Preyfish Populations
Indicator #17

Overall Assessment

Status: **Mixed**
Trend: **Deteriorating**
Rationale: **With the exception of Lake Superior, the Great Lakes fish communities continue to shift away from their natural state. In particular, food webs in the lower lakes are becoming more benthic as a result of the expansion of dreissenid mussels. As a consequence, preyfish populations dependent on pelagic invertebrate production and their salmonid predators have declined and non-native gobies are increasing owing to their ability to thrive in benthic food webs. Mitigation of these changes is not likely due to our inability to manipulate food webs from the bottom-up.**

Lake-by-Lake Assessment

Lake Superior
Status: Mixed
Trend: Improving
Rationale: Abundance of preyfish populations, dominated by native coregonids, fluctuates as a result of recruitment variation and predation by recovered lake trout populations. Non-native rainbow smelt remains as a principal component of prey fish assemblage. Round gobies are now present in western Lake Superior and Eurasian ruffe continues to colonize inshore waters and embayments.

Lake Michigan
Status: Mixed
Trend: Deteriorating
Rationale: Non-native preyfish populations are at historic lows and densities of non-native round goby are low and stable. However, the decline in *Diporeia* and increasing colonization of dreissenids may signal a shift in food web toward a benthic organization and further community change.

Lake Huron
Status: Mixed
Trend: Deteriorating
Rationale: Non-native preyfish populations are at historic lows but densities and distribution of non-native round goby are increasing. The decline in *Diporeia* and increasing colonization of dreissenids may signal a shift in food web toward a benthic organization and further community change.

Lake Erie
Status: Mixed
Trend: Deteriorating
Rationale: Preyfish populations are at historic lows while abundance and distribution of non-native round goby is increasing. Ongoing dreissenid colonization is resulting in further benthification of food web.

Lake Ontario
Status: Mixed
Trend: Deteriorating
Rationale: Non-native preyfish populations are at historic lows while abundance and distribution of non-native round goby is increasing. Ongoing dreissenid colonization is resulting in further benthification of food web. Large areas of deep water are devoid of fish much of the year.

Purpose
- To assess the abundance and diversity of preyfish populations
- To infer the stability of predator species necessary to maintain the biological integrity of each lake

Ecosystem Objective
The importance of preyfish populations to support healthy, productive populations of predator fishes is recognized in the Fish Community Goals and Objectives (FCGOs) for each lake. For example, the Fish Community Objectives (FCOs) for Lake Michigan specify that in order to restore an ecologically balanced fish community, a diversity of prey species at population levels matched to primary production and predator demands must be maintained. This indicator also relates to the 1997 Strategic Great Lakes Fisheries Management Plan Common Goal Statement for Great Lakes fisheries agencies.

State of the Ecosystem
Background
The preyfish assemblage forms important trophic links in the aquatic ecosystem and constitutes the majority of the fish production in the Great Lakes. Preyfish populations in each of the lakes are currently monitored on an annual basis in order to quantify the population dynamics of these important fish stocks leading to a better understanding of the processes that shape the fish community and to identify those characteristics critical to each species. Populations of lake trout, Pacific salmon, and other salmonids have been established as part of intensive programs designed to rehabilitate (or develop new) game fish populations and commercial fisheries. These economically valuable predator species sustain increasingly demanding and highly valued fisheries, and information on their status is crucial. In turn, these apex predators are sustained by preyfish populations. In addition, some preyfishes, such as the bloater and the lake herring, which are native species, and the rainbow smelt, which is non-native, are also directly important to the commercial fishing industry. Therefore, it is very important that the current status and estimated carrying capacity of the preyfish populations be fully understood in order to fully address (1) lake trout restoration goals, (2) stocking projections, (3) present levels of salmonid abundance and (4) commercial fishing interests.

The component of the Great Lakes fish communities that we classify as preyfish comprises species – including both pelagic and benthic species – that prey on invertebrates for their entire life history. As adults, preyfish depend on diets of crustacean zooplankton and macroinvertebrates *Diporeia* and *Mysis*. This convention also supports the recognition of particle-size distribution theory and size-dependent ecological processes. Based on size-spectra theory, body size is an indicator of trophic level, and the smaller, short-lived fish that constitute the planktivorous fish assemblage discussed here are a discernable trophic group of the food web. At present, bloaters (*Coregonus hoyi*), lake herring (*Coregonus artedi*), rainbow smelt (*Osmerus mordax*), alewife (*Alosa pseudoharengus*), and deepwater sculpins (*Myoxocephalus thompsonii*), and to a lesser degree species like lake whitefish (*Coregonus clupeaformis*), ninespine stickleback (*Pungitius pungitius*), round goby (*Neogobius melanostomus*) and slimy sculpin (*Cottus cognatus*) constitute the bulk of the preyfish communities (Figure 1).

