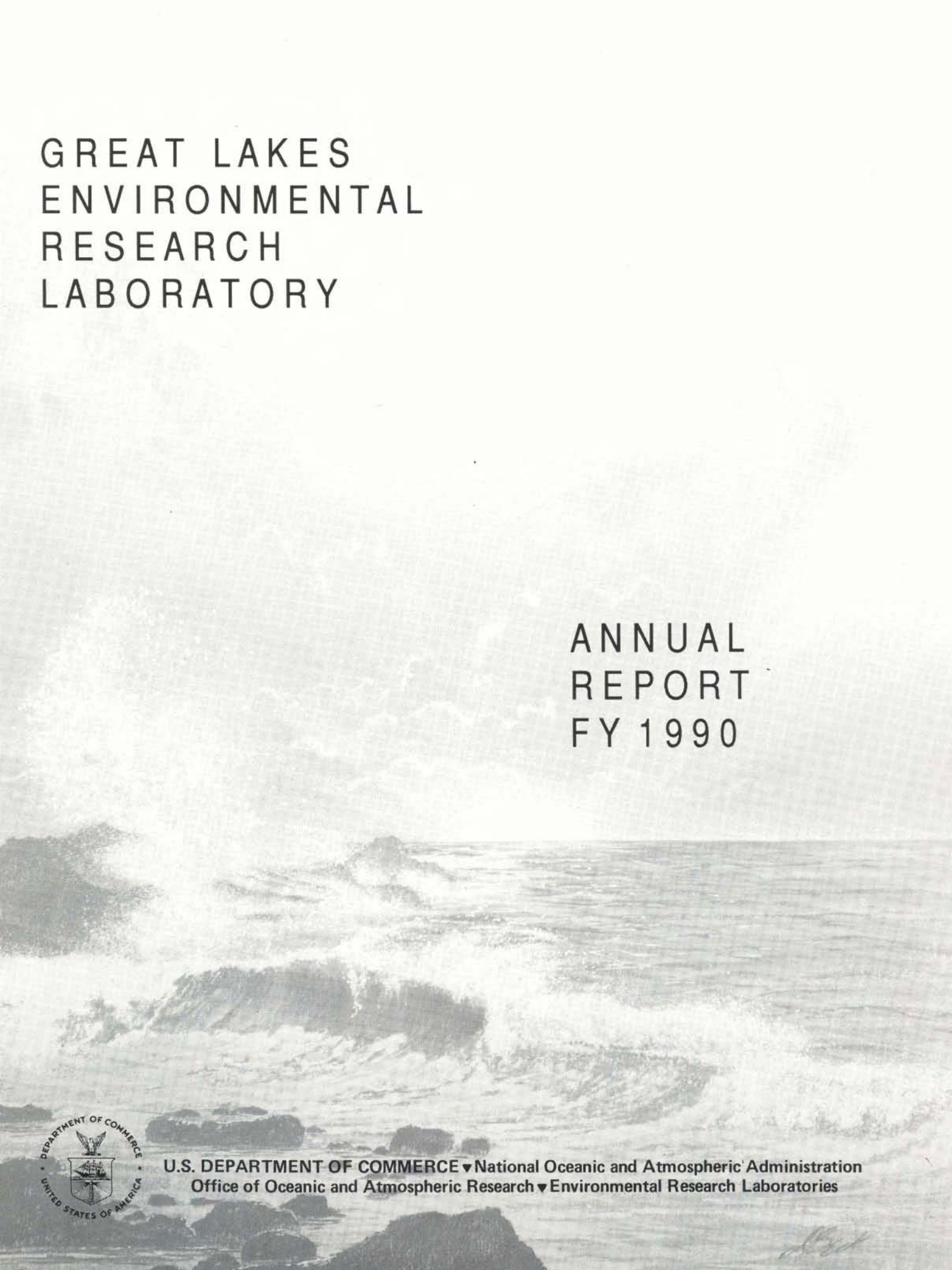
GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY

ANNUAL REPORT FY 1990



U.S. DEPARTMENT OF COMMERCE ▾ National Oceanic and Atmospheric Administration
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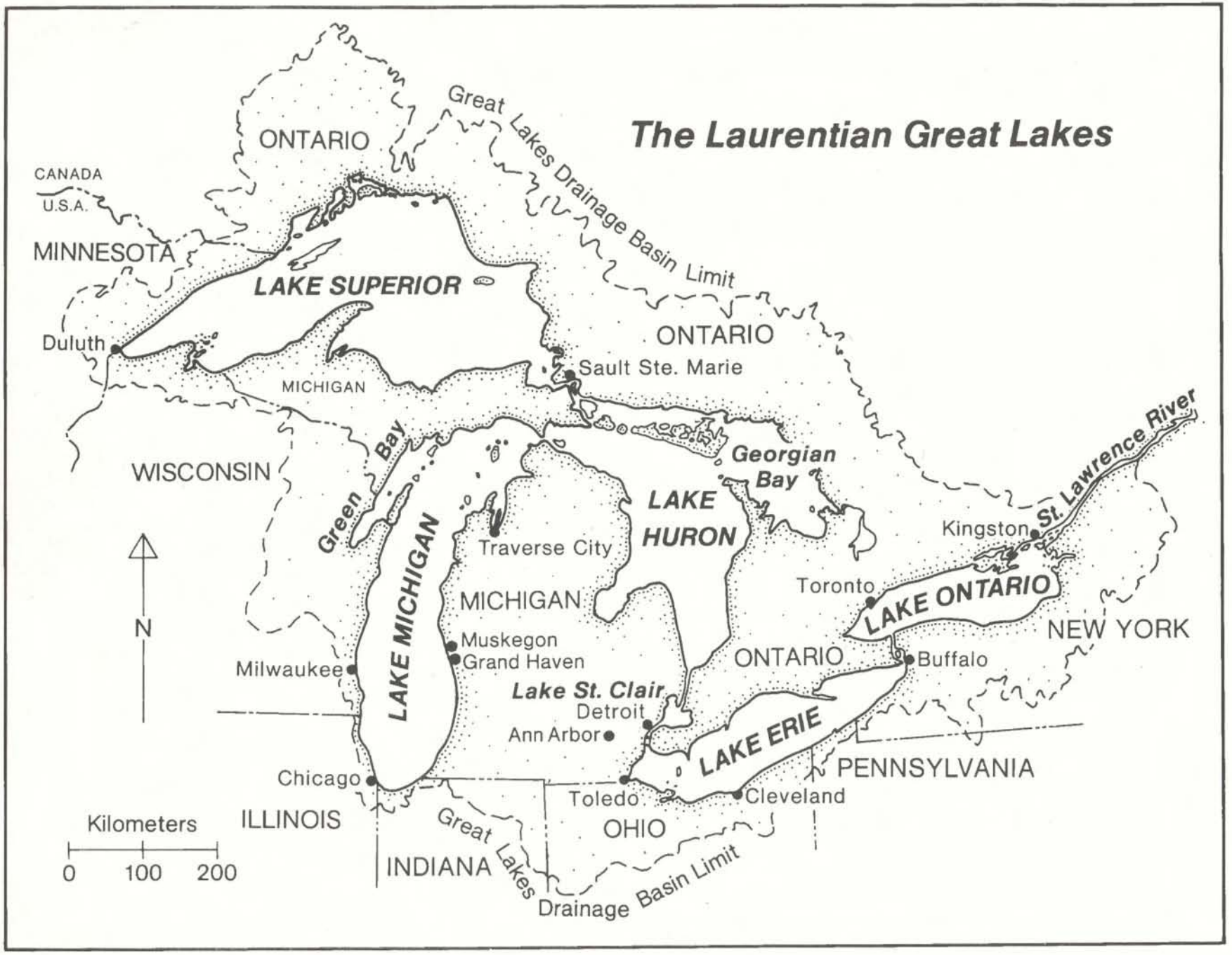
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CANADA
U.S.A.
ONTARIO
Great Lakes Drainage Basin Limit
MINNESOTA
LAKE SUPERIOR
Duluth
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Sault Ste. Marie
MICHIGAN
WISCONSIN
Green Bay
Georgian Bay
St. Lawrence River
LAKE HURON
LAKE MICHIGAN
Traverse City
Kingston
Toronto
LAKE ONTARIO
MICHIGAN
NEW YORK
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Great Lakes Drainage Basin Limit

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ANNUAL REPORT FY 1990

Director

Alfred M. Beeton

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Introduction

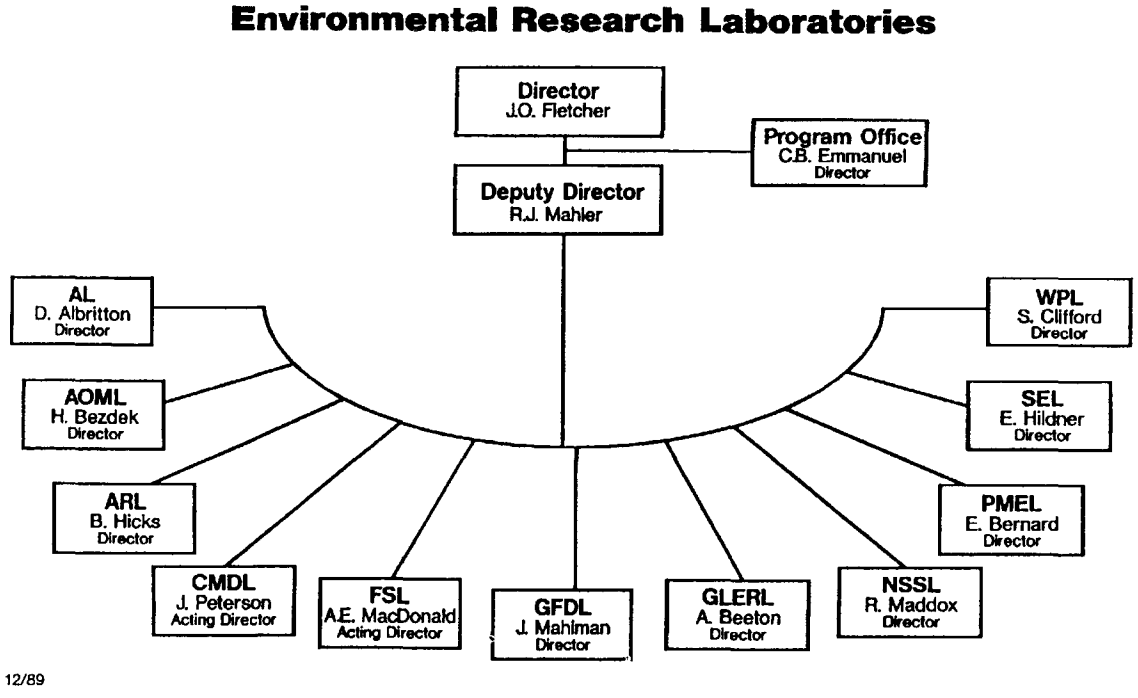


Figure 1. Organization structure of NOAA's Environmental Research Laboratories

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

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 has traditionally been focused on investigations to improve our understanding of, and ability to predict, the biological, chemical, and physical processes occurring in natural ecosystems. Such processes affect 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 populations using 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 made available on a regular basis 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 purposes ranging from purely informational to actual applications and operational use. During FY 90, 45 scientific publications by GLERL authors were published, and 55 talks were presented by GLERL staff at scientific and public meetings and in local schools.

This annual report describes the significant activities and accomplishments of GLERL staff during the period October 1, 1989 - September 30, 1990. For

general information on how to obtain GLERL products, see the Outreach section of this report.

GLERL's scientific programs are organized into six coordinated research programs considered critical to the NOAA mission and to Great Lakes problems (Non Indigenous Species, Pollutant Effects, Coordinated Ecosystem Research, Climate Variability and Global Change, Marine Hazards and Water Management, Green Bay Coordinated Research); two major activities (the Nutrient Enhanced Coastal Ocean Productivity, NECOP, program, and CoastWatch) and several independent research projects. There are also a number of support units that provide technical, operational, and administrative assistance to the scientific staff:

▼ a Marine Operations and Instrumentation Laboratory, where instruments and systems for hands-on and automated field collection of data are designed, built, and maintained;

▼ a Computer and Information Systems Group that maintains GLERL's in-house computer network, interfaces with off-site mainframe and super computers, and provides related user support to the GLERL staff and others;

▼ an Information Services Group that is responsible for providing editorial and publications support to the GLERL staff, distributing GLERL publications, and responding to related information requests;

▼ a Library that maintains a research collection tailored to GLERL staff needs and which offers special retrieval services for materials not in the existing holdings;

▼ the R/V *Shenehon*, GLERL's research vessel and the primary platform used by GLERL staff for field operations on the lakes;

▼ and an Administrative Office that provides personnel, budget, purchasing, and facility information and

