated organic contaminants to benthos. U.S. Geological Survey, Menlo Park, CA, January 23, 1992.

LANDRUM, P.F. Bioavailability of sediment-associated organic contaminants to benthos. Institute of Marine Sciences, University of California, Santa Cruz, CA, January 22, 1992.

LANDRUM, P.F. Bioavailability of sediment-associated organic contaminants to benthos. Chevron Research and Technology Company, Richmond, CA, January 24, 1992.

LANDRUM, P.F. Bioavailability of sediment-associated organic contaminants to benthos. Ecotoxicology Program, University of California, Davis, CA, January 27, 1992.

LANDRUM, P.F. Bioavailability of sediment-associated organic contaminants to benthos. Department of Environmental and Water Resources Engineering, University of Michigan, Ann Arbor, MI, February 18, 1992.

LEE, D.H. The impacts of climate change on Great Lakes levels and outflows under existing regulation criteria. Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 11-15, 1992.

LESHKEVICH, G.A. Great Lakes CoastWatch data distribution. Coordination Meeting, Great Lakes Ecological Process Pilots (GLEPP), U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, NV, February 5, 1992.

LESHKEVICH, G.A., D.J. SCHWAB and G.C. MUHR. NOAA's CoastWatch: Satellite environmental monitoring of the Great Lakes. Conference on Remote Sensing for Marine and Coastal Environments, Marine Spill Response Corp (MSRC), ERIM-Environmental Research Institute of Michigan, NOAA-NESDIS, New Orleans, LA, June 16, 1992.

LIU, P.C. Chaotic dynamics and ocean waves statistics. Sixth International Symposium on Stochastic Hydraulics, International Association for Hydraulic Research, Taipei, Taiwan, ROC, May 18, 1992.

LIU, P.C. Exploring chaotic attractors for the Great Lakes water levels. Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 11-15, 1992.

MCNAUGHT, D.C. Pseudofeces formation by *Dreissena*: Costs and benefits. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

MILLER, G.S., J. SAYLOR, G. LESHKEVICH, A. BRATKOVICH, and D. DONG. Physical variability and structure associated with vernal thermal fronts in southeastern Lake Michigan. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Santa Fe, NM, February 13, 1992.

NALEPA, T.F., J. CAVALETTO and M. FORD. Distribution and physiological condition of zebra mussels in Lake St. Clair. 2nd International Zebra Mussel Conference, Ontario Hydro, Ministry of Environment, Toronto, Ontario, Canada, December 12, 1991.

NALEPA, T.F., J. CAVALETTO and M. FORD. Seasonal and annual changes in the general condition of *Dreissena polymorpha* from Lake St. Clair. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

QUINN, F.H. A regional precipitation index for Lake Michigan-Huron water level fluctuations. 5th Conference of Climate Variations, American Meteorological Society and Committee on Climate Variations, Denver, CO, October, 1991.

QUINN, F.H. The sensitivity of water resources management to climate change: A Great Lakes case study. Climate Change and Water Resources Management Conference, U.S. Environmental Protection Agency, Albuquerque, NM, November 4, 1991.

QUINN, F. The effects of climate change on the water resources of the Great Lakes. AAAS '92, American Association for the Advancement of Science, Chicago, IL, February 11, 1992.

QUINN, F.H. The development of climate analog scenarios for Great Lakes water levels studies. Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 13, 1992.

QUINN, F.H. Great Lakes Hydrology. NOAA Colloquium on Operational Environmental Prediction, National Meteorological Center, Camp Springs, MD, June 19, 1992.

REID, D.F. Large Lakes of the World: A proposed Global Science Initiative. 1991 Biennial Meeting on Great Lakes Water Quality, Traverse City, MI, September 29 - October 2, 1991.

ROBBINS, J.A. Long-term fate of ^{137}Cs in the Laurentian Great Lakes. International Workshop on the Importance of External Perturbations for Short- and Long-term Changes in Large Lake Systems. University of Konstanz, Konstanz, Germany, October 22, 1991.

ROBBINS, J.A. On the fate of radionuclides in lakes. Department of Biology and Department of Environmental Engineering, Michigan Technological University, Houghton, MI, April 2, 1992.

ROBBINS, J.A. Radionuclides in limnology. Center for Great Lakes Studies, University of Wisconsin, Milwaukee, WI, January 31, 1992.

ROBBINS, J.A. Sedimentary record of contamination of the St. Marys River system. Lake Superior Ecosystem Research Center, Michigan Technological University, Houghton, MI, April 1, 1992.

ROBBINS, J.A. The fate of nuclear fallout in the Laurentian Great Lakes. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD, April 22, 1992.

ROBBINS, J.A. Uncertainty in Lead-210 dating of sediments. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

ROBBINS, J.A., N.R. MOREHEAD, and A. Mudroch. History of contamination of Lake George and its impact on biogenic silica production from 1750 to 1986. American Society of Limnology and Oceanography 1992 Aquatic Sciences Meeting, Santa Fe, NM, February 9-14, 1992.