The successful colonization of Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario by non-native dreissenids, notably the zebra mussel (*Dreissena polymorpha*) in the early 1990s and more recently the quagga mussel (*Dreissena bugensis*), has had a significant impact on the trophic structure of those lakes by shunting pelagic planktonic production to mussels, an energetic dead end in the food chain as few native fishes can eat the mussels. As a result of profound ongoing changes in trophic structure in four Great Lakes, these ecosystems will continue to change, and likely in unpredictable ways.

In Lake Erie, the preyfish community is unique among the Great Lakes in that it is characterized by relatively high species diversity. The preyfish community comprises primarily gizzard shad (*Dorosoma cepedianum*) and alewife (grouped as clupeids); emerald (*Notropis atherinoides*) and spottail (*N. hudsonius*) shiners, silver chubs (*Hybopsis storeriana*), trout-perch (*Percopsis omiscomaycus*), round gobies and rainbow smelt (grouped as soft-rayed); age-0 yellow perch (*Perca flavescens*) and white perch (*Morone americana*), and white bass (*M. chrysops*) (grouped as spiny-rayed).

State of Preyfish Populations
Lake Superior: Mixed, improving
Since 1994, biomass of the Lake Superior preyfish has declined compared to the peak years in 1986, 1990, and 1994, a period when lake herring was the dominant preyfish species and wild lake trout populations were starting to recover. Since the early 1980s, dynamics in preyfish biomass have been driven largely by variation in recruitment of age-1 lake herring. Strong year classes in 1984, 1988-1990, 1998, and most recently 2003 were largely responsible for peaks in lake herring biomass in 1986, 1990-1994, 1999, 2004-2005. Prior to 1984, the non-native rainbow smelt was the dominant preyfish, but fluctuating population levels and recovery of native coregonids after 1984 resulted in reduced smelt biomass and rank among preyfish species. During 2002 to 2004, rainbow smelt biomass declined to the lowest levels in the 27 years since 1978, though a moderate recovery occurred in 2005. There is strong evidence that declines in rainbow smelt biomass are tied to increased predation by recovered lake trout populations.

