A Survey of the Fishes of Lake Winnipeg and Interactions of the Introduced White Bass with the Native Ichthyofauna of Hudson Bay Drainage: with emphasis on young-of-the-year fishes in nearshore environments

by

Gavin Frank Hanke

A thesis submitted to the Faculty of Graduate Studies in partial fulfilment of the requirements for the degree of Master of Science

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A SURVEY OF THE FISHES OF LAKE WINNIPEG AND INTERACTIONS OF THE INTRODUCED WHITE BASS WITH THE NATIVE ICHTHYOFAUNA OF HUDSON BAY DRAINAGE: WITH EMPHASIS ON YOUNG-OF-THE-YEAR FISHES IN NEARSHORE ENVIRONMENTS

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ABSTRACT

This project examined the littoral zone fish communities of Lake Winnipeg and adjacent waterways to determine 1) the distribution of all nearshore fishes, 2) the seasonal use of nearshore habitat by pelagic fish, 3) the food resources used by nearshore fish, 4) the fish species that are sympatric with white bass and 5) the diet similarity among fish species in sympatry with the invading white bass. Four basic distribution patterns were identified for the fishes of the Red River, Lake Winnipeg and their tributaries, and these are presented as individual species maps. Fish move inshore in early to late June and remain there until September. All combinations of pelagic fish occured in samples, suggesting no spatial or temporal habitat shift in the presence of white bass. Pelagic insectivorous, pelagic piscivorous, pelagic zooplanktivorous and benthic insectivorous feeding guilds were defined from analysis of the diets of nearshore fishes. Feeding guilds appeared stable throughout the summer with the exception of emerald shiners, which ate zooplankton and insects in varying proportions. Diet analysis determined that yellow perch, emerald shiner, goldeye, juvenile walleye and sauger and cisco feed on the same zooplankton species as juvenile white bass. Adult white bass feed on the same fish as adult walleye and sauger. Pelagic fish commonly found in sympatry with the white bass include goldeye, mooneye, walleye, sauger, emerald shiner, and yellow perch. These fish are found throughout the lake with no northward range retreat in response to invasion of white bass. Segregation by time occurs in this lake and minimizes contact between white bass, cisco and lake whitefish. There is no evidence of abundance decline, habitat shift or diet shift in native fish in relation to the presence of white bass and therefore there is no evidence for competition resulting from the white bass invasion. The success of white bass is due to exploitation of abundant food items (calanoid copepods and leptodorid cladocerans when young and emerald shiners and perch as adults) thereby eliminating competition with native piscivores. The rapid growth, and the lack of potential predators (walleye and sauger) in Lake Winnipeg also contributed to the success of the white bass.

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LIST OF ABBREVIATIONS FOR ZOOPLANKTON DATA ANALYSIS

Abreviation	Taxon/Category
Bosmn	Bosminidae
Calan	calanoid copepods
Cladc	unidentified cladocera
Cyclo	cyclopoid copepods
Daphn	Daphniidae
Lepto	Leptodoridae
Sidid	Sididae

Abbreviation	Collection Site
Arnes	Silver Harbor Beach
Beacon	Beaconia Beach
BeavCr	Beaver Creek Campground
CmpMrt	Camp Morton Campground
CNeus	Camp Neustadt
GrdMar	Grand Marais Beach
Hillsd	Hillside Beach)
Hnaus	Hnausa Harbor
Hussv	Hussavik Road
Manig	Manigotagan Beach
Matlok	Matlock Beach
McEhl	McEhleran Road Beach
Ponema	Ponema Beach
Rivtn	Riverton Sandy Point Beach
SandB	Sandy Bay Beach
SandH	Sandy Hook
TravB	Traverse Bay
WillP	Willow Point
WinnB	Winnipeg Beach

INTRODUCTION

Occurrence of Exotic Fishes in the Lake Winnipeg Watershed:

There are two fundamental ways in which exotic fish reach Manitoba. First and most importantly, there is human intervention, such as authorized and unauthorized stocking of game species, accidental and intentional introductions of live bait or other nongame species (Franzin *et al.* (1994), Carlton and Geller (1993)), illegal release of tropical and temperate aquarium specimens (Nelson and Paetz (1992), Hanke and Stewart (1994)) and accidental escape from culture ponds (Atton 1959). The second source of exotic biota is by natural dispersal within the drainage from headwaters with intermittent or permanent connection to an adjacent drainage system (Stewart and Lindsey 1970, Stewart *et al.* 1985, Stewart 1988 and McCulloch (1994)).

In recent history, several warm water fish species have entered or have been introduced to the Red River and Lake Winnipeg tributaries (Appendix I). Of these recent faunal additions, the golden redhorse, bigmouth buffalo, carp, rainbow smelt and white bass have successfully entered Lake Winnipeg (Hanke and Stewart 1994). The stonecat has used Lake Winnipeg to disperse to the Brokenhead River (McCulloch 1994) but has not been collected in the lake itself so far. Similarly, the black crappie has used the Lake Winnipeg to disperse up the eastern tributaries but only rarely is collected in the lake.

The Garrison Diversion Project and Potential for Fish Transfer:

Man-made drainage connections provide links between water bodies and are effective avenues for introduction of exotic species (Stewart *et al.* 1985). In 1965 the United States Government authorized the Garrison Diversion Project (Loch *et al.* 1979). The Garrison Diversion Project is intended to divert water from the Missouri River to communities within the Hudson Bay Drainage basin. Water would be transferred between drainage basins, via canals and pumping stations, for municipal, industrial, agricultural and recreational use. A filtering screen placed in the McClusky canal was initially considered as an effective barrier to the dispersal of fishes from the Missouri drainage to the Hudson Bay Drainage (Loch *et al.* 1979). Peterka *et al.* (1983) considered the transfer of exotic species into the Hudson Bay Drainage via the Garrison Diversion unlikely due to the route of water through fish screens, pumping stations and irrigation equipment. Transfer of species however is possible in the event of overflow from heavy rains, screen failure, power failure or if the irrigation system has waste water run off ditches to carry excess water to natural streams (Peterka *et al.* 1983). Multiple screen barriers, routine monitoring, overflow prevention and direct filtration would be required before water could be transferred into Hudson Bay watershed (Sayler 1990).

There are 64 fish species in Lake Winnipeg and its tributaries, 58 species in the Red and Assiniboine Rivers and 38 species in Lake Manitoba and its tributaries (Appendix II). Currently there are 16 additional fish species in the Missouri River headwaters that are not present in the Hudson Bay Drainage (Loch *et al.* 1979). Of the 21 species originally described by Loch *et al.* (1979) as potentially problematic, the smallmouth buffalo (*Ictiobus bubalus*) and yellow bullhead (*Amieurus natalis*) are known from the Red River and/or its headwaters in North Dakota and Minnesota (Koel and Peterka 1994), the rainbow smelt (*Osmerus mordax*) is established in Lake Winnipeg (Campbell *et al.* 1991) and the carp (*Cyprinus carpio*) is widely distributed in the Hudson Bay Drainage in Manitoba (Atton 1959).

Effects of Exotic Fish Introductions:

Potential effects of introduced stocks or species include alteration of habitat, trophic and spatial relationships of native species, gene pool deterioration due to reproduction of native species with introduced conspecifics and hybridization and disease introduction (Crossman 1991). Presently no effects of the addition of the golden redhorse, bigmouth buffalo, rainbow smelt, pumpkinseed (*Lepomis gibbosus*), bluegill (*L. macrochirus*), spotfin shiner (*Cyprinella spiloptera*) and goldfish (*Carassius auratus*) have been observed. No studies have been done on the effects of carp, rainbow smelt, black crappie and smallmouth bass introductions in Manitoba. Of the species listed by Loch *et al.* (1979), only the Utah chub (*Gila atraria*) and the gizzard shad (*Dorosoma cepedianum*), if transferred, present a significant threat to the Hudson Bay fauna through interaction with the native fish (Peterka *et al.* 1983). Peterka *et al.* (1983) give evidence that the shortnose gar (*Lepisosteus platostomus*), pallid sturgeon (*Scaphirhynchus albus*), shovelnose sturgeon (*Scaphirhynchus platorhynchus*), paddlefish (*Polyodon spathula*) and river carpsucker (*Carpiodes carpio*) are unlikely to be transferred via the Garrison Diversion based on their large size, large eggs and because the sturgeon and the gar do not commonly ascend small tributaries of the Missouri River system. The Utah chub is also unlikely to be introduced because its eastern range limit is in Montana (Peterka *et al.* 1983). Red shiners (*Cyprinella lutrensis*) are common in Lake Francis Case (Gasaway 1970, Walburg 1977) and represent a significant threat if they move upstream to Lake Sakakawea. Upstream transfer of the red shiner via the live bait trade is possible, as a result of the vague regulations governing live bait fish in North Dakota, South Dakota and Minnesota fishing regulations (Meronek *et al.* 1995). Red shiners are aggressive and could compete with native Hudson Bay fishes for food and preferred habitat (Rinne 1991, Douglas *et al.* 1994). In addition, red shiners show rapid evolution of metabolic compensation for cooler temperatures even in southern limits of their North American range (King *et al.* 1985, Zimmerman and Richmond 1981) and are habitat generalists which prefer turbid water (Jennings and Saiki 1990, Matthews 1985). Red shiners are a threat to the cyprinid fishes of the Red and Assiniboine Rivers.

McCulloch (1994) completed the first detailed study of the effects of the stonecat (*Noturus flavus*), on the native fishes of the Hudson Bay Drainage. The stonecat, first collected in 1969 (Stewart and Lindsey 1970), appears to have dispersed quickly by occupying an unoccupied niche and as a result does not appear to interact significantly with resident species with which it is sympatric (McCulloch 1994). In contrast to the stonecat, the abundance of the spotfin shiner (*Cyprinella spiloptera*) appears to be negatively correlated to the abundance of the native river shiner (*Notropis blennius*) in the Red and Assiniboine Rivers (unpublished data) suggesting a potential interaction between these two minnow species.

To further address the problem of the effects of invading fish, the Interbasin Biota Transfer Studies Program funded a study to examine the exotic and native fish fauna of Lake Winnipeg. This project is divided into two parts. The first part was a complete survey of the nearshore fish fauna of Lake Winnipeg and most of the tributaries entering the lake. The second part examined the current distribution and the seasonal patterns of habitat use and diet of native fishes for comparison with the invading white bass (*Morone chrysops*). Juveniles of species may overlap in habitat use and in diet regardless of spatial and dietary segregation of adults (Matthews *et al.* 1992). The examination of diet of the nearshore fishes of Lake Winnipeg focused on the smaller individuals to determine resource overlap and potential for interaction among species. These smaller fishes include young-of-the-year (YOY) individuals for each species, survival of which is critical to population viability (Shuter and Post 1990). Extensive overlap of diet and habitat preference among species indicates only that similar resources are being used (Sale 1974). If resources are abundant then there exists only a potential for interaction as a result of the presence of the new species. Interactions occur between species using similar resources only when those resources are limited (Sale 1974). The common use of resources which may result in interactions among species can take two forms. Exploitation of a resource, is defined as the use of a resource regardless of the presence of another species or individual. Competition for a resource is defined as the race for a resource to the exclusion of a neighbor (regardless of species).

The null hypothesis tested by this study is that native species do not shift their geographic range, habitat use and/or diet in the presence of the white bass. The null hypothesis states that native species and the invading white bass share resources. Fish are categorized into feeding guilds for comparison of dietary data. Guilds are defined as groups of species or individuals utilizing a common set of resources in a similar way (Root 1967).

METHODS

Description of the Study Area:

The largest remnant of glacial Lake Agassiz is Lake Winnipeg. Lake Winnipeg is a large shallow unstratified lake (Brunskill *et al.* 1980) with a large northern basin and smaller southern basin (Figure 1). The limnology of the North Basin has remained relatively unchanged since the 1930's but the South Basin has become more eutrophic as a result of increased human activity (Brunskill *et al.* 1980). The major tributaries entering Lake Winnipeg include the Red, Dauphin, Fisher and Saskatchewan Rivers draining from the West and the Winnipeg, Manigotagan, Bloodvein, Berens and Poplar rivers which drain the Precambrian Shield to the East (Figure 1). The rivers entering from the East deliver clear to slightly turbid, slightly acidic, humic water (Brunskill *et al.* 1980). The western rivers drain agricultural land in the South and forested land further North. The western rivers are clear to slightly turbid, unstained and alkaline, due to the Palaeozoic sedimentary rock West of Lake Winnipeg (Brunskill *et al.* 1980). The Red River enters the South Basin of Lake Winnipeg and is responsible for the turbidity of the southern end of the lake. Water from Lake Winnipeg drains northward via the Nelson River into Hudson Bay.

Prior to the formation of Lake Agassiz, meltwater streams from the Saskatchewan River drainage flowed southward to the Missouri River. These streams may have allowed the first invasion of fish into the Hudson Bay region (Stewart and Lindsey 1983). Early connections to the Mississippi River via the Minnesota River spillway may have allowed fish invasion into Glacial Lake Agassiz (Stewart and Lindsey 1983). These early invaders may have been pushed out of the Hudson Bay system by glacial advances roughly 12000 years ago. The first connections for fish dispersal into the Hudson Bay Drainage from the Great Lakes occurred roughly 11000 years ago (Stewart and Lindsey 1983). Subsequent intermittent connections of Lake Agassiz to the Missouri, Great Lakes and Mississippi Drainages were the primary sources of fish for the colonization of what would become the Hudson Bay Drainage (Stewart and Lindsey 1983). The northward shift of the drainage pattern of Glacial Lake Agassiz to present day Hudson Bay occurred roughly 7500 years ago following the separation of connections with the Mississippi, Missouri and Great Lakes drainages (Stewart and Lindsey 1983). Until recently the ichthyofauna primarily consisted of species adapted to cool water as defined by Hokanson (1977). The lack of stratification of Lake Winnipeg (Brunskill *et al.* 1980) precludes the establishment of cold water adapted species. Cold water species such as brook trout (*Salvelinus fontinalis*) and lake trout (*Salvelinus namaycush*) are restricted to headwater lakes and tributaries of Lake Winnipeg (unpublished data) and are found further North in the Nelson River system.

Tributary Survey Collections:

Survey samples were collected at all major tributaries entering Lake Winnipeg upstream to the first impassable waterfall. Samples were also collected from the lake shore adjacent to tributary mouths (Figure 2). Additional accessible sites on the lake shore were collected to fill in gaps between rivers (Appendix III). Samples in September of 1989 were collected by the University of Manitoba, Biology of Fishes (22.467) class field trip along the West side of the lake North to Gull Harbor. Sample sites in the North Basin, (Belanger, Mukutawa, Berens and Poplar Rivers in 1991 and Pigeon River in 1992) were accessed by float plane. The Bloodvein River was accessed by ferry from Pine Dock, on the West side of the lake. All other sites were accessed by road. Collecting effort was concentrated in the South Basin of the lake due to better road accessibility.

Collections were made in August of each year except for the Saskatchewan, Dauphin, Jackhead and Fisher Rivers which were sampled in the spring of 1992 as weather permitted. Only one sample at the Fisher River was possible due to the weather. Subsequent time constraints and changes to the focus of the project prevented a return trip to the Fisher River in August of 1992. Sample sites were selected to cover all habitat types available.

Specimens in the survey were collected with gill nets, beach seines, electrofishing (Smith-Root Model 12 Electrofisher), set lines and by dipnet where habitat permitted. The use of several gear types minimized the bias imposed by each individual method (Weaver *et al.* 1993). The gill nets used varied between the 1991 and 1992-93 sampling years so comparison of gill net effort between years was impossible. The gill nets used in 1992-93 were 5.1, 8.9, 15.2, and 22.8 cm. stretched measure, commercially produced 1.8 X 30 m. gill nets with continuous float and lead line. Gill nets were tied end to end in a continuous gang and were anchored on the bottom. Gill nets were set either obliquely (with the smallest mesh net inshore), or parallel to shore to sample areas too deep to sample effectively with other methods.

Electrofishing was used in fast water in tributary streams and in habitats with obstructions which prevented the use of net gear. Electrofishing consisted of one operator and one dipnetter or a lone operator carrying a dip net. Voltage and pulse frequency were varied according to the conductivity of the water to maintain a 0.25 ampere peak current through the water sampled. Dip nets were used alone in rock pools with stranded fish or along rock outcrops.

The results of the survey are presented as maps showing locations where each species was collected. The species maps are divided into four categories, 1) lacustrine species collected throughout the lake, 2) riverine species collected only in the Red River and the South Basin of the lake, 3) riverine species that were rarely collected in the lake and 4) those species restricted to the Red River and Lake Winnipeg headwaters.

Collections of Lake Winnipeg Beach Habitat:

White bass and other near shore fishes were collected with a beach seine (7.5 m. by 1 m. with a 1 $m.^2$ bag and 6 mm. stretched mesh). Either of two identical seines was used for each sample and so comparison of collections between years is possible. Seine hauls were about 24 m. long (some varied in length depending on local conditions). The seine was pulled parallel to shore and after 24 m. was pivoted and run up onto the beach. Collections were all made in 1 to 1.2 m. water depth. Collections in 1993 and 1994 were planned so as to maintain consistent samples between sites. Wind direction was the primary factor deciding the side of the lake sampled on a given trip. The windward shore was always sampled to eliminate the artifact of differing wave action intensity on the fish community and seine efficiency. Two or more seine hauls were pooled for most sites. Single seine hauls were made at sites where seinable habitat was limited. Catches from individual seine hauls from 1994 were kept separate to determine variability between seine hauls at a given site and to examine spatial distribution of each species along the beach. Beach seine samples tend to underestimate benthic species (Lyons 1986) but the sandy substrate at most sites minimized cover for benthic fish (except for those shorelines which have rocky substrate). Site matching, to consistently sample beach habitat, was possible among all locations except the Saskatchewan River. The Saskatchewan River site was a sheltered boat launch, which was the only accessible shoreline site with fine grained substrate. The substrate at lacustrine sites around the mouth of the Saskatchewan River consisted of large limestone plates which provided cover for benthic species and hindered seine progress.

Processing and Documentation of Collections:

All fish were killed with an overdose of 2-Phenoxy-ethanol before fixation in 10% (vol./vol.) formaldehyde. The abdomens of fish over 15 cm. total length were slit open to the right of the midline once dead to allow rapid fixation of the viscera. Fish collected from the survey of 1991 and 1992 were stored in 50% isopropanol (following a one week rinse in water) while those collected in 1993 and 1994 were permanently stored in the 10% formaldehyde. Fishes stored in alcohol were not used for diet analysis because body weight would be reduced by dehydration compared to those stored in formalin.

Temperature of the lake water (°C) was measured with a mercury thermometer. Qualitative descriptions of substrate type, vegetation density, water turbidity, water colour, wood fall, debris or other cover, wave strength, water flow, water depth and weather were recorded for each site. A label was added to each collection with location name, time, date and water temperature.

All fish were identified to species and counted except for recently hatched young which were identified to the lowest taxon possible.

Information on the timing of white bass spawning was collected from examination of angled adult fishes and from communication with provincial fisheries personnel.

Plankton Samples:

Plankton samples were taken at all sites collected in 1993 for comparison with fish diets. A Wisconsin net (12 cm. diameter opening, 18 cm. diameter collar, with 80 µm. mesh size) was towed roughly 24 m. (same as the seine hauls) at each collection site. Each plankton tow filtered about 271.4 l. of water. The zooplankton collected were fixed in 5% vol./vol. formaldehyde and stored in a labeled bag. After fixation, the sample was stirred and a 10 ml. subsample was drawn from the original sample and the zooplankters were counted. Zooplankton were identified to order (for copepods) and to family for cladocera using Pennak (1989) and Balcer *et al.* (1984). Insects, Arachnids and Oligochaetes also were identified to order using Chu (1949), Eddy and Hodson (1950), Pennak (1953), Lehmkuhl (1979), Merritt and Cummins (1984). The zooplankton counts for each 10 ml. subsample were extrapolated to the total volume of the original sample.

The plankton counts calculated for the original sample then were expressed as numbers per liter based on the volume originally filtered by the Wisconsin net (Appendix VI).

Data Analysis:

Species Composition and Abundance

Latitude Trends within Lake Winnipeg

Since the ichthyofauna of South Basin of Lake Winnipeg is homogeneous (Hanke and Stewart 1994) samples from South Basin sites from 1993 and 1994 were pooled for investigation of latitudinal trends. Data for each species were expressed as percent catch for each site. These data from both sides of the lake were grouped to the nearest minute of latitude. Regressions of latitude against abundance were plotted for the common pelagic species (white bass, emerald shiner, yellow perch, goldeye, mooneye, walleye, sauger and spottail shiner) to determine latitudinal trends in abundance. Simpson's diversity index also was used to examine latitudinal trends in species diversity. Simpson's diversity index describes the probability that two specimens randomly drawn from a sample are different species (Krebs 1989). The calculation for Simpson's diversity index is as follows:

$$\mathbf{1 - D = 1 - \Sigma\,(\mathit{pi})^2}$$

where 1-D = Simpson's index of diversity

p_i = proportion of species i in the community

Species Composition at Hillside Beach

All collections in 1994 were at Hillside Beach (Appendix III). Students t-tests (assuming unequal variance between groups) were used to determine if differences in species abundance occurred between 1993 and 1994 August collections from Hillside

Beach. Similar tests for other time periods were not possible due to the lack of overlap between years at Hillside Beach.

Collections were performed during daylight hours, biweekly between June and August to examine the seasonal use of Hillside Beach. Additional collections from September 1994 were examined. Samples were arbitrarily grouped by date of collection into early June (1st to 15th), late June (16th to 30th), early July (1st to 15th), late July (16th to 31st), early August (1st to 15th), late August (16th to 31st) and September time periods.

These data were plotted as percent catch for each species for all summer collections to determine presence and seasonal overlap in beach use among species. Simpson's diversity index was used to examine seasonal trends in species diversity.

Distribution of Zooplankton:

Plankton samples were analyzed using hierarchical cluster analysis (using complete linkage as the clustering algorithm and chord distance as the similarity function) and symmetrically weighted correspondence analysis using SYN-TAX V (Podani 1993) to determine geographic trends in zooplankton presence.

Fish Diet Analysis:

The stomach contents of the fishes collected at Hillside Beach (Appendices III and V) were examined to determine dietary preferences. Fishes from other sites were examined to verify lake-wide dietary preferences for those species found at Hillside Beach.

Fork length (FL), total mass (TW) and eviscerated mass (EW) were recorded for each fish. Eviscerated mass was used in place of total mass, to minimize effects of stomach fullness and gonad maturity on the length-mass plots. Total gonad mass (GW), was recorded if possible and gonads were described to determine reproductive status and sex of specimens. The stomach was removed from each fish and placed in water. Each stomach was split longitudinally and the contents were removed and stirred to separate individual items. Intact (greater than 3/4 complete) copepods, insects and arachnids were identified to order using Chu (1949), Eddy and Hodson (1950), Lehmkuhl (1979), Merritt and Cummins (1984), Pennak (1989) and Balcer *et al.* (1984). Intact cladocera were identified to family using Pennak (1989) and Balcer *et al.* (1984). Partially digested fish were identified to family if possible. In many cases well digested fish were identifiable by relative proportions of axial musculature but were not identified to family unless characteristic features were evident. Stomach contents commonly consisted of well digested items represented only by hollow exoskeletons. Mass of stomach contents was not recorded as a result of the differences in digestive state. Stomach contents were enumerated as done by Nelson (1980), to try to overcome the bias due to timing of digestion (Sloan *et al.* 1996). Simple enumeration of dietary items is probably a good indicator of importance for similar sized items (in this case zooplankton). The value (biomass) of larger items such as arthropods and fish are comparatively underestimated by simple enumeration of stomach contents (Glenn and Ward 1968) if found with more numerous small items. Detritus and algae were coded as presence/absence for individual fish.

Scatter plots of fork length against eviscerated mass were used to identify size groups for each species of fish within seasonal divisions. Size was used as the criterion for classifying fish since gape is related to size of prey ingested (Gerking 1994). Within each species, fish were classified into size groups based on natural clusters resulting from the length: eviscerated mass plots. In a few cases size classification was subjectively defined at what appeared to be constrictions between clusters in the length: mass plots. Items in the diet for each size category were summarized (mean ± standard deviation), the percentage of empty stomachs and the total number of fishes examined were noted. In addition, the raw data set (number of individuals of a particular dietary item) was summed for all prey categories over all individual fish in each predator size category and species. Each prey taxon was expressed in this summarized data set as a proportion of the total number of stomach contents for each group of fish. These data were used for multivariate analysis of community structure. This summarized data set was used in place of raw data as the original data set contained too many zeros and statistical analysis was not possible. Hierarchical complete linkage cluster analysis using SYN-TAX V (Podani 1993)(with chord distance as a similarity function and complete linkage as the clustering algorithm) was used to graphically display functional groups of fish with similar feeding habits. In addition to the cluster analysis, symmetrically weighted correspondence analysis using SYN-TAX V (Podani 1993) was performed using the summarized diet data set. Correspondence analysis gives a symmetrical ordination of both predators and prey. The resulting two ordinations facilitate determination of the dietary items responsible for the observed predator ordination pattern. The results of the multivariate analysis were used to assign the size groups defined for each fish species to feeding guilds. Diet overlap between size categories for each fish species was estimated with Renkonen's index (also known as percent similarity) using the same data set as for the multivariate analysis (Krebs 1989). Renkonen's index was used as no estimate of prey abundance was available for most collections. The calculation for Renkonen's index follows (Knight *et al.* 1984, Krebs 1989):

$$\mathbf{P}_{jk} = [\sum^{n} (\textbf{minimum } p_{ij}\, p_{ik})]100$$

where P_{jk} = percentage overlap between species j and k

$p_{ij} p_{ik}$ = proportions resource i is of the total resources used by species j and species k and

n = total number of resource states

Plankton samples taken with fish samples at Hillside Beach in 1993, allowed the determination of preference, or bias in the selection of prey items for zooplanktivorous fish species. Manley's index of preference for constant prey populations (Krebs 1989) was used to determine bias in selection of zooplankton. The constant prey calculation was used because the proportion of zooplankton eaten is small in relation to the total inshore zooplankton population (Krebs 1989). The calculation is as follows:

$$\alpha_i = (r_i / n_i)(1 / \sum_{m}^{i=1} (r / n))$$

where

α_i = Manley's Alpha (preference index) for prey type i

r_i = proportion of prey type i in the diet (i = 1,2,3 ...m)

n_i = proportion of prey type i in the environment and

m = number of prey types available

RESULTS

Abundance Differences between Years:

Statistically significant differences of percent catch by species in late August samples at Hillside Beach occurred between 1993 and 1994. An increase was found for emerald shiners (t = -8.68, 20 df, α = .05) between the two years whereas white bass (t = 7.98, 15 df, α = .05) and walleye (t = 2.36, 14 df, α = .05) abundance decreased between 1993 and 1994 (Table 1). No other species were found to have significant differences in abundance between years for late August South Basin samples. Not withstanding these abundance differences, the data set from 1993 was included in subsequent analyses of diet and habitat use. The data set used for examination of latitudinal abundance trends was grouped over all years (1991-1994) to the nearest minute of latitude. This pooling of data sets from each year should minimize the differences observed for Hillside beach for 1994. Pairwise comparisons between years for months other than August were not possible due to lack of overlap of sampling dates. No difference in inshore water temperature was found between years for samples in the South Basin so temperature data were pooled for 1989 to 1994 (Figure 3). The pooled temperature data were roughly the same as that reported by Patalas and Salki (1992).

Diversity Trends by Latitude:

Species richness remained stable throughout the lake (Table 2, Figure 4). The single sample at the Jackhead River was an exception to the species richness seen elsewhere, with only one species collected in this sample. Simpson's diversity index increased towards the northern and southern ends of the lake (Table 2, Figure 5) suggesting that the North and South ends of the lake were more diverse than the Narrows, perhaps due to input from the large tributaries. Again the Jackhead River sample was unique in having a Simpson's diversity index of zero (all fish were of the same species).

Distribution of Fishes in Lake Winnipeg:

Fish collected by the seine tended to be small individuals, since large fish can escape the relatively slow moving net (Neilsen and Johnson 1989).

Species distribution maps fit into four categories; 1) species with lakewide distribution (Figure 6 A), 2) riverine species restricted to the South Basin and the Red River (Figure 6 B), 3) riverine species that used the lake as a dispersal route (Figure 6 C) and 4) headwater species that were either never collected in the lake or were only rarely collected in the lake around the mouth of tributaries (Figure 6 D). Fish often move between the lower reaches of tributaries and lacustrine environments (Tables 3 and 4). Inclusion of a species in one of the above four categories does not imply complete exclusion from other environments. Species that were restricted to headwaters are noted below.

Species maps for the Lake Winnipeg watershed are found in Appendix IV. Chestnut lamprey and silver lamprey were collected rarely and their distributions are largely unknown. Fishes that were lakewide (Figure 6 A) include lake cisco, lake whitefish, rainbow smelt, goldeye, mooneye, quillback, longnose sucker, emerald shiner, spottail shiner, flathead chub, longnose dace, burbot, troutperch, white bass, johnny darter, yellow perch, logperch, river darter, sauger, walleye, mottled sculpin, slimy sculpin, spoonhead sculpin and freshwater drum. All but the smelt, cisco, lake whitefish, flathead chub, white bass and spoonhead sculpin also commonly were found in tributaries of Lake Winnipeg. The range of the quillback probably was underestimated by the limited collecting effort in the North Basin. The larger fishes are collected by the commercial fishery and smaller species are collected primarily from nearshore environments (Table 4). The distribution of rainbow smelt was inferred from commercial gill net catches in which individual fish snagged their teeth on the gill net knots. Smelt also were collected in Playgreen Lake just North of Lake Winnipeg (Remnant 1995, personal communication). The flathead chub and spoonhead sculpin were documented poorly by this survey since they do not commonly use nearshore environments (Table 4) and because flathead chub rarely were taken from the commercial fishery. The introduced lacustrine species that were lakewide include the rainbow smelt and white bass (Table 4). Only the spoonhead sculpin appears to be rare in Lake Winnipeg (Table 4) despite repeated collections in nearshore rocky environments.

The two riverine species that used Lake Winnipeg but were restricted to the South Basin (category two) were the silver chub and river shiner (Table 3)(Figure 6 B). Silver chub were very common in the Red River, contrary to Parker *et al.* (1987), and were rare in Lake Winnipeg (Table 3). Silver chub most often were collected offshore with smaller mesh gill nets. Only one silver chub was collected by seining from the eastern side of the South Basin of Lake Winnipeg at Hillside Beach. River shiners similarly were common in the Red River and were rare in Lake Winnipeg.

Sixty seven percent of the fish of the Lake Winnipeg watershed were headwater and or riverine species which used the lake as a dispersal route (Figure 6 C) or were headwater fish which were not detected in the lake (Figure 6 D)(Table 3). Many riverine fish were found, but were not common, in lacustrine environments (Table 3). Riverine species that used Lake Winnipeg for dispersal between tributaries include lake sturgeon, central mudminnow, northern pike, bigmouth buffalo, golden redhorse, white sucker, silver redhorse, shorthead redhorse, carp, pearl dace, golden shiner, blacknose shiner, weed shiner, mimic shiner, finescale dace, northern redbelly dace, fathead minnow, all catfish, black crappie, rock bass, smallmouth bass, blackside darter, Iowa darter, brook stickleback and ninespine stickleback. The lake chub was only collected in the lower Saskatchewan River. Of these riverine species, only the carp (Atton 1959) and the smallmouth bass were intentionally introduced to the Lake Winnipeg watershed with subsequent dispersal in Manitoba. Black crappie may have dispersed to Lake Winnipeg via the Winnipeg River or from the headwaters of the Red River. Black crappie were collected from the Red River and tributaries on the East side of Lake Winnipeg North to the Poplar River and on the West side in the Icelandic River. One adult black crappie was noted from the Saskatchewan River (unpublished data) but collections from this survey failed to recover more specimens at this site. The smallmouth bass was collected only in the lower reaches of the Winnipeg River. Carp were collected or observed in all Lake Winnipeg tributaries and sporadically collected on lake shorelines. The current northern extreme of the known range of the bigmouth buffalo is the Icelandic River. The golden redhorse was collected in the Red River, a small creek entering the West side of Lake Winnipeg near Ponema (50° 28' N, 96° 57' W) and the Brokenhead and Winnipeg Rivers to the East. Of these riverine species, blacknose shiner, weed shiner, finescale dace, northern redbelly dace, brown bullhead, stonecat, rock bass and blackside darter were not collected from the lake, though they must have used the lake to attain their current distribution.

Species restricted to headwater tributaries include the northern brook lamprey, goldfish, spotfin shiner, hornyhead chub, common shiner, bluntnose minnow, rosyface shiner, sand shiner, creek chub, white crappie and pumpkinseed. The most recent white crappie collected in Manitoba was caught in September of 1989. Reproducing goldfish (unpublished data) occurred in a retention pond in the southern end of Winnipeg and may have entered the Red River via a ditch which has ample flow during the spring (Hanke and Stewart 1994). The invading spotfin shiner has not entered Lake Winnipeg and was rarely collected in the lower Red River. Spotfin shiners were more abundant in the upper Red River and the lower Assiniboine River (unpublished data).

White bass were collected throughout the Red River from Winnipeg to the delta at the South end of Lake Winnipeg. The currently known northern extent of the range of white bass in Manitoba (and in North America) is the mouth of the Mukutawa River (53° 10'N, 97° 26'W) on the Northeast side of Lake Winnipeg. No white bass were taken from the West side of the North Basin of the lake. White bass were collected throughout the South Basin of the lake. White bass were seen ascending the fish ladder at the Fairford Dam

(51° 34'N, 98° 41'W) (W. Lysack, 1993 personal communication) and now are believed to be in Lake Manitoba.

Samples between 1991 and 1994 show that white bass were common in seine hauls in the South Basin of Lake Winnipeg (Figure 7 A). Comparable samples in the North Basin show white bass to be rare in collections. A regression line (Y= -0.281 X + 14.883, r^2=.44, p= 0.00033*)(the asterisk signifying that the regression accounted for a significant portion of the variation at the 5% level) using mean percent of catch for each minute of latitude supported the decrease in abundance of white bass in inshore collections with increasing latitude (Figure 7 A).

Other common pelagic near-shore species such as the emerald shiner (Figure 7 B) and the yellow perch (Figure 7 C) appeared more evenly distributed between the two basins of the lake. The regression lines of the mean percent of catch of emerald shiner (Y= 0.142 X -6.59, r^2=.11, p= 0.104)(Figure 7 B), yellow perch (Y= 0.0528 X -2.328, r^2=.0245, p= .455)(Figure 7 C) and spottail shiner (Y= 0.077 X -3.857, r^2=.364, p= .0014*)(Figure 7 H) in seine hauls suggested that abundance of these species increased slightly with latitude in collections of inshore waters.

Walleye (Y= -0.0554 X + 2.937, r^2=.22, p= .0188*)(Figure 7 D), sauger (Y= -0.0299 X + 1.569, r^2=.186, p= .0316*)(Figure 7 E), goldeye (Y= -0.0345 X + 1.809, r^2=.203, p= .0238*)(Figure 7 F) and mooneye (Y= -0.00762 X + .399, r^2=.079, p= .173)(Figure 7 G) all had regression lines that described a decrease in abundance in collections with increasing latitude.

Spatial pattern on Hillside Beach in August:

A series of nine seine collections, each haul being 24 m. long, along the full length of Hillside Beach between 11:00 and 13:00 on August 21, 1994, were performed to determine spatial patterns of each species. These collections were performed only once so daily and seasonal patterns could not be estimated. Three distinct spatial patterns were noted. The first pattern, characterized by the emerald shiner, which was present in all collections and was the most abundant species in all samples (Figures 8 A and 9) averaging 87% of the catch per seine haul. A second pattern is characterized by white bass, yellow perch and the river darter. Each species in this second pattern was present in approximately 50% of the collections. Perch on average represented 1% of the catch (Table 5) over all of the collections (if samples without perch are included) to a maximum of 3%. Samples containing perch were separated by samples with no perch (Figure 8 B). The variance in catch of perch was lower than for all other species (Figure 9, Table 5) which resulted from several small groups being collected. In contrast to the perch only one large school of white bass was intercepted (Figure 8 C) which resulted in increased variance in catch. As with the perch, samples with white bass were separated by samples without bass (Figure 8 C). White bass accounted for up to 30% of seine haul catch but over all collections averaged only 5% of the catch (Table 5). The third species in this second spatial pattern was the river darter. River darters were found in five collections and in one, darters represented 17% (Table 5) of the catch (Figure 8 D). River darters were present in samples one, two, three, six and nine (Figure 8 D). Variation in catch of the river darter was higher than for perch (Table 5), as only one large group of darters was intercepted (Figure 8 D). The third pattern is characterized by the mottled sculpin, walleye and silver chub. Representatives of this third pattern were present in only one to two of the collections each. A single silver chub (Figure 8 E) in an otherwise small sample, and a single walleye (Figure 8 F) were found in samples two and nine respectively. The silver chub in sample two represented the first record from the East side of the South Basin of Lake Winnipeg. The single walleye represented 6% of the catch of sample nine. Mottled sculpin (Figure 8 G) represented 2.5% and 6% of the catch of the respective collections. The percent catch results for single individuals for these 9 collections are an artifact of small sample size.

Seasonal use of Nearshore Sandy Habitat:

Three species (emerald shiner, yellow perch and river darter) appeared in samples in early to late June. A gradual increase in species richness was seen as other taxa moved inshore in July (Table 6, Figure 10). By late July the community had stabilized to approximately 8 species (Table 6, Figure 10). A maximum number of 13 species was observed simultaneously using the near shore habitat during the day in the South Basin. Of the three collections with this maximum number of species, two were in late July and one was in late August. By late September species richness began to drop (Table 6, Figure 10). The increase in Simpson's index between early and late June (Table 6, Figure 11) was due to the increase in number of species (Table 6, Figure 11). Simpson's diversity index remained relatively stable throughout the summer and peaked in early August when several species were abundant in the nearshore habitat.

White bass were present in the near-shore habitat by early June (Figure 12 A). White bass YOY first appeared in collections on June 30th, (1994) in the South Basin. By mid to late August, YOY and yearling white bass were the most abundant fish (by number) in seine collections (Figure 12 A). The frequency of white bass in catches declined by mid-September.

The yellow perch had a similar pattern of seasonal beach use (Figure 12 B) to that of the white bass. Yellow perch abundance increased between early and late July collections due to the increase in YOY collected by the seine net. The abundance of perch peaked in early August and declined in late August and September.

Emerald shiners were present in samples throughout the summer (Figure 12 C). Emerald shiners were the dominant fish in early to late June (Figure 12) and in early to late September when white bass and yellow perch were uncommon. The apparent drop in abundance of emerald shiners in early August (Figure 12 C) was concurrent with the increase in number of YOY of white bass and yellow perch in seine collections.

Walleye, sauger, goldeye, mooneye and spottail shiner combined accounted for less than 20 percent of the fish in collections (Figure 12). Walleye appeared to show the same pattern of beach use as YOY yellow perch and white bass (Figure 12 E). Walleye increased in abundance in early July collections and again in early August. Walleye abundance peaked in late August.

In contrast to the other fish using the beach, sauger, goldeye, mooneye and spottail shiners appeared to have bimodal abundance patterns in these samples, being more abundant in spring and in early autumn (August and September) (Figures 12 D, F, G and H respectively). Gravid troutperch (Figure 13) appeared inshore from June to early July, and then disappeared presumably after spawning.

Most other species (Appendix V) were not collected consistently. Electrofishing of the gravel on the shoreline that the seine crossed, showed that benthic species (longnose dace, darters, sculpins and burbot) were abundant within the coarse substrate of the shoreline and were not present offshore on the sandy substrates.

Adult carp, channel catfish, burbot, white bass, perch, drum, walleye and sauger frequently hit the legs of the collectors as they escaped around the ends of the seine wings. As a result, these larger fish were poorly represented in collections.

Zooplankton:

Correspondence analysis of zooplankton samples showed no obvious trends in spatial pattern. Zooplankton samples were collected only in 1993 and were grouped by month as described for the fish. Ordination and cluster analysis of sample sites based on zooplankton composition showed no geographic patterns. The first three ordination axes for collection sites were displayed along with the ordination of zooplankton to show which zooplankters were responsible for the observed geographic similarities. The second and third ordination axes also help to determine those sites that were obscured in figures because of strong similarity (for example the closely grouped cluster in Figure 17 are separated in Figure 18). Cluster analysis also clarifies the members of closely spaced groups in the ordination plots since cluster analysis reduces the pattern observed in the ordination to one dimension. Sites from late July (Figures 14, 15 and 16), early August (Figures 17, 18 and 19) and late August (Figures 20, 21 and 22) that were grouped together consist of eastern and western locations (Figure 1, Appendix III) and did not sort by latitude.

Diet of Nearshore Fishes:

Emerald Shiner (*Notropis atherinoides*)

In early June, Emerald shiners formed three relatively distinct size groups (Figure 23). The diets of these size groups were summarized in Table 7. The fish in the smallest size group (23-36 mm. FL), fed on a combination of copepods and odonate nymphs. A bosminid cladoceran, dipteran larva and an adult homopteran were found as the only items in the stomachs of three individual fish (Table 7). The fish of the second size group (43-53 mm.) appear to have fed primarily on benthic items (Table 7). The diets of the largest size group (55-71 mm.) were much more varied (Table 7).

In late June, four size groups were subjectively defined at places on the length mass plot where only one fish is represented at a given length (Figure 24). The majority of fish in the first size group (19-32 mm.) fed primarily on zooplankton (Table 8), while some ate Diptera pupae, Diptera adults and adult Homoptera (Table 8). The majority of fishes in the second size group of emerald shiners (33-51 mm.) also fed on zooplankton (Table 8). The third size group (52-72 mm.) fed predominantly on zooplankton, Diptera pupae, Diptera larvae and adult Homoptera (Table 8). Larger emerald shiners (73-86 mm.) from late June, appeared to select larger items such as adult Hemiptera, Ephemeroptera nymphs, Diptera pupae, Diptera adults and adult Homoptera in comparison to smaller individuals. One large emerald shiner had eaten a larval white bass (Table 8).

In early July samples, only two size groups of emerald shiners were subjectively distinguished (Figure 25). The diets of these two groups were similar to early and late June diets for similar sized shiners (Table 9). Most smaller shiners (16-48 mm.) fed on zooplankton and Diptera pupae. The larger size group (49-72 mm.) ate similar prey as the smaller fish.

Few emerald shiners were caught in late July (Table 10). These fish were divided into two size groups (Figure 26). Again, emerald shiners from late July primarily ate zooplankton and Diptera pupae. Fish in the small group (31-47 mm.) ate zooplankton and insects whereas those in the larger group (56-70 mm.) ate insects alone (Table 10).

Early August emerald shiners were subjectively divided into two size groups (Figure 27). A high percentage of these early August fish had empty stomachs (Table 11). Those in the smaller size group (20-51 mm.) with food ate primarily copepods Diptera pupae (Table 11). Three small fish had eaten only leeches (Hirudinidae) (Table 11). The largest size group (53-67 mm.) contained only two fish that had eaten, taking only zooplankton (Table 11).

Fish collected in late August formed two weak size clusters (Figure 28) divided somewhat arbitrarily at 55-56 mm. fork length. The majority of the fishes in the smaller size group (18-55 mm.) fed on zooplankton (Table 12). Most of fish of the larger size group had insects in their stomachs (Table 12).

Emerald shiners from September appeared to fit into two size groups (Figure 29). Fifty percent of the small and 42% of the larger fish had empty stomachs (Table 13). The majority of fishes in the smaller size group (Table 13) fed on zooplankton. Only eleven fish in the smaller size group had taken insects (Table 13). There appeared to be a difference in diet preference between the smaller (21-44 mm.) and the larger size group (46-73 mm.). The majority of larger emerald shiners had eaten aquatic insects (Table 13). Only four larger emerald shiners had eaten zooplankton as compared to the 39 in the smaller size group.

White Bass (*Morone chrysops*)

White bass first appeared in late June samples. Only two large fish were collected in late June (Figure 30). Most of the white bass in the 22-47 mm. size group had taken zooplankton (Table 14). Four small fish had unidentified YOY fish in their stomachs. The two 252 mm. white bass had eaten percid, moronid and cyprinid fish (Table 14).

One large and 38 small white bass were collected in early July (the large bass being omitted from Figure 31). The large bass (365 mm.) had eaten a single fish which was unidentifiable (Table 15). The smaller bass (16-24 mm.) ate only zooplankton. Calanoid copepods and leptodorid cladocera were the dominant item in these small bass.

Only three bass were collected in late July (Figure 32). The only small (24 mm.) bass had taken calanoid copepods and unidentifiable cladocera (Table 16). The two larger bass (both 190 mm.) had taken fish and aquatic insects. One of the bass had only cyprinids in its stomach whereas the other had eaten Ephemeropteran nymphs, Diptera pupae and percid fish (Table 16).

Early August bass again fall into two size groups (Figure 33). The larger individual (196 mm. FL) was omitted from Figure 33 for clarity. The diet of the smaller size class (20-41 mm.) was variable. The majority of fish fed on calanoid copepods and leptodorid cladocera (Table 17) with cyprinid YOY and other unidentifiable fish taken by twenty bass (Table 17). The single large white bass (Table 17) had eaten only percid fish.

White bass collected in late August were divided into three groups (Table 18). The largest fish (255 mm. fork length) was omitted from Figure 34 for clarity. As for earlier samples, calanoid copepods and leptodorid cladocera were the most important food items (Table 18) of small white bass. Of the 67 small fish examined, only 8 had fish in their stomachs. The majority of fish in the second size group (54-77 mm.) also fed on calanoid copepods and cladocera (Table 18). Eight fish in this group had taken YOY cyprinids (Table 18). The largest white bass collected (255 mm.) had taken only cyprinids (Table 18).

No white bass were collected in September from Hillside Beach.

Yellow Perch (*Perca flavescens*)

Perch (48-63 mm. FL.) from early June were grouped together (Figure 35). As with the small white bass, perch stomachs contained primarily calanoid copepods and cladocera (Table 19) though others had ostracods and Diptera larvae.

Three size groups of perch were distinguished in late June samples (Figure 36). Most fish in the smaller size group (30-63 mm.) fed on calanoid copepods and leptodorid cladocera (Table 20). Fish eggs were the predominant item in stomach of one small individual. Larger perch (72-91 mm.) also appeared to take zooplankton with the majority of fish feeding on calanoid copepods and leptodorid cladocera (Table 20). The larger size perch (105-193 mm.) predominantly fed on calanoid copepods (Table 20) and to a lesser extent on leptodorid cladocera. Few perch (regardless of size group) had insects in their stomachs.

There were two size groups of perch in the early July samples (Figure 37). Most fish were in the small size group (21-76 mm.) and most had calanoid copepods in their stomachs (Table 21). Four small perch had eaten fish eggs (Table 21). The two larger perch (97 and 150 mm.) did not specialize on any one item (Table 21). Unidentifiable fish, Diptera larvae, ephemeropteran nymphs and calanoid copepods were found in the stomachs of both larger perch.

Only small perch were collected in late July (Figure 38). These fish had calanoid copepods in their stomachs (Table 22). Daphniid and bosminid cladocera and cyclopid copepods were found in a few stomachs. Only one of the fish in these late July collections had eaten Diptera pupae.

All yellow perch collected in early August were small individuals (Figure 39). As with the white bass and earlier collections of small perch, most fish fed on calanoid copepods (Table 23). Other items (smaller zooplankton, leptodorid cladocera and Diptera pupae) were taken by few fish and were rare in comparison with the calanoid copepods (Table 23).

Yellow perch from late August appear to fall into three size groups (Figure 40). The majority of fish in each size class fed on calanoid copepods (Table 24). Leptodorid cladocera were also found in many fish from each group. The only apparent difference in diet between the sizes of perch is the presence of insects in the stomachs of two of the larger fish (Table 24). One fish from the largest group (55-58 mm.) had taken primarily Diptera larvae.

Two size groups of perch were defined from September samples (Figure 41). The larger fishes all had empty stomachs (Table 25). Smaller perch (49-64 mm.) were entirely zooplanktivorous. Both of the smaller fish with stomach contents had taken bosminid cladocera, with one fish taking some daphniid cladocera and the other taking calanoid copepods (Table 25).

Sauger (*Stizostedion canadense*)

Saugers first appeared in late June collections. Three size groups were distinguished (Figure 42). All of the fish with stomach contents had eaten fish. The smallest size group (60-75 mm.) contained two saugers that had eaten percids and one that had eaten a white bass (Table 26). In the second size group (116-152 mm.) five fish had unidentifiable fish remains, four had eaten percids, two had white bass and another two saugers had eaten cyprinids (Table 26). Most saugers in the two larger size groups had unidentifiable fish in their stomachs. Insects were occasionally taken by saugers (Table 26).

The early July saugers were divided into three size classes (Figure 43). The single fish in the smallest size group had eaten only calanoid copepods (Table 27). One of the two saugers between 110 and 120 mm. had only cyprinid fish while the other had leptodorid cladocera and Ephemeroptera nymphs (Table 27). One of the three larger sized saugers had eaten a cyprinid fish, a second sauger had a percopsid fish while the third sauger had not eaten.

Only three saugers were collected in late July (Figure 44). The smallest (69 mm.) had eaten percid fish while the larger two (118-276 mm.) had unidentifiable fish remains in their stomachs (Table 28).

Four saugers (Figure 45) were collected in late August. All of these four had eaten fish. Three had percid fish and two had unidentifiable fish remains (Table 29).

No saugers were collected in September at Hillside Beach.

Walleye (*Stizostedion vitreum*)

As with the sauger, walleye first appeared in late June collections. Two size groups were defined from late June collections (Figure 46). Only one of the smaller walleye (41-48 mm. size group) had eaten (Table 30) and had taken only white bass. Two walleye in the larger size group (138-288 mm.) had unidentifiable fish remains in their stomachs, one had only percids in its stomach and four had eaten cyprinids (Table 30).

Walleye collected in early July were broken into two size groups (Figure 47). Seven of the smaller fish (34-47 mm.) had calanoid copepods in their stomachs. Two walleye had eaten fish (one with white bass and one with cyprinids) and one fish had eaten cladocera that were unidentifiable (Table 31). Four of the larger walleye (103-248 mm.) had eaten fish that were unidentifiable, one had eaten cyprinids and two contained Ephemeroptera nymphs. One walleye had almost exclusively eaten leptodorid cladocera (Table 31) and another had eaten Diptera pupae and calanoid copepods.

Two walleye (121-265 mm.) were collected in late August but both had empty stomachs.

No walleye were collected in September from Hillside Beach.

Goldeye (*Hiodon alosoides*)

Goldeye collected in late June were grouped into two size classes (Figure 48). The smaller size group (60-92 mm.) had a varied diet with bosminid and unidentifiable cladocera and Diptera larvae as the most important items (Table 32). Larger goldeye (116-142 mm.) did not appear to specialize on any one item (Table 32). Only Diptera larvae, Diptera pupae, Coleoptera adults and Hymenoptera adults were selected by more than one fish.

Goldeye were collected next in late August and were placed into one size group (Figure 49). Most of these fish had large items in their stomachs. Only two fish had eaten leptodorid cladocera (Table 33). Other goldeye had taken Ephemeroptera nymphs, Hymenoptera adults and Diptera pupae (Table 33).

No goldeye were collected in September.

Mooneye (*Hiodon tergisus*)

Mooneye from late June were divided into two groups (Figure 50). Like the goldeye, mooneye had a varied diet (Table 34). Eight fish were found with bosminid cladocera as the dominant food item while others had unidentifiable cladocera, Diptera larvae and Hymenoptera adults (Table 34). Larger mooneye fed on insects (Table 34). Hemiptera adults, odonate nymphs and Diptera larvae appeared to be the most important dietary items of larger mooneye (Table 34).

No mooneye were collected in July and early August samples.

The few mooneye collected in late August (Figure 51) were grouped together for diet analysis. Unlike the goldeye collected in late August, mooneye fed primarily on leptodorid cladocera (Table 35). The only insect taxon found in more than one stomach was adult Hymenoptera (Table 35).

No mooneye were collected in September.

Freshwater Drum (*Aplodinotus grunniens*)

All small drum (41-51 mm.) from late June (Figure 52) had fed immediately prior to collection (Table 36). Diptera larvae were found in all stomachs. Leptodorid and unidentifiable cladocera also appeared important, representing fifteen and 66% of the total contents of two individuals stomachs, respectively (Table 36). The two larger drum (159-180 mm.) collected had empty stomachs.

No drum were collected in July, August and September samples.

River Darter (*Percina shumardi*)

The only river darter collected in early June had an empty stomach.

River darters collected in late June were divided into two groups (Figure 53). The small individual (24 mm.) had only Diptera larvae in its stomach (Table 37). Diptera larvae were also the predominant item in the diets of large river darters (51-62 mm.)(Table 37). Fish eggs were eaten by three darters, as were Diptera pupae. Ephemeroptera nymphs and Trichoptera larvae were less abundant in river darter stomachs.

The four river darters from early July (47-55 mm.)(Figure 54) had similar diets as those from late June. Diptera larvae and fish eggs were the most important items (Table 38). Other items in decreasing order of importance included Ephemeroptera nymphs (in three fish), Diptera pupae (in 2 fish) and Trichoptera larvae in one fish (Table 38).

The single river darter collected in late July had eaten, Diptera larvae, Trichoptera larvae and fish fry (listed as unidentified in the summary table) (Table 39).

Eight river darters (Figure 55) were collected in late August. These fish were grouped together for analysis. Most of these fish had Trichoptera and Diptera larvae in their stomachs (Table 40). Only two fish had eaten zooplankton. In one of these zooplanktivorous fish, zooplankton was the dominant item (Table 40). Other insect taxa were found in three or fewer stomachs and were not abundant in any.

The single river darter (45 mm.) caught in September had only Trichoptera larvae in its stomach (Table 41).

Logperch (*Percina caprodes*)

The logperch collected in late June were grouped together (Figure 56). The diets of these logperch were similar to the river darters. Diptera larvae were found in ten logperch stomachs and were numerically dominant in each (Table 42). Diptera pupae were common in eight stomachs, Trichoptera larvae in two and Ephemeroptera nymphs were found in three stomachs (Table 42). Calanoid copepods, odonate nymphs, Coleoptera larvae and Lepidoptera larvae were each found in one stomach (Table 42).

Two logperch were collected in early July and were of similar size (Figure 57). One had unidentifiable copepods in its stomach and the other, had eaten Diptera larvae, Diptera pupae and fish eggs (Table 43).

No logperch were collected in late July.

Two small individuals were collected in early August (Figure 58). One fed primarily on calanoid copepods, with a few smaller cladocera (Table 44). The second ate Ephemeroptera nymphs and Trichoptera larvae (Table 44).

Six logperch were collected in late August which were placed into two size classes (Figure 59). Most fish in the smaller size group (29-41 mm.) had eaten Ephemeroptera nymphs, Diptera larvae and Diptera pupae. Of these three items, Diptera larvae were most abundant within each stomach (Table 45). One of the smaller logperch ate only calanoid copepods (Table 45). Ephemeroptera nymphs were the dominant item in one of the large logperch (Table 45). Both of the fish in the large size group had taken Trichoptera larvae and Diptera larvae.

Five logperch between 47-77 mm., were collected in September (Figure 60). All individuals had primarily eaten Diptera larvae (Table 46). Four fish had Trichoptera larvae and Diptera pupae (Table 46) and one individual had eaten Ephemeroptera nymphs.

Troutperch (*Percopsis omiscomaycus*)

Troutperch were first collected in late June and divide into two size groups (Figure 61). All troutperch from late June had mature gonads. Of the fish in the smaller size group (49-58 mm.), 58% had empty stomachs. The diet of each fish was restricted to few items and was dominated by a single item. Leptodorid and unidentifiable cladocera and Diptera larvae were in three stomachs each (Table 47). One individual had only ostracods and another, only an unidentified insect (Table 47). Forty seven of the larger troutperch (60-78 mm.) had empty stomachs. Those that had eaten however, also had a restricted diet, dominated by a single prey species. Diptera larvae were the dominant item in 28 fish, leptodorids in thirteen and unidentifiable cladocera in twelve (Table 47). Ephemeroptera were the dominant item in three troutperch. One troutperch had eaten only fish eggs (Table 47). Cyclopid copepods, Diptera pupae, Diptera adults and ostracods were rare in the diet in late June.

Troutperch from early July were grouped together (Figure 62). Forty percent of these troutperch had empty stomachs. Leptodorid cladocera were the dominant item in sixty stomachs. Unidentifiable cladocera and Diptera larvae were dominant in 41 and 31 stomachs respectively (Table 48). Diptera pupae were found in only three stomachs but were the dominant item in those individuals. Sidid cladocera, calanoid copepods, Ephemeroptera nymphs and Trichoptera larvae were uncommon dietary items, found in less than sixteen fish (Table 48).

Only one troutperch (62 mm.) was collected in late July (Table 49). This individual had only eaten Diptera larvae. No troutperch were taken in August and September.

Lake Cisco (*Coregonus artedi*)

Lake cisco were caught only in September. The two individuals collected had taken calanoid copepods (Table 50). Unidentifiable copepods comprised 28% of the contents of one of the stomachs.

Silver Chub (*Macrhybopsis storeriana*)

A single 59 mm. silver chub was collected at Hillside Beach in late August. Sixty seven percent of the stomach contents of this fish were Ephemeroptera nymphs and 33% were Diptera pupae (Table 51).

Mottled Sculpin (*Cottus bairdi*)

Two mottled sculpin (27 and 30 mm.) were collected from Hillside beach in late August. One had only Ephemeroptera nymphs in its stomach. Ostracods account for seventy one percent of the stomach contents of the other individual with the remaining 29% being Diptera larvae (Table 52).

Diet overlaps and guild structure:

Early June

For descriptive purposes, overlap in diet will arbitrarily be considered "moderate" between values of 50 and 74% and strong between 75 and 100%.

Analysis of diet overlap for early June shows that moderate overlap (66%) occurred between perch (48-63 mm.) and emerald shiners (43-53 mm.) (Table 53). Similarly, a moderate overlap (57%) occurred between small emerald shiners (23-36 mm.) and the largest emerald shiners (55-71 mm.)(Table 53). No estimate of overlap was possible between the river darter, which had an empty stomach, and other species. The similarity between these fish was paralleled in the results of the cluster analysis and correspondence analysis (Figures 63, 64 and 65). Cluster analysis and the ordination results were essentially identical to the results from Renkonen's index. In the cluster analysis, the fish size groups were widely dispersed (Figures 64 B and 65 B). The first ordination axis effectively separated the two groups defined in Figure 63. One group fed primarily on calanoid copepods and the other which had taken cyclopid copepods. Each size group of fish had unique dietary items, which explained the dense clusters of prey item labels for each predator category. These items included Diptera larvae and unidentified copepods in smallest emerald shiners, Diptera adults in the mid-sized emerald shiners, Daphniid and unidentifiable cladocera, cyprinids, Coleoptera adults, Hemiptera adults and Ephemeroptera nymphs in the largest emerald shiners (Table 7) and ostracods in yellow perch (Table 19).

Late June

Analysis of diet overlap for late June (Table 54) showed moderate overlap between 19-32 mm. emerald shiners and 33-51 mm. (62%) and 52-72 mm. (53%) emerald shiners. Moderate overlap (53%) also occurred between large emerald shiners (73-86 mm.) and 52-72 mm. emerald shiners. Small mooneye (42-79 mm.) had moderate overlap with 33-51 mm. (64%) and 52-72 mm. (51%) emerald shiners. Similarly, 52-72 mm. emerald shiners overlapped with 60-92 mm. goldeye (55%) and 116-142 mm. goldeye (54%). Large emerald shiners (73-86 mm.) had a moderate diet overlap with 30-63 mm. (73%), 72-91 mm. (70%) and 105-193 mm. (70%) yellow perch (Table 54).

Moderate diet overlap occurred between 49-58 mm. troutperch and 24 mm. river darters (67%), 51-62 mm. river darters (69%) and 58-100 mm. logperch (67%). The diet of 60-78 mm. troutperch also had moderate overlap with 24 mm. river darters (63%), 51-62 mm. river darters (64%) and 58-100 mm. logperch (64%). Moderate diet overlap (70%) occurred between 60-78 mm. troutperch and 41-51 mm. freshwater drum (Table 54).

Small sauger (60-75 mm.) had moderate diet overlap with 116 to 152 mm. sauger (56%) and 138-288 mm. walleye (51%). The diet of 138-288 mm. walleye had moderate overlap with 116 and 152 mm. (55%) and 216- 222 mm. sauger (58%). Moderate diet overlap (72%) occurred between 116-152 mm. and 216-22 mm. sauger (Table 54).

Strong diet overlap occurred between the two size groups of troutperch (89%). The diet of the freshwater drum strongly overlapped (75%) with 49-58 mm. troutperch, 24 mm. (90%) and 51-62 mm. (86%) river darters and with logperch (87%)(Table 54). Strong diet overlap occurred between 30-63 mm. and 72-91 mm. (92%) perch, 30-63 mm. and 105-193 mm. perch (88%) and 72-91 mm. and 105-193 mm. perch (96%). Strong overlap also occurred between 24 mm. river darters and 51-62 mm. river darters (86%), 24 mm. river darters and 58-100 mm. logperch (87%) and between 51-62 mm. river darters and 58-100 mm. logperch (95%).

The diet of 24-47 mm. white bass overlapped moderately with the 73-86 mm. emerald shiners (70%), and strongly overlapped 30-63 mm. (90%), 72-91 mm. (97%) and 105-193 mm. (98%) yellow perch (Table 54).

The diet of large white bass overlapped moderately with both size groups of walleye and the 60-75 mm. size group of saugers, all being 50% (Table 54).

Cluster analysis defined 4 major groups (Figure 66). The first two groups (from here on subjectively linked) were piscivores, which included all sizes of walleye, sauger and all large white bass. This group segregated along the first ordination axis (Figure 67) since they were the only species that ate fish. A second large weakly defined group consisted of all goldeye, mooneye, river darters, freshwater drum, and troutperch (Figure 66). Fish in this group primarily ate bosminid cladocera and aquatic insects (Figures 67 and 68). The third group contained three species, small white bass, yellow perch and all sizes of emerald shiners (Figure 66). These fish primarily ate calanoid and unidentifiable copepods and leptodorid, daphniid and sidid cladocera (Figures 67 and 68).

Early July

Moderate diet overlap occurred between 47-55 mm. river darters and 79-82 mm. logperch (58%), 97-150 mm. yellow perch (65%), and with 365 mm. white bass (50%) (Table 55). Moderate overlap also occurred between the two size groups of walleye (62%) and between 103-248 mm. walleye and 50-89 mm. troutperch (53%). Small yellow perch (21-76 mm.) had moderate overlap with 24-48 mm. emerald shiners (50%) (Table 55). Large yellow perch (97-150 mm.) had moderate overlap with 365 mm. white bass (53%). Moderate diet overlap also occurred between the two size groups of emerald shiner (54%) and between 24-48 mm. emerald shiner and 16-24 mm. white bass (59%)(Table 55).

Strong overlap occurred between 34-47 mm. walleye and 50-89 mm. troutperch (75%). Small (21-76 mm.) yellow perch overlapped strongly with 39 mm. sauger (93%), 49-72 mm. emerald shiner (75%), and 16-24 mm. white bass (80%)(Table 55). Small white bass (16-24 mm.) also had strong dietary overlap with 39 mm. sauger (76%) and 49-72 mm. emerald shiners (85%). Small sauger (39 mm.) had a strong dietary overlap (71%) with 49-72 mm. emerald shiners (Table 55).

As for late June, there were four groups defined by cluster analysis (Figure 69). The first two contained the larger walleye, sauger and troutperch (Figure 69). Large saugers were separated from the first group since they were the only fish that ate percopsid fish (Table 27). Large walleye, troutperch and 110-120 mm. sauger, formed a group because they all ate leptodorid cladocera and Ephemeroptera (Tables 27, 48 and 31)(Figures 70 and 71). Troutperch were the only fish that ate sidid cladocera (Table 48).

Small walleye, small sauger, both size groups of emerald shiners, small perch and small white bass formed a third well defined group (Figure 69). These fish primarily ate calanoid copepods and other zooplankton (Figures 70 and 71). Large white bass, large perch, river darters and logperch formed the last group (Figure 69). The three species in this group primarily took Trichoptera larvae, Diptera larvae and unidentified fish (in many cases eggs) (Figures 70 and 71).

Late July

Only one moderate and one strong overlap in diet occurred between fishes caught in late July (Table 56). Most fish showed no overlap in diet. Troutperch (62 mm.) and 54 mm. river darters had a moderate (62%) diet overlap. White bass (24 mm.) overlapped strongly (96%) with 37 mm. yellow perch (Table 56). Cluster analysis (Figure 72) and the ordination (Figure 73) defined three feeding groups. White bass (24 mm.) and 37 mm. yellow perch were closely linked and were grouped with emerald shiners (Figure 72) based on zooplankton in their diets (Figure 73 and 74). Large emerald shiners were only distantly related to the zooplanktivorous group because they predominantly fed on aquatic insects (Table 10) with few fish taking calanoid copepods. Troutperch and river darters were grouped together (Figures 72 and 74) based on the presence of Diptera larvae in their diets. Large white bass and saugers were grouped together (Figures 73 and 74) because of the cyprinids and percids in their diet.

Early August

Only three strong dietary overlaps occurred in the samples from early August (Table 57) which grouped these three fishes closely in the cluster analysis (Figure 75). Logperch and yellow perch had a strong overlap (78%) because of calanoid copepods and unidentifiable cladocera in their stomachs. Logperch and white bass also had a strong overlap (78%)(Table 57) because of the shared presence of calanoid copepods, Ephemeroptera nymphs, Trichoptera larvae and unidentifiable cladocera in their diets (Figures 76 and 77). Perch and small white bass had the strongest overlap (98%) (Table 57) because they shared six dietary items (calanoid and cyclopid copepods, daphniid, leptodorid and unidentifiable cladocera and Diptera pupae)(Figures 76 and 77). The closely linked bass and perch were also grouped with the smallest emerald shiners (Figure 75) because of the shared presence daphniid and leptodorid cladocera, calanoid copepods and Diptera pupae in their diets (Figures 76 and 77).

Late August

Strong dietary overlap occurred between 32-43 mm. and 45-54 mm. (82%) and between the 45-54 mm. and 55-58 mm. (82%) yellow perch (Table 58). The smallest (32-43 mm.) perch and the 55-58 mm. perch had a moderate overlap (72%). Strong overlap also occurred between 54-77 mm. white bass and 45-54 mm. yellow perch (82%) and between the 22-51 mm. white bass and all three size groups of yellow perch (32-43 mm.)(96%), (45-54 mm.)(84%) and (55-58 mm.)(75%) (Table 58). Moderate overlaps occurred between 22-51 mm. and 54-77 mm. white bass (74%) and between 54-77 mm. white bass and 32-43 mm. (71%) and 55-58 mm. (66%) yellow perch. This group containing yellow perch and the two smaller size groups of white bass were also closely linked in the cluster analysis results (Figure 78). Within the darters, moderate overlap occurred between the 29-41 mm. logperch and the river darters (74%)(Table 58, Figure 78). A strong overlap occurred between the single silver chub and goldeye (80%) (Figure 78). Other notable overlaps occurred between the two size groups of emerald shiners and between the two groups of logperch, between the large logperch and mottled sculpin, and between mooneye and both sizes of emerald shiner (Table 58). Cluster analysis defined a group containing mooneye, goldeye and both sizes of yellow perch (Figure 78). Correspondence analysis results were also similar to Renkonen's index and cluster analysis. The first two axes separated piscivorous fish (sauger and the large white bass) from the other fish (Figure 79). Axes 3 and 4 separated the remaining fishes (Figures 80 and 81). The piscivorous species were grouped at the center of the ordination in Figure 81. Sauger were weakly linked with the small white bass because of the cyprinid and unidentifiable fishes found in some of the small white bass (Table 18). The white bass-yellow perch cluster was strongly influenced by calanoid copepods and unidentified cladocera (Figure 81). River darters, logperch and sculpin were influenced by Diptera larvae and Trichoptera larvae (Figure 81). The mooneye, goldeye and emerald shiner group was weakly defined but fishes in this group primarily ate insects (Diptera pupae and adults, Hemiptera, Ephemeroptera, aphids, Hymenoptera adults and Coleoptera adults) and leptodorid cladocera (Figure 81).

September

No strong or moderate diet overlaps occurred between fishes collected in September (Table 59). Cisco and yellow perch and the two size groups of emerald shiner overlapped the greatest (Table 59). Cluster analysis defined three basic groups (Figure 82). Logperch and river darters formed a group based on Diptera and Trichoptera larvae (Figures 83 and 84). The two emerald shiner groups were closely linked (Figure 82) because of their insectivorous diet (Figures 83 and 84). Cisco and yellow perch were grouped because of the zooplankton in their stomachs (Figures 83 and 84). A single 35 mm. spottail shiner, a 91 mm. white bass and three 77-80 mm. yellow perch were collected in September but all had empty stomachs.

Manley's Alpha Preference Index for Zooplanktivorous Species:

The three Hillside Beach collections where dietary and environmental data were collected were July 30th, August 12th and August 16th, 1993. The three fish that primarily ate zooplankton were emerald shiners (Table 60), yellow perch (Table 61) and white bass (Table 62). The diet of emerald shiners from 1993 suggested a strong preference for daphniid cladocera early (0.8261) and again later (0.9504) in the summer. Later in the season, emerald shiners also showed a strong preference (1.000) for leptodorid cladocera and emerald shiners showed a strong preference for calanoid copepods in all three samples (0.8804, 1.000 and 0.6129 respectively)(Table 60). One emerald shiner in the late July sample took bosminid cladocera over other available items (Table 60).

Perch and white bass appeared to consistently select calanoid copepods over other items (Tables 61 and 62). Few perch or bass in the samples took other zooplankton and these other zooplankton were not strongly selected (Tables 61 and 62). Thirty four white bass from August 12th and 33 white bass from August 16th had taken leptodorid cladocera. These leptodorids were not as strongly selected (0.3789, 0.1552) as were calanoid copepods (0.8837, 0.8868) in relation to presence in the environment.

Information on White Bass spawning in Lake Winnipeg:

Spawning of white bass has never been observed in the tributaries of Lake Winnipeg. On June 3, 1993, R. Januz (personal communication) noted ripe female bass (though not running eggs) in a pool of the lower Icelandic River. Adult white bass were collected downstream of Wood Falls on the Manigotagan River on June 16th 1992. The gonads of these fish were not fully developed suggesting that they had not spawned. Male white bass that were running milt and ripe females were angled from the Winnipeg River approximately 2 km. West of Pine Falls, on June 25, 1995 by K. W. Stewart. I found no evidence of adult white bass moving inshore to spawn in shallow water along the beaches of Lake Winnipeg.

DISCUSSION

Sampling Methods:

Most rivers and beach sites of Lake Winnipeg were sampled repeatedly within each year. Exceptions to this sampling scheme include rivers on the Northeast side of the lake and the Fisher River that, because of accessibility and time constraint, were sampled only once. Faunal description of these rivers is tentative. Most sites from the South Basin of the lake were sampled several times each year. More sites were accessible in the South Basin which increased the resolution of fish distributions. The frequency of most fishes in nearshore samples allows a high degree of confidence in the distribution described for each species from seine and electrofishing samples. Few additional fish are obtained by sampling offshore (Clady and Nielsen 1978). As mentioned previously, larger fish are poorly represented in seine collections and since few gill net samples were made in the lake, the species distributions for the lake are based on smaller individuals. The invading rainbow smelt are most often collected from gill net knots and again, since few gill net sets were made in this survey, no rainbow smelt were collected. The distributional data set collected in this survey provides a baseline for future faunal comparison.

Fish Distributions:

The two basic ways in which the Hudson Bay drainage receives invading species are by natural connection with adjacent drainage systems with subsequent exchange of biota and by anthropogenic additions of biota, both intentional and accidental. The results of the survey of Lake Winnipeg suggest that invading fishes enter the lake from two southern sources. There was no evidence of fish invasion from northern rivers into Lake Winnipeg. The first invasion route is from downstream dispersal in the Red River and the second, from downstream dispersal in the Winnipeg River. The survey data do not allow the discrimination of entry route for fishes that were found in both the Red and Winnipeg Rivers. Recent invaders such as the brown bullhead, golden redhorse and black crappie may have entered the lake from one or both riverine sources. The bigmouth buffalo and the golden redhorse are natural dispersal from the United States. The white crappie and spotfin shiner probably entered Manitoba by downstream dispersal in the Red River. The recently discovered presence of the golden redhorse above the hydroelectric dam at Pine Falls (Winnipeg River) suggests that either (1) this species has been in Manitoba longer than previously thought (Franzin *et al.* 1986) (2) has used both recent routes of invasion or (3) was introduced by man above the Pine Falls dam. The apparent increase of the golden redhorse and bigmouth buffalo probably is due to increased collecting effort in recent years

The distribution of fishes in the Lake Winnipeg system fit into four categories, 1) fishes found throughout Lake Winnipeg, 2) those found in the Red River and the South Basin of the lake, 3) those found in tributaries that only rarely use the lake and 4) those restricted to headwaters that never enter the lake. Fishes that have the first distribution pattern are tolerant of turbid lacustrine environments. These fish are found throughout the lake in open water. Lake whitefish, cisco, goldeye, mooneye, sauger, walleye are examples of native fishes that are found throughout the lake. Those invading fish that are tolerant of turbidity, such as the rainbow smelt, white bass, and bigmouth buffalo, are able to spread from their riverine source throughout Lake Winnipeg. The two fish in the second distributional pattern are the silver chub and the river shiner. These two species are common in the Red River but are rare in Lake Winnipeg. The northern extreme of the known range of both species is the Narrows of Lake Winnipeg. Fish with the third distributional pattern, such as black crappie and the golden, weed and mimic shiners, are most commonly collected in clear water but use the lake to "stream hop" between the tributaries along the eastern shore. These fish were able to cross to the West side of the lake at the narrows and are found in the Icelandic and Fisher Rivers. The western side of Lake Winnipeg has only 4 substantial tributaries (as compared with the 11 tributaries of the East side) and as a result does not appear to be as effective an avenue for dispersal of riverine fish. Blackside darter, hornyhead chub, common shiner and stonecat (McCulloch 1994) are found in the southern-most tributaries entering Lake Winnipeg. These four fish, are not found in northern tributaries, but must have used the lake to attain their present range. Other fish such as the carp, tadpole madtom, channel catfish and bullheads are tolerant of turbidity but are more commonly found in the tributaries of the lake. Their distribution probably reflects selection of low energy environments upstream of river mouths. The faunal composition of the lower reaches of tributaries is well known because of intensive collections, with several different gear types, in all rivers except the Mantago and Fisher Rivers. The use of several different collecting methods helps overcome the bias imposed by each method (Weaver *et al.* 1993) and the combined data set provides a relatively complete faunal representation. Fishes in the fourth distribution category include species such as the lake chub, creek chub, pearl dace, rosyface, sand and spotfin shiners and northern brook lamprey. These riverine fish were not found in Lake Winnipeg, despite extensive sampling around the mouth of the rivers in this survey. Survey collections focused on the lower reaches of the tributaries entering the lake, downstream of the first waterfalls. Few of these waterfalls restrict fish dispersal. The sampling of headwaters of rivers North of the Icelandic River on the West side and North of the Manigotagan River on the East side, was beyond the scope of this survey. The distributions of headwater fishes in these northern tributaries are poorly known as a result of the limited sampling. Because of extensive sampling independent of this survey, the headwater fish faunas of southern rivers are well known (McCulloch and Franzin 1996, Koel and Peterka 1994, Stewart *et al.* 1985, Scott and Crossman 1973, and unpublished data).

Distribution of White Bass:

White bass in Manitoba were first detected in the South Basin of Lake Winnipeg in 1963 (Scott and Crossman 1973). They were previously known in the Red River system from the Sheyenne River in North Dakota (Owen *et al.* 1981). Exploratory gill net collections between 1948 and 1951 did not detect white bass in the South Basin of Lake Winnipeg (Hewson 1957). White bass probably dispersed downstream to Lake Winnipeg in the mid- to late 1950's or early 1960's. White bass must have remained rare in the lake after colonization as no report of white bass was made from gill net collections in the summer of 1972 (Davidoff 1973).

White bass have increased in abundance in the Red River and Lake Winnipeg since 1972 (Stewart and Lindsey 1983). White bass regularly appear in gill net collections in the Red River above the St. Andrews Dam at Lockport (University of Manitoba student collections) and are found in lower portions of the Assiniboine River, West to the town of Headingley (S. Cahill, 1995 personal communication). White bass also appear to use the fish ladder at the Lockport Dam (J. Willis, 1994 personal communication) and are abundant in the Red River delta (J. Tyson, 1991 personal communication).

Recent collections of YOY white bass from both North and South Basins and the commercial fishery in the South Basin of Lake Winnipeg (A. Kristofferson, 1995 personal communication) suggest that white bass are now very common. Single 7.5 m. seine samples, in this survey, have collected up to 40 adults and up to 1100 YOY and or yearling white bass. In many collections in Lake Winnipeg, YOY and yearling white bass were more abundant than the dominant percid, the yellow perch and cyprinid, the emerald shiner. A similar pattern of invasion and dominance was noted for white perch (*Morone americana*) in portions of the Great Lakes (Johnson and Evans 1990). Johnson and Evans (1990) noted that the invasion and domination of communities by white perch was correlated with the local decline of predator species (walleye). White bass were collected at all near shore sites throughout the South Basin of Lake Winnipeg. White bass also were taken from the Red River, the Icelandic River, the Winnipeg River to Pine Falls, the Manigotagan River below Wood Falls and at the mouth of the Black River all of which enter the South Basin of Lake Winnipeg.

The survey collections made along North Basin shorelines and tributaries show the white bass is present but is still comparatively rare, compared with similar South Basin sites. In the North Basin, white bass were taken in and around the Pigeon, Berens, Poplar and Mukutawa (Big Black) Rivers. White bass taken from northern sites include YOY and yearling individuals indicating white bass young can survive in the North Basin of Lake Winnipeg. The known distribution of white bass in the North Basin reflects sampling effort around tributaries as there are few sites accessible by road. No white bass were collected from the survey of the shorelines and tributaries of the western portion of the North Basin of Lake Winnipeg. Anecdotal reports of white bass from the commercial fishery around the Nelson River are unsubstantiated. Extensive gill net collections North of Lake Winnipeg in Playgreen Lake have failed to recover adult white bass (J. Tyson, 1995 personal communication). White bass were seen ascending the Fairford Dam fish ladder which opens into Portage Bay, Lake Manitoba (W. Lysack, 1993 personal communication). Access to the Fairford Dam is via the Dauphin River, Lake St. Martin and then the Fairford River which suggests that white bass, while absent from current collections, are present on the West side of the lake.

The second recently invading species with lake-wide distribution is the rainbow smelt (*Osmerus mordax*). Rainbow smelt were first documented in Lake Winnipeg in 1990 but may have been present since 1975 (Campbell *et al.* 1991) and have only recently been recovered in commercial nets with increasing frequency (K. W. Stewart unpublished data). The effect of the smelt on Lake Winnipeg is not known.

