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Fathom Five National Marine Park of Canada

State of the Park Report

Claire McNeil
Andrew Promaine

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Parks Canada Parcs Canada

Full fathom five thy father lies;
Of his bones are coral made:
Those are pearls that were his eyes:
Nothing of him that doth fade,
But doth suffer a sea-change
Into something rich and strange.

- William Shakespeare, The Tempest

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1.0 EXECUTIVE SUMMARY

The State of the Park Report for Fathom Five National Marine Park of Canada focuses on the ecological health of the park and, to the extent possible and practical, the health of the regional ecosystem. Presented in a framework of criteria, elements and indicators, the report provides the best possible description of the state of park ecosystems and any long term trends that may affect their condition. The State of the Park Report provides a tool to evaluate the effectiveness of park management in achieving the principle of ecological sustainability.

In order to evaluate ecological health with respect to the defined objective of ecological sustainability, the report investigates four separate criteria: physical, chemical, biological, and social sustainability. These criteria are further examined through a series of identified elements and indicators, which quantify how park ecosystems and park management are functioning. The comparison of indicators to an established target enables a science-based evaluation of ecosystem health and highlights management priorities for the future on the basis of perceived threats to the ecological sustainability of the marine park.

The State of the Park Report reveals that overall, Fathom Five is a healthy oligotrophic environment, with above standard water quality capable of supporting a healthy ecosystem. However, the ecosystem is under stress by non-native species, isolated areas of sediment contamination and increasing shoreline development. Impacts to nearshore habitats are anticipated to grow due to increasing development pressure and the projected decline in water levels. Some concerns stem, to a large extent, from lake-wide pressures, while others reflect our limited understanding of ecosystem stressors and processes. Our ability to manage Fathom Five is clearly compromised by our poor understanding of the levels and impacts of visitor use, the impacts of shoreline development, and the presence of species at risk and invasive species within the marine park.

The report clearly identifies the need for Parks Canada to define its role as the steward of an interlinked complex of aquatic and terrestrial environments within the larger Great Lakes ecosystem. Although invasive species and sources of contamination and may not be found within the boundaries of Fathom Five, they are of immediate concern to ecosystem sustainability. It is no longer acceptable to assume that broad-scale ecological issues are the responsibility of other government agencies. Participation in lake and basin-wide planning exercises such as the Canada-Ontario agreement may be the only area where we can aid or influence other organizations to work towards ecological sustainability. It is only through partnerships that Parks Canada will achieve the desired goal of ecological sustainability.

While management partnerships are clearly important, science partnerships are equally significant. With the absence of a consistent, ongoing monitoring program, there remains a lack of effective information to influence overall management direction. An established monitoring program is vital to a comprehensive understanding of stressors and ecosystem change within Fathom Five National Marine Park, and is ultimately the most effective means of incorporating ecological knowledge into management decisions.

2.0 INTRODUCTION

This section provides background information regarding Fathom Five, the concept of the State of the Park Report and the evolution of the framework used as a reporting structure. In addition, an ecological vision for Fathom Five in the year 2020 is provided.

2.1 Fathom Five National Marine Park of Canada

Fathom Five National Marine Park of Canada, established in 1987, is Canada's first marine protected area. Parks Canada's system of marine parks, known as "National Marine Conservation Areas" (NMCA's), are currently more of a concept than a reality. Parks Canada's vision of marine protected areas includes 29 NMCA's across the country, intended to be "representative of the Atlantic, Arctic and Pacific Oceans and the Great Lakes" and "of sufficient extent and configuration as to maintain healthy marine ecosystems" (Parks Canada Agency, 2000). Three NMCA's have been established to date, and two more are undergoing feasibility studies. In many respects Fathom Five is the flagship of this nascent park system, with 15 years of history and a well-developed vision of what a marine conservation area can and should be.

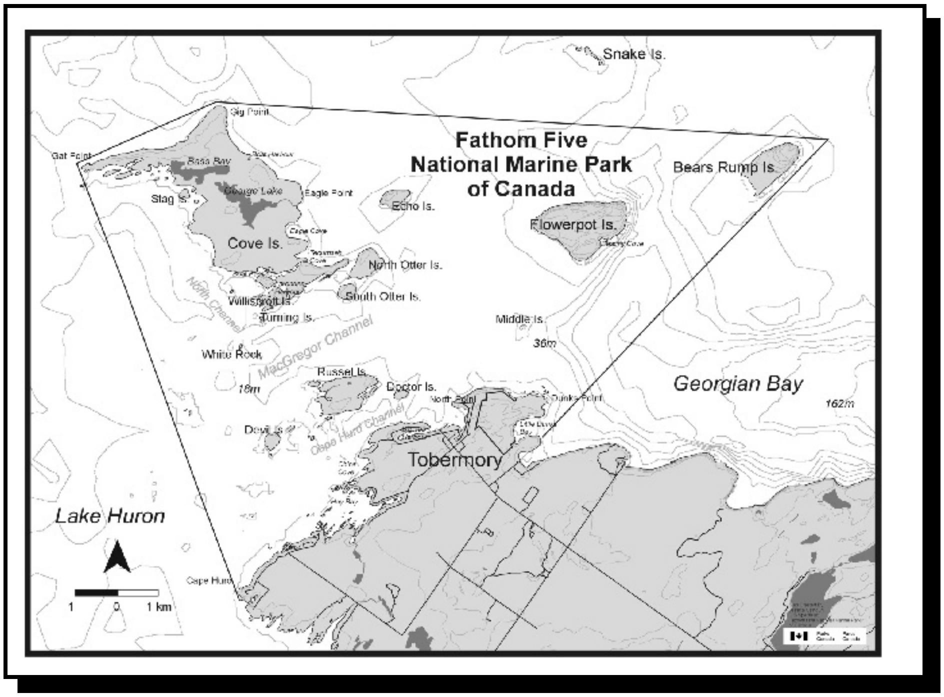


Figure 1. Fathom Five National Marine Park of Canada

As stated in the Canada National Marine Conservation Areas Act,

> "Marine conservation areas shall be managed and used in a sustainable manner that meets the needs of present and future generations without compromising the structure and function of the ecosystems, including the submerged lands and water column, with which they are associated (Parks Canada Agency, 2002. Section 4(3))."

Put in general terms, Fathom Five is to be managed for ecological sustainability. The term "ecological integrity," the stated management objective in the Canada National Parks Act, provides a useful corollary. Although both terrestrial and marine parks are essentially protection-oriented, the

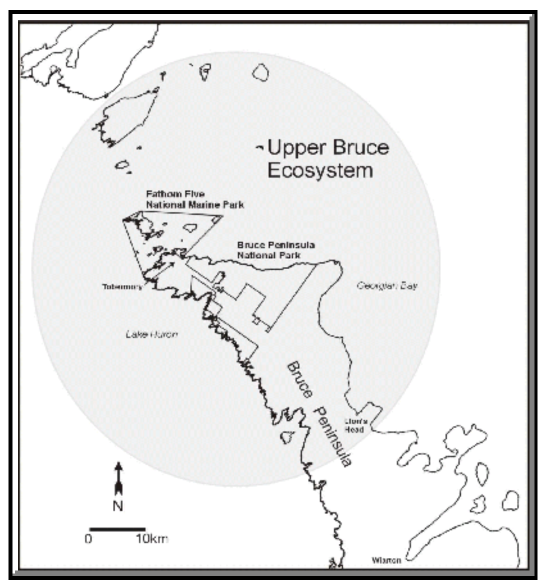


Figure 2. Location of Fathom Five National Marine Park and Bruce Peninsula National Park

fundamental concept of ecologically sustainable use incorporates a different approach into marine park management. While terrestrial parks lean towards preservation of the ecosystem in a state essentially unaltered by human activity, marine parks focus on conservation, rather than preservation.

Fathom Five's origin as a protected area stems from its rich cultural history and the stunning vista of water and islands stretching to the horizon. In 1972, a provincial park of the same name was created to protect the vast array of historic shipwrecks in the area, renowned as the "diving capital of Canada." In 1987, a federal-provincial agreement transferred jurisdiction of 11,175 hectares to Parks Canada, creating a protected area representative of the Georgian Bay Marine Region (Parks Canada, 1998a). Within the park boundary there are 21 islands owned by Parks Canada, as well as the "Land Base" area on the mainland adjacent to the town of Tobermory. Parks Canada jurisdiction extends from the high water mark on land and includes the water column, lakebed and Parks Canada-owned terrestrial portions within its boundary. Figures 1 and 2 indicate the location of the marine park at the tip of the Bruce Peninsula in Lake Huron.

The park's location at the terminus of the Bruce Peninsula leaves it straddling the relatively discrete water masses of Georgian Bay and Lake Huron. Fathom Five is characterised by dolomite shorelines, high wave exposure and oligotrophic waters, and contains habitats representative of both Lake Huron and Georgian Bay (Geomatics International, 1993). Prevailing winds, water currents, cliffs, islands and reefs combine to create diverse biological conditions within the park and surrounding area, including contrasting littoral ecosystems on the Lake Huron and Georgian Bay sides of the peninsula. Fathom Five also encompasses a submerged portion of the Niagara Escarpment, and the transition zone over the escarpment is a highly productive area which attracts many aquatic species (ESP, 1993).

