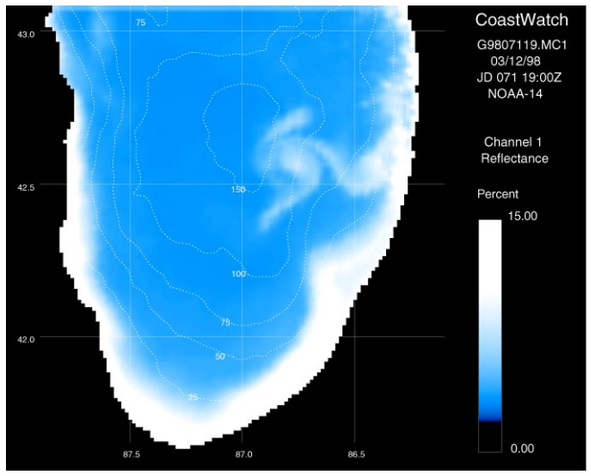
Episodic Events: Great Lakes Experiment

The Impact of Episodic Events on the Nearshore-Offshore Transport and Transformation of Biogeochemically Important Materials in the Great Lakes

In August, 1997 the NOAA-Coastal Ocean Program and National Science Foundation-Coastal Ocean Processes began a jointly funded program to study the impact of episodic events in Lake Michigan. EPA-GLNPO (Great Lakes National Program Office) has become a partner in this effort. The EEGLE program is being coordinated by NOAA-GLERL and is scheduled to include three field years and two years of subsequent interpretation and product development.

Episodic Event: Recurrent Coastal Plume

In lakes and coastal ecosystems a tight coupling exists between contaminated sediments and overlying water through the process of sediment resuspension. The materials available for resuspension at the sediment-water interface have been mixed by organisms and physical processes through an interval that represents approximately 20 years. Once or twice a year, massive resuspension of the large inventories of nutrients and contaminants deposited over the past few decades (e.g. P, ^{137}Cs, PCBs), results in much greater fluxes to the water column than from all external inputs and profoundly influences biogeochemical processes in coastal ecosystems.



March 12, 1998 sediment resuspension event. White areas are regions of high turbidity.

Ecological Importance

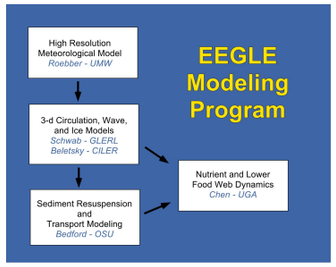
Satellite observations of suspended sedimentary material in Lake Michigan illustrate a unique opportunity to investigate an annually recurrent major episode of nearshore-offshore transport, a 10 km wide plume of resuspended material extending over 300 km along the southern shores of the lake which veers offshore along the eastern shore, coincident with the area of highest measured sediment accumulation in the lake. The inventory of particulate matter in the plume, on April 2, 1996, was estimated to be approximately 1 million tons, equal to the total annual load of fine sediments into the southern basin. The 1998 event appears to have been larger.

We believe this type of event is ideal for studying internal recycling of biogeochemically important materials and ecosystem responses. While we are focusing on a particular episodic process in southern Lake Michigan, the program results will be applicable to similar events in many coastal areas.

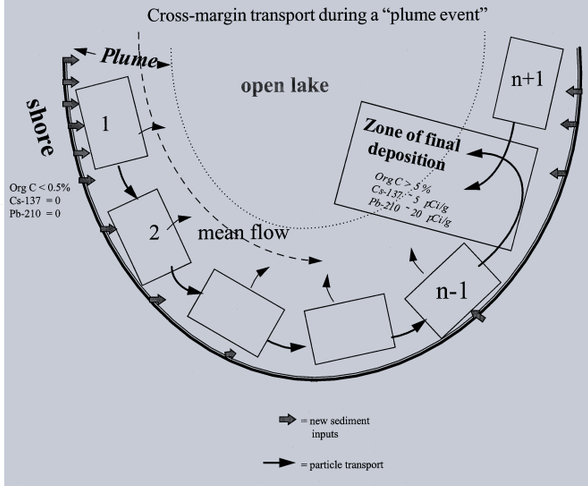
R/V LAKE GUARDIAN in Chicago.

Study Approach

One of the challenges of studying episodic events is the "unpredictable" timing of the particular event. The onset of the annually recurrent southern Lake Michigan plume has been documented as early as February (1995) and as late as May (1994). A team of over 40 environmental scientists from federal agencies and universities have put together a comprehensive interdisciplinary research program to study the Lake Michigan plume. Teams of specialists in remote sensing, physical oceanography, HF radar, hydrodynamic, meteorological, and sediment transport modeling, post-depositional sediment behavior, environmental radiotracers, phosphorous processes, phytoplankton processes, copepod reproduction, and lower food web structure are all coordinating their efforts, focusing on the same study region. This provides a unique opportunity for new insights into coupling between biological, chemical, and physical processes.



