# NORFOLK MORAINE FISHERIES BASELINE STUDY

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Environmental Explorations is a partnership among Orville Burch, Edward Emmons, and Scott Hoffman. All three have participated in this project sponsored by the Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Water Resources Management, Division of Coastal Zone Management, with funding from a federal coastal zone management grant. We hereby acknowledge with our signatures that the contents of this report are true and conform to the best of our abilities to the contract entered into with sponsoring agency on September 9, 1985.

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TABLE OF CONTENTS:

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Courier Concepts, Sandusky, Ohio

LIST OF FIGURES:

LIST OF TABLES:

EXECUTIVE SUMMARY:

Their were four objectives to this program. We believe that each of these objectives were achieved. The purpose of this executive summary is to highlight each objective.

Objective 1. To characterize the fish populations on the Norfolk Moraine. This was achieved using a combination of collection gear designed to collect various sizes and life stages of fish. A total of 18 species of fish comprising 12 Families were collected (pages 13-14).

Objective 2. To establish the nature and extent of the utilization of the Moraine as a spawning site. This was achieved by determining the abundance and distribution of larval fish (methods pages 7-8). Three species apparently utilize the Norfolk Moraine area to a large extent; burbot, rainbow smelt, and yellow perch (page 38).

Objective 3. To establish the nature and extent of the utilization of the Moraine as a nursery site. We attempted and proposed to achieve this objective by analyzing the foraging of larval fish. Successful foraging by larval fish on the Moraine would indicate the importance of the area for future fisheries resources. All larval fish collected, however, were of the prolarval stage and had not yet begun to consume prey (see pages 42-44). We were indirectly able to conclude that the Moraine was important as a nursery area because of the abundance of young-of-the-year fish (pages 24 and 34). A total of 10 species of fish were collected along the Moraine representing an early year class. We believe that the abundance of young-of-the-year fish was a result of the utilization of the area as a nursery site. More informations about this aspect of the Moraine, however, should be ascertained.

Objective 4. To assess the impact of commercial sand and gravel dredging on the existing and future fisheries resource. This was achieved by establishing and analyzing the fisheries composition in a control zone relative to the composition in a proposed dredge zone and a dredged zone (pages 3-6). No apparent large scale effect of dredging on the fisheries resources along the Moraine were evident (pages 46-47). However, we caution against extrapolation of this data beyond the scope of present dredge activity and recommend additional analysis of localized and immediate dredge effects (pages 47-49).

## INTRODUCTION:

In 1985, Environmental Explorations initiated biological investigations of the Norfolk Moraine area of Lake Erie, Erie, Pennsylvania. The study, sponsored by the Commonwealth of Pennsylvania, Division of Coastal Zone Management, was to evaluate the effects of commercial sand dredging on the population structure of fish and zooplankton. Evaluations were to be made by determining the baseline fisheries resource along the Moraine and comparing that baseline data to data collected from a dredged area and from an area proposed for dredging.

The objectives of this program were:

- o to characterize the fish populations on the Norfolk Moraine,
- o to establish the nature and extent of the utilization of the Moraine as a spawning site,
- o to establish the nature and extent of the utilization of the Moraine as a nursery site, and
- o to assess the impact of commercial sand and gravel dredging on the existing and future fisheries. resource.

The importance of this study is readily apparent. Past environmental perturbations of Lake Erie have radically altered the biotic population structure of the Lake (Christie 1974, Leach and Nepszy 1976, Schneider and Leach 1977, Nicholls 1980,Trautman

1981). Now with the Lake in a "recovery" stage there is a renewed interest in prudent, cohesive, environmental management of the Lake Erie resource. One way to achieve this is to assess baseline population structure and determine the effects that proposed degradations may have on that population structure. Historicaly, these degradations have involved both physical and chemical alterations as well as biotic changes caused by the invasion of exotic species such as rainbow smelt, sea lamprey, and more recently white perch. Although this study is primarily concerned with physical alterations, we will also discuss the occurence of a new member of the Lake Erie biota.

Dredging of sand and/or gravel from Lake Erie could have a serious impact on the spawning and forage activity of fishes in the immediate area of the dredging and even potentially throughout the basin (Slotta et al. 1974, Lehmann 1979, Johston 1981, Laskowski-Hohe and Prater 1981). Dredging involves the physical removal of part of the lake bottom. The material dredged, not only has a commercial value, but it is often of great value as a spawning and foraging habitat for fish. Studies in estuarine environments have demonstrated that dredging has a detrimental effect on reproductive success (Huet 1965, Bayless 1968). Clean areas of sand and gravel are used by many species of Lake Erie fish. Scott and Crossman (1973) list over 30 species of Lake Erie fish that require either sand or gravel for successful spawning. Goodyear et al. (1982) lists eight species that spawn in the area of the Norfolk Moraine. In addition, Balon (1975) lists over twenty larval forms that require sand or gravel as a nursery area. As the number of suitable spawning areas decrease, those that remain become increasing important to the Lake Erie fisheries resource. The Norfolk Moraine could have an even greater significance because of its geologic nature. The Moraine represents an upwelling of sand, more shallow than the surrounding substrate, and therefore potentially more valuable as a spawning site.

In addition to altering or destroying potential spawning areas, dredging could also potentially increase the amount of turbidity in the areas being dredged. The increased turbidity could decrease phytoplankton productivity, or decrease the foraging efficiency of zooplankton and larval fish (Confer et al. 1978). Either of these events could have a detrimental impact on fisheries resources along the Norfolk Moraine, since all of these organisms contribute to the overall biotic structure of the lake environment.

Study Site:

The Norfolk Moraine is located in the east-central basin of Lake Erie in Erie County, Pennsylvania. For the purpose of this study the area was sectioned into three sampling areas. These areas were labeled as 'dredge", "proposed dredge", and "control" (Figure 1).

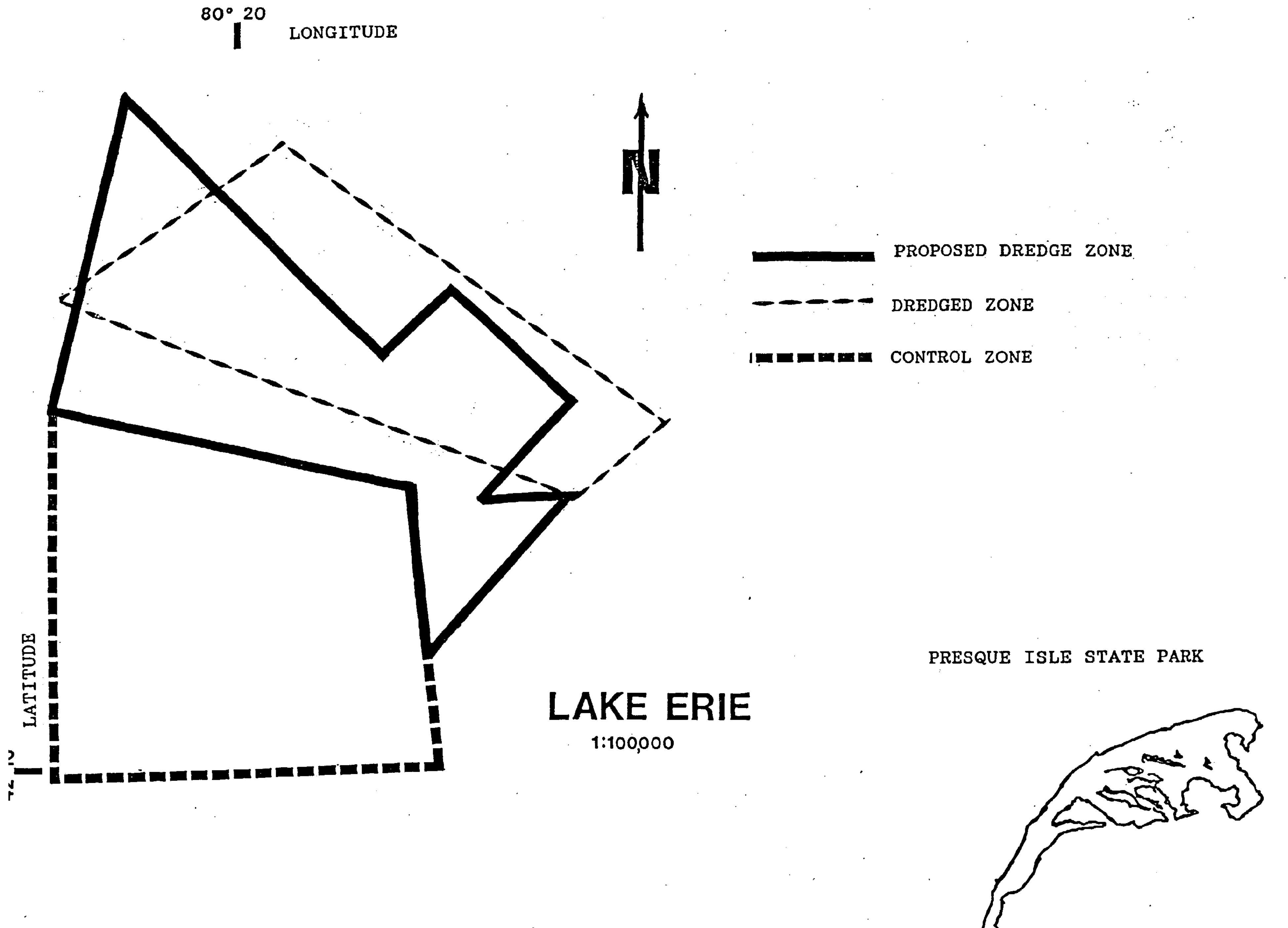


FIGURE 1. SAMPLE AREA

The "dredge area" is an approximately 12 square mile area that is currently being dredged by Erie Sand Steamship Company. The "proposed dredge" area is a 19.6 square mile area that overlaps and abutts the dredge area to the south and west. The "control" area was defined by Environmental Explorations with assistance from the Division of Coastal Zone Management, and from the Pennsylvania Fish Commission. The "control" area, since it would be used as a baseline area had to be an area comparable in size and depth with the other two areas. It was also important that the control area be sited as to be unaffected by activities in the dredge area. The control area was therefore the area abutting the proposed dredge zone. In this manner the proposed dredge area served as a buffer zone between the control area and the dredge area.

For sampling and analysis purpose, each of the three sampling areas were divided into one square mile quadrates. These quadrates were constructed to serve as replicate sampling sites in each area, and to provide a mechanism to randomly sample the area. During each collection period, three quadrates from each of the three areas were selected using a table of random numbers. All appropriate sampling tasks for that collection effort were then conducted in those selected quadrates. This prevented biased sampling of any site in the area over another, and provided for statistical replicates.

Individual quadrates were located within the area using a

Loran C. In addition to the Loran C, traditional navigational techniques (ie. compass bearing, navigational maps, and time/distance measurements) were used as a check on the Loran C system, and to establish back-up procedures. All systems proved to be accurate to within approximately 0.1 miles.

## Methods:

### Gill Nets:

Adult fish were collected using bottom deployed gill nets. Three gill nets were set monthly in each sampling area. All sets per month were conducted within a seven day period to insure comparability of samples. Each gil net measured 6 X 450 feet with nine, 50 feet-mesh panels. The panels were arranged in ascending order from 1 to 5 inch-stretch mesh, in increments of one-half inch. The duration of each net set was 24 hours, however, the nets were checked and reset after 12 hours to provide data on day versus night catch efficiency.

All fish collected by gill nets were identified to species, measured, and released. Both species identification and length were recorded for each separate mesh size. In addition, all fish were checked for spawning condition, and for the presence of any unusual marks or scars. The purpose of the latter was to check for any recent lamprey attacks on the fish.

Otter Trawls:

Bottom otter trawls were used to collect young-of-the-year (YOY) and adults of smaller species. The otter trawl was a 16-foot headrope with a one-quarter inch-mesh cod end (Figure 2). Three trawl hauls were made each month in each sampling area. The trawls were fished for 10 minutes at a speed of three nautical miles (NM) per hour. All fish collected were identified to species, measured, sexed when possible, and released.

