The fish community of
Cootes Paradise marsh

SEASONAL FISH COMMUNITY USE
OF THE
GREAT LAKES COASTAL MARSH
COOTES PARADISE
AS RERPODUCTIVE HABITAT

BY

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Abstract

Cootes Paradise is a 250 ha coastal marsh, located at the western most point of Lake Ontario, adjoining Hamilton Harbour. Currently the marsh is severely degraded. Only 15% of the marsh remains vegetated, while the rest exists as an open water turbid bay. Stresses affecting the marsh include a very high carp population, excessive nutrient and sediment input, and water level regulation. Both Cootes Paradise and Hamilton Harbour are the targets of an extensive remediation plan, known as the Hamilton Harbour Remedial Action Plan (HHRAP 1991).

Coastal marshes are recognized for their importance as reproductive areas for the fish community. Considering the importance of marshes to fish, there is a surprising lack of information available. There have been very few comprehensive studies of whole fish communities and their use of marshes, and even fewer which address reproductive utilization. Herdendorf et. al. (1986) listed fish community structure and utilization of marshes for spawning, nursery and feeding areas as the top priorities of coastal wetland research.

This study examines the fish community of Cootes Paradise for the purpose of providing detailed information on the fish community in association with the HHRAP, as well as examining fish community use of the marsh with respect to reproductive utilization.

The study included both temporal and spatial coverage of the marsh fish community. In an attempt to capture whole fish community data for Cootes Paradise, fish community surveys were done monthly during the ice-free portion of the season. Surveys were initiated in the summer of 1994, followed by 3 full seasons between 1995 and 1997. Further to this, Cootes Paradise was subdivided into 3 habitat types including off-shore, near-shore, and lower river. These habitats were further subdivided into sub-habitats, based on habitat variables that included wind fetch, nutrient enrichment, and degree of vegetation. A total of 8 sub-habitat types were

included. Within each sub-habitat type four 50 m transects were located. The transects were surveyed by electrofishing.

A total of 47,512 fish covering 47 species were captured in the study. Annual species diversity averaged 38 species, while monthly richness followed a seasonal trend with a maximum of 34 species occurring in July. Most species of fish were found to exist only in the near-shore habitat. Also the near-shore habitat had substantially more fish (Exposed sub-habitat – 187 / transect) than the off-shore habitat (Bay sub-habitat - 8 / transect).

All species demonstrated migration into and out of the marsh in association with spawning periods and spawning habitat guilds. Most species of non YOY fish had highest densities at corresponding spawning times and in correlation to spawning habitat guilds. Habitat preferences of YOY species also generally reflected a species spawning habitat guild. Total non YOY populations were also generally at a peak during spawning periods. The non YOY of most species showed a distinct migration out of the marsh following spawning periods. Samples taken two months prior to a species spawning periods had almost no fish of the species occurring in the marsh, while samples taken two months following peak spawning periods resulted in almost no larger fish of a species being found in the marsh.

The dominant fish species of the marsh was adult carp. In the electrofishing data, adult carp represented 90% of the biomass, but only 10% of the total catch. Only six other species had substantial adult population, while most other species are represent by less than 15 individuals in the data set. These six species included, brown bullhead, white sucker, gizzard shad, white perch, spottail shiner and pumpkinseed, and are reflective of the state of the harbour (the adult habitat).

The most abundant species in the marsh include YOY of gizzard shad, white perch and spottail shiners, reflecting the marsh's role as reproductive habitat. Maximum numbers of fish occurred in late August, with as many as 800 fish being captured in a single transect. At this time the fish community consisted almost entirely of YOY fish.

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Introduction

Wetlands

A wetland is defined as land that is seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. The presence of the water has caused the formation of hydric soils, and has favoured the dominance of either hydrophytic or water tolerant plants (OMNR 1984). Wetland is a broad term encompassing a wide range of wetland types including, bogs, fens, swamps and marshes. Marshes include significant subgroups including, river floodplain wetlands, coastal wetland, and estuaries. The classification of a wetland depends on the degree of water cover, the plant community, and the soil conditions.

Wetland functions are generally grouped into three categories, hydrological (including water quality), social, and biological (Reid et al. 1980, OMNR/CWS 1984, Patterson 1984). They are integral in the ecological function of the environment. They provide storage of water preventing floods. They remove nutrients from the water and transform them to plant material. They settle out suspended sediments. They buffer wave action preventing shoreline erosion, and they are of enormous social and economic value. In the United States an estimated 3/4 of total fish production, supporting all fisheries, is dependent upon marshes and other wetland environments (Recreational Fisheries Institute, 1995). In Canada wetlands provide $10 billion in revenues per year to the Canadian economy (Recreational Fisheries Institute, 1995). In Ontario over $800 million are spent each year by people enjoying wetland related activities (Recreational Fisheries Institute, 1995). These include a broad range of activities from hunting and fishing, to bird watching and canoeing, to a peaceful place to rest and enjoy nature. Often wetland environments are the only remaining natural areas within urban centers.

Ecologically wetlands are recognized as one of the most important habitat types. Herdendorf (1987) states that the ecological value of Great Lakes coastal wetlands is "immense". Wetlands are among the most productive environments on the earth. Whittaker (1970) listed net primary productivity of freshwater marshes as 2000 $g/m^2/yr$, similar to tropical forests. Richardson (1978) found cattail marsh primary production to be 2740 $g/m^2/yr$. In coastal marshes, fluctuating water levels in association with lake seiches, analogous to ocean tides may enhance levels of primary production, acting as nutrient recyclers (Dorcey et al. 1983).

Plant production is the base of the trophic food web that extends into both aquatic and terrestrial ecosystems (Stephenson 1988). Vegetation is the dominant feature of wetlands. Wildlife density and diversity are related to diversity and interspersion of vegetation types, or the amount of "edge" habitat (Odum 1971). The idea of "edge" should also be viewed at the scale of an individual plant, with the edge of each plant representing "edge habitat" (Stephenson 1988). The interspersion of vegetated areas within a marsh has been shown to be especially important to waterfowl (Harris et al. 1983, Murkin et al. 1982). Fish diversity and density have been shown to be highest in near-shore, shallow, and especially vegetated areas of lakes (Randall et al 1996, Minns 1989, Keast et al. 1978).

The idea that wetlands act as nutrient sinks is a controversial generalization (King 1985). Wetlands should be considered as part of a larger ecological system whose value is best described as nutrient transformation. The larger aquatic ecosystems may include tributary streams that drain into and out of the marsh, the marsh or estuary itself, and the attached lake. Each of these components provides critical habitat in the life cycle of a wide variety of animals including mammals, birds, amphibians, reptiles and fish. The role of the marsh in the aquatic system is usually related to reproduction and nursery habitat (Jude and Pappas 1992, Painter et al 1989, Whillans 1979). They represent ideal areas for reproduction because they are nutrient rich, generally warmer than other aquatic environments, and provide protection from predators due to their shallow nature and dense plant composition.

The Ministry of Natural Resources, and Environment Canada have developed an evaluation system for wetlands. The evaluation system rates wetlands based on biological, hydrological, and sociological importance, as well as any special features of a wetland. Each category is scored out of a possible 250 points. Wetlands receiving a score of 650 points or more are considered provincially significant and are rated as either class 1 or 2 wetlands. This status means that they are considered valuable enough to be protected from human development, and receive special consideration during regional planning.

Status of Wetlands

It is estimated that wetlands represent only 3% of world's land and freshwater, and Canada contains 1/4 of the world's remaining wetlands (Recreational Fisheries Institute 1995). Prior to European settlement southern Ontario contained an estimated 2.3 million hectares of wetlands alone (Rowntree 1979). Since the 1800's an estimated 20 million ha, equal to 1/7 of Canada's total wetland base, has been drained or lost to other functions. In southern Ontario 68% of wetlands have been lost or severely degraded (Recreational Fisheries Institute 1995, Snell 1982). Wetlands were formerly viewed, and still are to some extent, as problem areas unsuitable for agriculture, a block to transportation, and sometimes as a source of pestilence and disease (Reid 1982, Firth 1966). Major losses of wetlands have occurred where human activities have been most concentrated (Patterson and Whillans 1985). This is most apparent along the shores of the lower Great Lakes. MuCullough (1982) reported an 83% loss of coastal marshes within the "golden horseshoe", an area encompassing the western portion of Lake Ontario. The name golden horseshoe is derived from the area's aerial appearance at night.

In 1993, the Strategic Plan for Wetlands of the Great Lakes Basin was developed called the Great Lakes Wetlands Conservation Action Plan, or GLWCAP (NCC 1997). It is a partnership between Environment Canada, Ontario Ministry of

Natural Resources, The Federation of Ontario Naturalists, and The Nature Conservancy of Canada. The goal is to create, reclaim, rehabilitate and protect 6,000 ha. of wetland habitat in the lower Great Lakes Basin by the year 2001. The long-term goal is to protect 30,000 hectares within the Great Lakes Basin by 2020. Another important goal is to develop comprehensive wetland databases. Remedial Action Plans (RAP) have also been developed, targeted at severely degraded sites around the Great Lakes. The two largest coastal marshes of western Lake Ontario, Ashbridges Bay (600 ha.), and Cootes Paradise (250 ha.) are identified by the International Joint Commission (IJC) as severely degraded. Both are undergoing restoration as part of Remedial Action Plans.

Stresses on wetlands

Stresses resulting in the degradation of wetlands are numerous and include; input of excessive suspended sediments, input of excessive nutrients, filling and dredging, water level control, and biological destruction and invasion by non native species. These stresses can act synergistically resulting in more severe impacts than would be observed from the individual stresses acting cumulatively (Francis et al. 1979, 1985). In marshes, annual water level cycles, and longer-term water cycles serve to maintain the diversity of plants, and habitat heterogeneity within a wetland. This is a form of the intermediate disturbance hypothesis, which states that species richness and diversity are highest at intermediate levels of disturbance as individual niche stability is low, and niche diversity is high (Krebs 1985). Water level manipulation generally stabilizes water levels increasing niche stability, and consequently decreasing plant diversity. When water level control is combined with the invasion by non native species such as purple loosestrife (*Lythrum sp.*) and the physical disturbance provided by large Asian carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*), not only is the niche availability reduced, but also *only* the "toughest" plant species are able to remain. Marshes consequently are often reduced to turbid open bays interspersed with water lilies, with large stands of loosestrife and/or cattails in the shallow waters where carp accessibility is restricted.

Importance of Wetlands to fish

Fish are generally associated only with those wetlands classified as marshes. The most significant function of marshes for fish is as reproductive and/or nursery habitat (Weller 1981, Herdendorf 1987, Stephenson 1990). Stephensen (1990) demonstrated as seasonal fish migration into and out of 5 coastal marshes, with 89% of the species using the marshes for reproduction. Leslie and Timmins (1992) examined larval fish abundance in Hamilton Harbour and Cootes Paradise, and found Cootes Paradise to have significantly higher abundances. Lane et al (1996 a) examined spawning habitat characteristics of Great Lakes fish species, and found most reproduce in water depths of less than 2m, depths common to marshes.

Marshes are also important for the conversion of nutrients to fish biomass, which can then be transported out of the marsh to larger fish that do not actively forage within wetlands. Marshes are also areas of refuge from extreme environmental events, such as wind storms which generate high waves on lakes, or from rain storms which dramatically increase water velocity and discharge in rivers (Halyk and Balon 1983).

The utilization of marshes by fish is both seasonally and functionally variable. Some species may only be found in a marsh in the spring, while others may only be seen in the fall. Species with which most people are familiar, are those found there in the summer. Jude and Pappas (1992) examined utilization of the Great Lakes and nine associated coastal marshes by 113 fish species. They classified the fish into 3 major categories: 1) lake fish (31 species), 2) a transitional community utilizing lakes, rivers, and marshes (35 species), and 3) a community of fish found to be closely associated with marshes (47 species). Classification of the fish species is undoubtedly biased due to sampling during only the summer months, traditional survey times. Many of the species listed in the lake fish taxocene are those who utilize the lake in the summer, but in spring and/or fall can often be found within a marsh.

Lake herring (*Coregonus artedii*) are classified by Jude and Papas (1992) as being strongly associated with the lake. Lake herring spend their summers in the hypolimnetic waters of the lake, but come fall move into the shallower near-shore waters to spawn. Holmes and Whillans (1984) indicated that historically in the fall, large numbers of lake herring could be found within Cootes Paradise, a large Lake Ontario coastal wetland. The behavior of lake herring is very similar to a species considered a traditional marsh species, the northern pike (*Esox lucius*). However, the difference between the two is that northern pike spawn within a marsh in the spring rather than the fall and then return to the lake, leaving their young in the marsh for the summer. Certainly young herring would not be precluded by abiotic variables in the months of March, April and May in any marsh along the Great Lakes, and would thus be able to capitalize on the abundant food. With few exceptions, the absence of particular fish species within a marsh appears to be a reflection of the time of survey or the lack of a particular species within the larger system, not the lack of attempted utilization.

Current Marsh Fisheries Knowledge

Considering the importance of marshes to fish, the rarity of healthy marshes, and the desire to rehabilitate these marshes, there is a surprising lack of information available. Excluding Stephenson (1990), there have been no comprehensive studies of whole fish communities and their reproductive utilization of Great Lakes coastal marshes. Herdendorf et.al. (1986) listed fish community structure and utilization of marshes for spawning, nursery and feeding areas as the top priorities of coastal wetland research. The International Joint Commission (IJC 1981) identified a need for basic data and site specific information to answer questions about fish use of

Great Lakes Coastal wetlands, in order to make predictions and responses to environmental changes. Minns (1995) reiterated the need for young of the year habitat information. Liston and Chubb (1985) called for more fisheries studies of Great Lakes wetlands to answer basic questions of seasonal community composition, spawning use, nursery use, food webs and migratory patterns in different types of wetlands.

Study Objective

Research on fish communities of the littoral habitats in the Great Lakes 'Areas of Concern' was initiated by the Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans in Burlington Ontario in 1988. The primary objective of the project was to identify how fish production varied spatially in different littoral habitats, and develop models whereby fish production could be predicted from different habitat features. Hamilton Harbour, located at the western tip of Lake Ontario is identified by the IJC as one of the Great Lakes 'Areas of Concern'. An important objective of the Remedial Action Plan (RAP) developed for Hamilton Harbour is the restoration of the fish and wildlife of Cootes (Hamilton Harbour RAP stage 1 1989). Hamilton Harbour was included in the study, but intensive study of Cootes Paradise was not under taken due to its incompatibility with the project's sampling scheme (Randall et al. 1993).

Currently, the two key stresses affecting Cootes Paradise are the high carp population, and the input of excessive amounts of sediment from the watershed (Hamilton Harbour RAP stage 1 1989). Other stresses include high nutrient input, urbanization, regulated lake water level, and erosive wave action (COA 1989). The objectives of the Hamilton Harbour RAP focus's on the stresses, and are being addressed through point source reduction of sediment from agricultural and urban runoff, water level manipulation, and carp exclusion. Carp are considered the most significant factor. From 1951 to 1956, the Royal Botanical Gardens (RBG) initiated commercial fishing to remove carp within Cootes Paradise and Hamilton Harbour. This resulted in significant regrowth of the Cootes Paradise macrophytes (Simser 1982). This also coincided with a number of low water years and a emergent macrophyte replanting effort within the marsh, allowing for the effect of the carp removal to be somewhat discounted. However, replanting efforts in recent years have demonstrated that unless carp are excluded, the replanting will be unsuccessful (RBG unpublished). A marsh unaffected by carp is the goal for Cootes Paradise. A carp barrier/fishway was installed in the Desjardin Canal, the entrance to Cootes Paradise in 1995-1996. The barrier has operated successfully in 1997 and 1998.

The purpose of this study is to:

- Determine spatial and temporal use of the marsh by the various fish species present.
- Examine the reproductive utilization of the marsh by these fish.

Fish habitat consists of many dimensions and includes both biotic and abiotic elements. Abiotic elements may include water depth, water temperature, substrate type, the degree of water movement, and the presence of structural elements such boulders (Scott and Crossman 1973, Lane et al. 1996a, 1996b, 1996c). Biotic elements may include degree and type of vegetation, nutrient enrichment, and woody debris (Scott and Crossman 1973, Lane et al. 1996a, 1996b, 1996c). These elements combine to generate a variety of niches into which fish have specialized. The more complex the habitat the greater the potential niches (Krebs 1984).

The complexity of a coastal marsh habitat is generated by its unstable environment (fluctuating water levels, temperatures, and productivity) which generates a diversity of aquatic vegetation types and densities. Coastal marshes also tend to be located on the deltas created at the mouths of rivers. This provides for a variety of substrates through sediment deposition over the delta (Knighton 1989), as well as standing and flowing water. A study of fish utilization of marshes should therefore cover the range of fish habitat variables present, particularly in relation to spawning habitat. Important elements of spawning habitat include a range of substrate types, aquatic vegetation types, temperatures, and water movements (Lane et al. 1996a).

Cootes Paradise

Cootes Paradise is located on a glacial outwash at the western end of Lake Ontario (Figure 1). Despite its location between the cities of Hamilton, Dundas, and Burlington the adjacent land has remained in a relatively natural state, as it is owned and managed by the Royal Botanical Gardens as conservation land. Cootes Paradise is 250 hectare coastal marsh, rated by the OMNR as a class 1 wetland. Approximately 15% of the marsh currently contains aquatic vegetation (Painter et al.1989). The marsh vegetation currently consists predominantly of manna grass (*Glyceria maxima*) in the western end above the water line, with stands of cattails (*Typha sp.*), interspersed with bur-reed (*Sparganium sp.*) along the western shorelines (Painter et al.1989). The average depth of Cootes Paradise during the summer months is 0.7 m with a maximum depth of 1.5 m. Annual water fluctuation averages 0.5 m with peak water levels occurring in June (Painter et al.1989). Three permanent tributaries, Spencer's Creek, Chedoke Creek, and Borer's Creek, and six ephemeral tributaries flow into Cootes Paradise. The connection of Cootes Paradise to Hamilton Harbour is through a canal, know as the Desjardin Canal which averages 2.5 m deep, and approximately 15 m wide.

Cootes Paradise is within the second most important waterfowl staging area on Lake Ontario, and the third most important in the lower Great Lakes (Canadian Wildlife Service). Fish species such as Atlantic salmon and lake sturgeon formerly spawned in its major tributary, Spencer's Creek. Largemouth bass, northern pike, and lake herring supported substantial fisheries during the early part of the century (Holmes and Whillans 1984). Cootes Paradise was once completely vegetated with a wide variety of emergent and submergent aquatic plants, which provided critical habitat to fish and wildlife. The now degraded habitat of Cootes Paradise supports a fish community dominated by carp (*Cyprinus carpio*), brown bullhead (*Ameiurus nebulosus*), white perch (*Morone americana*), and gizzard shad (*Dorosoma cepedianum*) (Port 1985, Leslie & Timmins 1992, Theÿsmeÿer & Cairns 1995). Substantial seasonal migrations of adult alewife (*Alosa psuedoharengus*) and spottail shiners (*Notropis hudsonius*) also occur. Forty other fish species have also been identified within these studies as occurring within Cootes Paradise, but in very low numbers.

The degradation of Cootes Paradise is a result of a number of stresses, both past and present culminating in the loss of vegetation within the marsh (COA 1989, Holmes 1988, Painter et al. 1989). Originally, the town of Dundas, located at the western end of Cootes Paradise attempted to become a shipping port in the mid 1800's. To facilitate this a canal, know as the Desjardin Canal, was dug through the marsh and cut through Burlington heights, a postglacial sand bar bounding the eastern end of the marsh. Water flow from Spencer's Cr., the largest tributary, was directed down the canal, These two factors dramatically altered the water flow and sediment transport conditions of the marsh. High sediment input and the fact that Hamilton Harbour was a more suitable shipping port resulting in the demise of the canal before the turn of the century. All that remains of the canal is a short section in which Spencer's Cr. still flows, now as the "willow line", a few dock pilings within the marsh, and the canal channel through Burlington heights, which is now the only connection between Cootes Paradise and Hamilton Harbour (figure 1). Such high loads of sediment were entering the marsh in the early part of the century that the marsh began to fill in. Plans were afoot to turn Cootes Paradise into agricultural farmland (Hamilton Spectator 1997). Up until the early 1900's the marsh remained almost completely vegetated (Painter et al. 1989). After this marsh vegetation steadily declined. In the mid 1950's marsh vegetation made a resurgence following the removal of some 230,000 carp. However, the carp removal and the resurgence of vegetation were short lived. Since aquatic macrophytes are the foundation of the marsh food web, the loss of marsh vegetation combined with inputs of nutrients from the Dundas Sewage treatment plant, agricultural runoff, and combined sewer overflows during rain events has generated a hypereutrophic bay with little ecological structure to assimilate the nutrients.

Carp have been identified as a major stress of Cootes Paradise (Hamilton Harbour RAP 1989, Holmes 1988, Painter et al. 1989). Marshes affected by carp are often reduced to turbid open bays sometimes interspersed with water lilies, and with large stands of loosestrife and cattails in the shallower waters where carp accessibility is reduced. The carp is large minnow species (up to 120 cm) native to Asia and eastern Europe. Carp were brought to North America in the 1870's, then as a popular game fish (Holt et al. 1974). They were given as gifts between U.S. senators and stocked in ponds throughout the continent. From there they spread throughout the watersheds. By 1900 carp had become plentiful in most waters. No native North American fish species larger than 10 cm in length exhibit a similar ecological niche to that of carp. The niche of carp is characterized as being a warm water, soft bottom, benthic foraging species. The benthic foraging behavior of carp physically uproots aquatic macrophytes, and resuspends the bottom sediments. The most significant impact of carp is found in areas composed of fine substrates (i.e. marshes), specifically where clays and silts which have water column residence times of days in undisturbed conditions, can be maintained in suspension (Knighton 1992). The resulting turbid water further restricts the macrophyte growth by limiting light penetration.

With the loss of marsh plants, the turbidity problem is further magnified by the wind. Without plants, fetch is dramatically increased. The currents generated by the wind and wave action in a shallow bay prolong or prevent the settling of the fine suspended sediments supplied by degraded tributaries, and carp foraging. The loss of plants and increased fetch also leads to increased shoreline erosion as a result of the increased wave energy. When the sediments resettle, they may bury important features of fish habitat, fish eggs, invertebrates, as well as young aquatic macrophytes. In a study by Qin & Threlkeld (1990) in which mesh exclosures excluded carp, sediment deposition rates within the exclosures were as high as 8 cm per season. Projects targeted at reduction and removal of the carp within Cootes

Paradise have been pursued since the early 1950's (Royal Botanical Gardens Technical Workshop Summary Report 1997).

The watersheds of the permanent tributaries flowing into Cootes Paradise are all degraded and input excessive amounts of sediment into Cootes Paradise. Permanent tributaries include Spencer's Cr., Borer's Cr. and Chedoke Cr. The largest of the tributaries is Spencer's Cr., with a summer base flow of 0.75 m^3/s. The upper watershed is a mix of agricultural and natural lands. The lower portion is urbanized, and has been channelized. Suspended sediment loads of 800 mg/l have been recorded in lower Spencer's Cr. following a severe rainstorm (Prescott unpublished). If following a rainstorm Spencer's Cr. carried an average of 500 mg/l for two days with an average discharge of $2m^3/s$, a total of 86,400 kg of sediment would enter Cootes Paradise. Chedoke Cr. is the most severely degraded. The 403 expressway was built up the Chedoke Cr. valley, and along with urbanization of much of the watershed most of the Creek has been channelized and/or encased in concrete. The surface runoff within the urbanized portion of the watershed is directed into the creek. Sanitary sewer channels run parallel with storm drains resulting in combined sewer overflows into the creek, and consequently Cootes Paradise. Borer's Cr. is becoming increasingly urbanized, with much of the remainder of the watershed being agricultural. In-marsh turbidity following a rainstorm often results in Secchi depths of less than 5 cm (pers. observ.).

The large quantities of sediment entering the marsh are much greater than would naturally occur. Consequently, there has been substantial infilling of the marsh. A cursory comparison of the marsh's bathymetry from 1948 (Painter et al. 1989), to current water depths measured at the 8 off-shore electrofishing sites used in this study, indicates that the marsh has filled in an average of 50 cm over the past 50 years. The infilling of the marsh has altered the potential plant community by altering the depth of the marsh, and changing the substrate type. The extent of the effect has not yet been defined. The alteration of the plant community will consequently affect all other aspects of marsh ecology.

Cootes Paradise should have a diverse fish community. Within the Great Lakes watershed, there exist 158 species of freshwater fish covering some 25 families. Lane et al. (1996a) listed spawning depth for 120 Great Lakes species, and found only 6 which did not spawn in depths of less than 1 m. The number of species which can inhabit an area is governed by the size of the area and the habitat heterogeneity (Mahon & Balon 1977, Rahel 1984, Tonn & Magnuson 1982, Eadie & Keast 1984, Minns 1989). Cootes Paradise is a comparatively large-scale wetland (250 hectares), and the Hamilton Harbour and Lake Ontario system are among the largest fresh water bodies in the world, providing the capacity for a very large number of species. Although current habitat heterogeneity in Cootes Paradise is low, ranges of various habitat variables do exist including varying degrees of emergent and submergent macrophytes, substrates (clay to cobble), temperatures (cool and warm water), and depths (0.1 - 1.5 m). River species and river spawning species are also potential fish community members, as there are a number of marsh tributaries. The addition of those species using the wetland during early spring or late fall should be included in the species list, although the extent of this is not well understood. Considering these facts and eliminating those species, which have not recently been found within Lake Ontario or eastern Lake Erie, Cootes Paradise has a potential annual species list of 136 species. Cootes Paradise is considered as having high rehabilitation potential (Holmes 1988, Whillans 1984).

Methods

The purpose of this study was (i) to assess marsh use by fish, (ii) to assess the importance of a marsh for the recruitment of young of the year (YOY), and (iii) to collect information on changes in the fish community resulting from the exclusion of carp. An intensive field-sampling program was undertaken. The sampling was an extension of a Cootes Paradise fish survey program initiated by the Department of Fisheries and Oceans in 1994. Its purpose was to obtain baseline data on the fish community before the installation of the Carp Barrier (Theÿsmeÿer & Cairns 1995). The current database contains data collected between July 1994 and September 1997.

The sampling program was designed to provide a detailed *monthly* assessment of the entire fish community during the ice-free part of the year (April to October). To assess the entire fish community, Cootes Paradise was broken into habitats, including off-shore, near-shore, and lower river sites. Each habitat was broken into sub-habitats, creating a total of 8 sub-habitats. Four 50 m transects were allotted to all but one sub-habitat, in which two 50 m transects were placed (total 30 transects). The transects within each sub-habitat were located to provide spatial coverage of the marsh (Figure 1).

Fish were collected by electrofishing the transects. At the completion of each transect the species and sizes, along with various habitat variables were recorded. Fish were released after processing. Each monthly survey took approximately one week. The field-sampling program resulted in a monthly sample over the ice-free portion of the season that covered the range of depths, substrates, nutrient levels, water temperatures, water flows, and vegetation types present within Cootes Paradise.

Sampling Period

The sampling program assumed that during the ice covered portion of the season there was an insignificant number of fish within the marsh. Cootes Paradise is ice covered from mid November to mid March, and depending on the water level and severity of the winter can freeze to the bottom. As a result there is little to no habitable space within Cootes Paradise. Furthermore, the combination of ice cover and shallowness will result in the water temperature being close to 0°C in winter. The deeper water found in the Harbour will be approximately 4°C, warmer than Cootes Paradise, and consequently be more favourable to fish. This combination of factors should result in the marsh being devoid of fish during the winter months.

Transects were surveyed during the last week of each month. Surveys took place during daylight hours between 9:00 AM and 5:00 PM. Sampling was not done in April 1995, Sept. 1995 or October 1997. Each survey required 4 to 8 days, the length of time depending on the number of fish to be processed.

Table 1. Cootes Paradise electrofishing surveys dates

	April	May	June	July	Aug.	Sept.	Oct.
1994				C	C		
1995		C	C	C	C		C
1996	C	C	C	C	C	C	C
1997	C	C	C	C	C	C	

Habitats

Habitat Identification

Examination of ecological characteristics of fish indicate temperature, depth, vegetation type and density, water flow, structural features, and substrate type are the key habitat features which separate fish species into niches (Scott & Crossman 1973, Lane et al. 1996a 1996b, 1996c). Five habitat types were initially designated in 1994 for the Cootes Paradise fish monitoring program. The habitats included; protected shoreline, exposed shoreline, nutrient enriched, marsh (emergent vegetation), and open water. The habitat divisions were based on exposure to the prevailing winds, degree of vegetation, and the level of nutrient enrichment. Nutrient enriched sites represented protected and marsh habitats closely associated with nutrient sources (Sewage treatment plant or Combined sewer overflow). The habitat dividing parameters generated differences in other habitat features including substrate type, amount of overhanging vegetation, and amount of woody debris. These variables have been demonstrated to be predictors of variation of fish community composition (Randall et al. 1996, Rahel 1984, Tonn and Magnusson 1982). Wind fetch in particular is an important controlling factor in habit, as the degree of wind fetch affects substrate type, vegetation and woody debris. Minns et al. (1995) found that dense macrophyte cover would not occur if fetch was greater than 2 km.

In 1994, an OBM (NAD 27) map of the Cootes Paradise was examined for the presence of the habitat categories, and potential locations for survey sites were identified. A preliminary on-site survey of Cootes Paradise was done to examine suitability of the potential sampling locations. Four 50 m transects were allotted to each habitat type to create a balanced survey approach. Transects of each habitat were placed such that they provided both spatial coverage of Cootes Paradise, and were representative of the particular habitat type in the immediate area.

The resulting 1994 fish data generated a detailed picture of the fish community, but did not appear to adequately capture the total fish community or cover all types of fish habitat within the marsh. Other 1994 marsh fish community data (Theÿsmeÿer and Cairns 1995), collected during the drainage of a 9 hectare area of marsh showed substantially different relative abundance of some species. This latter fish community data showed similar relative abundance to the 1985 study of the marsh fish community (Leslie and Timmins 1992), indicating the electrofishing data was lacking. The lack of gizzard shad YOY in the electrofishing transects, contrasted with their corresponding dominance within the drained area. In addition, fluvial spawning species, whose YOY used the marsh, were not adequately represented. Further to this carp were lacking in the off-shore transect catches, but large numbers were observed in the off-shore area. In 1995 two habitat types, bay habitat, and lower Spencer's Cr. were added.

Fish community results from 1995 indicated that the bay habitat provided much of the missing community information. Both gizzard shad (yoy) and carp were abundant in the bay habitat. Similar fish communities are found when comparing the 1995 electrofishing transect data to the 1994 drained area data. The addition of the bay habitat provided a habitat with intermediate depth class, and low wind exposure. Lower Spencer's Creek also provided a different fish community information. Water flow in lower Spencer's Cr. was minimal but temperature in the creek was found to be lower than within the marsh (Table 13). The resulting fish survey sites covered the range of depth, substrate, vegetation, nutrient enrichment, temperature, structure, and water flow within the marsh.

Exploratory electrofishing in lower Chedoke Cr. in 1995 indicated that it also might provide valuable information, similar to that of Spencer's Cr. Two transects were added in Chedoke Cr. in 1996, expanding spatial coverage of lower river habitat within the marsh. The addition of the transects was also useful for providing baseline information prior to rehabilitation measures (Combined sewer overflow tank) occurring upstream within the Chedoke Cr. drainage

Thirty transects covering eight habitats were sampled in 1996 and 1997 surveys (Table 2, Figure 1). The eight habitat types were classified into three larger habitat groupings. The three groupings included near-shore, off-shore, and lower river habitats. The eight habitats were then classified as sub-habitat types of the larger habitat types.

Examination of the fish catch data indicated that two of the transects originally categorized as nutrient enriched (N1 & N2) were not so. Examination of water chemistry data (Table 10,Table 12) confirmed this. Both transects were located near the mouth of Chedoke Cr. The classification was related to combined sewer overflows (CSO) entering Chedoke Cr. Transect N1 had habitat characteristics consistent with protected habitats (P*). The resulting fish community and water chemistry information was also similar to protected habitats. Transect N1 was reclassified as P5. Transect N2 had habitat characteristics of the marsh habitat. The transect also had similar fish community and water chemistry to that of marsh habitat. Transect N2 was reclassified as M5. The remaining nutrient enriched sites were located near the Dundas sewage treatment plant. One transect had marsh habitat characteristics, while the other had protected habitat characteristics.

Table 2. Number of transects surveyed within sub-habitats and equivalent areas

Habitat	Sub-habitat	Code	Number of transects 1995	1996	1997	Transect size	Area sampled
Off-shore	Bay	B	4	4	4	50m x 2m	400 m^2
	Open water	O	4	4	4	50m x 2m	400 m^2
	Exposed	E	4	4	4	50m x 3m	600 m^2
Near-shore	Protected	P	5	5	5	50m x 3m	750 m^2
	Marsh	M	5	5	5	50m x 2m	500 m^2
	Enriched	E	2	2	2	50m x 2m	400 m^2
Lower river	Spencer's Cr.	R	4	4	4	50m x 2m	400 m^2
	Chedoke Cr.	C		2	2	50m x 2m	400 m^2
Totals			**28**	**30**	**30**		**3450 m^2**

Habitat Surveys

Habitat variables were divided into two categories, stable habitat features, and unstable habitat features. Stable habitat features were those which remained constant over the course of the study. Stable habitat features included substrate, overhanging vegetation, woody debris and wind fetch. Stable habitat variables were surveyed in July of 1995 by estimation. Fetches were measured on an OBM map of Cootes Paradise. Unstable habitat features were those which changed over the course of the season and between years. Unstable habitat features included temperature, depth, vegetation, water clarity (Secchi depth), dissolved oxygen, conductivity, cloud cover, and wind. Unstable habitat features were collected at the completion of each transect.

