ROYAL BOTANICAL GARDENS
NATURE SANCTUARIES

Coastal Marshes, Natural Fish Hatcheries

Fish Communities at Royal Botanical Gardens Hamilton, Ontario, Canada

PROJECT Paradise
Restoring Great Lakes Coastal Wetlands

COASTAL MARSHES

Most coastal marshes are found where a river drains into a larger body of water. The nutrient laden sediments eroded from the watershed are deposited at the river mouth, creating a shallow enriched bay. The combination of a constant supply of nutrients and warm shallow water creates a highly productive environment supporting a wide assortment of aquatic plants, fish, birds and wildlife.

Hamilton Harbour's once expansive marshlands historically supported an estimated one third of the fish populations of Lake Ontario. By the mid-1800s this resource developed an extensive commercial fishery. To oversee the fishery, one of Canada's first fisheries officers, John Kerr, was appointed in 1864. Numerous historical quotes from Kerr & Kerr attest to the fishery the marshes once supported, a fishery that was collapsing by the turn of the century.

> *"Pike and bass spearing excellent, 90 barrels caught."* Kerr & Kerr 1868
>
> *"Salmon, herring, ciscos caught in abundance."* Kerr & Kerr 1874
>
> *"At least 10 000 pike shot"* Kerr & Kerr 1886
>
> *"Spearing poor only a few sunfish and perch."* Hamilton Times 1912

The importance of these marshes as fish nurseries was recognized early on. During the mid-1800s when a large commercial fishery was developing, the marshes were formally protected for *"the natural propagation of fish."* Their importance to the fishery was a significant contributing factor in the eventual designation of Royal Botanical Gardens marshlands as a sanctuary in 1927.

Today, RBG marshlands represent the bulk of what remains of the once vast coastal wetlands of Hamilton Harbour. In fact, Cootes Paradise, rated as a Class 1 wetland, is the largest remaining coastal marsh in western Lake Ontario. Unfortunately only a fraction of RBG marshes remain undisturbed today. However, they remain important staging areas for migrating waterfowl, and vital fish nurseries for most fish species in the harbour and the western end of Lake Ontario.

In the 1800s fish were so abundant that spearing in ice fishing huts was a popular fishing method.

Decline and Recovery of RBG Marshlands

The dramatic increase in population surrounding the area and the rise of industry brought many changes upon the marshes. As an example, Cootes Paradise was once covered by emergent and submergent vegetation, and intertwined with many stream channels. By the 1930s the cover was reduced to 85%, and had declined to only 15% by 1985. With vegetation loss came the disappearance of the stream channels, and the decline of fish and wildlife populations.

A variety of stresses were responsible. The streams flowing into Cootes Paradise had been contaminated with sewage effluent, agricultural runoff, and large amounts of eroding soil. Within the marsh the feeding and spawning activity of carp eliminated many marsh plants. Soil washed into the marsh was stirred up by wind and wave action, and by the foraging of large carp. Limited light penetration occurs, further inhibiting plant growth. Changes in both lake and stream flooding patterns and invasion on non-native plant species have also disrupted the natural functioning of the marsh.

In 1989 following a study by the International Joint Commission (IJC) of highly degraded areas on the Great Lakes, restoration of the fish and wildlife populations in the Hamilton Harbour area was initiated. For the restoration of Cootes Paradise and the Grindstone Estuary to be successful, RBG and other partners in the Hamilton Harbour Remedial Action Plan agreed that pollution abatement programs in the watershed and effective carp control in the marsh were essential.

RESTORATION GOALS

The overall goal is to restore a fully functional, balanced and self-sufficient aquatic ecosystem. This requires the restoration of all the components of the system, including the harbour, marshlands, floodplains, and streams. Each piece acts as fish habitat for different life cycle stages. On RBG property, the major ecosystem components are marshlands and floodplain habitat. The role of these is a reproductive habitat.

The RBG fish community goal is to restore these reproductive habitats so that all native fish populations can successfully reproduce. Restored marsh habitat includes the re-establishment of emergent and submergent aquatic plant communities, marsh river channels, and large woody debris (logs and stumps). In this type of environment, yellow perch, instead of the current gizzard shad, would again become the dominant fish species.

