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. Past studies of trends in Lake Superior were somewhat conflicting, but recent data indicate that declines are not occurring. *Diporeia* are currently gone or very rare in Lake Erie.**

Lake-by-Lake Assessment

Lake Superior

Status: Good

Trend: Unchanging

Rationale: One long-term monitoring program showed that *Diporeia* abundances were declining in offshore areas, but remained unchanged in the nearshore. Recent data collected by this monitoring program now shows that the population in offshore areas has increased, demonstrating that relatively large annual fluctuations can occur. Other sampling programs show no overall trend.

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 2007) indicated that overall abundances were lower by 93% compared to abundances found in 2000 (Fig. 1). *Diporeia* are now completely gone or rare at depths less than 60 m and continue to decline at depths greater than 60 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: In one 2005 survey of 11 sites, *Diporeia* declined at two sites and increased slightly at two sites compared to 2004, and remained absent at six sites in both years. In another survey of 14 sites in 2005, changes were variable. It was not found at sites less than 90 m over most of the lake. Between 2005 and 2007 several sites along the south side as deep as 150 m had lost their populations.

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, Lake Ontario, and Lake Huronn (Figure 1), and they are completely gone or very rare in Lake Erie. Recent results of monitoring programs in Lake Superior indicate that the population is not declining but can be highly variable. 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).

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.

Assessing Data Quality

Insert “x” under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	X					
2. Data are traceable to original sources	X					
3. The source of the data is a known, reliable and respected generator of data	X					
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin	X					

5. Data obtained from sources within the U.S. are comparable to those from Canada	X					
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report	X					
Clarifying Notes:						

Acknowledgments

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T.F. Nalepa, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI (2008)

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List of Figures

Figure 1. Distribution and abundance (number per square meter) of the amphipod *Diporeia* spp. in Lake Huron in 2000, 2003, and 2007. Small crosses indicate location of sampling stations.
Source: National Oceanic & Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory

Figure 2. Distribution and abundance (number per square meter) of the amphipod *Diporeia* spp. in Lake Ontario in 1995, 2004, 2005, and 2007.
Source: Great Lakes Lab for Fisheries & Aquatic Sciences, Fisheries & Oceans

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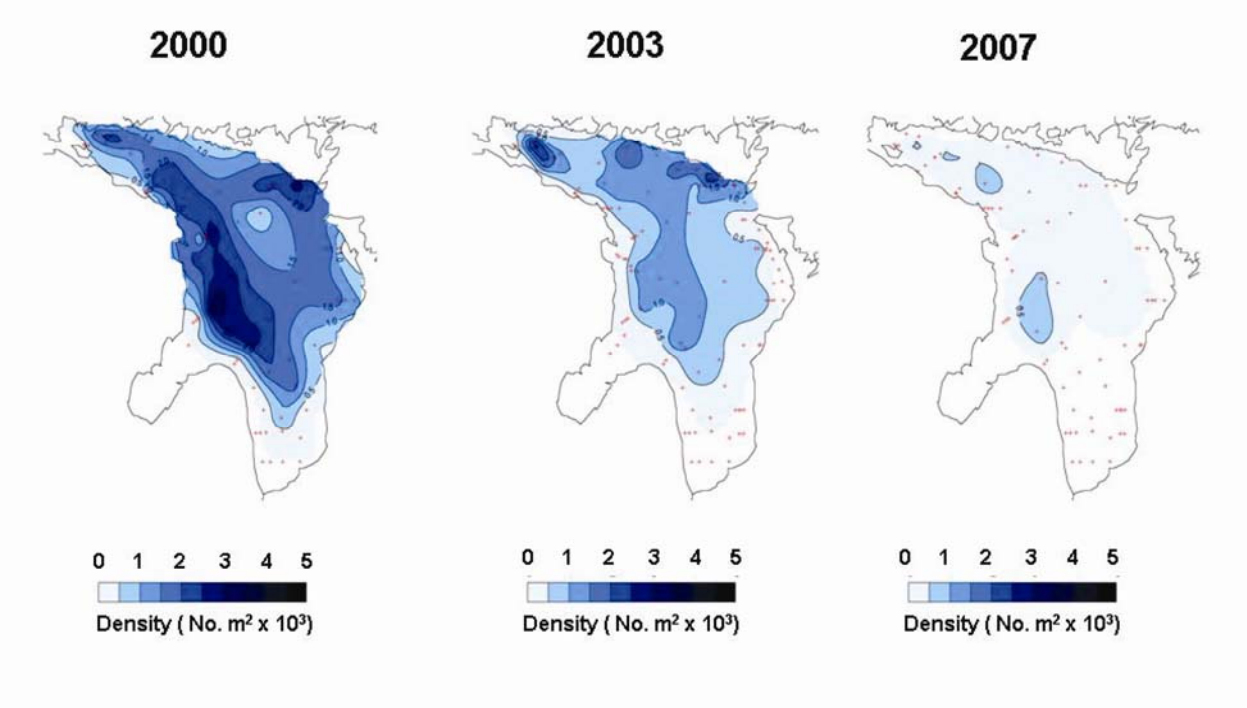