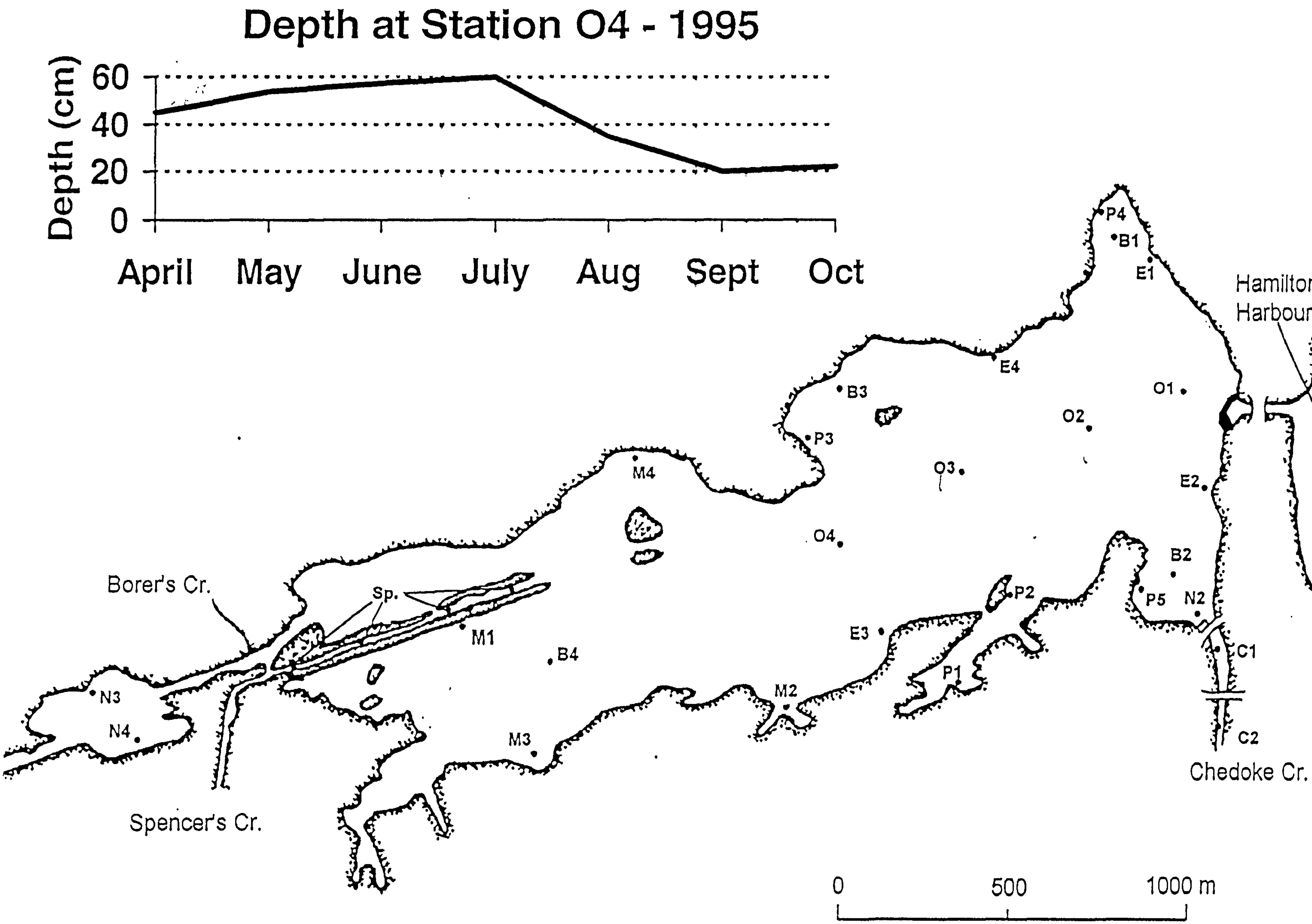

Figure 1. Cootes Paradise electrofishing sites

Habitat Descriptions

NEAR-SHORE HABITAT

- **Exposed Shoreline (E)**: defined as an area with exposure to the prevailing west wind, and characterized by coarse bottom substrate (cobble and gravel), some overhanging terrestrial vegetation, a comparatively steeper off-shore slope, sometimes undercut banks, and woody debris, including driftwood which may or may not act as structure depending on water level.

- **Protected Shoreline (P)**: defined as shoreline with overhanging terrestrial vegetation and low exposure to the prevailing west wind, and characterized by a sand/mud/clay bottom with fallen woody debris serving as structure.

- **Marsh (M)**: defined as an area of shallow water adjacent to stands of emergent plants (generally cattails), characterized by fine substrate (clay, mud), and patches of woody debris serving as structure.

- **Nutrient enriched (N)**: defined as an area associated with an external source of nutrient input (sewage treatment plant), characterized by a mixture of protected and marsh style habitats.

OFF-SHORE HABITAT- both sub-habitats contain essentially no structure.

- **Open Water (O)**: defined as an area 50 m or more away from shore, and characterized by soft bottom (clay, silt detritus), exposed to the prevailing wind, with a depth usually greater than 50 cm.

- **Bay (B):** defined as an area 50 m or more away from shore, and characterized by soft bottom (clay, silt, detritus), and protection from the prevailing wind, and a depth usually 50 cm or less.

LOWER RIVER HABITAT

- **<u>Spencer's Cr. (R):</u>** defined as the low gradient (<1%) portion of Spencer's Cr. from the Cootes Paradise to Cootes Dr, characterized by depths of 1-2 m, a lack of pools and riffles, with predominantly sand substrate. Shoreline vegetation is dense consisting of predominantly of speckled alders and black willow, and contributes considerable woody debris. Water flow ranges from 0 - 0.3 m/s depending on the time of year.

- **<u>Chedoke Cr. (C):</u>** defined as the low gradient (<1%) portion of Chedoke Cr. from its exit of concrete encasement to Cootes Paradise, characterized by depths of 1-2 m, a lack of pools and riffles, and a predominantly fine gravel substrate (broken shale). The shoreline is generally eroding sandbanks with grass cover, and the occasional tree or shrub. Water flow is minimal and is more a function of water movement in and out of the marsh.

Habitat Quantity

A map of the Cootes Paradise was examined to determine the approximate quantity of each of the sub-habitat types. Location of each of the sub-habitat types was identified and plotted on a map of Cootes Paradise. A field survey of Cootes Paradise was then done to verify the location approximate boundaries, and classification of each of the sub-habitat types. The resulting information was then plotted on a base map of Cootes Paradise, and with the aid of Tydig GIS software located at the Department of Fisheries and Oceans (Burlington), the quantity of each sub-habitat was approximated (Table 3). The base map used was an OBM (1982) 1:10,000, NAD27 using a Transverse Mercator Projection. All the transects were georeferenced using a Magellan Nav5000 Pro hand held geographic positioning unit with differential beacon receiver. Reference coordinates were taken only at the northern or eastern end of a transect, the location depending upon the transects orientation. Co-ordinates were verified on the base map, and in many cases corrected. Co-ordinates are accurate to 5 m. The co-ordinates of the transects are listed in appendix A.

Table 3. Summary of the areas (ha) of the sub-habitats of Cootes Paradise

Habitat category	Sub-habitat	Length of Shore (m)	Width of habitat (m)	Transect Width (m)	Area (ha.)	Percent of habitat
Near-shore	*Exposed*	4,236	3	3	1.25	0.7
	Protected	5,229	3	3	1.55	0.8
	Marsh	5,255	5	2	2.6	1.4
	Enriched	1,135	West Pond	2	5.0	2.7
Off-shore	*Bay*	-	-	2	69	37
	Open Water	-	-	2	104.4	57
Lower river	*Spencer's Cr.*	1,000	3	2	0.7	0.4
	Chedoke Cr.	800	3	2	0.5	0.3
Total		**17,625**			**185**	**100**

A total of 185 hectares was determined to be habitable by fish with the remainder being above the water line, or isolated from the main body of Cootes Paradise. Cootes Paradise is dominated by off-shore habitat (94%). Although the near-shore habitats are only 3% of the total habitat, they represent 17.5 km of shoreline.

Field Sampling

Electrofishing was chosen as the sampling technique because of its ease, speed, and proactive capture of fish. Stephenson (1988) found sampling within marsh environments was best done by electrofishing. The four transects of each habitat were spaced as equally as possible over the wetland. All transects except the off-shore habitat types were placed parallel against the shoreline. Protected and exposed transects were 3 meters wide while nutrient enriched, open water, bay, river, and marsh transects were 2 meters wide. This was dictated by the electrofishing procedure. The order of transect sampling was dictated by their proximity to each other, and sampling order during each survey was similar. Transects were sampled between 9:00 AM, and 5:00 PM.

Water turbidity was an important factor affecting sampling efficiency in Cootes Paradise, as rarely was the entire water column visible. To combat this problem, the electrofishing dip nets were passed through the entire water column of the shocking area so as to capture any fish not visible. Passing the nets through the water column also generated water currents that moved fish not in view, into view. Also stunned fish not netted eventually float to the surface bringing them into view. This technique appeared to be successful in overcoming the turbidity problem.

The electrofishing crew consisted of 3 or 4 members all of who were trained in proper operating and safety procedures, CPR, and First Aid. Each crewmember was equipped with shoulder length waterproof gloves and chestwaders. One crewmember operated the anode, while the other members netted the immobilized fish. All fish netted in a transect were placed in a live well. Electrofishing was done from a boat (marsh, enriched, bay, Spencer, Chedoke) or by walking the transect (exposed, protected, and some enriched). Walking was preferable due to the ease of mobility, and sampling control it provided, however softness of the substrate and water depth dictated that a boat be used for certain habitat types. Electrofishing a transect by walking created a 3 m wide transect, while using the boat limited the transect width to 2 m. This was a result of the boat covering a portion of the electroshocking field.

Survey Equipment

The boat used was an 5.5 m (18ft) flat bottom Grumman®. The boat was powered by a 25 hp Johnson® outboard engine. During transect electrofishing from the boat, propulsion was provided by a Minn Kota® 2 hp electric trolling motor. A quiet electric trolling motor was used to minimize disturbance of the fish, and no fish disturbance appeared to occur when the trolling motor was in operation. It was observed that when the outboard motor was in operation fish were disturbed (carp evasion was evident). The large flat bottom boat provided access in the shallow water (>10 cm deep), substantial space for working and equipment storage, and stability.

The electrofisher used was the Smith-Root 5 GPP portable electrofishing unit with a 9 HP generator, a tote barge, and one 20 ft anode line and anode. The anode used a 30 cm diameter anode ring (standard size). A 50 liter live well was strapped to the rear of the tote barge. The unit was operated with a metered output suited to the water temperature and conductivity (400-600 volts and 3-6 amps). Appendix B lists the electrofisher settings used during the course of the study.

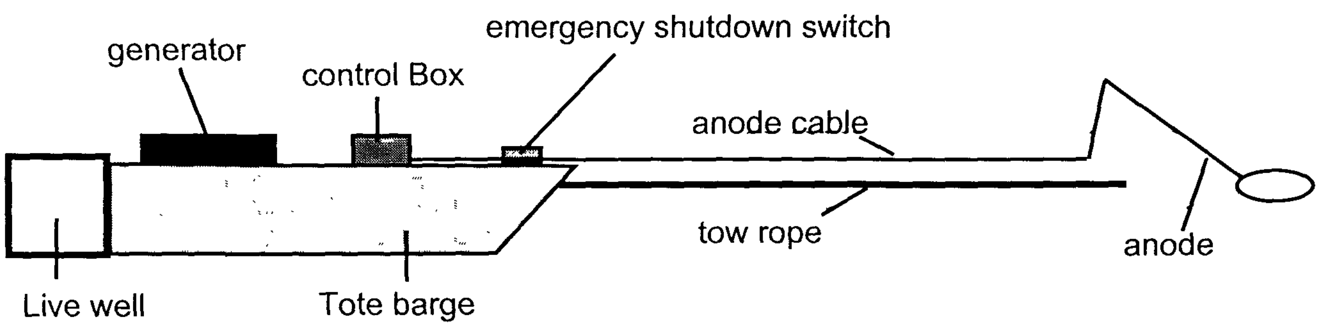

Figure 2. Electrofishing equipment and set up.

Electrofishing Technique

The goal of the electroshocking was to capture as many fish within the transect as possible while trying to minimize fish size and species biases generated by the gear. To facilitate this transects were electroshocked in a modified form of point sampling. Transect electrofishing is used by the Department of Fisheries and Oceans as the field sampling procedure (Valere 1996). Point sampling by electrofishing has also been successfully used for evaluating habitat use (Copp and

Garner 1995, Garner 1996). The number of point samples within a transect was not standardized.

There were two reasons for the hybridization of these techniques, both based on the premise of trying to prevent fish size and behaviour from biasing the sampling results. The first reason, modified point sampling of the transect was chosen relates to fish behavior within an electroshocking field. An electroshocking field has a gradient of intensity, with the most intense portion of the field at the anode. At a certain distance from the anode the field is weak enough that the fish can feel it, but not be stunned. The escape behaviour of fish is variable, some fish (pelagic species) flee, while structure-preferring species tend to hide. Also, although larger fish are more easily shocked, they are better able to escape the field. This is because larger fish are better able to propel themselves from the shocking field during the short time before the electrofisher stuns them. If a transect is electrofished with a constant shock, the result can be biased toward those fish whose behaviour is to hide and/or which are not quick enough to escape the field.

The second reason point sampling was used was due to the number of fish within a transect. Catches of fish were often between 200 and 400 individuals per transect, and sometimes as high as 900 fish per transect. With such high numbers of fish the time required to remove all the fish from the field would result in a high degree of mortality if the electroshocker was continually shocking. As well, the rate of progress through the transect would be so slow as to allow most fish on the periphery of the approaching field to escape. The consequence would be only an unbiased sample from the location where the electofisher was initially activated.

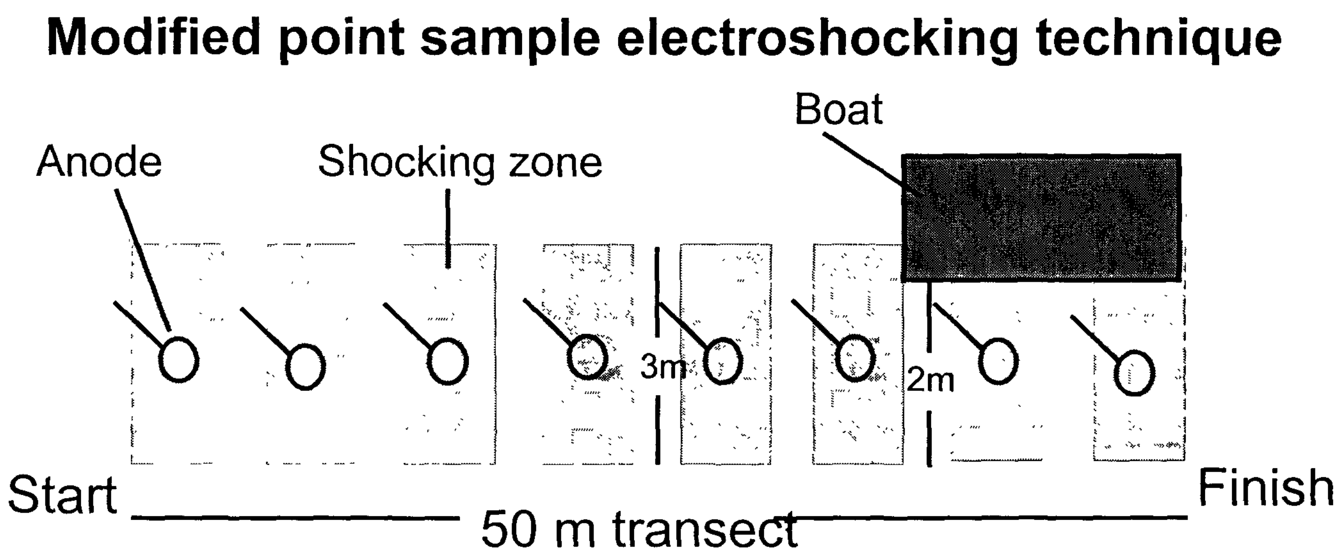

Figure 3. Electrofishing survey technique.

Electrofisher Settings

Due to the range of fish types and sizes which can potentially bias the results, the gear was set to a level which would shock all of the most resistant fish falling within 2 meters of the anode. Due to the high numbers of fish and the differential resistance to electroshocking of different species, not all individuals could be removed from the field before mortality occurred. Cyprinid species, particularly bluntnose minnow during the warm summer temperatures often suffered significant mortality (up to 50% of the catch). The objective was to minimize the degree of mortality of fish within a transect. Total fish mortality for a transect rarely exceeded 5% of the total catch.

Sample Processing

At the completion of each transect fish species, time of day, electroshocking effort and settings, and habitat conditions were recorded on a field data sheet (Table 21). The conditions included water temperature, conductivity, dissolved oxygen, percent macrophyte cover, Secchi depth, transect depth, air temperature, wind direction, wind strength, and sky conditions (i.e. sunny or cloudy). A bottle of water was also collected, which was subsequently analyzed for chlorophyll A, and suspended solids. Dissolved oxygen, temperature, was measured using a YSI model 58 digital meter. Conductivity was measured using YSI model 33 S-C-T meter. Plant cover was quantified by visual estimation (Valere 1997). The percent cover (% of the transect) of the dominant and subdominant aquatic plants were recorded by visual estimation. Other occurring aquatic plants were noted and a total percent plant cover for the transect was then recorded. Plant covers in 1995 were recorded on three separate occasions for each transect (May, July and October). In 1996 and 1997 plant cover was recorded for each transect as the fish surveys were carried out.

Fish captured in each transect were sorted by species, and then young of the year (YOY) were separated from the juvenile and adult fish. The fork length in millimeters, and weight to the nearest 0.1 grams was recorded for a maximum of 10 individuals in each group. This means a maximum of 10 YOY of each species and/or ten juvenile and adult fish of each species from each transect were measured. If YOY could not be positively identified, then a random sample of 20 - 30 individuals of a species had the fork length and weight recorded. If the number individuals of a species captured in a transect exceeded the 10 or 20 fish limits, the remaining individuals were counted and weighed as a group. Fish were weighed using a Sartorius® model p600 (600g ±0.1g), Sartorius® model p6 (6kg ±1g), or Sartorius® 50 kg (±20g) portable scale. The p600 scale was used unless the weight of a fish exceeded the scale capacity. Fish too heavy for the p600 scale were weighed on the appropriate scale.

Young of the Year Identification

Identification of young of the year (YOY) was an important component of the sampling program. This was usually done in the field at the time of collection. YOY were generally easy to identify based on their relative length. Up to 10 YOY of each fish species were measured for each transect. If it could not be determined whether a fish was a YOY then a total of 20 to 30 individuals were measured. YOY were then separated and/or confirmed by the plotting the length frequency distribution for each species during each survey. Difficulties in separating the YOY from non-YOY in the field occurred at certain times of the year for certain species. Length frequency distributions were plotted to assist in separating YOY fish, however in some situations YOY were still difficult to discern. Species involved in this category included bluntnose minnow (*Pimephales notatus*), fathead minnow (*Pimephales promelas*), and johnny darter (*Etheostoma nigrum*). The species in question have a short life span (<3 years), could potentially mature within their first year of life, and were fractional spawners. The result was that young of the year covering a wide range of sizes were captured. Catches of two species were too low to produce length distributions. Fish in this category included golden shiner (*Notemigonus crysoleucas*), and blackchin shiner (*Notropis heterodon*). Papers containing growth and age information were used to provide guidance in the separation of YOY from non-YOY fish in these cases (Colgan and Grant 1982, Gale and Deutsch 1985, Kissick 1987, Mahon and Balon 1977, Gale 1983, Keast and Eadie 1983, Cooper 1978).

Data Management

The data were entered into a spreadsheet, either Quattro Pro 5.0® or Excel 5.0®. Data collected on the field sampling data sheet (Table 21) were split into two categories, fish related information, and environmental information. Two tables were generated on this basis. In the fish table, information pertaining to each fish represented a data record. This included, species name, length, weight, number caught, transect captured, and date captured. In addition, in the fish table each fish was marked as either YOY on non YOY. The MNR numeric species code was also added. In the environmental table, each transect was a recorded as an individual data record. For each transect the record contained the date, time, and the various parameters collected. A third table was also generated, which contains the stable habitat variables including fetch, overhanging vegetation, woody debris, substrate, shoreline vegetation, and shoreline slope.

Data were entered at the completion of a monthly survey. This helped in data verification, as the results of the survey were still fresh in the mind. Once the data were entered into the spreadsheet, they were verified. As each transect was entered, the data was visually inspected and the total numbers of fish were counted to insure that all fish in a transect were entered. Once an entire survey was entered, further data verification was done with pivot tables, length vs. weight graphs, and visual inspection of the data. Once data verification was complete, a summary of the survey was printed. Summaries are given in Appendix C

Once a survey was entered and verified it was imported to a database. The database program used was Microsoft Access 2.0®. The database contains all data collected from 1994 to 1997. The database contains four tables, fish information, environmental information, physical habitat features, and ecological characteristics of fish. The four tables were connect using the relevant fields (transect and date, or species name) creating a relational database (Table 4). Relationships between tables were checked using null queries to assure relational integrity. Monthly summaries were also generated and compared to spreadsheet monthly summaries to ensure data integrity.

The environmental table of the database had a number of fields added to it to assist in ease of data manipulation. Additional fields contained information related to the month of each survey, the year, the habitat category, the sub-habitat type, and the sub-habitat repetition number.

Table 4. Structure of the electrofishing database. Relational elements are indicated by lines.

Table:	Fish ecology	Cootes Fish	Environmental	Habitat
Fields:	Family	Transect ----------	Transect ----------------	Transect
	Scientific name	Date ---------------	Date	Cobble
	Common name	Common name	Time	Gravel
	MNR code ----------	MNR code	Secchi	Sand
	Native/Exotic	Length	Dissolved oxygen	Silt
	Spawning temp.	Weight	Temperature	Clay
	Maturity Age	Quantity	Conductivity	Overhanging branches
	Maximum size		Wind direction	Woody debris
	Adult trophic group			Wind
Strength	Trees			
	Fecundity		Sky conditions	Shrubs
	Spawning guild		Average depth	Grass
	Spawning group		3 m depth	Fetch
	Spawning habitat		Effort	Shoreline slope
	Maximum age		Amps	
			Volts	
			Dominant plant	
			% cover	
			Subdominant plant	
			% cover	
			Total cover	
			Other plants	
			Sample Month	
			Year	
			Repetition	
			Habitat	
			Sub-habitat	
# of records	158	18,556	572	30

Fish Community Analysis

The goal of the study is to determine the marsh's fish community, and assess the reproductive utilization by these fish. To accomplish this, comparisons of the fish catches between habitat types and months, for individual species and their YOY are made. This is done to demonstrate how habitat preferences, seasonal migrations, and YOY vs. non YOY densities relate to spawning period (Lane et al. 1996a), and identified spawning substrate (Balon 1978). Before comparisons were made, clustering of all transects was done to ensure grouping of transects by sub-habitats where valid. The cluster analysis was based on the mean *number* of fish caught per transect. To derive the information related to *numbers* of fish, the entire data set from 1994-1997 was included in the clustering. Two styles of clustering were preformed, a relative species abundance by transect, and an index of similarity between transects

Cluster analysis of the fish data

Calculating the base matrix

The base matrix represents the mean number of non YOY and YOY species by transect. The mean number represented the mean catch of an individual YOY or non YOY within a transect, calculated using the entire data set. To derive the mean catch within a transect, the data was first log transformed (x+1) to normalize it. Following the calculation of the mean catch of each species and YOY by transect the data was antilogged to return the values to normal numbers.

Clustering by relative abundance

To cluster the transects by the relative abundance of the species and YOY, the relative abundance of each species and YOY was calculated by transect using the base matrix (Table 17**Error! Reference source not found.**). The resulting relative abundance matrix was then clustered using Systat 5.0. Clustering was done by columns (transect) using Euclidean distances and Wards minimum variance method.

Reproductive utilization

To assess reproductive utilization of the marsh, comparisons are made between habitat types and months using abundance of individual species and their YOY. To demonstrate habitat preferences of the different species and the YOY of a species, a geometric mean catch per transect was calculated within each of the habitat categories. This was done to standardize the catch data, as the number of transects surveyed within each habitat was not equal. The relative abundance of an individual species and YOY among habitats was then calculated. The relative abundance of each species and YOY within each habitat's fish community was also calculated. Sampling efficiency of the gear was not included in the calculations.

To derive information on the seasonal abundance of an individual species and the YOY within the marsh estimations of total monthly populations of each species and YOY were made. Sampling efficiency was not included in the calculation, as electrofishing sampling efficiencies are not specifically known. To calculate the monthly population estimates, the geometric mean catch per transect within each habitat was first calculated for each species by YOY and non YOY for each month. Mean catch per transect was calculated to standardize catch data as each month did not have a similar level of sampling effort. The mean values were then converted to per hectare values for each of the eight habitat types. The per hectare values were then multiplied by the corresponding number of hectares of each habitat within the marsh. The population size within each habitat was then summed to generate a total marsh population for each species and YOY for each month. The relative abundance by month of an individual species and YOY was then determined. The relative abundance of each species and YOY within the monthly fish community was also calculated. Totals of number and biomass are given as transect totals, and habitat area weighted totals. Data used to generate area weighted total biomass values over the course of the season were generated in a similar fashion, using geometric mean biomass by habitat.

This study focuses on comparisons within the individual species, as sampling efficiency of an individual species is assumed constant over the course of the year and between habitat types. Comparisons between species are provided, but are confounded, as electrofishing sampling efficiencies differ between individual species. Species which are pelagic and schooling are difficult to sample as they are best able to evade the gear (i.e. gizzard shad), while species associated with structure such as vegetation, woody debris or rocks (i.e. pumpkinseeds) are more likely to hold their position and be captured. Benthic species are also difficult to capture as the muddy water makes them less likely to be seen.

Biomass values between habitat and over the course of the season are included to give an indication of existing biomass within the marsh prior to the implementation of a carp barrier (Table 14). The generation of total biomass values includes only the 1994-1996 data.

Results

Habitat Trends

Habitat features were divided into two categories, *stable habitat features*, and *unstable habitat features*. Stable habitat features are those that remained constant over the course of the study and included fetch, substrate, cover, and woody debris. Unstable habitat features are those which change from month to month or year to year, and as a result were measured during each survey. Unstable habitat features, included water temperature, dissolved oxygen, Secchi depth, water depth, aquatic plants and conductivity. Other variables such as wind and cloud cover were also recorded, but will not be examined in detail. A broad range of wind conditions were not captured, as sampling of a site was generally not done during high wind exposure conditions due to its difficulty. Although each sub-habitat is often not unique at the level of a single habitat variable, the combination of features generates discrete sub-habitats. In general, structural habitat elements tend to be unique across sub-habitats, while chemical parameters are unique at the habitat category level. Table 13 lists the series of habitat variables recorded during one sampling time (July 96), illustrating how they combine to generate habitat differences between each of the sub-habitat types.

Stable Habitat features

Substrate is an important variable of fish habitat, and is especially important component of spawning habitat. Many fish spawn on specific types of substrates including both plant material and geologic material (Balon & Noakes 1990). For example, spottail shiners and logperch prefer sand, bluegills prefer fine gravel, yellow perch prefer aquatic vegetation, while pumpkinseed will use a range of substrates from sand to plant material (Lane et al. 1996a).

Since Cootes Paradise is located on a glacial outwash, the surrounding hills are composed predominantly of sand and fine gravel, while the basin of the marsh is filled with clay, silt, and sand. The result is that much of the bottom material of the marsh is a combination of clay, silt, and sand (98%), with sand, gravel and cobble occurring as a ribbon along most of the north, east and southern shorelines. The combined length of these shorelines is approximately 11.5 km (Table 3). The western shore is defined predominantly by marsh habitat (emergent vegetation, ~ 6 km), and consequently geologic material is not exposed to weathering. The diversity and quantity of substrates within Cootes Paradise provides necessary spawning substrate to the range of Great Lakes fish species (Table 5).

The size of the substrate in the near-shore area is related to the amount of fetch, with courser substrate occurring on more exposed sites. The degree of exposure to the wind also affects two other important features of physical habitat, the shoreline vegetation, and the near-shore woody debris. Protected areas had the highest amount of shoreline vegetation (Table 5). Shoreline vegetation is important source of food and cover. Allochthonous materials from the vegetation are important nutrient source at the base of the food web. Overhanging branches from trees and shrubs also represent a source of protection from predators, and a direct source of food in the form of insects that drop from the vegetation.

Table 5. Physical features of the various sub-habitat types of Cootes Paradise. Values represent means of the sub-habitat variable. Information was collected by visual estimation.

Sub-habitat	Fetch (m)	Cobble (%)	Gravel (%)	Sand (%)	Clay (%)	Mud (%)	Woody debris (%)	Overhanging vegetation (%)
Marsh	206	0.2	3.8	11	14	71	16	1.4
Enriched	140	0	0	0	10	90	8	0
Exposed	1,657	33.8	17.5	40	7.5	1.2	15	32
Protected	38	10.4	23.8	47	5	13.8	43	66
Open water	1,522	0	0	0	88.7	11.3	1	0
Bay	146	0	0	2.4	80.2	14.6	4	0
Spencer's Cr.	0	0	0	83.8	10.5	5.7	33	45
Chedoke Cr.	0	15	40	10	25	10	15	2.5

When the trees and shrubs fall into the water, they provide a source of habitat. Woody debris acts as cover, and when macrophytes are absent, debris represents the only form of cover in the water. Woody debris is important to certain fish species as a nesting substrate (bluntnose minnows, fathead minnows, and various darters). Protected habitats of Cootes Paradise have much more woody debris than other sub-habitats (Table 5). Although exposed shorelines are more likely to receive woody debris, the wind and wave action on the exposed shore result in lower quantities of wood remaining in the water. Exposure to the wind also results in a less stable shoreline, and can create beach area or undercut banks, also an important habitat feature. On beach areas the vegetation is set back from the water's edge, consequently reducing the influence of shoreline vegetation.

Unstable Habitat features

Wetland Vegetation

The aquatic vegetation consisted primarily of emergent macrophytes, dominated by manna grass (*Glyceria sp.)*, with strips of cattails (*Typha sp.*) along the western shorelines, interspersed with patches of purple loostrife (*Lythrum sp.*), bur-reed (*Sparganium sp.*), sedge (*Scirpus sp.).* and smartweed (*Polygonum sp.*). Most of the vegetated area remains above the water line or at the waterline interface, except for a short period in the spring when the vegetation is inundated by snow melt water and spring rains. During seasons with abnormally high water levels the water level inundates the emergent plants, including some of the manna grass (1996 and 1997). Water levels at the outer edge of the cattails are represented by average depths associated with the marsh sub-habitat type (Table 7). Submergent macrophytes consisted of a few small patches of water lilies (*Nymphaea sp.*), and sago pond weed (*Potamogeton pectinatus*). The pond weed was almost exclusively found in lower Spencer's Creek, with a few plants observed in the bay, protected, and exposed habitats. The combined coverage of these species appeared to be no more than 10 m^2.

In 1996, in association with implementation of the Carp Barrier at the marsh entrance, and a consequently reduced carp population some submergent vegetation began to appear in the May survey (Table 6). All submergent vegetation observed was sago pondweed (*P. pectinatus).* Unfortunately the destructive impact of the carp returned, as the integrity of the Carp Barrier was not complete or was breached, and the carp entered Cootes Paradise. At the time of the June 1996 sampling survey, carp densities were similar to past years. Emergent vegetation remained the same as 1995.

Table 6. Average aquatic vegetation percent cover (%) measured within the Cootes Paradise transects ('95-'97)

		Off-shore			*Near-shore*			*Lower river*	
Year	Month	Bay	Open water	Exposed	Protected	Marsh	Enriched	Spencer	Chedoke
	May	0.5	0.0	5.0	1.0	29.4	15.0	1.8	
1995	July	0.3	0.0	5.0	2.0	29.8	15.0	22.8	
	Oct	0.0	0.0	0.0	0.0	30.0	ND	0.0	
	April	0.0	0.0	0.0	0.8	23.3	0.3	0.0	0.5
	May	0.1	0.0	1.3	1.4	31.8	16.0	0.0	1.5
	June	0.0	0.0	1.0	2.6	29.4	15.8	1.3	1.0
1996	July	0.1	0.0	0.3	2.6	31.2	14.3	4.3	1.0
	Aug	0.0	0.0	0.0	2.0	30.5	13.2	1.0	1.0
	Sept	0.0	0.0	0.0	1.0	31.0	14.5	0.0	1.5
	Oct	0.0	0.0	0.0	0.0	19.5	ND	0.0	0.5
	April	0.0	0.0	0.0	0.0	29.3	15.0	0.0	0.0
	May	0.0	0.0	0.0	1.1	30.5	16.0	1.3	0.0
1997	June	1.0	0.8	2.0	2.7	34.1	16.3	3.8	2.5
	July	5.9	2.9	3.0	15.6	51.4	29.0	17.5	0.0
	Aug	5.6	2.0	8.9	18.8	72.6	26.0	8.0	1.5
	Sept	2.6	0.2	18.5	9.7	61.5	ND	2.5	0.0

In 1997, the Carp Barrier successfully prevented carp from entering Cootes Paradise. A large impact on water clarity and vegetation growth was observed (Table 6). All survey transects had submergent plant growth, although in many it was limited to only a few plants. In some transects (marsh and exposed) submergent plant cover was as high as 60% at the peak of the growing season (Aug.). The dominant plant was *P. pectinatus*, or sago pondweed. The majority of this occurred in the area around the mouth of Spencer Cr. and it extended out to near transect O4. Other plant sp. observed included. *P.crispus, P.foliosus, P.nodosus, Zanichellia palustris, Myriophyllum spicatum, Ceratopyllum sp., Elodea canadensis, Nymphaea sp., Nuphar sp.,* and *Vallisneria sp.*

The submergent plant growth underwent a season change. In the early season (April to June) the submergent plants were predominantly *P.pectinatus*, with some *P.crispus* and *Zanichellia palustris.* Highest densities occurred in the west end, while the east end was essentially devoid of plants. As the season progressed, the *Potamogeton sp.* died off, and *Myriophyllum spicatum*, *Ceratopyllum sp.,* and *Elodea canadensis* became dominant, with some water lilies *Nymphaea sp.* occurring. The later season plant distribution was also concentrated in the west end. However, a significant number of submergent plants were present around the shoreline of the entire marsh. In the east end of the marsh a measurable amount of submergent vegetation occurred.