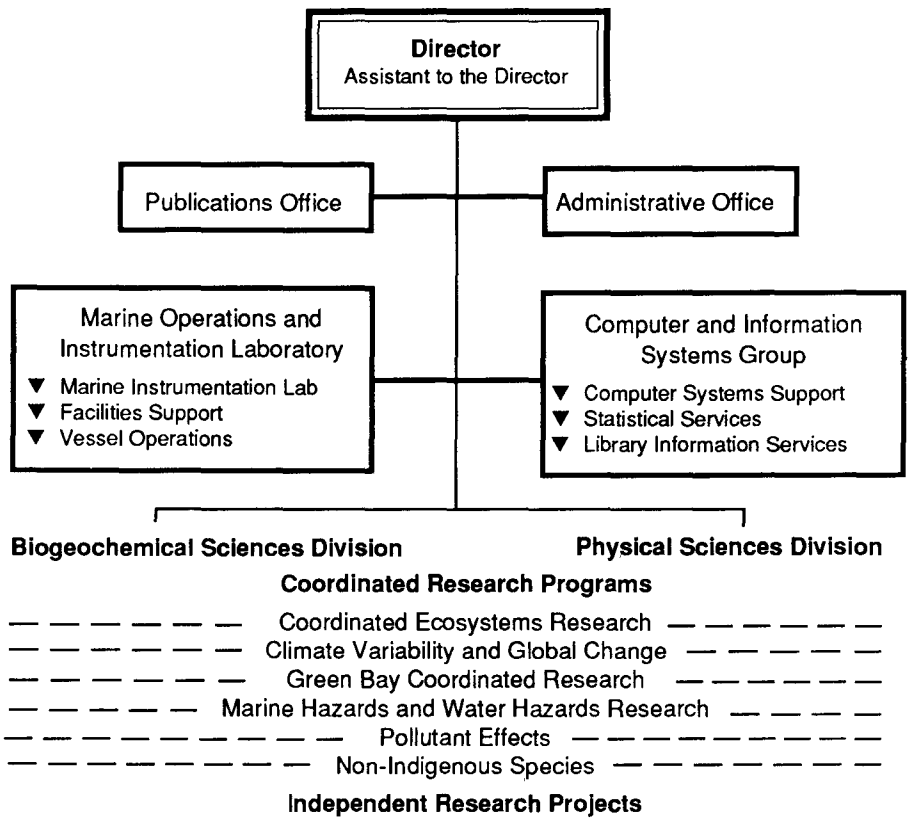
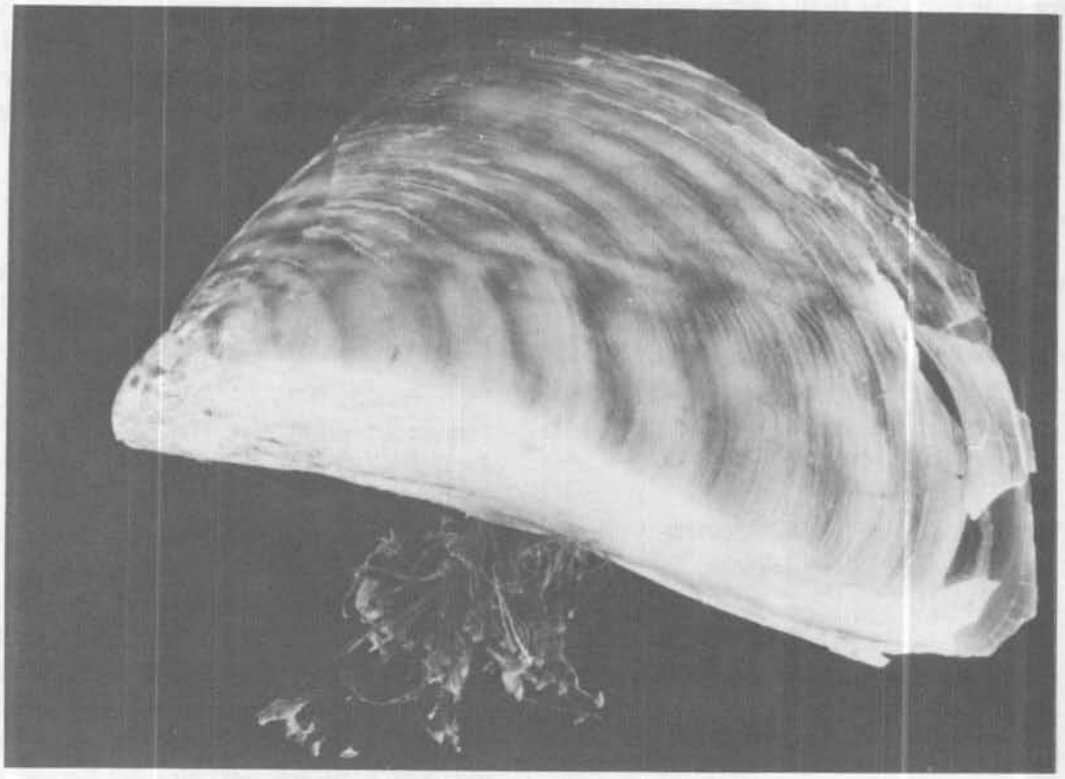


Figure 2. GLERL's Organizational Structure

Non-Indigenous Species

T.F. Nalepa, Program Leader



The zebra mussel (Dreissena polymorpha).

Recently, two species were introduced into the Great Lakes that have the potential to dramatically alter trophic relationships of the entire ecosystem: the zebra mussel (*Dreissena polymorpha*), and the spiny water flea (*Bythotrephes cederstroemi*). *Dreissena* is capable of increasing in numbers very rapidly and is both a voracious filter-feeder and a high-density fouling organism. This species is likely to have a profound effect on the cycling of materials as well as ecological implications to other species. *Bythotrephes* has become a dominant member of the plankton in all the Great Lakes. Our own preliminary work suggests that *Bythotrephes* is a voracious selective predator. Recent shifts in zooplankton community structure from *Daphnia*, the favorite food of *Bythotrephes*, to copepods in Lake Michigan have been hypothesized to be caused by *Bythotrephes*. The goal of this program is to expand our knowledge of the biology and the ecological effects of non-indigenous species in the Great Lakes. Individual scientific studies within this coordinated research program, principal investigators, objectives of the studies, and FY 90 accomplishments follow.

Examining the Impacts 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 define 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 process-oriented changes, and (3) to monitor changes in the abundance and distribution of the zebra mussel in the bay. During FY 90, samples for phytoplankton, zooplankton, and benthos were taken at 13 representative stations throughout the bay in May, July, and September. In addition, CTD casts were made (vertical profiles) at the same stations and primary production determined. Arrangements were made with the Bay City Water Plant and the Saginaw-Midland Water Plant station to begin taking weekly water samples for later analysis.

Metabolic Physiology of the Zebra Mussel, *Dreissena Polymorpha*.

Project Scientist: M.A. Quigley

Objectives of the program are to (1) seasonally determine oxygen consumption and nitrogen (ammonia) excretion of zebra mussels collected from Lake St. Clair, and (2) seasonally determine lipid content and C:N ratios of soft tissue from zebra mussels collected from Lake St. Clair. During FY 90, zebra mussels were collected from two sites in Lake St. Clair (one site with high abundance and one with low abundance) once a month beginning in April. A diver survey of unionids and zebra mussels was conducted in Lake St. Clair in September. Samples were collected at 30 stations located throughout the lake.

Fish and *Bythotrephes*: A Story of Aversion Conditioning, Recruitment, and Food Web Structure.

Project Scientist: H.A. Vanderploeg

The objective of this program is to determine the effect of *Bythotrephes* on the feeding and selectivity of juvenile fishes on Great Lakes zooplankton. In FY 90, we set up aquaria and fish holding tanks in the GLERL cinematography lab and videotaped a series of experiments that demonstrated the development of aversion conditioning in perch to attacking *Bythotrephes*. D. R. Barnhisel completed behavioral analyses of the tapes.

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
Participating Scientists: W.S. Gardner, and J.R. Liebig

Objectives of the program are to (1) determine in situ selectivity and predation rates of *Bythotrephes cederstroemi* on zooplankton in 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 N 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. Accomplishments in FY 90 include the analysis of the results of in situ feeding experiments performed over the past 2 years, and the initiation of weekly *Bythotrephes* sampling for population dynamics study which began in June 1990 at an offshore and inshore station.

Direct Observations on the Trophic Ecology of the *Dreissena* Early Life Stages: The Critical Planktonic Period.

Project Scientist: H.A. Vanderploeg

Objectives of the study are to (1) observe feeding mechanisms, particle choice, and feeding rates of *Dreissena* larvae, (2) determine nutritional requirements of *Dreissena* larvae, and (3) determine vulnerability of *Dreissena* eggs and larvae to zooplankton. Since this program was only recently instituted, initial results will be reported in FY 91.

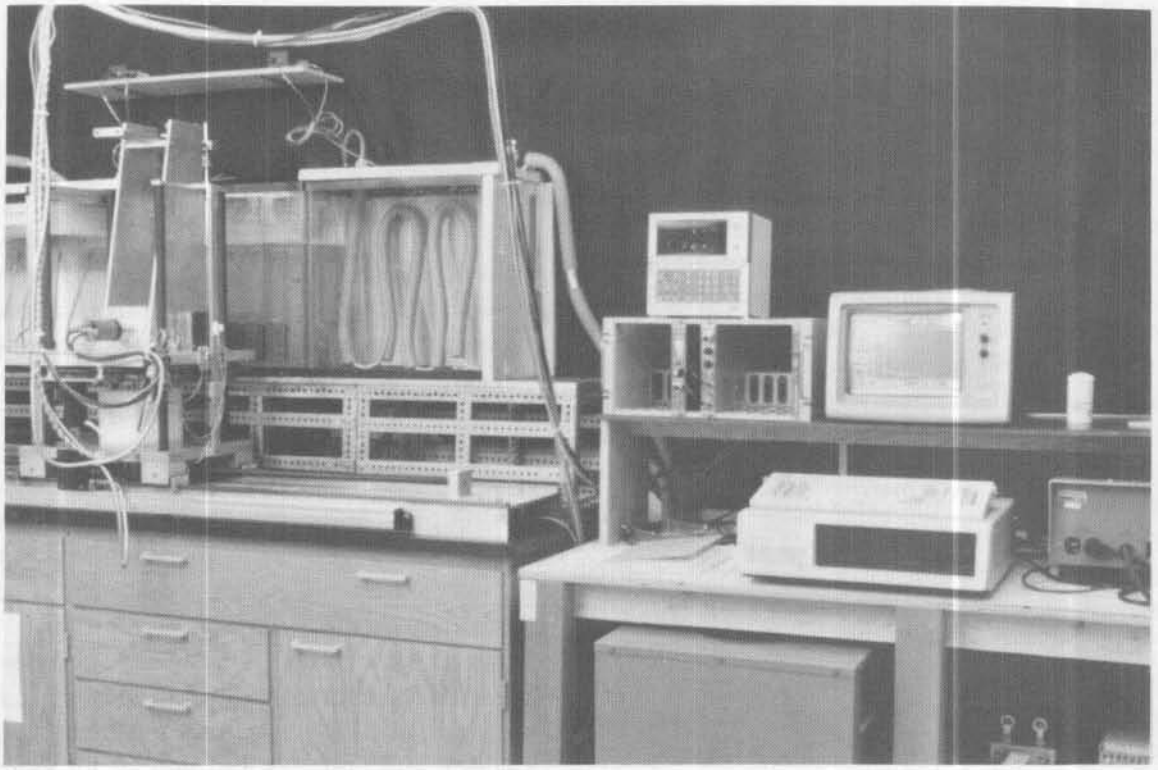
Toxicokinetics and Bioaccumulation of Organic Contaminants by the Zebra Mussel.

Project Scientist: P.F. Landrum

This project will primarily employ selected members from two classes of compounds, the chlorinated hydrocarbons primarily polychlorinated biphenyls (PCB's) and the polycyclic aromatic hydrocarbons (PAH's). These selected chemicals will be representative of both their class and of the physical 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. Due to the recent start-up of this program, no results are reported. In FY 91, the field work and priorities for kinetics testing will be planned for the up-coming field season, toxicokinetics for accumulation from water by zebra mussels will be examined for selected PAH and PCB congeners, the respiration rate will be determined for comparison with uptake clearance of the contaminants, and the lipid content of the mussels will be examined for effects of lipid content on elimination.

Pollutant Effects

P.F. Landrum, Program Leader



The Gamma Scan System is used to study the role of benthic organisms to transport contaminants in the sediments and to measure the effect of contaminants on bioturbation.

The goal of the Pollutant Effects Coordinated Research Program is to increase understanding of the dynamics, fate, and effects of contaminants in the ecosystem. The research effort will be a combination of process studies and mathematical modeling that will improve our understanding and ability to predict contaminant fate and effects in the Great Lakes. This research will lead to improved contaminants effects forecasting and management approaches. This program will attempt to address the following questions: (1) For a given load of toxic contaminant, what level of exposure can be expected for various biota? (2) What is the assimilative capacity for toxic contaminants defining no-effect loads for both species and communities? (3) What kind of prediction can be applied to catastrophic events to insure best management decisions? (4) What are the effects of long-term low-level contaminant exposure?

Sediment-Associated Toxic Organics: Fate and Effects.

Project Scientist: P.F. Landrum

Throughout, the project will primarily employ selected members from two classes of compounds: The chlorinated hydrocarbons and the polycyclic aromatic hydrocarbons (PAHs). Objectives of the program are as follows: Using *Diporeia* sp., develop one or two subacute bioassays for sediment-associated pollutants; investigate the use of bioturbation by benthos as a chronic effects endpoint for sediment-associated pollutants; determine the assimilation efficiency of *Diporeia* for ingested sediment-associated organic pollutants; examine the role of aging and organic carbon content on biological availability to *Diporeia* of selected organic contaminants associated with sediments; and develop a comprehensive contaminant fate simulation model 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 90, we completed initial examinations of many of the major variables that could affect the bioavailability of sediment-associated contaminants. The 28-day mortality bioassay and the sediment/avoidance preference bioassay were employed as a portion of the U.S. Environmental Protection Agency's (EPA) program of Assessment and Remediation of Contaminated Sediments (ARCS). An approach was investigated with some of the very toxic sediments to establish the amount of toxicity equivalents by diluting the sediments with either a reference sediment or clean sand. Characterization of the amphipod *Diporeia* was advanced by examining responses to stressors, salinity, temperature, and cadmium (Cd) toxicity. The experiment to examine the role of contact time between the contaminant and sediment particles used selected PAHs as the model contaminants. The bioavailability of compounds was generally reduced with increased aging and contact time between the sediment and the contaminant. The first studies on the role of organic carbon on sediment-associated contaminant bioavailability exposed *Diporeia* to sediments containing three levels of organic carbon plus a fourth sediment where only the fine fraction was dosed. A mechanistic model to describe the bioaccumulation of sediment-associated organic contaminants was developed. The bioavailability of selected chlorinated hydrocarbons sorbed to sediments was investigated with *Diporeia*. A study was performed to investigate the effect of aging and changes in contact time between sediments and contaminants on the partition coefficients between sediment particles and interstitial water.

