

plankton communities. In addition, *Cercopagis* may impact fish populations by competing with newly-hatched fishes for small prey items, or conversely, by becoming prey itself for fish beyond the first year.

### **Prevention of Future Introductions from Ballast Water**

The primary vector for unintentional invasions of aquatic nuisance species is ballast water in ships. Over the past 10 years, virtually all of the known invasive species introductions have been associated with ballast water. The problem of exotics in ballast water has risen to attention in the U.N. International Maritime Organization (IMO) as a serious environmental issue and has now received attention from a number of the maritime nations, with Australia, Canada, and the U.S. taking the lead.

The Great Lakes regime established under the U.S. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 and NISA (1996) is as yet the only general, mandatory control regime that is based on research and guidelines previously developed by Canada and Australia. The existing Great Lakes regime requires vessels entering from the sea to either exchange ballast during their ocean voyage or seal ballast tanks for the duration of their stay. The increase in salinity from a ballast exchange kills many freshwater organisms that may be in the vessel's tanks.

### **The Challenge of Managing Ballast Water**

It is now widely recognized that ballast exchange is not safe or practical for a significant number of ships without some alteration of tanks or piping systems. Therefore, it is imperative to develop improvements in the design of ballast systems allowing for either improved exchange or treatment of the water. The problem is further compounded by the fact that many water vessels enter the Lakes fully loaded and, thus, have no ballast on board ("NOBOB" vessels). However, there is always a small amount of ballast water that cannot be pumped out and that water is enough to support fishlife. Also, over time, bottom sediment collects in ballast tanks and that "mud" can likewise support fish and plant life.



**Preventing the introduction of exotics via ballast water is of paramount importance in the Great Lakes.**

The most recent review of potential ballast water control options conducted by the U.S. National Research Council Marine Board indicated that four options should be given priority consideration: (1) filtering; (2) nonoxidizing biocides; (3) heat; and (4) retrofitting or redesign of ballast systems to allow safe and effective exchange. These approaches are addressed in a "Binational Ballast Water Research Strategy and Plan" laid out in the 1996-1997 *Binational Report on Protection of Great Lakes Water Quality* submitted by Canada's Department of Fisheries and Oceans, Transport Canada Marine Safety, and the U.S. Coast Guard in October 1997. This binational report presents a clearly focused plan, supported by both the Canadian and U.S. agencies responsible for regulating ballast water, for conducting the additional work that needs to be done to raise the level of protection for the Great Lakes watershed and the North American continent in the near future.



## **Coast Guard Actions to Prevent Invasive Species Introductions**

In 1998, the Coast Guard published a draft national ballast management program pursuant to NISA and is expected to issue final rules for U.S. national ballast management. Beginning on July 1, 1999, all ships entering the U.S. must tell the Government what they have done on the high seas to protect American waterways from invading species. This interim regulation puts into action a 1996 law extending to all ports measures that had been in effect only on the Great Lakes. The year 2000 is the earliest date an international ballast management regulation (currently under development by the IMO) could be enacted. In a move supportive of the Coast Guard measures, the National Aquatic Nuisance Species Task Force passed a resolution on April 30, 1999, to accelerate its efforts to eliminate invasive species that enter U.S. harbors through ballast water pumped from ships.

Preventing introductions via ballast water will not end the potential for new invasive species in the Great Lakes. Intentional and unintended releases will still occur. Educating the public about the impacts of these foreign invaders to the basin ecosystem and restoring native populations are equally important components for addressing this ongoing issue.

## **MONITORING THE GREAT LAKES**

Ongoing monitoring is essential to successfully manage the natural resources and ensure the environmental protection of the Great Lakes. Yearly or cyclical monitoring ensures that the effectiveness of long-term programs can be assessed and enables the early detection of new environmental problems. Special short-term studies can help elucidate more specialized information as needed. Together, this information helps researchers and managers separate the effects of each of the stressors that influence the biology and chemistry of the Great Lakes. Through a partnership of Federal, State, and Tribal agencies, the Great Lakes monitoring programs help develop more informed and improved decisions for restoring and maintaining a healthy ecosystem.