Abundance Trends by Latitude:

The discussion of latitudinal trends in abundance of lacustrine fishes is limited by the limited sampling in the North Basin of the lake. Emerald and spottail shiners and yellow perch, appear evenly distributed between the two basins of Lake Winnipeg. Since these three small pelagic fish are susceptible to seine collection (Weaver *et al.* 1993) the results are a close approximation of latitudinal trends for these species. White bass in contrast are more abundant in the South Basin and are rarely collected in the North Basin. In the South Basin of Lake Winnipeg, white bass rival yellow perch as the second most abundant fish in the nearshore environments of Lake Winnipeg. The distribution and abundance described for white bass is probably more accurate than for walleye, sauger, mooneye and goldeye since the YOY bass remain in shallow water throughout the summer and, like shiners and perch, are susceptible to seine nets. The trend observed in the abundance of the white bass suggests that it is well established in the South Basin and is currently invading the North Basin. Anecdotal evidence suggests that the white bass is on the West side of the lake at least to the Dauphin River. White bass probably used the Dauphin River, Lake St. Martin and the Fairford River to reach the Fairford Dam at Lake Manitoba. Most of the white bass collected in the North Basin were YOY and yearlings, indicating that white bass have not reached their physiological northern limit in the lake. The northern limit is governed by the length of growing season and the ability of young to store energy for their first winter (Shuter and Post 1990).

The latitudinal abundance trends for walleye, sauger, goldeye and mooneye are identical to that of white bass from beach seine samples but the known distributions of these fish (Heuring 1993, Remnant 1991, Davidoff 1978, Hagen 1978, Kennedy and Sprules 1967) suggest that they are present, but were poorly represented in the limited sampling of the North Basin. In addition, the abundance of walleye, sauger, goldeye and mooneye in northern collections is probably underestimated due to their ability to evade the seine net (Neilsen and Johnson 1989). Gill net samples perhaps would overcome some of the size bias imposed by the seine net (Weaver *et al.* 1993) for these four pelagic species. The presence of the goldeye, mooneye, walleye and sauger in the South Basin shows that they are found in the presence of the white bass. The current survey represents a short time interval and since there are no comparable collections from previous years, no assessment of abundance trends is possible from before the introduction of white bass.

Spatial pattern and seasonal Use of Beach:

The sequential samples along Hillside Beach suggest that in Lake Winnipeg, white bass and yellow perch form discrete schools in the nearshore environment. Yellow perch and white bass were present in some collections, separated by samples where they were absent, suggesting that perch and white bass are contagiously distributed along the beach. These data for Hillside Beach support findings for other lakes, that the white bass and perch are schooling fish (Cahn 1927). The presence of white bass and perch in the same collections (Figures 8 B and C) and observations of mixed schools of YOY along the Hnausa pier, suggest that they are not mutually exclusive. Emerald shiners were found in all collections. The distribution of river darters in sequential samples along the beach suggests contagious distribution along the shoreline. Because of seine selectivity, little confidence is placed on the spatial distribution of benthic species (darters and sculpin) and of larger fish such as walleye and sauger. The last sample (Figure 8 F) contained a single walleye. This sample terminated at a rock breakwater, which probably prevented its escape.

Emerald shiners are the first fish to move inshore in April as determined from a sample at McEhleran Creek in 1993. At Hillside Beach, yellow perch, emerald shiners and river darters were found inshore in early June. Yearling white bass appear inshore in late June. Young-of-the-year white bass were first collected in early to late July and both yearling and YOY remained near shore till early September. Most other species consistently were present within monthly periods. Multiple samples were taken for each monthly period which increased confidence in the observed seasonal patterns of beach use. Data used for determination of seasonal patterns were primarily from 1994, with only three samples from 1993. Estimation of yearly variation was not possible beyond comparison of the three samples from 1993 and those from 1994. Since samples from other South Basin sites from different times of the day confound spatial and temporal patterns, examination of seasonal trends in fish presence focused on samples from Hillside Beach. Some South Basin samples from 1993 confirm the seasonal trends observed at Hillside Beach. Estimation of diel periodicity of use of the nearshore habitat also was not possible due to the lack of early morning and late evening samples. The seasonal presence of white bass with other pelagic fish at Hillside Beach and at other South Basin sites suggests that there is a potential for interaction between these species for habitat and for prey. The only species that did not remain in the nearshore environment throughout the summer were the troutperch, cisco and lake whitefish. Troutperch were present only in late June to early July. A similar pattern of seasonal troutperch presence near shore was noted by Knight *et al.* (1984) in lake Erie. Juvenile cisco and lake whitefish were found sporadically in the summer of 1993 but only collected in September of 1994. Cisco were found inshore in large schools in September of 1991 at Hillside Beach. This seasonal inshore movement of cisco and whitefish matches description of spawning aggregations observed in other lakes in Canada (Scott and Crossman 1973) though these fish collected at Hillside Beach were not mature.

Zooplankton:

Patalas and Salki (1992) state that the zooplankton community of Lake Winnipeg has changed little in forty years except for the increase in abundance in the South Basin due to cultural eutrophication. The three most abundant copepods, that account for about 80% of the fauna of Lake Winnipeg, are *Diacyclops bicuspidatus*, *Acanthocyclops vernalis* and *Diaptomus ashlandi*. Differences in the zooplankton fauna occur in the plume of tributaries that enter the lake (Patalas 1981, Patalas and Salki 1992). Zooplankton are most abundant in July in the South Basin and numbers decline steadily toward October (Patalas and Salki 1992).

Zooplankton often are contagiously distributed within a lake (Balcer *et al.* 1984). Zooplankton collections in this survey were towed for the same length as for the seine hauls to minimize bias in catch due contagious plankton distribution. The Wisconsin net was held away from the body to minimize disturbance due to walking while sampling. Samples also were slowly raised to the surface, while walking inshore to collect the entire water column of the nearshore area sampled. The speed of sampling probably minimized escape of "fast" species such as *Leptodora* (Balcer *et al.* 1984).

The results of the analysis of the zooplankton data suggests that there is no geographic pattern in the nearshore zooplankton composition of the South Basin of Lake Winnipeg. The samples taken in 1993 were dominated by bosminid cladocera and cyclopid copepods with leptodorid (*Leptodora*), daphniid (*Daphnia*) and sidid (*Diaphanosoma*) cladocera and calanoid copepods fairly scarce. The zooplankton collected in 1993 represent the core species for the pelagic zone of the lake as defined by Patalas (1981). The relative rarity of the larger species may be due to the fact that daphniid and leptodorid cladocera and calanoid copepods lie near the bottom during the day (Balcer *et al.* 1984) and move up into the water column at night. *Bosmina* sp. and *Diaphanosoma* sp. are found near the surface in the day (Balcer *et al.* 1984) but of these two, only *Bosmina* sp. were common in collections. The rarity of the larger zooplankton such as sidid, daphniid and leptodorid cladocera and calanoid copepods suggests that the fishes of Lake Winnipeg are selecting for larger prey and not for the more abundant bosminid cladocera and cyclopid copepods. These results of the current collections confirm the observations of Patalas (1981), that the offshore lacustrine zooplankton fauna of Lake Winnipeg is, as with the fish fauna, homogeneous and dominated by a few species. For discussion of fish feeding habits I will assume that the zooplankton composition is homogeneous throughout the South Basin of Lake Winnipeg at the ordinal and familial level.

Diets, Guild Structure and Dietary Overlap:

The diet analysis suffers from the same collecting bias as described for the seine hauls and distributional data set. The weakness of the diet data set is in the small numbers of some fish species examined. Specimens examined from samples from additional sites in the South Basin confirm that fish diets are consistent with observations at Hillside Beach. The simple enumeration of stomach contents imposes a bias, overestimating the importance of smaller items and underestimating the importance of large items. While enumeration does not estimate biomass of prey ingested (Glenn and Ward 1968), it does limit bias due to differing digestive state of items. Many items were identified from hollow exoskeletons or in the case of vertebrates, from diagnostic bones. These well digested items will not provide an accurate estimate of the food value of prey. The other advantage of simple enumeration of stomach contents is that examination of many specimens is possible (Glenn and Ward 1968).

These diet data confirm that each fish species in Lake Winnipeg takes similar food as described for conspecifics in other Canadian populations (Scott and Crossman 1973). A seasonal shift in prey use also is seen in the diets with fish taking progressively larger prey as they grow. No estimate of diel feeding periodicity is possible since most collections were taken in the mid-morning and late afternoon. Additional work is required to examine daily feeding patterns of Lake Winnipeg fishes. The fish examined were divided into size categories instead of by age group. Size, while correlated with age, is more important in determining prey selection by fish (Gerking 1994). Grouping fish by size rather than age allowed more fish to be examined because since no time is spent processing and reading age structures. A separate study is required to examine age structure and growth rates of Lake Winnipeg fish.

Feeding guilds, while subjective, are defined as groups of organisms that use common resources in a similar manner (Root 1967). The discussion of guild structure is limited to fish and does not include other taxa (for example piscivorous insect larvae, garter snakes, terns and gulls) which may fit into the defined guilds. Therefore, the guilds discussed here are most appropriately defined as taxonomic guilds following Jaksic (1981) since fish are only a subset of possible members for each guild. The observed guild structure may be a result of fish responding opportunistically to changing resource availability (Jaksic 1981), combined with gaps in resource availability and or morphological limitations of consumer species (Pianka 1980). Guild boundaries and overlaps within guilds are also related to the taxonomic level to which prey items are identified (Hansen *et al.* 1986, Schoener 1974). In addition, trophic structure is complicated by ontogenetic diet shifts (Tonn *et al.* 1986). Since fish often take resources opportunistically, the defined groups are not absolute and are meant to provide basic classification based on the most common dietary items.

The inshore fishes of Lake Winnipeg appear to divide into three or four basic feeding guilds, a pelagic zooplanktivorous group, a pelagic insectivorous group, a benthic insectivorous group, and a pelagic piscivorous group. The pelagic insectivores include the emerald shiner, goldeye and mooneye. Matthews (1986) found that emerald shiners are more abundant inshore during the day. The diets of emerald shiners were highly variable and diverse. Scott and Crossman (1973) state that the diet of emerald shiners includes zooplankton (calanoid copepods, leptodorid and daphniid cladocera) and to a lesser extent aquatic insects (chironomid larvae). Emerald shiners examined from Lake Winnipeg are either grouped with the pelagic zooplanktivores or with surface feeding insectivores such as the goldeye or mooneye (Kennedy and Sprules 1967). Young-of-the-year goldeye primarily ate calanoid copepods, daphniid cladocera and Diptera larvae as found by Donald and Kooyman (1977) and Nelson (1980). Post-larval goldeye ate more daphniid cladocera, Hemiptera and aerial insects, again like those examined from the Peace-Athabasca River delta by Donald and Kooyman (1977). Young-of-the-year goldeye selected five daphniid species whereas older fish took only the two larger daphniids suggesting size selective predation. Yearling and older goldeye ate Hemiptera and a variety of terrestrial and aquatic insects (adult chironomids, Coleoptera and Trichoptera) (Donald and Kooyman 1977). Scott and Crossman (1973) describe a similar diet for the mooneye. Goldeye apparently take food in relation to abundance (Donald and Kooyman 1977). Scott and Crossman (1973) state that goldeye and mooneye would only compete with other surface feeding insectivorous fishes. Scott and Crossman (1973) also state that competition among individuals is minimized by turbid water. At Hillside Beach, goldeye and mooneye were collected in late June and late August samples. In the June samples, the two *Hiodon* species were weakly grouped with the benthic feeding fish such as darters and freshwater drum based on their use of aquatic insect larvae. Morphological differences in feeding structures probably separate the pelagic surface feeding goldeye and mooneye from the benthic species (Schoener 1974), minimizing interspecific competition. Contrary to the studies cited in Scott and Crossman (1973), larger emerald shiners in late July form a descrete pelagic insectivorous feeding guild. In early August, the larger emerald shiners also were separated from other species because they fed almost exclusively on leptodorid cladocera. In late August, all emerald shiners, the single silver chub specimen and the two *Hiodon* species were loosely linked by the presence of leptodorid cladocera, and aerial and aquatic insects, in their diets. All emerald shiners collected in September fed primarily on leptodorid cladocera and larval and adult insects and were the only members of the insectivorous feeding guild this late in the season. Goldeye, mooneye and emerald shiners appear to follow and feed on the most abundant prey items (Scott and Crossman 1973). The abundance of zooplankton (Sale 1974) and water turbidity (Scott and Crossman 1973) probably minimizes interaction between species. In this study, large emerald shiners appeared more opportunistic in that they switched between insects and zooplankton regardless of the presence of potential competitors. Gillen and Hart (1980) found that minnows feed on common resources when those resources are abundant and appear to specialize as resources diminish. Hansen *et al.* (1986) found that the maximum diet breadth coincided with the greatest prey abundance, with diet shifts paralleling seasonal shifts in prey abundance. Similarly, Zaret and Rand (1971) found that resource partitioning in a tropical community coincided with low resource availability. While they conclude that competition structured the resource separation in tropical systems, I believe the varied diets and opportunistic use of abundant resources cause the observed shifts in resource use in Lake Winnipeg. Gaps between species diets may result from preference, prey size specificity imposed by morphological limits, and from shifts in prey availability.

The common benthic fishes include the river darter, the logperch, troutperch, freshwater drum, mottled and slimy sculpin, burbot and longnose dace. The diet of benthic species appeared consistent between size groups with most fish taking Ephemeroptera nymphs, Trichoptera larvae and Diptera larvae and pupae. The diet of the troutperch includes insect larvae (Diptera larvae and Ephemeroptera) and larger troutperch take some small fish (Scott and Crossman 1973). Similarly, adult logperch feed on insect larvae, primarily Diptera and Ephemeroptera while young logperch eat more Cladocera and copepods (Scott and Crossman 1973). Keast and Webb (1966) state that logperch eat primarily Diptera larvae, amphipods, isopods, odonate (Anisoptera) nymphs and Ephemeroptera nymphs, using their nose to root out concealed prey from the substrate. No analyses of river darter diets are known for Canadian populations (Scott and Crossman 1973). The results of this survey substantiate the description in Scott and Crossman (1973) and Thomas (1970 *in* Becker 1983) that the river darter is primarily insectivorous (Diptera and Trichoptera) with young individuals taking copepods and Cladocera. Young freshwater drum eat zooplankton and Diptera larvae (Scott and Crossman 1973) and as fish grow, aquatic insect larvae become more important prey items. Larger freshwater drum eat fish (darters and emerald shiners) and crayfish (Daiber 1952). Gastropods and bivalves are believed to be more important items in the diet of riverine drum (Scott and Crossman 1973). Adult drum were not collected at Hillside Beach. Young-of-the-year drum were collected in late June. These few drum had eaten primarily Diptera larvae. The only sculpins collected by seine at Hillside Beach were mottled sculpins in late August samples. These fish had eaten ostracods and Diptera larvae. Sculpins are also known to take Ephemeroptera and Plecoptera nymphs, Trichoptera larvae, crayfish, small fish and fish eggs (Scott and Crossman 1973).

Burbot, longnose dace and slimy sculpins were not collected by seine at Hillside Beach. Their inclusion in the benthic community follows survey collections of the South Basin of the lake, where these species were electrofished from the coarse substrate along the shore. Small burbot, longnose dace and slimy sculpin, as with the benthic species collected at Hillside Beach, are primarily insectivorous (Gee and Northcote 1963, Gerald 1966, Scott and Crossman 1973, Gibbons and Gee 1972, McCulloch 1994). Prey selection by longnose dace depends on prey abundance and availability (Gerald 1966). Burbot shift to a diet of crayfish, molluscs and fish as they mature. Adult burbot opportunistically take a wide variety of available fish, fish eggs and insect larvae with larger individuals taking fish almost exclusively (Scott and Crossman 1973).

Sympatric darter species selected the most abundant prey items (Todd and Stewart 1985). The diets of the benthic fishes of Lake Winnipeg also appear to converge on few items such as Trichoptera and Diptera larvae, Diptera pupae, Ephemeroptera nymphs, and appear also to include fish eggs and larval fish when present. The observed overlap in these benthic species may again be an artifact of diets that are convergent on the most abundant items, as is seen in darter populations (Hlohowskij and White 1983, Wynes and Wissing 1982). Unlike benthic stream populations, the benthic fish fauna of Lake Winnipeg is found along the shoreline in a thin band of coarse substrate that shifts with wave action, and also around permanent man-made breakwaters. There appears to be little opportunity for spatial segregation along this narrow stretch of suitable substrate. In studies of benthic stream populations, species segregate spatially between substrate type and current velocity (Hlohowskij and Wissing 1986, Gibbons and Gee 1972, Englert and Seghers 1983) and temporally based on spawning habits (Wynes and Wissing 1982). In addition, Hlohowskij and Wissing (1986) found that two darter species segregated by use of coarse substrate, with the fantail darter commonly found within interstitial spaces and the greenside darter on the upper surfaces of rocks. A similar spatial segregation may occur in the Lake Winnipeg benthic community. Since longnose dace, sculpin and burbot are rarely collected by seines, they may, like the fantail darter, prefer to inhabit the interstitial spaces in the shoreline substrate. In contrast, troutperch, logperch and river darter are fairly regularly collected by seining, suggesting that they prefer to live on the upper surface of rocks. Logperch in Lake Winnipeg live above the substrate and pick organisms from under the small rocks along the shoreline (personal observation). The morphology of the head and body of benthic fishes also is a possible segregating factor (Hlohowskij and Wissing 1986, Scholsser and Toth 1984). Species such as logperch, longnose dace and river darter, with acutely pointed noses would be able to exploit food items from crevices that are unavailable to blunt-headed species such as burbot and sculpin. If segregation of diet and habitat use occurs within the benthic community of Lake Winnipeg, it is beyond the resolution of this survey. More detailed examination of the benthic fishes is required.

Interactions of White Bass in Lake Winnipeg:

Early lists of the fishes of the Hudson Bay drainage (Bisset 1927, Bajkov 1928) included the white bass (as *Roccus chrysops*) but did not list any localities or museum specimens. The first detailed publication of the fishes of Manitoba (Hinks 1943) and the subsequent publications by Keleher (1952) and Keleher and Kooyman (1957) did not include white bass.

As described above, white bass are abundant in the South Basin of Lake Winnipeg. The increase in abundance of the white bass in the South Basin of the lake is too rapid to be attributed to any climatic change since the limnology of the lake has changed little in the last 60 years (Brunskill *et al.* 1980). The only changes in lake Winnipeg are a result of cultural eutrophication of the South Basin (Brunskill *et al.* 1980) which resulted in increased abundance of zooplankton prey (Patalas and Salki 1992). Similar rapid increases in abundance of white bass following initial colonization are noted for Lakes Francis Case and Oahe in North and South Dakota (Walburg 1977, June 1976).

The latitudinal trends in abundance for the other two common pelagic species, the emerald shiner and yellow perch, do not match that of the white bass in Lake Winnipeg. Emerald shiners and yellow perch appear equally abundant in both basins of the lake. If white bass were adversely affecting the pelagic fish community, then the abundance of yellow perch and emerald shiner (potential competitors as juveniles and prey items for adult bass) would be expected to be lower in the South Basin of the lake in the presence of bass than in the North Basin where white bass are relatively rare. The presence of cisco, lake whitefish (Scott and Crossman 1973), walleye, sauger, goldeye (Davidoff 1978, Hagen 1978, Kennedy and Sprules 1967), mooneye and the invading rainbow smelt (Franzin *et al.* 1994 and unpublished data) in both basins of Lake Winnipeg indicates that their range has neither shifted northward, nor is there evidence of South-North trends in abundance of any pelagic species in the presence of white bass.

Shuter and Post (1990) define a critical thermal threshold for winter survival of YOY fish. The length of the winter dormant period and associated starvation, limits the northern distribution of a species (Johnson and Evans 1990). The distribution of pelagic fishes throughout Lake Winnipeg and the presence of yearling white bass in the North Basin suggests that the critical thermal threshold for these species lies further North.

The thermal stability of Lake Winnipeg prevents evaluation of temperature change and the lacustrine ichthyofauna. Should predictions of climatic warming prove true, simulations (Magnuson *et al.* 1990, Shuter and Post 1990) suggest that cool and warm water species will expand their range northward in response to the increase in available thermal habitat. This expansion would be facilitated by the increased length of the growing season, increased growth (Hill and Magnuson 1990) with the increased survivability of YOY fish (Johnson and Evans 1990, Shuter and Post 1990, Johnson and Evans 1991). Warmer climate would also facilitate earlier spawning of fish, thereby increasing the length of the growing season for YOY fish. If an increase in survival of warm water fishes occurred, the resultant increase in fish density would amplify any ecological interactions between fishes (Hill and Magnuson 1990). The range of cold water adapted species is expected to retreat northward with increasing lake temperature (Meisner 1990). Of the fishes in Lake Winnipeg, the whitefish and cisco (defined as cool water stenothermic species) (Hokanson 1977) would be expected to show a retreat northward in a climate warming event. The other fish in Lake Winnipeg fall within Hokanson's (1977) temperate meso- and eurythermal categories and would probably disperse northward should the climate warm.

Invasions of exotic fish into freshwater systems threaten native species and community stability (Prout *et al.* 1990). The success of a species entering a community with little or no competition for abundant resources is not influenced by its pattern of resource use (Sale 1974). The interaction among species therefore would not tend to reduce overlap in resource use and overlap would be greater than if competition had influenced the establishment of the community (Sale 1974). Since there is no evidence of either a northward shift in the distribution, or shift in habitat use of fishes, in the presence of the invading white bass, then the white bass and the native ichthyofauna must coexist with minimal interaction. Species segregation usually occurs by habitat (Werner *et al.* 1977) with species diversity within a lake being related to habitat heterogeneity (Eadie and Keast 1984). Schoener (1974) also states that resource partitioning usually occurs spatially, with trophic and temporal segregation being more rare. The uniform sandy shorelines of Lake Winnipeg on coarse inspection, have only 1) pelagic offshore, 2) pelagic inshore and 3) sediment water interface (benthic) habitats. The benthic habitat sediment grades from sand offshore to coarse gravel inshore. Aquatic macrophyte beds are usually restricted to tributaries because of the turbidity of the lake. The sparse rocky habitat in the South Basin is almost entirely man-made, consisting of harbors and rock breakwaters. The offshore community was not sampled in this survey of the lake. The examination of the diet of Lake Winnipeg fish focused on representatives from the inshore benthic and pelagic community at Hillside Beach. The common inshore pelagic fishes include white bass, emerald shiner, yellow perch, walleye, sauger, lake whitefish, cisco, goldeye and mooneye. The benthic fishes commonly include longnose dace, mottled and slimy sculpin, river, Iowa and johnny darters, troutperch, burbot and logperch. Species found in the same habitat generally segregate by food (Schoener 1974). The zooplankton of Lake Winnipeg were eaten by most fishes at some ontogenetic stage. Predation on zooplankton is limited by gape (Schael *et al.* 1991), gill raker spacing, the attack of the zooplanktivore and the evasive capabilities of the prey (Wankowski 1979, O'Brien 1979). The diets of larval fish vary less in prey species composition when compared to other ontogenetic stages of a species (Gerking 1994). The small gape of the larval fish limits potential prey items to smaller phyto- and zooplankton (Gerking 1994). In general there is a progression in diet from small to larger items as predators grow, but fish rarely take the largest items that they are capable of ingesting (Schael *et al.* 1991). Beyond the first year, fish in Lake Winnipeg begin to include larger items such as insects and larval and juvenile fish. The dependence of the YOY of several fish species on zooplankton suggests that competition for plankton would be great. Intense competition within diverse communities is believed to cause segregation of resources between predators (Schoener 1974) and as consumer species accumulate, resources will be further subdivided to minimize overlap.

White bass belong in two of the four basic feeding guilds. Young white bass are included in the pelagic zooplanktivorous group and adults are pelagic piscivores. Competition is believed to be highest between individuals and or species within a guild rather than between guilds (Pianka 1980). Adult and juvenile fish tend to segregate by trophic structure and habitat in complex systems (Moyle and Vondracek 1985) with each species using a portion of the available resources (Sale 1974). When several species live in sympatry, the amount of overlap in resource use is a measure of similarity not necessarily implying competition among species (Sale 1974). When resources are not limiting, resource use may overlap to any degree (Sale 1974).

White bass are schooling (Cahn 1927, McNaught and Hassler 1961) visual predators (Greene 1962). According to Devine and Shiozawa (1984) activity of small white bass peaks in mid- to late afternoon. Wissing (1969) found that feeding peaks were completed by sunset and that feeding does not occur till the next morning. Completely evacuated stomachs were found 6-8 hours after sunset (Wissing 1969). Feeding by white bass may be limited by a critical minimum light level in the evening or when fish reach satiation (Wissing 1969). Sequential samples at Hillside beach suggests that individual schools of young white bass occur in the turbid water along the beaches of Lake Winnipeg. Juvenile white bass initially fed on copepod nauplii in Lake Oahe, South Dakota (Nelson 1980). As the white bass approach 5 mm. in length, they switch to cyclopid copepods and then to calanoid copepods (Nelson 1980). Matthews *et al.* (1992) found that juvenile white bass ate copepods, Diptera larvae (chironomids), corixids and larval fish. Cladocera also are taken when abundant (Griswold and Tubb 1977). Cladocera are relatively unimportant item in the diet of Lake Oahe white bass (Nelson 1980). Insects are taken less often than crustaceans (Bonn 1952) probably relating to encounter rate in the water column rather than preference. Wissing (1969) states that small white bass are not usually size selective, instead they feed on the most abundant zooplankton. Contrary to Wissing (1969), white bass collected early in the season from Lake Winnipeg fed primarily on calanoid copepods, not on the smaller more abundant bosminind cladocera or cyclopid copepods. Larval fish become increasingly important in the diet of small white bass later in the season. The results of the diet analysis of white bass follow other populations where the diet shifts to include larval fish as juveniles grow (Michaletz *et al.* 1987). An exception to size related predation was noted by Bonn (1952) where white bass up to 12 cm. continued to feed on copepods. There was no indication of any shift in zooplankton preference throughout the season as small white bass continually selected the large calanoid copepods over other zooplankton in daytime samples. Michaletz *et al.* (1987) also found that white bass and yellow perch preyed heavily on calanoid copepods despite the evasive abilities of the copepods and the ability of gill rakers to trap smaller items. The white bass in Lake Francis Case, South Dakota, appeared not to select the largest items, favoring more abundant, slightly smaller prey (Michaletz *et al.* 1987).

Like white bass, yellow perch in Lake Winnipeg move inshore in June and remain there till late in the summer. Yellow perch were the dominant pelagic fish in Lake Mendota, Wisconsin, in June and moved inshore later in the summer (Post *et al.* 1995). The pelagic larval phase of yellow perch is believed to be a response to heavy predation in the littoral zone (Whiteside *et al.* 1985). As in Lake Winnipeg, Whiteside *et al.* (1985) found that perch move inshore once they reach 25 mm. in length. Keast and Welsh (1968) found that perch feed at dawn and dusk with pronounced inshore feeding migrations. In Lake Oahe, yellow perch showed a similar pattern of dietary preference to white bass but began to take calanoid copepods at 7 mm.. By 14 mm. both perch and white bass take calanoid copepods over other items (Nelson 1980). Daphniid cladocera do not become important in the diet of perch till they reached 20 mm. in length (Nelson 1980). Whiteside *et al.* (1985) found that perch initially fed on copepods and their diet diversified to include Cladocera, insect larvae, ostracods and amphipods as the fish grew. Michaletz *et al.* (1987) also found that yellow perch switch from a diet of leptodorid and daphniid Cladocera and calanoid copepods to piscivory later in their first season. Prout *et al.* (1990) found that perch fed on the most abundant zooplankton in Oneida Lake, which may not be the largest prey item available (Mills *et al.* 1984). Larger perch from the Great Lakes feed on leptodorid cladocera, copepods, Diptera larvae and emerald shiners (Griswold and Tubb 1977). The strong diet overlap of white bass and yellow perch relates to their shared use of the nearshore habitat, the composition of the zooplankton community, visual prey detection and temporal similarity of mouth morphology (Michaletz *et al.* 1987). Interestingly, moronid bass are able to take 2-12 times as much food as perch, in a given time interval, because of their stomach morphology (Prout *et al.* 1990). White bass and yellow perch are most likely to compete if resources become limited (Michaletz *et al.* 1987).

Small emerald shiners show some degree of overlap in diet with white bass and yellow perch, but emerald shiner diets appear to be more variable. In late June samples, the diet of larger emerald shiners appeared to be similar to that of perch and white bass based on the zooplankton in their diets. All emerald shiners from early July and small emerald shiners from late July and early August ate similar items as the small perch and white bass. Larger emerald shiners ate more insects and either formed a distinct feeding guild or were grouped with goldeye and mooneye as described below.

The diet of YOY walleye primarily includes Cladocera, copepods, ostracods and insect larvae (Raney and Lachner 1942) but switch to fish at 60-70 mm. (Swanson and Ward 1988, Braekevelt *et al.* 1989). Sauger and walleye YOY from Lake Oahe, South Dakota, primarily ate cyclopid copepods and Diptera larvae (Nelson 1980) and appear to take larger prey as they grow (Swanson and Ward 1988, Vandenbyllaardt *et al.* 1991). Fish fry were selected by sauger and walleye larger than 10 mm. (Nelson 1980). Shifts in prey from copepods to fish as predators grow probably fits optimal foraging models as gape size increases (Crowder 1985, Gerking 1994). There does not appear to be significant inshore interaction between small white bass, small sauger and small walleye since few of the latter two species were found inshore in summer. Raney and Lachner (1942) found that schools of YOY walleye move offshore as summer progressed. In addition, Devine and Shiozawa (1984) found that walleye are more common inshore in the evening and during the night in other lakes. Since walleye are active in turbid water throughout the day (Vandenbyllaardt *et al.* 1991) I attribute the low catch either to absence from the nearshore habitat as described by Raney and Lachner (1942) or their ability to escape from the relatively slow seine net.

Small cisco (*Coregonus artedi*) are almost exclusively planktivorous (Cahn 1927, Nelson and Hassler 1942), though some individuals take molluscs, insect larvae and fish. Cisco apparently move offshore shortly after hatching and remain there. Few cisco and lake whitefish were collected at Hillside Beach and in the survey of the South Basin of the lake. The planktivorous cisco and lake whitefish appear to be remain offshore during the summer when the young white bass and perch are inshore. The cisco collected in September 1993 at Hillside Beach all had calanoid copepods in their stomachs. Similarly, cisco from other sites around the lake had primarily eaten calanoid copepods. A single large uncataloged collection of cisco was taken at Hillside Beach in 1991 in late September, suggesting that they move inshore late in the open-water season and while the diets of white bass and cisco are similar, seasonal use of the near-shore environment minimizes interaction between these two species.

The adult white bass currently is the only epipelagic piscivore in the South Basin of Lake Winnipeg. Adults do not appear to use nearshore habitats (Cahn 1927) though one feeding school of 40 individuals was collected nearshore in the shelter of man-made harbor at Balsam Bay in survey samples. According to Matthews (1986) adult white bass move inshore in the evening and are able to avoid nets during the day, possibly explaining their absence in my samples. Similarly, large walleye are more common inshore in the evening and during the night in other lakes (Devine and Shiozawa 1984). Walleye often are the dominant piscivore in North-temperate lakes (Lyons and Magnuson 1987). Perch, sauger, walleye and white bass shift from zooplankton to fish as they mature, with the shift being well defined in all but perch. Large perch often take zooplankton, aquatic insects and fish, adding complexity to trophic interactions. Large white bass are primarily piscivorous (Cahn 1927, Gasaway 1970 and Nelson and Hasler 1942), taking emerald shiners, perch and occasionally aquatic insects. Emerald shiners, cisco and perch are the most common fish in the diets of walleye in Lake Winnipeg (Remnant 1991, Hagan 1978) and other lakes (Gasaway 1970, Parsons 1971, Raney and Lachner 1942 and Knight *et al.* 1984). Juvenile and older sauger also are piscivores with pelagic fishes being the most common item (Parsons 1971, Wahl and Nielsen 1985). As for the white bass, walleye and sauger occasionally take aquatic insects (Raney and Lachner 1942, Knight *et al.* 1984, Wahl and Nielsen 1985). Contrary to these and other diet analyses, Hagen (1978) found that small and juvenile walleye fed heavily on aquatic insect larvae when abundant and to a lesser extent on fish. Walleye, sauger and white bass are described as opportunists (Raney and Lachner 1942, Knight *et al.* 1984, Hagen 1978) and take advantage of the most abundant food items. This selection of the most abundant items is discussed by Knight *et al.* (1984) as a factor reducing cannibalism. Perch are the only spiny rayed fish to be consistently eaten by Lake Winnipeg piscivores, perhaps as a result of the fusiform shape of the perch relative to the laterally compressed, deep bodied freshwater drum and white bass. Selection of perch relates to morphological limitations of the predator (Parsons 1971, Gerking 1994) and the availability of prey. Walleye are known to shift their diets in favor of YOY perch when available in early summer (Parsons 1971, Lyons 1987). In Lake Winnipeg, juvenile and adult white bass, walleye and sauger feed primarily on yellow perch and emerald shiners throughout the summer. The similarity of diet and nearshore habitat use suggests that a potential for interaction exists between adult white bass, sauger and walleye. Competition between these three species probably is minimal as prey species (yellow perch and emerald shiners) are extremely abundant.

When offshore, the white bass is a surface feeding fish (McNaught and Hassler 1961) which serves to segregate adult bass in the water column from the sauger and walleye which school near the bottom in turbid lakes (Scott and Crossman 1973). Baker and Ross (1981) considered segregation by depth to be significant in structuring shallow stream communities.

Adult yellow perch were not common in nearshore habitats of Lake Winnipeg. Sandheinrich and Hubert (1984) found that adult perch were more abundant in 5-10 m. depths in areas with no vegetation, in Lake West Okoboji, Iowa. The fishes in Lake West Okoboji appeared to segregate by habitat not by diet (Sandheinrich and Hubert 1984). Yellow perch are more opportunistic than walleye and saugers (Knight *et al.* 1984) feeding on smaller perch, shiners, aquatic insects and zooplankton. The opportunistic nature of perch also is believed to limit competition between perch and other piscivorous percids (Knight *et al.* 1984). Knight *et al.* (1984) found that the diets of different size groups of perch overlapped to the greatest extent in spring when fish were consuming insects and zooplankton. Overlap was reduced later in the summer as larger perch focused on small shiners and perch. Large yellow perch in Lake Winnipeg continue to feed on zooplankton and also take larger items such as insects and fish. As described previously for the insectivorous group, shifts in resource partitioning of piscivores occurred because of the variability in fish taxa eaten and the dynamic aspect of prey abundance within preferred habitat. Size of prey also may be important since predator growth is related to size of prey ingested (Wankowski 1979). When offshore, fish appear to segregate by position in the water column (Baker and Ross 1981) and perhaps to a lesser extent by prey size selection. The vertical distribution of fish in offshore pelagic zone of Lake Winnipeg is not known. I found no dietary segregation when piscivores were inshore. Competition appears minimal between piscivores since the most abundant prey items are selected when inshore.

The success of the white bass is in part due to their use of the two most abundant food resources in Lake Winnipeg, calanoid copepods by young fish and the emerald shiners and yellow perch by adults. The success of the white bass also may be due to their growth and morphology. The white bass grows rapidly and is deep bodied with stout fin spines. Once white bass reach 20 cm. in length, they are effectively free from predation, except by the commercial fishery. Size-limited predation and slow growth is known to limit recruitment (Parsons 1971) but once large enough, fish are relatively invulnerable to predation (Colby *et al.* 1987). The only piscivore large enough to eat adult white bass is the northern pike. Northern pike are rare in the turbid nearshore and offshore habitats of Lake Winnipeg. Only one individual was collected in September 1991 from Hillside Beach, another from Beaconia Beach, July 30th, 1993 and another, offshore near the Saskatchewan River, June 10th, 1992. The addition of a piscivore that is relatively free from predation can change the forage fish community. White bass, large perch, walleye and sauger preferentially feed on emerald shiners and yellow perch because they are the most abundant forage fish in the lake (Hagen 1978). Similar prey selection is noted for piscivores in the Great Lakes (Raney and Lachner 1942, Knight *et al.* 1984). Should white bass become so numerous that the adults reduce recruitment of young perch and emerald shiners, piscivores may switch to alternate prey species as the preferred prey population declines (Lyons and Magnuson 1987). This increased pressure on other less abundant forage fish may adversely effect the whole community by increasing predation on common benthic species (Lyons and Magnuson 1987) such as darters, troutperch, small burbot and the three sculpin species.

In contrast to the white bass, the invading rainbow smelt (Campbell *et al.* 1991, Franzin *et al.* 1994) is a smaller more slender species and is susceptible to predation by most walleye and sauger in the lake (Remnant 1991) and by white bass. The rainbow smelt has been recovered only recently in commercial nets with increasing frequency (unpublished data). Like the white bass, the smelt is considered an opportunist (Evans and Loftus 1987), taking food from throughout the water column from a seemingly unlimited supply (Remnant 1991). Young-of-the-year and yearling smelt eat zooplankton and may interact with small walleye, cisco and whitefish (Remnant 1991) in the offshore pelagic habitat.

The environmental factors that facilitate the expansion of white bass also favor similar expansion of another warm water species. The range of the bigmouth buffalo appears to be expanding into the South Basin of Lake Winnipeg (Hanke and Stewart 1994). Like white bass, young bigmouth buffalo feed on zooplankton and as they mature switch to aquatic insects and molluscs (Johnson 1963). Bigmouth buffalo, like the white bass, are relatively free from predation after their first year since they grow too large to be eaten by walleye and sauger.

Observations of White Bass Spawning:

Currently white bass appear to spawn in late June to mid-July based on angling reports from tributaries of Lake Winnipeg. Spawning for white bass in lower reaches of tributaries of Lake Oahe occurred in mid- May to mid- June when water was 15°C to 17°C (Nelson 1980). Sexually mature white bass appear to congregate down stream of impassable water falls or in pools of smaller rivers in early June (R. Januz, 1994 personal communication). No evidence is found for white bass using lake shores as spawning shoals in place of rivers. White bass spawn in roughly 1 to 2 meters of water over firm substrates (Riggs 1955). Eggs are scattered in the water column and sink, where they adhere to the substrate (Riggs 1955). White bass shed roughly half of their ova during the spawning period (Ruelle 1977). Water temperature of the tributaries sampled in late June to July were between 15.5°C and 22.9°C, which matches literature records for spawning thresholds for southern populations (Becker 1983, Nelson 1980). Climatic warming would allow spawning earlier in the season as water temperatures would increase earlier in the spring. This would have two results, an increase in survival of eggs of warm water species and an extended growing season for YOY fish (Shuter and Post 1990). Larger YOY fish would be better able to survive their first winter (Johnson and Evans 1990). Differences in white bass abundance noted between 1993 and 1994 collections may be due to a high mortality rate of YOY that winter. Similar variability between years is noted for white bass in South Dakota (Gasaway 1970) and is attributed to winter mortality. Larval white bass are pelagic (Becker 1983) and are found inshore. Since white bass spawn later than perch (Becker 1983), overlap in larval use of the pelagic zone is minimized (Prout *et al.* 1990) but white bass are inshore when larval perch move into the shallows (Whiteside *et al.* 1985).

CONCLUSIONS

1) The ichthyofauna of Lake Winnipeg shows a North-South gradation of species composition (primarily of benthic and riverine species) between the Red River and the two basins of the lake, though the fauna is homogeneous within each basin (Hanke and Stewart 1994).

2) There are no major barriers to dispersal between the Red River and Lake Winnipeg. The ultimate northern limit to the distribution of a species therefore, is the ability of YOY to store reserves to survive the first winter period of dormancy (Shuter and Post (1990). Of the species that have entered the lake, white bass (*Morone chrysops*) are the most mobile and are now found in both basins. The lack of northern limit to the distribution of this species in Lake Winnipeg suggest that the critical thermal threshold for the young of these warm water fish is further North in the Nelson River.

3) There does not appear to be a decline in abundance or reduction of the range of pelagic species in the presence of white bass. In addition, there does not appear to be any habitat segregation of the nearshore environment of Lake Winnipeg in the presence of white bass.

4) Fish in Lake Winnipeg appear to be opportunistic feeders. Diets of most species vary throughout the summer. These dietary shifts may reflect seasonal and or local changes in prey availability. Young of the year and yearling white bass have similar diet to small yellow perch, young emerald shiners, young walleye and sauger and both species of whitefish. The observed overlap in diet is a result of the different species diets converging on the most abundant resources with little or no apparent competition for the abundant zooplankton. Elrod *et al.* (1981, in Prout *et al.* 1990) suggests that diet of white

perch is related more to availability rather than selectivity. A similar pattern is seen for Lake Winnipeg fishes where many fish feed on few prey taxa.

5) Adult white bass are epipelagic piscivores and eat primarily emerald shiners and yellow perch. Sauger and walleye also take these two abundant forage species but are found near the bottom of the lake. The vertical segregation and selection of the most abundant prey items by bass, walleye and sauger minimizes any potential for competition.

6) The analysis of feeding groups from late August shows four feeding guilds in the near-shore habitat of Lake Winnipeg. These include pelagic insectivores, pelagic piscivores, pelagic zooplanktivores and benthic insectivores. Juvenile white bass are pelagic zooplanktivores and adult white bass are pelagic piscivores. These categories, while subjective, provide a convenient framework for discussion of feeding relationships within the community. Within each of the feeding groups that contain white bass, there is strong interspecies diet overlap. In addition, the fishes in the same feeding guilds as white bass are distributed throughout the lake with no apparent northward shift range or habitat use. There appears to be no adverse effect on the diet, range and habitat use of the native fish community of Lake Winnipeg following the introduction of white bass.

7) The abundance of adequate nearshore habitat for young fish, the spatial segregation of adult bass, turbid water and abundant food resources probably minimized potential competitive interactions between native fish species and the invading white bass. The success of the white bass also is due to fast growth rate, deep body and stout spines which limits predation risk to all but the smallest white bass. Once white bass mature, their only effective predator is man. The white bass, like the stonecat (McCulloch 1994), appears to have established itself in the Hudson Bay drainage and become very abundant with minimal effects on the native fauna. The establishment and success of the white bass also may be related to the decline of walleye and sauger stocks

due to over fishing with resultant reduction of predators of the YOY and yearling bass (Prout *et al.* 1990).

8) The addition of a predator that is relatively free from predation can change the trophic structure of a community. The abundant white bass may affect the recruitment of prey species. Reduction of abundant prey species may force other piscivores, such as walleye and sauger, to switch from perch and emerald shiners to benthic species. The increased pressure on benthic species may adversely affect the whole community.

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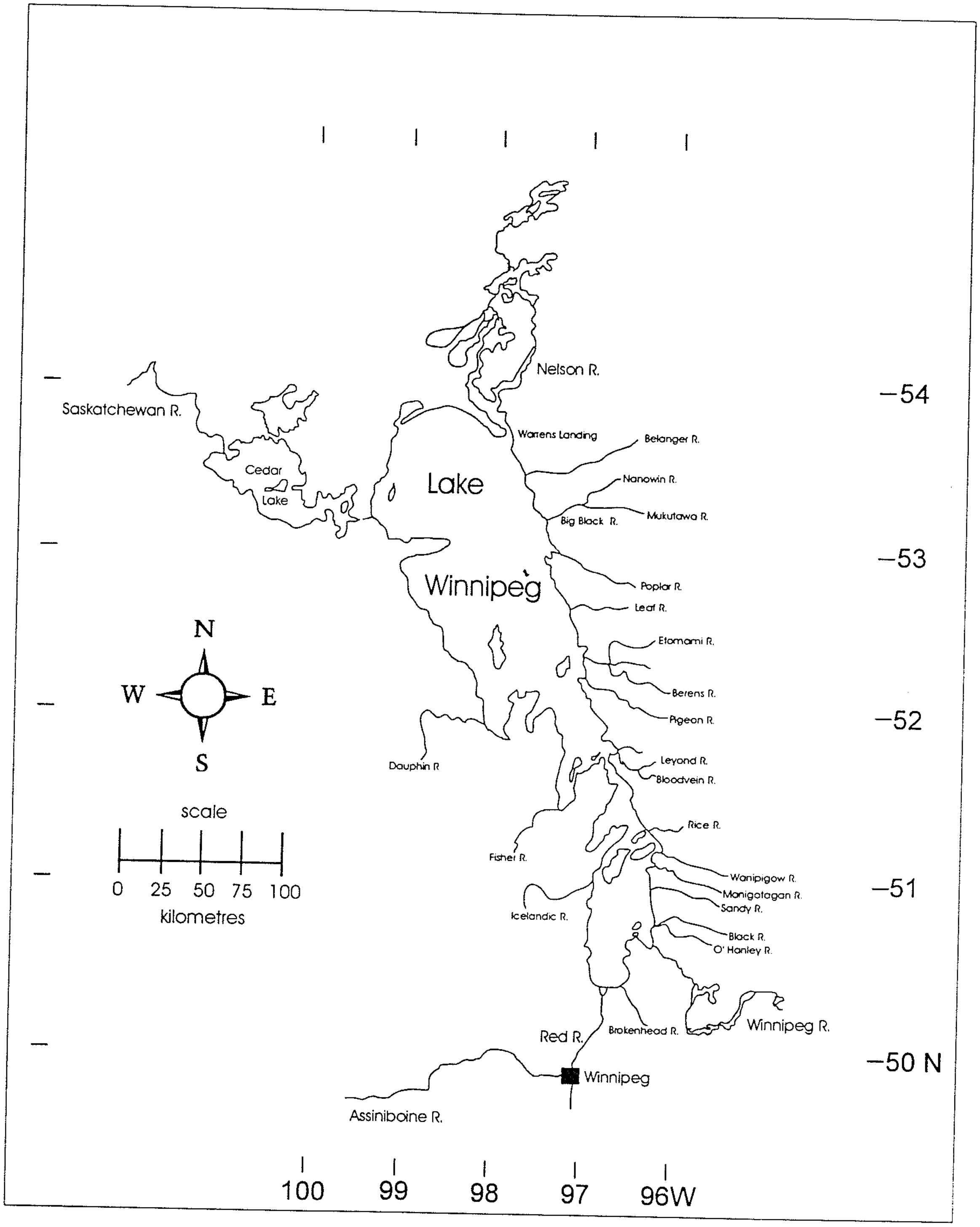


Figure 1. Lake Winnipeg and associated tributaries, size of print indicates importance of each river to the lake.

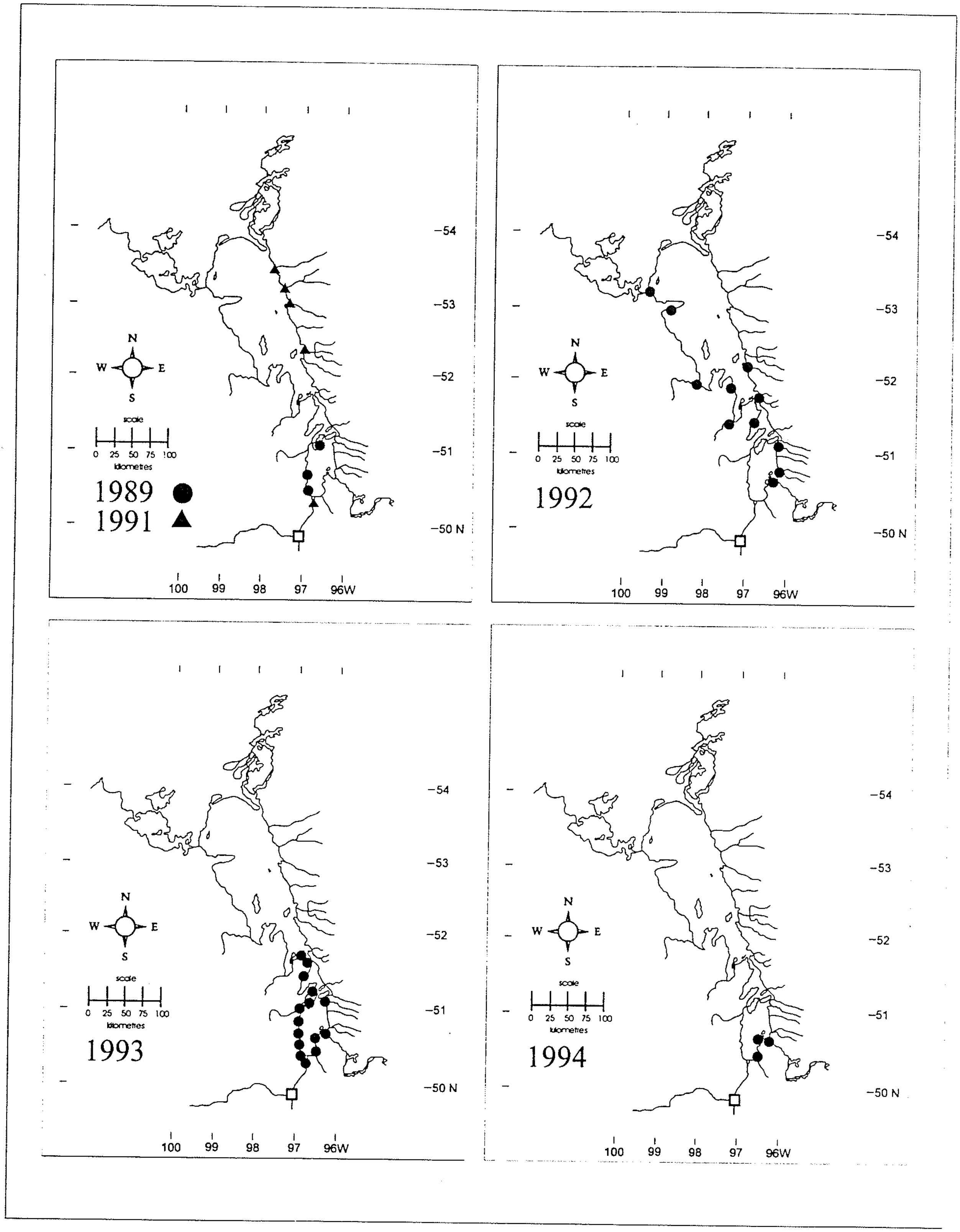


Figure 2. Geographic distribution of collecting effort between years for the shorelines of Lake Winnipeg

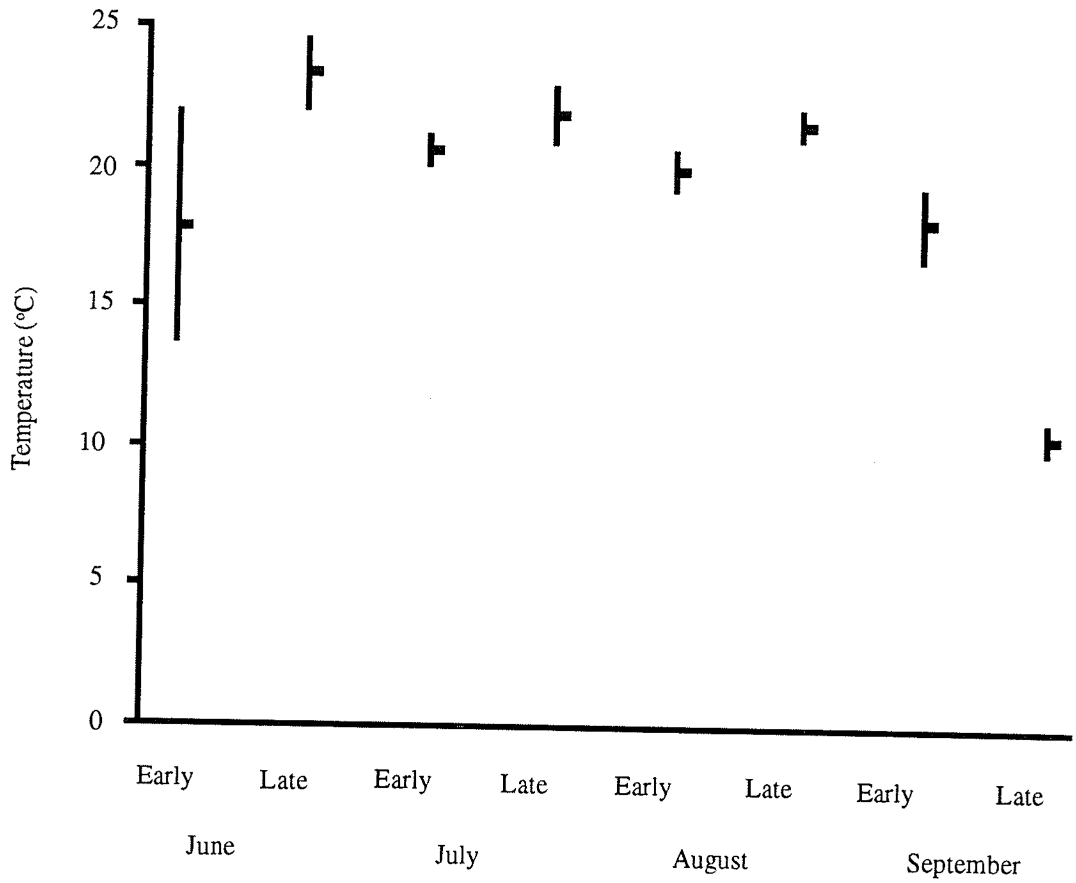


Figure 3. Water temperature (°C) for the years 1989 to 1994 (mean +/- 95% confidence limits) throughout the summer for all nearshore South Basin sites of Lake Winnipeg

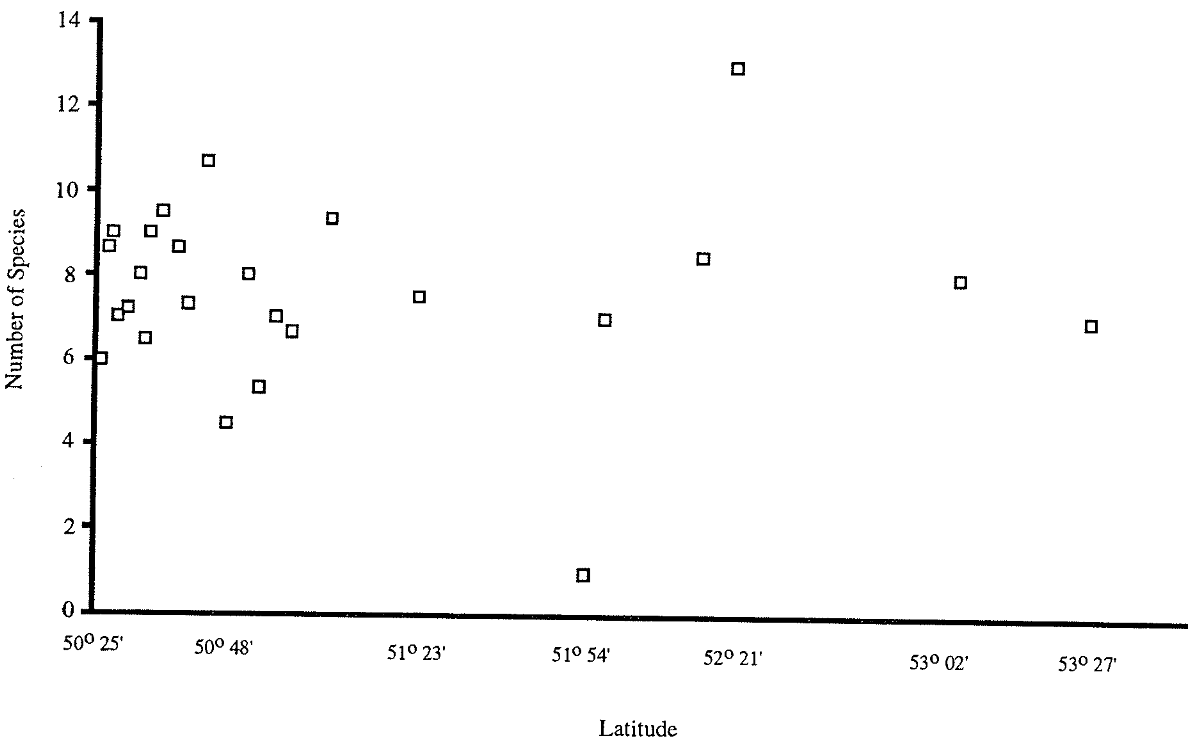


Figure 4. Number of species for seine hauls grouped to the nearest minute of latitude for collections between 1991 and 1994

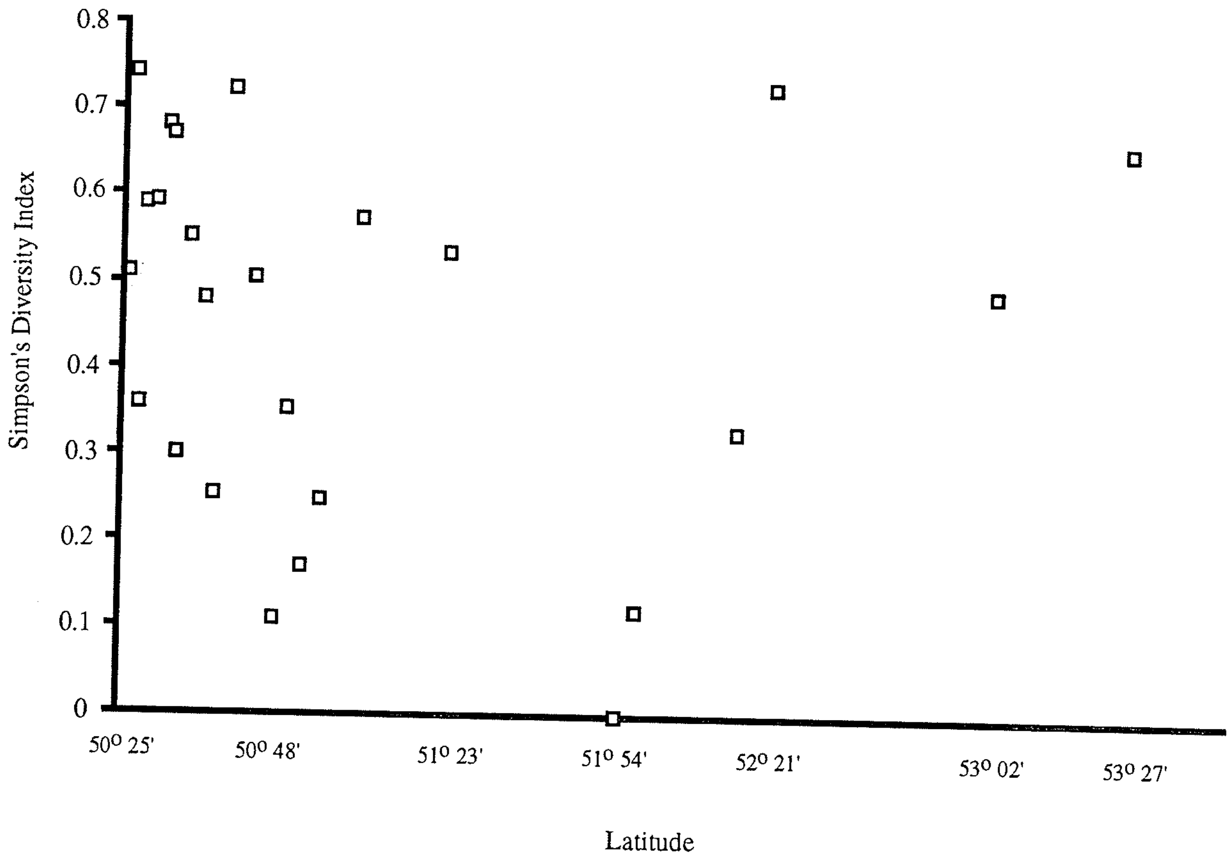


Figure 5. Simpson's diversity index for seine hauls grouped to the nearest minute of latitude for collections between 1991 and 1994

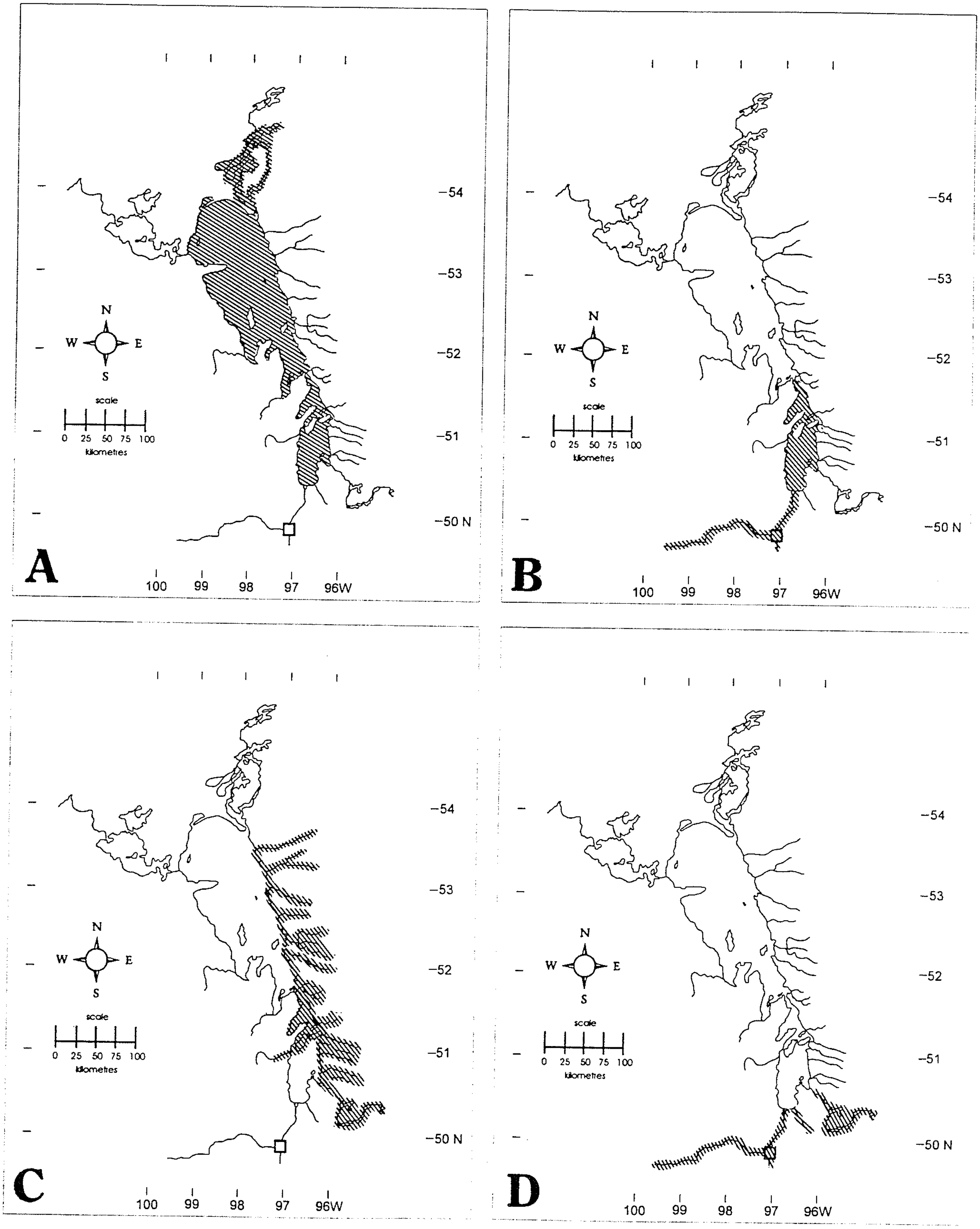


Figure 6. Four maps of general fish distribution in Lake Winnipeg A) through out the lake, B) restricted to the South Basin, C) Winnipeg River and eastern tributaries and D) headwater species that do not enter the lake

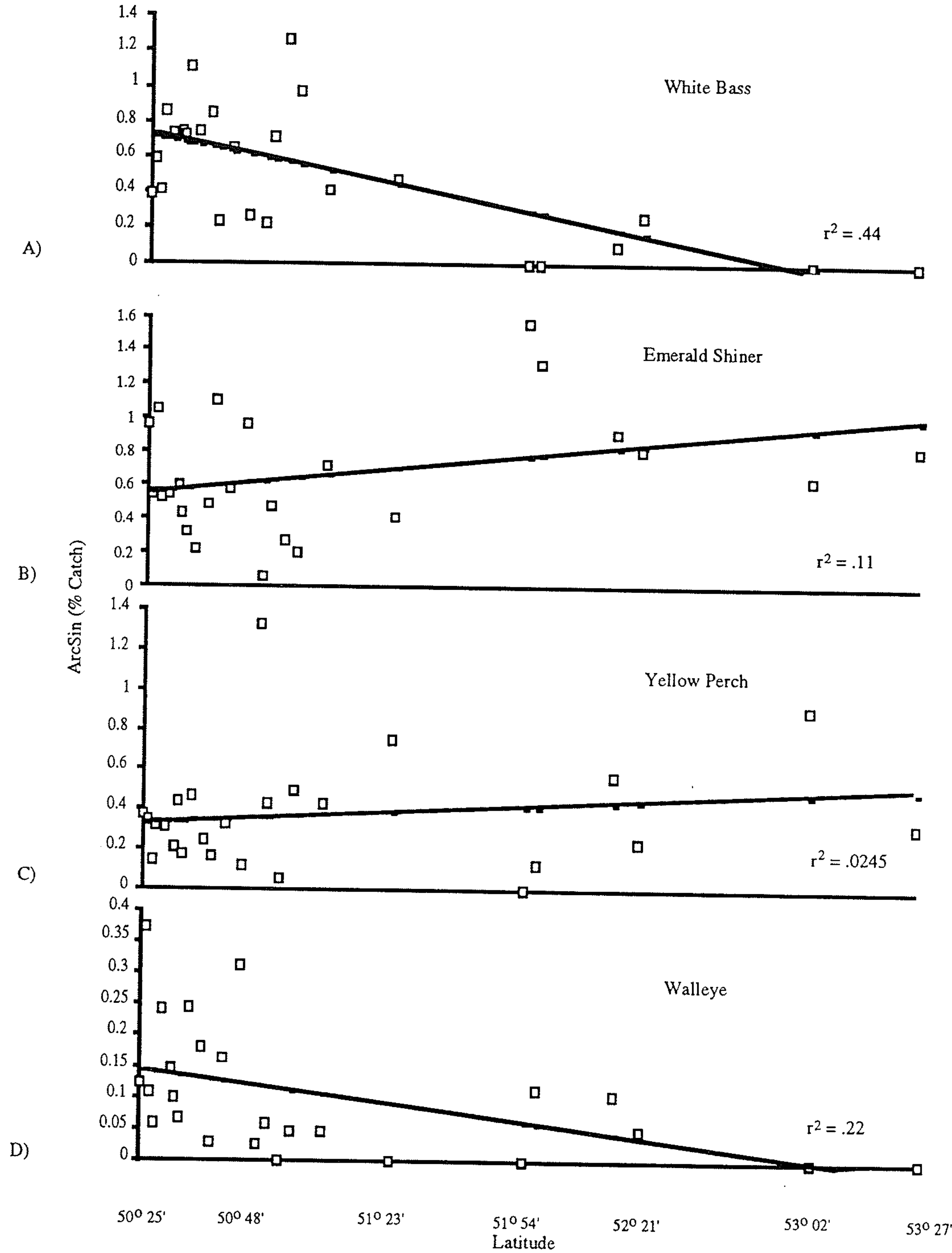
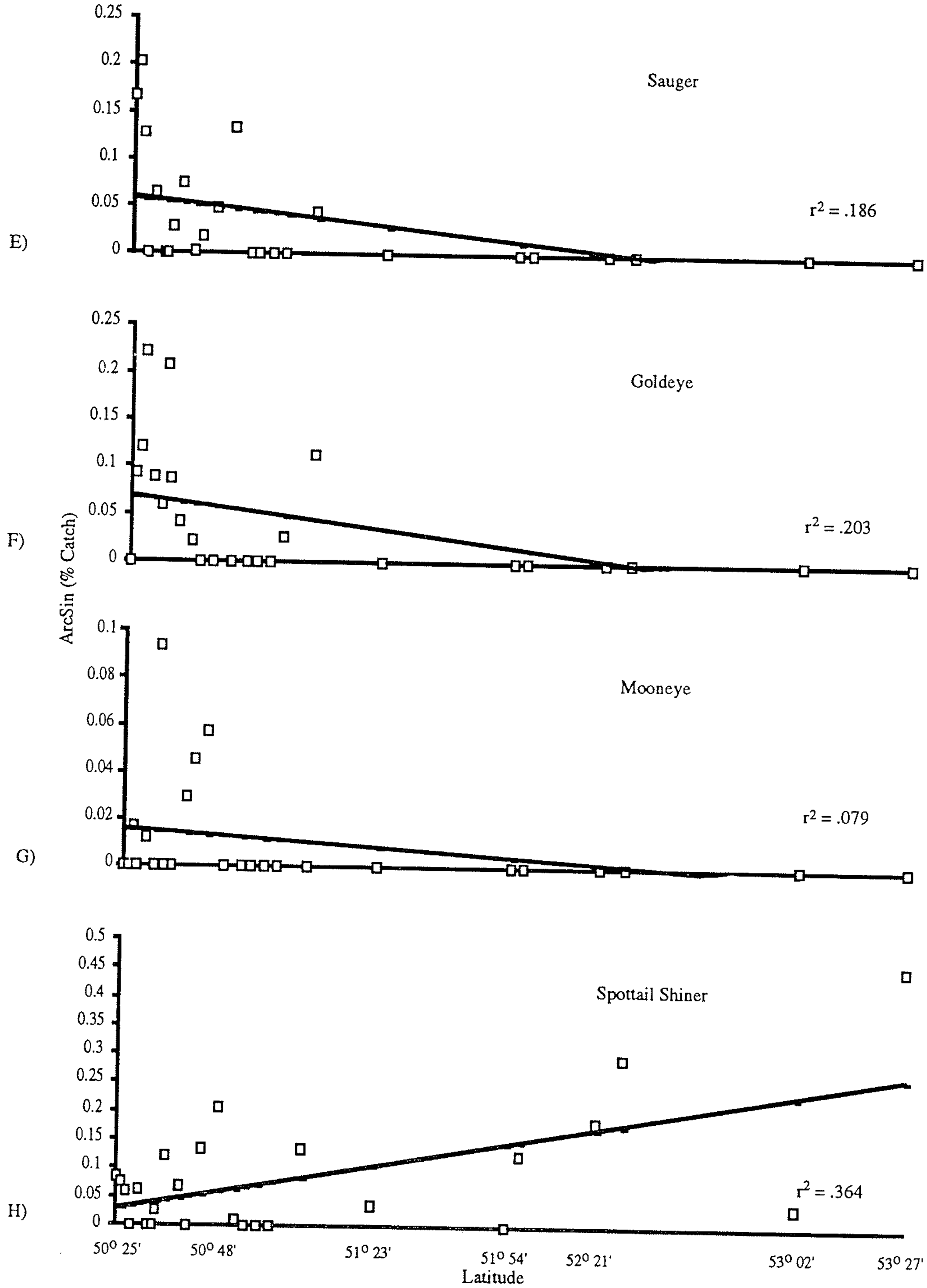


Figure 7. Regressions of the mean percent catch for seine hauls with latitude, A) white bass, B) emerald shiner, C) yellow perch, D) walleye, E) sauger, F) goldeye, G) mooneye and H) spottail shiner

Figure 7. Continued



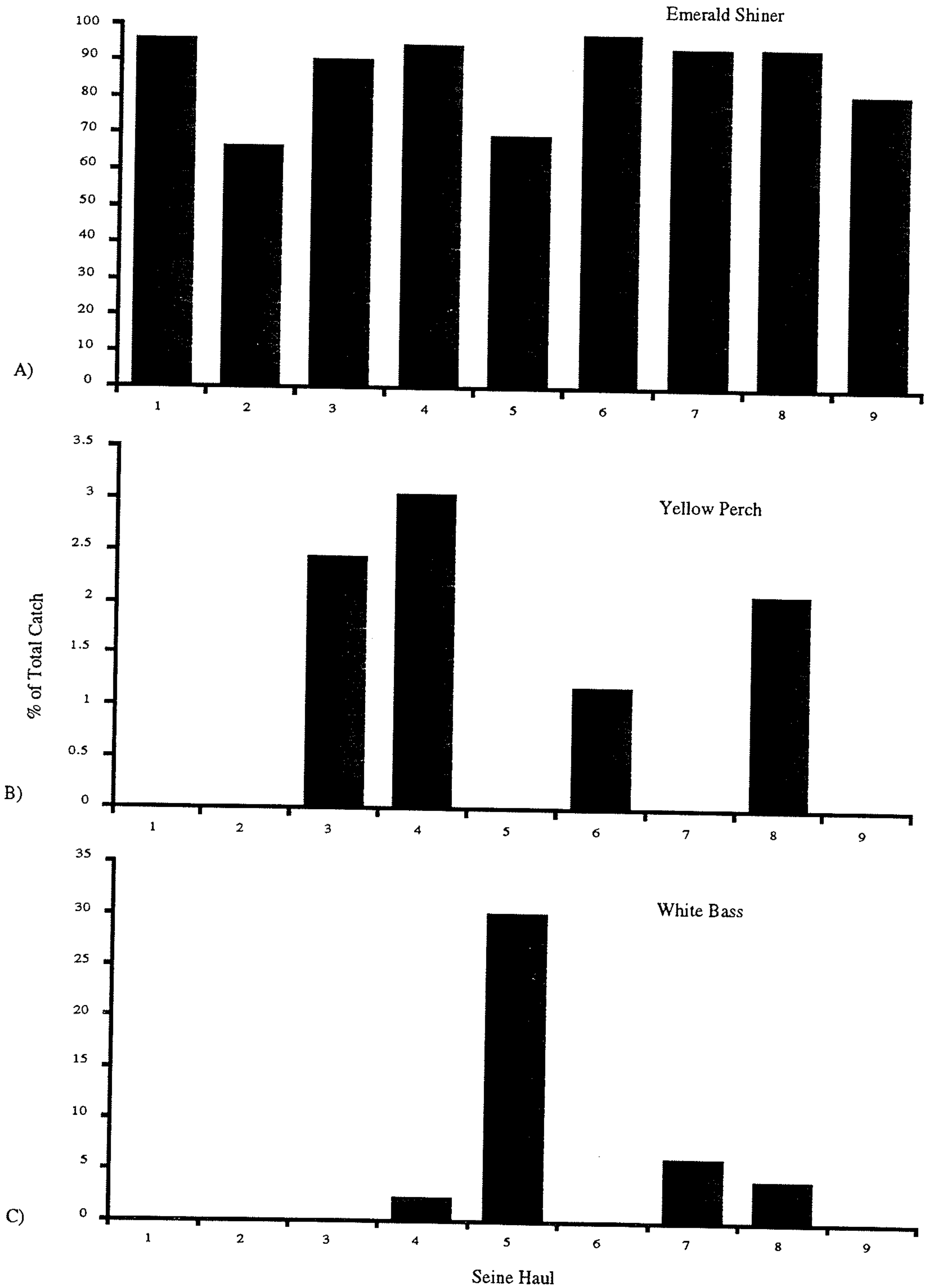


Figure 8. Presence (% catch) of, A) emerald shiner, B) yellow perch, C) white bass, D) river darter, E) silver chub, F) walleye and G) mottled sculpin, in nine consecutive seine hauls along Hillside Beach, August 21, 1994

Figure 8. Continued

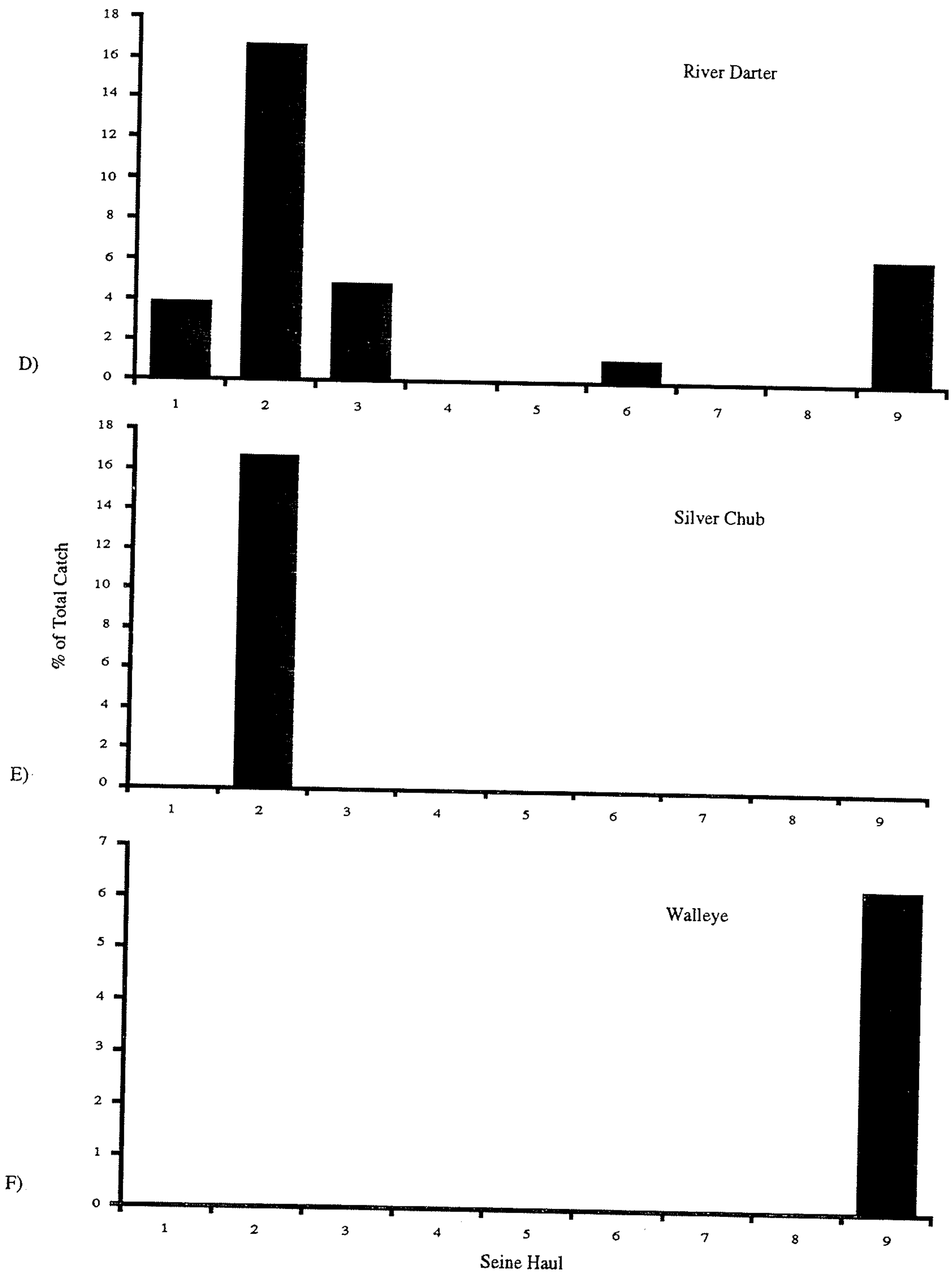
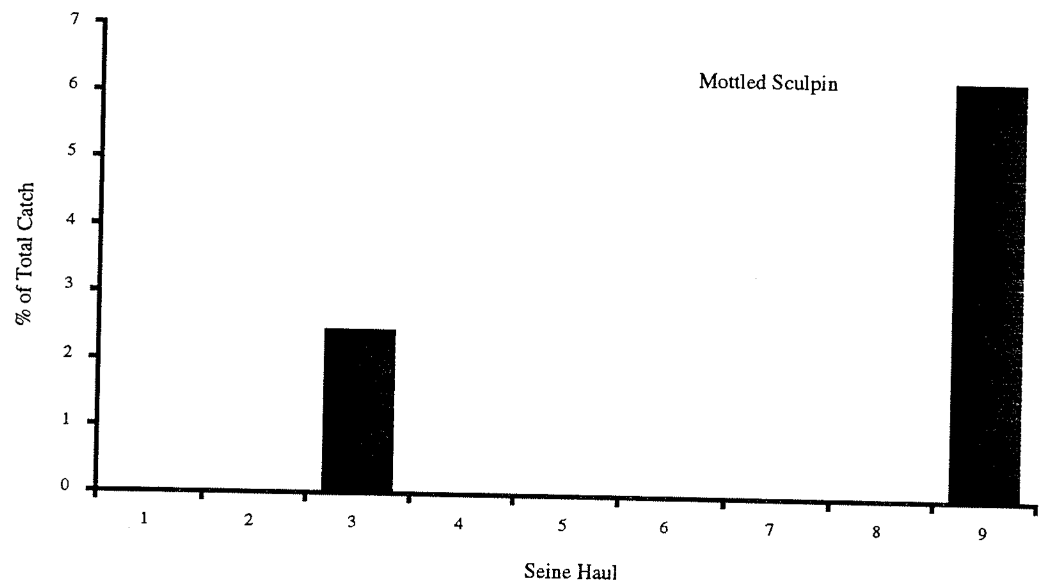