Physiological and Biochemical Measures of Contaminant Effects.

Project Scientist: P.F. Landrum

The study is divided into measures at both a physiological level and a biochemical level. The physiological responses such as respiration and excretion are organism responses that are indicative of the integration of all biochemical processes within the animal. Biochemical measures focus on specific enzyme systems or small groups of enzymes of similar function that may be effected by a perturbation. Physiological measures: (1) The atomic O:N ratios (number of oxygen atoms consumed during respiration divided by the number of nitrogen atoms excreted) will be measured in the amphipod *Diporeia* sp. and the usefulness as a physiological measure of stress will be determined. Biochemical measures: (2) The catecholamines (dopamine, norepinephrine and epinephrine) will be measured in the chironomid, *Chironomus tentans* to establish normal physiological levels and explore the possibility that changes in these levels represent an indicator of sublethal stress. In FY 90, the O:N ratio for *Diporeia* sp. was examined on both a north-south and east-west transect near Grand Haven in Lake Michigan. In addition, the method for measuring catecholamines in invertebrates by high performance liquid chromatography (HPLC) with fluorescence detection was perfected.

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. During the past fiscal year, all chironomids in the Saginaw Bay samples were identified to species, and oligochaetes were identified to species in 2 of the 6 data sets. Samples for the fish exclosure experiments were collected in August 1990. The data on long-term trends in mussel populations in western Lake Erie were analyzed.

Bioenergetics of the Great Lakes Amphipod *Diporeia* sp.

Project Scientist: M.A. Quigley

The overall objective for this project is to obtain a detailed energy (carbon flow) budget in *Diporeia* sp. defined in the overall context of Ricker's (1968) energy budget equation. A mass-balance-based model will then be constructed from available data complemented with data from project sampling/experiments.

During FY 90, we assembled and began use of a personal computer-based microscope/digitizer system that allows for rapid and reliable completion of *Diporeia* body length measurements needed for production estimates.

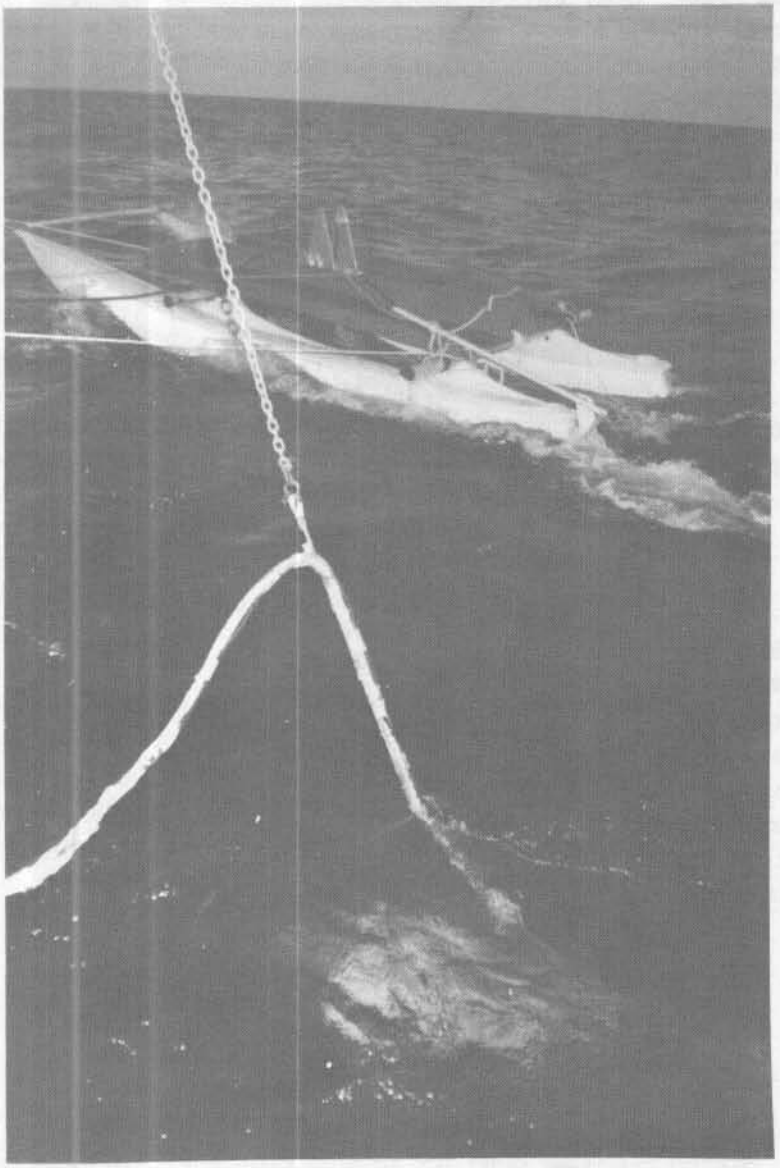
Bioavailability and Toxicity of Sediment-Associated Toxic Organic Contaminants.

Project Scientist: P.F. Landrum

A previous project developed important background information and a proposed mechanistic model for the accumulation of sediment-associated contaminants. However, the influence of sediments on the fate and effects of organic contaminants in the aquatic environment continues to remain poorly understood. In light of our previous efforts, the research will take two directions. First, studies of the bioavailability of sediment-associated contaminants will continue to generate the data required to verify and expand our mechanistic model. The second area will be the effect of these sediment-associated contaminants in the exposed organisms and the factors that alter the toxicity with an aim toward establishing predictive models based on structure activity relationships. EFFECTS: (1) The bioassays developed at GLERL will continue to be calibrated against other bioassays with field collected material and through the use of standard toxicants. (2) Measures of bioturbation by benthos as a chronic effects end point for sediment-associated pollutants will continue to be developed. (3) Investigate the influence of manipulations of sediment such as dilutions, storage, additions of bulk contaminants like silicon oil on the toxicity of organic contaminants. FATE: (4) Determine the assimilation efficiency of *Diporeia* sp. for ingested sediment-associated organic pollutants. (5) Continue to develop the data required to improve the parameterization of the mechanistic bioaccumulation model. (6) Validate the kinetics data obtained with laboratory manipulated sediments by exposing *Diporeia* sp. to field collected sediments containing similar contaminants. (7) 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. Since this study is new, no results for FY 90 are reported.

Coordinated Ecosystem Research

G.L. Fahnenstiel, Program Leader



This catamaran was converted for use in acoustic doppler current profiler measurements for study of fish biosize and biomass.

The dynamics of Great Lakes ecosystems, including those of their fish populations, are controlled by the actions of humans and nature. Long-term observations of ecosystem components (e.g., the abundance of fish, plankton, nutrients) demonstrate that they can be highly variable in time and space. Identifying the cause(s) of this variability is, therefore, a worthy goal because it will lead to an understanding of the relative importance of different influences on ecological dynamics. The goal of the Coordinated Ecosystem Research program is to improve predictions of ecological change that result from natural and man-made perturbations. The early part of this program will focus on improving predictions of food web dynamics that support a $2-4 billion per year Great Lakes salmonine fishery. A key aspect of the program is to understand relationships between the dynamics of forage fish, the lower food web that supports their growth, and characteristics of the physical environment. Specific studies will be conducted to (1) quantify temporal and spatial trends and variability, (2) identify first order relationships among fish populations, lower food web, and physical factors, and (3) provide estimates of biotic biomass for use in ecological simulation models.

Whole-Lake Physical Variability.

Project Scientists: M.J. McCormick, A. M. Bratkovich, and G. A. Leshkevich

The objective of this program is to estimate the whole-lake spatial distribution of temperature and velocity structure and its correlation with simultaneous measurements associated with the upper and lower food web.

In FY 90, we contributed to numerous planning documents for GLERL's participation in the Coastal Ocean Program (COP), compared METOCEAN platform performance against National Data Buoy Center (NDBC) meteorological data and data obtained from Mini-TOD drifters, conducted several Lagrangian cluster experiments in Lake Ontario with Canadian scientists, and participated in designing and implementing a fully portable platform (catamaran) for making accoustic doppler current profiler (ADCP) measurements.

Microplankton in the Great Lakes: Whole-Lake Biomass and Production Estimates and their Associated Temporal and Spatial Variability.

Project Scientists: G.L. Fahnenstiel and G. A. Leshkevich

This program seeks to provide whole-lake estimates of microplankton biomass and examine the spatial and temporal variability to provide production estimates of microplankton preferably on a whole-lake basis, and to provide support information as needed to evaluate the role of microplankton. In FY 90, we participated as a member of the Coastal Fisheries Ecosystem Development team and conducted a cruise in Lake Ontario.

Spatial Distribution and Production of Zooplankton in Lake Michigan.

Project Scientists: G.A. Laird Pernie, H.A. Vanderploeg, and A.M. Bratkovich

The objectives of this program are to (1) determine spatial distribution of macrozooplankton to identify areas of intense connection between phytoplankton and zooplankton and between zooplankton and fishes in Lake Michigan for intensive lake-wide spring, late summer, and fall cruises, and (2) to determine secondary production in Lake Michigan from biweekly collections at representative sites. This is a new program and commencement of work depends on external funding.

The Microbial Food Web in the Great Lakes.

Project Scientists: G.L. Fahnenstiel and G. A. Lang

This program seeks to develop a carbon based model of the microbial food web that can be interfaced into existing plankton models and provide relevant experimental and descriptive data on the microbial food web as needed for the carbon based model. In FY 90, we finished analysis of data collected on *Synechococcus*, compared cellular production rates of picoplankton populations in the Gulf of Mexico and in the Great Lakes with differential filtration and autoradiography, conducted four cruises on the Great Lakes designed to examine the importance of protozooplankton, i.e. abundance, composition and role in carbon cycling, finished the analysis of red fluorescing communities in the Great Lakes, and conducted experiments on the diel division cycle of *Synechococcus*.

Food Quality in Pelagic Food Webs.

Project Scientist: H.A. Vanderploeg
Contributing Scientists: N.M. Butler, W.S. Gardner, G.A. Paffenhofer, and J.R. Strickler

The objective of this program is to develop mechanistic models of effect of food quality on selection ingestion, assimilation, and lipid storage by

zooplankton. Progress in FY 90 included continuing work on feeding mechanisms of *Diaptomus* and other copepods (*Limnocalanus, Senecella*) using high-speed microcinematography and traditional feeding experiments. We discovered that copepods could use mechanical cues to perceive particles and, once a particle is captured, particle rejection occurs at the mouth. Our results also showed that it is probable that both mechanical and chemical cues are used and that mechanoperception becomes important to large particles, whereas chemoperception dominates for small particles. We monitored seasonal lipid content, composition, and reproductive status of *Limnocalanus macrurus* females to understand its life cycle strategy.

Whole-Lake Estimates of Macrobenthos Production and Biomass.

Project Scientist: T.F. Nalepa

The objectives of this program are to obtain whole-lake estimates of the abundance, biomass, and production of *Diporeia* sp. and *M. relicta* and to determine spatial variation in these two species and examine potential relationships to upwelling/downwelling, primary production, and fish aggregations. The plan for 1990 was to continue picking and sorting through the benthic samples collected in southern Lake Michigan in 1986 and 1987. This task has currently been completed.

Pelagic/Benthic Energy Transfer and Bioenergetics Models of Macroinvertebrates.

Project Scientists: W.S. Gardner, M.A. Quigley, and S.A. Fitzgerald

The objectives of this study are to (1) develop a model for the seasonal transfer of carbon from the pelagic euphotic zone to benthic macroinvertebrates, (2) to examine mechanisms of energy transfer from phytoplankton to *Diporeia* sp. and *Mysis relicta*, (3) to provide data and develop energetics (carbon flow) models for the benthic macroinvertebrates *Diporeia* sp. (and *M. relicta)*, and (4) to estimate *Diporeia* sp. production rates and variability at one site in Lake Michigan. A specific plan of action was developed to (1) elucidate the seasonal input rates and composition of "new carbon" reaching the benthos, (2) estimate the fate (benthic biomass production vs. respiration) of the incoming particulate carbon, (3) examine the biochemical partitioning of the carbon in the organisms, and (4) develop a carbon budget to quantify the input, alteration, and burial rates of carbon from settling particles in Lake Michigan. Following this action plan, a sediment-trap program was established to characterize the quality and quantity of organic carbon, nitrogen, biogenic silica, and diatom species that are deposited at the sediment/water interface at our 45-m depth research site. Naturally occurring radioisotopes (^{210}Pb, ^{137}Cs, ^{7}Be) will be used to estimate the residence time of particles in the water column and to correct the mass fluxes measured in the traps for the percentage of material that is resuspended. An experiment has been started to feed ^{14}C-labeled diatoms to *Diporeia* sp. in microcosms and then monitor ^{14}C as respired carbon dioxide, dissolved organic carbon metabolic intermediates, and animal biomass.

The Influence of Ice Cover and Spring Weather on Larval Survival and Year Class Strength of Northern Lake Michigan Whitefish (*Coregonus Slupeaformis*).