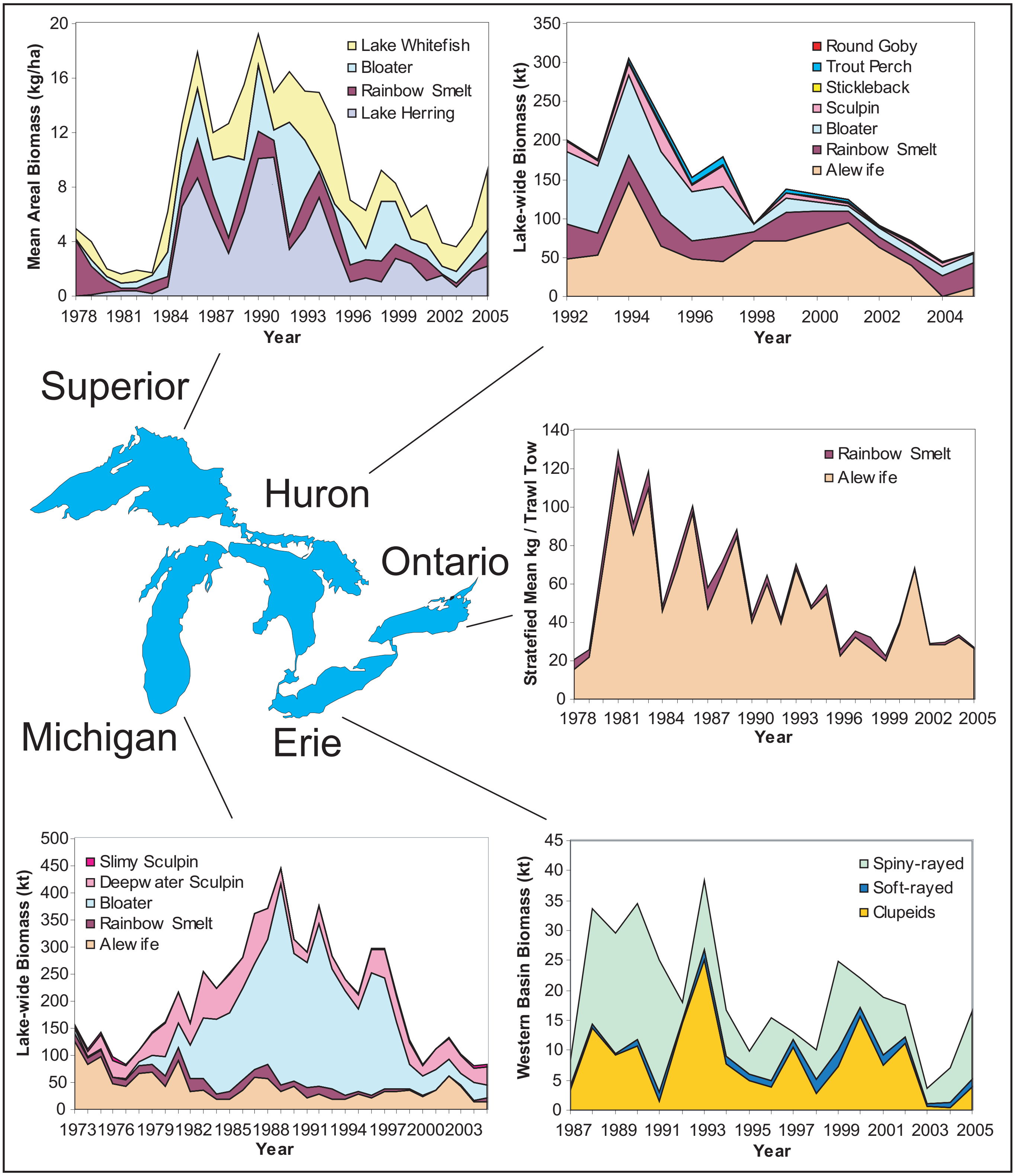

Figure 1. Preyfish trends based on annual bottom trawl surveys.

All trawl surveys were performed by USGS - Great Lakes Science Center, except for Lake Erie, which was conducted by the USGS, Ohio Division of Wildlife and the Ontario Ministry of Natural Resources (Lake Erie Forage Task Group), and Lake Ontario, which was conducted jointly by USGS and the New York State Department of Environmental Conservation.

Sources: U.S. Geological Survey - Great Lakes Science Center, Ohio Division of Wildlife, Ontario Ministry of Natural Resources, and New York State Department of Environmental Conservation.

Biomass of bloater and lake whitefish has increased since the early 1980s, and biomass for both species has been less variable than that of lake herring. Other preyfish species, notably sculpins, burbot, and ninespine stickleback have declined in abundance since the recovery of wild lake trout populations in the mid-1980s. Thus, the current state of the Lake Superior preyfish community appears to be largely the result of increased predation by recovered wild lake trout stocks and, to a lesser degree, the resumption of human harvest of lake trout, lake herring, and lake whitefish.

Lake Huron: Mixed, deteriorating
The Lake Huron fish community changed dramatically from 2003 through 2006, primarily due to a 99% decline in alewife numbers. Loss of alewife appears due to heavy salmonid predation that resulted from increased Chinook salmon abundance as a result of wild reproduction. Alewife population decline was followed immediately by increased reproduction of other fish species; record year classes of walleye and yellow perch were produced in Saginaw Bay, while in the main basin increased reproduction by bloaters (chubs), rainbow smelt, and deepwater sculpins was observed. In 2004, U.S. Geological Survey (USGS) surveys captured 22 wild juvenile lake trout, more than had been captured in the 30 year history of those surveys. However, despite increased reproduction by prey species, biomass remains low because newly recruited fish are still small. No species has taken the place of alewife, and prey biomass has declined by over 65%. Salmon catch rates by anglers declined, as did average size and condition of those fish. The situation is exacerbated by changes at lower trophic levels. The deepwater amphipod *Diporeia* has declined throughout Lake Huron's main basin, and the zooplankton community has grown so sparse that it resembles the assemblage found in Lake Superior. The reasons underlying these changes are not known, but the most widely held hypothesis is that zebra and quagga mussels are shunting energy into pathways that are no longer available to fish.

Lake Michigan: Mixed, deteriorating
Bloater abundance in Lake Michigan fluctuated greatly from 1973 to 2005, as the population showed a strong recovery during the 1980s but rapidly declined during the late 1990s. Bloater populations may have a cyclic pattern with a period of about 30 years. The substantial decline in alewife abundance during the 1970s and early 1980s has been attributed to increased predation by salmon and trout. The Lake Michigan deepwater sculpin population exhibited a strong recovery during the 1970s and early 1980s, and this recovery has been attributed to the decline in alewife abundance. Alewives have been suspected of interfering with reproduction of deepwater sculpins by feeding upon deepwater sculpin fry. Slimy sculpin abundance appeared to be primarily regulated by predation from juvenile lake trout. Slimy sculpin is a favored prey of juvenile lake trout. Temporal trends in abundance of rainbow smelt were difficult to interpret. Yellow perch year-class strength in 2005 was the highest on record dating back to 1973. Thus, early signs of a recovery by the yellow perch population in the main basin of Lake Michigan were evident. The first catch of round gobies in the annual lakewide survey occurred in 2003, and round goby abundance in the main basin of the lake has remained low through 2005.