Figure 8. Continued

G)



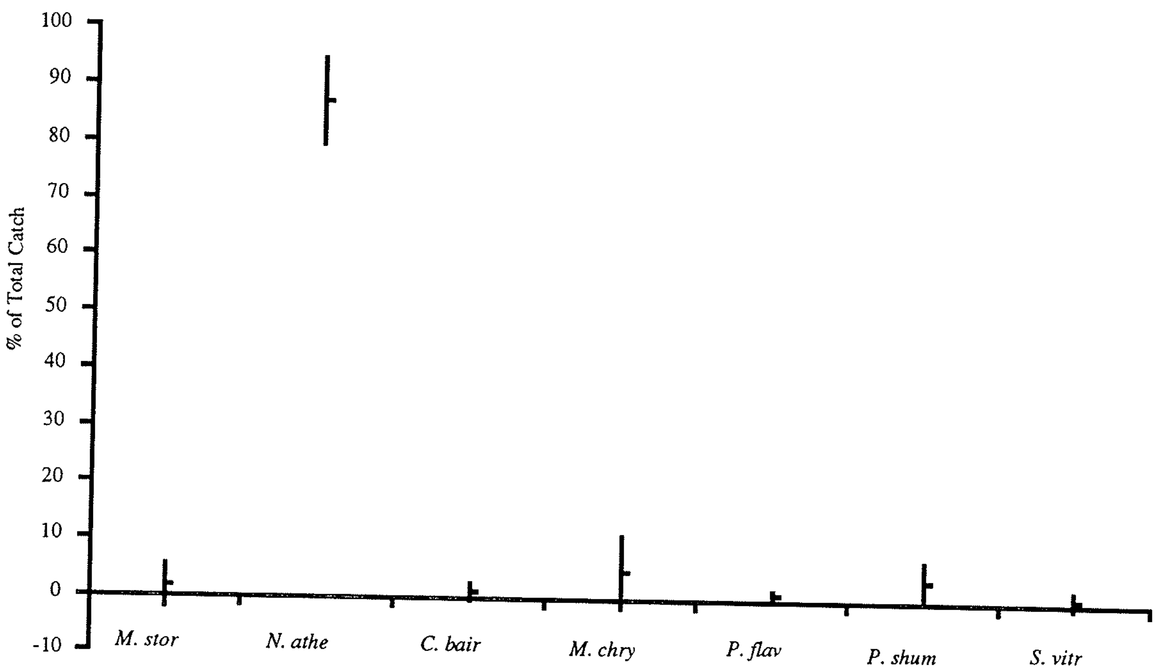


Figure 9. Presence (mean % catch and 95% confidence limits) for each species collected in the nine seine hauls along Hillside Beach, August 21, 1994

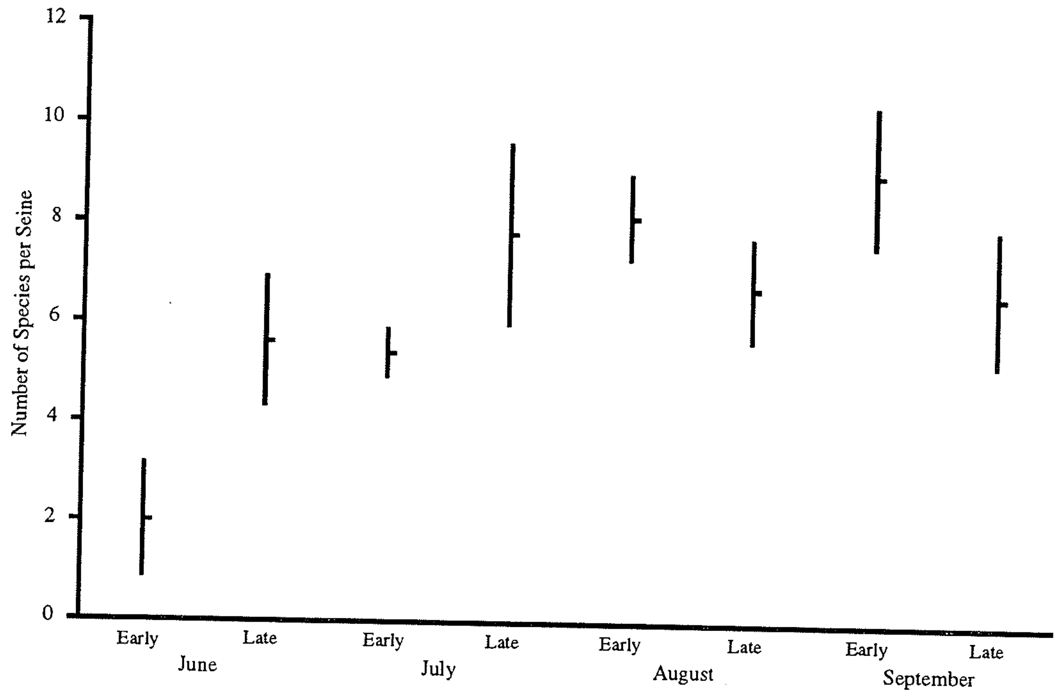


Figure 10. Seasonal changes and 95% confidence limits in number of species for seine samples from Hillside Beach, grouped into biweekly intervals

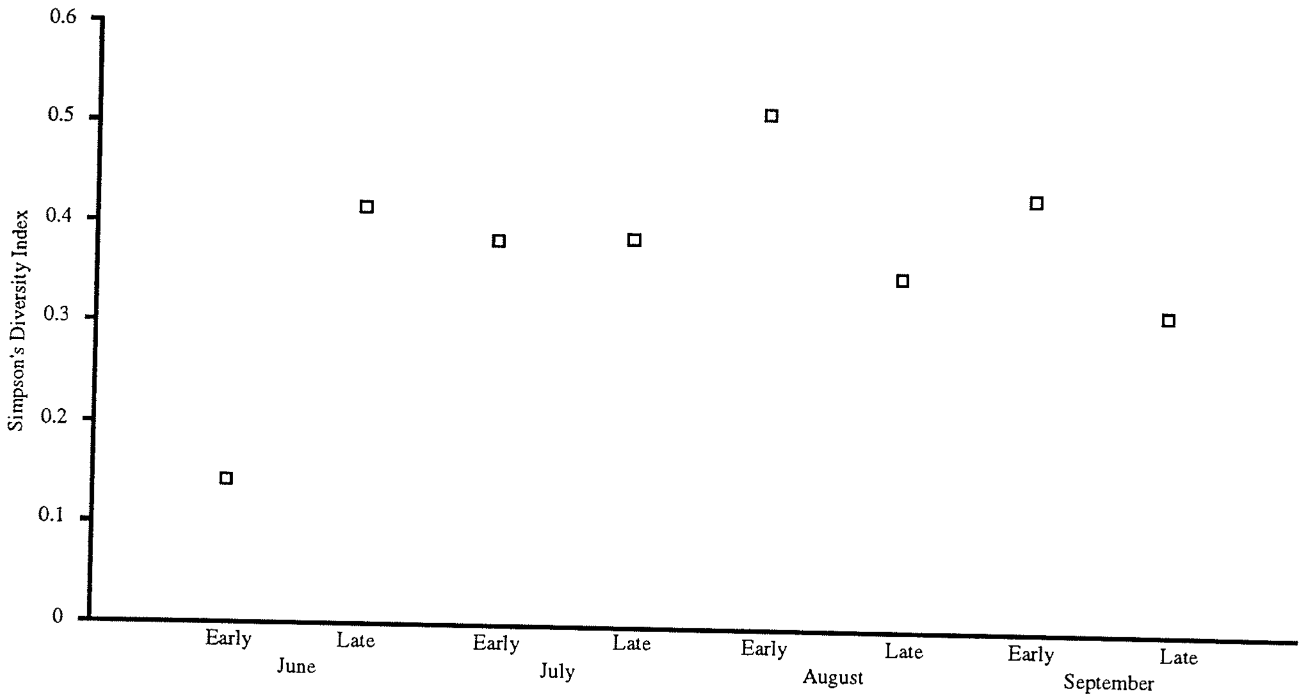


Figure 11. Changes in Simpson's diversity index (using mean number of species for each time interval) throughout the seasons at Hillside Beach, grouped into biweekly intervals

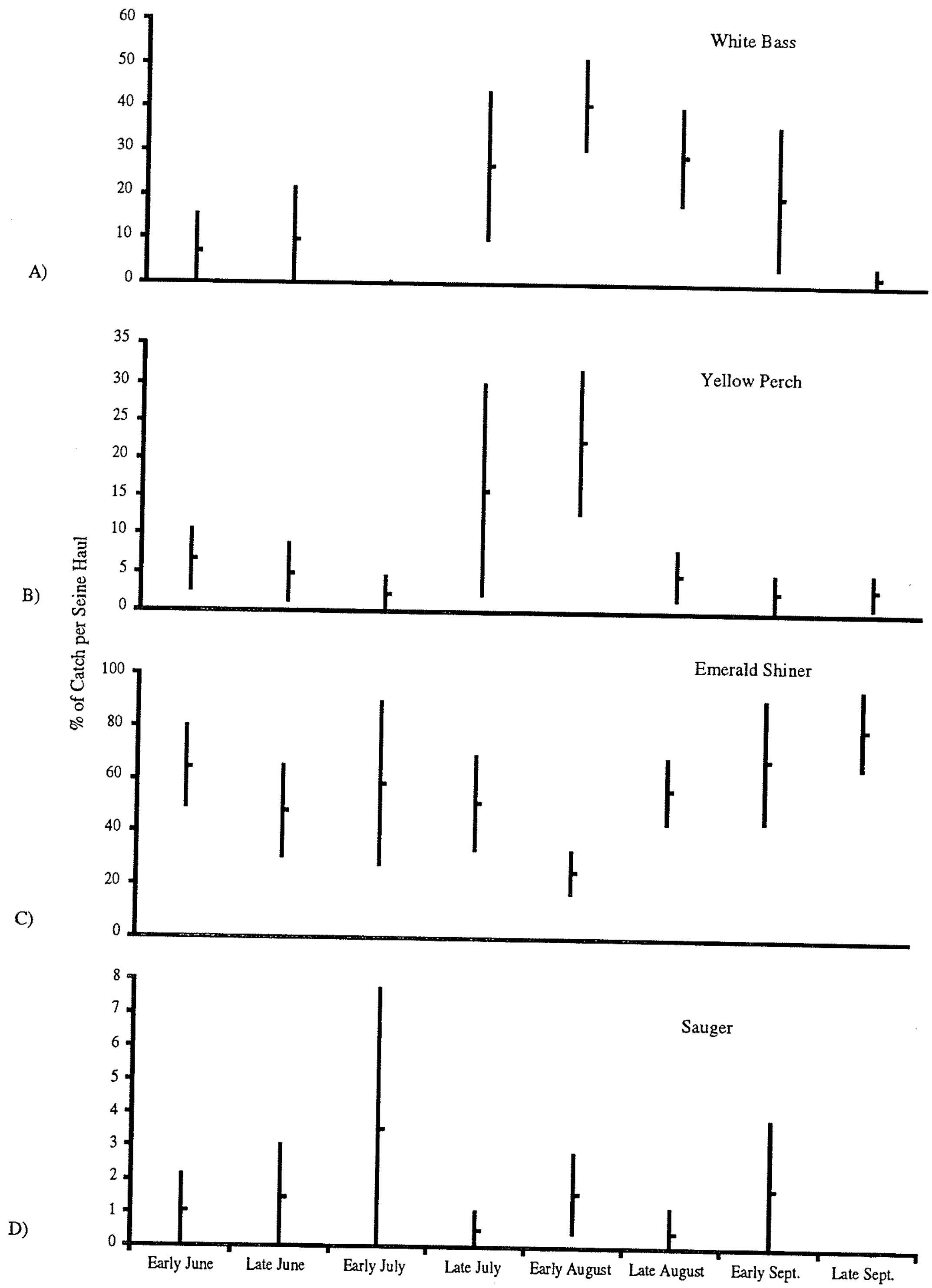
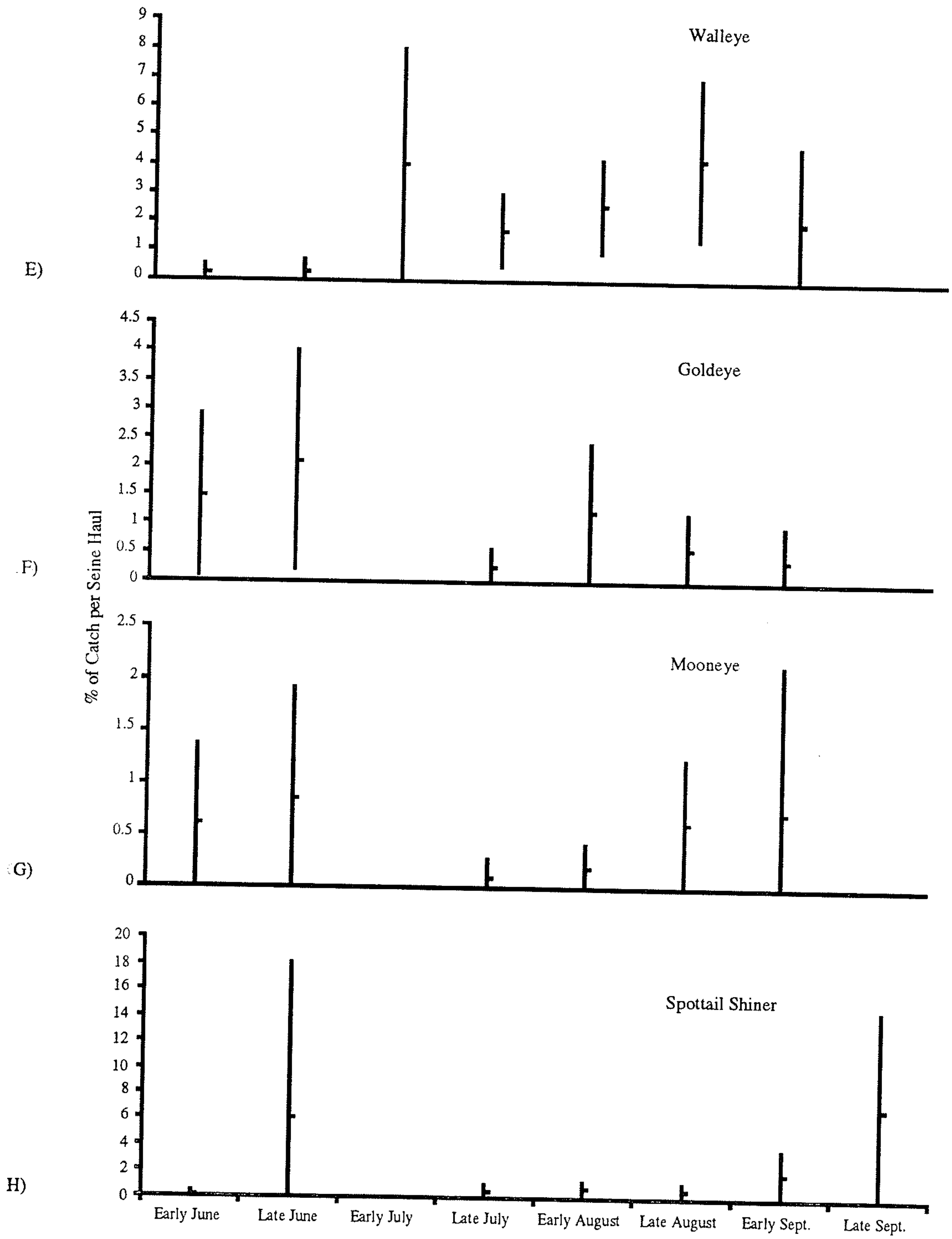


Figure 12. Seasonal appearance and abundance changes (mean +/- 95% confidence limits) of A) white bass, B) yellow perch, C) emerald shiner, D) sauger, E) walleye, F) goldeye, G) mooneye and H) spottail shiner, at Hillside Beach

Figure 12. Continued



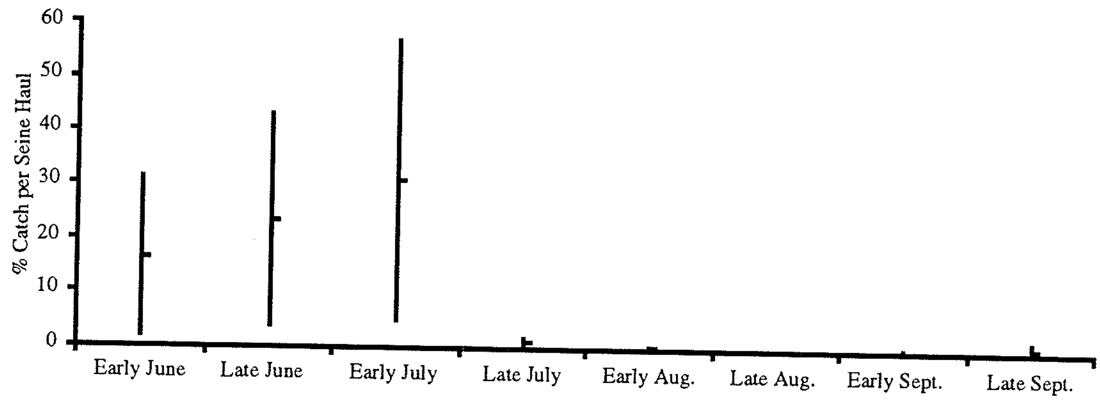


Figure 13. Seasonal appearance and abundance changes (mean and 95% confidence limits) of troutperch at Hillside Beach

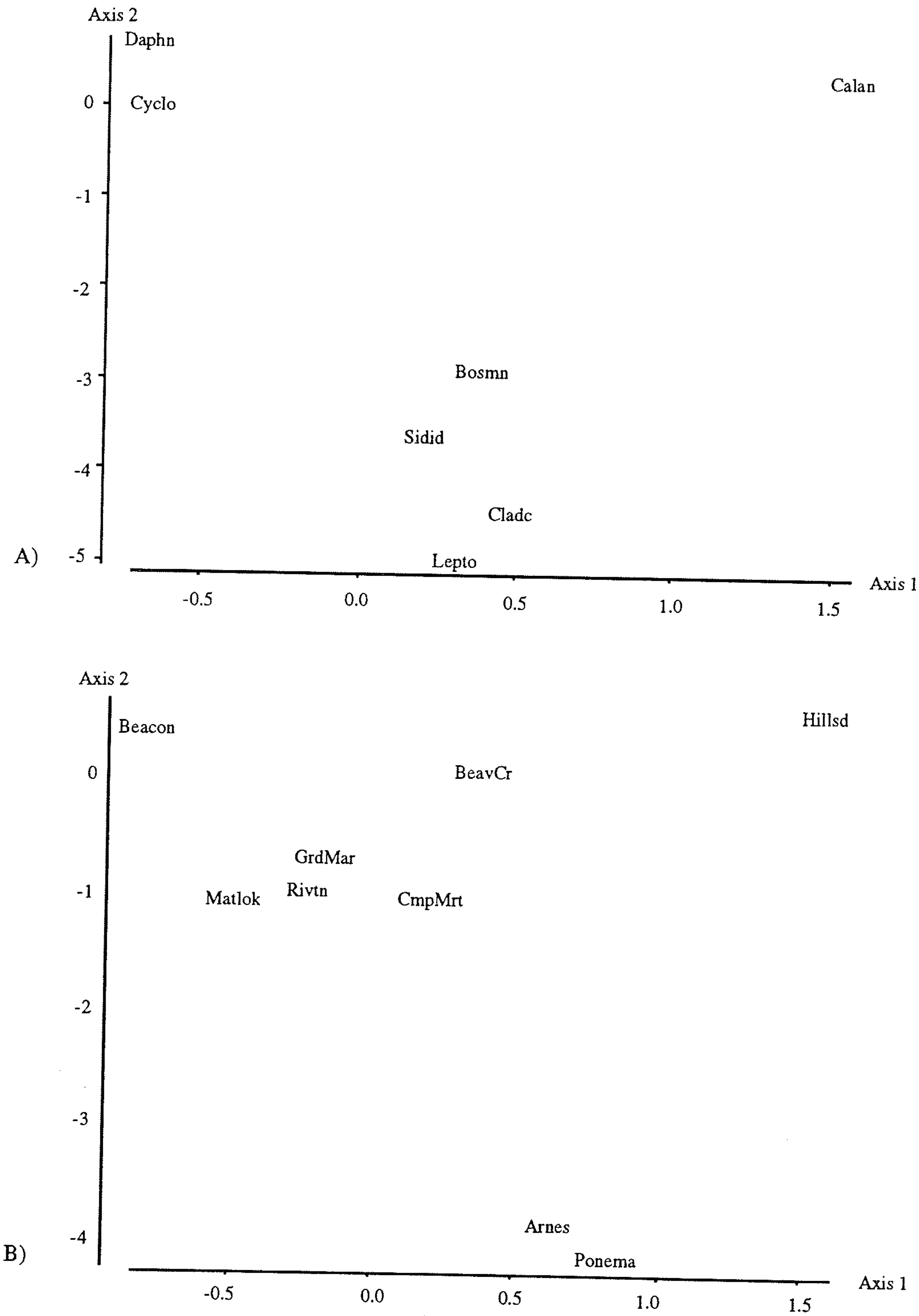


Figure 14. Correspondence analysis axes 1 and 2 for late July, 1993, zooplankton samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

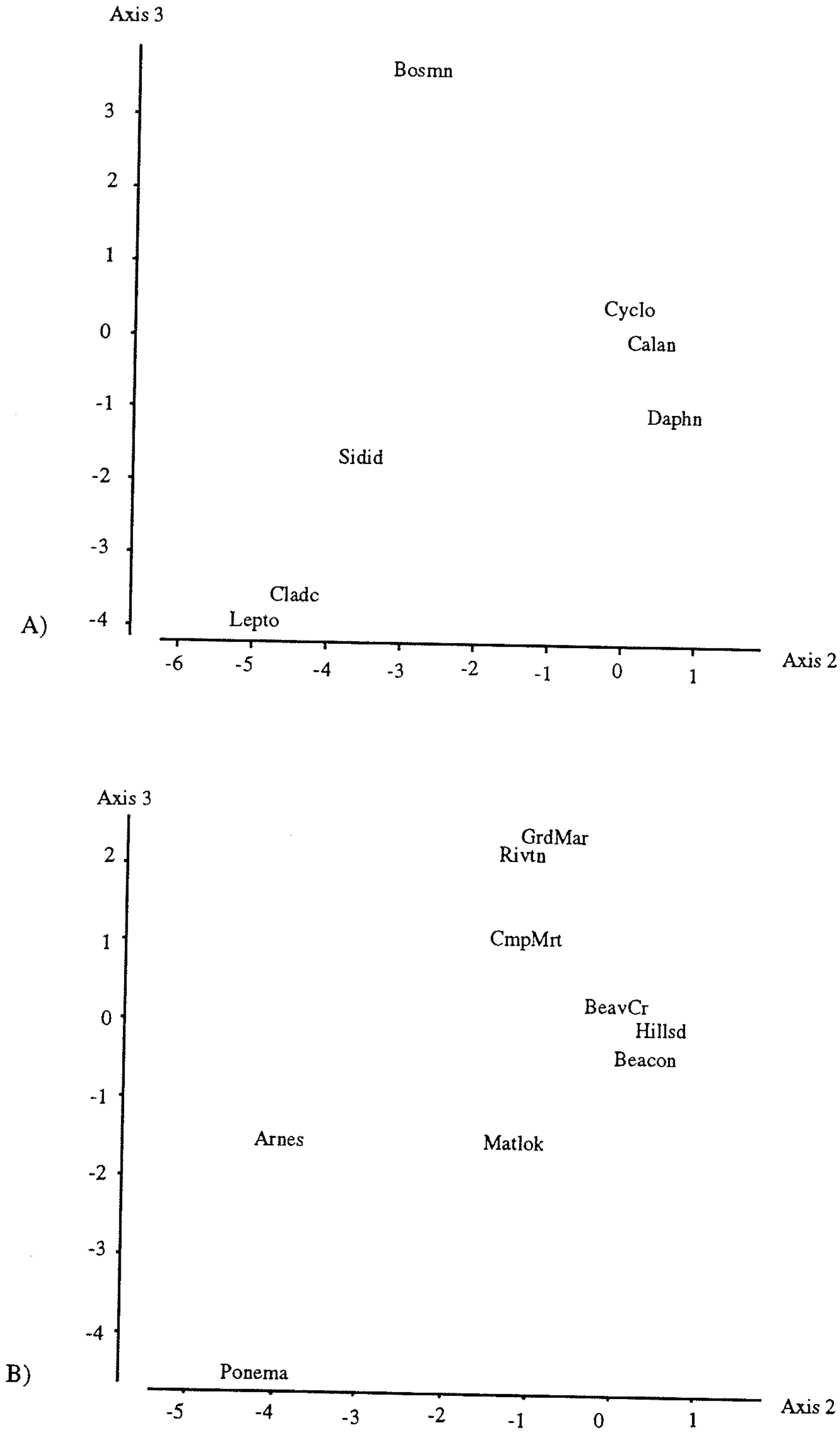


Figure 15. Correspondence analysis axes 2 and 3 for late July, 1993, zooplankton samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

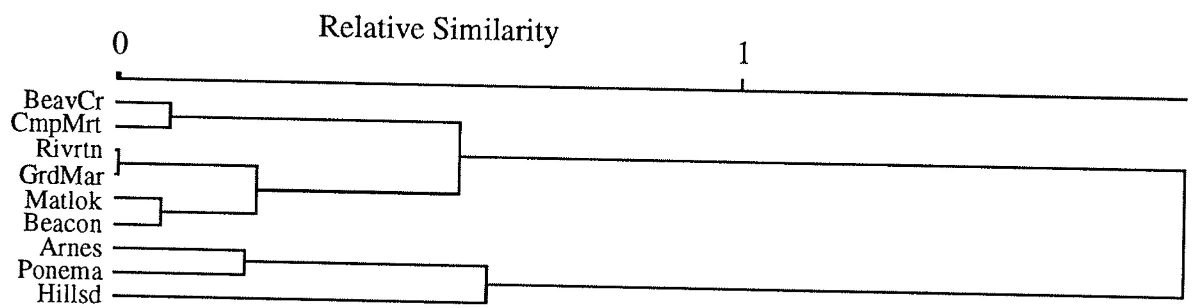


Figure 16. Cluster analysis results for late July, 1993, sample sites based on similarity of zooplankton composition

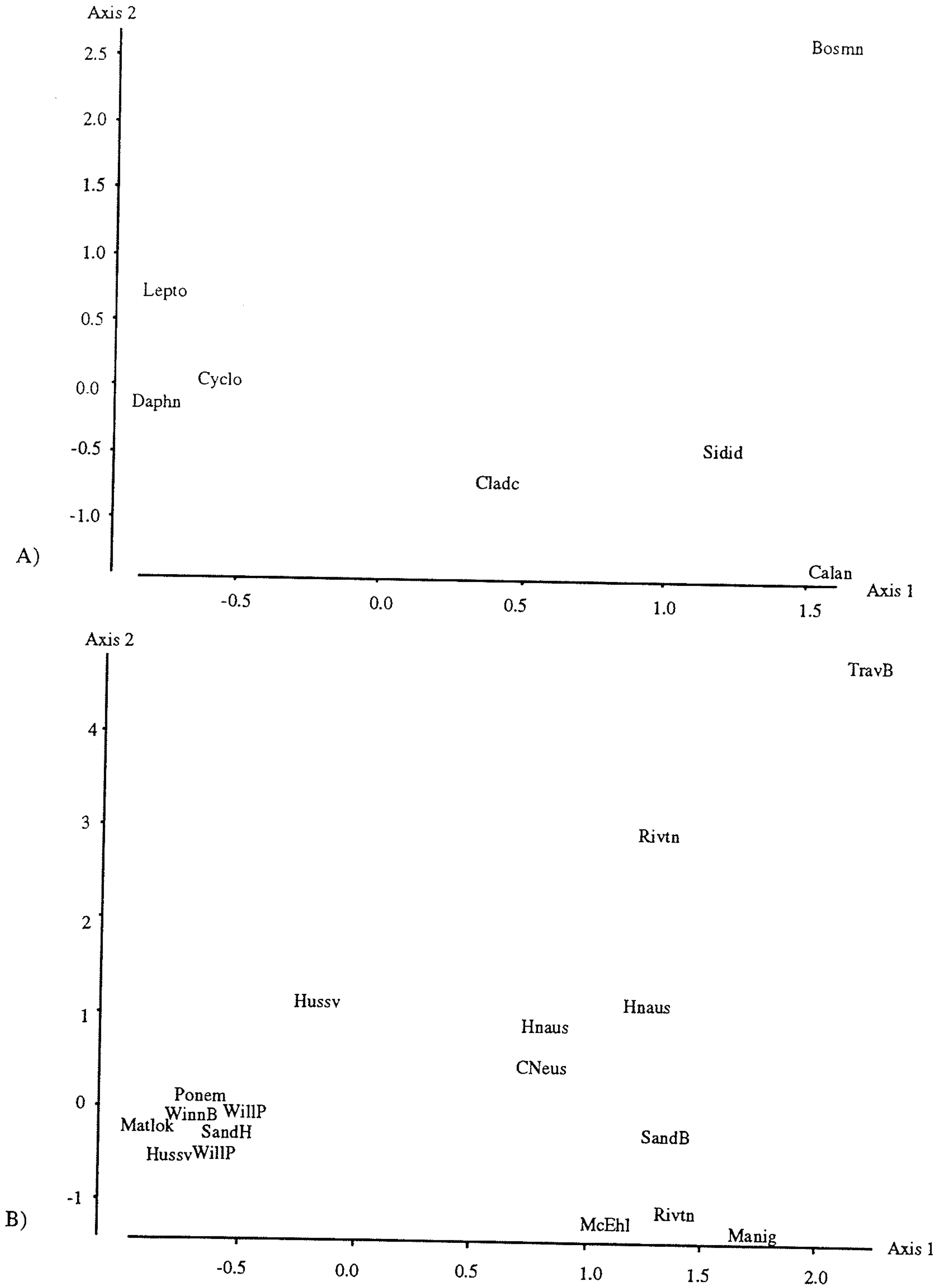


Figure 17. Correspondence analysis axes 1 and 2 for early August, 1993, zooplankon samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

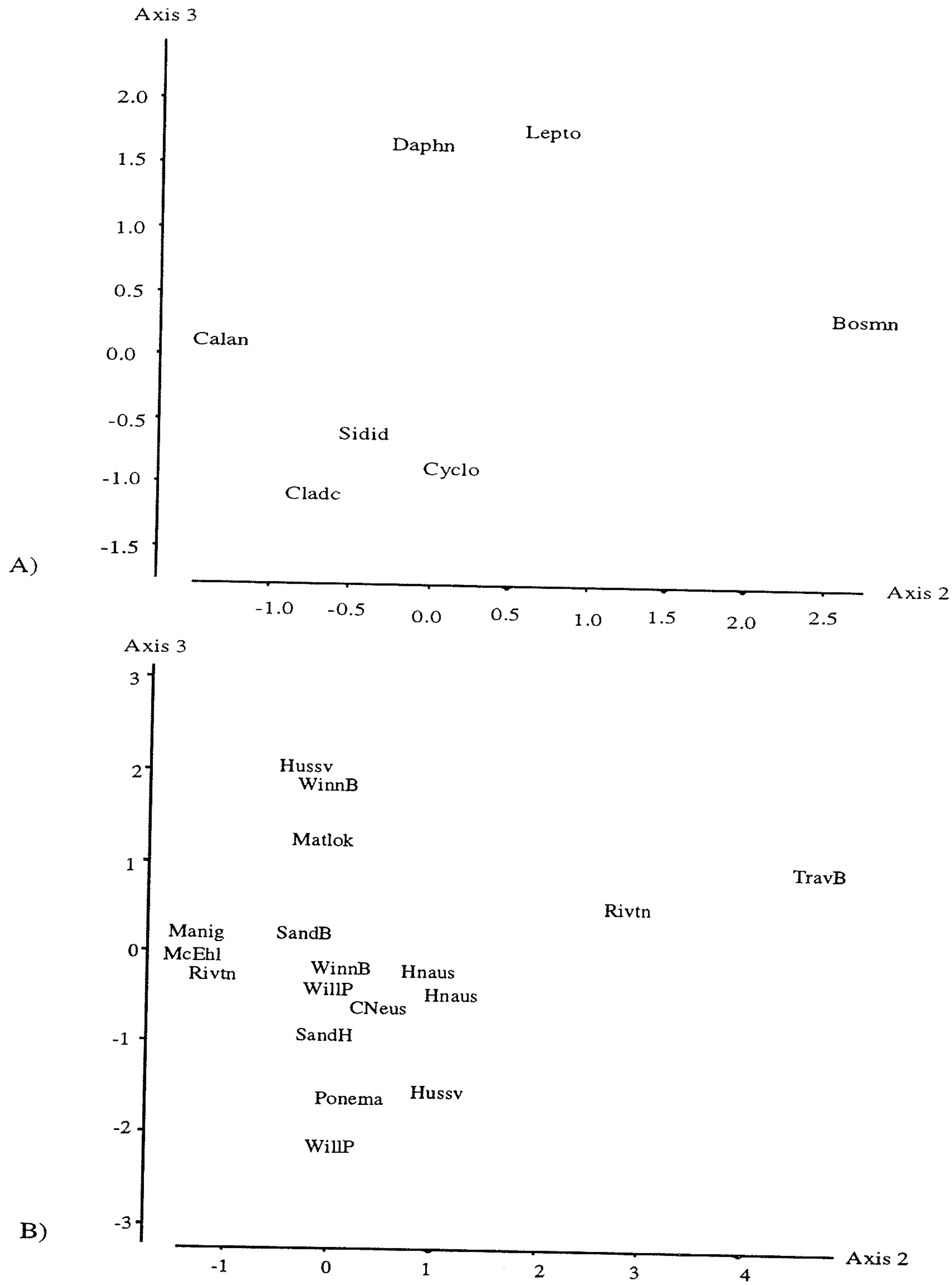


Figure 18. Correspondence analysis axes 2 and 3 for early August, 1993, zooplankton samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

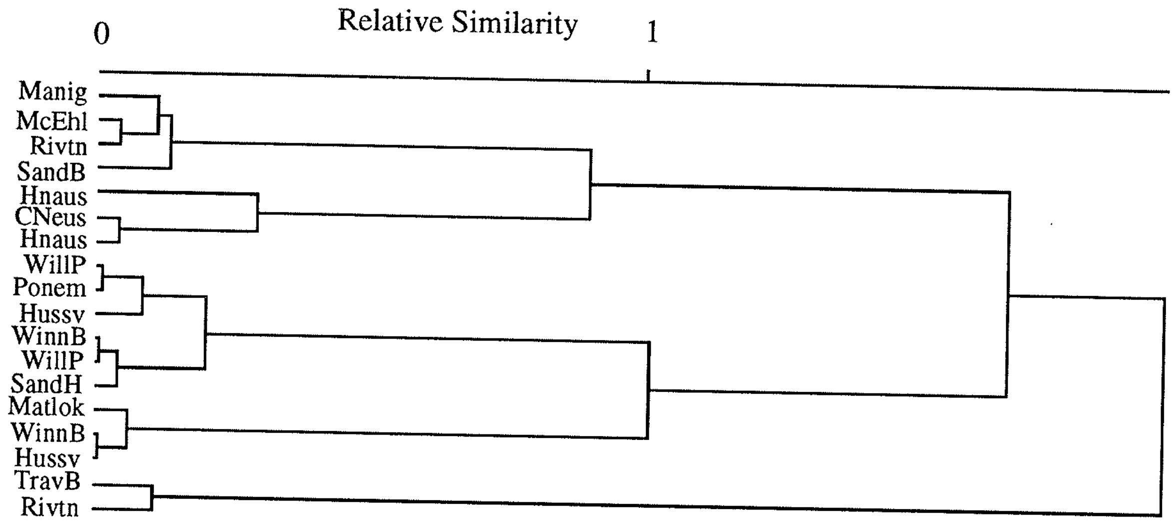


Figure 19. Cluster analysis for early August sample sites based on similarity of zooplankton composition

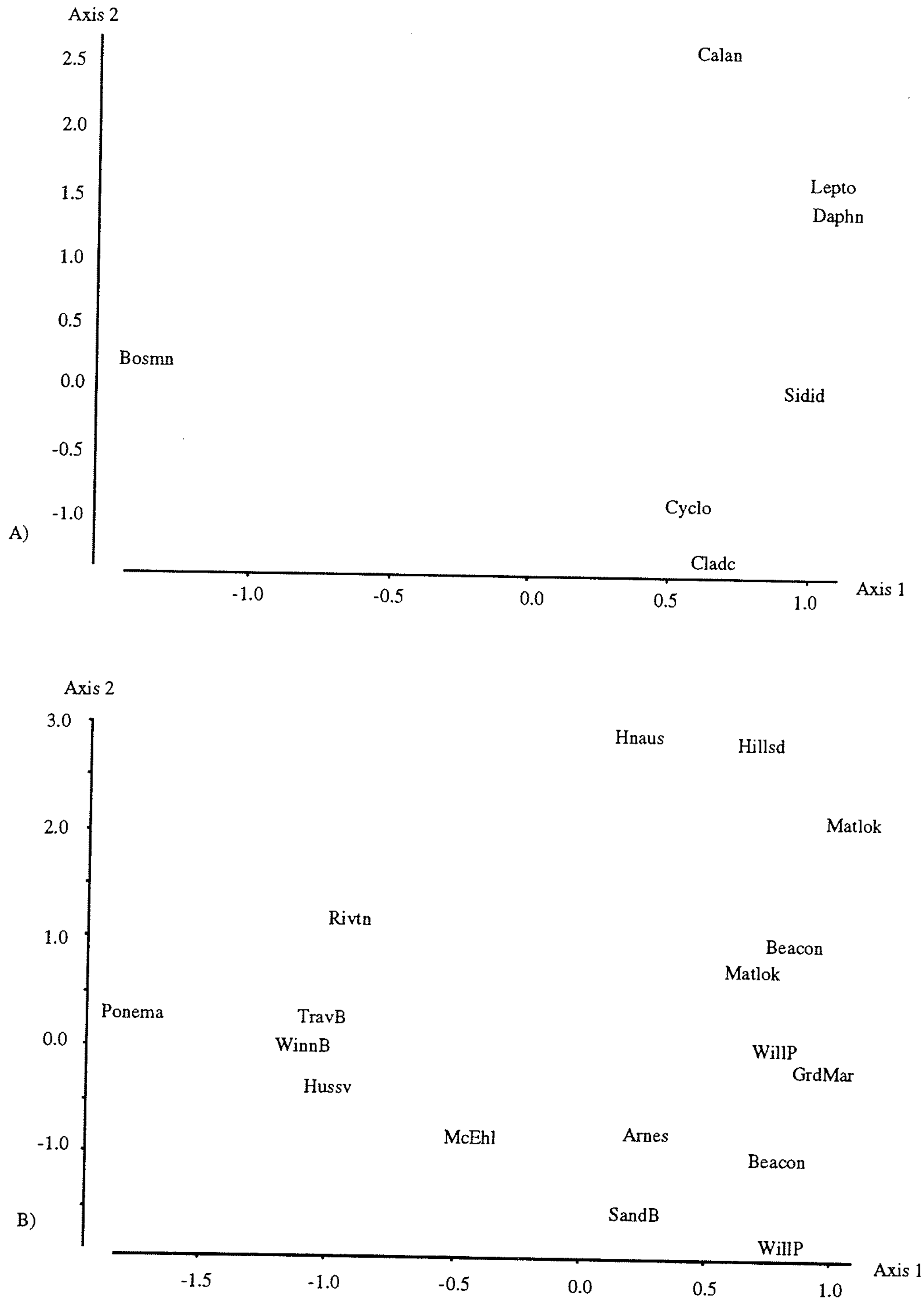


Figure 20. Correspondence analysis axes 1and 2 for late August, 1993, zooplankton samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

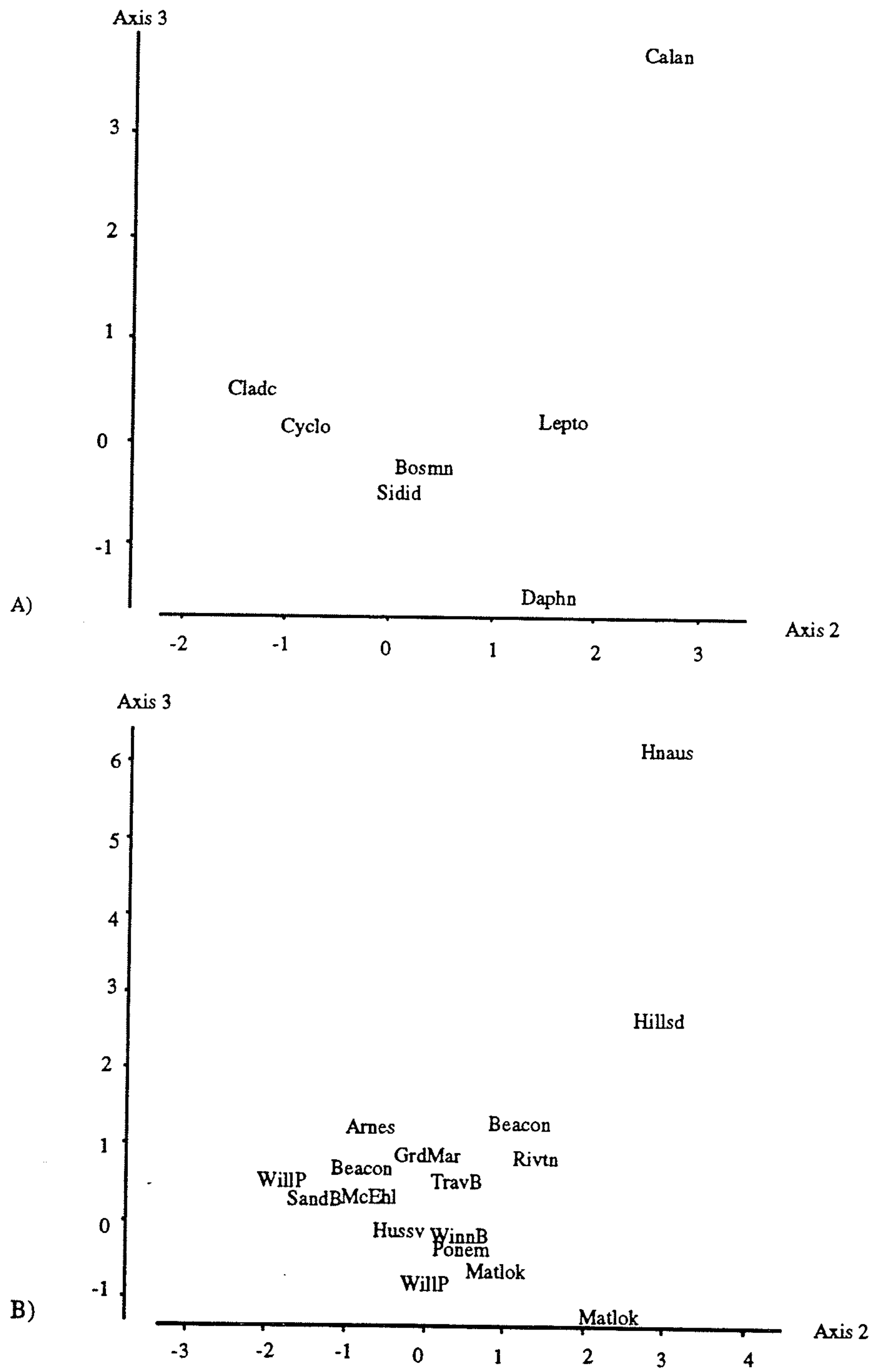


Figure 21. Correspondence axes 2 and 3 for late August, 1993, zooplankton samples from the South Basin of Lake Winnipeg, A) zooplankton species and B) sample sites

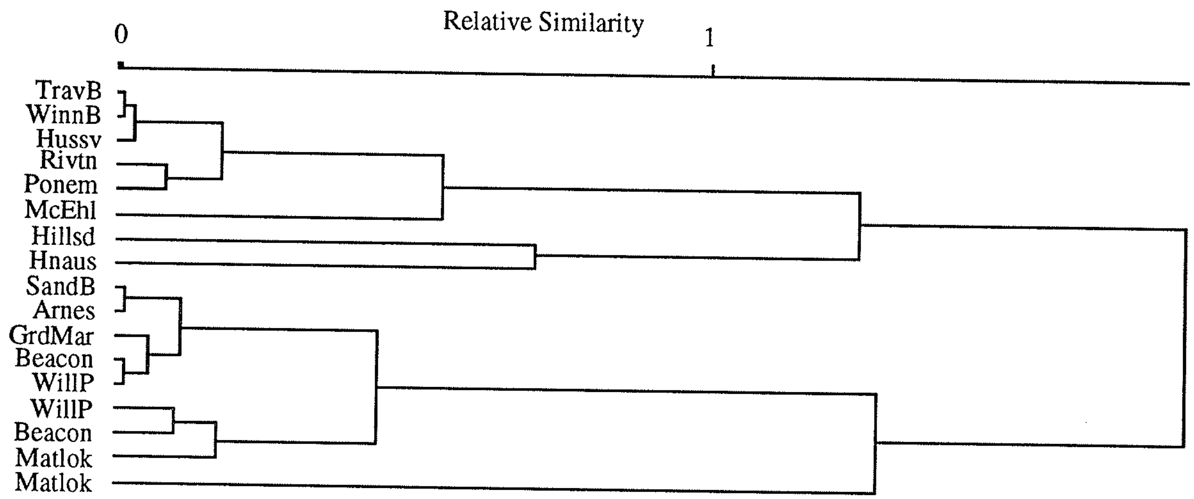


Figure 22. Cluster analysis results for late August sample sites based on similarity of zooplankton composition

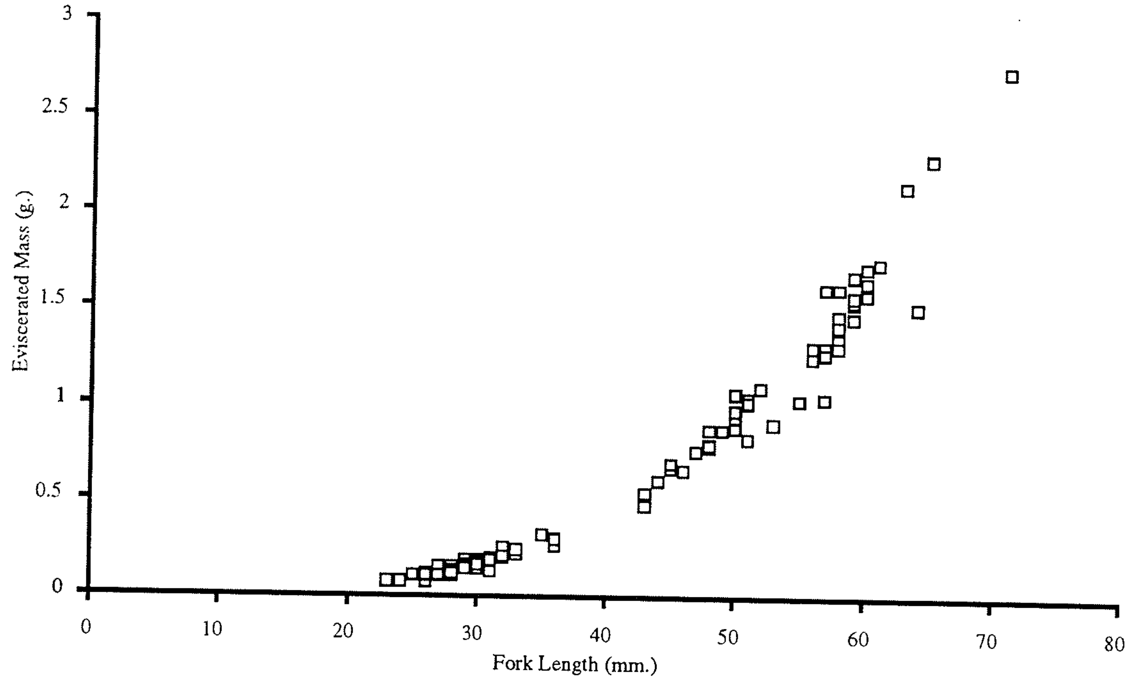


Figure 23. Scatter plot of fork length against eviscerated mass for emerald shiners from early June collections at Hillside Beach

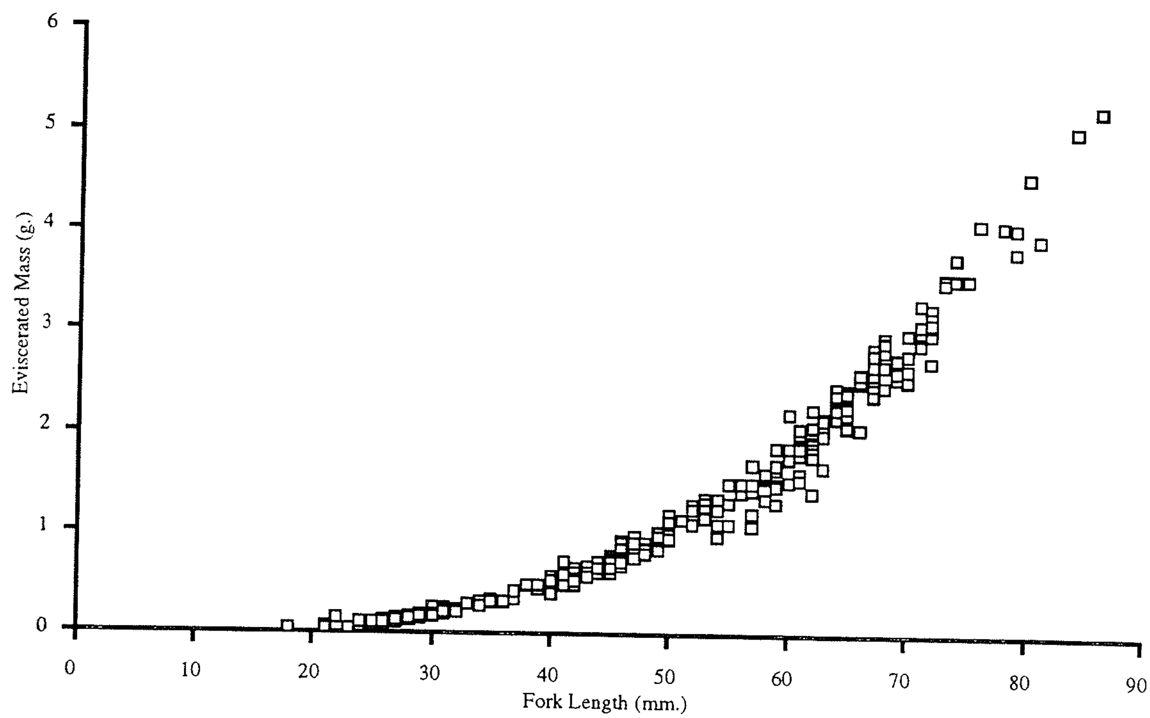


Figure 24. Scatter plot of fork length against eviscerated mass for emerald shiners from late June collections at Hillside Beach

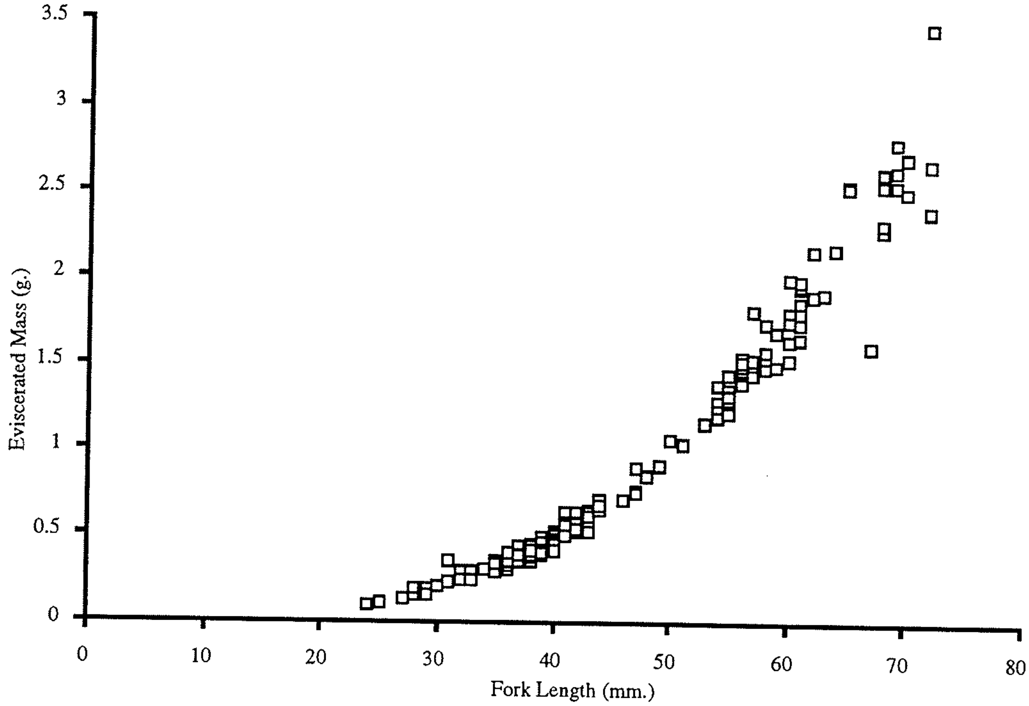


Figure 25. Scatter plot of fork length against eviscerated mass for emerald shiners from early July collections at Hillside Beach

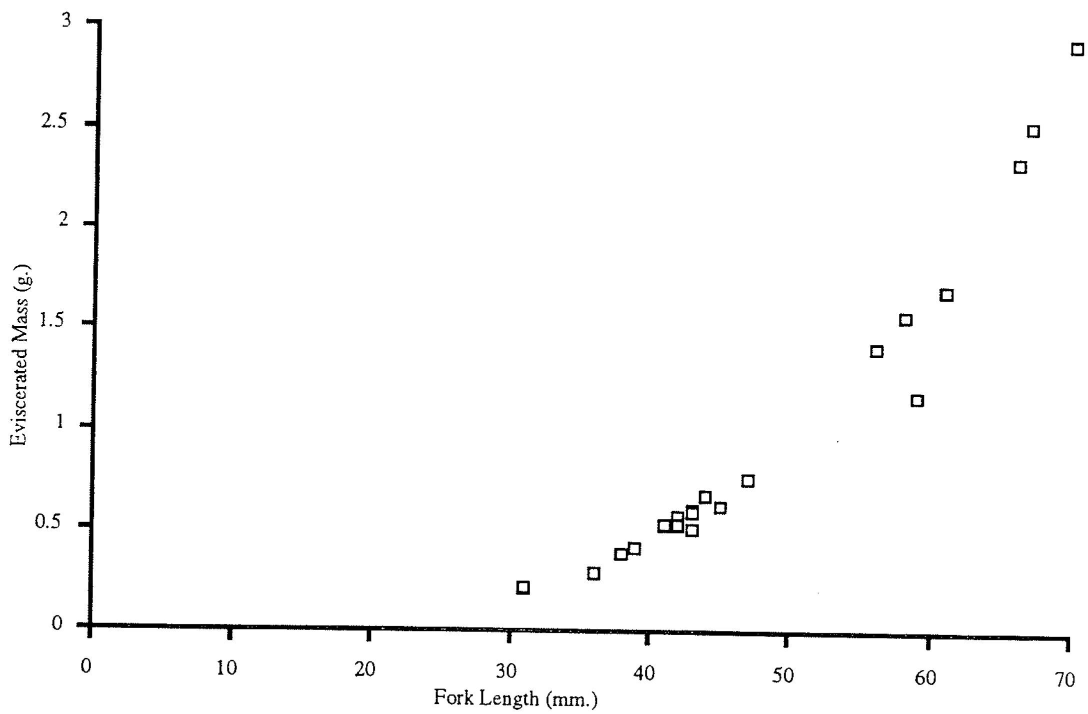


Figure 26. Scatter plot of fork length against eviscerated mass for emerald shiners from late August collections at Hillside Beach

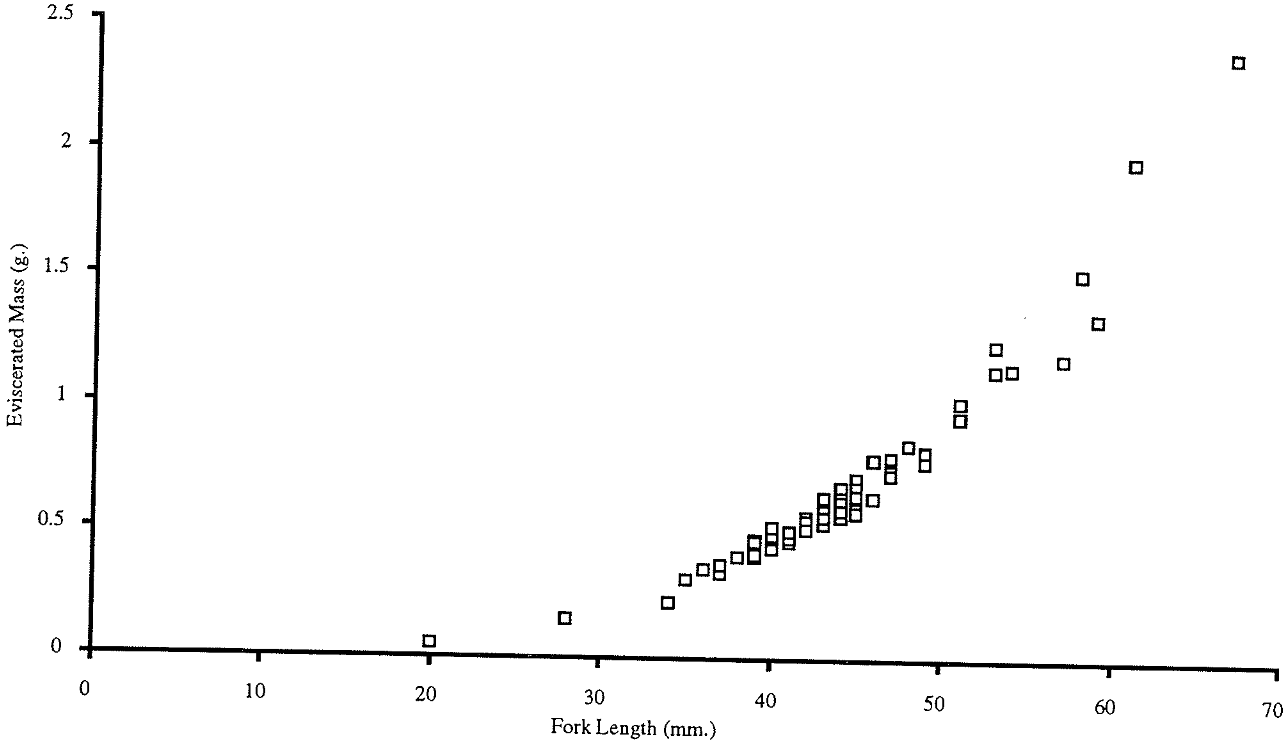


Figure 27. Scatter plot of fork length against eviscerated mass for emerald shiners from early August collections at Hillside Beach

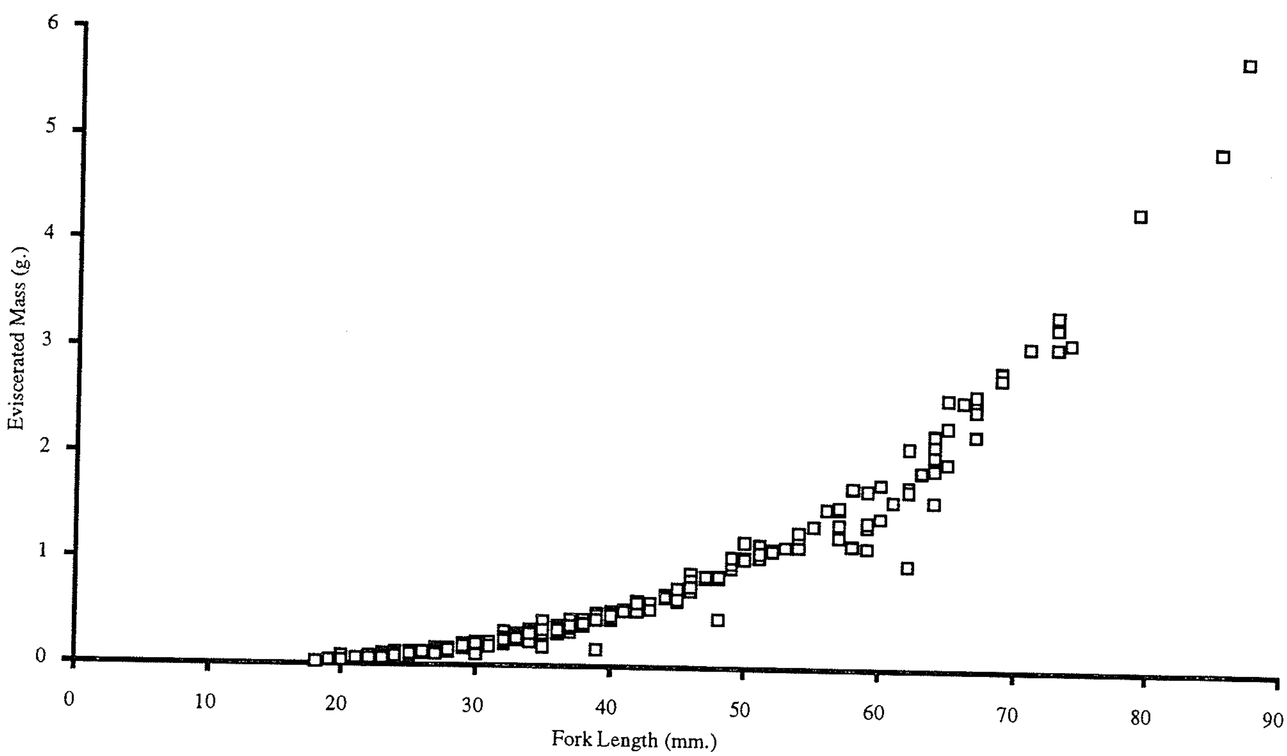


Figure 28. Scatter plot of fork length against eviscerated mass for emerald shiners from late August collections at Hillside Beach

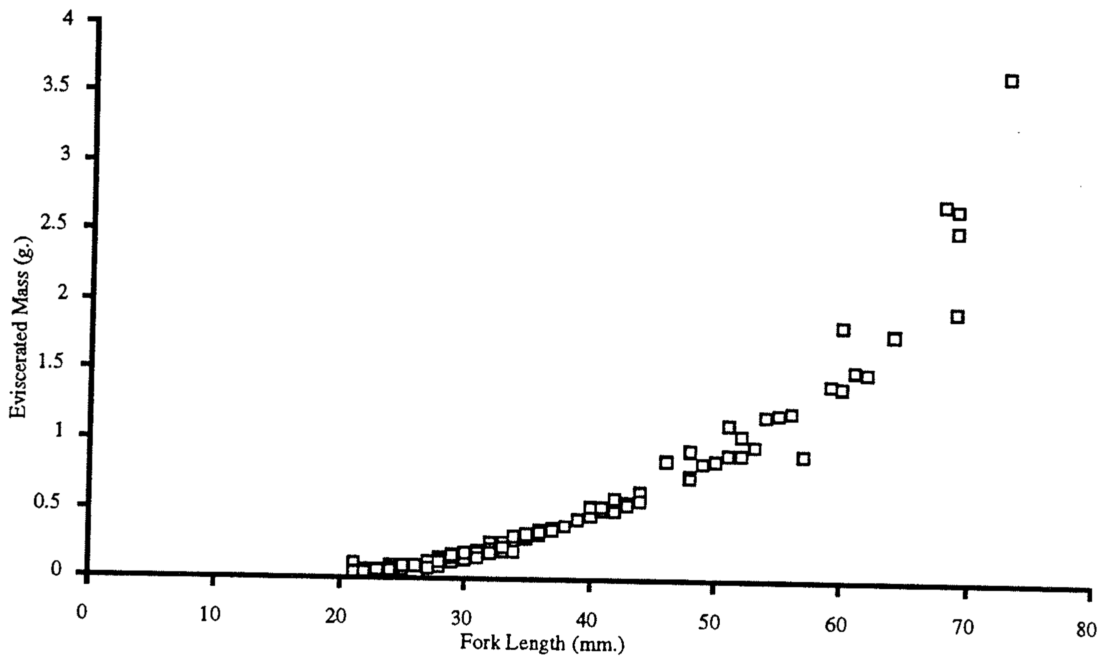


Figure 29. Scatter plot of fork length against eviscerated mass for emerald shiners from September collections at Hillside Beach

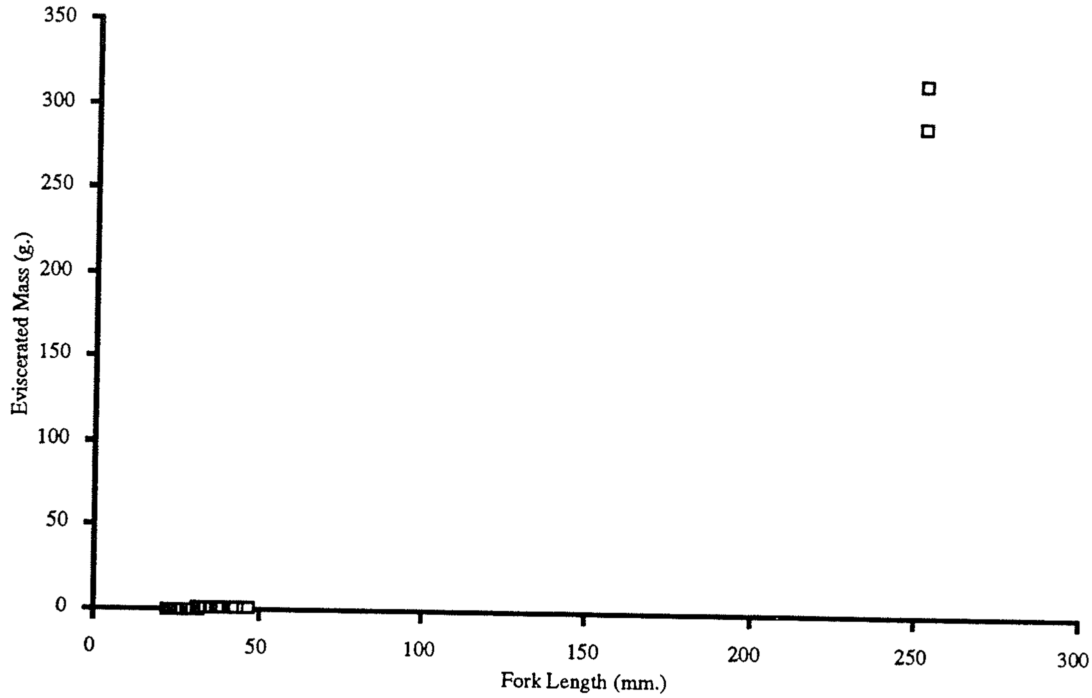


Figure 30. Scatter plot of fork length against eviscerated mass for white bass from late June collections at Hillside Beach

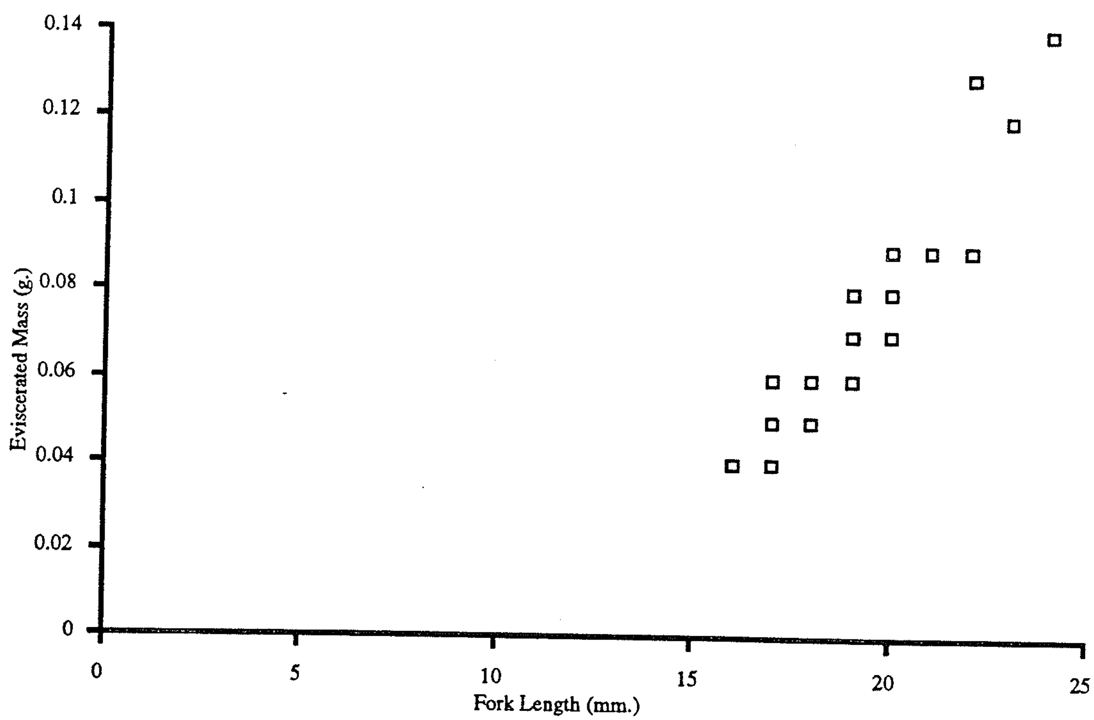


Figure 31. Scatter plot of fork length against eviscerated mass for white bass from early July collections at Hillside Beach, the single large individual has been removed for clarity

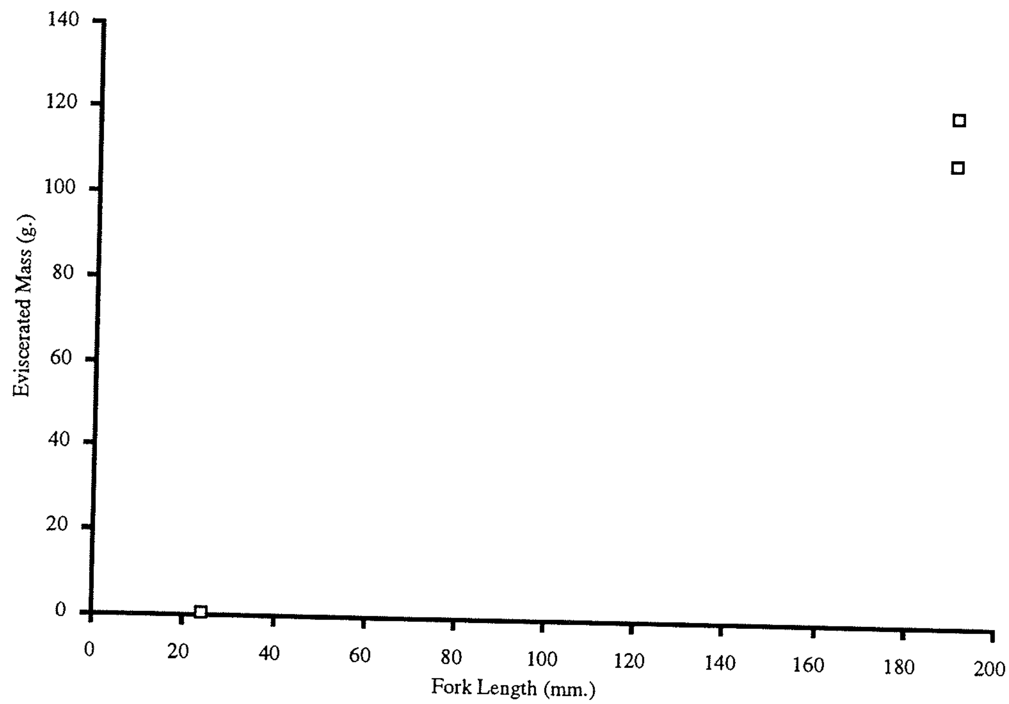


Figure 32. Scatter plot of fork length against eviscerated mass for white bass from late July collections at Hillside Beach

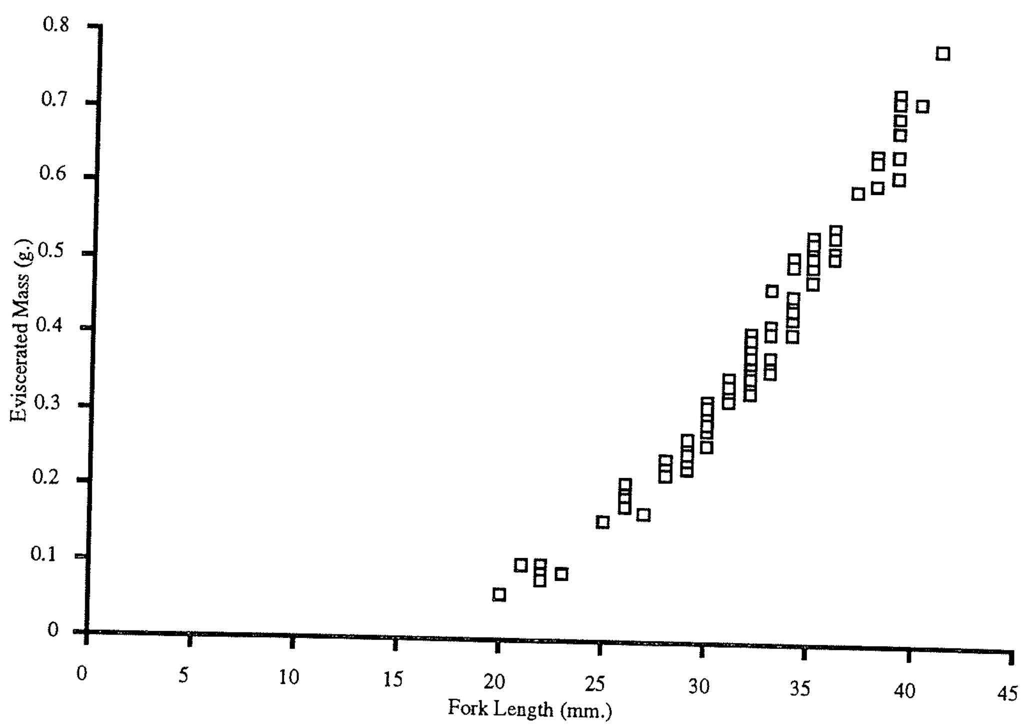


Figure 33. Scatter plot of fork length against eviscerated mass for white bass from early August collections at Hillside Beach

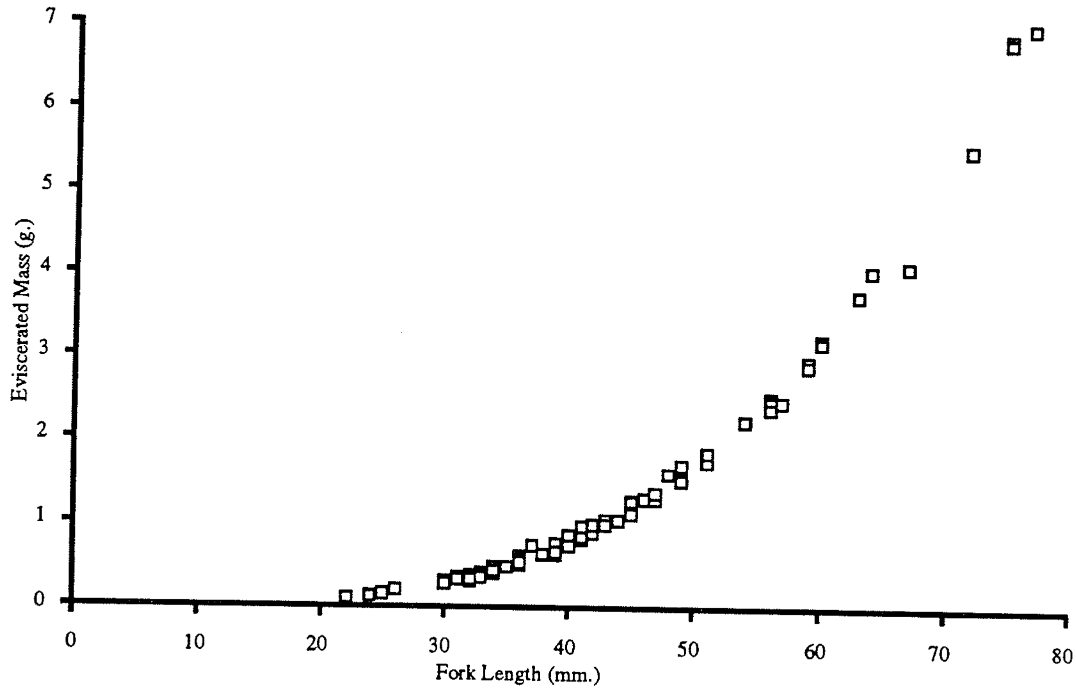


Figure 34. Scatter plot of fork length against eviscerated mass for white bass from late August collections at Hillside Beach

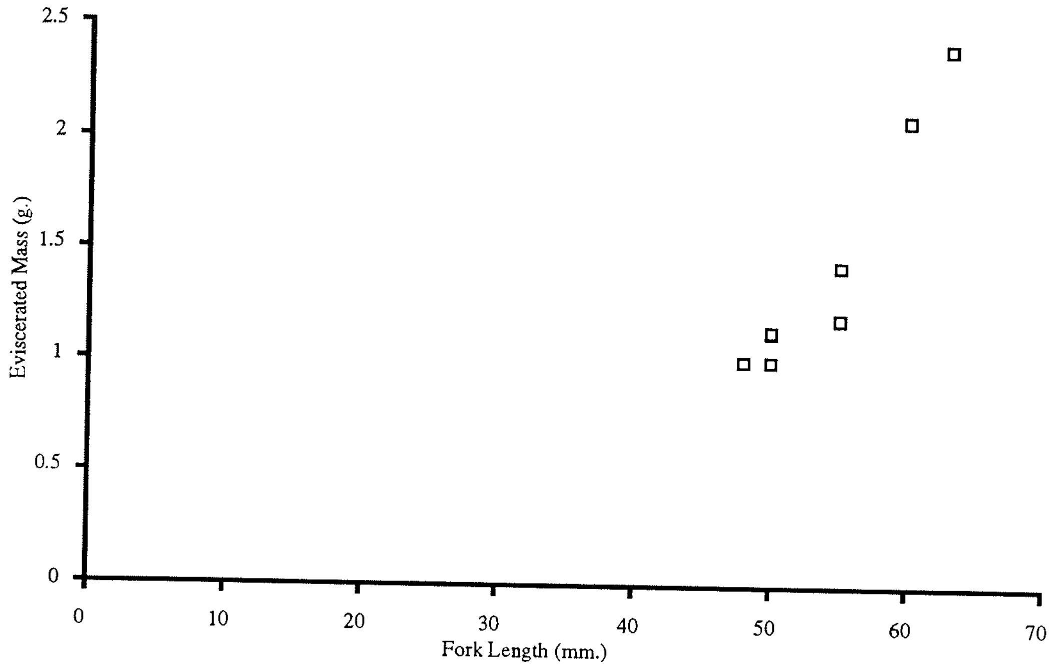


Figure 35. Scatter plot of fork length against eviscerated mass for yellow perch from early June collections at Hillside Beach