At the local scale, Fathom Five is part of the greater ecosystem of the upper Bruce Peninsula, which contains the largest forested area in southern Ontario and is home to numerous rare species, habitats and unique natural and cultural features. The natural and cultural heritage of the upper Bruce Peninsula is also protected by Bruce Peninsula National Park of Canada, which is operated in conjunction with Fathom Five. Small communities dot the northern peninsula, providing a scenic home to permanent and seasonal residents.

At another scale, Fathom Five can be seen as a microcosm of the Great Lakes Basin Ecosystem, home to 33 million inhabitants. The Great Lakes play a pivotal role in the health, culture, recreation and economic well-being of these inhabitants and provide the direct source of drinking water for 8.5 million Canadians (fully 25 percent of Canada's population). The waters of the Great Lakes impact the health and well being of a further three million Canadians living downstream along the St. Lawrence River (Environment Canada and U.S. EPA, 2002).

Geographically, Fathom Five is relatively isolated from the highly developed areas of the Great Lakes , and reflects the ecological conditions of Lake Huron, a deep, cold-water lake with major water inputs from Lake Superior and Lake Michigan. Lake Huron has the second largest surface area, and the third largest volume of the Great Lakes, and is considered the fourth largest freshwater lake in the world (Environment Canada et. al., 1997). At any scale, Fathom Five National Marine Park provides an excellent example of sustainable use and conservation.

Lake Huron[a]		Fathom Five	
Length	332 km	Length[d]	12.1 km
Breadth	245 km	Breadth[e]	17.75 km
Maximum Depth	229 m	Maximum Depth	90.3 m
Shoreline length[b]	6,157 km	Shoreline length	119 km
Surface Area	59,600 km^2	Surface Area	112 km^2
Population[c] < U.S (1990) < Canada (1991) Total	 1,502,687 1,191,467 2,694,154	Population[f] < Seasonal (2000) < Permanent (2000) Total	 7,483 3,352 10,835

[a] Statistics from Environment Canada and U.S. EPA, 2001
[b] Including islands
[c] Populations for Lake Huron based on watershed boundaries
[d] Fathom Five length calculated between Gig Point and Cape Hurd,
[e] Fathom Five breadth calculated between Bear's Rump and Gat Point
[f] Population statistics shown are for the Municipality of Northern Bruce Peninsula, from just south of the village of Lion's Head to Tobermory, an area of 575 km^2. Seasonal population shown is the number of non-resident electors.

2.2 State of the Park Report

A State of the Park report acts as an accountability and feedback document for park management. The goal of the document is to provide a clear, measured understanding of Fathom Five National Marine Park's ecological sustainability, and an evaluation of long term changes or trends in ecological sustainability, where such can be documented. A secondary purpose of the document is to objectively review the results of the park's resource conservation activities, and assess their impact in achieving the goal of maintaining ecosystem structure and function: are our efforts making a positive difference? Prepared on a five year cycle, the State of the Park report is a major contributor to the

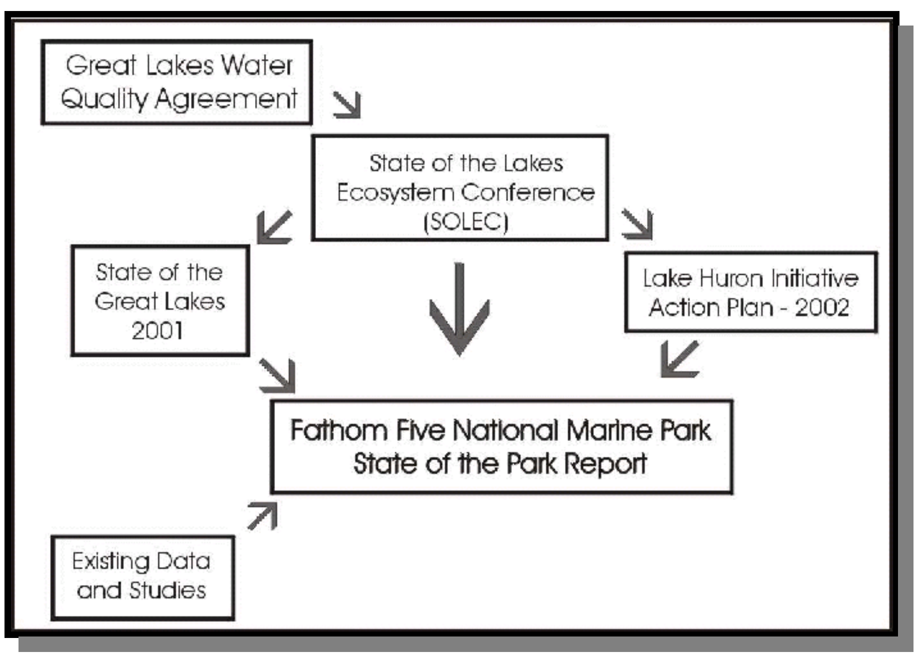


Figure 3. Contributing documents to the State of the Park Report

management plan review process. Park management plan revisions will reflect the answer to the question above, as management priorities will be realigned on the basis of the State of the Park Report findings if the answer is negative. The report will also feed into the "State of Protected Heritage Areas Report" prepared every two years and presented to Parliament and Canadians, and will be an important and interesting report in its own right for Parks Canada staff, partners and the local community.

Ideally, a State of the Park report is performed as a roll-up of five years of monitoring data obtained through a park's "Ecological Integrity Monitoring Program". However, Fathom Five does not currently have a formal monitoring program, and information on the state of the park's ecosystem has therefore been obtained through other means. As a starting point, we drew from research conducted within Fathom Five to provide a scientific and quantifiable understanding of the state of the marine ecosystem. In order to compensate for the lack of "in-house" monitoring data, we also looked for data available from other organizations within the Great Lakes. Rather than going at this in a haphazard fashion, we looked for data that reported on and reflected the goals outlined within the Great Lakes Water Quality Agreement (*"...to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem"*) between the Governments of Canada and the United States (IJC, 1987).

The desire to fashion a State of the Park Report that could reflect both the local and regional scales of the Fathom Five ecosystem led us to the State of the Lakes Ecosystem Conference (SOLEC), a grouping of government, academic, and scientific agencies bordering the Great Lakes and concerned with evaluating their aquatic health. In 2001, a summary of 33 SOLEC indicators was published in the "State of the Great Lakes 2001" report by the Governments of Canada and the United States, and provided a review of Great Lakes aquatic health in terms of its physical, chemical, and biological components.

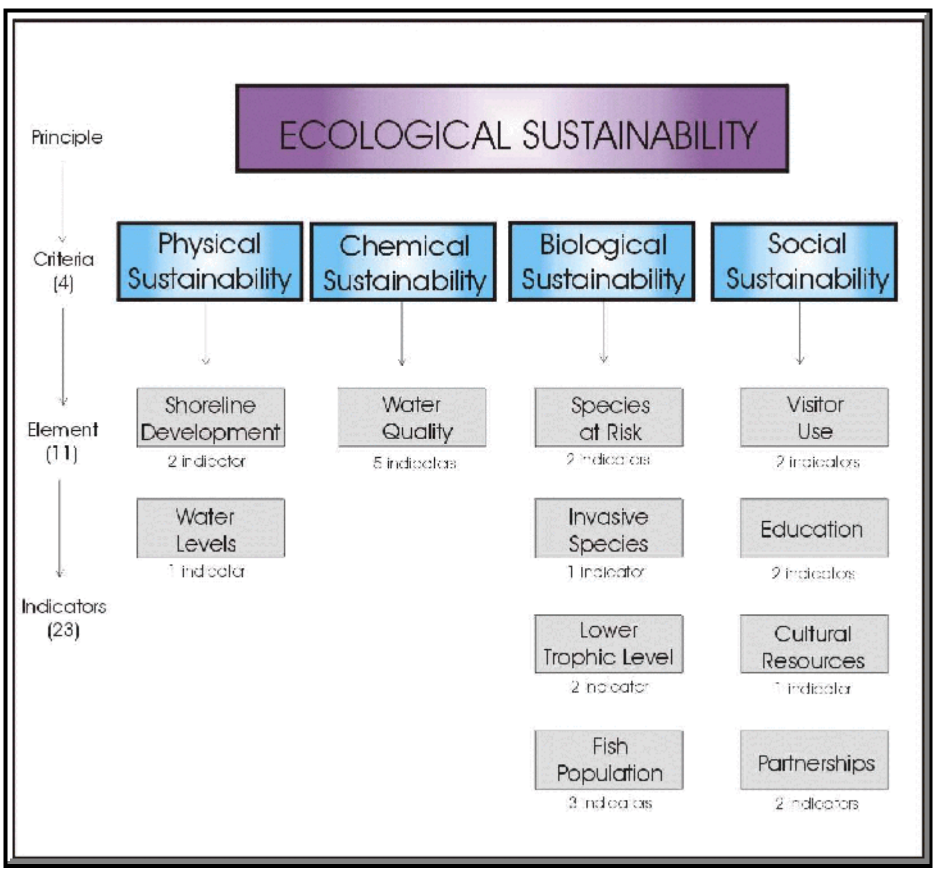


Figure 4. Indicator Framework, Fathom Five National Marine Park

2.3 Reporting Framework

A review of other evaluation frameworks within the conservation field (e.g. CCFM, 1997; Parks Canada 1998b- see Appendix B) led to the development of a framework based on one overriding principle, with criteria, elements and indicators as an evaluation template for ecological sustainability. The *principle* of the framework reflects the management goal of NMCA's (ecological sustainability), while the *criteria* reflect the Great Lakes Water Quality agreement objective (stated above), which focuses on the chemical, physical, and biological components of ecosystem. The social criterion was added to incorporate human and cultural elements into the evaluation of ecosystem health.