**Monitoring the health of the Great Lakes is a cooperative effort involving all levels of government .**

### **Open Water Monitoring**

Open water programs help track progress made towards mitigating long-standing problems in the Great Lakes, such as PBTs and nutrient enrichment (eutrophication). Monitoring programs help determine sources of PBTs and how they move through the ecosystem. Similarly, nutrient trends and loads can be determined, as well as the resulting effects on nuisance algae, oxygen concentrations, and fish community structure. These studies help direct resources to where they will have their greatest impact.

Three Federal agencies implement significant open water monitoring on the Great Lakes: NOAA, USGS, and EPA's GLNPO (air toxicants monitoring is addressed in the air toxics section of this report).

### **National Oceanic and Atmospheric Administration**

Most of NOAA's Great Lakes research is performed at the GLERL. GLERL is multi-disciplinary, with the goal of developing and advancing improved understandings of the structure and function of the Great Lakes and

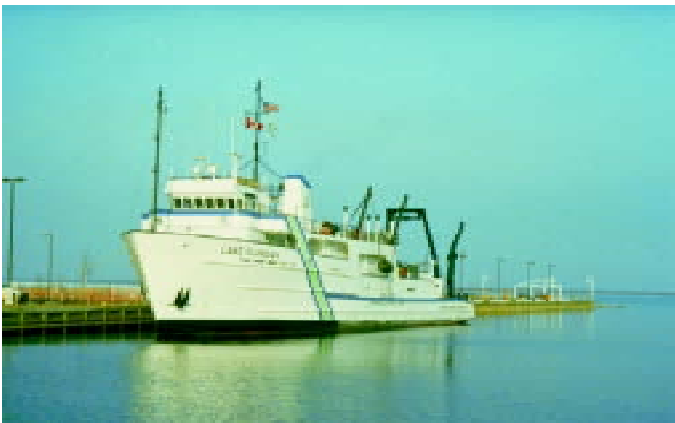


other coastal ecosystems. GLERL performs research in several core programmatic areas, furthering our understanding of the Great Lakes ecosystems and how they can be sustained. These core programs include field and laboratory nonindigenous species research, lower food web studies, toxic organic contaminants studies, and climate change analyses.

### **U.S. Geological Survey**

The USGS Great Lakes Science Center (GLSC) uses interdisciplinary approaches, teams, and collaboration to provide the information needed to solve the complex biological issues and natural resource management problems facing the Great Lakes ecosystem. Center staff have a wealth of expertise in fish stock assessment and community dynamics, aquatic habitat and food web interactions, nearshore and coastal wetlands, terrestrial ecology, and exotic species.

The GLSC operates five research vessels, one on each lake. The vessels are equipped for fish population assessment studies, as well as for limnological and habitat sampling. The Center also has extensive laboratory facilities. Studies are conducted in the field and in the Center's laboratories to provide information for management of populations and control of exotic nuisance species. Key species, such as lake trout and their prey, are studied to restore and enhance fish populations. Field studies range from evaluating habitat, such as oak savannah, to determining the spread of zebra mussels and their impact.



EPA's state of the art Great Lakes Research Vessel, *R/V Lake Guardian*.

### **Great Lakes National Program Office**

As part of its long-term trends program, the EPA's GLNPO conducts biannual monitoring surveys of the Great Lakes from the *R/V Lake Guardian*.

The objectives of the surveys are to:

- assess the state of water quality in the open lake basins (water greater than 30 meters in depth or greater than 3 miles from shore);
- provide data to detect and evaluate trends and annual changes in nutrients, phytoplankton, and zooplankton; and
- provide data sufficient to verify or modify water quality models.

The *R/V Lake Guardian* also assists other Great Lakes monitoring as well, including the Lake Michigan Mass Balance and the Episodic Events-Great Lakes Experiment (EEGLE) Study.

### **Cooperative Monitoring Programs**

Certain Great Lakes studies are beyond the scope of any one agency. Various partnerships of Federal, State, and Tribal agencies have been established for several new Great Lakes monitoring programs over the past 2 years as well as continuing their efforts on the ongoing Great Lakes Fish Contaminant Monitoring Program.