Project Scientist: R.A. Assel
Contributing Scientists: R.W. Brown and W.W. Taylor

The goal of this project is to assess the influence of climatic factors on the egg and larval survival and eventual year class formation of lake whitefish. Ice cover models were developed for three areas of northern Lake Michigan (1) the northern section of Green Bay, (2) the north shore of Lake Michigan in the vicinity of Naubinway, MI, and (3) the Grand Traverse - Little Traverse Bay - Fox Island - N. Manitou Island region of the northeast shore. A stepwise regression approach was used to select model parameters and to construct whitefish recruitment models for northern Green Bay and the north shore of Lake Michigan.

Climate Variability & Global Change in Large Lakes

S.J. Bolsenga, Program Leader

Scenarios developed at GLERL indicate that Great Lakes ice conditions will dramatically alter with global warming.

For climate change to be understood more adequately, the processes included in the General Circulation Model (GCM) analyses must be extensively studied. Some of these processes include vertical dynamical heat fluxes, heat transport by deep lake currents, deep lake convective dynamics, deep water circulation, biogeochemical cycling, and the effect of ice. By better understanding these processes and in studying the regional aspects of climate change, GLERL's Coordinated Research Program on Climate Variability/Global Change in Large Lakes will contribute to the immense problem of understanding global climate change. A limited number of ongoing studies have been internally funded and are currently producing results. Additional studies have been proposed for outside funding both by GLERL researchers alone and by GLERL researchers jointly with scientists from the Cooperative Institute for Limnology and Ecosystems Research (CILER). Planning activities for involvement with the NOAA Ecological Systems & Dynamics Project, National Science Foundation (NSF) Long Term Ecological Research Sites and Global Change Research, the Freshwater Initiative, the Global Exchange and Water Cycle Experiment, U.S.-U.S.S.R. Working Group VIII, and the Joint U.S. Canadian Study on the Impacts of Climate Change on the Great Lakes are currently underway to integrate involvement with activities outside of GLERL.

An Exploratory Study of Great Lakes 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 90, we conducted an extensive literature review over the field of chaos and chaotic dynamics, made tentative analysis on Lake Erie daily water level data, and participated in the NATO Advanced Study Institute on "fractal geometry and analysis."

Ecological Monitoring.

Project Scientist: G.A. Laird Pernie

The primary objective of this project is to monitor plankton dynamics to recognize changes due to climate change caused by increases in atmospheric CO_2. Increases in atmospheric CO_2 may lead to changes in absolute temperature, the onset and duration of thermal stratifications, and critical inorganic carbon dynamics - all of which are important ecological functions. We also seek to monitor, on a routine basis, several critical biological, chemical, and physical parameters to detect detailed seasonal and vertical variations. Finally, we seek to develop a computer data base capable of compiling and presenting the monitoring data in a form that will be accessible to interested scientists and agencies. In FY 90, we developed and submitted a FY 90 planning document for the ecological monitoring project within the climate program. We also compiled some monitoring data. Thus far in 1990, biweekly field trips to one station have been successfully accomplished.

Impact of Climate Change on Large Lake Ice Cycles.

Project Scientists: R.A. Assel and D.M. Robertson

The objectives of this program are (1) to develop improved models to better simulate the seasonal cycle of ice formation and loss on Lakes Erie and Superior, (2) to define trends in Grand Traverse Bay and Lake Mendota freezeup, breakup, and ice cover over the past 140 years and quantify (model) these changes in terms of seasonal changes in air temperature, (3) to reconstruct the past 140 years of Lake Michigan ice cover, and (4) to provide historic information on ice cover trends, cycles, and variations on the Great Lakes that will be useful in placing the ice cover of the 1990s and beyond in historical perspective. In FY 90, the monthly ice cover concentrations typical of severe winters and mild winters on Lakes Erie and Superior between 1897-98 and 1982-83 were identified. Average 700-mb heights and associated circulation patterns coincident with contemporary severe and mild winters were identified.

Climate Impacts on Large Lake Hydrology.

Project Scientist: T.E. Croley, II

This research will lead to a reassessment of the effect of global warming, as represented by a doubling of atmospheric CO_2, on large-lake water supplies and has the following objectives: Refine hydrologic modeling abilities for basin runoff and lake evaporation; assess and improve linkages between hydrologic models and developing atmospheric mesoscale models and atmospheric general circulation models (GCMs); estimate hydrologic impacts of anticipated or experimental climate changes. This program is a new start this year and current progress, except for planning activities, is limited.

Water Resources and Climate Change Contingency Planning.

Project Scientist: H.C. Hartmann

This project has two main objectives: Identify opportunities and constraints for effective long-term water resources contingency planning that include climate change considerations; develop and assess options for decreasing the sensitivity of water resource management to climatic variability. In FY 90, a broad array of potential adaptive strategies for Great Lakes water management was developed within three general policy-objective categories: (1) reducing regional

impacts of climate change, (2) reducing vulnerability to climate change impacts, and (3) equitably distributing climate change impacts. Based on a review of existing Great Lakes institutions and policies that have relevance to water quantity management and/or climate change, a number of strengths and weaknesses were identified, and several themes concerning barriers to further progress in contingency planning were discerned. The previous accomplishments provided a basis for identifying necessary preconditions for fostering regional climate change contingency planning, appropriate institutional attributes and mechanisms for conducting a contingency planning process, and specific elements that should be included in contingency plans.

Current Velocity Profile Measurements in the Straits of Mackinac Using Acoustic Doppler Current Profilers (ADCP's): A Pilot Study.

Project Scientists: J.H. Saylor and G.S. Miller

This study seeks to measure current profiles in strongly stratified shear flow, relate these data to the numerous bi-lake hydraulic and hydrodynamic forcing processes, and provide the framework for a future expanded study of the water volume transport process through the Straits. Two moorings were deployed in the Straits in June 1990. A two-day temperature survey using a Seabird CDT system was completed in August 1990.

Thermal Structure Monitoring for Climate Change.

Project Scientist: M.J. McCormick

The main objectives of this project are to (1) 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, (2) to concurrently provide data for improving numerical models that can simulate and predict the thermal structure in the lakes, and (3) to improve our understanding of the physics of lakes by analyzing the results of objectives (1) and (2). A "permanent" monitoring site was established in Lake Michigan near meteorological buoy NDBC 45007 in the spring and summer of FY 90. Three moorings were deployed. Two are subsurface with one mooring consisting of 5 vector averaging current meters (VACMs) recording hourly temperature and velocity data, while the other contains 11 thermistors recording temperatures at 3 hour intervals. The third mooring is surface deployed and will be retrieved in the fall. The subsurface moorings will record data throughout the winter until retrieved next spring. Once retrieved, the moorings will be refurbished and redeployed as soon as possible.

Marine Hazards and Water Management Research

H.C. Hartmann, and D.J. Schwab, Co-Program Leaders

Storms during high lake levels can cause severe damage.

Natural hazards encompass a wide variety of environmental phenomena that pose threats of loss of lives or property and social or economic disruption. Large waves, high and low lake levels, heavy snowfalls, ice, and erosion are important natural 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. The program is comprised of four broad components: Prediction, Climatology and Statistics for Decision Making, Process Studies, and Interface with Policy and Decision Makers.

Great Lakes Snow Characteristics.

Project Scientist: S.J. Bolsenga
Contributing Scientists: R.A. Assel and D.C. Norton

The objectives of this study are to compile monthly, yearly, and period of record snowfall maps for the Great Lakes basin, to analyze the spatial and temporal variation of the snowfall using 5, 10, 20, and 30 year monthly averages over the period of record of the database, and to develop quantitative relationships between northern hemisphere circulation patterns and Great Lakes snowfall/snow cover. In FY 90, a case study of the ice cover, winter severity, and early winter snowfall for winter 1989-90 was analyzed because of the anomalous temperatures of December 1989 and January 1990. A snowfall database was built for eight Great Lake states and Ontario through 1986. A new method to produce annual snowfall sums incorporating all available monthly data was developed with a Surface III graphics package. We also computed regional monthly snowfall grids from 1951-1986 and made 5, 10, and 30 year average annual grids.

Great Lakes Evaporation, Water Supply Forecasting, and Simulation.

Project Scientist: T.E. Croley, II

The objectives of this study are as follows: (1) Lake Evaporation: assess potential of determining groundwater fluxes using the evaporation models; update hydrometeorological data report; develop models on lake segments with ice-cover models; build lake surface temperature and cloud cover models; classify lake surface temperature patterns with special respect to the weather situation; develop models of the heat flux at the lake surface. (2) Water Supply Forecasting: add capability for generating probabilistic outlooks to forecast package; make the forecast package easily used and implemented; evaluate the package to assess adequacy in forecasting net basin supplies to appraise worth of improved lake evaporation techniques, to further determine error components, to analyze the importance of initial conditions, and to examine the utility of gamma aerial snowpack water equivalent measurements for Great Lakes water supply forecasting; compare the forecast package with climate-based and existing trend-regression analyses. (3) Water Supply Simulation: develop an Integrated-System Hydrologic Package for use by intra- and inter-division personnel and outside agencies. In FY 90, we developed shallow-water and deep-water concepts of heat storage and tested them against observed heat storage and surface temperature data, expanded the heat storage superposition model to include heat deficiency modeling as superposition and to introduce mixing of aged heat additions, and assessed the alternate long-wave radiation and sensible heat functions and tried other physically-based models for solar radiation and reflection.

In addition, we incorporated water surface temperature observations as boundary conditions in lake evaporation simulations and forecasts, incorporated a revised lake evaporation model into the forecast package, developed database management software for incorporation of improved evaporation and water temperature estimates into water supply outlooks, and developed the water supply package for use on personal computers.

Great Lakes Water Level Statistics for Decision Making.

Project Scientist: H.C. Hartmann

This project is for development of improved water level statistics that reflect existing hydrologic and hydraulic conditions, the long lag-response of the lakes to meteorologic variability, secular changes in climatic regimes, and the needs (e.g., varied planning horizons, understanding the limits of lake level statistics) of diverse Great Lakes decision makers. In FY 90, we developed a resampling strategy for estimating Great Lakes levels statistics, patterned after well-known bootstrap techniques, and demonstrated its application using a 130-year record of monthly mean water levels for Lake Erie. The resampling analyses clearly show that lake level exceedance probabilities should be conditioned on the length of the planning horizon, the starting month of the planning horizon, the initial lake level, and the climatic regime. Our methodology offers distinct advantages in that it can be extended to additionally consider storm and wind

effects on levels, to incorporate levels data available prior to continuous records, and to develop other types of lake levels statistics useful to decision makers, such as duration and time-to-exceedance probabilities.

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 90, a system for acquiring and storing routine meteorological observations from NDBC buoys, CMAN stations, Coast Guard and other coastal stations, and ships was implemented. Two methods for objective analysis of wind data were examined: an inverse power law method and a two-step exponential weighting method. The inverse power law method appears to be suitable for use in the Great Lakes.

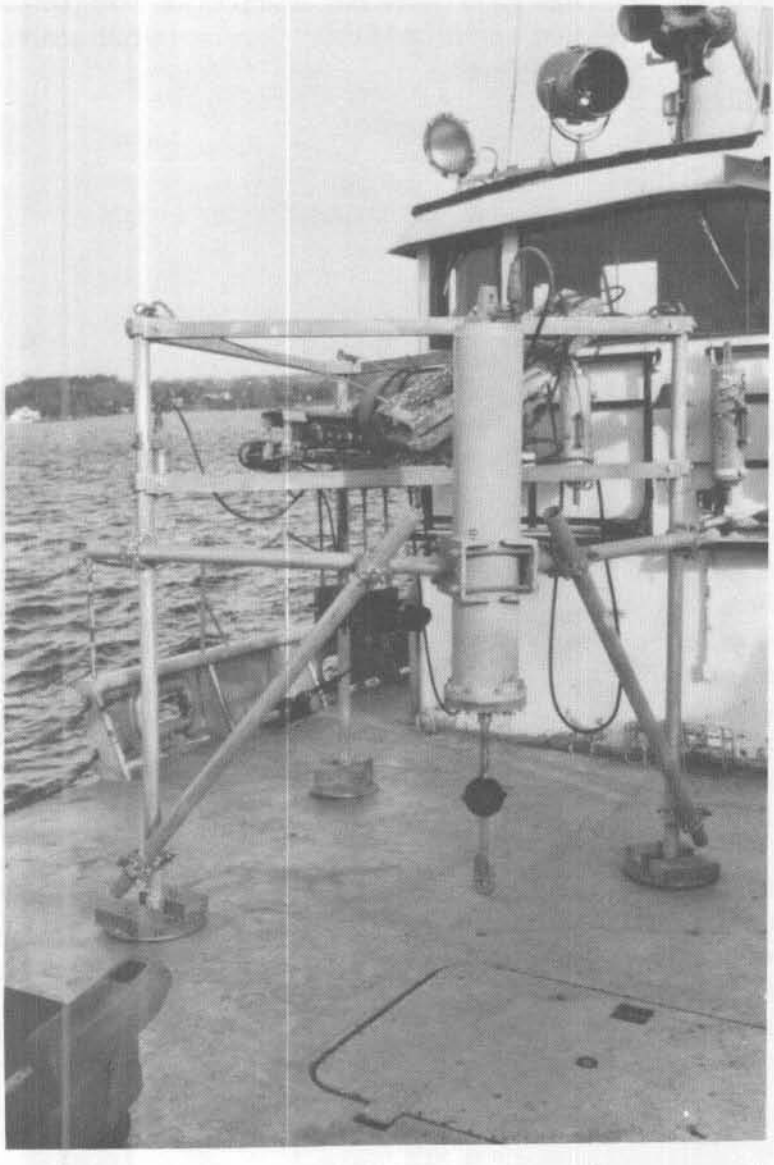
Assessment of Shallow Water Effects on Great Lakes Wind Waves.

