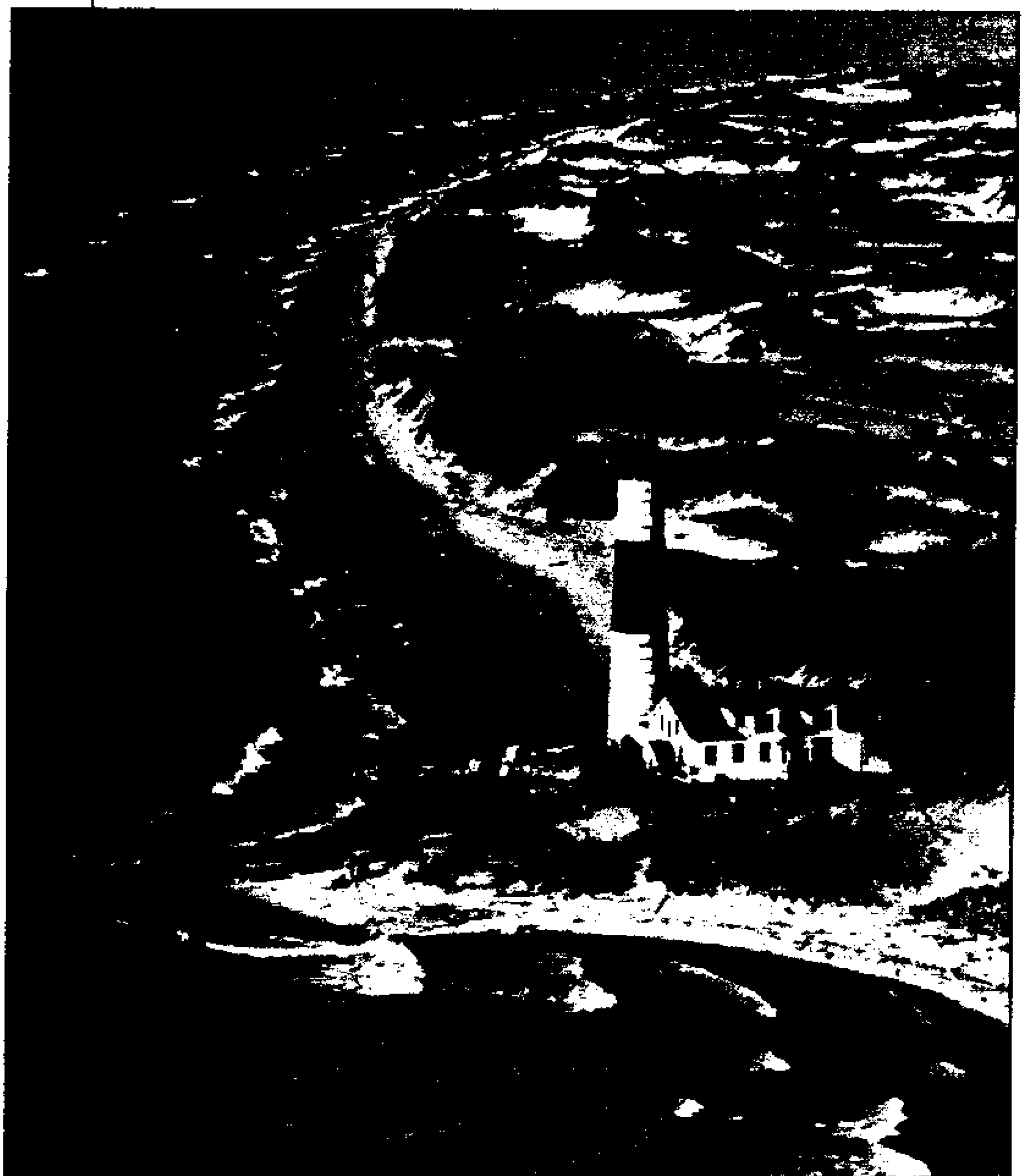

Great Lakes Coastal Erosion Research Needs

Workshop Summary

Coastal erosion is a continuing process. Our awareness of erosion is heightened during periods of extremely high water levels. To live successfully on the coastline and maintain coastal structures effectively we must learn to understand and accept the erosional process. One vivid example of this process is the severe erosion experienced over a sixteen-year period at the Big Sable Point Lighthouse. (above photo 1970; cover photo 1986)

Great Lakes Coastal Erosion Research Needs

Workshop Summary

July 8 and 9, 1987 — Ann Arbor, Michigan

Sponsored by:
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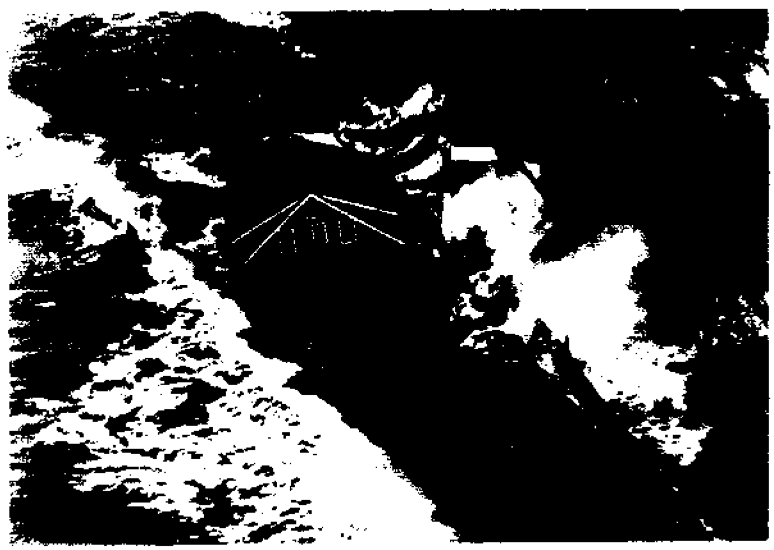
INTRODUCTION

The Great Lakes encompass over 9000 miles of coastline, and the Great Lakes basin provides a home to 15 percent of the US population and 50 percent of Canada's population. Of the entire Great Lakes shoreline, 83 percent is privately owned land, valued between $100 and $1000 per linear foot. Fluctuations in Great Lakes water levels have resulted in large losses along the Great Lakes shorelines. The high water period of 1951-52 caused an estimated loss of $61 million per year. A US 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 of property (land and structures) loss occurred.



The third, and most recent, occurrence of record-setting high lake levels during this century and the resultant severe storm damage throughout the Great Lakes region have once again pointed to the need for an increased understanding of coastal processes to minimize loss through better coastal resources management programs.

The goal of the Workshop on Great Lakes Coastal Erosion Research Needs was to bring together researchers and administrators in the Great Lakes region to increase awareness of Great Lakes coastal engineering research, increase communication among the researchers, and to identify, as a group, research needs and the roles that each organization can play in contributing to a better understanding of the coastal environment.

In the first portion of the program, representatives of each organization described their research programs, areas of expertise, and their plans for the next few years. Once the group was familiar with the activities of participating organizations, five working groups were designated to direct efforts towards identifying research needs in the following areas:

Field Experimentation
Baseline Data Collection
Analysis of Existing Data
Instrumentation
Numerical Modelling

These specific areas of research were addressed through informal discussions of the state-of-the-art and the immediate research needs. The groups were asked to identify specific research needs, list the requirements for meeting the needs, and identify the organization or organizations best suited to provide mechanisms for accomplishing the goals. At the close of the first day, to unify the efforts of the individual groups, each working group presented an informal list of topics that had been identified as areas for further discussion and development. This stimulated an exchange of needs which transcended the working group boundaries and focused the final discussions and recommendations.

On the second day of the workshop there were more detailed group discussions during which solid recommendations were written. Finally, to close the workshop, each group leader presented the group's final recommendations and a consensus was reached.

This report summarizes the recommendations of the workshop. Condensed versions of each presentation are furnished in an appendix.

Workshop participants gave overwhelming support to a completely coordinated research effort involving participation from local, national, and international groups. It was also recognized that Great Lakes researchers have a responsibility to inform the remainder of the coastal research community of their findings, which can be used to further the understanding of the coastal processes on ocean coasts as well.

The workshop recommendations, presented below, reflect the need to advance the understanding of coastal responses to process and trends in the nearshore environment and to improve prediction and analysis techniques. These improvements would do much to enhance the capabilities of coastal resource management programs.

Field Experimentation

Problem: The lack of information about Great Lakes coastal processes requires that major field studies be undertaken.

Recommendations: Conduct a large-scale field experiment integrating coastal kinematic and dynamic measurements with coastal processes monitoring. This would provide information necessary to the understanding of coastal current dynamics, current/sediment interaction, and sediment transport dynamics.

Evaluate the performance and effects of structures through both site-specific and generic studies. This would provide organizations with additional information upon which to base regulatory and construction decisions.

Conduct a coastal evolution study aimed at further developing the "Larsen Curve" of long-term (Holocene) Great Lakes water level fluctuations. This would aid in predicting future high lake levels and preparing for the coastal response.

Baseline Data Collection

Problem: To adequately verify numerical modelling and analysis techniques, comprehensive baseline data collection guidelines and programs must be initiated to provide spatial and temporal coverage necessary.

Recommendations: Establish a permanent Great Lakes field research facility to provide long-term monitoring of coastal parameters in a selected Great Lakes environment. The facility should provide support for evaluation of instrumentation, investigation of coastal processes, and evaluation of numerical models.

Develop a strong program for monitoring the Great Lakes coastal environment. This is essential to the understanding of nearshore processes and the establishment of a solid base for the design and evaluation of coastal structures.

Establish basic guidelines and standardize data collection techniques to facilitate the usefulness of field measurements in analysis procedures.

Analysis of Existing Data

Problem: There is a vast pool of existing data that should be tapped to lend insight to coastal engineering research.

Recommendation: Catalog existing data so that it may be used in present research programs. Use of the data should also provide insight into how best to collect both baseline and experimental data in the future.

Instrumentation

Problem: An important step toward the understanding of any coastal process is the accurate and efficient measurement of its physical parameters. Deficiencies presently exist in the available bathymetric data, shallow water directional wave information, sediment transport measurement capabilities, and portable data acquisition systems.

Recommendations: Develop a rapid autonomous survey profiler that would enable an aggressive precision hydrographic survey program to be conducted in all kinds of weather.

Develop a radar remote shallow water directional wave gauge that would be easier to deploy and have lower maintenance costs than conventional devices.

Assemble a data acquisition system with portable multi-sensor platforms and universal instrument ports.

Investigate the use of acoustical and optical instrumentation to measure three-dimensional sediment transport.

Numerical Modelling

Problem: Agencies involved in evaluating structures and their effects on the adjacent shoreline need to be able to predict sediment transport and shallow water waves, particularly in response to climatological events.

Recommendation: Give immediate research attention to developing numerical models of sediment transport and shallow water waves. In addition, document existing modelling techniques and make them available to potential users.

Coordination

Problem: Research should be more coordinated than at present.

Recommendation: Organize an annual, informal symposium on Great Lakes coastal geology and coastal engineering to promote discussion on these topics.

