

The Great Lakes - Coastal Ocean Program Workshop

**Forming an Initiative:
Coastal Zone Management and
the Laurentian Great Lakes**

Proceedings

**November 5 -6, 1992
Ypsilanti, Michigan**

**Proceedings prepared by
Cooperative Institute for Limnology and Ecosystem Research (CILER),
University of Michigan, Ann Arbor, Michigan
and
National Oceanic and Atmospheric Administration/
Great Lakes Environmental Research Laboratory (NOAA/GLERL),
Ann Arbor, Michigan**



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Cosponsored by the National Oceanic and Atmospheric Administration - Coastal Ocean Program (NOAA - COP), the Cooperative Institute for Limnology and Ecosystems Research (CILER), and the Great Lakes Environmental Research Laboratory (GLERL).

1.0 Workshop Overview.....	1
1.1 Background.....	3
1.2 Workshop Goals and Agenda.....	5
• Statement of Goals.....	5
• Agenda.....	6
1.3 Workshop Participants.....	8
• List of participants.....	8
• List by subgroup.....	12
• Steering Committee.....	18
2.0 Contaminant Processes Subgroup.....	19
2.1 Presenter's summary.....	19
2.2 Presentation Material.....	23
2.3 Recorder's report.....	25
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	
3.0 Coastal Hazards/Physical Processes Subgroup	26
3.1 Presenter's summary.....	26
3.2 Recorder's report.....	29
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	

4.0 Nutrient Processes Subgroup	33
4.1 Presenter's summary.....	33
4.2 Recorder's report.....	38
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	
5.0 Trophic Dynamics/Non-Indigenous Species/Habitat Subgroup	42
5.1 Presenter's summary.....	42
5.2 Recorder's report.....	46
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	
6.0 Remediation/Resource Management.....	50
6.1 Presenter's summary.....	50
6.2 Recorder's report.....	55
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	
7.0 System Integration/Data Management Subgroup	57
7.1 Presenter's summary.....	57
7.2 Recorder's report.....	64
• Subgroup statement or question of critical problem	
• Outline of subgroup issues	
8.0 Next Steps: Management Issues.....	69
Appendix: Sample invitation letters to workshop participants.....	70
• Letter to Presenter	
• Letter to Subgroup Chair	
• Letter to Subgroup Recorder	
• Letter to Participants	

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1.0 Workshop Overview

Funded by NOAA's Coastal Ocean Program, the Great Lakes - Coastal Ocean Program Workshop was held at the Radisson Conference Center in Ypsilanti, Michigan on November 5 - 6, 1992. The initial guidelines for the workshop were established by a steering committee comprised of scientists from the Great Lakes region; the workshop proceedings were organized by a management team from the Cooperative Institute for Limnology and Ecosystem Research (CILER) and the Great Lakes Environmental Research Laboratory (GLERL). The 63 workshop participants included scientists covering a wide range of disciplines and drawn from the entire Great Lakes region and beyond. Representatives were present from Great Lakes Basin universities, NOAA's Coastal Ocean Program, the Michigan Department of Natural Resources, the National Weather Service, and the U.S. Fish and Wildlife Service.

Workshop Objective: The primary objective of the workshop was to develop the conceptual framework for an integrated yet focused research proposal defining the Great Lakes Initiative under NOAA's Coastal Ocean Program.

Workshop Organization: The workshop participants were divided among six subgroups:

- Contaminant Processes
- Coastal Hazards/Physical Processes
- Nutrient Processes
- Trophic Dynamics/Non-Indigenous Species/Habitat
- Remediation/Resource Management
- System Integration/Data Management

The subgroups met together with the charge to produce a subgroup report that would include the following items:

- Item 1: Statement of critical issues and needs for the subprogram
- Item 2: Set of clear research objectives for the subprogram

- Item 3: Set of critical research/monitoring/synthesis components for the subprogram
- Item 4: Definition of research management issues
- Item 5: Identification of products to be developed and users of the products

The subgroups reconvened as a whole group in plenary sessions each day.

Workshop Results: At the conclusion of the subgroup and plenary sessions, the general agreement among the workshop participants was to focus the basic research question:

How do episodic events (e.g.. storms, runoff events, upwelling, downwelling, lake ice breakup, thermal bars) affect ecosystem function and the sources, transport, transformation, fate, and effects of important biogeochemical constituents as they move through the coastal interface zone to open-lake waters?

The products of the workshop will be a full report of the workshop proceedings as well as a draft of the Program Proposal to the NOAA Coastal Ocean Program.

1.1 Workshop Background

The Laurentian Great Lakes ecosystem is a major resource to the North American continent and this ecosystem continues to be under severe environmental stress.

The Great Lakes region:

- Contains 20% of the world's surface fresh water and 90% of the surface fresh water in the United States. Persistent toxic contaminants threaten the viability of this essential fresh water system.
- Supports a rich, diverse, and continually-evolving flora and fauna. The lives of these plants and animals are endangered by contaminants, excess nutrients, and other perturbations to the system.
- Provides the basis for multi-billion dollar commercial, recreational, and agricultural activities which both contribute to and are affected by the perturbations and degradation of the ecosystem

The Environmental Issues:

The environmental issues arise from the resource demands of major population centers, the responsibility for human impact on the ecosystem itself, the environmental pressures from heavy industry, and a long natural water renewal time. The Great Lakes region is a young ecosystem which is susceptible to perturbations from:

- Species invasions such as the zebra mussel
- Anthropogenic stresses from agriculture and industry
- Episodic weather events such as storms

During the last two decades, the Great Lakes region has benefited from ecosystem management efforts. For example, excess nutrients, resulting in massive plankton bloom, chronic shoreline nuisance weed production, and extensive fish kills during the 1960s and 1970s, have been greatly reduced with the removal of phosphorous from detergents sold in the region and the investment of billions of dollars in sewage treatment plants. More recently, the research and management response to the invasion of the zebra mussel in

the Great Lakes ecosystem has been swift and aggressive. However, the following critical problems still need to be addressed:

- **Input of excess nutrients from uncontrolled non-point sources such as storm water runoff and spring runoff.**
- **Input of contaminated sediments from non-point sources such as storm water runoff and atmospheric deposition.**
- **Resuspension and transport of contaminated sediments during episodic events such as floods and storms.**
- **43 Areas of Concern in the coastal areas of the Great Lakes including both those AOCs which export contaminants directly into the main body of the lake and those AOCs which export contaminants through a bay to the main body of the lake. The concentration of contaminants within embayments may play an important role in the transfer of contaminants through the food chain.**

The overarching variables in these critical problems are the episodic events which force the biogeochemical constituents through the coastal interface zones. The consequences of these events are poorly understood, hard to predict, and difficult to manage.

1.2 Workshop Goals

Statement of Goals

Workshop Objective: To develop the conceptual framework for an integrated yet focused research proposal defining the Great Lakes Initiative under NOAA's Coastal Ocean Program.

Coastal Ocean Program Goals

- To improve predictions of fish stocks to better conserve and manage living marine resources.
- To improve predictions of coastal ocean pollution to help correct and prevent degradation.
- To improve predictions of coastal hazards to protect human life and personal property.

Great Lakes - Coastal Ocean Program Objectives:

- **Scientific Objective:** To obtain a new level of quantitative understanding of the processes that dominate the transports, transformations, and fates of biologically, chemically, and geological important constituents through and across the coastal boundary zones of the Great Lakes ecosystems. (adapted from Coastal Ocean Processes Goal Statement.)
- **Management Objective:** To provide effective management of the Great Lakes coastal regions through the development of a quantification synthesis of coastal processes.

Coastal Ocean Program - Great Lakes Workshop

November 5-6, 1992
Ypsilanti, Michigan

Workshop Agenda

Thursday, November 5 8:00 a.m. - 5:00 p.m.

Registration 7:30 - 8:00 a.m.

Opening Remarks:..... 8:00 - 8:30 a.m.

A.M. Beeton, GLERL
R. Moll, CILER
J. C. Mathes, University of Michigan
Sarah Campbell, University of Michigan

Workgroup Topics: The Saginaw Bay Perspective..... 8:30 - 10:30 a.m.

<u>Subprogram</u>	<u>Presenter</u>
Contaminant Processes	P. Landrum, GLERL
Coastal Hazards/Physical Processes	D. Schwab, GLERL
Nutrient Processes	W. Gardner, GLERL
Trophic Dynamics/Non-Indigenous Species/ Habitat.....	G. Fahnenstiel, GLERL
Remediation/Resource Management	G. Goudy, MDNR
System Integration/Data Management	V. Bierman, Limno-Tech

Break 10:30 - 10:45 a.m.

Coastal Ocean Program Overview: 10:45 - 11:00 a.m.
Don Scavia, Director

Workgroup Session..... 11:00 a.m. - noon

Charge to Workgroup participants is to produce a group report to include the following items:

- Item 1: Statement of critical issues and needs for the subprogram
- Item 2: Set of clear research objectives for the subprogram
- Item 3: Set of critical research/monitoring/synthesis components for the subprogram
- Item 4: Definition of research management issues
- Item 5: Identification of products to be developed and users of the products

<u>Subprogram Workgroup</u>	<u>Chair</u>	<u>Recorder</u>
Contaminant Processes	S. Eisenreich	P. Van Hoof
Coastal Hazards/ Physical Processes	A. Bratkovich/K. Bedford	J. Saylor
Nutrient Processes	D. Armstrong	R. Moll
Trophic Dynamics/Non-indigenous Species/Habitat	J.C. Makarewicz	H. Vanderploeg
Remediation/Resource Management	J. Ribbens	S. Campbell
System Integration/Data Management	J. DePinto	J.C. Mathes

Coastal Ocean Program - Great Lakes Workshop

Thursday, November 5, continued

lunch 12:00 - 1:00 p.m.
Workgroup Sessions 1:00 - 5:00 p.m.

Friday, November 6 8:00 a.m. - 5:00 p.m.

Plenary Session: Present Workgroup Reports 8:00 - 10:00 a.m.
Workgroup Sessions: Prepare Final Reports 10:00 - noon
lunch 12:00 - 1:00 p.m.
Workgroup Sessions: Prepare Final Reports, cont. 1:00 - 2:00 p.m.
Plenary Session: Identify Program/Proposal Objectives 2:00 - 3:00 p.m.
Recording Group Session 3:00 - 5:00 p.m.

