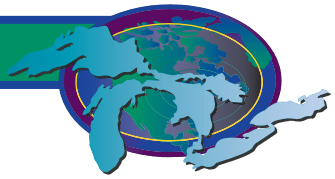

Abundances of the Benthic Amphipod *Diporeia* spp.

Indicator #123

Overall Assessment

Status: **Mixed**
Trend: **Deteriorating**
Rationale: **Abundances of the benthic amphipod *Diporeia* spp. continue to decline in Lake Michigan, Lake Huron, and Lake Ontario. While it is presently gone or rare in shallow waters in each of these lakes, it is also declining in deeper, offshore waters. The decline in the latter regions is temporally linked to the expansion and increase of quagga mussels. Studies on trends in Lake Superior are conflicting, but the general opinion of researchers is that declines are not occurring. *Diporeia* are currently gone or very rare in Lake Erie.**

Lake-by-Lake Assessment

Lake Superior

Status: Mixed
Trend: Unchanging
Rationale: Data sets are conflicting on current trends of *Diporeia* populations in Lake Superior. One long-term monitoring program shows that *Diporeia* abundances are declining in offshore areas (greater than 90 m), but abundances in nearshore areas (less than 65 m) remain unchanged. Other long and short-term sampling programs show no overall trend in either offshore or nearshore areas.

Lake Michigan

Status: Poor
Trend: Deteriorating
Rationale: *Diporeia* abundances continue to decline in Lake Michigan. A recent lakewide survey (in 2005) indicated abundances were lower by 84% compared to abundances found in 2000. *Diporeia* are now completely gone from depths less than 80 m over most of the lake, and abundances are in the state of decline at depths greater than 80 m.

Lake Huron

Status: Poor
Trend: Deteriorating
Rationale: *Diporeia* abundances continue to decline in Lake Huron. The most recent lakewide survey in the main basin (in 2003) indicated abundances were lower by 57% compared to abundances found in 2000. *Diporeia* are now completely gone from depths less than 60 m except in the northeastern end and continue to decline at depths greater than 60 m. Annual monitoring at 11 sites indicated that, in 2005, *Diporeia* were gone from five sites and abundances were lower compared to 2004 at the other six sites. Because of insufficient data, trends for Georgian Bay and the North Channel are not known. However, limited temporal and spatial data from the southern end of Georgian Bay showed that *Diporeia* have been declining since 2000 and are now completely gone at depths less than 93 m.

Lake Erie

Status: Poor
Trend: Deteriorating
Rationale: Because of shallow, warm waters, *Diporeia* are naturally not present in the western and central basins. *Diporeia* declined in the eastern basin beginning in the early 1990s and have not been found since 1998.

Lake Ontario

Status: Poor
Trend: Deteriorating
Rationale: Based on several limited surveys in 2005, *Diporeia* continue to decline in Lake Ontario. In one survey of 11 sites, *Diporeia* declined at two sites and increased slightly at two sites compared to 2004. It was not found at six sites in both years. In another survey of 14 sites, *Diporeia* declined at sites less than 140 m, but increased slightly at sites greater than 190 m. It was not found at sites less than 90 m over most of the lake.

Purpose

- To provide a measure of the biological integrity of the offshore regions of the Great Lakes by assessing the abundance of the benthic macroinvertebrate *Diporeia*

Ecosystem Objective

The ecosystem goal is to maintain a healthy, stable population of *Diporeia* in offshore regions of the main basins of the Great Lakes, and to maintain at least a presence in nearshore regions.

State of the Ecosystem

Background

This glacial-marine relic was once the most abundant benthic organism in cold, offshore regions (greater than 30 m (98 ft)) of each of the lakes. It was present, but less abundant in nearshore regions of the open lake basins, but naturally absent from shallow, warm bays, basins, and river mouths. *Diporeia* occurs in the upper few centimeters of bottom sediment and feeds on algal material that freshly settles to the bottom from the water column (i.e., mostly diatoms). In turn, it is fed upon by most species of Great Lakes fish; in particular by many forage fish species, which themselves serve as prey for the larger piscivores such as trout and salmon. For example, sculpin feed almost exclusively upon *Diporeia*, and sculpin are fed upon by lake trout. Also, lake whitefish, an important commercial species, feeds heavily on *Diporeia*. Thus, *Diporeia* was an important pathway by which energy was cycled through the ecosystem, and a key component in the food web of offshore regions. The importance of this organism is recognized in the Great Lakes Water Quality Agreement: Supplement to Annex 1 – Specific Objectives (United States and Canada 1987).