PARTICIPANTS

Thirty-seven participants representing the following organizations were present at the workshop:

- The University of Michigan
- Michigan State University
- Purdue University
- Ohio State University
- Grand Valley State College
- Michigan Sea Grant College Program
- Illinois/Indiana Coordinated Area Sea Grant Project
- State of Michigan, Department of Natural Resources
- Indiana Department of Natural Resources
- Ohio Division of Geological Survey
- Illinois State Geological Survey
- Indiana Geological Survey
- Chicago Shoreline Commission
- US Army Engineering Waterways Experiment Station
  - Coastal Engineering Research Center
- US Army Corps of Engineers,
  - Detroit District
  - North Central Division
- National Oceanic and Atmospheric Administration
  - Great Lakes Environmental Research Laboratory
- US Geological Survey
- National Park Service
  - Sleeping Bear Dunes National Lakeshore
  - Indiana Dunes National Lakeshore
- National Weather Service
- Argonne National Laboratory
- Tekmarine, Incorporated

Numerous other organizations were invited to participate in the workshop; however, due to the short time frame, representatives were unable to attend. These groups included:

- University of Illinois
- University of Akron
- University of Wisconsin - Madison
- University of Toronto
- National Sea Grant College Program
- Ohio Sea Grant Program
- Wisconsin Sea Grant Institute
- Canada Centre for Inland Waters
- US Naval Civil Engineering Laboratory
- W.F. Bailard and Associates

Working Groups

FIELD EXPERIMENTATION

There are four major areas requiring immediate investigation in the Great Lakes: coastal kinematics and hydrodynamics, coastal processes, engineering structure performance, and coastal evolution. Highest priority should be given to a large-scale field experiment integrating coastal kinematic and dynamic measurements with coastal process monitoring. Studies of engineering structure performance, involving both existing, site-specific structures and prototype generic structures located at the large-scale coastal experiment site, should be conducted. Strong support was given to investigations of Great Lakes coastal evolution as evidenced in the recent geologic (past 10,000 years) record of lake advance and retreat. Two evolutionary components are of major interest to contemporary coastal problems: natural sediment deposition/erosion trends and verification of long term lake level changes.

Great Lakes Coastal Experiment

Recent coastal dynamics/processes experiments on US tidal shores, such as the SUPERDUCK experiments, have shown definitive results in the areas of shallow water wave transformation and longshore currents. However, much more field experimental information must be obtained in order to advance the understanding of coastal current dynamics, current/sediment interaction, and sediment transport dynamics.

Tidal factors tend to "contaminate" wave dynamic effects and related processes. This factor alone provides strong argument for a tideless Great Lakes coastal dynamics/process experiment to further the understanding of shallow water wave and current dynamics. This experiment should be designed to evaluate coastal process response to wave and current forcing.

In addition, results should be carefully evaluated with respect to previous ocean coastal experiments in order to gain generality or provide insight from non-tidally influenced results.

The primary requirements for the coastal kinematics and dynamics experiment were identified as:

- offshore directional wave climate;
- shallow-water directional wave climate;
- longshore current profiles across the surf zone and offshore to closure depth;
- cross-shore current distribution;
- wave transformation across the nearshore and surf zone.

The primary requirements for the coastal process portion of the coastal experiment were identified as:

- bottom profiles under most weather conditions;
- longshore bedload and suspended sediment;
- cross-shore bedload and suspended sediment.

Process measurement capability continues to be one of the most important developmental needs for successful conduct of this or any other coastal process experiment. Instrumentation for nearshore directional wave measurements, suspended sediment measurements, and rapid autonomous profiling are discussed in the instrumentation working group's recommendations.

Engineering Structures Performance and Effect

Two types of field measurement programs need to be undertaken in the study of engineering structures performance and their effect on adjacent coast. First, there is a need to study the performance and effect of existing, site-specific engineering structures. Second, there should be a study of generic structures in conjunction with the coastal dynamics and process experiment discussed above.

There is an extremely useful data base of engineering structure design, construction, and performance information from a wide variety of coastal structures which should be compiled and analyzed. This task is treated in greater detail by the analysis of existing data working group.

There should be strong support for site-specific monitoring of Great Lakes coastal structures. The primary requirements for such monitoring were identified as:

- pre-construction bathymetric, sedimentologic, and coastal recession information;
- post-construction bathymetric, sedimentologic, and coastal recession information at a minimum of 1-year intervals (6 months preferred);
- site-specific wave climate data over the performance life of the structure;
- storm wave and performance data as frequently as possible.

The following questions concerning specific engineering structures should be considered in planning and implementation of field monitoring programs:

- what is the proper stone size to wave climate relation for revetment design?
- what are the optimal design considerations for effective groin performance; e.g., filled versus unfilled?
- what is the relationship between beach nourishment size and performance life for various wave climates?
- what is the downdrift impact (positive and negative) of all types of shore protection structures?

There is an excellent potential for obtaining highly detailed coastal structures performance data by conducting small-scale test "generic structures" experiments during a large coastal dynamics and process experiment. Small-scale structures could be constructed, on a temporary basis, to replicate shore crossing and shore parallel erosion mitigation devices. The advantage of such a study is that more wave and current, sediment transport, and bathymetric data could be collected around these test structures than could normally be collected at a site-specific monitoring project.

Coastal Evolution Study

There is a great deal of information which can be gained from studies of the recent geologic (past 10,000 years) history of coastal evolution in the Great Lakes. Along active depositional shorelines, such as southern Lake Michigan, there is a detailed geological history of coastal adjustment and development which can be interpreted with respect to lake levels and lake dynamics. This type of information has potential to contribute to the understanding of contemporary questions on shoreline response to long-term lake level changes. It will also provide additional insight into the question of long-term lake level "cycles" and their range during post glacial adjustment.

The Illinois State Geological Survey has initiated a study of this type in southern Lake Michigan in cooperation with the U.S. Geological Survey. Similar studies have been proposed by the Indiana Geological Survey. These studies should be given a high priority. Cooperation such as is necessary to fulfill the requirements of this study, should be encouraged and supported by these and other agencies in other Great Lakes research efforts.

There are five needs in of coastal engineering research: A permanent Great Lakes field research facility; a comprehensive program in baseline coastal processes data collection; standardization of measurement, collection and storage techniques; coordination of field efforts; and an annual symposium. It is important that numerical models and existing data be accessible, as discussed as treated in the conclusions of the numerical modelling and analysis of existing data working groups.

Great Lakes Field Research Facility

The organization of a permanent Great Lakes coastal processes field research facility is of high priority. Such a facility would provide Great Lakes scientists and engineers with a site at which to conduct generic coastal processes research with the support of long-term monitoring of coastal parameters and on-site instrumentation. Several recommendations by other working groups support this recommendation: The instrumentation group's recommendation to provide a field site at which to test developing coastal engineering measurement devices with background data support; the numerical modelling groups recommendation to provide an additional source of data for numerical model verification; and the field experimentation group's recommendation to provide a site for study of coastal processes and generic structure response.

A location for this facility has recently become available: the Big Sable Point Lighthouse, located along the eastern shoreline of Lake Michigan, on U.S. Coast Guard-owned property within Ludington State Park. This location is relatively centrally located within the western Great Lakes along a long reach of undeveloped coastline. Housing for researchers exists, and an experienced electrical technician is in residence to maintain and operate coastal monitoring equipment. The Michigan Department of Natural Resources has given its support to such an operation, insuring security for the site and interpretive programs for park visitors. In addition, this site would require only a modest investment of funds to initiate long-term coastal monitoring.

The site, located on a promontory along the windward shoreline, does not entirely lend itself to "generic" coastal research; however, numerous benefits can be gained from research in this type of environment. Also, the existing local erosion problem must be solved to assure the long-term integrity of the working lighthouse structure. This will be a costly problem, but short-term erosion mitigation has already been applied and the need for the working lighthouse should help provide support for alleviation of the long-term problem.

The Michigan Sea Grant College Program is the likely organization to pursue an agreement among possible participants and initiate a feasibility study of the recommendation.

Guidelines for Baseline Data Collection

Substantial effort must be directed towards measuring and mapping coastal processes, especially in the nearshore zone and in hazard-prone upland areas. The following baseline data are essential to understanding nearshore processes and providing a solid base for design and evaluation of proposed shore protection and navigation structures:

- nearshore bathymetry - 1 ft. contour intervals to 30' offshore water depth;
- detailed topography for flood hazard area;
- mapped patterns of sediment transport - direction and rate;
- nearshore sediment distribution - texture, thickness, grain size;
- shoreline recession rates - long term and short term changes;
- expansion of water level gauging system;
- shoreline physiography and detailed bluff stratigraphy;
- comprehensive shoreline aerial photography;
- nearshore wave and current data;
- overwater winds.

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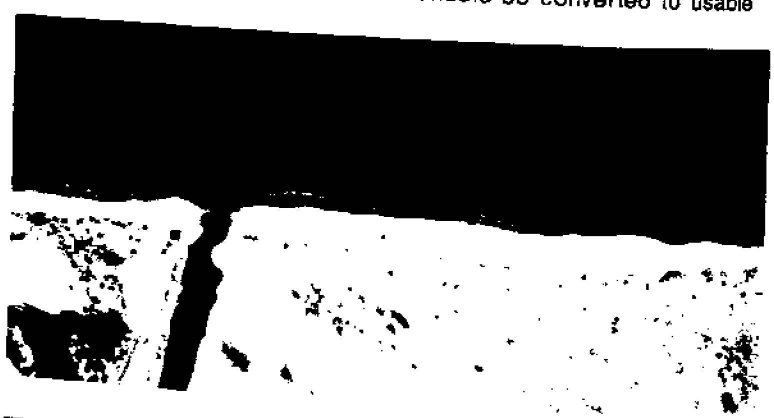
- shoreline physiography and detailed bluff stratigraphy;
- comprehensive shoreline aerial photography;
- nearshore wave and current data;
- overwater winds.

These data would also provide the basis for developing and validating predictive models. The level of detail for data collection would vary along the shoreline depending upon variability of the shoreline physiography and influence of major navigation structures. Standard techniques and accuracy requirements should be developed for use by all agencies involved in the data collection, and the data should be provided to a central computerized data base with both analytical and graphics capability such as those operated by the Great Lakes Environmental Research Laboratory or the State of Michigan Department of Natural Resources.

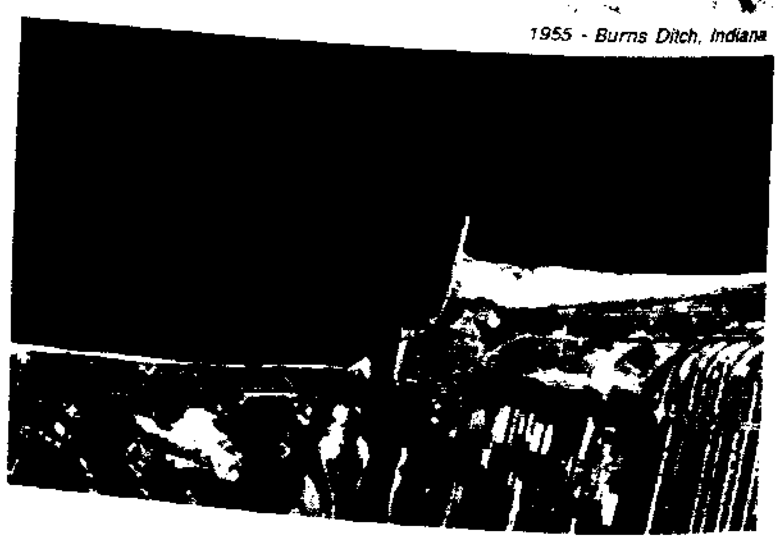
The analysis of existing data and the resulting refinement ofresource management guidelines may benefit two broad areasof coastal engineering research: structures and their effects on the environment, and coastal processes and trends. In general, there is merit in the evaluation of existing data bases prior to the initiation of costly new studies, so that gaps can be defined and duplication of effort reduced. Also, there is a strong need for the improved communication of this information to the general public and policy makers in order to facilitate prudent decisions concerning activities in the coastal zone and management of coastal resources.

Structures and Their Effects

Better understanding of the effects of structures in the coastal environment is sorely needed. A large source of information is already on hand and should be exploited before costly new studies are initiated. The analysis of existing data will not be a trivial task in that three steps are required. First, the plethora of existing information must be placed into some common frame of reference in the coastal environment. For example, aerial photographs, topographic maps, survey lines, etc. should be converted to usable



1955 - Burns Ditch, Indiana



1975 - Burns Ditch, Indiana

information that relates to the effects of structures. Second, technical reports should be prepared from this extensive data base summarizing the information. Third, the technical reports should have companion reports prepared for the layperson and town managers. In addition, small brochures should be made available for the riparian who is considering building a structure. A result of this activity should be a clear understanding of how to proceed with future studies of the effects of structures in the coastal environment.