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Contaminant Processes

2.0 Contaminant Processes Subgroup

2.1 Presenter's Summary:

Nearshore Processes in the Fate, Distribution, and Bioaccumulation of Anthropogenic Contaminants

Prepared by Peter F. Landrum
Great Lakes Environmental Research Laboratory, NOAA
Ann Arbor, Michigan

Background:

Anthropogenic contaminants in the Great Lakes remain the top concern. Problems such as reproductive difficulties in Lake Trout, benthic community structure modification and toxic effects for fish eating birds and mammals suggest that the controls on contamination are still not adequate to maintain a healthy ecosystem. Because of the efforts to reduce point sources, e.g. industrial and municipal discharges, the current contaminant loads are thought to come from non-point sources, e.g. storm water runoff, atmospheric deposition and release from sediments through resuspension and food chain transfer.

Most of the more contaminated areas in the Great Lakes occur in the nearshore environment as exemplified by the 42 Areas of Concern as classified by the International Joint Commission. These sites represent sources of contaminants to the open environments of the Great Lakes. There generally exist two categories of such sites: those that export material directly to the main body of the lake and those that export contaminants through a bay to the main body of a lake. The dynamics and the ecology of these two general types of sites are totally different; thus, a contaminant exiting from a point source, e.g. a river, will encounter vastly different environmental rate processes and ecologies. Because of the expected differences in the processes and rates, the bioavailability and food chain accumulation and effects would be expected to differ for the same contaminant load.

In addition to the differences in the physical systems, the ecology of the two types of systems are different and the relative contribution of the ecology to the fate and transport of the contaminants would be expected to vary. Further, the ecology of the Great Lakes is undergoing change. The invasion of the zebra mussel has generally altered the fate and distribution of particles in shallow areas. Since many of the contaminants of concern sorb strongly to particles, such changes in the dynamics of particles will generally effect the dynamics of the contaminants.

Critical Issues:

While most of the important processes have been identified for the fate and distribution of contaminants, the dynamics of such processes are not well studied. Thus, the relationship between the rates for the major physical processes that distribute water and particles through these environments and rates of sorption, desorption, and bioaccumulation are generally not known. The contribution of these nearshore environments to the total food chain accumulation of contaminants and their effects on both the nearshore organisms and the total lake food chain remain to be considered.

Further, there have been several concepts brought to light that have generally not been part of previous efforts to describe the fate and distribution of contaminants through an ecosystem. These include such processes as the role of dissolved and colloidal organic matter on transport and bioaccumulation of contaminants through dynamic environments, the importance of sorption and desorption processes on the transport, distribution and bioaccumulation of contaminants, and the relative balance of the pathways and rates of the various processes and their affect on bioaccumulation.

The bay systems may play an important role in the transfer of contaminants through the food chain. First these areas are major areas of productivity, they are nursery beds for several fish species, and they effectively present a resistance to the movement of contaminants to the main body of the lakes. If the ultimate removal process is deep water sediment burial, then such a resistance will effectively increase the exposure of the ecosystem components to contaminants.

Products:

An improved understanding of the role of the transport dynamics in relation to the pathways and rates for contaminant accumulation through the coupling of physical, chemical and biological studies will help define the fraction of contaminant entering the food chain from these two types of systems and will lead to a better definition of the important sources of food chain contaminants and major sources for ecosystem effects.

The impact of the zebra mussel on the fate and transport of contaminants in nearshore systems as well as the food chain accumulation and distribution of contaminants will be defined and the total ecological effect of their introduction will be refined. Further, the utility of the zebra mussel as a biomonitor for long term trends in contamination will be determined.

Improved predictability and modeling of contaminant fate and distribution. The processes such as the role of sediments as influenced by hydrodynamic flow regimes and events, dissolved and colloidal organic matter and alteration of the ecosystem by the zebra mussel can be incorporated to provide improved realism.

Users:

The products resulting from the initiative would be used by the regulatory community and the scientific community.

Regulatory Community would use the products for:

- Long term monitoring of environmental trends
- Human health advisories
- Assessment of nearshore contamination and the potential effects on the whole lake
- Improved predictabions of contaminant effects

Scientific Community would use the products to:

- Better define which processes dominate in nearshore environments for both physical transport and contaminant fate and transport
- Provide improved definition of the important processes affecting bioaccumulation in these dynamic systems

Potential Study Site:

Saginaw Bay has been suggested as the first potential study site for improving our understanding of dynamics of nearshore system processes. This site has been the subject of numerous studies for both eutrophication and toxic contaminant effects on the ecosystem and the work has been summarized as a part of EPA's Assessment and Remediation of Contaminated Sediments Program (Brandon *et al.* 1991). Effects of toxic contaminants in the bay continue to exert effects on fish eating birds and benthic community structure. Fish consumption advisories remain in effect for sections of the bay.

Saginaw Bay provides a unique opportunity to compare and expand our current understanding of the impact of dynamic processes on the fate, transport and bioaccumulation of contaminants with that of past studies. Further, because of the recent invasion by the zebra mussel and the extent of potential change in the system as a result of this invasion, the role of the zebra mussel in changing contaminant dynamics can be investigated. Models of both eutrophication (Bierman *et al.* 1984) and polychlorinated biphenyl contamination (Richardson *et al.* 1983). The contaminants model incorporated the advective processes, sedimentation, and resuspension. The model also assumed rapid equilibrium between sorption and desorption processes. The relative dynamics of such processes and their importance should be incorporated into new models. The models also did not incorporate bioaccumulation processes. Since bioaccumulation and the effects of accumulated compounds are the most important issues, the relative dynamics of the physical processes should be compared to the bioaccumulation processes to determine the fraction of load that will enter the food chain.

Several processes that were considered unimportant, e.g. photolysis, in the original model may have to be incorporated now because of changes in the physical system caused by the introduction of the zebra mussel. The light penetration has dramatically increased; thus, photolysis may now be important.

Overall, significant improvements in understanding the importance and effects of process dynamics in the fate, transport and bioaccumulation can be made by comparison with the past studies of the area. This study should help define the long term trends for contaminant problems within Saginaw Bay through comparison with previous data.

References:

Bierman, V. J. Jr., D. M. Dolan, and R. Kasprzyk. Retrospective analysis of the response of Saginaw Bay, Lake Huron, to reductions in phosphorous loadings. Environ. Sci. Technol. 18:23-31.

Brandon, D. L., C. R. Lee, J. W. Simmers, H. E. Tatem, and J. G. Skogerboe. 1991. Information Summary, Area of Concern: Saginaw River and Saginaw Bay. U.S. Environmental Protection Agency Report, EL-91-7, Great Lakes National Program Office, Chicago.

Richardson, W.L., V. E. Smith, and R. Wethington. 1983. Dynamic Mass Balance of PCB and suspended solids in Saginaw Bay - A case study. In Physical Behavior of PCBs in the Great Lakes. D. Mackay, S. Patterson, S.J. Eisenreich, and M. S. Simmons, Eds., Ann Arbor Sci., Ann Arbor, pp. 329-366.

2.0 Contaminant Processes Subgroup

2.2 Presentation Material:

Day 1 Contaminant Subprogram

I. Objectives

1. Overall Scientific Objective

To obtain a new level of quantitative understanding of the processes that dominate contaminant exposure and effects to aquatic organisms.

2. Research Objectives

- A. Develop strategies to quantify the concentration of significant contaminants in various media to which organisms are exposed.
- Various media include water, sediment, and food which vary over time and space.
 - Identify critical pathways of exposure to organisms.
 - Emphasis on temporal characteristics
- B. Develop strategies to quantify the concentration of significant contaminants at target sites in organisms.
- Transport into and redistribution of contaminants to target sites.
 - Determine critical pathways into and within organisms for delivery to target sites.
 - Emphasis on temporal characteristics.

II. Components of Exposure and Effects

1. Concentration (f(t))

<u>Inputs</u>	<u>Outputs</u>	<u>Internal</u>
<u>Processes</u>		
Tributaries	Outflow	Transport
Atmosphere-water Exchange	Air-water Exchange	-sediment-water exchange
Shoreline Erosion	Sediment Burial	--sediment processes
Point Sources	Degradation	--circulation
Runoff	Groundwater	Transformation
Groundwater		--chemical
		--biological
		--physical

2. Organism (f(t))

<u>Inputs</u>	<u>Outputs</u>	<u>Internal</u>
<u>Processes</u>		
Ingestion (food)	Respiration (water)	Biotransformation
Respiration (water)	Elimination	Internal Distrib
Integument Transport (water)	--fecal --urine	

Critical Components to Environmental Bioavailability:

- Concentration
- Bioavailability: Kinetics, Speciation

3. Organism Effects

- Acute vs. Chronic
- Individual, Population, Community Levels

Day 2 Contaminant Subprogram

Research Objectives:

--Overall Objective: Develop strategies to quantify the concentration of significant contaminants in various media to which organisms are exposed.

--Hypothesis: Sediment-water interactions control the fate and bioavailability of sediment associated contaminants in Great Lakes' embayments.

Products:

- Time to reduce contaminant body burdens in fish (implicit assumption that sediment-water interactions control fish and benthos contaminant concentrations).
- Distribution of contaminant residue times.

2.0 Contaminant Processes Subgroup

2.3 Recorder's Report: Prepared by Patricia Van Hoof, GLERL

Subgroup Objectives:

- Overall Objective: Develop strategies to quantify the concentration of significant contaminants in various media to which organisms are exposed.
- Hypothesis: Sediment-water interactions control the fate and bioavailability of sediment associated contaminants in Great Lakes' embayments.

Outline of Subgroup Process

Defining the issues:

What are the important factors controlling an aquatic organism's exposure to pollutants?

- contaminant concentrations in various media (distribution and fate processes)
- organism (exposure pathways)
- time

Forming a research hypothesis:

Sediment-water interactions control the fate and bioavailability of sediment-associated contaminants in Great Lakes' embayments.

Research Objectives:

1. Map the residence times of sedimentary constituents.
 - select constituents typical of site (tracers)
 - determine residence times in sediments at a site
 - determine exposure concentrations to benthic organisms
2. Quantify the fluxes of contaminants between sediment and water.
 - process and quantify information on sediment-associated contaminant settling, re-suspension, adsorption/desorption, and diffusion.
 - need information on the importance of episodic and rare events
3. Determine the bioavailability of selected contaminants to organisms.

Products:

1. Distribution of contaminant residence times.
2. Time to reduce contaminant body burdens in fish and benthos.

Coastal Hazards / Physical Processes

3.0 Coastal Hazards/Physical Processes Subgroup

3.1 Presenter's Summary:

Coastal Ocean Program Great Lakes Initiative Coastal Hazards and Physical Processes

Prepared by David J. Schwab, GLERL

Background

The coastal environment absorbs the primary stresses exerted by hydrodynamic forces on the shoreline. It also absorbs the primary loadings of contaminants and nutrients introduced into the marine environment from terrestrial sources. Coastal areas are home to about half the U.S. population and a large percentage of U.S. industries. The coastal environment is heavily utilized for transportation, commerce, and recreation. NOAA's mission includes both protection of life and property in the coastal zone and also the responsibility for scientific leadership in the management of coastal resources.