ROBBINS, J.A., and N.R. MOREHEAD. History of contamination of the St. Marys River and Lake George. Spring Meeting, American Geophysical Union, Montreal, Quebec, Canada, May 11-15, 1992.

ROBBINS, J.A., N.R. MOREHEAD, A. Mudroch, R. Rossmann, and P. Kauss. History of contamination of the St. Marys River and Lake George. 25th Great Lakes Regional Meeting, American Chemical Society Meeting on Environmental Chemistry, University of Wisconsin, Milwaukee, WI, June 1-2, 1992.

SCHWAB, D.J. Generation and use of gridded overwater wind fields in the Great Lakes. 35th Annual Conference on Great Lakes Research, University of Waterloo, Waterloo, Ontario, Canada, May 31-June 4, 1992.

THOMS, S.R., P.F. LANDRUM, and J.A. ROBBINS. Sediment reworking by *Stylodrilus heringianus* in the presence of DDT: Vertical feeding distributions and particle selective transport. 12th Annual Meeting, Society of Environmental Toxicology and Chemistry, Washington, DC, November 3-7, 1991.

VANDERPLOEG, H.A., J.R. LIEBIG, and M. Omair. *Bythotrephes* predation on Great Lakes zooplankton measured by a modified *in situ* method. Societas Internationalis Limnologiae International Congress (SIL), University of Barcelona, Barcelona, Spain, August 21-27, 1992.

Acronyms

AAPS	Ann Arbor Public Schools
ADCP	Acoustic doppler current profiler
ARCS	Assessment and Remediation of Contaminated Sediments
AVHRR	Advanced Very High Resolution Radiometer
CCIW	Canada Centre for Inland Waters
CD-ROM	Compact Disk - Read Only Memory
CER	Coordinated Ecosystem Research
CHARM	Coupled Hydrosphere Atmosphere Research Model
CILER	Cooperative Institute for Limnology and Ecosystems Research
COP	Coastal Ocean Program
CSCS	Consolidated Scientific Computing System
CTD	Conductivity, temperature, and depth
CZE	Capillary Zone Electrophoresis
DOC	Dissolved organic carbon
DOM	Dissolved organic matter
DON	Dissolved organic nitrogen
E-MAP	EPA Mapping Program
EEO	Equal Employment Opportunity
EPA	U.S. Environmental Protection Agency
ERL	Environmental Research Laboratories
ERS	Earth Resources Satellite
FEDLINK	Federal Library and Information Network
FIBS	Field by Information Blending and Smoothing
FNOC	Fleet Numerical Oceanographic Center
FY	Fiscal Year
GOES	Geostationary Observational Environmental Satellite
GCM	General Circulation Model
GIS	Geographic Information System
GLERL	Great Lakes Environmental Research Laboratory
GPS	Global Positioning System
HOC	Hydrophobic Organic Compound
HPLC	High performance liquid chromatography
IDIDAS	Interactive Digital Image Display and Analysis System
IMSL	International Mathematics and Statistical Library
MARC	Machine-Readable Cataloging
MICIS	Midwestern Climate Information System
MOIL	Marine Operations and Instrumentation Laboratory
LAN	Local area network
LAVc	Local Area VAXcluster
LC50	Lethal concentration in environment resulting in 50% mortality.
LD50	Lethal dose which results in 50% mortality of population.
LORAN-C	Location Radio Navigation- Coordinates
MAR	Mississippi Atchafalaya River
MLC	Michigan Library Consortium
MRP	Mississippi River Plume
MRP/GS	Mississippi River Plume/Gulf Shelf
MRP/IGS	Mississippi River Plume/Inner Gulf Shelf

NDBC	National Data Buoy Center
NECOP	Nutrient enhanced coastal ocean productivity
NESDIS	National Environmental Satellite, Data, and Information Service
NIST	National Institute of Standards and Technology
NLIN	NOAA Library and Information Network
NMC	National Marine Center
NOAA	National Oceanic and Atmospheric Administration
NOCN	National Ocean Communication Network
NSF	National Science Foundation
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OCLC	Online Computer Library Center
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PDMS	Polydimethylsiloxane
POC	Particulate organic carbon
POM	Particulate organic matter
PMEL	Pacific Marine Environmental Laboratory
RNN	Regional Network Node
SAR	Synthetic aperture radar
SEAS	Shipboard Environmental Acquisition System
SIMS	Stable Isotope Mass Spectrometer
SPM	Suspended particulate material
SST	Sea Surface Temperature
TM	Thematic Mapper
VACM	Vector averaging current meter
WLLN	Washtenaw-Livingston Library Network
XBT	Expendable Bathythermograph

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