The U.S. Army Corps of Engineers could be the ideal group to undertake this task since much of the information required to develop a deeper understanding of coastal structures already exists within the Corps. They appear to have an excellent grasp of both municipal and private structures and can draw on an extensive national network of information from both the Great Lakes and marine coasts.

Coastal Processes and Trends

Many of the issues and/or topics in coastal erosion processes are inadequately understood. In particular, there is an imprecise understanding of longshore currents and associated sediment transport processes and of water level variation. Additional aspects of this topic include the effects of general lake-wide circulation and similar basin-wide events such as seiches and coastal flooding.

Progress in the understanding of coastal processes along open coastlines will require a mixture of data analysis and numerical modelling. It is important that analysis of existing information occur before new studies are implemented. The analysis of existing data will provide an informed overview of the types of information that are currently available and how that information matches the needs of the numerical models and analyses. Once those needs are recognized, new studies designed to provide a complete suite of data could be initiated. The Great Lakes coastal experiment recommended by the field experimentation group and the baseline data collection guidelines proposed by the baseline data collection working group should work from this basis.

The major requirement for conducting such a study is the formation of a data base from the multiple sources of information currently available. Further, that data base must be reliable in the sense that the data should be of high quality and from known and approved sampling techniques. Collation of such a data base will not be a simple task, but the potential for reward more than exceeds the required effort. The collective knowledge of the group recalled the following data bases which should be of use in this project:

- Great Lakes water level data (only reliable back to 1900);
- geologic records;
- National Data Buoy Center wind and wave data (only back to 1981);
- meteorological data;
- ice charts and ice cover records (satellite derived);
- extensive Corps of Engineers data bases (harbor surveys, photographs, beach surveys); and
- records of numerous local planning agencies.

The identified data bases allow the analysis of contemporary trends (since 1900), but not of historical patterns. The geologic record must be tapped to gain further insight to these patterns. Discussion of this activity is found in the recommendations of the field experimentation working group.

Results from this type of analysis will have large implications for coastal resource management. For example, if a better understanding of the factors which control lake levels emerges, more informed decisions concerning construction in the coastal zone can be made. Coastal set-back limits can be more realistically established if cycles in water levels are more fully understood. These policy-related aspects of the analysis of trends in Great Lakes coastal processes may prove just as important as the scientific discoveries themselves.

There is a basic need for the following four types of coastal engineering data collection equipment: a rapid autonomous survey profiler, a remote shallow water directional wave gauge, a coastal data acquisition system and portable multisensor platform, and a sediment transport measurement device. In most cases, the technology for the development of such devices exists within the research community. Development of this instrumentation is an important research need.

Rapid Autonomous Survey Profiler

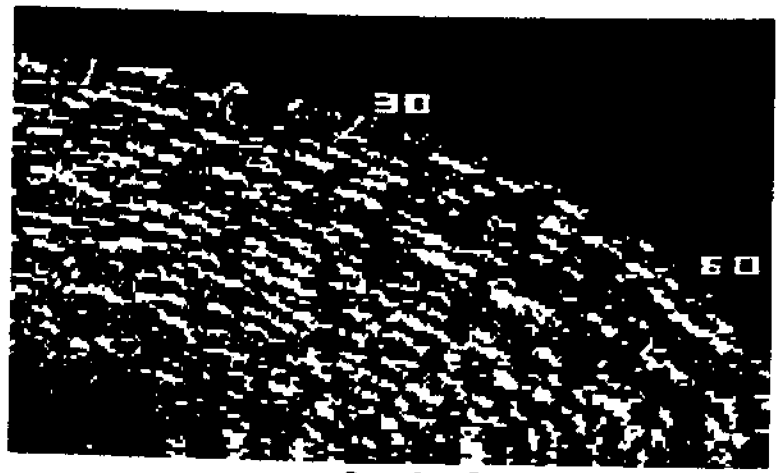
A rapid bathymetric profiler is needed to maintain survey lines through all weather conditions or to mount an aggressive baseline data collection involving numerous survey lines. This device would support activities recommended by the baseline data collection, field experimentation, and numerical modelling working groups.

Conventional techniques for nearshore hydrographic surveying are time consuming, involve high manpower and are weather dependent, factors resulting in a costly venture. Ideally, this proposed instrument would be operable by a two-person field crew from a 4x4 pickup truck or other such vehicle under a variety of weather conditions. The device would function autonomously as a bottom roving vehicle with onboard processor and data storage. The profiler would use either mini-ranger or Global Positioning System for accurate horizontal positioning, depending upon the existence of surveyed bench marks and the extent of survey coverage. The technology for such an advancement presently exists.

Remote Shallow Water Directional Wave Gauge

Accurate measurements of nearshore directional wave spectra are relatively nonexistent. The numerical modelling work group listed acquisition of these data as a high priority in shallow water wave model verification. In addition, the baseline data collection and field instrumentation groups identified a need for these data in determining the effects of incident conditions on the coastal environment.

Conventional methods of wave measurement, such as the PUV gauge, suffer from questionable reliability, high maintenance, and poor results in shallow water. The use of microwave remote sensing instrumentation to obtain nearshore directional wave spectra is recommended. The instrumentation exists, but further theoretical investigation into the relation between radar return intensity and wave energy is required.



Raster Scan Radar Image from 1 meter sea.

In the meantime, conventional shallow water directional wave gauging is greatly needed. Throughout the Great Lakes, deep water measurement and predictive capabilities are well developed, but no shallow water gauging program exists.

Coastal Data Acquisition System and Portable Multisensor Platforms

Increased standardization and decreased cost in field data acquisition were pinpointed as engineering needs by the field experimentation and baseline data collection groups. To facilitate a multi-user data acquisition system with diverse applications, a data acquisition system linked to portable floating multisensor platforms with telemetry/satellite links and universal instrument ports is needed. This system could be adapted for use under numerous environmental and logistical conditions. Such an advancement would encourage piggy-back experiments and coordination among Great Lakes research groups.

Sediment Transport Measurement

The fundamental mechanisms of sediment transport have yet to be understood. The first step towards insight into this process involves the field measurement of sediment transport in the nearshore region. The need therefore exists for an accurate way to measure three-dimensional sediment transport which is a quantity closely related to hydrodynamics and a measurement requiring sampling at rates above the incident wave period. It is very important to develop improved acoustic and optical instruments for both salt- and freshwater use. It was recognized, however, that accurate sediment transport measurement is a difficult problem of long standing within coastal oceanography.

There are three major needs in Great Lakes modelling research: development of shoreline evolution/sediment transport models, development of hydrodynamic models, and assessment and technology transfer of modelling capabilities. In all cases, high priority should be placed on model verification and testing and increased understanding of physical phenomena through field measurement programs. High priority should be given to enhancing the capabilities of predicting shoreline evolution and shallow water wave modelling, leading to an efficient suite of numerical models intended to aid in the design and evaluation of engineering structures.

Shoreline Evolution/Sediment Transport Models

To efficiently and adequately address the numerous requests for shoreline structure permits and to evaluate the effects of large navigational structures in the Great Lakes, a suite of numerical models, specifically designed to aid in the design and evaluation of nearshore structures is critically needed.

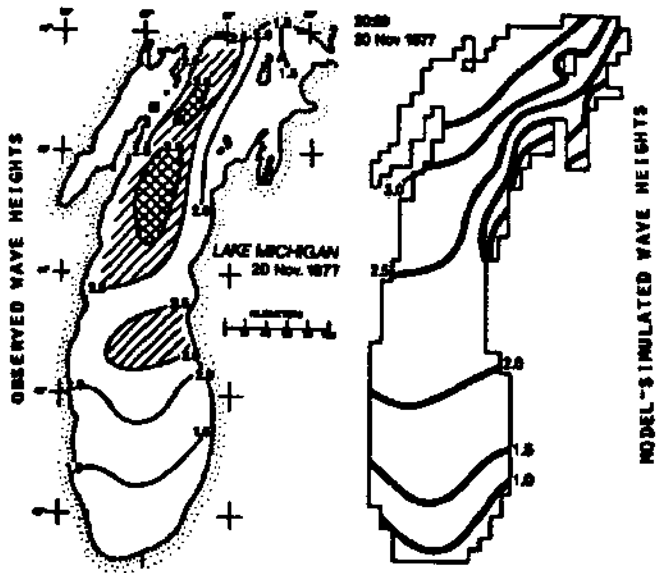
It is probably best to observe multiple sites to support the development and verification of improved shoreline evolution models. To meet this requirement, a convenient way to collect general data quickly and inexpensively is needed, such as the rapid autonomous survey profiler and other devices recommended by the instrumentation working group. Field measurement programs of this nature were also proposed by the field experimentation working group.

Sediment transport models also require verification through field measurement. Verification efforts would benefit greatly from the Great Lakes coastal experiment proposed by the working group in field experimentation.

Hydrodynamic Models

Hydrodynamic models are generally well developed compared to sediment models. However, because of the variety of spatial and temporal scales associated with physical processes, various components of the overall problem have typically been decoupled and resulting solutions superimposed to give overall prediction. For example, storm surge and design wave heights often result from the same events. Present models usually treat these as independent processes. This may lead to significant error in determining recurrence intervals for flooding, etc. The validity of such an approach has not been established.

Several model development and verification efforts are presently underway. Lake circulation models, depending upon specific computational needs, still possess some gaps with respect to understanding relevant physical processes. Models of flow at



GLERL Wind Wave Model[1]

nearshore structures, wave runup, etc., require turbulence models for accurate predictions, but the present state of turbulence modelling retains some major inadequacies. Deep water wave forecasting is generally satisfactory, with most of the uncertainty associated with the meteorological forcing function. Shallow water forecasting models are developed but still require proper verification through extensive measurement programs. Most recently, the Great Lakes WAVEDISS experiments, a cooperative effort between the Great Lakes Environmental Research Laboratory and the Canada Centre for Inland Waters, have provided some measurements.

The highest priority hydrodynamic model development is that for shallow water wave forecasting, due to the close tie to sediment transport and shoreline evolution modelling.

1. Liu, P.C., Schwab, D.J., and Bennett, J.R., 1984, Comparison of a two-dimensional wave prediction model with synoptic measurements in Lake Michigan: Journal of Physical Oceanography, Vol. 14, No. 9.

A Great Lakes wave gauging program as discussed by the instrumentation and baseline data collection working groups would enhance this effort by providing shallow water directional spectra in concert with the deep water wave measurements of the National Data Buoy Center instrumented buoys. In addition, any Great Lakes coastal experiment would provide useful information. Joint projects to ensure that the data collected is suited for model verification were highly recommended.

Assess Status of Current Modelling Capability

Critical assessment of the capabilities of existing numerical models should be performed in addition to the verification efforts undertaken by the model developers. Verification efforts often do not clearly indicate the relevance of the models to general applications, nor do they always represent the effort that is required to achieve a high degree of correspondence. Needed are:

- a critical assessment of the limitations and capabilities of the various models;
- an understanding of the uncertainties in the application of the models; i.e., confidence limits and ranges of validity;
- an identification of the modelling needs of users and an indication of what further research is needed to enhance the quality and utility of overall prediction (e.g., improved data input, algorithms, etc.)

Technology Transfer

In multidimensional models, extensive data inputs describing geometry are required. It would be useful to avoid duplication of efforts in constructing these data sets. Therefore, development of a standard grid system, on which bathymetry, etc. are specified, would be desirable. For instance, the Great Lakes Environmental Research Laboratory models of depth integrated circulation and deep water waves presently operate on a standard Great Lakes square grid bathymetry. It would be necessary to keep this standard data base up-to-date and modified to support future developments in modelling capabilities.