The *elements* of the framework were derived largely from existing work throughout Lake Huron and the Great Lakes, in particular SOLEC and the Lake Huron Initiative Action Plan (Michigan DEQ, 2002a). The resulting framework, (Figure 4) is a reporting structure based on four criteria of ecological sustainability, with each criteria further broken down in to 11 elements and 23 indicators. While no single criterion or indicator is a measure of sustainability on its own, in combination they provide an effective tool for examining trends or changes in the status of Fathom Five's ecosystem health.

Each indicator has been crafted with a final summary of its status relative to a target. The targets are based largely on our vision and understanding of ecological sustainability. Where available, we concur with existing guidelines such as the Great Lakes Water Quality Agreement. It is anticipated that these targets will evolve over time.

One clear benefit of working within this framework is the ease of shifting from a local perspective to a lake-wide perspective and vice-versa. The incorporation of data from studies performed within Fathom Five with data from other agencies around the Great Lakes basin allows us to place local ecosystem health within the spatial context of the broader lakewide ecosystem. In turn, use of indicators already reported on by other agencies extends the use of this report beyond the park level, as data reported on here will more readily feed into scientific reports such as SOLEC's "State of the Great Lakes," providing a case study of an area of Lake Huron in the context of research done elsewhere.

3.0 ECOLOGICAL VISION

By the year 2020, Fathom Five National Marine Park of Canada will be scheduled under the National Marine Conservation Areas Act. It will be recognized as a core area of ecological sustainability throughout the Great Lakes. The marine park will be renowned for its marine heritage and aquatic conservation values. Canadians everywhere will embrace and understand the idea that Fathom Five is a critical part of a system of marine protected areas, which provide clean water, pristine shorelines, healthy populations of native species and intact natural processes. Both the Georgian Bay and Lake Huron marine zones will be represented within the National Marine Conservation Area system.

In 2020, Parks Canada staff, partners and area residents continue to cherish the fact that Fathom Five is part of the Niagara Escarpment and defend the beauty and unique status of the Niagara Escarpment World Biosphere Reserve. We also take pride in our Great Lakes heritage and our place within the Lake Huron watershed. Both Fathom Five and Bruce Peninsula National Park of Canada form part of a larger network of protected private, Aboriginal, municipal, and provincial lands, creating a "green" corridor from Manitoulin Island to Niagara Falls. This protected areas network complements work done regionally for sustainable management of the watershed. The broader landscape includes farms, forests, fisheries, and tourism, all managed to meet the social and economic needs of the area. The protected areas network is recognized by everybody as necessary to protect biodiversity, which in turn is valued for its own sake. Protected areas are regarded as benchmarks against which change in other areas can be measured and evaluated.

This sustainable network is the result of cooperation and partnerships. Protected areas are managed cooperatively by those responsible for land and water use decisions that influence the natural landscape and watershed. This cooperative management is based on respect, equity and empowerment; as a result, there is true integration between local communities and the marine park.

The two national parks on the peninsula are committed to the conservation and restoration of ecological integrity and sustainability. Monitoring of a series of indicators has been implemented, allowing people to understand the ecological structure and function of the marine park. Species such as lake trout are better understood, appreciated and able to maintain a self-sustaining population. Within a Lake Huron context, Fathom Five is noted as an ecological benchmark reflecting broader landscape change within the Great Lakes.

Fathom Five continues to be renowned for its cultural integrity. The heritage lighthouse at Cove Island has been recognized for its historic and cultural significance in the Great Lakes and is maintained to ensure its commemorative value will remain unimpaired. The Bruce Peninsula/Fathom Five visitor centre has become a regional centre for ecological understanding, strategically located in relation to a large portion of the Canadian population. It provides a resource for schools, citizens and industry. The area has maintained its status as the “dive capital of Canada”, with SCUBA divers actively promoting safety and conservation of the marine park. The visitor experience includes operational practices that are renowned for their innovation and “environmentally friendly” approaches.

Staff at all levels are confident in the pursuit of their mandate, supported by legislation and guiding principles that clearly identify the protection of ecological sustainability as the first priority of the marine park. Staff are creative and bold in their approach to finding solutions to challenges that may affect ecological sustainability. In particular, staff provide the highest quality visitor experience while maintaining cultural and natural resources of the marine park.

Staff firmly advocate for protection beyond our boundary, and that influence has created awareness and sparked action among other jurisdictions to support land use decisions that protect land, air, water, wildlife and vegetation. In particular, provincial and municipal governments and industry leaders work closely with the parks to find sustainable solutions to development issues. Due to the success of our ecological integrity monitoring and reporting programs, both parks are respected as world leaders in linking resource conservation information to community planning exercises. These parks are centres of learning and enjoyment; they are catalysts for personal growth and action, places that can and do change our lives.

4.0 CURRENT STATE OF ECOLOGICAL SUSTAINABILITY OF THE PARK

The following sections are presented in the framework shown below. Background information on each element is provided, followed by the indicator data. Indicator results are summarized in comparison to a target.

Table 1. State of the Park Reporting Framework

Principle	Criterion	Element	Indicator
ECOLOGICAL SUSTAINABILITY	Physical Sustainability	Water Level	< Water levels
		Shoreline Development	< Shoreline Property Development < Dock Facility Development
	Chemical Sustainability	Water Quality	< Ionic Chemistry < Nutrients < Contaminants in the Water Column < Contaminants in Wildlife < Contaminants in Sediment
	Biological Sustainability	Lower Trophic Levels	< Phytoplankton < Zooplankton
		Fish Population	< Nearshore Habitat < Fish Community Structure < Resource Harvesting
		Invasive Species	< Invasive Species
		Species at Risk	< Aquatic Species at Risk < Terrestrial Species at Risk
	Social Sustainability	Education	< Outreach Programs < Interpretive Programs
		Partnerships	< Research < Working Relationships in the Greater Park Ecosystem
		Visitor Use	< Marine Visitation < Terrestrial Visitation
		Cultural Resources	< Shipwreck Stability

1.0 Criteria: Physical Sustainability

1.1 Element: Water Levels

Background

Water levels are monitored throughout the Great Lakes, as lake level trends can significantly effect the ecological health of the nearshore aquatic and terrestrial environment. Despite increasing human consumption of water, dredging of outlet channels, regulation on outflows and diversions into or out of the basin, natural factors (climate, weather) remain the primary influence on lake levels (GLIN, 2002a). Generally, there is a pattern of seasonal change, but the long-term cycle is unpredictable.

Long-term fluctuations:
- Reflect persistent low or high net basin supplies
- Resulted in the extreme lows of 1925 and 1964-65 and extreme highs of 1974 and 1985-86.

Seasonal fluctuations
- Reflect the annual hydrological cycle (higher net basin supplies in spring/early summer).
- Evaporative loss is low in spring/summer and higher in the fall and early winter due to the temperature of the air over the lakes and its capacity to hold moisture.
- Seasonal fluctuations average 0.4m on Lake Huron, with minimum level in Feb. and maximum in July.

From: GLIN, 2002a

The natural fluctuations in lake levels are important in maintaining species diversity along the shores of the Great Lakes, as vegetation communities along shorelines are adapted to fluctuating water levels. Under stable conditions, competitively dominant plants such as trees and shrubs take over. Long-term fluctuations lead to more diverse habitat and higher species richness. High water levels kill trees and shrubs, and subsequent low water levels allow germination of seeds, the growth of a multitude of species, and replenishment of the seed bank. This habitat is more productive for aquatic mammals, waterfowl, invertebrates and fish, which rely on shoreline vegetation for food, shelter and protection from predators (USGS, 2002a).

Water levels in the Great Lakes have been recorded by the Canadian Hydrographic Service (CHS) since 1918 and are currently referenced to the International Great Lakes Datum (IGLD) 1985 of 176m asl (metres above sea level). The reference datum is selected so that water levels are above datum approximately 95% of the time, and is updated every 25 to 30 years to adjust for movement of the earth's crust (DFO, 2001).

<u>*1.1.1 Indicator: Water Levels*</u>

Water levels have been declining in Tobermory since 1997, as seen in Figure 5. The recent decline in water levels evident on the graph reflects a combination of lower precipitation, higher temperatures and higher evaporation rates (GLERL, 2002). Although low water levels are not yet indicative of any long-term trend, global climate change models have predicted a long-term decline in Great Lake water levels in response to increased temperature and evaporation and more variable and extreme seasonal precipitation. The long-term average level of Lake Huron is projected to decrease significantly, which will impact shoreline vegetation communities, wildlife species and property owners within and adjacent to the marine park.