For fish species where natural recovery of a population is not viable despite the presence of appropriate habitat, fish from outside populations will be reintroduced into the marsh fish community. This may include species, which have been lost from the area, such as walleye, muskie and redbelly dace, and species where the populations were reduced to very few individuals such as smallmouth bass and golden shiner.

Restoring the marsh's fish nursery function is the main focus of the fish community restoration.

There are also numerous specific theoretical fish community goals generated based on *potential* available habitat if the system was entirely restored. Examples of these include numbers such as 8 kg of native fish/transect (monitoring site), an average of less than 0.5 adult carp/transect, 20 native species/transect, and a seasonal total of 100 species.

The goals are to be attained by restoring the fundamental system conditions to as close to historical as possible. This includes substantially reducing the input of nutrients and sediment from the watersheds and sewage treatment plants, reconnecting ditched creeks to their floodplains, and eliminating aggressive non native species, such as carp, purple loosestrife and European manna grass.

CARP AS WETLAND DESTROYERS

The common carp (*Cyprinus carpio*) is native to Asia. Carp are adapted to a river mouth marsh environment. They forage by rooting through the soft bottom for clams, snails, and insect larva. This foraging re-suspends the bottom sediment, muddying the water, and physically uproots the marsh's aquatic plants. The loss of the marsh plant community occurs when there are too many carp, and the rate of uprooting exceeds the rate of plant re-growth.

Reducing the carp populations is the vital first step in the marsh restoration process. This improves water clarity, increases food resources, and allows for natural recovery of the wetland vegetation. Also, replanting efforts can occur successfully. The marsh goal is to reduce the carp population density from 800 kg/ha. of marsh (1995), to less than 50 kg/ha, and eliminate all adult carp and carp reproduction.

The common carp's bottom foraging behaviour can result in massive marsh vegetation destruction.

Characteristics

- Niche: Benthivore of river mouth marshes
- Food: Snails, clams, aquatic insects
- Maximum size: 120 cm (4ft.)
- Maximum age: 40 years
- Spawning: Flooded vegetation, water 17°C
- Reproduction: 1 000 000 eggs at 60 cm (24 in.)

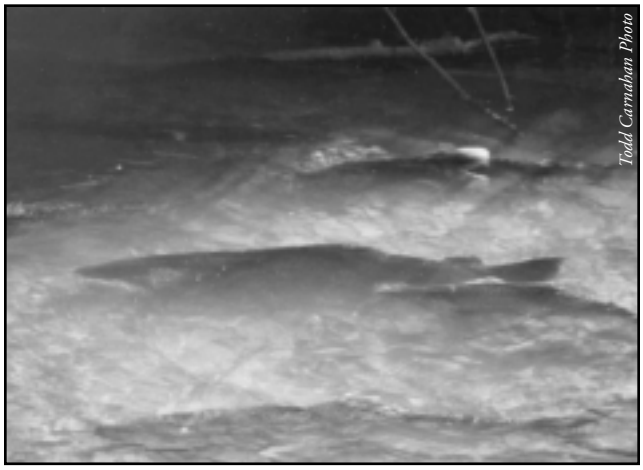
FISHERIES MONITORING AT RBG

Of Royal Botanical Gardens' 900 hectares of natural lands, more than 300 hectares are aquatic environments. These include an incredible diversity of habitats, ranging from cold Niagara Escarpment creeks, to the warm and fertile coastal marshes of Lake Ontario. This diversity and abundance of aquatic habitat provides for almost unparalleled fish diversity. More than 60 species of fish inhabit the waters found within RBG's property. Most of RBG's aquatic habitats are of great ecological significance, representing the best and often only remaining spawning and nursery habitat for virtually every fish species in Hamilton Harbour and western Lake Ontario.