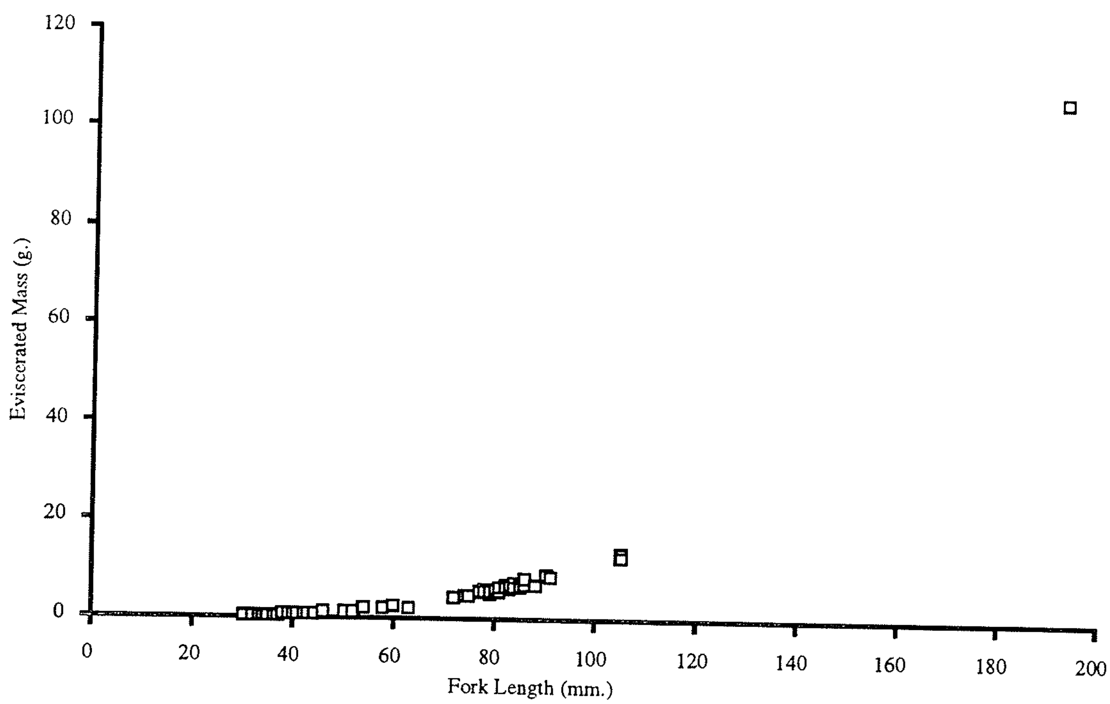


Figure 36. Scatter plot of fork length against eviscerated mass for yellow perch from late June collections at Hillside Beach

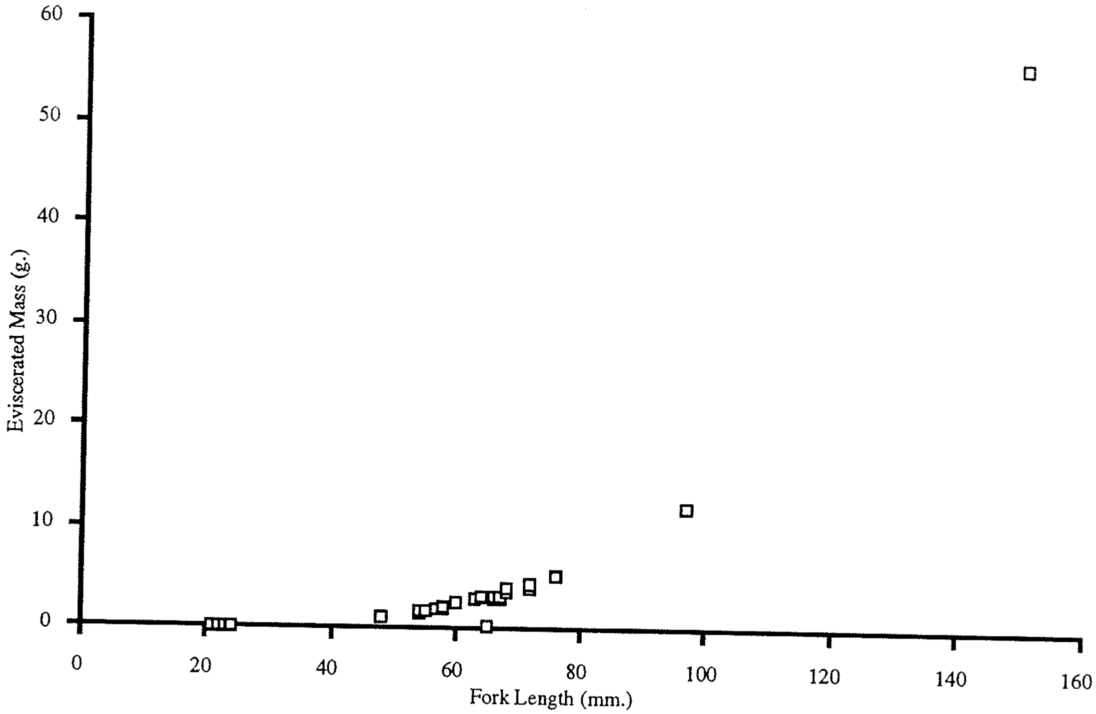


Figure 37. Scatter plot of fork length against eviscerated mass for yellow perch from early July collections at Hillside Beach

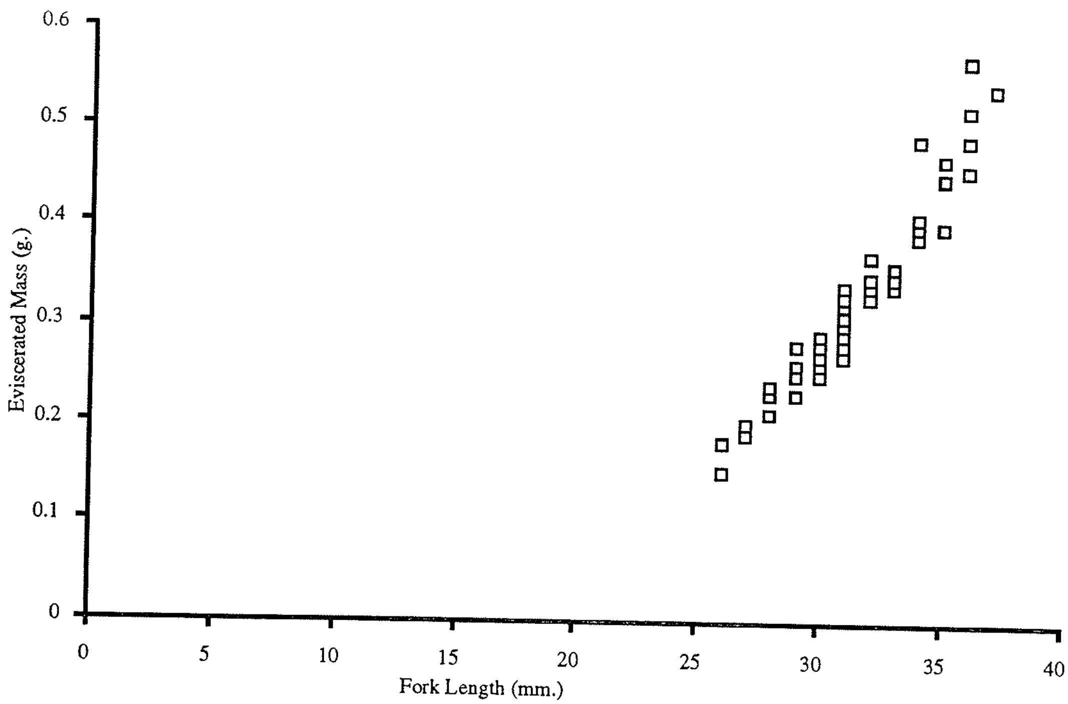


Figure 38. Scatter plot of fork length against eviscerated mass for yellow perch from late July collections at Hillside Beach

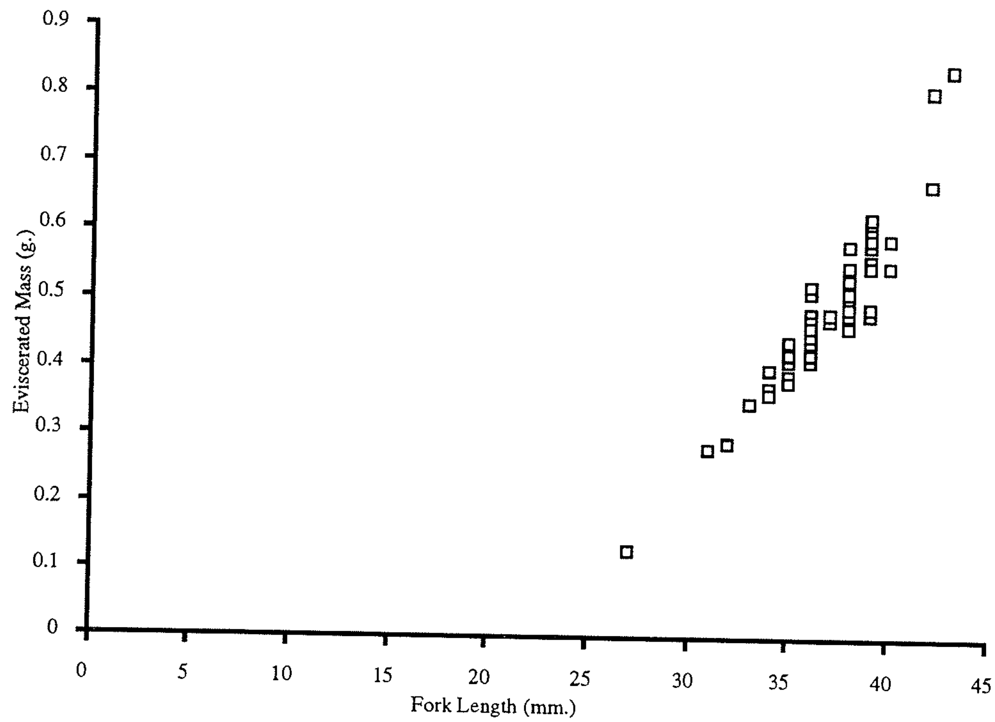


Figure 39. Scatter plot of fork length against eviscerated mass for yellow perch from early August collections at Hillside Beach

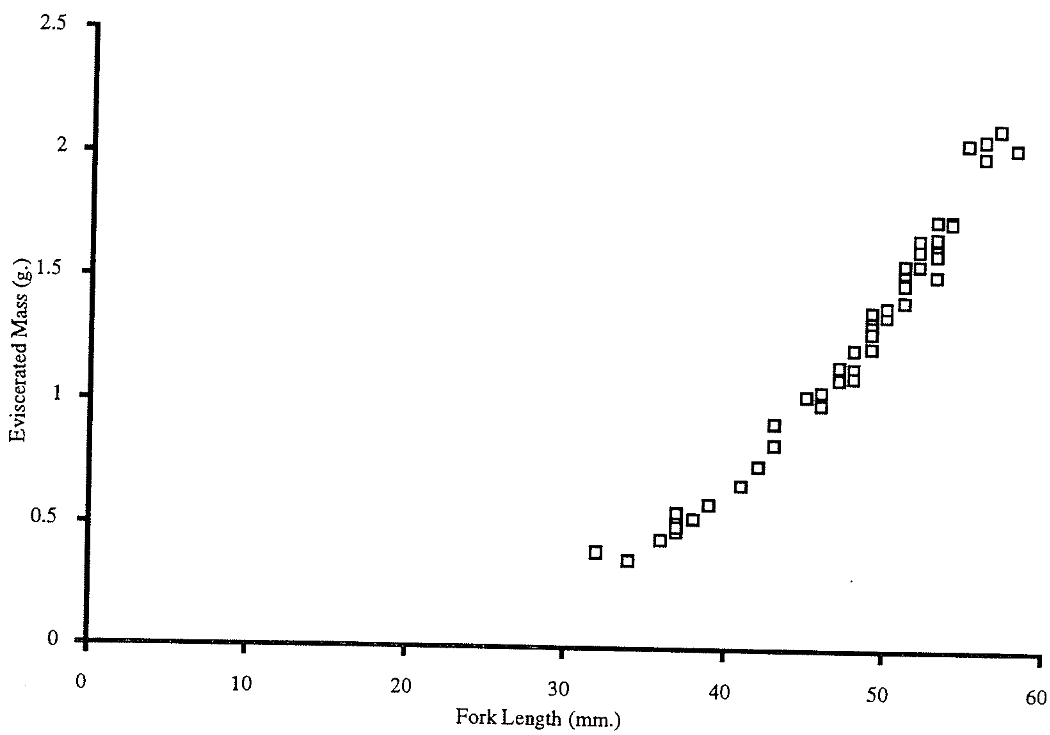


Figure 40. Scatter plot of fork length against eviscerated mass for yellow perch from late August collections at Hillside Beach

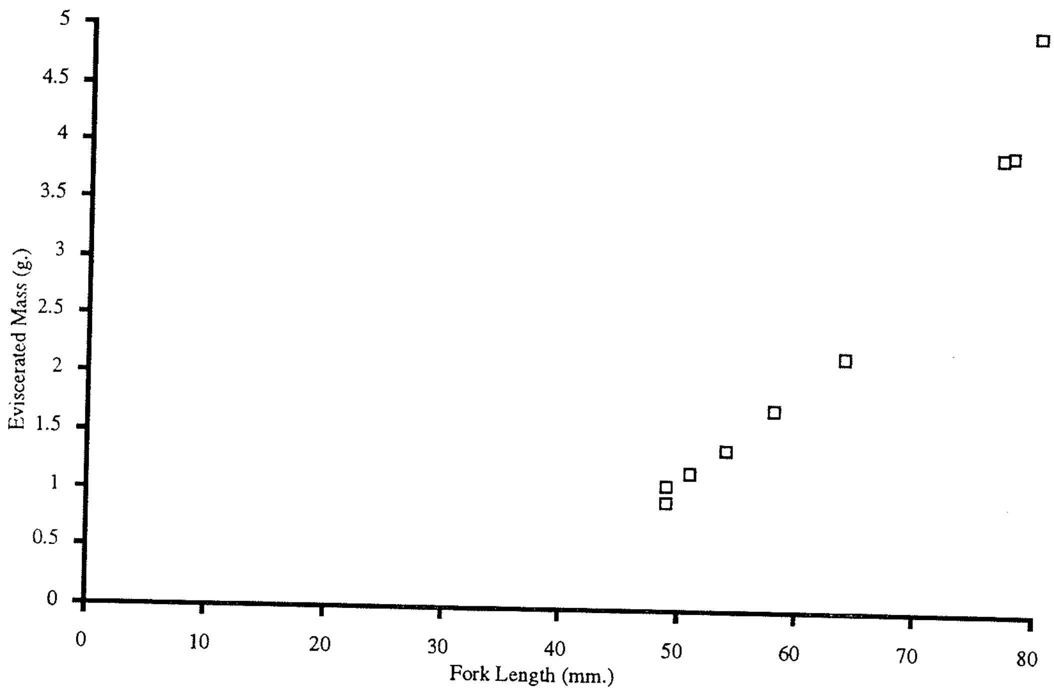


Figure 41. Scatter plot of fork length against eviscerated mass for yellow perch from September collections at Hillside Beach

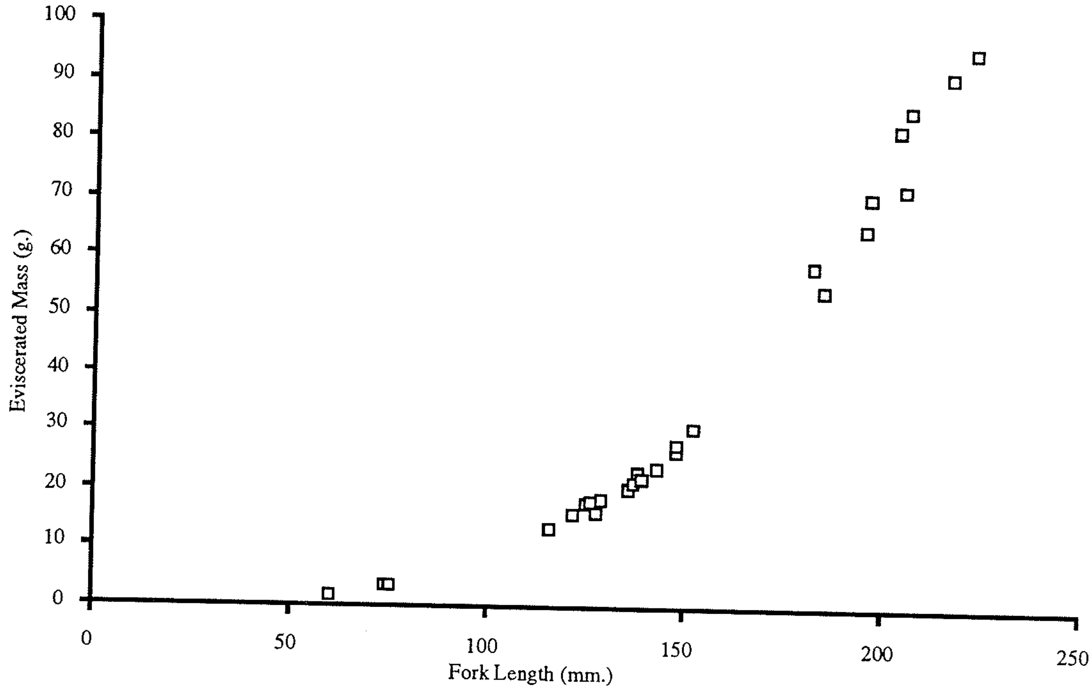


Figure 42. Scatter plot of fork length against eviscerated mass for sauger from late June collections at Hillside Beach

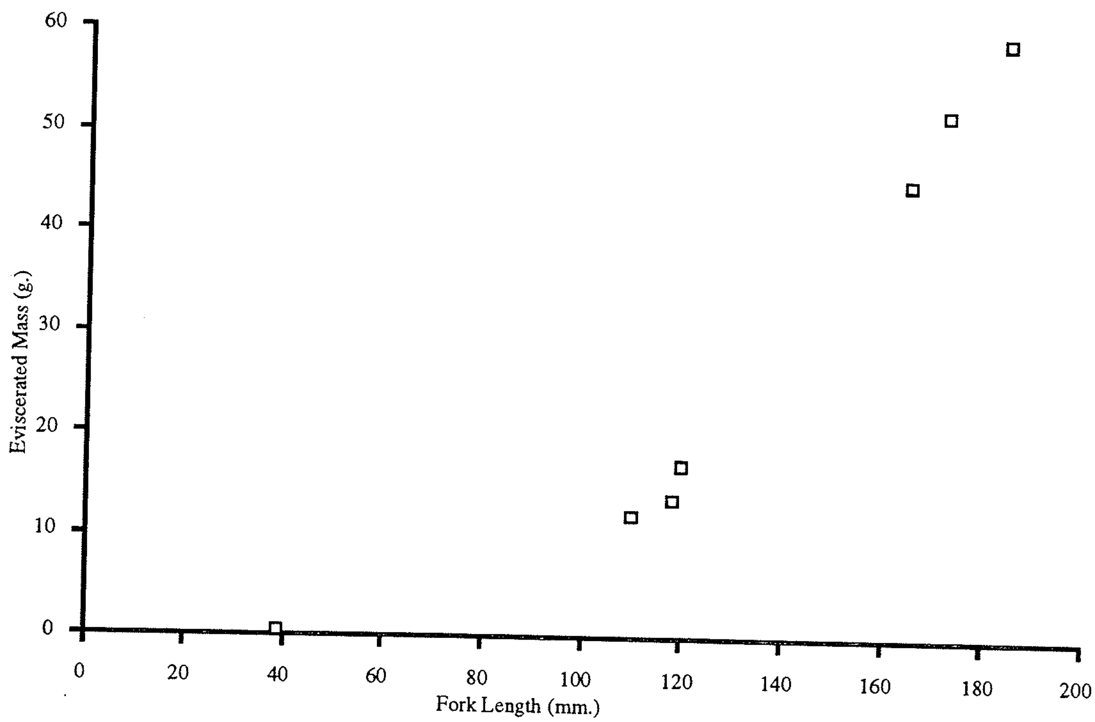


Figure 43. Scatter plot of fork length against eviscerated mass for sauger from early July collections at Hillside Beach

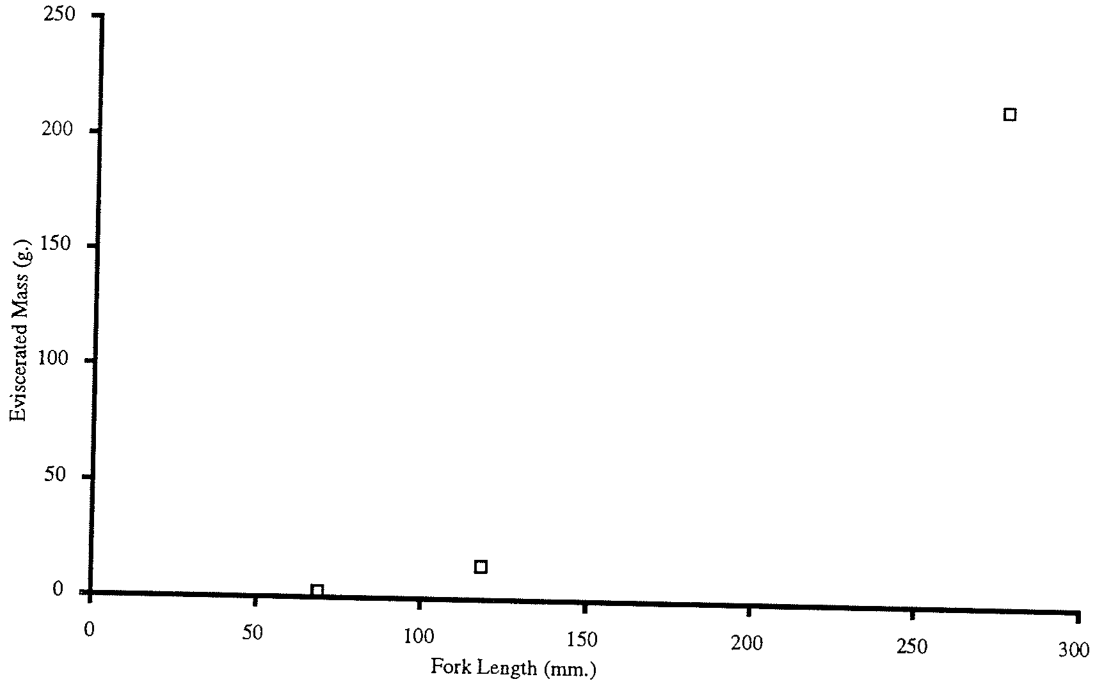


Figure 44. Scatter plot of fork length against eviscerated mass for sauger from late July collections at Hillside Beach

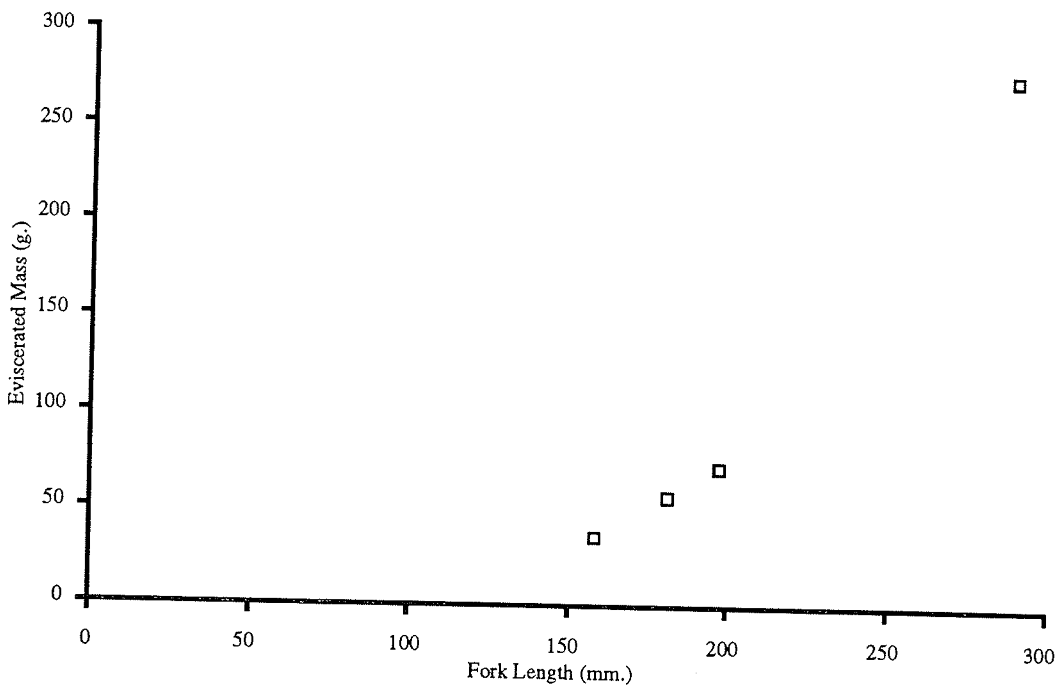


Figure 45. Scatter plot of fork length against eviscerated mass for sauger from late August collections at Hillside Beach

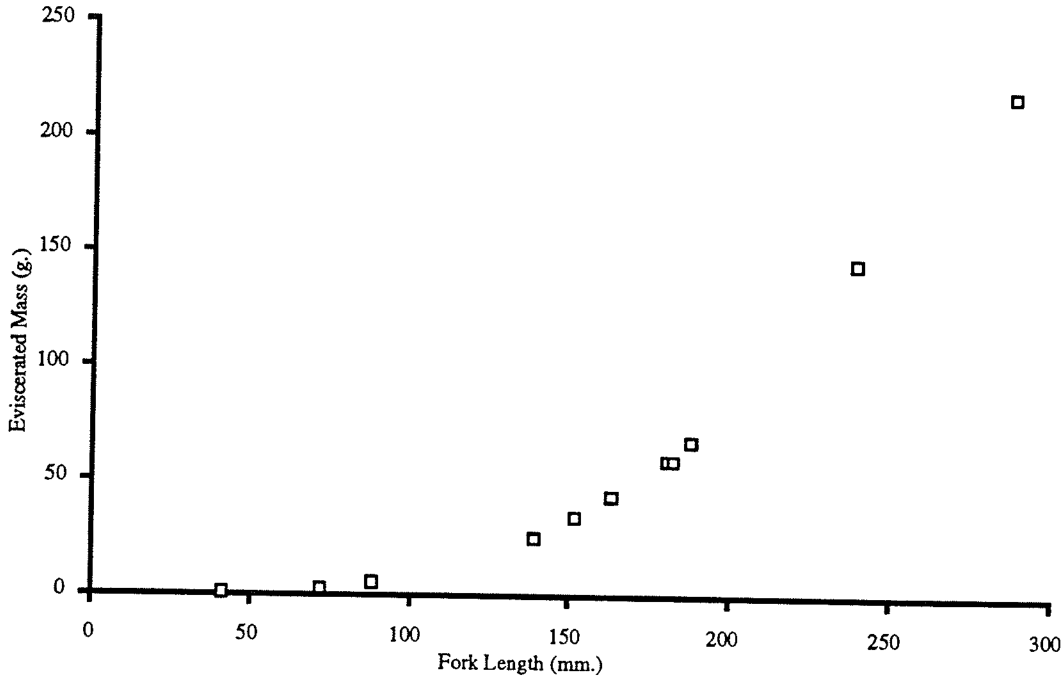


Figure 46. Scatter plot of fork length against eviscerated mass for walleye from late June collections at Hillside Beach

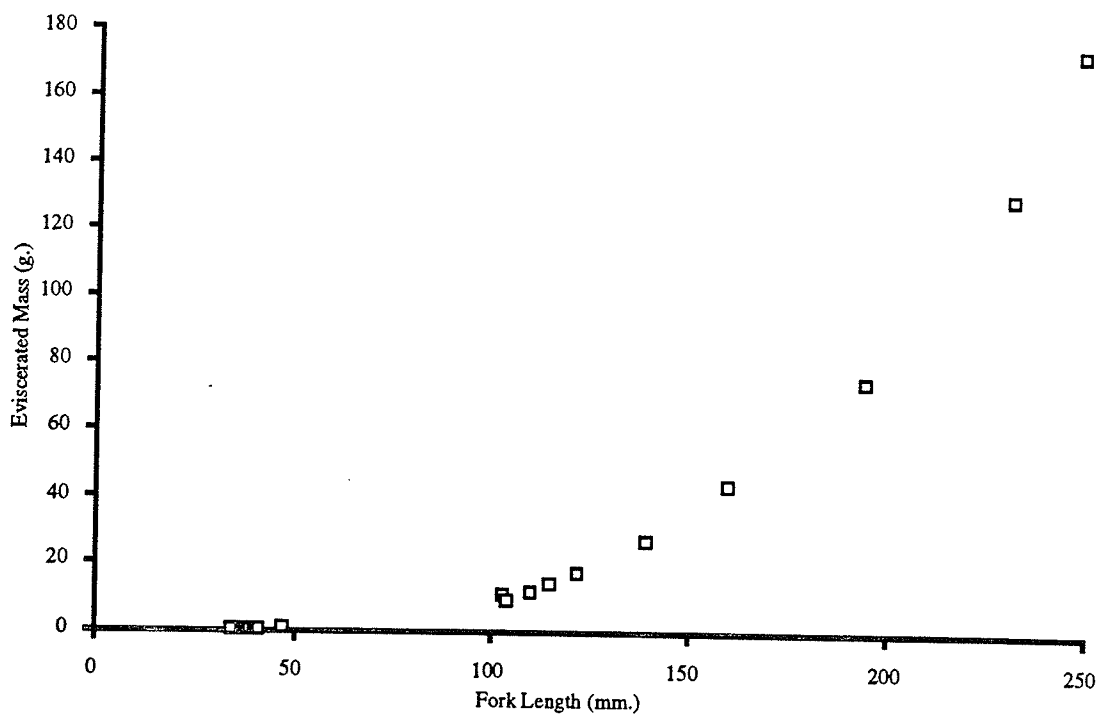


Figure 47. Scatter plot of fork length against eviscerated mass for walleye from early July collections at Hillside Beach

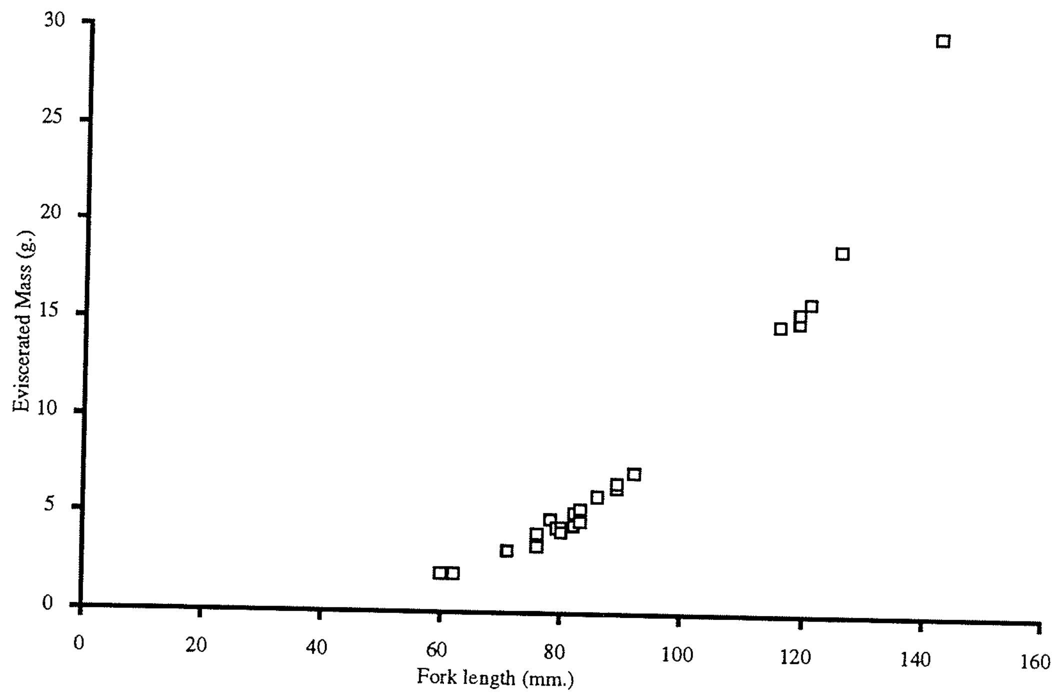


Figure 48. Scatter plot of fork length against eviscerated mass fro the goldeye from late June collections at Hillside Beach

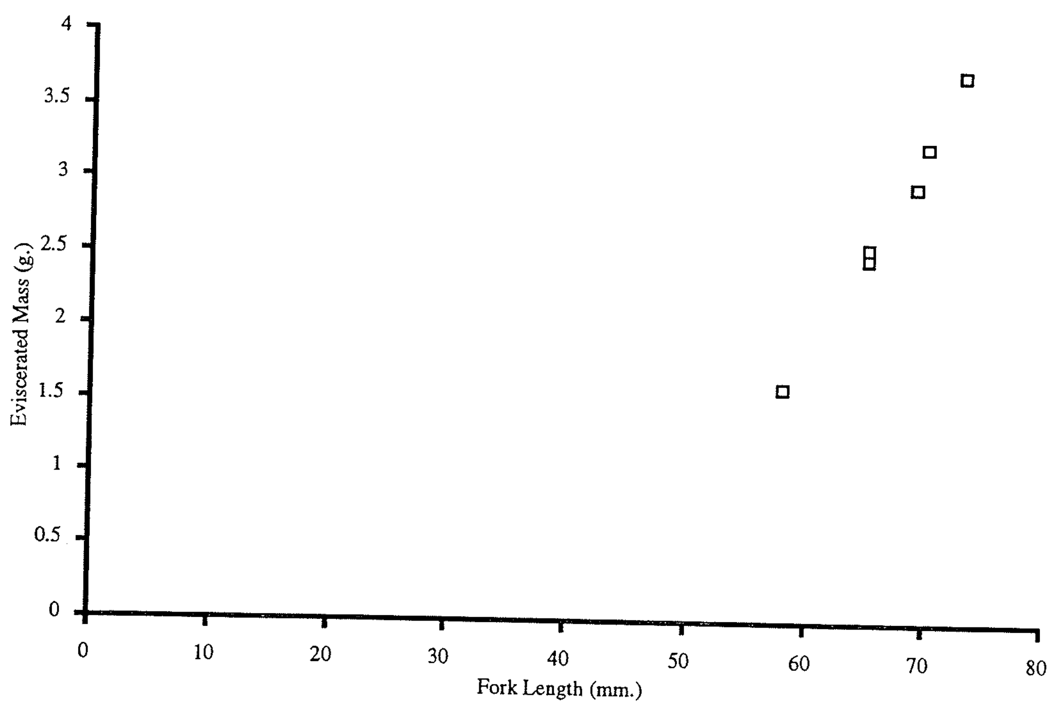


Figure 49. Scatter plot of fork length against eviscerated mass for goldeye from late August collections at Hillside Beach

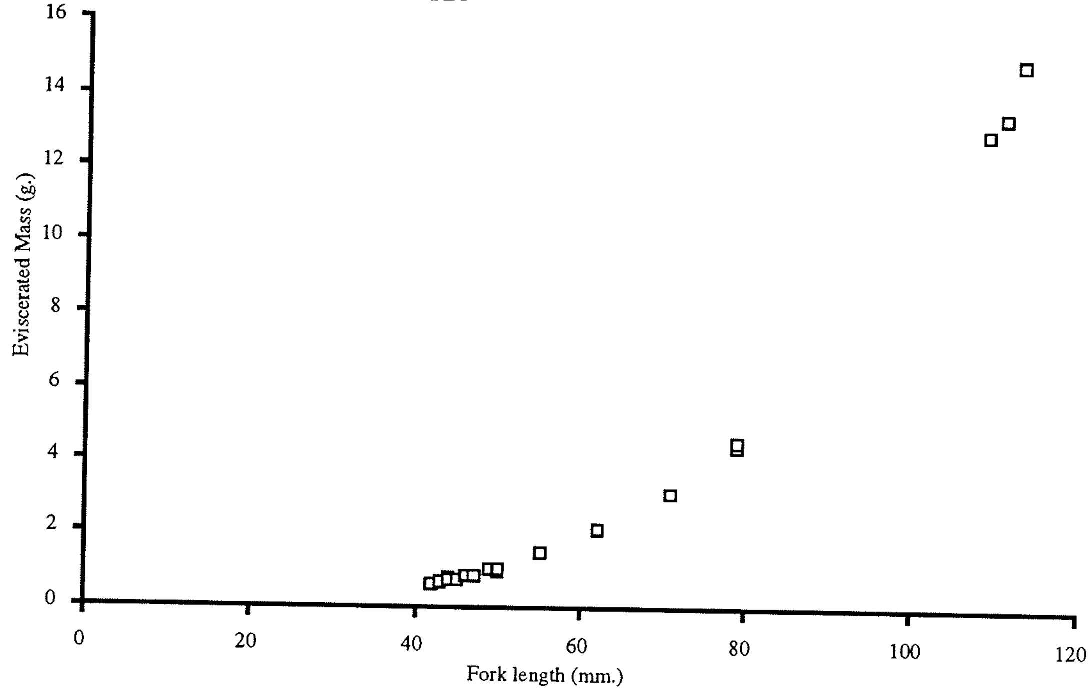


Figure 50. Scatter plot of fork length against eviscerated mass for mooneye from late June collections at Hillside Beach

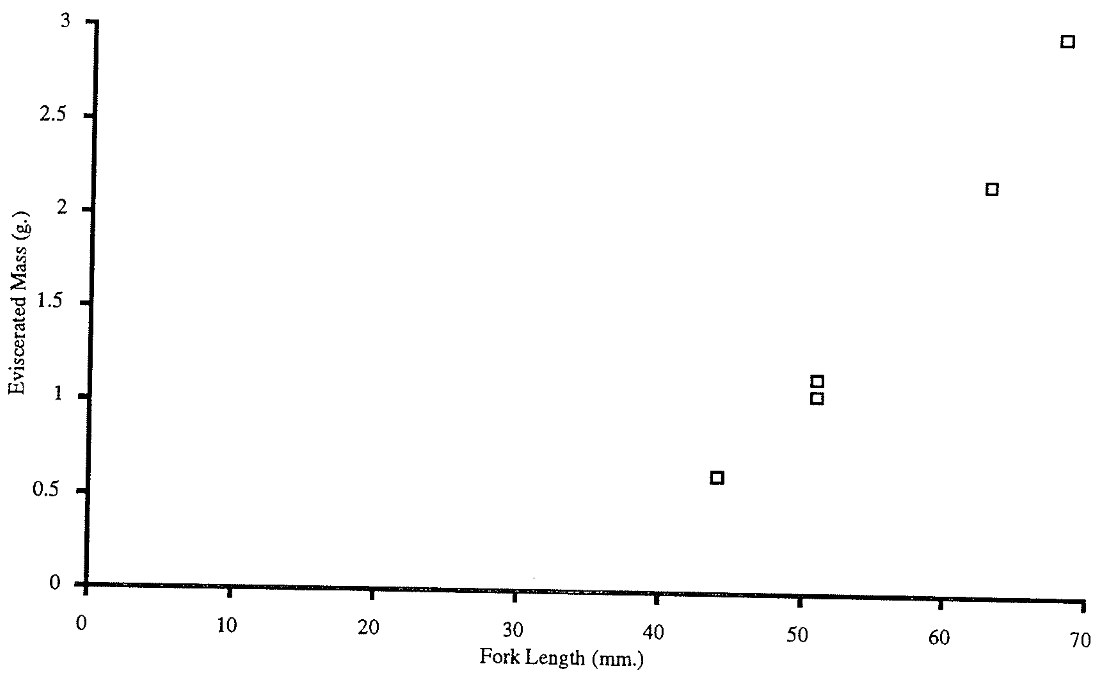


Figure 51. Scatter plot of fork length against eviscerated mass for mooneye from late August collections at Hillside Beach

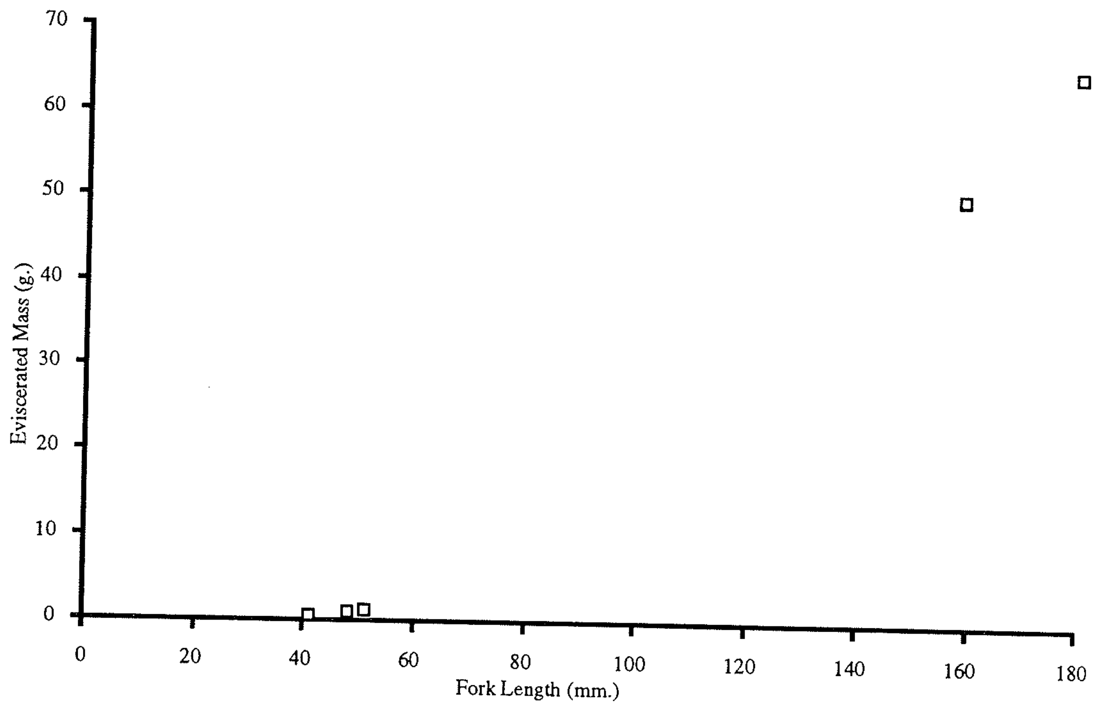


Figure 52. Scatter plot of fork length against eviscerated mass for freshwater drum in late June collections at Hillside Beach

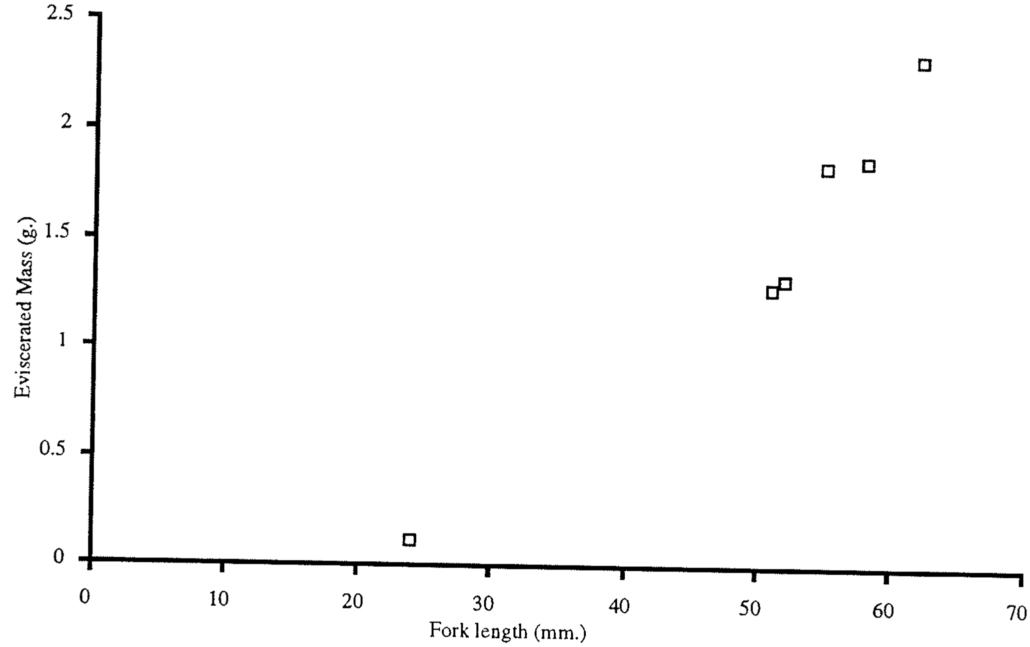


Figure 53. Scatter plot of fork length against eviscerated mass for river darters from late June collections at Hillside Beach

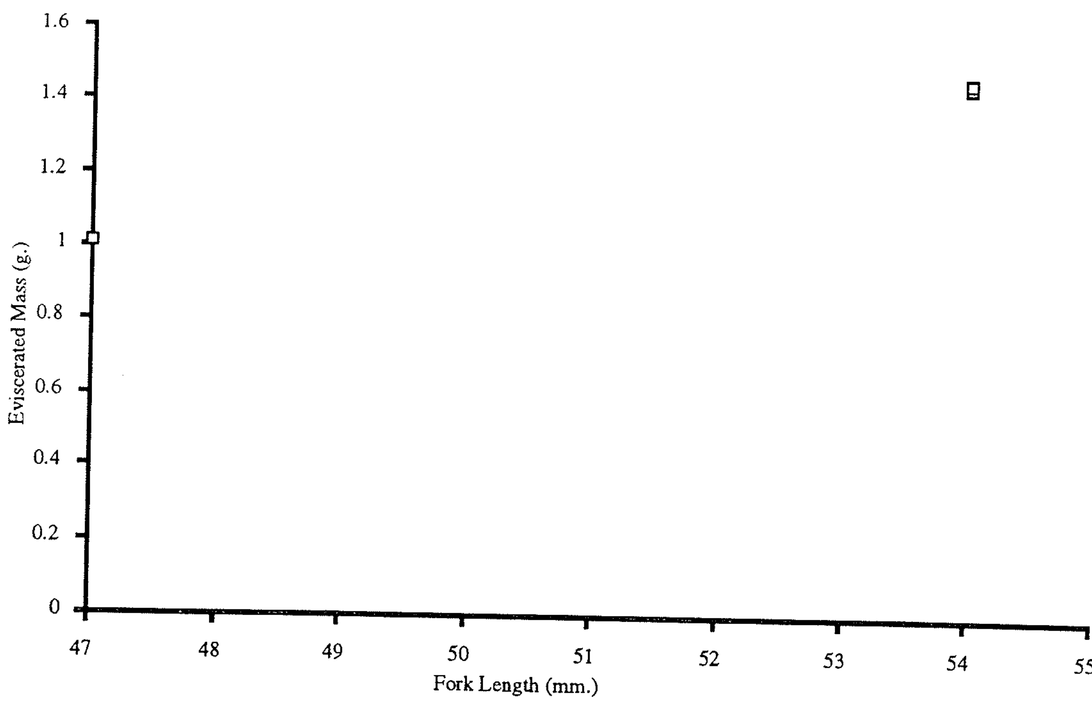


Figure 54. Scatter plot of fork length against eviscerated mass for river darters from early July at Hillside Beach

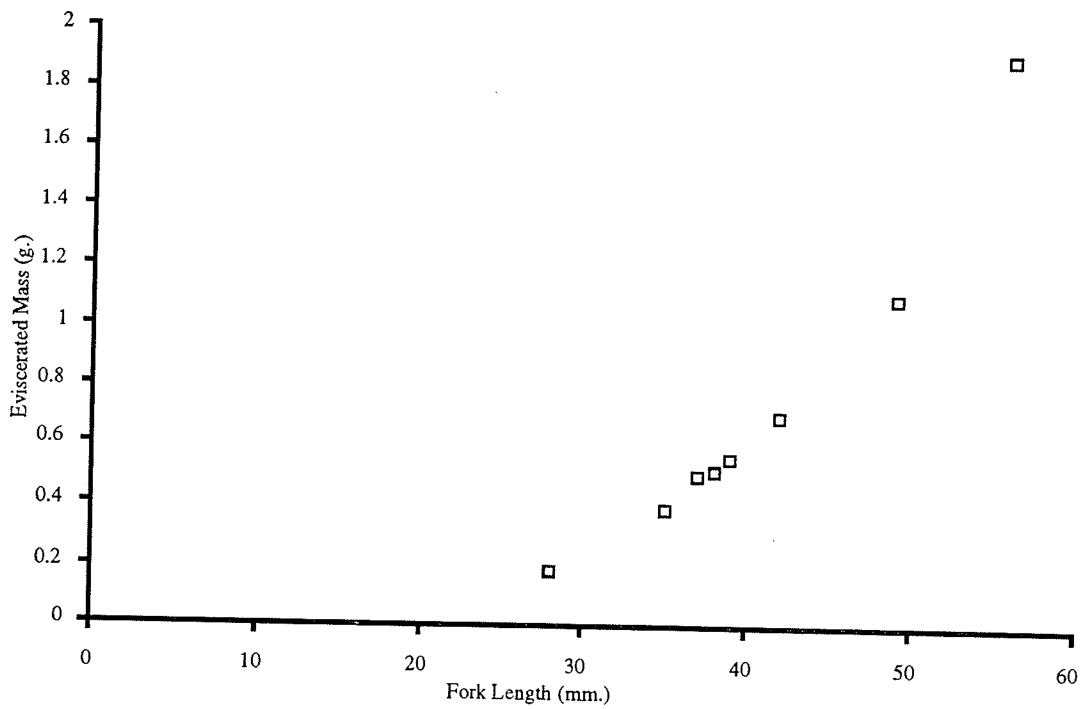


Figure 55. Scatter plot of fork length against eviscerated mass for river darters from late August collections at Hillside Beach

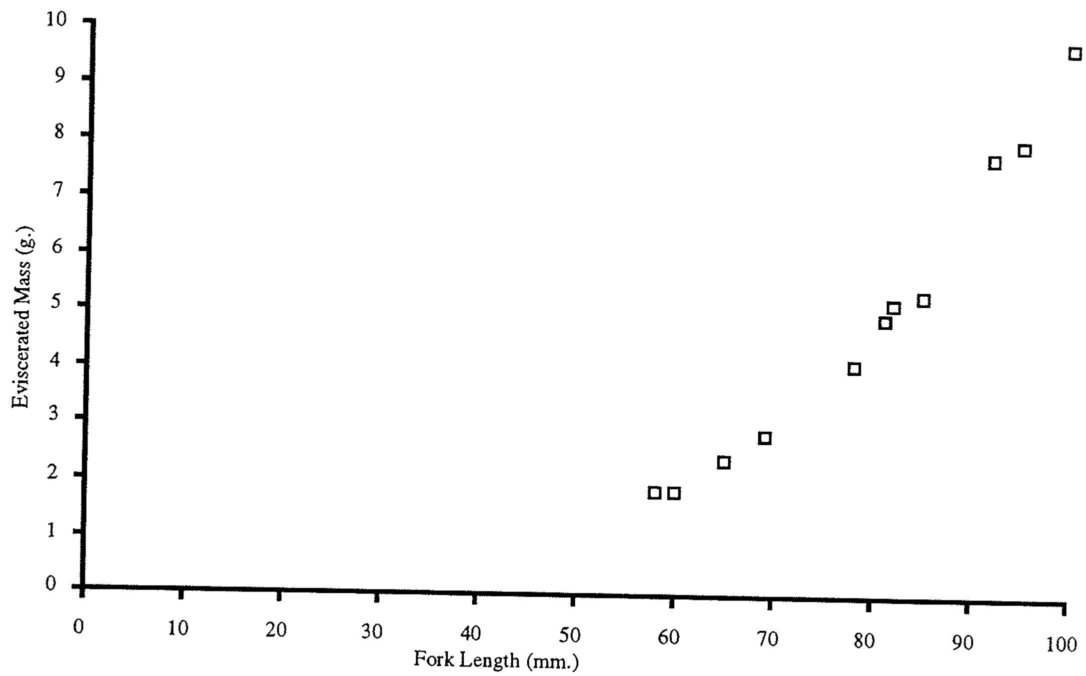


Figure 56. Scatter plot of fork length against eviscerated mass for logperch collected from late June collections at Hillside Beach

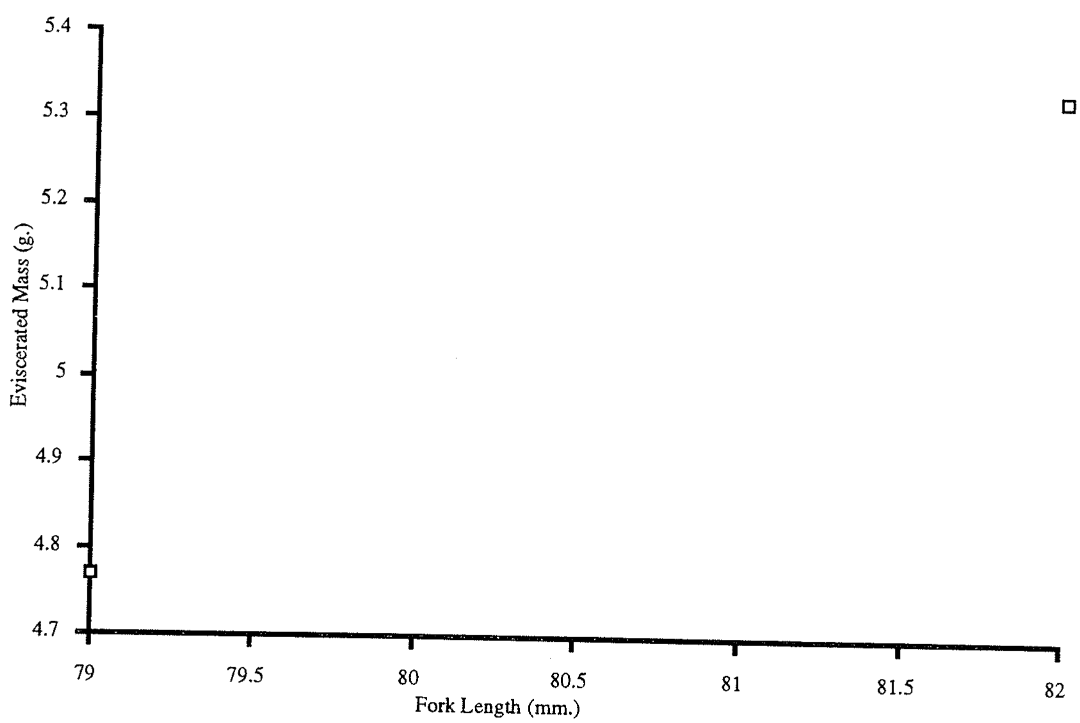


Figure 57. Scatter plot of fork length against eviscerated mass for logperch collected from early July collections at Hillside Beach

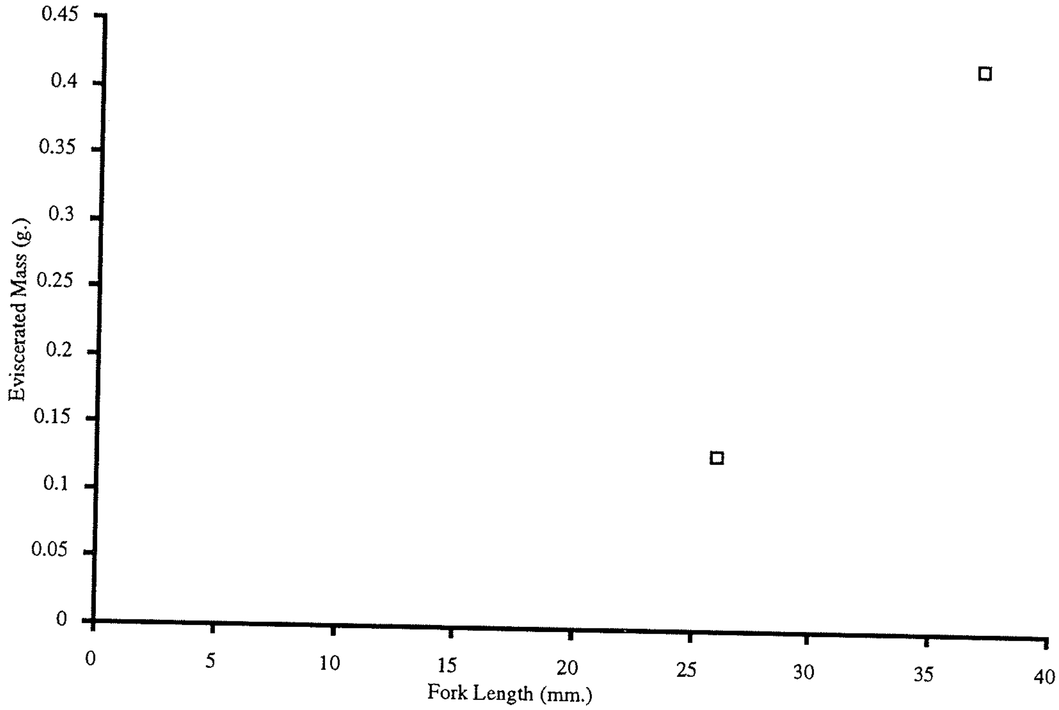


Figure 58. Scatter plot of fork length against eviscerated mass for logperch collected from early August collections at Hillside Beach

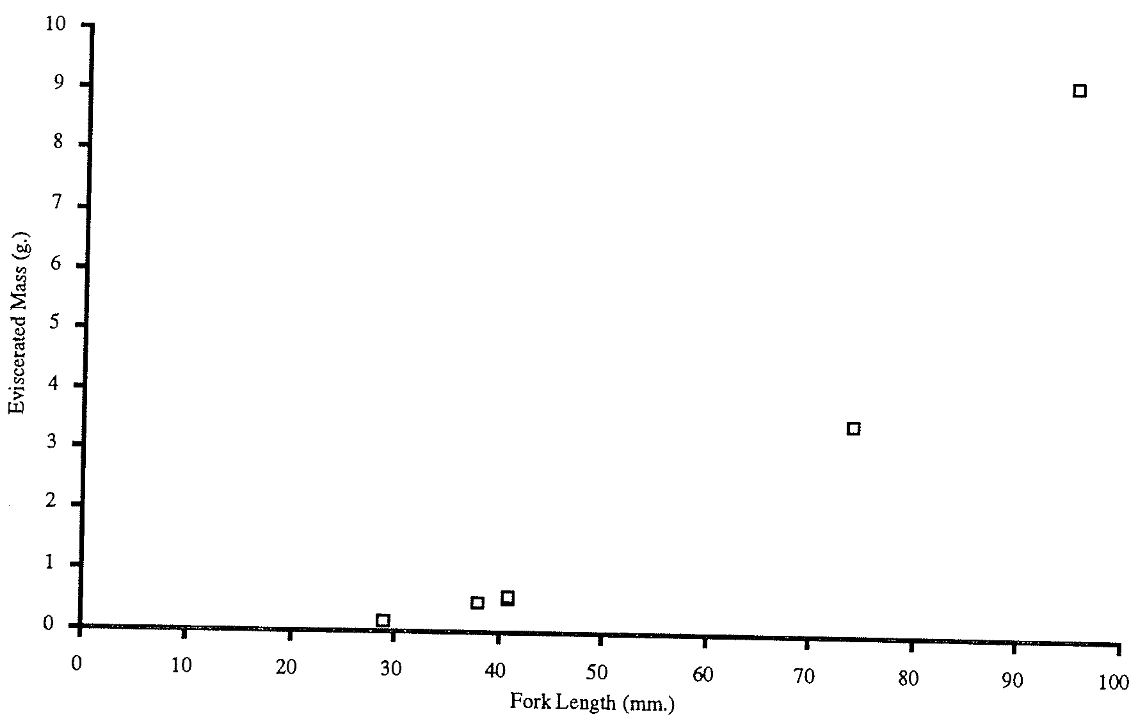


Figure 59. Scatter plot of fork length against eviscerated mass for logperch collected from late August collections at Hillside Beach

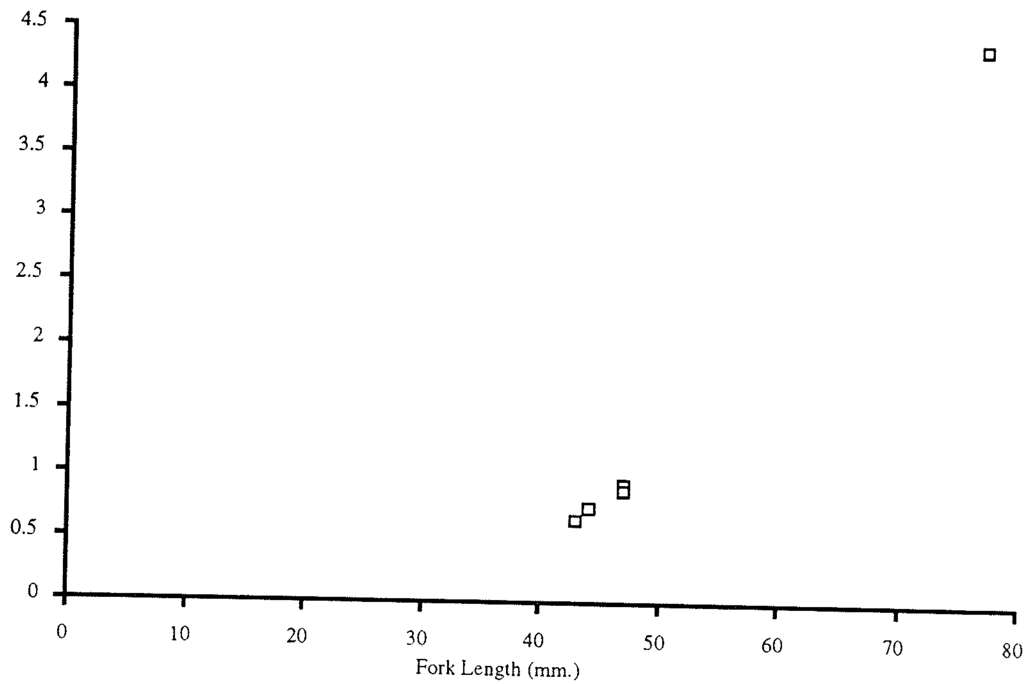


Figure 60. Scatter plot of fork length against eviscerated mass for logperch collected from September collections at Hillside Beach

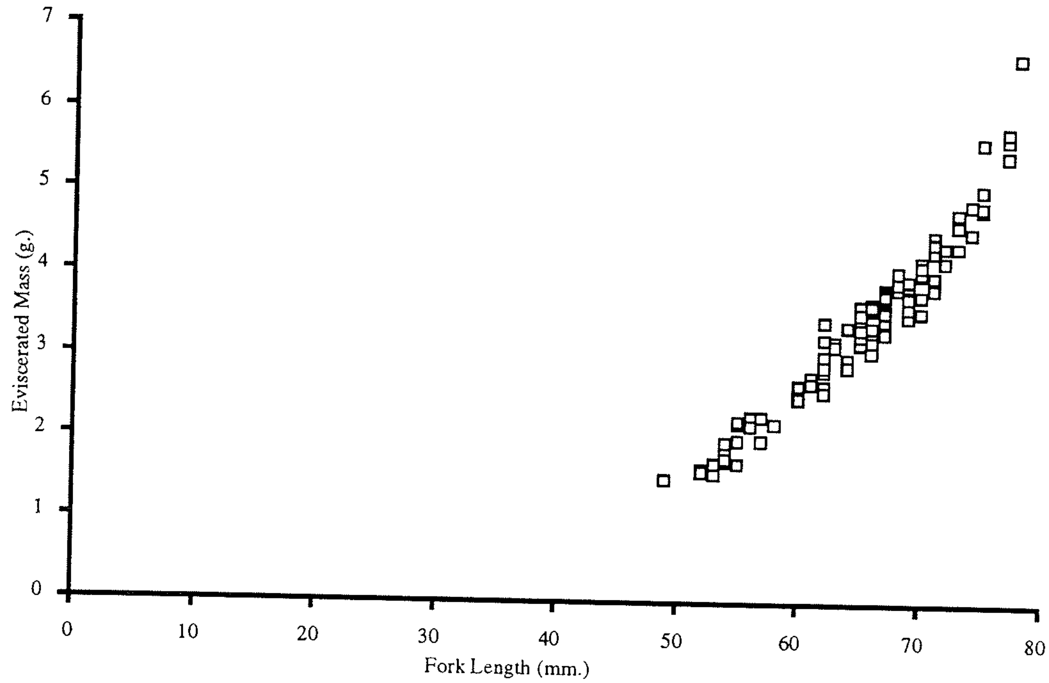


Figure 61. Scatter plot of fork length against eviscerated mass for troutperch from late June collections at Hillside Beach

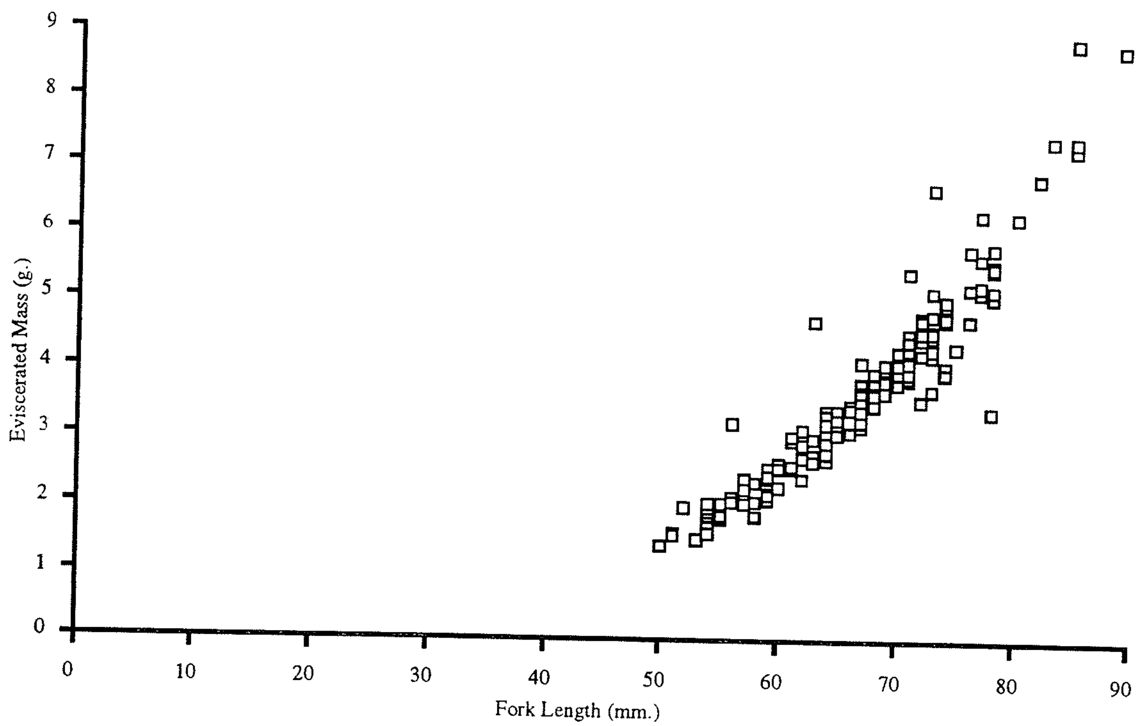


Figure 62. Scatter plot of fork length against eviscerated mass for troutperch from early July collections at Hillside Beach

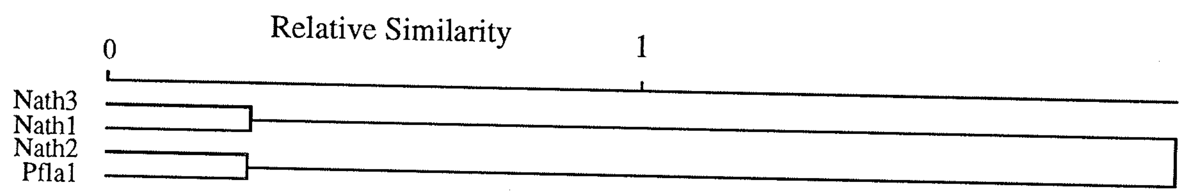
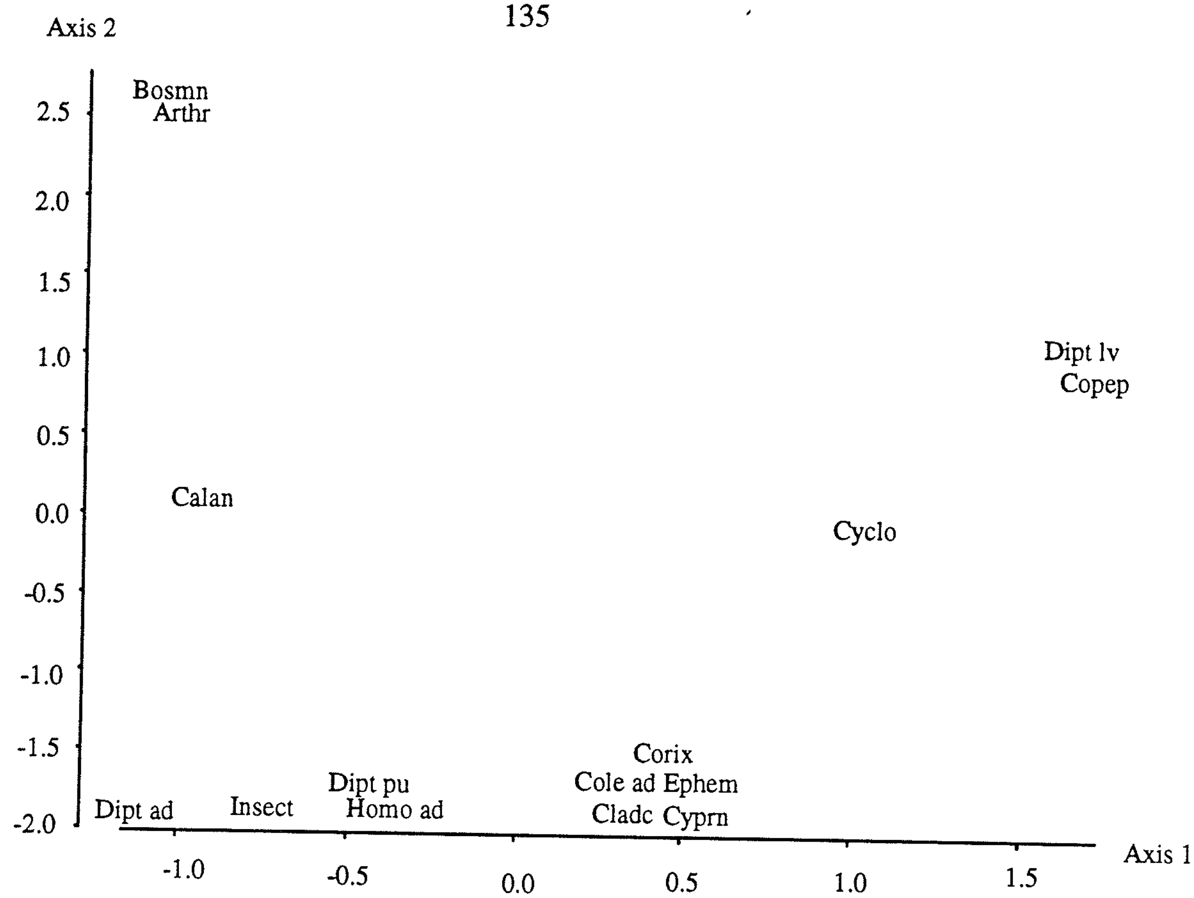


Figure 63. Cluster analysis fishes based on diet from early June at Hillside Beach, Pflav1 = *Perca flavescens* (48-63 mm.), Nath1 = *Notropis atherinoides* (23-36 mm.), Nath2 = *Notropis atherinoides* (43-53 mm.), Nath3 = *Notropis atherinoides* (55-71 mm.)

Figure 64. Axes 1 and 2 from correspondence analysis of early June fishes at Hillside beach, A) ordination of fish, Pflav1 = *Perca flavescens* (48-63 mm.), Nath1 = *Notropis atherinoides* (23-36 mm.), Nath2 = *Notropis atherinoides* (43-53 mm.), Nath3 = *Notropis atherinoides* (55-71 mm.), B) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Calan = Calanoid copepods, Cyclo = Cyclopid copepods, Copep = unidentifiable copepods, Corix = Corixid adult, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole ad = Coleoptera adult, Homo ad = Homoptera adult, Insect = unidentifiable insect, Arthr = Ostracod, Cyprn = Cyprinid fish.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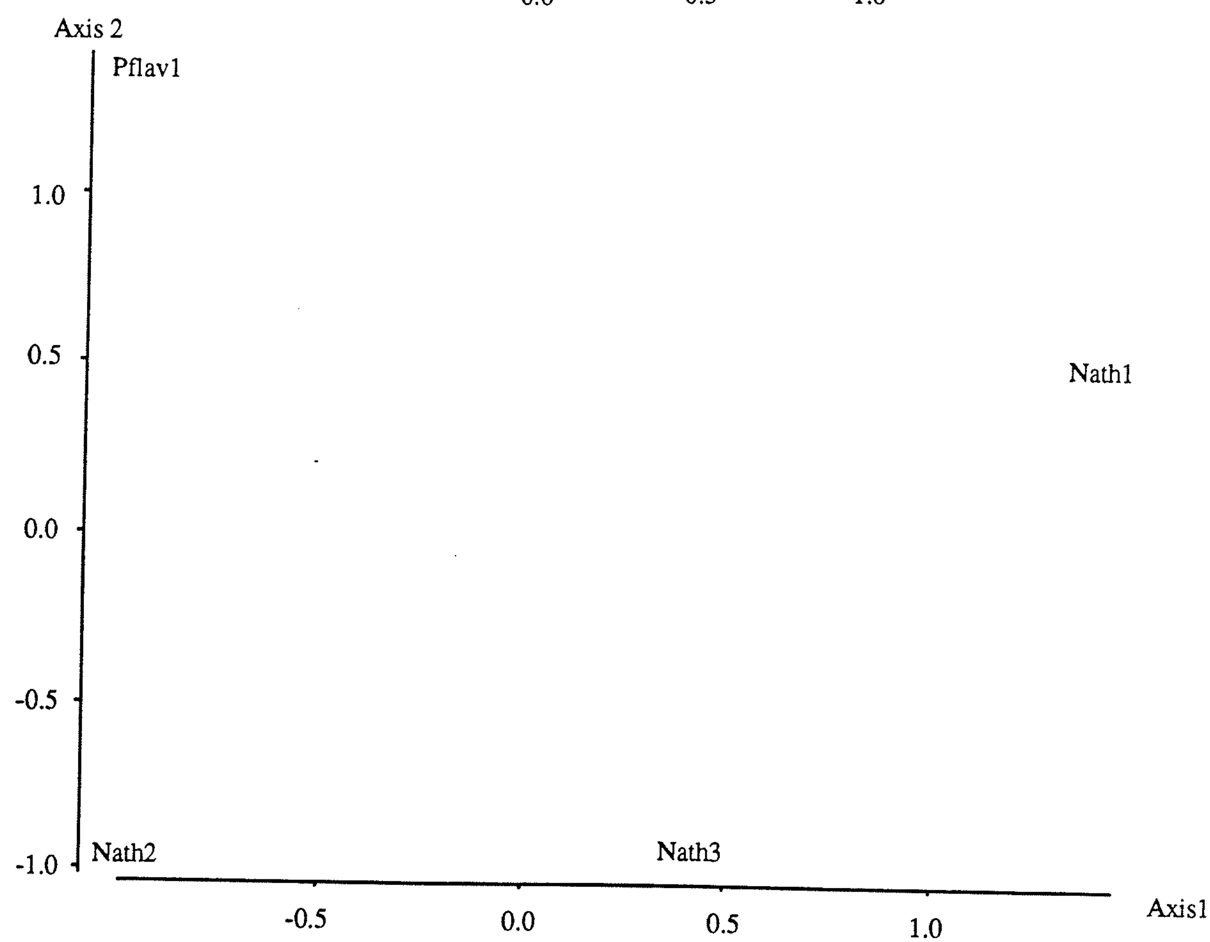
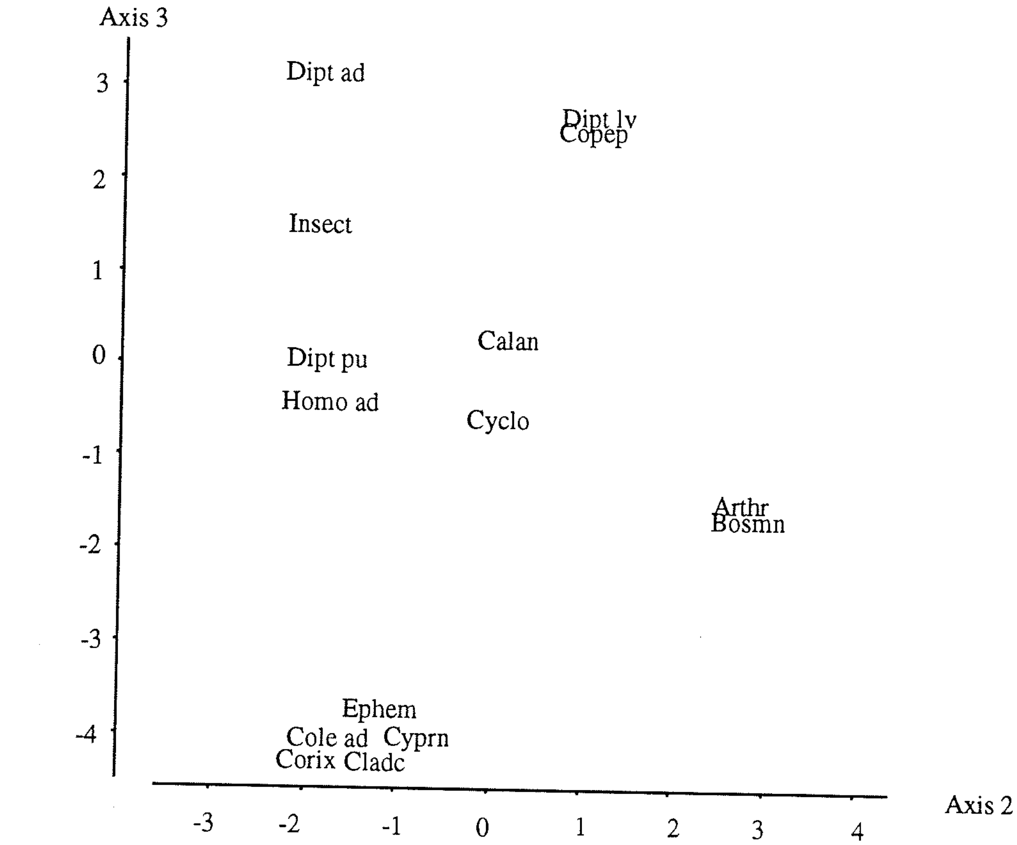
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Bosmn
Arthr
Dipt lv
Copep
Calan
Cyclo
Corix
Dipt pu
Cole ad Ephem
Dipt ad
Insect
Homo ad
Cladc Cyprn
-1.0
-0.5
0.0
0.5
1.0
1.5
Axis 1

A)

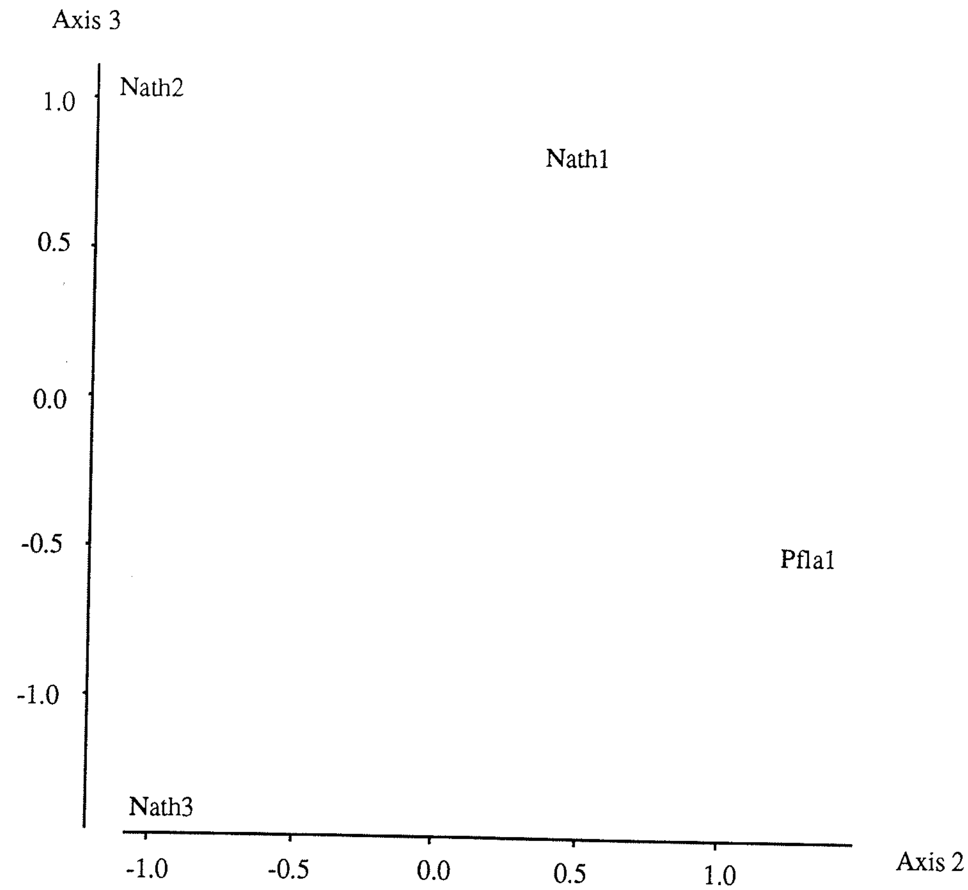

Axis 2
Pflav1
1.0
0.5
0.0
-0.5
-1.0
Nath1
Nath2
Nath3
-0.5
0.0
0.5
1.0
Axis1

B)

Figure 65 Axes 2 and 3 from correspondence analysis of early June fishes at Hillside beach, A) ordination of fish, Pflav1 = *Perca flavescens* (48-63 mm.), Nath1 = *Notropis atherinoides* (23-36 mm.), Nath2 = *Notropis atherinoides* (43-53 mm.), Nath3 = *Notropis atherinoides* (55-71 mm.), B) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Calan = Calanoid copepods, Cyclo = Cyclopid copepods, Copep = unidentifiable copepods, Corix = Corixid adult, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole ad = Coleoptera adult, Homo ad = Homoptera adult, Insect = unidentifiable insect, Arthr = Ostracod, Cyprn = Cyprinid fish.