Project Scientist: P.C. Liu

This program seeks to quantitatively assess the importance of shallow water effects on wind waves in the Great Lakes, to identify as well as quantify the circumstances and locations in which shallow water effects have a significant impact on deep water waves, and improve understanding and prediction techniques of shallow water waves. The GLERL WRIPS Waverider buoy was deployed in the shallow water of Green Bay during the autumn of 1989 along with an overwater meteorological station. Data from the buoy and the meteorological station will be used for model testing in this constricted and shallow embayment. The state-of-the-art third generation WAM wave prediction model has been successfully implemented for the applications of Great Lakes waves studies.

Green Bay

N. Hawley, Program Leader



Bottom resting tripod deployed to monitor sediment concentrations and currents in Green Bay.

The presence of toxic organic materials in the water, sediment, and biota of Green Bay has long been a cause for concern and has severely effected the bay's fishery. In order to address the problems in the bay, the U.S. EPA has undertaken the Green Bay Mass Balance Study with two major objectives (1) to provide information to aid and support regulatory activities in Green Bay, and (2) to pilot the use of the mass balance approach to regulation of toxic substances in Green Bay.

Sediment Resuspension in Green Bay.

Project Scientist: N. Hawley

The objectives of this study are to develop an empirical relationship which predicts bottom resuspension in Green Bay as a function of current velocity, and to measure the horizontal flux of sediment in and out of southern Green Bay. In FY 90, tripods were serviced and redeployed at approximately 5 week intervals. The summer 1989 data has been edited, filtered where necessary, and corrected. The data has been plotted and inspected and is now ready for analysis. The winter data has been plotted and filtered, but fouling corrections have not yet been determined.

Water Volume Transport Measurements in Green Bay.

Project Scientists: J.H. Saylor and G.S. Miller

The objectives of this program are to measure the water volume exchange between the upper and lower parts of Green Bay, and to provide measurements for calibrating improved hydrodynamic models for simulating Green Bay circulation and water volume transport. In FY 90, all current and temperature measuring instruments were removed from the bay during October 1989. An acoustic doppler profiler was redeployed in Death's Door Passage in November 1989. It operated during winter, part of the time under the ice, until retrieval in June 1990. All recorded data were translated from magnetic tape cassettes to VAX compatible formats, edited, and put together as a Green Bay data archive. Several differing algorithms were developed and tested to compute water volume transports on key Green Bay cross sections. Tests to insure conservation of mass and accuracy are continuing. All data in the Green Bay archive were provided to the U.S. EPA Large Lakes Research Station.

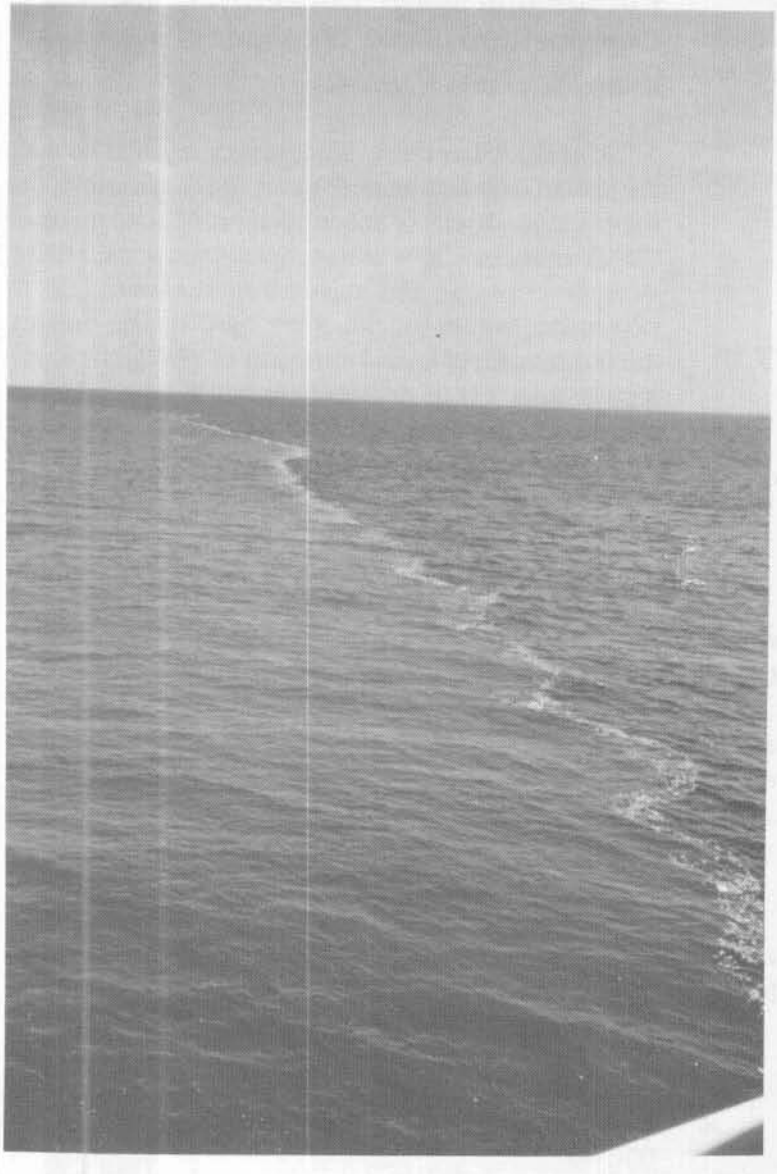
Sediment Resuspension and Particle Settling Velocities in Green Bay.

Project Scientist: B.J. Eadie

This study seeks to quantify the seasonal flux of resuspended sediments within the bay, and estimate net ensemble particle and particulate organic carbon (POC) settling velocities at monthly intervals. Sediment traps have been deployed and retrieved at U.S. EPA stations in Green Bay. Samples have been dried, weighed, and stored frozen. Organic carbon analysis was completed.

NECOP

B.J. Eadie, Program Leader



The Mississippi River Plume (left) as it dissipates into the Gulf of Mexico (right).

The Nutrient Enhanced Coastal Ocean Productivity (NECOP) program is one of a series of NOAA-wide programs dealing with major problems in the coastal ocean. The central hypothesis is that the increased nutrient input from the Mississippi River has led to increased productivity with undesirable consequences. GLERL is involved in a number of studies, all of which are new starts in FY 90. Since substantial results are not yet available, only the objectives of the studies are given.

Buoyancy and Nutrient Exchange in the Mississippi Outflow Region.

Project Scientists: A. M. Bratkovich
Contributing Scientists: M. Dagg, S. Dinnel, G.L. Fahnenstiel, G. Hitchcock, S. Lohrenz, P. Ortner, T. Whitledge, and W. Wiseman

The primary objectives of this study are to establish an 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.

Retrospective Analysis of Nutrient Enhanced Coastal Ocean Productivity in Sediments from the Louisiana Continental Shelf.

Project Scientists: B.J. Eadie and J.A. Robbins
Contributing Scientists: T. Nelsen, J. Trefry, S. Metz, P.T. Blackweller, B. McKee, and K. von Damm

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

Primary Production and Vertical Flux of Organic Carbon from Mississippi River Plume and Adjacent Shelf Waters.

Project Scientists: G.L. Fahnenstiel, S. Lohrenz, D. Redalje, and G. Knauer

The research will address the following objectives: (1) Characterize photoautotrophic community dynamics in relation to optical conditions, nutrient inputs, and other aspects of the physical/chemical environment, (2) examine the relationship between phytoplankton production, growth, and biomass and the vertical export of fixed carbon from surface waters of the Mississippi River Plume/Inner Gulf Shelf (MRP/IGS), 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.

Suspended Sediment on the Louisiana Continental Shelf: Concentrations, Compositions, and Transport Pathways.

Project Scientist: N. Hawley

This study has three major objectives: (1) To map the spatial distribution and, to the extent possible, the temporal variations of suspended particulate material (SPM) concentrations and compositions in the Mississippi River plume and adjacent shelf waters, (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 what, if any, relationships exist 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.

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

Project Scientists: W.S. Gardner and B.J. Eadie
Contributing Scientists: J.B. Cotner, M.B. Lansing, and J.F. Cavaletto

The objectives of this study are to define the chemical and isotopic composition of riverine and MRP/GS dissolved organic matter (DOM), and to determine the biological reactivity of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON).

CoastWatch

D.J. Schwab and G.A. Leshkevich, Co-Program Leaders

The CoastWatch product currently received at GLERL is satellite derived surface temperature. The original images are in color.

CoastWatch is a NOAA-wide program within the Coastal Ocean Program (NCOP) designed to focus on specific regional and national priorities in the coastal environment. NOAA resources are being brought together to provide a cohesive and near-real time delivery system to allow time-critical "decision support" in response to rapidly emerging coastal environmental situations. GLERL has been chosen as the focal point in the Great Lakes region for this program. Two subprograms are included in the CoastWatch program.

The general objectives of CoastWatch are (1) To provide access to near-real time and retrospective satellite and aircraft observations for the coastal ocean of the U.S. for federal, state, and local decision making, (2) to develop workstations and associated software systems for integrated analyses of environmental quality, coastal hazards, and wetlands change, (3) to develop a communications system supporting distribution of near-real time and historical satellite and in situ observations to national and regional coastal users, and (4) to develop and implement a database management and display system that supports integrated coastal ocean applications.

Great Lakes CoastWatch and NOAA Ocean Communications Network

Project Scientists: D.J. Schwab, G. A. Leshkevich, and G. E. Spalding

The specific objectives of this project at GLERL are to establish operations of the Great Lakes Regional National Ocean Communication Network (NOCN) Node (RNN), to identify regional CoastWatch users and their NOAA data needs, and to develop and supply useful products to participants in the Great Lakes CoastWatch program.

In FY 90, a computer initiative for Great Lakes RNN was developed and computer equipment for communications, data display, data storage, and data analysis was purchased.

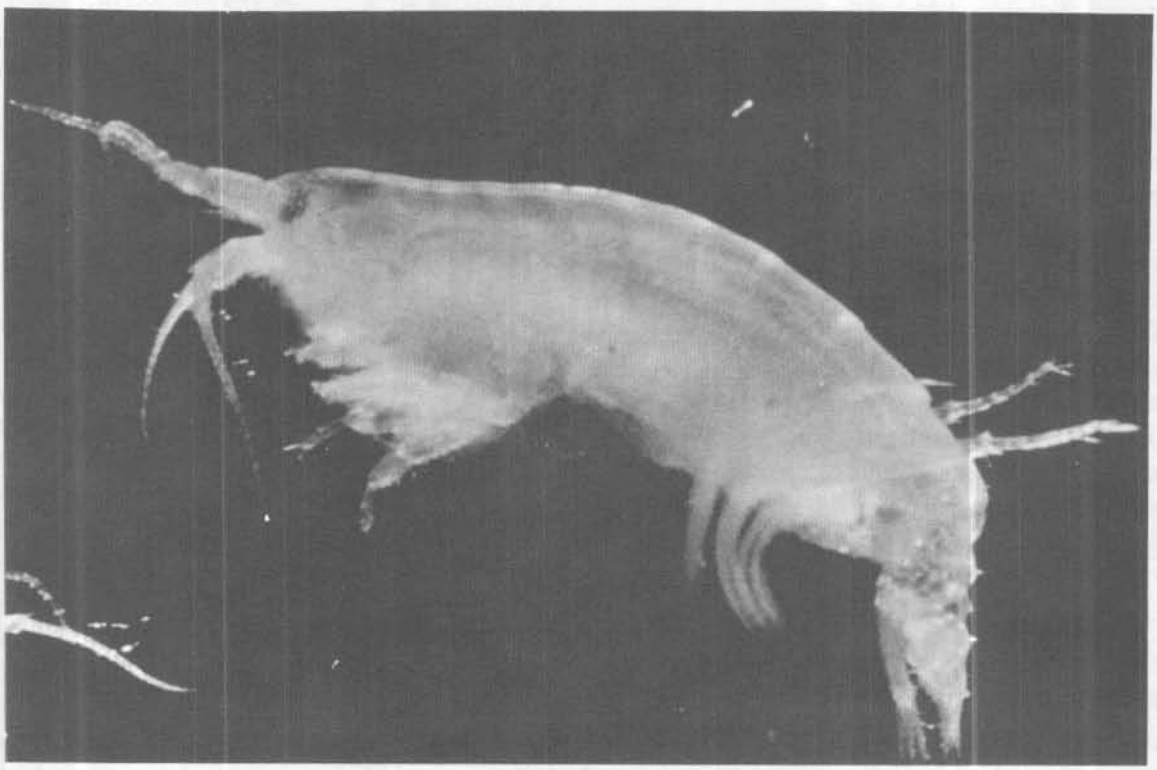
Great Lakes CoastWatch Product Development and Research

Project Scientist: G. A. Leshkevich

As a CoastWatch Regional Site, GLERL will establish operations of the Great Lakes RNN, identify regional CoastWatch users and their NOAA data needs, and supply useful products to participants in the Great Lakes CoastWatch Program. The CoastWatch product currently being received over the NOCN Node for use and redistribution is satellite derived surface temperature. Other products are planned including turbidity, ocean color, ice mapping etc., many using new satellite sensors such as SeaWiFs and Synthetic Aperture Radar (SAR). However, research is needed not only for the validation and implementation of this data in the Great Lakes region, which can lead to the enhancement or improvement of the Great Lakes CoastWatch product being distributed, but also for the development of regional products and uses of benefit to GLERL and its local CoastWatch sites.

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

Independent Research Projects



Diporeia *sp., used in many GLERL research projects, was previously classified as* Pontoporeia hoyi.

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. Titles of the projects with principal investigators and contributing scientists are listed below.

Exchange Processes in Coastal Environments.