In addition, increased accessibility to models and standard data sets for the Great Lakes would be of significant value. For ground water researchers, for example, there is a clearing house that provides information on the various models and also makes those in the public domain available to users. A similar effort is needed for coastal engineering applications.

A combination of state and federal agencies involved in coastal processes research and regulation of structures (state resource agencies and geological surveys, Sea Grant College Programs, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, Coastal Engineering Research Center, etc.) would be best suited to undertake this type of research. The mechanisms necessary to support this effort involve increased funding and coordination of effort, along with the establishment of a field research station.

Standardization of Measurement, Data Collection and Storage Techniques

Widely varying measurement and collection methods and manipulations of data make it difficult to evaluate the quality of the data and transport information between studies. There is a need to provide standards by which data is collected, stored, and processed. Such standards should list the baseline data that should be collected at most field areas and suggest methods of data collection and storage, as well as laboratory procedures, coordinate systems and datums. These guidelines should not limit creativity nor be rigid, but provide a source for techniques and presentation of data that would make the information more useful to a wide range of disciplines.

There probably exists no one organization best suited to conduct this task. However, some federal institutions publish pamphlets outlining techniques and procedures that could be used as a basis for such a standardization. An efficient way to accomplish this goal would be to form a committee that would address these needs, make recommendations, and publish a standard reference manual.

COORDINATION OF FIELD STUDIES AND OTHER EFFORTS

Coordination of Great Lakes field activities was identified by all working groups as requisite to accomplishing the magnitude of effort required to fulfill the recommendations of this workshop.For example, instrumentation would be greatly enhanced by coordinated research that would enable pooling of instrumentation for field activities. The high cost of field studies would be reduced if different agencies/groups could "piggy back" data collection in order to share transportation costs, equipment rental, etc. Numerical modelling verification activities would benefit from direct input to field data collection activities. Many other benefits of coordinated activities could be listed.

To accomplish this goal, increased communication is necessary in the form of a written document, a computer bulletin board, or open communication among the various organizations conducting Great Lakes research.

Annual Symposium

The participants of the workshop recommended the creation of an informal, annual, symposium on Great Lakes coastal geology and coastal engineering to apprise participating researchers of plans and efforts in Great Lakes research through informal presentations and discussions. The Michigan Sea Grant College Program has volunteered to host such a symposium.

Appendix A

Summary of Presentations

Welcome and Introduction

Michael G. Parsons

Chairman, Dept. of Naval Architecture and Marine Engineering
The University of Michigan
Director Designate, Michigan Sea Grant College Program

Dr. Parsons welcomed the participants and explained the evolution and purposes of the workshop.

The Workshop on Great Lakes Coastal Erosion Research Needs is sponsored by the Michigan Sea Grant College Program and The University of Michigan Department of Naval Architecture and Marine Engineering. These two organizations are presently experiencing changes in their programs; each is increasing its role in coastal processes and coastal engineering. With this change and the resultant increased contact with coastal researchers and administrators, the growing need for coordination of efforts between the numerous groups involved in Great Lakes research has become evident. In addition, recent initiatives of the US Geological Survey, the US Army Waterways Experiment Station Coastal Engineering Research Center, the National Sea Grant College Program, and other organizations point to the integration of Great Lakes research by establishment of cooperative programs.

To address the need for cooperation, this workshop was initiated to bring together researchers from throughout the Great Lakes region, including Canada, to increase awareness and communication and to identify, as a group, the research needs and roles that each organization might play in contributing to a better understanding of the Great Lakes coastal environment.

Because of the short time scale in the planning, some important participants were unable to attend. The two most obvious are the Canada Centre for Inland Waters, whose members were attending an annual National Research Council meeting on coastal processes, and coastal engineering personnel from the National Sea Grant College Program Office, who were involved in a site visit in Delaware. However, the general response is most encouraging.

A Perspective on Great Lakes Coastal Erosion

Guy A. Meadows Department of Naval Architecture and Marine Engineering
The University of Michigan

Dr. Meadows described the physical and political reasons for the workshop, explained the organization of the agenda and the specific goals of each working group, and discussed a list of potential coastal research needs for the group to consider during the following presentations.

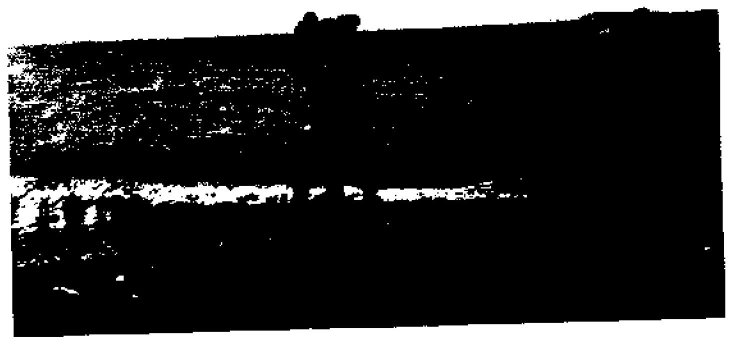
In the last few years, the Great Lakes have seen record-setting high water levels and severe storm wave conditions, resulting in increased shoreline erosion. In addition, shifts in wind patterns and strom tracks have altered the effects of shoreline structures, causing erosion in what may once have been accretionary zones and vice versa. These physical phenomena, combined with increased political and academic attention to shoreline response spurred by public and private interests, have resulted in the need for a strong, coordinated research effort aimed at better understanding of Great Lakes coastal processes.

The goal of this workshop is to address this need by bringing together participants from throughout the region to play a critical role in identifying Great Lakes coastal erosion and engineering research problems. This group will identify the critical research needs, define mechanisms by which to address these needs, and define which organizations or ongoing programs are best suited to accomplish these goals.

To stimulate thought and discussion, the following are several possible areas of research coordination.

- A need exists to establish the "state of the shoreline." The 1975 "Management of High Risk Erosion Areas" guidelines should be reestablished and high risk areas defined. The definition of set-back distances and erosion rates during "worse case conditions" would discourage unwise construction, thus debreasing future property loss and damages.

- The initiation of a long-term coastal monitoring program to assess the present shoreline damage and create a geophysical data base would aid in preparation for the next water level fluctuation cycle. Representative precision hydrographic survey profiles should be conducted in natural and structurally impacted areas to provide greater insight to the effects of structures on the adjacent shoreline. Survey lines established in the 1960's and 1970's by the Coastal Engineering Research Center (CERC) could be reoccupied for further comparison.



- A wave and current monitoring program for the Great Lakes would enhance our data base for wave, sediment transport, and shoreline response model verification. The National Data Buoy Center buoys are utilized for deep water climatology. But, in order to bring this wave data into the coastline, shallow water directional wave gauging is necessary, such as the CERC wave gauging program for the Atlantic, Gulf and West coasts.

- A permanent Great Lakes field research station would greatly enhance these latter two efforts by supplying support for long-term instrumentation installation and maintenance as well as a controlled location in which to conduct coastal research. A site of opportunity exists along the eastern shore of Lake Michigan at Big Sable Point Lighthouse located within Ludington State Park. This station provides buildings in which to house sensitive instrumentation and scientific and engineering personnel. Location within the state park provides for a long reach of undeveloped coastline and a protected future.

- Shorter term programs to study sediment transport under a variety of conditions, including ice cover, and the establishment of sediment budgets throughout the Great Lakes would be of great value. In addition, the identification of offshore sand deposits for the purposes of beach nourishment programs, and assessment of the impact of removal of this sediment from the offshore region would be useful.

- Numerical modelling efforts in predicting shoreline evolution could benefit from many of these programs, leading to an efficient means of coastal structure permitting and analysis.

- The important task of disseminating results of this research to the public could be accomplished through a number of informative programs. For instance, a local 48-hour wave forecasting program for recreational harbors, including real time wave and current data for the Great Lakes wave gauge sites, would aid in bringing these coastal engineering advancements to the general public.

Because of the magnitude of effort needed, a coordinated program with the various parties represented here is the only way to address these problems. In an attempt to accomplish this goal, five working groups have been defined: instrumentation, numerical modelling, field experimentation, analysis of existing data, and baseline data collection. The task of the working groups is to assess the present state of the art and identify deficiencies, or gaps, in our understanding. It is obvious that no one of these groups can stand alone, so to integrate working group efforts, each leader will present a preliminary summary of the research topics identified in each group at the end of the first day. It is intended that these presentations will stimulate further discussion and unify the efforts across the working group boundaries.

The Effects of Sea Level Variation on the Coast

William L. Wood Director, Great Lakes Coastal Research Laboratory
Department of Civil Engineering
Purdue University

Dr. Wood gave a detailed treatment of the state of knowledge about Great Lakes water level variations, centering on coastal engineering and erosion issues. He identified important concerns associated with both rising and falling water levels. In addition, he discussed the temporal and spatial scales of water level and variations identified program needs in each category.

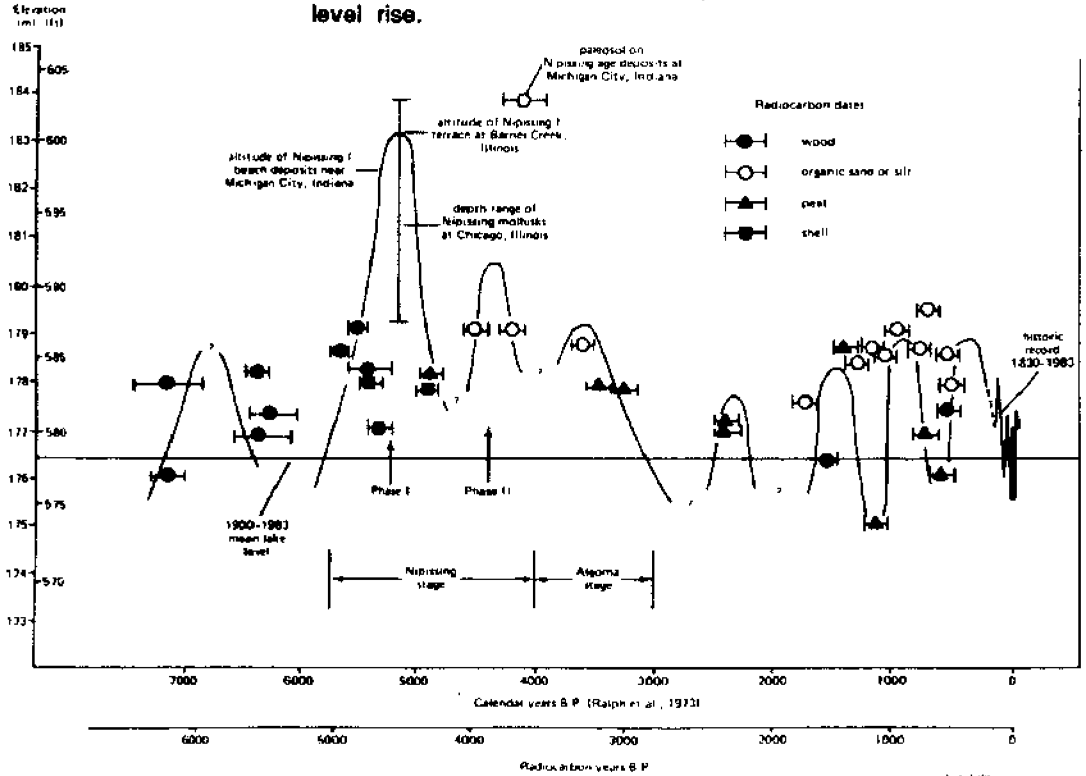
Rising lake levels create a number of issues pertinent to coastal engineering and erosion. To establish coastal construction control lines, or set-back limits, we must very clearly differentiate between encroachment, recession, and erosion. Shoreline encroachment refers to the effect of water level rise with no subsequent recession or erosion. Coastal recession is the landward translation of the shoreline profile with no net loss of sediment. Coastal erosion indicates translation accompanied by net loss of sediment. Coastal flooding becomes important with the advent of rising water levels. In addition, structural overtopping during high water levels is a primary concern of designers.