With increasing pressure to maximize the utilization of the coastal environment for commercial and recreational purposes and at the same time to preserve and restore natural coastal resources, it is becoming more difficult to make informed management and policy decisions regarding shoreline usage. Approximately 15 percent of the U.S. population and 50 percent of the population of Canada reside in the Great Lakes region. Numerous federal, provincial, state, and municipal parks, recreation areas, and nature preserves are present along the shores of the lakes. A wide variety of shoreline types exist including sandy beaches, cobble beaches, clay bluffs, exposed bedrock coasts, coastal wetlands, and developed areas. In order to effectively manage the disparate uses of the coastal environment, accurate predictions of current and future coastal conditions, and estimations of the impacts of proposed actions on the coastal environment are required. A specific example would be the common problem of contaminated sediment in a harbor. Should it be dredged and removed, or buried in place, or allowed to flush out naturally into the lake? What impact would each of these actions have on the coastal environment? How can the most cost-effective strategy be determined?

Critical Research Issues

There are several research areas in which critical research issues need to be addressed before we can provide a definitive answer to questions like these.

- Sedimentation, resuspension, and transport of particulates - How do physical processes in nearshore and offshore areas determine when, where, and how much particulate matter (and associated contaminants) is

resuspended and deposited? How much of the sediment inventory of contaminants is released locally in storm/runoff events?

- Bottom boundary layer - Not enough is known about the detailed physics at the water-sediment interface to confidently predict sediment-water exchange of particulates and dissolved constituents.
- Coastal currents - How are currents in the littoral zone generated by waves and wind forcing? How are they affected by local topography and shoreline geometry?
- Coastal erosion - How do waves, storm surges, and hydrologic processes affect erosion rates? Can we predict when and where critical areas of erosion will occur? Can we develop cost effective ways to mitigate adverse changes to critical areas?
- Frontal processes - What effect do strong temperature gradients due to the springtime thermal bar or summertime upwelling events have on the redistribution of important chemical and biological constituents?
- Ice - How does ice affect everything described above?

Approach

In order to address these critical issues in physical processes and coastal hazards research, we suggest a four element approach:

- Bring together information on important nearshore physical processes affecting the coastal environment including shoreline erosion, sediment resuspension and transport, and nearshore currents. Methods for predicting shoreline evolution, littoral transport of sediment, disposition of material introduced from rivers, and hazardous spill trajectories would be developed. These methods would then be applied on a region by region basis to the practical problems of dredged material disposal, discharge regulation, hazardous spill response and contingency planning, and natural resource preservation and management.
- Sponsor basic scientific research projects in the field of coastal processes that relate to factors which are limiting the effective development of predictive techniques. These include nearshore wave prediction, the effect of waves on nearshore currents, fluid-bedform interactions, sediment mobilization, and shoreline evolution. Projects coupled with contaminant and nutrient research would be encouraged.
- Conduct the operation of a Coastal Environmental Prediction System. The System would consist of a series of computer models for integrating observed

environmental conditions with numerical simulations of coastal physics and ecology to provide maps and other assessments of present conditions and also short-term and long-term predictions. The system could also be used for scenario testing and risk assessment.

- Operate a permanent field research and experimentation station on the lakeshore. This facility would allow researchers to conduct long-term experiments on coastal processes in a natural environment.

Costs and Benefits

Of the 9000 miles of Great Lakes coastline, 83 percent is privately-owned land valued at between \$100 and \$1000 per lineal foot. During periods of high water levels, physical damage to shorelines can be extensive. Estimated property losses during the high water period of 1951-1952 were \$61 million per year. A U.S. Army Corps of Engineers study indicated that during the high water period of 1972-76, an estimated \$170 million was spent on private shoreline protection structures, while \$231 million worth of property (land and structures) was lost. Costs of pollution cleanup are also high. The activities of the proposed Program for Environmental Prediction could reduce these costs by several percent, resulting in a significant cost to benefit ratio.

Timeliness

The technology now exists to combine observations and model results for coastal environmental predictions in a manner useful for technical management of coastal resources. Observation systems are available which would serve the purposes of an environmental information and prediction system, but further observational studies are required to calibrate and validate predictions. A prototype Great Lakes Forecasting System is being developed under partial NOAA sponsorship and would serve as a basis for the Coastal Forecasting System proposed here. Similar efforts are underway for Chesapeake Bay, the California coast, the Gulf coast, the Gulf of Maine, and several estuaries, but none is as far along in terms of producing useful products for environmental management as the Great Lakes system. In addition, recent EPA and U.S. Army Corps of Engineers initiatives relating to Great Lakes coastal environmental problems will provide a basis for inter-agency collaboration in the development of the Program.

3.0 Coastal Hazards/Physical Processes Subgroup

3.2 Recorder's report: Prepared by Alan Bratkovich, GLERL

- **Statement of Primary Research Question/Objective**

What are the effects of hydrometeorological storms on coastal waves, currents, water stage, and mass distributions? How rapidly are base conditions perturbed and what are the quantitative measures of the perturbations? What measurements are required for quantitative estimates of a specified accuracy? Can the changes and new physical state of the systems be quantified by analytical and/or numerical modeling techniques?

- **Outline of subgroup issues**

I. Defining the critical issues

A. Waves, storm surges, flooding, and hydrologic processes that inundate and erode coastal areas causing hazard to life and property.

B. Sediment transport, resuspension, and deposition in coastal and offshore environments that may focus and concentrate sediment-bound contaminants.

C. Onshore and offshore transport of suspended particulate matter and dissolved substances. Transport may be accelerated or impeded by thermal (density) fronts and coastal and bottom boundary layers. Prediction of spill trajectories.

D. Formation, movement, and thawing of the winter ice cover and its influence on the processes of lake physics. Role of the ice in accumulating, storing, and transporting sediment and contaminants.

E. New technologies for observing and measuring the physical, chemical, and biological variables and utilization of them in basin simulation activities.

II. Research Areas/Themes

A. Study of Historical Data

Analysis of historical data sets to facilitate research planning and study site selection.

B. Episodic Forcing

The study of event-driven forcing of physical processes in coastal areas. Forecasting of coastal hazards for protection of life and property during hydrometeorological storms. Improvement of forecasting capabilities by development of regional forecast systems including shallow-water modifications.

C. New Technology

Evaluation of new technology and the incorporation of verified products into forecast systems. New technologies include the NWS Doppler radar installations, synthetic aperture radar satellites, SeaWiFS and ocean color scanner satellites, the proposed Grand Haven, Michigan based HF radar system, and emerging in-situ measurement systems and telecommunications technologies for near-real-time reporting.

D. Ice

Winter observations to include the effects of ice in the dominant seasonal and annual cycles of physical processes. Ice cover is an important variable in the winter ecology and winter economy of the Great lakes. As a hazard, ice can damage ships or delay ship schedules by obstructing bays, harbors, or the connecting channels of the Great Lakes. Ice movement can damage shore installations, i.e., docks, breakwaters, houses. Frazil ice can cause damage to turbines in hydroelectric power plants. River ice jams cause flooding, damage to docks and other shoreline property and loss of hydropower generation capacity. Ice scour of lake bottoms causes destruction of nearshore bars, sediment transport, and damage of installations on the lake bottom, such as electric cables, oil or gas lines, and water intakes. Ice formation affects energy and mass exchange at the lakes surface and thus it affects sedimentation, resuspension, and transport of particulates. Little is known about the effects of ice on coastal currents, waves, coastal erosion, lake evaporation, and lake-effect snowfall in the nearshore zone of the Great Lakes.

E. Thermal Fronts

The study of frontal processes to determine the role they play in accelerating or retarding the mixing of water masses and the accumulation of biogenic materials. Fronts associated with the annual cycle of lake water warming in the spring and cooling in the fall, with upwelling and downwelling events, and with riverine

sources are often present and they influence the transport of materials across the coastal zone.

F. Suspended Sediment Transport

Potential pathways for the movement of suspended particulate matter (SPM) from the lake coasts include bottom and surface boundary (nepheloid) layers and the interior of the water column. Materials transported from the shelf to the deeper, more tranquil benthic environments, whether subsequently remineralized or not, would normally be incorporated into the sediments and thus, effectively be removed from the water column. The character and magnitude of this flux is poorly known because the physical processes that control the transport of the SPM are poorly known. These processes include interior and boundary layer circulation, turbulence levels (diffusion), and water column stability. A study to quantify these fluxes is necessary and it requires a comprehensive program of physical, chemical and biological measurements. It is certain that the materials are transported in high-energy, event-driven episodes. Such measurements, yielding detailed information on the character and intensity of the flow field, will be of direct use in the development of particulate matter resuspension criteria and in the initialization and verification of circulation models.

III. Products of Research

A. Research Advances

1. Improved coastal forecast systems.
2. Improved knowledge of onshore/offshore water mass and suspended sediment exchange processes.
3. Understanding of the annual variation of meteorological forcing and ice effects on physical processes.
4. Evaluation of the usefulness of new technology to studies of the Great Lakes and other coastal environments.

B. Resource Management

1. Improved forecasting of storm-driven threats to human life and coastal property.

2. Improved prediction of oil and hazardous chemical spill trajectories.
3. Sediment resuspension potentials and the movement of particle-bound contaminants.
4. Ice forecasting and movement.
5. Improved lake physics models on which to build chemical and biological simulations.

Nutrient Processes

4.0 Nutrient Processes Subgroup

4.1 Presenter's Summary:

Nutrient Cycling in Saginaw Bay and Other Great Lakes Coastal Regions

Presented by Wayne Gardner, GLERL

Operating assumptions

- I. Nutrient cycling is critical to several aspects of coastal system dynamics including water quality, ecosystem structure and function, and sediment biogeochemistry.
- II. Information is important to:
 - Water quality managers
 - Municipal and industrial users of water
 - Wetland managers
 - Fishery resource managers
 - Freshwater and marine aquatic scientists

Critical Issues Concerning Nutrient Cycling in Coastal Systems

- I. Effects of nutrient inputs and recycling on water quality.
 - A. Important issue because good water quality is important for municipal water supplies, recreation, industry, and agriculture
 - B. Already know:
 1. High inputs of phosphorus and other nutrients from point sources (e.g. sewage discharges) cause increased levels of nitrogen-fixing bluegreen algae that degrade water quality by increasing turbidity and taste and odor problems.
 2. Reduction of point sources of phosphorus inputs, and bans of phosphorus from detergents, have reduced the frequency and intensity of bluegreen algae blooms and have greatly improved the water quality of Saginaw Bay and other coastal regions.
 - C. Remaining questions:
 1. What are the dominant forms and input rates of on-point source nutrients, such as those from agricultural runoff and coastal erosion, and how do these different forms affect the water quality of coastal regions?
 2. Will increased measures to monitor and control non-point sources of nutrients be cost-effective in terms of increased water quality in coastal regions?