Project Scientist: A. Bratkovich
Collaborating Scientists: R. Bernstein, L. Breaker, W. Chang, D. Chelton, L. Crowder, M. Dagg, S. Dinnel, G. Fahnenstiel, B. Hickey, G. Hitchcock, D. Hoss, B. Jones, M. Kosro, G. Laird, G. Lawrence, J. Ledwell, G. Leshkevich, R. Moll, G. Meadows, R. Moll, P. Ortner, J. Rice, L. Rosenfeld, L. Sanford, J. Saylor, L. Washburn, and T. Whitledge

This program 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 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.

Carbon Biogeochemistry in Lakes and Coastal Ecosystems.

Project Scientist: B.J. Eadie
Contributing Scientists: J.A. Robbins, G. Bell, G.A. Laird Pernie, A. Mudroch, J. Coakley, F. Rosa, C. Parrish, D. Adams, J. Val Klump, P. Meyers, C. Lohman, S. Eisenreich, J. Baker, and R. Lively

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 CO2 gas exchange, remineralization of organic carbon (primary production is assumed known from published data, but this parameter is very weak), formation of CaCO3, vertical flux of carbon species, dissolution rate of CaCO3, remineralization of carbon in sediments and transport across the sediment water interface.

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.

Upper Niagara River Cooperative Flow Model.

Project Scientist: J.A. Derecki

This research will lead to a better understanding of unsteady flows in the upper Niagara River and to improved determination of flows and river profiles under various flow conditions.

Upper Niagara River Unsteady Flow Model.

Project Scientist: J.A. Derecki

The Niagara River is the only Great Lakes connecting channel that does not have a hydraulic transient model for the simulation of unsteady flows. This study seeks to develop an unsteady flow model for the upper Niagara River above the Falls, and to calibrate the model by reavaluation of the bottom roughness parameters.

Detroit River Unsteady Flow Analysis.

Project Scientist: J.A. Derecki

This research will lead to a better understanding of the unsteady flow conditions, including flow reversals in the river, and to improved calibration of the existing Detroit River unsteady flow models by using an acoustic doppler current profiler flow meter at the Fort Wayne section of the Detroit River.

Resuspension of Bottom Sediments in Lake Superior.

Project Scientist: N. Hawley

This program seeks to measure the frequency, duration, and magnitude of sediment resuspension episodes using instrumented platforms deployed in Whitefish Bay and off the Keewenaw peninsula; to experimentally measure erosion threshold velocities using a bottom-resting flume; and to relate these measurements to the properties of the bottom material.

Dynamics of the Bottom Boundary Layer in Lake Michigan.

Project Scientists: 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.

Taxonomic Clarification of Great Lakes Pontoporeiid Amphipod.

Project Scientist: M.J. Quigley
Contributing Scientists: E.L. Bousfield and M. Luttenton

This work will focus on determining the taxonomic diversity of pontoporeiid amphipods of the upper Great Lakes and describing corresponding species morphology, distribution and habitat. Preliminary studies of Lake Michigan adult pontoporeiid amphipods has indicated that at least four separate species may exist along a nearshore-offshore gradient.

Nitrogen Dynamics.

Project Scientist: W.S. Gardner
Contributing Scientists: S. Fitzgerald and J. Cottner

This study will provide improved methodologies to measure fluxes of important nitrogen compounds that reflect nitrogen dynamics in lakes, wetlands, or marine coastal regions; identify, quantify, and compare major processes controlling nitrogen regeneration from lake and marine coastal sediments; and identify and quantify major nitrogen regeneration processes in lake and/or marine pelagic waters.

Facilities and Services

A GLERL scientist works with zebra mussels in the lipid laboratory.

GLERL's research facility is a modern building with over 24,600 square feet of usable space, including 19 laboratories (4,100 sq. ft.), conference rooms (990 sq. ft.), a library (1,250 sq. ft.), and computer resources (1,220 sq. ft.). In addition to general laboratory equipment, GLERL has a fully-equipped low-level radioisotope analysis laboratory, a stable isotope mass spectrometer (SIMS), several gas chromatographs and liquid scintillation counters, a high pressure liquid chromatography system, a multi-channel Coulter Counter, a full complement of growth chambers and incubators, stereo and inverted microscopes, and a fully equipped multi-purpose epifluorescence microscope. GLERL also maintains and operates a High Speed Microcinematography Laboratory housed in a temperature-controlled environmental chamber. The combination of high-speed (500 frames per second) and precise control of temperatures between 1° and 30° C allows advanced studies of the feeding behavior of zooplankton over the broad range of temperatures found in the natural Great Lakes environment. In addition, a separate Cold Room is maintained for conducting experiments and growing biological cultures at low temperatures.

Computer Facility

The GLERL Computer Facility consists of a Local Area VAXcluster (LAVc) of nine VAX computers on site and the capability of accessing a Cyber 855 mainframe and a Cyber 205 supercomputer at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. GLERL is one of five remote nodes to the NIST facility, which is known as the Department of Commerce Consolidated Scientific Computing System (CSCS). GLERL is also the Great Lakes Regional Node of the National Ocean Communications Network.

User terminals and microcomputers throughout the GLERL facility are hardwired to a communications switch that allows users to access the LAVc as well as the Cyber computers in Gaithersburg. Off-site access to the system is available through telephone lines and a private network that links NIST and all remote connections to the CSCS systems.

A variety of applications, including real time and near-real time data acquisition, data reduction, graphics, large scale modeling, statistical and mathematical analysis, telecommunications, and word processing support more than 80 accounts. Laboratory office automation, administrative/accounting functions, and scientific applications are supported by more than 85 loosely networked microcomputers.

During FY90, the Computer and Information Systems Group conducted an inventory of data bases archived at GLERL. The program is an ongoing activity of a GLERL Data Committee and contributes to the larger-scale NOAA effort of archiving usable data and making that data available for use by all interested scientists. A listing of the data base categories and the scientisits responsible for collection/archiving is given below.

Current Meter and Water Temperature
1. Lake Huron Nov. 1974 thru 1975 - Miller
2. Lake Michigan 1976 thru 1989 - Miller
3. Lake Erie 1979 thru 1980 - Miller

Drifter Data
1. Lake Erie 1986 - Miller
2. Lake Michigan (Green Bay) 1989 - Miller

Wave Data
1. Lake Michigan 1973 - Liu
2. Lake Michigan 1975 thru 1977 - Liu

Computerized Bathymetry Data
1. Lake Superior - Schwab
2. Lake Michigan - Schwab
3. Lake Huron - Schwab
4. Lake St. Clair - Schwab
5. Lake Erie - Schwab
6. Lake Ontario - Schwab

Meteorological Data (Air Temperature, Wind Speed and Direction)
1. Lake St. Clair 1986 (July thru October) - Hawley
2. Detroit River 1987 thru 1989 - Derecki
3. Lake Michigan (Green Bay) May 1989 thru May 1990 - Hawley

Vertical Velocity Profiles
1. St. Clair River 1984 thru 1986 - Derecki
2. Detroit River 1986 thru 1986 - Derecki

Biological and Chemical Water Data
1. Lake Michigan, Offshore 1983 thru 1990 - Laird Pernie

Sediment Trap Data (Mass flux, Some Chemical Characteristics)
1. Lake Michigan 1977 thru 1990 - Eadie
2. Lake Michigan (Green Bay) 1989, 1990 - Eadie
3. Lake Superior 1984 thru 1985, 1987 thru 1988 - Eadie
4. Lake Huron 1984 thru 1985, 1987 thru 1988 - Eadie

Water Data (Temperature Profiles)
1. Lake Michigan April, May 1989 and 1990 - Bratkovich

Water Temperature Data XBT
1. Lake Superior for the Autumn Months 1976 thru 1979 - Assel
2. Lake Superior for the Winter Months 1973 thru 1976 - Assel

Water Data (Temperature, Salinity, Transparency, etc.)

1. Lake Michigan (Green Bay) May 1989 thru May 1990 - Hawley
2. Lake St. Clair 1986 (May thru October) - Hawley
3. Lake Michigan 1975 thru 1990 - Bell
4. Gulf of Mexico (North) June, July 1990 - Bratkovich

Water Characteristics (Chemical, Physical, Bottom Sediment, etc.)

1. Lake Erie, June thru Nov. 1965, April thru Dec. 1967 - Bell
2. Lake Huron, May thru Nov. 1966 - Bell
3. Lake Superior and St. Marys River, May thru Nov. 1968 - Bell
4. Lake Superior, May thru Nov. 1969 - Bell
5. Lake Michigan, May thru Nov. 1970 - Bell
6. Lake Michigan, May thru Nov. 1975 - Bell
7. Lake Ontario, Oswego, Rochester Harbor, May thru Nov. 1971 - Bell
8. Lake Ontario, Oswego Harbor, May thru Nov. 1972 - Bell
9. Lake Ontario, 4 cruises July thru Nov. 1972 - Bell
10. Straits of Mackinac, May thru Nov. 1973 - Bell
11. Lake St. Clair and Detroit River, May thru Nov. 1974 - Bell.

Shipboard Meteorological Data

1. For all Great Lakes cruises from 1965 thru 1975 - Bell

Library

The GLERL library staff provide library and related services in support of the laboratory's research activities. A program-oriented research collection is maintained, with special retrieval services available when the existing collection cannot meet the needs of individual researchers. Library services include acquisition, circulation, interlibrary loan, reference, and online information retrieval for laboratory-affiliated personnel. The library staff expedite on-demand document retrieval and provide expanded reference capability on behalf of scientists through direct access arrangements with the University of Michigan libraries. GLERL Library facilities and collection are available for public use on-site during normal business hours.

Collection holdings include 4,440 books, 4,985 unbound periodical volumes, and 3,100 technical reports in program subject areas of climatology, contaminant organics, hydrology, hydraulics, ice, limnology, mathematical modeling, meteorology, nutrients, oceanography, sedimentation, and wave motion. The Great Lakes Basin is emphasized. The library also receives 191 current periodical titles. The technical reports collection is supported by the GLERL library reports catalog database and may be searched on-site using interactive search options.

During FY 90, the library staff submitted existing card catalog records for the retrospective conversion into machine readable format and inclusion in the Online Computer Library Center's (OCLC) catalog. Another project was initiated to re-catalog some of the technical reports from the GLERL reports catalog database into the OCLC catalog. Converted records from both projects will be included in the NOAA libraries union catalog which is searchable on CD-ROM in NOAA libraries. Also during this fiscal year, the library processed its second highest number of interlibrary loan requests.

In FY 91, the library staff plan to continue to catalog older materials into the collection as well as convert existing database records into the OCLC database. As these efforts are completed, the library will have the majority of its collection integrated into the NOAA union list catalog where records will be accessible using interactive Boolean search options.

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 Online Computer Library Center, Inc. (OCLC).

Information Services - Publications Unit

The Publications Unit staff are responsible for providing editorial and publications support to the scientific staff, for distributing GLERL publications, and for responding to publications and information requests from the public. They also produce and update brochures and informative fixed and portable displays concerning GLERL's work and/or important environmental issues.

For FY 90, the Information Services Group completed displays that were exhibited at an Earth Day Open House held at GLERL, a presentation at the University of Michigan in association with Earth Day, and at a zebra mussel conference in Washington, DC. Displays were also exhibited for a visit to GLERL by students from Eastern Michigan University's Summer Institute, and at an Open House held at Muskegon, MI in honor of the relocation of our vessel operations.

Research products generated during FY 90 include 45 scientific articles, reports, and books, and 55 formal presentations. There were over 2,200 documented requests for GLERL information, with over 3,100 items mailed as a result of those requests.

The Publications Unit maintains and updates eight mailing lists for GLERL products. New NOAA-series publications are automatically distributed according to these mailing lists. All new publications, including journal articles and books, are added to our six-month update listing of new publications, which keeps 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 Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-1593

Vessel Operations

In FY 90, as a result of the reorganization, Vessel Operations and the Marine Instrumentation Laboratory were combined and are now designated the Marine Operations and Instrumentation Laboratory (MOIL).

▼ Muskegon Vessel Operations Facility

The base for Vessel Operations was moved during June from Grand Haven, MI to Muskegon, MI. The old Coast Guard Base with two buildings and 1.3 acres of land was declared surplus by the Coast Guard, 9th District, and leased to GLERL for 1 year to establish a Vessel Operations Facility. While this is a temporary agreement with the Coast Guard, Congressional action has been initiated to transfer the title from the Coast Guard to NOAA through the efforts of Representative Robert W. Davis (Coast Guard and Navigation Subcommittee of the House Merchant Marine and Fisheries Committee) and Representative Guy Vander Jagt (Ways and Means Committee). Mr. Rick Chapla, Department of Planning and Economic Development, City of Muskegon, has been helpful in facilitating the move.

There is dockage for the R/V *Shenehon* and a smaller research launch in the Coast Guard mooring basin adjacent to the main building. A 5 year lease for 100 feet of dockage has also been obtained from the Corps of Engineers at the Government Mooring Basin approximately 0.3 miles from the main building.

The main building has 10 rooms, a full basement, two toilets and a shower room, and storage in the attic. The large galley can be converted to a laboratory in the future. This facility has great potential for the establishment of a lake-side laboratory for GLERL which can have a continuous supply of lake water and will allow some studies to be conducted that are not feasible at the laboratory in Ann Arbor. There is a separate building which is being utilized for a crew office, a workshop, and for storage of ship supplies and equipment. A third building, on

The R/V Shenehon, docked at the new Vessel Operations Facility located in Muskegon, MI, is fully equipped for oceanographic studies and is the primary vessel used throughout the Great Lakes to collect the data used in most GLERL products.

city property, is being used for storage of research equipment.

The City of Muskegon sponsored a 1-day Open House and welcoming reception to celebrate the arrival of GLERL and the R/V *Shenehon* to the new Muskegon facility. GLERL personnel set up displays and conducted tours. The U.S. and NOAA flags were raised as the new facility was dedicated. The event was well attended by the public, and GLERL received television, radio, and newspaper coverage.

