Critical Habitats for Young Fishes in Coastal Areas of West-Central Lake Erie

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Abstract

Larval fish were collected from nearshore sites in the west-central basin of Lake Erie from 2000 through 2002. More than 20 species of fish were identified from collections made mid-April through August. Overall fish densities were highest in 2000 and lowest in 2002. Emerald shiners were the most abundant species each year. Gizzard shad, rainbow smelt, white perch, and yellow perch were also abundant. Relative abundance of some species changed with year; rainbow smelt were most numerous in 2000 whereas clupeids were most numerous in 2000 and 2002. Thus far, water temperature and dissolved oxygen appear to follow similar trends among sites and years. However, turbidity changed drastically with year and site. Benthic invertebrate assemblages in soft substrate were primarily composed of oligochaetes, chironomids, nematodes, and clams at all sites throughout the study. Dreissenid mussels were the most abundant taxonomic group of invertebrates over hard substrate. Zooplankton differed with year and site; veligers, rotifers, and nauplii were the most important taxonomic groups. The open-water nearshore zone of the west-central basin of Lake Erie clearly serves as a nursery area for a variety of larval fishes. Future analyses will determine the effects of abiotic and biotic factors on the larval fish community.

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Introduction

The nearshore zone is an important nursery area for the Great Lakes. Of the 120 fish species that spawn in the Great Lakes, all but five can spawn in waters as shallow as 1 m (Lane et al. 1996a). This zone is an important nursery area because it provides refuge and food for young fishes. During at least a portion of their first year of life, 129 species of Great Lakes fish are found in lake habitats generally less than 2 m deep (Lane et al. 1996b). However, the linkage between nearshore and offshore use by different life stages of most fishes in the Great Lakes is poorly known. Although fish assessment surveys targeting adult and juvenile fish have been routinely conducted in the Great Lakes using bottom trawls, the early life history stages of most fish are not routinely sampled. With the exception of a few species, such as walleye *Stizostedion vitreum* (Mion et al. 1998) and lake whitefish *Coregonus clupeaformis* (Freeberg et al. 1990), the recruitment dynamics of fishes is poorly known in the Great Lakes, partly because these life stages are difficult to sample. Knowledge of the mechanisms affecting the occurrence and relative abundance of species would greatly enhance our ability to predict the responses of fish populations to perturbations.

The larval stage is critical for determining recruitment in fish; larval fish must quickly find limited sources of food to grow and survive. Interactions among larval species can also be important. Larval lake whitefish (feeding on native plankton) can suppress feeding and growth of similar-sized, larval lake herring *Coregonus artedi* (Savino and Hudson 1995, Davis and Todd 1998). Larval fish are also extremely vulnerable to fish predators, but fast growth reduces their vulnerability to some predators (Brandt et al. 1987, Miller et al. 1988). In fish that exhibit no parental care, species that produce larger larvae at hatch have a longer window of opportunity to capture food before the onset of starvation (Miller et al. 1988). Among alewife *Alosa pseudoharengus*, yellow perch *Perca flavescens*, and bloater larvae *Coregonus hoyi*, size is more important than species in determining feeding ability in laboratory studies with novel prey, *Artemia* (Miller et al. 1992). As fish grow they can take advantage of an increasing variety of prey (Schael et al. 1991). In some cases, this increase in size allows a shift in diet to a new source of prey, such as from zooplankton to macroinvertebrates to fish (Hayes and Taylor 1990). However, the addition of competitors and predators into the system can complicate patterns in ontogenetic diet shifts (Werner and Gilliam 1984, Post and McQueen 1988, Werner and Hall

1988, Osenberg et al. 1992). Even intraspecific competition can alter ontogenetic diet shifts (Post et al. 1997). Hence, species interactions can be an important determinant of growth rates and survival of young fishes.

Nearshore habitats can also affect growth and survival of young fishes by providing a range in options of food and shelter. Cobble and sand areas offered different levels of refuge and prey items for slimy sculpin *Cottus cognatus* and young-of-the-year lake trout *Salvelinus namaycush* through the growing season (Hudson et al. 1995). Young bluegill sunfish *Lepomis macrochirus* use shallow depths to avoid predators in areas with no vegetation (DeVries 1990). Turbid waters can act as a refuge from visual predators, but can also decrease the ability of larvae to feed (Breitburg 1988, Miner and Stein 1996). High turbidity may also exert important selective forces on the susceptibility of zooplankton to visually feeding planktivores (such as larval fish) and on zooplankton productivity (Krieger and Klarer 1991). Quality of habitat is also important in conferring advantages to habitat complexity (Dionne and Folt 1991). For example, *Myriophyllum*, an exotic macrophyte, provides extremely high structural complexity, but does not provide suitable foraging habitat for either macroinvertebrates or larval fish (Keast 1984).