3. What are the effects of coastal wetlands in modifying the concentrations and bioavailability of nutrient inputs from non-point sources?
- D. Products that should be developed:
1. Publications/reports in scientific literature that describe the nature and magnitude of "key" processes (physical, chemical, and biological) affecting the concentrations, bioavailability, and fate of nutrients from non-point sources in coastal regions including wetlands.
 2. Conceptual and mathematical models describing the concentrations, bioavailability, and fate of nutrients from non-point sources in coastal ecosystems.
- E. Key information needed to improve predictability and management:
1. Bioavailability, effects, and fate of nutrient inputs from "non-point" sources.
 2. Effects of meteorological events such as storms on the effects and fate of nutrients from non-point sources.
 3. Effects of wetlands on the fate and bioavailability of nutrients from non-point sources.
 4. Interactions of nutrients and other contaminants introduced into coastal environments from non-point sources.
 5. An understanding of how the physical or hydrological processes affect the transport and availability of nutrients from non-point sources.

II. Effects of nutrient inputs and recycling on ecosystem dynamics and fishery resources.

- A. Important issue because an understanding of ecosystem dynamics is critical to making management decisions that affect both water quality and fisheries. Recreation provided by coastal fishery resources is an important economic factor both at the local and state level.
- B. Already know:
1. Quantity and composition of phytoplankton strongly depends on the concentrations and ratios of available nutrients including phosphorus, silica, and nitrogen.
 2. Food quality, determined by the composition of phytoplankton, is a major factor affecting the composition and production rates of invertebrates (pelagic and benthic) that in turn serve as prey for forage fish in coastal ecosystems.
- C. Remaining questions:
1. What is the relative importance of different trophic foodweb scenarios (e.g. phytoplankton-zooplankton-fish, phytoplankton-bacteria-protozoan-zooplankton-fish, phytoplankton-benthos-

- fish) or combinations on the production rates and composition of fish in coastal ecosystems?
2. To what extent will nutrient concentrations and ratios, and seasonal (or sporadic) rates of input, affect the dynamics and relative importance of the different foodweb scenarios in production of fish prey in coastal ecosystems?
 3. How will the presence of exogenous species, such as the zebra mussel, affect the cycling and ratios of available nutrients and, in turn, the composition and production rates of phytoplankton in different coastal regions?
 4. How will interactions of different anthropogenic and biogeochemical nutrient source functions for the different nutrients (e.g. riverine inputs, internal recycling, sediment regeneration) affect phytoplankton production and composition in different coastal regions?
 5. What percentage of primary production occurs at sediment surfaces vs. overlying waters in different coastal regions?
 6. To what extent do unattached phytoplankton capture nutrients at the sediment water interface followed by entrainment into photic zones?
- D. Products that should be developed:
1. Publications/reports in scientific literature that describe the nature and magnitude of "key" processes affecting the concentrations, turnover rates, and fate of available nutrients in coastal regions.
 - a. Quantify the relative importance of the different heterotrophic components (pelagic bacteria, microzooplankton, mesozooplankton, sediment bacteria, benthic animals) and chemical/biochemical dissolution in providing critical nutrients (nitrogen, phosphorus, and silica) to phytoplankton.
 - b. Quantify sinks for available nutrients in coastal ecosystem, including offshore transport, sediment burial (see sediment biogeochemistry section below), fish removal, and atmospheric release processes.
 2. Conceptual and mathematical models describing foodweb effects on nutrient dynamics and phytoplankton composition and production rates in different coastal regions.
 3. Models and publications describing the effects of nutrient ratios on the quality of food (or substrates) available to heterotrophic organisms, including zooplankton, benthos, and microorganisms that serve directly or indirectly as food for higher trophic organisms such as forage fish.
- F. Key information needed to improve predictability and management:

1. An understanding of how foodweb processes affect the quantity, composition, and supply rates of critical nutrients needed by phytoplankton.
 - a. Define the relative importance of internal nutrient regeneration as compared to external inputs to providing nutrients to phytoplankton on different time scales.
 - b. Define the importance of the microbial food web in foodweb dynamics and in the recycling of the different nutrients in coastal regions of different trophic status (e.g. Saginaw Bay and Thunder Bay).
 - c. Define relative importance of pelagic vs. benthic remineralization as supply mechanisms for available phosphorus, nitrogen and silica in coastal regions.
 - d. Evaluate how changes in foodweb structure would affect the nutrient cycling relationships defined in a, b, and c.
2. Comprehensive ecosystem and nutrient dynamics models that include information about nutrient ratios, microbial food webs, pelagic and benthic food webs, and pelagic-benthic nutrient coupling processes in coastal ecosystems of different trophic status.
3. An understanding of how physical morphology of bay systems affects nutrient cycling and food web dynamics.

III. Sediment biogeochemistry in selected coastal environments with contrasting inputs of nutrients from anthropogenic sources.

- A. Important issue because sediment-water interactions are important components of nutrient cycling in coastal ecosystems, and sediment biogeochemistry must be understood and quantified to produce mass balances of nutrient inputs and sinks in these systems. Results from such studies are also important to more global issues such as climate change, and estuary dynamics in coastal marine systems.
- B. Already know:
 1. Sediment decomposition of organic material is an important source of nutrients to overlying waters in coastal ecosystems.
 2. Sediment burial, transport, and nutrient transformation processes (e.g. denitrification) can be important sinks for nutrients in coastal ecosystems.
 3. The redox state of surface sediments can dramatically affect nutrient cycling processes in coastal waters.
 4. Pelagic/benthic nutrient interactions are extensive in shallow coastal regions.
- C. Remaining questions:
 1. How much of the total nutrient loads from riverine inputs are biogeochemically regenerated or removed over different time scales in coastal ecosystems?

2. How important are sediment nutrient regeneration processes relative to pelagic nutrient regeneration processes in mineralizing organic materials and supplying nutrients to phytoplankton in coastal ecosystems of different morphologies and trophic status?
 3. What is the relative importance of animals, surface bacteria, and longer term diagenic processes in supplying nutrients to overlying waters?
 4. To what extent do sediment biogeochemical processes serve as nutrient sinks in different coastal ecosystems such as rivers, wetlands, and bays?
- D. Products that should be developed:
1. Improved methodologies to measure in situ biogeochemical reaction rates at sediment-water interfaces.
 2. Mass balance biogeochemical models for carbon, nitrogen, phosphorus, and silica in different coastal environments.
 3. Research publications that define and quantify the different processes that regulate inputs, remineralization rates, sinks, and other transformations of major nutrients in coastal ecosystems.
- E. Key information needed to improve predictability and management:
1. An understanding, definition, and quantification of first-order biogeochemical processes that affect nutrient remobilization in coastal ecosystems of different trophic status.
 2. An understanding, definition, and quantification of first-order biogeochemical processes that remove nutrients in coastal ecosystems of different trophic status.
 3. Determine the importance of wetland biogeochemical processes in removing (or adding) available nutrients from water containing nutrient pollutants from agricultural or other non-point sources.

4.0 Nutrient Processes Subgroup

4.2 Recorder's Report: Prepared by Russell Moll, CILER

Statement of Primary Research Question/Objective

How do episodic events affect the delivery, fate, and effects of non-point source-delivered materials (nutrients, sediment, toxic substances) in the coastal zone? What might the effects be on ecosystem structure and function?

Outline of Subgroup Issues

I. Key Issue(s) for Nutrient Processes in the Coastal Zone

What are the benefits of reducing non-point source inputs of materials (nutrients) into the coastal zone?

Assimilative Capacity

Recent research has shown that the Great Lakes have a very finite capacity to assimilate various types of nutrient inputs. That capacity is now being exceeded in many areas, both on a local basis and a whole-lake basis. Non-point sources are known to be a major source of nutrients. An overall reduction in non-point sources will contribute substantially toward the reduction of nutrient concentrations in the Great Lakes.

Biological Response

The aquatic biota, especially the microflora and fauna, respond very quickly to inputs of excessive nutrients. These responses include excessively high levels of productivity, shifts in the species composition and increases in the species numbers. Reduction of non-point nutrient inputs will serve to mitigate the effects of the excessive nutrient loadings.

Water Quality Impact/Benefits

A chronic problem in many parts of the Great Lakes is degraded water quality. Over the past fifteen years, great progress has been made in reducing nutrient loading via the control of major point sources. The challenge that lies ahead is to reduce non-point sources to continue the effort to control nutrient loadings to the Great Lakes. An extra benefit of this activity will be the reduction of the loadings of toxic substances which also make their way into the lakes via non-point sources.

II. Research Areas/Themes

1. Biogeochemical cycling of critical materials (nutrients) in coastal zones

The coastal zone of the Great Lakes receives by far the greatest load of critical materials of any section of the lakes. This area receives inputs from point sources, river runoff, and non-point sources. General knowledge of biogeochemical processes shows that much of the material that enters the nearshore zones of the Great Lakes has been transformed before it reaches the open lake environment. In many instances the critical materials never reach the open lake. A suite of interrelated processes appears to have a major effect on the movement of these materials. A major research area is to decipher these processes. Some of the key processes requiring study are:

- Diagenesis of particulate nutrients in the water column
- Diagenesis at the sediment-water interface; burial and recycling
- Importance of internal recycling versus external sources
- Response times

2. Linkages among physical-chemical-biological processes controlling nutrient transport and fate

Perhaps the least understood topic surrounding nutrient input/cycling in the Great Lakes is the linkages between physical processes and other processes. The physical processes appear to control the mixing and hence distribution of most critical materials. The physical processes also appear to regulate important processes such as sediment deposition and resuspension. Yet there is a very imprecise knowledge of physical processes in the nearshore zone and quantitatively how those processes contribute to key chemical and biological processes. Two suggestions for study in this area are:

- Great Lakes Forecasting Model: physics-based dynamic model with high spatial and temporal resolution; link to chemical/biological processes and/or models
- Sediment resuspension, transport, and nutrient availability

3. Importance of storm events/disturbances

In general the Great Lakes appear to be driven to a great extent by storm events. The lakes appear to assume a general condition of stasis between storm events. The storms then perturb the systems and the physical, chemical, and biological conditions respond to that storm

event. However, the importance of this hypothesis is relatively untested and should be the subject of a major research program.

4. Spatial and temporal variability and associated forcing functions

Because sampling during key events such as storms is difficult, there is a poor base of information about the processes that effect the distribution of nutrients. Research is needed to quantify the importance of scale in the distribution of nutrients as they are affected by both large and small forcing functions. This research will likely require new sampling approaches including new equipment.