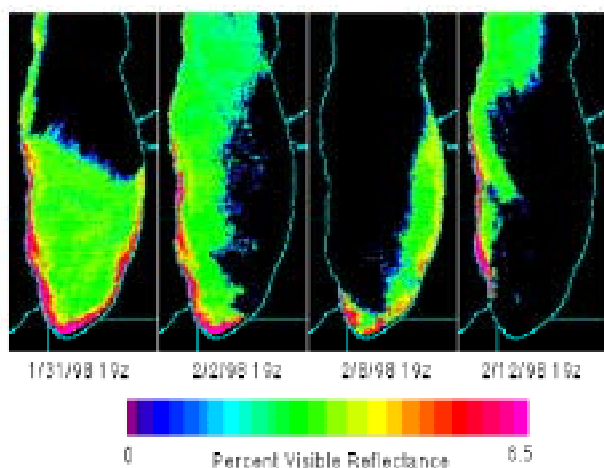
### **Great Lakes Fish Contaminant Monitoring Program**

The Great Lakes Fish Contaminant Monitoring Program (GLFMP) began in 1980 as a cooperative effort by EPA, the U.S. Food and Drug Administration, the Biological Resources Division of the USGS (formerly part of FWS), and the eight



Great Lakes States, to monitor and better define the fish contaminant problem in the Great Lakes. The GLFMP has, since its inception, served as a model for interagency cooperation and coordination.

There are two major components of this program. The first focuses on evaluating the impacts of contaminants on the fishery; the second focus is on quantifying potential human exposure to contaminants through fish consumption. The impacts on the fishery are investigated by the collection and analysis of lake trout (walleye in Lake Erie) and their primary forage from each of the Great Lakes. Water column contaminant data have also been collected to assist interpretation of fish contaminant trends, and to allow for calculation of exposure of open lake fish to contaminants.



**Figure 29. Southern Basin Plume as identified during the EEGLE study (Source: NOAA-GLERL/**

Potential human exposure to contaminants is monitored by sampling two popular sport species: coho and chinook salmon. The inclusion of coho salmon in this program also provides a snapshot of contaminant concentrations across the Great Lakes in fish of consistent age. These top predator species typically have shorter exposures than the lake trout and walleye. Coho and chinook salmon are collected by the eight Great Lakes States from tributary mouths during the fall spawning run. In Lake Erie, rainbow trout are also collected from the Ohio and Pennsylvania waters.

### ***Episodic Events-Great Lakes Experiment (EEGLE) Study***

NOAA's GLERL is leading a study of the impact of episodic storm events on sediment resuspension and constituent transport, and the subsequent ecological effects, in Lake Michigan. During 1998, a record resuspension event occurred, creating a plume of high turbidity that spread around the perimeter of the southern basin (Figure 29). A total of 38 cruises on four different vessels totaling approximately 120 days and a 1-day Coast Guard helicopter drifter deployment flight were conducted. In addition to extensive sampling of the resuspension plume and background environments, several new instruments were tested.

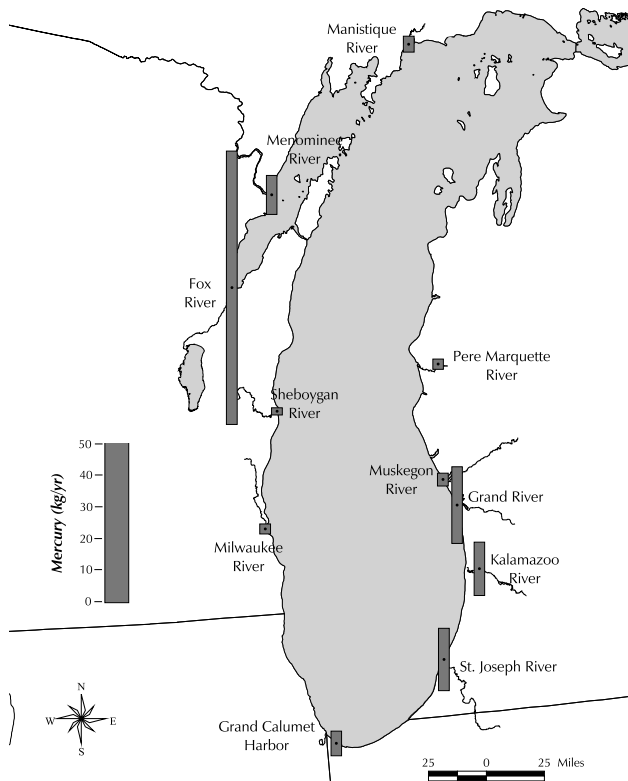
A complementary study of the importance of such episodic resuspension events to the cycling of contaminants has also been initiated by GLNPO. Researchers onboard the *R/V Lake Guardian* measured levels of PCBs and PAHs in both the air and water in order to determine the influence of this plume on the rate of exchange of toxicants between air and water.