Degradation of habitats, either through physical or chemical modifications, may lead to substantial changes in the structure of fish assemblages. Structural changes may result directly from poor habitat quality (e.g., low oxygen concentrations, unsuitable spawning areas) or indirectly through effects on the food web (e.g., elimination or reduction of habitat suitable for prey species). Spawning habitat preferences are critical for some species; yellow perch typically spawn near sparse vegetation in shallow waters whereas salmon *Oncorhynchus* spp., lake sturgeon *Acipenser fulvescens*, and walleye spawn over rock or gravel substrates (Scott and Crossman 1973). Altering habitat quality can change the utility of the nearshore habitat as a refuge or feeding area. Reduction of macrophyte beds reduces associated prey (Gerrish and Bristow 1979). Siltation in rocky habitats may reduce the value of a refuge and change the prey base. Contaminated areas may diminish prey condition, affecting antipredator behaviors and thereby increasing vulnerability to predators (Mesa et al. 1994). In Lake Erie, 34 fish species are recognized as rare, threatened, endangered, extirpated, extinct, or of special concern (Environment Canada and US EPA 1997); of these, those species that are not extinct or extirpated - and possibly other species - may be adversely affected by alterations of habitat quantity and quality.

In this study we began to examine the role of species interactions and physical factors in determining nearshore, larval fish assemblages. Our sites were at the mouths of three Ohio rivers (Huron, Vermilion, Black) in the west-central basin of Lake Erie (Fig. 1). Here, coastal areas contain beaches, bluffs, extensive stretches of armored shoreline, and only one appreciable wetland (Old Woman Creek). These coastal areas abut an open-water, non-vegetated and high-energy zone, which biologically is one of the least studied areas of Lake Erie, in part due to logistical difficulties. Nearshore bottom substrates (<12 m) in the west-central basin include vast areas of mud (similar to the western basin) as well as exposed bedrock (similar to the central basin). Thus, the west-central basin affords an excellent opportunity to study the effects of variation in physical habitat on aquatic communities that occur in both types of habitats (soft and hard substrate) in nearshore areas of Lake Erie. The primary objective of this study is to determine species composition and relative abundances of larval fishes in the nearshore area of west-central Lake Erie from April through September. In addition, we study the availability of pelagic and benthic invertebrate prey and determine if they directly or indirectly affect the survival of the native larval fish assemblage. Knowledge of the factors affecting the occurrence and relative abundance of fish species would greatly enhance our ability to predict the response of fish populations to perturbations.

Methods

A series of grid cells (30 seconds longitude x 30 seconds latitude) were laid out within an arc centered on each river mouth and having a radius of 4 km (Fig. 2). Previously, the Ohio Geological Survey and the USGS conducted sidescan sonar surveys to describe substrate type of the entire coastal area of the Ohio waters of Lake Erie within ~ 3.4 km of the shore (Fuller 1998). Hence, each grid could be described as containing soft or hard substrate or a combination of both. For grid cells containing both substrate types, the sections were described geospatially. On each sampling date, a total of six random grid cell stratified by substrate (three over soft substrate, three over hard substrate) were sampled near each river mouth. Huron and Vermilion sites were sampled routinely each year. In 2001, the Lorain (Black River) site was sampled during every other sampling trip. In 2002, the Lorain site was sampled routinely with the other two sites.