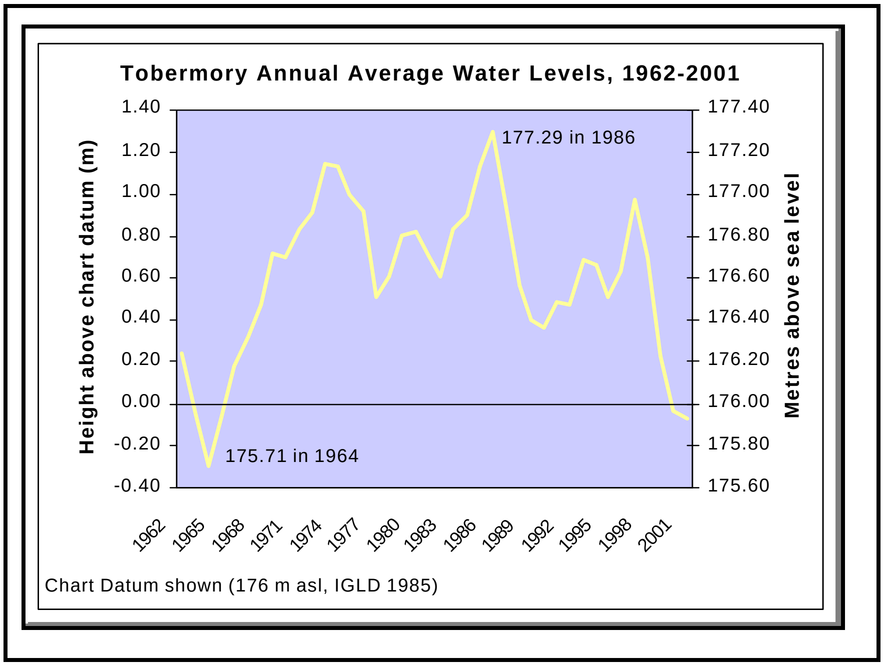


Figure 5. Tobermory Annual Average Water Levels, 1962-2001

A climate modelling exercise completed for the Southern Lake Huron region (from Sarnia to Tobermory) provides a scenario for the year 2050. The projection is based on data from three climate modelling centres, Environment Canada's Second Generation General Circular Model, NASA's Goddard Institute for Space Science and Princeton University's Geophysical Fluid Dynamics Laboratory. The scenario postulates that by 2050, temperatures will rise by 3°C and the maximum water level will approach the lowest recorded level for Lake Huron, while the minimum level will reach two metres below the current lake level (Lake Huron Centre for Coastal Change, 2002). The future range is shown in relation to the historical range in Figure 6.

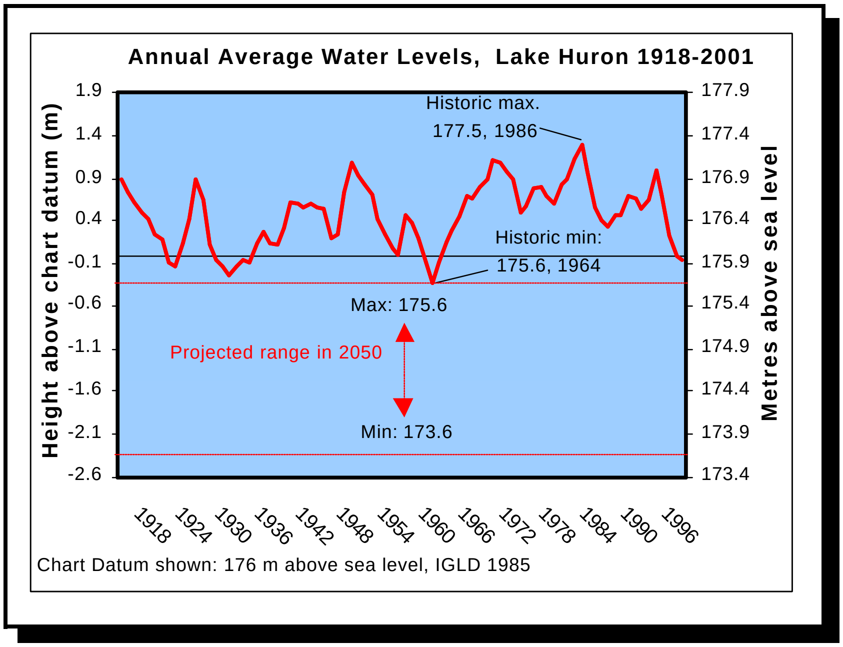


Figure 6. Annual average water levels in Lake Huron from 1918-2001.

A large magnitude and long term decline in water level such as this would have significant implications for shoreline species composition and abundance, nearshore fish habitat, and shoreline development, especially along the shallowly sloped western shore of the marine park.

- Dryland plants would colonize the fringes of shoreline marshes and fens
- Shoreline wetlands would slowly migrate lake-ward
- Shoreline morphology would alter with a lower zone of wave action
- Communities of species would be destroyed or displaced to the new high water line
- Emergent vegetation would gain habitat and come to dominate the shoreline
- Small inlets would become isolated from the lake
- Reduced passage of fish into bays (e.g. Bass Bay)
- Increased shoreline development pressure

From: Environmental Adaptation Research Group, 2002; Geomatics International, 1993)

- **Key message:** Water levels are important to ecosystem structure and function.
- **Target:** Maintain historic range and variability in water levels between 177.5 and 173.6 m asl.
- **Current status:** Water levels at 175.93 (2001).

1.2 Element: Shoreline Development

Background

Shoreline development is a concern throughout the Great Lakes basin. Over 2.5 million people live in the Lake Huron Basin, predominantly in the southern portion. As cottages and urban centres around the lake expand, there is a corresponding increase in shoreline development. Development of property along the shoreline is generally correlated with a loss or decline in health of aquatic nearshore habitat. The loss of nearshore habitat and development of coastal wetlands are considered primary concerns affecting the ecological health of Lake Huron (Environment Canada and U.S. EPA, 2001).

The shoreline around the marine park contains few areas that are protected from wave action, where sediment deposition occurs and aquatic vegetation becomes established, which makes the few protected bays with associations of aquatic macrophytes regionally significant. These areas are particularly sensitive to development. As stated in the aquatic resources inventory for the marine park:

> Protecting the bays containing significant aquatic plant communities involves managing the area surrounding the bays as well; managing an aquatic system does not stop at the shoreline. Setting aside a bay as a protected area, for example, is not an adequate measure if the adjacent terrestrial system is not managed to prevent downstream detrimental effects (Geomatics International, 1993).

It should be clarified here that shoreline residential development is by no means disapproved of by Parks Canada; indeed the Parks Canada Marine Operations Base is one of the larger developments along the shoreline. It is the real and potential ecological impacts of such development - particularly on water quality and nearshore habitat - that are of concern. Potential impacts of shoreline development are outlined below.

Table 2. Ecological impacts of shoreline development

Development Zone	Landscape Change	Environmental Impact
Upland/ Riparian	< Non-native species < Clearing < Maintaining a lawn < Increased hardened surface (driveways, patios, roofs) < Septic systems	< loss of habitat < increased fertilizer & pesticide use < increased runoff & erosion < loss of natural temperature regulation (shade, etc.) < loss of filtering capacity < loss of water quality
Shoreline	< Erosion control structures (retaining walls) < Vegetation removal	< loss of insect “rain” for fish and shade from overhanging vegetation < loss of buffer against waves, wind & rain < increased erosion < loss of habitat for fish, birds, amphibians
Littoral	< Removal of downed trees < Beach development < Docks and other permanent structures	< loss of aquatic plants and provision of oxygen, food and shelter for wildlife < disruption of currents and water circulation < smothering of spawning areas from sediments < loss of water quality < loss of wildlife species

From: Living by Water Project, 2002; Ford 2000.

The following two indicators, shoreline residential development and dock facility development, focus on physical development of the nearshore and terrestrial environment to give a holistic perspective on the ecological health of Fathom Five.

1.2.1 Indicator: Shoreline Residential Development

Shoreline residential development in the Bruce Peninsula has increased steadily over time, as it has in the entire Great Lakes basin. Property ownership and the population base have shifted from year-round residents to a predominance of seasonal cottagers. Of the total length of the shoreline within the marine park, 23% is available for development on the mainland. Figure 7 shows the Fathom Five mainland shoreline and the Parks-Canada owned Land Base property.

Table 3. Shoreline statistics

Total Shoreline	119 km	
Islands	88.4 km	74%
Mainland shoreline (excluding Land Base)	27.3 km	23%
Land Base property	3.3 km	3%

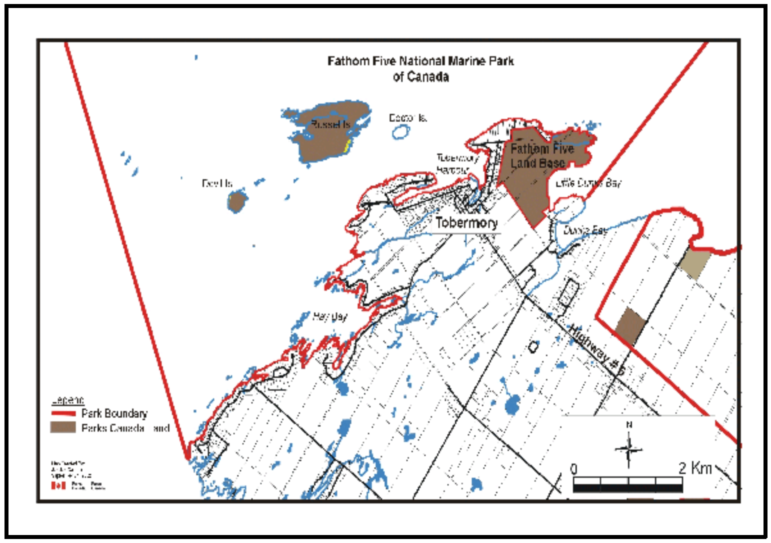


Figure 7. Fathom Five mainland shoreline.