### ***Lake Michigan Mass Balance***

The Lake Michigan Mass Balance Study/Enhanced Monitoring Program is the largest multimedia toxic contaminant monitoring and modeling project ever undertaken by EPA. It is designed to answer questions that will help environmental managers make well informed, scientifically-based decisions on reducing toxic pollutants in Lake Michigan. The mass balance model will determine what effects reduction in pollutant loads will have on the lake and, in particular, on contaminant levels in fish tissue. The model's findings will help target future Lake Michigan LaMP toxic load reduction efforts at the Federal, State, Tribal, and local levels. EPA will use the lake models, including computational transport models, mass balance models, and bioaccumulation models, in conjunction with measured constituent loadings, to simulate the seasonal cycle of primary production in the lake, as well as the transport, exchange, phase distribution, and biogeochemical transformation of the target chemical pollutants through the water column and the sediments.







**Figure 30.** The Lake Michigan Mass Balance Study has identified levels of mercury loadings from various Lake Michigan tributaries (Source: Lake Michigan Mass Balance, U.S. EPA, 1999).

### **St. Louis River Loading Study**

In September 1999, the MPCA, under an EPA grant, completed a study on toxicants loading to Lake Superior from the Duluth-Superior Harbor. The study found that some toxic contaminants (such as mercury, dieldrin, DDT, PCBs, and 2,3,7,8-TCDD) regularly exceed water quality standards in parts of the lower St. Louis River. The MPCA has listed the reaches that exceed standards for these chemicals on the draft 2000 303(d) list. The study also found that the load of some chemicals leaving the harbor and entering Lake Superior was greater than the load to the harbor from the St. Louis and Nemadji Rivers. This suggests that the harbor is an additional source of dieldrin, DDT, and PCBs. The study also estimates that the St. Louis River system contributes less than 2 percent of the toxicants loading to Lake Superior.

### **Lake Ontario Biomonitoring Project**

The Lake Ontario Biomonitoring Project is a cooperative long-term study being carried out by NYSDEC, FWS, the MCDH, and Cornell University. The program provides basic information on the status of the lower food web of Lake Ontario and links with closely allied projects such as current Sea Grant projects assessing the role of embayments and inshore habitats as critical nursery grounds for alewife; the ecology of new exotic zooplankton, *Cercopagis pengoi*; and the early life history of trout and salmon. Nutrients, phytoplankton, and zooplankton are sampled from spring through fall at several embayment, nearshore and openwater stations that allow the identification of temporal and geographic trends. This information will help better understand the impacts that the zebra and quagga mussels have had on the system. A similar cooperative monitoring project is being initiated for Lake Erie.

### **A New Partnership: The Lake Michigan Monitoring Coordination Council**

The Lake Michigan Monitoring Coordination Council was established jointly by various Federal, State and Tribal agencies involved in the environmental protection and resource management efforts in the Lake Michigan basin, in conjunction with the National Water Quality Monitoring Council. Its mission is to provide a forum for the coordination and support of monitoring activities in the basin and to develop and make available a shared resource of information, based on accepted standards and protocols, that is usable across agency and jurisdictional boundaries.

### **State of the Lakes Ecosystem Conference (SOLEC)**

The third biennial SOLEC was held October 21-23, 1998, in Buffalo, NY, and attended by over 450 people who make decisions that affect the Great Lakes. During the year prior to SOLEC'98, an intensive binational effort was directed toward establishing a consistent, easily understood set of ecosystem indicators to allow for more



coordinated monitoring and better reporting on progress achieved under the GLWQA. The indicators were organized around seven principal categories: open and nearshore waters, coastal wetlands, nearshore terrestrial areas, human health, land use, and stewardship. After the conference, the list was refined to reflect the comments and observations received at SOLEC'98, and it will be widely distributed for review and suggestions by all Great Lakes stakeholders.