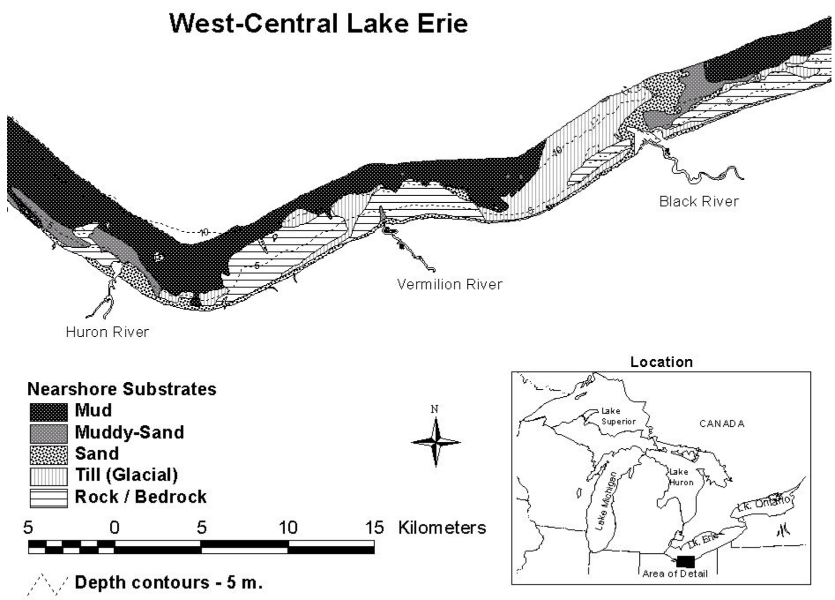

Figure 1. Substrate map of the nearshore area (within 5 km) along the west-central basin of Lake Erie. Study sites located at the mouths of the Huron, Vermilion, and Black Rivers.

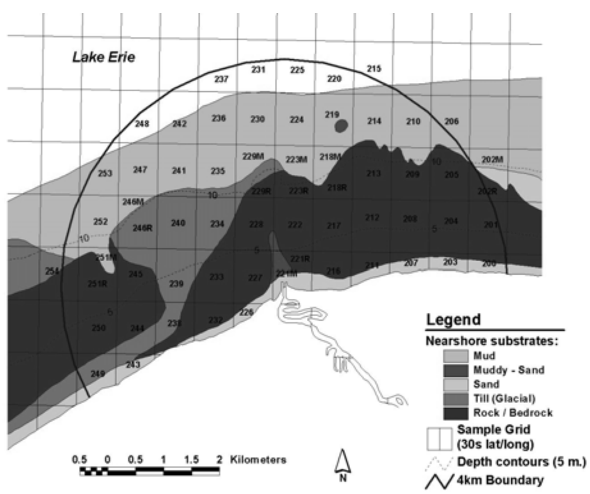

Figure 2. Map of grid design for the site at Vermilion, Ohio. Dark semi-circle is the 4 km boundary line used around each river mouth.

Larval fish were collected with a neuston net (500-μ mesh, 2 x 1 m frame) towed for 5 minutes at the water surface using the stratified, random sampling design described above. Larval fish samples were taken weekly from mid-April through May then biweekly until September. Samples were first drained of excess water and then preserved in >75% ethanol. In the laboratory, samples were sorted under a dissecting microscope, fish were enumerated and measured, and taxonomic identifications were made to the lowest possible level.

Zooplankton samples were collected at each larval fish sampling site with a vertically hauled plankton net of 64-μ mesh and 50-cm diameter mouth opening. Each sample had an alka-seltzer tablet added (narcotizing and buffering agent) and was then rinsed through a bucket of the same mesh and preserved in buffered and sugared 5% formalin. In the laboratory, individuals were identified (Balcer et al. 1984), enumerated, and measured to the nearest 0.1 mm.

Benthic macroinvertebrate samples were taken seasonally (spring, summer, and fall). Three soft sediment grid cells and three hard sediment grid cells were sampled at each river site and season. Samples in areas of sand, silt, or mud were collected with a standard (484 cm^2) Ponar grab (Davis et al. 1991). Samples in areas of hard substrate were collected by divers first using a portable suction sampler over two ¼ m^2 plots and then manually removing remaining dreissenid mussels (Hudson and Oliver 1983). Grab and suction samples were concentrated in the field by washing them through a 500-μ mesh sieve and preserved in a 10% formalin-phloxine B mixture. Macrozoobenthic organisms in the sample were identified to major taxon, counted, and measured in the laboratory.

At each sampling station we recorded GPS coordinates (Garmin) and water depth (sounding line of Ray Jefferson Model 202, depth computer). Water samples were taken at the water surface and 1-m above the substrate with a Kemmerer bottle. Water quality was assessed by measuring dissolved oxygen concentrations (Yellow Springs Instruments Model 54 Oxygen Meter), turbidity (LaMotte 2020 turbidimeter), clarity (Secchi disk), temperature, conductivity (Oakton TDSTestr3), and pH at each site. Water samples were taken for phosphorus and chlorophyll-a analyses seasonally in 2001. In 2002, a flourimeter (Aquaflor 8000) was used to obtain chlorophyll-a at each sampling station along with the other measures of water quality.