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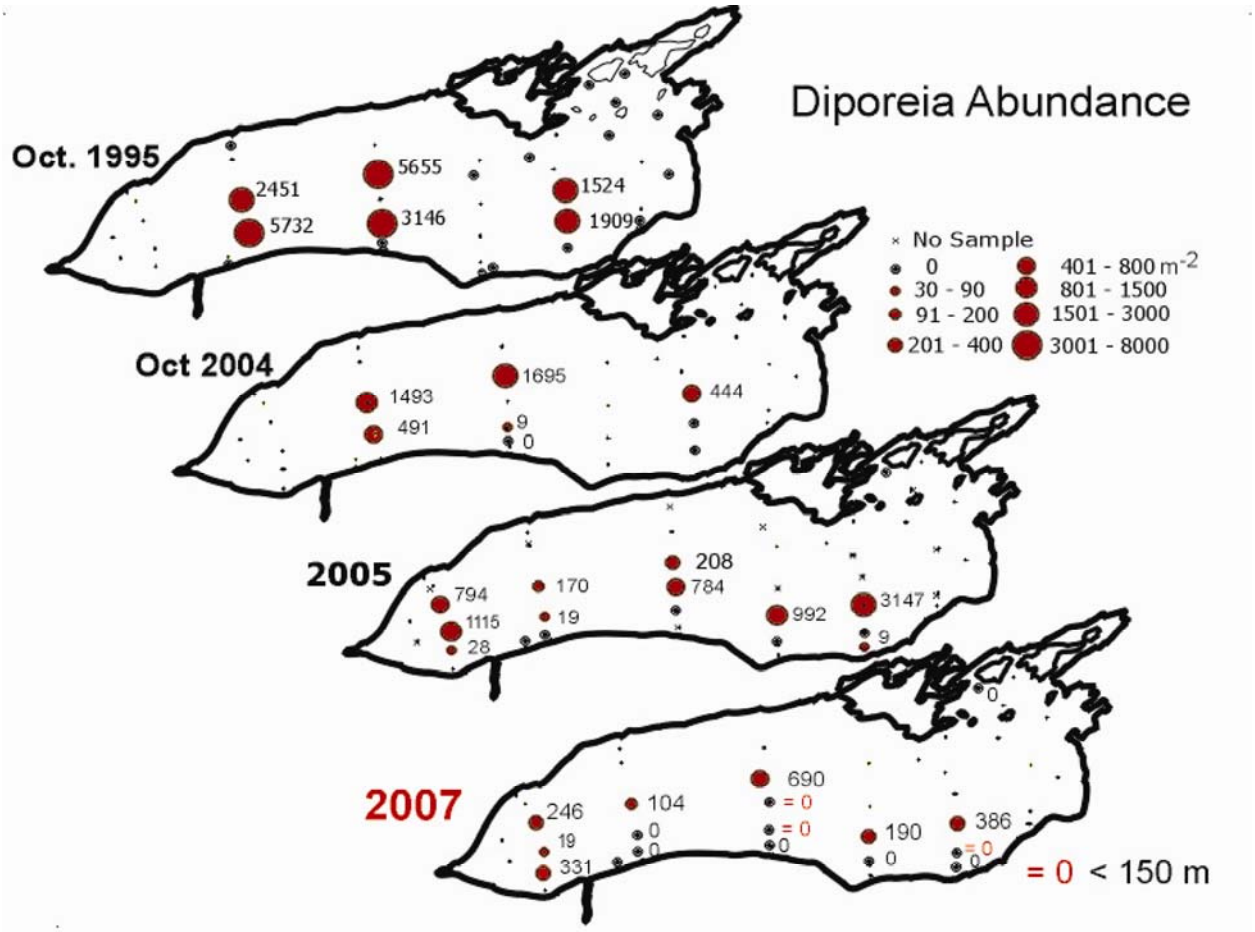

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