The research community tends to react primarily to the concept that a problem exists with rising water levels and that the problem ceases, in a research sense, as the water level decreases. However, there are concerns with lower water levels that are just as important in the long-term scheme of useful research and development on the Great Lakes: shoreline withdrawal, coastal progradation, structural overtopping, and harbor and coastal navigation. Accompanying any significant fall in lake levels, resulting in progradation, is a jurisdictional question over ownership rights. Overtopping becomes an issue with falling levels as the water depth near structures changes from the optimum depth of effectiveness. And, coastal navigation becomes hazardous as water levels fall.

To assess research needs in instrumentation and measurement programs for Great Lakes water level variations, we must break this subject down into temporal and spatial scales.

Scales of temporal variability for the Great Lakes cover daily, annual, ten-year, and long-term changes. Daily variations are those produced by storms, possessing a great deal of vertical scale change in a very short time. The annual cycle is the time scale we are most familiar with. Ten-year and long-term temporal variations in the Great Lakes are least understood. In the past, work has concentrated inconclusively on ten-year cycles. However, C. Larsen's work[1] in long-term variations certainly warrants further research, in that his curve indicates that even though we are experiencing record high lake levels on a ten-year time scale, we are at a low as indicated by the long-term fluctuations.

With respect to vertical variation in water levels, concern over ocean sea level rise has been popularized. In examining the scale of vertical motion, however, the Great Lakes variations are one to two orders of magnitude larger than those anticipated on the ocean coasts. The ocean level rise is certainly an issue for which preparation should be initiated. However, the dramatic fluctuations on the Great Lakes warrant attention due to their widespread impact, and the unique opportunity to assess shoreline processes in response to water level variations prior to drastic oceanic sea level rise.



Holocene lake level fluctuations in southern Lake Michigan based on radiocarbon dating

1. Larsen, C.E., 1985, A stratigraphic study of beach features on the southwestern shore of Lake Michigan, new evidence of Holocene lake level fluctuations: Illinois State Geological Survey, Environmental Geology Notes 112, 31 pp.

Effects of Engineering Structures on the Shoreline

David Dykstra Vice President
Tekmarine, Incorporated

Mr. Dykstra outlined the effects that numerous engineering structures have had on their adjacent shoreline. In particular, he described those structures that have conclusively stabilized adjacent shorelines. He discussed detached segmented breakwaters, offshore facilities, and artificial barrier island/beach complexes.

Serious population pressure problem in Japan has led to the need for land use planning and the establishment of beaches for recreation. As one acceptable solution, the Japanese have a long history of successful segmented breakwaters. These structures reduce the wave energy behind the breakwater, creating a region of accretion, and thus more usable property. This is a drastic measure which causes loss of the classical shoreline, but in the case where the creation of more property is beneficial, this concept has demonstrated a great deal of merit. The Administration of Transport in Japan conducted a survey of approximately 2500 segmented breakwater sites and was able to characterize their performance. Typical dimensions of the breakwaters surveyed were approximately 50 m offshore in water depths of 3 to 4 m, with 50 m length and a 5 to 6 m crest above mean sea level. In general, accretion is expected behind a segmented breakwater. The accretion is predominantly a tombolo formation, creating a "scalloped" shoreline. These structures remain effective during overtopping and submergence by reducing incident wave energy and subsequent sediment transport at the shoreline -- a concern in the Great Lakes with recent high water levels.

Lakeview Park, Lorain, Ohio[1]

The use of offshore facilities has been implemented at many locations. In some cases, a protected area, such as a marina, is established behind the facility. Or the structure may favor accretion in the vicinity. For example, Chicago's offshore airport, Meigs Field, protects an adjacent marina. In a Great Lakes area where property is limited, this expensive alternative may prove useful.

A third engineering structure, used extensively in Copenhagen, is the artificial barrier island or beach which may be used for recreational purposes, while establishing boat harbors and reducing direct shoreline erosion problems. The success of this concept requires a limited section of shoreline, where the project creates its own littoral zone in which sediment sources and sinks may be controlled. Jetties are typically used to control alongshore sediment movement.

1. Pope, J., and Dean, J. L., 1986, Development of design criteria for segmented breakwaters: 20th Coastal Engineering Conference Proceedings/CER Council ASCE/Taipei, Taiwan.

State of Michigan Coastal Engineering Needs

Chris Shafer Chief, Great Lakes Shorelands Section
Michigan Department of Natural Resources

Mr. Shafer described the State of Michigan's needs to improve management of the coastal zone. The Michigan Department of Natural Resources' overwhelming responsibilities as a regulatory and construction agency in a period of rapidly fluctuating lake levels have led to a serious need for coastal engineering data for decision-making purposes. Mr. Shafer voiced the State of Michigan's commitment towards a cooperative research program.

The State of Michigan's coastal processes data needs stem from two primary responsibilities: regulation and construction. These are similar to the responsibilities of the US Army Corps of Engineers. The Department of Natural Resources (DNR) regulates all shore protection and navigational structures along Michigan's 3288 miles of Great Lakes shoreline, and on the bottom lands or in the waters of the Great Lakes. Last year, over 2100 permits for shore protection structures, docks, and navigation structures on the Great Lakes were processed, as well as an additional 2000 permits on the connecting channels and drowned river mouths. Of the entire 6600 permits handled this year, over 4000 were related to the coastal area.

Construction activities involve the regulation of additional construction and actual building of facilities in approximately 600 miles of designated high risk erosion and flood hazard areas. The Waterways Section of the DNR is responsible for design, construction and maintenance of public access facilities, marinas, and safe water harbors. They have constructed, in cooperation with the Corps of Engineers, over 60 harbors of refuge and marinas, and over 200 public access sites, contributing to a total of $5.6 million per year spent in the coastal area. This large amount points to the serious need for coastal engineering data.

The data needs of the State of Michigan DNR are for more detailed and more current data upon which to base decisions in regulation and construction. Through their permitting processes, the State and the Corps of Engineers have a large influence on the proposal, design, and construction of shoreline structures. To facilitate the large task of providing permits for structures along the Michigan shoreline, for example, certain structures, such as low profile groins, are set into a minor project category, presumably having relatively minimal impact on the shoreline. Consequently, numerous contractors adapt their projects to fit into this category to expedite the permitting process.

The primary objective of the regulatory program is to prevent adverse impacts to the environment. Greater weight is placed on avoiding adverse impact than on the effectiveness of the structure. (Thus, effectiveness of numerous permitted structures may suffer.) Therefore, better data is needed to assure proper evaluation of the impact of a particular structure as well as of its engineering effectiveness.

The specific data needs of the State of Michigan DNR are very practical and applied and include: updated nearshore bathymetry, since much of the existing information is over 30 years old; accurate wave runup data in flood hazard areas; detailed topography in flood hazard areas, to 1 or 2 foot contours; real nearshore wave measurements to improve hindcast and predictive methods using offshore wave parameters; littoral drift rate measurements accurate and fast predictive models that can be run on microcomputers to evaluate shore protection structures and monitoring of the impacts and effectiveness of various shoreline structures.

The State of Michigan's objective in citing these needs is to be in a substantially better decision-making position the next time water levels rise. The State pledges complete cooperation in developing and implementing a good, solid program for coastal processes data acquisition and monitoring in the Great Lakes, and in providing technical assistance in designing studies to address the data needs. One facet of this program, the coastal engineering field station, has been discussed with the Parks Division and they are amenable to providing part of the shoreline and park facilities to support such a station.

Detroit District Corps of Engineers Coastal Engineering Needs

Thomas Nuttle Chief, Hydraulics and Hydrology Branch
US Army Corps of Engineers, Detroit District

Mr. Nuttle briefly outlined the structure of the US Army Corps of Engineers, citing the reach of coastline within the Detroit District as second in size only to Alaska. He then presented six advances in research and methodology which, if accomplished, would enable the Detroit District to make engineering decisions based on increased knowledge, thus eliminating costly conservatism in design and evaluation of coastal engineering structures.

The Great Lakes have recently experienced three high water episodes, 1951, 1973 and 1986. Yet a movement was initiated during the low-water period of the early 1960's to construct weirs at the mouth of the St. Clair River to raise water levels slightly. This proposal was resisted and, ironically, in the year of projected completion, the water levels reached new record highs (1973). During interim low-water periods, we should work to alleviate the problems of the next high water period rather then forgetting the effects of high water.

The continental US is divided by the US Army Corps of Engineers into 10 civil work divisions. The Great Lakes and upper Mississippi River form the North Central Division. Among the functions of this division are the performance of limited tasks aimed at lake level regulation, and the concentration of efforts on shoreline erosion. Three districts of the North Central division perform work on the Great Lakes: Buffalo District, Chicago District, and Detroit District. The Detroit District office handles over 3000 miles of shoreline along Minnesota, Wisconsin and Michigan. The reach of coastline within the Detroit District is second in size only to Alaska, and the Great Lakes shoreline suffers from much higher population pressure.

To better administer coastal engineering management to this large domain, the Corps of Engineers has six basic needs.

1. Additional research is needed to determine adequate amounts of armor stone required for revetment construction.

2. There is a need to establish the relationship between fill particle size and the operation of groins. A groin system south of Port Sheldon provides an example of too-fine fill being washed out of the groin compartments.

3. Research is needed to determine the effects of rising lake levels on erosion. The Detroit District has hypothesized that erosion results from rising lake levels, rather than static high levels.

4. The quantitative and qualitative relationships between beach particle size and nearshore transport rates should be established. Fine and medium sand seems to move normally to the shore from the beach until it reaches one of the offshore sandbars. Then it moves rapidly alongshore. Coarser materials are more stable at the water's edge and appear to be less likely to be carried to the offshore bars.

5. There needs to be improved methods for quantifying the extent of erosion expected downdrift of shore protection structures on the Great Lakes. Presently, the District sets structure lengths based primarily upon engineering judgment and field observations.

6. An improved methodology for calculating design waves on the Great Lakes is needed for the design of coastal structures.

If these needs could be met, the Detroit District and other organizations could then base decisions on research conclusions rather than on basic engineering judgment, thus eliminating needless conservatism in the design of coastal structures.

National Park Service Role in Great Lakes Coastal Engineering Research

Dale Engquist and Richard Peterson

Superintendents, Indiana Dunes and Sleeping Bear Dunes National Lakeshores, National Park Service

Mr. Engquist and Mr. Peterson described the National Lakeshores' commitment to the preservation of natural shoreline processes and their experiences in dealing with pressure to provide shoreline protection. They also pointed out that the Park Service itself does not engage in coastal engineering research, but it benefits from the research of others. Indiana Dunes National Lakeshore is located along the Indiana shoreline of southern Lake Michigan and Sleeping Bear Dunes National Lakeshore is located in northern Lake Michigan on the Leelanau Peninsula .

The role that Indiana Dunes National Lakeshore has played in coastal engineering research has been one of a consumer, recognizing the need for quality coastal data. The park's objective is to maintain the shoreline naturally. Through coastal research performed in the past, the park has the ability to defend policies and decisions concerning shoreline maintenance.

The park was established in 1966, during a period of rising lake levels. The Indiana Dunes encompass 18 miles of Indiana's 45-mile coastline and includes federal, state, local and private in-holdings. The concern about shoreline erosion began in the early 1970's as the lake levels reached record heights. Homeowners wishing to protect "their" beaches and assess shoreline threats pressured the park to implement shoreline protection. The park generally objected to coastal structures and sought coastal data and expertise to defend their position and management plans. The result is a shoreline situation report prepared by the Great Lakes Coastal Research Laboratory, Purdue University[1], presenting a complete data base and assessment of the shoreline and adjacent nearshore area within the park.