Results

Larval fish were captured at our sites each year from April through August (Fig. 3). Overall trends showed peak abundances in June or July. Trends in fish density were similar at the Vermilion and Huron sites, but densities were usually higher at Huron (Fig. 4). Generally, fewer fish were captured at the Lorain site each year. Fish densities could vary greatly at a site among years, but fish densities were generally highest in 2000 and lowest in 2002 (Fig. 4). At Vermilion, fish abundance lagged about one to two weeks in the spring of 2001 and 2002, as compared to the spring of 2000. Fish abundance peaked in June and again in July of 2000 at Vermilion; much lower peaks were noted in 2001 and 2002. At Huron, trends in spring fish densities were also delayed in 2001 and 2002 compared to 2000. However, summer peak abundances in 2001 and 2002 were lower but approached those of 2000. Fish densities were not

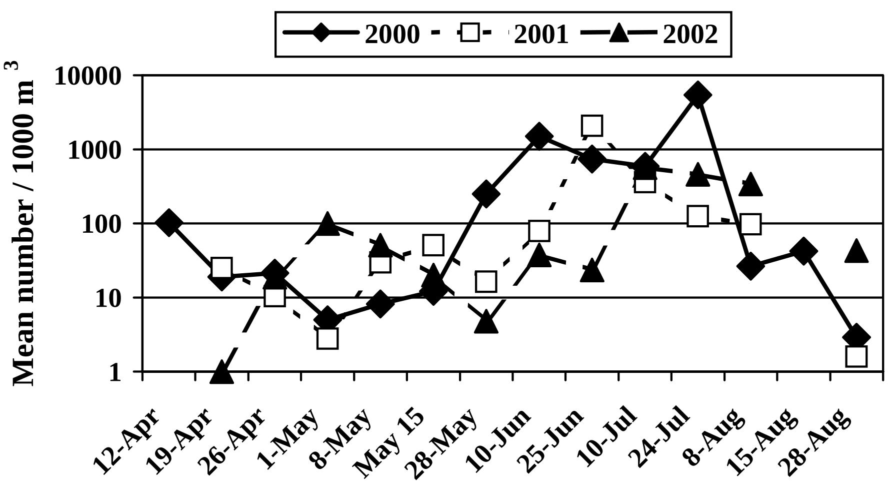

Figure 3. Densities (mean number/1000 m^3) for larval fish at all sites during the Lake Erie Nearshore Study 2000-2002.

recorded in Lorain in 2000 and only intermittently in 2001; however, the fish abundance found in 2001 was similar to that in 2002**.**

Over 20 fish species were collected during the three years of study (Table 1). Most species were found in each year of the study and several species were consistently prominent. Lake whitefish were the primary species collected in April each year (Fig. 5, Table 2). A large number of cyprinids were collected each year and provided the peak abundances (primarily emerald shiners) noted each summer, primarily in 2001. Percids (yellow perch, walleye, and logperch, primarily) were found in May and June; centrarchids (*Lepomis, Micropterus, and Pomoxis* spp.) were notable most summers; and *Morone* spp. (white perch and white bass) were noted in small numbers throughout the summer. Rainbow smelt were most numerous in 2000. Clupeids (alewife and gizzard shad) were most numerous in 2000 and 2002.