Larval Fish:

Larval fish were sampled from each area twice monthly with nine samples collected from each of the three areas during each collection effort. Collections were made similtaneously from three discrete depths; surface, mid-depth, and epibenthic, using a standard conical plankton net with a 0.5-m diameter mouth and of 500 um-mesh (Figure 3). The epibenthic net was mounted to a steel sled designed specifically for this project. Each tow was for 10 minutes at a speed of 1-2 NM/h. Flow rates were measured using a Clarke-Bumpus flow meter mounted outside the mouth of the epibenthic sled net. All samples were preserved in 10% formalin and returned to the lab for identification, enumeration, and analysis of diet. All larval fish collected were identified to lowest possible taxonomic division using larval fish diagnostic keys and descriptive papers (Ayer 1985, Snyder 1979, Cooper 1978, Mansueti 1964, Norden 1961). Each individual larval fish was

OTTER TRAWL

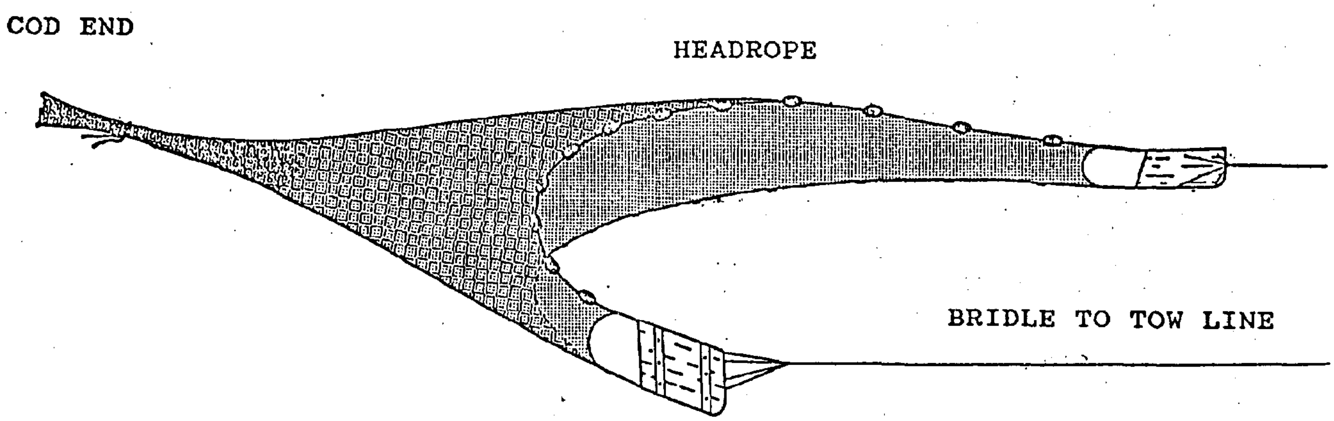


FIGURE 2. SCHEMATIC DIAGRAM OF OTTER TRAWL

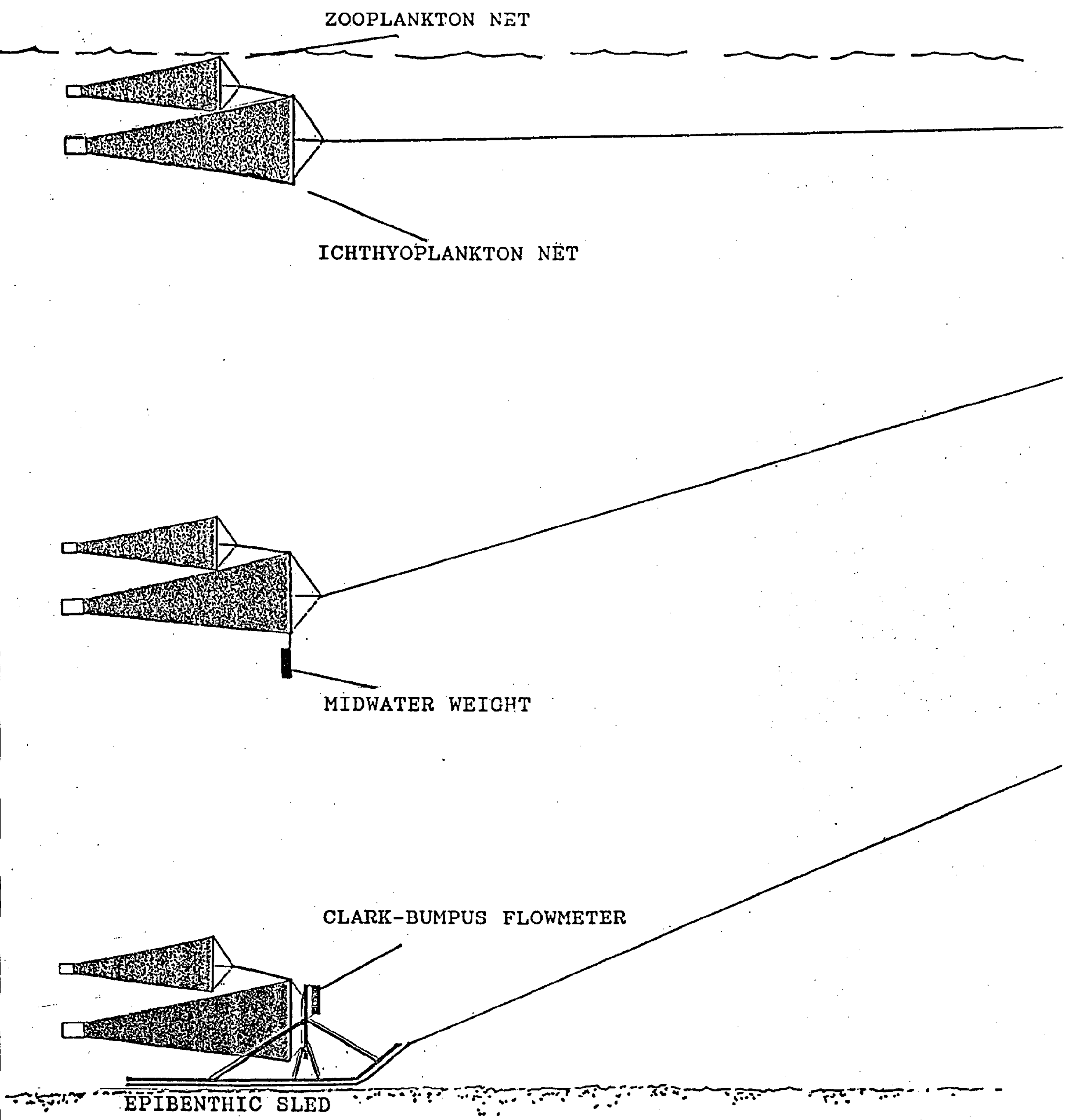


FIGURE 3. SCHEMATIC DIAGRAM OF PLANKTON NET CONFIGURATIONS

measured in mm to total length and classified as either a prolarvae, mesolarvae, or metalarvae based on morphological characteristics established and described by Snyder (1976). Each individual was then placed in a depression microscope slide and the gut was teased apart and the contents removed via the procedures developed and described by Burch (1982). All items in the gut were identified to the lowest possible taxonomic division and enumerated.

## Zooplankton:

Concurrent with the larval fish sample, a zooplankton sample was collected from each of the three depths. Collections were made with standard conical zooplankton nets of 0.3-m diameter and of 343 um-mesh (Figure 3). Tows were of a ten minute duration and volume of water filtered was determined using Clark-Bumpus flowmeter readings. Samples were preserved in 5% unbuffered formalin and returned to the lab for identification and enumeration.

Identification was made to lowest possible taxon using a compound light microscope and diagnostic keys (Balcer et al. 1984, and Torke 1974). Counts were made using a 1.3 ml Sedwick-Rafter counting cell or a 10 ml zooplankton counting wheel. For each sample a total of 10 ml was analyzed with subsamples removed using a 1 ml or a 2 ml Hensen-Stemple pipette. Estimates of density were calculated using the formula:

Number cubic meter = N(S)/V(Q)

where N is the total number of zooplankters in the subsample, S is the volume of the sample (ml), V is the combined volume counted (ml), and Q is the quantity of water strained as determined by the flow meter readings (m3)

## Data Analysis:

### Gill Nets and Trawls:

For gill net and trawl data, mean length and standard error were calculated for each species by month and area. For gill net data, catch per unit effort statistics were also calculated for each species, as the number of fish caught/foot of mesh/hour. For trawl data, the catch per unit effort was calculated as number caught/minute. Originally a jackknifed technique of variance estimation for catch per unit effort data was proposed. In addition to the jackknife technique, we also calculated the more familiar and simplier parametric standard error of the mean, to compare the two techniques. Both techniques yielded variance estimates of similar magnitude. We therefore present the final data analysis as the standard errors of the mean instead of the more complicated jackknife estimation. We believe that the use of the standard errors of the mean will allow this data to be compared more easily to data from other studies.

Larval Fish:

For larval fish, collection density estimates were made using number of taxon/cubic m of water filtered. Descriptive statistics such as mean and standard error of the mean were used for each lifestage of each taxon.

Area Comparison:

Comparisons between areas to assess the effects of dredging on fish populations on the Norfolk Moraine were made using a Multidimensional Contingency Table Analysis (MDCTA). This analysis was conducted using the catch per unit effort statistic. This design required the enumeration of fish by species in each area by date and time (day-night). The data resultes in a three way table with area (A), date (D), and time (T) all being factors that may interact to determine fish distributions. The MCDTA can analyze for significance of the main effects (A, D, T) as well as interactions between the main effects (Fraser and Emmons 1984, Bishop et al. 1975). The interaction of the main effect test are analogous to the Analysis of Variance (ANOVA) test but do not require the assumptions associated with that more familiar ANOVA. In addition, a hierarchy of log-linear models were constructed to predict the log-expected frequencies for each cell of the contingency table. The G statistic was used to test successive models in the hierarchy for significant improvement of fit.

Comparisons of length frequencies of each species (adult, young-of-the-year, and larval) between areas for each were done using a Kruskal-Wallis test. This test is nonparametric in nature and tests the length distributions of each species by date to detect a difference in the median length of a species between areas.

## RESULTS:

### Gill Net Collections:

A total of 72 gill net sets were made during the sampling period of October 1985 through September 1986 representing three net sets per area per month. This resulted in a total of 1798 hours of gill netting in the Norfolk Moraine study site. A total of 2791 individuals representing 18 species of fish were collected (Table 1). Yellow perch was the most abundant species representing over 46 % of the total catch (Table 2). Other dominate species include white perch, freshwater drum, troutperch and rainbow smelt. These five species accounted for over 92 % of the total fish catch. In terms of net efficiency, the smaller mesh panels (1.5, 1.0, and 2.0 inch mesh) collected 74 % of the total catch. The large mesh panels, although collecting fewer individuals, were important, increasing the total number of species collected (Table 2).

Table 1. Species list of fish collected by all methods from the Norfolk Moraine, Erie Co., PA.

| Scientific Name | Common Name |
|---|---|
| Family Clupeidae | |
| *Alosa pseudoharengus* | Alewife |
| *Dorosoma cepedianium* | Eastern Gizzard Shad |
| Family Salmonidae | |
| *Oncorhynchus kisutch* | Coho Salmon |
| *Coregonus artedii* | Cisco |
| *Coregonus clupeaformis* | Lake Whitefish |
| *Salvelinus namaycush* | Lake Trout |
| Family Osmeridae | |
| *Osmerus mordax* | Rainbow Smelt |
| Family Cyprinidae | |
| *Notropis hudsonius* | Spottail Shiner |
| Family Catostomidae | |
| *Catostomus commersoni* | White Sucker |
| Family Ictaluridae | |
| *Ictalurus nebulosus* | Brown Bullhead |
| Family Percopsidae | |
| *Percopsis omiscomaycus* | Trout Perch |
| Family Gadidae | |
| *Lota lota* | Eastern Burbot |
| Family Percicthyidae | |
| *Morone chrysops* | White Bass |
| *Morone americana* | White Perch |
| Family Centrarchidae | |
| *Ambloplites rupestris* | Northern Rockbass |
| Family Percidae | |
| *Stizostedion vitreum* | Walleye |
| *Perca flavescens* | Yellow Perch |
| Family Sciaenidae | |
| *Aplodinotus grunniens* | Freshwater Drum |

Table 2. Abundance of species collected by gill nets for each mesh size of net. Mesh size is measured in inches.

| | MESH SIZE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | Total |
| Alewife | -- | -- | 1 | 3 | -- | -- | -- | -- | -- | 4 |
| Gizzard Shad | -- | -- | 1 | -- | -- | -- | 1 | -- | 1 | 3 |
| Coho Salmon | -- | -- | -- | -- | -- | -- | 2 | 2 | 1 | 5 |
| Cisco | -- | -- | -- | 2 | 3 | -- | -- | -- | -- | 5 |
| Lake Whitefish | -- | -- | 4 | -- | 3 | 7 | 8 | 1 | -- | 23 |
| Lake Trout | -- | -- | -- | -- | -- | -- | -- | 1 | -- | 1 |
| Rainbow Smelt | 88 | 70 | 1 | -- | 1 | -- | -- | -- | -- | 160 |
| Spottail Shiner | 52 | 3 | -- | -- | -- | -- | -- | -- | -- | 55 |
| White Sucker | -- | 1 | 1 | -- | 5 | 10 | 17 | 18 | 4 | 56 |
| Brown Bullhead | -- | -- | 2 | -- | -- | -- | -- | -- | -- | 2 |
| Trout Perch | 199 | 39 | 1 | -- | -- | -- | -- | -- | -- | 239 |
| Burbot | -- | -- | -- | -- | 2 | 18 | 11 | 22 | 19 | 72 |
| White Bass | -- | 2 | -- | 6 | 2 | 1 | 1 | 1 | -- | 13 |
| White Perch | 98 | 216 | 137 | 29 | 12 | 4 | -- | -- | 1 | 497 |
| Rockbass | -- | -- | 1 | -- | -- | -- | -- | -- | -- | 1 |
| Walleye | -- | -- | -- | -- | -- | 1 | 3 | 8 | 2 | 14 |
| Yellow Perch | 254 | 636 | 199 | 132 | 46 | 19 | 11 | 1 | -- | 1298 |
| Freshwater Drum | 2 | 14 | 49 | 78 | 74 | 53 | 39 | 19 | 15 | 343 |
| TOTAL | 693 | 981 | 397 | 250 | 148 | 113 | 93 | 73 | 43 | 2791 |
| PERCENT NUMBER | 25 | 60 | 74 | 83 | 88 | 92 | 95 | 98 | 100 | |
| PERCENT SPECIES | 33 | 44 | 72 | 78 | 83 | 89 | 95 | 100 | | |

Catch statistics were computed for each species by area, date, time, and mesh. Statistics computed include mean catch per unit effort (number caught/foot of mesh/hour) and standard errors of the mean. Only the catch statistics of the five most dominant fish species (yellow perch, white perch, drum, trout perch and smelt) are presented in tabular form to facilitate presentation of the data. Catch indices from all species were included in the statistical analysis between areas, dates and times.