5. Limiting factors controlling biological processes - spatial and temporal controls

In general, most biological processes in the Great Lakes appear mediated by a combination of the physical and chemical environment. For example, temperature regulates the rate of many processes. What remains unknown is the scale of the key regulating processes in relation to biological processes; do small scale changes in the physical and/or chemical environment have significant effects on biological processes?

6. Food web structure and function

Despite many years of research concerning the Great Lakes biota, there are still a large number of unknown linkages in the structure and function of the food web. The reason for this large number of uncertainties stems in part from the shift role that organisms may take in the food web in different parts of the aquatic environment. Deciphering those complex and shifting roles will require a substantial research program which in particular should include:

- Influence of nutrients
- Influence of response to nutrient inputs

7. Impacts of nonindigenous species on nutrient cycling in coastal zones

Over the course of the past two hundred years, the Great Lakes have suffered from a continuing stream of invading organisms. In most instances these new arrivals have only a relatively minor effect on the system. But, on occasion a major change is induced in the Great Lakes. The consequence to date is a completely altered food web in the Great Lakes. This altered food web has profound effects on the distribution and cycling of all critical materials including nutrients. As studies of nonindigenous species are initiated, some effort should also go into the effects on the nutrient pool in the Great Lakes.

8. Linkages of nutrient cycling to other materials (i.e., contaminants)

Many of the processes that affect the cycling of nutrients apply equally to the cycling of other materials such as contaminants. In particular, research into the cycling of the particulate phase of nutrients could reveal a great deal about the movement of contaminants, especially in the nearshore zone.

9. Water quality problems related to macrophyte and attached algae

Over the past few years, water clarity in the nearshore zone of the Great Lakes has greatly improved. Some of that improvement is due to reduced nutrient loads and some is due to the presence of zebra mussels. A consequence of the improved water clarity is the expanded growth of aquatic macrophytes and attached algae. The growth of these organisms could be sufficient to cause nuisance problems in some areas. A better understanding of the ties between water clarity, nutrient loads and macrophytes/attached algae is needed to help control this potentially difficult problem.

III. Products of Research

1. Research advances

- Deeper understanding of the linkages among physical-chemical-biological processes
- Advancement in technology of data collection/aquatic environment sampling
- New and/or better linkages among models

2. Resource management

- Identify regions and characteristics most sensitive to non-point source inputs
- Information produced on the benefits of source reductions; forecasting and cost/benefit water quality ratios

**Trophic Dynamics / Non-Indigenous Species /
Habitat**

5.0 Trophic Dynamics/Non-Indigenous Species/Habitat Subgroup

5.1 Presenter's Summary:

Trophic Dynamics and Habitats

Prepared by a nonpartisan policy committee.
Gary Fahnenstiel, GLERL - Presenter

A convenient place to begin our quest into understanding trophic dynamics in the Great Lakes is the concept of large marine ecosystems (LME). This concept is embraced by NOAA and emphasizes the importance of an integrated program of monitoring and process research to detect change and assess impacts of a variety of stress, such as global change, non-indigenous species, and overharvesting. We believe the LME approach is applicable to the Great Lakes because the general research issues in trophic dynamics/habitats are similar regardless of the salinity of the water. Saginaw Bay/Lake Huron represents an ideal LME site because it forms a semi-enclosed basin, and species diversity and richness at most trophic levels is reduced as compared to marine coastal systems. Further, many of the key species/taxa of the Lake Huron are also important in a variety of large lakes that extend from the Canadian Arctic to the Laurentian Great Lakes. Recent perturbations (eutrophication, aggressive fisheries stocking programs, zebra mussel, etc.) in the Great Lakes including Saginaw Bay and Lake Huron have produced significant changes in the structure and function of the ecosystem and have underscored our limited understanding of these ecosystems.

Before we can adequately address the direction of future research, we should examine the past. Our basic promise regarding previous Great Lakes research can be summarized as follows:

**WE ARE OBSERVATIONALLY IGNORANT
OF THE GREAT LAKES ECOSYSTEM.**

Certainly, this statement applies to many areas of scientific research, but it is especially representative of Great Lakes ecology. Basic ecological research on the Great Lakes has been devastatingly underfunded in the past 10-15 years, which has resulted in a relatively limited data base. Most ecological information in the Great Lakes is limited to description of food web structure and community composition. Where process information exists, it is usually in the form of production and sedimentation rates and fate of particulate matter (NSF Report). The financial and logistic constraints of Great Lakes research have dictated relatively limited spatial and temporal sampling and relatively small scale experiments. Work on population dynamics and food web interactions has been frustrated by inadequate sampling, heterogeneity of water masses, and patchiness of species in space and time (NSF Report).

Given the limited resources available for Great Lakes research, we believe a viable ecosystem research program can be implemented that will address important gaps in our understanding if we adopt the following two statements:

There is a tractable set of dominant processes that can be measured on key species/taxa which occur throughout the great Lakes.

Multidisciplinary efforts are needed if we are to measure and understand these processes.

Predictions of ecological change in aquatic systems are often limited by our understanding of natural versus man-made variability. Traditionally, sampling was dictated more by operational convenience rather than by the scientific question. This shortcoming has been highlighted by several workshops in the past which have noted that the lack of understanding of the spatial and temporal dynamics of the Great Lakes is one of the major gaps in Great Lakes research. This gap has even frustrated our questions about population dynamics and community interactions (NSF Report; International Joint commission 1988; Keller 1989). Thus, one of the first questions that needs to be addressed relating to trophic dynamics and habitats is:

What are the dominant scales (temporal and spatial) of variation for key components of the food web?

Recent studies in Lake Michigan have revealed striking and complex spatial and temporal variability of key planktivore density that were clearly linked to other environmental processes (S. Brandt, pers. comm.). Aggregations of fishes and zooplankton were often in the form of layers affiliated with thermal fronts and there also is evidence of large-scale migration of fishes in response to episodic events. These large scale features and variability argue strongly against any whole-lake extrapolations based on limited sampling of a small geographic area of the lake, such as those used in the past by fisheries and water quality management groups. The role of episodic events such as storms on trophic dynamics and habitats has not been adequately addressed. Further, the importance of physical-biological coupling in contributing to species/taxa distributions is not fully understood in the Great Lakes due to a lack of adequate sampling. Once we have a basic understanding of the dominant scales of variation and have some idea about where organisms are found in the Great Lakes, we can begin to address the study of causal mechanisms. This leads us to our second major research focus:

What are the dominant factors (key hurdles) controlling growth and loss processes for key species/taxa in the food web?

The abundance of any species/taxa is controlled by the combination of growth and loss processes, and if we are ever to predict species/taxa distributions, we must determine the factors which regulate these processes. Often, production and growth of a key species is limited by a particular "bottle-neck" which occurs within a relatively short time period. For example, much of the variability in fish stocks and zooplankton may be established during the early stages of life; lower food web variability and physical factors are thought to be major contributors to this variability.

Most coastal environments, including Saginaw Bay contain a variety of habitat types: pelagic, littoral, benthic, riverine. Future research on trophic dynamics should focus not only on each habitat but also on the interactions among habitats. Linkages between habitats should be investigated as well as their relative roles to the trophic dynamics of the entire system. For example, the coupling and importance of the pelagic/benthic habitats has received much attention with the establishment of the zebra mussel. An important question might be: What is the role of the zebra mussel in functioning as conveyors of pelagically-derived materials to the benthos? Saginaw Bay also has well established pelagic and littoral habitats and one might address the relative importance of pelagic phytoplankton production versus littoral macrophytes. Finally, matter is produced both within the bay and also transported into the bay from the river. Future studies should examine the relative importance of both sources to the metabolism of the entire bay as well as to individual key processes, i.e. benthic production. Comparative studies in different habitats can lead to important discoveries.

Finally, future studies must use modern state-of-the-art technology (acoustic samplers, optical counters, fluorometers, satellite imagery, etc.) if we are to adequately sample appropriate scales. Any future Great Lakes program must encourage and support the use of this technology, and even in some cases where appropriate, technology development.

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5.0 Trophic Dynamics/Non-Indigenous Species/Habitat Subgroup

5.2 Recorder's report: Prepared by Henry Vanderploeg, GLERL

- Subgroup statement or question of critical problem.

How do episodic events (e.g. storms, runoff events, upwelling, lake ice, thermal bars, fronts) and long-term perturbations of annual event cycles affect ecosystem function and the sources, transport, transformation, fate, and effects of important biogeochemical constituents as they move through the coastal interface zone to open-lake water?

- **Outline of subgroup issues**

- I. Key Issues:**

- General Goal Statement:

Recognizing that the Great Lakes are a young, simple ecosystem susceptible to perturbations such as species invasion and anthropogenic stresses, our goal is to be able to predict the effect of such perturbations on ecosystem structure and function.

- General Issues (Management)

1. Variability in fish stocks and other key species (a key species is the fish of interest, or a species important to ecosystem function, or one of essential value to fish stocks).
2. Invasion susceptibility of Great lakes and impacts.
3. Role of episodic events (e.g. storms, upwelling, ice cover) or changes in event cycles (e.g. calm instead of storms in winter) on trophic dynamics.
4. Role of trophic dynamics in contaminant dynamics.

- II. Research Issues:**

Variability in fish stocks and other key species. Of particular concern here are early life stages of fishes and zooplankton (key species) which are most sensitive to food supply and physical factors.

- Physical Factors

1. Wind-induced water turbulence -- effects on phytoplankton physiology; effects on patch structure of phytoplankton; and effects on feeding and recruitment success of zooplankton and larval fishes.

2. Fronts/stratification -- Are these regions of increased phytoplankton production efficiently utilized by zooplankton? Are they areas of intense biogeochemical cycling? Empirical evidence suggests timing of set up of thermocline, which is highly variable in the Great Lakes, may be an important determinant of lower food web dynamics, seasonal succession of plankton, and larval fish recruitment.
3. Currents -- Effects on dispersal of key species or larval fishes.
4. Storms -- Their effects on turbulence, stratification, currents, sediment (with nutrients and contaminants) resuspension, and runoff.
5. Light -- Effects on phytoplankton and feeding success of larval fishes. Light may vary in response to cloudiness, ice and snow cover, resuspension of sediments.
6. Ice (and snow cover on ice) -- Effects on nutrient recycling, on fish egg survival, on primary and zooplankton production due to water column stability, and on light transmittance through the ice surface.