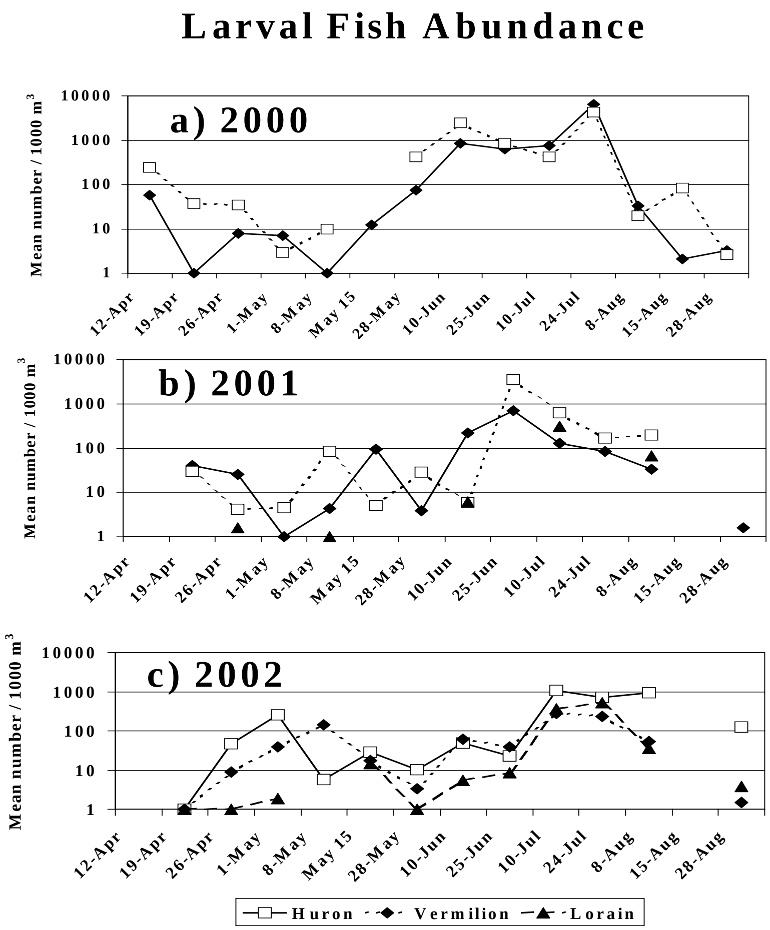

Figure 4. Larval fish abundance (mean number/1000 m^3) during the Lake Erie Nearshore Study during (a) 2000, (b) 2001, and (c) 2002.

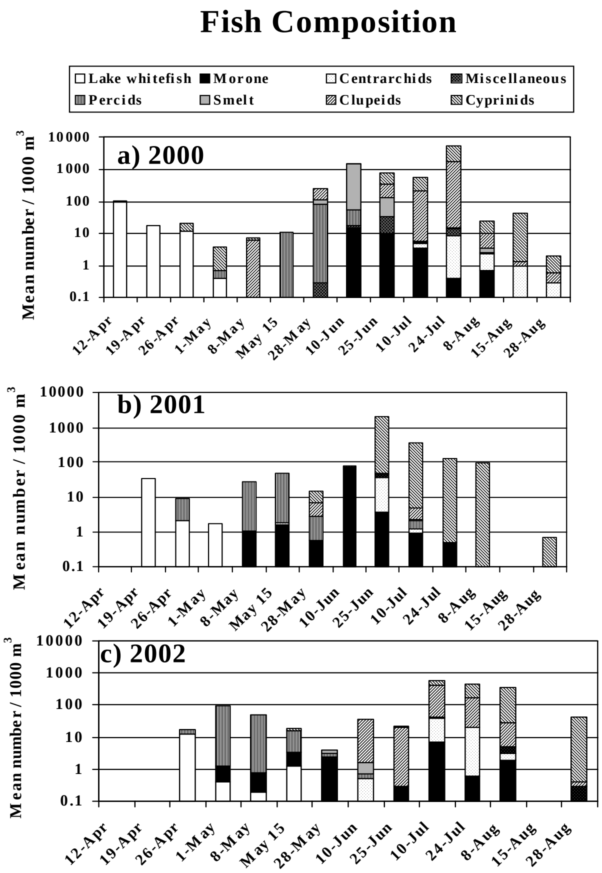

Figure 5. Taxonomic composition (mean number/1000 m^3) of groups of larval fish caught during Lake Erie Nearshore Study during (a) 2000, (b) 2001, and (c) 2002.

Abiotic Factors

Several abiotic factors were measured each year. Water temperature did not change noticeably among the three study years and could not account for the differences in overall and species abundances noted (Fig. 6). Dissolved oxygen changed somewhat with year, but correlations with changing species abundance were not readily apparent (Fig. 7).

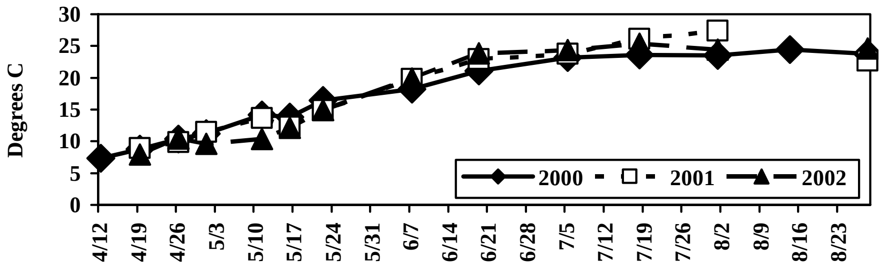

Figure 6. Mean surface temperature (˚C) for all sites during the Lake Erie Nearshore Study 2000-2002.