Yellow perch were collected in all mesh panels except the 5.0 inch and were observed in every sampling month (Table 3). Peak abundances of perch were noted during May, June, July, and August. Gravid yellow perch were collected in April.

The catch statistics for white perch indicated that collections of this species were restricted to the smaller mesh panel (< 3.5 inches) with most collected in mesh less than 2.0 inches. White perch catch per unit effort remained relatively constant during the collection period with a slight peak in abundance occuring during the autumn months of October and November (Table 4). White perch were observed in spawning condition in April and May with ripe males collected in April and May, and gravid females observed only during May.

Freshwater drum were collected primarily in October and November (Table 5). Drum were collected in only two other months and then in low numbers. All mesh panels except 1.0 inch mesh proved to be equally effective in catching freshwater drum.

Table 3. Summary of catch statistics for yellow perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| | | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|---|
| MONTH | MESH | CPUE* | STDERR | CPUE | STDERR | CPUE | STDERR |
| | 1.0 | 0.17 | 0.055 | 0.08 | 0.038 | 0.06 | 0.052 |
| | 1.5 | 0.30 | 0.137 | 0.11 | 0.019 | 0.09 | 0.010 |
| | 2.0 | 0.11 | 0.074 | 0.08 | 0.019 | 0.08 | 0.025 |
| | 2.5 | 0.04 | 0.000 | 0.04 | 0.008 | 0.04 | 0.006 |
| October | 3.0 | 0.03 | 0.000 | -- | --- | 0.05 | 0.010 |
| | 3.5 | 0.04 | 0.013 | 0.01 | 0.000 | -- | --- |
| | 4.0 | 0.03 | 0.000 | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.05 | 0.038 | 0.02 | 0.003 | 0.06 | 0.006 |
| | 1.5 | 0.07 | 0.046 | 0.11 | 0.018 | 0.09 | 0.006 |
| | 2.0 | 0.03 | 0.010 | 0.04 | 0.008 | 0.05 | 0.002 |
| | 2.5 | 0.04 | 0.000 | 0.05 | 0.010 | 0.03 | 0.019 |
| November | 3.0 | 0.02 | 0.000 | 0.02 | 0.005 | 0.01 | 0.000 |
| | 3.5 | 0.01 | 0.000 | 0.02 | 0.005 | 0.01 | 0.000 |
| | 4.0 | 0.01 | 0.000 | 0.01 | 0.000 | 0.01 | 0.000 |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | -- | --- | 0.07 | 0.012 | -- | --- |
| | 2.0 | 0.11 | 0.021 | 0.13 | 0.333 | -- | --- |
| | 2.5 | -- | --- | 0.06 | 0.000 | 0.08 | .0154 |
| April | 3.0 | -- | --- | -- | --- | 0.09 | 0.000 |
| | 3.5 | -- | --- | 0.07 | 0.012 | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.15 | 0.014 | 0.01 | 0.018 | 0.23 | 0.140 |
| | 1.5 | 3.31 | 1.067 | 3.40 | 0.546 | 4.70 | 1.051 |
| | 2.0 | 0.20 | 0.048 | 0.60 | 0.224 | 0.50 | 0.003 |
| | 2.5 | 0.31 | 0.231 | 0.09 | 0.054 | 0.22 | 0.175 |
| May | 3.0 | 0.15 | 0.000 | 0.01 | 0.000 | 0.07 | 0.002 |
| | 3.5 | 0.08 | 0.000 | -- | --- | 0.05 | 0.000 |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.08 | 0.004 | -- | --- | -- | --- |
| | 1.5 | 2.88 | 0.612 | 1.58 | 0.258 | 1.48 | 0.872 |
| | 2.0 | 0.15 | 0.006 | 0.31 | 0.004 | 0.25 | 0.012 |
| | 2.5 | 0.26 | 0.000 | 0.12 | 0.008 | 0.09 | 0.002 |
| June | 3.0 | 0.07 | 0.004 | 0.06 | 0.000 | 0.07 | 0.016 |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour.

Table 3. Summary of catch statistics for yellow perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| | | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|---|
| DATE | MESH | CPUE | STDERR | CPUE | STDERR | CPUE | STDERR |
| | 1.0 | 1.64 | 0.655 | 1.25 | 0.532 | 1.45 | 0.236 |
| | 1.5 | 0.53 | 0.183 | 0.07 | 0.001 | 0.79 | 0.155 |
| | 2.0 | 0.89 | 0.021 | 0.58 | 0.008 | 0.38 | 0.009 |
| | 2.5 | 0.07 | 0.002 | 0.12 | 0.004 | 0.19 | 0.000 |
| July | 3.0 | -- | --- | -- | --- | 0.01 | 0.001 |
| | 3.5 | 0.01 | 0.002 | 0.05 | 0.000 | 0.02 | 0.003 |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 1.26 | 0.022 | 0.98 | 0.168 | 1.31 | 0.564 |
| | 1.5 | 1.31 | 0.231 | 1.07 | 0.199 | 1.48 | 0.627 |
| | 2.0 | 0.74 | 0.333 | 0.58 | 0.210 | 0.86 | 0.184 |
| | 2.5 | 0.12 | 0.004 | 0.15 | 0.003 | 0.09 | 0.003 |
| August | 3.0 | 0.02 | 0.000 | 0.04 | 0.001 | -- | --- |
| | 3.5 | -- | --- | 0.01 | 0.000 | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.25 | 0.012 | 0.31 | 0.009 | 0.24 | 0.007 |
| | 1.5 | 0.34 | 0.14 | 0.41 | 0.017 | 0.51 | 0.281 |
| | 2.0 | 0.28 | 0.007 | 0.19 | 0.005 | 0.26 | 0.008 |
| | 2.5 | 0.09 | 0.002 | 0.12 | 0.006 | 0.09 | 0.006 |
| September | 3.0 | -- | --- | -- | --- | -- | -- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour.

Table 4. Summary catch statistics for white perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| MONTH | MESH | CONTROL CPUE* | CONTROL STDERR | DREDGE CPUE | DREDGE STDERR | PROPOSED CPUE | PROPOSED STDERR |
|---|---|---|---|---|---|---|---|
| | 1.0 | 0.04 | 0.001 | 0.05 | 0.001 | 0.05 | 0.001 |
| | 1.5 | 0.21 | 0.123 | 0.06 | 0.010 | 0.06 | 0.021 |
| | 2.0 | 0.07 | 0.011 | 0.05 | 0.025 | 0.08 | 0.000 |
| | 2.5 | 0.01 | 0.000 | 0.01 | 0.001 | 0.02 | 0.002 |
| October | 3.0 | 0.01 | 0.000 | 0.01 | 0.000 | 0.02 | 0.001 |
| | 3.5 | -- | --- | -- | --- | 0.02 | 0.000 |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.01 | 0.003 | 0.04 | 0.010 | 0.03 | 0.006 |
| | 1.5 | 0.05 | 0.025 | 0.07 | 0.047 | 0.07 | 0.019 |
| | 2.0 | 0.02 | 0.001 | 0.03 | 0.010 | 0.04 | 0.011 |
| | 2.5 | 0.01 | 0.000 | -- | --- | 0.01 | 0.002 |
| November | 3.0 | 0.01 | 0.000 | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | -- | --- | 0.13 | 0.050 | 0.09 | 0.002 |
| | 2.0 | 0.07 | 0.015 | 0.13 | 0.024 | 0.09 | 0.000 |
| | 2.5 | -- | --- | -- | --- | 0.04 | 0.009 |
| April | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | 0.09 | 0.000 |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | 0.08 | 0.010 | 0.01 | 0.006 | 0.08 | 0.056 |
| | 2.0 | -- | --- | 0.01 | 0.042 | -- | --- |
| | 2.5 | -- | --- | -- | --- | 0.01 | 0.000 |
| May | 3.0 | -- | --- | -- | -- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.04 | 0.008 | -- | --- | -- | --- |
| | 1.5 | 0.50 | 0.242 | 0.32 | 0.158 | 0.37 | 0.172 |
| | 2.0 | 0.11 | 0.006 | -- | --- | -- | --- |
| | 2.5 | 0.04 | 0.000 | -- | --- | 0.04 | 0.012 |
| June | 3.0 | -- | --- | -- | --- | 0.04 | 0.000 |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour of set.

Table 4. Summary catch statistics for white perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| MONTH | MESH | CONTROL CPUE | CONTROL STDERR | DREDGE CPUE | DREDGE STDERR | PROPOSED CPUE | PROPOSED STDERR |
|---|---|---|---|---|---|---|---|
| July | 1.0 | -- | -- | -- | --- | 0.07 | 0.000 |
| | 1.5 | -- | --- | 0.06 | 0.014 | 0.14 | 0.008 |
| | 2.0 | 0.07 | 0.012 | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| August | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | 0.12 | 0.031 | 0.14 | 0.000 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | 0.07 | 0.000 |
| | 3.0 | 0.01 | 0.000 | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| September | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | 0.09 | 0.012 | 0.02 | 0.003 | 0.04 | 0.007 |
| | 2.0 | 0.03 | 0.002 | 0.07 | 0.009 | 0.01 | 0.000 |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour.

Table 5. Summary catch statistics for freshwater drum by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| MONTH | MESH | CONTROL CPUE* | CONTROL STDERR | DREDGE CPUE | DREDGE STDERR | PROPOSED CPUE | PROPOSED STDERR |
|---|---|---|---|---|---|---|---|
| October | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | 0.10 | 0.031 | -- | --- | -- | --- |
| | 2.0 | 0.04 | 0.000 | 0.03 | 0.000 | 0.02 | 0.000 |
| | 2.5 | 0.03 | 0.007 | 0.04 | 0.000 | 0.03 | 0.010 |
| | 3.0 | 0.05 | 0.014 | 0.04 | 0.013 | 0.02 | 0.000 |
| | 3.5 | 0.03 | 0.007 | 0.02 | 0.006 | 0.02 | 0.000 |
| | 4.0 | 0.03 | 0.014 | 0.03 | 0.006 | 0.02 | 0.000 |
| | 4.5 | 0.02 | 0.007 | -- | --- | -- | --- |
| | 5.0 | 0.01 | 0.000 | -- | --- | 0.03 | 0.010 |
| November | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | -- | --- | 0.01 | 0.000 | -- | --- |
| | 2.0 | 0.03 | 0.000 | 0.01 | 0.000 | 0.04 | 0.012 |
| | 2.5 | 0.02 | 0.006 | 0.05 | 0.015 | 0.05 | 0.000 |
| | 3.0 | 0.01 | 0.033 | 0.02 | 0.033 | 0.03 | 0.019 |
| | 3.5 | 0.03 | 0.000 | 0.03 | 0.007 | 0.02 | 0.006 |
| | 4.0 | 0.01 | 0.000 | 0.02 | 0.000 | 0.02 | 0.000 |
| | 4.5 | 0.01 | 0.000 | 0.02 | 0.005 | -- | --- |
| | 5.0 | 0.01 | 0.000 | -- | --- | -- | --- |
| April | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | -- | --- | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | 0.13 | 0.012 | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| July | 1.0 | -- | --- | -- | --- | -- | --- |
| | 1.5 | -- | --- | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | -- | -- | --- |
| | 3.5 | 0.07 | 0.013 | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour of set.

The catch statistics for trout perch indicated that the smaller mesh panels were most effective in collecting this species (Table 6). Trout perch were collected throughout the sampling period in relatively constant densities with a slight peak in abundance occuring during June. Trout perch in spawning condition were observed in May and June.

Rainbow smelt were collected in every sampling month with catches densities highest in July and August (Table 7). Smelt in spawning condition were observed in May and June.