Axis 3
3
2
1
0
-1
-2
-3
-4
Dipt ad
Dipt lv
Copep
Insect
Calan
Dipt pu
Homo ad
Cyclo
Arthr
Bosmn
Ephem
Cole ad
Cyprn
Corix
Cladc
-3
-2
-1
0
1
2
3
4
Axis 2

A)


Axis 3
1.0
0.5
0.0
-0.5
-1.0
Nath2
Nath1
Pfla1
Nath3
-1.0
-0.5
0.0
0.5
1.0
Axis 2

B)

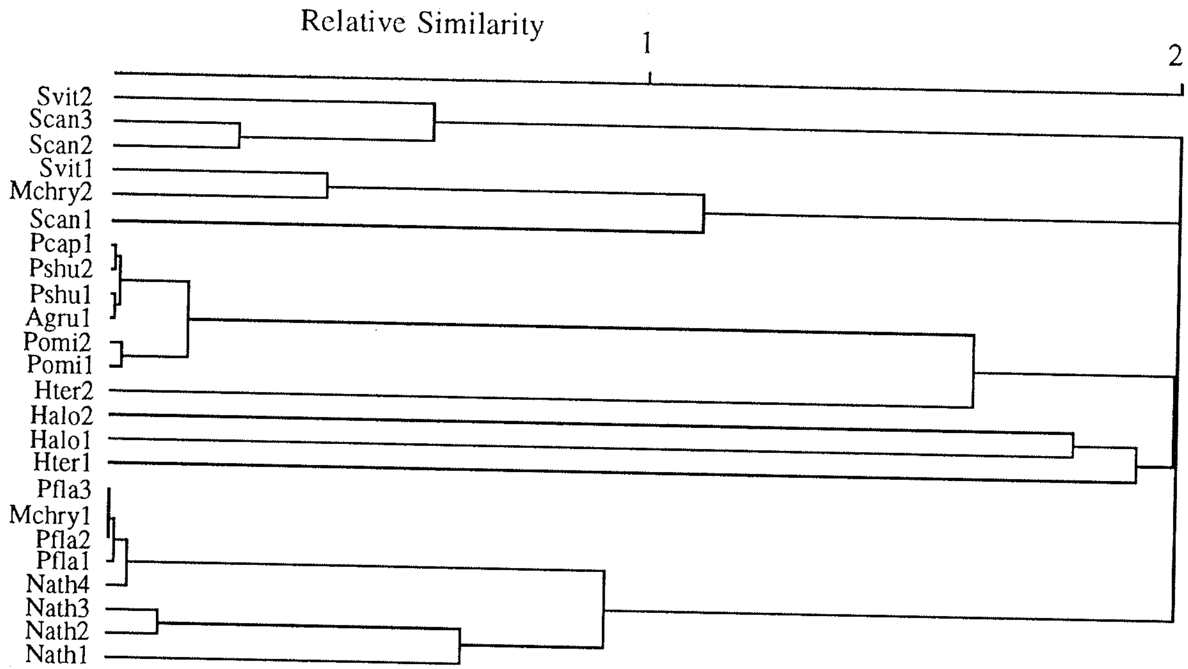
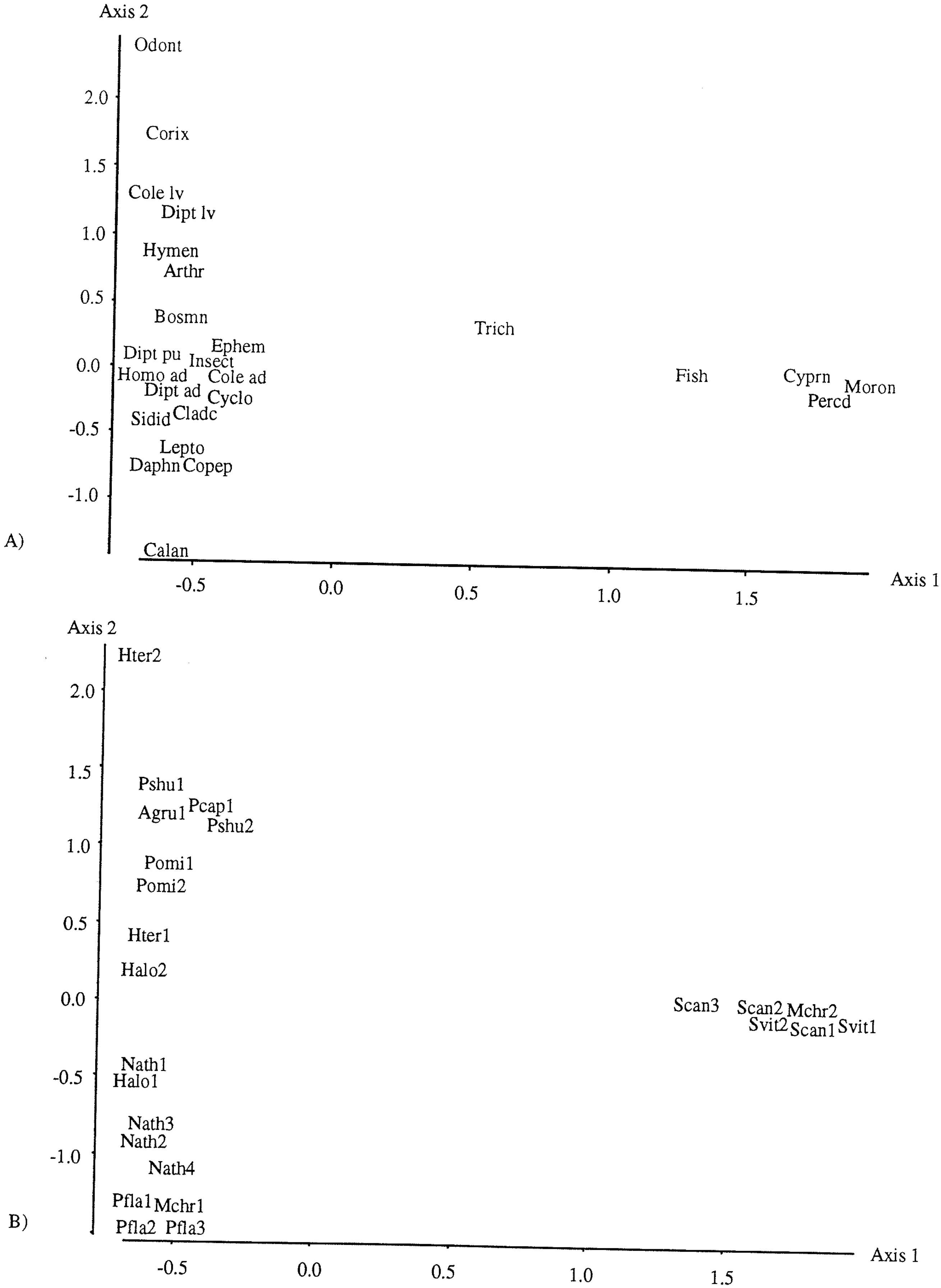


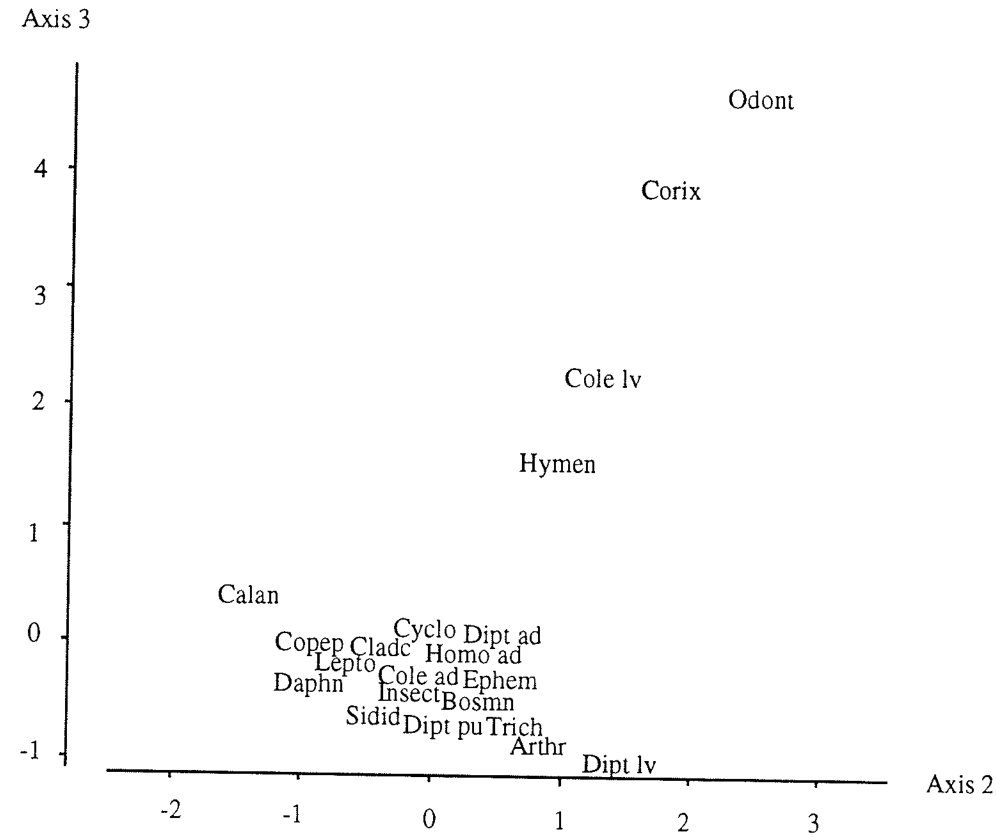
Figure 66. Results of cluster analysis of late June fish diets from Hillside Beach, Agrun1 = *Aplodinotus grunniens* (41-51 mm.), Pcapr1 = *Percina caprodes* (58-100 mm.), Hterg1 = *Hiodon tergisus* (42-79 mm.), Hterg2 = *H. tergisus* (109-113 mm.), Halos1 = *H. alosoides* (60-92 mm.), Halos2 = *H. alosoides* (116-142 mm.), Pomis1 = *Percopsis omiscomaycus* (49-58 mm.), Pomis2 = *P. omiscomaycus* (60-78 mm.), Pflav1 = *Perca flavescens* (30-63 mm.), Pflav2 = *P. flavescens* (72-91 mm.), Pflav3 = *P. flavescens* (105-193 mm.), Mchry1 = *Morone chrysops* (22-47 mm.), Mchry2 = *M. chrysops* (252 mm.), Nathr1 = *Notropis atherinoides* (19-32 mm.), Nathr2 = *N. atherinoides* (33-51 mm.), Nathr3 = *N. atherinoides* (52-72 mm.), Nathr4 = *N. atherinoides* (73-86 mm.), Pshum1 = *Percina shumardi* (24 mm.), Pshum2 = *P. shumardi* (51-62 mm.), Svitr1 = *Stizostedion vitreum* (41-48 mm.), Svitr2 = *S. vitreum* (138-288 mm.), Scana1 = *S. canadense* (60-75 mm.), Scana2 = *S. canadense* (116-152 mm.), Scana3 = *S. canadense* (182-206 mm.), Scana4 = *S. canadense* (216-222 mm.)

Figure 67. Axes 1 and 2 from correspondence analysis of late June fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Sidid = Sididae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Corix = Corixidae adult, Trich = Trichoptera larvae, Odont = Odonata nymph, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Arthr = Ostracods, Moron = Moronidae, Cyprn = Cyprinidae, Percid = Percidae, Fish egg = unidentified fish and B) symmetrical ordination of fish size groups, Agrun1 = *Aplodinotus grunniens* (41-51 mm.), Pcapr1 = *Percina caprodes* (58-100 mm.), Hterg1 = *Hiodon tergisus* (42-79 mm.), Hterg2 = *H. tergisus* (109-113 mm.), Halos1 = *H. alosoides* (60-92 mm.), Halos2 = *H. alosoides* (116-142 mm.), Pomis1 = *Percopsis omiscomaycus* (49-58 mm.), Pomis2 = *P. omiscomaycus* (60-78 mm.), Pflav1 = *Perca flavescens* (30-63 mm.), Pflav2 = *P. flavescens* (72-91 mm.), Pflav3 = *P. flavescens* (105-193 mm.), Mchry1 = *Morone chrysops* (22-47 mm.), Mchry2 = *M. chrysops* (252 mm.), Nathr1 = *Notropis atherinoides* (19-32 mm.), Nathr2 = *N. atherinoides* (33-51 mm.), Nathr3 = *N. atherinoides* (52-72 mm.), Nathr4 = *N. atherinoides* (73-86 mm.), Pshum1 = *Percina shumardi* (24 mm.), Pshum2 = *P. shumardi* (51-62 mm.), Svitr1 = *Stizostedion vitreum* (41-48 mm.), Svitr2 = *S. vitreum* (138-288 mm.), Scana1 = *S. canadense* (60-75 mm.), Scana2 = *S. canadense* (116-152 mm.), Scana3 = *S. canadense* (182-206 mm.), Scana4 = *S. canadense* (216-222 mm.)

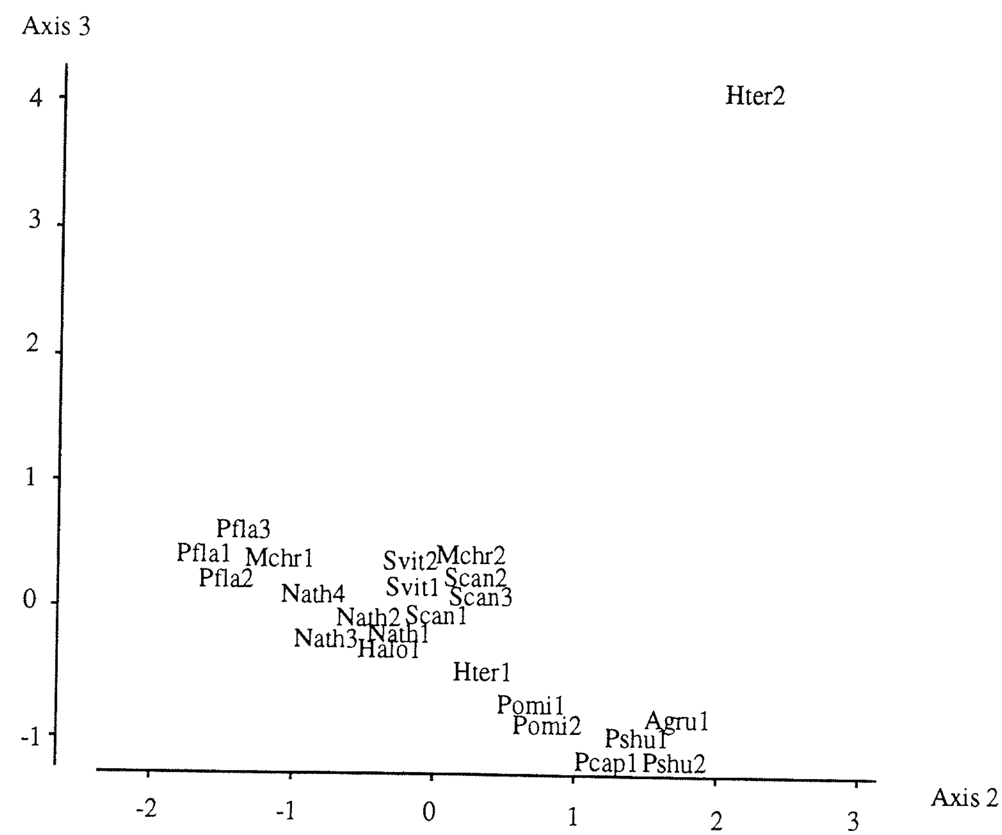


Axis 2
Odont
2.0
Corix
1.5
Cole lv
Dipt lv
1.0
Hymen
Arthr
0.5
Bosmn
Trich
Dipt pu
Ephem
Insect
0.0
Homo ad
Cole ad
Fish
Cyprn
Moron
Dipt ad
Cyclo
Percd
Sidid
Cladc
-0.5
Lepto
Daphn
Copep
-1.0
A)
Calan
-0.5
0.0
0.5
1.0
1.5
Axis 1
Axis 2
Hter2
2.0
1.5
Pshu1
Agru1
Pcap1
Pshu2
1.0
Pomi1
Pomi2
0.5
Hter1
Halo2
0.0
Scan3
Scan2
Mchr2
Svit2
Scan1
Svit1
Nath1
-0.5
Halo1
Nath3
Nath2
-1.0
Nath4
Pfla1
Mchr1
B)
Pfla2
Pfla3
-0.5
0.0
0.5
1.0
1.5
Axis 1

Figure 68. Axes 2 and 3 from correspondence analysis of late June fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Sidid = Sididae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Corix = Corixidae adult, Trich = Trichoptera larvae, Odont = Odonata nymph, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Arthr = Ostracods, Moron = Moronidae, Cyprn = Cyprinidae, Percid = Percidae, Fish egg = unidentified fish and B) symmetrical ordination of fish size groups, Agrun1 = *Aplodinotus grunniens* (41-51 mm.), Pcapr1 = *Percina caprodes* (58-100 mm.), Hterg1 = *Hiodon tergisus* (42-79 mm.), Hterg2 = *H. tergisus* (109-113 mm.), Halos1 = *H. alosoides* (60-92 mm.), Halos2 = *H. alosoides* (116-142 mm.), Pomis1 = *Percopsis omiscomaycus* (49-58 mm.), Pomis2 = *P. omiscomaycus* (60-78 mm.), Pflav1 = *Perca flavescens* (30-63 mm.), Pflav2 = *P. flavescens* (72-91 mm.), Pflav3 = *P. flavescens* (105-193 mm.), Mchry1 = *Morone chrysops* (22-47 mm.), Mchry2 = *M. chrysops* (252 mm.), Nathr1 = *Notropis atherinoides* (19-32 mm.), Nathr2 = *N. atherinoides* (33-51 mm.), Nathr3 = *N. atherinoides* (52-72 mm.), Nathr4 = *N. atherinoides* (73-86 mm.), Pshum1 = *Percina shumardi* (24 mm.), Pshum2 = *P. shumardi* (51-62 mm.), Svitr1 = *Stizostedion vitreum* (41-48 mm.), Svitr2 = *S. vitreum* (138-288 mm.), Scana1 = *S. canadense* (60-75 mm.), Scana2 = *S. canadense* (116-152 mm.), Scana3 = *S. canadense* (182-206 mm.), Scana4 = *S. canadense* (216-222 mm.)


Axis 3
Odont
Corix
Cole lv
Hymen
Calan
Copep
Cladc
Cyclo
Dipt ad
Homo ad
Lepto
Daphn
Cole ad
Ephem
Insect
Bosmn
Sidid
Dipt pu
Trich
Arthr
Dipt lv
Axis 2
4
3
2
1
0
-1
-2
-1
0
1
2
3

A)


Axis 3
Hter2
Pfla3
Pfla1
Mchr1
Pfla2
Svit2
Mchr2
Svit1
Scan2
Scan3
Nath4
Nath2
Scan1
Nath3
Nath1
Halo1
Hter1
Pomi1
Pomi2
Agru1
Pshu1
Pcap1
Pshu2
Axis 2
4
3
2
1
0
-1
-2
-1
0
1
2
3

B)

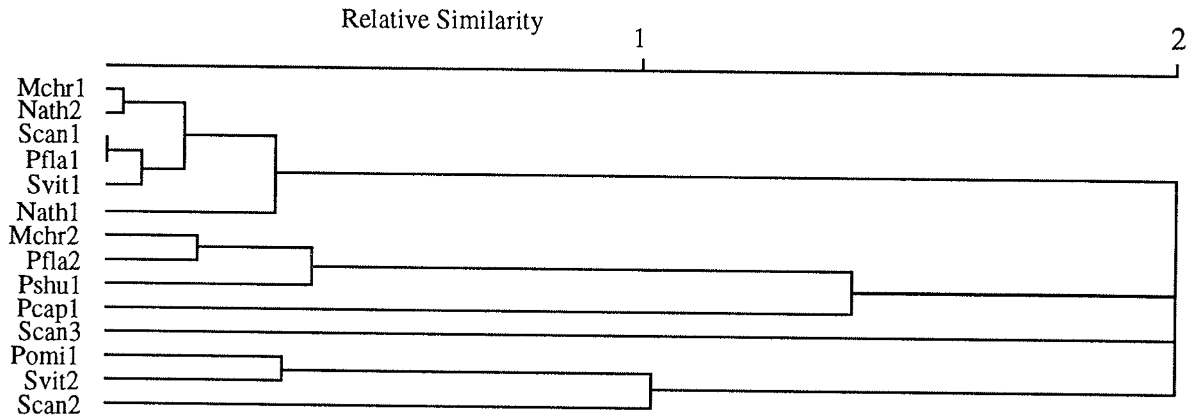
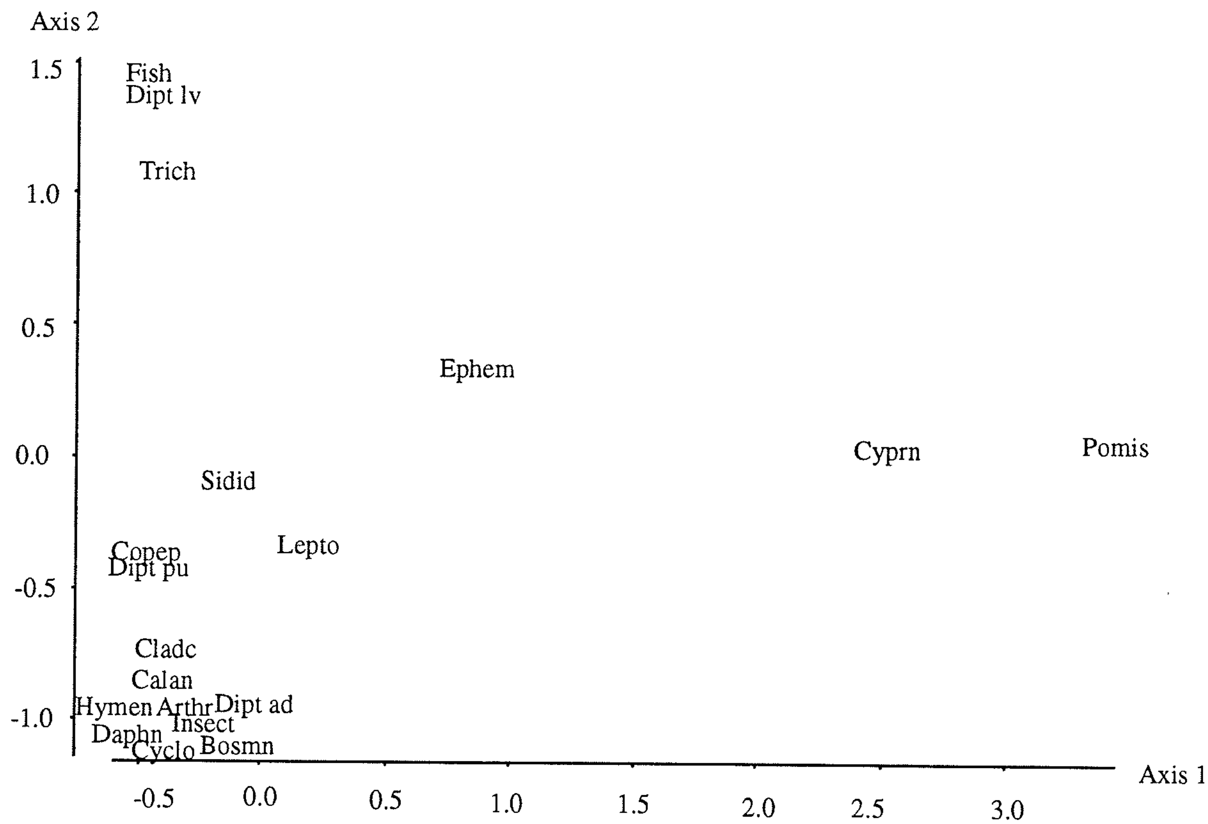


Figure 69. Results of the cluster analysis of early July fishes from Hillside Beach based on diet, Pcapr1 = *Percina caprodes* (79-82 mm.), Pomis1 = *Percopsis omiscomaycus* (50-89 mm.), Pflav1 = *Perca flavescens* (21-76 mm.), Pflav2 = *P. flavescens* (97-150 mm.), Mchry1 = *Morone chrysops* (16-24 mm.), Mchry2 = *M. chrysops* (365 mm.), Nathr1 = *Notropis atherinoides* (24-48 mm.), Nathr2 = *N. atherinoides* (49-72 mm.), Pshum1 = *Percina shumardi* (47-55 mm.), Svitr1 = *Stizostedion vitreum* (34-47 mm.), Svitr2 = *S. vitreum* (103-248 mm.), Scana1 = *S. canadense* (39 mm.), Scana2 = *S. canadense* (110-120 mm.), Scana3 = *S. canadense* (165-184 mm.), Scana4 = *S. canadense* (216-222 mm.)

Figure 70. Axes 1 and 2 from correspondence analysis of early July fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Sidid = Sididae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Hymen = Hymenoptera adult, Insect = unidentifiable insect, Arthr = unidentified arthropoda, Pomis = Percopsidae, Cyprn = Cyprinidae, Fish = unidentified fish and B) symmetrical ordination of fish size groups, Pcapr1 = *Percina caprodes* (79-82 mm.), Pomis1 = *Percopsis omiscomaycus* (50-89 mm.), Pflav1 = *Perca flavescens* (21-76 mm.), Pflav2 = *P. flavescens* (97-150 mm.), Mchry1 = *Morone chrysops* (16-24 mm.), Mchry2 = *M. chrysops* (365 mm.), Nathr1 = *Notropis atherinoides* (24-48 mm.), Nathr2 = *N. atherinoides* (49-72 mm.), Pshum1 = *Percina shumardi* (47-55 mm.), Svitr1 = *Stizostedion vitreum* (34-47 mm.), Svitr2 = *S. vitreum* (103-248 mm.), Scana1 = *S. canadense* (39 mm.), Scana2 = *S. canadense* (110-120 mm.), Scana3 = *S. canadense* (165-184 mm.), Scana4 = *S. canadense* (216-222 mm.)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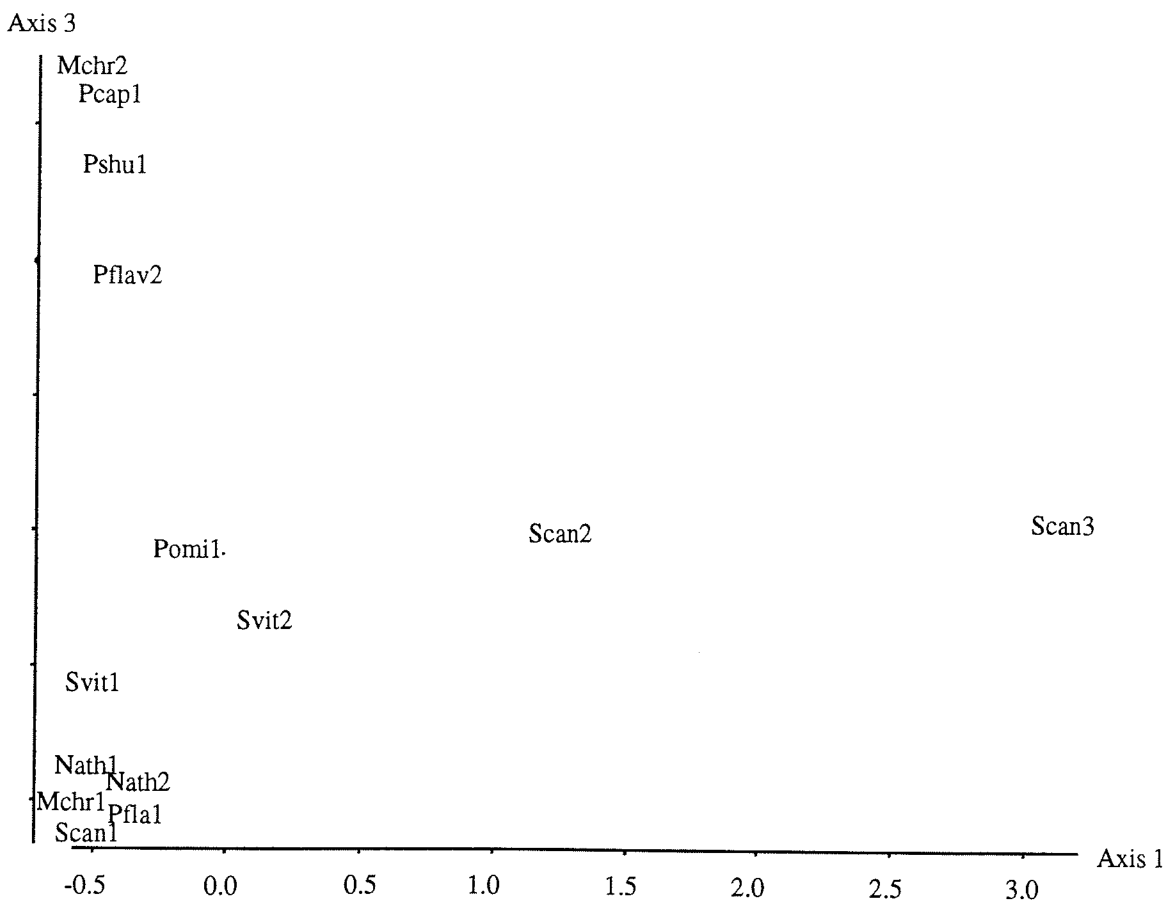
1.0
0.5
0.0
-0.5
-1.0
Fish
Dipt lv
Trich
Ephem
Cyprn
Pomis
Sidid
Lepto
Copep
Dipt pu
Cladc
Calan
Hymen
Arthr
Dipt ad
Insect
Daphn
Cyclo
Bosmn
Axis 1
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

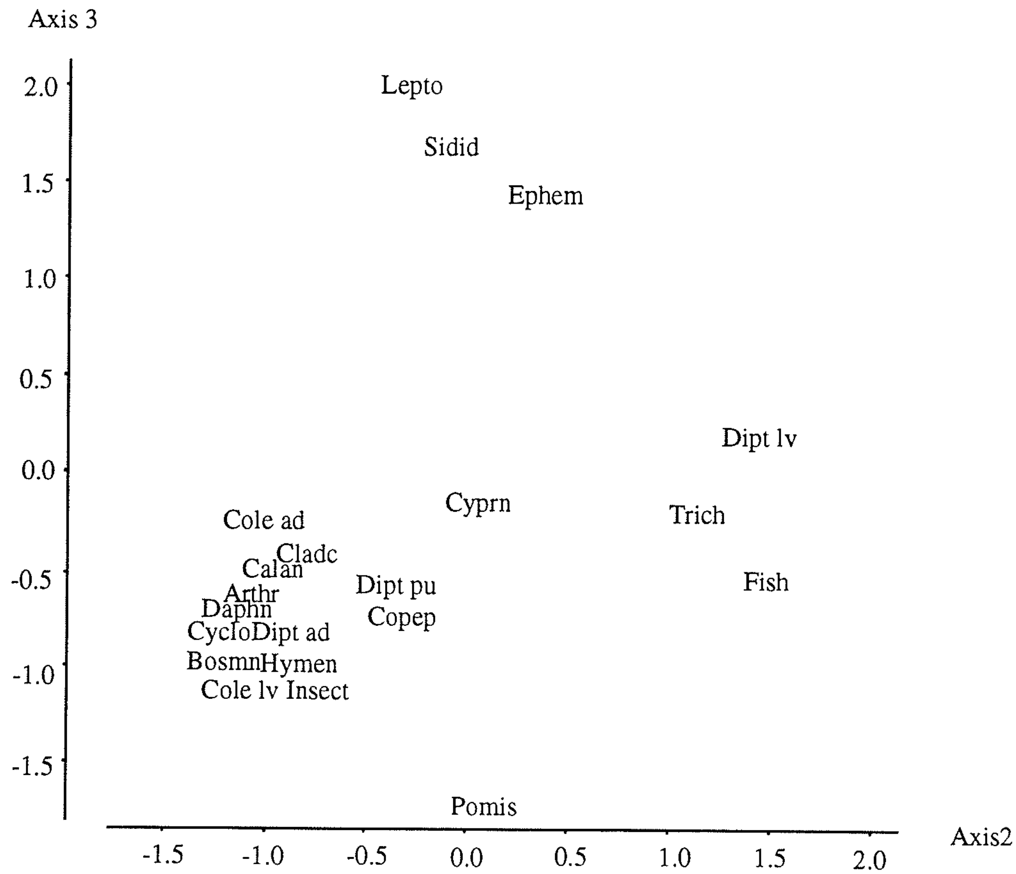
A)


Axis 3
Mchr2
Pcap1
Pshu1
Pflav2
Pomi1
Scan2
Scan3
Svit2
Svit1
Nath1
Nath2
Mchr1
Pfla1
Scan1
Axis 1
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

B)

Figure 71. Axes 2 and 3 from correspondence analysis of early July fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Sidid = Sididae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Hymen = Hymenoptera adult, Insect = unidentifiable insect, Arthr = unidentified arthropoda, Pomis = Percopsidae, Cyprn = Cyprinidae, Fish = unidentified fish and B) symmetrical ordination of fish size groups, Pcapr1 = *Percina caprodes* (79-82 mm.), Pomis1 = *Percopsis omiscomaycus* (50-89 mm.), Pflav1 = *Perca flavescens* (21-76 mm.), Pflav2 = *P. flavescens* (97-150 mm.), Mchry1 = *Morone chrysops* (16-24 mm.), Mchry2 = *M. chrysops* (365 mm.), Nathr1 = *Notropis atherinoides* (24-48 mm.), Nathr2 = *N. atherinoides* (49-72 mm.), Pshum1 = *Percina shumardi* (47-55 mm.), Svitr1 = *Stizostedion vitreum* (34-47 mm.), Svitr2 = *S. vitreum* (103-248 mm.), Scana1 = *S. canadense* (39 mm.), Scana2 = *S. canadense* (110-120 mm.), Scana3 = *S. canadense* (165-184 mm.), Scana4 = *S. canadense* (216-222 mm.)

A)


Axis 3
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
Lepto
Sidid
Ephem
Dipt lv
Cyprn
Trich
Cole ad
Cladc
Calan
Arthr
Daphn
CycloDipt ad
BosmnHymen
Cole lv Insect
Dipt pu
Copep
Fish
Pomis
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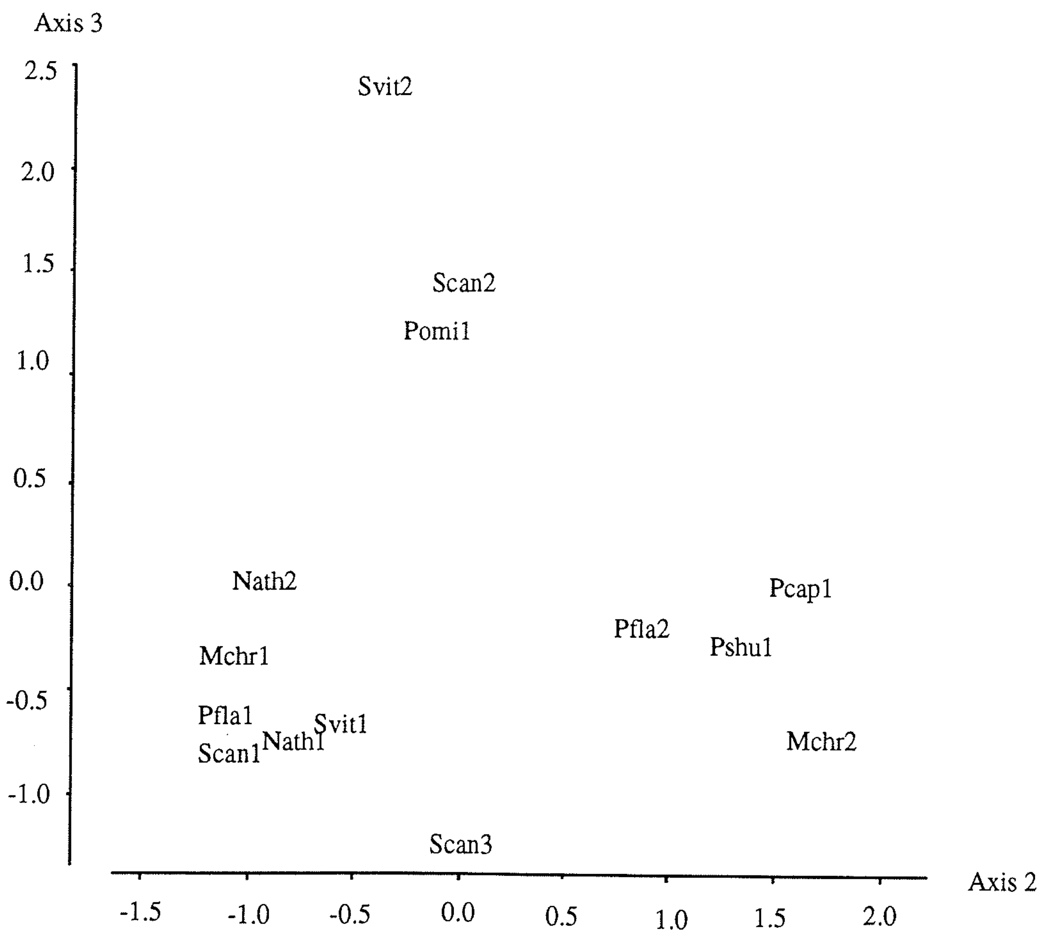
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Axis2

B)


Axis 3
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Svit2
Scan2
Pomi1
Nath2
Pcap1
Pfla2
Pshu1
Mchr1
Pfla1
Svit1
Scan1
Nath1
Mchr2
Scan3
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Axis 2

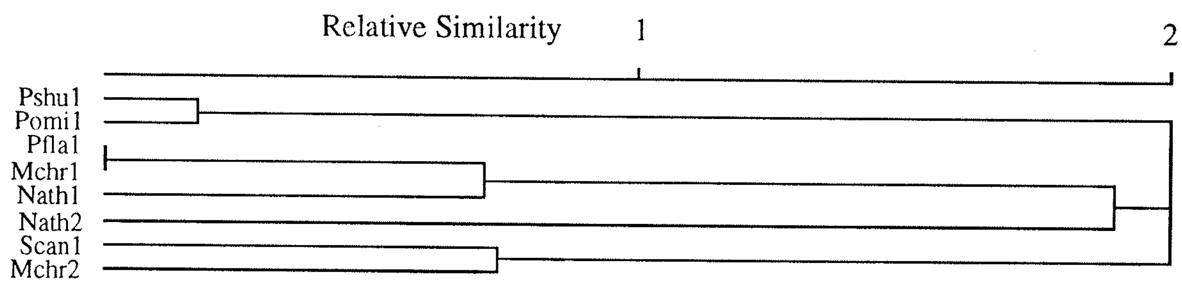
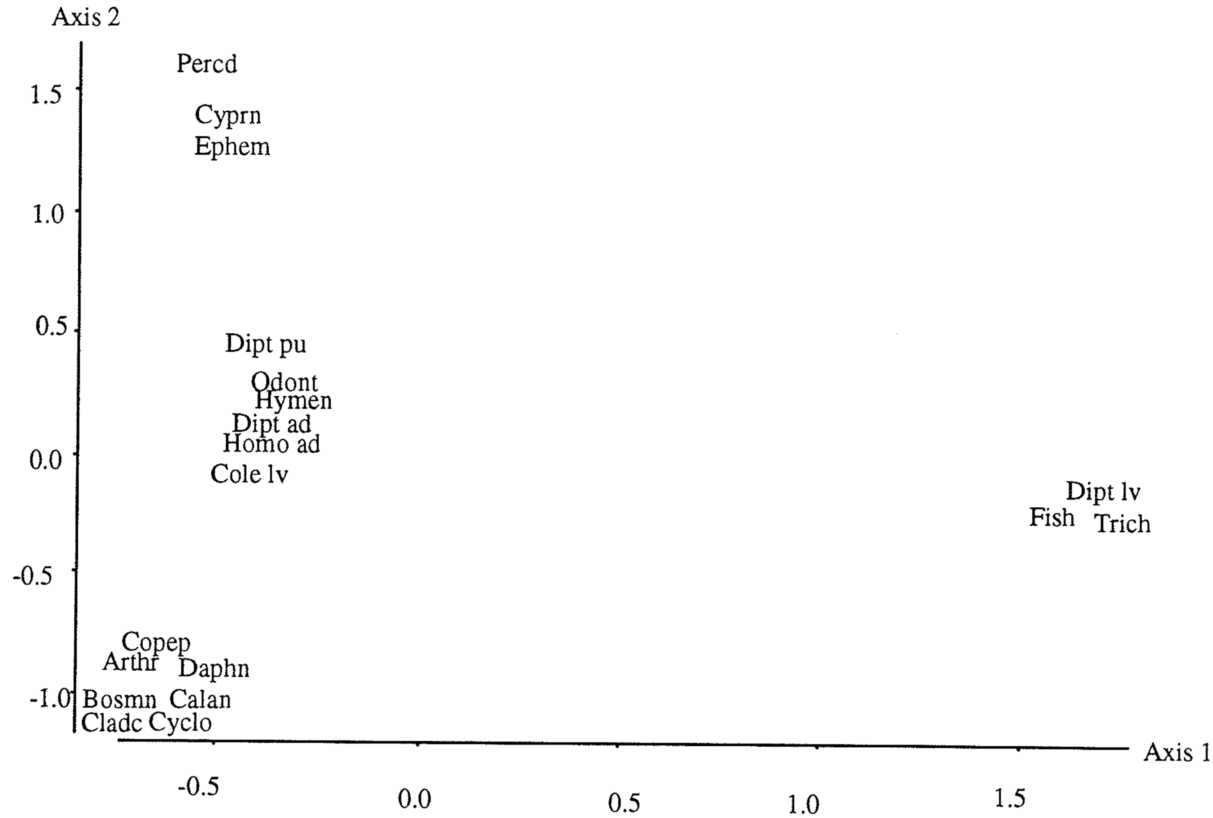
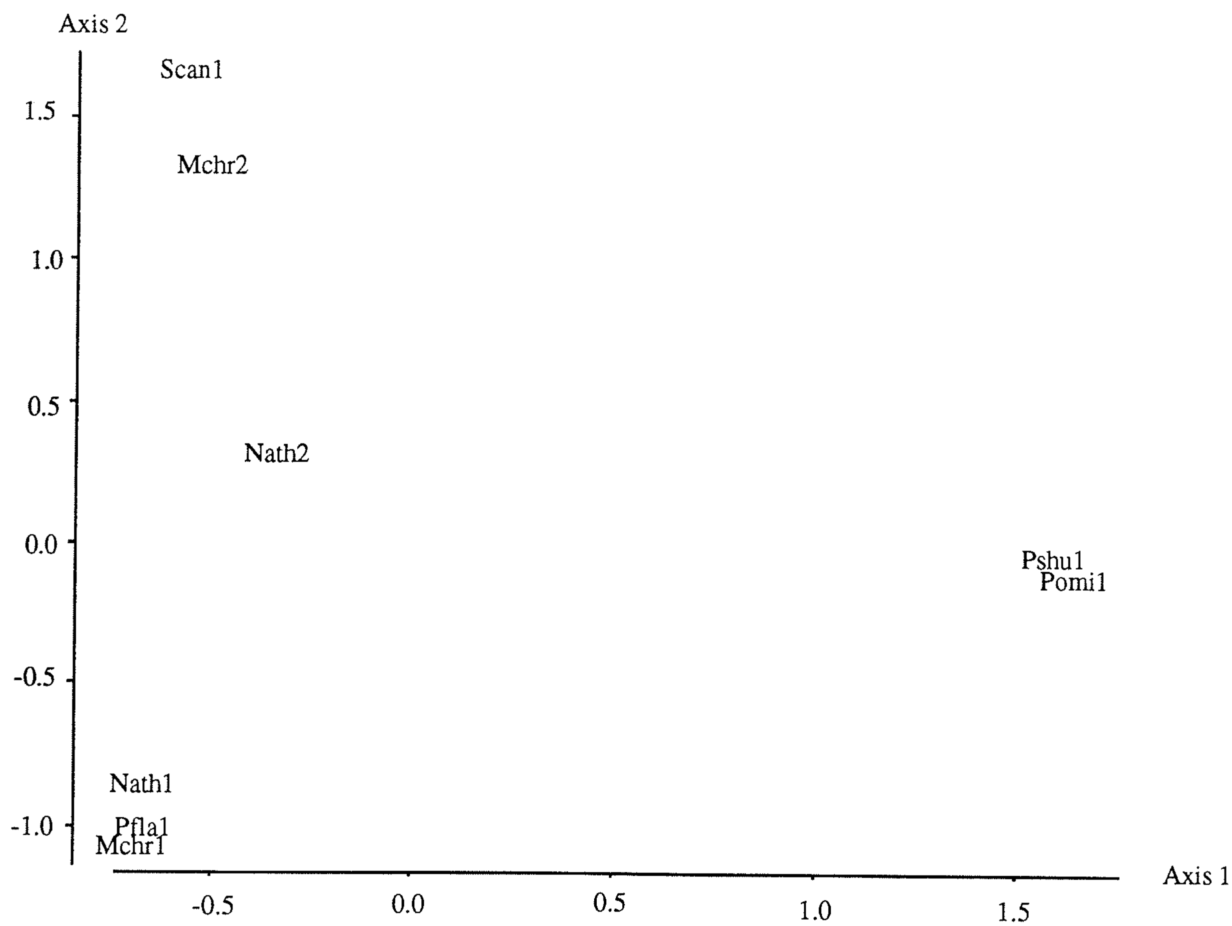


Figure 72. Results of the cluster analysis of late July fish based on diet from Hillside Beach, Mchry1 = *Morone chrysops* (24 mm.), Mchry2 = *M. chrysops* (190 mm.), Nathr1 = *Notropis atherinoides* (31-47 mm.), Nathr2 = *N. atherinoides* (56-70 mm.), Pomis1 = *Percopsis omiscomaycus* (62 mm.), Scana1 = *Stizostedion canadense* (69 mm.), Scana2 = *S. canadensis* (118-276 mm.), Pflav1 = *Perca flavescens* (37 mm.) and Pshum1 = *Percina shumardi* (54 mm.)

Figure 73. Axes 1 and 2 from correspondence analysis of late July fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Odont = Odonata nymph, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Arthr = unidentified Hydrachnellae, Percd = Percidae, Cyprn = Cyprinidae, Fish = unidentified fish and B) symmetrical ordination of fish size groups, Mchry1 = *Morone chrysops* (24 mm.), Mchry2 = *M. chrysops* (190 mm.), Nathr1 = *Notropis atherinoides* (31-47 mm.), Nathr2 = *N. atherinoides* (56-70 mm.), Pomis1 = *Percopsis omiscomaycus* (62 mm.), Scana1 = *Stizostedion canadense* (69 mm.), Scana2 = *S. canadensis* (118-276 mm.), Pflav1 = *Perca flavescens* (37 mm.) and Pshum1 = *Percina shumardi* (54 mm.)

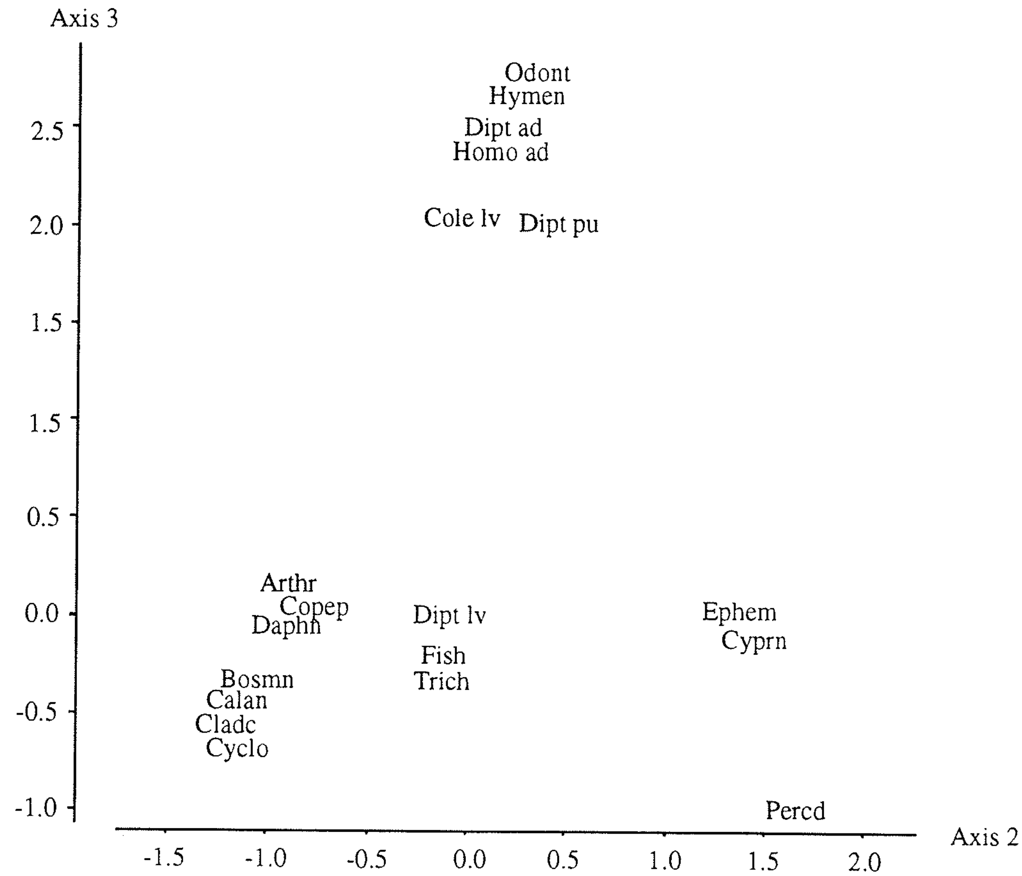

Axis 2
Percd
Cyprn
Ephem
1.5
1.0
0.5
0.0
-0.5
-1.0
Dipt pu
Odont
Hymen
Dipt ad
Homo ad
Cole lv
Dipt lv
Fish
Trich
Copep
Arthr
Daphn
Bosmn
Calan
Cladc
Cyclo
Axis 1
-0.5
0.0
0.5
1.0
1.5

A)

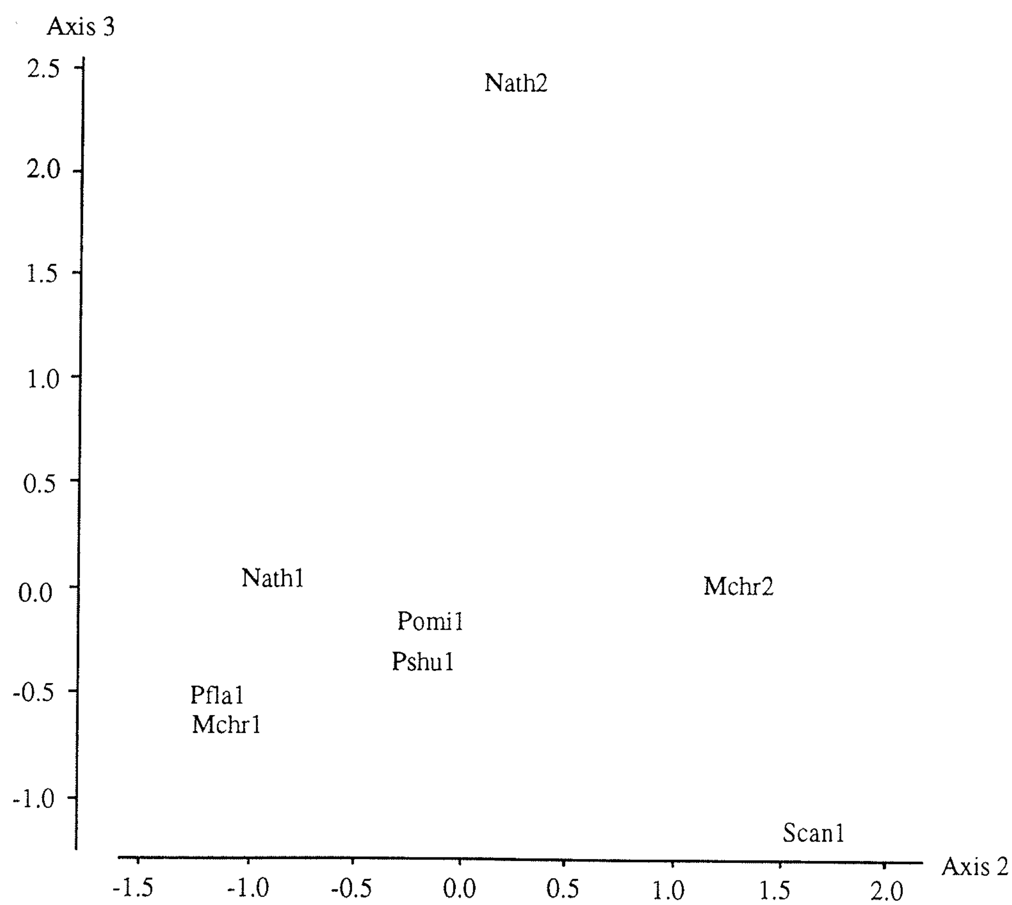

Axis 2
Scan1
Mchr2
1.5
1.0
0.5
0.0
-0.5
-1.0
Nath2
Pshu1
Pomi1
Nath1
Pfla1
Mchr1
Axis 1
-0.5
0.0
0.5
1.0
1.5

B)

Figure 74. Axes 2 and 3 from correspondence analysis of late July fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentifiable copepods, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Cole lv = Coleoptera larvae, Dipt lv, pu, ad = Diptera larvae, pupae and adult respectively, Odont = Odonate nymph, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Arthr = unidentified Hydrachnellae, Percd = Percidae, Cyprn = Cyprinidae, Fish = unidentified fish and B) symmetrical ordination of fish size groups, Mchry1 = *Morone chrysops* (24 mm.), Mchry2 = *M. chrysops* (190 mm.), Nathr1 = *Notropis atherinoides* (31-47 mm.), Nathr2 = *N. atherinoides* (56-70 mm.), Pomis1 = *Percopsis omiscomaycus* (62 mm.), Scana1 = *Stizostedion canadense* (69 mm.), Scana2 = *S. canadensis* (118-276 mm.), Pflav1 = *Perca flavescens* (37 mm.) and Pshum1 = *Percina shumardi* (54 mm.)


Axis 3
Odont
Hymen
Dipt ad
Homo ad
Cole lv
Dipt pu
Arthr
Copep
Daphn
Dipt lv
Ephem
Cyprn
Fish
Trich
Bosmn
Calan
Cladc
Cyclo
Percd
Axis 2
2.5
2.0
1.5
1.5
0.5
0.0
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0

A)


Axis 3
Nath2
Nath1
Mchr2
Pomi1
Pshu1
Pfla1
Mchr1
Scan1
Axis 2
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0

B)

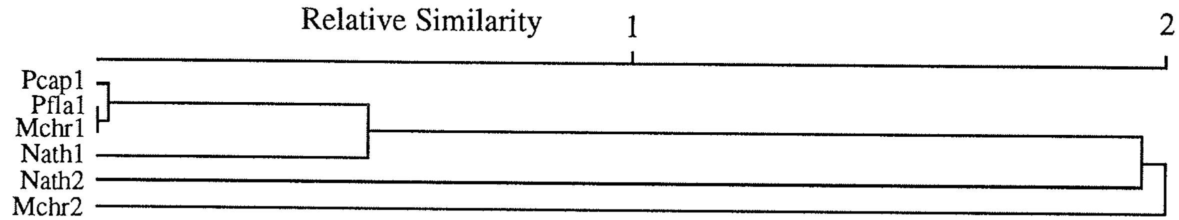
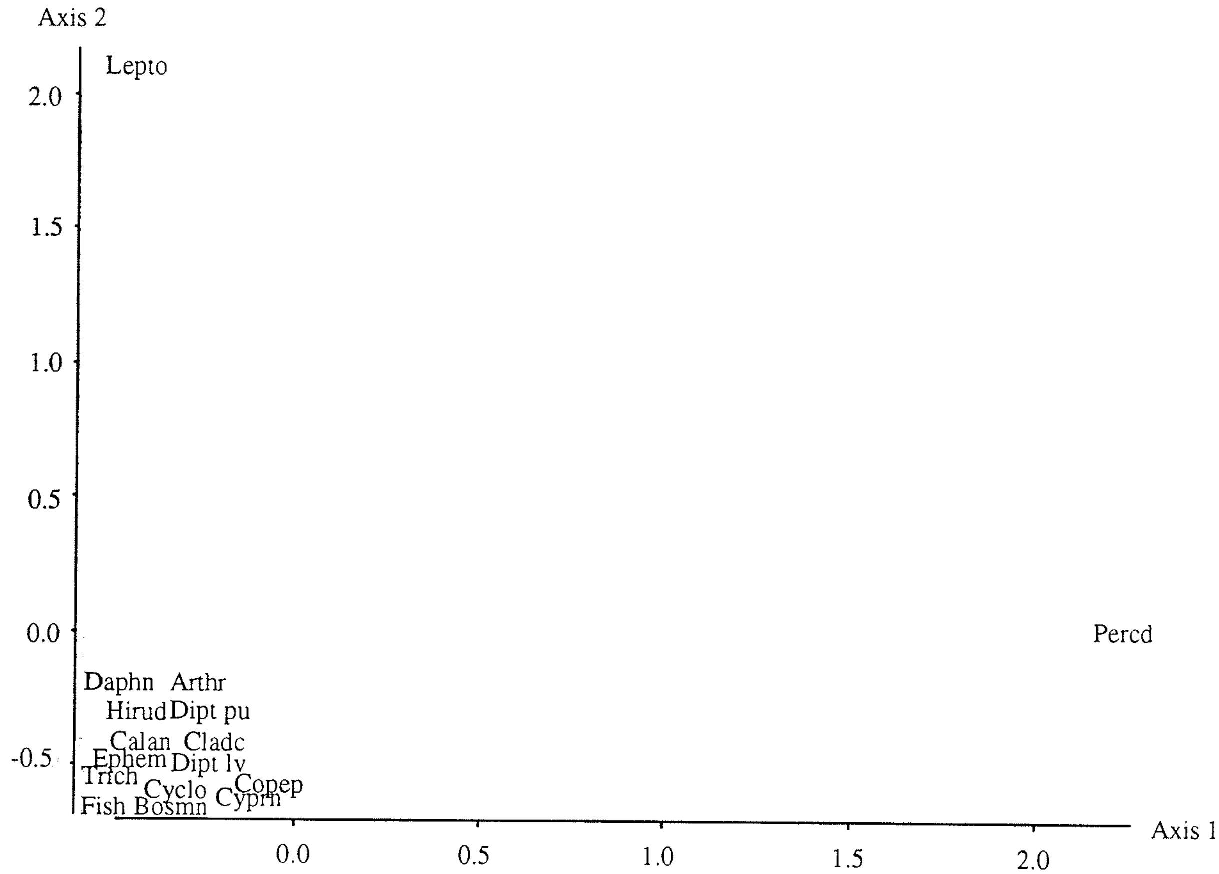


Figure 75. Results of the cluster analysis of diets of early August fishes from Hillside Beach, Pflav1 = *Perca flavescens* (27-43 mm.), Pcap1 = *Percina caprodes* (26-37 mm.), Mchry1 = *Morone chrysops* (20-41 mm.), Mchry2 = *M. chrysops* (196 mm.), Nath1 = *Notropis atherinoides* (20-51 mm.) and Nath2 = *N. atherinoides* (53-67 mm.)

Figure 76. Axes 1 and 2 from correspondence analysis of early August fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Arthr = unidentified Arthropod, Cyprn = Cyprinidae, Fish = unidentified fish and Hirud = hirudinid leech and B) symmetrical ordination of fish size groups, Mchry1 = *Morone chrysops* (20-41 mm.), Mchry2 = *M. chrysops* (196 mm.), Nathr1 = *Notropis atherinoides* (20-51 mm.), Nathr2 = *N. atherinoides* (53-67 mm.), Pflav1 = *Perca flavescens* (27-43 mm.) and Pshum1 = *Percina caprodes* (26-37 mm.)

A)


Axis 2
Lepto
2.0
1.5
1.0
0.5
0.0
-0.5
Percd
Daphn
Arthr
Hirud
Dipt pu
Calan
Cladc
Ephem
Dipt lv
Trich
Cyclo
Copep
Cyprn
Fish
Bosmn
Axis 1
0.0
0.5
1.0
1.5
2.0

B)

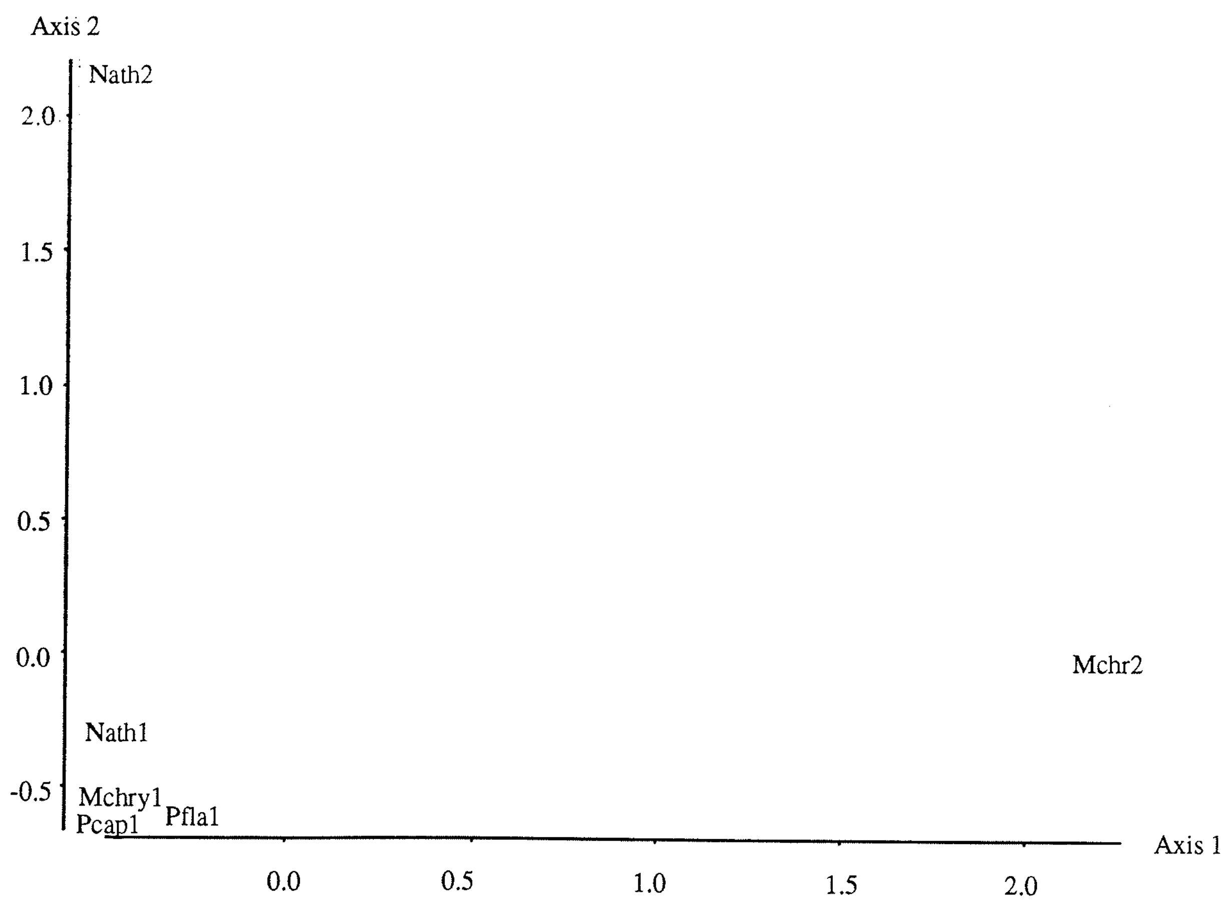
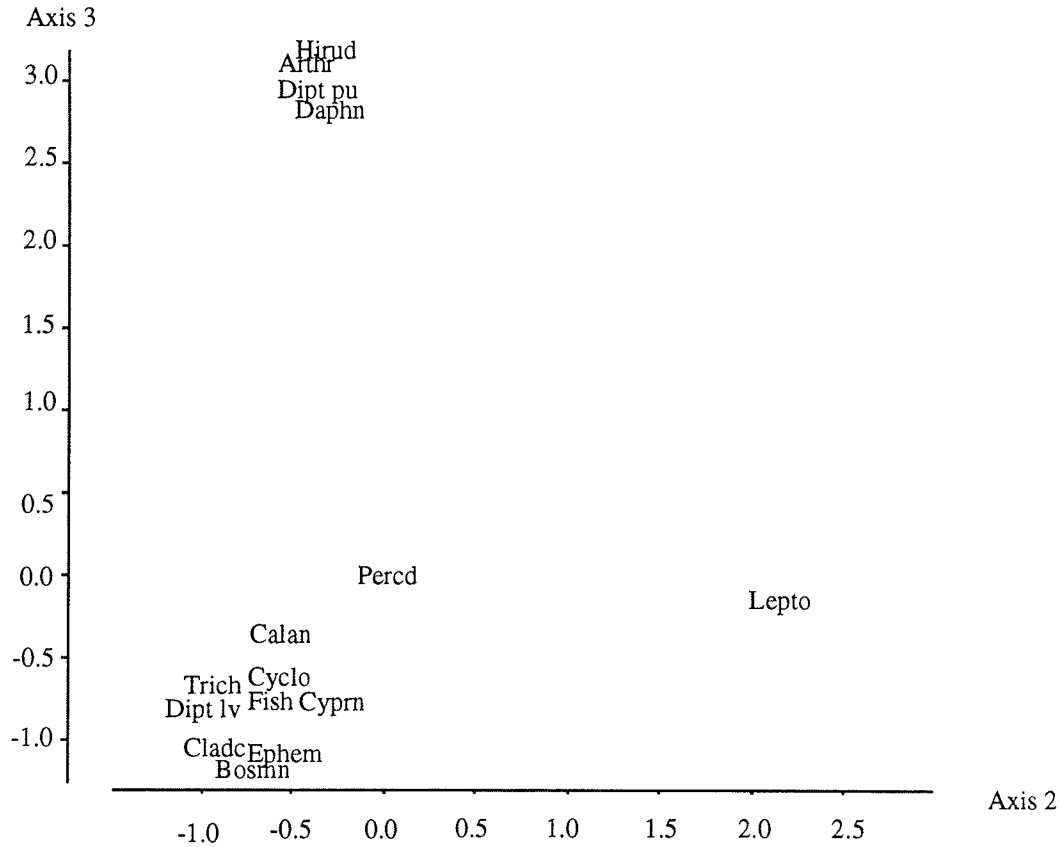
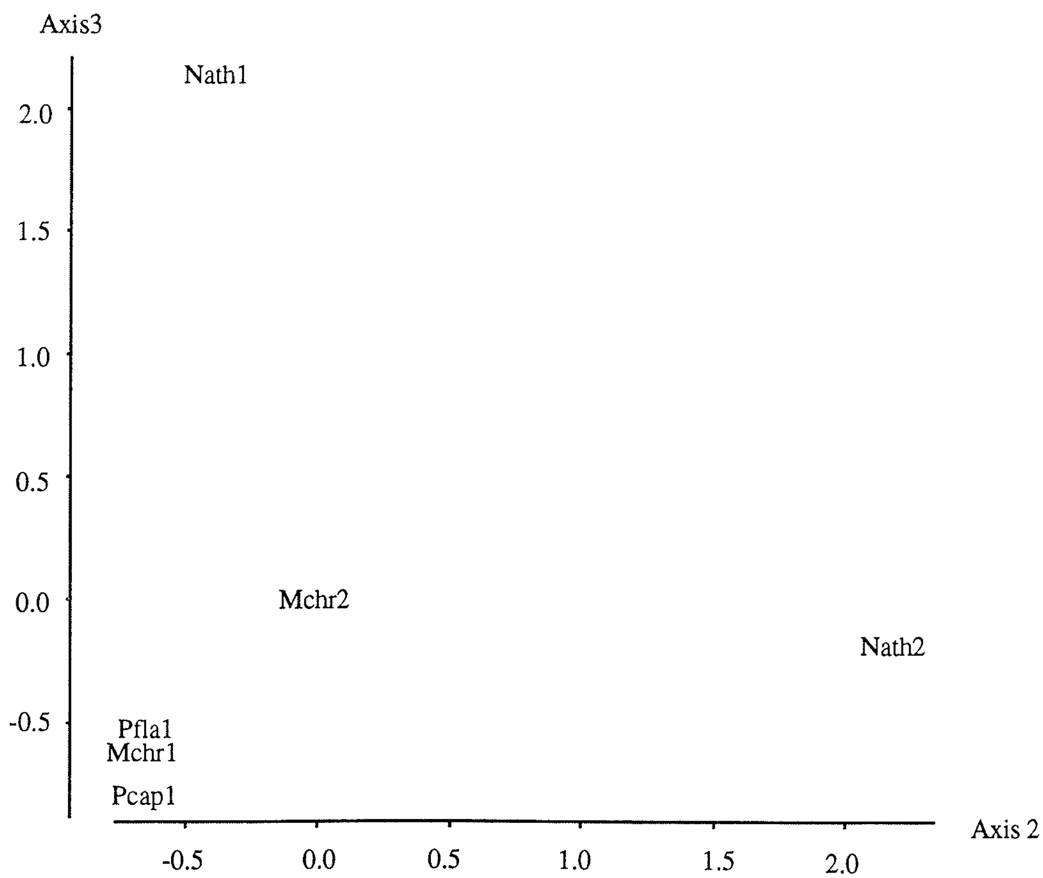

Axis 2
Nath2
2.0
1.5
1.0
0.5
0.0
-0.5
Mchr2
Nath1
Mchry1
Pfla1
Pcap1
Axis 1
0.0
0.5
1.0
1.5
2.0

Figure 77. Axes 2 and 3 from correspondence analysis of early August fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Arthr = unidentified Arthropod, Cyprn = Cyprinidae, Fish = unidentified fish and Hirud = hirudinid leech and B) symmetrical ordination of fish size groups, Mchry1 = *Morone chrysops* (20-41 mm.), Mchry2 = *M. chrysops* (196 mm.), Nathr1 = *Notropis atherinoides* (20-51 mm.), Nathr2 = *N. atherinoides* (53-67 mm.), Pflav1 = *Perca flavescens* (27-43 mm.) and Pshum1 = *Percina caprodes* (26-37 mm.)


Axis 3
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Hirud
Arthr
Dipt pu
Daphn
Percd
Lepto
Calan
Trich
Cyclo
Dipt lv
Fish
Cyprn
Cladc
Ephem
Bosmn
Axis 2
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5

A)


Axis3
2.0
1.5
1.0
0.5
0.0
-0.5
Nath1
Mchr2
Nath2
Pfla1
Mchr1
Pcap1
Axis 2
-0.5
0.0
0.5
1.0
1.5
2.0

B)

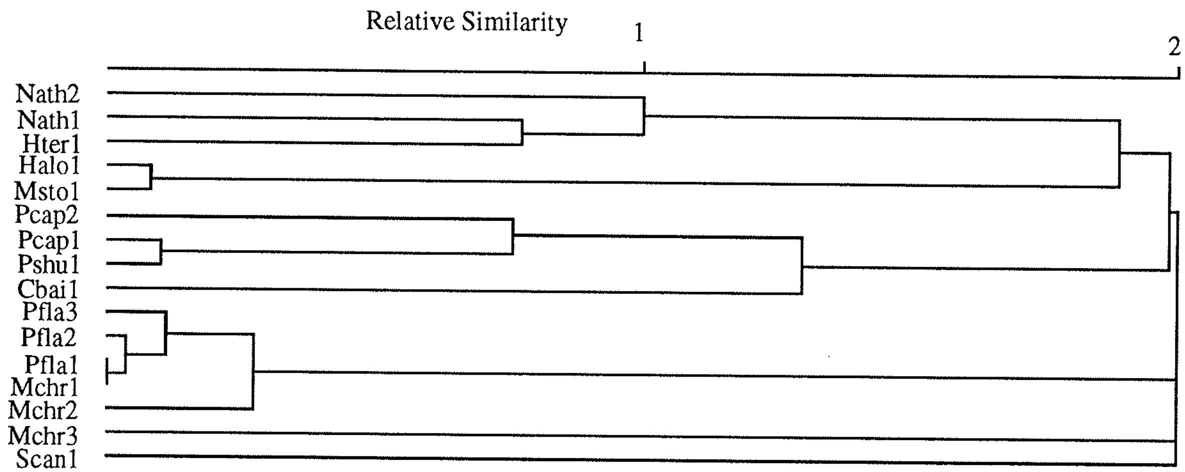


Figure 78. Results of cluster analysis of late August fishes based on diet similarity, Nath1 = *Notropis atherinoides* (18-55 mm.), Nath2 = *N. atherinoides* (56-87 mm.), Hter1 = *Hiodon tergisus* (44-68 mm.), Halos = *H. alosoides* (58-73 mm.), Msto1 = *Macrhybopsis storeriana* (59 mm.), Pcap1 = *Percina caprodes* (29-41 mm.), Pcap2 = *P. caprodes* (74-95 mm.), Pshu1 = *P. shumardi* (28-56 mm.), Cbai1 = *Cottus bairdi* (27-30 mm.), Pfla1 = *Perca flavescens* (32-43 mm.), Pfla2 = *P. flavescens* (45-54 mm.), Pfla3 = *P. flavescens* (55-58 mm.), Scan1 = *Stizostedion canadense* (158-289 mm.), Mchr1 = *Morone chrysops* (22-51 mm.), Mchr2 = *M. chrysops* (54-77 mm.) and Mchr3 = *M. chrysops* (255 mm.)

Figure 79. Axes 1 and 2 from correspondence analysis of late August fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Sidid = Sididae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentified copepods, Corix = Corixid adults, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Insect = unidentified insect, Percd = Percid fish, Cyprn = Cyprinid fish, Fish = unidentified fish, and B) symmetrical ordination of fish size groups, Nath1 = *Notropis atherinoides* (18-55 mm.), Nath2 = *N. atherinoides* (56-87 mm.), Hter1 = *Hiodon tergisus* (44-68 mm.), Halos = *H. alosoides* (58-73 mm.), Msto1 = *Macrhybopsis storeriana* (59 mm.), Pcap1 = *Percina caprodes* (29-41 mm.), Pcap2 = *P. caprodes* (74-95 mm.), Pshu1 = *P. shumardi* (28-56 mm.), Cbai1 = *Cottus bairdi* (27-30 mm.), Pfla1 = *Perca flavescens* (32-43 mm.), Pfla2 = *P. flavescens* (45-54 mm.), Pfla3 = *P. flavescens* (55-58 mm.), Scan1 = *Stizostedion canadense* (158-289 mm.), Mchr1 = *Morone chrysops* (22-51 mm.), Mchr2 = *M. chrysops* (54-77 mm.) and Mchr3 = *M. chrysops* (255 mm.)