1. School of Civil Engineering Great Lakes Coastal Research Laboratory, Purdue University, 1986, "Executive Summary: Indiana Dunes National Lakeshore Shoreline Situation Report," 38 pp.

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If these needs could be met, the Detroit District and other organizations could then base decisions on research conclusions rather than on basic engineering judgment, thus eliminating needless conservatism in the design of coastal structures.

The Sleeping Bear Dunes National Lakeshore encompasses 60 miles of relatively undeveloped and unimpacted shoreline. The management intent of this park is also the preservation of natural processes. Few shoreline structures are needed, but the park maintains public access sites and dredges at the mouth of the Platte River to support coho salmon fishing activities. One hundred fifty original residential properties existed within the park: some have been moved and some lost to erosion. However, the park has successfully denied all requests for shoreline protection.

The role that Sleeping Bear Dunes may play in coastal erosion research is that of providing a good laboratory for studying unimpacted shoreline processes, and playing an interpretive role by relaying this information to the public. Presently, interpretive programs describing the geology of the park exist, but there is a need for a coastal processes program.

Great Lakes Environmental Research Laboratory Role in Great Lakes Coastal Engineering Research

Alfred M. Beeton Director
Great Lakes Environmental Research Laboratory

Dr. Beeton described the structure of the National Oceanic and Atmospheric Administration (NOAA) and the Great Lakes Environmental Research Laboratory (GLERL). He also summarized the coastal processes research performed by GLERL.

NOAA consists of five major branches: National Ocean Service, National Weather Service, National Marine Fisheries Service, National Environmental Satellite Data and Information Service, and the Office of Oceanic and Atmospheric Research. There are nine Environmental Research Laboratories, three of which are aquatic, under the latter of the branches. The Great Lakes Environmental Research Laboratory mission is to conduct research on the Great Lakes, estuarine and coastal environments. The specific purpose of the laboratory is to perform integrated, interdisciplinary environmental research in support of resource management and environmental services.

GLERL is subdivided into 5 research groups of which the Physical Limnology and Meteorology Group is most closely associated with coastal engineering activities. The group is assigned the tasks of improving climatological information, developing and testing improved predictive methods, and improving the understanding of underlying physical processes. The two major work units within the group are Water Movements and Temperature, and Prediction of Surface Waves, Levels, and Marine Winds. The present NOAA initiative for GLERL is to study global trends in climate and determine the effects on the Great Lakes.

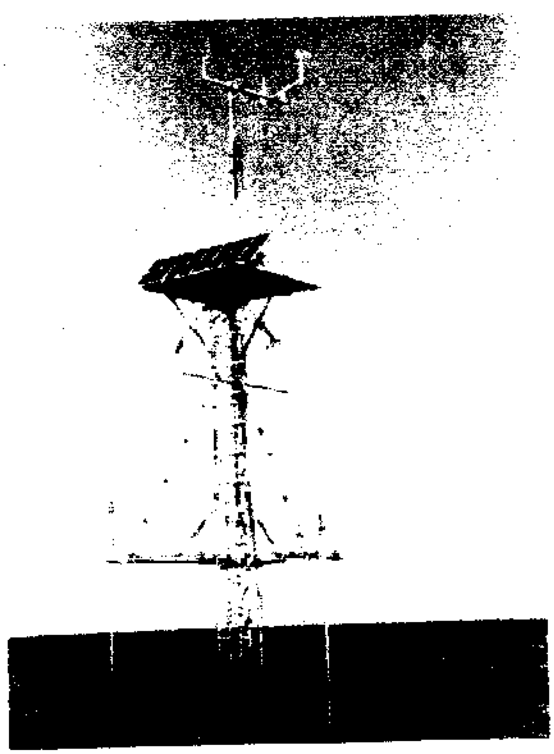
Some of the research topics that have been studied by the Water Movements and Temperatures Project include:

- Measuring of large-scale circulation and determination of the importance of wind stress curl as a driving force;
- Quantifying water volume exchange characteristics;
- Profiling the coastal current structure from the surf zone to deep water;
- Observing vorticity waves in deep lake basins;
- Measuring currents in the benthic boundary layer and determining the structure of flow in the bottom Ekman layer;
- Developing the lake circulation modeling system and "Pathfinder" trajectory prediction system for the Great Lakes;

Some of the research accomplishments in the Prediction of Surface Waves, Levels and Marine Winds Project are:

- Developing and implementing the operational Lake Erie storm surge forecast model;
- Obtaining synoptic wave measurements in Lake Michigan;
- Developing a wave direction measurement system and comparing it with airborne SAR measurements;
- Analyzing data from the Lake Erie surf zone experiment (LEX '81);
- Developing and validating a numerical wave prediction model for the Great Lakes;
- Developing a storm surge planning program (SSPP) for microcomputers;
- Synthesizing long-term wave climate information;
- Analyzing wave attenuation, variability and dissipation in shallow seas (WAVEDISS '85).

These research programs summarize GLERL's present coastal processes work. GLERL is looking forward to continued cooperative research programs, such as the WAVEDISS experiments conducted jointly with the Canada Centre for Inland Waters.



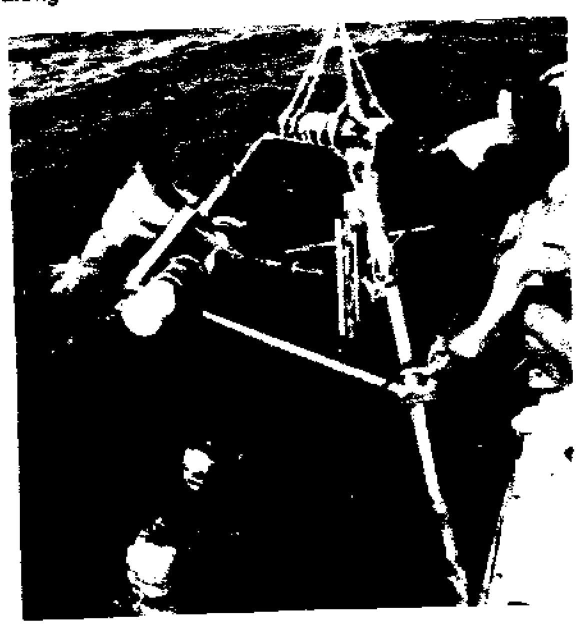
Coastal Engineering Research Center Role in Great Lakes Engineering Research

Charles L. Vincent Senior Scientist
Coastal Engineering Research Center

Dr. Vincent gave a brief description of the primary research programs in which CERC is presently participating. He noted that there is no specific Great Lakes program, but that the Great Lakes provide a good laboratory for coastal research.

The Coastal Engineering Research Center (CERC) is one of six laboratories constituting the US Army Engineer Waterways Experiment Station (WES). The other laboratories are the Hydraulics Laboratory, Geotechnical Laboratory, Structures Laboratory, Environmental Laboratory, and Information Technology Laboratory. CERC concentrates its research efforts on generic coastal problems, rather than on site-specific activities. There are presently four general research programs in operation at CERC: Coastal Flooding and Storm Protection, Harbor Entrances and Coastal Channels, Shore Protection and Restoration, and Coastal Structure Evaluation and Design.

Under the Coastal Flooding and Storm Protection program, the highest priority work unit research at CERC is directed toward wave estimation for design. This work unit involves development of a shallow water spectral hindcast model, hurricane and narrow fetch models, and determination of wave height distribution. Other work includes implementation of a directional wave test facility. Much field research under this program is conducted at the CERC's Field Research Facility located just north of Duck, North Carolina, along the outer banks coastline.



The Harbor Entrances and Coastal Channels program involves field investigation of waves and currents in these areas and includes field, laboratory, and numerical modelling efforts. Inlet processes are also studied.

The Shore Protection and Restoration program is presently emphasizing longshore sediment transport and coastal modelling systems. One work unit is involved in revising the CERC sediment transport formulae and expanding to measurements with differing sediment sizes. The DUCK 85 and SUPERDUCK cooperative experiments involved numerous individual efforts in this field, and a Great Lakes surf zone sediment transport experiment is presently in the planning stages for fall 1988.

The Coastal Structure Evaluation and Design program is directed toward the placement of the monochromatic wave approach to structural design. Efforts at present are directed at seawalls, revetments, and rubblemound structures.

The Great Lakes is a magnificent laboratory for the world's coasts with respect to sea level rise; therefore the concept of a Great Lakes field research facility is of great interest and has a potentially high pay-off.

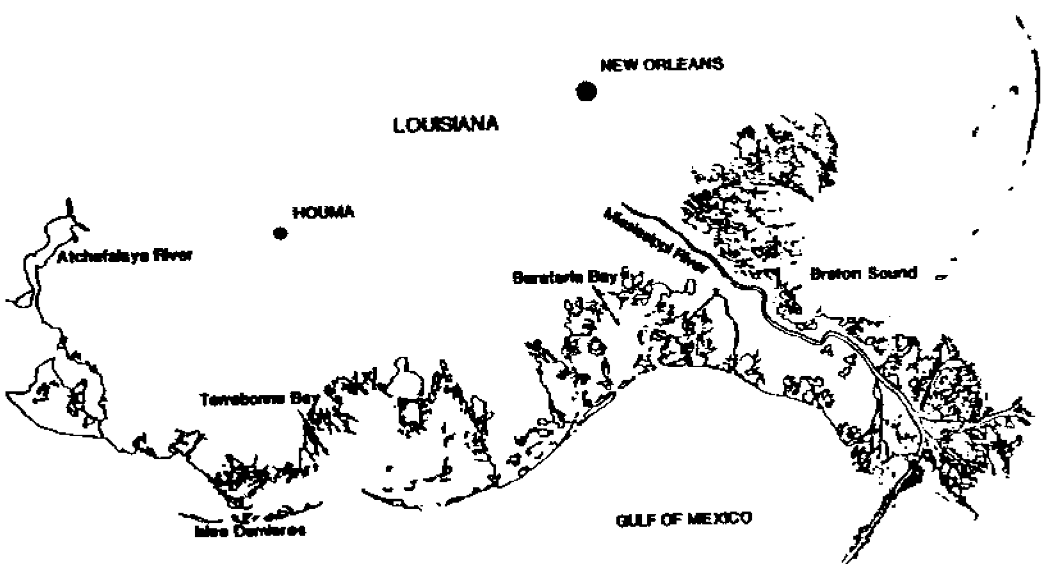
U.S. Geological Survey Role in Great Lakes Geological Research

Jeff Williams
U.S. Geological Survey
914 National Center
Reston, VA 22092

Mr. Williams described the US Geological Survey's Coastal Program, in particular a multi-phase, multi-year project being conducted in Louisiana. He then described a study planned for southern Lake Michigan, to be conducted in cooperation with the Illinois State Geological Survey and others.

The Survey concentrates in three areas of coastal research: erosion, pollution, and resources. In the area of erosion, a five-year project is being carried out in the Isles Dernieres and Chandeleur Islands regions of the Louisiana Gulf Coast[1]. This is a barrier island complex, suffering from severe erosion, that serves to protect 41 percent of the nation's wetlands. The study, starting in 1986, consists of work in three areas: geological development of the barrier islands, quantitative processes of barrier island erosion, and applications and transfer of the technical results.

The geological development phase of the program concentrates on establishing the geological framework within which the islands were formed and transgress landward, involving regional



1. Sallenger, A.H. Jr., S. Penland, S.J. Williams, and J.R. Suter, 1987, "Louisiana Barrier Island Erosion Study," *Coastal Sediments '87*, American Society of Civil Engineers, New Orleans, LA, pp. 1503-1516.

stratigraphy and geomorphology. To investigate regional stratigraphy, high resolution geophysical profiles and vibracores with supplemental surface sampling and drilling are being analyzed. Geormorphological investigations utilize historic charts, pre- and post-storm video tapes, photography, and beach profiles.

