Routine and Nearshore Monitoring of Lake Michigan

Paul Horvatin
U.S. Environmental Protection Agency
Great Lakes National Program Office (GLNPO)
GLNPO Mission

“... restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem.”

Great Lakes Water Quality Agreement of 1978, Article II
GLNPO Monitoring Programs

- Limnology Program
- Biological Monitoring Program
- Integrated Atmospheric Deposition Network (IADN)
- Great Lakes Fish Monitoring Program
Water Quality Metrics

**Nutrients**
- Total Phosphorus
- Total Dissolved Phosphorus
- Nitrite + Nitrate
- Soluble Reactive Silica
- Particulate C,N,P

**Conventionals**
- pH, turbidity, alkalinity, specific conductance
Particulate Phosphorus Trends

Lake Huron - Spring

Lake Michigan - Spring
Biological Monitoring Program
“Rerouting” the Food Pathway...

- Mudpuppies, Crayfish
- Invertebrates
- Mussels
- Round Goby
- Piscivorous Birds: Loons, Cormorants, Grebes, Terns, Mergansers, Gulls
- Diving Ducks: Long-tailed, Scoter, Goldeneye
- Piscivorous Fish: Bass, Sturgeon, Lake Trout
- Shorebirds: Loons, Cormorants, Grebes, Terns, Mergansers, Gulls
- Dabbling Ducks
- Carp, Drum, Sculpin
- Algae
- Sediment

G. Mclaughlin, USGS, modified
Avian Type E Botulism Die-Off Events
History and Mortality Areas of the Great Lakes
Recent changes: The Quagga Invasion

*Source: Thomas F. Nalepa; Great Lakes Environmental Research Laboratory, NOAA*
Decline of *Diporeia* in Lake Michigan
Changes in Species Richness

Integrated Atmospheric Deposition Network

- Established in 1990
- Measures > 80 contaminants in air and precipitation
  - mostly traditional organics (PCBs, PAHs, organochlorine pesticides) with some auxiliary work for Hg
- 15 stations
  - 5 master, 10 satellite
  - 10 in Canada, 5 in U.S.
PCB concentration in precipitation

PCB Concentration (pg/L) in Precipitation
1994-1995 all seasons

PCBs (pg/L)

0 2000 4000 6000 8000

Chicago
Benton Harbor
Grand Haven
Frankfort
Green Bay
Menominee
Escanaba
Manistique
Mackinaw City
Gary
Milwaukee
Great Lakes Fish Monitoring Program

- Valuable long-term data (established in the 1970s)
- Monitors trends in bioaccumulative organic chemicals using top predator fish as biomarkers (*whole open water fish*)
- Assess potential human exposure to organic contaminants found in these fish (*sportfish fillets*)
- Provides information on new compounds of concern entering the ecosystem
GLFMP Contaminant List

- PCB congeners
- PCB co-planars
- Hexachlorobenzene
- Octachlorostyrene
- alpha BHC
- Lindane
- Dieldrin
- Heptachlor epoxide-b
- Cis-chlordane
- Trans-chlordane
- Oxychlordane
- Cis-nonachlor
- Trans-nonachlor
- pp,-DDT

- pp,-DDE
- pp,-DDD
- Endrin
- Mirex (Lake Ontario only)
- Toxaphene & homologs
- PCDD/Fs
- PBDEs
- Hg
- Fraction lipid
- PCNs
- PBB-153
- PFOS
Great Lakes Fish Monitoring Program

PCBs in Lake Michigan Lake Trout

PCBs (ppm)

0 5 10 15 20 25

Contaminants that drive Great Lakes fish consumption advisories in the U.S. and Canada

PCBs
Mercury
Toxaphene
Chlordane
Dioxin
Application of a uniform fish consumption advisory for PCB concentrations in coho salmon (2002)

PCBs (ppm)

- Superior
- Huron
- Michigan
- Erie
- Ontario

- Six meals per year
- Unlimited consumption
- One meal per week
- One meal per month
GLNPO’s Nearshore Monitoring Program

- Nearshore monitoring challenge: limited availability of research vessels and resources to survey the extensive (>10,000 miles) shoreline

- Importance of nearshore surveys - nearshore waters are highly variable, high human interaction, can help inform federal/state/local monitoring programs and Great Lakes observing system
The Near Shore Areas Are Rapidly Changing