▼ Research Vessel *Shenehon*

The *Shenehon* is owned and operated by GLERL. It is based at the old U.S. Coast Guard Station at Muskegon, MI and is the primary platform used in support of GLERL's open lake field investigations. The vessel is 65.6 feet long, has a 6.5-ft mean draft, a 700-nautical-mile cruising range, and a 10-knot cruising speed. Navigational equipment includes a Sperry Gyrocompass, Raytheon Radar, two LORAN-C units, a Sperry Auto Pilot, and a Raytheon Depth Sounder. A 55-channel radiotelephone is available for ship-to-shore communications. Electrical power is provided by a modern 20-kW, 3-phase Onan generator, 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. Electro-hydraulic 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. A data acquisition system, separate from the Shipboard Environmental (Data) Acquisition System (SEAS), records and plots data from a Sea Tech transmissometer coupled to an electronic bathythermograph. The system includes equipment to record, process and plot water temperature data collected using Sippican Expendable Bathythermograph (XBT) probes.

The *Shenehon* is a designated NOAA weather reporting station and has a SEAS installed by the National Ocean Service. This system, the first installed in the Great Lakes, provides increased capability to collect and transmit weather data using satellite communications.

A 25-foot Bertram cruiser has been modified for use as an auxiliary research platform which is transported by trailer to remote sites. Navigational equipment includes radar, a magnetic compass, a 91-channel radiotelephone, a Loran-C and a 50-kHz depth sounder, and a 120-kHz depth sounder with digital and video displays. An electric winch is available for deployment and retrieval of light sampling equipment. An inflatable life raft was added during FY 90.

▼ Research Support

The majority of the work supported by the *Shenehon* and the Bertram 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.

During FY 90, cruises were made in Lake Michigan, Straits of Mackinac, Saginaw Bay, and into Green Bay. The cruises into Green Bay were made as part of a cooperative study with the Environmental Protection Agency (EPA) and with the University of Wisconsin. The Bertram cruiser was used primarily for biological studies (7 weeks) in Saginaw Bay, and for temperature transects in Lake Michigan.

Sediment traps were deployed at two stations in Lake Michigan and at five stations in Green Bay to monitor the vertical mass and chemical flux. Instrument tripods were deployed over the winter in Green Bay to study bottom currents and the resuspension of sediments.

Current meters and temperature sensors were deployed in Green Bay over the winter as part of a bottom boundary layer study and to determine water currents in Green Bay. Two acoustic doppler profilers were removed from Green Bay and deployed in the Straits of Mackinac. Current and temperature sensors were deployed in the center of the southern basin of Lake Michigan.

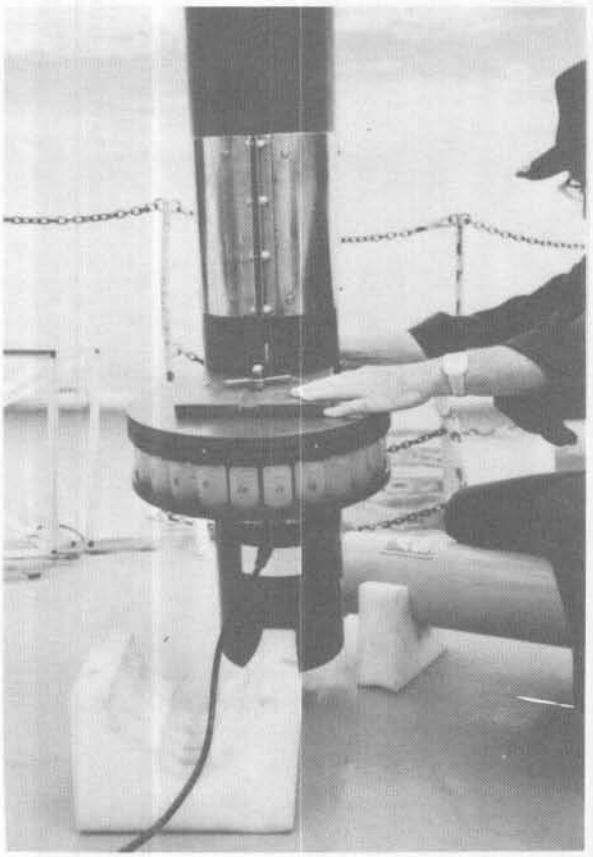
The 100-meter station off Grand Haven, MI continued to be the site monitored using sediment traps and periodic water and plankton samplings to study temporal variations in water quality as well as vertical mass and chemical flux as determined by trap samples. Particular emphasis was placed on carbon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

A prototype sediment trap of GLERL design for collecting sequential samples in the water column was successfully tested in Lake Michigan. The trap will be deployed along with two sequencing traps of PMEL design during the winter in Lake Michigan. Several more traps of the GLERL design will be constructed and deployed throughout the Great Lakes.

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

▼ 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 44 AMF Vector Averaging Current Meters, 16 AMF Acoustical Releases, 7 Mini-TOD Drifter Buoys, 1 Adamo-



The GLERL-designed sediment trap for collecting sequential samples in the water column was successfully tested in Lake Michigan.

Rupp Waverider WRIPS Buoy, 5 Aanderaa Thermistor String Recorders, 5 Marsh McBirney 585 Current Meters, 1 RD Instrument Co. RDRR-1200 Acoustical Doppler Current Profiler, and 2 RDSC-600 Acoustical Doppler Current Profilers.

During FY 90, MOIL staff, in conjunction with the Great Lakes Engineering Company, Ann Arbor, MI, built and tested a sequential sediment sampler that would withstand working pressure of 200 meters with 23 discrete samples of individual preset exposure times from 1 minute to 1 year. A microcomputer is the controller of the system and serves as a data logger for in situ measurements. Present plans call for adding six more to our inventory.

We acquired a used catamaran and converted it into a towed vehicle for downward current profiling using our RDRR-1200 Acoustical Doppler Current Profiler.

Modifications were made to our old inventory of drifters to allow external disconnection of power and downloading of data without opening the sealed instrument which will result in faster field usage turnaround. These drifters were used in conjunction with Canadian scientist on Lake Ontario.

Outreach Activities

In recognition of Earth Day 1990, GLERL, along with several other local research agencies, opened their doors to continue to inform the public of current research activities.

The GLERL mission includes the development of environmental information, data, and service tools for users in government and private organizations. Identifying the environmental information needed to fulfill this mission is a vital activity of GLERL staff and helps guide our research programs. Participation on boards, commissions, task forces, and committees is an essential part of this effort. Equally important is the role played by the Publications Unit, which supports all aspects of publishing GLERL's products, making them available to those who need them, answering information requests, and creating displays and general literature concerning GLERL's products and work.

International and Interagency Participation

Staff participation on boards, commissions, task forces, and committees provides a mechanism for defining new research initiatives, identifying user needs, and guiding 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.

During FY 90, GLERL staff participated as members of the following boards, committees, and task forces:

International Joint Commission

▼ Great Lakes Science Advisory Board (A. Beeton, U.S. Chair)
- Council of Great Lakes Research Managers (D. Reid, Alternate)

▼ Corporate Management Committee (A. Beeton)

▼ Great Lakes Water Quality Board, Surveillance Work Group
- Great Lakes Surveillance Subcommittee (B. Eadie)
- Lake Michigan Task Force (B. Eadie)
- Lake Erie Task Force (J. Robbins)
- Lake Huron Task Force (T. Nalepa)
- Upper Connecting Channels Task Force (J. Derecki)
- Workshop on Applications of Mass Balance to the Management of Toxic Substances in the Great Lakes (B. Eadie, Co-chair)

▼ Great Lakes Water Levels Reference
- Functional Group 1: Hydrology, Hydraulics, and Climate (F. Quinn)
- Functional Group 3: Socio-Economic and Environmental Impact Assessment Group (H. Hartmann)

▼ Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data
- Hydrometeorology and Modeling Subcommittee (T. Croley, II)
- River Flow Subcommittee (F. Quinn)

▼ International Great Lakes Levels and Flows Advisory Board (F. Quinn, U.S. Co-chair)

▼ Biennial Meeting 1991 Program Subcommitte (A. Beeton)

Other interagency, professional society, and international activities:

▼ International Association for Great Lakes Research
- Board of Directors (D. Schwab, Treasurer) (T. Nalepa, M. Quigley, G. Fahnenstiel)
- IAGLR Membership and Endowment Committee (M. Quigley, Chair)
- *Journal of Great Lakes Research* (F. Quinn, Associate Editor)

▼ National Research Council
- Postdoctoral Program (A. Beeton, W. Gardner, H. Vanderploeg, P. Landrum)

▼ The University of Michigan
- Cooperative Institute for Limnology and Ecosystems Research (CILER) (A. Beeton, S. Bolsenga)
- Biological Station Executive Committee (A. Beeton)
- Ph.D Committees (A. Beeton, S. Tarapchak, A. Bratkovich)

▼ Ohio Sea Grant
- Zebra Mussel Project (A. Beeton)
- Lake Erie Ice Studies (S. Bolsenga)

▼ American Society for Testing and Materials Sediment Toxicity Subcommittee (P. Landrum)

▼ Assessment and Remediation of Contaminated Sediments (ARCS, USEPA)
- Toxicity/Chemistry Work Group (P. Landrum)
- Management Advisory Commiteee (D. Reid)

▼ *Chemosphere*, Board of Editors (P. Landrum)

▼ Department of Commerce Consolidated Scientific Computing System Technical Committee (G. Spalding)

▼ Great Lakes Commission
- Drought Management and Great Lakes Water Levels Task Force (H. Hartmann, F. Quinn)
- Great Lakes Speakers Bureau Directory (G. Laird Pernie, F. Quinn, H. Hartmann)

- Task Force on Emergency Preparedness (D. Reid)
- Observer delegate (A. Beeton)

▼ Great Lakes Environmental Action Program (Great LEAP/USCOE) (A. Beeton, G. Leshkevich)

▼ Great Lakes Protection Fund
- Technical Advisory Committee (A. Beeton)

▼ Great Lakes GIS Coordinating Committee (G. Leshkevich)

▼ Great Lakes Water Quality Agreement EPA Policy Committee (A. Beeton)

▼ Green Bay Mass Balance Study (USEPA)
- Field Operations Committee (N. Hawley)
- Management Committee (A. Beeton)
- Modeling Work Group (J. Saylor)
- Technical Advisory Committe (B. Eadie)
- Lake Ontario Dioxin Superfund Management Panel (B. Eadie)

▼ *Handbook of Environmental Chemistry*, Advisory Board (P. Landrum)

▼ Huron River Watershed Council (S. Tarapchak, Advisor)
- Portage Lake Project (A. Beeton)

▼ International Mathematics and Statistical Library (IMSL) North American Users Group (L. Herche, Co-chair)

▼ International Association of Theoretical and Applied Limnology (A. Beeton, U.S. Representative)

▼ Lake Ontario Nutrient Cycle/Foodweb Modeling Workshop (S. Tarapchak)

▼ NASA/Lockheed Freshwater Initiative (S. Bolsenga)

▼ NCAR Great Lakes Climate Change Program (S. Bolsenga)

▼ NOAA Climate and Global Change Program
- Ecosystems Working Group (D. Reid, S. Bolsenga)

▼ NOAA Coastal Ocean Program
- Coastal Fisheries Ecosystem Component Interline Office Development Team (G. Fahnenstiel)
- Observations and Predictions Component Interline Office Development Team (A. Bratkovich)
- Physical Impacts Component (D.Schwab)

▼ NOAA/ERL Satellite Requirements Committee (S. Bolsenga, G. Leshkevich)

▼ NOAA Estuarine Habitat Research Workshop (W. Gardner)

▼ NOAA Mississippi River Plume/Gulf Shelf Region Research Planning Workshop (W. Gardner)

▼ NOAA Technical Subcommittee, New Bedford Superfund Action (B. Eadie)

▼ NOAA NECOP Technical Advisory Committee (B. Eadie, A. Bratkovich)

▼ NOAA/NESDIS Coastwatch Program (G. Leshkevich, D. Schwab, G. Spalding)

▼ NSF Long-Term Ecological Research Network (S. Bolsenga, S. Tarapchak)

▼ Regional Response Team (RRT), Region V
- Department of Commerce Alternate Representative (D. Reid)

▼ Michigan Sea Grant Research Advisory Committee (J. Saylor, A. Bratkovich)

▼ State of Michigan, Department of Natural Resources
- Great Lakes Information System Technical Advisory Committee (A. Beeton)

- Michigan Great Lakes Fund (A. Beeton)
- Toxic Substances Control Commission (A. Beeton, Commissioner)

▼ State University of New York (SUNY) Buffalo, Great Lakes Programs
- Advisory Board (F. Quinn)

▼ U.S.-Canada Ice Information Working Group
- Great Lakes Ice Issues Subcommittee (R. Assel, U.S. Co-chair)

▼ International Great Lakes - St. Lawrence Ice Information Working Group (R. Assel, U.S. Co-chair, S. Bolsenga)

▼ U.S. Environmental Protection Agency Policy Committee (A. Beeton, S. Bolsenga Alternate)

▼ U.S. Soil Conservation Service (A. Beeton, Technical Advisor)

▼ U.S. Department of State
- Cooperative Study on Chernobyl Fallout in Masurian Lakes, Poland (J. Robbins)
- Mongolian Cooperative Research Program (S. Bolsenga)

▼ Waterloo Natural History Association (H. Hartmann)

▼ Wayne County Community College
- Technical Advisory Committee (H. Booker)

GLERL scientists also:

- Conducted cooperative research with scientists from the University of Konstanz, W. Germany on a comprehensive study of Chernobyl Fallout in Lake Konstanz.

- Conducted cooperative research study of evaporation and climate change with scientists from the USSR Academy of Sciences.