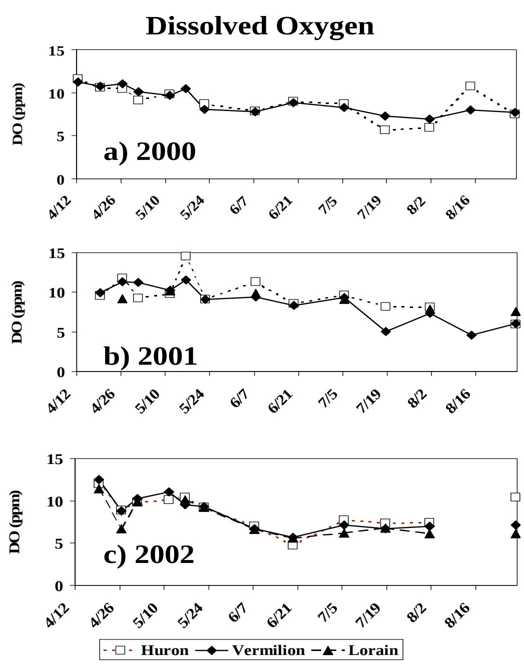

Figure 7. Mean surface dissolved oxygen (ppm) for all sites during the Lake Erie Nearshore Study during (a) 2000, (b) 2001, and (c) 2002.

Turbidity showed the most variability among years and seasons (Fig. 8). Turbidity was lowest in 2001 when storm events were infrequent. In 2000, turbidity was relatively high in the summer. In 2002, turbidity was highest in the spring. Further analyses among all abiotic factors will be undertaken to identify any detectable affects on larval fish abundances.

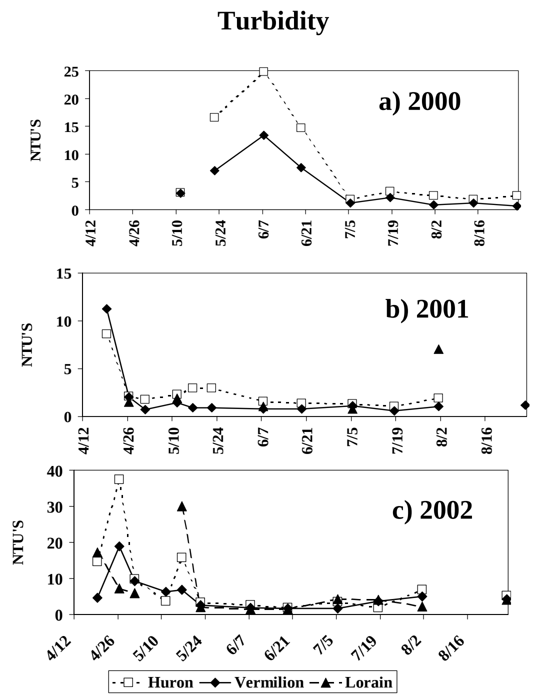

Figure 8. Mean surface turbidity (ntu) for all sites during the Lake Erie Nearshore Study during (a) 2000, (b) 2001, and (c) 2002.

Invertebrates

The benthic invertebrate communities on hard and soft substrate were analyzed. Oligochaetes were the most common invertebrate taxa over the three years and at the three sites in soft substrate (Fig. 9). Chironomids, nematodes, and clams were the other abundant taxa. Lorain had fewer clams and more chironomids than the other two sites.

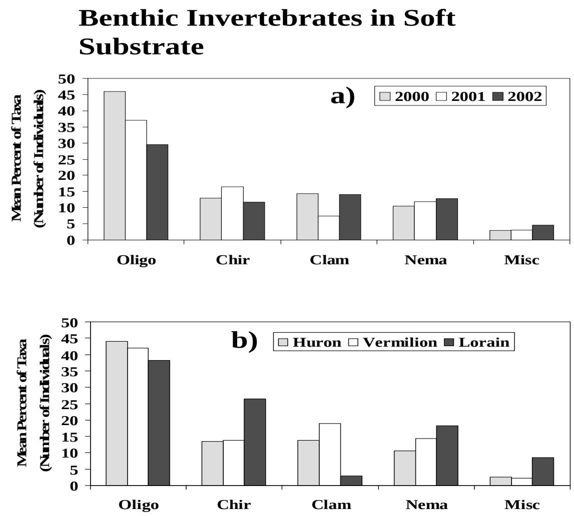

Figure 9. Composition of benthic invertebrates caught over soft substrates during the Lake Erie Nearshore Study 2000-2002. Values are in mean percent of taxa for the major groups by (a) year and by (b) site.