In order to determine population levels, breeding success, and measure responses to restoration efforts, throughout the broad spectrum of habitats, RBG employs a variety of monitoring programs. These include visual spawning surveys, electrofishing surveys and Fishway research. The information is shared with Fisheries and Oceans Canada, Ontario Ministry of Natural Resources, and local Conservation Authorities, and is a key in local fishery decisions. The information also contributes on an international level, particularly in the area of coastal marsh research.

VISUAL SPAWNING SURVEYS

Visual spawning surveys have been conducted at RBG since the early 1900s. It simply involves the counting of spawning individuals or their nests. Initially surveys counted spring spawning northern pike in the floodplain ponds of lower Grindstone Creek. At the time these spawning pike, less than 200 in number, represented the bulk of the harbour population.



Chinook salmon, a native to the west coast, is one of a number of species monitored during spawning surveys.

In 2000, spawning surveys were expanded to include the below escarpment section of all streams flowing into RBG properties. These surveys were designed with the goal of providing an opportunity to invite public participation. These simple surveys specifically target large stream spawning species, including various suckers, walleye, trout, and salmon, and involve simply counting fish and nests by section of stream.

The streams have been divided into sections of approximately 0.5 km, marked by easily identifiable features such as dams or bridges. The surveys are multi-purpose providing information on numbers of fish, locations of spawning, barriers to migration, and identifying areas for protection and restoration.

ELECTROFISHING SURVEYS

Electrofishing is the most common technique used in shallow water fish community monitoring, because of its ability to effectively collect fish in a broad range of shallow water habitats. As a result, it is the primary technique used for fish community monitoring at RBG.

Electrofishing involves placing a low-voltage, localized electrical field in the water. When the field is on, a fish's muscles are immobilized temporarily, allowing them to be easily netted. Netted fish are held in a water tank until information can be recorded. Once completed the fish are returned unharmed to the area from which they were captured.

Electrofishing is the primary fish community monitoring technique used at RBG.

There are approximately 40 long-term monitoring sites throughout RBG's aquatic habitats. Most sites were established between 1994 and 1996. Surveys occur on a monthly basis throughout the spring to measure the spawning adult populations, and again at the end of August to measure the number of young produced.

FISHWAY RESEARCH

The Fishway is located in the connecting channel between the adult fish habitat of the harbour and Lake Ontario, and the spawning habitat of Cootes Paradise and its tributary streams. As a result it provides an unprecedented opportunity to document information on a broad variety of fish species and their spawning runs (*also see Fishway Fact Sheet*).

The Fishway consists of six large cages, which catch and move adult fish both in and out of the marsh. All fish captured are counted by species, with a portion of each species having more detailed information including length, weight, sex, and health recorded. The information is complemented with environmental data, such as water temperature, rainfall, water flow, and barometric pressure. When all the data is combined it generates some of the most extensive research on cues triggering fish migrations. Most migration occurs during the spring season when the spawning runs of various species are passed in and out.

Steelhead is one of the many species that pass through the Fishway. A scale sample is used to determine age.

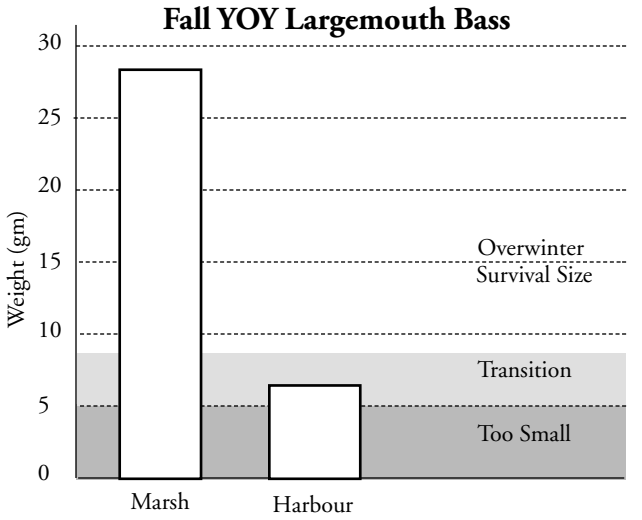
Fish imprint on their reproductive areas, returning to reproduce in the same area year after year. This fact is taken advantage of at the Fishway in the form of a microchip identification program. A portion of the less common species, including pike, bass, walleye, bowfin and channel catfish are implanted with microchip tags. In addition to the standard Fishway information collected, these species have scale samples taken during the tagging process to determine their ages. This provides very detailed information on specific individuals, including times of migration, growth, and survivorship, and in the case of many species, represents some of the most detailed information on their populations gathered anywhere.

