Exploration of Submerged Sinkholes in Lake Huron

Discovering the Sinkholes of Lake Huron

In June of 2001, in collaboration with Great Lakes Environmental Research Laboratory and the State of Michigan, the Institute for Exploration conducted an extensive side-scan sonar survey throughout the deep-water portions of the Thunder Bay National Marine Sanctuary to get a clearer image of the extent of shipwrecks in the area. To the researchers' surprise, a number of submerged sinkholes and pockmarks were also discovered on the lakebed.

From about 10,000 to 8000 years ago Lake Huron's limestone bedrock was exposed due to extremely low lake levels following the last glacier maximum. Karst sinkholes were created when a chemical reaction between limestone and acidic water dissolved away passages or holes in the rock, leaving behind weakly supported ceilings that could easily collapse or sink. The Lake Huron sinkholes were subsequently covered with water and are currently seeping groundwater to the bottom of the lake, providing a unique habitat for aquatic life.

Exploring the Sinkholes

Researchers from Grand Valley State University, the University of Wisconsin-Stout, and GLERL identified three sinkhole communities along a depth gradient in Thunder Bay National Marine Sanctuary for further exploration (Figure 1). In September 2003, researchers used the University of Michigan's remotely operated vehicle, M-ROVER, to map the Isolated Sinkhole, the deepest of these sinkholes at 93 meters, and collect samples to be analyzed.

The dimensions of the Isolated Sinkhole are approximately 55 m by 40 m, with a maximum depth of approximately 3 m. Two deeper sections of the sinkhole; one on the northeast rim and a second area about 20 m to the south appear to be sources of vent plume water as shown in the temperature and conductivity maps. The temperature map (Figure 2) covers a range from 3.9°C to 7.5°C. Normal temperatures in the Great Lakes at these depths are typically 4°C. Conductivity map values (Figure 3) range from 122.6 µS/cm (microsiemens per cm) to 1821.2 µS/cm. The high conductivity of the plume is attributed to the high levels of Chloride and Sulfate, which indicate that the source of the sinkhole plume is the Silurian-Devonian aquifer.

Misery Bay sinkhole (1 m).

Aerial view of the Middle Island sinkhole (20 m).

Isolated sinkhole (93 m).

Water samples from the deep region of the sinkhole and its associated venting plume were collected by pumping the samples to the surface via a peristaltic pump. The plume had a visibly cloudy appearance and a strong hydrogen sulfide odor.

Observations revealed that the sinkhole environment contains unique

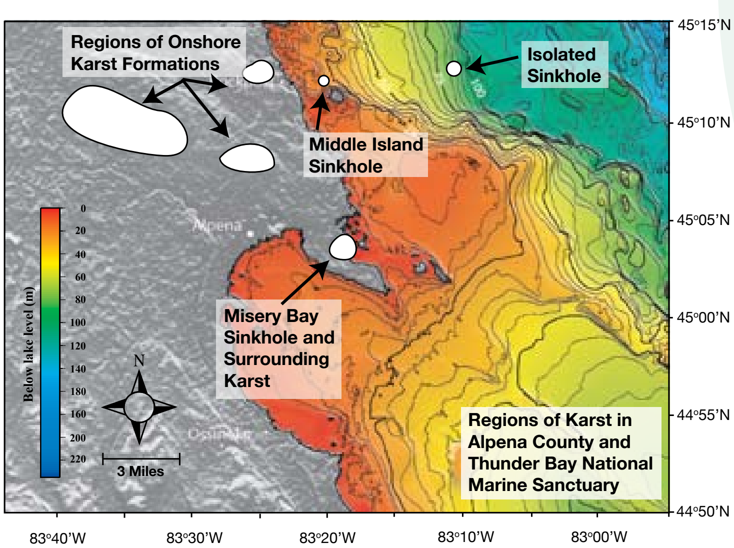


Figure 1. Above-ground and offshore karst formations and submerged sinkholes near Alpena, MI.

A comparison of Lake Huron water and sinkhole vent water.

Parameter (Units)	Lake Water	Vent Water
Conductivity (µS/cm)	140	1700
Temperature (°C)	3.5	7.0
Chloride (mg/L)	13	175
Sulfate (mg/L)	16	1457
Total P (mg/L	0.004	3.230
DOC (mg/L)	2.5	9.8
POC (mg/L)	0.9	405

biogeochemical conditions (See above table). The venting water was 3.5°C warmer than the surrounding water and had 10-fold higher concentrations of chloride, 100-fold higher concentrations of sulfate, and 1000-fold higher concentrations of total phosphorus.

