Indicator: Abundance of Burrowing Mayflies in the Western Basin of Lake Erie

Background

Burrowing mayfly populations (*Hexagenia* spp.) were extirpated in the 1940s and 1950s from western Lake Erie. During the first half of the twentieth century, major urban impacts, such as municipal and industrial pollution associated with urban growth, greatly decreased the likelihood of mayfly reoccurrence (Schloesser 2005). Before the 1950s, mayflies were found in nearshore areas, harbors, and tributary mouths throughout the Great Lakes (Schloesser 2005). Mayfly populations do well in shallow, productive lakes with soft, organically rich sediments (Figure 1). They are important in the diets of many Lake Erie sport and commercial fish such as yellow perch, freshwater drum, channel catfish, trout perch, spottail shiner, and mooneye (Ohio Lake Erie Commission 2004).

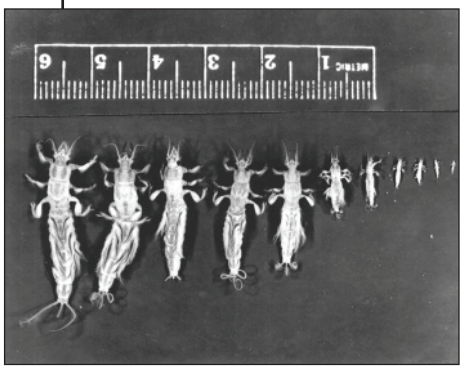

Figure 1. Hexagenia *spp. nymphs. Difference in body length, from 1 to 30 mm, is mostly dependent upon age and food (Photo credit: U.S. Geological Survey).*

Mayflies are considered an ecological "keystone" species and their presence is believed to be an important environmental indicator of mesotrophic (i.e., moderately productive) conditions. Mayflies are ecologically important as a trophic indicator, linking detrital (bottom litter) energy resources directly to the many fish species that feed on *Hexagenia* (USGS 2005). Mayfly nymphs prefer to burrow in soft sediment, which often carries high concentrations of pollutants in contaminated areas. Nymphs are intolerant of polluted sediment associated with eutrophication and a lack of oxygen in the lowest layer of the water column (Ohio Lake Erie Commission 2004). Extended lack of oxygen eliminates the nymphs. Mayflies are also useful indicators because they are highly visible, relatively easy to sample, and provide "real proof" that lake restoration has been effective. Mayflies may be used to measure restoration progress and success/failure of aquatic restoration goals in the western basin because enough data are being collected to establish biological reference points suitable for the public to understand ecosystem health.

Status and Trends

Hexagenia spp. mayfly nymphs returned to sediments of western Lake Erie in 1992-93 after an absence of 40 years (Krieger et al. 1996). Their recovery was aided by pollution abatement programs combined with the invasion of exotic zebra mussels in 1986 that changed the trophic status of nearshore waters of the Great Lakes. By 1997 abundances of nymphs were similar to historical abundances before extirpation in the mid-1950s (Schloesser et al. 2000). Although mayflies were historically (pre-1950s) abundant and

important in the food web of western Lake Erie, there is very limited information prior to the 1950s and they disappeared from the lake shortly after an anoxic period (i.e., no dissolved oxygen near sediments) in 1953. This anoxia was attributed to organic loadings from municipal wastes. Between 1960 and 1990, few mayflies were found in Lake Erie (Schloesser 2005).

Between 1997 and 2004, mayflies gradually increased in distribution, spreading eastward in nearshore sediment and, by 2004, were present throughout the entire western basin of Lake Erie. However, their reestablishment in nearshore areas of the central and eastern basins was unsuccessful during that time (Krieger et al. In press). In 2004, biological reference points (density descriptors of excellent, good, fair, poor, and imperiled) were established based on mayfly abundance in the western basin (Ohio Lake Erie Commission 2004). These reference points are category descriptors of ranges of nymph densities that are easily understood by the general public and allow agencies to more easily communicate progress toward goals of lake-wide management plans (Schloesser 2005).

Recovery of the mayfly population in western Lake Erie has happened much quicker than models predicted (Schloesser et al. 2000). Again, few mayflies were present in western Lake Erie between the 1950s and 1992. Beginning in the early 1990s, the average number of nymphs in the soft bottom sediments increased. They increased between 1992 and 1997, then decreased in 1998. Data indicate there is a large year-to-year variation of nymph density (Figure 2). A three-year running average is now used to dampen this annual density variability and aid interpretation of population abundance. Researchers are investigating possible physical and biological causes to explain instability of mayfly abundance in Lake Erie and have discovered one or more parameters responsible for failed reproduction. It is believed that western Lake Erie stratifies for short periods of time causing a lack of oxygen. It is well documented that the central and eastern basins of the lake stratify for several months every year. The shallow nature of the western basin allows wind-induced turnover to occur frequently, severely limiting stratification events and duration.