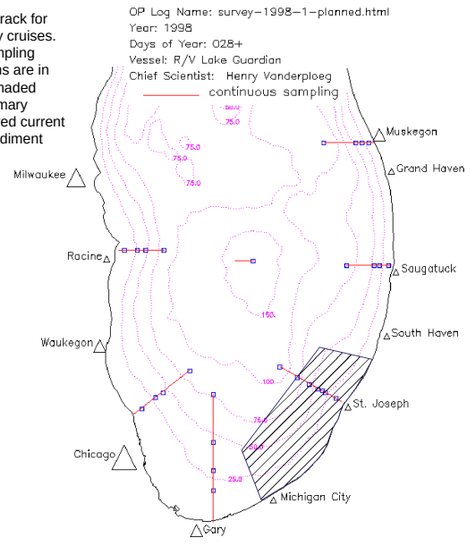
In early fall of 1997, the first large array of scientific equipment was deployed in a 1,500 square mile region off of St. Joseph, Michigan. Some of these moorings measured water velocities and temperatures throughout the water column, others collected the plume materials as they sank towards the lake bottom. These measurements were complemented by satellite-tracked drifters used to measure the large scale circulation and to track the plume itself when it occurs. For the first time anywhere in the Great Lakes, two coastal over-the-horizon radar sites were also installed and used to study surface currents, winds, and wind waves. During the 1998 plume event, multiple shipboard surveys, including rare late-winter cruises, were completed and data and samples were collected for further analysis.



A simple conceptual model of the movement of particles in the coastal plume in the southern basin of Lake Michigan. Particles derived from the western shore move counter-clockwise with the mean circulation. Major questions include how quickly these particles move from source to sink, the number of deposition/resuspension cycles that they undergo in transit, the transformations that occur in route, and offshore transport. An important parameter therefore is the residence time for particles within the plume, a function of both the inventory in each compartment and the flux "down stream." Radionuclides may be used to "clock" the speed with which particles move and yield the "apparent age" of particles within the system.

During this first year, the program was fortunate to have the opportunity to examine a very large event. Only once before, in its 37 years of intake turbidity records, did the St. Joseph water treatment plant experience an event of similar magnitude. Although not scheduled to be a full field year, efforts were made to exploit this opportunity. Seventeen cruises on four different vessels totaling approximately 60 days and a 1 day Coast Guard helicopter drifter deployment flight have been completed so far.

Planned ship track for EEGLE survey cruises. Boxes are sampling stations, depths are in meters. The shaded area is the primary focus for moored current meters and sediment traps.



Preliminary Findings and Products

Preliminary findings from our efforts include:

- high particle fluxes associated with the event synchronized throughout the basin
- elevated phosphorus concentrations within the plume
- low primary production (due to light limitation)
- elevated bacterial recycling within the plume
- elevated PCB concentrations within the plume.

The critical question is how does the ecosystem respond to these events which differ in timing and intensity.

In addition to publications and presentations at scientific meetings, there have been coordinated press releases, 11 newspaper articles, and other outreach including:

- Briefing to St Joseph City Commissioners and Public, St. Joseph, MI, June 1998.
- Briefing to the Board of Directors of the Lake Michigan Federation, Milwaukee, WI, Feb. 1998.
- 2-pg EEGLE Brochure distributed to all PIs in program for further distribution (1500 copies), GLERL Publication, 2p, September, 1997.

Additional information can be downloaded from:
www.glerl.noaa.gov/eegle/
Satellite images of the Lake Michigan plume can be downloaded from:
www.glerl.noaa.gov/eegle/resources/
and the GLERL Home Page URL is:
www.glerl.noaa.gov

Eleven of these sequential sediment samplers developed at GLERL were deployed in southern Lake Michigan to collect plume particles as they settle towards the lake bottom. The traps are programmed to collect 23 samples over a period of 10 days each.

Box coring from the University of Michigan's R/V LAURENTIAN

Current meters aboard the R/V SHENEHON.

Participants

Plans

Survey cruises will continue throughout the summer to evaluate the plume's effect on the lake ecology. Fifteen current meters have been retrived, and deployment of more extensive mooring arrays (current meters and traps) are scheduled for late summer/fall. Most of our planned effort in the summer will be the interpretation of the first years' data. New activities have been added to the EEGLE program: (1) the EPA-Great Lakes National Program Office has funded an important study to examine the impact of the plume on PCB cycling, (2) NOAA-GLERL has provided funding for the Physical Group of the Canada Centre for Inland Waters to deploy five ADCP current meters and two meteorological towers and also funding for the purchase and deployment of pressure sensors to measure waves under ice.