- Water Clarity has greatly increased
- Dreissinid mussels appear to accelerate the nearshore Phosphorous Cycle
- 2006 Study on Phosphorus input and uptake-mouth of Milwaukee River
  - River Input=120 mg m\(^{-2}\)
  - Mussel Excretion=506 mg m\(^{-2}\)
- Cladophora production has greatly increased

Source: Harvey Bootsma, et.al
GLNPO’s solution

- Incorporate real-time, nearshore data collected over a large shoreline distance.
- Will supplement the GLNPO Open Water surveys.
- Nearshore waters (defined as ~20 m contour) will be sampled in all five Great Lakes.
- Will use the R/V Lake Guardian and newly-acquired Triaxus platform.
Specifications

- Triaxus is a towed instrument platform that will house several sensors:
  - SeaBird CTD & D.O. probe
  - Active Fluorometer
  - Laser Optical Plankton Counter (LOPC)
  - Nitrate Analyzer
  - Side-Scan Sonar
  - Fluoroprobe
TRIAXUS 3D Towed Undulating Vehicle
SeaBird CTD

- Monitors multiple parameters:
  - Temperature
  - pH
  - Conductivity
  - Dissolved oxygen
  - Fluorescence
Active Fluorometer

- Used to determine the photosynthetic efficiency of phytoplankton in both oligotrophic and mesotrophic environments.
- Utilize the relationship between chlorophyll fluorescence and photosynthesis to characterize phytoplankton 'health'.
The LOPC is an optical plankton counter with an imaging capability. Particles pass through a laser light beam and block the light falling on an array of sensors oriented perpendicularly to the flow direction. Particles as small as 100 µm can be detected, sized, and counted. Concentration densities as high as 1,000,000 particles per cubic meter can be quantified. Can be towed at speeds up to 12 knots.
Nitrate Analyzer
Side-Scan Sonar

- Used for mapping the bottom of the lake and creating habitat maps.
Fluoroprobe

- Directly measures the chlorophyll content
- Also detects the presence of algae and allocates them to various spectral algae classes (blue algae/cyanobacteria, green algae, diatoms/dinoflagellates/chrysophycia, cryptophycia)
Cooperative Enhanced Monitoring Schedule

• 2006 – Lake Superior
• 2007 – Lake Huron
• 2008 – Lake Ontario
• 2009 – Lake Erie
• 2010 – Lake Michigan
Purpose & Benefits of Surveys

- Provide statistically-valid, scientifically-defensible reports on the condition of U.S. waters
- Answer key questions:
  - Extent of waters supporting healthy ecosystems, recreation?
  - Extent of resource affected by key water quality problems/stressors?
  - Is water quality improving?
  - Are we spending pollution control dollars wisely?
Benthic Invertebrate Index

- Poor benthic index score: low diversity, higher pollution-tolerant and fewer pollution-sensitive species

- Benthic index based upon regional and sub-regional reference conditions

- Poor benthos often co-occurs with degraded water quality and sediment quality
Fish Tissue Contaminant Index

- Whole-body burdens were determined for 16 compounds
- Not always market species and market length
- Compared to risk-based thresholds (4-8oz. meals/month) for cancer and non-cancer endpoints
- Site ranked poor if score exceeds maximum value guidance criteria range
Water Quality Index

- WQI made up of five indicators: DIN, DIP, chlorophyll a, water clarity, and dissolved oxygen
- Regional and sub-regional reference conditions (e.g., higher water clarity for SAV beds or active SAV restoration programs vs. high natural turbidity or extensive wetlands)
- Site ranked poor if two or more measures exceeded reference condition
Sediment Quality Index

- SQI made up of three indicators: exposure sediment toxicity, contaminant concentrations and total organic carbon (TOC)
- Exposure toxicity evaluates survival of *Ampelisca abdita* in 10-day static test
- Almost 100 contaminant compounds are compared to effects concentrations associated with adverse biological effects (ERM and ERL)
- High TOC sediments harbor contaminants and can release them later at high temperatures
- Site is rated poor if one or more of the 3 indicators are in poor category
For More Information

GLNPO web site

http://www.epa.gov/glnpo/
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