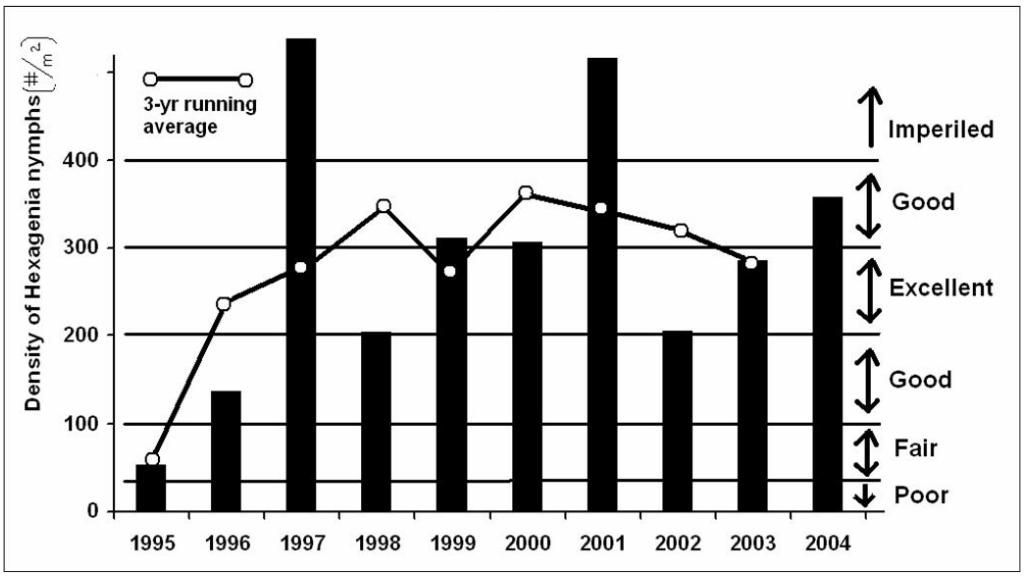

Figure 2. Density of Hexagenia *nymphs in the western basin of Lake Erie, 1995-2004 (based on the three-year running averages and biological reference point density descriptors; some minor differences exist in annual sampling sites; data collected by USGS).*

The 2003, three-year running average population of mayfly nymphs per square meter is equal to a rating of "excellent" under the biological reference point scoring system. The rating for this species between 1996 and 2004 ranged between good and excellent, but the mayfly population in portions of the basin exhibited large variation and appeared threatened in some years, possibly as a result of fluctuating dissolved oxygen concentrations. Any increase in the input of limiting nutrients (phosphorus) will probably yield an increase in primary and secondary productivity which, in turn, could lead to larger variation and possible declines in dissolved oxygen concentrations in summer months (Ohio Lake Erie Commission 2004). However, a very low percentage of the hundreds of basin-wide dissolved oxygen measurements have been below the concentration believed to be lethal to mayfly populations. Exceedingly high nymph density, as well as exceedingly low nymph density, may indicate an ecological imbalance. High nymph density may indicate a state of nutrient enrichment which, if continued, could cause oxygen depletion (Krieger 1999).

Management Next Steps

Mayfly nymph density for Lake Erie has been designated by the State of the Lake Ecosystem Conference (SOLEC) as an important indicator. Mayfly density and other SOLEC indicators will be used to report to the International Joint Commission and the public on progress made in restoring the chemical, physical, and biological integrity of the Great Lakes, as called for in the Canada-U.S. Great Lakes Water Quality Agreement (USGS 2005). As pollution-abatement programs continue, more Great Lakes areas should experience recovery of burrowing mayflies in the next 10-20 years (Schloesser 2005). Continued efforts are needed to adequately control municipal, industrial, and agricultural sources of pollution consistent with the Great Lakes Water Quality Agreement.

The Lake Erie Commission has set a desired abundance of 201-300 mayfly nymphs per square meter as a level to sustain the Lake Erie fishery (Ohio Lake Erie Commission 2004). This quantitative target may be incorporated in food web, nutrient, and hydrodynamic modeling in support of ecosystem-based management.

Research/Monitoring Needs

Emerging mayfly swarms in early summer are once again a major annual event warranting continuation of mayfly research. Research should continue to test surface and subsurface sediments to determine the cause of annual variation and exceedingly high and low abundances of mayflies. Parameters that should be investigated include sediment oxygen depletion and demand, pH, conductivity, organic content, persistent toxic organics, and grain size. This research will help determine the causes of unstable population abundances in western Lake Erie (Schloesser 2005).

References

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Links for More Information

Biological indicators of watershed health: http://www.epa.gov/bioindicators/html/mayflies.html

Ohio Lake Erie Commission, biological indicator: http://www.epa.state.oh.us/oleo/reports/leqi/leqi2004/pdf/biologicalindicator.pdf

Report on tracking rapid population change of burrowing mayflies in the central basin of Lake Erie: http://www2.heidelberg.edu/wql/FINALREPORT.pdf

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