On a broad scale, abundances are directly related to the amount of food settling to the bottom, and population trends reflect the overall productivity of the ecosystem. Abundances can also vary somewhat relative to shifts in predation pressure from changing fish populations. In nearshore regions, this species is sensitive to local sources of pollution.

Status of *Diporeia*

Diporeia populations are currently in a state of dramatic decline in Lake Michigan (Figure 1), Lake Ontario (Figure 2), and

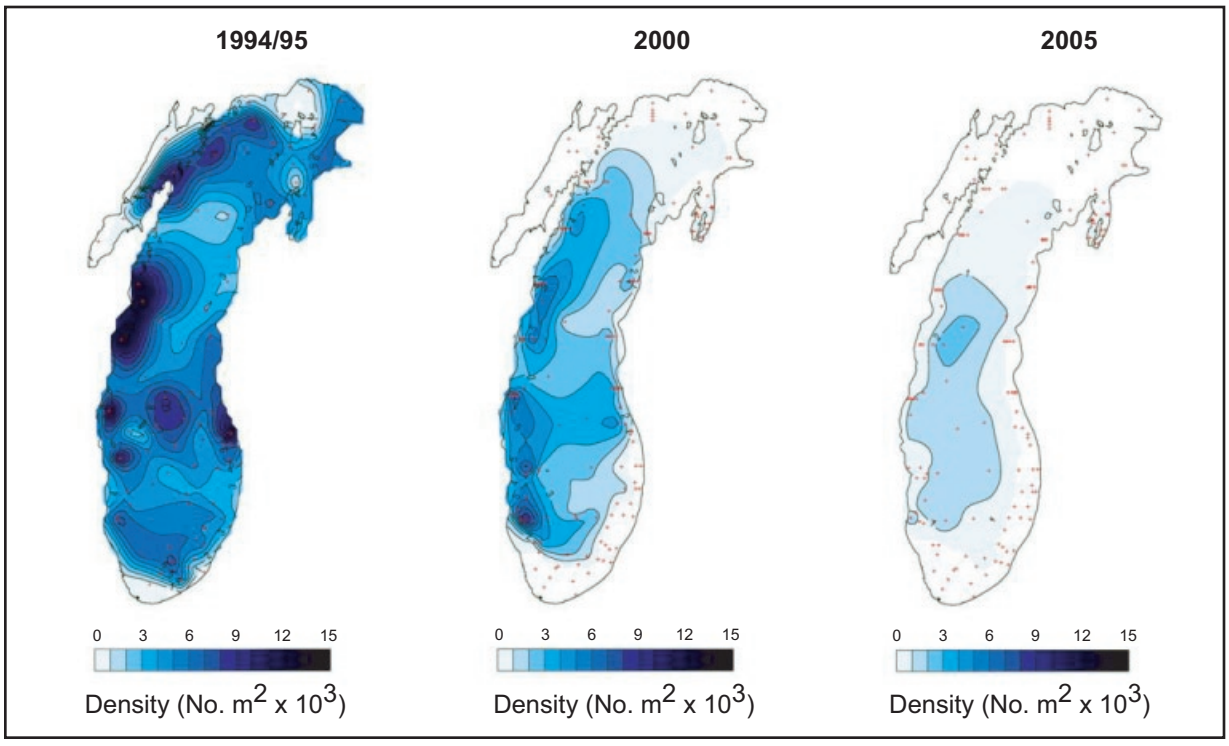

Figure 1. Distribution and abundance (number per square meter) of the amphipod *Diporeia* spp. in Lake Michigan in 1994-1995, 2000, and 2005.
Small crosses indicate location of sampling stations.
Source: National Oceanic & Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory

Lake Huron, and they are completely gone or very rare in Lake Erie. Results are conflicting for Lake Superior. One data set shows a trend of declining abundances in offshore waters, but other data sets show no trend. In all the lakes except Lake Superior, abundances have decreased progressively from shallow to deeper areas. Initial declines were first observed in all lake areas within two to three years of when zebra mussels (*Dreissena polymorpha*) or quagga mussel (*Dreissena bugensis*) first became established. These two species were introduced into the Great Lakes in the late 1980s via the ballast water of ocean-going ships. Reasons for the negative response of *Diporeia* to these mussel species are not entirely clear. One hypothesis is that dreissenid mussels are out-competing *Diporeia* for available food. That is, large mussel populations filter food material before it reaches the bottom, thereby decreasing amounts available to *Diporeia*. However, evidence suggests that the reason for the decline is more complex than a simple decline in food because *Diporeia* have completely disappeared from areas where food is still settling to the bottom and where there are no local populations of mussels. Also, individual *Diporeia* show no signs of starvation before or during population declines. Further, *Diporeia* and *Dreissena* apparently coexist in some lakes outside of the Great Lakes (i.e., Finger Lakes in New York).

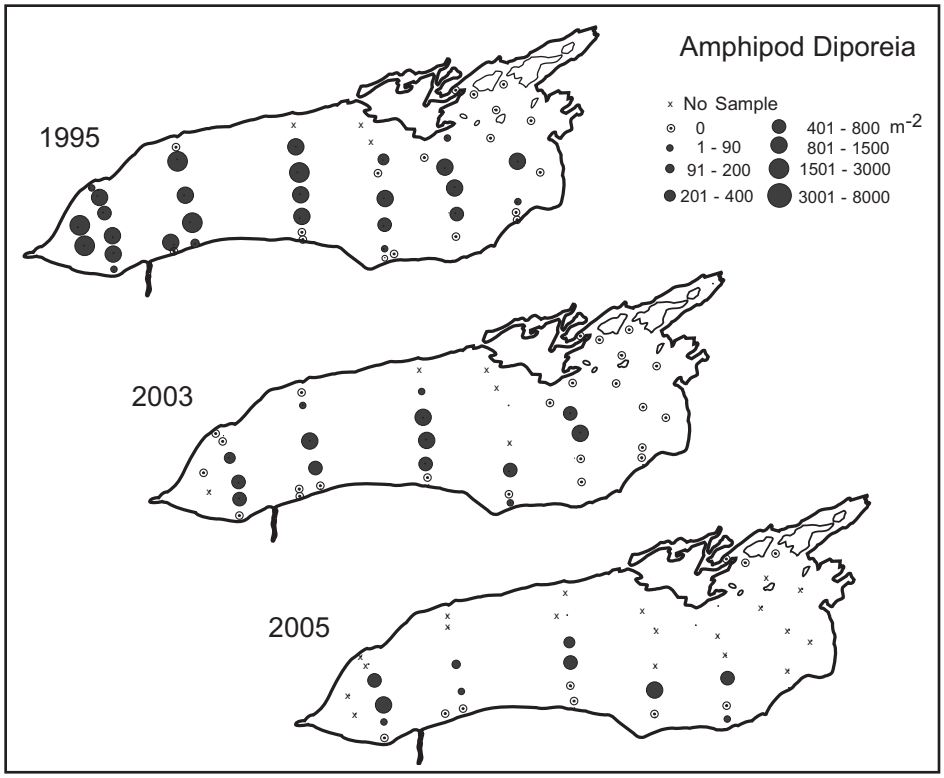

Figure 2. Distribution and abundance (number per square meter) of the amphipod *Diporeia* spp. in Lake Ontario in 1995, 2003, and 2005.
Small crosses indicate a site where no sample was taken.
Source: Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences

Pressures

As populations of dreissenid mussels continue to expand, it may be expected that declines in *Diporeia* will become more extensive. In the open waters of Lake Michigan, Lake Huron, and Lake Ontario, zebra mussels are most abundant at depths less than 50 m (164 ft), and *Diporeia* are now gone or rare from lake areas as deep as 90 m (295 ft). Recently, quagga mussel populations have increased dramatically in each of these lakes and are occurring at deeper depths than zebra mussels. The decline of *Diporeia* at depths greater than 90 m can be attributed to the expansion of quagga mussels to these depths.