The statitical analysis of the catch per unit effort data for differences between the variables date, area, and time was accomplished utililzing multi-demensional contigency table analysis (MDCTA). In this analysis, the mean catch per unit effort (CPUE) per treatment was calculated with treatment defined as a combination of the date, area, and time variables (effects). The results of the full rank model (containing all variables plus all potential interactions) are presented in Table 8. Of all possible treatments only date significantly affected adult fish distributions on the Norfolk Moraine. This finding is not unexpected, since adult fish are highly vagile and migrate to spawning ground at specific times, often correlating to temperature cues (Kelso and Leslie 1979, Hokanson 1977, Kowalski et al. 1977, Ross et al. 1977, Barnes and Tubb 1973,). During that time they are often the most abundant species collected. After the spawning activities cease, however, they become less

Table 6. Summary catch statistics for trout perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| | | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|---|
| MONTH | MESH | CPUE* | STDERR | CPUE | STDERR | CPUE | STDERR |
| | 1.0 | 0.14 | 0.048 | 0.07 | 0.019 | 0.07 | 0.010 |
| | 1.5 | 0.03 | 0.003 | 0.01 | 0.000 | -- | --- |
| | 2.0 | -- | --- | -- | --- | 0.02 | 0.008 |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| October | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.07 | 0.028 | 0.03 | 0.006 | 0.07 | 0.009 |
| | 1.5 | -- | --- | 0.01 | 0.000 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| November | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.07 | 0.011 | 0.05 | 0.003 | 0.16 | 0.019 |
| | 1.5 | -- | --- | 0.06 | 0.009 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| April | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.08 | 0.003 | 0.17 | 0.015 | 0.01 | 0.000 |
| | 1.5 | -- | --- | -- | --- | 0.01 | 0.000 |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| May | 3.0 | -- | --- | -- | -- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.15 | 0.038 | 0.03 | 0.010 | 0.11 | 0.008 |
| | 1.5 | 0.04 | 0.000 | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| June | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour of set.

Table 6. Summary catch statistics for trout perch by month, area, and mesh size for gill net collections from the Norfolk Moraine.

| MONTH | MESH | CONTROL CPUE | CONTROL STDERR | DREDGE CPUE | DREDGE STDERR | PROPOSED CPUE | PROPOSED STDERR |
|---|---|---|---|---|---|---|---|
| July | 1.0 | 0.07 | 0.005 | 0.02 | 0.001 | 0.04 | 0.011 |
| | 1.5 | 0.02 | 0.000 | 0.01 | 0.000 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| August | 1.0 | 0.05 | 0.004 | 0.06 | 0.016 | 0.05 | 0.013 |
| | 1.5 | 0.01 | 0.000 | 0.01 | 0.000 | 0.01 | 0.000 |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| September | 1.0 | 0.12 | 0.010 | 0.09 | 0.003 | 0.04 | 0.009 |
| | 1.5 | -- | --- | 0.02 | 0.00 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour.

Table 7. Summary of catch statistics for rainbow smelt by month, area, mesh size for gill net collections from the Norfolk Moraine.

| MONTH | MESH | CONTROL CPUE* | CONTROL STDERR | DREDGE CPUE | DREDGE STDERR | PROPOSED CPUE | PROPOSED STDERR |
|---|---|---|---|---|---|---|---|
| | 1.0 | 0.05 | 0.034 | 0.03 | 0.009 | 0.07 | 0.010 |
| | 1.5 | 0.10 | 0.025 | 0.01 | 0.000 | -- | -- |
| | 2.0 | -- | --- | -- | --- | 0.02 | 0.008 |
| | 2.5 | -- | --- | | | | |
| October | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.01 | 0.000 | -- | --- | 0.01 | 0.000 |
| | 1.5 | -- | --- | 0.01 | 0.000 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| November | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.01 | 0.002 | 0.06 | 0.008 | 0.11 | 0.052 |
| | 1.5 | 0.07 | 0.006 | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| April | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.08 | 0.003 | 0.06 | 0.055 | 0.02 | 0.008 |
| | 1.5 | -- | --- | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| May | 3.0 | -- | --- | -- | -- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.04 | 0.000 | 0.03 | 0.010 | 0.07 | 0.014 |
| | 1.5 | -- | --- | -- | --- | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| June | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour of set.

Table 7. Summary of catch statistics for rainbow smelt by month, area, mesh size for gill net collections from the Norfolk Moraine.

| | | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|---|
| MONTH | MESH | CPUE | STDERR | CPUE | STDERR | CPUE | STDERR |
| | 1.0 | -- | --- | 2.41 | 1.052 | 1.57 | 0.981 |
| | 1.5 | -- | --- | -- | --- | 0.07 | 0.006 |
| | 2.0 | -- | --- | -- | --- | 0.07 | 0.000 |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| July | 3.0 | -- | --- | -- | --- | 0.07 | 0.000 |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 1.33 | 0.997 | 1.01 | 0.750 | 1.21 | 0.379 |
| | 1.5 | 0.02 | 0.001 | 0.05 | 0.002 | 0.04 | 0.008 |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| August | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |
| | 1.0 | 0.13 | 0.012 | 0.04 | 0.009 | 0.09 | 0.005 |
| | 1.5 | 0.02 | 0.000 | 0.01 | 0.00 | -- | --- |
| | 2.0 | -- | --- | -- | --- | -- | --- |
| | 2.5 | -- | --- | -- | --- | -- | --- |
| September | 3.0 | -- | --- | -- | --- | -- | --- |
| | 3.5 | -- | --- | -- | --- | -- | --- |
| | 4.0 | -- | --- | -- | --- | -- | --- |
| | 4.5 | -- | --- | -- | --- | -- | --- |
| | 5.0 | -- | --- | -- | --- | -- | --- |

* CPUE represents the mean number caught/foot of mesh/hour.

Table 8. Results of MDCTA for adult fish data. Area, date, and time with their interactions are the effects. NS indicates a p-value > .05.

| Effect | G-Value | DF | P-value |
|---|---|---|---|
| Date | 25.596 | 7 | 0.001 |
| Area | 0.742 | 2 | NS |
| Time | 1.314 | 1 | NS |
| Date*Area | 3.464 | 14 | NS |
| Date*Time | 7.324 | 7 | NS |
| Area*Time | 1.141 | 2 | NS |
| Date*Area*Time | 17.714 | 14 | NS |

abundant in the collections. Although not significant, there was a trend toward fewer fish in the dredge area than found in the control area. This trend can be seen by comparing the total number of individiuals collected in both areas, as summarized in Tables 3 through 7.

The analysis of differences of fish length between areas by month was accomplished using a Kruskal-Wallis test of median length of each species. Results of this analysis are presented in Tables 9 through 16 with means and standard errors of the length of each species tabulated by area. Few significant differences in length were detected between areas. Those differences that did exsist, show no systematic trend indicating any potential differences between the lengths of fish utilizing the dredge, preposed dredge, and control areas.

YOUNG OF YEAR COLLECTIONS:

Young of year and smaller species were collected using small (16 ft.) headrope otter trawls. A total of 72 hauls were conducted, 24 per area, representing 240 trawl minutes per area or 720 total trawl minutes. Rainbow smelt was the most susceptable species collected by trawling with significant captures of trout perch and white perch also reported (Table 17). Trawling was generally more effective in in the autumn months and least effective during the spring. Trawling was generally the

Table 9. Mean length in mm for fish collected by gill net during October with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | | |
|---|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR | |
| Alewife | 165 | 5.00 | -- | -- | -- | -- | |
| Gizzard Shad | 400 | -- | -- | -- | -- | -- | |
| Coho Salmon | -- | -- | -- | -- | -- | -- | |
| Cisco | -- | -- | 275 | -- | -- | -- | |
| Whitefish | 390 | -- | 420 | -- | -- | -- | |
| Lake Trout | -- | -- | -- | -- | -- | -- | |
| Rainbow Smelt | 107.5 | 1.46 | 110 | 5.77 | -- | -- | |
| Spottail Shiner | -- | -- | -- | -- | -- | -- | |
| White Sucker | 495 | -- | 352.5 | 48.15 | 385 | 24.67 | * |
| Brown Bullhead | -- | -- | 255 | -- | -- | -- | |
| Trout Perch | 95.9 | 1.07 | 103.8 | 2.95 | 96.9 | 1.88 | * |
| Burbot | 513 | 35.07 | 458.4 | 43.96 | -- | -- | |
| White Bass | -- | -- | 192.5 | 47.50 | 300 | -- | |
| White Perch | 126.8 | 8.24 | 151.8 | 28.19 | 122.8 | 8.23 | |
| Rockbass | -- | -- | -- | -- | 295 | -- | |
| Walleye | 456.7 | 18.78 | 440 | 25.00 | 445 | -- | |
| Yellow Perch | 151.7 | 4.82 | 150.7 | 5.58 | 158.7 | 8.99 | |
| Freshwater Drum | -- | -- | -- | -- | -- | -- | |

* indicates a significant difference between areas.

Table 10. Mean length in mm for fish collected by gill net during November with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | | |
|---|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR | |
| Alewife | 145 | -- | -- | -- | -- | -- | |
| Gizzard Shad | -- | -- | -- | -- | -- | -- | |
| Coho Salmon | -- | -- | -- | -- | -- | -- | |
| Cisco | -- | -- | -- | -- | -- | -- | |
| Whitefish | 310 | -- | 317.5 | 46.48 | 435 | 5.00 | * |
| Lake Trout | -- | -- | -- | -- | -- | -- | |
| Rainbow Smelt | 110 | -- | -- | -- | 117.5 | 2.50 | |
| Spottail Shiner | -- | -- | -- | -- | -- | -- | |
| White Sucker | 445 | 17.98 | 343.1 | 26.22 | 380.8 | 38.48 | * |
| Brown Bullhead | -- | -- | -- | -- | -- | -- | |
| Trout Perch | 95.2 | 0.80 | 99.7 | 1.18 | 96.2 | 0.88 | * |
| Burbot | 513 | 35.07 | 494 | 80.45 | 528.3 | 67.72 | |
| White Bass | -- | -- | -- | -- | -- | -- | |
| White Perch | 127.1 | 7.27 | 116.5 | 4.39 | 118.3 | 4.34 | |
| Rockbass | -- | -- | -- | -- | -- | -- | |
| Walleye | -- | -- | -- | -- | 425 | __ | |
| Yellow Perch | 153.2 | 5.52 | 164.6 | 4.15 | 160.3 | 5.40 | * |
| Freshwater Drum | 215.5 | 13.93 | 233.3 | 10.29 | 209.7 | 11.05 | |

* indicates a significant difference between areas.

Table 11. Mean length in mm for fish collected by gill net during April with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR |
| Alewife | -- | -- | -- | -- | -- | -- |
| Gizzard Shad | -- | -- | -- | -- | -- | -- |
| Coho Salmon | -- | -- | -- | -- | -- | -- |
| Cisco | -- | -- | -- | -- | -- | -- |
| Whitefish | -- | -- | -- | -- | -- | -- |
| Lake Trout | -- | -- | -- | -- | -- | -- |
| Rainbow Smelt | 117.5 | 7.50 | 120 | -- | 135 | -- |
| Spottail Shiner | -- | -- | 95 | -- | 95 | -- |
| White Sucker | -- | -- | -- | -- | 282.5 | 87.50 |
| Brown Bullhead | -- | -- | -- | -- | -- | -- |
| Trout Perch | 95 | -- | 117.5 | 12.5 | 90 | 2.04 |
| Burbot | 516.7 | 61.97 | 590 | -- | 543.3 | 28.33 |
| White Bass | 265 | -- | -- | -- | -- | -- |
| White Perch | 145 | -- | 125 | 10.41 | 155 | 27.54 |
| Rockbass | -- | -- | -- | -- | -- | -- |
| Walleye | -- | -- | -- | -- | -- | -- |
| Yellow Perch | 176.7 | 1.67 | 197.1 | 24.88 | 192.5 | 2.50 |
| Freshwater Drum | -- | -- | -- | -- | -- | -- |

* indicates a significant difference between areas.

Table 12. Mean length in mm for fish collected by gill net during May with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | | |
|---|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR | |
| Alewife | -- | -- | -- | -- | -- | -- | |
| Gizzard Shad | -- | -- | -- | -- | -- | -- | |
| Coho Salmon | -- | -- | -- | -- | -- | -- | |
| Cisco | -- | -- | -- | -- | -- | -- | |
| Whitefish | -- | -- | -- | -- | -- | -- | |
| Lake Trout | -- | -- | -- | -- | -- | -- | |
| Rainbow Smelt | 125 | 10.00 | 100 | -- | 130 | 20.00 | |
| Spottail Shiner | -- | -- | -- | -- | -- | -- | |
| White Sucker | -- | -- | -- | -- | -- | -- | |
| Brown Bullhead | -- | -- | -- | -- | -- | -- | |
| Trout Perch | 90 | -- | 90 | -- | 90 | -- | |
| Burbot | 487.5 | 27.92 | 540 | 32.40 | 556.8 | 21.29 | |
| White Bass | -- | -- | -- | -- | -- | -- | |
| White Perch | 110 | -- | 125 | 5.00 | 115 | 7.64 | |
| Rockbass | -- | -- | -- | -- | -- | -- | |
| Walleye | -- | -- | 470 | -- | -- | -- | |
| Yellow Perch | 132.7 | 2.30 | 134.8 | 2.31 | 141.9 | 2.29 | * |
| Freshwater Drum | -- | -- | -- | -- | -- | -- | |

* indicates a significant difference between areas.