FISHERIES SCIENCE

Research on RBG marshlands led to an important fish habitat discovery. Seasonal monitoring of the marshes indicated that substantial seasonal migrations occur. The spring arrival and departure of adult fish matched spawning times. Later season monitoring found the marsh to be almost exclusively young-of-the-year (YOY) fish. Parallel monitoring in the harbour found an absence of adult fish during their spawning times, and almost no YOY fish. This indicated that the marsh functions as a subcomponent of the aquatic ecosystem, acting as spawning and nursery habitat.

This research raised the question, why did these fish specifically choose the marsh environment for reproduction? The answer became clear when the size of YOY largemouth bass were compared. The majority of YOY bass produced in the harbour did not grow large enough to survive the winter hibernation period. In contrast the average marsh YOY bass was five times larger, and had ample energy reserves for survival.

The faster marsh growth comes as a direct result of the differences between environments. A marsh's shallow nature allows it to warm up much earlier in the season, and attain warmer temperatures in the summer season. This results in earlier spawning times and much greater food production. Production is further enhanced by nutrients from the watershed, and the protection afforded by the marsh vegetation. Annually Cootes Paradise marsh produces over 10 million YOY fish for the harbour and Lake Ontario system.



The key to the marsh importance as a reproductive habitat lies in energetics. As with most species, all YOY bass produced in the marsh grow much faster, a result of the warmer, more fertile habitat. In the case of bass the difference is enough reserves to survive the winter.

RESTORATION INITIATIVES

RBG has undertaken numerous projects to promote native fish populations through the restoration of critical habitats. Most projects focus on the restoration of critical marshland nursery habitat, affecting a broad range of species. The exclusion of carp, reduction in suspended sediments and nutrients, and regeneration of aquatic vegetation are fundamental elements of all the marsh restoration projects. Other projects include the recreation of floodplain pond habitat, stream channel rehabilitation, improvements to fish access, and the strategic placement of tree stumps and logs.

COOTES PARADISE FISHWAY

The carp is an aggressively invasive fish introduced from Asia in the late 1800s. All of RBG marshlands suffer from high carp populations. Carp, which may grow to 120 cm, are adapted for foraging, "rooting" in soft marsh bottoms among the roots of plants. Because of their large size, the rooting physically uncovers and uproots aquatic plants and re-suspends the fine bottom sediment, muddying the water. Since aquatic plants are the foundation of the marsh ecosystem, their loss causes the system to collapse, leaving a dynamic marsh a shallow open lake.

To remedy the carp problem in the 250 ha Cootes Paradise marsh, and regenerate this massive and invaluable fish nursery, a number of project partners conceived and constructed the Cootes Paradise Fishway (*see Fishway Fact Sheet*). The barrier uses a large grate system with bars spaced 5 cm apart. This width of grating prevents access to carp longer than 30 cm while maintaining water exchange. Since all fish including carp leave the marsh for the winter, the barrier excludes them when they return in the spring. To accommodate the movements of native fish the barrier is equipped with a fishway.

The Cootes Paradise Fishway commenced operations in 1997. The effect has been dramatic.

The first year of carp exclusion occurred in 1997. Results have been the anticipated reduction in suspended sediment and clearer water, and improvements in marsh habitat through re-growth of aquatic plants. These habitat improvements have translated into improvements in fish reproductive success.

MARSH HABITAT REPLANTING

The basic structural and habitat element of a marsh is its aquatic plants. As of 1995 only 15% of Cootes Paradise and the Grindstone Estuary remained vegetated, with much of the remaining vegetation consisting of cattails and non-native manna grass. The remaining 85% was a barren mud bottom much like a freshly bulldozed field.