Along the shoreline of Fathom Five, significant cottage and year-round residential developments are located in Big Tub, Tobermory Harbour, Grant Watson Drive, Hay Bay and Cape Hurd. A comparison of air photos over time provides a means of evaluating the change in residential development along the shoreline. Table 4 and Figure 8 illustrate shoreline development changes between 1978 and 1994 (areas were designated high and low density dependent on the relative proximity of driveways). Significant changes are evident in Hay Bay.

Table 4. Shoreline Development- Fathom Five Mainland 1978 and 1994

	1978	1994
No residential development	14.9 km	7.1 km
Potential residential development (road access)	1.7 km	3.2 km
Low density residential development	4.5 km	6.6 km
High density residential development	9.5 km	13.7 km

Note: Little Tub Harbour is not within the marine park

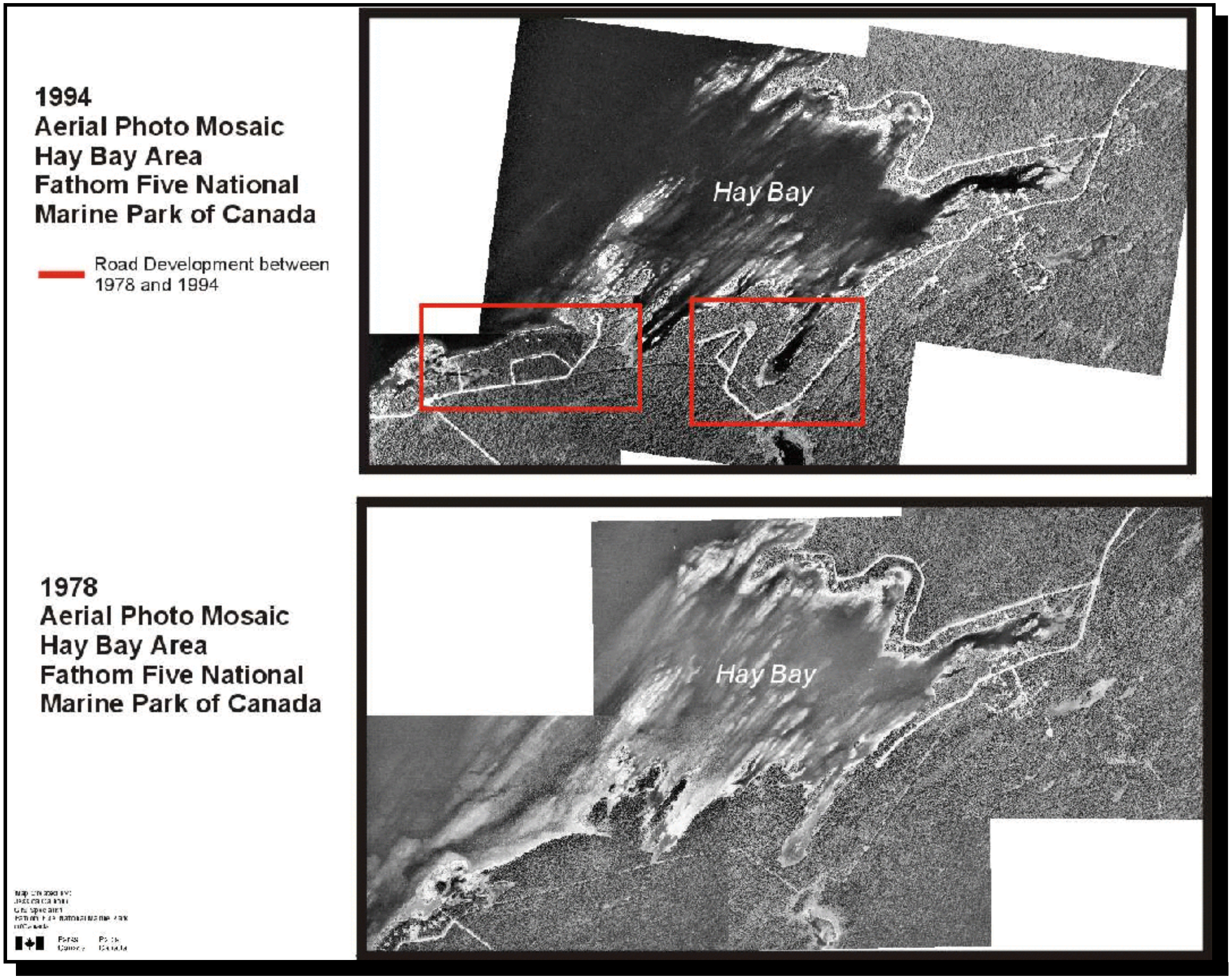


Figure 8. Shoreline development changes between 1978 and 1994, Hay Bay.

As of 1994, only 7.1km of 27.3 km (26%) of mainland shoreline, excluding the Parks-Canada owned Land Base, remained fully undeveloped (no road access). With the inclusion of the 3.3 km of Land Base shoreline, this comes to 34% of mainland shoreline in an undeveloped state. It should be noted that this statistic does no more than indicate the *potential* for an enlarged area of ecological impacts, and does not indicate the extent of change to the shoreline in the areas developed to date. Overall, property owners in the marine park are interested in preserving terrestrial and aquatic habitat along the shoreline. Local residents have more knowledge about historic changes in the health of the nearshore aquatic environment than does Parks Canada. Both the park and the community stand to gain from collaboration on projects of mutual interest, specifically with regards to nearshore habitat and water quality.

< **Key message**: Aquatic habitat cannot be isolated from the ecological state of the upland area.
< **Target**: 35% of mainland shoreline be conserved (developed with ecological concerns incorporated into planning).
T **Current status**: 34% of mainland property is undeveloped

1.2.2 Indicator: Dock Facility Development

Although changing land use above the high water mark is a concern, the development of structures within the water is also environmentally significant. All physical works undertaken below the high water mark within the marine park boundary are subject to the environmental assessment (EA) process. On average, the park receives 6 applications per year for in-water work. Dock repairs and constructions are the most common permit applications, although the park also receives requests for mooring structures, boat ramps, break walls, swim platforms, and dredging. Policy guidelines restrict the types of projects allowed in different areas. Restricted areas are generally nearshore shallows with organic substrate and aquatic plant growth suitable for fish habitat.

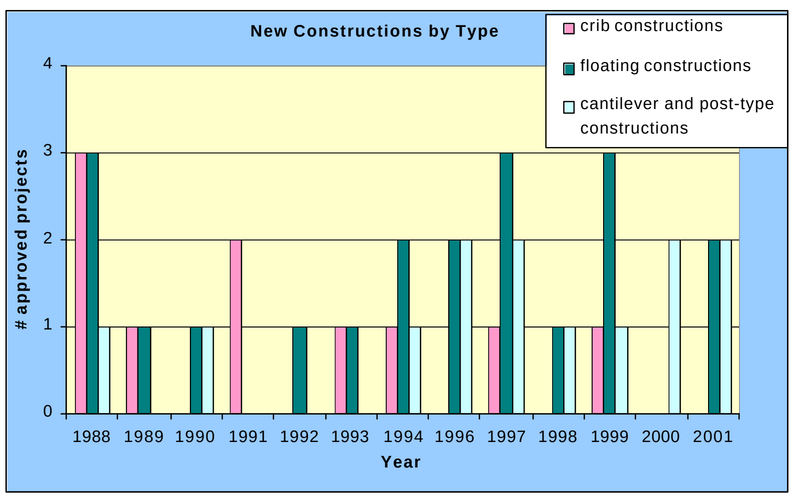


Figure 9. Dock construction within Fathom Five, by type (1988-2001).

The marine park has maintained records of all in-water projects that have undergone the EA process since park establishment in 1987. As is evident in Figure 10, shoreline work applications are concentrated in Hay Bay and Big Tub Harbour. Since 1988, new dock constructions have shifted from crib-style to less habitat-destructive types such as post docks, floating docks and cantilever docks.

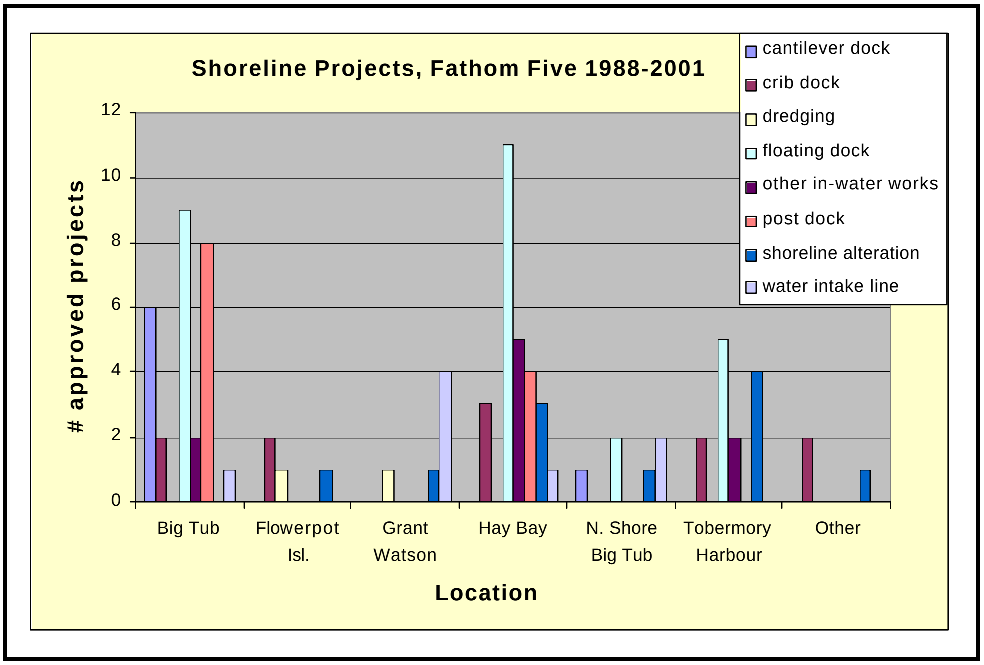


Figure 10. Shoreline alteration within Fathom Five, by location (1988-2001).