Table 13. Mean length in mm for fish collected by gill net during June with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR |
| Alewife | -- | -- | -- | -- | -- | -- |
| Gizzard Shad | -- | -- | -- | -- | -- | -- |
| Coho Salmon | -- | -- | -- | -- | -- | -- |
| Cisco | -- | -- | -- | -- | -- | -- |
| Whitefish | 219.8 | 24.35 | 170 | -- | 246.9 | 21.65 |
| Lake Trout | -- | -- | 495 | -- | -- | -- |
| Rainbow Smelt | 125 | -- | 110 | -- | 117.5 | 7.50 |
| Spottail Shiner | -- | -- | -- | -- | -- | -- |
| White Sucker | 390 | 15.73 | -- | -- | 330 | -- |
| Brown Bullhead | -- | -- | -- | -- | -- | -- |
| Trout Perch | 89 | 3.35 | 90 | -- | 91.7 | 6.01 |
| Burbot | 471.7 | 13.01 | -- | -- | 605 | 35.00 |
| White Bass | -- | -- | -- | -- | -- | -- |
| White Perch | 113.6 | 2.45 | 105 | -- | 120 | 20.00 |
| Rockbass | -- | -- | -- | -- | -- | -- |
| Walleye | 390 | -- | -- | -- | -- | -- |
| Yellow Perch | 131 | 1.43 | 125 | 1.94 | 122.5 | 1.44 |
| Freshwater Drum | -- | -- | -- | -- | -- | -- |

* indicates a significant difference between areas.

Table 14. Mean length in mm for fish collected by gill net during July with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR |
| Alewife | -- | -- | -- | -- | -- | -- |
| Gizzard Shad | -- | -- | -- | -- | -- | -- |
| Coho Salmon | -- | -- | 420 | -- | 445 | -- |
| Cisco | -- | -- | -- | -- | -- | -- |
| Whitefish | 310 | 5.41 | -- | -- | 280 | -- |
| Lake Trout | -- | -- | -- | -- | -- | -- |
| Rainbow Smelt | -- | -- | 127.9 | 1.36 | 126 | 0.95 |
| Spottail Shiner | -- | -- | -- | -- | -- | -- |
| White Sucker | 363.3 | 43.33 | 385 | 35.71 | 352.5 | 21.45 |
| Brown Bullhead | -- | -- | -- | -- | -- | -- |
| Trout Perch | -- | -- | -- | -- | -- | -- |
| Burbot | 550 | -- | 532.5 | 57.5 | 531.3 | 41.44 |
| White Bass | -- | -- | -- | -- | -- | -- |
| White Perch | 95 | 20.42 | 115 | 10.13 | 106.7 | 1.67 |
| Rockbass | -- | -- | -- | -- | -- | -- |
| Walleye | 390 | -- | -- | -- | 445 | -- |
| Yellow Perch | 130.7 | 1.01 | 133.5 | 4.08 | 131.3 | 3.15 |
| Freshwater Drum | 200 | -- | 205.4 | 4.41 | 240 | -- |

* indicates a significant difference between areas.

Table 15. Mean length in mm for fish collected by gill net during with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR |
| Alewife | -- | -- | -- | -- | -- | -- |
| Gizzard Shad | -- | -- | -- | -- | -- | -- |
| Coho Salmon | 450 | -- | -- | -- | 405 | -- |
| Cisco | -- | -- | -- | -- | -- | -- |
| Whitefish | -- | -- | 310 | 2.00 | -- | -- |
| Lake Trout | -- | -- | -- | -- | -- | -- |
| Rainbow Smelt | 126.4 | 3.44 | 128.1 | 2.61 | 127 | 2.50 |
| Spottail Shiner | -- | -- | -- | -- | -- | -- |
| White Sucker | 380.2 | 37.21 | 361.3 | 15.40 | 374.5 | 21.25 |
| Brown Bullhead | -- | -- | -- | -- | -- | -- |
| Trout Perch | -- | -- | -- | -- | -- | -- |
| Burbot | 580 | 34.23 | 525 | -- | 550 | 25.00 |
| White Bass | -- | -- | -- | -- | -- | -- |
| White Perch | -- | -- | -- | -- | -- | -- |
| Rockbass | -- | -- | -- | -- | -- | -- |
| Walleye | 420 | -- | -- | -- | 390 | -- |
| Yellow Perch | 132.4 | 2.78 | 134.1 | 3.15 | 135.3 | 2.77 |
| Freshwater Drum | 215 | -- | 225 | 4.00 | 244.5 | 12.25 |

* indicates a significant difference between areas.

Table 16. Mean length in mm for fish collected by gill net during September with standard errors.

| SPECIES | CONTROL | | DREDGE | | PROPOSED | |
|---|---|---|---|---|---|---|
| | MEAN | STDERR | MEAN | STDERR | MEAN | STDERR |
| Alewife | -- | -- | -- | -- | -- | -- |
| Gizzard Shad | -- | -- | -- | -- | -- | -- |
| Coho Salmon | 450 | -- | -- | -- | 405 | -- |
| Cisco | -- | -- | -- | -- | -- | -- |
| Whitefish | -- | -- | 310 | 2.00 | -- | -- |
| Lake Trout | -- | -- | -- | -- | -- | -- |
| Rainbow Smelt | 129.6 | 2.15 | 130.1 | 3.10 | 127.4 | 1.95 |
| Spottail Shiner | -- | -- | -- | -- | -- | -- |
| White Sucker | 340 | -- | -- | -- | 365.5 | 15.55 |
| Brown Bullhead | -- | -- | -- | -- | -- | -- |
| Trout Perch | 96.4 | 1.40 | 97.5 | 2.5 | 97.1 | 1.79 |
| Burbot | 640 | -- | -- | -- | 595 | -- |
| White Bass | -- | -- | -- | -- | -- | -- |
| White Perch | 135.5 | 2.50 | 127.5 | 5.00 | 125 | -- |
| Rockbass | -- | -- | -- | -- | -- | -- |
| Walleye | 550 | -- | 490.5 | 20.00 | -- | -- |
| Yellow Perch | 135.1 | 2.33 | 135.9 | 2.96 | 136.7 | 2.04 |
| Freshwater Drum | 265.4 | 20.10 | 280.6 | 15.5 | 245.5 | 17.51 |

* indicates a significant difference between areas.

Table 17. Catch statistics for trawl data by month.
CPU = number caught per trawl minute.

| Month | Species | CONTROL N | CONTROL CPU | DREDGE N | DREDGE CPU | PROPOSED N | PROPOSED CPU |
|---|---|---|---|---|---|---|---|
| October | Gizzard Shad | 5 | 0.17 | 0 | 0.00 | 1 | 0.03 |
| | Rainbow Smelt | 64 | 2.13 | 99 | 3.30 | 71 | 2.73 |
| | Spottail Shiner | 1 | 0.03 | 3 | 0.10 | 6 | 0.20 |
| | Trout Perch | 40 | 1.33 | 9 | 0.30 | 17 | 0.57 |
| | White Perch | 29 | 0.97 | 3 | 0.10 | 22 | 0.73 |
| | Yellow Perch | 4 | 0.13 | 3 | 0.10 | 3 | 0.10 |
| November | Gizzard Shad | 5 | 0.17 | 0 | 0.00 | 1 | 0.03 |
| | Rainbow Smelt | 8 | 0.27 | 20 | 0.67 | 0 | 0.00 |
| | Trout Perch | 6 | 0.20 | 10 | 0.33 | 20 | 0.67 |
| | White Sucker | 0 | 0.00 | 1 | 0.03 | 0 | 0.00 |
| | White Bass | 1 | 0.03 | 0 | 0.00 | 0 | 0.00 |
| | White Perch | 8 | 0.27 | 31 | 1.03 | 16 | 0.53 |
| | Walleye | 0 | 0.00 | 1 | 0.03 | 0 | 0.00 |
| | Freshwater Drum | 0 | 0.00 | 5 | 0.17 | 1 | 0.03 |
| April | Rainbow Smelt | 1 | 0.03 | 0 | 0.00 | 1 | 0.03 |
| | Spottail Shiner | 0 | 0.00 | 1 | 0.03 | 0 | 0.00 |
| | Trout Perch | 2 | 0.67 | 1 | 0.03 | 1 | 0.03 |
| | Yellow Perch | 0 | 0.00 | 0 | 0.00 | 2 | 0.67 |
| May | Rainbow Smelt | 9 | 0.30 | 0 | 0.00 | 7 | 0.23 |
| | Spottail Shiner | 0 | 0.00 | 0 | 0.00 | 1 | 0.03 |
| | Trout Perch | 3 | 0.10 | 1 | 0.03 | 0 | 0.00 |
| | Yellow Perch | 1 | 0.03 | 1 | 0.03 | 0 | 0.00 |
| June | Rainbow Smelt | 1 | 0.03 | 4 | 0.17 | 1 | 0.03 |
| | Trout Perch | 2 | 0.07 | 2 | 0.07 | 2 | 0.07 |
| | Yellow Perch | 4 | 0.13 | 2 | 0.07 | 0 | 0.00 |
| July | Rainbow Smelt | 0 | 0.00 | 4 | 0.17 | 2 | 0.07 |
| | White Perch | 4 | 0.13 | 2 | 0.07 | 4 | 0.13 |
| | Yellow Perch | 0 | 0.00 | 0 | 0.00 | 1 | 0.03 |
| | Freshwater Drum | 0 | 0.00 | 2 | 0.07 | 0 | 0.00 |
| August | Gizzard Shad | 2 | 0.07 | 2 | 0.07 | 0 | 0.00 |
| | Rainbow Smelt | 2 | 0.07 | 3 | 0.10 | 2 | 0.07 |
| | White Perch | 3 | 0.10 | 1 | 0.03 | 4 | 0.13 |
| | Freshwater Drum | 1 | 0.03 | 0 | 0.00 | 0 | 0.00 |
| September | Rainbow Smelt | 3 | 0.10 | 4 | 0.13 | 4 | 0.13 |
| | Trout Perch | 2 | 0.07 | 1 | 0.03 | 3 | 0.10 |
| | White Perch | 4 | 0.13 | 4 | 0.13 | 6 | 0.20 |
| | Yellow Perch | 2 | 0.07 | 1 | 0.03 | 1 | 0.03 |
| | Freshwater Drum | 3 | 0.10 | 2 | 0.07 | 0 | 0.00 |

least effective method used to collect fish along the Norfolk Moraine, and did not contribute any species of fish to the total species list produced by the other methods deployed during this study. Trawling was, however, the most effective method to collect small fish (<200 mm SL). If additional fisheries studies are to be performed along the Norfolk Moraine we would recommed either using a larger trawl, or to discontinue the practice of trawling.

The comparison of catch per unit effort data between areas and dates utilizing the MDCTA yielded similar results to that for the gill net data (Table 18). Again, as with the gill net data, a significant difference between date was observed. Again, this is not an unexpected result. Trawling is only effective for small fish, either young-of-the-year or small adults. Over the season as the young-of-the-year fish grow they can easily avoid the trawl and are therefore captured at lower frequencies. The small adults have behaviors similar to the larger adults collected in the gill nets, and are also collected in high abundances only during peak spawning times. The timing of fish spawning is species specific with some fish spawning early, other spawning late, and still other with protracted spawning throughout most of the spring and summer. This temporal distribution has been widely recorded in the literature (Kelso and Leslie 1979, Wapora 1978, Hokanson 1977, Kowalski et al. 1977, Ross et al. 1977, Barnes and Tubb 1973, Houde 1969,).

Table 18. Results of MDCTA for fish collected by trawl. Date, area and their interactions are the effects. NS indicates a p-value > .05.

| Effect | G-Value | DF | P-value |
|---|---|---|---|
| Date | 17.481 | 7 | 0.041 |
| Area | 2.254 | 2 | NS |
| Date*Area | 11.484 | 18 | NS |

No significant difference between areas was found indicating that dredging had no apparent effect on the species of fish or the numbers of individuals using the areas. This finding is elaborated on further in the Conclusion/Recommendation section.

**LARVAL FISH AND ZOOPLANKTON COLLECTIONS:**

A total of 117 larval fish and zooplankton tows were conducted during the sampling period. This represents 39 tows per area at three different collection depths for a total of 351 samples or 3,510 tow minutes each for zooplankton and larval fish.

**Larval Fish:**

Larval fish were collected only between May 11, 1986 and July 19, 1986. A total of three different species were collected totalling 1,338 larvae. Of the 1,338 collected all, except for seven, were prolarvae (See page for further information on the life stages of larval fish). Larval fish were collected at all depths with more individuals collected in the midwater zone (Table 20).