- Continued to develop a cooperative research program with the People's Republic of China. As part of this program, GLERL hosted a visiting scientist who came to GLERL to learn sediment analysis techniques.

- Hosted a four-month visit by a hydrobiologist from the VNIIVO Institute, All-Union Scientific Research Institute for Water Protection in Kharkov, USSR, as part of the Environmental Protection Exchange Program.

- Established a cooperative zebra mussel monitoring effort with the U.S. Coast Guard wherein Coast Guard staff survey and report zebra mussel infestations on navigation buoys as they are recovered for winter storage.

- Participated in an ad-hoc international "mussel watch" committee to act as a clearinghouse and validation point for reported zebra mussel sightings. This committee has been instrumental in attempting to control unfounded rumors about the spread of the zebra mussel and in providing accurate, verified data.

- Conducted a cooperative research project with the Department of Pathology at The University of Michigan Medical School.

- Conducted cooperative research with scientists at Michigan State University, Department of Fish and Wildlife.

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

- Worked with EROS Data Center in Sioux Falls, SD on obtaining and installing LAS image-processing software at GLERL.

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

- Conducted cooperative research with scientists at NASA/Goddard to measure bidirectional reflectance of ice.

- Conducted cooperative research with the Naval Ocean and Atmospheric Research Lab (NOARL).

- Collaborated with scientists at Michigan State University to study the ecology of the larvae of the mosquito *Anopholes*, a vector of malaria.

- Conducted cooperative research with the U.S. Fish and Wildlife Service on under-the-ice ecology.

- Served as adjunct professors at The University of Michigan.

- Served on an expert advisory/review panel for Carnegie-Mellon University's Physical-Technical Systems Class on Catastrophic Spills on the Great Lakes.

- Served as expert advisors for the U.S. Navy acoustics research program in Lake Pend Oreille, ID.

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

- Measured lipids for scientists at the University of Waterloo, Canada.

- Measured lipids in marine zooplankton for a cooperative study with Memorial University of Newfoundland, Canada.

- Conducted a cooperative study on lipids with scientists from the University of Stockholm, Sweden.

- Established a cooperative Great Lakes bathymetry charting project with scientists at NOAA's National Geophysical Data Center.

- Hosted students from several area schools. The students were given laboratory tours and briefed on 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 90, GLERL sponsored 20 in-house seminars as part of the GLERL Informal Seminar Series. Our staff made 55 presentations concerning GLERL's work at public and professional meetings.

In FY 90, GLERL staff members served as co-chairman of the following sessions:

- Sediment Toxicity: Bioavailability and Field Assessments at the Tenth Annual Meeting of the Society of Environmental Toxicology and Chemistry.
- Organic Substances and Sediments in Water: Biological Processes: Bioaccumulation and Bioturbation 199th National Meeting of the American Chemical Society.
- Nutritional Biochemistry, Behavior, and Physiology at the National Science Foundation workshop Future Directions in Zooplankton Biology (H. Vanderploeg).
- Organized and chaired an IJC Workshop on Applications of the Mass Balance Approach to the Management of Toxic Substances in the Great Lakes held in Barrie, Ontario, Canada in March 1990 (B. Eadie).

Technology Transfers

GLERL staff responded to approximately 2,200 requests for information during FY 90 and provided 3,100 items to service those requests. Many of the products that GLERL produces and distributes involve, to some degree, a transfer of both technology and data. During FY 90, 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 Snowfall Maps

- Interactive Concepts, Inc.

Hydrologic Response Model

- University of Minnesota
- Provided continuing assistance to the US Army Corps of Engineers, Detroit District

Net Basin Supply Forecast Package

- US Army Corps of Engineers, Detroit District
- US Army Corps of Engineers, Buffalo District
- US Army Corps of Engineers, Hydrologic Engineering Center
- New York Power Authority

Wave Forecast Model

- US Army Corps of Engineers
- University of Wisconsin

"Pathfinder" Trajectory Prediction System

- US Department of the Interior
- US Coast Guard
- McMaster University

Thiessen Weighting Package

- Michigan State University
- University of Florida

Satellite Drifter Programs

- Scripps Oceanographic Institute

Large Basin Runoff Model

- Michigan State University
- The Water Network

Lake Evaporation Model

- Atmospheric Environment Service

Real-time Interactive Data Acquisition Software

- R.D. Instrument Co.

GLERL's data gathering equipment was shared with:

- The University of Michigan, Great Lakes Research Division
- Michigan State Police

Plans for construction of sediment traps were shared with:

- University of Minnesota
- University of Stockholm, Sweden
- Great Lakes Engineering Company

Lipid Methodology

New micro-methods developed at GLERL to measure lipids in aquatic invertebrates were transferred to:

- National Water Research Institute, Burlington, Ontario
- National Hydrology Research Institute, Saskatchewan, Canada.
- Hatfield Marine Science Center, Newport, Oregon.

Eastern Michigan University's Summer Institute

During July 1990, GLERL scientists participated in a career night event and hosted a lab tour for high school honor students participating in EMU's Summer Institute Program. The Summer Institute Program is funded by the Michigan Department of Education and is designed to provide college-bound students with an introduction to university life.

GLERL and Great Lakes Education - Partners for Excellence

In conjunction with NOAA's desire to better inform the public of its research efforts, GLERL is involved in a number of Great Lakes community educational programs. In FY 90, 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 public schools' curriculum in the area of environmental science, particularly with respect to the Great Lakes and aquatic sciences. Designated partnership activities included:

▼ 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.

Southeast Michigan Science Fair

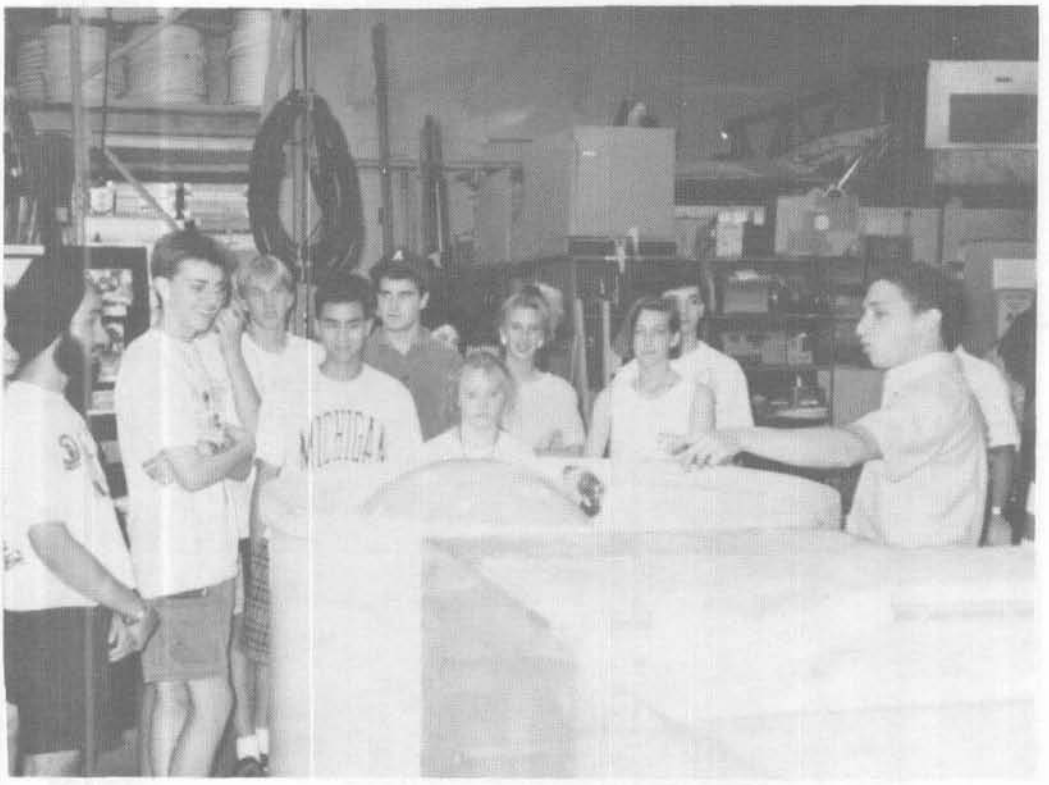
In conjunction with the 32nd Annual Southeast Michigan Regional Science Fair, GLERL sponsored awards for outstanding projects in aquatic science in each of the Science Fair divisions: Senior Projects, Junior Projects, and Junior Models and Collections. GLERL staff (T. Croley, D. Schwab, H. Vanderploeg, J. Saylor, and A. Beeton) 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. Each participant is assigned to a GLERL research scientist who supervises the student's work and activities related to an active GLERL research project.

Teacher-at-GLERL Project

During FY 89, GLERL scientists (A. Beeton, D. Reid) initiated a project to host a middle school science teacher at GLERL for a one-semester sabbatical funded by the Ann Arbor Public Schools (AAPS) System. After several discussions with AAPS officials and a formal written proposal, the project was accepted and sabbatical funds were allocated for the 1991 school year. Ms. Sandy Aquino, a science teacher at Tappan Middle School, has been selected for the project and will be resident at GLERL from January to June, 1991 to develop curriculum enhancements in the area of aquatic environmental science.



High school students participating in Eastern Michigan Univesity's Summer Institute Program were given a tour of the laboratory. Here, a GLERL scientist explains the use of GLERL's data gathering equipment.

▼GLERL Seminars▼

October 18, 1989
Jackson, George.
Department of Oceanography, Texas A & M University. Understanding small scale planktonic interactions by simulating chemotactic behavior in the presence of fluid flow.

October 31, 1989
Gatt, Joel.
University of Wisconsin. Use of isotopic signatures for developing water balances: potential applications to the Great Lakes.

November 8, 1989
Qi, Yu-Zao.
Institute of Hydrobiology, Jinan University, China. Red tide and eutrophication in Shenzhen Bay, China.

November 29, 1989
Sherr, Evelyn.
University of Georgia Marine Institute, Sepelo Island, GA. Jumping through the microbial loop: Roles of protozoa in aquatic food web.

December 6, 1989
Taylor, William.
University of Waterloo, Canada. Small versus large zooplankton: mechanisms underlying top-down effects in lakes.

December 12, 1989
Masse, Ann.
National Water Research Institute, Canadian Center for Inland Waters. Frontal dynamics - Niagara River plume in Lake Ontario.

February 1, 1990
Privalsky, Victor.
Academy of Science, Moscow, USSR. Climatic variability: stochastic models, predictability and spectra.

February 2, 1990
Ferronsky, Sergei.
Academy of Science, Moscow, USSR. The atmospheric energy: measurement process.

February 7, 1990
Fitzgerald, Sharon.
GLERL. The biogeochemistry of amino acids in sediments from the Great Lakes.

March 14, 1990
Barnhisel, Rae.
University of Michigan. Great Lakes fish aversion to *Bythotrephes cederstroemi.*

April 11, 1990
Cuhel, Russel.
Center for Great Lakes Studies, Milwaukee, WI. Sulfate assimilation and the global sulfur cycle.

April 12, 1990
Cuhel, Russell.
Center for Great Lakes Studies, Milwauke, WI. Evidence for phosphorus deficiency in the Sargasso Sea.

April 24, 1990
Derecki, Jan.
GLERL. Video enhancement and documentation of underwater research operations.

May 3, 1990
Spiesberger, J.
Woods Hole Oceanographic Institute, Woods Hole, MA. Global warming and acoustic tomography of oceans.

May 31, 1990
Johnson, R.K.
Swedish Environmental Protection Agency. Time-series analysis of profundal zoobenthos in Sweden's Great Lakes.

June 19, 1990
Robertson, D.M.
Centre for Water Research, University of Western Austrailia. The use of lakewater temperature and ice cover as climatic indicators.

August 8, 1990
Magnuson, J.
University of Wisconsin. Long-term ecological research on lakes and global change.

August 29, 1990
Leshkevich, George.
GLERL. Digital image processing at GLERL using the IVAS/LAS system.

August 30, 1990
Tseng, W., and K. Buttleman.
NESDIS. NOAA's Coastwatch Program and the Interactive Digital Image Display and Analysis System (IDIDAS).

September 26, 1990
Walline, P.D.
Lake Kinneret Lab, Tiberias, Israel. Fisheries research at the Kinneret Limnological Laboratory.

FY 90 Staff

	Full Time	Part Time	Other
Office of the Director	10	0	1
Physical Sciences Division	18	2	7
Biogeochemical Sciences Division	23	2	14
Marine Operations and Instrumentation Laboratory	5	4	2
Computer and Information Systems Group	7	1	0
TOTAL	63	9	24

Office of the Director

Beeton A.M. - Director
Noble, P.E. - Secretary
Bolsenga, S.J. - Asst. to Director
Johengen, T.H.*

Administration

Mark, S.V. - Head
Lashbrook, E.K.
Lee, J.P.
Mull, R.C.

Information Services

Bolsenga, S.J. - Head
Darnell, C.M.
Hubbard, B.D.
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.

Library Facility

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

Physical Sciences Division

Quinn, F.H. - Head
Lawton, B.J. - Secretary
Assel, R.A.
Bratkovich, A.W.
Clites, A.H.
Croley, T.E., II
Derecki, J.A.
Dong, D.Y.†
Gottlieb, E.S.*
Hartmann, H.C.
Hawley, N.
Huff, L.E.†
Hunter, T.S.
Jankuski, D.A.†
Kelley, R.N.
Leshkevich, G.A.
Liu, P.C.
Mazure, S.R.*
McCormick, M.J.
Miller, G.S.
Muhr, G.C.
Norton, D.C.
Saylor, J.H.
Schwab, D.J.
Sellinger, C.E
Shenot, J.M.*
Thomas, J.D.†

Marine Operations and Instrumentation Laboratory

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