A name like the "Dead Zone" may frighten many people away, but Lake Erie scientists flock to the lake at the mere mention of these words. The Dead Zone is located in the lake's central basin between Lorain, Ohio and Erie, Pennsylvania, and consists of bottom water with low oxygen concentrations. During this past summer, a large group of researchers participated in the 2005 International Field Year on Lake Erie to study the well-known phenomenon (see *Twine Line* Vol. 24 No. 5 from September/October 2002) using large research vessels from the National Oceanic and Atmospheric Association. This research was supported by a large group of funding agencies, including Ohio Sea Grant. A smaller group of researchers from Stone Laboratory on Gibraltar Island investigated the frequency and duration of low dissolved oxygen concentrations in what is becoming known as the 'Mini Dead Zone' in the Sandusky subbasin. This work was supported by the Ohio Lake Erie Protection Fund, Ohio Sea Grant, and research endowments from Stone Laboratory.

On cruises aboard F.T. Stone Laboratory's R/V Erie Monitor, the scientists sampled 11 stations from the mouth of the Sandusky River, into Sandusky Bay, and out into Sandusky subbasin from June through mid-August to determine how nutrients from the Sandusky watershed and algae from Sandusky Bay affect the development of areas of low dissolved oxygen in the Sandusky subbasin (what they call the Algal Loading Hypothesis). What they found was a bit of a surprise.

Based upon sampling of one station in the middle of the Sandusky subbasin during summer of 2002, the scientists predicted that only parts of the subbasin would become hypoxic (have oxygen concentrations less than 4 mg/L) or anoxic (oxygen concentrations approaching 0 mg/L). They discovered, however, that nearly the entire subbasin deeper than 12 m (40 ft) was anoxic by mid-July (approximately 200 km², an area the size of the island of Aruba or one-third the size of Lake County, Ohio). This Mini Dead Zone remained nearly devoid of oxygen until late-August when the combination of cooler temperatures and wind allowed the bottom waters to mix with surface waters, replenish-

To measure the progression of the 'mini' dead zone in the Sandusky subbasin and how leading from the watershed affected it, Joe Conroy and other researchers from F.T. Stone Laboratory took biological samples in the Sandusky Bay, such as the phytoplankton sample shown here.
oxygen concentrations (like parts of the western or central basins), but understanding what the fish actually do remains to be studied.

While the existence of the Mini Dead Zone was known, its large area and duration were not. Its presence can have many detrimental effects, but further research into understanding how it forms and how it affects other organisms in the lake (including game fish) needs to be completed. Controlling its size or eliminating it completely may only be accomplished through further remediation in the watershed, which requires an active and interested group of citizens to, as was often heard as a rallying cry when Lake Erie was “dying” in the late-1960s, “Save our Lake!”

2) some clear signal at the time and place of sampling (rather than back in the lab) that indicates the presence of heavy metals.

For the organism “standard” Sayre and Rajamani are using *Chlamydomonas reinhardtii*, a ubiquitous microalga that occurs in both soil and water (fresh and marine), in environments from the Sahara to Antarctica. The microalga is amenable to the genetic manipulation required to turn it into a sensor, and at the same time is amenable to the creation of barriers that keep the new design from reproducing in nature. For the clear signal, the researchers have expressed in *Chlamydomonas* a protein indicator from which a fluorescent yellow is sign that heavy metals are present.

The fluorescent signal is at the heart of this biosensor's efficiency. It relies on Sayre's and Rajamani's creation of a three-protein “sandwich.” Two proteins (from jellyfish) that fluoresce blue or yellow flank a third protein called metallothionein (from chickens), which provides attachment sites for heavy metals. In the absence of heavy metals, metallothionein is a relaxed coil holding the two fluorescent proteins far apart, each contributing to a fluorescence ratio of about 1:1. When heavy metals from the environment bind to it, metallothionein folds more tightly into a dumbbell shape, bringing the two fluorescent proteins closer together. In this closer proximity, exciting both proteins with light of a specific wavelength causes energy from the blue protein to transfer to the yellow protein, causing the ratio of yellow to blue fluorescence to more than double. Enhanced yellow fluorescence indicates heavy metals in the environment. Binding sites on metallothionein have different affinities for different metals, something Sayre and Rajamani also hope to exploit to make the protein more metal-specific.

Having expressed their heavy metal biosensor in strains of *Chlamydomonas*, the researchers will now measure the proteins fluorescent response in the presence of various metals at various concentrations. Eventually they plan to concentrate and sequester these engineered *Chlamydomonas* cells in sealed probes and adapt them to existing optic systems. The result should be portable fluorescence devices that efficiently identify and quantify bioavailable heavy metals at the sites of contamination.

For more information about this Sea Grant project, contact Dr. Sayre at 614.292.9030 or sayre.2@osu.edu

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Development of a zone of hypoxia (low oxygen) and anoxia (no oxygen) in Lake Erie's Sandusky subbasin during the summer of 2005. Scientists from F.Y. Stone Lab originally predicted only parts of the subbasin would have low oxygen concentrations but instead found that nearly the entire subbasin deeper than 40 feet was anoxic by mid-July and remained low in oxygen until late August. This area was nearly one-third the size of Lake County, Ohio and could restrict fish species such as walleye or yellow perch from using the deep water in this area.