As a result of this habitat loss, reproduction by the native fish had been all but eliminated. Starting in 1997, with the elimination of carp from Cootes Paradise, natural re-vegetation and the recovery of nursery habitat is occurring. Carp exclusion will be complete in the Grindstone Estuary in 2001, using other exclusion methods, and similar results are anticipated.

Over 40 species of aquatic plants are grown in RBG's aquatic nursery to aid the marsh restoration process.

The natural regeneration of the marsh will require many years, as most of the native plants have been reduced or entirely destroyed. To enhance the regeneration of marsh habitat, RBG established an aquatic plant nursery. The nursery grows over 40 aquatic plant species. These are planted in the marsh by staff and volunteers, as well as being sold to other restoration projects in Ontario. The planting increases diversity, and initiates the growth of new patches of plants.

STUMPS AND LOGS

Stumps and logs are important elements of fish habitat. In marshes they provide both structural cover in shallow water, particularly early in the season when aquatic plant growth is still limited and are a source of food as many aquatic insects are attracted to the decomposing wood. In streams, in addition to their structural and biological functions they generate turbulence and redirect water flow, creating deep pools.

In Cootes Paradise and the Grindstone Estuary virtually all of the stumps and logs have been carried to the shorelines and piled up by the wind and waves. This came as a direct result of the loss of the marsh vegetation, which formerly physically held the wood in place and dampened wave action. As of the end of 1999, over 200 large stumps and numerous large tree limbs have been placed back into the marshlands. In an effort to mimic shoreline deadfall cover, a number of large tree trunks have been dug into the bank and projected out over the water. These are particularly important as nesting cover for a variety of fish including bass, sunfish and crappie.

In the past, deadfall trees were cut out of Grindstone and Spencer Creek in an effort to maintain an open free flowing channel. As a result both creeks had few areas of debris cover or pools. This practice has since been modified and deadfall trees are now strategically cut to generate pool and debris habitat, while maintaining an open channel.

GRINDSTONE ESTUARY

The 50 ha. marsh located at the mouth of Grindstone Creek is an invaluable fish nursery habitat. However, it currently exists as a shallow muddy open water bay, a result of the same factors affecting Cootes Paradise, too many carp, and excessive sediment and nutrient inputs. To address these problems a different approach to marsh restoration is occurring.

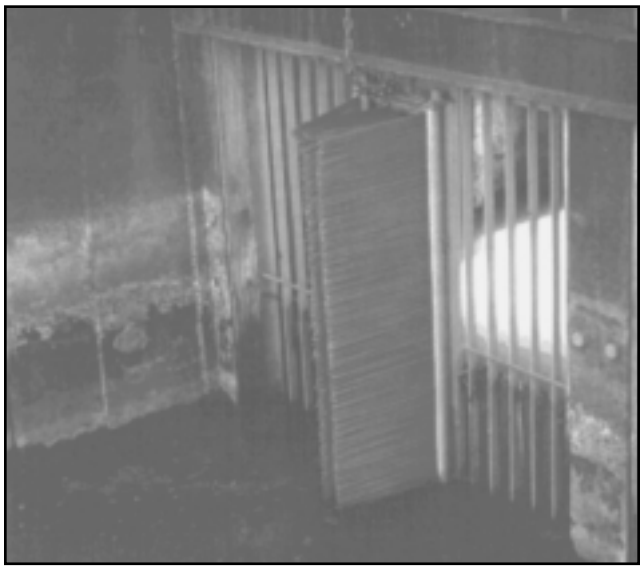
In a multi-year project beginning in 1999, recycled Christmas trees are being placed along both sides of the former Grindstone Creek channel. The trees provide a framework into which sediment from the watershed is deposited, rebuilding a natural riverbank. The trees also immediately redefine the channel and isolate the adjacent marsh areas. Isolating these marsh areas reduces their supply of sediment and nutrients and carp are excluded. These marsh areas remain connected to the channel both hydraulically and ecologically through mini carp barriers. As a result of the project, one kilometer of riverbank and 11 ha. of marsh area are being restored, and over 100 000 Christmas trees are being recycled.