Management Implications

The continuing decline of *Diporeia* has strong implications to the Great Lakes food web. As noted, many fish species rely on *Diporeia* as a major prey item, and the loss of *Diporeia* will likely have an impact on these species. Responses may include changes in diet, movement to areas with more food, or a reduction in weight or energy content. Implications to populations include changes in distribution, abundance, growth, recruitment, and condition. Recent evidence suggests that fish are already being affected. For instance, growth and condition of an important commercial species, lake whitefish, has declined significantly in areas where *Diporeia* abundances are low in Lake Michigan, Lake Huron, and Lake Ontario. Also, studies show that other species such as alewife, slimy sculpin, and bloater have been affected. Management agencies must know the extent and implications of these changes when assessing the current state and future trends of the fishery. Any proposed rehabilitation of native fish species, such as the re-introduction of deepwater ciscoes in Lake Ontario, requires knowledge that adequate food, especially *Diporeia*, is present.

Comments from the author(s)

Because of the rapid rate at which *Diporeia* populations are declining and their significance to the food web, agencies committed

to documenting trends should report data in a timely manner. The population decline has a defined natural pattern, and studies of food web impacts should be spatially well coordinated. Also, studies to define the cause of the negative response of *Diporeia* to *Dreissena* should continue and build upon existing information. With an understanding of exactly why *Diporeia* populations are declining, we may better predict what additional areas of the lakes are at risk. Also, by better understanding the cause, we may better assess the potential for population recovery if and when dreissenid populations stabilize or decline.

Acknowledgments
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Sources

Dermott, R. 2001. Sudden disappearance of the amphipod *Diporeia* from eastern Lake Ontario, 1993-1995. *J. Great Lakes Res*. 27:423-433.

Dermott, R., and Kerec, D. 1997. Changes in the deepwater benthos of eastern Lake Erie since the invasion of *Dreissena*: 1979-1993. *Can. J. Fish. Aquat. Sci*. 54:922-930.

Hondorp, D.W., Pothoven, S.A., and Brandt, S.B. 2005. Influence of *Diporeia* density on the diet composition, relative abundance, and energy density of planktivorous fishes in southeast Lake Michigan. *Trans. Am. Fish. Soc*. 134:588-601.

Lozano, S.J., Scharold, J.V., and Nalepa, T.F. 2001. Recent declines in benthic macroinvertebrate densities in Lake Ontario. *Can. J. Fish. Aquat. Sci*. 58:518-529.

Mohr, L.C. and Nalepa, T.F. 2005. Proceedings of a workshop on the dynamics of lake whitefish (*Coregonis clupeaformis*) and the amphipod *Diporeia* spp. in the Great Lakes. Great Lakes Fish. Comm. Tech. Rep. 66.

Nalepa, T.F., Rockwell, D.C., and Schloesser, D.W. 2006. *Disappearance of* Diporeia *spp. in the Great Lakes: workshop summary, discussion, and recommendations*. NOAA Technical Memorandum GLERL-136, Great Lakes Environmental Research Laboratory, Ann Arbor, MI.

Nalepa, T.F., Fanslow, D.L., Foley, A.J., III, Lang, G.A., Eadie, B.J., and Quigley, M.A. 2006. Continued disappearance of the benthic amphipod *Diporeia* spp. in Lake Michigan: is there evidence for food limitation? *Can. J. Fish. Aquat. Sci*. 63: 872-890.

Nalepa, T. F., Fanslow, D. L., Pothoven, S. A., Foley, A. J. III, and Lang, G. A. 2007. Long-term trends in benthic macroinvertebrate populations in Lake Huron over the past four decades. *J. Great Lakes Res*. 33: 421-436.

Owens, R.W., and Dittman, D.E. 2003. Shifts in the diets of slimy sculpin (*Cottus cognatus*) and lake whitefish (*Coregonus clupeaformis*) in Lake Ontario following the collapse of the burrowing amphipod *Diporeia*. *Aquat. Ecosys. Health Manag*. 6:311-323.

United States and Canada. 1987. *Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987*. Ottawa and Washington.

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