Food Web Dynamics

1. Mismatch between predator and prey (e.g., larval fish and zooplankton prey) -- Suitable concentration of appropriate prey may not be available to predator because of changes in food web structure or weather-driven changes in lower food web dynamics.
2. Predation effects -- What are effects of predation on recruitment of important larval fishes or key species?
3. Biomass and concentration of key variables -- Biomass of important species has not been sampled at high enough frequency or spatial resolution to detect interannual changes. This same point applies to important variables like nutrients that drive food web dynamics.
4. Spatial coupling -- Where are the key species and what are they doing there? Often the average concentrations of prey in the water are not enough to support the predator. Evidence is accumulating that predators are able to use relatively fine-scale patches, which do exist in nature, to increase their feeding rates. Much work remains to be done in defining these patches and evaluating the predator's ability to use them. Also, the relation of patches to events needs to be explored.
5. Theoretical studies -- These models of food web dynamics will have to be spatially explicit and include effects of physical forcings on patch development and destruction.

Critical Habitats

1. Role and Function -- What is the function and role of critical habitats (such as spawning reefs) and how are these habitats linked with the rest of the environment?
2. Spatial Extent -- What is the spatial extent of critical habitats and how much habitat is required?
3. Altered Habitats -- Can they be rehabilitated?

Invasion Susceptibility of Great Lakes and Impacts

1. Role of trophic dynamics -- What niches are susceptible to invasion and what is the role of trophic dynamics (system function) in affecting invasion potential?
2. Invader impact -- How does a successful invader interact at various trophic levels and with key species?
3. Invader characteristics -- What species are likely to invade and what characteristics allow it to outcompete native species?
4. Invasion potential and climate change -- Many of the open lake key native species of the upper Great lakes are cold water species at the southern end of their range (e.g. lake trout, whitefish, *Mysis*, amphipods, copepods). Will climate warming make the Great Lakes more susceptible to invasion?

Episodic Events, Recruitment and Contaminant Dynamics

1. Theme development -- As the workshop progressed in parallel working groups, episodic events emerged as a common research theme. We have detailed above various weather-driven physical factors important to fish stocks and other key species. We are interested in understanding the role of episodic events in affecting interannual variability in key species/taxa such as sport fishes, forage fishes, zooplankton, phytoplankton, and benthos of commercial value or importance to ecosystem function and biogeochemical cycling. We may think of the seasons in a year providing a roughly typical periodic sequence of events that results in a seasonal succession of plankton that can vary considerably from year to year because of variability of the typical event cycle. Interannual variability in the recruitment success of larval fishes and zooplankton is event-driven.

Turbulence and stratification have important roles in determining feeding success of larval fishes and zooplankton. Turbulence increases nutrient availability and encounter rate with prey. Stratification allows development of phytoplankton blooms and patches that zooplankton can exploit. The emerging paradigm is that organisms are adapted to take advantage of a highly spatially and temporally variable environment. This has extreme importance to biogeochemical cycling in that chemical inputs are event-driven and the event itself conditions the response to the chemical input. Patches or fronts represent areas of intense biogeochemical cycling. We are ignorant about the temporal and spatial variability in the Great Lakes. Basically we need to know where the organisms are and what they are doing with a very fine temporal and spatial resolution.

2. Processes, time scales, and implementation -- Important processes include nutrient uptake and photosynthesis, feeding, growth, nutrient recycling, and reproduction and recruitment success of zooplankton and fishes. Except for photosynthesis, all variables must be measured in the lab or in enclosures under the various conditions to simulate the environmental forcings. Biomass can be measured by emerging optical and acoustical methods at the same rate as physical variables. Time variability on the system of concern could be examined using these sensors on moorings with a time resolution on the order of minutes to capture events. These results integrated over the year allow evaluation of their impact for seasonal and interannual variability. Towed instruments of the same kind would give details spatial of structure. Also attention must be given to measuring physical and chemical variables phased appropriately with biological variables. In addition, certain variables such as turbulence have not been routinely measured by physicists; physicists and biologists are going to have to cooperate here.

III. Products of Research

We will be able to relate interannual variability of certain key species to specific events or pattern of events, which are weather-driven. That is, we will be taking the first steps in predicting recruitment success from weather patterns. We will have developed a monitoring system that will give us quasi-real-time biomass at the same sampling frequency as the events, thus allowing us to evaluate importance of events to ecosystem response. Following the seasonal development of biomass will allow us to decide, for example, when is the best time to release salmon smolts into the lake to ensure their survival. The high sampling rate will allow for meaningful comparison of interannual abundance necessary for detecting climate change effects. We will have gained insight into how organisms use a temporally and spatially variable environment and how this affects biogeochemical cycling.

Remediation / Resource Management

6.0 Remediation/Resource Management Subgroup

6.1 Presenter's Summary:

Remediation and Resource Management

Prepared by Greg Goudy, Michigan Department of Natural Resources

What is Remediation/Resource Management?

In the context of this workshop - focus on Environmental Quality and Natural Resources

However, in addition to data on environmental quality and natural resources, Remediation/Resource Management policy decisions also consider politics, economics, local community desires, organizational structures, existing laws and regulations, funding sources, goals and objectives, and history.

Three principal objectives to Remediation/Resource Management:

- Restoring degraded environments and biological communities
- Protecting undegraded environments and biological communities
- Enhancing existing resources where feasible

Three major attributes of Remediation/Resource Management and how a Great Lakes - Coastal Ocean Program could help:

- Decision-making process
- Information needs
- Coordination of implementation activities

Decision-making process essentially drives the other two attributes and is critical to Remediation/Resource Management. It is important that researchers become more involved in it.

Who is involved?

- Who decides what is degraded.
- Who decides what should be restored, protected or enhanced and what priority each should have.
- Who decides how we should achieve these objectives; which actions should be taken; how they should be implemented; and how they should be paid for.

Best way to identify the participants is to describe how decisions historically are made.

- What are present conditions?

Research/Assessment

(Universities/Agencies(local, state, federal)/Businesses)

-Where do we want to go?

Agency managers/Elected officials.

-How do we get there?

Same as above plus agency staff, public, agency committees.

In this time of dwindling financial resources, it is important that all actors involved work together to forge common goals and coordinate efforts to address them. Correct management decisions cannot be made unless adequate scientific data is available. Researchers cannot collect appropriate data unless funds are directed to those activities. Funds would not be available for appropriate research unless the public and their elected officials provide support for these activities.

Typically, it has been difficult to get adequate interaction among researchers, agency managers, local officials/legislators and the public.

We are fortunate in the Great Lakes Basin to have several new efforts to facilitate better interaction: Both the US and Canada have agreed (in the GLWQA) to develop:

-Lakewide Management Plans for each of the Great Lakes.

-Remedial Action Plans for specific Areas of Concern.

These two efforts take an ecosystem approach to restoring beneficial uses in these areas. They require multimedia, multiprogram, multiorganizational interaction and coordination.

How would a NOAA Great Lakes - Coastal Ocean Program fit in?

-Would certainly be relevant to LaMPs.

-Would be relevant to AOCs that include large areas of the Great Lakes such as Saginaw Bay and Green Bay.

-Would also be relevant to connecting channel AOCs.

In Saginaw Bay, there is another opportunity for the Great Lakes - Coastal Ocean Program in the Saginaw Bay National Watershed Initiative process. The program addresses environmental and resource issues in the entire Saginaw Bay watershed. The program differs from the RAP in that it is broader in scope, both geographically and topically.

-The Initiative is to operate through a community structure.

-NOAA representation through program committee and technical committee. Opportunity to integrate Great Lakes - Coastal Ocean Program.

- The initiative process is also important because we currently view the RAP as an environmental subcomponent of the initiative.
- Anticipate developing the Stage Two RAP through the initiative process.
- Certainly want to coordinate Saginaw Bay RAP with Great Lakes - Coastal Ocean Program where possible.

Information Needs for Remediation/Resource Management

Three types of research, all three needed for Remediation/Resource Management:

- Basic research important to understanding what can be done (what is possible).
- Applied research is important to knowing how it can be done (remediated or managed).
- Environmental assessment or resource assessment monitoring activities define current conditions.
- Monitoring is research in cases where recent data are not available.
- Take current NOAA zebra mussel project on Saginaw Bay for example.

Research topics/issues for Remediation/Resource Management, partial list relevant to a Great Lakes - Coastal Ocean Program.

Contaminants: In addition to contaminant processes (including bio-uptake pathways), need information on:

- Which contaminants are present and what are the differences among media, including biota?
- What are concentrations and quantities?
- What is chemical speciation of ambient concentrations and what does that mean from a toxicological standpoint?
- Where are sources and what are the loads and their trends?
- What is the relationship between contaminant loads and bioavailability?
- Fate and distribution, where do they go and how fast?
- What are the impacts on biota?
- Field validation of bioassay tests.
- Chemical specific versus synergistic effects.
- If remediated, what and when ecosystem changes would be expected?
- If remediated, are there any benefits to public health?

Remediation techniques

- What are feasible remediation techniques in terms of technology and cost and where are they applicable?
- What do you do with contaminated sediments that are removed?

Physical Processes

Sediments

- Relate contaminate concentrations to characteristics such as grain, size, and organic matter content.
- Resuspension (susceptibility, magnitude, contaminants released).
- Sedimentation.
- Associated retransport of contaminants.
- Effects of water level changes on habitat, biota and resource use.

Nutrients

- How much productivity due to system recycling versus input loads.
- Impacts of future load changes on communities
- Which watersheds are contributing the most and how much is that?
- What are loading trends?
- Relationship between loads, ambient concentrations/bioavailability, and ecosystem response.

Communities and Habitat

Communities

- Can we achieve self-reproducing populations?
- Measures of biomass and production at all trophic level.
- Impacts of:
 - contaminants on populations - body burdens, toxicity (acute and chronic), reproductive abnormalities, tumors, physiology
 - Exotic species on communities
 - Forage base changes
 - Interspecies competition

Habitat

- Which areas (geographically) are most important and why, and for which species?
- Areas with biggest losses/gains and what are the current rates?
- Impacts of habitat losses/gains on affected populations.

-Which locations could/should be enhanced/protected?

System Integration/Data Management

- Getting information into decision making process
- Getting data into computer databases accessible by others
- Making information GIS compatible where appropriate
- Making appropriate use of predictive modeling

Miscellaneous Issues

- Dredging vs. in-situ remediation
- Public education on ecosystem, pollution prevention, recycling

Coordination of implementation activities starts back at the decision making stage.

- It is important to integrate the research study conclusions with the policy making process.
- It is important that the policy decisions involving future research deal with resources currently available or needed, including state of knowledge on an issue, staff expertise, equipment, cost, time frame.
- It is important that researchers are involved in the decision making process so that these capabilities and constraints are adequately considered in:
 - Developing appropriate research policies.
 - Making sure priority issues are addressed first and that closely interrelated issues are addressed concurrently if possible.
 - Requesting the appropriate amount of funds.

From there, it is important for the various groups involved to get the policy decision (plans, concepts, etc.) incorporated into the appropriate funding mechanisms. Only then do we get to the cooperative implementation of related activities projects, and programs.