Lake Erie: Mixed, deteriorating
The preyfish community in all three basins of Lake Erie has shown a declining trend. In the eastern basin, rainbow smelt (part of the soft-rayed group) have shown declines in abundance over the past two decades. The declines have been attributed to lack of recruitment associated with expanding dreissenid colonization and reductions in productivity. The western and central basins also have shown declines in preyfish abundance associated with declines in abundance of age-0 white perch and rainbow smelt, although slight increases for white perch have been reported in the past couple years. The clupeid component of the preyfish community is at the lowest level observed since 1998 and well below the mean biomass for 1987 to 2005. The biomass estimates for western Lake Erie were based on data from bottom trawl catches, depth strata extrapolations (less than and greater than 6 m (20 ft)), and trawl net measurements using acoustic mensuration gear.

Lake Ontario: Mixed, deteriorating
The non-native alewife, and to a lesser degree non-native rainbow smelt, dominate the preyfish community. Their populations remain at levels well below those of the early 1980s. Rainbow smelt have an abbreviated age and size structure that suggests the population is under heavy predation pressure. Abundance of the non-native round goby is increasing and round goby have the potential to cause a decrease in native, bottom-dwelling preyfish populations such as slimy and deepwater sculpins, and trout-perch. Deepwater sculpin populations have not been reported for the lake since 1972, though collected sporadically between 1996 and 2004. During 2005 and 2006, catches of deepwater sculpin increased and juveniles dominated the catches suggesting that the long-depressed population was recovering. Deepwater ciscoes, however, have not been reported in the lake since 1983 and the large area of the lake they once occupied is largely devoid of fish for much of the year.

Pressures
The influences of predation by salmon and lake trout on preyfish populations appear to be common across all lakes. Additional pressures from *Dreissena*, which are linked to the collapse of *Diporeia,* are strong in all the Great Lakes except Lake Superior. Bottom-up effects on the preyfish populations have already been observed in Lake Ontario, Lake Huron, and Lake Michigan, suggesting that dynamics of preyfish populations in those lakes could be driven by bottom-up rather than top-down effects in future years. Moreover, the effect of non-native zooplankters, *Bythotrephes* and *Cercopagis*, on preyfish populations, although not fully understood at present, has the potential to increase bottom-up pressure.

Management Implications
Recognition of significant predation effects on preyfish populations has resulted in recent salmon stocking cutbacks in Lake Michigan and Lake Huron and only minor increases in Lake Ontario. However, even with a reduced population, alewives have exhibited the ability to produce strong year classes when climatic conditions are favorable such that the continued judicious use of artificially propagated predators seems necessary to avoid domination by alewife. This is not an option in Lake Superior where lake trout and salmon are almost entirely lake-produced. Potential bottom-up effects on preyfish would be difficult to mitigate owing to our inability to effect change. This scenario only reinforces the need to avoid further introductions of non-native species into the Great Lakes ecosystems.

Comments from the author(s)
It has been proposed that in order to restore an ecologically balanced fish community, a diversity of prey species at population levels matched to primary production and predator demands must be maintained. However, the current mix of native and naturalized prey and predator species, and the contributions of artificially propagated predator species into the system, confound any sense of balance in lakes other than Lake Superior. The metrics of ecological balance as the consequence of fish community structure are best defined through food-web interactions. It is through understanding the exchanges of trophic supply and demand that the fish community can be described quantitatively and ecological attributes such as balance can be better defined and the limits inherent to the ecosystem realized.

Continued monitoring of the fish communities and regular assessments of food habits of predators and preyfish will be required to quantify the food-web dynamics in the Great Lakes. This recommendation is especially supported by continued changes that are occurring not only in the upper but also in the lower trophic levels. Recognized sampling limitations of traditional capture techniques (bottom trawling) have prompted the application of acoustic techniques as another means to estimate absolute abundance of preyfish in the Great Lakes. Though not an assessment panacea, hydro-acoustics have provided additional insights and have demonstrated utility in the estimates of preyfish biomass.

Protecting or re-establishing rare or extirpated members of the once prominent native preyfish communities, most notably the various members of the whitefish family (*Coregonus* spp.), should be a priority in all the Great Lakes, but especially so in Lake Ontario where vast areas of the lake once occupied by extirpated deepwater ciscoes are devoid of fish for much of the year. This recommendation should be reflected in future indicator reports. Lake Superior, whose preyfish assemblage is dominated by indigenous species and retains a full complement of ciscoes, should be examined more closely to better understand the trophic ecology of its more natural system.

With the continuous nature of changes that seems to characterize the preyfish populations, and the lower trophic levels on which they depend, the appropriate frequency to review this indicator is on a 5-year basis.

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