The quantitative processes phase of the program includes investigation of sea level rise, overwash processes, offshore sediment loss, and longshore sediment transport processes. Sea level rise is quantified by local tide station readings. Overwash processes are studied in low relief areas instrumented with acoustic altimeters, pressure sensors, electromagnetic current meters and other devices. Offshore sediment loss will be investigated through direct measurements and calculations of suspended sediments, and bottom changes. It is anticipated that investigations of longshore sediment transport processes will improve models for use in the sand and mud environment.

The applications of this research will provide coastal managers and engineers with improved techniques for determining renourishment rates of artificially nourished beaches, locating potential sources of offshore borrow sand, and improving set-back laws through a better understanding of shoreline erosion processes.

The tools and techniques utilized in the Louisiana barrier island study will apply to a Great Lakes study planned for the southern portion of Lake Michigan. This study is proposed as a cooperative effort between the USGS, the Illinois State Geological Survey, and other state geological surveys and universities. This five-year study will focus on developing a better understanding of past lake levels so that the potential for high lake levels in the future may be assessed, and on identifying critical processes leading to erosion so that erosion caused by high lake levels may be better predicted. The three tasks of the investigation include: shallow geological framework, long term lake level history, and the critical erosion processes.

Shallow geological framework will be investigated utilizing bathymetric and seismic surveys, and comparing present information with historical data. In addition, the distribution and extent of coastal sands will be delineated.

Lake level history over the past few hundred to few thousand years will be investigated by coring and mapping coastal deposits at numerous locations in southern Lake Michigan.

Investigation of critical erosion processes will involve long term monitoring of sites through beach and nearshore profile changes as related to lake level rise and storm frequency.

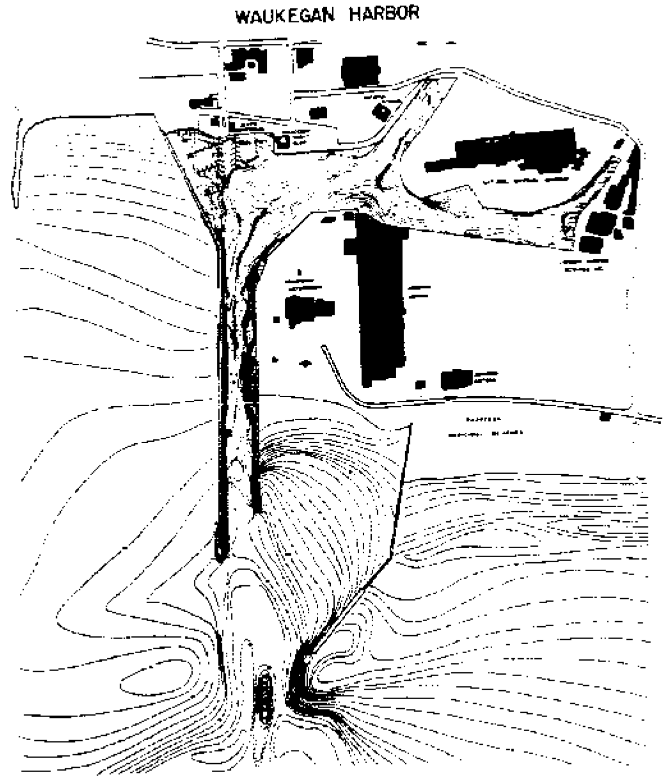
Illinois State Geological Survey Role in Great Lakes Coastal Engineering Research

Michael J. Chrzastowski   Illinois State Geological Survey

Dr. Chrzastowski summarized the characteristics of the 63 miles of Illinois shoreline, which ranges from urban areas, to till bluffs, to beach accretion plains. He described the primary coastal engineering and processes research in which the Illinois State Geological Survey (ISGS) is involved.

In the area of coastal engineering, the ISGS contributes to the design and redesign of shore defense structures and makes recommendations for renourishment of beaches. The ISGS recommendation to the Chicago Park Commission has been to nourish the beach faces with pea gravel, which will have a longer residence time than sand, and to use sand across the berm and sun bathing areas for the comfort of park visitors. With regard to coastal processes research, the ISGS is involved in the determination of bluff recession rates, sediment budgets and the locations of drift cells, southern Lake Michigan sediment dynamics, and bathymetric profiling of the Illinois shoreline. The ISGS produces detailed bathymetric maps for the Illinois shoreline with resolution to 1 foot of water depth.

WAUKEGAN HARBOR

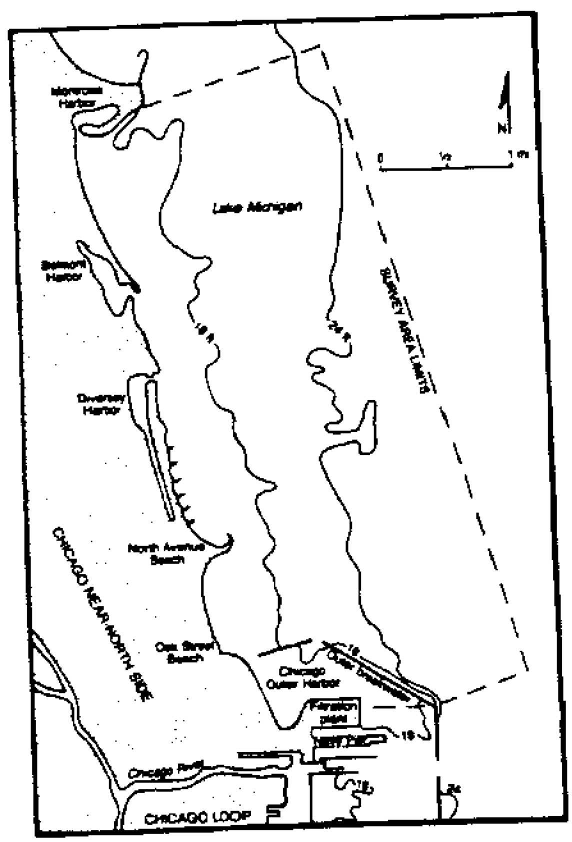


In addition, the ISGS is presently planning a cooperative research program with the US Geological Survey along the Illinois shore of Lake Michigan. The US Geological Survey will draw upon the expertise of the ISGS to implement all phases of the program. Bathymetric and seismic surveys are presently planned for Chicago's near north side (shown below). Also to be investigated is the local geological framework and historical lake level fluctuation.

The ISGS is committed to the examination of the Holocene lake level record. Investigation is needed for definition of the error bars on the "Larsen curve" (see page 34), and for location of additional sites to study.

The present needs of the ISGS, and Great Lakes research in general, include:

- more detailed information on nearshore sediment dynamics;
- an understanding of long-term lake level history;
- half-foot to one-foot contour topographic mapping along the shoreline; and
- better communication between the states involved in Great Lakes research, such as conducting informal yearly meetings.



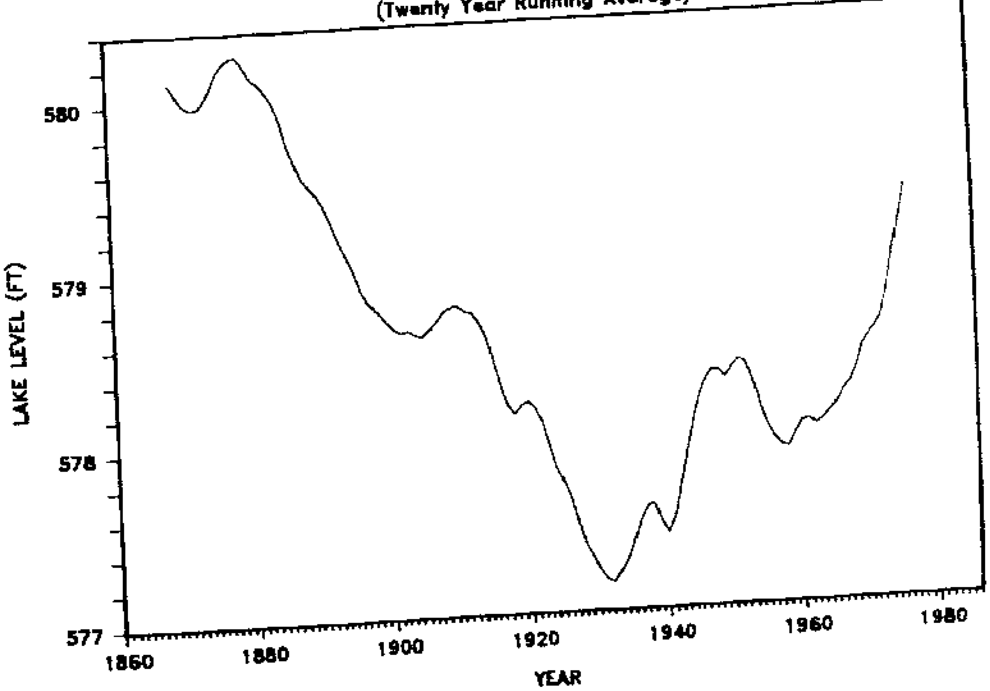
Indiana Geological Survey Role in Great Lakes Coastal Engineering Research

Todd Thompson Indiana Geological Survey

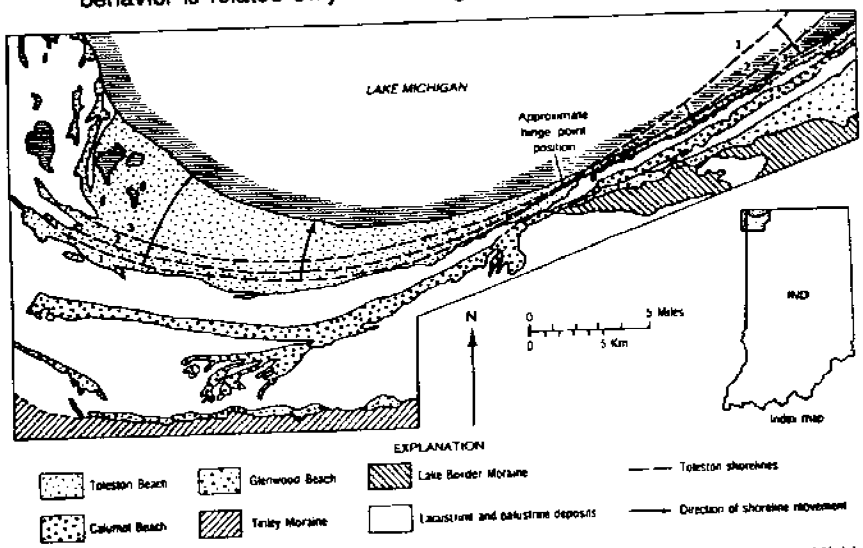
Dr. Thompson discussed historical patterns of lake-level behavior in the Lake Michigan basin from 1860 to 1986. He then described the value of the geologic record as a source of information about lake-level variations and announced the Indiana Geological Survey's intent to study the dune/beach complexes in northern Indiana.

A twenty-year moving average shows that lake level was high in the late 1800's, low in the 1930's and has been steadily rising into the 1980's. This data set suggests that a cycle of between 100 and 150 years occurs in the Lake Michigan basin, but this partial wavelength does not accurately define long-term lake-level behavior and cannot be used as a predictive tool. An alternative source of information is needed to estimate the magnitude and timing of future lake-level events. The geologic record is an important source of information about lake-level variation and can be used to predict future lake level change.

LAKE MICHIGAN: LAKE LEVEL
(Twenty Year Running Average)



The altitude of geomorphic features and sedimentary deposits such as beach ridges, coastal terraces, delta platforms, foreshore deposits and the contacts between nearshore sediments can be used to determine the altitude of past lake levels. The age of these levels can be established by careful consideration of spatial and stratigraphic relationships and by radiocarbon dating. However, this type of information is only useful if the record of shoreline behavior is related only to a change in lake level and



Geomorphic features along the southern shore of Lake Michigan

not to variations in sediment supply or hydrographic regime. The best pure record of lake-level fluctuation occurs along the southern shore of Lake Michigan in the Indiana Dunes. Here, over 140 beach ridges contain a 6000-year record of lake-level behavior in the Lake Michigan basin.