The analyses of invertebrates over hard substrates is still ongoing. Thus far, dreissenid mussels were by far the most numerous and had the largest biomass of all taxa observed on hard substrate. Other invertebrate taxa found in the hard substrate included oligochaetes, chironomids, amphipods, ephemeropterans, gastropods, planaria, hydra, and nematodes. Quagga mussels (*Dreissena quagga*) were as prevalent as zebra mussels (*D. polymorpha*), even at relatively shallow depths, and the length frequencies of both mussel species overlapped almost completely (Fig. 10). In May of 2000 and 2002, the length frequency of zebra mussels exhibited two peaks – one around 5 mm and the other near 20 mm. However, the smaller-sized mussels were absent in May 2001. Quagga length frequencies had a peak between 20-24 mm in May of 2000 and 2001, with a peak of about 13 mm in May 2002. Once analyses of invertebrates over hard substrate is completed, we will be able to determine seasonal changes in abundance and species composition.

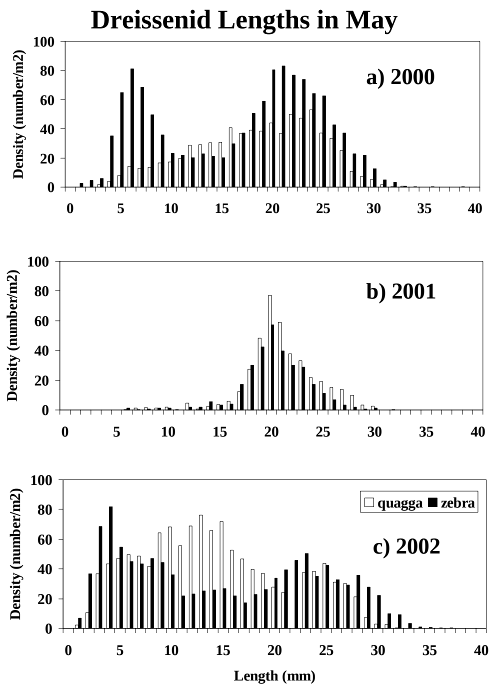

Figure 10. Length frequencies of dreissenid mussels caught over hard substrates during the Lake Erie Nearshore Study during May of (a) 2000, (b) 2001, and (c) 2002. Density values are mean number/m^2.

Zooplankton was abundant through most of the study. Zooplankton analyses for samples collected in 2002 are not completed yet. Thus far, overall zooplankton densities were lower in 2000 than 2001 (Fig. 11). In both years, densities were lowest in April and peaked in late summer; however, 2001 showed a decline in August. A declining pattern from west to east was apparent for both years. In 2000, densities were much higher at Huron than Vermilion until

August. In 2001, densities were again highest at Huron, with a large peak in July, but were about the same at Vermilion and Lorain.

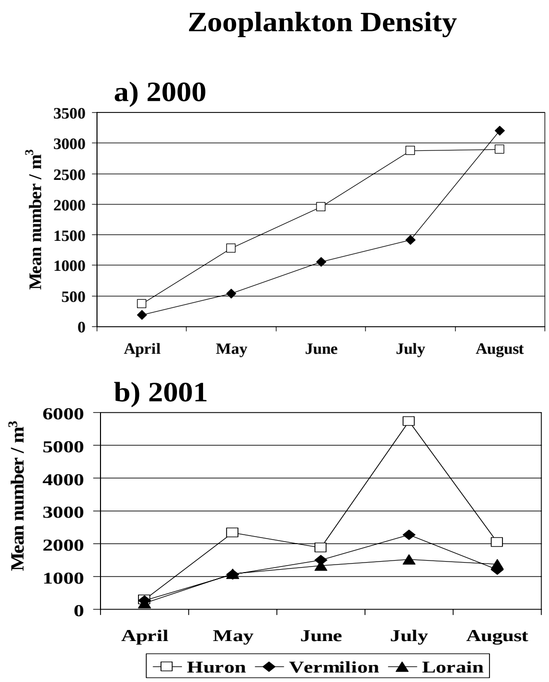

Figure 11. Zooplankton densities (mean number/m^3) for the first two years of the Lake Erie Nearshore Study 2000-2001. Values are averaged for each month during (a) 2000 and (b) 2001.

Zooplankton composition was mainly dominated by three groups: dreissenid veligers, copepod nauplii, and rotifers (Fig. 12a). When considered at the species level, over 100 taxa were collected during the two years. Veligers made up a much greater percentage of the assemblage in 2001 than in 2000, which was the opposite trend observed in nauplii and rotifers (Fig.12b). Zooplankton densities were highest at the Huron site, where veligers dominated. In April, nauplii made up about 70% of the zooplankton community (Fig.12c). From May through August, veligers were again the dominant group. The other groups were relatively consistent throughout the season, although cyclopoid copepod, and cladoceran populations peaked in June.