Due to low catch densities generating low expected values when divided among all possible treatments (area, date, depth) a MDCTA of effects was not appropriate. Therefore effects were

Table 19. Mean lengths (mm) and standard errors for trawled fish.

| Month | Species | CONTROL MEAN | CONTROL STDERR | DREDGE MEAN | DREDGE STDERR | PROPOSED MEAN | PROPOSED STDERR | |
|---|---|---|---|---|---|---|---|---|
| | Gizzard Shad | 198.6 | 6.67 | 0 | 0.00 | 200 | 0.00 | |
| | Rainbow Smelt | 114.1 | 1.28 | 114.0 | 0.75 | 114.5 | 0.96 | |
| October | Spottail Shiner | 100.0 | 0.00 | 101.7 | 1.67 | 96.6 | 1.67 | |
| | Trout Perch | 98.1 | 0.87 | 108.9 | 2.17 | 106.8 | 1.54 | * |
| | White Perch | 98.4 | 1.86 | 106.7 | 14.24 | 104.1 | 2.52 | |
| | Yellow Perch | 133.8 | 12.31 | 115.0 | 5.77 | 113.3 | 9.28 | |
| | Gizzard Shad | 131.0 | 4.30 | 0 | 0.00 | 135 | 0.03 | |
| | Rainbow Smelt | 111.9 | 1.32 | 110.0 | 0.96 | 0 | 0.00 | |
| | Trout Perch | 103.3 | 2.97 | 99.0 | 1.25 | 102.5 | 1.43 | |
| November | White Sucker | 0 | 0.00 | 280 | 0.00 | 0 | 0.00 | |
| | White Bass | 255 | 0.00 | 0 | 0.00 | 0 | 0.00 | |
| | White Perch | 99.4 | 4.77 | 92.9 | 1.67 | 103.4 | 3.84 | |
| | Walleye | 0 | 0.00 | 240 | 0.00 | 0 | 0.00 | |
| | Freshwater Drum | 0 | 0.00 | 136.0 | 8.57 | 140.0 | 0.00 | |
| | Rainbow Smelt | 110.0 | 0.00 | 0 | 0.00 | 100 | 0.00 | |
| April | Spottail Shiner | 0 | 0.00 | 85.0 | 0.00 | 0 | 0.00 | |
| | Trout Perch | 92.5 | 2.50 | 95.0 | 0.00 | 90.0 | 0.00 | |
| | Yellow Perch | 0 | 0.00 | 0 | 0.00 | 97.5 | 7.50 | |
| | Rainbow Smelt | 102.8 | 1.47 | 0 | 0.00 | 104.3 | 1.30 | |
| May | Spottail Shiner | 0 | 0.00 | 0 | 0.00 | 90.0 | 0.00 | |
| | Trout Perch | 91.7 | 1.67 | 100 | 0.00 | 0 | 0.00 | |
| | Yellow Perch | 100 | 0.00 | 85 | 0.00 | 0 | 0.00 | |
| | Rainbow Smelt | 110 | 0.00 | 112.0 | 1.22 | 115 | 0.00 | |
| June | Trout Perch | 97.5 | 2.50 | 95 | 0.00 | 92.5 | 2.50 | |
| | Yellow Perch | 101.3 | 0.13 | 92.5 | 2.50 | 0 | 0.00 | |
| | Rainbow Smelt | 0 | 0.00 | 120 | 0.00 | 125 | 2.50 | |
| July | White Perch | 107.5 | 3.50 | 107.5 | 1.44 | 112.5 | 2.65 | |
| | Yellow Perch | 0 | 0.00 | 0 | 0.00 | 120 | 0.00 | |
| | Freshwater Drum | 0 | 0.00 | 165.5 | 6.50 | 0 | 0.00 | |
| | Gizzard Shad | 100 | 0.00 | 102.5 | 1.25 | 0 | 0.00 | |
| August | Rainbow Smelt | 122.5 | 2.50 | 120 | 0.00 | 125 | 2.50 | |
| | White Perch | 115.0 | 1.33 | 125 | 0.00 | 117.5 | 3.00 | |
| | Freshwater Drum | 145 | 0.00 | 0 | 0.00 | 0 | 0.00 | |
| | Rainbow Smelt | 127.5 | 2.50 | 128.0 | 2.25 | 130 | 0.00 | |
| | Trout Perch | 97.5 | 1.00 | 90 | 0.00 | 95 | 0.00 | |
| September | White Perch | 122.5 | 1.50 | 124.5 | 1.41 | 126.4 | 3.33 | |
| | Yellow Perch | 127.5 | 4.50 | 75 | 0.00 | 120 | 0.00 | |
| | Freshwater Drum | 155 | 4.55 | 162 | 3.36 | 0 | 0.00 | |

* indicates significant difference between areas $p < 0.05$.

Table 20. Results of larval fish collections in the Norfolk Moraine.

| DATE | AREA | DEPTH | SPECIES | N | N/m3 | MEAN LENGTH | STDERR |
|---|---|---|---|---|---|---|---|
| | | Surface | Burbot | 8 | 0.04 | 4.50 | 0.000 |
| | Control | Midwater | Burbot | 23 | 0.13 | 4.49 | 0.031 |
| | | Bottom | Burbot | 8 | 0.04 | 4.50 | 0.000 |
| | | Surface | Burbot | 4 | 0.02 | 4.50 | 0.000 |
| 5/11/86 | Dredge | Midwater | Burbot | 12 | 0.06 | 4.50 | 0.000 |
| | | Bottom | Burbot | 2 | 0.02 | 4.50 | 0.000 |
| | | Surface | Burbot | 4 | 0.02 | 4.50 | 0.000 |
| | Proposed | Midwater | Burbot | 24 | 0.012 | 4.53 | 0.024 |
| | | Bottom | Burbot | 2 | 0.02 | 4.50 | 0.000 |
| | | Surface | Burbot | 4 | 0.02 | 4.60 | 0.014 |
| | | | Y. Perch | 5 | 0.03 | 5.38 | 0.114 |
| | Control | Midwater | Burbot | 16 | 0.09 | 4.50 | 0.000 |
| | | | Y. Perch | 3 | 0.02 | 5.35 | 0.122 |
| | | Bottom | Burbot | 1 | 0.01 | 4.50 | --- |
| | | Surface | --- | -- | --- | --- | --- |
| 5/21/86 | Dredge | Midwater | Burbot | 5 | 0.03 | 4.50 | 0.000 |
| | | Bottom | Burbot | 3 | 0.02 | 4.50 | 0.000 |
| | | Surface | --- | -- | --- | --- | --- |
| | Proposed | Midwater | Burbot | 6 | 0.04 | 4.50 | 0.000 |
| | | Bottom | --- | -- | --- | --- | --- |
| | | Surface | Smelt | 72 | 0.26 | 5.00 | 0.000 |
| | | | Y.Perch | 18 | 0.05 | 5.69 | 0.059 |
| | Control | | Burbot | 4 | 0.01 | 4.75 | 0.144 |
| | | Midwater | Smelt | 788 | 4.48 | 5.00 | 0.000 |
| | | Bottom | Burbot | 3 | 0.01 | 4.50 | 0.000 |
| | | Surface | --- | -- | --- | --- | --- |
| 6/12/86 | Dredge | Midwater | Smelt | 131 | 0.37 | 5.00 | 0.000 |
| | | Bottom | Burbot | 2 | 0.01 | 4.50 | 0.000 |
| | | Surface | Y. Perch | 1 | 0.01 | 5.50 | --- |
| | Proposed | Midwater | Smelt | 73 | 0.21 | 5.00 | 0.000 |
| | | | Burbot | 4 | 0.02 | 5.00 | 0.000 |
| | | Bottom | Y. Perch | 1 | 0.01 | 6.00 | --- |

Table 20. Results of larval fish collections in the Norfolk Moraine.

| DATE | AREA | DEPTH | SPECIES | N | N/M3 | MEAN LENGTH | STDERR |
|---|---|---|---|---|---|---|---|
| | | Surface | Y.Perch | 1 | 0.01 | 6.00 | --- |
| | Control | Midwater | Smelt | 11 | 0.09 | 5.50 | 0.000 |
| | | Bottom | Burbot | 1 | 0.01 | 5.00 | --- |
| | | Surface | --- | -- | --- | -- | --- |
| 6/27/86 | Dredge | Midwater | Smelt | 9 | 0.01 | 5.50 | 0.000 |
| | | | Y. Perch | 1 | 0.01 | 6.00 | 0.000 |
| | | Bottom | --- | -- | --- | -- | --- |
| | | Surface | Smelt | 2 | 0.01 | 6.30 | 0.030 |
| | Proposed | Midwater | Smelt | 21 | 0.06 | 5.67 | 0.500 |
| | | | Y. Perch | 4 | 0.01 | 5.50 | 0.000 |
| | | Bottom | Burbot | 2 | 0.01 | 5.00 | 0.000 |
| | | Surface | Smelt | 8 | 0.03 | 6.30 | 0.300 |
| | Control | Midwater | Smelt | 3 | 0.01 | 6.00 | 0.000 |
| | | Bottom | --- | -- | --- | --- | --- |
| | | Surface | --- | -- | --- | --- | --- |
| 7/19/86 | Dredge | Midwater | Smelt | 4 | 0.01 | 5.63 | 0.125 |
| | | Bottom | --- | -- | --- | --- | --- |
| | | Surface | Smelt | 4 | 0.01 | 6.25 | 0.225 |
| | Proposed | Midwater | Smelt | 10 | 0.04 | 6.30 | 0.335 |
| | | | Y. Perch | 2 | 0.01 | 6.50 | 0.000 |
| | | Bottom | --- | -- | --- | --- | --- |

tested pair-wise using a standard Chi-square contingency table analysis rather than testing all effects similtaneously. The results of the pair-wise test indicate that a significant association exsist between date and depth (Chi-square = 24.92, $p<0.05$) and date and area (Chi-square = 26.78, $p<0.05$). These results indicate that some differences do exist between area, date, and depth in terms of larval fish density. Generally larval fish were more abundant in the control area than in the dredge or proposed dredge sites; and more individuals were collected at the midwater depth than at the surface or bottom.

**Zooplankton:**

A total of 21 species of zooplankton were collected (Table 21). Of the 21 species, 14 were cladocereans and seven were copopods. Of significance, was the collection of _Bythotrephes cerderstroemi_, a invading species of zooplankton only first reported from Lake Erie in the Fall of 1985 (Bur et al. 1986).

Densities of zooplankton were greatest in the midwater zone and highest during June and July and lowest during April (Table 22, also see appedices for zooplankton species densities). These density values were used to examine differences between areas, dates, and depths in a MDCTA. Results of the MDCTA indicated that date, depth, and the date-depth interaction were all

Table 21. List of zooplankton species collected from the Norfolk Moraine.

| Species |
|---|
| Order Cladocera |
| *Leptodora kindti* |
| *Polyphemus pediculus* |
| *Holopedium gibberum* |
| *Diaphanosoma birgei* |
| *Sida crystallina* |
| *Alona spp.* |
| *Ceriodaphnia spp.* |
| *Chydorus sphaericus* |
| *Eubosmina coregoni* |
| *Bosmina longirostris* |
| *Bythotrephes cerderstroemi* |
| *Daphnia galeata* |
| *Daphnia longiremis* |
| *Daphnia retrocurva* |
| Suborder Calanoida |
| *Limnocalanus macrurus* |
| *Eurytemora affinis* |
| *Skistodiaptomus oregonensis* |
| *Leptodiaptomus minutus* |
| Suborder Cyclopoida |
| *Mesocyclops edax* |
| *Acanthocyclops vernalis* |
| *Diacyclops thomasi* |

Table 22. Mean total density of zooplankton for each area by date and depth of collection. All densities are divided by 10000.

| DATE | CONTROL | | | DREDGE | | | PROPOSED | | |
|---|---|---|---|---|---|---|---|---|---|
| | B | M | S | B | M | S | B | M | S |
| 9/22/85 | 101.2 | 334.9 | 128.0 | 13.85 | 277.6 | 353.2 | 138.9 | 318.2 | 207.1 |
| 10/12/85 | 71.72 | 133.7 | 82.79 | 42.84 | 160.9 | 115.9 | 72.40 | 200.8 | 137.4 |
| 10/26/86 | 38.38 | 113.0 | 60.01 | 49.85 | 117.5 | 85.52 | 37.62 | 134.4 | 75.46 |
| 4/14/86 | 0.697 | 13.87 | 5.199 | 1.027 | 6.257 | 5.179 | 1.127 | 4.157 | 36.67 |
| 4/27/86 | 3.746 | 9.361 | 16.94 | 3.396 | 8.110 | 17.33 | 3.515 | 9.107 | 16.60 |
| 5/11/86 | 16.56 | 60.25 | 33.13 | 11.60 | 66.32 | 25.47 | 66.92 | 47.47 | 18.41 |
| 5/21/86 | 110.4 | 154.3 | 97.87 | 17.66 | 13.07 | 38.97 | 108.1 | 78.84 | 32.88 |
| 6/12/86 | 78.52 | 150.3 | 102.6 | 253.6 | 140.4 | 331.4 | 69.06 | 248.6 | 72.47 |
| 6/27/86 | 36.32 | 55.11 | 47.53 | 53.86 | 122.1 | 32.55 | 34.28 | 105.1 | 46.53 |
| 7/19/86 | 181.5 | 58.28 | 85.70 | 148.5 | 39.04 | 107.1 | 321.0 | 76.17 | 71.63 |
| 8/01/86 | 92.67 | 98.05 | 52.26 | 84.07 | 121.1 | 88.20 | 133.3 | 106.9 | 80.65 |
| 8/16/86 | 91.24 | 88.01 | 66.78 | 69.41 | 94.85 | 67.04 | 75.77 | 75.09 | 66.11 |
| 9/13/86 | 36.79 | 72.78 | 32.37 | 36.23 | 57.97 | 26.04 | 32.29 | 57.66 | 25.89 |

B = Epibenthic
M = Midwater
S = Surface

significant (Table 23). This idicates that zooplankton densities varied between dates, with fewer collected in the Spring, that densities varied by depth, with more collected in the mid-water zone, and that the relationship of zooplankton density with depth changed during the collection period. These results are not unexpected given the temperature dependent life cycle of most planktonic crusteacean species (Balcer et al. 1984, Evans et al. 1980, Mackas et al. 1980) and the tendencey for water temperature to vary vertically and temporally.