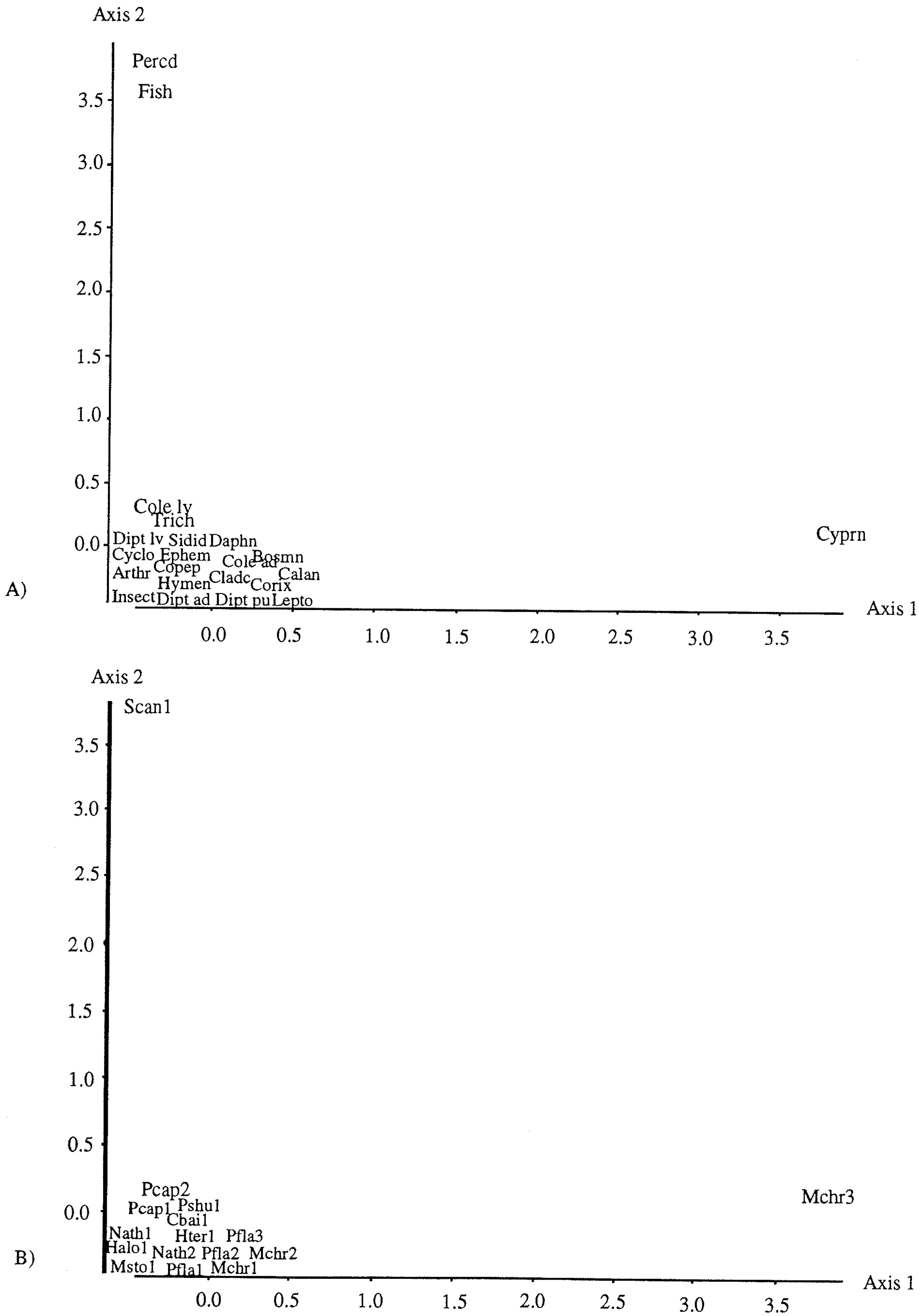

Axis 2
Percd
Fish
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Cole ly
Trich
Dipt lv
Sidid
Daphn
Cyclo
Ephem
Cole ad
Bosmn
Arthr
Copep
Hymen
Cladc
Corix
Calan
Insect
Dipt ad
Dipt pu
Lepto
Cyprn
A)
Axis 1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Axis 2
Scan1
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Pcap2
Pcap1
Pshu1
Cbai1
Nath1
Hter1
Pfla3
Halo1
Nath2
Pfla2
Mchr2
Msto1
Pfla1
Mchr1
Mchr3
B)
Axis 1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

Figure 80. Axes 2 and 3 from correspondence analysis of late August fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Sidid = Sididae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentified copepods, Corix = Corixid adults, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Insect = unidentified insect, Percd = Percid fish, Cyprn = Cyprinid fish, Fish = unidentified fish, and B) symmetrical ordination of fish size groups, Nath1 = *Notropis atherinoides* (18-55 mm.), Nath2 = *N. atherinoides* (56-87 mm.), Hter1 = *Hiodon tergisus* (44-68 mm.), Halos = *H. alosoides* (58-73 mm.), Msto1 = *Macrhybopsis storeriana* (59 mm.), Pcap1 = *Percina caprodes* (29-41 mm.), Pcap2 = *P. caprodes* (74-95 mm.), Pshu1 = *P. shumardi* (28-56 mm.), Cbai1 = *Cottus bairdi* (27-30 mm.), Pfla1 = *Perca flavescens* (32-43 mm.), Pfla2 = *P. flavescens* (45-54 mm.), Pfla3 = *P. flavescens* (55-58 mm.), Scan1 = *Stizostedion canadense* (158-289 mm.), Mchr1 = *Morone chrysops* (22-51 mm.), Mchr2 = *M. chrysops* (54-77 mm.) and Mchr3 = *M. chrysops* (255 mm.)

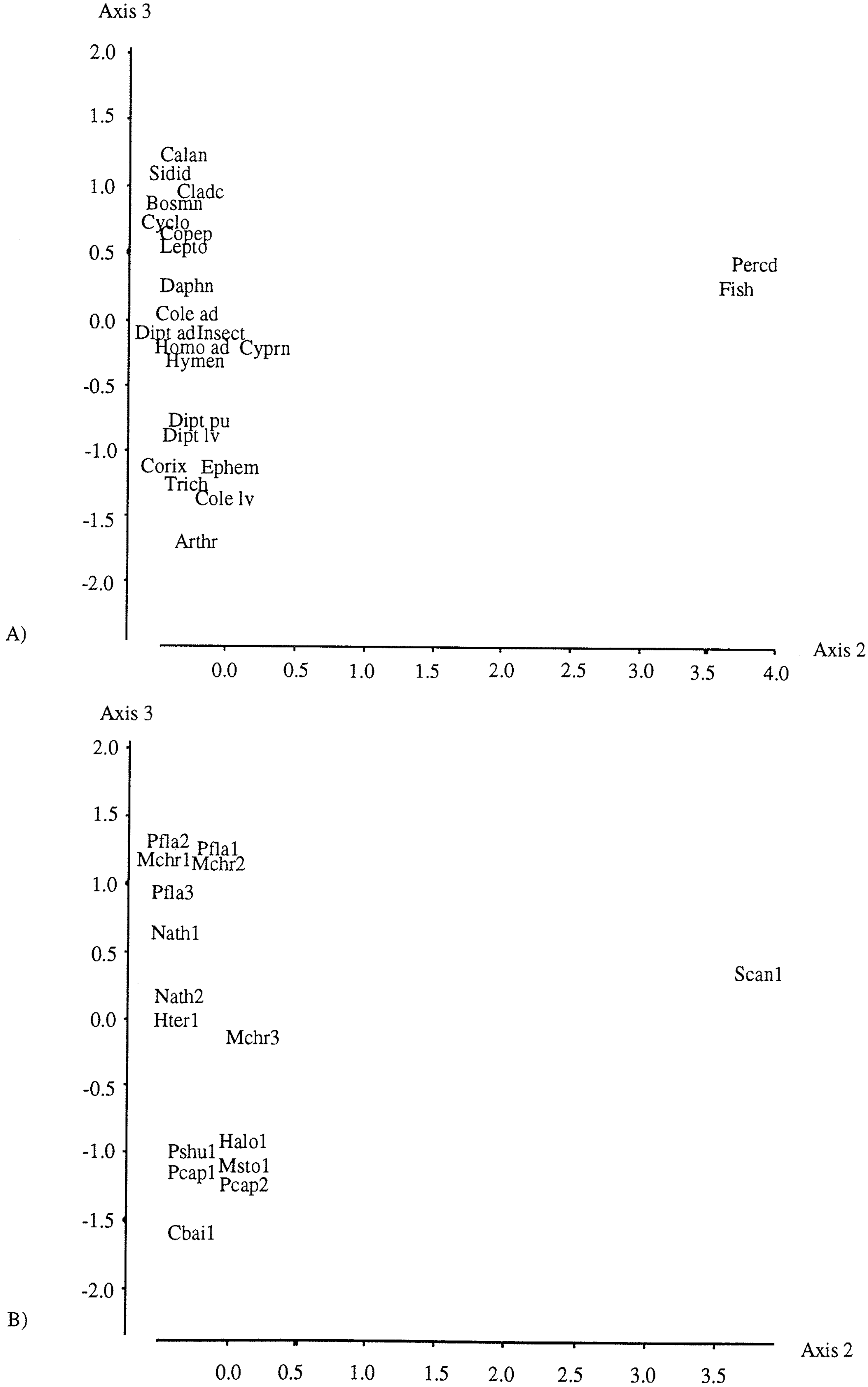
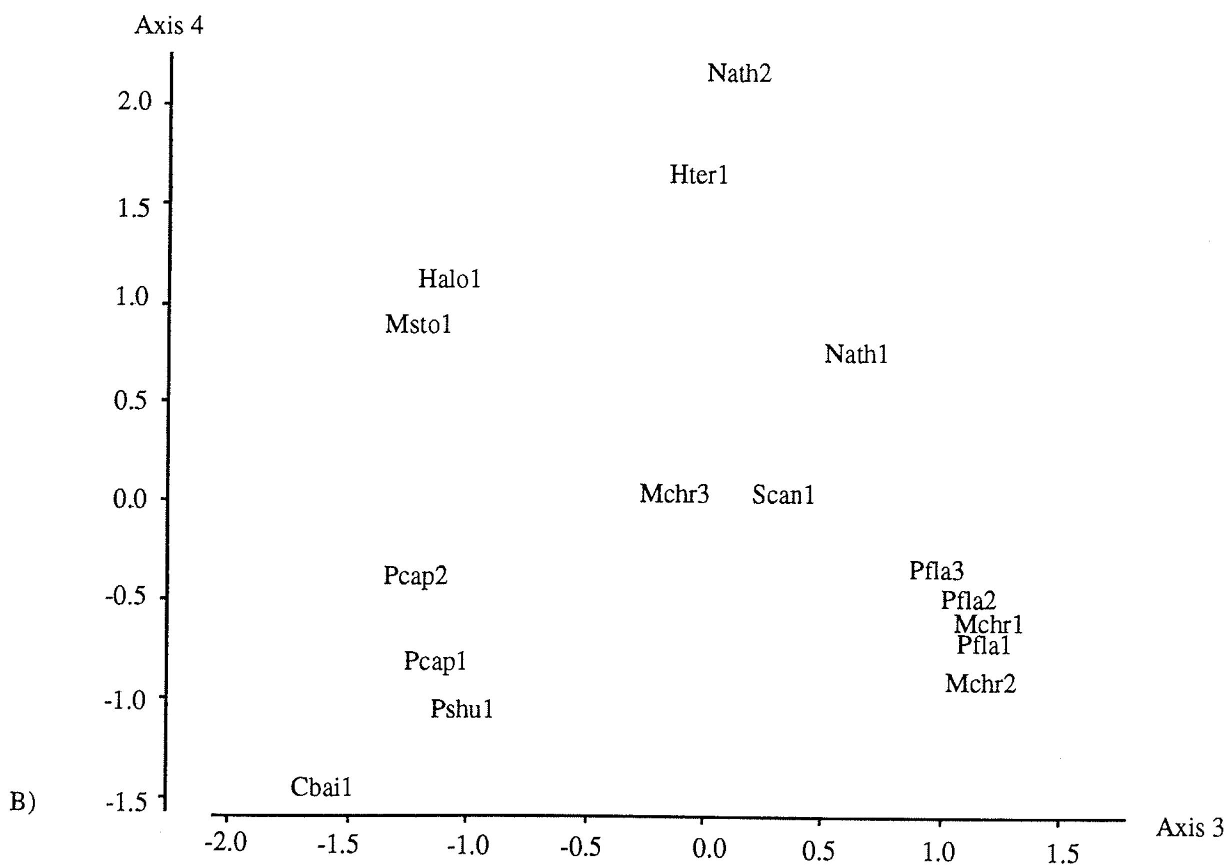

Axis 3
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Calan
Sidid
Cladc
Bosmn
Cyclo
Copep
Lepto
Daphn
Cole ad
Dipt ad
Insect
Homo ad
Cyprn
Hymen
Dipt pu
Dipt lv
Corix
Ephem
Trich
Cole lv
Arthr
Percd
Fish
A)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Axis 2
Axis 3
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Pfla2
Pfla1
Mchr1
Mchr2
Pfla3
Nath1
Scan1
Nath2
Hter1
Mchr3
Halo1
Pshu1
Msto1
Pcap1
Pcap2
Cbai1
B)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Axis 2

Figure 81. Axes 3 and 4 from correspondence analysis of late August fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Sidid = Sididae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentified copepods, Corix = Corixid adults, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Ephem = Ephemeroptera nymph, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Insect = unidentified insect, Percd = Percid fish, Cyprn = Cyprinid fish, Fish = unidentified fish, and B) symmetrical ordination of fish size groups, Nath1 = *Notropis atherinoides* (18-55 mm.), Nath2 = *N. atherinoides* (56-87 mm.), Hter1 = *Hiodon tergisus* (44-68 mm.), Halos = *H. alosoides* (58-73 mm.), Msto1 = *Macrhybopsis storeriana* (59 mm.), Pcap1 = *Percina caprodes* (29-41 mm.), Pcap2 = *P. caprodes* (74-95 mm.), Pshu1 = *P. shumardi* (28-56 mm.), Cbai1 = *Cottus bairdi* (27-30 mm.), Pfla1 = *Perca flavescens* (32-43 mm.), Pfla2 = *P. flavescens* (45-54 mm.), Pfla3 = *P. flavescens* (55-58 mm.), Scan1 = *Stizostedion canadense* (158-289 mm.), Mchr1 = *Morone chrysops* (22-51 mm.), Mchr2 = *M. chrysops* (54-77 mm.) and Mchr3 = *M. chrysops* (255 mm.)


Axis 4
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Daphn
Cole ad
Dipt ad
Homo ad
Hymen
Insect
Corix
Lepto
Dipt pu
Cyclo
Copep
Ephem
Bosmn
Cyprn
Percd
Fish
Cladc
Cole lv
Sidid
Trich
Calan
Dipt lv
A)
Arthr
Axis 3
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0


Axis 4
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
Nath2
Hter1
Halo1
Msto1
Nath1
Mchr3
Scan1
Pcap2
Pfla3
Pfla2
Mchr1
Pfla1
Pcap1
Mchr2
Pshu1
B)
Cbai1
Axis 3
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5

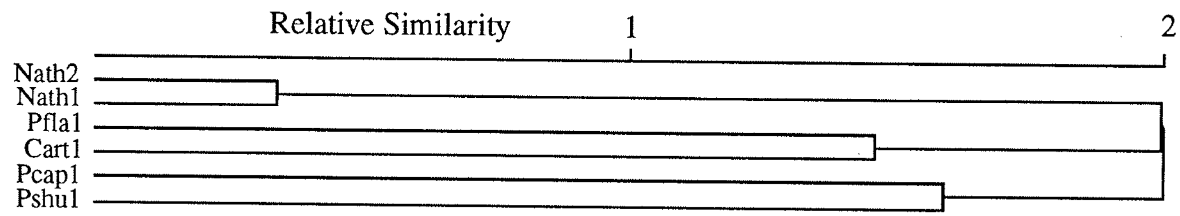
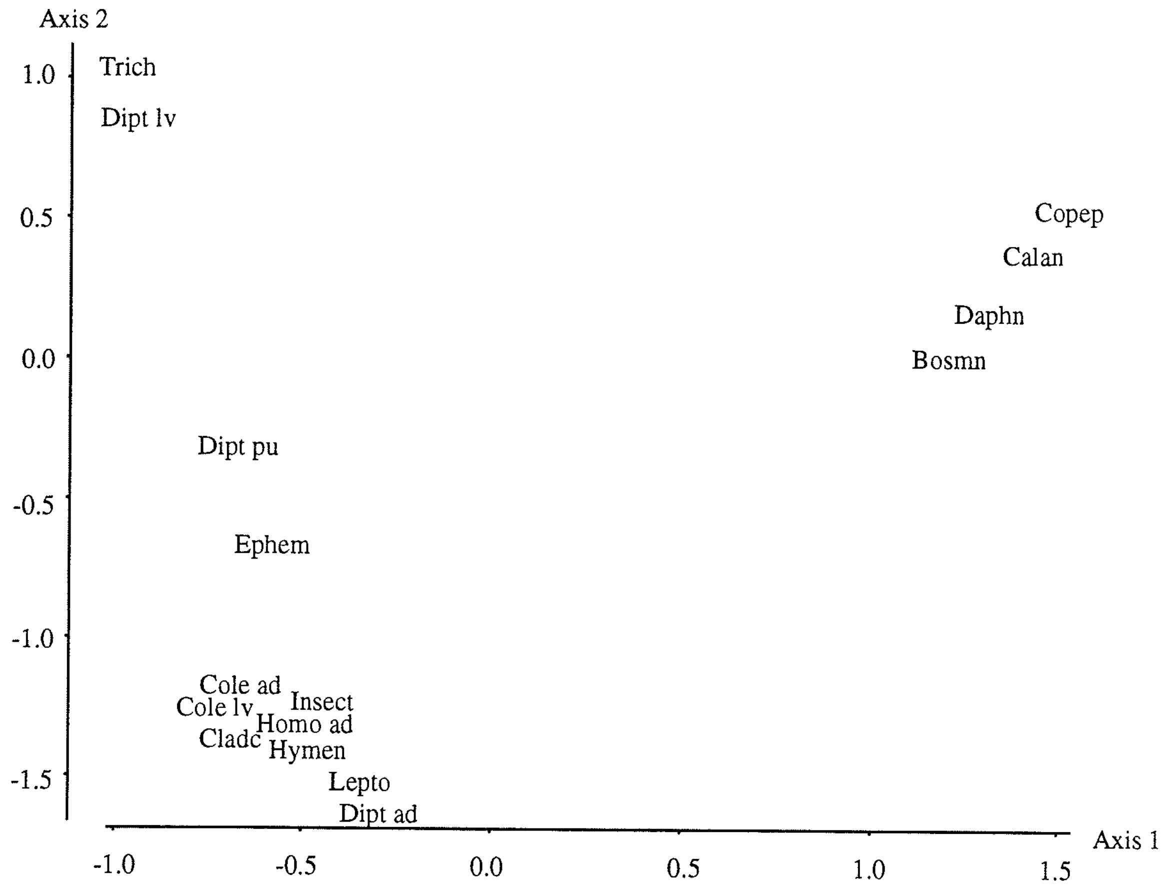
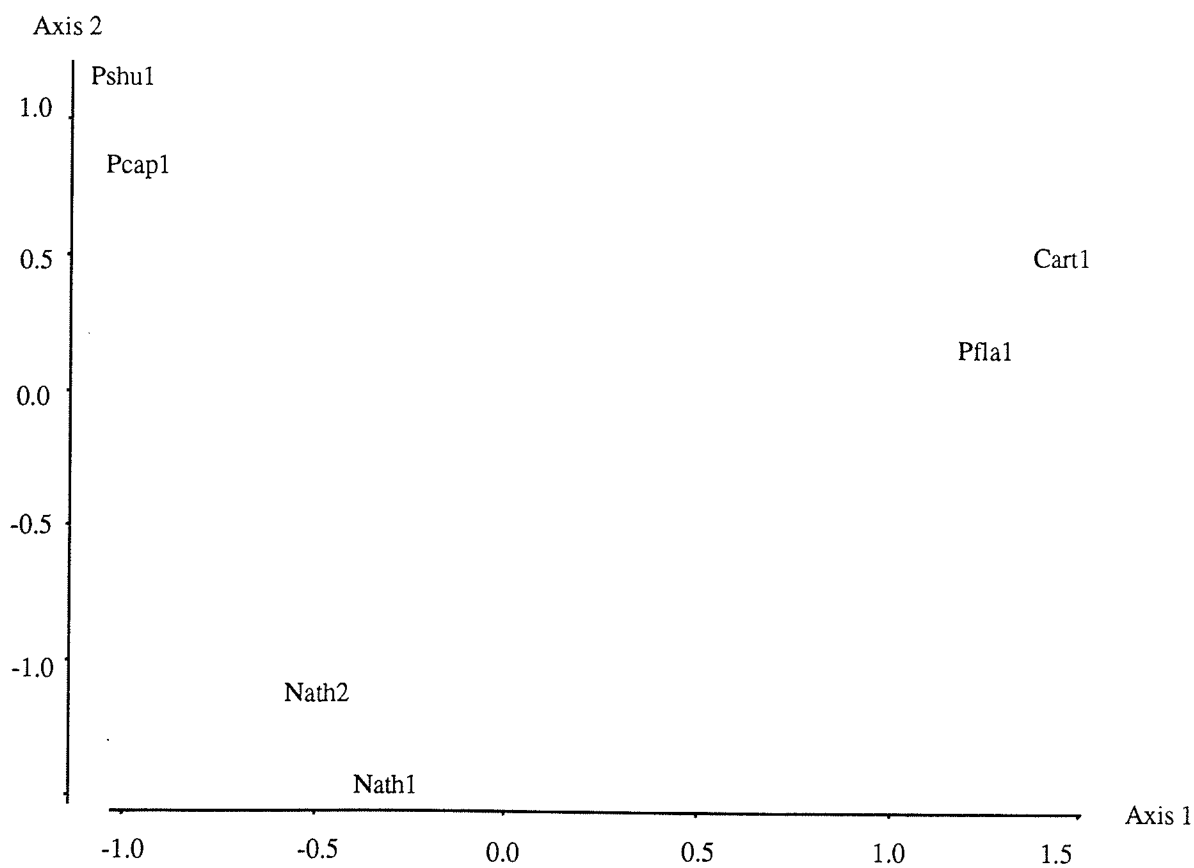


Figure 82. Results of the cluster analysis of diets of September fishes from Hillside Beach, Pflav1 = *Perca flavescens* (49-64 mm.), Pshu1 = *Percina shumardi* (45 mm.), Pcap1 = *Percina caprodes* (43-77 mm.), Cart1 = *Coregonus artedi* (75-76 mm.), Nath1 = *Notropis atherinoides* (21-44 mm.) and Nath2 = *N. atherinoides* (46-73 mm.)

Figure 83. Axes 1 and 2 from correspondence analysis of September fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentified copepods, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Insect = unidentified insect and B) symmetrical ordination of fish size groups, Pflav1 = *Perca flavescens* (49-64 mm.), Pshu1 = *Percina shumardi* (45 mm.), Pcap1 = *Percina caprodes* (43-77 mm.), Cart1 = *Coregonus artedi* (75-76 mm.), Nath1 = *Notropis atherinoides* (21-44 mm.) and Nath2 = *N. atherinoides* (46-73 mm.)

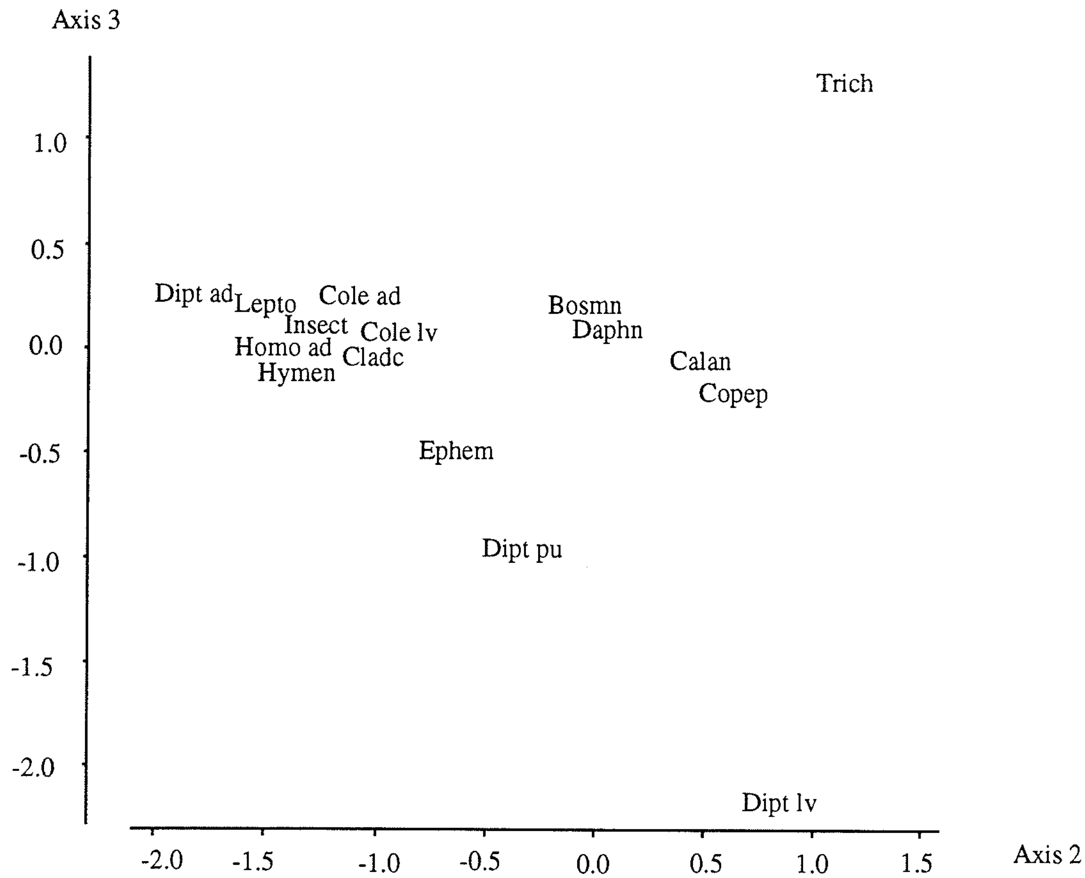

Axis 2
1.0
0.5
0.0
-0.5
-1.0
-1.5
Trich
Dipt lv
Copep
Calan
Daphn
Bosmn
Dipt pu
Ephem
Cole ad
Cole lv
Insect
Homo ad
Cladc
Hymen
Lepto
Dipt ad
Axis 1
-1.0
-0.5
0.0
0.5
1.0
1.5

A)

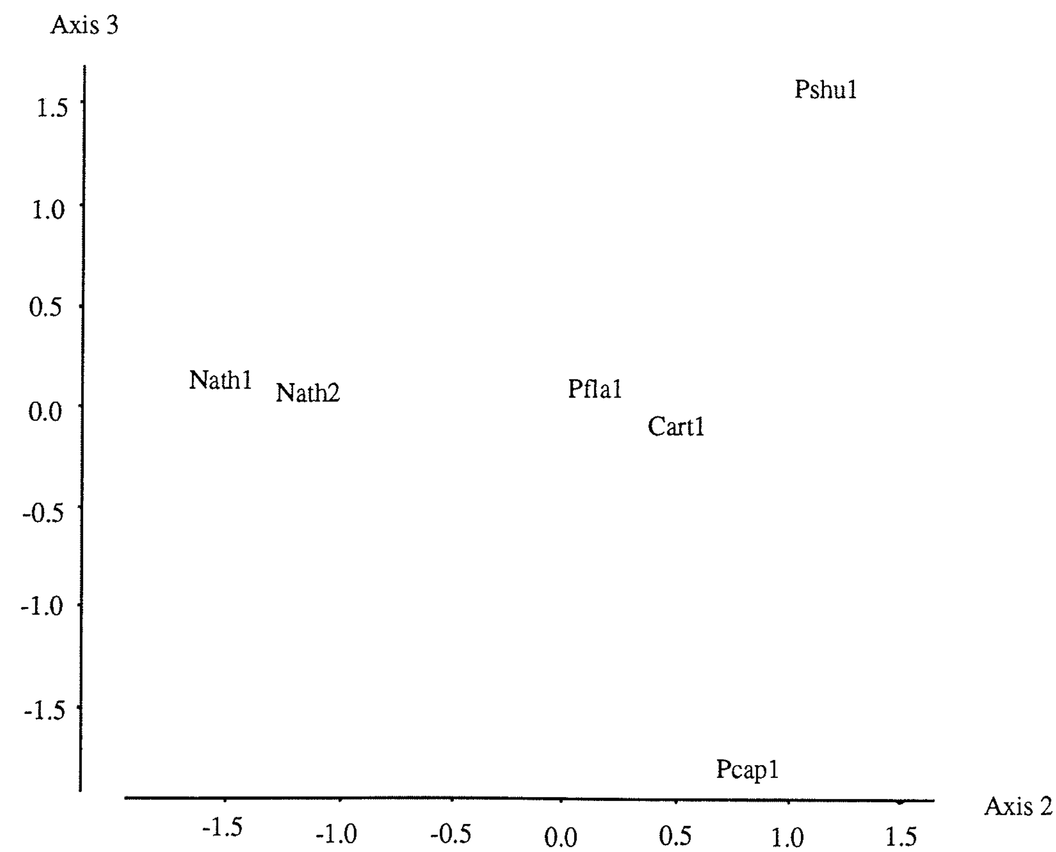

Axis 2
1.0
0.5
0.0
-0.5
-1.0
Pshu1
Pcap1
Cart1
Pfla1
Nath2
Nath1
Axis 1
-1.0
-0.5
0.0
0.5
1.0
1.5

B)

Figure 84. Axes 2 and 3 from correspondence analysis of September fish diets from Hillside Beach, A) ordination of dietary items, Daphn = Daphniidae, Bosmn = Bosminidae, Lepto = Leptodoridae, Cladc = unidentifiable cladocera, Calan = calanoid copepods, Cyclo = cyclopid copepods, Copep = unidentified copepods, Ephem = Ephemeroptera nymph, Trich = Trichoptera larvae, Dipt lv = Diptera larvae, Dipt pu = Diptera pupae, Dipt ad = Diptera adult, Cole lv = Coleoptera larvae, Cole ad = Coleoptera adult, Hymen = Hymenoptera adult, Homo ad = Homoptera adult, Insect = unidentified insect and B) symmetrical ordination of fish size groups, Pflav1 = *Perca flavescens* (49-64 mm.), Pshu1 = *Percina shumardi* (45 mm.), Pcap1 = *Percina caprodes* (43-77 mm.), Cart1 = *Coregonus artedi* (75-76 mm.), Nath1 = *Notropis atherinoides* (21-44 mm.) and Nath2 = *N. atherinoides* (46-73 mm.)


Axis 3
Trich
1.0
0.5
Dipt ad
Lepto
Cole ad
Bosmn
Insect
Cole lv
Daphn
0.0
Homo ad
Cladc
Calan
Hymen
Copep
-0.5
Ephem
-1.0
Dipt pu
-1.5
-2.0
Dipt lv
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Axis 2

A)


Axis 3
Pshu1
1.5
1.0
0.5
Nath1
Nath2
Pfla1
0.0
Cart1
-0.5
-1.0
-1.5
Pcap1
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Axis 2

B)

Table 1. Values calculated (mean ± standard deviation) for comparisons of fish abundance at Hillside Beach between 1993 and 1994

	Year 1993	1994
emerald shiner	24.36 ± 22.36	84.47 ± 13.76
white bass	59.29 ± 25.19	3.73 ± 7.17
walleye	6.74 ± 9.39	0.694 ± 1.96

Table 2. Mean species richness and Simpson's diversity index for each minute of latitude, for August collections of Lake Winnipeg

Latitude	50° 25'	50° 26'	50° 27'	50° 28'	50° 30'	50° 32'
Species Richness	6.000	8.667	9.000	7.000	7.200	8.000
Simpson's Index	0.510	0.740	0.357	0.589	0.593	0.680

Latitude	50° 33'	50° 34'	50° 36'	50° 39'	50° 41'	50° 44'
Species Richness	6.500	9.000	9.500	8.667	7.333	10.667
Simpson's Index	0.671	0.299	0.552	0.480	0.254	0.722

Latitude	50° 48'	50° 52'	50° 54'	50° 57'	51° 00'	51° 07'
Species Richness	4.500	8.000	5.333	7.000	6.667	9.333
Simpson's Index	0.505	0.110	0.354	0.170	0.248	0.572

Latitude	51° 23'	51° 54'	51° 57'	52° 15'	52° 21'	53° 02'
Species Richness	7.500	1.000	7.000	8.500	13.000	8.000
Simpson's Index	0.535	0.000	0.120	0.327	0.728	0.490

Latitude	53° 27'
Species Richness	7.000
Simpson's Index	0.660

Table 3. A summary of fish species presence in riverine environments entering Lake Winnipeg, R= rare, U= Uncommon, M= moderately abundant, C= common

Scientific Name	Common Name	Native or Introduced	Benthic	Pelagic	Lake use
Ichthyomyzon fossor	northern brook lamprey	N	R		
I. castanaeus	chestnut lamprey	N	R		R
I. unicuspis	silver lamprey	N	R		R
Acipenser fulvescens	lake sturgeon	N	R		R
Umbra limi	central mudminnow	N		M	R
Esox lucius	northern pike	N		C	R
Catostomus commersoni	white sucker	N		C	U
Ictiobus cyprinellus	bigmouth buffalo	N		U	R
M. anisurum	silver redhorse	N		M	U
Moxostoma erythrurum	golden redhorse	N		U	?
M. macrolepidotum	shorthead redhorse	N		M	U
Carassius auratus	goldfish	I		?	
Cousius plumbeus	lake chub	N		R	?
Cyprinella spiloptera	spotfin shiner	N		M	
Cyprinus carpio	carp	I		C	U
Luxilus cornutus	common shiner	N		C	
Macrhybopsis storeriana	silver chub	N		C	R
Margariscus margarita	pearl dace	N		U	?
Nocomis biguttatus	hornyhead chub	N		M	
Notemigonus crysoleucas	golden shiner	N		C	R
Notropis blennius	river shiner	N		M	U
N. heterolepis	blacknose shiner	N		U	
N. rubellus	rosyface shiner	N		U	
N. stramineus	sand shiner	N		M	
N. texanus	weed shiner	N		M	R
N. volucellus	mimic shiner	N		M	R
Phoxinus eos	northern redbelly dace	N		M	
P. neogaeus	finescale dace	N		M	
Pimephales notatus	bluntnose minnow	N		U	
P. promelas	fathead minnow	N		C	U
Semotilus atromaculatus	creek chub	N		R	
Amieurus melas	black bullhead	N		M	U
A. nebulosus	brown bullhead	N		M	U
Ictalurus punctatus	channel catfish	N		C	U
Noturus flavus	stonecat	N		C	?
N. gyrinus	tadpole madtom	N		M	R
Culaea inconstans	brook stickleback	N		C	U
Pungitius pungitius	ninespine stickleback	N		C	R
Ambloplites rupestris	rock bass	N		C	
Micropterus dolomieui	smallmouth bass	I		U	R
Lepomis gibbosus	pumpkinseed	N		R	
Pomoxis annularis	white crappie	I		R	
P. nigromaculatus	black crappie	I		M	R
Etheostoma exile	iowa darter	N	U		U
Percina maculata	blackside darter	N	M		

Table 4. A summary of fish species present in lacustrine environments of Lake Winnipeg, not including the Red River, R= rare, U= Uncommon, M= moderately abundant, C= common

Scientific Name	Common Name	Native or Introduced	Benthic Inshore	Benthic Offshore	Pelagic Inshore	Pelagic Offshore	River use
Coregonus artedi	lake cisco	N			C	C	R
C. clupeaformis	lake whitefish	N			C	C	R
Osmerus mordax	rainbow smelt	I				M	?
Hiodon alosoides	goldeye	N			M	M	U
H. tergisus	mooneye	N			M	M	M
Carpiodes cyprinus	quillback	N	U	?			U
Catostomus catostomus	longnose sucker	N	C	C			M
Notropis atherinoides	emerald shiner	N			C	C	M
N. hudsonius	spottail shiner	N			M	M	M
Platygobio gracilis	flathead chub	N	?	R			?
Rhinichthys cataractae	longnose dace	N	C	?			M
Lota lota	burbot	N	C	C			M
Percopsis omiscomaycus	troutperch	N	C	C			U
Morone chrysops	white bass	I			C	C	M
Etheostoma nigrum	johnny darter	N	M	?			M
Perca flavescens	yellow perch	N			C	C	M
Percina caprodes	logperch	N	C	?			M
P. shumardi	river darter	N	C	?			C
Stizostedion canadense	sauger	N			C	C	U
S. vitreum	walleye	N			C	C	M
Cottus bairdi	mottled sculpin	N	C	?			M
Cottus cognatus	slimy sculpin	N	C	?			M
C. ricei	spoonhead sculpin	N	R	?			
Aplodinotus grunniens	freshwater drum	N			M	M	U

Table 6. The number of species of fish and Simpsons diversity index averaged for all collections within biweekly intervals in the South basin of Lake Winnipeg, UCL = upper 95% confidence limit, LCL = lower 95% confidence limit

	Early June	Late June	Early July	Late July	Early August	Late August	Early Sept.	Late Sept.
species richness								
mean	2.0000	5.6154	5.4000	7.7692	8.1333	6.7083	9.0000	6.6000
maximum	3	9	6	13	13	13	10	8
minimum	1	3	5	3	4	3	7	5
UCL	3.1316	6.8813	5.8801	9.5606	8.9565	7.7127	10.3859	7.9293
LCL	0.8684	4.3495	4.9199	5.9779	7.3101	5.7039	7.6141	5.2707
Simpson's Diversity Index								
	0.142	0.415	0.383	0.388	0.516	0.351	0.433	0.317

Table 7. Dietary items (mean proportion of stomach contents ± standard deviation) for emerald shiners for early June Hillside beach samples

Length Range		Cladocera Bosminidae	Cladocera unidentified	Copepoda Calanoidea	Copepoda Cyclopoidea	Copepoda unidentified	Insecta Hemiptera adult	Insecta Ephemeroptera nymph
23-36 mm.		0.02	-	-	0.7335±0.2681	0.4361±0.2959	-	-
Number of Stomachs		1			27	21		
% Empty	39.21							
51 Fish								
43-53 mm.		-	-	0.9924±0.0198	-	-	-	-
Number of Stomachs				7				
% Empty	28.57							
21 Fish								
55-71 mm.		-	0.2	0.4944±0.4022	0.5216±0.4164	-	0.0964±0.0657	0.0464±0.0228
Number of Stomachs			1	3	5		2	2
% Empty	44.44							
27 Fish								

Table 7. continued

Length Range	Diptera larvae	pupae	adult	Coleoptera adult	Homoptera adult	unidentified	Pisces Cyprinidae
23-36 mm.	1	1		-	-	-	-
Number of Stomachs	1	1					
43-53 mm.	-	0.7096±0.3864	0.25	-	0.25	0.5	-
Number of Stomachs		10	1		1	1	
55-71 mm.	-	0.6828±0.3256	-	0.033	0.125	0.2361±0.10485	0.35
Number of Stomachs		13		1	1	3	1

Table 8. Dietary items (mean proportion of stomach contents ± standard deviation) of the emerald shiner for late June Hillside Beach samples

Length Range	Cladocera Daphniidae	Bosminidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	unidentified
19-32 mm.	0.5	0.9524±0.0824	0.5135±0.3077	0.6146±0.2038	0.6833±0.2447	0.5416±0.4389	0.9286±0.1237
Number of Stomachs	1	3	13	8	13	3	3
% Empty 3.64							
55 fish							
33-51 mm.	0.2208±0.1446	0.3204±0.2344	0.7198±0.3578	0.5207±0.4168	0.8308±0.2252	-	0.6333±0.3382
Number of Stomachs	3	3	78	13	35		10
% Empty 9.23							
130 fish							
52-72 mm.	0.8940±0.1832	0.1666	0.7285±0.3636	0.5636±0.3646	0.5243±0.4016	-	-
Number of Stomachs	7	1	27	26	25		
% Empty 19.66							
117 fish							
73-86 mm.	-	-	-	0.4733±0.5429	0.9441±0.079	-	-
Number of Stomachs				2	2		
% Empty 15.38							
13 fish							

Table 8. Continued

Length Range	Insecta Hemiptera adult	Ephemeroptera nymph	Odonata nymph	Trichoptera larvae	Diptera larvae	pupae	adult	Coleoptera adult
19-32 mm.	-	-	-	0.5	0.5	0.6187±0.3296	0.4643±0.3499	0.5
Number of Stomachs				1	1	30	5	1
33-51 mm.	-	-	-	1	-	0.6200±0.3703	0.4524±0.3759	-
Number of Stomachs				1		15	4	
52-72 mm.	0.0884±0.0163	0.1579±0.1119	-	0.1944±0.1203	0.1293±0.0635	0.557±0.374	0.5675±0.3372	0.2732±0.1574
Number of Stomachs	2	3		3	3	22	19	4
73-86 mm.	0.2050±0.0556	0.3135±0.3423	0.1428	0.2222	0.0714	0.2676±0.1832	0.4105±0.3714	0.5
Number of Stomachs	3	2	1	1	1	3	5	1

Table 8. Continued

Length Range	Hymenoptera adult	Homoptera adult	unidentified	Pisces Moronidae	scales
19-32 mm.	0.5	0.4688±0.3869	-	-	-
Number of Stomachs	1	4			
33-51 mm.	0.6667±0.4714	0.25	0.5111±0.4834	-	0.1607±0.1263
Number of Stomachs	2	1	3		2
52-72 mm.	0.2202±0.0861	0.3723±0.3637	0.4538±0.4002	-	0.6346±0.2443
Number of Stomachs	5	14	10		4
73-86 mm.	0.1428	0.3947±0.3734	-	1	0.7143
Number of Stomachs	1	3		1	1

Table 9. Dietary summary (mean proportion of stomach contents ± standard deviation) for the emerald shiner for early July at Hillside Beach

Length Range		Cladocera Daphniidae	Bosminidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	unidentified	Insecta Ephemeroptera nymph	Trichoptera larvae
16-48 mm.		0.4360±0.4077	0.125	0.2727±0.2247	0.2914±0.1977	0.6456±0.3163	0.6089±0.3348	0.7586±0.2563	0.2	0.0625
Number of Stomachs		6	1	7	21	59	8	21	1	1
% Empty	9.84									
132 fish										
49-72 mm.		0.0326±0.0245	-	0.3362±0.3104	0.2793±0.4815	0.7168±0.2646	-	0.4263±0.2269	0.0344	0.0526
Number of Stomachs		2		33	4	34		3	1	1
% Empty	16.39									
61 fish										

Table 9. Continued

Length Range	Diptera larvae	pupae	adult	Coleoptera larvae	adult	Hymenoptera adult	unidentified	Arachnida Hydrachnellae	Pisces unidentified eggs
16-48 mm.	0.2233±0.1735	0.5564±0.3465	.625±0.530	0.5	0.25	0.4926±0.4411	0.4234±0.4325	0.1639±0.0375	-
Number of Stomachs	5	76	2	1	1	3	4	3	
49-72 mm.	0.0064	0.4615±0.3758	0.037	-	0.2865±0.2129	-	-	0.0503±0.0303	0.5666±0.3419
Number of Stomachs	1	20	1		3			3	3

Table 10. Dietary summary (mean proportion of stomach contents ± standard deviation) for emerald shiner for late July at Hillside Beach

Length Range		Cladocera Daphniidae	Bosminidae	unidentified	Copepoda Calanoidea	unidentified	Insecta Ephemeroptera nymph
31-47 mm.		0.3271±0.3729	0.1	0.0692±0.0435	0.8307±0.1879	0.8207±0.1429	0.25
Number of Stomachs		6	1	2	5	4	1
% Empty	6.25						
16 fish							
56-70 mm.		-	-	-	0.3333	-	-
Number of Stomachs					1		
% Empty	28.57						
7 fish							

Table 10. Continued

Length Range	Odonata nymph	Diptera Larvae	pupae	adult	Coleoptera larvae	Hymenoptera adult	Homoptera adult	Arachnida Hydrachnellae
31-47 mm.	-	-	0.4248±0.3716	0.2466±0.2335	0.5	0.04	0.3333	0.1
Number of Stomachs			8	3	1	1	1	1
56-70 mm.	0.3095±0.3095	0.3333	0.5289±0.3099	0.2307	0.0769	0.4285	0.3333	-
Number of Stomachs	2	1	5	1	1	1	1	

Table 11. Dietary summary (mean proportion of stomach contents ± standard deviation) for emerald shiners from early August, Hillside Beach

Length Range		Cladocera Daphniidae	Leptodoridae	Copepoda Calanoidea	Insecta Diptera pupae	unidentified	Annelida Hirudinidae
20-51 mm.		1	1	0.95±0.1118	0.75±0.433	1	1±0
Number of Stomachs		1	1	5	3	1	3
% empty	80.3						
66 fish							
53-67 mm.		-	1	1	-	-	-
Number of Stomachs			1	1			
% empty	75.0						
8 fish							

Table 12. Dietary summary (mean proportion of stomach contents ± standard deviation) for emerald shiners caught in late August, Hillside Beach

Length Range		Cladocera Daphniidae	Bosminidae	Leptodoridae	unidentified	Copepoda Calanoidea
18-55 mm.		0.6322±0.3258	0.0485±0.0115	0.8576±0.2694	0.6751±0.3075	0.3909±0.3368
Number of Stomachs		18	4	101	141	64
% empty	18.8					
409 fish						
56-87 mm.		0.7095±0.3142	-	0.8016±0.305	1	1
Number of Stomachs		5		9	1	1
% empty	24.5					
49 fish						

Table 12. Continued

Length Range	Cyclopoidea	unidentified	Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae
18-55 mm.	0.443±0.3039	0.2872±0.3043	0.3247±0.2617	0.101±0.1551	0.2289±0.1538	0.6364±0.3208
Number of Stomachs	101	8	22	4	5	58
56-87 mm.	0.083	-	0.395±0.3323	0.3338±0.2899	-	0.719±0.2751
Number of Stomachs	1		6	6		8

Table 12. Continued

Length Range	Diptera adult	Coleoptera adult	Hymenoptera adult	Homoptera adult	unidentified	Pisces unidentified
18-55 mm.	0.2958±0.0886	0.1667	0.1918±0.1924	0.25	0.5097±0.3913	0.7133±0.4011
Number of Stomachs	4	1	6	1	15	5
56-87 mm.	0.2292±0.1473	0.2857±0.303	0.48±0.3271	1.0±0.0	0.65±0.1732	-
Number of Stomachs	2	2	5	2	4	

Table 13. Dietary summary (mean proportion of stomach contents ± standard deviation) for emerald shiners from September samples, Hillside Beach

Length Range		Cladocera Bosminid	Leptodorid	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Ephemeroptera nymph	Trichoptera larvae
21-44 mm.		0.8821±0.1979	.9927±0.03	0.6813±0.3565	0.5	-	-	-
Number of Stomachs		13	17	8	1			
% empty	50.6							
89 fish								
46-73 mm.		-	1	0.494±0.5808	0.0833	0.25	0.0833	1
Number of Stomachs			1	2	1	1	1	1
% empty	42.3							
26 fish								

Table 13. Continued

Length Range	Diptera larvae	pupae	adult	Coleoptera larvae	adult	Hymenoptera adult	Neuroptera	unidentified
21-44 mm.	-	0.7166±0.2981	0.5±0.0	-	-	1.0±0.0	-	1.0±0.0
Number of Stomachs		5	2			2		2
46-73 mm.	0.0476	0.6041±0.3146	-	0.3333	0.2917±0.0589	0.6111±0.3469	0.3333	0.5238±0.6734
Number of Stomachs	1	4		1	2	3	1	2

Table 14. Dietary items (mean proportion of stomach contents ± standard deviation) of the white bass for late June Hillside Beach samples

Length Range		Cladocera Daphniidae	Bosminidae	Leptodoridae	Copepoda Calanoidea	unidentified	Insecta Ephemeroptera nymph
22-47 mm.		0.0155±0.0057	0.2166±0.1649	0.0998±0.1361	0.9527±0.1047	0.0192	0.0330±0.0122
Number of Stomachs		2	2	43	139	1	2
% Empty	0.71						
140 fish							
252 mm.		-	-	-	-	-	-
Number of Stomachs							
% Empty	0.00						
2 fish							

Table 14. Continued

Length Range	Diptera larvae	pupae	adult	unidentified	Pisces Percidae	Moronidae	Cyprinindae	unidentified
22-47 mm.	0.0182±0.0124	0.0594±0.0938	0.0312	0.0196	-	-	-	0.0847±0.0866
Number of Stomachs	8	4	1	1				4
252 mm.	-	-	-	-	0.5	0.5±0	0.5	-
Number of Stomachs					1	2	1	

Table 15. Dietary summary (mean proportion of stomach contents ± standard deviation) for white bass for early July at Hillside Beach

Length Range		Cladocera Daphniidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	unidentified	Pisces unidentified
16-24 mm.		1	0.6771±0.2902	0.3333	0.8601±0.2368	0.5833±0.1178	1	-
Number of Stomachs		1	8	1	28	2	1	
% empty	13.16							
38 fish								
365 mm.		-	-	-	-	-	-	1
Number of Stomachs								1
% Empty	0							
1 fish								

Table 16. Dietary summary (mean proportion of stomach contents ± standard deviation) of white bass for late July at Hillside Beach

Length Range		Cladocera unidentified	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Diptera pupae	Pisces Percidae	Cyprinidae
24 mm.		0.0294	0.9705	-	-	-	-
Number of Stomachs		1	1				
% Empty	0						
1 fish							
190 mm.		-	-	0.4	0.2	0.4	1
Number of Stomachs				1	1	1	1
% Empty	0						
2 fish							

Table 17. Dietary summary (mean proportion of stomach contents ± standard deviation) of white bass from early August, Hillside Beach

Length Range		Cladocera				Copepoda	
		Daphniidae	Bosminidae	Leptodoridae	unidentified	Calanoidea	Cyclopoidea
20-41 mm.		0.0278±0.02	0.0099	0.0635±0.1714	0.0425±0.0674	0.9649±0.0635	0.0272±0.0222
Number of Stomachs		5	1	34	22	103	5
% empty	0.96						
104 fish							
196 mm.		-	-	-	-	-	-
Number of Stomachs							
% empty	0						
1 fish							

Table 17. Continued

Length Range	Insecta				Pisces		
	Ephemeroptera	Trichoptera	Diptera		Percidae	Cyprinidae	unidentified
	nymph	larvae	larvae	pupae			
20-41 mm.	0.0123	0.0714	0.0312±0.0236	0.0206±0.0086	-	0.0447±0.0501	0.0546±0.0568
Number of Stomachs	1	1	4	3		14	6
196 mm.	-	-	-	-	1	-	-
Number of Stomachs					1		

Table 18. Dietary summary (mean proportion of stomach contents ± standard deviation) for white bass collected in late August, Hillside Beach

Length Range		Cladocera Daphniidae	Bosminidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Ephemeroptera nymph
22-51 mm.		0.0772±0.0645	0.0196±0.0152	0.2052±0.2488	0.0825±0.1028	0.8426±0.1945	0.1527±0.0196	0.0154±0.011
Number of Stomachs		3	2	38	26	65	2	2
% empty	0.0							
67 fish								
54-77 mm.		-	-	0.2539±0.4296	0.354±0.2674	0.593±0.2979	0.0041	-
Number of Stomachs				3	12	12	1	
% empty	6.25							
16 fish								
255 mm.		-	-	-	-	-	-	-
Number of Stomachs								
% empty	0.0							
1 fish								

Table 18. Continued

Length Range	Diptera		Pisces	
	larvae	pupae	Cyprinidae	unidentified
22-51 mm.	0.0226±0.0131	0.0404±0.0523	0.2284±0.1784	0.0291±0.0059
Number of Stomachs	2	5	6	2
54-77 mm.	-	0.0269±0.0293	0.352±0.4185	-
Number of Stomachs		2	8	
255 mm.	-	-	1	-
Number of Stomachs			1	

Table 19. Dietary items (mean proportion of stomach contents ± standard deviation) for yellow perch from early June Hillside Beach Samples

Length Range		Cladocera Bosminidae	Copepoda Calanoidea	Cyclopoidea	Insecta Diptera pupae	Arthropoda Ostracoda
48-63 mm.		0.2883±0.2350	0.7078±0.2909	0.4195±0.5028	0.01	0.01
Number of Stomachs		2	3	3	1	1
% Empty	42.86					
7 Fish						

Table 20. Dietary items (mean proportion of stomach contents ± standard deviation) of the yellow perch for late June Hillside Beach samples

Length Range	Cladocera Daphniidae	Leptodoridae	unidentified	Copepoda Calanoidea	unidentified	Insecta Hemiptera adult
30-63 mm.	0.238	0.4177±0.3469	0.1384±0.1786	0.8175±0.2701	-	0.2
Number of Stomachs	1	24	12	45		1
% Empty 1.92						
52 fish						
72-91 mm.	-	0.16±0.287	0.0121±0.0102	0.9216±0.0744	1	0.1263±0.2491
Number of Stomachs		21	16	27	1	2
% Empty 3.13						
32 fish						
105-193 mm.	-	0.0398±0.0539	0.0084	0.9505±0.0532	-	0.0031±0.002
Number of Stomachs		2	1	2		2
% Empty 33.33						
3 fish						

Table 20. Continued

Length Range	Ephemeroptera nymph	Diptera larvae	pupae	unidentified	Pisces eggs	scales
30-63 mm.	-	0.0291±0.0209	0.0291±0.0209	-	0.9473	-
Number of Stomachs		3	3		1	
72-91 mm.	0.0025±0.0004	0.0027	0.0027	-	-	0.1427±0.1034
Number of Stomachs	2	1	1			3
105-193 mm.	-	-	-	0.0045	-	-
Number of Stomachs				1		

Table 21. Dietary summary (mean proportion of stomach contents ± standard deviation) of yellow perch from early July at Hillside Beach

Length Range	Cladocera Daphniidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Ephemeroptera nymph	Trichoptera larvae
21-76 mm.	0.5609	0.079±0.0703	0.0762±0.0853	0.8758±0.2328	0.1077±0.0833	-	-
Number of Stomachs	1	5	4	25	2		
4% Empty							
26 fish							
97-150 mm.		0.0757	-	0.3939±0.3856	-	0.0783±0.0464	0.0909
Number of Stomachs		1		2		2	1
0% Empty							
2 fish							

Table 21. Continued

Length Range	Diptera larvae	pupae	Pisces unidentified	eggs
21-76 mm.	0.0287±0.0301	0.01379±0.0001	-	0.3857±0.40025
Number of Stomachs	2	2		4
97-150 mm.	0.0934±0.0249	-	0.3510±0.3392	-
Number of Stomachs	2		2	

Table 22. Dietary summary (mean proportion of stomach contents ± standard deviation) of yellow perch for Late July at Hillside Beach

Length Range	Cladocera Daphniidae	Bosminidae	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Diptera pupae
26-37 mm.	0.1786±0.2105	0.1054±0.0757	0.0762±0.0636	0.9304±0.13	0.1596±0.1284	0.0333
Number of Stomachs	5	8	29	71	6	1

0% Empty

71 fish

Table 23. Dietary summary (mean proportion of stomach contents ± standard deviation) of the yellow perch for early August, Hillside Beach

Length Range		Cladocera Daphniidae	Leptodoridae	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Diptera pupae
27-43 mm.		0.0081	0.0273±0.0085	0.0224±0.0088	0.9935±0.0164	0.0301±0.0259	0.0426±0.0324
Number of Stomachs		1	2	2	57	3	4
% empty	1.72						
58 fish							

Table 24. Dietary summary (mean proportion of stomach contents ± standard deviation) for yellow perch collected in late August, Hillside Beach

Length Range		Cladocera Daphniidae	Leptodoridae	Sididae	unidentified	Copepoda Calanoidea	Cyclopoidea	Insecta Diptera larvae	pupae
32-43 mm.		0.0467±0.0172	0.6136±0.3755	-	0.0538±0.0258	0.9157±0.1668	-	-	-
Number of Stomachs		2	3		3	13			
% empty	17.6								
17 fish									
45-54 mm.		-	0.456±0.4136	0.0227	0.4988±0.3379	0.6632±0.3507	-	-	-
Number of Stomachs			21	1	7	27			
% empty	0.0								
31 fish									
55-58 mm.		-	0.8744±0.1162	-	0.0649±0.0109	0.5283±0.4699	0.0081	0.9524	0.0476
Number of Stomachs			2		2	4	1	1	1
% empty	0.0								
5 fish									

Table 25. Dietary summary (mean proportion of stomach contents ± standard deviation) for yellow perch from September collections, Hillside Beach

Length Range		Cladocera Daphniidae	Bosminidae	Copepoda Calanoidea
49-64 mm.		0.05	0.8625±0.1945	0.225
Number of Stomachs		1	2	1
% empty	75			
8 fish				
77-80 mm.		-	-	-
Number of Stomachs				
% empty	100			
3 fish				

Table 26. Dietary items (mean proportion of stomach contents ± standard deviation) of the sauger for late June Hillside Beach samples

Length Range		Insecta Hemiptera adult	Trichoptera larvae	Pisces Percidae	Moronidae	Cyprinidae	unidentified
60-75 mm.		-	-	1.0±0	1.0	-	-
Number of Stomachs				2	1		
% Empty	0.00						
3 fish							
116-152 mm.		-	-	0.9167±0.1667	0.6667±0.4714	1.0±0	1.0±0
Number of Stomachs				4	2	2	5
% Empty	14.29						
14 fish							
182-206 mm.		-	0.5	1.0±0	-	0.5±0	0.875±0.25
Number of Stomachs			1	2		2	3
% Empty	0.00						
7 fish							
216-222 mm.		0.5	-	-	-	-	0.75±0.3536
Number of Stomachs		1					2
% Empty	0.00						
2 fish							

Table 27. Dietary summary (mean proportion of stomach contents ± standard deviation) for the sauger from early July at Hillside Beach

Length Range	Cladocera Leptodoridae	Copepod Calanoidea	Insecta Ephemeroptera nymph	Pisces Cyprinidae	Percopsidae
39 mm.	-	1	-	-	-
Number of Stomachs		1			
0% Empty					
1 fish					
110-120 mm.	0.5	-	0.5	1	-
Number of Stomachs	1		1	1	
33.33% Empty					
3 fish					
165-184 mm.	-	-	-	1	1
Number of Stomachs				1	1
33.33% Empty					
3 fish					

Table 28. Dietary summary (mean proportion of stomach contents ± standard deviation) of sauger from late July at Hillside Beach

Length Range	Pisces Percidae	unidentifed
69 mm.	1	-
0% Empty	1	
1 fish		
118-276 mm.	-	1
50% Empty		1
2 fish		

Table 29. Dietary summary (mean proportion of stomach contents ± standard deviation) for sauger collected in late August, Hillside Beach

Length Range		Pisces Percidae	unidentifiable
158-289 mm.		0.75±0.433	0.875±0.1767
Number of Stomachs		3	2
% empty	0.0		
4 fish			

Table 30. Dietary items (mean proportion of stomach contents ± standard deviation) of the walleye for late June Hillside Beach samples

Length Range		Pisces Percidae	Moronidae	Cyprinidae	unidentified
41-48 mm.		-	1.0	-	-
Number of Stomachs			1		
% Empty	66.67				
3 fish					
138-288 mm.		1.0	-	0.9375±0.0265	1.0±0
Number of Stomachs		1		4	2
% Empty	12.50				
8 fish					

Table 31. Dietary summary (mean proportion of stomach contents ± standard deviation) for the walleye from early July at Hillside Beach

Length Range	Cladocera Leptodoridae	unidentified	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Diptera pupae	Pisces Moronidae	Cyprinidae	unidentified
34-47 mm.	-	0.0333	0.8761±0.2061	-	-	0.3333	0.5	
Number of Stomachs		1	7			1	1	
0% empty								
7 fish								
103-248 mm.	0.9497	-	0.0376	0.35±0.2121	0.0084	-	0.751±0.4979	0.825±0.2362
Number of Stomachs	1		1	2	1		1	4
20% Empty								
10 fish								

Table 32. Dietary items (mean proportion of stomach contents ± standard deviation) of the goldeye for late June Hillside Beach samples

Length Range	Cladocera Daphniidae	Bosminidae	Sididae	unidentified	Copepoda unidentified	Insecta Corixidae adult	Diptera Larvae
60-92 mm.	0.0500	0.5783±0.306	0.5647±0.2999	0.1843±0.2664	0.0486±0.0413	0.1000	0.2352±0.2096
Number of Stomachs	1	14	3	10	4	1	13
% Empty 0.00							
21 fish							
116-142 mm.	-	-	0.0303	0.0222	-	-	0.1838±0.0931
Number of Stomachs			1	1			3
% Empty 16.66							
6 fish							

Table 32. continued

Length Range	pupae	adult	Coleoptera larvae	adult	Hymenoptera adult	Homoptera adult	unidentified	Arachnida Hydrachnellae
60-92 mm.	0.3037±0.2576	0.0551±0.0237	0.2238±0.2491	0.3544±0.5595	0.0714±0.0511	-	-	-
Number of Stomachs	6	4	2	3	7			
116-142 mm.	0.2071±0.1357	0.0222	0.1111	0.0619±0.0431	0.4489±0.4004	0.6667	0.0222	0.0222
Number of Stomachs	2	1	1	3	4	1	1	1

Table 34. Dietary items (mean proportion of stomach contents ± standard deviation) of the mooneye for late June Hillside Beach samples

Length Range	Cladocera Bosminidae	Sididae	unidentified	Copepoda unidentified	Insecta Corixidae adult	Odonata nymph	Trichoptera larvae
42-79 mm.	0.7141±0.293	0.0724±0.0262	0.1497±0.0735	0.0111	0.3333	0.5	0.2666±0.3299
Number of Stomachs	8	3	6	1	1	1	2
% Empty 7.14							
14 fish							
109-113 mm.	-	-	-	-	0.2592	0.6026±0.4855	
Number of Stomachs					1	2	
% Empty 33.33							
3 fish							

Table 34. Continued

Length Range	Diptera larvae	pupae	Coleoptera larvae	adult	Hymenoptera adult	Homoptera adult
42-79 mm.	0.3025±0.2689	0.525±0.3182	-	-	0.2475±0.2887	0.0313
Number of Stomachs	9	2			4	1
109-113 mm.	0.3333	0.0741	0.0371	0.0455±0.0120	-	-
Number of Stomachs	1	1	1	2		

Table 35. Dietary summary (mean proportion of stomach contents ± standard deviation) for mooneye collected in late August, Hillside Beach

Length Range		Cladocera Leptodoridae	Insecta Ephemeroptera	Diptera larvae	pupae	adult	Coleoptera adult	Hymenoptera adult	Homoptera adult
44-68 mm.		0.6383±0.3567	0.2857	0.25	0.25	0.1667	0.1428	0.4791±0.5008	0.1964±0.0757
Number of Stomachs		4	1	1	1	1	1	2	2
% empty	0.0								
5 fish									

Table 36. Dietary items (mean proportion of stomach contents ± standard deviation) of the freshwater drum for late June Hillside Beach samples

Length Range		Cladocera Leptodoridae	unidentified	Copepoda Calanoidea	Insecta Diptera larvae	Coleoptera adult
41-51 mm.		0.1521	0.6666	0.0772±0.0478	0.657±0.4357	0.0555
Number of Stomachs		1	1	2	3	1
% Empty	0.00					
3 fish						
159-180 mm.		-	-	-	-	-
Number of Stomachs						
% Empty	100.00					
2 fish						

Table 37. Dietary items (mean proportion of stomach contents ± standard deviation) of the river darter for late June Hillside Beach samples

Length Range	Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera Larvae	pupae	Pisces eggs
24 mm.	-	-	1.0	-	-
Number of Stomachs			1		
% Empty 0.00					
1 fish					
51-62 mm.	0.125	0.1681±0.1974	0.6786±0.3299	0.1053±0.0969	0.2765±0.4113
Number of Stomachs	1	2	5	3	3
% Empty 0.00					
5 fish					

Table 38. Dietary summary (mean proportion of stomach contents ± standard deviation) of river darters from early July at Hillside Beach

Length Range	Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae	Pisces unidentified eggs
47-55 mm.	0.0849±0.0233	0.1111	0.3886±0.4203	0.1444±0.1099	0.7264±0.349
Number of Stomachs	3	1	3	2	3

0% Empty

4 fish

Table 39. Dietary summary (mean proportion of stomach contents ± standard deviation) of the river darter from late July at Hillside Beach

Length Range	Insecta Trichoptera larvae	 Diptera larvae	Pisces unidentified
54 mm.	0.25	0.625	0.125
Number of Stomachs	1	1	1

0% Empty

1 fish

Table 40. Dietary summary (mean proportion of stomach contents ± standard deviation) for river darters collected in late August, Hillside Beach

Length Range	Cladocera unidentified	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae	unidentified	Arthropoda Ostracoda
28-56 mm.	0.7894	0.0526	0.1052	0.2627±0.2802	0.6999±0.2651	0.0546±0.0424	0.1	0.05
Number of Stomachs	1	1	1	7	7	3	1	1

% empty 0.0

8 fish

Table 41. Dietary summary (proportion of stomach contents) of the river darter from September, Hillside Beach

Length Range	Insecta Trichoptera larvae
45 mm.	1
Number of Stomachs	1
% empty	0
1 fish	

Table 42. Dietary items (mean proportion of stomach contents ± standard deviation) of the logperch for late June Hillside Beach samples

Length Range	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Odonata nymph	Trichoptera larvae	Diptera larvae	pupae	Coleoptera larvae	Lepidoptera larvae
58-100 mm.	0.0138	0.1061±0.131	0.0571	0.3737±0.1179	0.8224±0.2341	0.0755±0.0517	0.0285	0.0063
Number of Stomachs	1	3	1	2	10	8	1	1

% Empty 9.09

11 fish

Table 43. Dietary summary (mean proportion of stomach contents ± standard deviation) for the logperch from early July at Hillside Beach

Length Range	Copepoda unidentified	Insecta Diptera larvae	pupae	Pisces unidentified eggs
79-82 mm.	1	0.7522	0.0088	0.2389
Number of Stomachs	1	1	1	1

0% Empty

2 fish

Table 44. Dietary summary (proportion of stomach contents) of the logperch from early August, Hillside Beach

Length Range		Cladocera Bosminidae	unidentified	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Trichoptera larvae
26-37 mm.		0.05	0.05	0.9	0.6666	0.3333
Number of Stomachs		1	1	1	1	1
% empty	0					
2 fish						

Table 45. Dietary summary (mean proportion of stomach contents ± standard deviation) for the logperch collected in late August, Hillside Beach

Length Range		Copepoda Calanoidea	Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae	Coleoptera larvae	Pisces unidentified
29-41 mm.		1	0.2377±0.2665	0.0909	0.5206±0.3608	0.2114±0.2153	-	-
Number of Stomachs		1	3	1	3	3		
% empty	0.0							
4 fish								
74-95 mm.		-	0.7222	0.3262±0.1733	0.2549±0.2558	0.0385	0.0128	0.0641
Number of Stomachs			1	2	2	1	1	1
% empty	0.0							
2 fish								

Table 46. Dietary summary (mean proportion of stomach contents ± standard deviation) for logperch from September, Hillside Beach

Length Range		Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae
47-77 mm.		0.0345	0.3467±0.415	0.6138±0.3341	0.1243±0.0637
Number of Stomachs		1	4	5	4
% empty	0				
5 fish					

Table 47. Dietary items (mean proportion of stomach contents ± standard deviation) of the troutperch for late June Hillside Beach samples

Length Range	Cladocera Leptodoridae	unidentified	Copepoda Cyclopoidea	Insecta Ephemeroptera	Diptera larvae	pupae
49-58 mm.	0.9583±0.0722	0.8888±0.1925	-	-	0.7083±0.5051	-
Number of Stomachs	3	3			3	
% Empty 58.33						
24 fish						
60-78 mm.	0.8286±0.2724	0.7153±0.3909	0.2	0.8333±0.2866	0.7785±0.299	0.0384
Number of Stomachs	13	12	1	3	28	1
% Empty 47.73						
88 fish						

Table 47. Continued

Length Range	Diptera adult	unidentified	Ostracoda	Pisces eggs
49-58 mm.	-	1	1	0.3333
Number of Stomachs		1	1	1

Length Range	Diptera adult	unidentified	Ostracoda	Pisces eggs
60-78 mm.	0.1	-	0.0954±0.0064	1
Number of Stomachs	1		2	1

Table 48. Dietary summary (mean proportion of stomach contents ± standard deviation) of the troutperch from early July at Hillside Beach

Length Range	Cladocera Leptodoridae	Sididae	unidentified	Copepoda Calanoidea	Insecta Ephemeroptera nymph	Trichoptera larvae	Diptera larvae	pupae
50-89 mm.	0.7661±0.2783	0.3796±0.5381	0.6149±0.3627	0.0129	0.2574±0.2486	0.1087±0.045	0.6811±0.346	0.75±0.433
Number of Stomachs	60	3	41	1	15	5	31	3

39.88% Empty

168 fish

Table 49. Dietary summary (mean proportion of stomach contents ± standard deviation) of troutperch for late July at Hillside Beach

Length Range	Insecta Diptera larvae
62 mm.	1
0% Empty	1
1 fish	

Table 50. Dietary summary (mean proportion of stomach contents ± standard deviation) for lake cisco from September samples, Hillside Beach

Length Range	Copepoda Calanoidea	Unidentifiable
75-76 mm.	0.8571± 0.202	0.2857
Number of Stomachs	2	1

% empty 0.0

2 fish

Table 51. Dietary summary (proportion of stomach contents) for the silver chub collected in late August, Hillside Beach

Length Range		Insecta Ephemeroptera nymph	Diptera pupae
59 mm.		0.6667	0.3333
Number of Stomachs		1	1
% empty	0.0		
1 fish			

Table 52. Dietary summary (mean proportion of stomach contents ± standard deviation) for mottled sculpin collected in late August, Hillside Beach

		Insecta Ephemeroptera nymph	Diptera larvae	Ostracods
27-30 mm.		1	0.2857	0.7143
Number of Stomachs		1	1	1
% empty	0.0			
2 fish				

Table 53. Dietary overlap using Renkonen's index (percentage overlap) for all species and size categories for early June samples at Hillside Beach, Pflav = yellow perch, Nathr = emerald shiner, Pshum = river darter

		Pshum 39 mm.	Pflav 48-63mm.	Nathr 23-36 mm.	Nathr 43-53 mm.	Nathr 55-71mm.
Pshum	39 mm.	100				
Pflav	48-63mm.	0	100			
Nathr	23-36 mm.	0	10.46	100		
Nathr	43-53 mm.	0	66.48	0.08	100	
Nathr	55-71mm.	0	26.38	57.62	37.30	100

Table 54. Dietary overlap using Renkonens' index (percentage overlap) for all size categories and species for late June samples at Hillside Beach, Mchry = white bass, Nathr = emerald shiner, Pomi = troutperch, Agrun = freshwater drum, Hterg = mooneye, Halos = goldeye, Scana = sauger, Svitr = walleye, Pflav = yellow perch, Pshum = river darter, Pcapr = logperch

		Mchry		Nathr				Pomi		Agrun	Hterg	
		22-47 mm.	252 mm.	19-32 mm.	33-51 mm.	52-72 mm.	73-86 mm.	49-58 mm.	60-78 mm.	41-51 mm.	42-79 mm.	109-113 mm.
Mchry	22-47 mm.	100.00										
	252 mm.	0.00	100.00									
Nathr	19-32 mm.	26.90	0.00	100.00								
	33-51 mm.	39.27	0.00	62.74	100.00							
	52-72 mm.	40.77	0.00	53.02	78.12	100.00						
	73-86 mm.	70.51	0.43	37.13	40.43	53.76	100.00					
Pomi	49-58 mm.	5.50	0.00	24.70	19.98	28.49	13.49	100.00				
	60-78 mm.	5.60	0.00	24.48	28.02	31.00	8.35	89.30	100.00			
Agrun	41-51 mm.	6.70	0.00	9.79	7.77	9.27	6.99	75.19	70.40	100.00		
Hterg	42-79 mm.	11.65	0.00	39.95	64.20	51.41	16.93	21.84	28.39	7.83	100.00	
	109-113 mm.	0.10	0.00	18.27	2.92	6.25	17.94	0.00	1.06	0.39	17.25	100.00
Halos	60-92 mm.	10.07	0.00	38.90	37.18	55.20	18.89	26.10	30.47	9.14	42.60	9.33
	116-142 mm.	2.13	0.00	30.18	5.52	54.10	16.34	5.19	3.86	2.66	17.41	31.25
Scana	60-75mm.	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	116-152 mm.	0.33	47.92	0.00	0.33	1.81	4.74	1.79	0.26	0.00	0.00	0.00
	216-222 mm.	0.33	38.89	0.53	0.61	1.95	5.17	1.79	0.26	0.00	0.40	11.11
Pflav	30-63mm.	90.12	0.88	35.77	47.68	49.33	73.23	13.65	13.79	7.78	18.77	0.15
	72-91 mm.	97.50	0.00	29.00	41.44	44.28	70.80	7.83	7.70	5.15	14.95	0.03
	105-193 mm.	98.21	0.00	25.46	37.78	39.12	70.17	3.88	3.88	4.73	10.55	0.00
Pshum	24 mm.	0.12	0.00	0.53	0.00	0.20	0.43	67.86	63.06	90.73	1.59	0.00
	51-62mm.	0.54	0.00	7.79	2.86	5.03	8.11	69.64	64.11	86.01	9.13	9.84
Pcapr	58-100mm.	0.34	0.00	8.99	2.70	3.45	5.38	67.97	64.12	87.53	10.33	12.02
Svitr	41-48 mm.	0.00	50.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00
	138-288mm.	0.36	50.00	0.00	0.33	2.00	2.59	1.79	1.06	0.00	0.40	9.09

Table 54. Continued

		Halos 60-92 mm.	116-142 m	Scana 60-75mm.	116-152 mm.	216-222	Pflav 30-63mm.	72-91 mm.	105-193 mr	Pshum 24 mm.	51-62mm.	Pcapr 58-100mm.	Svitr 41-48 mm.	138-288mm.
Halos	60-92 mm.	100.00												
	116-142 mm.	13.02	100.00											
Scana	60-75mm.	0.00	0.00	100.00										
	116-152 mm.	0.00	1.14	56.25	100.00									
	216-222 mm.	0.00	1.14	44.44	72.22	100.00								
Pflav	30-63mm.	18.90	2.52	0.88	0.98	0.98	100.00							
	72-91 mm.	12.32	3.19	0.00	0.43	0.43	92.33	100.00						
	105-193 mm.	9.23	1.82	0.00	0.00	0.00	88.71	96.01	100.00					
Pshum	24 mm.	0.00	0.00	0.00	0.00	0.00	0.20	0.01	0.00	100.00				
	51-62mm.	6.87	8.39	0.00	4.15	6.74	0.44	0.48	0.00	86.01	100.00			
Pcapr	58-100mm.	7.66	9.52	0.00	0.00	2.83	0.46	0.16	0.11	87.41	95.85	100.00		
Svitr	41-48 mm.	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
	138-288mm.	0.13	9.09	51.52	55.11	58.59	0.98	0.45	0.00	0.00	4.66	1.47	0.00	100.00

Table 55. Dietary overlap between fishes from Hillside Beach, early July using Renkonens' index (percent overlap), Svitr= walleye, Pflav= yellow perch, Scana= sauger, Pomis= troutperch
Pshum= river darter, Pcapr= logperch, Mchry= white bass, Nathr= emerald shiner

		Pshum 47-55 mm.	Pcapr 79-82 mm.	Svitr 103-248 mm	Svitr 34-47 mm.	Pflav 97-150 mm.	Pflav 21-76 mm.	Scana 165-184 mm.
Pshum	47-55 mm.	100.00						
Pcapr	79-82 mm.	58.12	100.00					
Svitr	103-248 mm.	5.14	4.35	100.00				
Svitr	34-47 mm.	41.23	40.85	62.24	100.00			
Pflav	97-150 mm.	65.51	30.50	13.19	32.41	100.00		
Pflav	21-76 mm.	2.45	2.45	7.83	6.56	22.94	100.00	
Scana	165-184 mm.	0.00	0.00	1.58	0.95	0.00	0.00	100.00
Scana	110-120 mm.	6.52	0.00	35.70	35.49	12.00	1.96	33.33
Scana	39 mm.	0.00	0.00	3.56	2.14	18.67	93.34	0.00
Pomis	50-89 mm.	25.25	23.03	53.29	75.22	35.56	27.69	0.00
Nathr	49-72 mm.	5.20	2.90	26.42	26.76	26.44	75.43	0.00
Nathr	24-48 mm.	7.47	7.42	6.05	7.80	21.21	50.16	0.00
Mchry	365 mm.	50.00	22.50	3.56	14.16	53.33	2.17	0.00
Mchry	16-24 mm.	0.00	1.32	15.40	15.30	25.33	80.52	0.00

Table 55. Continued

		Scana 110-120 mm	Scana 39 mm.	Pomis 50-89 mm.	Nathr 49-72 mm.	Nathr 24-48 mm.	Mchry 365 mm.	Mchry 16-24 mm.
Scana	110-120 mm.	100.00						
Scana	39 mm.	0.00	100.00					
Pomis	50-89 mm.	35.00	24.58	100.00				
Nathr	49-72 mm.	21.08	71.44	46.91	100.00			
Nathr	24-48 mm.	1.64	46.04	29.02	54.04	100.00		
Mchry	365 mm.	0.00	0.00	0.00	0.99	0.00	100.00	
Mchry	16-24 mm.	11.84	76.32	37.98	85.17	59.48	0.00	100.00

Table 56. Diet overlap using Renkonens' index (percent similarity) between late July fishes at Hillside Beach, Mchry = white bass, Nathr = emerald shiner, Pomis = troutperch, Scana = sauger, Pflav = perch and Pshum = river darter

		Mchry 24 mm.	Mchry 190 mm.	Nathr 31-47 mm.	Nathr 56-70 mm.	Pomis 62 mm.	Scana 69 mm.	Scana 118-276 mm.	Pflav 37 mm.	Pshum 54 mm.
Mchry	24 mm.	100								
Mchry	190 mm.	0	100							
Nathr	31-47 mm.	38.69	6.52	100						
Nathr	56-70 mm.	2.94	16.66	9.56	100					
Pomis	62 mm.	0	0	0	3.22	100				
Scana	69 mm.	0	0	0	0	0	100			
Scana	118-276 mm.	0	0	0	0	0	0	100		
Pflav	37 mm.	96.96	0.05	40.08	3.17	0	0	0	100	
Pshum	54 mm.	0	0	0	3.22	62.5	0	0	0	100

Table 57. Dietary overlap using Renkonens' index (percent overlap) for early August, Hillside Beach fishes, Mchry = white bass, Nathr = emerald shiner, Pflav = yellow perch and Pcapr = logperch

		Mchry 20-41 mm.	Mchry 196 mm.	Nathr 20-51 mm.	Nathr 53-67 mm.	Pflav 27-43 mm.	Pcapr 26-37 mm.
Mchry	20-41 mm.	100					
Mchry	196 mm.	0	100				
Nathr	20-51 mm.	41.93	0	100			
Nathr	53-67 mm.	3.09	0	6.76	100		
Pflav	27-43 mm.	98.2	0	41.27	2.3	100	
Pcapr	26-37 mm.	78.78	0	40.9	2.22	78.38	100

Table 58. Dietary overlap using Renkonens' index (percent overlap) for fishes collected in late August
Scana = sauger, Hterg = mooneye, Cbair = mottled sculpin, Pshum = river darter,
Mstor = silver chub, Pcapr = logperch, Halos = goldeye, Mchry = white bass,
Pflav = yellow perch and Nathr = emerald shiner

		Scana 158-289 mm.	Hterg 44-68 mm.	Cbair 27-30 mm.	Pshum 28-56 mm.	Mstor 59 mm.	Pcapr 29-41 mm.	Pcapr 74-95 mm.	Halos 58-73 mm.
Scana	158-289 mm.	100							
Hterg	44-68 mm.	0	100						
Cbair	27-30 mm.	0	11.54	100					
Pshum	28-56 mm.	0	7.11	24.18	100				
Mstor	59 mm.	0	11.54	22.22	3.27	100			
Pcapr	29-41 mm.	0	15.38	34.62	74.68	23.97	100		
Pcapr	74-95 mm.	3.78	13.81	44.44	47.09	31.82	44.28	100	
Halos	58-73 mm.	0	26.33	22.22	5.38	80.99	24.79	33.93	100
Mchry	22-51 mm.	0.06	9.39	0.11	4.58	0.28	4.46	0.33	3.09
Mchry	54- 77 mm.	0	0.40	0	10.57	0.11	4.25	0.11	0.40
Mchry	255 mm.	0	0	0	0	0	0	0	0
Pflav	32-43 mm.	0	9.22	0	2.05	0	4.13	0	2.82
Pflav	45-54 mm.	0	16.43	0	10.46	0	4.13	0	2.82
Pflav	55-58 mm.	0	32.26	5.36	10.31	0.27	9.76	5.63	3.08
Nathr	18-55 mm.	0.21	40.18	1.09	13.60	5.31	9.73	3.67	8.55
Nathr	56-87 mm.	0	47.43	5.97	6.91	11.64	12.47	10.93	19.56

Table 58. Continued

		Mchry 22-51 mm.	Mchry 54- 77 mm.	Mchry 255 mm.	Pflav 32-43 mm.	Pflav 45-54 mm.	Pflav 55-58 mm.	Nathr 18-55 mm.	Nathr 56-87 mm.
Mchry	22-51 mm.	100							
Mchry	54- 77 mm.	74.59	100						
Mchry	255 mm.	0.22	0.91	100					
Pflav	32-43 mm.	96.66	71.99	0	100				
Pflav	45-54 mm.	84.55	82.21	0	82.51	100			
Pflav	55-58 mm.	75.13	66.41	0	72.54	82.39	100		
Nathr	18-55 mm.	20.05	34.98	0	17.66	34.26	39.11	100	
Nathr	56-87 mm.	10.26	0.75	0	10.35	16.73	28.98	44.68	100

Table 59. Dietary overlap using Renkonens' index (percent overlap) for September fishes at Hillside Beach, Cart = cisco, Pshum = river darter, Pcapr = logperch, Pflav = yellow perch and Nathr = emerald shiner

		Cart 75-76 mm.	Pshum 45 mm.	Pcapr 43-77 mm.	Pflav 49-64 mm.	Nathr 21-44 mm.	Nathr 46-73 mm.
Cart	75-76 mm.	100					
Pshum	45 mm.	0	100				
Pcapr	43-77 mm.	0	15.58	100			
Pflav	49-64 mm.	21.95	0	0	100		
Nathr	21-44 mm.	0.24	0	3.37	5.54	100	
Nathr	46-73 mm.	1.23	7.41	18.95	1.23	47.64	100

Table 60. Manley's index of preference for the diets of emerald shiner from Hillside Beach

			Cladocera				Copepoda	
17:00	30/7/93		Daphniidae	Bosminidae	Leptodoridae	Sididae	Calanoidea	Cyclopoidea
13 fish	30-47 mm.	Mean	0.8261	1.0000	-	-	0.8804	-
		Standard Deviation	0.2882				0.2378	
		Minimum	0.3162				0.3595	
		Maximum	1				1	
		n	6	1			8	
10:00	12/8/93							
11 fish	35-67 mm.	Mean	-	-	1.0000	-	1.0000	-
		Standard Deviation			0.0000		0.0000	
		Minimum			0.0000		0.0000	
		Maximum			1		1	
		n			2		6	
14:00	16/8/93							
6 fish	28-57 mm.	Mean	0.9504	-	0.0222	-	0.6129	-
		Standard Deviation	0.0990				0.5474	
		Minimum	0.7742				0.2258	
		Maximum	1				1	
		n	5		1		2	

Table 61. Manley's index of preference for the diets of yellow perch from Hillside Beach

17:00	30/7/93		Cladocera Daphniidae	Bosminidae	Leptodoridae	Sididae	Copepoda Calanoidea	Cyclopoidea
71 fish	26-37 mm.	Mean	0.4574	0.7174	-	-	0.8553	0.3740
		Standard Deviation	0.3940	0.1574			0.3177	0.2315
		Minimum	0.0414	0.4989			0.0407	0.1318
		Maximum	0.9297	0.9404			1	0.7431
		n	5	8			71	6
10:00	12/8/93							
57 fish	27-43 mm.	Mean	-	-	0.3753	-	0.9856	0.0242
		Standard Deviation			0.0761		0.0705	0.0209
		Minimum			0.3215		0.5709	0.0066
		Maximum			0.4291		1	0.0474
		n			2		57	3
14:00	16/8/93							
9 fish	34-46 mm.	Mean	0.1273	-	-	-	0.9717	-
		Standard Deviation	0.0432				0.0582	
		Minimum	0.0968				0.8421	
		Maximum	0.1579				1	
		n	2				9	

Table 62. Manley's index of preference for the diets of white bass from Hillside beach

			Cladocera Daphniidae	Bosminidae	Leptodoridae	Sididae	Copepod Calanoidea	Cyclopoidea
17:00	30/7/93							
1 fish	24 mm.		-	-	-	-	1	-
10:00	12/8/93							
105 fish	20-41 mm.	Mean	-	-	0.3789	-	0.8837	0.0202
		Standard Deviation			0.2101		0.1971	0.0171
		Minimum			0.0779		0.1550	0.0029
		Maximum			1		1	0.0428
		n			34		103	5
14:00	16/8/93							
48 fish	22-45 mm.	Mean	0.2135	0.0291	0.1552	-	0.8868	0.3553
		Standard Deviation	0.1924	0.0222	0.2218		0.1628	0.0363
		Minimum	0.0774	0.0134	0.0047		0.3077	0.3297
		Maximum	0.3495	0.0448	1		1	0.3810
		n	2	2	33		47	2

Appendix I. A list of fishes that were introduced to the Hudson Bay Drainage

common name	scientific name	distribution	first literature record
sockeye salmon	*Oncorhynchus nerka*	isolated introductions	Scott and Crossman 1973
cutthroat trout	*O. clarki*	isolated introductions	unpublished records
rainbow trout	*O. mykiss*	isolated introductions	Hinks 1943
arctic char	*Salvelinus alpinus*	isolated introductions	unpublished records
brook trout	*S. fontinalis*	isolated introductions	Keleher and Kooyman 1957
grayling	*Thymallus arcticus*	isolated introductions Fort Whyte Nature Center	unpublished records
brown trout	*Salmo trutta*	isolated introductions	Keleher and Kooyman 1957
muskellunge	*Esox masquinongy* and hybrids	Winnipeg R. and tributaries isolated western introductions	Scott and Crossamn 1973
rainbow smelt	*Osmerus mordax*	L. Winnipeg (see Appendix IV)	Campbell *et al.* 1991
carp	*Cyprinus carpio*	L. Winnipeg and tributaries (see Appendix IV) L. Manitoba and tributaries	Hinks 1943
goldfish	*Carassius auratus*	Red R. at the city of Winnipeg (see Appendix IV)	Hanke and Stewart 1994
white bass	*Morone chrysops*	Red R. L. Winnipeg (see Appendix IV) L. Manitoba (?)	Scott and Crossman 1973
white crappie	*Pomoxis annularis*	Red. R.	Stewart *et al.* 1985
black crappie	*P. nigromaculatus*	Red R. L. Winnipeg (see Appendix IV)	Scott and Crossman 1973
largemouth bass	*Micropterus salmoides*	Fort Whyte Nature Center L. Minnewasta (?)	Hinks 1943
smallmouth bass	*M. dolomieui*	Winnipeg R. system (see Appendix IV)	Hinks 1943
pumpkinseed	*Lepomis gibbosus*	LaSalle R. Red R. L. Minnewasta	Hanke and Stewart 1994 and unpublished data
bluegill	*Lepomis macrochirus*	Rat R.	Hanke and Stewart 1994

Appendix II: Current list of fishes present in the Red and Assiniboine Rivers, Lakes Winnipeg and Manitoba and the respective tributaries entering each lake modified from Hanke and Stewart (1994), Stewart et at. (1985) and K.W. Stewart unpublished data.