The emergent plants showed limited recovery, with *Polygonum sp.* and *Sparganium sp.* increasing. *Polygonum sp.* showed the most dramatic results with the size of the patches in some places appearing to double in size. A number of patches reached the state of flower blooming, something previously not observed in Cootes (pers. observ.). The flowering was quite noticeable as the pink flower clusters are at the top of the stalk. A few individual *Sparganium sp.* plants were scattered throughout the west end of Cootes Paradise. The cattails did not appear to advance into the marsh, and within some transects was observed to be receding. This was perhaps a result of the exceptionally high water levels. Water levels along the outer edge of the cattails as measured within marsh transects were between 50 and 70 cm for much of the 1997 season (Table 7).

At the completion of a fish survey transect a considerable quantity of submergent plants had often accumulated in the live well. A variety of invertebrates, formerly rarely or not seen at all were found, presumably captured with the plant material. A number of damsel fly (Zygoptera) and dragon fly nymphs (Anispotera), snails (Gastropoda), backswimmers (Hemiptera), stick bugs(Hemiptera), and even a few crayfish (Crustacea) were observed.

Water levels

Water levels on Lake Ontario follow an annual cycle (Table 7, Table 4), with peak water levels occurring in late May to early June, and minimum water levels occurring during the winter months. During 1995, water levels were lower than 1996 or 1997. Water levels in 1996 and 1997 were higher than average water level years, and the water level in 1997 was the highest level recorded on Lake Ontario in recent history. The higher water levels allowed for limited access to the remaining vegetation during the season 1996 and 1997 season. This is an important factor for spring spawning species like northern pike, and yellow perch, which require vegetation as spawning substrate.

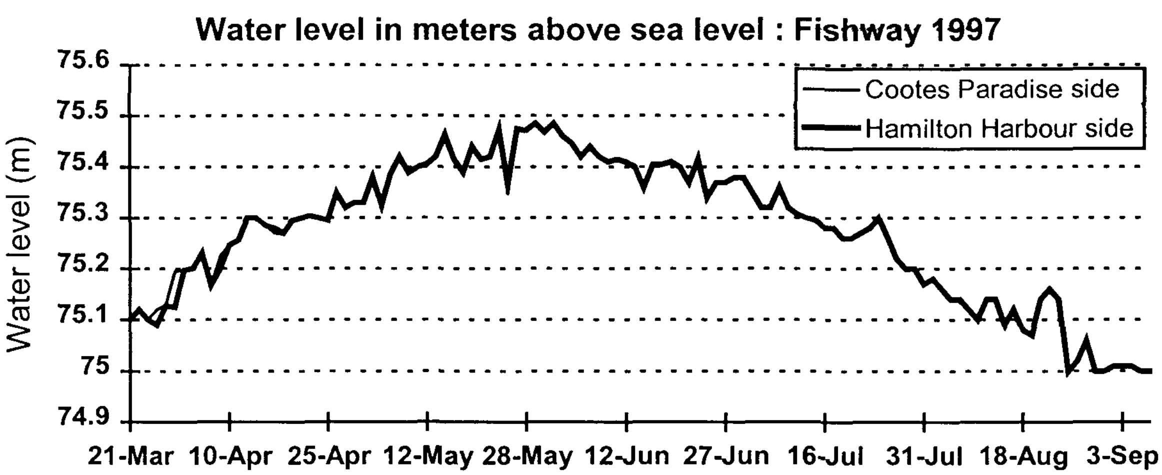

Figure 4. Cootes Paradise water levels in meters above sea level, recorded on the inside and outside of the Carp Barrier (From Theÿsmeÿer 1997).

Water levels also fluctuate on a daily basis as much as 10-15 cm, although fluctuations are generally less than 5 cm (Table 4). The main causes of the water level fluctuations are tide and seiche effects occurring in Lake Ontario. Substantial rain events on the watershed, or Lake Ontario itself also caused noticeable water level increases of a few centimeters. The inconsistent water levels between locations and sampling months in are reflective of the daily fluctuations in water level.

Ice cover in 1995 and 1996 lasted from early November to mid March (pers. observ.). Ice cover did generally not occur in the area (1-2 ha.) surrounding the exit to Hamilton Harbour. This is a result of tide and seiche effects on Lake Ontario pushing the deep Harbour water into Cootes Paradise. During February 1995 several holes were bored through the ice to determine ice thickness and water depth. At this time ice thickness had reached approximately 50 cm on average. This resulted in most of the wetland being frozen to the bottom or having only a few centimeters of water. Ice thickness in the winter of 1996 was approximately 20 cm on average (pers. observ.). The thinner ice combined with the higher water level resulted in almost all the wetland having at least a few centimeters of water, and over half having > 20 cm of water. Water temperatures measured under the ice were measured at between 0.2°C and 2°C.

A personal survey in February 1996 to investigate ground water inputs (air temp. -6°C) revealed that much of the south and north shorelines had substantial quantities of ground water seeping in. This was apparent, as the ice along the shoreline was either water covered or partly melted. Two springs with notable flow were found, one in Westdale Cut, and one along the south shore approximately 100 m west of the Twin Marshes (transect M2).

Table 7. Water depths (cm) recorded at selected electrofishing transects between 1995 and 1997. Water depths are referenced to water levels recorded at the Carp Barrier (meters above sea level).

	1995				1996				1997				1997
	East	Middle	West	Near-	East	Middle	West	Near-	East	Middle	West	Near-	Carp Barrier
Month	O1	O4	B4	shore	O1	O4	B4	shore	O1	O4	B4	shore	(meters)
April					130	85	55	38	130	100	83	52	75.30
May	90	55	45	22	150	110	75	55	158	110	100	60	75.42
June					140	100	83	53	135	100	90	58	75.36
July	100	65	50	24	130	90	60	42	134	95	80	43	75.22
Aug					115	65	45	33	115	80	60	31	75.08
Sept					110	50	20	27	98	70	40	29	74.95
Oct	60	20	10	13	90	40	15	24					74.84

Secchi depth

Water clarity in Cootes Paradise was generally found to be high in the spring and fall, and low during the summer (Table 8). Summer Secchi discs averaged 30 cm, although could be quite variable (range 4 - 120 cm). Secchi depths were generally lowest in the near-shore habitat, highly variable in the lower river habitat, and highest in the off-shore habitat. Secchi depths averaged nearer 40 cm during the summer months. Secchi depths measured in the marsh habitat were ~ 5 cm during carp spawning times. Clarity of the lower river transects was often measured at 2 - 5 cm following a rainstorm, and during these events fish sampling was postponed until water clarity improved.

Water clarity in the fall was very good, with the marsh bottom clearly visible. However, due to the shallow nature of the marsh this fact is difficult to document with a Secchi disc. The clear water in the fall corresponds with a lack of carp in the marsh, and reduced levels of primary production. During this time, the effect of fetch becomes visible. At the start of the October 1996 sampling period, water clarity within the marsh was observed to be near 1 m. During the course of the survey a strong west wind (30-40 km/hr) occurred, and lasted for 3 days. Consequently, sediment was entrained along the exposed eastern shoreline. This suspended sediment then spread though out the marsh. By the end of windstorm, the entire marsh was affected.

Water clarity in the spring of 1996 in Spencer's Cr. was very good. During the spring of 1996 the creek was flowing at a substantially elevated level, and was supplying large quantities of clear water to the marsh. This was likely driven by a previous fall of substantial rainfall and a winter with higher than usual snowfall accumulations. This resulted in a larger than normal baseflow discharge throughout the spring of 1996. I estimated baseflow creek discharge to be 5 to 6 m^3/s at the time of sampling in May. Normal summer base flow of Spencer's Cr. is estimated to be approximately 0.2 m^3/s. The prolonged high flow of water resulted in clear water flowing out Spencer's Cr. (Secchi 180 cm), and consequently generated large clear patches within the marsh. The carp barrier further enhanced the marsh Secchi depths in May. The carp barrier did not prevent carp access in 1996, but it did delay it. This was evident by the thousands of carp observed on the Harbour side of the barrier in May and June.

Table 8. Average Secchi depth (cm) by habitat type in Cootes Paradise.
(E - estimated Secchi depth based on nearby measurement)

Habitat	Year	April	May	June	July	Aug	Sept	Oct
	1995					31		
Lower river	1996	180.3	88.3	43.7	28.5	34.5	78.0	132.5
	1997	120.8	124.8	39.8	45.5	38.5	68.3	
	1995					27.6		
Near-shore	1996	39.3	37.1	31.7	27.0	26.9	44.1(E)	54.5(E)
	1997	82.1(E)	76.8(E)	60.4	38.0	37.0	59.2(E)	
	1995					31.4		
Off-shore	1996	65.1	39.5	39.6	28.0	30.8	45.6	63.1
	1997	94.4	85.1	87.1	47.6	39.3	45.8	
	1995					26.2		
Marsh avg.	1996	74.4	48.0	36.5	27.6	29.4	51.3	76.5
	1997	93.2	88.4	64.9	42.4	38.0	56.5	

In 1997, the Carp Barrier functioned successfully. Catches of carp were much lower than in past years (May: 1995 - 215 carp, 1996 - 302 carp, 1997 - 19 carp). The Secchi depth in 1997 was substantially larger in all months than in past years. Secchi depth was generally 10 to 30 cm better than in past years. The supply of clear water from the marsh tributaries was not as near as significant in 1997 as in 1996. The water in Spencer's Cr. was not as clear, and more importantly was supplying the marsh with substantially less volume of water.

Water turbidity did not affect fish sampling success for much of 1997. For much of the sampling season, visibility was to the bottom or near it. The clear water in 1997 helped support past data collected off-shore where few fish had been captured. When fish were present in 1997, they were clearly visible. In early June 1997 Secchi depth reached the bottom over the entire marsh. This represented Secchi depths of greater than 160 cm. Secchi depths recorded at the Carp Barrier reached 200 cm at this time (Figure 5), and water flowing out of the marsh was clearer than water flowing into the marsh from the harbour. This level of water clarity at this time was much greater than anticipated given past years.

The exceptionally clear spring water clarity in 1997 resulted from a combination of factors. The combination of the functioning Carp Barrier, and a cold spring delaying movement of other fish species into the marsh, dramatically reduced levels of suspended sediment in the marsh. With the reduced suspended sediment, the lack of fish, and the cool water, zooplankton thrived, clearing phytoplankton from the water. Fish catches in May 1997 were 25% of past years (1995 - 909 fish, 1996 785 fish, 1997- 201 fish). Only 11 of the 201 fish captured in the May 1997 came from off-shore habitats. Wind velocities recorded at this time were similar to past years and averaged about 11 km/hr. With the lack of suspended sediment and planktivorous fish, zooplankton, specifically a cool water Daphnia species able to flourish (S. Wolfenden pers. com. McMaster University). The Daphnia filtered out essentially all the phytoplankton clearing the water. During peak Daphnia levels, a sample of a liter of water appeared to contain 100's of large Daphnia. In mid June zooplankton populations crashed, apparently due to lack of food, and never recovered (Wolfenden pers. com.). The lack of recovery was likely a result of planktivorous fish (young of the year) numbers steadily increasing.

Secchi depths continued to decline over the course of the summer, reaching a low in Aug. Correspondingly fish catches increased to record numbers. (June 841 fish, July 5,732 fish, Aug 10,564 fish). Undoubtedly the combinations of increasing planktivory, and increasing numbers of fish searching the bottom sediments were the contributing factors to the decreasing Secchi depth. In September as primary production declined, and fish left the marsh (Sept. 3,098 fish) Secchi depth improved (Table 8).

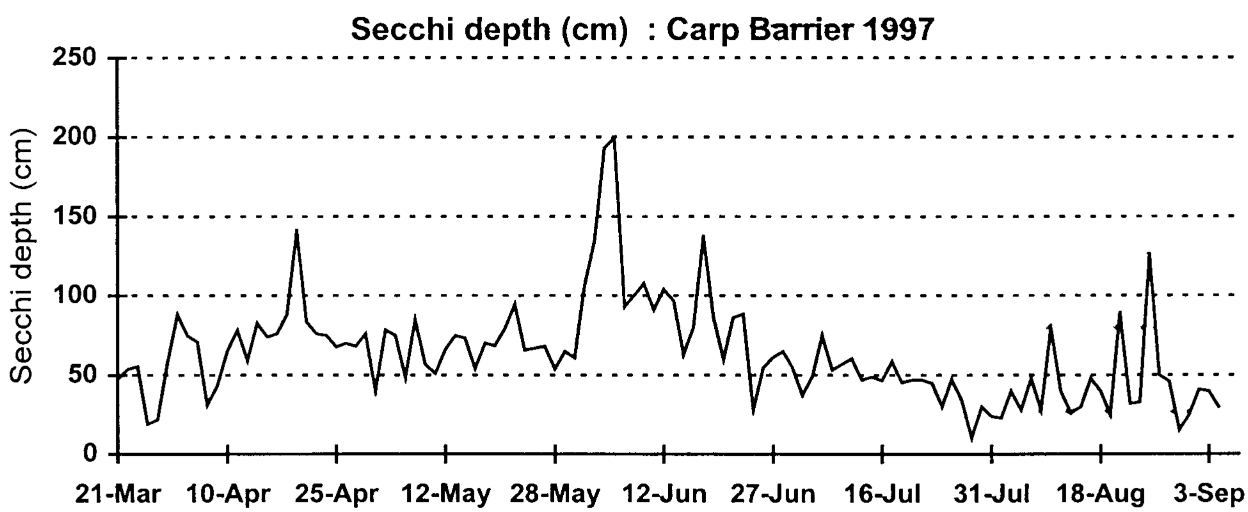

Figure 5: Average daily Secchi disc depths recorded at the Carp Barrier during 1997. (From Theÿsmeÿer 1997).

With the exclusion of the carp, the effect of the other factors on water clarity became more obvious. Wind effects were noticeable as before, acting on the exposed shorelines. The effects of suspended sediments from rainstorms were intermittent but dramatic, and the effects appeared to last close to a week. Site visits to the marsh tributaries following a rainstorm found them **all** to be supplying excessive amounts of suspended sediment to the marsh. At the mouth of each of the tributaries a plume of suspended sediment existed, the size of which was proportional to the size of the tributary. The most significant sediment plumes were associated with Chedoke Cr., Spencer's Cr., and Borer' s Cr. Chedoke Cr. appeared to have the largest, however the sediment plume from Chedoke Cr. tended to track along the eastern shoreline and out to the Harbour, thereby limiting it's effect on the marsh. The plumes from the Borer's Cr., and Spencer's Cr. were clearly visible as a defined line through the marsh water. The plumes never affected the entire marsh, but tended to effect more than half of the marsh. Generally, the entire back half of the marsh was effected by a sediment plume. The degree of affect on plant growth was difficult to ascertain, as most of the plant growth was also concentrated in this area. As the plumes migrated towards the eastern end, sediment settled, and was mixed with Harbour water, diluting the turbidity.

Temperature

Due to the shallow nature of the marsh, water temperature in the marsh closely follows the air temperature (Figure 6). This can result in dramatic temperature changes within the marsh. In 1997 in late June, the water temperature fell 10°C in 5 days. This can result in spawning temperatures for many species being reached throughout the year. It also means that spawning temperatures in the marsh will be reached earlier than in deeper water bodies.

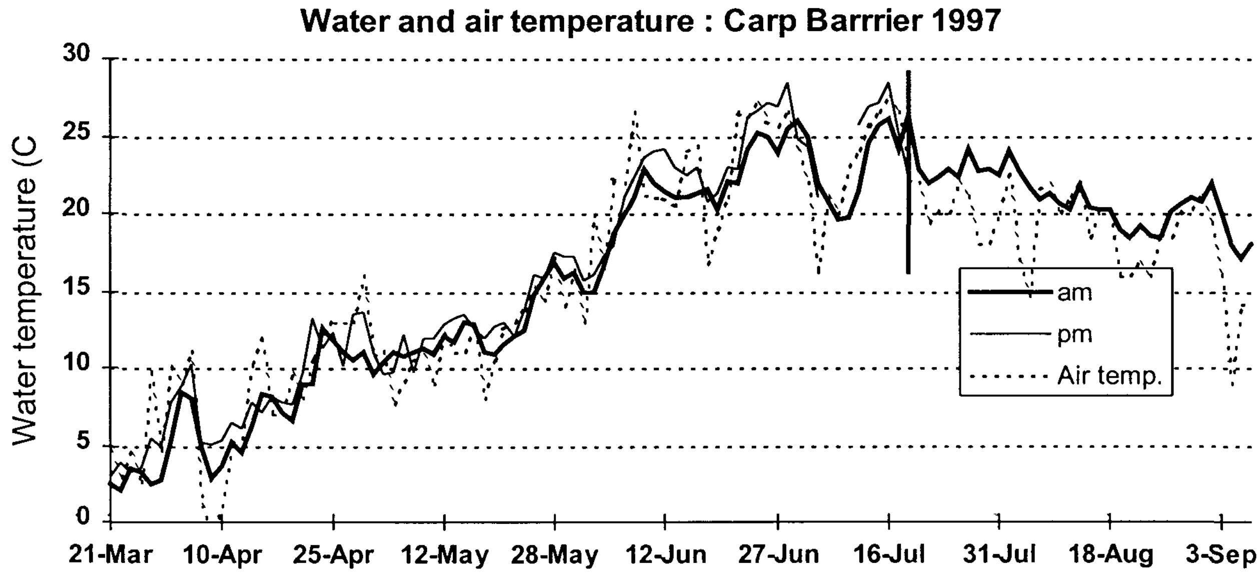

Figure 6: Temperature measured at lift time at the Carp Barrier during 1997. AM measurements recorded at approximately 8:45 am, PM measurements recorded at approximately 2:45 PM. Measurements after July 19 are AM measurements only. (From Theÿsmeÿer 1997).

The water temperature regime was different for each of the three years studied (Table 9). The 1995 season represented a long hot season, while both 1996 and 1997 were cooler years. The spring in 1995 was short indicated by the average temperature of 31.5°C recorded in the enriched habitat in May, and temperatures above 20°C recorded in all habitats. Conversely, temperatures in May 1996 were all below 20°C, with an average of 18°C, while in May 1997 temperatures averaged only 13°C. Average temperatures throughout the 1995 season remained above 20°C. This provided a long growing season, and well defined spawning periods for the fish. Overall, 1996 was the coolest year, with temperatures lower throughout the year.

Table 9. Average temperature (°C) by habitat type in Cootes Paradise

Habitat	Year	April	May	June	July	Aug	Sept	Oct
Enriched	1995		31.5	26.0	26.0			
	1996	15.8	18.8	24.9	25.8	24.1	21.9	
	1997	11.0	14.1	28.5	24.7	26.0		
Lower River	1995		18.1	22.6	23.3	20.8		9.5
	1996	10.3	16.0	21.1	20.7	21.3	14.0	7.4
	1997	8.3	11.5	23.6	22.3	19.6	15.0	
Near-shore	1995		22.7	26.1	25.1	26.1		10.9
	1996	12.9	18.5	23.9	25.3	24.7	16.9	8.8
	1997	9.8	12.9	27.0	25.7	22.5	15.3	
Off-shore	1995		21.3	24.6	23.8	24.6		12.4
	1996	11.5	18.0	20.8	23.3	22.9	14.6	7.1
	1997	9.1	12.7	26.0	24.6	19.9	19.6	

Differences in temperatures were noted between the habitats (Table 9). Temperatures in the lower river habitat were lower than elsewhere, while temperatures in the enriched sub-habitat were much higher than other habitats. Off-shore and near-shore habitats had temperatures that were intermediate, with the near-shore habitat being slightly warmer. Temperatures in the lower river habitats remained low enough to support cold water species. Temperatures recorded in Spencer's Cr. never exceeded 23.5°C, and were lower when measured close to the bottom. Chedoke Cr. also was found contain cold water, although due to the lower discharge its effect was less pronounced.

Temperatures were consistently highest in the enriched sites, and closely approximated the air temperature, and in some cases were slightly warmer. Water temperatures in the enriched habitat were likely higher due to the shallowness of West Pond, and the dark colour of the sediment. The higher temperatures also indicates that the enriched transects were not affected by the cooler water discharged from the sewage treatment plant.

Dissolved Oxygen

Dissolved oxygen levels varied over the course of the season (Table 10). In the spring and fall dissolved oxygen values tended to be at saturation values. In the summer months, due to phytoplankton production, values reached various degrees of supersaturation. Dissolved oxygen levels were observed to increase as the day progressed, most notably on sunny days (Table 11), and were consistently higher during sunny periods. Oxygen depletion was observed to occur at night, however oxygen levels were generally not observed below 6 mg/l in the morning. The exception to this occurred during the June sampling period. In June in shaded transect, dissolved oxygen levels were observed at a level considered to be low for most fish species (<4.0 mg/l). Dissolved oxygen levels were also impaired in some of the marsh transects in May and June when they contained high numbers of spawning carp (>40 carp / transect). Carp are able to tolerate very low dissolved oxygen levels (Scott and Crossman 1973). In all transects with impaired oxygen values, the number of fish caught was noticeably reduced, although in the marsh transects this could also have been a result of physical exclusion by the high numbers of carp.

Table 10. Average dissolved oxygen (mg/l) by habitat within Cootes Paradise

Habitat	Year	April	May	June	July	Aug	Sept	Oct
	1995		20.0	15.5	16.1			
Enriched	1996	18.1	19.7	11.3	20.0	13.5	13.6	
	1997	20.0	15.2		12.2	20.0		
	1995		9.7	8.1	10.2	10.9		12.3
Lower River	1996	12.7	10.4	11.0	12.6	8.8	11.5	12.5
	1997	13.8	11.8	6.6	12.3	9.1	10.9	
	1995		10.9	8.8	11.7	11.3		14.5
Near-shore	1996	11.3	9.1	10.4	11.5	11.8	8.9	11.9
	1997	13.8	12.8	3.9	15.1	16.5	10.0	
	1995		14.2	8.4	10.4	9.7		13.9
Off-shore	1996	12.1	9.7	8.4	11.7	9.1	10.0	12.0
	1997	14.0	12.6	4.0	8.7	9.7	9.0	

In June 1997 oxygen levels were low marsh wide (Table 10). Values were measured consistently less than 4.0 mg/l, while as in past years had averaged between 8 and 11 mg/l. Temperatures were also warmer than other years reducing saturation values, but the values were less than saturation. No difference in oxygen values within the water column occurred. This indicates mixing was influencing the values, and atmospheric oxygen was likely preventing the marsh from becoming anoxic. The depressed oxygen values were associated with large amounts of filamentous algae growing on the entire marsh bottom. The algae floated to the surface, and formed large decaying mats.

Table 11. Dissolved oxygen levels recorded in Cootes Paradise on July 18,1995.

Sample time	Transect	D.O. (mg/l)
10:15 AM	E1	10.1
12:00 PM	P4	13.4
1:45 PM	E4	14.8
3:00 PM	P3	17.2

Oxygen values varied through the marsh depending on the degree of enrichment and water mixing. The enriched sub-habitat had values up to 4 times saturation (>20 mg/l @ 30°C) recorded on a regular basis. It is important to note that maximum value the D.O. meter can record is 20 mg/l. Values in the Spencer's Cr. sub-habitat were always recorded to be at saturation, an expected situation since rivers are highly mixed environments. The values collected within Spencer's Cr. indicate the validity of the other readings, and Spencer Cr. values were generally collected on the same day as enriched values

Conductivity

Differences in conductivity were observed over the course of the season, and between habitats. The conductivity increased as the season progressed, and the ratio of rainfall, and evaporation changed. Both Chedoke Cr., and enriched sub-habitats had elevated conductivity levels as compared to other sub-habitats. The conductivity values served to confirm the salt rich nature of these waters, and the effect of sewage input.

Table 12. Average specific conductance (μS/cm) by habitat within Cootes Paradise

Habitat	Year	April	May	June	July	Aug	Sept	Oct
Enriched	1996	1022	955	1005		875	760	
	1997	705	795	980	930	795		
	1995							597
Lower River	1996	816	745	777		887	622	601
	1997	564	641	801	810	763	668	
	1995							642
Near-shore	1996	650	624	696		688	610	543
	1997	489	542	671	725	591	545	
	1995							562
Off-shore	1996	615	610	650		628	552	465
	1997	467	467	679	709	604	565	

During base flow conditions, the ratio of ground-water to surface runoff increases, consequently elevating conductivity in river environments. This was observed in both Spencer's Cr. and Chedoke Cr. Lower Spencer's Cr. water was also influenced by water flowing out of the enriched habitat. With the completion of the Combined Sewer Overflow tank in the Chedoke Cr. watershed in winter 1996 it was anticipated that conductivity values would decrease in 1997. In the spring of 1997 conductivity values were lower. However as the season progressed conductivity values were similar to that in 1996. It is unknown whether the elevated conductivity levels were a result of continued input of sewage water, residual chemical constituents from past years, or a reflection of the geological nature of the watershed. Wenghofer et al. (1997) measured mean annual baseflow conductivity values of 1072 μS/cm in Redhill Cr. an adjacent watershed.

Table 13. Summary of features within the habitats of Cootes Paradise - July 1996. (Suspended sediment, and chlorophyll A are from Prescott unpublished)

Habitat	Sub-habitat	Fetch (m)	Mean Particle Size (mm)	Woody debris (%)	Over-hanging branches (%)	Depth (cm)	Aquatic plants (%)	Chlor. A (ug/l)	Water Temp (°C)	D.O. (mg/l)	Cond. (uS/cm)
Off	*Bay*	160	0.02	0.5	0	78	0.1	124	23.3	12.6	648
Shore	*Open water*	1500	0.01	0	0	115	0	113	23.4	10.9	608
	Exposed	1800	18	24	30	41	1.5	138	25.5	12.5	615
Near	*Protected*	50	11	45	35	41	2.6	130	25.9	11.1	698
Shore	*Marsh*	200	0.07	25	2	48	30	147	24.2	11.2	736
	Enriched	120	3.3	12	15	35	5	358	25.8	>20.0	875
Lower	*Spencer's Cr.*	0	1.5	50	60	65	4	4	19.8	9.1	878
River	*Chedoke Cr.*	0	10	2	10	50	2	222	22.6	19.6	905

Cluster analysis of the fish community data

The goal of the study was to assess marsh use by the fish community. To accomplish this, comparisons are made between habitat types, and between months for individual species and the YOY. This is done to demonstrate how habitat preferences, seasonal migrations, and YOY vs. non YOY densities related to spawning period (Lane et al. 1996a), and identified spawning substrate (Balon 1978). Before comparisons were made, clustering of all transects was done to ensure grouping of transects by habitats where substantiated.

The cluster analyses of the data verified the sub-habitat classification used to break down Cootes Paradise into smaller habitat units (
Figure 7). The transects within sub-habitat clustered together with a very high degree of similarity. However, the habitat divisions of near-shore, off-shore, and lower river were not well grouped.

In the case of the relative abundance clustering, the Open water sub-habitat was unique, with transect B4 linking in with this group. The remainder of the Bay sub-habitat transects clustered more closely to the Spencer Cr. transects, rather than the Open water. The Bay-Spencer's cluster the grouped with a Protected-Exposed cluster. Both the Protected and Exposed subhabitats clustered together with a high degree of similarity. The Marsh and Enriched subhabitats clustered together, both of which had a high degree of similarity within sub-habitat transects The Marsh-Enriched cluster then grouped with a mixed group of four transects. This cluster then grouped with the Bay-Spencer-Protected-Exposed cluster, and then with the open water.

The mixed cluster of four transects included P5, P1, M5, C1. All four of these transects could be related to a proximity to combined sewer overflows (CSO). Chedoke Cr. were C1 is located has incurred substantial CSO's. These CSO's are currently the subject of remediation efforts. Chedoke Cr. empties into the bay were transects P5 and M5 are located. P1 is located at the back of Westdale Cut. The creek entering the back of Westdale cut also incures CSO's.

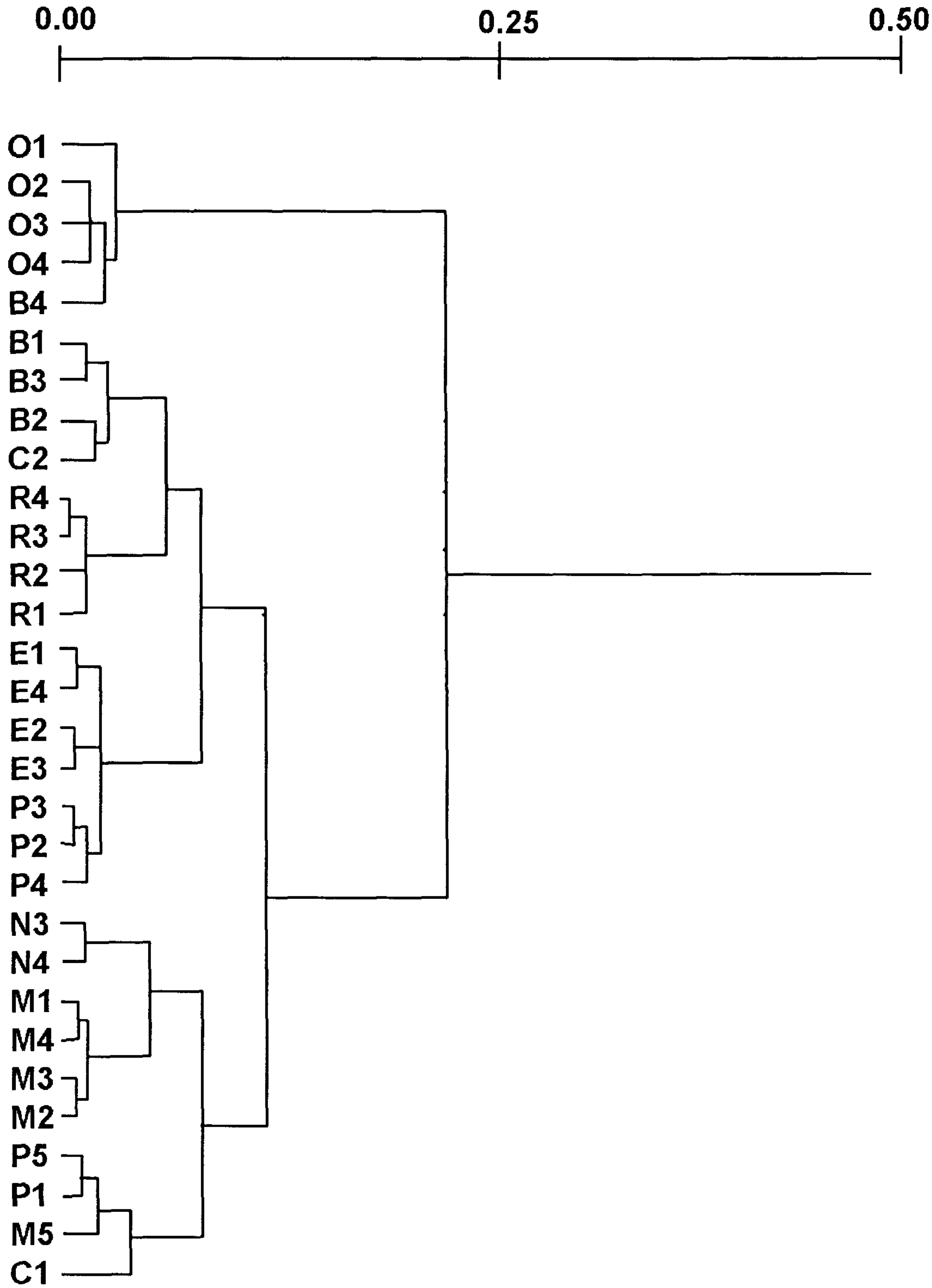

Figure 7. Hierarchical dendogram of Cootes Paradise electorfishing transects based on relative abundance within a transect, using Euclidean distances and Ward's minimum variance method.

Fish Community

The four years of marsh electrofishing surveys (1994-1997) which included 580 transects yielded 47,512 fish (Table 14). A total of 47 species of fish covering 15 families were captured (Table 16). Adult and juvenile fish dominated the early season fish community, while the later season fish community was dominated by YOY. All species showed a distinct seasonal migration into the marsh in the spring, and out of the marsh in the fall (Table 18). The migration could be subdivided into spring migration in and out of adults, and a later season migration out of YOY (Table 14). Two species carp and gizzard shad were dominant. Species including, white perch, spottail shiner, pumpkinseed, and brown bullhead were also numerous. Alewife and white suckers had seasonally high numbers of adults. All other species were rare and generally restricted to small areas associated with specific habitats.