Rotifers (approx. 50 species) were dominated by five genera *Polyarthra*, *Keratella*, *Synchaeta*, *Conochilus*, and *Euchlanis*. Of the observed crustacean groups, cyclopoid copepods were dominated by a variety of copepodites and *Diacyclops thomasi*. Calanoid copepods were dominated by various copepodites and *Skistodiaptomus oregonensis*. Small cladocerans were dominated by *Bosmina longirostris* and large cladocerans were dominated by *Daphnia mendotae* and *D. retrocurva*. There were also about eight miscellaneous taxa that accounted for less than 1% of the total count of zooplankton.

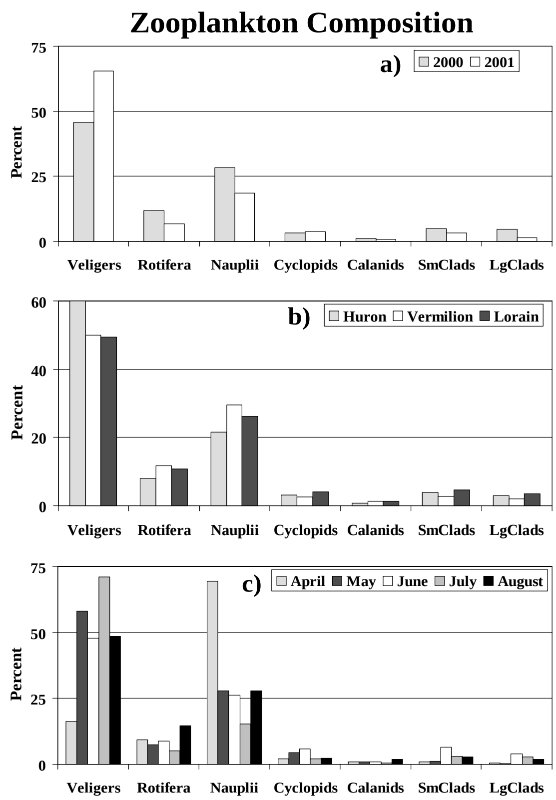

Figure 12. Percent composition of major zooplankton groups for the first two years of the Lake Erie Nearshore Study 2000-2001. Group values are presented by (a) year, (b) location, and (c) month.

Deleted: site

In summary, the open-water, nearshore zone of the west-central basin in Lake Erie serves as a nursery ground for a large variety of fish. Densities of individual fish species and abiotic conditions can vary widely by year and with site. Turbidity may be one factor to consider in further analyses and studies. Invertebrate prey densities can also vary considerably, both spatially and temporally. At this time, we are in the process of completing the invertebrate analyses. Future planned work includes the multivariate statistical analyses of abiotic and biotic factors that may affect the species composition and density of the larval fish community.

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Table 1. Fish species recorded in neuston tows.

Species	Common name	Group shown in Figure 5	Years Collected
Coregonus clupeaformis	Lake whitefish	Whitefish	All
Osmerus mordax	Rainbow smelt	Smelt	All
Alosa pseudoharengus	Alewife	Clupeid	2002
Dorosoma cepedianum	Gizzard shad	Clupeid	All
Carassius auratus	Goldfish	Cyprinids	2000, 2002
Cyprinus carpio	Carp	Cyprinids	2000
Luxilus cornutus	Common shiner	Cyprinids	All
Notemigonus crysoleucas	Golden shiner	Cyprinids	2000
Notropis atherinoides	Emerald shiner	Cyprinids	All
Notropis hudsonius	Spottail shiner	Cyprinids	All
Morone americana	White perch	Morone	All
Morone chrysops	White bass	Morone	All
Etheostoma nigrum	Johnny darter	Percids	2001
Percina caprodes	Logperch	Percids	All
Perca flavescens	Yellow perch	Percids	All
Stizostedion vitreum	Walleye	Percids	All
Lepomis spp.	Sunfish	Centrarchid	All
Lepomis macrochirus	Bluegill	Centrarchid	2000, 2001
Micropterus salmoides	Largemouth bass	Centrarchid	2000
Pomoxis spp.	Crappie	Centrarchid	All
Pomoxis nigromaculatus	Black crappie	Centrarchid	2000
Aplodinotus grunniens	Freshwater drum	Misc	All
Carpiodes cyprinus	Quillback carpsucker	Misc	2001
Erimyzon sucetta	Lake chubsucker	Misc	2000, 2001
Ictiobus spp.	Buffalo	Misc	2000
Neogobius melanostomus	Round goby	Misc	2001