Species	Red R.	Assiniboine R.	Lake Winnipeg South basin	tributaries	North basin	tributaries	Lake Manitoba lake	tributaries
Petromyzontidae								
Ichthyomyzon castanaeus	x	x	x	x	x	x		
Ichthyomyzon fossor				x				
Ichthyomyzon unicuspis	x		x	x	x	x		
Acipenseridae								
Acipenser fulvescens	x		x	x	x	x		
Hiodontidae								
Hiodon alosoides	x	x	x	x	x	x	x	x
Hiodon tergisus	x	x	x	x	x	x	x	x
Salmonidae								
Coregonus artedi	x		x		x		x	
Coregonus clupeaformis			x		x			
Coregonus zenithicus					x ?			
Oncorhynchus mykiss			x?					
Salvelinus namaycush						x		
Osmeridae								
Osmerus mordax			x		x			
Umbridae								
Umbra limi	x	x	x	x	x	x	x	x
Esocidae								
Esox lucius	x	x	x	x	x	x	x	x
Cyprinidae								
Carassius auratus	x							
Cyprinella spiloptera	x	x						
Cyprinus carpio	x	x	x	x	x	x	x	x
Couesius plumbeus					x	x		
Luxilus cornutus	x	x		x				
Macrhybopsis storeriana	x	x	x					
Margariscus margarita				x	x	x		x
Nocomis biguttatus				x		x		
Notemigonus crysoleucas	x	x		x		x	x	x

Appendix II. continued

Species	Red R.	Assiniboine R.	Lake Winnipeg South basin	tributaries	North basin	tributaries	Lake Manitoba lake	tributaries
Cyprinidae continued								
Notropis atherinoides	x	x	x	x	x	x	x	x
Notropis blennius	x	x	x	x	x	x		
Notropis dorsalis	x	x						
Notropis heterodon		x						
Notropis heterolepis	x	x	x	x	x	x	x	x
Notropis hudsonius	x	x	x	x	x	x	x	x
Notropis rubellus				x				
Notropis stramineus	x	x						
Notropis texanus				x		x		
Notropis volucellus				x		x		
Phoxinus eos	x	x		x		x		
Phoxinus neogaeus	x	x		x		x		x
Pimephales notatus				x				
Pimephales promelas	x	x	x	x	x	x	x	x
Platygobio gracilis	x	x	x		x			
Rhinichthys atratulus	x	x						x
Rhinichthys cataractae	x	x	x	x	x	x		x
Semotilus atromaculatus	x	x						x
Catostomidae								
Carpiodes cyprinus	x	x	x	x	x	x	x	x
Catostomus catostomus			x	x	x	x		
Catostomus commersoni	x	x	x	x	x	x	x	x
Ictiobus cyprinellus	x	x	x	x		x	x	x
Moxostoma anisurum	x	x	x	x	x	x		
Moxostoma erythrurum	x	x		x				
Moxostoma macrolepidotum	x	x		x		x	x	x
Ictaluridae								
Amieurus melas	x	x		x		x		x
Amieurus nebulosus	x	x		x		x		x
Ictalurus punctatus	x	x	x	x	x	x	x	x
Noturus flavus	x	x		x				
Noturus gyrinus	x	x	x	x	x	x		x

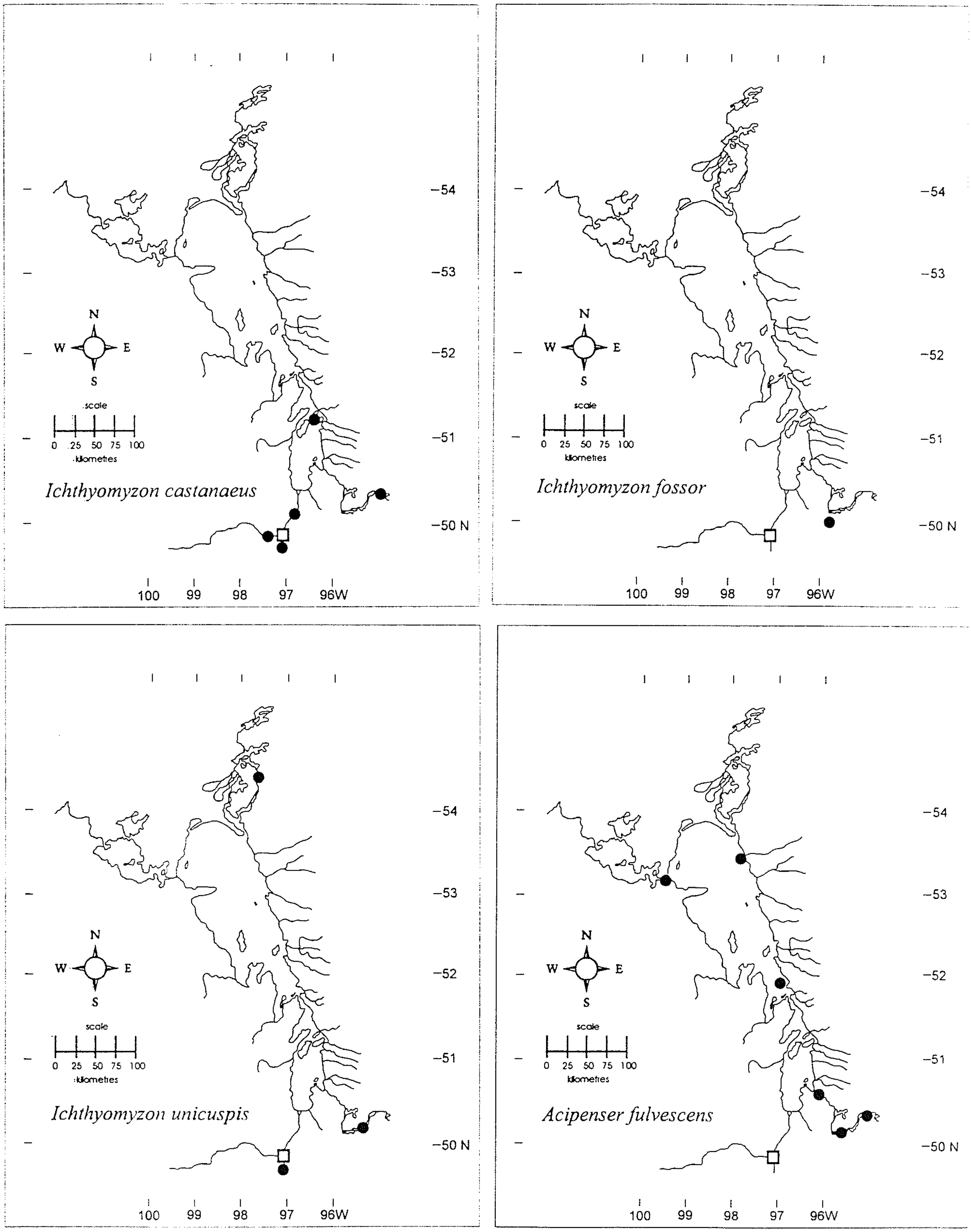
Appendix II. continued

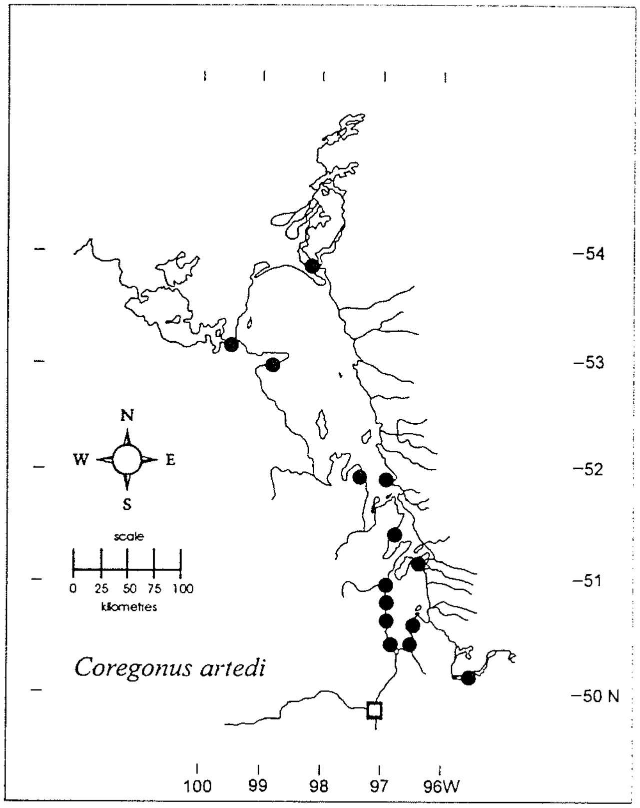
Species	Red R.	Assiniboine R.	Lake Winnipeg South basin	tributaries	North basin	tributaries	Lake Manitoba lake	tributaries
Gadidae								
Lota lota	x	x	x	x	x	x	x	x
Percopsidae								
Percopsis omiscomaycus	x	x	x	x	x	x	x	x
Gasterosteidae								
Culaea inconstans	x	x	x	x	x	x	x	x
Pungitius pungitius	x	x	x	x	x	x	x	x
Cottidae								
Cottus bairdi	x		x	x	x	x		x
Cottus cognatus			x	x	x	x		
Cottus ricei			x		x			
Moronidae								
Morone chrysops	x		x	x	x	x	x	
Centrarchidae								
Ambloplites rupestris	x	x		x		x		
Lepomis gibbosis	x							
Lepomis macrochirus	x							
Micropterus dolomieui			x	x				
Pomoxis annularis	x							
Pomoxis nigromaculatus	x		x	x	x	x		
Percidae								
Etheostoma exile	x	x	x	x	x	x	x	x
Etheostoma nigrum	x	x	x	x	x	x	x	x
Perca flavescens	x	x	x	x	x	x	x	x
Percina caprodes	x		x	x			x	
Percina maculata	x	x		x				
Percina shumardi	x	x	x	x	x	x	x	
Stizostedion canadense	x	x	x	x	x	x	x	x
Stizostedion vitreum	x	x	x	x	x	x	x	x
Sciaenidae								
Aplodinotus grunniens	x	x	x	x	x	x	x	x

Appendix III: Brief description of Lake Winnipeg sites sampled in this survey.

Site Name	Side of Lake	Lake Basin	Description	Latitude	Longitude	Substrate	Cover
Matlock	West	South	at end of Ralph Road	50° 26'	96° 57'	sand, gravel	none
Ponema	West	South	public beach opposite 15 Lake Drive	50° 28'	96° 57'	sand, cobble	sparse reed bed, scattered boulders
Sandy Hook	West	South	private beach at end of Eighth Ave.	50° 32'	96° 59'	sand, cobble	scattered boulders
Winnipeg Beach	West	South	junction of Prospect Ave. and Spruce St.	50° 30'	96° 58'	sand	none
Hussavick Road	West	South	at end of Hussavick Road	50° 34'	97° 00'	sand	sparse reed bed
Willow Point	West	South	beach on North side of point	50° 36'	96° 57'	sand, gravel	none
Willow Point	West	South	beach on South side of point	50° 36'	96° 57'	silt, sand	cut bank, terrestrial grass
McEhleran Road	West	South	beach at end of McEhleran Road	50° 39'	96° 59'	sand, gravel	none
Camp Morton	West	South	beach just South of Camp	50° 42'	96° 59'	sand, gravel	scattered boulders
Arnes	West	South	beach just North of Silver Harbor	50° 48'	97° 00'		
Camp Neustadt	West	South	at end of Camp Neustadt Road	50° 52'	96° 59'	sand, gravel	none
Hnausa	West	South	beach just North of Hnausa pier	50° 54'	97° 00'	sand, gravel	none
Balaton Beach	West	South	at end of Balaton Beach Road	50° 57'	96° 57'	sand	none
Riverton	West	South	Sandy Point public beach	51° 00'	97° 00'	sand	none
Gull Harbor	West	South	public beach at South end of Harbor Bay	51° 12'	96° 37'	sand	none
Beaver Creek	West	North	public beach just North of Provincial Camp	51° 23'	96° 55'	sand	scattered boulders
Jackhead River	West	North	beach just Northwest of Jackhead Point	51° 54'	97° 17'	sand	none
Dauphin River	West	North	beach roughly 2 km. South of river mouth	51° 56'	98° 01'	sand	none
Dauphin River	West	North	beach just North of river mouth	51° 57'	98° 01'	gravel	terrestrial vegetation
Long Point	West	North	beach at end of Long Point Road	53° 02'	98° 40'	sand, gravel	none
Saskatchewan River	West	North	boat ramp down stream of Grand Rapids Dam	53° 12'	99° 16'	gravel	dock piles
Patricia Beach	East	South	public beach just West of safety markers	50° 25'	96° 36'		
Beaconia	East	South	public beach directly West of town	50° 27'	96° 35'	sand	none
Balsam Bay	East	South	public beach just North of pier	50° 30'	96° 35'	sand	boulder breakwaters
Grand Marais	East	South	public beach along Grand Marais Blvd.	50° 33'	96° 38'	sand, gravel, cobble	none
Traverse Bay	East	South	beach at end of Traverse Bay East road	50° 39'	96° 24'	sand, gravel	none
Hillside Beach	East	South	public beach at end of Hillside Point Road	50° 41'	96° 35'	sand, gravel	none
Sandy Bay	East	South	public beach at end of HWY 504	50° 44'	96° 32'	sand, gravel	none
Black River	East	South	public beach just North of river mouth	50° 50'	96° 19'	sand	none
Manigotagan River	East	South	public beach just North of river mouth	51° 07'	96° 20'	sand	none
Pigeon River	East	North	beach roughly 1 km. South of River mouth	52° 15'	97° 02'	sand, clay	sparse reed bed
Berens River	East	North	bay between hotel and river channel	52° 21'	97° 03'	sand	sparse aquatic macrophyte bed
Poplar River	East	North	shoreline roughly 2 km. from river mouth	53° 00'	97° 24'	sand	sparse aquatic macrophyte bed
Mukutawa River	East	North	small bay inside of river mouth	53° 10'	97° 24'	sand	sparse aquatic macrophyte bed
Belanger River	East	North	beach South of river mouth	53° 27'	97° 41'	sand	none

Appendix IV: Distribution maps for fish collected in the survey of shorelines and tributaries of Lake Winnipeg between 1989 and 1994.


Ichthyomyzon castanaeus
Ichthyomyzon fossor
Ichthyomyzon unicuspis
Acipenser fulvescens
N
W
E
S
scale
0 25 50 75 100
kilometres
-54
-53
-52
-51
-50 N
100
99
98
97
96W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W
E
S
scale
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kilometres
Coregonus artedi
-54
-53
-52
-51
-50 N
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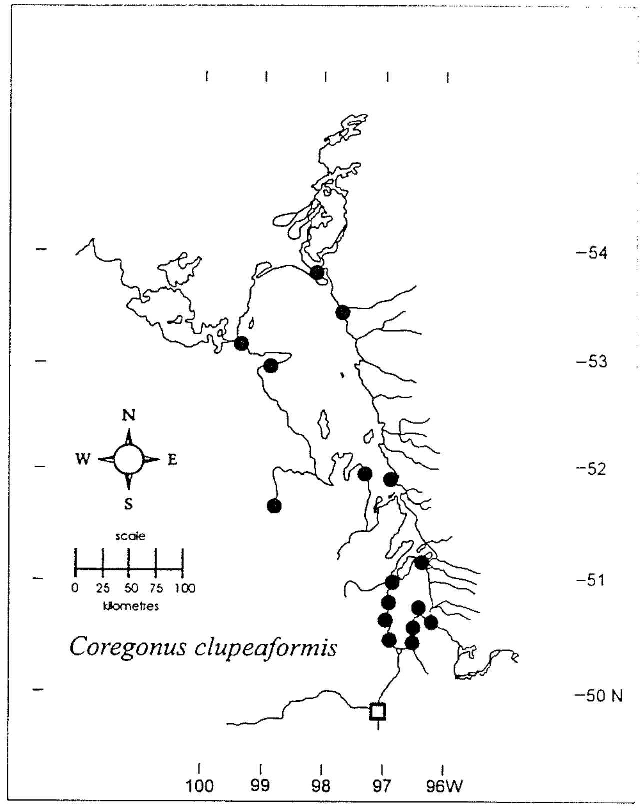
99
98
97
96W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W
E
S
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kilometres
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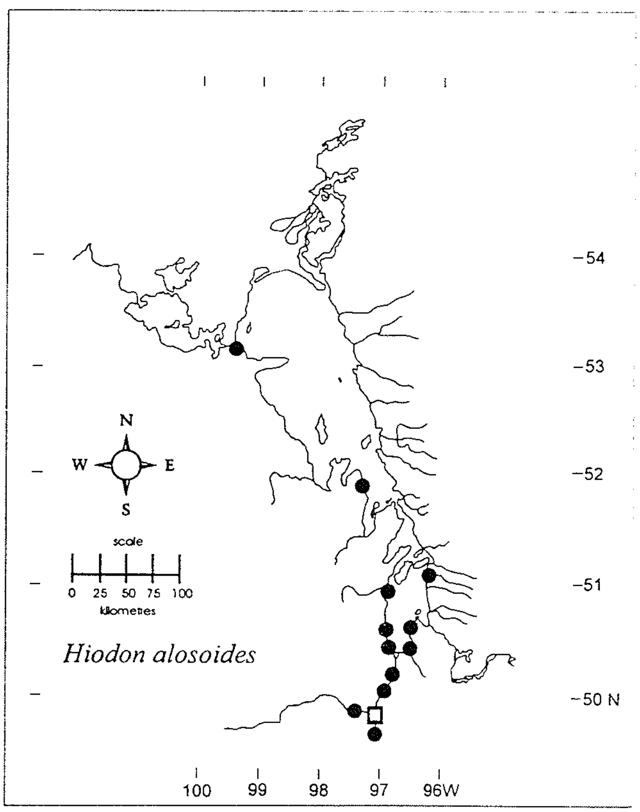
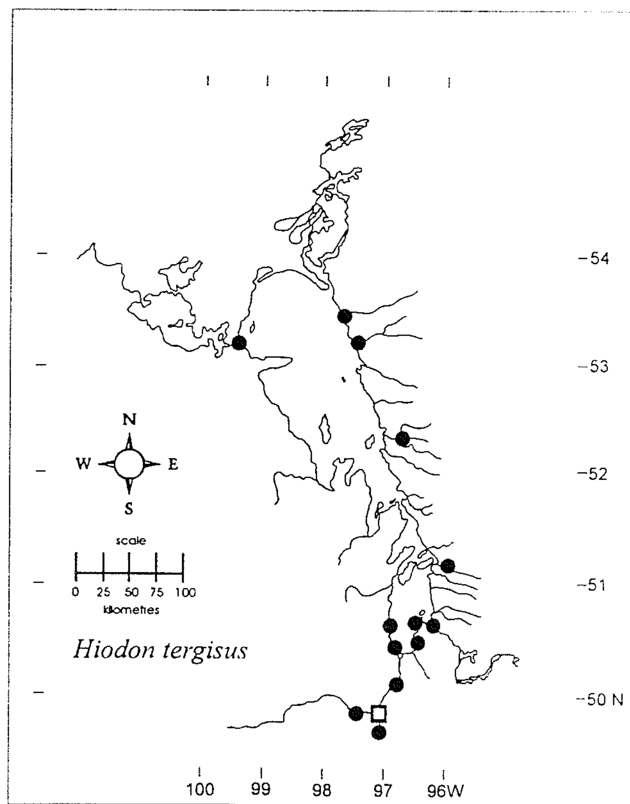
-53
-52
-51
-50 N
100
99
98
97
96W


N
W
E
S
scale
0 25 50 75 100
kilometres
Hiodon alosoides
-54
-53
-52
-51
-50 N
100
99
98
97
96W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W
E
S
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kilometres
Hiodon tergisus
-54
-53
-52
-51
-50 N
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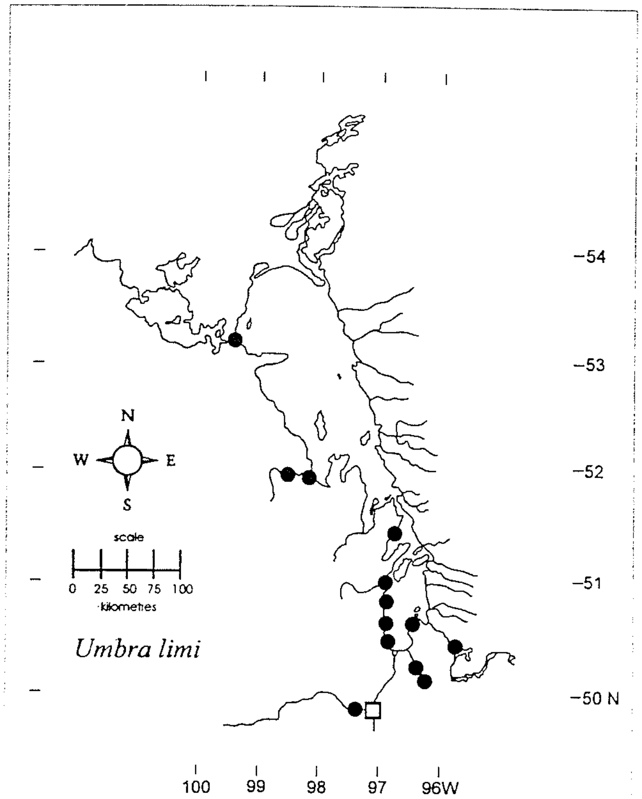
96W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W
E
S
scale
0 25 50 75 100
kilometres
Umbra limi
-54
-53
-52
-51
-50 N
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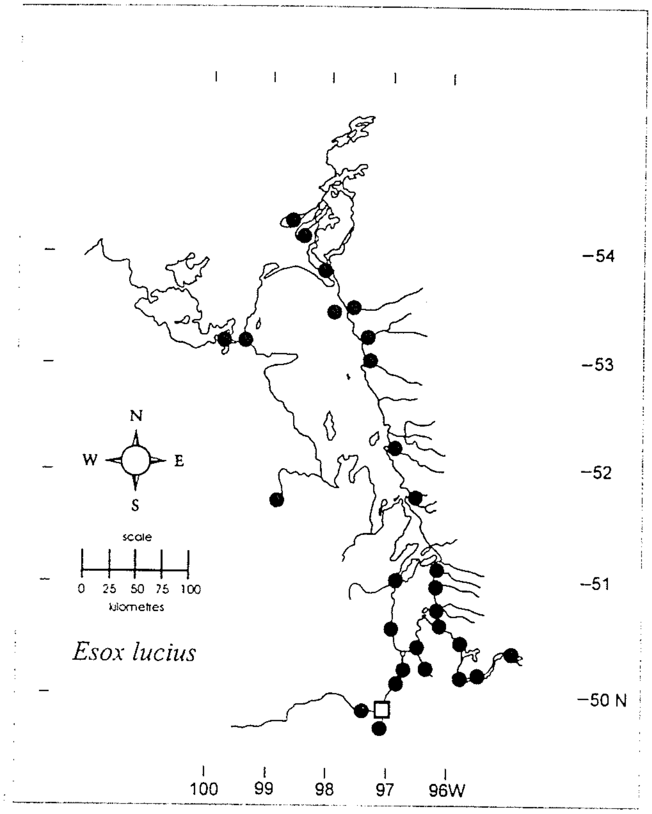
98
97
96W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W
E
S
scale
0 25 50 75 100
kilometres
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-53
-52
-51
-50 N
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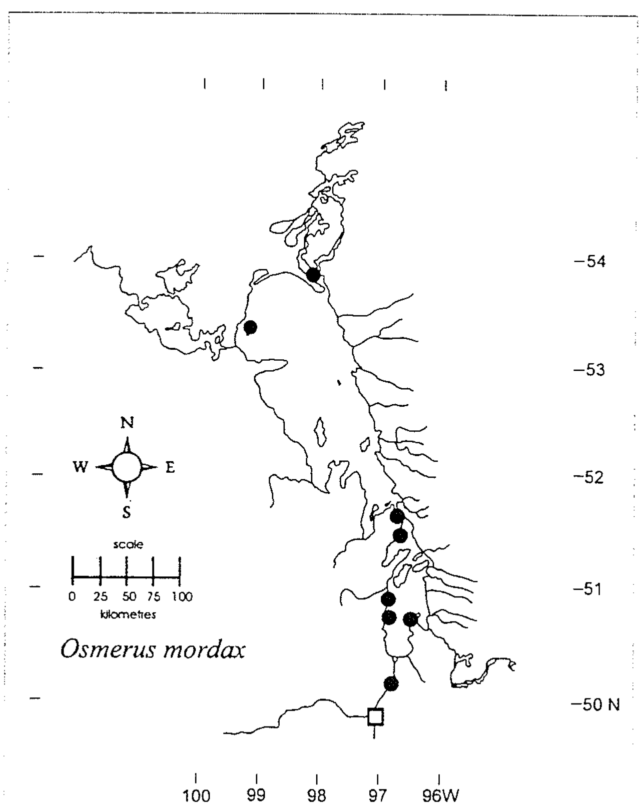
96W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E
S
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kilometres
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-53
-52
-51
-50 N
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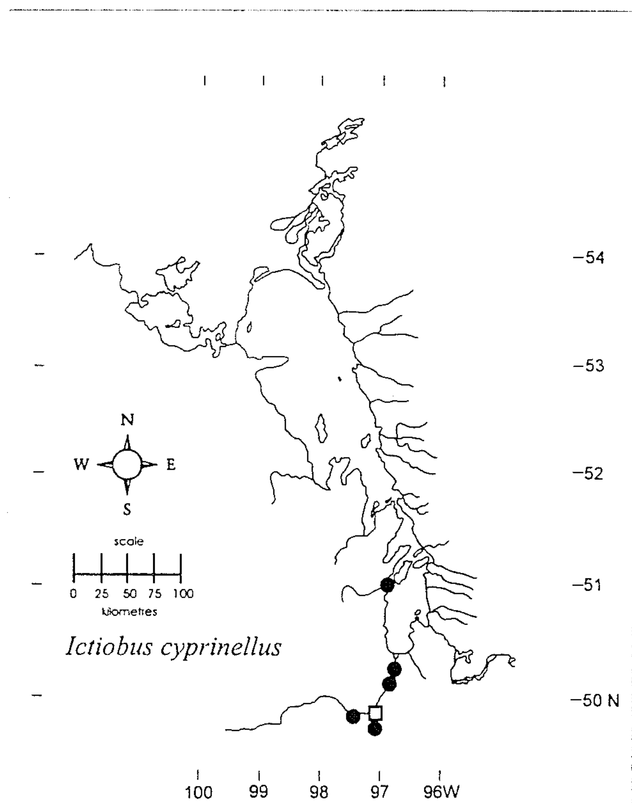
96W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W
E
S
scale
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kilometres
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-54
-53
-52
-51
-50 N
100
99
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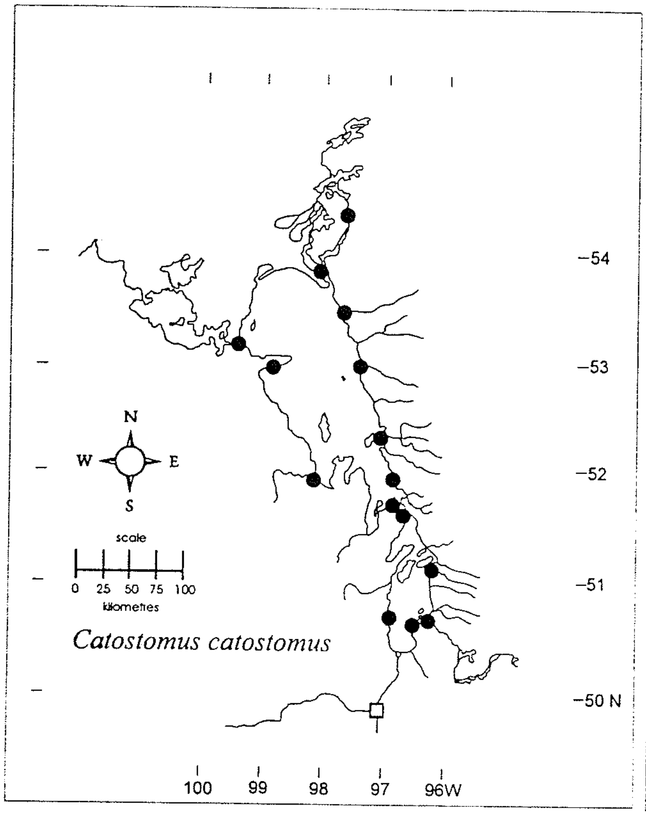
97
96W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W
E
S
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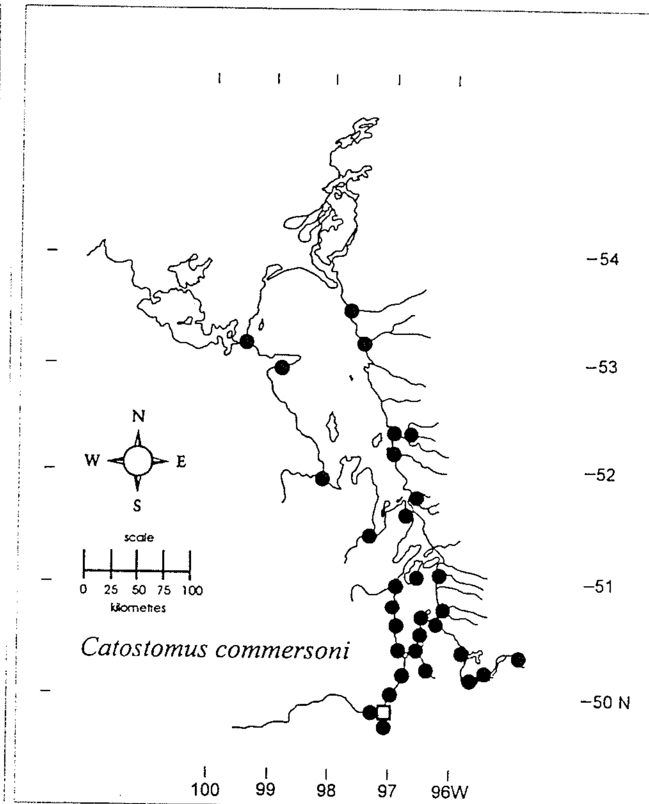
kilometres
Catostomus catostomus
-54
-53
-52
-51
-50 N
100
99
98
97
96W


N
W
E
S
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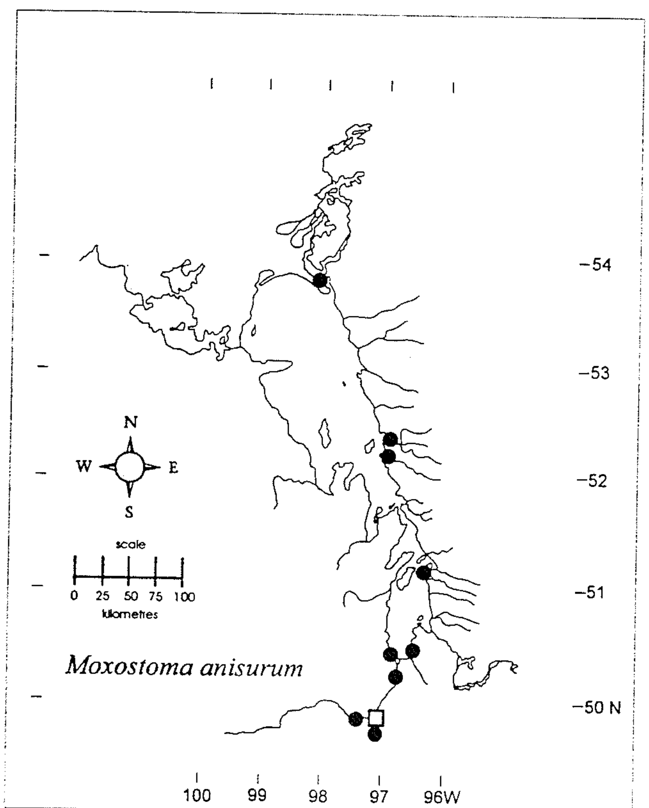
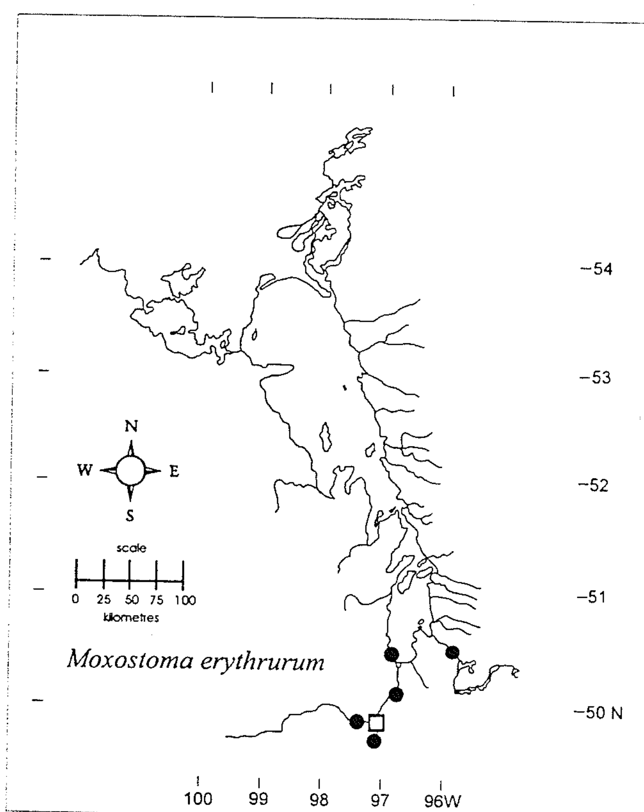
kilometres
Catostomus commersoni
-54
-53
-52
-51
-50 N
100
99
98
97
96W


N
W
E
S
scale
0 25 50 75 100
kilometres
Moxostoma anisurum
-54
-53
-52
-51
-50 N
100
99
98
97
96W


N
W
E
S
scale
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kilometres
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-54
-53
-52
-51
-50 N
100
99
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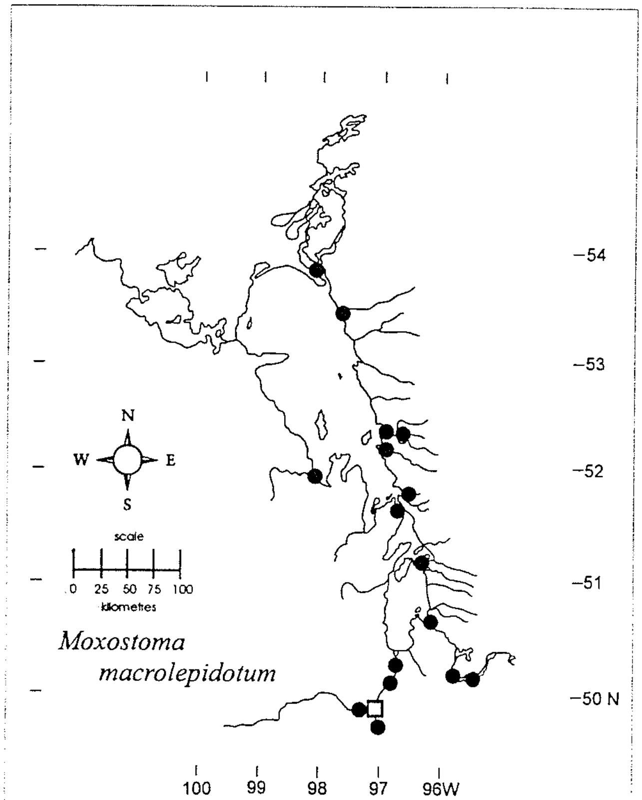
97
96W


N
W
E
S
scale
0 25 50 75 100
kilometres
Moxostoma macrolepidotum
-54
-53
-52
-51
-50 N
100
99
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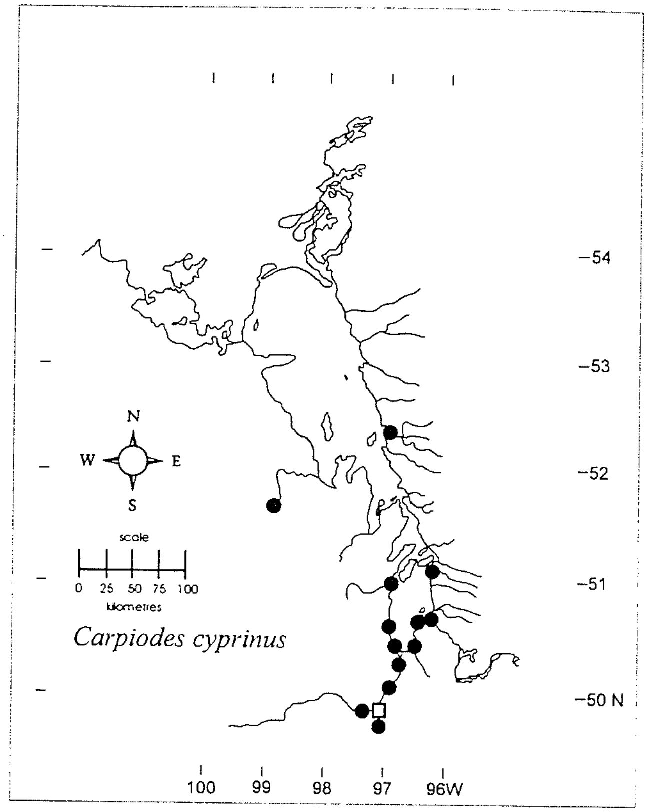
97
96W


N
W
E
S
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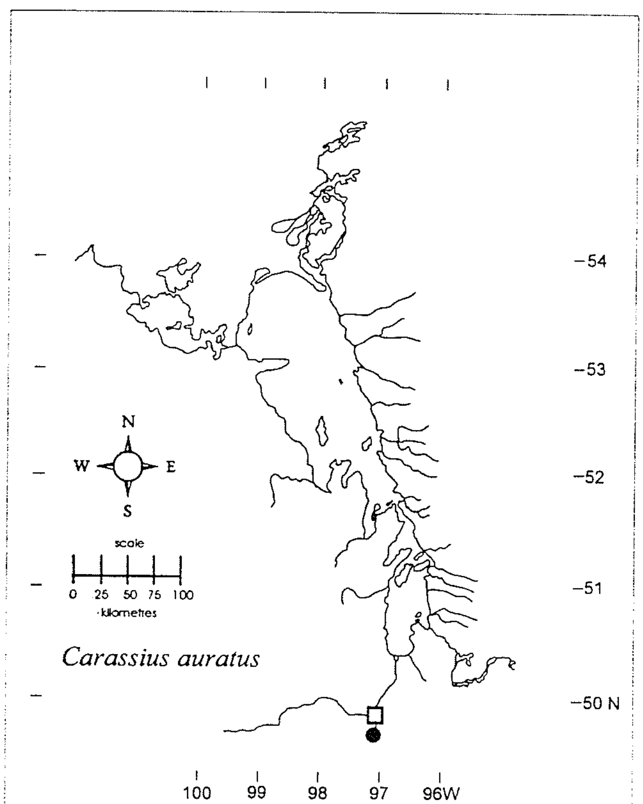
kilometres
Carpiodes cyprinus
-54
-53
-52
-51
-50 N
100
99
98
97
96W


N
W
E
S
scale
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kilometres
Carassius auratus
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-53
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-51
-50 N
100
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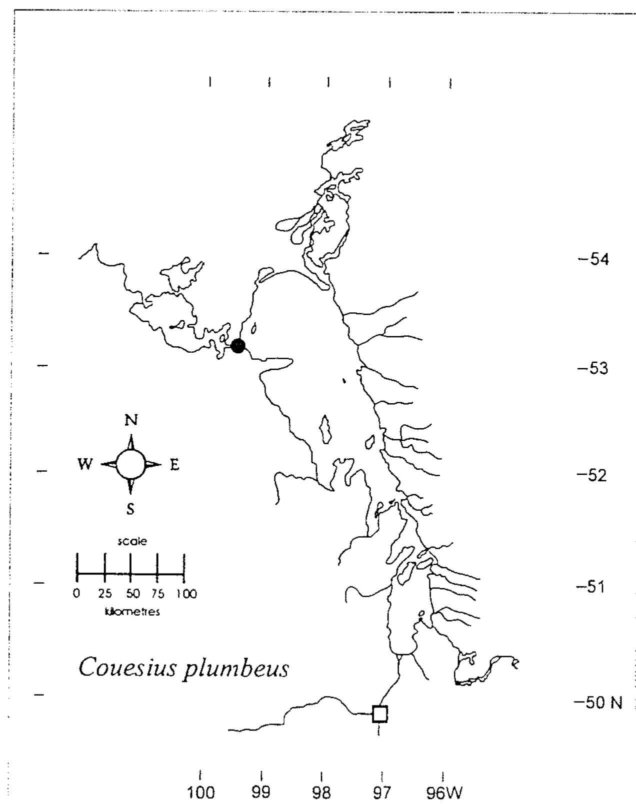
97
96W


N
W
E
S
scale
0 25 50 75 100
kilometres
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-54
-53
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-51
-50 N
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99
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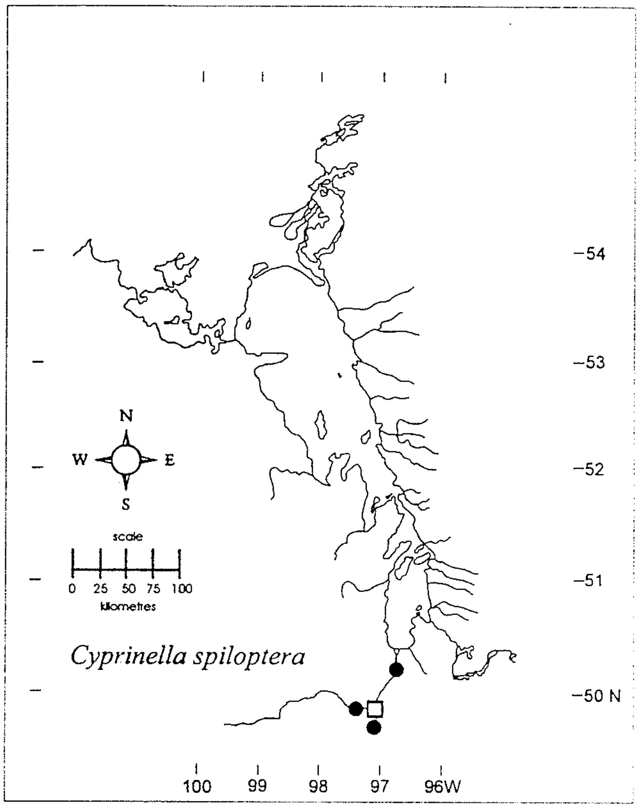
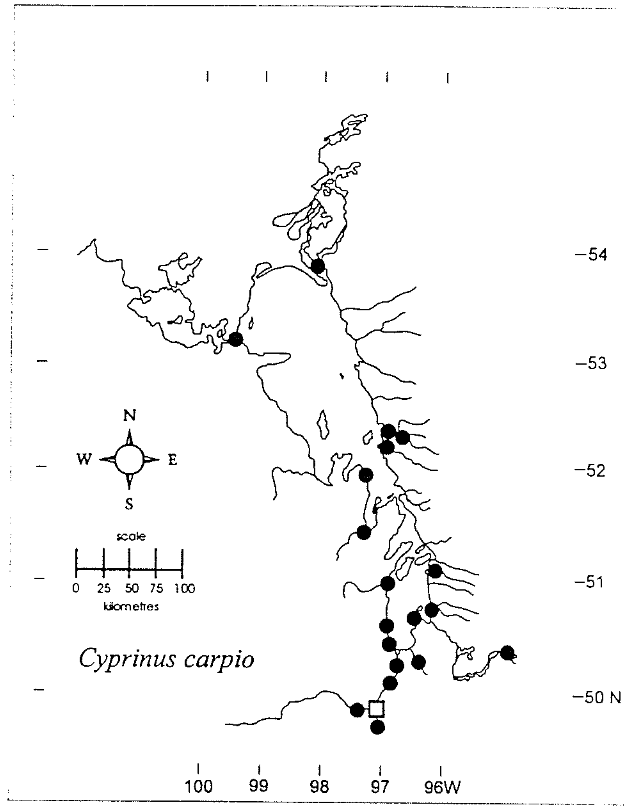
97
96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Cyprinella spiloptera
100
99
98
97
96W


-54
-53
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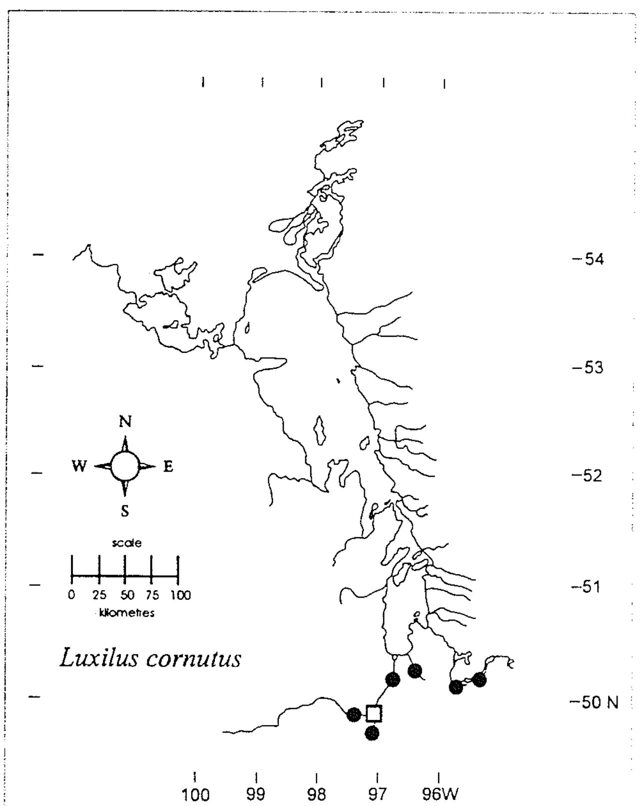
N
W
E
S
scale
0 25 50 75 100
kilometres
Cyprinus carpio
100
99
98
97
96W


-54
-53
-52
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-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Luxilus cornutus
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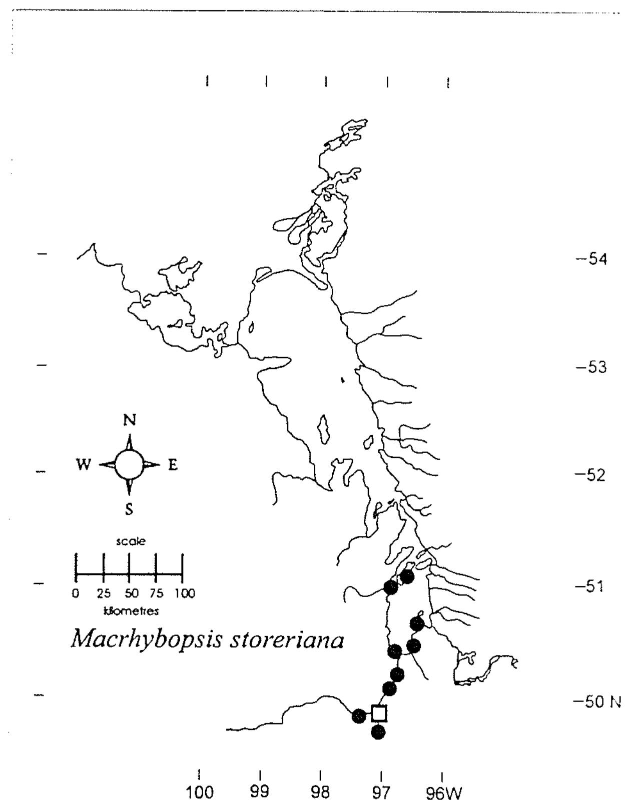
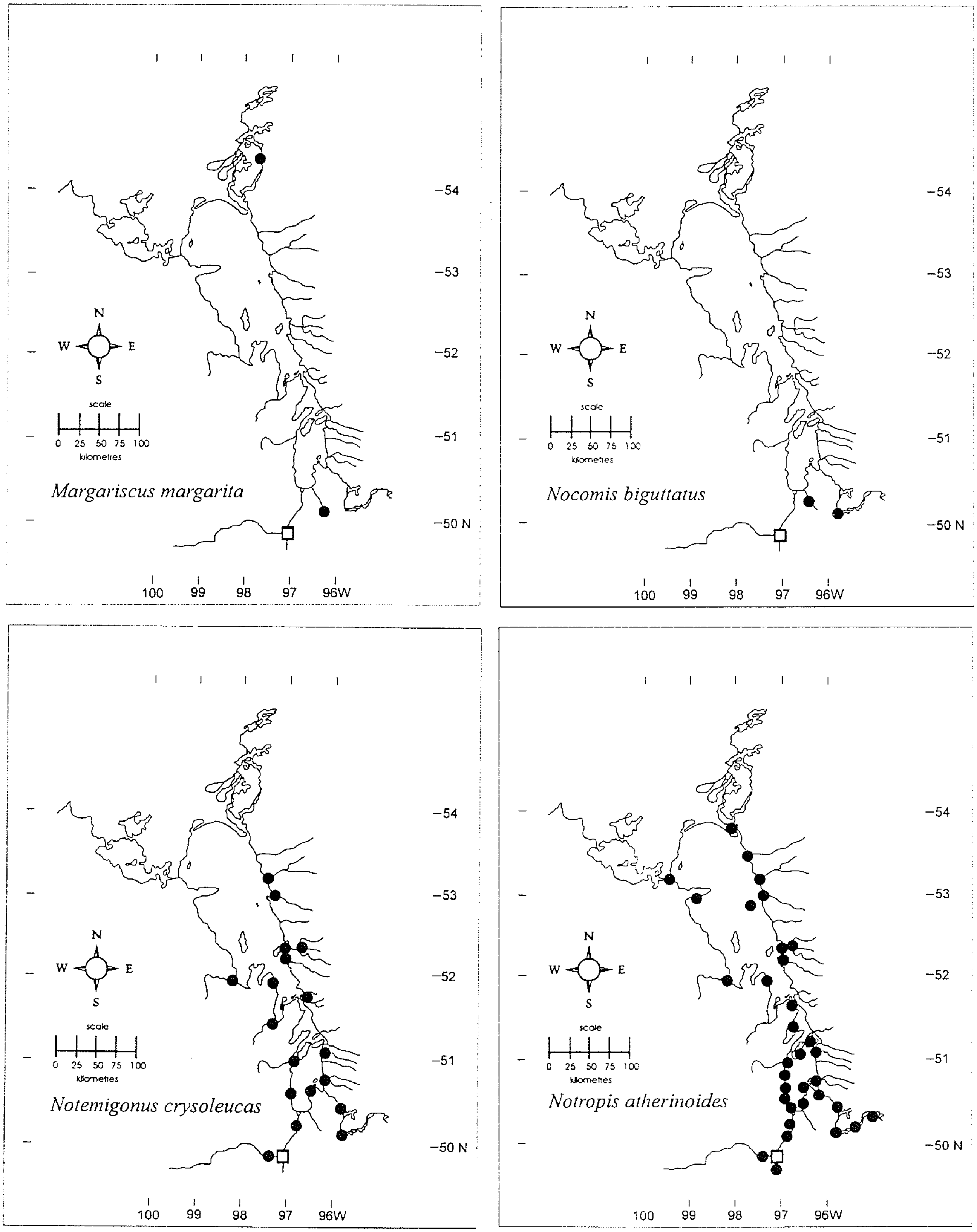
99
98
97
96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Macrhybopsis storeriana
100
99
98
97
96W


Margariscus margarita
Nocomis biguttatus
Notemigonus crysoleucas
Notropis atherinoides
N
W
E
S
scale
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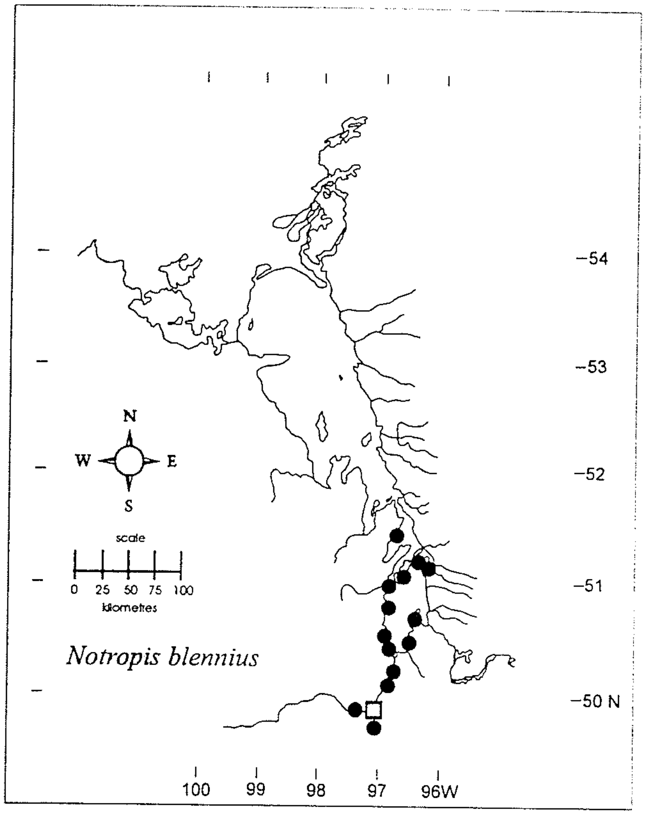
kilometres
-54
-53
-52
-51
-50 N
100 99 98 97 96W


N
W
E
S
scale
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kilometres
Notropis blennius
-54
-53
-52
-51
-50 N
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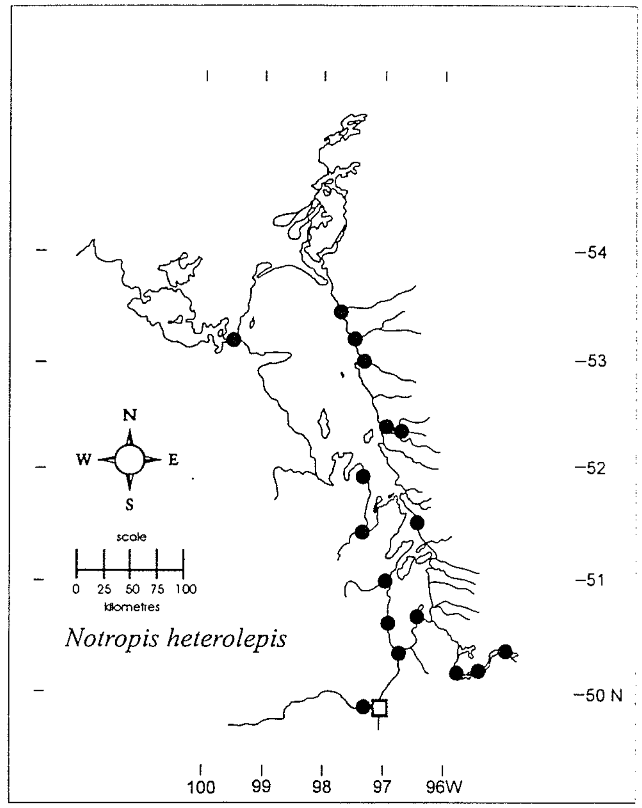
97
96W


N
W
E
S
scale
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kilometres
Notropis heterolepis
-54
-53
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-51
-50 N
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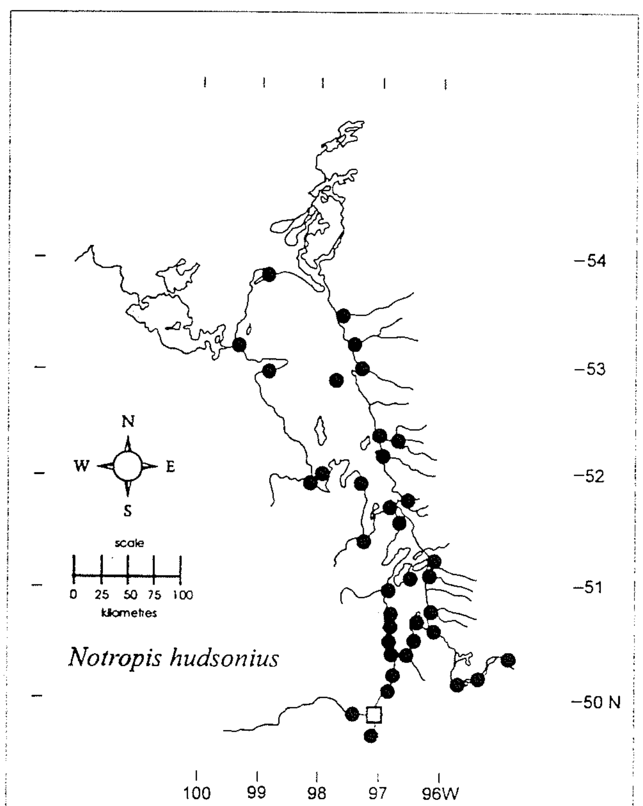
N
W
E
S
scale
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kilometres
Notropis hudsonius
-54
-53
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-51
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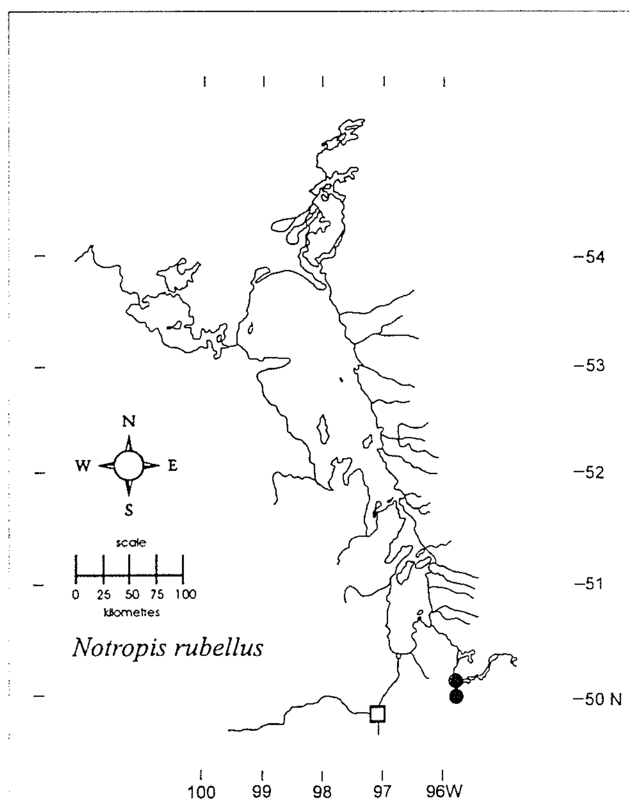
N
W
E
S
scale
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kilometres
Notropis rubellus
-54
-53
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-51
-50 N
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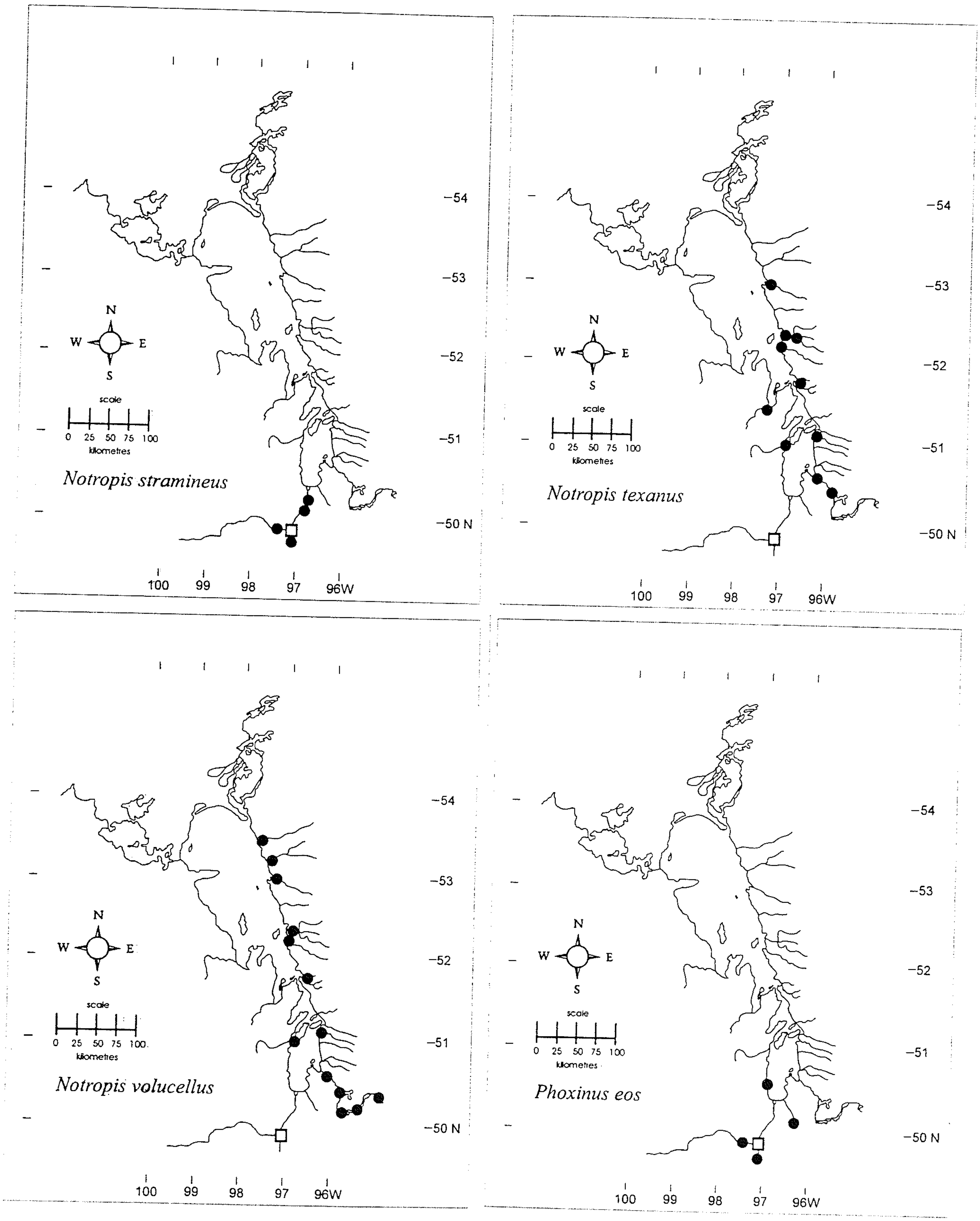
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kilometres
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-54
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-50 N
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98
97
96W
N
W
E
S
scale
0 25 50 75 100
kilometres
Notropis texanus
-54
-53
-52
-51
-50 N
100
99
98
97
96W
N
W
E
S
scale
0 25 50 75 100
kilometres
Notropis volucellus
-54
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-51
-50 N
100
99
98
97
96W
N
W
E
S
scale
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kilometres
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-51
-50 N
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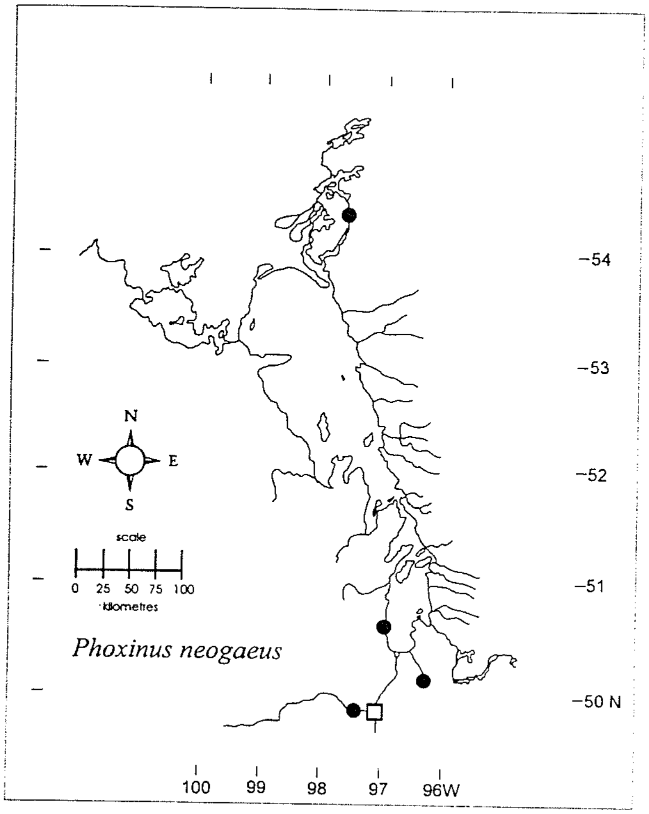
96W



N
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S
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kilometres
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-51
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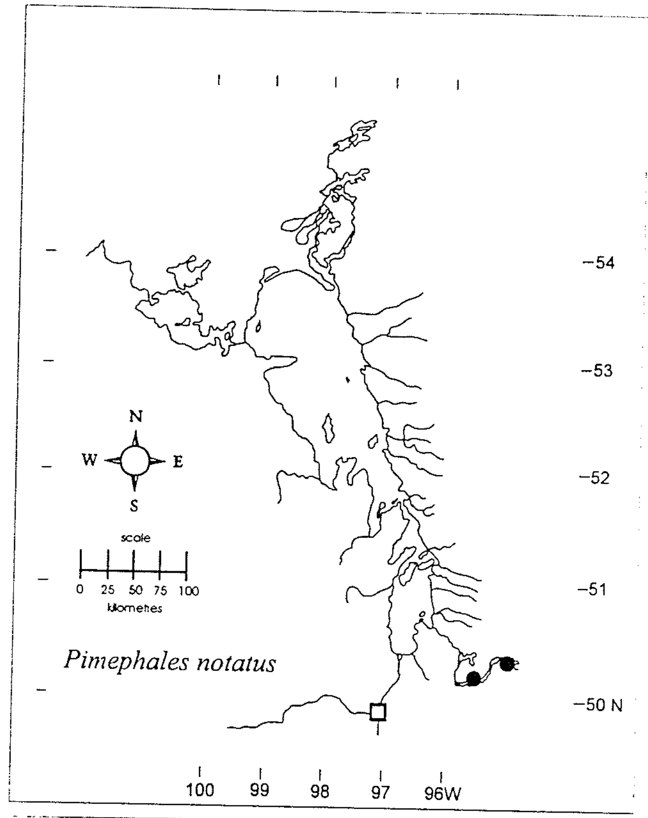

N
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E
S
scale
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kilometres
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-51
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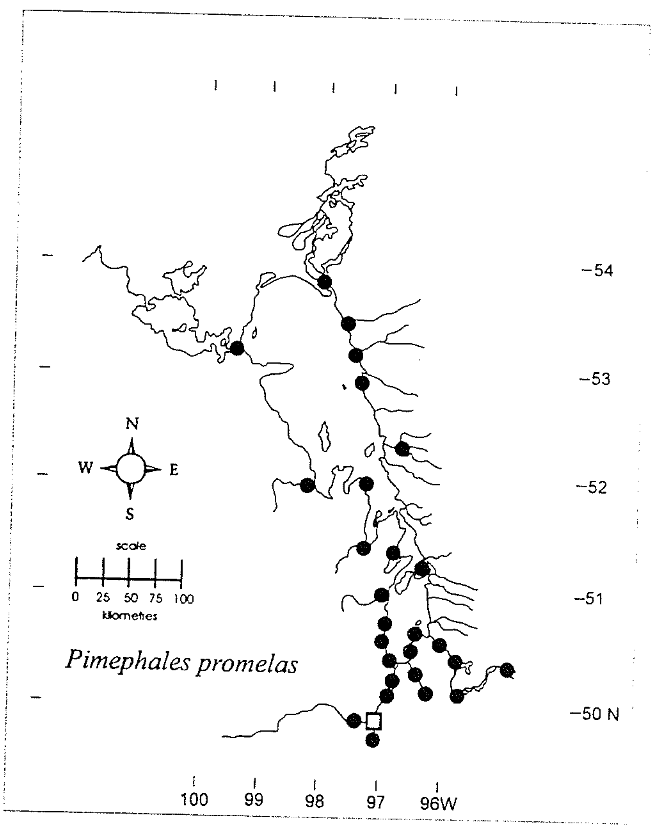

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S
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kilometres
Pimephales promelas
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-51
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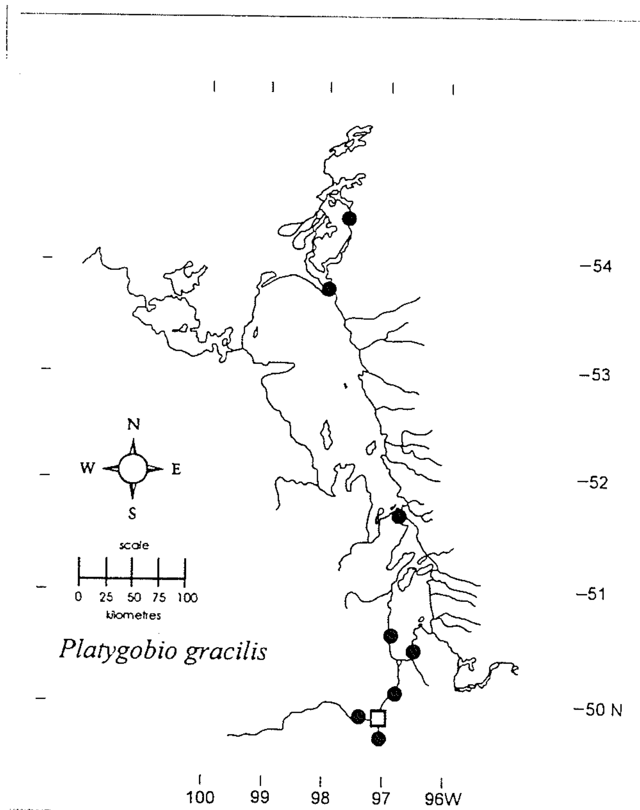
96W