Table 14. Seasonal summary of Cootes Paradise electrofishing data. An electrofisher catch efficiency has not been incorporated. Transect = 50 m

Category	April	May	June	July	Aug.	Sept.	Oct	Totals
Total fish	769	3,879	4,775	11,869	21,667	4,484	1,328	47,512
Percent YOY	0	52	49	79	90	96	97	82
Fish / transect	12.4	43	53	107.9	196.9	74.7	23	81.9
Fish/ha. (area adj.)	171	261	416	997	800	267	125	
Total biomass (kg)	275.1	1375.1	877.4	924.3	538.1	86.2	32.3	4108
Biomass / transect	9.17	23.7	15.1	11.9	6.9	3.1	0.6	10.6
Kg / ha. (area adj.)	65.9	109.0	118.5	92.9	229.3	7.8	41.2	
Total species	20	32	31	34	32	27	25	47
Species / transect	2.7	3.7	4.7	7	7	5.4	3.1	5.1
Total transects	62	90	90	110	110	60	58	580

Table 15. Summary of Cootes Paradise electrofishing data by habitat. An electrofisher catch efficiency has not been incorporated. Transect = 50 m

Category	Bay	Open water	Exposed	Protected	Marsh	Chedoke	Spencer	Enriched
Total fish	633	271	13,039	18,649	10,744	1,999	2,132	1,261
Percent YOY	77	71	81	83	75	72	83	72
Fish / transect	8	3	163	187	107	77	30	32
Total biomass (kg)	104	39	659	1,091	1,416	92	380	326
Biomass/ transect	2.1	0.7	12	16	20	6.6	7.9	13
Total species	24	18	30	35	25	21	29	20
Species / transect	2.2	1.3	8.1	8.1	5.6	6	4.5	4.8
Total Transects	84	80	80	100	100	26	72	38
Transect area (m^2)	100	100	150	150	100	100	100	100

Species Richness

A total of 47 species were captured during this study (Table 16). The fish community was changing from month to month, and as a result species richness and composition within a single month were never the same, and were never equal to the total species richness of 47 species (Table 14,Table 18). Monthly richness was relatively constant during the months of May and August (~32 species). Highest species richness occurred in July (34 species). The highest monthly average transect richness was 7 species, occurring in both July and August. April and October had the lowest monthly average, with 2.7 and 3.1 species per transect respectively. The maximum transect richness was 17 species, occurring in the protected habitat in August 1997. Richness also differed substantially between habitats (Table 15). The off-shore transects had the lowest richness with an average of 2.2 species per transect in the bay habitat, and 1.3 species per transect in the open water habitat. Highest species richness occurred in the protected and exposed habitats with an average of 8.1 species per transect in both habitats.

Adults of five species were not captured. Black bullhead, blackside darter, largemouth bass, bowfin, blacknose dace and river chub were captured as YOY, and in the case of largemouth bass and river chub also as juveniles. Blacknose dace, river chub, and blackside darters are river species, and populations exist in Spencer's Cr. (Laurence 1997). Black bullhead, largemouth bass, and bowfin all require passage over the carp barrier to access the marsh. In 1997, adults of all species were captured at the Fishway (Theÿsmeÿer 1997). All three were rare with less than 20 individuals of each being transferred to Cootes Paradise. Four species, bowfin, blackside darter, threespine stickleback, and black bullhead were captured for the first time in the marsh assessment program in 1997.

YOY of all but eight of species were captured. All eight species were rare with total catches of less than 5 individuals, indicating lack of capture of these YOY was likely due to population size and lack of spawning success. The eight species included: silver shiner, spotfin shiner, blackchin shiner, brook stickleback, threespine stickleback, bigmouth buffalo, brown trout, and rainbow trout. YOY rainbow trout exist in Spencer's Cr. (Laurence 1997). As with YOY rainbow trout the capture of many of the species was specific to a particular habitat types and/or months.

Table 16. Fish species of Cootes Paradise, and spawning habitat characteristics (Lane et al. 1996a and Balon 1975).

Common Name	*Latin name*	Spawning temp.	Spawning period in Cootes	Spawning guild	Spawning habit
Alewife	*Alosa pseudoharengus*	15	May-June	phytolithophils	egg scatterer
Bigmouth buffalo	*Ictiobus cyprinellus*	16	May-June	phytophils	egg scatterer
Black bullhead	*Ameiurus melas*	21	May-June	lithophils	nester
Black crappie	*Pomoxis nigromaculatus*	19	May-June	phytophils	Nester
Blackchin shiner	*Notropis heterodon*	17	May-June	phytophils	egg scatterer
Blacknose dace	*Rhinichthys atratulus*	21	May-June	lithophils	egg scatterer
Blackside darter	*Percina maculata*	16	May	lithophils	egg hider
Bluegill	*Lepomis macrochirus*	22	June-Aug	lithophils	nester
Bluntnose minnow	*Pimephales notatus*	20	May-Aug	speleophils	nester
Bowfin	*Amia calva*	17	May-June	phytophils	nester
Brook silversides	*Labidesthes sicculus*	21	May-June	phytolithophils	egg scatterer
Brook stickleback	*Culaea inconstans*	16	May	ariadnophils	nester
Brown bullhead	*Ameiurus nebulosus*	21	May-June	speleophils	nester
Brown trout	*Salmo trutta*	7	Oct.	lithophils	egg hider
Central mudminnow	*Umbra limi*	13	April	phytophils	egg scatterer
Channel catfish	*Ictalurus punctatus*	26	July-Aug	speleophils	nester
Chinook salmon	*Oncorhynchus tshawytscha*	8	Oct.	lithophils	egg hider
Common carp	*Cyprinus carpio*	18	May-June	phytophils	egg scatterer
Common shiner	*Luxilus cornutus*	16	May	lithophils	nester
Creek chub	*Semotilus atromaculatus*	13	May	lithophils	egg hider
Emerald shiner	*Notropis atherinoides*	23	June-Aug	pelagophils	egg scatterer
Fathead minnow	*Pimephales promelas*	16	May-June	speleophils	nester
Freshwater drum	*Aplodinotus grunniens*	22	June-July	pelagophils	egg scatterer
Gizzard shad	*Dorosoma cepedianum*	20	June	lithopelagophils	egg scatterer
Golden shiner	*Notemigonus crysoleucas*	20	May-June	phytophils	egg scatterer
Goldfish	*Carassius auratus*	17	May-June	phytophils	egg scatterer
Green sunfish	*Lepomis cyanellus*	22	June-Aug	lithophils	nester
Johnny darter	*Etheostoma nigrum*	15	May-June	speleophils	nester
Largemouth bass	*Micropterus salmoides*	17	May-June	phytolithophils	nester
Logperch	*Percina caprodes*	16	May	psammophils	egg scatterer
Northern pike	*Esox lucius*	9	April	phytophils	egg scatterer
Pumpkinseed	*Lepomis gibbosus*	20	June-July	phytolithophils	nester
Rainbow trout	*Oncorhynchus mykiss*	10	April	lithophils	egg hider
River chub	*Nocomis micropogon*	18	May-June	lithophils	egg hider
Silver shiner	*Notropis photogenis*	20	May-June	pelagophils	egg scatterer
Spotfin shiner	*Cyprinella spiloptera*	18	May-June	phytolithophils	egg scatterer
Spottail shiner	*Notropis hudsonius*	18	May-June	psammophils	egg scatterer
Tadpole madtom	*Noturus gyrinus*	24	June-Aug	speleophils	nester
Threespine	*Gasterosteus aculeatus*	17	May-June	ariadnophils	nester
Trout-perch	*Percopsis omiscomaycus*	12	April-May	lithophils	egg scatterer
White perch	*Morone americana*	14	May	phytolithophils	egg scatterer
White sucker	*Catastomus commersoni*	8	April	lithophils	egg scatterer
Yellow perch	*Perca flavesens*	7	April	phytolithophils	egg scatterer

Table 17. Relative abundance (%) of Cootes Paradise YOY and non YOY fish across habitats, and within habitats (bracketed). Mean species lengths for non YOY are seasonal means, while YOY are mean lengths at the end of August unless otherwise noted (J-July, S-Sept., O-Oct.).

Species	Bay		Open water		Exposed		Protected		Marsh		Chedoke		Spencer		Enriched		Total Catch	Mean (mm)
Alewife	19	*(0.8)*	62	*(5.9)*									20	*(0.2)*			**26**	141
Alewife (yoy)	100	*(0.6)*															**4**	33
Bigmouth Buffalo									100	*(<0.1)*							**2**	364
Black Bullhead (yoy)							100	*(0.2)*									**32**	26 (J)
Black Crappie					39	*(<0.1)*	31	*(<0.1)*	31	*(<0.1)*							**6**	183
Black Crappie (yoy)	7	*(1.1)*			35	*(0.5)*	20	*(0.2)*	20	*(0.4)*	19	*(0.4)*					**152**	67
Blackchin Shiner															100	*(0.1)*	**1**	42
Blacknose Dace (yoy)													100	*(<0.1)*			**1**	37 (0)
Blackside Darter (yoy)					34	*(<0.1)*	27	*(<0.1)*					38	*(<0.1)*			**3**	36 (J)
Bluegill					18	*(0.3)*	48	*(0.7)*	13	*(0.3)*	18	*(0.7)*			2	*(0.1)*	**217**	87
Bluegill (yoy)	3	*(5.2)*			23	*(1.5)*	56	*(6.8)*	9	*(0.3)*	6	*(0.4)*	1	*(0.2)*	2	*(0.2)*	**1,608**	35
Bluntnose Minnow	<1	*(0.2)*			37	*(1.9)*	26	*(1.0)*	1	*(0.1)*	7	*(0.4)*	8	*(1.7)*	21	*(5.6)*	**490**	56
Bluntnose Minnow	<1	*(0.2)*	<1	*(0.4)*	41	*(11.4)*	33	*(5.9)*	3	*(0.6)*	1	*(0.1)*	8	*(5.0)*	13	*(4.2)*	**2,771**	45
Bowfin (yoy)					100	*(<0.1)*											**1**	167 (S)
Brook Silversides	23	*(0.3)*			38	*(<0.1)*	19	*(<0.1)*	19	*(<0.1)*							**11**	78
Brook Silversides (yoy)	25	*(1.1)*	9	*(0.7)*	21	*(<0.1)*	9	*(<0.1)*	31	*(0.1)*			5	*(<0.1)*			**33**	52
Brook Stickleback													100	*(0.1)*			**3**	31
Brown Bullhead	3	*(1.9)*	1	*(1.5)*	10	*(0.3)*	17	*(0.7)*	39	*(2.6)*	20	*(1.3)*	2	*(0.3)*	8	*(0.7)*	**500**	168
Brown Bullhead (yoy)	2	*(3.6)*	<1	*(1.1)*	19	*(6.4)*	18	*(6.7)*	27	*(19.0)*	13	*(4.3)*	(<1)	*(0.1)*	20	*(3.8)*	**4,235**	67
Brown Trout							100	*(<0.1)*									**1**	405
Carp	2	*(7.7)*	1	*(3.3)*	10	*(1.9)*	15	*(2.3)*	27	*(6.3)*	5	*(1.6)*	7	*(6.2)*	32	*(12.4)*	**1,588**	483
Carp (yoy)	1	*(1.4)*			13	*(7.9)*	12	*(5.0)*	19	*(12.4)*	4	*(1.2)*	5	*(4.4)*	47	*(20.0)*	**3,413**	95
Carp x Goldfish	6	*(0.5)*			11	*(<0.1)*	11	*(<0.1)*	18	*(0.1)*	17	*(0.2)*	2	*(<0.1)*	35	*(0.3)*	**31**	353
Carp x Goldfish (yoy)					29	*(<0.1)*	15	*(<0.1)*			57	*(0.1)*					**4**	90
Central Mudminnow									100	*(<0.1)*							**1**	96
Channel Catfish			36	*(0.4)*	36	*(<0.1)*	29	*(<0.1)*									**3**	225
Channel Catfish (yoy)					31	*(<0.1)*	69	*(0.1)*									**25**	53
Chinook Salmon													100	*(<0.1)*			**1**	880
Chinook Salmon (yoy)	100	*(0.2)*															**1**	99

Table 17. continued

Species	Bay	Open water	Exposed	Protected	Marsh	Chedoke	Spencer	Enriched	Total Catch	Mean (mm)
Common Shiner							6 (<0.1)	94 (1.0)	**1**	69
Common Shiner (yoy)				4 (<0.1)			35 (0.5)	61 (0.5)	**11**	47
Creek Chub			39 (0.1)	32 (<0.1)			29 (0.2)		**18**	73
Creek Chub (yoy)				34 (<0.1)			42 (0.3)	24 (0.1)	**14**	43
Emerald Shiner	17 (1.3)	13 (6.3)	30 (0.1)	27 (0.2)	6 (<0.1)	7 (0.1)			**79**	58
Emerald Shiner (yoy)	18 (1.3)		44 (0.1)	31 (0.1)	7 (<0.1)				**39**	38
Fathead Minnow			29 0.6	17 (0.2)	3 (<0.1)	35 (2.4)	2 (0.1)	13 (0.3)	**176**	56
Fathead Minnow (yoy)	3 (10)	3 (5.9)	19 (2.0)	14 (1.9)	7 (0.9)	10 (1.5)	6 (1.5)	39 (5.7)	**856**	49
Freshwater Drum	10 (0.2)	60 (2.2)	10 (<0.1)	8 (<0 1)			12 (<0.1)		**10**	356
Freshwater Drum (yoy)			79 (0.1)	21 (<0.1)					**10**	80
Gizzard Shad	16 (0.5)	15 (1.1)	27 (0.1)	9 (<0.1)	15 (<0.1)	18 (0.1)			**24**	334
Gizzard Shad (yoy)	15 (20.0)	15 (37.0)	18 (2.4)	11 (0.6)	18 (1.6)	6 (0.7)	2 (0.3)	17 (1.9)	**841**	82
Golden Shiner				100 (<0.1)					**2**	118
Golden Shiner (yoy)			56 (<0.1)	44 (<0.1)					**2**	58
Goldfish	3 (0.2)			11 (<0.1)	27 (0.1)	29 (0.2)		29 (0.2)	**19**	181
Goldfish (yoy)	1 (0.2)		8 (0.1)	14 (0.1)	32 (1.0)	18 (0.5)	2 (0.1)	26 (0.7)	**152**	70
Green Sunfish			10 (0.1)	24 (0.1)	11 (0.1)	24 (0.3)	8 (0.3)	23 (0.4)	**57**	87
Green Sunfish (yoy)			5 (<0.1)	33 (<0.1)	9 (<0.1)		9 (0.1)	44 (0.2)	**13**	39
Johnny Darter			58 (0.2)	19 (0.1)			14 (0.3)	9 (0.1)	**47**	66
Johnny Darter (yoy)	<1 (0.2)		44 (2.2)	27 (0.8)	1 (<0.1)		27 (4.2)		**518**	52
Largemouth Bass			28 (0.4)	42 (0.4)	15 (0.3)	5 (0.1)	3 (0.2)	7 (0.2)	**153**	158
Largemouth Bass (yoy)			25 (0.3)	33 (0.4)	15 (0.4)	10 (0.3)	17 (1.6)		**205**	87
Logperch			60 (1.5)	30 (0.7)	1 (<0.1)		9 (0.8)		**343**	103
Logperch(yoy)	<1 (0.2)		57 (7.9)	32 (3.9)	3 (0.4)	(<1) (0.1)	7 (4.5)		**1,903**	69
Mirror Carp			10 (<0.1)	25 (<0.1)	17 (<0.1)		6 (<0.1)	42 (0.2)	**13**	515
Mirror Carp (yoy)			12 (<0.1)	25 (<0.1)	37 (0.1)	19 (0.1)	7 (<0.1)		**20**	105
Northern Pike				3 (<0.1)	3 (<0.1)	48 (0.2)	28 (0.3)	17 (0.1)	**12**	438
Northern Pike (yoy)	5 (0.2)	5 (0.4)	5 (<0.1)	30 (0.1)	10 (<0.1)	15 (0.1)	11 (0.1)	20 (0.1)	**19**	224
Pumpkinseed	1 (3.0)	<1 (1.1)	23 (8.6)	26 (9 2)	22 (13.0)	22 (14.0)	2 (3.8)	4 (2.7)	**4,676**	86
Pumpkinseed (yoy)	2 (18.0)	<1 (5.2)	17 (17.0)	36 (29 0)	17 (33.0)	9 (53.0)	6 (29.0)	12 (24.0)	**12,903**	41
Pumpkinseed x Bluegill	37 (0.2)			31 (<0.1)	31 (<0.1)				**3**	74
Pumpkinseed x Green				11 (<0.1)		89 (0.1)			**3**	120
Rainbow Trout	16 (0.2)	33 (0.7)				51 (0.1)			**4**	538

Table 17. continued

Species	Bay		Open water		Exposed		Protected		Marsh		Chedoke		Spencer		Enriched		Total Catch	Mean (mm)
River Chub					100	*(<0.1)*											**1**	50
River Chub (yoy)					56	*(<0.1)*	44	*(<0.1)*									**4**	35 (J)
Silver Shiner													100	*(<0.1)*			**1**	59
Spotfin Shiner							100	*(<0.1)*									**2**	75
Spottail Shiner	5	*(3.3)*	2	*(2.2)*	22	*(1.1)*	11	*(0.7)*	10	*(1.4)*	35	*(2.3)*	6	*(1.2)*	10	*(1.9)*	**513**	83
Spottail Shiner (yoy)	8	*(6.8)*	9	*(17.0)*	7	*(0.3)*	12	*(11 0)*	2	*(0.2)*	38	*(6.2)*	11	*(2.1)*	11	*(1.1)*	**2353**	50
Tadpole madtom					17	*(<0.1)*	69	*(0.1)*	14	*(<0.1)*							**16**	70
Tadpole Madtom (yoy)							100	*(0.1)*									**21**	37
Threespine Stickleback							100	*(<0.1)*									**1**	60
Trout Perch			18	*(0.4)*	67	*(<0.1)*	15	*(<0.1)*									**6**	86
Trout Perch (yoy)													100	*(2.3)*			**48**	56
White Perch	3	*(2.2)*	2	*(2.2)*	37	*(1.4)*	15	*(0 5)*	11	*(0.5)*	16	*(1.2)*	2	*(0.3)*	15	*(1.6)*	**371**	148
White Perch (yoy)	3	*(5.1)*	1	*(4.1)*	59	*(20.0)*	22	*(8.1)*	7	*(1.9)*	2	*(0.2)*	4	*(3.4)*	2	*(0.5)*	**4371**	68
White Sucker	1	*(0.3)*	3	*(1.5)*	1	*(<0.1)*	2	*(<0.1)*	2	*(<0.1)*	75	*(2.6)*	13	*(0.8)*	3	*(0.1)*	**82**	217
White Sucker (yoy)	1	*(0.2)*			3	*(<0.1)*	3	*(<0.1)*	3	*(0.1)*	5	*(0.2)*	51	*(8.3)*	35	*(9.4)*	**202**	59
Yellow Perch	2	*(0.2)*			15	*(0.1)*	24	*(0.1)*	3	*(<0.1)*	52	*(0.4)*	5	*(0.1)*			**38**	135
Yellow Perch (yoy)	1	*(1.3)*	<1	*(0.4)*	18	*(1.6)*	18	*(1.8)*	20	*(2.20*	23	*(3.5)*	22	*(15.0)*	4	*(0.4)*	**1173**	79
Total fish	633		271		13,039		18,649		10,744		1,999		2,132		1,261		47,512	

Table 18. Relative abundance (%) of YOY and non YOY fish over the course of a season, and within a month (bracketed) in Cootes Paradise. Maximum catch and corresponding habitat and sampling period are included to indicate fish densities, and to demonstrate the correlation to spawning times, as in some cases higher total numbers of fish occurred in the marsh at other times (i.e. carp).

Species	April	May	June	July	Aug.	Sept.	Oct	Max. #/trans.	Habitat	Date
Alewife	-	6 (3)	71 (17)	18 (1)	6 (1)	-	-	4	Open water	June '95
Alewife (yoy)	-	-	-	-	100 (1)	-	-	4	Bay	Aug '95
Bigmouth Buffalo	-	100 (<1)	-	-	-	-	-	2	Marsh	May '95
Black Bullhead (yoy)	-	-	-	100 (<1)	-	-	-	32	Protected	July '97
Black Crappie	54 (<1)	-	10 (<1)	36 (<1)	- (<1)	-	-	1	Exp. & Marsh	April '95 & '97
Black Crappie (yoy)	-	-	8 (<1)	68 (<1)	21 (<1)	2 (<1)	-	21	Exposed	*July '97*
Blackchin Shiner	-	-	-	100 (<1)	-	-	-	1	Enriched	July '96
Blacknose Dace (yoy)	-	-	-	-	-	-	100 (<1)	1	Spencer's	Oct '96
Blackside Darter (yoy)	-	-	-	100 (<1)	-	-	-	1	Multiple	*Aug '97*
Bluegill	4 (<1)	21 (1)	21 (<1)	31 (<1)	23 (<1)	1 (<1)	-	10	Protected	July '96
Bluegill (yoy)	-	-	<1 (<1)	1 (<1)	47 (3)	36 (5)	17 (13)	262	Protected	Aug '96
Bluntnose Minnow	14 (2)	21 (2)	46 (2)	14 (<1)	5 (<1)	1 (<1)	-	44	Exposed	*June '97*
Bluntnose Minnow	-	-	3 (<1)	47 (2)	28 (2)	14 (2)	8 (6)	511	Exposed	*July '97*
Bowfin (yoy)	-	-	-	-	-	100 (<1)	-	1	Exposed	*Sept '97*
Brook Silversides	94 (2)	5 (<1)	1 (<1)	<1 (<1)	-	-	-	3	Protected	May '96
Brook Silversides (yoy)	-	-	-	3 (<1)	44 (1)	53 (4)	-	9	Marsh	July '96
Brook Stickleback	-	-	100 (<1)	-	-	-	-	2	Spencer's	June '96
Brown Bullhead	3 (2)	30 (10)	52 (8)	12 (1)	4 (<1)	0 (<1)	-	59	Marsh	May '96
Brown Bullhead (yoy)	-	-	2 (<1)	28 (2)	42 (4)	23 (7)	6 (8)	1083	Marsh	*July '97*
Brown Trout	-	-	-	-	-	-	100 (<1)	1	Protected	Oct '96
Carp	8 (33)	16 (23)	19 (14)	16 (3)	32 (9)	1 (1)	9 (23)	47	Marsh	May '95
Carp (yoy)	-	-	3 (1)	21 (2)	62 (6)	6 (2)	8 (11)	640	Exposed	*Aug '97*
Carp x Goldfish	4 (<1)	2 (<1)	7 (<1)	56 (<1)	29 (<1)	1 (<1)	-	3	Protected	June '96
Carp x Goldfish (yoy)	-	-	-	33 (<1)	-	-	68 (<1)	2	Exposed	July '96
Central Mudminnow	-	-	-	-	100 (<1)			1	Marsh	July '94
Channel Catfish	-	-	99 (1)	1 (<1)	-	-	-	1	Exp. & Prot.	July '96
Channel Catfish (yoy)	-	-	-	51 (<1)	24 (<1)	12 (<1)	12 (<1)	12	Protected	July '95
Chinook Salmon	-	-	-	-	-	-	100 (<1)	1	Spencer's	Oct '95
Chinook Salmon (yoy)	-	100 (1)	-	-	-	-	-	1	Bay	May '95
Common Shiner	-	7 (<1)	93 (<1)	-	-	-	-	13	Enriched	June '95
Common Shiner (yoy)	-	-	-	89 (<1)	11 (<1)	-	-	6	Enriched	July '95

Table 18. continued

Species	April	May	June	July	Aug.	Sept.	Oct	Max. #/trans.	Habitat	Date
Creek Chub	-	12 *(<1)*	16 *(<1)*	41 *(<1)*	21 *(<1)*	10 *(<1)*	-	2	Spencer's	June '95
Creek Chub (yoy)	-	-	12 *(<1)*	64 *(<1)*	13 *(<1)*	-	11 *(<1)*	2	Spencer's	July '95
Emerald Shiner	3 *(1)*	11 *(2)*	19 *(1)*	33 *(1)*	20 *(1)*	14 *(1)*	-	15	Open water	*July '97*
Emerald Shiner (yoy)	-	-	-	-	15 *(1)*	82 *(4)*	3 *(1)*	7	Bay	Sept '96
Fathead Minnow	6 *(<1)*	14 *(<1)*	30 *(<1)*	49 *(<1)*	-	1 *(<1)*	-	15	Protected	*June '97*
Fathead Minnow (yoy)	-	-	11 *(3)*	71 *(6)*	14 *(1)*	4 *(1)*	<1 *(1)*	141	Protected	*Aug '97*
Freshwater Drum	-	<1 *(<1)*	87 *(1)*	5 *(<1)*	7 *(<1)*	<1 *(<1)*	-	2	Open water	Aug '95
Freshwater Drum (yoy)	-	-	-	36 *(<1)*	64 *(<1)*	-	-	3	Exposed	Aug '96
Gizzard Shad	23 *(5)*	32 *(3)*	1 *(<1)*	<1 *(<1)*	<1 *(<1)*	-	44 *(10)*	8	Exposed	June '95
Gizzard Shad (yoy)	-	-	<1 *(<1)*	77 *(45)*	17 *(12)*	6 *(11)*	-	167	Exposed	Aug '95
Golden Shiner	-	50 *(<1)*	-	50 *(<1)*	-	-	-	1	Protected	May '95
Golden Shiner (yoy)	-	-	-	-	42 *(<1)*	-	58 *(<1)*	1	Exposed	Aug '96
Goldfish	9 *(<1)*	5 *(<1)*	8 *(<1)*	6 *(<1)*	72 *(<1)*	-	-	4	Marsh	June '95
Goldfish (yoy)	-	-	-	10 *(<1)*	15 *(<1)*	66 *(1)*	10 *(<1)*	40	Marsh	Aug '95
Green Sunfish	-	11 *(<1)*	20 *(<1)*	33 *(<1)*	27 *(<1)*	8 *(<1)*	-	6	Protected	July '95
Green Sunfish (yoy)	-	-	14 *(<1)*	17 *(<1)*	46 *(<1)*	16 *(<1)*	8 *(<1)*	2	Protected	Aug '96
Johnny Darter	29 *(1)*	42 *(<1)*	18 *(<1)*	6 *(<1)*	2 *(<1)*	2 *(<1)*	-	5	Exposed	May '95.
Johnny Darter (yoy)	-	-	1 *(<1)*	19 *(<1)*	24 *(<1)*	54 *(2)*	2 *(<1)*	117	Exposed	*July '97*
Largemouth Bass	-	2 *(4)*	19 *(<1)*	35 *(<1)*	40 *(<1)*	-	4 *(<1)*	10	Exposed	Aug '96
Largemouth Bass (yoy)	-	-	-	21 *(<1)*	58 *(<1)*	15 *(<1)*	6 *(<1)*	10	Marsh	Aug '95
Logperch	-	6 *(<1)*	30 *(1)*	41 *(<1)*	24 *(<1)*	-	-	28	Exposed	July '96
Logperch(yoy)	-	-	5 *(<1)*	64 *(3)*	26 *(1)*	5 *(1)*	<1 *(<1))*	179	Exposed	*June '97*
Mirror Carp	11 *(<1)*	4 *(<1)*	40 *(<1)*	33 *(<1)*	11 *(<1)*	-	-	1	Multiple	Multiple
Mirror Carp (yoy)	-	-	-	21 *(<1)*	71 *(<1)*	8 *(<1)*	-	5	Protected	*Aug 97*
Northern Pike	50 *(<1)*	-	21 *(<1)*	11 *(<1)*	4 *(<1)*	-	13 *(<1)*	2	Chedoke	*June '97*
Northern Pike (yoy)	-	-	67 *(2)*	2 *(<1)*	31 *(<1)*	-	-	5	Protected	*June '97*
Pumpkinseed	2 *(4)*	19 *(21)*	31 *(18)*	26 *(4)*	21 *(4)*	2 *(1)*	<1 *(1)*	157	Marsh	Aug '94
Pumpkinseed (yoy)	-	-	<1 *(<1)*	24 *(13)*	50 *(32)*	25 *(42)*	1 *(11)*	760	Marsh	Aug '97
Pumpkinseed x Bluegill	-	-	67 *(<1)*	33 *(<1)*	<1 *(<1)*	-	-	1	Multiple	Multiple
Pumpkinseed x Green	-	-	-	25 *(<1)*	21 *(<1)*	-	54 *(<1)*	1	Multiple	Multiple
Rainbow Trout	<1 *(<1)*	43 *(<1)*	-	-	-	-	57 *(1)*	1	Open water	May '96-'97
River Chub	-	-	-	-	100 *(<1)*	-	-	1	Exposed	Aug '96
River Chub (yoy)	-	-	-	100 *(<1)*	-	-	-		Exposed	*July '97*
Silver Shiner	-	-	-	-	-	-	100 *(<1)*	1	Spencer's	Oct '96
Spotfin Shiner	-	50 *(<1)*	50 *(<1)*	-	-	-	-	1	Protected	May 95, June 96

Table 18. continued

Species	April		May		June		July		Aug.		Sept.		Oct		Max. #/trans.	Habitat	Date
Spottail Shiner	23	*(25)*	26	*(13)*	51	*(13)*	<1	*(<1)*	<1	*(<1)*	<1	*(<1)*	-		81	Marsh	April '96
Spottail Shiner (yoy)	-		1	*(<1)*	8	*(4)*	52	*(7)*	32	*(5)*	7	*(3)*	-		2000	Protected	May '95
Tadpole madtom	-		5	*(<1)*	11	*(<1)*	11	*(<1)*	52	*(<1)*	21	*(<1)*	-		4	Protected	*Aug '97*
Tadpole Madtom (yoy)	-		-		-		11	*(<1)*	31	*(<1)*	58	*(<1)*	-		7	Protected	Sept '96
Threespine Stickleback	-		100	*(<1)*	-		-		-		-		-		1	Protect	*May '97*
Trout Perch	5	*(<1)*	95	*(1)*	-		-		-		-		-		2	Exposed	April '95
Trout Perch (yoy)	-		-		-		43	*(<1)*	57	*(<1)*	-		-		34	Spencer's	*Aug '97*
White Perch	4	*(3)*	46	*(16)*	39	*(7)*	6	*(<1)*	4	*(<1)*	-		-		34	Exposed	June '95
White Perch (yoy)	-		-		<1	*(<1)*	29	*(5)*	54	*(11)*	14	*(8)*	3	*(10)*	644	Exposed	Aug '95
White Sucker	66	*(16)*	29	*(3)*	1	*(<1)*	2	*(<1)*	2	*(<1)*	<1	*(<1)*	<1	*(<1)*	16	Chedoke	April '96
White Sucker (yoy)	-		-		31	*(1)*	50	*(<1)*	15	*(<1)*	4	*(<1)*	<1	*(<1)*	110	Enriched	*June '97*
Yellow Perch		*(1)*	14	*(<1)*	4	*(<1)*	6	*(<1)*	8	*(<1)*	-		-		4	Protected	*April '97*
Yellow Perch (yoy)	-		-		2	*(1)*	31	*(2)*	41	*(3)*	26	*(5)*	<1	*(<1)*	101	Spencer's	*Aug '97*
Transect totals	769		3,879		4,775		11,869		21,667		4,484		1,328				

Reproductive Utilization

All species, for which adults were captured, demonstrated migration into and out of the marsh with reported spawning periods. (Table 16,Table 18). As spawning times are different for individual species, the result was a fish community that changed as the year progressed. Figure 9 provides a graphic example of the data for two species with differing spawning times and habitat characteristics, brown bullhead and white perch. Non YOY white perch have highest abundance in May, and were most commonly found in the exposed habitat. This correlates with their spawning time (temp. 14°C), and their habitat preference is consistent with preferred spawning habitat. Non YOY Brown bullheads have highest abundance in June and are most commonly found in the marsh sub-habitat. This correlates with their spawning time (temp. 20°C), and their habitat preference is consistent with preferred spawning habitat. For both species, the subsequent YOY had highest abundance in August, preferring habitats similar to non YOY of the respective species.

Most species of non YOY fish had highest *densities* corresponding to reported spawning times, and consistent to spawning habitat guilds (Table 16,Table 17). For example the highest density of carp was found in the marsh habitat in May, with a maximum catch of 47 fish in a transect. Habitat preferences of YOY species also generally reflected a species spawning habitat guilds (Table 18). Total non YOY *populations* were also generally at a peak during spawning periods. The non YOY of most species showed a distinct migration out of the marsh following spawning periods. Samples taken two months prior to a species spawning period had almost no fish of the species occurring in the marsh, while samples taken two months following peak spawning periods resulted in almost no larger fish (adults) of a species being found in the marsh.

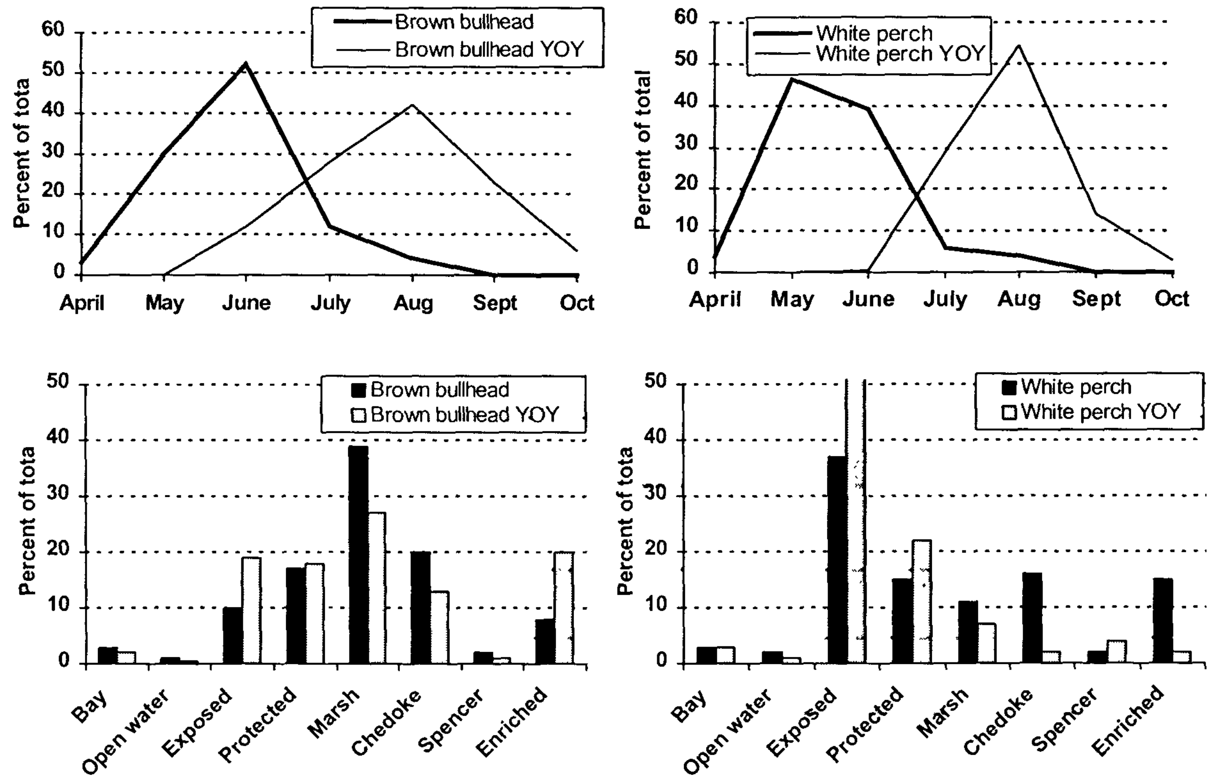

Figure 9. Seasonal pattern of occurrence of YOY and non YOY brown bullhead and white perch in Cootes Paradise. The pattern demonstrates the marsh's role as reproductive habitat as the highest numbers of non YOY for both species occur at corresponding spawning times. The highest numbers also corresponds to preferred spawning substrate (Table 16).