## CONCLUSIONS/RECOMMENDATIONS:

### RESULTS:

### ADULT FISH:

A total of 18 species of fish comprising 12 families were collected. Yellow perch were the most abundant species and most of these were of an early year class. This indicates that the Norfolk Moraine may effectively serves as an early nursery ground especially since larval yellow perch were also collected. The abundance of this year class also indicates a favorable future resources of yellow perch along the Moraine.

### LARVAL FISH:

There are three accepted life stages of most larval fish,

Table 23. Results of MDCTA for zooplankton density. Area, date, depth and their interactions are the effects. NS indicates a p-value > .05.

| Effect | G-Value | DF | P-value |
|---|---|---|---|
| Date | 27.231 | 11 | 0.009 |
| Area | 2.214 | 2 | NS |
| Depth | 6.146 | 2 | 0.032 |
| Date*Area | 24.433 | 22 | NS |
| Date*Depth | 36.239 | 22 | 0.026 |
| Area*Depth | 2.746 | 4 | NS |
| Date*Area*Depth | 22.384 | 44 | NS |

prolarvae, mesolarvae, and metalarvae (Snyder 1976). The stage basically describes the development stages in terms of gut, and fin morphology. Generally prolarvae are those larvae that have a yolk sac and only a nonfunctional developing gut. Prolarvae generally feed endogenously on the yolk contained in the yolk sac. When the yolk is absorbed the gut is completely developed and functional and feeding switches from endogenous to exogenous. This is a critical period in the life history of fish, since a lack of an exogenous food source, or an inability to locate a food source is detrimental.

Most of the larval fish collected along the Norfolk Moraine were prolarvae and therefore no determination of prey selectivity could be assessed. The few mesolarvae collected had not consumed any prey. The reason for this is only speculative, and since so few were collected no trends were apparent.

Reasons for the low catch of meso- and metalarvae are not known. The techniques employed conform to standard techniques which have been utilized sucessfully (e.g., Bowles et al.1976; Wapora Inc. 1978;1979; Thayer et al. 1978). For any future sampling of larval fish along the Norfolk Moraine we recommend either increasing tow speed (Noble 1970) or increasing net diameter and aspect (Dr. David Jude, Great Lakes Research Division, University of Michigan, Ann Arbor, Mich.).

Larval fish are weak swimmers (Rulifson and Huish 1975), and although they may be dispersed by wind generated currents, their occurence in an area is a general indication that the area was used by the adult to spawn. Few species of fish, however, are able to spawn in waters as deep as those on the Moraine. An apparent exception to this is the burbot. Burbot usually spawn over gravel areas in water of 1-4 feet (Scott and Crossman 1973). Little is known about the status of burbot in Lake Erie, but they seem to be successful at spawning at depths of 50-60 feet. The larvae of the burbot, however, are semibouyant and are easily dispersed within the water column (Balon 1975). This accounts for the distribution of larvae collected from all depths.

In addition to the collection of burbot larvae, our data indicates a trend of more individual larve located at mid-depth than at any of the other depths. The reason for this spatial distribution is unknown, although spatial distribution preferences have been reported by others (Lewis 1978, Wapora 1978). Possible explantions for this pattern may be the position of the thermocline and/or the high densities of zooplankton also found in the midwater region.

Zooplankton:

Zooplankton were extremely abundant in all sampling areas along the Moraine. We initially proposed to collect zooplankton to determine potential prey selectivity by larval fish. Since we collected zooplankton samples throughout the sampling period we chose to include the zooplankton data in the report to provide a more complete baseline of the biota of the Norfolk Moraine.

The results of the zooplankton collections indicted that plankters were abundant in all sampling areas. Dominant species collected include: Bosmina longirostris, Eubosmina coregoni, and three species of Daphnia. These species are important food sources for many species of larval and juvenile fishes such as yellow perch, freshwater drum, and white perch. Also abundant in the collections, was a species of zooplankton that is not native to Lake Erie. This species, Bythotrephes cerderstroemi, was first reported in Lake Erie by Bur et al. 1986. This species is a pelagic cladoceran native to Europe. Bythotrephes is predaceous, feeding primarily on Bosmina and prefers cooler oligotrophic waters (Bur et al., 1986). High densities of this species were observed in mid-July in the epibenthic collections. What impact this new invader will have on the native zooplankton assemblage is not known, although and impact may be postulated given this species diet, habitat, and rapid expansion throughout the waters of Lake Erie (pers. comm. Dr David Klarer, Old Woman Creek National Research Reserve, Huron, Ohio).

## RECOMMENDATIONS AND ANALYSIS OF IMPACT:

Based on the results of this study we would conclude that commercial sand dredging has no detectable influence on the distribution and abundances of the sampled biota of the Norfolk Moraine. We qualify this statement, however, in that we believe additional information should be gathered to determine the immediate and localized effects of dredging. Caution should also be taken when attempting to extroplolate the impact of increased dredging activities using the information in this report. This study was of a one year duration, this time scale, in our opinion, is inadequte to discern the true biotic relationships of the sampling areas and establish an adequate baseline from which predictions can be made.

This study compared areas of approximately equal size to reduce potential sampling bias. In effect, this introduced a problem in sampling scale that perhaps masked any potential localized effects of dredging. The area actually dredged is small relative the overall size of the permitted dredge area. Areas within the permitted zone, if never dredged or dredged infrequently, may compare favorably with proposed dredge and control sampling areas. Conversations with Erie Sand and Steamship Company further support this belief, in that dredging of the entire area does not occur with equal intersity.

**Impact of intensive dredging versus light dredging (i.e. 1,000,000 C.Y. every five years versus 200,000 C.Y. per year).**

The study as design and implemented cannot adequately address this question. The comparisons made in this instance essentially examine two seperate hypothesis on the effects of dredging. One focuses on the relative impact of constant low levels of disturbance on an ecosystem. The second, addresses a short duration, intense purterbation with a long recovery time in between.

All natural communities are dynamic systems with the densities and age-structure of populations varying temporally and spatially. This variation reflects species-specific responses to gradients in the habitat as well as changes in the physical environment over time. Disturbance in natural communities, whether natural, or those perpetuated by man have the following components: 1). areal extent, the size of the disturbed area; 2). Intensity, the strength of the disturbing force; 3). Severity, a measure of the damaged caused by the disturbance; and 4). Frequency, the number of disturbances per unit time (Sousa 1984).

The disturbance regime represents a combination of the relative magnitude of these four components and determines the species-specific responses observed following environmental perturbation.

The project design employed in this study only enables us to comment on the impact of dredging relative to the areal extent of the disturbance regime. Given this, a simple five-fold extrapolation of our data would not adequately address the effects of changes in intensity, severity and frequency components of the disturbance regime.

To adequately examine the effects of infrequent, high intensity disturbances (i.e. 1,000,000 cubic yards every five years) a project should be initiated to examine how variations in intensity, severity, and frequency influence the species-specfic responses to dredging. In addition, more information on the autecology of all species inhabiting the proposed dredge site is necessary.

## Integration of Results:

As part of our contract we agreed to integrate our study with others conducted on the Norfolk Moraine (Ecology and Environment 1984, Herdendorf 1985). The three studies, including our project, all address different aspects of dredging effects along the Norfolk Moraine. Each study contributes significant information that when integrated provides a more comprehensive assessment of the effect of dredging.

During dredging operations bottom sediments are mechanically disturbed. This results in two basic types of disturbance. One is the physical removal of the sediments, resulting in the potential destruction of habitat, and the possible entrainment of fish eggs and larvae. This was addressed by Herdendorf (1985) and to a degree during our project. Neither the results of his study nor ours indicates a significant impact of the removal of substrate.

A second potential impact of dredging on the Lake Erie resource is the resuspension of sediments. The effect of this resuspension may be twofold. One, sediments accumulate toxins such as heavy metals, petroleum distillates, and pesticides (Morton 1977). A resuspension of sediments due to dredging activity resuspends the toxins as well. As a function of the project by Ecology and Environment (1984) pollution values of sediments were examined. Since only low levels of toxins were found in the sediment, resuspension of those sediments do not appear have a significant toxicological effect.

Secondly, dredging operations tend to increase turbidity in an area (Slotta et al. 1973). This increase in turbidity may resuilt in the reduction of light penetration that may decrease phytoplankton productivity (Sherk et al. 1974). Zooplankton species may also be sensitive to dredging. The zooplankton commmunity of Lake Erie is dominated by crustaceans, many of which are filter feeders. Being filter feeders, these species may be vulnerable to increased suspended solids due to dredging.

Any such disturbance could also be passed along to the fish community. Many larval fish depend upon phytoplankton and zooplankton during initial stages of exogenous feeding. In addition many juvenile and adult fish are filter feeders and would be effected in a manner similar to zooplankton. Further, those fish that are not filter feeders depend on sensitive visual acuity to locate and recognize potential prey items. Any increases in turbidity could severly effect their foraging efficency, hence potentially reducing recruitment to the Norfolk Moraine fish community (Confer 1978).

This study conducted by Environmental Explorations was designed to tie in many aspects of the other studies. An analysis of adult and young of the year fish allowed us to determine the baseline utilizatiuon of the area. In addition, the analysis of larval fish and zooplankton provided information relative to forage potential, as well as spatial and temporal distribution.

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Appendix 1. List of zooplankton species collected from the Norfolk Moraine with species abbreviations used throughtout appendices.

| Species | Species abbreviation |
|---|---|
| **Order Cladocera** | |
| *Leptodora kindti* | LK |
| *Polyphemus pediculus* | PP |
| *Holopedium gibberum* | HG |
| *Diaphanosoma birgei* | DB |
| *Sida crystallina* | SC |
| *Alona spp.* | AL |
| *Ceriodaphnia spp.* | CS |
| *Chydorus sphaericus* | KS |
| *Eubosmina coregoni* | EC |
| *Bosmina longirostris* | BL |
| *Bythotrephes cerderstroemi* | BC |
| *Daphnia galeata* | DG |
| *Daphnia longiremis* | DL |
| *Daphnia retrocurva* | DR |
| **Suborder Calanoida** | |
| *Limnocalanus macrurus* | CM |
| *Eurytemora affinis* | EA |
| *Skistodiaptomus oregonensis* | SO |
| *Leptodiaptomus minutus* | LM |
| *Epischura lacustris* | EL |
| **Suborder Cyclopoida** | |
| *Mesocyclops edax* | ME |
| *Acanthocyclops vernalis* | AV |
| *Diacyclops thomasi* | DT |

Appendix 2. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR SEPTEMBER 22, 1985.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | — | 42186 | 28450 | — | — | 83890 | — | — | 40739 |
| PP | 16330 | 42186 | 554791 | — | 105462 | 964741 | 48143 | 159994 | 26930 |
| HG | — | 126559 | 184930 | — | 84369 | 109057 | 74071 | 711081 | 285176 |
| DB | 269448 | 885913 | — | — | 123918 | 83890 | 244436 | 296286 | 189663 |
| KS | — | — | — | — | — | 33556 | — | — | — |
| EC | — | 295304 | 213381 | — | 369118 | 293616 | — | 414801 | 244436 |
| BL | — | 590609 | 78239 | — | 52731 | 125835 | — | 177772 | 61109 |
| DG | 645043 | 594828 | — | — | 711871 | 201337 | 585166 | 859231 | 916637 |
| DR | 24495 | 181401 | 163592 | — | 142374 | 251671 | 222215 | 266658 | 162957 |
| LM | — | — | — | — | 105462 | 251671 | 70717 | 177777 | — |
| SO | 32660 | 168745 | 42676 | — | 606408 | 629179 | 22221 | 88886 | 142580 |
| EL | — | 42186 | 7112 | — | — | — | — | — | — |
| ME | 24495 | 253118 | 7112 | — | 316387 | 125835 | 48143 | 35554 | 20369 |
| AV | — | 84372 | — | — | — | — | — | — | — |
| DT | — | — | — | — | — | 83890 | — | — | — |

* See species abbreviations in Appendix 1 for more detail.