GRINDSTONE CREEK FLOODPLAIN PONDS

Due to the extensive dredging, filling, and channelization, floodplain habitat is one of the most rare elements of aquatic habitat in the local aquatic ecosystem. These areas represent spawning and nursery habitat to a variety of fish species, the best known being northern pike.

A short distance upstream of the Grindstone Estuary one of the only remaining floodplain pond habitats connected with Hamilton Harbour can be found. However, as with all area marsh habitats they had become shallow muddy open water environments, and during floods were inundated with excessive amounts of sediment and nutrients.

The restoration of these ponds was one of the first endeavours initiated under Project Paradise. In 1994, the small road culvert that connected the ponds to the creek was replaced with a stop log structure, and channels were dug into the floodplain. Since then a small carp barrier has been added, and steps to increase the frequency of flooding, but reduce the volume of sediment and nutrient-laden water have been undertaken. As a result the water is now clear, aquatic plants are returning and the fish are successfully reproducing. Since these young fish move downstream to bigger marshes at two months old, a healthy Grindstone Estuary is a necessary compliment.



Fish access to the ponds has been improved while carp have been removed or excluded.


FISH SPECIES FOUND AT ROYAL BOTANICAL GARDENS

Species	Scientific Name	Status
Alewife	*Alosa pseudoharengus*	C
Bigmouth Buffalo	*Ictiobus cyprinellus*	VR
Black Bullhead	*Ameriurus melas*	R
Black Crappie	*Pomoxis nigromaculatus*	R
Blackchin Shiner	*Notropis heterodon*	VR
Blacknose Dace	*Rhinichthys atratulus*	R
Blackside Darter	*Percina maculata*	VR
Bluegill	*Lepomis macrochirus*	C
Bluntnose Minnow	*Minnow Pimephales notatus*	C
Bowfin	*Amia calva*	R
Brook Lamprey	*Ichthyomyzon fossor*	VR
Brook Silverside	*Labidesthes sicculus*	VR
Brook Stickleback	*Culaea inconstans*	VR
Brown Bullhead	*Ameriurus nebulosus*	A
Brown Trout	*Salmo trutta*	VR
Common Carp	*Cyprinus carpio*	A
Central Mudminnow	*Umbra limi*	R
Channel Catfish	*Ictalurus punctatus*	U
Chinook Salmon	*Oncorhyncus tshawytsha*	R
Common Shiner	*Luxilus cornutus*	U
Creek Chub	*Semotilus corporalis*	U
Emerald Shiner	*Notropis atherinoides*	C
Fantail Darter	*Etheostoma flabellare*	VR
Fathead Minnow	*Pimephales promelas*	C
Freshwater Drum	*Aplodinotus grunniens*	U
Gizzard Shad	*Dorosoma cepedianum*	A
Golden Redhorse	*Moxostoma erythrurum*	VR
Golden Shiner	*Notemigonus crysoleuscas*	VR
Goldfish	*Carassius auratus*	C
Green Sunfish	*Lepomis cyanellus*	R
Johnny Darter	*Etheostoma nigrum*	U
Lake Trout	*Salvelinus namaycush*	VR
Largemouth Bass	*Micropterus salmoide*	R
Logperch	*Percina caprodes*	U
Longear Sunfish	*Lepomis megalotis*	VR
Longnose Dace	*Rhinichthys cataractae*	U
Longnose Gar	*Lepisosteus osseus*	VR
Mimic Shiner	*Notropis volucellus*	VR
Northern Pike	*Esox lucius*	U
Pumpkinseed	*Lepomis gibbosus*	C
Quillback	*Carpoides cyprinus*	VR
Rainbow Darter	*Etheostoma caeruleum*	R
Rainbow Smelt	*Osmerus mordax*	R
Rainbow Trout	*Oncorhyncus mykis*	U
River Chub	*Nocomis micropogon*	U
Rock Bass	*Ambloplites rupestris*	VR
Rosyface Shiner	*Notropis rubellus*	R
Round Goby	*Neogobius melanostomus*	U
Sea Lamprey	*Petromyzon marinus*	VR
Shorthead Redhorse	*Moxostoma macrolepidotum*	VR
Silver Redhorse	*Moxostoma anisurum*	VR
Smallmouth Bass	*Micropterus dolomieui*	VR
Spottail Shiner	*Notropis hudsonius*	C
Tadpole Madtom	*Noturus gyrinus*	R
Threespine Stickleback	*Gasterosteus aculeatus*	VR
Trout-Perch	*Percopsis omiscomaycus*	VR
Walleye	*Stizostedion vitreum*	VR
White Bass	*Morone chrysops*	VR
White Crappie	*Pomoxis annularis*	VR
White Perch	*Morone americana*	A
White Sucker	*Catastomus commersoni*	C
Yellow Perch	*Perca flavescens*	U