Migration into and out of the marsh did not occur simultaneously across species (Table 18). This emphasizes the importance of the marsh as reproductive habitat as the presence of the non YOY of a species correlates to the species specific spawning time. This also generates substantially different fish community compositions within individual months (Table 18). In some cases, the migration picture of adults is clouded by the presence of juvenile fish, as juveniles were not specifically separated from adults. This was the case for largemouth bass, logperch, white perch, brown bullhead, and bluegill. During certain months for these species, juvenile fish (1+) represented the majority of the non YOY catch. For the latter three species, highest non YOY numbers still occurred in association with spawning times.

Carp, largemouth bass, and logperch were the only species that did not have highest non YOY marsh populations corresponding to spawning period, although in the case of carp densities were highest at spawning time. Also, in the case of carp direct observational evidence of spawning was obtained. Populations of the three species increased following spawning periods. The carp population was shown highest in August although total catch was highest in May due to spawning aggregations (Table 18). Both YOY and non YOY logperch numbers peaked in July. However, the majority of non YOY logperch were yearlings, easily identified in length frequency distributions. Logperch mature at age two. YOY largemouth bass were first captured in July (50-60 mm), while catches of YOY and non YOY were substantially higher in August. All of the non YOY largemouth bass captured were juveniles, and most were yearling fish (mean 190mm). The largest bass captured was 305mm.

Pumpkinseeds and white perch also had substantial numbers of juvenile fish captured. Most white perch captured in July were juveniles. Juvenile white perch were uncommon earlier in the season when adult white perch were most abundant. Most of the non YOY pumpkinseeds captured were small (mean 86mm), indicating they were yearlings and/or 2+ pumpkinseeds. Pumpkinseeds mature at age 2 or 3 (Portt et al. 1988). Age class separation by size frequency distribution was impossible due to substantial overlap in the length at age relationship. The largest pumpkinseeds (max. 184mm) and the highest numbers (31%) were consistently captured in June the primary spawning time.

For all but two species, blacknose dace and emerald shiner, samples taken two months following peak adult numbers tended to have the highest YOY numbers. This also generated substantially different relative abundance of YOY between months. Highest total YOY numbers occurred in July, and maximum YOY diversity and highest biomass occurred in August (Table 18,Table 14). For all species except bluegill YOY, numbers dropped sharply in September, marking a distinct migration out of the marsh (Table 18). The size of YOY species captured in September and October were generally substantially smaller than those captured in August, indicating fall spawning in some species. This included bluegill, pumpkinseeds, and bluntnose minnow.

The fact that YOY numbers for most species tended to peak in August in this study is an artifact of the sampling. This was a result of the sampling net mesh size used (5 mm). Although a mesh size of 5 mm made for ease of capture of most fish, very small fish could not be sampled as they passed through the net. For most species, the 5 mm mesh size provides effective capture starting at 25-30 mm in length. Consequently, the actual highest numbers for most species of YOY occur before August.

Three adult fish, carp, gizzard shad and northern pike return to the marsh in the fall (Table 18). Carp numbers rebounded to a limited extent in October after being almost non existent in the marsh in September. However, adult carp where only caught in the deeper water near the connection to the harbour. Gizzard shad were also caught in this area. In September, most of the marsh water was clear and less than 20 cm deep with no fish visible. Adult and juvenile northern pike were found in Chedoke Cr. and Spencer's Cr. in the fall. During the summer months, all the non YOY pike caught were juveniles, and they were only found in the cooler lower river habitats.

Dominant fish

Carp are the dominant fish in the marsh due to their large size and weight. At the same time they only represent approximately 10% of the total fish catch numbers. The average non YOY carp was 483mm in length and weighed an average 2.45 kg. The only other large size fish caught (>500 g) were adult and juvenile pike, and adult rainbow trout, chinook salmon, white sucker, freshwater drum, and gizzard shad. All of these species have small adult populations using the marsh, or were passing through the marsh to the tributaries. The two years with full seasonal sampling sessions (1996-1997) indicated the highest estimated adult carp population occurred in August, with a marsh average of 197 kg/ha or 79 adult fish/ha (no electrofishing efficiency included). At this time carp were distributed evenly between all habitats except open water habitat, where they were rare. As open water habitat represents about 55% of the marsh habitat, average marsh density was much lower than that off the other habitats. Open water density was 31 kg/ha while the other habitats were about 400 kg/ha (no electrofishing efficiency included).

Adult carp were most concentrated in the marsh habitat in May and June, where catches of up to 47 fish and greater than 100 kg/transect occurred. This roughly translates to densities of 12,000 kg/ha. and 5,000 fish/ha. These densities corresponds to their spawning time (May-June) and spawning guild (phytophils). At this time dissolved oxygen levels were often impaired (<4 mg/l), and Secchi depths were less than 10 cm. YOY carp were also most abundant in the marsh habitat and represented 10-20% of the total catch later in the season (Table 17). Also, later in the season large aggregations of YOY carp were found in the protected and exposed habitats (up to 500 fish/transect).

The off-shore habitat types represent 95% of the marsh area. The fish that were found in these habitats represent the dominant fish of the marsh. However, off-shore transects did not have the diversity or abundance of other habitats, with an overall average catch of 7.5 fish in a bay transect, and 3.4 fish in the open water transect (Table 17). Overall average catch values in both off-shore habitats were elevated by YOY catches later in the season (July and August). In comparison, near-shore habitats had average catches ranging from 107 to 187 fish per transect. The most abundant fish in both the bay and open water habitats were gizzard shad YOY (Table 17). The average gizzard shad YOY was 82 mm (11g) at the end of August. Gizzard shad YOY were spread evenly among all habitat types except the lower river habitats. Gizzard shad YOY were captured at a range of lengths in each of July and August, indicating a prolonged spawning period (29-110mm in Aug.1996). This was also observed for many of the later spawning species (spawning after May), including sunfish species, various minnows, carp, and johnny darters.

Adult gizzard shad were uncommon, with only 24 being captured over the course of the study. In no habitat did they represent more than 1.0% of the total catch. Only one of the 24 non YOY gizzard shad was a juvenile (140 mm), while the rest were adults (>350mm). As with all species, adult gizzard shad showed strong seasonal migration, with the majority of fish being captured during May sampling, in groups, in the exposed and marsh habitats. The aggregations presumably represented spawning groups, as May corresponds with their spawning time. However, Balon (1975) lists the gizzard shad spawning group as lithopelagophils (rock and gravel spawners) with pelagic larvae. This data indicates that the gizzard shad may be phytolithophils (spawning on a range of substrates). During the summer months adult gizzard shad represented less than 1% of the catch. In October adult gizzard shad returned to the marsh as indicated by the relative number found in October, 44% (Table 18). However, in October adult gizzard shad were captured in different sub-habitats than earlier in the season, the off-shore sub-habitats.

Other adult fish that were seasonally abundant included adult white sucker, brown bullhead, alewife, spottail shiner, white perch, and pumpkinseed. Later in the season YOY pumpkinseed, spottail shiner, white perch, and fathead minnow had significant relative abundances. A number of fish were relatively abundant in specific habitats, but not abundant overall. These included bluntnose minnow YOY and logperch in the exposed habitat, bluegill YOY in the protected habitat, white sucker YOY in the lower river habitats, and brown bullhead YOY in the marsh habitat. For these species highest densities of both non YOY and YOY correlate to their spawning group.

Discussion

Species Richness

A total of 47 species of fish were captured in the study. Annual species diversity averaged 38 species, while monthly richness followed a seasonal trend with a maximum of 34 species occurring in July. Other recent studies of the marsh have found 14 additional species (Theÿsmeÿer 1997, Leslie and Timmins 1992, Theÿsmeÿer and Cairns unpublished 1995). This brings the total number of species found in the marsh to 61. Although species richness is high, species diversity is low as all but seven species are rare. The ten additional species captured at the Cootes Paradise Fishway in 1997, but not within the marsh electrofishing surveys included: longnose gar (2 fish), shorthead redhorse (1), silver redhorse (2), golden redhorse (1), white bass (5), smallmouth bass (1), rock bass (many), longnose dace (1), northern brook lamprey (1) and lake trout (4) (Theÿsmeÿer 1997). This is likely a result of their small population sizes. Four other species recently captured in the marsh, but not in this study include quillback (Theÿsmeÿer and Cairns 1995), mimic shiner, striped shiner, and yellow bullhead (Leslie and Timmins 1992). Yellow bullhead may have been a misidentification as they were listed as common and so likely would have been captured in this study or at the Fishway. In Leslie and Timmins study only larval fish were identified, a much more challenging task.

The total species richness of Cootes Paradise exceeds that of other Great Lakes coastal marshes. Stephenson 1990 found species richness to range between 22 and 27 species for five Toronto coastal marshes. Liston and Chubb (1986) found 33 species in Munuscong Bay, along the St. Mary's River. Jude and Pappas (1992) summarized data from a number of marshes and showed species richness of 18 species in Pentwater marsh Lake Michigan, 46 species in total for the marshes of Lake Erie, and 40 species in a marsh adjacent to Green Bay Lake Michigan. Leslie and Timmins (1992) found 27 species of larval fish in Cootes Paradise in 1987.

A number of factors contribute to the marsh's high species richness. The intensity and comprehensiveness of this study is likely one of the reasons for the comparatively higher species richness of the marsh. Minns (1989) demonstrated that sampling methodology was an important factor in species richness. Other important factors include latitude (Barbour and Brown 1974), watershed area (Minns 1989), lake area (Minns 1989), habitat heterogeneity (Eadie and Keast 1984). Productivity should also be included as an important element, as larger amounts of food result in a smaller amount of niche area being required to support an individual.

The most significant reason for the high species richness of Cootes Paradise relates to its role in the ecosystem. A marsh and its tributaries represent spawning and nursery habitat to almost all species of fish found in the Great Lakes. Seasonal movements into and out of the marsh in association with spawning periods and habitats and the later predominance of YOY provide evidence to this. The movements in and out of the marsh and its importance as reproductive habitat are emphasized by the fact that species which were present or even dominant in one month (spawning month) were often rare or absent the next month. July appears to represent a hinge point between adult fish spawning and resulting YOY in the seasonal cycle of the marsh. Species diversity was highest in July as the broadest range of YOY, juvenile, and adult fish were present. There are a number of species that use the marsh that are unlikely to be present in July in a marsh of this latitude, but still use the marsh. This includes the fall spawning species. Since all fall spawning species are cold water species, their resulting YOY would be expected to abandon the marsh before July to avoid the warm summer temperatures.

Very high species richness would be expected in Cootes Paradise when considering the elements, which contribute to species richness and a marsh's role in the system. Cootes Paradise is a very large eutrophic marsh. Cootes Paradise is part of the largest harbour / marsh complex in Lake Ontario. Cootes Paradise is located at the lower end of the Great Lakes watershed, of one of the largest freshwater systems in the world. Habitat diversity and heterogeneity are currently low, however a broad range of habitat types remain, demonstrated by the broad range of substrates, depths, and vegetation densities present. Multiple tributaries drain into Cootes Paradise, providing habitat for river species, and river spawning species. One of the tributaries, Spencer's Cr., is of a sufficiently large size that it historically supported a populations of lake sturgeon and atlantic salmon (currently extirpated), the largest river spawning species occurring in the Great Lakes (Holmes and Whillans 1984).

Although species richness is high, it is below potential richness. Many of the species identified by Jude and Pappas (1992) as strongly associated with wetlands were not found. Many of the historically occurring species of Cootes Paradise were also not captured. This is in spite of the fact that historical records are limited to fish which were captured commercially (Holmes and Whillans 1984), meaning the majority of species would not have historical documentation.

One of the primary reasons for the current absence of many of these species is the almost complete lack of aquatic plants within the marsh. The foundation of a marsh food web is aquatic plants, and the use of a marsh ecosystem by the fish community has evolved in the presence of plants. Without the plants the physical habitat to which the fish community has adapted too, and the food chain, are altered so as to be unfavorable to the majority of fish species. If the marsh were to become revegetated, then the number of species, and the diversity of the species using the marsh are anticipated to dramatically increase as it would restore the most significant element of marsh habitat.

Reproductive Utilization

Reproductive utilization of habitat is defined as use as spawning and/or nursery habitat (Stephenson 1990). Direct observational evidence of spawning is difficult to obtain across the fish community in the marsh due to the turbid water, and the range of spawning times and behaviors of the large number of occurring species. The seasonal presence of adult species in association with spawning periods and at high density is taken as indicative of spawning utilization. Continued presence of adult fish in the marsh may indicate that the marsh represents adult habitat, or be a result of a protracted spawning period. Nursery utilization is indicated by the presence of YOY and juvenile fish, and provides evidence that species spawned in the marsh earlier in the year.

Figure 9, and Table 17 and 18 show most species captured demonstrated migration into and out of the marsh in association with spawning periods, and spawning habitat groups. Most species of non YOY fish had highest *densities* occurring at corresponding spawning times, and in correlation to spawning habitat groups. Migration into and out of the marsh did not occur simultaneously across species. This emphasizes the importance of the marsh as reproductive habitat as the presence of the non YOY of a species correlates to the species specific spawning time. Further to this, YOY were capture for 39 of the 47 species found in the study. Those species for which YOY were not captured were very rare, with each having less than 5 non YOY captured in the 4 years of study.

The data shows the niche divisions of spawning habitat, including habitat type and timing. The result is a complex seasonal succession of fish sharing spawning and nursery habitat. The niche divisions are demonstrated in the species specific movements into and out of the marsh, the differences in monthly species abundance, the habitat preferences and seasonal occurrence of YOY and non YOY. During April, pike are spawning in the emergent vegetation, yellow perch are spawning on submerged vegetation and debris, spottail shiners are spawning along the sandy/gravelly shorelines, and suckers are spawning in the tributaries. During May bowfin are nesting in the emergent vegetation, largemouth bass and crappies are nesting in the submergent vegetation and debris, smallmouth bass and logperch are nesting on the sandy/gravelly shorelines, and various minnows are spawning in the tributaries. The cycle continues through June and July, and then resumes in October, with salmon and trout spawning in the tributaries, and whitefish and cisco spawning on the sandy/gravelly shorelines. Interestingly, predator fish generally spawn before lower trophic level species, perhaps allowing their YOY to take advantage of the later YOY abundance of lower trophic level species.

Further evidence of the marshes importance as reproductive habitat is the very high species densities and biomass occur in association with spawning aggregations and later YOY. Carp densities in Cootes Paradise at spawning time have been measured as high as 47 fish per transect which represents 5,000 fish/ ha., or 12,000 kg/ha (sampling efficiency not included). Non YOY pumpkinseeds were caught in numbers as high as 157 fish per transect or approximately 12,000 fish/ha. Many marsh transects in August had YOY catches of 400-800 fish which represents a density of 33,000 - 60,000 fish/ha. In contrast the HHRAP target abundance for adult habitat, the littoral zone of Hamilton is 300 kg/ha (Minns et al. 1994). The actual marsh densities are higher, as the marsh values quoted do not account for sampling efficiency of the gear. Much higher densities would likely occur if Cootes Paradise were rehabilitated to a vegetated state, as this is the habitat condition species evolved with.

The marsh is also important nursery habitat for species that do not spawn within the marsh. Many river spawning species fall into this category. These species use the strategy of spawning within the river and allowing their larva to wash down the river mouth marsh. The enriched habitat, which was located in close proximity to Spencer's Cr. and had the highest numbers of YOY of river spawning species. YOY creek chub, common shiner, blacknose dace, river chub, blackside darters, white suckers, and chinook salmon were all found in the marsh. YOY white suckers captured in late August in the marsh were substantially larger than those captured in the lower portion of the rivers (90 mm vs 50 mm). Also, white suckers were abundant enough to observe a pattern of habitat shifting as the season progressed. In June and July white suckers were abundant in the lower river habitats. In August YOY white suckers were rare in these habitats. In August, and to a lesser extent in July they were present in all other habitats but open water. Their benthic nature, in combination with the deeper turbid water may have precluded their capture here. In September as with other species they left the marsh. Chinook salmon was found in the bay habitat in May, fitting their smolting behaviour from rivers. YOY salmon were not captured in the tributaries as higher gradient creek habitat was not included in the sampling program. A number of additional chinook salmon YOY were also caught in May, but not within the assessment program. Water temperature was approximately 24°C at this time.

Spawning for all species using a marsh is likely somewhat protracted. Temperature is one of the triggers for spawning initiation, with the other being photoperiod (Moyle and Cech 1988). Cootes Paradise is much shallower than Hamilton Harbour and consequently in the spring it warms more quickly. Fish in close proximity to the marsh would be triggered by these warmer temperatures earlier than fish farther into the harbour. This could be extended further, where in Lake Ontario the water warms even slower than Hamilton Harbour. This would mean fish in the lake will be triggered even later. Data collected at the Fishway in 1997 support this idea (Theÿsmeÿer 1997). Both white suckers and northern pike are early spring spawners, and provide a good example since their spawning temperature is reached quickly. Most of both of these species were moved into Cootes Paradise in late March, and early April. However, both species had unspawned adults arriving at the marsh as late as early May. Comparison of spawning time of carp in the harbour and Cootes Paradise also supports this idea. Carp have been seen spawning in Cootes Paradise predominantly in late May and early June. Carp are found to be spawning in mid May near the Dundas sewage treatment plant. YOY carp are first found a month early here (June) than in the rest of Cootes Paradise (July). Carp are found spawning in the harbour in early July (pers observ.).

Two species did not have highest abundances of non YOY at spawning time. Largemouth bass and logperch did not have peak abundance of non YOY at spawning time, and at spawning time were actually relatively rare compared to other months. This would indicate spawning currently may be more significant outside the marsh than inside. No adult largemouth bass were caught in Cootes Paradise during this study. This is could be a reflection of this species rarity, or nesting behaviour of bass. Guarding of a nest and territory would be difficult considering the abundance of carp, and confounded by water turbidity. Nests would likely be abandoned, as efforts to maintain a territory would require an excessive amount of time compromising nest care and spawning success. Visual observations could not confirm this due to water turbidity. The marsh was however still important to the bass as YOY and juvenile habitat as numbers increased to a maximum in August, indicating migration in, from outside the marsh. This corresponded with increasing densities of YOY of other species, which would represent forage for the bass. Logperch had peak YOY densities in July. This would be anticipated if they were using the marsh for spawning. Non YOY catches were also highest in July. However non YOY were predominantly juvenile logperch (easily determined by size class frequency). The spawning population of logperch may have been so small so as not to be captured in significant numbers by the assessment program, while reproductive success in the marsh was good.

A number of factors are involved in making a coastal marsh excellent reproductive habitat. The two most important consequences of these factors are the high productivity, and the protection afforded by the aquatic plants. The dramatic seasonal environmental fluctuations create highly productive habitat well suited for reproduction. Annual water level fluctuations and longer-term water level trends serve to maintain habitat diversity by generating plant community instability, thereby maintaining the community in an early succession and highly productive state (Stephenson 1990). The diversity of habitats serves to maintain a diversity of species. Also the dense marsh plants provide a refugia for the young fish. The variability of the environmental conditions also generates a situation of productive explosion in the spring, as the marsh is in an early successional and enriched state following the winter. The shallow and warm nature of the marsh, and the constant supply of nutrients from the tributary streams enhance productivity. The mixing of the marsh water and lake water further enhances productivity. This is a result of daily lake level fluctuations and lake water influxes from lake seiches and tides. This facilitates the release of nutrients from sediments and decaying vegetation as well as maintains water quality by preventing stagnation (Stephenson 1990, Geis 1979, Dorcey et al. 1983).

Dominant fish

The current fish species composition of Cootes Paradise is reflective of the available habitat in the Harbour and Cootes Paradise. As many as 61 species have been identified within the marsh within recent years, however only seven of these species can be considered has having populations of size, while most of the others are represented by less than 15 individuals in the data set. These seven include carp, brown bullhead, white sucker, gizzard shad, white perch, spottail shiner and pumpkinseed. The characteristics of the more abundant species include long life span, high fecundity, higher tolerance of degraded water quality, lower trophic level, occupation of a vacant niche, or pelagic in nature.

Adult species that are dominant are not similar to the dominant YOY species. This reflects the different roles the marsh (reproductive habitat) and the harbour (adult habitat) play in the life cycle of fish, and the importance of fish habitat in dictating the fish community. The dominant adult species reflect the habitat within the harbour, while YOY dominate the marsh with the species reflecting the habitat.

The dominant adult species is carp, with a significant although likely depressed number of brown bullheads, white perch and white suckers also occurring. These species are among the longer lived, and the most tolerant of the degraded water quality reflecting the harbours degraded habitat (COA 1989), particularly the low levels of dissolved oxygen. The longer life span allows for less dependence on yearly recruitment success as an individual will spawn many seasons over the course of it's life. Many of the fish species present are relatively small, although their YOY are quite large. This suggests that life span for many species is shortened, implicating habitat quality outside the marsh as an important limiting factor to their populations.

The most numerous species in the marsh include YOY of gizzard shad, white perch and spottail shiners. The fact that all are YOY is reflective of the ecological importance of a marsh as reproductive habitat. It also reflects the open water nature of the marsh, as all are pelagic species. These species are the most common and the predominant species in the off-shore habitats. Although these species are the most abundant fish in the marsh, the off-shore transect catches of these species are low (max. 42 YOY) as compared to total YOY species in near-shore habitats (max. 1,216 YOY). This indicates that much of the marsh energy is not being transferred to fish, and that if the marsh was in healthier state total YOY production for the marsh would be many times higher. However, it is important to note that pelagic species are more difficult to capture by electrofishing, biasing the pelagic species to be relatively lower in proportion to their actual numbers.

Pumpkinseeds were classified by Jude and Pappas (1992) as strongly associated with wetlands. Pumpkinseeds were most abundant in Cootes Paradise in June. They were however common throughout the summer. Pumpkinseeds are considered protracted spawners. The continuous catch of month old YOY pumpkinseeds from July to September would indicate this. However, while the species as a whole may have a protracted spawning period, spawning by an individual fish is not. The protracted spawning period may be the result of competition for nesting sites. Adult pumpkinseeds were found almost exclusively in the near-shore habitats (93%) at densities as high as 89 fish/50 m transect in June (5,960 fish/ha.). Largest pumpkinseeds were consistently captured in June, while in later months most were 75 -120 mm. This indicates that the larger pumpkinseeds obtained nesting sites early and spawned early, while smaller pumpkinseeds obtained sites later. Following spawning, pumpkinseeds left the marsh as indicated by the highest percentage of pumpkinseeds caught in June (31%). Keast and Eadie (1984) found the spawning period of pumpkinseeds was not protracted and lasted only 16 days during late June in Lake Opinicon. They indicated that they studied the inshore area of the lake that may not necessarily have been a marsh area where spawning fish would be most concentrated forcing a protracted spawning period. The comparatively small size of their YOY supports this idea. Pumpkinseed YOY in Lake Opinicon had mean size of 34 mm at the end of August without protracted spawning, while Cootes Paradise pumpkinseed YOY had a mean size of 41 mm at the same time, even with a protracted spawning period and broader range of YOY sizes. Both sites are eutrophic.

Adult spottail shiners and alewife are also seasonally dominant in correspondence to there spawning times in April and June. Both species are pelagic species, and with the current state of the fish community are not specifically dependent on a healthy marsh or harbour for reproduction or adult habitat. Both species are occupying habitats lacking most of their native fauna. In a healthy system, they would likely exist in lower numbers as the abundance of the other native lake species dependent on a healthy marsh would be dramatically higher, and consequently so would competition and predation. The success of pumpkinseeds is also likely at least partly a result of occupying a vacant niche. They are the only species of the more abundant fish, specific to the mid water of the vegetated littoral zone of the harbour.

Although seasonally significant numbers of alewife occur in the marsh, very few YOY alewife are found. Only 4 YOY alewife have been captured in four years of marsh monitoring (1994-1997). Their small size at the time of capture (33 mm Aug.) suggests they were not spawned in the marsh, but migrated into the marsh later. The lack of spawning success may be a result of the water temperature difference between the marsh, harbour and Lake Ontario. At the time of alewife arrival in the marsh water temperatures were between 20 - 25°C. Alewife spawning temperature is approximately 15°C, with spawning inhibited above 21°C (Lane et al. 1996a).

The near-shore area of the marsh accounts for a relatively small portion of the marsh, but represents the area where most fish species are currently found. This area would appear to represent important refugia for many of rare fish species. Near-shore habitats have the highest diversity of substrates and structural components, including over hanging branches and woody debris. Near-shore catches are significantly higher in biomass, number and species richness. Carp remain the dominant fish here. Pumpkinseed adults and young of the year are seasonally abundant in the near-shore of the marsh. The abundance of pumpkinseeds has been seen only in recent years, as before 1994 pumpkinseeds were much less abundant

(Valere 1996). The resurgence of pumpkinseeds is likely a result of improvement of littoral zone habitat within the harbour, which has undergone dramatic revegetation (V Cairns pers com.). The abundance of amphipods, isopods and snails in the near-shore area of the marsh (pers observ.), particularly exposed and protected habitats, is likely an important factor for the existence of pumpkinseeds in the marsh near-shore area. This is also a likely factor for the very high transect catches of various YOY species including carp (max. 640 fish), brown bullheads (max. 249 fish), white perch (max. 644 fish) and gizzard shad (max. 167 fish) which occur periodically in August in these habitat.

The fall fish community

By late September, few fish are found in the marsh. The declining water temperatures appear to be the trigger that causes the migration from the marsh. The likely reason for the fall migration out of the marsh is to avoid the inhospitable winter environment. The declining marsh water levels that occur in late summer and fall and the thickness of ice in winter have significant implications on the potential spatial location of the fish community within the marsh. During February 1995, several holes were bored through the ice to determine ice thickness and water depth. At this time ice thickness had reached approximately 50 cm on average. This resulted in most of the wetland being frozen to the bottom or having only a few centimeters of water. The combination of a lack of water under the ice, and the water present being very cold creates an inhospitable environment to fish.

Some adult predator species appear to move into the marsh in the fall, along with fall spawning species. However, information on the predators is limited as most predator species have been extirpated, or exist in very low numbers. The most abundant adult predator is northern pike. The return of northern pike to the marsh is difficult to assess due to the low population. However, to examine this possibility electrofishing was done down the length of lower Chedoke Cr. in two successive months, September and October (1995). A total of 6 pike were captured in mid

September, while 14 pike were captured in mid October. Adult gizzard shad appeared to follow a similar pattern. Operation of the Fishway in the fall of 1997 (Oct.) found a number of adult gizzard shad to be migrating out of the marsh around mid October. It seems likely that both species are excluded from the marsh by the warm summer temperatures. Juvenile pike (320-480mm) were only found in lower Spencer's and Chedoke Creeks throughout the summer. Both of these habitats have significantly lower temperatures than the marsh during the summer months. Temperatures were not measured above 23.5°C in either habitat during the summer.

Fish community classification

Jude and Pappas (1992) classified fish species in relation to wetlands into three categories including a group strongly associated with lakes, a group strongly associated with wetlands, and transitional group using both lakes and wetlands. However, almost all species are dependent on a marsh for nursery or spawning habitat, while all species benefit from the marsh productivity. Several of the fish identified in the lake taxocene by Jude and Pappas (1992) were found in the spring or fall in Cootes Paradise. It would seem that those fish classified by Jude and Pappas (1992) as strongly associated with wetlands, were those fish whose spawning time was during the late spring and early summer. Usually fish sampling occurs during these months and consequently gives the impression of their increased dependence on marshes. In this study, for almost all species of adult fish the maximum populations were found in the marsh in association with spawning time, and found at highest densities in habitats that reflected their spawning group classification. This demonstrates the importance of the marsh to the entire fish community as spawning and nursery habitat. It also demonstrates the fact that for an individual species use of the marsh is unlikely to include the entire ice-free period. In the case of burbot, whitefish and certain cisco species, spawning would take place under the ice in a marsh. This would preclude them from capture. However, staging near the marsh, prior to spawning in the marsh may lend these species to capture prior to ice cover. Marsh degradation is likely an important factor in the loss of these species, as these species would be most sensitive due to the long period of egg incubation required.

For all fish species, a classification system relating to wetlands should be as part of a transitional fish community as wetlands are uninhabitable in the winter due to low water levels and ice cover. The degree of usage of a wetland by a species varies with latitude and temperature regime. For example, a wetland fish community in northern Manitoba may contain whitefish, pike, and burbot, while a wetland fish community on Lake Ontario might also contain these species, but for a much shorter time period of the year. Conversely, species precluded by cooler temperatures in northern Manitoba, would be found in the Lake Ontario wetland between May and September. Also, many of the species of fish which were classified by Jude and Pappas (1992) as most strongly associated with wetlands were fluvial species such as river darter, river redhorse, fantail darter and stoneroller. This is reflective of the fact that many wetlands are formed at the mouth of a river. There are undoubtedly some species specifically using wetlands which have the majority of all life stages found in the marsh habitat, just as there are a few species that are unlikely to ever be found in a wetland. Classification of marsh use by fish should be in the categories of spawning habitat, nursery habitat, juvenile habitat, and adult habitat.

Implications for fisheries assessments

Marsh sampling has great potential for fish community analysis since for most species, a wetland represents a spawning area. Fish community assessment of a marsh should be broken in two components, adult sampling, and YOY sampling. During spawning time, the fish are aggregated in relatively small areas within the marsh. This allows for capture of species that would normally be out of the range of sampling (deeper water) or dispersed over large areas. The aggregations in a small area and a specific habitat also allow for an increased likelihood of capture of species that are not abundant. Capture of rare species can require a very intensive sampling program in the *adult habitat*. In the Cootes Paradise sampling program, which is quite intensive, based on the ratio of area sampled (4 transects x 100 m^2) to the area of the largest sub-habitat (open water, 104 ha.), it's possible for a species to be in the marsh and have a population of upwards of approximately 2,600 individuals and not be captured.

To ensure the best assessment of the entire fish community is accomplished, the marsh should be broken down into sub-habitats. The sub-habitats should contain a cross section of important fish habitat variables particularly pertaining to spawning habitat characteristics. A range of deeps, substrates, wind exposures, and vegetation types should be incorporated. Assessment over a range of habitats is most important when assessing degraded habitats such as Cootes Paradise, as the information is used to guide management decisions about the future of the habitat In Cootes Paradise, the near-shore sub-habitat types represented only 6% of the habitat area combined. However, they contained the majority of species, and a substantially higher abundance.

The near-shore habitats appeared to represent refugia to many species. Many of the fish captured in the near-shore were specific to just one sub-habitat type. This is particularly true for those species that are less abundant. However, the existence of less abundant species is just as important to the system as each fish species is best suited to use a particular habitat. Since the presence of a particular species is reflective of the available habitat, the fish that are less abundant likely only have limited available habitat space. The persistence of many species in such small habitat areas illustrates the importance of preserving and protecting habitat, particularly near-shore habitat which is the most susceptible to infilling

Assessment of both adult and YOY components of the marsh system is important. The adult fish community is reflective of habitat outside the marsh, while the YOY fish community is reflective of habitat inside the marsh. As virtually all fish species use a marsh, lack of a species within a marsh is a reflection of the lack of the species in the system, and not necessarily the lack of value of the marsh habitat. In a degraded system the lack of fish species within a marsh is more difficult to determine as the habitat is likely restricted and the species are localized, the population of the species are lower, and adult habitat and reproductive habitat are not necessarily consistent, consequently requiring higher effort in a narrower window of time to capture comprehensive marsh fish community data.

To assess the adult fish community using a marsh, sampling must be done over a series of months as fish presence in the marsh is generally limited to spawning time, and spawning times are not similar across species. For the lower Great Lakes area, sampling should occur on a monthly basis between the months of April and July, although for an individual marsh sampling time would be reflective of the latitude and temperature regime of the marsh. Sampling should be done again in the late fall for fall spawning species. Sampling only one month will bias fish community results to the particular species that are spawning at that time.

To assess the YOY fish community the months of July and August are best. In July maximum numbers of YOY tend to be present, while in August a measure of most YOY numbers and size, that will ultimately migrate out of the marsh to deeper water can be obtained. Samples obtained in July and August are likely to contain similar species but in dramatically different numbers, and provide data on marsh productivity. Assessment of the YOY fish community represents the true measure of marsh integrity as this reflects the marsh's role in the system, as reproductive habitat. Assessment of the adult fish earlier in the season will be reflective of the available adult habitat outside the marsh. Species richness and diversity are also excellent measures of marsh integrity, as over the course of season almost species present in a system will use a marsh. Since a marsh is reproductive habitat for most species, species richness and diversity should be highest during YOY periods. In Cootes Paradise the maximum number of species caught in a single 50 m transect was 17. This occurred in spite of the degraded nature of the harbour and the marsh, and the fact that almost half of the species of the original community have been extirpated.

The use of the marsh by fish has implications for fish community assessments done outside the marsh. If dramatic migrations of adults occur into the marsh in association with spawning periods, then during the spawning period of a particular species it will be absent outside the marsh. This would give the impression of the absence or rarity of a species within the system. Assessment done outside a marsh after August will also be heavily influenced by the marsh. Cootes Paradise demonstrates the dramatic movement of YOY fish out of the marsh in early September. It is likely that these fish would then appear in sampling done outside the marsh. Due to the abundance of YOY fish, results will be dramatically different than those obtained when YOY fish are still inside the marsh.