Because phosphorus is commonly the limiting nutrient for primary productivity in all of the Laurentian Great Lakes, the input of phosphorus into Lake Huron from sinkhole discharges may be of importance in terms of water quality.

The vent water also contained 5-fold higher concentrations of dissolved organic carbon (DOC) and 400-fold higher concentrations of particulate organic carbon (POC) relative to the surrounding lake water. Both DOC and POC are important in fueling the microbial food web. The combination of the high abundance of inorganic nutrients and organic matter helps biogeochemical processes to occur in the sinkhole.

The University of Michigan's remotely-operated vehicle M-ROVER was used for mapping and sample collection in the 93-m deep Isolated Sinkhole.

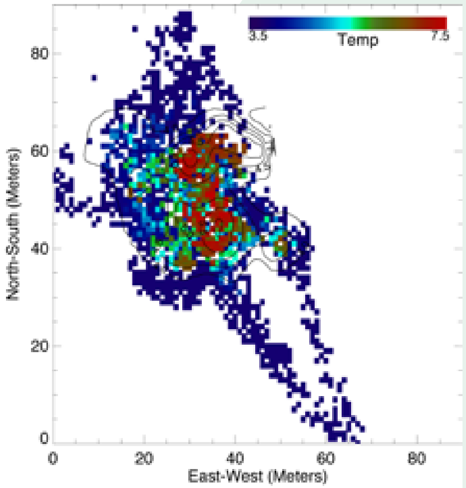


Figure 2. Temperature map of Isolated Sinkhole. Units in °C.

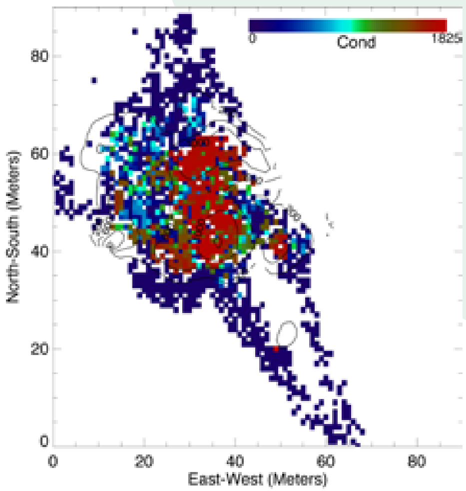
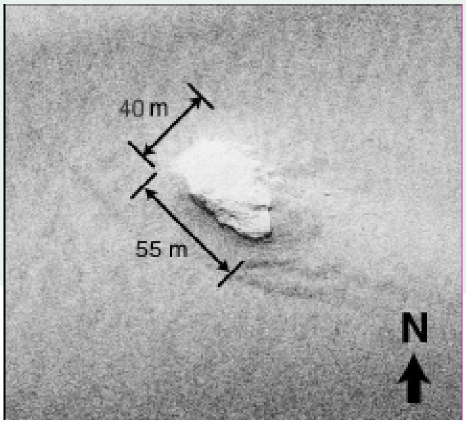


Figure 3. Conductivity map of Isolated Sinkhole. Units in microsiemens per cm (µS/cm).

Future Studies

Until recently it was thought that such unique habitats caused by steep environmental gradients were only found in oceans. Researchers are now considering the Lake Huron sinkholes to be analogous to marine vent ecosystems — freshwater biogeochemical "Hot Spots" where nutrients recycle rapidly and where novel organisms and community processes may be observed. Biological samples from the sinkholes are being collected by GLERL researchers for natural product research being done at the University of Michigan's Life Science Institute. Currently, with funding from the National Science Foundation, researchers are mapping the hydrography, developing bathymetric maps of the sinkhole sites, characterizing microbial communities, and assessing microbial abundance and growth rates to test the hypothesis that photosynthesis-dominated communities in shallow sunlit sinkholes give way to chemosynthesis-dominated sinkhole communities in deep water devoid of light. These analyses will provide a working picture of microbial life in sinkhole ecosystems of the Laurentian Great Lakes. A better appreciation of the diversity of life and life processes prevailing at the sinkholes should help us preserve and protect these unique ecosystems.



Side scan sonar image of the Isolated Sinkhole located at 93 m depth. Approximate dimensions are 40 x 55 m.

For More Information

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