- **Key Message**: Dock facility development affects nearshore aquatic habitat.
- **Target:** 0 new crib docks approved, no net loss of fish habitat
- **Current status:** 0 new crib docks approved 2001-2002, no net loss of fish habitat.

2.0 Criteria: Chemical Sustainability

2.1 Element: Water Quality
Background
Water quality is a growing public concern, and the quality of water in the Great Lakes watershed affects the well-being of every living organism in the basin. Canada has international obligations to maintain water quality in the Great Lakes as a signatory to the Great Lakes Water Quality Agreement (GLWQA). Lake-wide concerns with water quality during the late 1960s ultimately led to the development of the GLWQA. At that time, public concern was focused on nutrient enrichment in the Great Lakes. Over time, concerns have shifted from nutrient enrichment to the impacts of a range of persistent toxic substances and pathogens such as *e. coli.*

Pollutants in Great Lakes waters have led to a range of ecological health concerns. Nutrient additions (particularly phosphates) may lead to an explosion of microorganisms that deplete oxygen supplies required by aquatic fauna. Pollutants can cause changes in the acid-base balance of the system, and increased levels of toxic substances in sediments and the water column can lead to decreased habitat quality for wildlife. Ultimately, there may be health concerns for both humans and wildlife, as toxins taken up through the food chain can lead to bioaccumulation in top predators, causing diminished reproductive success, inhibited growth, cancer, and other chronic/lethal impairments (Michigan DEQ, 2002b).

In general, studies have indicated that the overall water quality of the upper Great Lakes (Superior, Michigan and Huron) is excellent, apart from a few degraded nearshore zones in urban areas (Michigan DEQ, 2002b). Baseline studies for Lake Huron (1974

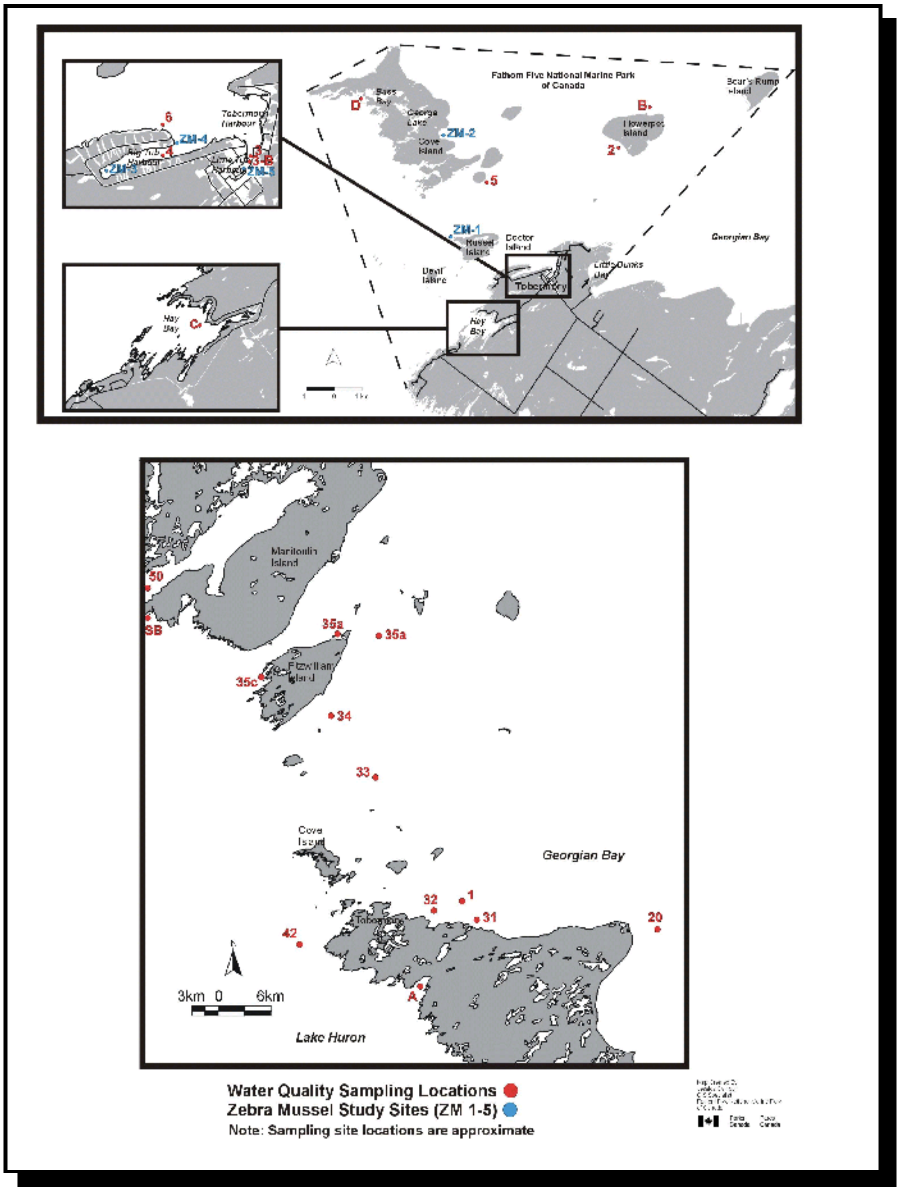


Figure 11. Water quality sampling locations.

and 1980) established that the lake had high water quality, with isolated evidence of human impact (Environment Canada et. al., 1997). The indicators presented below are based on the results of a water chemistry and contaminant level assessment conducted in 1994 in the marine park (sampling locations are shown in Figure 11). The 1994 study (completed in partnership by Parks Canada, Environment Canada and DFO) was essentially an extended version of the Environment Canada open lake cruises, which have been conducted throughout the Great Lakes since 1968 to fulfill Canada's obligations under the GLWQA. Supplementary data from other studies in the Great Lakes has also been included.

2.1.1 Indicator: Ionic Chemistry

Ionic chemistry (conductivity and major cation and anion constituents) reflects the concentration of dissolved solids in a water body, which in turn relates to regional geology, geochemistry and anthropogenic inputs. Study results from 1994 confirmed that the waters of Fathom Five are bicarbonate in nature, with a high buffering capacity and ionic chemistry intermediary to that of Lake Huron and Georgian Bay. Weathering of local bedrock results in enrichment in calcium, magnesium, carbonate, and phosphorus in the nearshore zone of the marine park (Environment Canada et. al., 1997).

Both chlorides and sulphates, which had increased significantly in Lake Huron over the past century (primarily due to industrial discharges) have levelled off from their historic maximum. Chloride concentrations have returned to near baseline conditions and sulphate concentrations have stabilized, with mean annual concentrations exhibiting little variation in Fathom Five since 1984 (McCrea et al, 2001; Environment Canada et. al., 1997). Figure 12 summarizes the conductivity and major ionic constituents for the Fathom Five study area during the spring of 1994, with comparative information for Georgian Bay and Lake Huron.

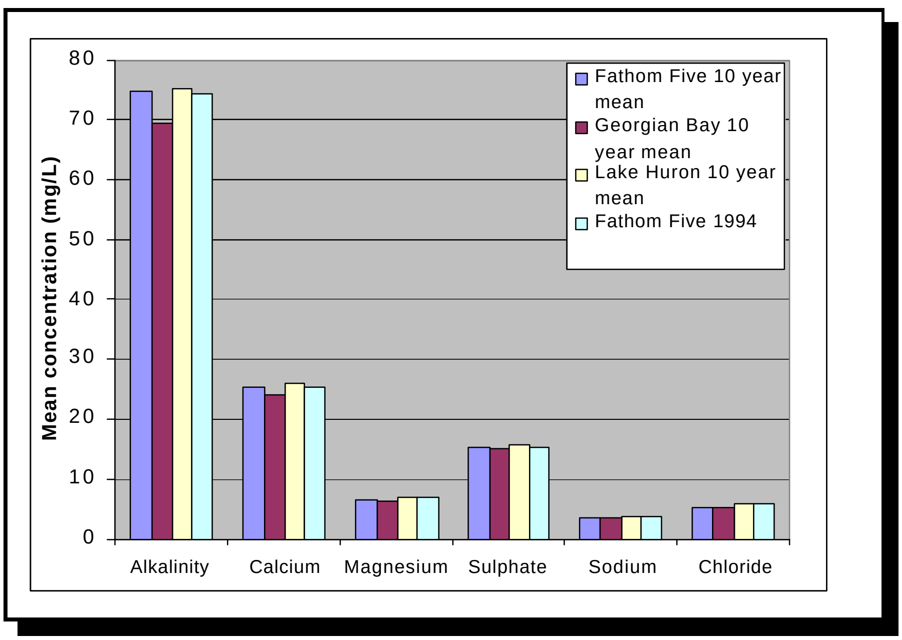


Figure 12. Major ionic constituents of Fathom Five, Georgian Bay and Lake Huron (from Environment Canada et. al., 1997)

< **Key message**: Chloride and sulphate concentrations reflect human induced change in lake ionic chemistry.
< **Target:** Chloride return to baseline conditions of 5 mg/L (sulphate baseline unknown).
T **Current status:** Chloride 5.8 mg/L and sulphate 15.3 mg/L in 1994

2.1.2 Indicator: Nutrient Concentrations

The 1994 study assessed trophic state and nutrient concentrations in the waters of Fathom Five. Trophic state, which is determined by nutrient concentration, indicates the biological activity supported in a lake (primarily in the form of algae) (GLNPO, 2002a). Trophic states are shown in Figure 13.