The Indiana Geological Survey intends to begin a study of the dune/beach complexes in northern Indiana (shown above) to better understand past lake-level and shoreline behavior in the southern part of the Lake Michigan basin. A proposal, "Lake-Level Variation in Lakes Michigan and Huron: Magnitude and Timing of Past and Future Fluctuations," has been prepared, and the Indiana Geological Survey is currently seeking funding for this project.

Argonne National Laboratory Role in Great Lakes Coastal Engineering Research

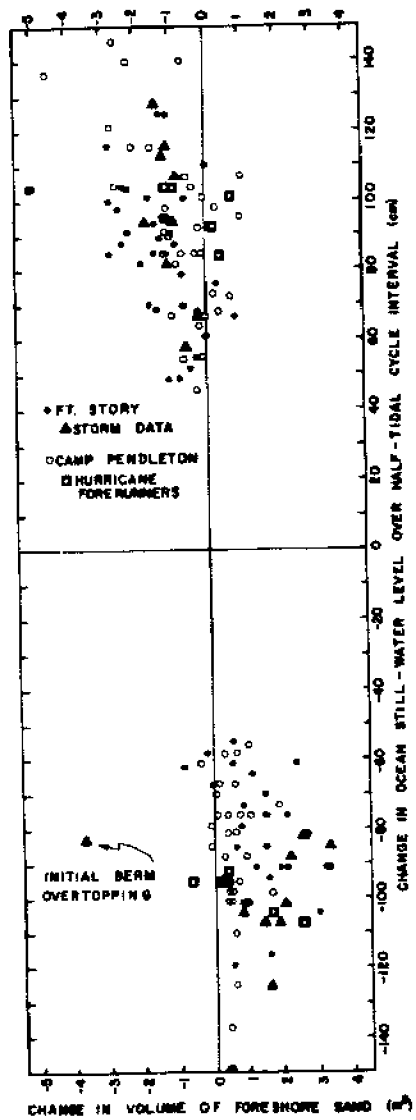
Wyman Harrison Argonne National Laboratory

Dr. Harrison opened with a description of the Argonne National Laboratory, indicating that it is owned by the U.S. Department of Energy and operated by the University of Chicago. He then described the coastal research of the Laboratory's Energy and Environmental Systems Division.

Argonne's Energy and Environmental Systems Division (EESD) began to study transport and dispersion in both air and water environments in the late 1960's. EESD has established a strong base of skills in modelling, field measurements systems, and model/measurement relationships. Models have been developed to predict the environmental impacts of newly deployed energy systems or changes in energy policy. Major studies have addressed ocean thermal energy conversion, satellite power systems, and sulfur dioxide air quality standards. Measurements have quite often been taken under circumstances in which existing data are inadequate and the physical problems complex, such as Lake Michigan coastal circulation, airport air quality measurements, and lakeward transport of oily waste from the Indiana Harbor Canal. Numerical model predictions for the dispersion of thermal plumes from power plants, as the plumes enter the Great Lakes, have been compared with prototype measurement values. Results from a Lake Michigan circulation model were compared with a reasonably long time series of wind and offshore lake current measurements. An essential element of model evaluation is the careful planning of field measurements for the specific evaluation.

An example of a typical model evaluation for the coastal environment is the one EESD performed on the University of Delaware's nearshore circulation and two-dimensional wave model. Field measurements for two storm events were taken on the western shore of Lake Michigan near Zion, Illinois, by EESD and university personnel. Inputs to the model were deep-water wave characteristics, nearshore bathymetry, and wind speed and direction. The Delaware model generates the wave field, two-dimensional nearshore currents, the location of the breaker zone, and mean changes in water level. EESD model evaluation consisted of model response studies based on field data for all necessary model parameters. The model response studies involved analyzing time steps and model resolution capabilities, as well as model sensitivity to variations in input values for wave characteristics, water level, and bottom friction. The data were compared with the wave field, nearshore current profiles, beach deformation, and runup measurements. In general, the model predicts peak currents and breaker location well, but has a problem in the area of the nearshore trough. Otherwise, model circulation simulations reflected well the effects of nearshore bathymetry, particularly the nearshore bars. The model showed some deficiencies along a barred coastline in its treatment of reflection from the bar, broken-wave dynamics, and horizontal mixing.

The varied experience of EESD provides tools for two types of sponsor needs: independent study and technical assistance. The former can lead to new models or measurement techniques, and the latter to research team input, policy review participation, and screening of models.



An ocean coast field investigation warranting attention because of its possible application to Great Lakes beach response studies is an 18-month study of beach profile changes in response to storms 20 years ago along the outer coast of Virginia. Results showed that the volume of eroded material over several storm-tide cycles was directly related to the volume of sand available prior to storm activity; that is, a large initial sand volume leads to beach erosion, and a low sand volume leads to deposition. More detailed studies of beach changes conducted over a lunar month showed that the rising tide generally produced erosion, whereas the falling tide produced deposition. These results are simply a short-term version of the long-term changes experienced along the sandy shores of the Great Lakes.

National Weather Service Role in Great Lakes Coastal Engineering Research

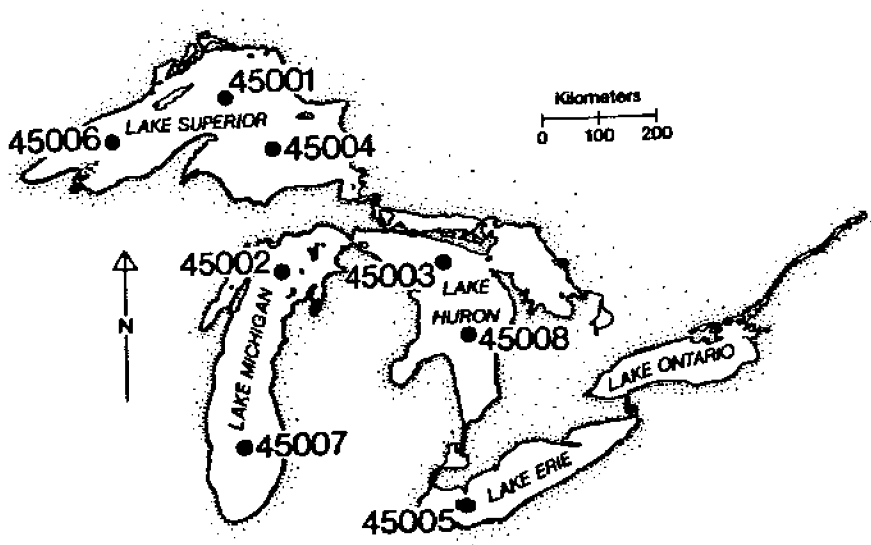
Robert Snider National Weather Service

Mr. Snider explained the mandate of the National Weather Service and described its data gathering, modelling, and forecasting activities that relate to the coastal zone.

The mandate of the National Weather Service (NWS), a branch of the National Oceanic and Atmospheric Administration (NOAA), is to warn of the approach and force of storms. It is neither a research nor data archive organization.

Presently, NWS activities consist of 75 percent data gathering and 25 percent forecasting and warning. To improve upon this, the NWS is undergoing a 5-to-8-year reorganization which will reverse these ratios through automated data gathering.

The NWS plays an indirect role in coastal engineering research, by gathering meteorological data and passing it on to the National Data Center. Wind waves, measurements of high importance to coastal engineers, are measured on the Great Lakes by a number of techniques. The most reliable of these is the National Data Buoy Center's automated weather reporting stations in 8 mid-lake locations (shown below). The buoys report air pressure, air temperature, water temperature, and wind velocity and direction



in addition to wave information. The return is greater than 75 percent for all buoys. This technique has, however, only been in operation since 1979 and thus the forecasting techniques do not yet reflect these more accurate measurements. The present forecasting techniques are based upon old wave data which are estimates provided by visual observation.

The Coastal Marine Network is a data base which reports meteorological data, including rainfall, throughout the coastal regions. This data base may contain high density data coverage useful in many coastal engineering applications.

Standard meteorological forecasts are based upon Upper Air Balloon Network data. The upper atmosphere is where the energy resides that produces physical processes on the Great Lakes. The National Meteorological Center transmits this data once every 12 hours, and the data is in turn analyzed and derived parameters are provided to local forecasting offices. The most important numerical weather models, from a coastal engineering standpoint, are the pressure pattern forecasting models which derive the winds over the water surfaces and thus waves and storms. Ship observations of wind are more trustworthy than the wave observations; however, the forecaster still works primarily from theoretical models.

Water level measurements are provided by the US Coast Guard and the US Army Corps of Engineers. This information constitutes the basis of the water level/flooding forecasts. The effects of water level on coastal erosion are not a concern of the NWS. Although the results are catastrophic, they are not considered imminent, as in the case of flooding. However, the same program which forecasts water levels for flooding could be used for coastal erosion concerns.

To gain access to the information collected by NWS, the user must contact the National Climatic Data Center in Asheville, North Carolina, for all data except that for ice and snow, which is compiled at the World Data Center for Glaciology in Boulder, Colorado. It is possible but costly to gain access to the NWS computer data base system. The Great Lakes Environmental Research Laboratory has this capability.

National Sea Grant Role In Great Lakes Coastal Engineering Research

Michael G. Parsons

Chairman, Dept. of Naval Architecture and Marine Engineering
The University of Michigan
Director Designate, Michigan Sea Grant College Program

Dr. Parsons described the National Sea Grant priorities relative to coastal processes as relayed to him by Mr. Curt Mason of the National Sea Grant Program Office.

The first National Sea Grant Coastal Processes Project, the Nearshore Sediment Transport Study (NSTS), and the Corps of Engineers' general investigation of tidal inlets have provided a wealth of information on hydraulic processes, but have left unanswered many questions concerning sediment transport. Developing initiatives in the US Geological Survey concerning coastal processes and the National Science Foundation workshop studying the development of coastal monitoring of sedimentation should enhance Sea Grant plans to develop initiatives to address coastal processes needs.

One of the Sea Grant objectives outlined in the 1976 reauthorization addresses ocean and coastal resources, including coastal problems. This called for "increased understanding, assessment, development, utilization and conservation of the nation's ocean and coastal resources by providing assistance to promote strong education base; responsive research and training activities, and broad and prompt dissemination of knowledge and techniques." The recognized need for coastal processes research, increased public awareness of coastal problems, and recognition within the academic community of the opportunity for constructive research presents an opportune time to develop a strategic Sea Grant initiative.

There are four basic research needs in the field of coastal processes which closely parallel those identified by other agencies in formulating their research projects.

Sediment Transport Processes:

- Development of measurement and prediction techniques under a variety of conditions;
- Detailed investigation of cross-shore sediment motion;
- Development of statistical data bases of temporal variability of tide and wind driven currents;
- Data collection during events of short time scale for understanding of long-term transport processes.

Coastal Hazards:

- Prediction of extreme events and effects of coastal environment (storms, hurricanes, tsunamis, ice, lake level or sea level fluctuations);
- Mitigation of damage;
- Provision of better ways to deal with physical and economic impacts.

Sea Level Rise:

- Improvement of sea and lake level rise and impact predictions;
- Assessment of impacts on engineering of shore protection structures and management strategies.

Inlet and Harbor Entrances:

- Increase understanding of sedimentary processes controlling inlet behavior (sediment storage, bypassing, channel stability, etc.);
- initiation of cooperative large scale field investigations for moveable bed model verification.

The consistently increasing focus on the coastal zone, combined with a dearth of knowledge in sediment processes affecting long term planning for major federal, state and local concerns, result in a real need for a Federal advocacy to encourage, fund, and coordinate a focused national effort.

Appendix B

Invitees

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