## PUBLIC ACCESS TO ENVIRONMENTAL INFORMATION



The U.S. Great Lakes Program recognizes the importance of citizen knowledge of and participation in issues of environmental significance. It is because of this that program partners constantly strive to identify new means of disseminating information to the public. The Internet has proven to be an excellent tool in the effort to increase public access to Great Lakes environmental information.

Many agency home pages on a wide variety of topics are now available to the public. The Great Lakes Information Network (GLIN), financially backed in part by GLNPO, provides information relating to the binational Great Lakes region at:

***<http://www.great-lakes.net>***

A great number of high quality spatial data sets covering the Great Lakes region are owned, enhanced, and used by a few Federal, State and Provincial agencies. At this time, there is no easy, reliable, and cost-effective mechanism to promote data-sharing and coordination. Based on GLIN's formula for building online partnerships among U.S. and Canadian agencies and organizations, the Great Lakes GIS Online project will provide a solid foundation for interagency spatial data sharing and collaboration.

EPA's "Surf Your Watershed" Internet site, which houses the Agency's first comprehensive

assessment of U.S. watersheds, allows the public to locate, use, and share environmental information on a particular watershed or community. The main purpose of "Surf Your Watershed" is to get environmental information into the hands of citizens and groups active in protecting and managing the environment. Providing the public with this information is an extremely important step in improving our nation's water quality and protecting the health of the American public. This site can be found at:

***[www.epa.gov/surf](http://www.epa.gov/surf)***

A particular watershed can be selected by using maps or searching by State, Indian Tribe, County, or zip code. A search can also be based local stream names, water bodies, or even large-scale ecosystems. At the state or watershed level, there is information regarding protection efforts, environmental/public health conditions, fish advisories, drinking water, land use, population, Superfund sites, and effluent discharges. The public also will be able to retrieve the overall score for a watershed, which will reflect conditions and vulnerability, additional information provided by states, and links to public and volunteer organizations working to protect and restore water at the regional, State, and watershed level. A map of the watershed or area can also be requested. An index of watershed indicators is located at:

***[www.epa.gov/surf/iwi](http://www.epa.gov/surf/iwi)***

The Great Lakes Computer Center provides a database to support regional information systems including Great Lakes Envirofacts, which consists of EPA facility information in an easily accessible format, RAPIDS, and the database of the Lake Michigan Mass Balance. The public is now able to easily search Great Lakes Envirofacts through the Internet at:

***[www.epa.gov/enviro](http://www.epa.gov/enviro)***

GLNPO, through a grant to the Great Lakes Commission, has developed a publicly-accessible homepage to provide information on AOCs. The site provides multi-part reports on each of the AOCs. The reports begin with



background information such as the location of the AOC, the use of the AOC, the community surrounding the AOC, and the reason why the AOC is polluted. The report also lists the status of each of the 14 beneficial uses. The final section of each article illustrates graphically the RAP status: how close to completion the RAP is for problem definition, planning, implementation, and restoration of beneficial use. The text portion of this section describes these efforts in detail. This information can be viewed at:

**[www.epa.gov/glnpo/aoc](http://www.epa.gov/glnpo/aoc)**

EPA continues to distribute large numbers of the popular third edition of *The Great Lakes: An Environmental Atlas and Resource Book*, which was co-authored with Environment Canada. This excellent resource has been distributed to many of the Basin's schools and libraries as well as to a variety of other public and private institutions. The atlas is also available on the Internet at:

**[www.epa.gov/glnpo/atlas/intro.html](http://www.epa.gov/glnpo/atlas/intro.html)**

EPA has initiated the Sector Facility Indexing Project to make it easier for the public to evaluate the environmental records of facilities and compare their environmental performance. This initiative is the first time that cross-program EPA data has been compiled in one place in a manner that will allow examination of facility-level environmental records. Data collected under the Clean Water Act, Clean Air Act, RCRA, and the TRI for five industry sectors (petroleum refining, iron and steel, pulp mills, primary nonferrous metals, and automobile assembly) relating to past compliance history, facility size, pollutant releases and toxicity, and surrounding population has been aggregated and is available for public review at:

**<http://es.epa.gov/oecalsfil>**

GLERL and the Ohio State University have successfully developed and implemented the Great Lakes Coastal Forecasting System, which makes regularly scheduled forecasts of the physical environment and related variables, such as surface water temperature, vertical temperature structure, water surface elevation

and currents for Lake Erie; and wind fields and wave heights for all the Great Lakes. This information can be found at:

**<http://superior.eng.ohio-state.edu/>**

The state of Michigan has created two web sites containing important Great Lakes information. The first site, describing the Lake Huron Initiative, can be found at:

**[www.deq.state.mi.us/logllhuron.html](http://www.deq.state.mi.us/logllhuron.html)**

Another site containing information on Great Lakes trends can be found at:

**[www.deq.state.mi.us/logllTrends.pdf](http://www.deq.state.mi.us/logllTrends.pdf)**

The Inland Seas Education Association will design, program, and set-up an interactive website to expand and enhance its education program entitled "Schoolship." Through the "virtual schoolship," those students unable to participate in education programs on-board an Inland Seas research vessel will be able to interact online. Students will be able to download and manipulate data, request specific information, and ask questions of Schoolship professionals and other Schoolship participants. They will be challenged to navigate through the website, perform virtual testing and sampling, view pictures, and record observations. The website will also facilitate participation in the pre/post "Schoolship" activities and will enable students to apply their knowledge to their own communities.



**The Great Lakes Science Center in Cleveland allows for "hands on" learning about the lakes.**



The Northern Michigan University Seaborg Center will create a comprehensive water quality monitoring program in their local watershed. Ten middle and high schools will monitor the quality of their local water supply with equipment provided by the Center. Data collected will then be posted on a website along with other water quality information and resources. Teachers in participating schools will attend two water education workshops in which they will learn how to incorporate interactive activities into their classroom curriculum. Participating schools will also conduct a public education session for their local community in which they will educate residents about water quality issues.

Cleveland's GLSC, a museum dedicated to educating the public on science and the Great Lakes in a hands-on, interactive manner, opened in July 1996 to throngs of school children and others, pushing first year attendance numbers well above the goal of 650,000. Aided by a \$2 million grant from EPA, the museum will use the hands-on approach to serve one of its primary goals of being an engine for science education for school-aged children.

## ENVIRONMENTAL REGULATION AND COMPLIANCE



Figure 31. Great Lakes Water Quality Initiative

The commitment to ecosystem protection is buttressed by strong compliance with and enforcement of environmental laws. State and Federal agencies continue to develop necessary

regulations and take enforcement actions around the Great Lakes region. Some examples follow.

### **Implementation of the Great Lakes Water Quality Guidance**

The Great Lakes Water Quality Guidance (the Guidance) establishes consistent goals for state water quality management plans, which are critical to the success of domestic and international efforts to protect and restore the Great Lakes Ecosystem. Over the past 2 years, all of the Great Lakes States and the Oneida Tribe have adopted and implemented revisions to their water quality standards to comply with the Guidance, with a few insignificant exceptions. The States are also using the procedures outlined in the Guidance to derive new criteria and values where they are needed to protect aquatic organisms, wildlife, and humans. New York State has chosen to apply the water quality standard-based provisions of the Guidance statewide. EPA is actively reviewing the State standards and implementation procedures, a process that turned out to be significantly more complex than was anticipated. Several Great Lakes Tribes are also developing water quality standards.

The Guidance uses current scientific principles and data analysis to address the threat of persistent toxic pollutants that accumulate in the Great Lakes food web. It was initially developed by the eight Great Lakes States, EPA, and other Federal agencies in consultation with citizens, local governments, and industries.

To further protect public health and help restore the Great Lakes, EPA proposed an amendment to the Guidance (published in the *Federal Register* on October 4, 1999) that would significantly reduce direct discharges of Guidance bioaccumulative chemicals of concern (BCCs) into the Great Lakes. These include mercury, PCBs, dioxin, chlordane, DDT and mirex. The proposal seeks to phase out the discharges of these BCCs into "mixing zones" – areas of the Lakes where discharges of toxic chemicals are allowed to mix with receiving waters and dilute. This proposal would prohibit new discharges of BCCs into mixing zones in the Great Lakes Basin