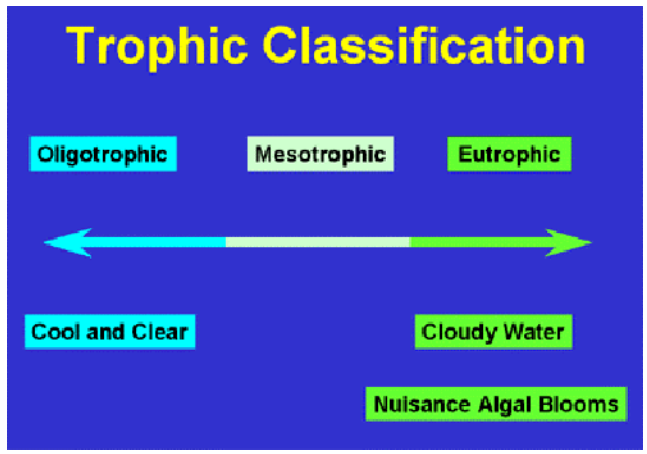


Figure 13. Trophic states (from GLNPO, 2002a)

Fathom Five waters are oligotrophic, which is the GLWQA goal for Lake Huron. Phosphorus is the main nutrient controlling trophic state in the Great Lakes, as it is the limiting factor for plant growth. Phosphorus loadings come from industrial and natural sources, including agricultural runoff, municipal sewage, phosphate detergents, and bedrock weathering (Environment Canada et. al., 1997). Ecological impacts of phosphorus and targets for loadings are shown in the table below.

Table 5. Phosphorus loading impacts and targets for Lake Huron

Impacts of phosphorus enrichment	< Excessive algal blooms, strong odour < Lack of dissolved oxygen, increased fish mortality < Change in fish species -certain species tolerate these conditions better
< GLWQA target	< Maintenance of oligotrophic state & relative algal biomass of L. Huron < Diminish load from 1976 level of 5050 metric tonnes/year to 4360 metric tonnes/year
< Spring TP[a] target	< L. Huron spring total phosphorus (TP) guideline is 5 ug/L < IJC[b] target used for State of the Great Lakes reporting < Historic concentrations were greater than 10 ug/L (1950s-60s)

[a] Spring TP is based on spring open-lake concentrations, which determine summer phytoplankton biomass
[b] International Joint Commission
From: Environment Canada et. al., 1997

Loadings to Lake Huron have remained below the GLWQA target, with the exception of 1982 and 1985, and spring TP concentrations have generally met the target since 1970 (GLIN, 2002b; Environment Canada and U.S. EPA, 2001). Fathom Five spring TP concentrations, which are generally lower than whole lake concentrations, averaged 4.9 mg/L over the period of 1985-1994. Spring TP concentrations in the Fathom Five area are shown in Figure 14.

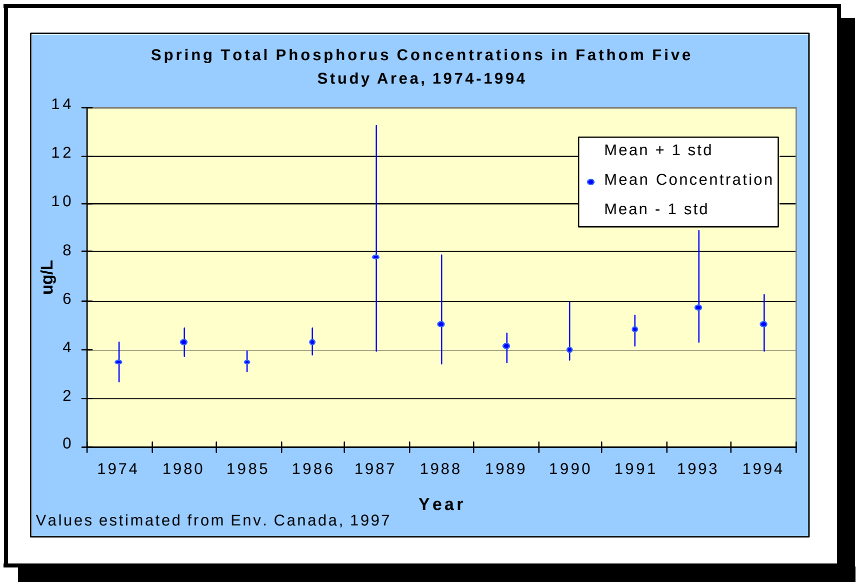


Figure 14. Spring total phosphorus concentrations in the Fathom Five study area, 1974-1994

Nearshore nuisance algal growth, an indicator of excess nutrient enrichment, is not currently a concern within the marine park boundary (Environment Canada et. al., 1997; McCrea et. al, 2001). Historically, a problem with eutrophication and nuisance algae may have existed, as a 1969 report on water pollution in Tobermory noted a fishy odour that increased in the summer and was related to the presence of blue-green algae. The report described water quality as poor in the two main town harbours, due to sewage inputs:

> A noticeable cause of pollution was the discharge of garbage and sewage from the large number of pleasure craft using the waters.... It was noted that septic tank and tile beds were not functional due to the lack of sufficient sandy soil to filter wastes. As a result, liquid effluent from tile beds flows over the rock to enter surface or groundwater along the rock into the waters of the harbour (Ontario Water Resources Commission, 1969).

Although dumping of raw sewage is no longer permitted, dysfunctional septic tanks and tile beds continue to be of concern in the area.

<	**Key message**: Spring Total Phosphorus concentration is a lakewide indicator for nutrient enrichment.
<	**Target:** Spring TP concentrations remain below the guideline of 5 ug/L and embayments remain free of nuisance algae.
T	**Current status:** Spring TP in Fathom Five open waters 4.9 ug/L (1994). No reports of nuisance algae in nearshore reaches.

2.1.3 Indicator: Contaminants in the Water Column

Monitoring of contaminant concentrations in Great Lakes open water is undertaken by Environment Canada in order to fulfill our obligations under the GLWQA. Inorganic and organic contaminant concentrations from the most recent Lake Huron surveillance cruise will be available in the next year, and in the interim, data from the 1987 cruise provides organic contaminants concentrations at Station 33, (Figure 11) just north of the marine park. All organic contaminant concentrations in 1987 met guidelines for the protection of aquatic life; most concentrations fell below the laboratory detection limits. Concentrations of the five contaminants detected at Station 33 are shown below in comparison to concentrations in Lake Superior, which is of comparable water quality to Lake Huron (Environment Canada et. al., 1997).

Table 6. Organochlorine contaminant concentrations (ng/L) in open water in Lake Huron and Lake Superior in 1987 (from Environment Canada et. al., 1997)

Organochlorine Compounds	L. Huron Stn. 33	L. Superior Stn. 80	Guideline[a]
Dieldrin	0.205	0.275	1
Lindane	0.285	1.038	10
Heptachlor epoxide	0.108	0.081	1
Total DCB	0.8	1	-
alpha-HCH	2.873	10.8	10

[a] CCREM, 1992

Inorganic contaminant concentrations (trace metals) were collected from seven open-water sites within the marine park and from Hay Bay as part of the 1994 study. Of the 15 metals analysed, five were detected in the open water and nearshore sites, however all met guidelines for the protection of aquatic life.

Table 7: Mean total trace metal concentrations (mg/L) detected in seven open-water sites in FFNMP and Hay Bay in 1994 (from: McCrea et. al, 2001).

Metal	Mean Open Water sites	Hay Bay	Guideline[a]
Aluminum	0.004	0.004	0.1
Iron	0.004	0.005	0.3
Manganese	0.0005	0	-
Nickel	0.0005	0	0.065
Vanadium	0.0001	0	-

[a] CCREM, 1992

< **Key Message:** Organic and inorganic contaminant concentrations in water are used as indicators of ecological health throughout the Great Lakes.
< **Target:** Concentrations meet guidelines for the protection of aquatic life.
T **Current status**: Organic & inorganic contaminants meet guidelines.

2.1.4 Indicator: Contaminant Concentrations in Wildlife

In addition to monitoring contaminant concentrations in open water, various agencies around the Great Lakes monitor contaminant concentrations in wildlife. Contaminants in water and sediment are taken up by aquatic organisms and bioaccumulate in fatty tissues, and uptake of contaminants through the food chain ultimately presents a source of risk to human health. Levels of organic contaminants and mercury are monitored in edible fish tissue for the purpose of issuing fish consumption advisories. Within the marine park area, there are consumption guidelines for lake trout, whitefish, round whitefish, ling, chub, cisco and bloater. Lake trout and whitefish have greater restrictions than other species, as outlined below. The area included in the fish advisory (Lake Huron zones H2 and GB2) is shown in Figure 15.