A system for marsh assessment should be developed in which baseline monthly relative fish assemblages are given. It is unlikely that that all species using the marsh will be present in all months and more specifically the relative abundance of a species at a location is specific to a time of the year. Assessments that include a single month can give a false image of the fish community. Further, assessments of the fish community done earlier in the year can yield entirely different results than later in the year as adult fish dominate early in the year, while YOY dominate later in the year. Also, adult fish communities are not necessarily reflective of resulting YOY fish communities and vice versa. Species specific spawning and YOY success in the marsh can be totally different than juvenile and adult survivorship outside the marsh. YOY numbers are also dramatically influenced by adult fecundity, and long lived species are less dependent on annual recruitment to maintain a large population.

High ratios of YOY to adults reflect successful nursery habitat, and poor adult habitat, while low YOY to adult ratios indicate the reverse. However, as the marsh represents mother nature's fish hatchery for most fish species, the ultimate measures of marsh fish community health are YOY diversity, size, and abundance.

Future Monitoring

The marsh represents a spawning and nursery area to the fish community. The Marsh Monitoring Manual metrics (Quinn et. al.1998) require continued fish community monitoring to assess fish community use of the marsh, and measure improvements in the marsh associated with it's rehabilitation. Future monitoring should continue to cover the range of substrates used by the different fish species over the course of the spawning season. It is most important that monitoring capture the resulting spawning success as this is the marsh's role for the fish community. Monitoring should also be able to capture changes in specific locations within the marsh that are identified as impaired by other factors (lower Chedoke Cr., and West Pond). The sampling program should also provide concurrent comparison for these sites. The monitoring however does not need to continue at the current level of monthly effort (30 transects). The sampling schedule of April to October should be maintained.

Future monitoring should continue using similar transects and a balanced sampling design. This accommodates the marsh monitoring manual matrix, which requires a balanced (between habitats) sampling design. Currently monitoring covers 9 substrate based sites. Four of these are exposed habitat (courser substrate - gravel), and 5 are protected habitat (sand and fine gravel). If marsh plant cover returns, the exposed habitat will no longer be exposed. Currently the transects have slightly different groups of fish utilizing them, presumably because of the wind exposure. However, clustering of the transects revealed that protected and exposed habitats were quite similar (Figure 7). For these reasons, future monitoring should include only 4 of the 9 transects, 2 protected, and 2 exposed sites. This then creates 4 sand/gravel substrate sites. The 4 transects are chosen to be representative of the marsh, representative of the substrate, and to provide spatial coverage of the marsh. Future monitoring should done using transects E2, P2, E4, and P4.

In the past 5 emergent transects were monitored. This can be reduced to 4 to balance the sampling effort. Transect M2 should be dropped, primarily due to it's difficulty of sampling. All the off-shore transects should be maintained, as these habitats represent the majority of marsh habitat, and are also the most severely impaired. This includes 4 existing bay habitat transects, and 4 open water habitat transects. There are currently 6 lower river transects. Four lower river habitat sites should be maintained, while two should be dropped. Lower river sampling should include 2 in Spencer's Cr., and the 2 in Chedoke Cr. Two transects in each site provides the opportunity for comparison between the two locations, while achieving the 4 habitat transects. Spencer's Cr. transects R4 and R1 should be maintained. The two transects in West Pond should also be maintained to provide information on this highly enriched area, as it currently shows further impairment then the rest of the marsh.

In the past sampling required 4 - 8 days depending on the number of fish. The removal of transects should ensure that sampling never requires more than 5 days. This primarily because of the removal of 5 substrate transects. These transects were the most time consuming as they tended to have very high numbers of fish.

Table 19. Summary of future sampling locations

Habitat	Sub-habitat	Quantity	Transects
Near-shore	Enriched	2	N3, N4
	Exposed	2	E2, E4
	Protected	2	P2, P4
	Marsh	4	M1, M3, M4, M5
Lower River	Spencer	2	R1, R3
	Chedoke	2	C1, C2
Off-shore	Bay	4	B1, B2, B3, B4
	Open Water	4	O1, O2, O3, O4
Total		22	

Summaries of *arithmetic* average biomass, quantity and species richness, by habitat, sub-habitat, and whole marsh are provided in Appendix A.

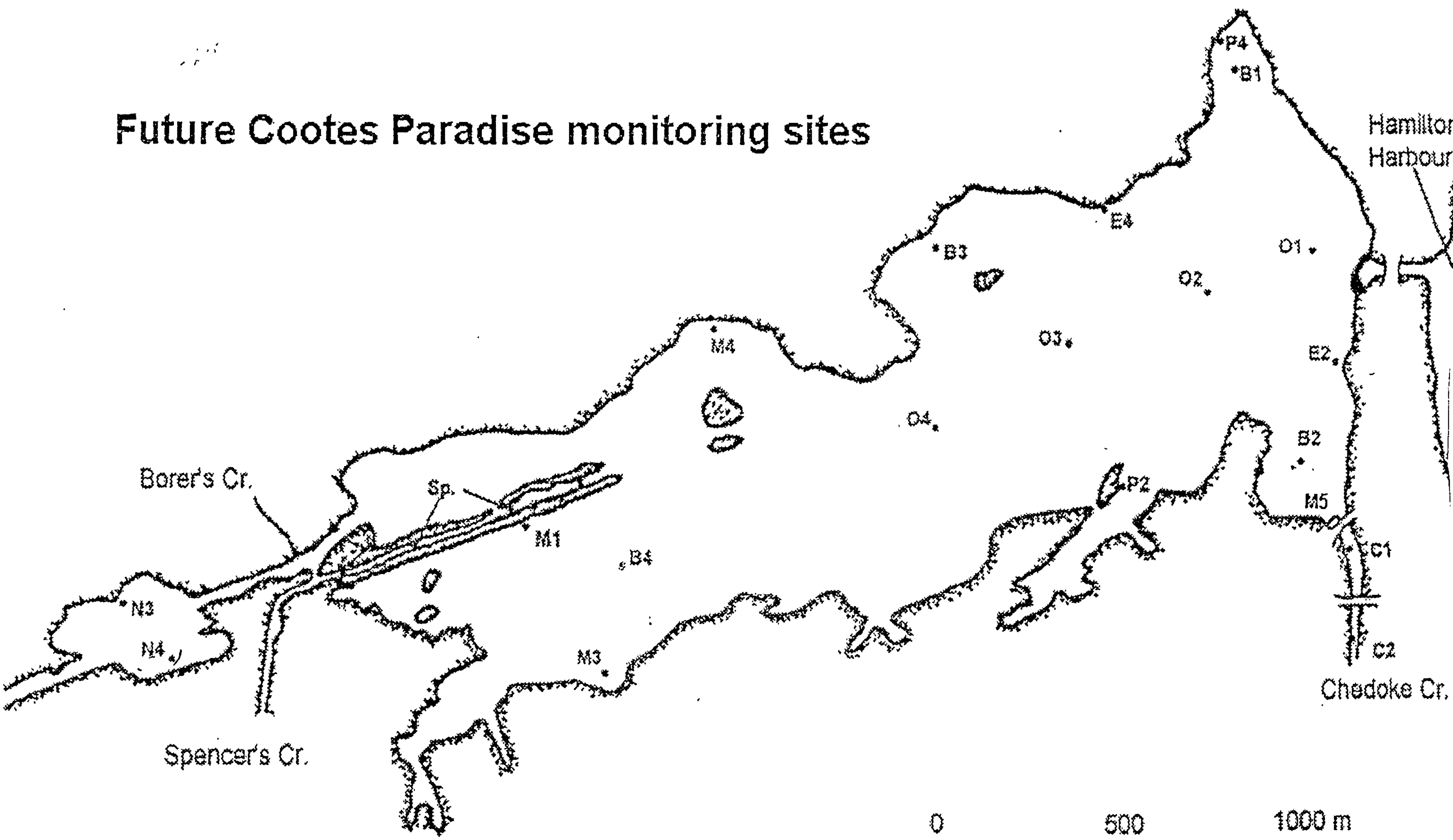

Figure 9. Future fisheries monitoring sites in Cootes Paradise

Equipment List

5.0 Smith Root electrofisher

- 1 punt
- 1 generator
- 1 5.0 control box
- 1 20 ft. anode cable
- 1 anode
- 1 1 ft x 1ft x 2.5 ft live well
- 1 tow rope

1 flat bottom boat (18 ft Grumman with 20 hp)

2 dip nets

1 measuring board

1 600 g scale (accuracy - 0.1g)

1 6 kg scale (accuracy 1 g)

5 2L buckets (for sorting fish)

1 dissolved Oxygen meter

1 temperature meter

1 conductivity meter

1 clip board

Data sheets

Opportunities of future papers

1) A very significant paper on the importance of a marsh for the recruitment of YOY is possible from the existing data. The paper would complement the information in this thesis, and would build on the thesis, showing why fish show distinct migration in and out of marshes in association with spawning periods, and what the true significance of marshes for fish recruitment is. The paper would compare Cootes Paradise and Hamilton Harbour. Areas to be investigated include, temperature profiles and the effect on spawning time, differences in productivity, productivity differences, YOY abundance, adult abundance, YOY richness and diversity, YOY size at the end of the growing season, and the importance of YOY size for overwintering.

2) A second paper that is possible is the effect carp exclusion from the marsh had on the on the fish of Cootes Paradise, and the fish using the adjacent Grindstone Cr. marsh. Things of interest include changes in species richness and diversity, abundance, and particularly growth rates of the YOY between sites and years. Changes in the fish should also be examined by spawning guilds and habitats (substrate groups, and nesting vs. scattering).

3) Fish reproduction on exposed versus protected shorelines can be examined from the data. The two habitat types are very similar, with the main difference being wind exposure. Differences in species richness and diversity, abundance, average fish sizes, and YOY growth rates should be examined. The study could go further and include the effect of adding rip rap to shorelines on the local fish community.

4) The data set currently extends from 1994 - 1997. Changes in the fish community have occurred during this time period, and different years have seen differential spawning success between species. A paper detailing fish community changes over time, and differences between years can be done. The paper should examine

richness, species abundance, trophic structure, and habitat variables that may contribute to the differences such as temperature and water level.

5) The data contains a substantial amount of information on many species, as well as habitats. Species specific papers relating to important habitat features are possible. Species with substantial amount of data include, carp, brown bullheads, pumpkinseed, spottail shiner, bluntnose minnow, fathead minnow, gizzard shad, white perch, and logperch. Interesting data are available for almost all species found.

6) A paper on the effect of carp on wetlands and resulting effects following carp exclusion is possible. The paper could examine, suspended sediment levels, plankton abundance over the course of the season and between habitats in association with carp abundance and behaviour (spawning). Information from other studies would be required.

7) A paper combining trends within the marsh aquatic community over the season and between years. The paper could include trends in the fish community, suspended sediment, zooplankton, phytoplankton, water levels, and temperature profiles. Data from other studies would be required.

Areas of Future research

1) Overwintering success of YOY fish appears to be an important limiting factor in Hamilton Harbour, as very few of the YOY fish are appearing the following spring. There are two aspects to this project. The first involves determining what the physical habitat requirements of overwintering fish are, particularly YOY. The second relates to YOY size and obtaining the necessary amount of energy reserves so as to be able to survive the dormant winter period. This second part relates back to paper one on Opportunities for Future Papers regarding the importance of marshes for producing large YOY.

2) Fish sampling is done entirely using electrofishing. Electrofishing represents the most effective and efficient way to sample the entire fish community. Determining electrofishing efficiency would be most useful in helping to extrapolate actual fish populations from the data. Also, there appears to be different efficiencies between species, which needs to be investigated.

3) The information relating to species specific habitat features and behaviour is currently incomplete. There are differences in habitat preference between seasons, and ages across species. The entire fish community should be detailed in an attempt to provide perspective on each species role in the ecosystem and each species niche. Two species that provide particular confusion for myself include brown bullhead and yellow bullhead. The two species have overlapping ranges, yet all available habitat information places them in exactly the same niche.

4) A detailed examination of the fish habitat potential of the marsh and harbour is required. This would involve assembling substrate, depth, temperature, and vegetation possibilities for the marsh and harbour. This information would then be contrasted against adult fish habitat niches to determine the potential harbour and marsh fish community. Adult habitat requirements are chosen, as adult fish require the largest space. The harbour's potential fish community can than be compared to available habitat for the other life stages of these species to determine if any habitat features would be limiting to the most suitable species. This information can then help guide future habitat adjustments and additions in the harbour and marsh.

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Table 20. Georeference co-ordintes of the Cootes Paradise transects

Habitat	Transect	Latitude	Longitude
Off-shore	O1	43° 16' 47.2	-79° 53' 41.7
	O2	43° 16' 46.7	-79° 53' 54.5
	O3	43 ° 16' 38.6	-79° 54' 11.2
	O4	43° 16' 30.8	-79° 54' 26.6
	B1	43° 17' 04.2	-79° 53' 50.3
	B2	43° 16' 31.8	-79° 53' 42.7
	B3	43° 16' 45.5	-79° 54' 26.6
	B4	43° 16' 23.6	-79° 54' 55.6
	B5	43° 16' 19.8	-79° 54' 24.0
	B6	43° 16' 19.5	-79° 55' 05.3
Near-shore	E1	43° 17' 00.9	-79° 53' 47.1
	E2	43° 16' 40.5	-79° 53' 38.3
	E3	43° 16' 22.7	-79° 54' 17.1
	E4	43° 16' 50.4	-79° 54' 04.4
	M1	43° 16' 22.4	-79° 55' 07.6
	M2	43° 16' 14.9	-79° 54' 28.1
	M3	43° 16' 10.3	-79° 54' 57.8
	M4	43° 16' 37.0	-79° 54' 47.6
	M5	43° 16' 23.1	-79° 53' 38.3
	N3	43° 16' 17.2	-79° 55' 53.2
	N4	43° 16' 10.7	-79° 55' 46.7
	P1	43° 16' 17.4	-79° 54' 08.6
	P2	43° 16' 27.7	-79° 54' 03.1
	P3	43° 16' 45.8	-79° 54' 30.8
	P4	43° 17' 05.2	-79° 53' 53.3
	P5	43° 16' 30.5	-79° 53' 46.3
Lower River	R1	43° 16' 27.6	-79° 55' 00.3
	R2	43° 16' 24.7	-79° 55' 10.3
	R3	43° 16' 21.7	-79° 55' 21.7
	R4	43° 16' 18.8	-79° 55' 32.8
	C1	43° 16' 19.8	-79° 53' 36.9
	C2	43° 15' 59.0	-79° 53' 37.8

Table 21. Field survey data sheet

Transect ____ ***Date*** ___/___/___ ***Time*** ___:___

Secchi ____cm	Wind dir _____	Weather _____
Cond. _____	W. Strgth _____	Shock ______
D.O. ____mg/l	Avg. depth _____	Amps _____
Temp. ____C	3 m depth _____	Volts _____

	Plant	*%*
Dominant		
Subdom.		
Other		

#	Species	Length	Weight	#	Species	Length	Weight
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Batches

Species	Quantity	Weight (g)	Species	Quantity	Weight (g)
Notes :					

Appendix A. Reference fisheries abundances for Cootes.

Table 22. Average number of fish per transect in each sub-habitat by sampling time between 1994 and 1997.

Year	Month	Bay	Open water	Chedoke	Spencer	Enriched	Exposed	Marsh	Protected
1994	July	-	2.0	-	-	14.5	67.0	68.2	77.0
1994	Aug	-	2.0	-	-	21.5	140.5	255.4	144.0
1995	May	2.5	2.3	-	25.5	3.5	54.5	42.0	470.6
1995	June	5.8	6.3	-	40.0	28.0	90.8	79.6	103.0
1995	July	23.8	3.8	-	105.8	47.0	169.0	110.0	189.4
1995	Aug	7.5	2.0	-	86.0	-	545.5	220.0	367.6
1995	Oct	2.0	1.0	-	13.0	-	76.8	2.4	43.2
1996	April	2.0	1.0	14.5	1.0	38.0	23.0	46.8	33.2
1996	May	4.0	1.0	27.5	3.5	20.0	38.8	45.2	55.0
1996	June	4.0	3.0	16.5	9.3	21.5	186.3	40.0	263.0
1996	July	6.0	13.5	41.0	12.3	108.0	171.8	67.0	172.2
1996	Aug	6.8	6.3	46.0	11.8	16.0	161.5	80.6	344.6
1996	Sept	4.8	1.0	44.5	7.0	21.0	72.0	44.8	139.6
1996	Oct	1.0	1.0	23.5	3.3	-	16.3	5.6	117.4
1997	April	1.3	1.3	27.5	1.0	3.0	4.0	4.6	12.2
1997	May	1.2	1.0	26.0	1.0	1.5	14.0	5.6	9.4
1997	June	2.8	2.8	12.5	3.3	126.0	103.0	7.8	14.4
1997	July	24.8	18.0	122.0	22.3	102.5	453.0	352.4	279.8
1997	Aug	13.8	3.3	402.0	155.0	58.5	677.5	558.0	685.4
1997	Sept	19.2	2.0	196.0	34.8	-	195.0	114.4	218.0

Table 23. Average number of fish per transect in each habitat group and overall by sampling time between 1994 and 1997.

Year	Month	Lower River	Near-shore	Off-shore	Marsh avg.
1994	July	-	63.9	2.0	51.6
1994	Aug	-	162.6	2.0	130.5
1995	May	25.5	174.3	2.4	103.9
1995	June	40.0	83.3	6.0	55.0
1995	July	105.8	141.7	13.8	100.0
1995	Aug	86.0	320.1	4.8	196.6
1995	Oct	13.0	33.6	1.5	21.5
1996	April	5.5	35.5	1.5	20.4
1996	May	11.5	43.5	2.5	26.2
1996	June	11.7	143.9	3.5	80.0
1996	July	21.8	131.2	9.8	76.9
1996	Aug	23.2	175.3	6.5	99.8
1996	Sept	19.5	78.3	2.9	46.4
1996	Oct	10.0	42.6	1.0	25.0
1997	April	9.8	6.6	1.3	5.6
1997	May	9.3	8.4	1.1	6.3
1997	June	6.3	48.4	2.8	26.3
1997	July	55.5	323.6	22.1	179.1
1997	Aug	237.3	565.3	9.6	330.1
1997	Sept	88.5	152.8	12.3	96.8

Table 24. Average transect fish biomass(g) in each sub-habitat by sampling time between 1994 and 1997.

Year	Month	Bay	Open water	Chedoke	Spencer	Enriched	Exposed	Marsh	Protected
1994	July	-	120	-	-	1412	11402	9322	14306
1994	Aug	-	45	-	-	2190	10138	4578	16733
1995	May	23	333	-	26993	2240	10092	51217	29167
1995	June	3243	951	-	14765	8365	16584	27897	33688
1995	July	1821	2634	-	15915	4308	12590	16223	14746
1995	Aug	12732	456	-	1940	-	7796	9365	6088
1995	Oct	13	1653	-	2829	-	661	57	141
1996	April	2277	0	360	413	41658	4962	30307	1791
1996	May	1089	3	7892	3227	47642	44610	57382	44997
1996	June	72	40	8321	16209	31463	15321	21461	19427
1996	July	11	25	10649	4176	17096	15590	40452	25004
1996	Aug	4789	441	7639	3055	5709	11342	13616	8784
1996	Sept	10	1318	11033	5137	965	3613	1338	3060
1996	Oct	0	1830	317	369	-	30	30	406
1997	April	729	601	4841	0	3261	36	4062	266
1997	May	286	43	3879	152	2769	2523	4963	2616
1997	June	366	290	1937	563	32017	806	6454	1032
1997	July	151	35	2918	527	6383	3288	11817	2685
1997	Aug	2817	23	2169	845	269	7590	6662	6270
1997	Sept	4837	20	889	99	-	657	446	620

Table 25. Average transect fish biomass(g) in each habitat and overall by sampling time between 1994 and 1997.

Year	Month	Lower River	Near-shore	Off-shore	Marsh avg.
1994	July	-	10441	95	8348
1994	Aug	-	9456	9	7576
1995	May	26993	27923	178	19863
1995	June	14765	24437	2097	16673
1995	July	15915	13364	2228	10547
1995	Aug	1940	7746	6594	6498
1995	Oct	2829	363	1106	1117
1996	April	395	16478	1138	9171
1996	May	4782	49101	546	27289
1996	June	13580	20541	56	13686
1996	July	6334	26490	18	15399
1996	Aug	4583	10549	2615	7240
1996	Sept	7103	2398	664	2877
1996	Oct	351	167	915	451
1997	April	1614	1769	678	1399
1997	May	1394	3345	189	1993
1997	June	1021	6543	336	3568
1997	July	1324	6152	104	3357
1997	Aug	1286	5972	1699	3758
1997	Sept	362	578	2910	1337

Table 26. Average number of species per transect in each sub-habitat by sampling time between 1994 and 1997.

Year	Month	Open Water	Bay	Spencer	Chedoke	Enriched	Exposed	Marsh	Protected
1994	July	1.8	-	-	-	2.5	6.0	4.6	7.4
1994	Aug	1.5	-	-	-	5.0	9.5	6.0	8.8
1995	May	1.3	1.0	5.8	-	2.5	7.5	4.6	7.8
1995	June	2.8	2.8	7.0	-	4.0	8.5	5.0	8.2
1995	July	2.3	3.5	12.5	-	6.5	8.3	6.6	9.6
1995	Aug	1.5	3.0	9.0	-	-	9.8	7.2	10.6
1995	Oct	0.5	0.8	4.0	-	-	5.5	1.0	4.6
1996	April	0.0	1.0	0.3	3.5	5.0	5.8	5.6	4.8
1996	May	0.3	3.0	2.0	7.0	6.0	7.5	5.4	6.2
1996	June	1.8	2.0	3.8	5.5	4.5	9.3	4.2	8.0
1996	July	2.5	1.5	5.8	6.0	8.5	10.0	7.0	10.6
1996	Aug	1.8	3.8	4.0	6.5	4.5	10.5	7.8	10.2
1996	Sept	1.0	1.3	3.8	4.0	5.5	8.8	6.0	7.6
1996	Oct	0.8	0.0	2.0	4.5	-	4.8	1.6	5.6
1997	April	0.3	0.5	0.0	6.5	2.5	2.3	2.8	4.8
1997	May	0.3	0.3	0.3	6.5	1.5	3.3	3.0	4.0
1997	June	0.8	1.2	2.3	4.5	5.5	7.0	3.0	4.6
1997	July	3.3	5.3	5.3	11.0	7.5	14.3	9.4	14.4
1997	Aug	1.0	3.2	9.5	10.5	5.5	12.8	9.8	11.6
1997	Sept	1.3	4.2	5.0	4.5	-	11.3	4.0	9.6

Table 27. Average number of species per transect in each habitat group and overall by sampling time between 1994 and 1997.

Year	Month	Lower River	Near-shore	Off-shore	Marsh avg.
1994	July	-	5.6	1.8	4.8
1994	Aug	-	7.6	1.5	6.4
1995	May	5.8	6.1	1.1	4.6
1995	June	7.0	6.8	2.8	5.6
1995	July	12.5	7.9	2.9	7.1
1995	Aug	9.0	8.0	2.3	6.5
1995	Oct	4.0	3.1	0.6	2.5
1996	April	1.3	5.3	0.5	3.2
1996	May	3.7	6.3	1.6	4.5
1996	June	4.3	6.7	1.9	4.9
1996	July	5.8	9.1	2.0	6.5
1996	Aug	4.8	8.8	2.8	6.4
1996	Sept	3.8	7.1	1.1	4.9
1996	Oct	2.8	3.4	0.4	2.5
1997	April	2.2	3.3	0.4	2.2
1997	May	2.3	3.2	0.3	2.1
1997	June	3.0	4.8	1.0	3.3
1997	July	7.2	11.9	4.5	8.7
1997	Aug	9.8	10.6	2.3	7.8
1997	Sept	4.8	7.1	3.0	5.4

Appendix B Environmental and electrofisher raw data.

Cootes Paradise electrofishing transects

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Near shore	Enriched	N3	25-Jul-94	11:00 AM		30			Sunny			West	10						111	300	4
Near shore	Enriched	N4	25-Jul-94	2:00 PM		30			Sunny			West	10						90	300	4
Near shore	Exposed	E1	19-Jul-94	12:00 PM		27			Sunny			West	15						150	300	4
Near shore	Exposed	E2	19-Jul-94	2:30 PM		27			Sunny			West	15						153	300	4
Near shore	Exposed	E3	26-Jul-94	9:30 AM		24.7			Sunny			West	20						136	300	4
Near shore	Exposed	E4	20-Jul-94	12:30 PM		27			Overcast				0						91	300	4
Near shore	Marsh	M1	26-Jul-94	2:10 PM		27			Overcast			West	20						160	300	4
Near shore	Marsh	M2	26-Jul-94	11:10 AM		25.9			Sunny			West	20						141	300	4
Near shore	Marsh	M3	25-Jul-94	2:00 PM		30			Sunny			West	20						122	300	4
Near shore	Marsh	M4	20-Jul-94	3:00 PM		28			Overcast			West	20						164	300	4
Near shore	Marsh	M5	21-Jul-94	10:45 AM		27.6			Hazy			West	10						137	300	4
Near shore	Protected	P1	22-Jul-94	2:00 PM		27			P.cloudy			Southwest	20						136	300	4
Near shore	Protected	P2	20-Jul-94	2:30 PM		29			P.cloudy			Southwest	20						124	300	4
Near shore	Protected	P3	20-Jul-94	1:30 PM		27			Overcast				0						126	300	4
Near shore	Protected	P4	20-Jul-94	10:00 AM		27			Overcast			West	10						140	300	4
Near shore	Protected	P5	21-Jul-94	12:30 PM		27			Overcast			West	20						169	400	6
Off shore	Open water	O1	27-Jul-94	10:30 AM		23.7			Overcast			East	20						56	300	4
Off shore	Open water	O2	27-Jul-94	10:30 AM		23.7			Overcast			Southeast	20						65	300	4
Off shore	Open water	O3	27-Jul-94	10:30 AM		23.7			Overcast				0						93	300	4
Off shore	Open water	O4	27-Jul-94	10:00 AM		23.7			Overcast				0						91	300	4
Near shore	Enriched	N3	12-Aug-94	11:20 AM		24			Overcast			Southwest	15						134	400	6
Near shore	Enriched	N4	12-Aug-94	11:40 AM		24			Overcast			Southwest	15						109	400	6
Near shore	Exposed	E1	8-Aug-94	1:00 PM		27			Sunny			West	35						197	400	6
Near shore	Exposed	E2	9-Aug-94	9:45 AM		22.8			Overcast			West	35						166	400	6
Near shore	Exposed	E3	11-Aug-94	2:00 PM		23			Overcast			West	20						160	400	6
Near shore	Exposed	E4	11-Aug-94	12:10 PM		24.3			Sunny			South	20						164	400	6
Near shore	Marsh	M1	11-Aug-94	12:00 PM		26			Overcast			West	2						155	400	6
Near shore	Marsh	M2	11-Aug-94	12:00 PM		26			Overcast			West	5						94	400	6
Near shore	Marsh	M3	15-Aug-94	10:15 AM		19			P.cloudy			Northwest	40						180	400	6
Near shore	Marsh	M4	12-Aug-94	2:00 PM		27			Overcast			East	40						194	400	6
Near shore	Marsh	M5	9-Aug-94	11:00 AM		22.8			Overcast			West	20						170	400	6
Near shore	Protected	P1	9-Aug-94	2:15 PM		24.3			Overcast			Calm	0						164	400	6
Near shore	Protected	P2	11-Aug-94	10:30 AM		23			Sunny			Southeast	10						250	400	6
Near shore	Protected	P3	10-Aug-94	2:45 PM		24.5			P.cloudy			Southeast	20						213	400	6
Near shore	Protected	P4	8-Aug-94	3:00 PM		28			Sunny			West	20						207	400	6
Near shore	Protected	P5	9-Aug-94	12:45 PM		23.6			Overcast			West	15						142	400	6
Off shore	Open water	O1	11-Aug-94	12:00 PM		25			Overcast			West	5						77	400	6
Off shore	Open water	O2	11-Aug-94	12:00 PM		25.6			Overcast			West	5						76	400	6
Off shore	Open water	O3	11-Aug-94	12:00 PM		21			Overcast			West	10						80	400	6
Off shore	Open water	O4	11-Aug-94	12:00 PM		21			Overcast			West	5						63	400	6
Near shore	Exposed	E1	26-May-95	11:00 AM		17.8			NR	30	50	Northeast	15		0		0	0	120	600	3
Near shore	Exposed	E2	26-May-95	2:00 PM		19.5			NR	25	50				0		0	0	162	600	3
Near shore	Exposed	E4	30-May-95	11:20 AM		19.2	12.8		NR	20	40	East	5	P.pectinatis	20		0	20	125	600	3
Near shore	Marsh	M2	31-May-95	1:30 PM		23	13.8		NR	20	25	West	25	Typha	12	sparganium	10	27	165	600	3
Near shore	Marsh	M5	29-May-95	10:15 AM		18			NR	40		West	35	Typha	30		0	30	145	600	3
Near shore	Protected	P1	30-May-95	2:45 PM		23	10		NR	20	40	West	10		0		0	0	169	600	3
Near shore	Protected	P2	30-May-95	1:00 PM		20.5	13.2		NR	30	60	West	15		0		0	0	137	600	3
Near shore	Protected	P4	26-May-95	12:15 PM		20.6			NR	20	40				0		0	0	114	600	3
Near shore	Protected	P5	29-May-95	11:15 AM		17			NR	30	40	West	25	Polygonum	1		0	1	113	600	3
Off shore	Bay	B1	30-May-95	11:45 AM		19.8			NR	80		West	5		0		0	0	65	600	3
Off shore	Bay	B2	26-May-95	3:00 PM		21.5			NR	40				P.pectinatis	2		0	2	100	600	3
Off shore	Bay	B3	31-May-95	12:50 PM		21.2	16.8		NR	50		West	20		0		0	0	55	600	3
Lower River	Spencer	R1	5-Jun-95	10:00 AM		17.5	9.2		NR			West	5	P.pectinatis	5		0	5	93	600	3
Lower River	Spencer	R1	29-Jun-95	1:55 PM		23	6.8		NR			Southwest	5						242	500	5

Cootes Paradise electrofishing transects — Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Off shore	Bay	B3	21-Jul-95	11:25 AM		24.5	12		NR	55		East	10		0		0	0	80	600	6
Off shore	Bay	B4	21-Jul-95	10:00 AM		24	9.2		NR	50		East	5		0		0	0	87	600	6
Off shore	Open water	O1	21-Jul-95	9:30 AM		20	8		NR	100		East	5		0		0	0	119	600	6
Off shore	Open water	O2	25-Jul-95	11:00 AM		24.8	8.4		NR	100		Southeast	5		0		0	0	72	600	6
Off shore	Open water	O4	21-Jul-95	10:50 AM		24	12		NR	60		East	10		0		0	0	79	600	6
Lower River	Spencer	R1	4-Aug-95	3:00 PM		23.6	11.3		NR	30	70	Calm	0	P pectinatis	60		0	60	305	500	5
Lower River	Spencer	R1	24-Aug-95	1:10 PM	33	22	11		NR			North	10						83	500	5
Lower River	Spencer	R2	24-Aug-95	12:45 PM	29	21.5	13.6		NR			Northwest	5						116	500	5
Lower River	Spencer	R2	8-Aug-95	1:45 PM		23.5	13		NR	30	75	East	15	P.pectinatis	10		0	10	195	500	5
Lower River	Spencer	R3	3-Aug-95	2:30 PM		23	8.6		NR	40	80	Southeast	15	P.pectinatis	20		0	20	183	500	5
Lower River	Spencer	R3	24-Aug-95	11:15 AM	35	20	9.6		NR			Northeast	10						94	500	5
Lower River	Spencer	R4	3-Aug-95	1:45 PM		23	8		NR	50	90	Southeast	15	P.pectinatis	1		0	1	234	500	5
Lower River	Spencer	R4	24-Aug-95	10:30 AM	27	19.5	9.4		NR			Northeast	10						189	500	5
Near shore	Enriched	N3	21-Aug-95						To Shallow												
Near shore	Enriched	N3	8-Aug-95	11:45 AM		26	14.2		NR	20		Northeast	15	Spyrogyra	50		0	50	142	500	5
Near shore	Enriched	N4	21-Aug-95						To Shallow												
Near shore	Enriched	N4	8-Aug-95	1:00 PM		26	18		NR	20		Northeast	15	Spyrogyra	50	Typha	20	70	110	500	5
Near shore	Exposed	E1	18-Aug-95	10:00 AM	36	27	10.8		NR			East	5						249	500	5
Near shore	Exposed	E2	18-Aug-95	1:15 PM	30	28	16.2		NR			East	5						335	500	5
Near shore	Exposed	E3	23-Aug-95	1:15 PM	26	25	12		NR			West	15						329	500	5
Near shore	Exposed	E4	23-Aug-95	11:00 AM	27	24	9.1		NR			West	10						299	500	5
Near shore	Marsh	M1	2-Aug-95	2:45 PM		24.5	7.3		NR	20	20	East	20	Typha	30		0	30	190	500	5
Near shore	Marsh	M1	22-Aug-95	12:45 PM	40	24.8	13		NR			Northwest	5						289	500	5
Near shore	Marsh	M2	2-Aug-95	11:30 AM		24.5	4.3		NR	15	25	East	15	Typha	12	sparganium	10	27	170	500	5
Near shore	Marsh	M2	23-Aug-95	2:45 PM	24	25.8	12		NR			Northwest	10						308	500	5
Near shore	Marsh	M3	3-Aug-95	11:00 AM		24	9		NR	20	25	Southeast	5	Typha	20	Sparganium	10	32	284	500	5
Near shore	Marsh	M3	25-Aug-95	10:30 AM	15	19	8.9		NR			East	20						213	500	5
Near shore	Marsh	M4	4-Aug-95	1:30 PM		28.5	9.9		NR	20	20	West	5	Typha	30		0	30	295	500	5
Near shore	Marsh	M4	25-Aug-95	12:00 PM	13	23	6.3		NR			East	20						184	500	5
Near shore	Marsh	M5	21-Aug-95	11:00 AM	30	28	10.4		NR			West	20						260	500	5
Near shore	Protected	P1	21-Aug-95	1:00 PM	32	27	4		NR			West	20						285	500	5
Near shore	Protected	P2	18-Aug-95	2:30 PM	25	29	16.2		NR			East	10						290	500	5
Near shore	Protected	P3	21-Aug-95	2:15 PM	22	30.8	13.2		NR			Northwest	20						315	500	5
Near shore	Protected	P4	18-Aug-95	11:00 AM	33	28	12.2		NR			Southeast	5						355	500	5
Near shore	Protected	P5	21-Aug-95	9:30 AM	33	28.2	13.2		NR			East	5						258	500	5
Off shore	Bay	B1	22-Aug-95	10:10 AM	35	24.5	9		NR			North	5						71	500	5
Off shore	Bay	B2	23-Aug-95	9:45 AM	15	22.6	8.3		NR			Southwest	10						165	500	5
Off shore	Bay	B3	22-Aug-95	11:20 AM	20	25.2	11		NR			West	5						97	500	5
Off shore	Bay	B4	24-Aug-95	2:00 PM	11	26	11.2		NR			Northwest	5						89	500	5
Off shore	Open water	O1	22-Aug-95	9:45 AM	20	24	5		NR			North	5						90	500	5
Off shore	Open water	O2	22-Aug-95	10:40 AM	24	24.5	8.5		NR			North	5						98	500	5
Off shore	Open water	O3	3-Aug-95	10:00 AM		23.8	8.3		NR	85		East	15		0		0	0	80	600	6
Off shore	Open water	O3	22-Aug-95	11:00 AM	22	24.5	9.5		NR			Northeast	5						97	500	5
Off shore	Open water	O4	24-Aug-95	2:30 PM	24	25.5	15.2		NR			Northwest	5						101	500	5
Lower River	Spencer	R1	19-Oct-95	2:00 PM		9.7	12.3	600	NR	30	40	East	15		0		0	0	105	400	4
Lower River	Spencer	R2	19-Oct-95	12:30 PM		9.6	12.1	600	NR	30	40	East	10		0		0	0	102	400	4
Lower River	Spencer	R3	19-Oct-95	11:30 AM		9.4	12.7	600	NR	40	60	East	10		0		0	0	105	400	4
Lower River	Spencer	R4	19-Oct-95	11:00 AM		9.5	12.1	590	NR	50	70	East	10		0		0	0	113	400	4
Near shore	Enriched	N3	18-Oct-95						To Shallow	5											
Near shore	Enriched	N4	18-Oct-95						To Shallow	5											
Near shore	Exposed	E1	16-Oct-95	11:00 AM		9.4	13	580	NR	20	40	Northwest	25		0		0	0	221	400	4
Near shore	Exposed	E2	17-Oct-95	10:50 AM		8.6	15.3	560	NR	15	30	Calm	0		0		0	0	324	400	4