6.0 Remediation/Resource Management Subgroup

6.2 Recorder's report: Prepared by Sarah Campbell, University of Michigan

Subgroup statement or question of the critical problem:

How do hydrometeorological events (storms, runoff, upwelling) affect the transport and availability of pollutants (toxics, nutrients, and sediments) and what are their quantitative impacts on ecosystems?

Outline of subgroup issues

Defining the issues:

- What kinds of questions might the resource managers have?
- The critical issues are:
 1. contaminated sediments
 2. zebra mussel invasion
 3. fluctuating water levels

- The critical questions for the resource manager are:
 1. Can nonpoint pollution first be demonstrated as a problem, and secondly, can the remediation of that problem be identified?
 2. How far inland should we draw the line of control?

Forming a research question:

What is the significance of sediments and sediment loads to ecosystem impairment?

Definition of terms:

- **Significance:** quantitative contribution
- **Sediment:**
 1. associated contaminants
 - toxics
 - nutrients
 2. particles
 - water clarity
 - habitat issues
- **Load:** external and resuspended
- **Ecosystem impairment**
 1. eutrophication
 2. physiological impairments
 3. imbalanced community structure
 4. reduced resource use
 5. habitat loss and/or degradation

The associated management questions are:

- **What are the expected results of remediation?**
 - Degree of improvement
 - Length of time for remediation

- **What are the mitigation practices required to achieve remediation?**

- **The Remediation/Resource Management subgroup merged with the System Integration/Data Management subgroup to develop the final product of the merged subgroup, the critical question presented to the final Workshop Plenary Session.**

System Integration / Data Management

7.0 System Integration/Data Management Subgroup

7.1 Presenter's Summary:

System Integration/Data Management

Prepared by Victor J. Bierman, Jr., Limno-Tech, Inc.

This summary contains a brief perspective on System Integration/Data Management as it pertains to a potential coastal research initiative in the Great Lakes. It is understood that the program objective for this initiative involves a quantitative synthesis of coastal processes for the purpose of effective management of Great Lakes coastal regions.

System Integration/Data Management differs from the other subprogram topics in this workshop because it is functional as opposed to disciplinary. Critical issues in this area are the following:

1. Articulation of study questions.
2. Development of well-defined study objectives.
3. Development of a synthesis approach.
4. Development and execution of an experimental program.
5. QA/QC and data management.
6. Coordination and phasing between experimental and syntheses efforts.
7. Development of predictive scenarios for management and control actions.
8. Final study products.

Examples will be drawn from historical experiences on Saginaw Bay as an initial candidate site. Because of their timeliness and program relevance, examples will also be drawn from the EPA-sponsored Green Bay Mass Balance Study (GBMBS) and the NOAA-sponsored Nutrient Enhanced Coastal Ocean Productivity (NECOP) Program for the Mississippi River Plume/Inner Gulf Shelf Region.

Appended to this summary is a very brief bibliography containing major data synthesis and modeling studies conducted on Saginaw Bay. These studies included development and field validation of mass balance models

for nutrients, phytoplankton chlorophyll, multiple phytoplankton functional groups, heavy metals and PCBs. Currently, an ecosystem modeling study of Saginaw Bay is being conducted to determine the impacts of long-term nutrient loading reductions and invasion by the zebra mussel.

Articulation of study questions is a critical issue because it includes consideration of end-users. Scientists tend to emphasize research questions to improve understanding of system processes, while managers (and most sponsors) tend to emphasize management questions and development of prediction capability. These two areas are not mutually exclusive because no quantitative assessment method can be useful to a manager unless it is scientifically credible. As an example, results from eutrophication modeling studies on Saginaw Bay were published in the scientific literature and were also used to develop the target phosphorus loading objective for the Bay in the 1978 Water Quality Agreement.

Study objectives must be well-defined and succinctly stated. Objectives should focus on cause-effect linkages as opposed to disciplinary areas. There should be linkages between external factors (constituent loadings, hydrometeorological factors, boundary conditions) and system responses. There should also be linkages among internal physical, chemical and biological processes.

It is critical that a synthesis approach be developed at the beginning of the program in order to frame the experimental design. Statistical or mass balance models can be used to describe linkages, test hypotheses and develop predictive methods. There has been a history of success with the mass balance approach on Saginaw Bay and in the Great Lakes. At the same time, this has not precluded development of useful statistical relationships and sub-models for processes that are stochastic or not well understood. Other important considerations in developing a synthesis approach are: principal dependent and independent variables, spatial domain and spatial scales, temporal scales and level of chemical-biological process resolution.

The experimental program should be driven by the synthesis approach. There should be complementary field monitoring and laboratory process studies. Important considerations for the field monitoring program are: site-specific physical parameters, external factors (loadings, hydrometeorological forcing functions, boundary conditions), principal dependent and independent variables, and process rates and fluxes. A most critical point is that if the study objectives include linkage between external factors and system responses, then a major portion of study resources must be allocated to measurement of these external factors. In previous studies on Saginaw Bay and in the GBMBS almost half of the total resources for field monitoring were expended on these factors. Another important

consideration is that there must be sufficient flexibility and funding for contingencies and modifications as the experimental program is executed.

Quality assurance/quality control (QA/QC) and data management should both be study program elements, complete with adequate personnel and resources. A central data base management system should be established for the study program and it should contain relevant historical data as well as program-generated data. There should be well-established protocols and schedules for data delivery from data generators to data users.

The QA/QA program for toxic chemicals in the GBMBS was unprecedented and should be considered a model for future toxic chemical studies in the Great Lakes. In previous studies on Saginaw Bay EPA STORET was successfully used to manage data for conventional physical-chemical constituents and heavy metals. STORET is not adequate, however, for high-resolution (e.g. congeners, multiple sample matrices) toxic chemical data or for biological data. The centralized data base management system in the NECOP program is a useful model for future studies in the Great Lakes.

A crucial issue is coordination and phasing between the experimental and synthesis efforts. An initial synthesis effort is required to drive the experimental design for the study program. This should be followed by an intensive experimental effort in parallel with only a background-level synthesis effort. Following delivery of a critical mass of program-generated data, there should be an intensive synthesis effort in parallel with phase-out of the experimental effort. Project reporting commitments should be consistent with this phased approach.

A negative example is the recent GBMBS in which there was a very long hiatus between implementation of the monitoring program and data delivery. This was cost-ineffective and detrimental to the overall study program. During the critical final phase of the GBMBS insufficient time was available to synthesize program-generated data and meet project reporting commitments. In the ongoing ecosystem study of Saginaw Bay, the modeling effort was designed to lag the experimental effort by approximately one year.

Development of management and control scenarios is a critical issue because it not only requires future projections for external hydraulic and constituent loadings, but also for hydrometeorological forcing functions and boundary conditions. For decadal-scale simulations values for these latter factors can be influenced by long-term system trends as well as by engineered control actions. In the GBMBS toxic chemical dynamics were found to be significantly influenced by Green Bay-Lake Michigan boundary conditions. Atmospheric deposition rates and gas phase concentrations also needed to be considered. Separate predictive scenarios were developed for all important

experimental forcing factors prior to actual predictive simulations with the Green Bay toxic chemical model.

The issue of final study products is important because a diversity of outputs will be required, depending on the target audiences. Technical reports, data bases and documented computer programs are necessary for completeness and as primary source materials. Publication of findings in peer-reviewed journals is necessary to establish scientific credibility. It is crucial to communicate study program results to senior managers and sponsors in the form of management-level synthesis documents and executive summaries. Other useful study products are workshops and PC-based demonstrations that emphasize use of study results to address critical management questions.

**Brief Bibliography of Data Synthesis
and Modelling Studies on Saginaw Bay**

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7.0 System Integration/Data Management Subgroup

7.2 Recorder 's Report: Prepared by Joseph DePinto, Subgroup Chair, State University of New York - Buffalo

Statement of Primary Research Question/Objective

How do major events (storms, runoff, upwelling, downwelling) affect the source, transport, transformation, fate, and effects of biologically, chemically, and geologically important constituents as they move from land-based sources through the coastal interface zone to open-lake waters?

[Forcing Function (event) --> Physical Processes --> Environmental Impacts]

Research Objectives for the Subprogram

Definition of System Integration

System Integration is a “funnel” that synthesizes research and field observations into an output (solution to problem or answer to question). Components:

- A data base consisting of all necessary model input and output data and all system observational data to be used for model calibration, confirmation, and application to the problem under investigation
- A group (sequence or hierarchy) of mathematical models that represent a physical, chemical, biological, and perhaps economic description of a site-specific and problem-specific domain
- A synthesis of models and data into an integrated simulation/prediction system

Assumptions

The Great Lakes, while a large system with much the same behavior as global scale systems, is a more tractable system than an ocean system: easier logistics, more bounded physically, simpler ecological structure and functioning.

For the nearshore zone relative to the whole lake, time and space scales compress; different processes become either more or less significant (e.g., need to understand sediment-water interactions at finer time and space resolution).

In coastal systems (tributaries, bays, harbors, nearshore shallow areas, etc.) major events play a significant role in transporting mass and in governing a system's response to stress.

The natural (stochastic) variability of a system must be considered to assess the uncertainty due to other sources of error (sampling, analysis, process description, and parameterization) or to assess the range of system response to human perturbations/stresses.

Critical Research Needs

Identify cause-effect linkages: between media, between processes, between disciplinary foci, between management issues, etc. (e.g., interactions between conventionals and toxics, between land-based sources of pollutants and receiving water response).

Improve couplings: between models and data; among the sequence/hierarchy of process-oriented models (e.g., hydrodynamics --> sediment transport --> contaminant fate and transport --> food chain bioaccumulation --> ecosystem effects); between geographical system models (e.g., land --> tributary --> bay/nearshore --> open water).

Understand how Non-Point Source contaminants make their way from land to open-lake (e.g., the linkages between NPS, tributary mass fluxes, delivery to embayments and coastal zones, and subsequent transport and redistribution in lakes).

Study physics, chemistry, and biology of a system on the same time and space scales to truly integrate the analysis (there is a general need for development of biological sampling protocols that can acquire data at fine scales similar to acquisition systems for physical data).

Develop an environmental climatology associated with storm events.

Process Integration Components

The role of storms in causing acute contaminant exposure events for system biota.

The role of major events in nutrient dynamics and system productivity.

The role of major events in altering aquatic ecosystem structure and functioning –physical transport of organisms, disruption of habitat and niches such as trout spawning areas.

The role of major events in controlling solids and associated contaminants from Non-Point Sources.

The impacts of major events on thermal bars and buoyant currents in the nearshore zone and the effect on governing delivery of materials to open water.

Adsorption/desorption dynamics during short time scales associated with events and subsequent impact on contaminant bioavailability.