STATUS KEY: A- abundant, C- common, U- uncommon, R- rare, VR-very rare

Surfing the Web - Interesting Sites

Royal Botanical Gardens, **www.rbg.ca**
University of Guelph, **www.aquatic.uoguelph.ca**
Great Lakes Wetlands Information, **www.great-lakes.net**
Environment Canada's Green Lane, **www.ec.gc.ca/envhome.html**
Environment Canada - Great Lakes Information, **www.on.ec.gc.ca/water/greatlakes/intro-e.html**

SUMMARY OF FISH FACT SHEET

- The marshlands surrounding Hamilton Harbour played a key role in supporting the fishery of the harbour and western Lake Ontario, providing spawning and nursery habitat.
- Most of the harbour's once extensive marshlands have been lost. What remains is found within the natural lands owned by Royal Botanical Gardens. These have been severely degraded by a number of human-induced stresses, including, excessive watershed erosion, over-enrichment from sewage, and the impacts of carp. The result has been the loss of plants, degraded stream channels, and impaired water quality.
- RBG natural lands contain a broad variety of aquatic habitats, ranging from cold escarpment creeks to large fertile marshlands. This diversity of habitats supports over 60 species of fish.
- To keep track of fish populations, and measure the success of restoration initiatives the RBG Science Department employs a variety of techniques including, visual spawning surveys, electrofishing surveys, and Fishway counts.
- The fish community monitoring has led to research illustrating a marsh's critical role as nursery habitat for fish.
- In the interest of restoring lost fish populations, the RBG Science Department has been involved in a number of habitat recovery initiatives. These include the restoration of marsh habitats and improvements to stream channels. Restoration techniques involve the exclusion of carp, reductions in sediment and nutrient inputs, replacement of lost aquatic plants and woody debris, and creek to floodplain reconnections.

For more information, contact:

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Fish and Wildlife Habitat Restoration Project
605 James St. North 3rd Floor
Hamilton, Ontario, L8L 1K1
Tel: 905-521-9334
Fax: 905-528-6282

Bay Area Restoration Council
McMaster University
Life Sciences Building, Room B130F
Hamilton, Ontario, L8S 4K1
Tel: 905-525-9140 ext. 27405
Fax: 905-522-6066 (address to BARC)

Hamilton Harbour RAP Office
Environment Canada
P.O. Box 5050, Burlington, Ontario, L7R 4A6
Tel: 905-336-6279/6278
Fax: 905-336-4906

Project Partners

Bay Area Restoration Council (BARC)
Department of Fisheries and Oceans
Environment Canada
Friends of the Environment Foundation
Great Lakes Sustainability Fund
Halton Region Conservation Authority
Hamilton Harbour Commissioners
Hamilton Harbour Remedial Action Plan Stakeholders
Hamilton Naturalists' Club
Hamilton Region Conservation Authority
McMaster University
Ontario Ministry of Environment and Energy
Ontario Ministry of Natural Resources
Royal Botanical Gardens
The Regional Municipality of Hamilton-Wentworth
The Regional Municipality of Halton
Waterfront Regeneration Trust

ROYAL BOTANICAL GARDENS Canada

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