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Off shore	Open water	O3	2-Aug-96	3:05 PM	30	24.7	14.8		Sunny	110		South	10		0		0	0	73	600	6
Off shore	Open water	O4	2-Aug-96	10:00 AM	21	23	10		Sunny	90		calm	0		0		0	0	94	600	6
Off shore	Open water	O4	28-Aug-96	10:00 AM	38	22.2	9.5	650	P.cloudy	65		East	15		0		0	0	63	600	6
Lower River	Spencer	R1	30-Sep-96	2:00 PM	70	13.9	12	620	P.cloudy	60	80	North	5		0		0	0	130	600	6
Lower River	Spencer	R2	30-Sep-96	2:15 PM	70	13.9	12	620	P.cloudy	60	80	North	10		0		0	0	140	600	6
Lower River	Spencer	R4	30-Sep-96	2:30 PM	88	13.7	12.2	690	P.cloudy	60	90	Northwest	5		0		0	0	100	600	6
Near shore	Enriched	N3	30-Sep-96	3:00 PM	40	22.1	20	710	Sunny	20		Calm	0	Typha	1	Juncus	0.5	1.5	139	400	6
Near shore	Enriched	N4	30-Sep-96	3:30 PM	80	21.6	7.2	810	P.cloudy	15		Calm	0	Typha	30		0	30	120	400	6
Near shore	Marsh	M5	3-Sep-96	2:30 AM	30	29.8	15.7	990	Sunny	40		Southeast	10	Typha	30	Polygonum	5	35	300	600	6
Near shore	Protected	P1	3-Sep-96	11:30 AM	35	25.2	10.2	710	Sunny	25	50	Calm	0		0		0	0	399	400	4
Near shore	Protected	P3	30-Sep-96	11:30 AM	50	14	10.5	500	P.cloudy	15	25	East	15		0		0	0	143	400	6
Near shore	Protected	P5	3-Sep-96	1:15 PM	38	26.8	11.6	850	P.cloudy	40	60	East	10	Polygonum	5		0	5	401	600	6
Off shore	Bay	B1	30-Sep-96	10:30 AM	25	14.9	9.7	520	Sunny	75		Calm	0		0		0	0	85	600	6
Off shore	Bay	B2	30-Sep-96	11:00 AM	20	14.8	7.7	590	Sunny	25		Calm	0		0		0	0	89	600	6
Off shore	Bay	B3	30-Sep-96	12:00 PM	20	15.6	10.4	500	Sunny	42		West	10		0		0	0	91	600	6
Off shore	Bay	B4	30-Sep-96	12:55 PM	150	13.9	12	620	Sunny	20		Calm	0		0		0	0	75	600	6
Off shore	Open water	O1	30-Sep-96	10:20 AM	30	14.3	9.1	490	Sunny	115		Calm	0		0		0	0	80	600	6
Off shore	Open water	O2	30-Sep-96	11:30 AM	30	16	10.3	540	Sunny	95		Calm	0		0		0	0	79	600	6
Off shore	Open water	O3	30-Sep-96	11:40 AM	20	13.4	8.8	540	Sunny	80		Calm	0		0		0	0	81	600	6
Off shore	Open water	O4	30-Sep-96	12:40 PM	70	13.9	12	620	Sunny	40		Calm	0		0		0	0	70	600	6
Lower River	Chedoke	C1	3-Oct-96	4:15 PM	40	15.4	8.9	810	Sunny	30	60	North	10		0		0	0	97	500	7
Lower River	Chedoke	C2	3-Oct-96	3:40 PM	100	14.9	12.7	490	Sunny	40	50	North	10	Polygonum	2	P.pectinatis	1	3	75	500	7
Lower River	Spencer	R3	3-Oct-96	1:40 PM	100	12.2	11	505	P.cloudy	50	100	East	5		0		0	0	86	600	6
Near shore	Exposed	E1	1-Oct-96	2:00 PM	35	20.1	10.9	550	Sunny	45	60	West	5		0		0	0	218	400	6
Near shore	Exposed	E1	29-Oct-96	9:30 AM	75	11	7.8	480	Sunny	30	50	Calm	0		0		0	0	174	400	4
Near shore	Exposed	E2	2-Oct-96	4:00 PM	23	16.9	6.4	750	Overcast	40	55	Southwest	10		0		0	0	249	400	6
Near shore	Exposed	E3	29-Oct-96	12:25 PM	10	9.5	13.2	510	Sunny	35	55	Southeast	10		0		0	0	130	300	3
Near shore	Exposed	E3	3-Oct-96	10:30 AM	20	12	8.9	500	Sunny	25	45	Northwest	15		0		0	0	208	400	6
Near shore	Exposed	E4	29-Oct-96	10:30 AM	50	12	9.3	500	Sunny	25	35	Southeast	10		0		0	0	175	300	3
Near shore	Exposed	E4	2-Oct-96	2:30 PM	20	19.1	9.9	600	Overcast	30	40	Northwest	35		0		0	0	164	400	6
Near shore	Marsh	M1	1-Oct-96	9:30 AM	40	14.4	12	610	Sunny	20		Calm	0	Typha	20		0	20	150	400	6
Near shore	Marsh	M2	1-Oct-96	12:00 PM	50	17.7	10.4	540	Sunny	30		Calm	0	Tyhpa	12	sparganium	10	27	130	400	6
Near shore	Marsh	M3	1-Oct-96	11:10 AM	40	15	10.4	490	Sunny	20		Calm	0	Typha	20	Spargnium	10	20	147	400	6
Near shore	Marsh	M4	1-Oct-96	10:30 AM	100	16.7	10.6	560	Sunny	20		Calm	0	Typha	30		0	30	197	400	6
Near shore	Marsh	M5	2-Oct-96	11:45 AM	30	17.9	7.2	1000	Overcast	30		West	35	Typha	30		0	30	130	400	6
Near shore	Protected	P1	29-Oct-96						To Shallow												
Near shore	Protected	P1	3-Oct-96	10:00 AM	85	11.1	0.6	600	P.cloudy	30	50	Northwest	35		0		0	0	159	400	6
Near shore	Protected	P2	3-Oct-96	9:00 AM	30	13.6	8.2	540	Sunny	30	60	Northwest	5	Polygonum	2		0	2	195	400	6
Near shore	Protected	P2	29-Oct-96	1:00 PM	35	10.7	12.9	480	Sunny	40	60	Southeast	10		0		0	0	173	300	4
Near shore	Protected	P3	29-Oct-96	11:30 AM	50	11.5	9.4	600	Sunny	20	25	South	5		0		0	0	170	300	4
Near shore	Protected	P4	29-Oct-96	10:00 AM	50	11.6	9.4	700	Sunny	30	45	North	5		0		0	0	209	350	4
Near shore	Protected	P4	1-Oct-96	3:00 PM	32	19.9	10.1	650	Sunny	25	45	West	5		0		0	0	180	400	5
Near shore	Protected	P5	2-Oct-96	9:30 AM	30	17.5	8.4	650	Overcast	45	65	West	15	Polygonum	3		0	3	171	400	6
Lower River	Chedoke	C1	1-Nov-96	1:00 PM	120	6.7	11.8	790	Overcast	55	60	West	40		0		0	0	147	300	3.5
Lower River	Chedoke	C2	1-Nov-96	2:30 PM	120	8	13.5	790	Overcast	25	40	West	30	Polygonum	1		0	1	67	300	3.5
Lower River	Spencer	R1	6-Nov-96	11:00 AM	145	7.4	13	520	Overcast	80	90	South	10		0		0	0	92	500	5
Lower River	Spencer	R2	6-Nov-96	11:13 AM	130	7.4	12.3	520	Overcast	60	70	South	30		0		0	0	90	500	5
Lower River	Spencer	R3	6-Nov-96	11:30 AM	140	7.4	12.1	490	Overcast	80	90	South	30		0		0	0	89	500	5
Lower River	Spencer	R4	6-Nov-96	11:40 AM	140	7.4	12.2	500	Overcast	100	120	South	30		0		0	0	78	500	5
Near shore	Enriched	N3	1-Nov-96						To Shallow												
Near shore	Enriched	N4	1-Nov-96						To Shallow												
Near shore	Exposed	E2	1-Nov-96	1:00 PM	10	4.6	13	480	Overcast	20	30	Northwest	30		0		0	0	101	300	3
Near shore	Marsh	M1	1-Nov-96						To Shallow												
Near shore	Marsh	M2	5-Nov-96	1:30 PM	100	7.3	16	500	Sunny	20		Southeast	15	Tyhpa	12	sparganium	10	27	93	400	4

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Near shore	Marsh	M3	5-Nov-96	1:14 PM	100	7.7	15.3	500	P.cloudy	20		Southeast	10	Typha	20	Spargnium	10	30	103	400	4
Near shore	Marsh	M4	1-Nov-96						To Shallow					to shallow							
Near shore	Marsh	M5	1-Nov-96	12:00 PM	100	6.9	12	780	Sunny	10	15	Northwest	40		0		0	0	98	300	3.5
Near shore	Protected	P5	1-Nov-96	10:00 AM	20	3.9	12.8	450	Sunny	20	30	Northwest	40		0		0	0	117	300	3
Off shore	Bay	B1	5-Nov-96	11:10 AM	45	6.9	12	480	Overcast	65		East	15		0		0	0	63	500	5
Off shore	Bay	B2	5-Nov-96						To Shallow												
Off shore	Bay	B3	5-Nov-96	12:10 PM	60	6.9	13.5	450	Overcast	42		East	10		0		0	0	87	400	4
Off shore	Bay	B4	5-Nov-96	12:40 PM	100	8	15.6	450	Overcast	15		East	15		0		0	0	84	400	4
Off shore	Open water	O1	5-Nov-96	11:00 AM	85	8.5	10.9	450	Overcast	90		East	15		0		0	0	73	500	5
Off shore	Open water	O2	5-Nov-96	11:30 AM	50	6.4	12 2	490	Overcast	80		East	15		0		0	0	82	500	5
Off shore	Open water	O3	5-Nov-96	11:50 AM	47	6.4	6.7	490	Overcast	70		East	15		0		0	0	87	500	5
Off shore	Open water	O4	5-Nov-96	12:30 PM	55	6.7	12.8	450	Overcast	50		East	15		0		0	0	102	400	4
Lower River	Chedoke	C1	22-Apr-97	10:30 AM	80	8.9	14.1	680	overcast	50	0	south	5		0		0	0	112	500	4.5
Lower River	Chedoke	C2	22-Apr-97	11:10 AM	45	9.2	13.4	950	overcast	50	70	south	5		0		0	0	80	400	4
Lower River	Spencer	R1	23-Apr-97	10:40 AM	150	7.6	13.2	420	sunny	95	120	southeast	10		0		0	0	113	450	4
Lower River	Spencer	R2	23-Apr-97	12:45 PM	150	8	14.1	445	sunny	60	80	east	5		0		0	0	116	450	4
Lower River	Spencer	R3	23-Apr-97	12:50 PM	150	8	14.1	445	sunny	100	150	east	5		0		0	0	81	450	4
Lower River	Spencer	R4	23-Apr-97	12:30 PM	150	7.9	14.1	445	sunny	100	150	east	5		0		0	0	89	450	4
Near shore	Enriched	N3	23-Apr-97	11:00 AM	38	10.9	20	700	sunny	47	0	southeast	10	Typha	1		1	1	98	450	4
Near shore	Enriched	N4	23-Apr-97	11:15 AM	35	11	20	710	sunny	50	0	southeast	10	Typha	30		0	30	151	450	4
Near shore	Exposed	E1	23-Apr-97	1:30 PM	83	11.1	14.6	600	sunny	50	85	east	5		0		0	0	188	450	4
Near shore	Exposed	E2	21-Apr-97	10:15 AM	120	7.8	13.2	480	sunny	50	70	calm	0		0		0	0	167	500	4.5
Near shore	Exposed	E3	21-Apr-97	12:55 PM	120	8	15	450	sunny	50	70	calm	0		0		0	0	168	450	4
Near shore	Exposed	E4	21-Apr-97	11:35 AM	105	9.6	13.5	490	sunny	30	50	calm	0		0		0	0	232	500	4.5
Near shore	Marsh	M1	23-Apr-97	10:15 AM	32	9.2	13.3	500	sunny	70	0	southeast	10	Typha	30		0	30	120	450	4
Near shore	Marsh	M2	22-Apr-97	2:30 PM	100	9.5	13.8	450	overcast	60	0	southwest	5	Typha	12	sparganium	10	27	173	450	4
Near shore	Marsh	M3	22-Apr-97	2:10 PM	100	9.7	15.5	460	overcast	70	0	southwest	5	Typha	20	sparganium	10	30	118	450	4
Near shore	Marsh	M4	22-Apr-97	1:40 PM	40	9.9	11.6	410	overcast	65	0	west	5	Typha	30		0	30	133	450	4
Near shore	Marsh	M5	23-Apr-97	2:00 PM	80	12.2	13.8	438	sunny	60	0	east	5	Typha	30		0	30	438	450	4
Near shore	Protected	P1	21-Apr-97	1:10 PM	100	10.4	12.8	500	sunny	60	40	southeast	5		0		0	0	209	450	4
Near shore	Protected	P2	21-Apr-97	1:25 PM	90	9.9	14	490	sunny	45	80	southeast	5		0		0	0	174	450	4
Near shore	Protected	P3	21-Apr-97	12:10 PM	95	9	14.3	490	sunny	45	50	southwest	5		0		0	0	205	500	4.5
Near shore	Protected	P4	21-Apr-97	11:00 AM	100	8.2	13.1	490	sunny	40	60	calm	0		0		0	0	219	500	4.5
Near shore	Protected	P5	21-Apr-97	2:45 PM	75	10.4	14.9	600	sunny	50	70	east	10		0		0	0	162	450	4
Off shore	Bay	B1	22-Apr-97	12:25 PM	105	9.1	14	490	overcast	118	0	calm	0		0		0	0	88	450	4
Off shore	Bay	B2	22-Apr-97	10:00 AM	75	8.9	14.3	480	overcast	60	0	calm	0		0		0	0	61	500	4.5
Off shore	Bay	B3	23-Apr-97	10:00 AM	66	9.2	13.2	475	sunny	72	0	southeast	10		0		0	0	76	450	4
Off shore	Bay	B4	22-Apr-97	1:25 PM	100	8.8	14	440	overcast	83	0	west	5		0		0	0	80	450	4
Off shore	Bay	B5	22-Apr-97	1:10 PM	80	9.5	13 9	460	overcast	88	0	calm	0		0		0	0	92	450	4
Off shore	Bay	B6	22-Apr-97	2:00 PM	95	9.8	14.2	460	overcast	85	0	southwest	5		0		0	0	74	450	4
Off shore	Open water	O1	22-Apr-97	12:20 PM	93	9	14.3	480	overcast	130	0	calm	0		0		0	0	54	450	4
Off shore	Open water	O2	22-Apr-97	12:40 PM	100	9	13.6	480	overcast	122	0	calm	0		0		0	0	69	450	4
Off shore	Open water	O3	22-Apr-97	12:50 PM	110	9	14.8	450	overcast	120	0	calm	0		0		0	0	63	450	4
Off shore	Open water	O4	22-Apr-97	1:00 PM	120	9.1	14.1	460	overcast	100	0	calm	0		0		0	0	68	450	4
Lower River	Chedoke	C1	20-May-97	10:55 AM	106	12.1	10.7	880	Sunny	90	120	Northeast	7		0		0	0	140	400	4
Lower River	Chedoke	C2	20-May-97	11:15 AM	116	12.2	11.5	1000	P.sunny	80	114	Northeast	10		0		0	0	119	500	4
Lower River	Spencer	R1	21-May-97	2:15 PM	137	11.2	10.6	500	P.Sunny	90	110	West	15		0		0	0	97	500	4
Lower River	Spencer	R2	21-May-97	3:10 PM	130	11.2	12.7	490	Sunny	75	100	West	15		0		0	0	116	400	4
Lower River	Spencer	R3	21-May-97	3:20 PM	130	11.2	12.7	490	Sunny	70	90	West	15	P.pectinatis	5		0	5	147	400	4
Lower River	Spencer	R4	21-May-97	3:00 PM	130	11.2	12.7	490	Sunny	70	95	West	15		0		0	0	132	400	4
Near shore	Enriched	N3	21-May-97	2:30 PM	70	13.9	15.3	790	P.sunny	62	0	West	10	Typha	2		0	2	138	500	4
Near shore	Enriched	N4	21-May-97	2:50 PM	70	14.3	15.1	800	P.sunny	65	0	West	15	Typha	30		0	30	131	500	4
Near shore	Exposed	E1	20-May-97	10:00 AM	72	11.7	11.4	510	P.sunny	70	90	West	15		0		0	0	154	400	3
Near shore	Exposed	E2	21-May-97	11:00 AM	68	11.4	12.8	550	Cloudy	60	80	Northwest	20		0		0	0	383	400	3

Cootes Paradise electrofishing transects

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Near shore	Exposed	E3	20-May-97	1:30 PM	75	12.3	13.5	530	cloudy	60	80	West	15		0		0	0	209	400	3
Near shore	Exposed	E4	20-May-97	11:55 AM	95	13.1	14	550	Sunny	60	70	West	10		0		0	0	306	400	3
Near shore	Marsh	M1	21-May-97	1:45 PM	150	12.9	13.8	510	P.Sunny	80	0	West	15	Typha	30		0	30	160	400	3
Near shore	Marsh	M2	22-May-97	1:20 PM	95	13.4	12.9	520	Sunny	65	0	Northeast	10	Typha	12	Sparganium	10	27	230	500	4
Near shore	Marsh	M3	23-May-97	11:12 AM	38	14.6	11.9	520	Sunny	69	0	West	5	Typha	15	Sparganium	15	35	140	500	4
Near shore	Marsh	M4	23-May-97	10:27 AM	81	13.4	11.1	500	Sunny	71	0	West	5	Typha	30		0	30	150	500	4
Near shore	Marsh	M5	21-May-97	10:30 AM	50	11.2	10.3	590	P.sunny	70	0	Northwest	15	Typha	30		0	30	178	400	3
Near shore	Protected	P1	20-May-97	2:45 PM	55	14.2	14.6	600	P.Sunny	50	65	West	15		0		0	0	243	400	3
Near shore	Protected	P2	20-May-97	2:30 PM	84	12.7	13.2	550	P.sunny	50	75	West	15		0		0	0	228	400	4
Near shore	Protected	P3	20-May-97	1:00 PM	63	13.3	13.7	520	P.sunny	30	50	West	15		0		0	0	349	400	3
Near shore	Protected	P4	20-May-97	10:30 AM	78	12.9	13.5	550	Sunny	60	80	West	15	P.crispis	0.5		0	0.5	230	400	3
Near shore	Protected	P5	21-May-97	9:30 AM	85	11.3	12	590	Cloudy	50	80	Northwest	15	Smartweed	5		0	5	232	400	3
Off shore	Bay	B1	21-May-97	1:00 PM	87	12.7	12 5	510	P.sunny	135	0	Northwest	15		0		0	0	116	500	4
Off shore	Bay	B2	22-May-97	10:39 AM	72	12.4	12 8	590	P.Sunny	75	0	West	7		0		0	0	69	500	4
Off shore	Bay	B3	21-May-97	1:30 PM	90	12.9	13.6	510	P.sunny	110	0	Northwest	15		0		0	0	60	500	4
Off shore	Bay	B4	22-May-97	1:40 PM	112	12.8	12.2	500	P.sunny	100	0	West	10		0		0	0	75	500	4
Off shore	Bay	B5	23-May-97	9:52 AM	69	12.9	9.6	510	Sunny	115	0	West	5		0		0	0	71	500	4
Off shore	Bay	B6	23-May-97	11:30 AM	61	13.7	12.7	510	sunny	105	0	West	10		0		0	0	105	500	4
Off shore	Open water	O1	22-May-97	9:53 AM	80	12.2	13	500	P.Sunny	158	0	West	7		0		0	0	72	500	4
Off shore	Open water	O2	22-May-97	10:10 AM	95	12.3	13.2	50	P.Sunny	148	0	West	7		0		0	0	73	500	4
Off shore	Open water	O3	22-May-97	10:26 AM	85	12.1	12.8	490	P.Sunny	135	0	West	7		0		0	0	69	500	4
Off shore	Open water	O4	22-May-97	1:10 PM	100	13.2	13.9	500	Sunny	110	0	West	10		0		0	0	96	500	4
Lower River	Chedoke	C1	26-Jun-97	10:00 AM	72	25.8	5	990	Sunny	80	120	Calm	0		0		0	0	107	500	6
Lower River	Chedoke	C2	26-Jun-97	10:30 AM	67	25.5	4.2	1020	Sunny	65	100	Calm	0	polygonum	5		0	5	99	500	6
Lower River	Spencer	R1	26-Jun-97	12:00 PM	25	22.3	7.7	700	P.sunny	70	100	Northwest	5		0		0	0	89	500	6
Lower River	Spencer	R2	26-Jun-97	1:00 PM	25	22.3	7.7	700	P.sunny	50	70	Northwest	5		0		0	0	90	500	6
Lower River	Spencer	R3	26-Jun-97	12:45 PM	25	22.3	7.7	700	P.sunny	70	100	Northwest	5		0		0	0	86	500	6
Lower River	Spencer	R4	26-Jun-97	12:00 PM	25	23.2	7	700	P.sunny	70	100	Northwest	5	P.pectinatis	15		0	15	86	500	6
Near shore	Enriched	N3	24-Jun-97	1:15 PM	22	28		980	Sunny	40	0	West	5	Typha	1	Juncus	0.5	1.5	138	500	6
Near shore	Enriched	N4	24-Jun-97	2:00 AM	25	29		980	Sunny	50	0	West	5	Typha	30	Mylfoil	1	31	150	500	6
Near shore	Exposed	E1	27-Jun-97	11:20 AM	75	27.7	3.7	650	Sunny	60	80	West	5	P.pectinatis	5	P.crispis	1	6	165	400	5
Near shore	Exposed	E2	27-Jun-97	12:40 PM	78	27.3	6.2	690	Sunny	65	82	Northwest	3	polygonum	2		0	2	147	400	5
Near shore	Exposed	E3	30-Jun-97	10:00 AM	85	26.8	4.4	650	Overcast	47	70	West	5		0		0	0	156	400	5
Near shore	Exposed	E4	30-Jun-97	10:40 AM	65	26.8	3.8	610	Overcast	38	53	West	10		0		0	0	127	400	5
Near shore	Marsh	M1	26-Jun-97	11:45 AM	45	26.8	2.8	660	Sunny	62	0	Northwest	7	Typha	30	P.pectinatis	2	32.5	89	500	6
Near shore	Marsh	M2	24-Jun-97	10:00 AM	75	25.2	2.2	670	Sunny	60	0	Calm	0	Spatganium	15	Typha	12	32	179	500	6
Near shore	Marsh	M3	24-Jun-97	11:40 AM	70	27.1	4	710	Sunny	60	0	West	5	Typha	25	Sparganium	10	40	140	500	6
Near shore	Marsh	M4	24-Jun-97	11:00 AM	90	26.2	3	690	Sunny	128	0	west	5	Typha	30	P.pectinatis	5	35	128	600	6
Near shore	Marsh	M5	25-Jun-97	10:30 AM	35	25.8	3.8	690	Sunny	60	0	West	15	Typha	30	P.pectinatis	1	31	218	400	6
Near shore	Protected	P1	25-Jun-97	2:30 PM	120	26.9	3.5	620	Sunny	50	70	West	15	Nymphea	0.5			0.5	190	400	6
Near shore	Protected	P2	25-Jun-97	2:00 PM	23	26.8	4.7	700	Sunny	60	90	west	20	polygonum	5	P.pectinatis	0.5	5.5	245	400	6
Near shore	Protected	P3	25-Jun-97	1:40 PM	80	27.9	4.1	700	Sunny	40	60	west	15		0		0	0	210	400	6
Near shore	Protected	P4	25-Jun-97	1:00 PM	23	28	4	750	Sunny	60	80	West	15	P.crispis	2	Mylfoil	0.5	2.5	253	400	6
Near shore	Protected	P5	25-Jun-97	11:45 AM	55	25.6	4.6	600	P.sunny	60	80	West	15	polygonum	5		0	5	318	400	6
Off shore	Bay	B1	23-Jun-97	11:30 AM	90	25.7	3.7	690	Sunny	130	0	Northwest	3		0		0	0	76	500	6
Off shore	Bay	B2	26-Jun-97	11:00 AM	75	27.2	5.2	700	Sunny	75	0	Northwest	5		0		0	0	62	500	6
Off shore	Bay	B3	23-Jun-97	1:02 PM	85	26.5	3.7	710	Sunny	80	0	East	10	Mylfoil	1		0	1	68	600	6
Off shore	Bay	B4	26-Jun-97	11:30 AM	70	26.8	3.9	620	Sunny	90	0	Northwest	5	P.pectinatis	2		0	2	62	500	6
Off shore	Bay	B5	23-Jun-97	9:40 AM	64	25.2	3	640	Sunny	110	0	Calm	0	P.crispis	1		0	1	114	600	6
Off shore	Bay	B6	24-Jun-97	11:15 AM	60	26	4.4	690	Sunny	103	0	west	10	P.crispis	2		0	2	62	500	6
Off shore	Open water	O1	23-Jun-97	11:17 AM	125	25.4	4.6	690	Sunny	135	0	Northwest	3		0		0	0	60	600	6
Off shore	Open water	O2	23-Jun-97	12:05 PM	52	25.1	3.5	680	Sunny	130	0	Northwest	3	Mylfoil	1		0	1	69	600	6
Off shore	Open water	O3	23-Jun-97	12:40 PM	130	25.9	3.7	680	Sunny	125	0	East	7	P.pectinatis	1.5	Mylfoil	0.5	2	71	600	6
Off shore	Open water	O4	23-Jun-97	1:20 PM	120	25.7	4	690	P.sunny	100	0	East	10		0		0	0	66	600	6

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Lower River	Chedoke	C1	25-Jul-97	12:40 PM	55	22.6	14.3	990	overcast	75	129	east	10		0		0	0	151	500	6
Lower River	Chedoke	C2	25-Jul-97	1:50 PM	40	22.5	20	930	overcast	60	75	east	5		0		0	0	162	500	6
Lower River	Spencer	R1	31-Jul-97	1:30 PM	50	21.8	10	720	sunny	70	100	south	5	P.pectinatis	50		0	50	107	500	6
Lower River	Spencer	R2	31-Jul-97	1:00 PM	45	22.8	9.3	760	sunny	50	100	west	10	P.pectinatis	10		0	10	110	500	6
Lower River	Spencer	R3	31-Jul-97	11:45 AM	45	22.8	9.3	760	sunny	60	100	west	10	P.pectinatis	5		0	5	84	500	6
Lower River	Spencer	R4	31-Jul-97	11:30 AM	38	21.4	10.7	700	sunny	50	90	northwest	10	P.pectinatis	5		0	5	131	500	6
Near shore	Enriched	N3	31-Jul-97	10:00 AM	30	24.2	13.7	940	sunny	30	0	northwest	5	Typha	2	Juncus	1	3	161	500	6
Near shore	Enriched	N4	31-Jul-97	11:00 AM	40	25.2	10.7	920	sunny	30	0	northwest	5	Typha	30	Spirogyra	20	55	109	500	5
Near shore	Exposed	E1	30-Jul-97	2:30 PM	47	27.1	12.4	700	sunny	45	60	west	1	mylfoil	0.5		0	0.5	254	400	5
Near shore	Exposed	E2	30-Jul-97	2:30 PM	35	25.7	10.7	690	sunny	40	60	southeast	5		0		0	0	322	400	5
Near shore	Marsh	M1	28-Jul-97	10:30 AM	45	27	12.9	820	sunny	50	0	west	10	Typha	30	p.pectinatis	20	50	136	450	5
Near shore	Marsh	M2	29-Jul-97	2:30 PM	25	27.2	9.9	800	P.sunny	50	0	northwest	10	P.pectinatis	30	Sparganium	15	72	282	500	6
Near shore	Marsh	M3	29-Jul-97	1:30 AM	35	26.6	16.2	790	p.sunny	50	0	north	5	Typha	20	Sparganium	10	40	283	550	6
Near shore	Marsh	M4	28-Jul-97	3:00 PM	45	27.8	11.5	820	sunny	48	0	west	5	P.pectinatis	30	Typha	30	60	231	550	6
Near shore	Marsh	M5	30-Jul-97	1:00 PM	48	27.8	12.4	730	sunny	62	0	east	1	Typha	30	P.pectinatis	2	35	367	400	5
Near shore	Protected	P5	30-Jul-97	11:30 AM	27	23.3	6.4	610	sunny	38	45	west	2	polygonum	5	P.pectinatis	2	8	387	400	5
Off shore	Bay	B1	25-Jul-97	11:00 AM	60	23.4	5.8	670	overcast	128	0	east	5	Mylfoil	5		0	5	118	600	6
Off shore	Bay	B2	25-Jul-97	12:10 PM	42	22.9	9.4	740	overcast	63	0	east	5		0		0	0	75	600	6
Off shore	Bay	B3	28-Jul-97	1:30 PM	45	28.2	10.7	690	sunny	78	0	northwest	10	Mylfoil	15	P.crispus	5	22	102	500	6
Off shore	Bay	B4	29-Jul-97	12:30 PM	25	25.4	9.5	750	sunny	80	0	north	10	P.pectinatis	5		0	5	101	550	6
Off shore	Bay	B5	25-Jul-97	2:30 PM	50	24.2	10.3	690	overcast	68	0	calm		mylfoil	0.5		0	0.5	158	600	6
Off shore	Bay	B6	29-Jul-97	1:00 PM	30	25.5	10.2	700	sunny	80	0	north	3	P.pectinatis	3		0	3	107	550	6
Off shore	Open water	O1	25-Jul-97	11:30 AM	65	22.5	5.7	650	overcast	134	0	east	5	Mylfoil	0.5		0	0.5	75	600	6
Off shore	Open water	O2	25-Jul-97	11:45 AM	58	22.6	6	660	overcast	130	0	east	5	Mylfoil	1		0	1	89	600	6
Off shore	Open water	O3	28-Jul-97	12:30 PM	52	26	9.8	720	sunny	110	0	northwest	5	P.pectinatis	5	Mylfoil	1	6	78	600	6
Off shore	Open water	O4	28-Jul-97	1:45 PM	49	26.9	9.2	820	sunny	95	0	northwest	10	p.pectinatis	3	mylfoil	1	4	125	600	6
Lower River	Chedoke	C1	27-Aug-97	10:50 AM	40	20	8	980	p.sunny	60	110	west	5	P.pectlatis	1		0	1	119	500	5
Lower River	Chedoke	C2	27-Aug-97	11:45 AM	45	19.3	9	900	p.sunny	30	70	west	5	grass	2		0	2	105	500	5
Lower River	Spencer	R4	27-Aug-97	2:45 PM	32	18.4	8.2	610	p.sunny	40	60	west	5	P.pectinatis	2		0	2	123	500	5
Near shore	Enriched	N3	27-Aug-97	1:30 PM	35	28	20	790	sunny	20	0	west	10	Algae	40	Typha	2	42	125	400	5
Near shore	Enriched	N4	27-Aug-97	2:15 PM	30	28	20	800	p.sunny	15	0	west	10	Spyrogyra	10		0	10	140	400	5
Near shore	Exposed	E1	25-Aug-97	1:30 PM	50	22.6	10.8	560	sunny	30	50	southeast	15	Mylfoil	8	Elodea	5	15.5	249	400	4
Near shore	Exposed	E2	29-Aug-97	11:20 AM	26	21.5	9.1	580	overcast	30	45	west	5	P.pectinatis	1		0	1	233	400	5
Near shore	Exposed	E3	1-Aug-97	2:00 PM	28	25.1	79	750	overcast	50	70	west	10	P.pectinatis	1		0	1	323	450	5
Near shore	Exposed	E3	28-Aug-97	1:00 PM	45	22.6	11.9	610	sunny	25	55	west	10	Mylfoil	1	Ceratophyllum	1	2	207	400	5
Near shore	Exposed	E4	1-Aug-97	10:30 AM	45	24.6	8.4	615	sunny	40	50	west	12	Elodea	5	P.pectinatis	3	10.5	271	400	5
Near shore	Marsh	M1	26-Aug-97	3:10 PM	40	22.6	113	720	overcast	40	0	southeast	5	P.pectinatis	30	Typha	30	75	150	500	5
Near shore	Marsh	M2	26-Aug-97	1:50 PM	55	21.7	10.4	650	p.sunny	40	0	calm	0	Ceratophyllum	40	Typha	12	95	117	600	6
Near shore	Marsh	M3	26-Aug-97	12:50 PM	47	21	8.6	600	overcast	50	0	southeast	5	P.pectinatis	40	Typha	30	73	151	600	6
Near shore	Marsh	M4	26-Aug-97	11:15 AM	33	20.4	4.6	690	p.sunny	40	0	southeast	5	P.pectinatis	40	Typha	30	80	141	600	6
Near shore	Marsh	M5	29-Aug-97	12:50 PM	20	21.5	8.6	520	p.sunny	37	50	north	10	Typha	30	P.pectinatis	5	40	353	400	5
Near shore	Protected	P1	1-Aug-97	3:30 PM	48	25.3	7.2	760	overcast	40	50	west	5	lemna	15		0	15	305	400	5
Near shore	Protected	P1	28-Aug-97	11:21 AM	43	21.1	7.3	650	sunny	40	70	west	5	Elodea	1	P.pectinatis	1	4	217	400	5
Near shore	Protected	P2	28-Aug-97	10:28 AM	25	21.6	8.8	580	sunny	35	55	west	20	Elodea	4	P.pectinatis	4	16	225	400	5
Near shore	Protected	P2	1-Aug-97	2:00 PM	35	25.3	8.8	740	overcast	50	70	west	5	Polygonum	5	P.pectinatis	2	7	279	400	5
Near shore	Protected	P3	1-Aug-97	12:00 PM	30	25.1	8.1	670	p.sunny	20	35	west	10	Elodea	7	P.crispus	4	13	250	400	5
Near shore	Protected	P3	28-Aug-97	2:15 PM	30	24.3	10.2	520	p.sunny	15	23	west	5	Mylfoil	5	Elodea	2	9	226	400	5
Near shore	Protected	P4	1-Aug-97	9:30 AM	45	23.7	7.1	660	sunny	45	60	west	10	P.crispis	15	Elodea	10	35	240	450	5
Near shore	Protected	P4	25-Aug-97	2:40 PM	50	23.7	10.5	601	sunny	35	50	east	15	Elodea	15	P.crispis	10	35	402	400	5
Near shore	Protected	P5	29-Aug-97	10:00 AM	25	20.5	7.4	520	overcast	15	20	west	5	polygonum	10	Elodea	10	30	252	400	5
Off shore	Bay	B1	25-Aug-97	10:20 AM	32	19.4	7.6	550	sunny	95	0	northeast	5	Mylfoil	15	Ceratophyllum	2	18	153	600	6
Off shore	Bay	B2	25-Aug-97	11:00 AM	30	19.7	12.8	650	sunny	50	0	notheast	5		0		0	0	69	600	6
Off shore	Bay	B3	25-Aug-97	11:45 AM	39	20.1	9.2	550	sunny	74	0	southeast	15	Mylfoil	10	Ceratophyllum	2	12.5	100	600	6
Off shore	Bay	B4	26-Aug-97	10:38 AM	50	20.7	9.1	620	overcast	60	0	southeast	5	Mylfoil	1		0	1	67	600	6