Flow-driven resuspension in tributaries and wind-driven resuspension in bays/nearshore zones of sediments and associated contaminants.

Project Integration and Management

Data management and maintenance of data bases should be an integral part of the program. Sufficient resources should be allocated to a centralized DBMS. QA/QC and data management should be considered in the initial program planning. An integrated means to archive research projects and their products should be established.

Models have great value as research tools that can synthesize (organize) large and disparate data sets, point out knowledge and data gaps, and help direct and focus field observation and process experimentation programs. Therefore, it would be very beneficial in planning and starting up this large, system-level program to conduct screening level modeling up front, using whatever existing data is available.

It is very important to have considerable interaction between "modelers" and "experimentalists" during the program. This interaction should not be in the form of a program review, but should be working sessions during which hypotheses are presented and discussed, research/measurement problems are discussed and analyzed in detail, etc.

Expectations for models and their role in the overall program should be carefully documented. Models are excellent diagnostic tools, but should not be used as predictive tools without carefully expressing the limits, caveats, and associated uncertainties involved in their use as predictive management tools.

The program needs to generate synthesis products early in the study period that are useful and that create a constituency for the science among the public, managers, politicians (e.g., publication of a high profile Program Description immediately after the planning phase).

Any Great Lakes Coastal Oceans Initiative should not only be cognizant of COP issues (environmental quality, habitat integrity, etc.) but should also recognize the primary issues/concerns facing other agencies in the Great Lakes that have management responsibilities (e.g., Great Lakes Fisheries Commission: fisheries, fish contamination, lamprey control; IJC: RAPs in AOCs; EPA: water quality, toxics, habitat, biological integrity).

Research Issues for Resource/Environmental Management

Determine the relative hierarchy of distributed sources to a system and the significance of events in manifesting those loadings.

Identify useful information for managing AOCs in Great Lakes (RAP process) and other areas.

Identify useful information for managing hazards to life and property from storm events.

Identify useful information regarding remediation of contaminated sediments -- short-term impacts of dredging, likelihood of contaminant export from "hot spots" during major events.

Define the effects of major events on environmental quality and integrity of habitats in coastal zones.

Develop a tool that can predict environmental impacts of major storm events that would follow the prediction of such events from weather models.

Predict impact scenarios on fish stocks of major events (using fish embryos, incubator habitats, and event monitoring).

Determine the products that resource managers need from system integrators.

Some Project Products/Outputs

Publicize the Objective of the COP GL Program -- identify the roles it will fulfill in managing Great Lakes water resources.

Make preliminary findings available to large constituencies/public constituencies.

Install a permanent Data Base Management System to make the results of experimental studies available in a form useful for managers/policy makers/public interest groups.

Develop integrated systems models for on-going research, monitoring, and resource management.

Early on, identify users -- state, regional, local, international (Canada) -- and bring them in (establish a network of related agencies, etc.).

Establish channels of communication with Great Lakes States congresspersons and senators to help create a national constituency for the Great Lakes watershed.

Produce studies, research articles, and papers for high profile science publications.

Next Steps: Management Issues

8.0 Next Steps: Management Issues

Previous programs supported by NOAA's Coastal Ocean Office have adhered to a two-step process in the selection of research program. The first step involves management decisions for setting an overall theme of research and general scope of the problem under investigation. The point of departure for each program is a broad societal question or issue surrounding the coastal environment. The second step is to restrict the scope of issues under that broad societal problem to one that is feasible for study.

The Great Lakes Initiative will follow this same approach. Through a series of workshops and technical discussions, the broad societal problem will be identified and the scope of the research problem focused to a tractable study. This workshop was the first step in that process.

Management of a Great Lakes Initiative will focus on supporting high quality research within the scope of the identified societal question. Funds available for research will be open to all qualified scientists with peer review serving as the main criterion in selecting the funded projects. As with other Coastal Ocean Programs, collaboration between NOAA investigators and the academic community on individual proposals will be encouraged. This approach lends itself well to CILER serving as the primary point of contact for the academic community interested in the Great Lakes Initiative.

Appendix

Appendix

Sample Letter to Presenter:

September 30, 1992

Dear Presenter:

We would like to thank you for agreeing to prepare a presentation covering the area of _____ for our November 5 - 6 Great Lakes Coastal Processes Workshop. The goal of this workshop is to produce the material required for the development of a coordinated program plan for a major coastal research initiative in the Great Lakes. GLERL has been encouraged by the NOAA-Coastal Ocean Program Office (which currently provides \$11.5M for several marine coastal research programs) and senior NOAA management to develop a Great Lakes program. The program objective is to:

Develop and provide the scientific information for effective management of the Great Lakes coastal regions through the development of a quantitative synthesis of coastal processes.

The workshop audience and participants will be multidisciplinary, including hydrologists, physical limnologists, ecologists, biogeochemists, and toxicologists, and so perspective in your presentation is more important than details. In a talk of approximately 15 minutes, we would like you to cover the following topics:

- Critical issues in the subprogram area
- Why are these issues important?
- What do we already know?
- What kinds of products should be developed?
- Who would be the users for these products?
- Key information needed to improve predictability and management of the critical issues

While you may be speaking of generic coastal issues, please consider that the Steering Committee has selected Saginaw Bay as the initial candidate site, and we request that you use this site as an example in your presentation.

In addition to your presentation, please prepare material for a summary section (same topics as above) of the document that will be the product of this workshop. This can be an annotated outline or any draft form (with key references) and it will be edited by the subprogram workgroup assigned to this topic at the workshop. As a guide, your summary should be no more than 3 pages. Any key figures would also be appreciated. Your summary

should be faxed to Sarah Campbell at (313) 763-1558 no later than October 30, 1992.

For your information, there will be presentations on the following topics:

<u>Subprogram Topic</u>	<u>Presenter</u>	<u>Telephone/Fax</u>
Contaminant Processes	Peter Landrum, GLERL	(313) 668-2276 (313) 668-2055
Coastal Hazards/ Physical Processes	David Schwab, GLERL	(313) 668-2120 (313) 668-2055
Nutrient Processes	Wayne Gardner, GLERL	(313) 668-2269 (313) 668-2055
Trophic Dynamics/Non-Indigenous Species/Habitat	Gary Fahnenstiel, GLERL	(313) 668-2275 (313) 668-2055
Remediation/Resource Management	Greg Goudy, MDNR	(517) 335-3310
System Integration/ Data Management	Victor Bierman, Limnotech	(219) 272-1138

You are encouraged to communicate with the other presenters.

Enclosed please find a preliminary agenda for the workshop. For information on travel expenses, please call us immediately at (313) 763-1437. Again, thank you for participating in this important role.

Sincerely,

A.M. Beeton, GLERL
Russell A. Moll, CILER

Enclosures

Sample Letter to Subgroup Chair:

September 28, 1992

Dear Chair:

On behalf of the Steering Committee, we would like to thank you for agreeing to chair the _____ subprogram at the first Great Lakes Coastal Processes Workshop. The Coastal Ocean Program within NOAA is interested in the development of a Great Lakes Initiative which would provide funding for an integrated and multi-disciplinary research program for the Great Lakes. The purpose of the workshop is to initiate planning for a coordinated coastal research program which would achieve the following goal:

Develop and provide the scientific information for effective management of the Great Lakes coastal regions through the development of a quantitative synthesis of coastal processes.

During the workshop, each subprogram workgroup will meet to develop a collaborative report to include the following components:

- An annotated summary section describing the particular issues confronting the subprogram. This section will be developed by the presenter and edited by the workgroup.
- A set of research objectives for the subprogram
- A prioritized list of critical research/monitoring/synthesis components required to achieve the research objectives.
- An initial survey of products to be developed and the users of the products

The subprogram workgroups will also have a recorder who will be responsible for recording the workgroup discussion and preparing the final report.

The workshop is scheduled for November 5 - 6 in Ann Arbor, Michigan. Please note there are travel funds available for the chairs of the subprograms. Enclosed is a preliminary agenda. If you have any questions or suggestions, please contact us at (313) 763-1437. Again, thank you for participating in this important role.

Sincerely,

A.M. Beeton, GLERL
Russell A. Moll, CILER

Sample Letter to Subgroup Recorder:

September 28, 1992

Dear Recorder

On behalf of the Steering Committee, we would like to thank you for agreeing to act as the recorder the _____ subprogram at the first Great Lakes Coastal Processes Workshop. The Coastal Ocean Program within NOAA is interested in the development of a Great Lakes Initiative which would provide funding for an integrated and multi-disciplinary research program for the Great Lakes. The purpose of the workshop is to initiate planning for a coordinated coastal research program which would achieve the following goal:

Develop and provide the scientific information for effective management of the Great Lakes coastal regions through the development of a quantitative synthesis of coastal processes.

During the workshop, subprogram workgroups will meet to develop a collaborative report to include the following components:

- An annotated summary section describing the particular issues confronting the subprogram. This section will be developed by the presenter and edited by the workgroup.
- A set of research objectives for the subprogram
- A prioritized list of critical research/monitoring/synthesis components required to achieve the research objectives.
- An initial survey of products to be developed and the users of the products

The subprogram recorder will be responsible for recording the workgroup discussion and preparing the final report during the workshop session. Each workgroup will also have a chair who will be responsible for guiding the overall process.

The workshop is scheduled for November 5 - 6 in Ann Arbor, Michigan. Please note there are travel funds available for the recorders of the subprograms. Enclosed is a preliminary agenda. If you have any questions or suggestions, please contact us at (313) 763-1437. Again, thank you for participating in this important role.

Sincerely,

A.M. Beeton, GLERL
Russell A. Moll, CILER

Sample Letter to Participant

October 23, 1992

Dear Participant:

On behalf of the Steering Committee, we would like to invite you to participate in the first Great Lakes Coastal Processes Workshop. The Coastal Ocean Program within NOAA is interested in the development of a Great Lakes Initiative which would provide funding for an integrated and multi-disciplinary research program for the Great Lakes. The purpose of the workshop is to initiate planning for a coordinated coastal research program which would achieve the following scientific goal:

To obtain a new level of quantitative understanding of the processes that dominate the transports, transformations, and fates of biologically, chemically, and geologically important constituents through and across the coastal boundary zones of the Great Lakes ecosystems.

The workshop is scheduled for November 5 - 6 in Ann Arbor, Michigan. You will be asked to participate in a subprogram workgroup in which specific research objectives for that subprogram will be formulated. Enclosed is a preliminary agenda.

Please let us know whether you will be able to participate in this important planning workshop. Limited travel funds for attending the workshop will be available. Please call Jennifer Smith at the University of Michigan, (313) 764-2426 to register or for further information.

Sincerely,

A.M. Beeton, GLERL
Russell A. Moll, CILER