N
W
E
S
scale
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kilometres
Platygobio gracilis
-54
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-51
-50 N
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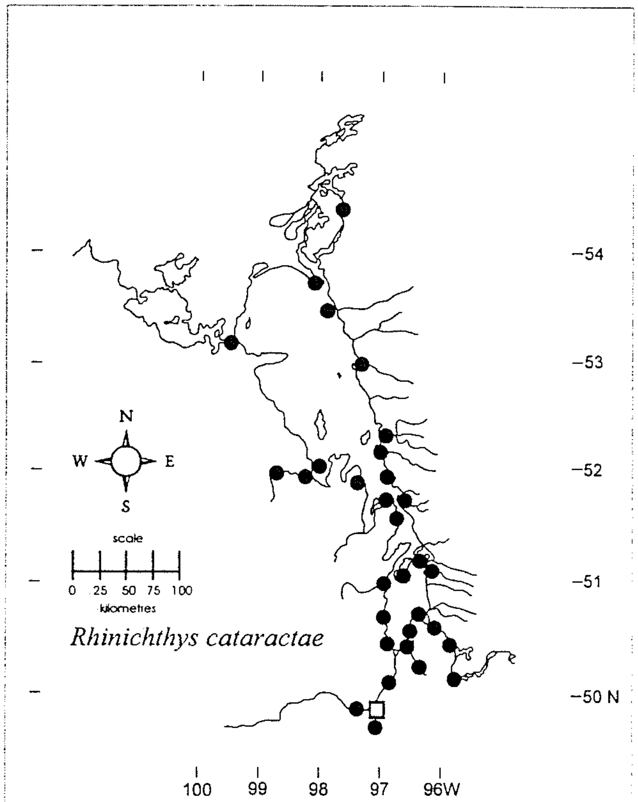
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S
scale
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kilometres
Rhinichthys cataractae
-54
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-51
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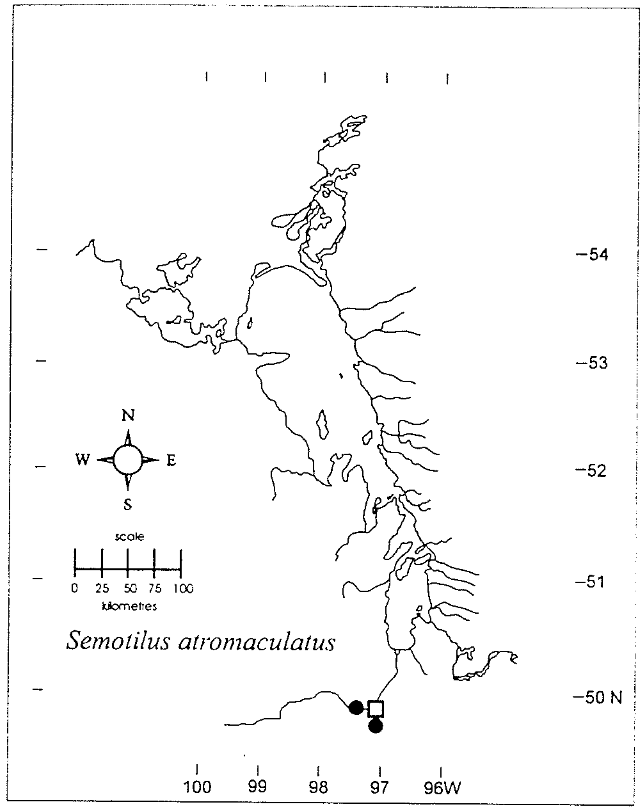
N
W
E
S
scale
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kilometres
Semotilus atromaculatus
-54
-53
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-51
-50 N
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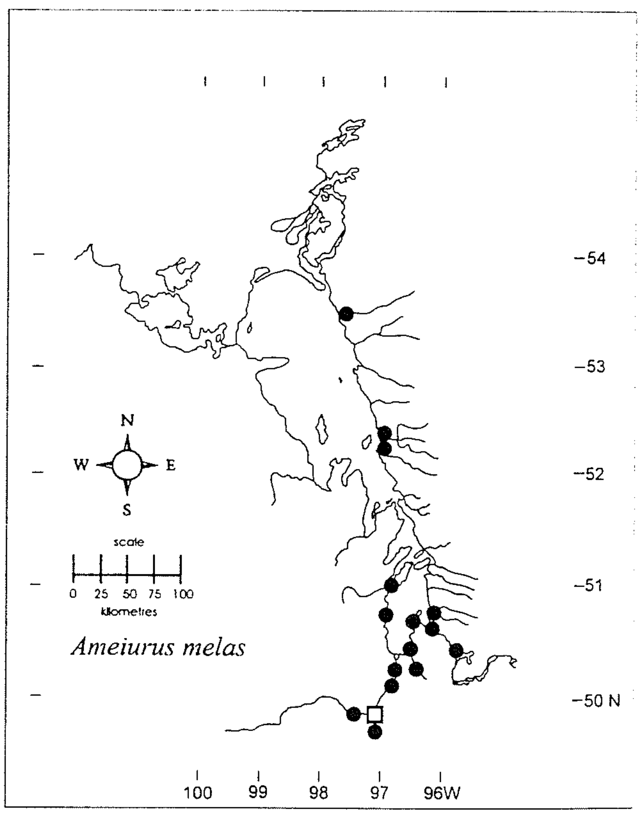
97
96W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E
S
scale
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kilometres
Ameiurus melas
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-51
-50 N
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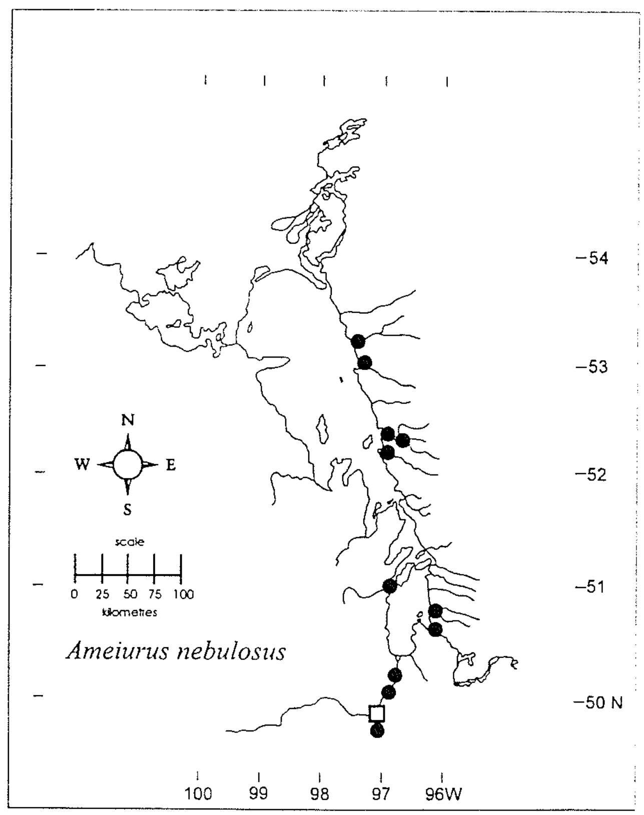
N
W
E
S
scale
0 25 50 75 100
kilometres
Ameiurus nebulosus
-54
-53
-52
-51
-50 N
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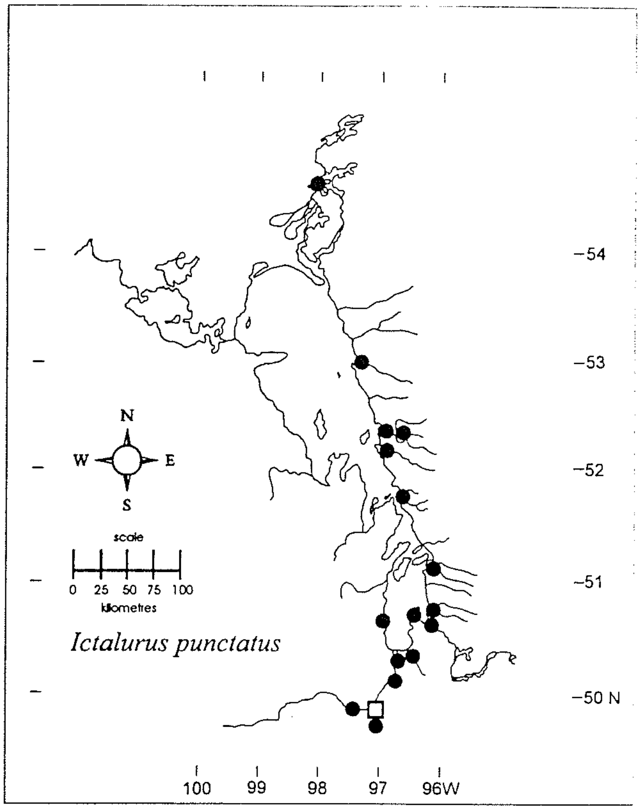
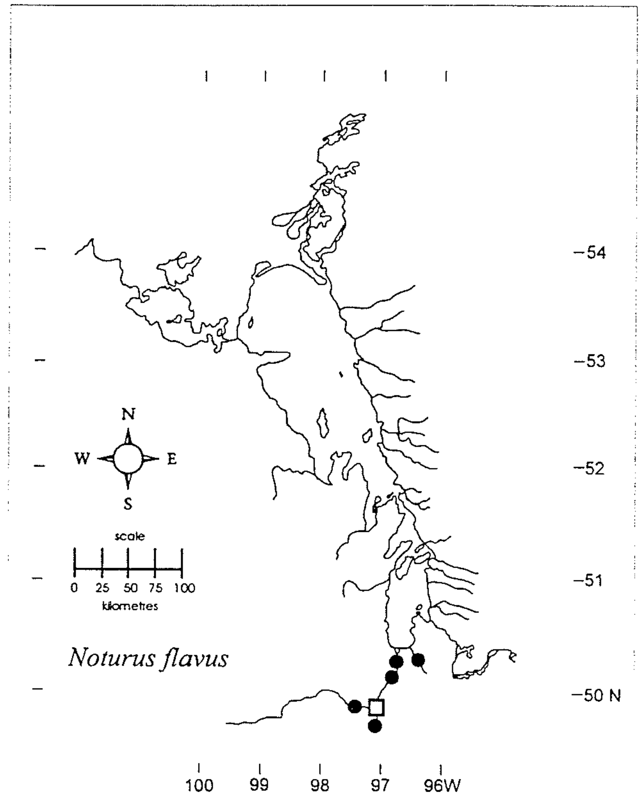
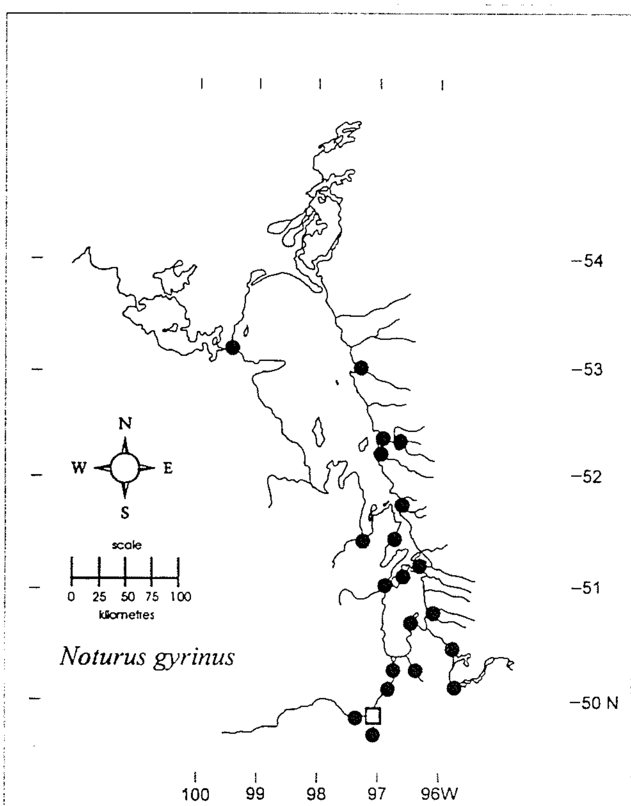
97
96W



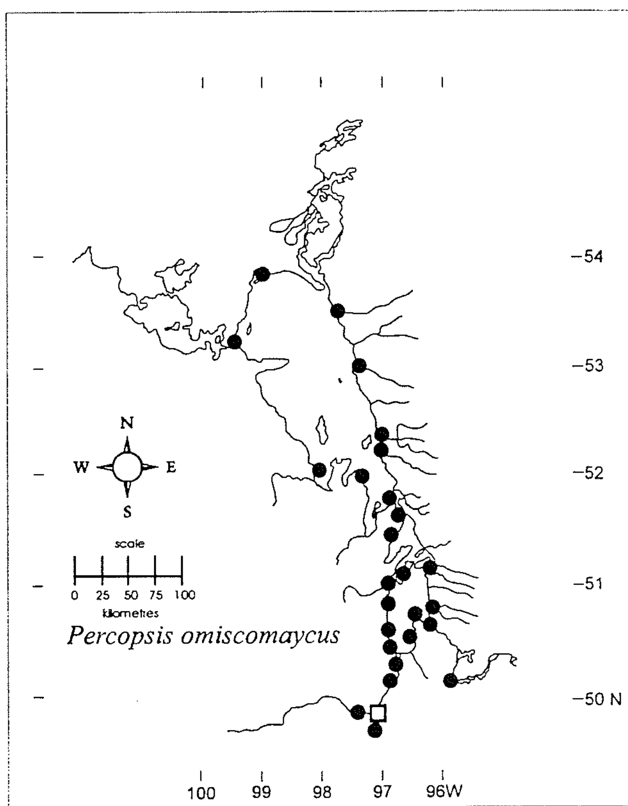
Ictalurus punctatus



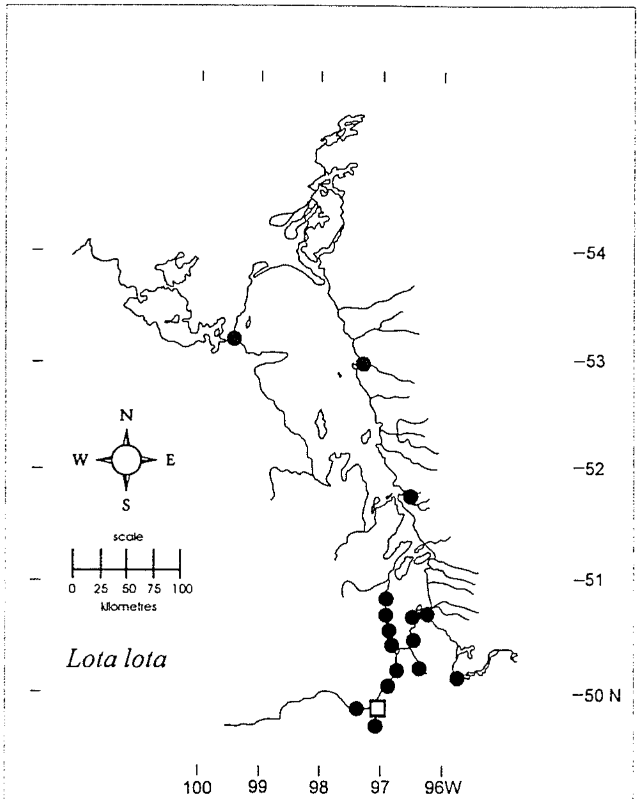
Noturus flavus

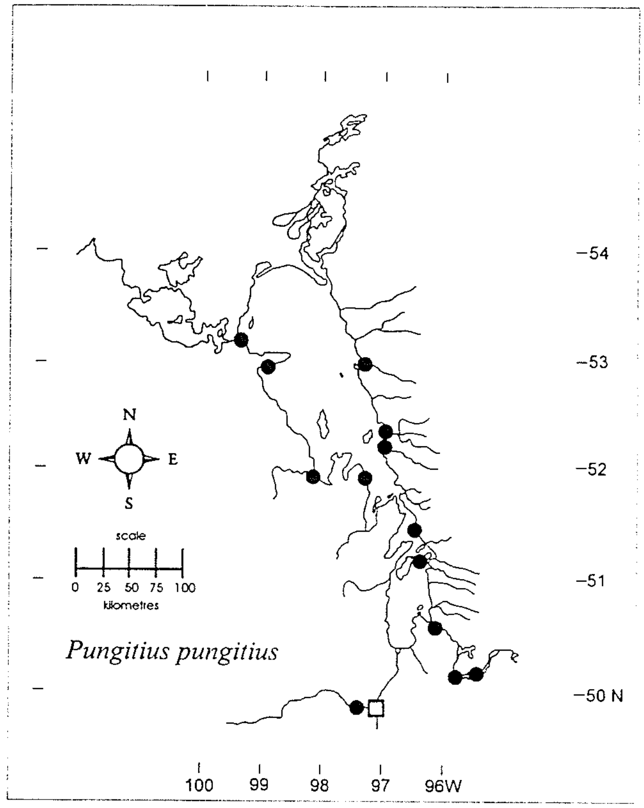


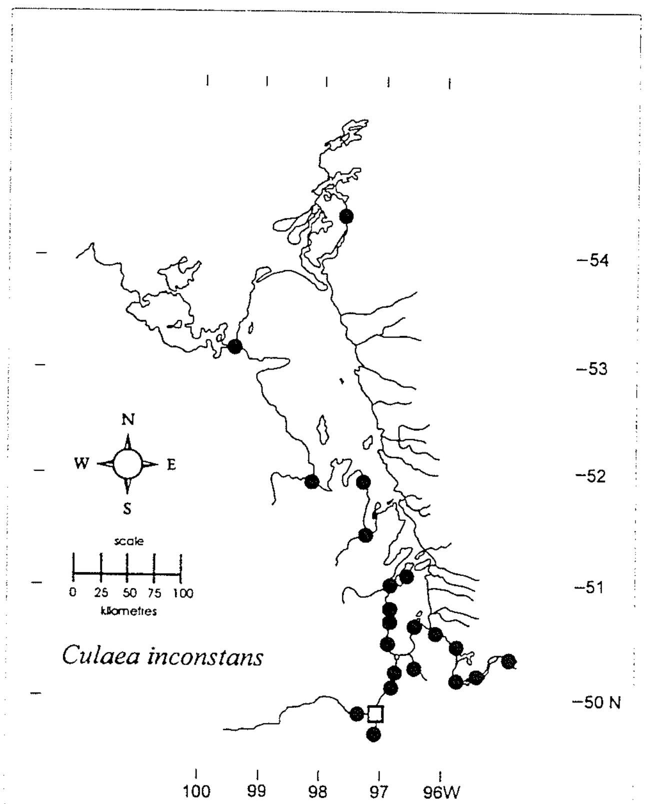
Noturus gyrinus

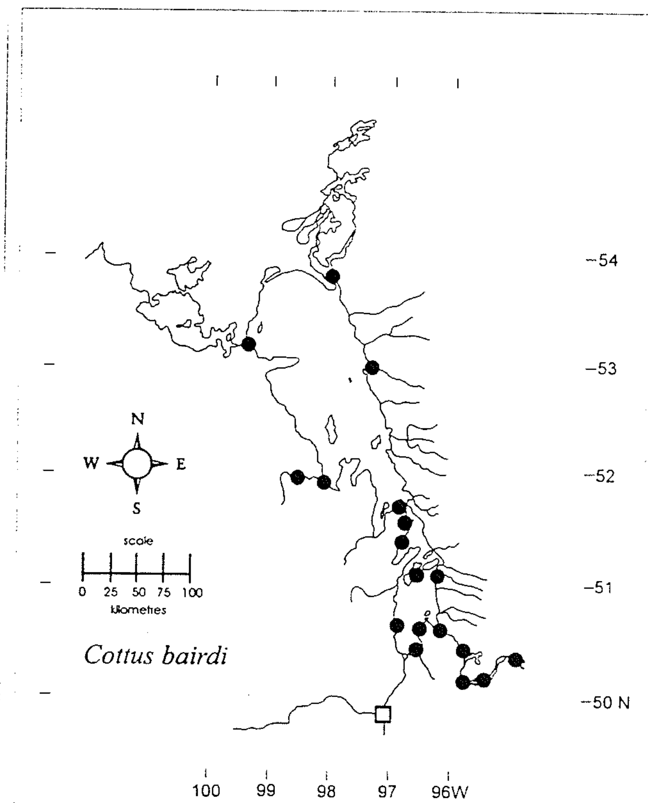


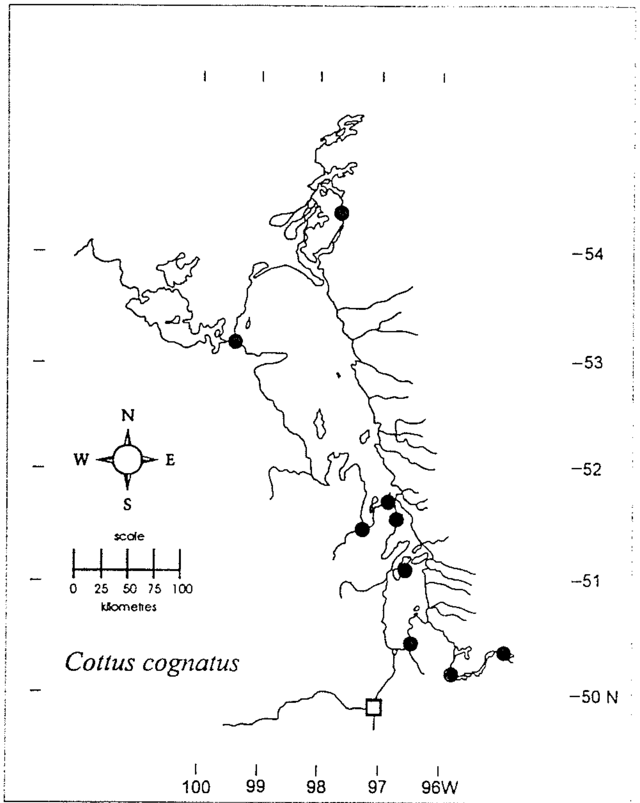
Percopsis omiscomaycus

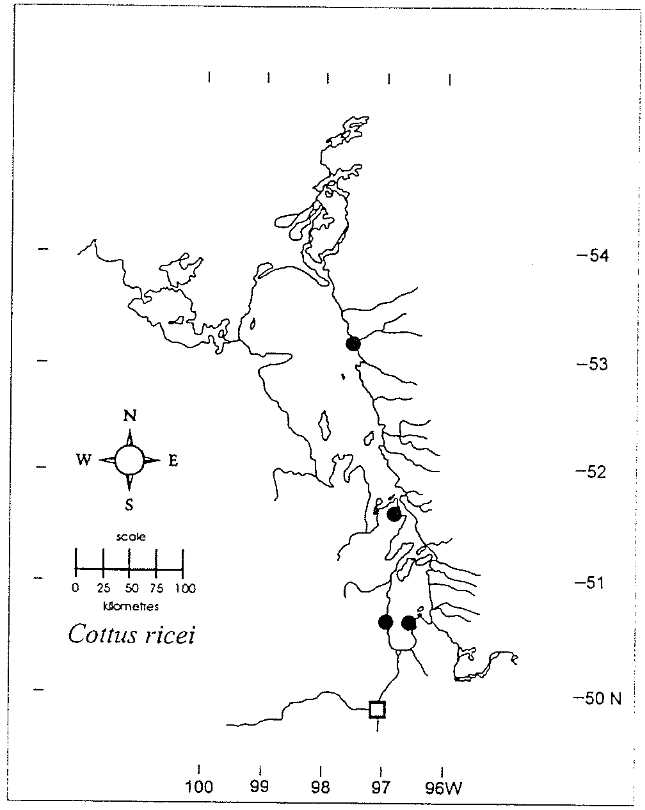

-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Lota lota
100 99 98 97 96W

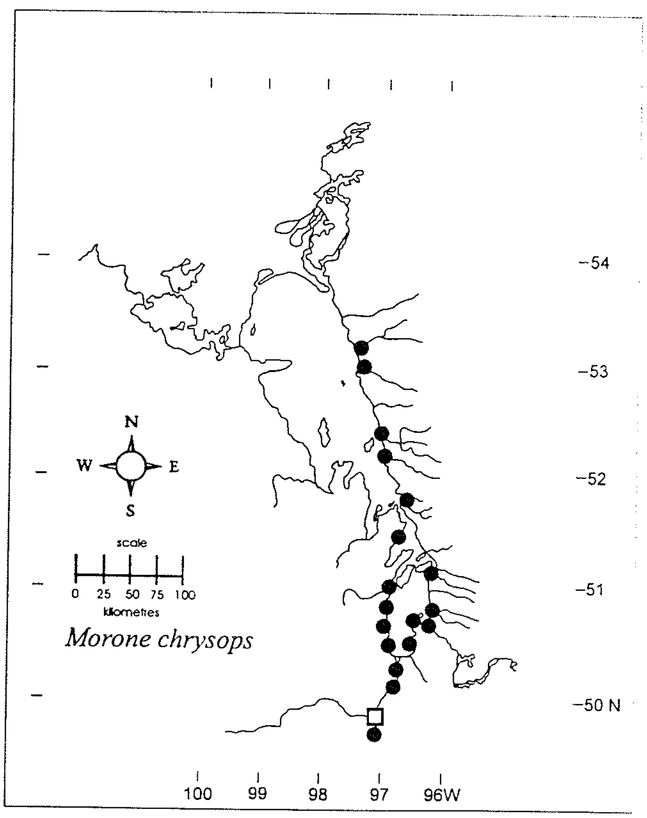

-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Pungitius pungitius
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Culaea inconstans
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Cottus bairdi
100 99 98 97 96W


-54
-53
-52
-51
-50 N
100
99
98
97
96W
N
W
E
S
scale
0 25 50 75 100
kilometres
Cottus cognatus


-54
-53
-52
-51
-50 N
100
99
98
97
96W
N
W
E
S
scale
0 25 50 75 100
kilometres
Cottus ricei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-50 N
100
99
98
97
96W
N
W
E
S
scale
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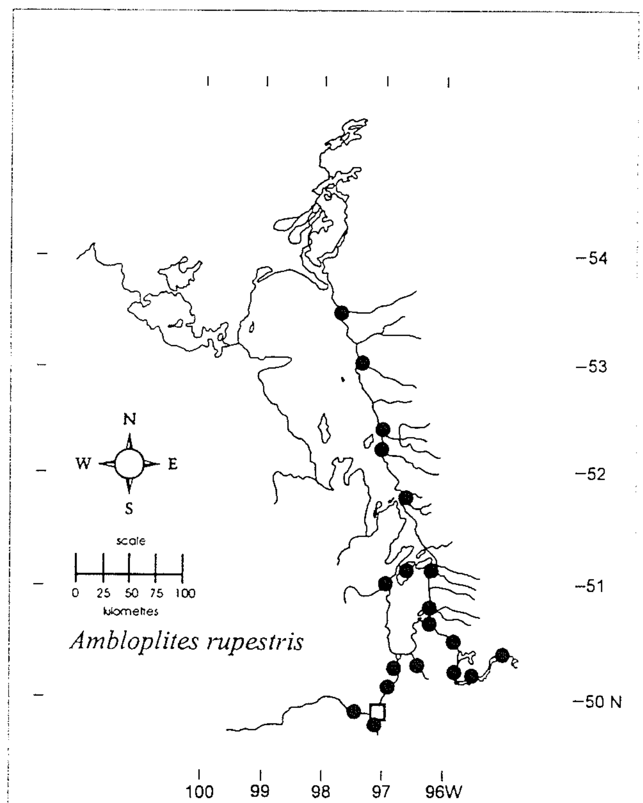
kilometres
Morone chrysops


-54
-53
-52
-51
-50 N
100
99
98
97
96W
N
W
E
S
scale
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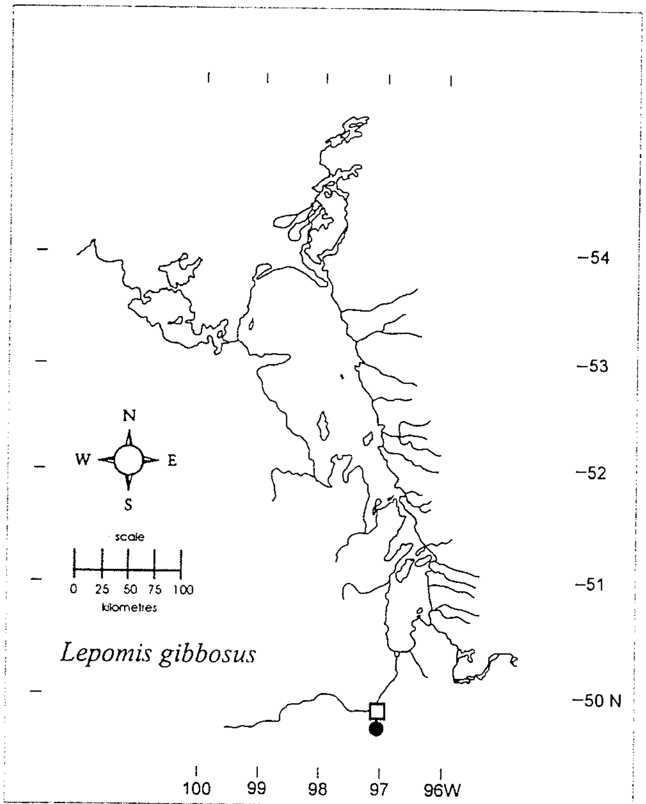
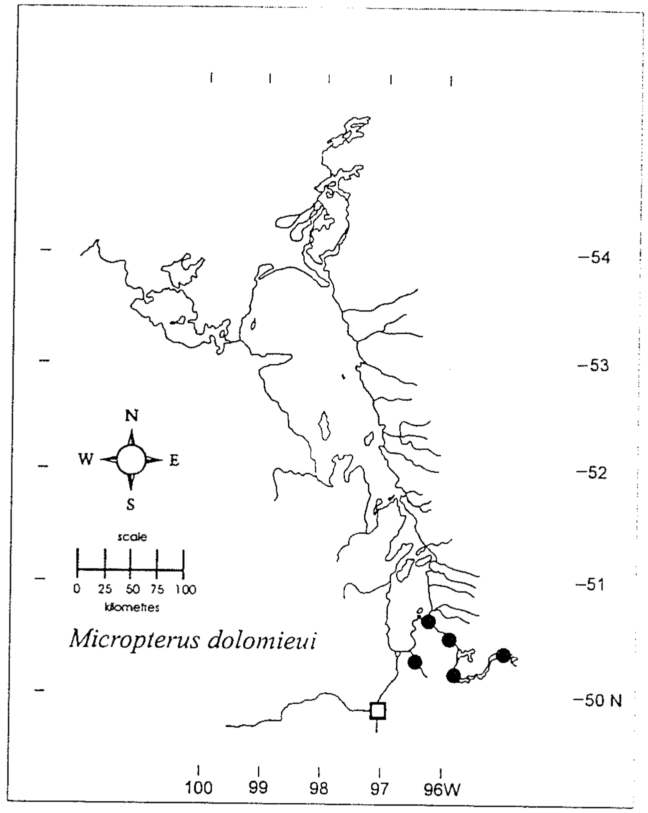
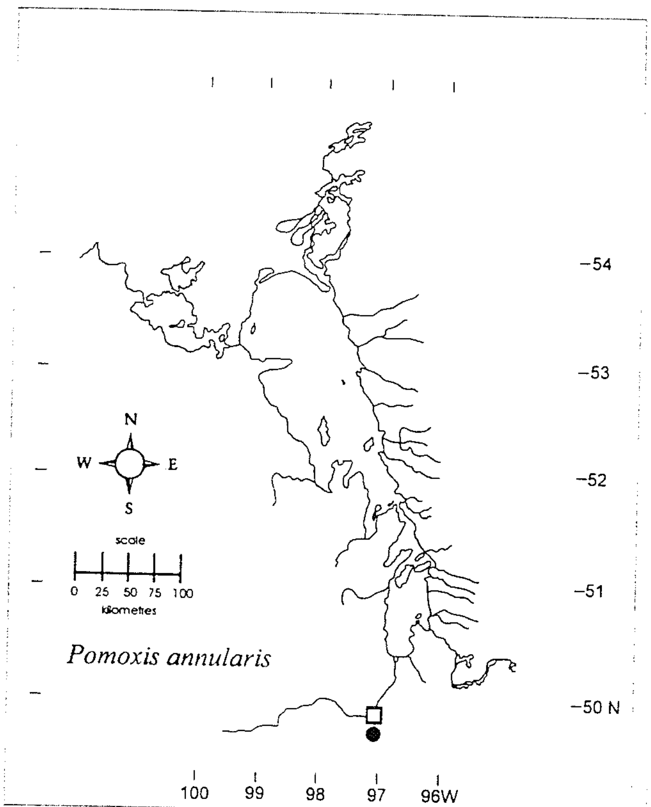
kilometres
Ambloplites rupestris



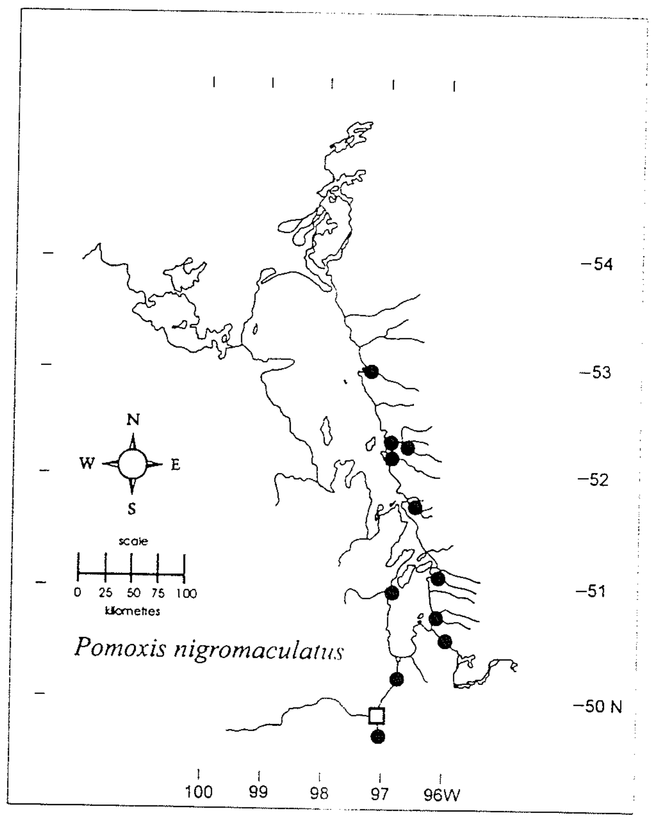
Lepomis gibbosus



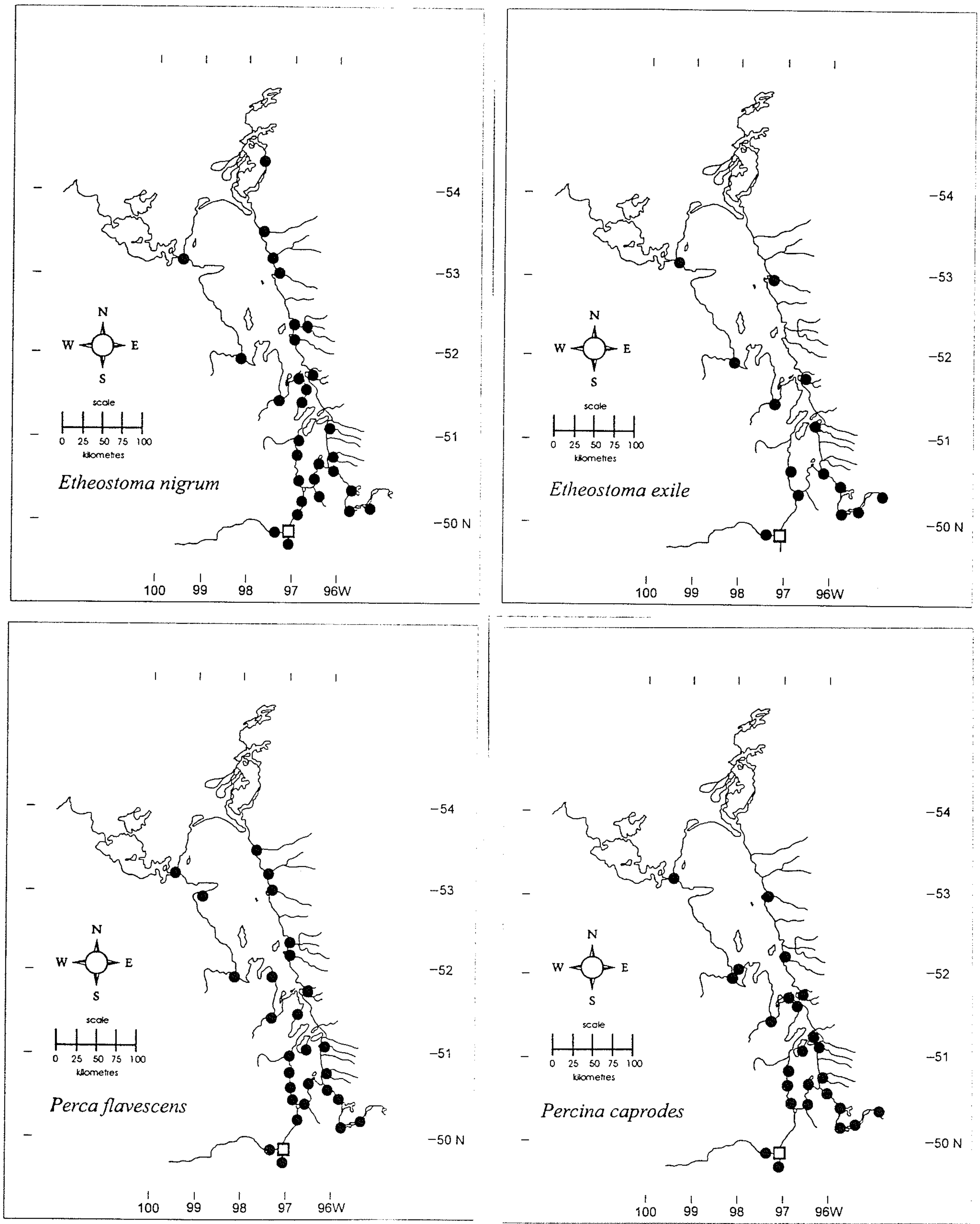
Micropterus dolomieui

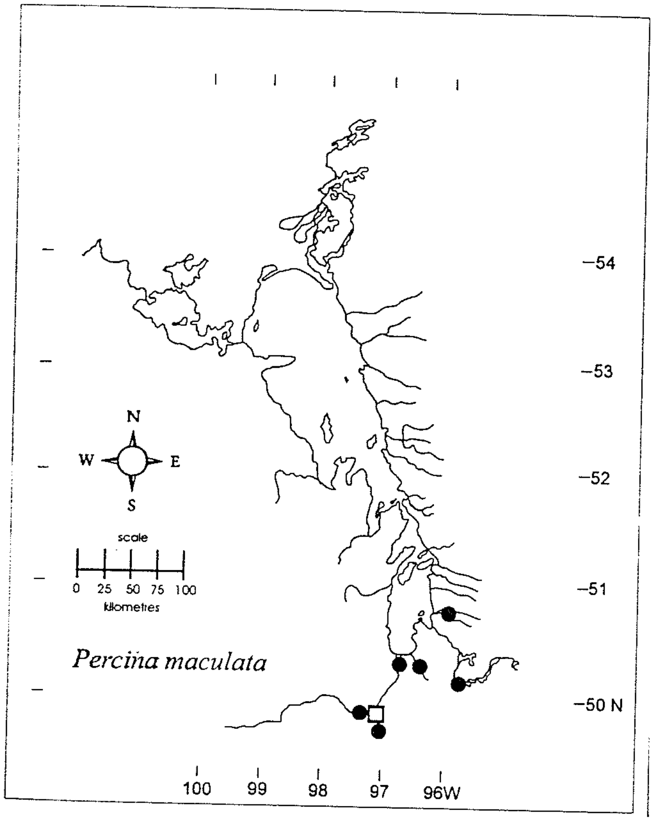


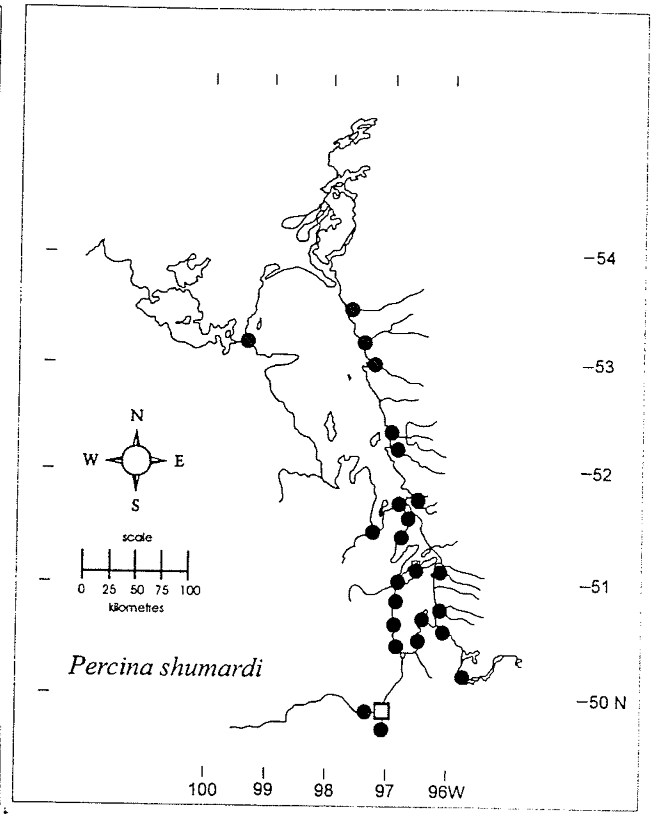
Pomoxis annularis

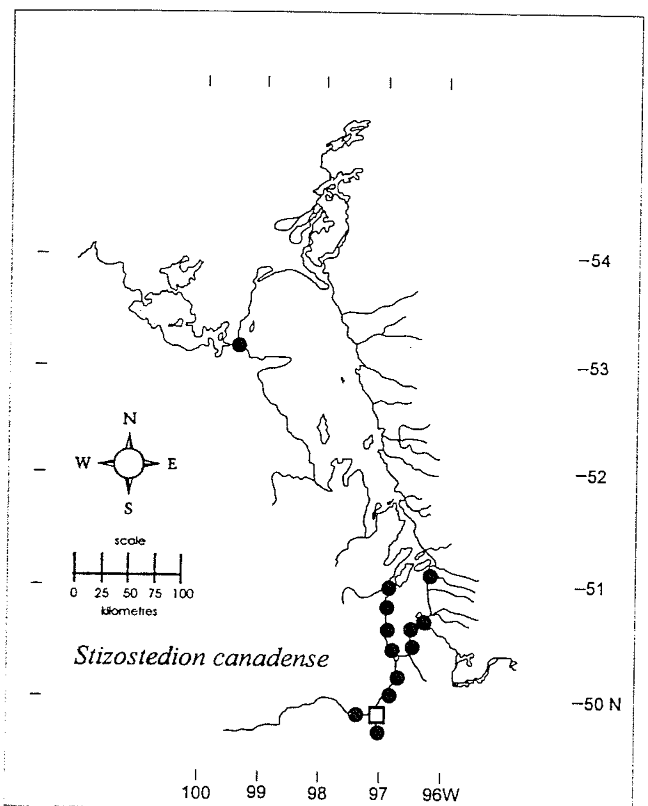


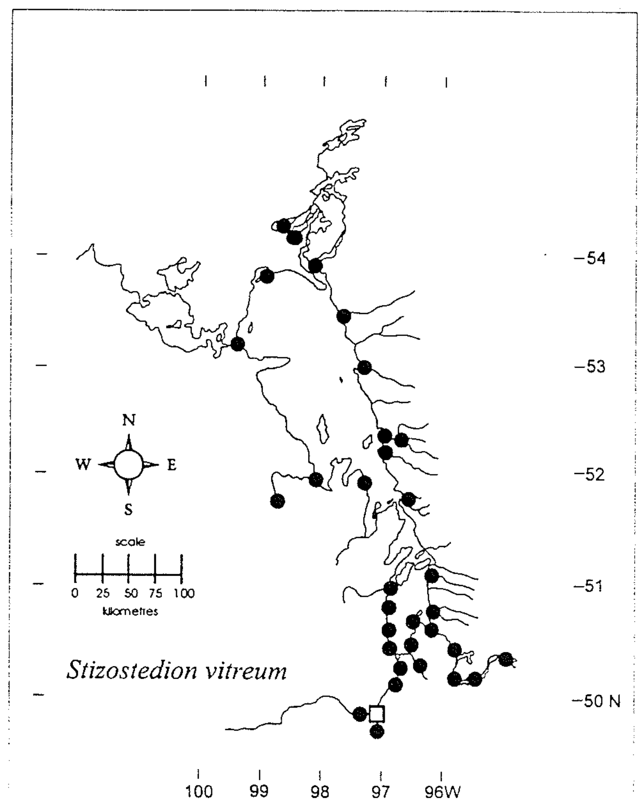
Pomoxis nigromaculatus

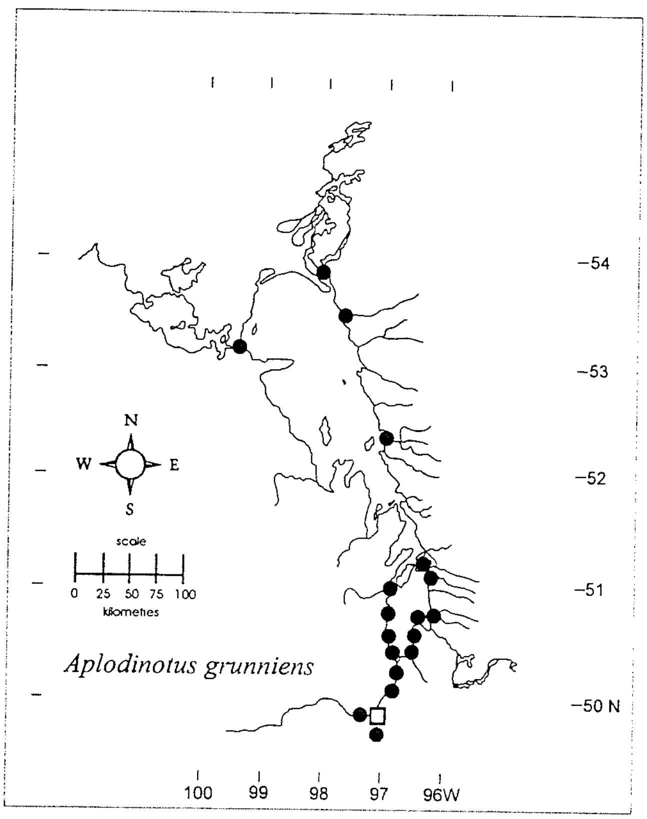

Etheostoma nigrum
Etheostoma exile
Perca flavescens
Percina caprodes
N
W
E
S
scale
0 25 50 75 100
kilometres
-54
-53
-52
-51
-50 N
100
99
98
97
96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Percina maculata
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Percina shumardi
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Stizostedion canadense
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Stizostedion vitreum
100 99 98 97 96W


-54
-53
-52
-51
-50 N
N
W
E
S
scale
0 25 50 75 100
kilometres
Aplodinotus grunniens
100
99
98
97
96W

Appendix V: Raw data for all beach seine collections between 1989 and 1994, GFH = collections from this survey, KWS = collections by K. W. Stewart

Site	Sandy Hook	Willow Pt.	Gull Harbor	Belanger R.
Researcher Catalog #	GFH8902	GFH8903	GFH8905	KWS9103
Date	23/9/89	23/9/89	23/9/89	5/8/91
Time	12:00	13:30	16:00	?
Northern Pike				
Cisco	2			
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	35	63	19	33
River Shiner				
Spottail Shiner	11	1	4	12
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace	1			
Quillback				
Longnose Sucker				5
White Sucker				1
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom			4	
Troutperch	2			
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	3		1	
Rock Bass			1	
Black Crappie				
Johnny Darter		5		3
Logperch	2			
Yellow Perch	3	4		6
River Darter				2
Sauger				
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Mukutawa R.	Mukutawa R.	Poplar R.	Poplar R.
Researcher Catalog #	KWS9106	KWS9107	KWS9108	KWS9109
Date	6/8/91	6/8/91	12/8/91	12/8/91
Time	?	?	?	?
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	127		9	81
River Shiner				
Spottail Shiner	6	28	40	59
Mimic Shiner	1	1		
Northern Redbelly Dace				
Fathead Minnow	1	1		
Longnose Dace				
Quillback				
Longnose Sucker			7	1
White Sucker	5			1
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch			9	
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass		1		1
Rock Bass			1	
Black Crappie				
Johnny Darter	1			4
Logperch				
Yellow Perch	25	76	2	
River Darter	4		27	
Sauger				
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Berens R.	Berens R.	Hillside B.	Jackhead R.
Researcher Catalog #	KWS9114	KWS9115	GFH9101	GFH9202
Date	14/8/91	18/8/91	8/6/91	2/6/92
Time	?	?	13:00	15:36
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner	2	2		
Emerald Shiner	35	335	348	67
River Shiner				
Spottail Shiner	29	9		
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace			7	
Quillback	3			
Longnose Sucker	4			
White Sucker	11			
Silver Redhorse	1			
Shorthead Redhorse				
Black Bullhead	1			
Brown Bullhead	1			
Channel Catfish				
Tadpole Madtom	2			
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	21	10	10	
Rock Bass	6	1		
Black Crappie	10	28		
Johnny Darter	17	8		
Logperch			8	
Yellow Perch	17	8	2	
River Darter		2	11	
Sauger				
Walleye		4		
Freshwater Drum	1			

Appendix V: Continued

Site	Saskatchewan R.	Black R.	Manigotagan R.	Manigotagan R.
Researcher Catalog #	GFH9211	GFH9218	GFH9221	GFH9222
Date	9/6/92	15/6/92	16/6/92	16/6/92
Time	17:30	16:35	13:12	13:38
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub	8			
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	1525	689	393	3
River Shiner				1
Spottail Shiner	158	13		11
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow	18			
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker	5			
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		6	4	
Burbot				
Brook Stickleback				
Ninespine Stickleback	32			
Mottled Sculpin				
White Bass		2		
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				
Yellow Perch	2	12		
River Darter			1	
Sauger				
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Beaver Cr.	Beaver Cr.	Long Pt.	Dauphin R.
Researcher Catalog #	GFH9227	GFH9230	GFH9246	GFH9251
Date	11/8/92	11/8/92	5/8/92	6/8/92
Time	17:44	19:35	16:00	13:52
Northern Pike				
Cisco	1		1	
Lake Whitefish			1	
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	300	4	263	373
River Shiner	11	2		
Spottail Shiner	6		1	6
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				1
Longnose Dace		1		
Quillback				
Longnose Sucker			11	
White Sucker	1		3	2
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		2		
Burbot				
Brook Stickleback				
Ninespine Stickleback			7	
Mottled Sculpin		1		
White Bass	15	29		
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				4
Yellow Perch	800	12	467	6
River Darter		2		
Sauger				
Walleye				5
Freshwater Drum				

Appendix V: Continued

Site	Pigeon R.	Pigeon R.	Matlock B.	Matlock B.
Researcher Catalog #	GFH9255	GFH9256	GFH93044	GFH93075
Date	18/8/92	18/8/92	29/7/93	9/8/93
Time	12:55	13:50	19:20	11:40
Northern Pike				
Cisco				
Lake Whitefish				30
Goldeye			6	1
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	47	2638	156	66
River Shiner				1
Spottail Shiner	13	35	1	2
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				1
Longnose Dace		1		
Quillback				
Longnose Sucker				
White Sucker	2	1		
Silver Redhorse				
Shorthead Redhorse		1		
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback		1		
Mottled Sculpin				
White Bass	5	6	98	24
Rock Bass				
Black Crappie		3		
Johnny Darter				
Logperch	2	2	1	
Yellow Perch	130	116	82	52
River Darter				
Sauger				28
Walleye	5	8	30	23
Freshwater Drum				

Appendix V: Continued

Site	Matlock B.	Matlock B.	Matlock B.	Ponema B.
Researcher Catalog #	GFH39087	GFH93121	GFH93123	GFH93042
Date	10/8/93	20/8/93	3/9/93	29/7/93
Time	17:20	18:30	11:20	17:00
Northern Pike				
Cisco			1	
Lake Whitefish		1.5	1.5	
Goldeye	1	2	0.5	4
Mooneye				
Lake Chub				
Carp				
Silver Chub		0.5		
Golden Shiner				
Emerald Shiner	60	22.5	136	203.5
River Shiner		1	0.5	
Spottail Shiner		1.5	0.5	0.5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow			0.5	
Longnose Dace				4
Quillback				0.5
Longnose Sucker				
White Sucker				0.5
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch			0.5	0.5
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	85	46.5	19	32
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				2
Yellow Perch	34	2	1	19
River Darter				0.5
Sauger	14			
Walleye	30	16		8
Freshwater Drum	5			0.5

Appendix V: Continued

Site	Ponema B.	Ponema B.	Winnipeg B.	Winnipeg B.
Researcher Catalog #	GFH93086	GFH93120	GFH93073	GFH93076
Date	10/8/93	20/8/93	5/8/93	9/8/93
Time	16:40	18:00	19:00	12:40
Northern Pike				
Cisco				
Lake Whitefish				9
Goldeye	14	13	9	
Mooneye			3	
Lake Chub				
Carp		1		
Silver Chub				
Golden Shiner				
Emerald Shiner	335	25	82	34
River Shiner				
Spottail Shiner			1	1
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow	1			
Longnose Dace	4			
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	628	74	644	187
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch			1	
Yellow Perch	138	10	36	81
River Darter		1		
Sauger				
Walleye	15		3	3
Freshwater Drum	1		1	

Appendix V: Continued

Site	Winnipeg B.	Winnipeg B.	Sandy Hook	Willow Pt.
Researcher Catalog #	GFH39119	GFH93124	GFH93077	GFH93071
Date	20/8/93	3/9/93	9/8/93	5/8/93
Time	17:20	12:20	13:10	16:20
Northern Pike				
Cisco				
Lake Whitefish	7	7.5		
Goldeye	1		1	
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	132	113	88	2
River Shiner	1			
Spottail Shiner	4	1.5		3
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				12
Longnose Dace			26	2
Quillback		1		
Longnose Sucker				
White Sucker			15	1
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				1
Ninespine Stickleback				
Mottled Sculpin				
White Bass	73	4.5	130	875
Rock Bass				
Black Crappie				
Johnny Darter				1
Logperch			5	1
Yellow Perch	42	1.5	12	1124
River Darter				1
Sauger		1.5		
Walleye	10		6	
Freshwater Drum				

Appendix V: Continued

Site	Willow Pt.	Willow Pt.	Willow Pt.	Hussavick Rd.
Researcher Catalog #	GFH93079	GFH93117	GFH93116	GFH93072
Date	9/8/93	20/8/93	20/8/93	5/8/93
Time	14:50	16:00	15:40	17:15
Northern Pike		1		
Cisco				
Lake Whitefish	17		1.5	
Goldeye	0.5		1.5	3
Mooneye				
Lake Chub				
Carp				2
Silver Chub				
Golden Shiner				
Emerald Shiner	30	6	7.5	2
River Shiner				
Spottail Shiner	2.5	31	0.5	
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow		3		
Longnose Dace				
Quillback				
Longnose Sucker	0.5			
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				3.5
Tadpole Madtom				
Troutperch	1.5			
Burbot				0.5
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	10.5	414	76	289.5
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	1	1		
Yellow Perch	43	52	1.5	3
River Darter		1		
Sauger	8.5	1		
Walleye	24		33.5	
Freshwater Drum		17		3.5

Appendix V: Continued

Site	Hussavick Rd.	Hussavick Rd.	McEhleran Rd.	McEhleran Rd.
Researcher Catalog #	GFH93078	GFH93118	GFH93041	GFH93080
Date	9/8/93	20/8/93	29/8/93	9/8/93
Time	14:20	16:40	15:20	17:20
Northern Pike				
Cisco				1
Lake Whitefish				
Goldeye		19	0.5	32
Mooneye				1
Lake Chub				
Carp		1		
Silver Chub				
Golden Shiner				
Emerald Shiner	689	23	120.5	380
River Shiner				
Spottail Shiner	1	2	5.5	2
Mimic Shiner				
Northern Redbelly Dace			0.5	
Fathead Minnow			0.5	1
Longnose Dace	1			
Quillback				
Longnose Sucker				
White Sucker	2		0.5	
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish		3		
Tadpole Madtom				
Troutperch			10	
Burbot				
Brook Stickleback			1	
Ninespine Stickleback				
Mottled Sculpin				
White Bass	775	653	1	2998
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	7	1	0.5	6
Yellow Perch	197	5	19	2851
River Darter				
Sauger		5	0.5	3
Walleye	23	5	6.5	40
Freshwater Drum	4	2		17

Appendix V: Continued

Site	McEhleran Rd.	Camp Morton	Arnes	Arnes
Researcher Catalog #	GFH93115	GFH93040	GFH93039	GFH93069
Date	20/8/93	29/7/93	29/7/93	5/8/93
Time	13:50	14:20	12:50	13:15
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye	1			
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	73	36	466	39
River Shiner				
Spottail Shiner				4
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker			1	
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		0.5		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	143	26.5	25	
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	3	2		
Yellow Perch	11	5		3
River Darter				
Sauger		0.5		4
Walleye	73	1.5	2	7
Freshwater Drum				

Appendix V: Continued

Site	Arnes	Camp Neustadt	Balaton B.	Hnausa B.
Researcher Catalog #	GFH93114	GFH93081	GFH93066	GFH93038
Date	20/8/93	9/8/93	5/8/93	29/7/93
Time	13:20	18:10	11:40	11:50
Northern Pike				
Cisco				
Lake Whitefish			1	
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	66	42	25	36
River Shiner				
Spottail Shiner	2	1		
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow		4		
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch			3	
Burbot				
Brook Stickleback		2		
Ninespine Stickleback				
Mottled Sculpin				
White Bass	27	777	325	235
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch		3		
Yellow Perch		14125	1	2
River Darter			1	
Sauger				
Walleye	7	9		
Freshwater Drum			1	

Appendix V: Continued

Site	Hnausa B.	Hnausa B.	Hnausa B.	Riverton B.
Researcher Catalog #	GFH93067	GFH93082	GFH93113	GFH93035
Date	5/8/93	9/8/93	20/8/93	28/7/93
Time	12:20	18:50	12:50	17:20
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	34	58	169	47
River Shiner			1	
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				2.5
Burbot				
Brook Stickleback				0.5
Ninespine Stickleback				
Mottled Sculpin				
White Bass	54	35	563	8.5
Rock Bass				
Black Crappie				
Johnny Darter		1		
Logperch		7		
Yellow Perch		848	3	22.5
River Darter		1		
Sauger				
Walleye	1	1	1	1.5
Freshwater Drum	1			

Appendix V: Continued

Site	Riverton B.	Riverton B.	Riverton B.	Gull Harbor
Researcher Catalog #	GFH93065	GFH93083	GFH93112	GFH93032
Date	5/8/93	9/8/93	20/8/93	28/7/93
Time	11:00	19:50	12:00	13:50
Northern Pike				
Cisco		1		
Lake Whitefish	6	4	1	
Goldeye			7	
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	24	21	53	88
River Shiner				
Spottail Shiner				1.5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				0.5
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch	5			
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	644	86	1107	
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				
Yellow Perch	52	391	28	
River Darter	1	1		
Sauger				
Walleye		3	5	
Freshwater Drum		1		

Appendix V: Continued

Site	Beaver Cr.	Manigotagan R.	Manigotagan R.	Manigotagan R.
Researcher Catalog #	GFH93030	GFH93055	GFH93091	GFH93088
Date	27/7/93	3/8/93	12/8/93	12/8/93
Time	19:10	13:20	17:00	13:48
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye		0.5	8	
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner		0.5		
Emerald Shiner	14	314	25	6
River Shiner	3		1	
Spottail Shiner		3	2	1
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback		1		
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish			1	
Tadpole Madtom				
Troutperch	3	0.5		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	4	21	30	5
Rock Bass				
Black Crappie		0.5	1	
Johnny Darter	0.5			
Logperch			3	
Yellow Perch	1	7	15	17
River Darter	0.5		3	9
Sauger		6.5		
Walleye		6.5		
Freshwater Drum			2	

Appendix V: Continued

Site	Sandy Bay	Sandy Bay	Sandy Bay	Sandy Bay
Researcher Catalog #	GFH93049	GFH93064	GFH93095	GFH93107
Date	30/7/93	4/8/93	12/8/93	16/8/93
Time	15:00	14:20	20:45	13:11
Northern Pike				
Cisco				
Lake Whitefish		11		
Goldeye				
Mooneye		1		0.5
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	294	20	9	29
River Shiner	2	1	2	
Spottail Shiner		3		4.5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace	1	3	1	0.5
Quillback				0.5
Longnose Sucker	2	4		0.5
White Sucker		1	1	0.5
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch	2	2		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	2	40	10	28.5
Rock Bass				
Black Crappie				
Johnny Darter	1			
Logperch	0	1		1.5
Yellow Perch	25	35	1	3.5
River Darter				0.5
Sauger				1.5
Walleye		1	1	3
Freshwater Drum				

Appendix V: Continued

Site	Albert B.	Traverse Bay	Traverse Bay	Traverse Bay
Researcher Catalog #	GFH93106	GFH93047	GFH93061	GFH93094
Date	16/8/93	30/7/93	4/8/93	12/8/93
Time	12:44	13:20	11:40	20:20
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye		3		3
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	30	16	52	24
River Shiner				
Spottail Shiner	1	1	1	5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace		1	2	1
Quillback				
Longnose Sucker			1	1
White Sucker			3	
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		1		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				1
White Bass	8	221	73	368
Rock Bass				
Black Crappie				
Johnny Darter			2	1
Logperch	1	2	3	
Yellow Perch		2	8	1
River Darter		1		3
Sauger	0			
Walleye	4		1	
Freshwater Drum		4		

Appendix V: Continued

Site	Traverse Bay	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH93105	GFH93051	GFH93096	GFH93108
Date	16/8/93	30/7/93	13/8/93	16/8/93
Time	12:10	17:35	10:30	14:00
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye	1			1.5
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	14	12	212	6.5
River Shiner				
Spottail Shiner	0.5			
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace	0.5			
Quillback			1	
Longnose Sucker	1			
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		0.5		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	130.5	2	1114	95
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	3	0.5	2	2
Yellow Perch	12.5	424	302	7.5
River Darter		0.5		
Sauger		1		
Walleye	1.5	0.5	2	
Freshwater Drum				0.5

Appendix V: Continued

Site	Hillside B.	Grand Marais	Grand Marais	Grand Marais
Researcher Catalog #	GFH93137	GFH93053	GFH93099	GFH93109
Date	18/9/93	30/7/9/3	13/8/93	16/8/93
Time	11:50	20:15	13:10	15:40
Northern Pike				
Cisco	0.5			
Lake Whitefish	0.25			
Goldeye			7	
Mooneye			1.5	
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	59.75	23	13.5	2
River Shiner				
Spottail Shiner	0.25			
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace		1		
Quillback				
Longnose Sucker				
White Sucker		1		
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		0.5		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				1
White Bass		32	11	16.5
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	1.25	1.5	1.5	1
Yellow Perch	2	11	8.5	4.5
River Darter				0.5
Sauger		1.5		
Walleye		1.5		1
Freshwater Drum	0.25	0.5		

Appendix V: Continued

Site Researcher Catalog # Date Site	Balsam Bay GFH93101 13/8/93 15:30	Balsam Bay GFH93110 16/8/93 17:00	Balsam Bay GFH93127 3/9/93 14:40	Beaconia GFH93054 30/7/93 21:00
Northern Pike				
Cisco				
Lake Whitefish			0.142857	
Goldeye	1.5	0.5		
Mooneye			0.42857	
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	18	21	5.28571	28.5
River Shiner				
Spottail Shiner		0.5	0.285714	0.5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace		1		
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse		0.5		
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				1.5
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	11	20	6.142857	32
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch			0.142857	0.5
Yellow Perch	6.5		0.85714	10
River Darter				
Sauger	4.5		0.714285	2.5
Walleye	3	20	0.857143	1
Freshwater Drum				

Appendix V: Continued

Site	Beaconia	Beaconia	Beaconia	Beaconia
Researcher Catalog #	GFH93103	GFH93111	GFH93128	GFH93136
Date	13/8/93	16/8/93	3/9/93	18/9/93
Time	16:40	18:00	15:30	9:50
Northern Pike				
Cisco				3.5
Lake Whitefish				1
Goldeye	17	2.5	0.625	
Mooneye		0.5		
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	310	417	33.25	486.5
River Shiner				
Spottail Shiner	4	0.5	2.25	2.5
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker	2			
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin			0.125	0.5
White Bass	237	11.5	11.25	3
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch			0.125	
Yellow Perch	21	4	1.5	6.5
River Darter	1		0.125	1.5
Sauger	17	3.5	0.625	
Walleye	7	5	1.125	
Freshwater Drum				

Appendix V: Continued

Site	Patricia B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH93104	GFH94002	GFH94005	GFH94008
Date	13/8/93	4/6/94	5/6/94	25/6/94
Time	17:30	20:40	10:00	15:30
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	362	10	251	12
River Shiner				
Spottail Shiner	4			
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				34
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin	80			
White Bass				
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	73			3
Yellow Perch		3		4
River Darter	15			3
Sauger	8			
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94009	GFH94010	GFH94011	GFH94017
Date	25/6/94	26/6/94	26/6/94	30/6/94
Time	20:00	9:30	13:30	10:00
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				1
Mooneye				3
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	9	7	39	226
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace		2	1	
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch	42	39	74	
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass				27
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch			5	1
Yellow Perch		1	1	68
River Darter			3	1
Sauger	1		1	
Walleye				2
Freshwater Drum				2

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94018	GFH94019	GFH94020	GFH94021
Date	30/6/94	30/6/94	31/6/94	31/6/94
Time	14:00	18:00	14:00	18:00
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye	14	7	8	3
Mooneye	3		7	1
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	465	12	65	197
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker			1	
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	33	51	19	25
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch	1			
Yellow Perch	5		7	35
River Darter	1			
Sauger			1	19
Walleye	3			7
Freshwater Drum	1			3

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94022	GFH94012	GFH94013	GFH94014
Date	31/6/94	1/7/94	1/7/94	2/7/94
Time	21:00	17:30	21:30	11:15
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye	2			
Mooneye	1			
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	36	17	132	294
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				1
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch		176	100	36
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	1		1	
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch		2		
Yellow Perch	5		8	4
River Darter				4
Sauger	4	26	3	
Walleye		10	3	11
Freshwater Drum	3			

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94015	GFH94016	GFH94028	GFH94029
Date	2/7/94	2/7/94	20/8/94	20/8/94
Time	15:00	19:00	10:00	10:00
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye			6	
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	2660	47	73	35
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch	23	26		
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass			2	1
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				
Yellow Perch	5	6		2
River Darter				
Sauger	1	5		
Walleye	2	11		
Freshwater Drum				

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94030	GFH94031	GFH94032	GFH94033
Date	20/8/94	20/8/94	20/8/94	20/8/94
Time	14:00	14:00	18:00	18:00
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye		1		
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	26	12	16	24
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	2			1
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				
Yellow Perch			1	28
River Darter		1		
Sauger				
Walleye			1	
Freshwater Drum				

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94034	GFH94035	GFH94036	GFH94037
Date	20/8/94	20/8/94	21/8/94	21/8/94
Time	21:00	21:00	11:30	11:30
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye	1			
Lake Chub				
Carp				
Silver Chub				1
Golden Shiner				
Emerald Shiner	18	34	25	4
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin				
White Bass	1	1		
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch		2		
Yellow Perch	2	2		
River Darter		1	1	1
Sauger	3			
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94038	GFH94039	GFH94040	GFH94041
Date	21/8/94	21/8/94	21/8/94	21/8/94
Time	11:30	11:30	11:30	11:30
Northern Pike				
Cisco				
Lake Whitefish				
Goldeye				
Mooneye				
Lake Chub				
Carp				
Silver Chub				
Golden Shiner				
Emerald Shiner	37	124	51	82
River Shiner				
Spottail Shiner				
Mimic Shiner				
Northern Redbelly Dace				
Fathead Minnow				
Longnose Dace				
Quillback				
Longnose Sucker				
White Sucker				
Silver Redhorse				
Shorthead Redhorse				
Black Bullhead				
Brown Bullhead				
Channel Catfish				
Tadpole Madtom				
Troutperch				
Burbot				
Brook Stickleback				
Ninespine Stickleback				
Mottled Sculpin	1			
White Bass		3	22	
Rock Bass				
Black Crappie				
Johnny Darter				
Logperch				
Yellow Perch	1	4		1
River Darter	2			1
Sauger				
Walleye				
Freshwater Drum				

Appendix V: Continued

Site	Hillside B.	Hillside B.	Hillside B.
Researcher Catalog #	GFH94042	GFH94043	GFH94044
Date	21/8/94	21/8/94	21/8/94
Time	11:30	11:30	11:30
Northern Pike			
Cisco			
Lake Whitefish			
Goldeye			
Mooneye			
Lake Chub			
Carp			
Silver Chub			
Golden Shiner			
Emerald Shiner	15	45	13
River Shiner			
Spottail Shiner			
Mimic Shiner			
Northern Redbelly Dace			
Fathead Minnow			
Longnose Dace			
Quillback			
Longnose Sucker			
White Sucker			
Silver Redhorse			
Shorthead Redhorse			
Black Bullhead			
Brown Bullhead			
Channel Catfish			
Tadpole Madtom			
Troutperch			
Burbot			
Brook Stickleback			
Ninespine Stickleback			
Mottled Sculpin			1
White Bass	1	2	
Rock Bass			
Black Crappie			
Johnny Darter			
Logperch			
Yellow Perch		1	
River Darter			1
Sauger			
Walleye			1
Freshwater Drum			

Appendix VI: Raw data for zooplankton collections with conversion to number of zooplankters per liter

Site	Matlock	Matlock	Matlock	Matlock
Time	19:20	11:40	17:20	18:30
Date	29/7/93	9/8/93	10/8/93	20/8/93
sample volume (l.)	0.0563	0.0223	0.0428	0.0140
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	31	203	7	37
Leptodoridae	18	1	0	18
Bosminidae	0	3	17	22
Sididae	11	1	7	2
Cladocera other	0	2	0	2
Calanoidea	16	7	0	4
Cyclopoidea	122	194	44	56
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0129	0.0334	0.0022	0.0038
Leptodoridae	0.0075	0.0002	0.0000	0.0019
Bosminidae	0.0000	0.0005	0.0054	0.0023
Sididae	0.0046	0.0002	0.0022	0.0002
Cladocera other	0.0000	0.0003	0.0000	0.0002
Calanoidea	0.0066	0.0012	0.0000	0.0004
Cyclopoidea	0.0506	0.0319	0.0139	0.0058
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Matlock	Ponema	Ponema	Ponema
Time	11:20	17:00	16:40	18:00
Date	3/9/93	29/7/93	10/8/93	20/8/93
sample volume (l.)	0.0267	0.0112	0.0303	0.0055
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	160	1	0	1
Leptodoridae	6	4	2	0
Bosminidae	23	2	0	310
Sididae	7	2	1	1
Cladocera other	3	3	0	0
Calanoidea	31	8	0	2
Cyclopoidea	59	20	21	29
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0315	0.0001	0.0000	0.0000
Leptodoridae	0.0012	0.0003	0.0004	0.0000
Bosminidae	0.0045	0.0002	0.0000	0.0126
Sididae	0.0014	0.0002	0.0002	0.0000
Cladocera other	0.0006	0.0002	0.0000	0.0000
Calanoidea	0.0061	0.0007	0.0000	0.0001
Cyclopoidea	0.0116	0.0017	0.0047	0.0012
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Winnipeg B	Winnipeg B	Winnipeg B	Sandy Hook
Time	19:00	12:40	17:20	13:10
Date	5/8/93	9/8/93	20/8/93	9/8/93
sample volume (l.)	0.0312	0.0468	0.0164	0.0354
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	37	350	34	93
Leptodoridae	0	1	1	0
Bosminidae	5	25	632	7
Sididae	3	4	1	2
Cladocera other	0	1	0	0
Calanoidea	3	39	18	36
Cyclopoidea	86	208	252	423
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0085	0.1207	0.0041	0.0243
Leptodoridae	0.0000	0.0003	0.0001	0.0000
Bosminidae	0.0011	0.0086	0.0764	0.0018
Sididae	0.0007	0.0014	0.0001	0.0005
Cladocera other	0.0000	0.0003	0.0000	0.0000
Calanoidea	0.0007	0.0135	0.0022	0.0094
Cyclopoidea	0.0198	0.0717	0.0305	0.1103
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Camp Neust	Hussavick	Hussavick	Hussavick
Time	18:10	17:15	14:20	16:40
Date	9/8/93	5/8/93	9/8/93	20/8/93
sample volume (l.)	0.0210	0.0130	0.1331	0.0242
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	2	1	82	0
Leptodoridae	0	0	2	0
Bosminidae	21	41	1	165
Sididae	1	1	3	5
Cladocera other	1	0	1	0
Calanoidea	25	1	5	1
Cyclopoidea	39	147	48	93
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0003	0.0001	0.0804	0.0000
Leptodoridae	0.0000	0.0000	0.0020	0.0000
Bosminidae	0.0032	0.0039	0.0010	0.0294
Sididae	0.0002	0.0001	0.0029	0.0009
Cladocera other	0.0002	0.0000	0.0010	0.0000
Calanoidea	0.0039	0.0001	0.0049	0.0002
Cyclopoidea	0.0060	0.0141	0.0471	0.0166
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Willow Pt.	Willow Pt	Willow Pt	Willow Pt
Time	16:20	14:50	15:40	16:00
Date	5/8/93	9/8/93	20/8/93	20/8/93
sample volume (l.)	0.0251	0.0350	0.0117	0.0282
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	3	450	282	10
Leptodoridae	0	0	3	0
Bosminidae	5	23	93	2
Sididae	19	24	36	13
Cladocera other	8	1	0	9
Calanoidea	3	54	15	0
Cyclopoidea	282	1245	581	454
Copepoda unid.	2	0	0	0
Zooplankters per Liter				
Daphniidae	0.0006	0.1161	0.0243	0.0021
Leptodoridae	0.0000	0.0000	0.0003	0.0000
Bosminidae	0.0009	0.0059	0.0080	0.0004
Sididae	0.0035	0.0062	0.0031	0.0027
Cladocera other	0.0015	0.0003	0.0000	0.0019
Calanoidea	0.0006	0.0139	0.0013	0.0000
Cyclopoidea	0.0522	0.3211	0.0501	0.0943
Copepoda unid.	0.0004	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Camp Morton	McEhleran	McEhleran	Arnes
Time	14:20	17:20	13:50	12:50
Date	29/7/93	9/8/93	20/8/93	29/7/93
sample volume (l.)	0.0247	0.0230	0.0122	0.0328
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	10	77	0	0
Leptodoridae	14	0	1	49
Bosminidae	20	13	59	42
Sididae	0	70	0	51
Cladocera other	0	8	7	1
Calanoidea	60	356	2	89
Cyclopoidea	100	169	67	57
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0018	0.0131	0.0000	0.0000
Leptodoridae	0.0025	0.0000	0.0001	0.0118
Bosminidae	0.0036	0.0022	0.0053	0.0102
Sididae	0.0000	0.0119	0.0000	0.0123
Cladocera other	0.0000	0.0014	0.0006	0.0002
Calanoidea	0.0109	0.0603	0.0002	0.0215
Cyclopoidea	0.0182	0.0286	0.0060	0.0138
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Arnes	Hnausa	Hnausa	Hnausa
Time	13:20	12:20	18:50	12:50
Date	20/8/93	5/8/93	9/8/93	20/8/93
sample volume (l.)	0.0121	0.0258	0.0138	0.0321
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	0	11	6	0
Leptodoridae	1	0	0	0
Bosminidae	12	109	27	13
Sididae	0	55	2	0
Cladocera other	0	1	0	0
Calanoidea	5	53	19	32
Cyclopoidea	45	78	35	13
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0000	0.0021	0.0006	0.0000
Leptodoridae	0.0001	0.0000	0.0000	0.0000
Bosminidae	0.0011	0.0207	0.0027	0.0031
Sididae	0.0000	0.0105	0.0002	0.0000
Cladocera other	0.0000	0.0002	0.0000	0.0000
Calanoidea	0.0004	0.0101	0.0019	0.0076
Cyclopoidea	0.0040	0.0148	0.0036	0.0031
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Riverton	Riverton	Riverton	Riverton
Time	17:20	11:00	19:50	12:00
Date	28/7/93	5/8/93	9/8/93	20/8/93
sample volume (l.)	0.0461	0.0545	0.0396	0.0576
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	25	26	9	2
Leptodoridae	3	1	0	0
Bosminidae	53	203	25	13
Sididae	22	6	20	0
Cladocera other	1	0	1	0
Calanoidea	71	17	161	3
Cyclopoidea	276	68	68	3
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0085	0.0104	0.0026	0.0008
Leptodoridae	0.0010	0.0004	0.0000	0.0000
Bosminidae	0.0180	0.0815	0.0073	0.0055
Sididae	0.0075	0.0024	0.0058	0.0000
Cladocera other	0.0003	0.0000	0.0003	0.0000
Calanoidea	0.0241	0.0068	0.0470	0.0013
Cyclopoidea	0.0938	0.0273	0.0198	0.0013
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Beaver Cr.	Manigotagan	Manigotagan	Traverse
Time	19:10	13:20	17:00	11:40
Date	27/7/93	3/8/93	12/8/93	4/8/93
sample volume (l.)	0.0400	0.0252	0.0653	0.0354
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	7	19	5	0
Leptodoridae	0	0	0	0
Bosminidae	1	35	5	40
Sididae	2	21	0	0
Cladocera other	2	0	3	0
Calanoidea	43	239	4	0
Cyclopoidea	46	40	32	1
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0021	0.0035	0.0024	0.0000
Leptodoridae	0.0000	0.0000	0.0000	0.0000
Bosminidae	0.0003	0.0065	0.0024	0.0104
Sididae	0.0006	0.0039	0.0000	0.0000
Cladocera other	0.0006	0.0000	0.0014	0.0000
Calanoidea	0.0127	0.0444	0.0019	0.0000
Cyclopoidea	0.0136	0.0074	0.0154	0.0003
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Traverse	Traverse	Sandy Bay	Sandy Bay
Time	20:20	12:10	14:20	20:45
Date	12/8/93	16/8/93	4/8/93	12/8/93
sample volume (l.)	0.0210	0.0260	0.0192	0.0230
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	1	1	16	5
Leptodoridae	0	0	0	0
Bosminidae	4	33	36	4
Sididae	0	0	8	1
Cladocera other	0	0	3	0
Calanoidea	1	4	81	12
Cyclopoidea	13	14	34	28
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0002	0.0002	0.0023	0.0008
Leptodoridae	0.0000	0.0000	0.0000	0.0000
Bosminidae	0.0006	0.0063	0.0051	0.0007
Sididae	0.0000	0.0000	0.0011	0.0002
Cladocera other	0.0000	0.0000	0.0004	0.0000
Calanoidea	0.0002	0.0008	0.0115	0.0020
Cyclopoidea	0.0020	0.0027	0.0048	0.0047
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Sandy Bay	Hillside	Hillside	Hillside
Time	13:11	17:30	10:30	14:00
Date	16/8/93	30/7/93	13/8/93	16/8/93
sample volume (l.)	0.0395	0.0147	0.0264	0.0918
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	0	124	0	1
Leptodoridae	0	3	5	4
Bosminidae	2	27	0	2
Sididae	0	13	11	1
Cladocera other	0	0	1	0
Calanoidea	0	1491	109	3
Cyclopoidea	8	117	137	1
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0000	0.0134	0.0000	0.0007
Leptodoridae	0.0000	0.0003	0.0010	0.0027
Bosminidae	0.0006	0.0029	0.0000	0.0014
Sididae	0.0000	0.0014	0.0021	0.0007
Cladocera other	0.0000	0.0000	0.0002	0.0000
Calanoidea	0.0000	0.1615	0.0212	0.0020
Cyclopoidea	0.0023	0.0127	0.0267	0.0007
Copepoda unid.	0.0000	0.0000	0.0000	0.0000

Appendix VI: continued

Site	Grand Marais	Grand Marais	Beconia	Beconia
Time	20:15	15:40	21:00	16:40
Date	30/7/93	16/8/93	30/7/93	13/8/93
sample volume (l.)	0.0315	0.0202	0.1077	0.0187
liters filtered	135.70	135.70	135.70	135.70
Zooplankters per 10 ml.				
Daphniidae	15	25	1097	23
Leptodoridae	3	9	9	0
Bosminidae	44	3	2	1
Sididae	6	6	28	7
Cladocera other	2	0	0	0
Calanoidea	76	19	97	42
Cyclopoidea	266	131	2260	502
Copepoda unid.	0	0	0	0
Zooplankters per Liter				
Daphniidae	0.0035	0.0037	0.8706	0.0032
Leptodoridae	0.0007	0.0013	0.0071	0.0000
Bosminidae	0.0102	0.0004	0.0016	0.0001
Sididae	0.0014	0.0009	0.0222	0.0010
Cladocera other	0.0005	0.0000	0.0000	0.0000
Calanoidea	0.0176	0.0028	0.0770	0.0058
Cyclopoidea	0.0617	0.0195	1.7937	0.0692
Copepoda unid.	0.0000	0.0000	0.0000	0.0000