Cootes Paradise electrofishing transects

Variables measured with each visit

Sites					Chemistry				Conditions					Aquatic vegetation					Electrofisher		
Habitat	Sub-hab.	Trans.	Date	Time	Secchi (cm)	Temp (C)	D.O. (mg/l)	Cond.	Sky	Avg. depth(cm)	3m depth	Wind Dir.	Wind (km/hr)	Dominant plant	Dom. cover (%)	Subdom. plant	Subdom. cover (%)	Total cover (%)	Fishing effort	Volts	Amps
Off shore	Bay	B5	25-Aug-97	12:00 PM	42	19.8	12	610	sunny	70	0	southeast	15		0		0	0	110	600	6
Off shore	Bay	B6	26-Aug-97	10:58 AM	30	20.8	9.3	710	overcast	60	0	southeast	5	Ceratophyllum	2		0	2	70	600	6
Off shore	Open water	O1	25-Aug-97	10:00 AM	48	18.5	8.7	600	sunny	115	0	northeast	5	P.pectinatis	0.5		0	0.5	78	600	6
Off shore	Open water	O2	25-Aug-97	10:40 AM	30	19	11	600	sunny	110	0	northeast	5		0		0	0	75	600	6
Off shore	Open water	O3	26-Aug-97	10:00 AM	42	20.4	9	590	overcast	100	0	southeast	5	P.pectinatis	1		0	1	61	600	6
Off shore	Open water	O4	26-Aug-97	10:22 AM	50	20.1	8.7	560	overcast	80	0	southeast	5	P.pectinatis	5	Mylfoil	2	6.5	55	600	6
Lower River	Chedoke	C1	19-Sep-97	10:30 AM	78	18.7	7.6	610	Overcast	50	70	calm	0		0		0	0	240	600	6
Lower River	Chedoke	C2	19-Sep-97	11:30 AM	80	17.4	6.1	800	Overcast	35	40	calm	0		0		0	0	175	600	6
Lower River	Spencer	R1	2-Sep-97	11:30 AM	38	20.2	9.9	640	overcast	40	60	west	5	P.pectinatis	20		0	20	208	500	5
Lower River	Spencer	R1	22-Sep-97	12:30 PM	70	13.2	11.1	650	Sunny	50	70	west	10	P.pectinatis	10		0	10	130	500	5
Lower River	Spencer	R2	22-Sep-97	3:00 PM	70	13.6	13.6	650	Sunny	45	60	west	10		0		0	0	113	500	5
Lower River	Spencer	R2	2-Sep-97	2:00 PM	38	20	9.2	750	overcast	40	60	west	5	P.pectinatis	5		0	5	160	500	5
Lower River	Spencer	R3	22-Sep-97	2:00 PM	60	13.6	13.6	650	Sunny	50	70	west	10		0		0	0	121	500	5
Lower River	Spencer	R3	2-Sep-97	1:30 PM	38	19.9	10.2	700	overcast	40	70	west	5	P.pectinatis	5		0	5	166	500	5
Lower River	Spencer	R4	22-Sep-97	1:30 PM	52	13.6	13.6	650	Sunny	50	70	west	10		0		0	0	131	500	5
Near Shore	Enriched	N3	22-Sep-97						To Shallow		0										
Near Shore	Enriched	N4	22-Sep-97						To Shallow		0										
Near Shore	Exposed	E1	23-Sep-97	10:00 AM	44	16.2	7.9	530	Overcast	30	40	west	5	Mylfoil	40	Elodea	20	65	252	400	4
Near Shore	Exposed	E2	24-Sep-97	12:45 PM	62	15.3	11.9	510	Sunny	40	60	west	6	Elodea	3	Mylfoil	1	4	273	400	4
Near Shore	Exposed	E3	24-Sep-97	12:00 PM	63	14.1	11.8	500	Sunny	40	50	west	5		0		0	0	322	400	4
Near Shore	Exposed	E4	23-Sep-97	11:45 AM	60	16.2	6.8	510	Overcast	30	50	west	5	Elodea	3	Mylfoil	2	5	309	400	4
Near shore	Exposed	E4	2-Sep-97	10:00 AM	38	23.5	10	470	sunny	30	50	northwest	10	P.pectinatis	10	Elodea	5	17	251	400	4
Near Shore	Marsh	M1	22-Sep-97						To Shallow		0										
Near Shore	Marsh	M2	22-Sep-97	9:45 AM	60	14.3	5.7	490	Sunny	30	0	southwest	10	Ceratophyllum	40	Elodea	20	90	154	500	5
Near Shore	Marsh	M3	22-Sep-97	10:30 AM	50	13.6	10	480	Sunny	20	0	west	10	Typha	20	Elodea	10	45	140	500	5
Near Shore	Marsh	M4	22-Sep-97	11:00 AM	60	16.1	13	500	Sunny	15	0	west	10	Typha	30	Ceratophyllum	15	65	176	500	5
Near Shore	Marsh	M5	24-Sep-97	2:20 PM	56	16.8	11	800	Sunny	25	0	calm	0	Typha	30	Elodea	15	46	279	400	4
Near Shore	Protected	P1	24-Sep-97	11:54 AM	80	13.1	14.5	640	Sunny	25	40	calm	0	Elodea	2	Coontail	1	4	208	400	4
Near Shore	Protected	P2	24-Sep-97	10:00 AM	62	14.3	11.1	520	Sunny	42	60	calm	0	Elodea	5	Mylfoil	1	6	256	400	4
Near Shore	Protected	P3	23-Sep-97	12:45 PM	60	16.2	8.1	482	P.sunny	30	40	west	5	Mylfoil	5	Elodea	2	7	265	400	4
Near Shore	Protected	P4	23-Sep-97	11:00 AM	60	16.6	6.5	530	Overcast	30	40	west	5	Mylfoil	20	Elodea	5	25	179	400	4
Near Shore	Protected	P5	24-Sep-97	1:30 PM	53	16.1	12.3	600	Sunny	28	43	calm	0	Elodea	5	polygonum	1	6.5	231	400	4
Off Shore	Bay	B1	18-Sep-97	10:10 AM	10	21.4	9.3	560	Sunny	83	0	southwest	10	Mylfoil	5		0	5	182	600	6
Off Shore	Bay	B2	19-Sep-97	10:00 AM	50	19.7	5.6	710	Overcast	30	0	southwest	10		0		0	0	105	600	6
Off Shore	Bay	B3	18-Sep-97	12:05 PM	46	20.8	12.2	570	Sunny	60	0	southwest	5	Mylfoil	5	Elodea	1	6.5	90	600	6
Off Shore	Bay	B4	18-Sep-97	11:00 AM	50	18.2	8.9	500	Sunny	40	0	calm	0		0		0	0	80	600	6
Off Shore	Bay	B5	18-Sep-97	11:15 AM	30	19.8	10.7	560	Sunny	50	0	west	5		0		0	0	150	600	6
Off Shore	Bay	B6	18-Sep-97	11:40 AM	80	19.5	10.4	570	Sunny	50	0	calm	0	Mylfoil	3	Ceratophyllum	1	4	85	600	6
Off Shore	Open Water	O1	18-Sep-97	10.00 AM	41	19.4	6.5	510	Sunny	98	0	west	3		0		0	0	69	600	6
Off Shore	Open Water	O2	18-Sep-97	10:25 AM	31	19 2	8	550	Sunny	98	0	west	3	P.pectinatis	0.1		0	0.1	79	600	6
Off Shore	Open Water	O3	18-Sep-97	10:30 AM	40	19.6	8.8	520	Sunny	80	0	west	3		0		0	0	80	600	6
Off Shore	Open Water	O4	18-Sep-97	10:45 AM	80	18 5	9.1	600	Sunny	70	0	calm	0	Mylfoil	0.5		0	0.5	92	600	6

Appendix C Monthly fish catch summary

Cootes Paradise monthly electrofishing summar (50 m transects) July 1994

Species	Total	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4
Bluegill	3													1	1			1			
Bluntnose Minnow	4														4						
Bluntnose Minnow (y	8							1							5	1	1				
Brook Silversides	1										1										
Brown Bullhead	12									2			4						6		
Brown Bullhead (yoy)	122							12	76	1	1	4	6		1	7	10	1	2		1
Carp	86					11	1	10	2	3	8	2	9	3	6	3		10	16	2	
Carp (yoy)	106							6		17	44	8	2	1	2	3	1	1		14	7
Emerald Shiner	1	1																			
Fathead Minnow	6						1								4	1					
Fathead Minnow (yoy	5			1													3			1	
Freshwater Drum	1		1																		
Gizzard Shad (yoy)	1									1											
Goldfish (yoy)	18										15					1			2		
Green Sunfish	1																		1		
Johnny Darter	1					1															
Largemouth Bass	7								1		1			1			1	3			
Largemouth Bass (yo	1								1												
Logperch(yoy)	52					6	7	1	15		1				2	6	1	10	3		
Mirror Carp (yoy)	2									1	1										
No Fish	1				1																
Pumpkinseed	269					10	25	30		6	17	19	3	44	35	10	4	24	39	3	
Pumpkinseed (yoy)	266						1	6	1	50	10	19	6	27	22	52	3	37	31	1	
Spottail Shiner	4						3		1												
Spottail Shiner (yoy)	11	1		1					1				1			2	4		1		
White Perch	16					7	7	2													
White Perch (yoy)	24		1	1			6	15				1									
Yellow Perch (yoy)	2								1						1						
Grand Total:	1031	2	2	3	1	35	51	83	99	81	99	53	31	77	83	86	28	87	101	21	8

Cootes Paradise monthly electrofishing summar (50 m transects) May 1995

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4
Alewife	1								1																				
Bigmouth Buffalo	2														2														
Bluegill	20										1		1						7		2	7	2						
Bluntnose Minnow	102										3	24	14		1				2	2	13	20				1	4	17	1
Brook Silversides	2												2																
Brown Bullhead	21											1		1	8	7	2	1										1	
Carp	215									3	4	8		47	10	14	36	2	24	11	1	12		1	2	13	17	7	3
Carp x Goldfish	3													2										1					
Chinook Salmon (yoy	1				1																								
Common Shiner	1																											1	
Creek Chub	2																				1							1	
Fathead Minnow	34											29			1				2									2	
Freshwater Drum	1																			1									
Gizzard Shad	2					2																							
Golden Shiner	1																						1						
Goldfish	1																			1									
Green Sunfish	6										1								1		1	1			1	1			
Johnny Darter	15									2	2		5									1						2	3
Largemouth Bass	3											1										1	1						
Logperch	4									1	1		1							1									
No Fish	2	1						1																					
Pumpkinseed	388		3	2						4	21	65	8	2	28	8	1	29	24	26	36	71	47	2		3	2	5	1
Spottail Shiner	34		3							1	3	2	1					5		1	2	1				1	2		12
Spottail Shiner (yoy)	2006																				2000		6						
Tadpole Madtom	1																		1										
White Perch	40						3		1	1	5	3			1	1	1		2	6	3	10	1						2
White Sucker	1								1																				
Grand Total:	2909	1	6	2	1	2	3	1	3	12	41	133	32	52	51	30	40	37	63	49	2059	124	58	4	3	19	25	36	22

Cootes Paradise monthly electrofishing summar (50 m transects) April, 1996

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Black Crappie	1											1																			
Bluegill	1																		1												
Bluntnose Minnow	20										4			3		1			2	1		3		5						1	
Brook Silversides	1	1																													
Brown Bullhead	14													3	2			2	1				3	3							
Carp	96		2							4				18	25	8		8	1				1	8	20		1				
Carp x Goldfish	1														1																
Emerald Shiner	6												1					2		1			2								
Fathead Minnow	4															1						2		1							
Gizzard Shad	4		1									2			1																
Goldfish	3													1		1								1							
Johnny Darter	2										1		1																		
Mirror Carp	1																							1							
No Fish	9			1	1	1	1	1	1																	1		1	1		
Northern Pike	3																	1					1	1							
Pumpkinseed	67									2	6	2			1	2	1	11	16				19							7	
Spottail Shiner	312		2							2	6	41	7	19	12	11		81		16	13	15	61	22	1					2	1
Trout Perch	5										2	1	1								1										
White Perch	36										2	2		4	5			8					1	13						1	
White Sucker	17																					1								16	
Yellow Perch	10									1	1	1	1			1			2		1		1							1	
Grand Total:	613	1	5	1	1	1	1	1	1	9	22	50	11	48	47	25	1	113	23	18	15	21	89	55	21	1	1	1	1	28	1

Cootes Paradise monthly electrofishing summar (50 m transects) May, 1996

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Bluegill	25									2		1	3		1	1			2	3	1	10		1							
Bluntnose Minnow	48									1			8							1	32	2		1	1		1		1		
Brook Silversides	4														1							3									
Brown Bullhead	65	1	1	1							1			14	20	4	5	4				2	8	2	1					1	
Carp	302		2							9	2	55	1	13	20	40	17	21	7	22	44	7	6	11	18		3		1	2	1
Carp x Goldfish	1											1																			
Emerald Shiner	4			1						1	2																				
Fathead Minnow	7										1										2			1			1			2	
Gizzard Shad	5	1														4															
Goldfish	2																								1					1	
Green Sunfish	1											1																			
Johnny Darter	2											1										1									
Logperch	10									4		2	1							1		1						1			
Mirror Carp	1																				1										
No Fish	3					1	1	1																							
Pumpkinseed	193			1	1					3	5	9	13	6	15	8	3	6	13	17	20	32	20		1					18	2
Rainbow Trout	1																													1	
Spotfin Shiner	1																				1										
Spottail Shiner	45		3	1	2						2		1		1	12		1			7		1			5				1	8
White Perch	58			1					1	1	1	14	8		1	5	1	1		3	3	1	1	1	1					3	11
White Sucker	7												1					1								1				2	2
Grand Total:	785	2	6	5	3	1	1	1	1	21	14	84	36	33	59	74	26	34	22	47	111	59	36	17	23	6	5	1	2	31	24

Cootes Paradise monthly electrofishing summar (50 m transects) Sept 1996

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Black Crappie (yoy)	1																		1												
Bluegill (yoy)	313									19	8	15	3	4		2	13	14	90	12	12	53	62	2						4	
Bluntnose Minnow	1										1																				
Bluntnose Minnow (y	58									2	6	3				1	2		3	1		33	6	1							
Brook Silversides (yo	3	2						1																							
Brown Bullhead	3										1				1			1													
Brown Bullhead (yoy)	22								1		2			2	2	4	1		4					1	1					4	
Carp	42					1				3		1						13		4			4	1		1	1		6		7
Carp (yoy)	16										3			1		1	4							6	1						
Carp x Goldfish	1																	1													
Emerald Shiner	1		1																												
Emerald Shiner (yoy)	9		7										1					1													
Fathead Minnow	1																				1										
Fathead Minnow (yoy	3										2	1																			
Gizzard Shad (yoy)	6		2				1				2													1							
Goldfish (yoy)	32		1								2					1		10			8		3	1	1					5	
Green Sunfish	1													1																	
Green Sunfish (yoy)	1																						1								
Johnny Darter (yoy)	15									4	1		2		1				1			3					1		2		
Largemouth Bass (yo	14											2	1		2				3	1	1	4									
Logperch(yoy)	46									11	6	1	9									15	2			1	1				
No Fish	2			1	1																										
Pumpkinseed	101									1	4	2		2		1	2	35	3	1			1							48	1
Pumpkinseed (yoy)	539									25	25	26	3	35	19	6	10	19	35	6	11	155	113	16	10	2		2	4	17	
Spottail Shiner	1											1																			
Spottail Shiner (yoy)	18		4									9	1													2	1				1
Tadpole Madtom (yo	8																		1			7									
White Perch (yoy)	114									8	28	24	19							25	1	3	6								
White Sucker	1																										1				
Yellow Perch (yoy)	19														4	6		2				1	1			1			2	2	
Grand Total:	1392	2	15	1	1	1	1	1	1	73	91	85	39	45	29	22	32	96	141	50	34	274	199	29	13	7	5	2	14	80	9

Cootes Paradise monthly electrofishing summar (50 m transects) Oct 1996

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Blacknose Dace (yoy	1																									1					
Bluegill (yoy)	183									7		2	5					1		10	4	143	9							2	
Bluntnose Minnow (y	328									4		7	1		1			1		3	8	296	2			4				1	
Brown Bullhead (yoy)	6																													6	
Brown Trout	1																					1									
Carp	3						1		1											1											
Carp x Goldfish (yoy)	2																				1									1	
Channel Catfish (yoy)	1									1																					
Creek Chub (yoy)	1																				1										
Emerald Shiner (yoy)	13										2				1						2		8								
Fathead Minnow (yoy	6																					4					2				
Golden Shiner (yoy)	1																						1								
Goldfish (yoy)	11															1					5		2							3	
Green x Pumpkinsee	1																													1	
Johnny Darter (yoy)	3									3																					
Largemouth Bass	1																			1											
Largemouth Bass (yo	5											1	1														1			2	
Logperch(yoy)	3									1			1									1									
No Fish	5	1	1	1	1			1																							
Northern Pike	1																												1		
Pumpkinseed	24														1			1		1			1							20	
Pumpkinseed (yoy)	103									3		7	10		7			7		5	4	35	12			2				10	1
Rainbow Trout	1					1																									
Silver Shiner	1																											1			
To Shallow	6													1			1		2					1	1						
White Perch (yoy)	36										2	3	4		5					18	2	2									
White Sucker	1																										1				
Yellow Perch (yoy)	2																			2											
Grand Total:	750	1	1	1	1	1	1	1	1	19	4	20	22	1	15	1	1	10	2	41	27	482	35	1	1	7	4	1	1	46	1

Cootes Paradise monthly electrofishing summar (50 m transects) April 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Black Crappie	1																	1													
Bluegill	5																		2				1							2	
Bluntnose Minnow	25										5	1			1				5			9		1						2	1
Brown Bullhead	12													2				1	3											6	
Carp	13														6		1	2	1					1	1						1
Carp x Goldfish	3														1			1												1	
Emerald Shiner	17										1										11	4	1								
Johnny Darter	7										1	1	2								2	1									
No fish	12		1	1	1	1		1	1	1						1										1	1	1	1		
Northern Pike	1																													1	
Pumpkinseed	37										1							1	2		1	2								30	
Rainbow Trout	1	1																													
Spottail Shiner	13											2			1			1		1	2	1	1		1					1	2
White Perch	6																	2							2						2
White Sucker	10						2														1	1								2	4
Yellow Perch	11												1		1				4	2		2	1								
Grand Total:	174	1	1	1	1	1	2	1	1	1	8	4	3	2	10	1	1	9	17	3	17	20	4	2	4	1	1	1	1	45	10

Cootes Paradise monthly electrofishing summar (50 m transects) June 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Alewife	2																												2		
Black Crappie (yoy)	23									10	5	8																			
Bluegill	11									2		1			2				4				1							1	
Bluegill (yoy)	1																		1												
Bluntnose Minnow	106									2	44									2				57			1				
Bluntnose Minnow (y	14									2	4									4			1	3							
Brown Bullhead	12		1				4				1				2		1													2	1
Carp	36									1				1	8	3	2	3		1			1	7	9						
Carp (yoy)	21																							21							
Carp x Goldfish	4														1			2							1						
Common Shiner	13																							13							
Fathead Minnow	33									4	2	3	3							3	1		15							2	
Fathead Minnow (yoy	21						3			2	1													15							
Freshwater Drum	1						1																								
Gizzard Shad (yoy)	15									4	11																				
Green Sunfish	5									1													3							1	
Johnny Darter	1									1																					
Logperch	7									6	1																				
Logperch(yoy)	182									179	2		1																		
No Fish	6	1		1	1	1		1	1																						
Northern Pike	2																														2
Northern Pike (yoy)	12									1								2	1	1		5	1			1					
Pumpkinseed	76									32	4		2		4		1	6		3			8	10	3					3	
Pumpkinseed (yoy)	3																		1				2								
Spottail Shiner	11																										1				10
Spottail Shiner (yoy)	1																		1												
Tadpole Madtom	1																					1									
White Perch	8										4							1					1	1		1					
White Sucker	3																									1		1	1		
White Sucker (yoy)	115																			1				110		3	1				
Yellow Perch	1																													1	
Yellow Perch (yoy)	81									53	13		2							4			5	2						2	
Grand Total:	828	1	1	1	1	1	8	1	1	300	92	12	8	1	17	3	4	14	8	19	1	6	38	239	13	6	3	1	3	12	13

Cootes Paradise monthly electrofishing summar (50 m transects) July 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Alewife	2	1						1																							
Black Bullhead (yoy)	32																			32											
Black Crappie (yoy)	73	1								4	21	2	3		2	5	1	8	5	1	1	9	8							2	
Blackside Darter (yoy	3												1									1							1		
Bluegill	16										1				3	1		4	3	2		2									
Bluegill (yoy)	6																		2	1	1	1	1								
Bluntnose Minnow	22									1		8	2						5	4	1									1	
Bluntnose Minnow (y	1196									511	14	10	350				6	8	23	161	66		37	9						1	
Brook Silversides	1	1																													
Brook Silversides (yo	8									1			2	3		1	1														
Brown Bullhead	15										4			1			5			1			2							2	
Brown Bullhead (yoy)	1218			1				2			15	9	4		1083	32	13	6	2	24	1		15	2	6					1	2
Carp	39											2	1	1	4	3	18			3				4	1						2
Carp (yoy)	406									1	99	46	21		38	17		35	16	22	9	8	5	67	15					7	
Carp x Goldfish	1		1																												
Carp x Goldfish (yoy)	2											2																			
Channel Catfish (yoy)	1									1																					
Creek Chub	7												4								1	2									
Creek Chub (yoy)	1																			1											
Emerald Shiner	21					15												1		4										1	
Fathead Minnow	83									3	3	11	11			1		1		1	11									40	1
Fathead Minnow (yoy	149		8				1	9	2	4	20	2	1			3	24	17		8	12		5	6	4					21	2
Freshwater Drum (yo	1												1																		
Gizzard Shad (yoy)	92		1	3			10	10	4	1	7		1	5		5	26	4				14		1							
Golden Shiner	1																		1												
Goldfish (yoy)	2												1						1												
Green Sunfish	6										1								3			1								1	
Green Sunfish (yoy)	1																							1							
Green x Pumpkinsee	1																					1									
Johnny Darter	1									1																					
Johnny Darter (yoy)	200									117	1		34						2	11	16	4	1			1	11		2		
Largemouth Bass	1																		1												
Largemouth Bass (yo	15									1	2		7						3		1	1									
Logperch	19									3			2							1		8	1				2		2		
Logperch(yoy)	241		1							39	15	22	25		4	2		5	30	56	10	29	2							1	
Mirror Carp (yoy)	1											1																			
Northern Pike	1																														1
Northern Pike (yoy)	1																			1											
Pumpkinseed	41								1		5		1		5	3	1	9	8		2	1								4	1
Pumpkinseed (yoy)	1030	1		10	6			10	3	2	94	22	23	3	29	52	3	164	108	28	32	88	236	41	36			1	1	32	5
River Chub (yoy)	4									1			1							1	1										
Spottail Shiner	4																														4
Spottail Shiner (yoy)	121		9		1			3										10					6	8	1	11			4	62	6
Tadpole Madtom	2										1												1								
Tadpole Madtom (yo	2																				1	1									
Trout Perch (yoy)	9																										7	1	1		
White Perch	8										1	6								1											
White Perch (yoy)	173	1			3			1			13	79	33		1	7		17		1	13		2							1	1
White Sucker	10																									2	3	1			4

Cootes Paradise monthly electrofishing summar (50 m transects) July 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
White Sucker (yoy)	11		1										1							1					2		1	2	1	2	
Yellow Perch (yoy)	336			3	1					9	20	16	7	13	7	2	8	31	56	23	5	26	38		1	1	22	5	6	10	26
Grand Total:	5637	5	21	17	11	15	11	36	10	700	337	238	537	26	1176	134	106	320	269	389	184	197	360	139	66	15	46	10	18	189	55

Cootes Paradise monthly electrofishing summar (50 m transects) Aug 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Black Crappie (yoy)	39	3									3		6	1				12	3	2	1	2	1							1	4
Bluegill	9																	4	5												
Bluegill (yoy)	21													1					2			18									
Bluegill x Pumpkinse	2																	1	1												
Bluntnose Minnow	3											1								2											
Bluntnose Minnow (y	368									108	17	48	23		1	4	21		3	79	53		1	8		1		1			
Brook Silversides (yo	3									1												1					1				
Brown Bullhead	8																1	1	1												5
Brown Bullhead (yoy)	716	12		1							3	17	35	20	259	178	36	29	1	8	12	5	15	12	10					60	3
Carp	10	3												1		1	1	2				2									
Carp (yoy)	2001	3		1							54	9	640	17	74	40	48	340			135	129	429	28	5	6	7		20	9	7
Creek Chub	4												1									3									
Creek Chub (yoy)	1																												1		
Emerald Shiner	7		1								3	3																			
Fathead Minnow (yoy	420		1							7	10	135	24	2	7	17	10	4		43	141	2	4	2			2	1	1	5	2
Gizzard Shad (yoy)	135	4		2	3	7			1		1	11	44	4	11	4	1	7		3	2	11	3					3		11	2
Goldfish	1																	1													
Goldfish (yoy)	10																	6						3		1					
Green Sunfish	5										1											1								1	2
Green Sunfish (yoy)	1																					1									
Johnny Darter (yoy)	113									35	2	2	11							10	5	16	1			5	6	14	6		
Largemouth Bass	1																						1								
Largemouth Bass (yo	18										3	2	2	1				1				7	1							1	
Logperch	6										3											2					1				
Logperch(yoy)	74									8	11	9	6			1				8		28	1				1		1		
Mirror Carp (yoy)	8										1							1			5										1
No fish	2						1	1																							
Northern Pike (yoy)	1																														1
Pumpkinseed	146										14	1	1	4	4	7	1	60	5	1		2	4				5		5	23	9
Pumpkinseed (yoy)	4721	20	1	11						56	203	297	268	146	183	109	172	760	309	316	324	272	397	30	15	35	90	25	53	544	85
Pumpkinseed x Gree	1																													1	
Spottail Shiner (yoy)	28		1						2		2	2					6						2			1	3	7	1		1
Tadpole Madtom	7														1				4				2								
Tadpole Madtom (yo	2																						2								
Trout Perch (yoy)	35																										34		1		
White Perch (yoy)	998									33	112	283	82		2			4	1	295	80	20	68				5	8	4	1	
White Sucker (yoy)	45											2	1	3		1	1								2		19	3	13		
Yellow Perch	3																										1			1	1
Yellow Perch (yoy)	575								1	2	21	10	20	39	28	21	15	52	12	3	4	77	17	2		75	101	32	20	7	16
Grand Total:	10548	45	4	15	3	7	1	1	4	250	464	832	1164	239	570	383	313	1285	347	770	762	599	949	85	32	124	276	94	126	665	139

(50 m transects) Sept 1997

Species	Total	B1	B2	B3	B4	O1	O2	O3	O4	E1	E2	E3	E4	M1	M2	M3	M4	M5	P1	P2	P3	P4	P5	N3	N4	R1	R2	R3	R4	C1	C2
Black Crappie (yoy)	3	1									1		1																		
Bluegill	1																				1										
Bluegill (yoy)	79	29		1						10			2		1			3	10		11	3	8								1
Bluntnose Minnow	1																			1											
Bluntnose Minnow (y	145									15	32	15	2					8	3	4	31	26	1			1	5		2		
Bowfin (yoy)	1									1																					
Brook Silversides (yo	2					1							1																		
Brown Bullhead (yoy)	26		4	1											2	3			3		3	2								8	
Carp	6	6																													
Carp (yoy)	16	1		1						2					1	1	2	5			3										
Channel Catfish (yoy)	1												1																		
Creek Chub	1												1																		
Emerald Shiner	1												1																		
Emerald Shiner (yoy)	14									4	5									4	1										
Fathead Minnow (yoy	177									4	23	4	14					7		103	18		1			3					
Gizzard Shad (yoy)	46	4		1		2	1		2											1	30		5								
Goldfish (yoy)	1																													1	
Green Sunfish	1																													1	
Green Sunfish (yoy)	1																		1												
Johnny Darter	1																									1					
Johnny Darter (yoy)	104			1						10	1	5	12			2		1		15	2	22	4			10	9	8	2		
Largemouth Bass (yo	12									1	1	1	1						4			3								1	
Logperch(yoy)	15									6		1	1						1	2		4									
Mirror Carp (yoy)	1																									1					
No Fish	1							1																							
Pumpkinseed	28									2		1							1	1			1					1		21	
Pumpkinseed (yoy)	2137	28	6	3						203	74	112	59		84	68	43	335	204	123	114	95	156			7	37	7	24	342	13
Spottail Shiner (yoy)	16									1		6						1		4		3				1					
Tadpole Madtom	1														1																
Tadpole Madtom (yo	3																		2	1											
To shallow	3													1										1	1						
White Perch (yoy)	179			2					1	25	80	9	11			2			4	19	24	1				1					
White Sucker (yoy)	9																									2	5		1	1	
Yellow Perch (yoy)	41			1	1					8	2	1	7			1			1	1	1	3				9	2				3
Grand Total:	3074	69	10	11	1	3	1	1	3	292	219	155	114	1	89	77	45	360	234	279	239	162	176	1	1	36	58	16	29	375	17