Appendix 3. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR OCTOBER 12, 1985.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| HG | 99800 | 34472 | 78321 | — | 16518 | 720018 | — | 12923 | 90408 |
| DB | 99280 | 379196 | 65267 | 77507 | 191609 | 43201 | 148376 | 646156 | 65094 |
| EC | 8237 | 48261 | 16374 | 38753 | 33036 | 115202 | 9597 | 77538 | 144654 |
| BL | 8273 | 20683 | 65267 | 23252 | 19821 | 86402 | 9898 | 34614 | 108490 |
| DG | 330935 | 620503 | 114218 | 193769 | 515363 | 118083 | 306645 | 904619 | 137421 |
| DL | — | 55155 | 195803 | 7750 | 528578 | 230405 | 19783 | 120615 | 361635 |
| DR | 99285 | 25577 | 195115 | 38753 | 118930 | 172804 | 138484 | 44800 | 253144 |
| LM | 12400 | 68944 | 16217 | 6206 | 66072 | 25920 | 11870 | 60307 | 32547 |
| SO | 1105 | — | — | 1105 | 13214 | — | — | — | — |
| ME | 49640 | 55155 | 6527 | 31003 | 33036 | 84602 | 69242 | 51692 | 108490 |
| AV | — | 1378 | 9791 | 2325 | 6706 | 2880 | — | 3446 | 3616 |
| DT | 8273 | 27599 | 64627 | 7948 | 66072 | — | 9891 | 51692 | 72327 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 4. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR OCTOBER 26, 1985.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | 2886 | 7087 | 2543 | 7492 | 9963 | 1588 | 6651 | --- | --- |
| HG | 14340 | 141753 | 89003 | 16650 | 142337 | 60381 | --- | 59622 | 59225 |
| DB | 28866 | 283506 | 47680 | 74928 | 284674 | 54025 | 73901 | 42587 | 54756 |
| EC | 14430 | 49613 | 28608 | 41626 | 35584 | 12711 | 33255 | 113556 | 20147 |
| BL | 7256 | 21262 | 6354 | 16507 | 21305 | 6359 | 22170 | 25051 | 5589 |
| DG | 129897 | 425259 | 47680 | 174883 | 412788 | 54055 | 110852 | 397483 | 49785 |
| DL | 21649 | 21262 | 95361 | 16650 | 49810 | 190678 | 7390 | 85175 | 151423 |
| DR | 101031 | 99227 | 158935 | 58277 | 106752 | 222458 | 44341 | 170350 | 152142 |
| ME | 21649 | 354438 | 95361 | 49952 | 33584 | 127118 | 36950 | 56783 | 101236 |
| AV | 7216 | 7087 | 6357 | 16650 | 14233 | 6355 | 14780 | 12552 | 6528 |
| DT | 34636 | 42525 | 22250 | 24976 | 64051 | 95391 | 51731 | 17035 | 52136 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 5. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR APRIL 14, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| DG | 3136 | — | 4295 | — | — | 3301 | — | — | 85887 |
| DL | — | 71987 | — | — | 41877 | — | — | 11877 | — |
| LM | 3161 | 173127 | 19028 | 10270 | 20699 | 27328 | 11272 | 29692 | 273278 |
| AV | — | 4181 | 4284 | — | — | 958 | — | — | 4024 |
| DT | — | 45206 | 24378 | — | — | 20199 | — | — | 3537 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 6. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR APRIL 27, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| DG | 5124 | 5623 | 7896 | 4489 | 6985 | 10258 | --- | 6258 | 10263 |
| DL | --- | --- | 4558 | --- | --- | 8960 | --- | --- | --- |
| DR | 4502 | 1258 | --- | --- | 988 | --- | 3658 | 852 | --- |
| LM | 26783 | 58964 | 98615 | 19834 | 50187 | 94355 | 28843 | 41257 | 90125 |
| SO | --- | --- | --- | --- | --- | --- | --- | 964 | 8527 |
| AV | --- | 5196 | 6287 | --- | 2167 | 4129 | --- | 1078 | 5583 |
| DT | 1052 | 22569 | 43591 | 9634 | 20782 | 55634 | 2647 | 40658 | 51482 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 7. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR MAY 11, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| EC | — | — | — | — | — | — | — | — | 29644 |
| BL | — | — | — | — | — | — | — | — | 29644 |
| DG | — | — | — | — | — | — | — | — | 17030 |
| DL | — | 5226 | — | 16374 | — | 78228 | 37577 | — | — |
| DR | — | — | — | 32749 | — | — | — | — | — |
| LM | 126237 | 96363 | 153749 | 16374 | 502565 | — | 10705 | 438922 | 76696 |
| CM | — | 10453 | — | — | — | — | — | — | — |
| SO | — | — | 16422 | — | 40026 | — | 14273 | — | — |
| AV | 4024 | — | — | — | — | — | — | — | — |
| DT | 35371 | 490422 | 161150 | 50537 | 120595 | 176441 | 606619 | 35724 | 37426 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 8. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR MAY 21, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| AL | 29031 | — | — | — | — | — | — | — | — |
| EC | — | 184200 | 405455 | 17633 | — | — | 12607 | — | — |
| BL | — | 231998 | 203847 | — | 51930 | 25976 | 44602 | 114724 | 298414 |
| DG | — | 39201 | — | — | — | — | — | — | — |
| DL | — | 264208 | — | 123644 | 437708 | 363676 | 194873 | 147080 | 30391 |
| LM | 203220 | 338599 | 218118 | 35326 | 111279 | — | 45380 | 88249 | — |
| SO | — | — | — | — | 96071 | — | — | 176498 | — |
| AV | 29043 | — | — | — | — | — | 6030 | 29416 | — |
| DT | 842219 | 327859 | 135987 | — | 610185 | — | 777185 | 232390 | — |

* See species abbreviations in Appendix 1 for more detail.

Appendix 9. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR JUNE 12, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | -- | 58251 | -- | -- | 14786 | -- | 78440 | 158249 | -- |
| HG | -- | -- | -- | -- | -- | -- | -- | 28227 | -- |
| DB | -- | -- | -- | -- | -- | -- | 88884 | -- | -- |
| EC | 12080 | 174755 | 229442 | 116520 | 98199 | 30390 | 87440 | 108240 | 83860 |
| BL | 24160 | 378637 | 193215 | 31314 | 249618 | 45586 | 87844 | 267600 | 119800 |
| DG | 6040 | -- | 241518 | 873906 | 1040 | 130390 | -- | -- | 299501 |
| DL | -- | 75727 | 181139 | 436953 | 318090 | 45586 | 263532 | 330611 | 65890 |
| DR | 6040 | 145629 | -- | 509779 | 178788 | 30441 | 84480 | 371257 | 59900 |
| LM | -- | -- | -- | 145651 | -- | -- | -- | -- | -- |
| EL | -- | -- | -- | -- | -- | -- | -- | -- | 5990 |
| SO | 6040 | 343685 | -- | 145651 | 298800 | -- | -- | 854921 | 59900 |
| ME | -- | 267958 | -- | 138368 | 201114 | 33880 | -- | 145468 | 11980 |
| AV | -- | -- | -- | -- | -- | -- | -- | 34227 | -- |
| DT | 24160 | 58251 | 181139 | 138368 | 44109 | 15195 | -- | 186753 | 17970 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 10. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR JUNE 27, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | 5679 | 43678 | -- | -- | 25087 | 7054 | 6248 | 85124 | -- |
| DB | 148963 | 86254 | 14205 | 135896 | 52143 | 21452 | 98863 | 52143 | 19854 |
| EC | 22152 | 15826 | 20541 | 25483 | 19862 | 2104 | 1842 | 14275 | 11283 |
| BL | 10254 | 31526 | 17537 | 12561 | 42158 | 15961 | 9984 | 22356 | 18542 |
| DG | 16254 | 6014 | 101526 | 17852 | 8527 | 120568 | 9635 | 10548 | 196351 |
| DL | -- | 29477 | 284568 | 1059 | 412563 | 99865 | 5961 | 412516 | 101548 |
| DR | 16582 | 46125 | -- | 24725 | 85126 | 985 | 42650 | 10248 | 1268 |
| LM | 10586 | -- | -- | 12581 | -- | -- | 9524 | -- | -- |
| EL | 1532 | 9586 | 14856 | 1053 | 12045 | 21486 | 2594 | 10536 | 55826 |
| SO | 35127 | 145695 | -- | 125827 | 189250 | 1478 | 22138 | 202586 | 2516 |
| ME | 85632 | 125488 | 19856 | 158347 | 256841 | 23648 | 124862 | 196325 | 36254 |
| DT | 10362 | 14251 | 5263 | 21045 | 21036 | 9952 | 13633 | 31652 | 17452 |

* See species abbreviations in Appendix 1 for more detail.

Appendix 11. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR JULY 19, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | — | — | — | — | 41735 | — | — | — | — |
| BC | 297608 | 73462 | 93839 | 305285 | 166533 | — | 124193 | 157125 | — |
| DB | 263519 | 86150 | 40541 | 188318 | — | — | — | 32577 | — |
| BL | — | — | — | — | — | — | 186290 | — | — |
| DG | 575412 | 317904 | 430635 | 416619 | 130198 | 858524 | 906612 | 464613 | 132142 |
| DL | — | 105288 | 85043 | — | 51964 | 195636 | 434677 | — | 584151 |
| DR | 59981 | — | 121624 | 62107 | — | — | 142822 | — | — |
| EL | 23172 | — | — | 15619 | — | — | 186290 | — | — |
| SO | 262114 | — | 85335 | 216444 | — | 17199 | 298064 | 53822 | — |
| EA | — | — | — | — | — | — | 124193 | — | — |
| ME | 199938 | — | — | 185503 | — | — | 807257 | 53628 | — |
| AV | 132909 | — | — | 95106 | — | — | — | — | — |

* See species abbreviations in Appendix 1 for more detail.

Appendix 12. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR AUGUST 01, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | -- | 136933 | -- | -- | 129141 | -- | -- | -- | -- |
| BC | 720735 | 177051 | 15714 | 596142 | 201768 | 59597 | 11000115 | 220789 | 14986 |
| EC | -- | -- | -- | 5092 | -- | -- | 14113 | -- | -- |
| DG | 148723 | 531154 | 423172 | 197777 | 691482 | 166874 | 157159 | 717566 | 333771 |
| DL | -- | -- | 50597 | -- | -- | 622155 | -- | -- | 457652 |
| EL | 57201 | -- | 33156 | 41706 | -- | 33451 | 61704 | -- | -- |

* See species abbreviations in Appendix 1 for more detail.

Appendix 13. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR AUGUST 16, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | — | 1025 | — | — | 2698 | 958 | — | 2251 | — |
| BC | 621041 | 241893 | 21563 | 423569 | 198561 | 19531 | 488725 | 152142 | 15267 |
| EC | 7425 | — | — | 3201 | — | — | 2214 | — | — |
| DG | 215631 | 616589 | 525433 | 202487 | 722563 | 298635 | 166644 | 505421 | 366251 |
| DL | — | — | 101254 | — | — | 322518 | — | 59614 | 244753 |
| SO | 1295 | — | — | — | — | — | 5483 | — | — |
| EL | 24782 | 10425 | 19563 | 33285 | 9201 | 28745 | 35244 | 15562 | 34844 |
| ME | 42258 | 10249 | — | 31567 | 15487 | — | 59462 | 15963 | — |

* See species abbreviations in Appendix 1 for more detail.

Appendix 14. ZOOPLANKTON DENSITIES BY DATE, AREA, DEPTH, AND SPECIES. DATA PRESENTED BELOW FOR SEPTEMBER 13, 1986.

| * | Control | | | Dredge | | | Proposed | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | B | M | S | B | M | S | B | M | S |
| LK | 5247 | 2024 | 550 | 4430 | 2467 | 814 | 6288 | 2450 | 1040 |
| BC | 101251 | 98634 | --- | 135468 | 88756 | 15621 | 88472 | 75269 | --- |
| PP | 22514 | 31152 | 526 | 25455 | 29985 | 1042 | 31422 | 28566 | 2218 |
| EC | 6521 | 1054 | --- | 2045 | 486 | --- | 7816 | 2231 | --- |
| BL | 2015 | 950 | 1025 | 6314 | 1115 | 955 | 1844 | 1059 | 2243 |
| DG | 220484 | 505218 | 263485 | 166477 | 404202 | 187699 | 174511 | 422538 | 188621 |
| DL | --- | --- | 55876 | --- | --- | 48755 | --- | --- | 61422 |
| ME | 9853 | 88752 | 2153 | 22154 | 52667 | 5536 | 12599 | 44524 | 3335 |

* See species abbreviations in Appendix 1 for more detail.