Table 8. Fish consumption advisory for take trout and whitefish in FFNMP area. Zones are shown in brackets (from OMNR, 2001)

Fish species	Contaminants of concern	Advisory (# meals per month)	
		Women & children[a]	General Population
Lake trout	Mercury PCBs mirex/photomirex pesticides dioxins and furans	< No fish >45 cm (H2) < Maximum 4 meals/month of fish >25cm (GB2)	< Maximum 4 meals/mo of fish> 45 cm; 2 meals/mo of fish > 75 cm (H2) < Maximum 8 meals/mo of fish>25 cm (GB2)
Whitefish		< Maximum 4 meals/month of fish>45 cm; no fish >65 cm; (H2) < Maximum 4 meals/mo of fish>25 cm (GB2)	< Maximum 8 meals /month of fish >45 cm; 2 meals/mo if fish >65 cm (H2) < Maximum 8 meals/mo of fish>25 cm (GB2)

[a] women of childbearing age, children<15

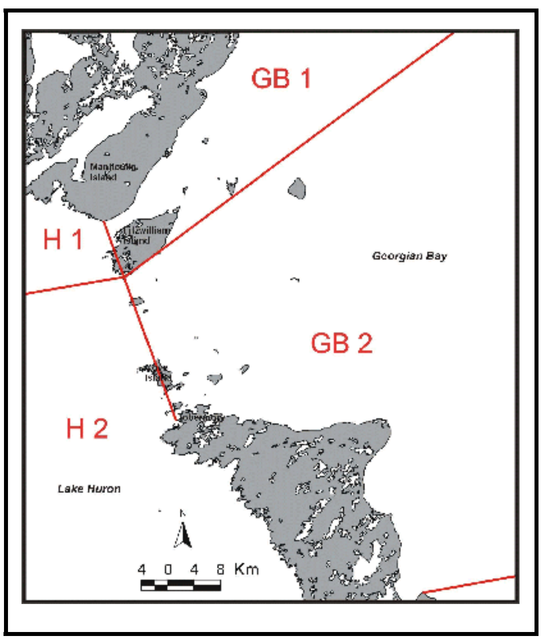


Figure 15. Fish consumption advisory zones.

A study on contaminant concentrations in zebra mussels has also been undertaken in the marine park. In 1994-95, mussels from five sites (shown in Figure 11) within the marine park were tested for metals. Levels of iron, lead, cadmium and tin were found to be elevated. Results are presented in Figures 16 and 17 in relation to background levels from uncontaminated waters in Western Europe (Brand et. al, 1996).

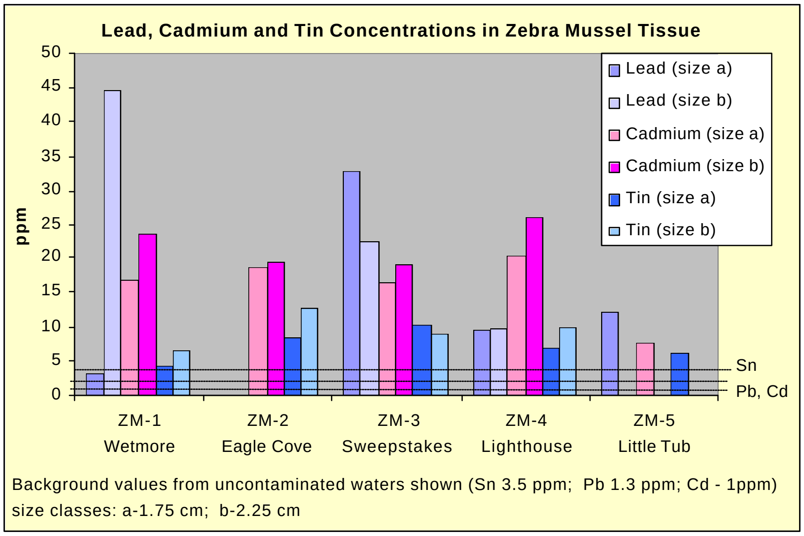


Figure 16. Contaminant concentrations in zebra mussel tissue (from Brand et. al, 1996)

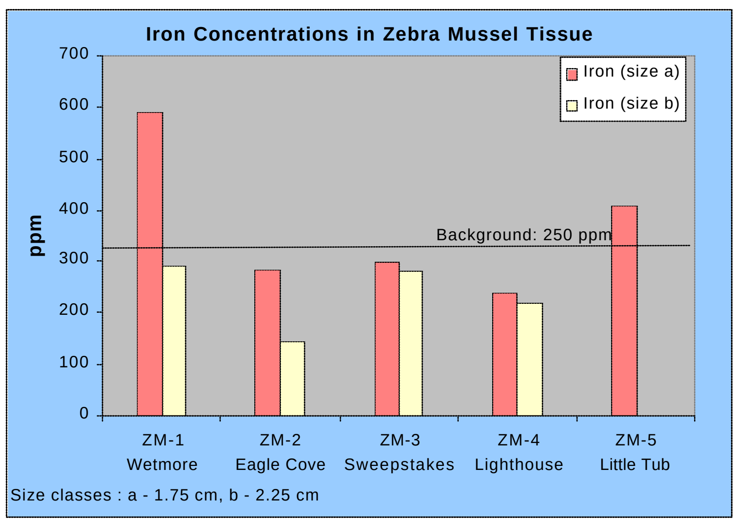


Figure 17. Contaminant concentrations in zebra mussels

< **Key message**: Contaminant concentrations in wildlife are indicative of the aquatic health of the Great Lakes ecosystem.

< **Target:** No fish consumption advisory within marine park area, concentrations in zebra mussels return to background levels

Y **Current status:** Lake trout and whitefish consumption advisory, heavy metals above background levels in zebra mussels

2.1.5 Indicator: Contaminant Concentrations in Sediment

Contaminated sediments are believed to be the major source of contaminants to the food chain in the Great Lakes. Over 3,000 kilometres, or roughly 20% of the Great Lakes shoreline is considered impaired because of sediment contamination (U.S. EPA, 2002). Contaminants adhere onto sediments and accumulate over time, and as a result may be present or elevated even when concentrations in the water column are too low to be detected (USGS, 2002b).

Benthic (bottom-dwelling) organisms are directly impacted by contaminant-laden sediments, with potential risk to human health through bioaccumulation up the food chain. In 1996, eleven metals and inorganic phosphorus were analysed in sediments within and around the marine park. Nine of eleven metals exceeded provincial and/or federal guidelines (Munawar et. al., 2001). Results are presented below.

Site	Total P	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Zn
1	**683**	**<1**	**70**	**31**	0.02	**953**	**45**	16	69
2	**608**	**1**	**45**	15	0.02	**2610**	**63**	**36**	72
3	534	**1**	**41**	**31**	0.05	423	**38**	**53**	92
3	284	**1**	**33**	**23**	0.06	288	**27**	14	78
3-B	379	**1**	**44**	**31**	**0.24**	353	**29**	**113**	**137**
4	566	**1**	**42**	**36**	0.1	296	**38**	**71**	102
4	388	**2**	**46**	**36**	0.09	259	**39**	**120**	109
5	264	**<1**	**39**	14	0.01	306	**23**	8	41
6	243	**1**	**35**	**16**	0.02	295	**22**	20	57
B	201	**1**	20	8	0.02	196	**18**	15	39
35a	492	**<1**	**40**	11	0.01	286	**20**	6	36
35c	407	**<1**	**35**	**18**	0.02	378	**25**	22	56
SB	317	**<1**	**28**	14	0.02	270	**16**	17	41
Great Lakes[1]	n/a	1.1	n/a	**25**	n/a	**400**	**31**	**23**	**65**
Lake Huron[2]	n/a	**0.2-1.8**	n/a	**31-48**	**0.04-0.08**	**30-47**	**30-51**	**14-36**	**60-88**
LEL[3]	**600**	**0.6**	**26**	**16**	**0.2**	**460**	**16**	**31**	**120**
SEL[3]	2000	10	110	110	2	**1100**	75	250	820
ISGQ[4]	n/a	0.6	**37.3**	**35.7**	0.17	n/a	n/a	35	123
PEL[4]	n/a	3.5	90	197	0.486	n/a	n/a	91.3	315

From Munawar et.al, 2002

1 - Background for the Great Lakes based on pre-colonial sediment horizon

2 - Background for Lake Huron based on depositional basins

3 - Ministry of Environment and Energy, 1994. LEL Lowest Effect Level, SEL - Severe Effect Level

4 - CCME, 1999 ISGQ Interim Sediment Quality Guideline, PEL Probable Effect Level

Aluminum, inorganic phosphorus and cobalt concentrations met guidelines and are not shown

Results exceeding guidelines shown in **bold**

Table 9. Metal concentrations in sediments in and around FFNMP

Tests to determine contaminant availability and toxicity to the benthic community indicated that the elevated levels are not causing major ecological impact, and for the most contamination was marginal, with concentrations exceeding only the provincial "Lowest Effect Level" (LEL) (Munawar et. al., 2001). Results are summarized below.

Table 10. Sediment toxicity analysis (from Munawar et. al., 2001)

Trace metal concentrations in sediment	< Manganese was the sole metal to exceed the provincial "SEL" (at site 2, Echo Island) < Lead exceeded the federal "PEL" at sites 3B and 4 (Little Tub and Big Tub, respectively). This may be related to boat maintenance activities, particularly scraping of paint. < Marginal contamination of phosphorus (above provincial LEL) at sites 1 and 2
Bioavailability testing[1]	< Uptake of lead not a concern < Uptake of zinc at sites 4, 6 (Big Tub) and 3B (Little Tub) could lead to impacts < Potential risk for copper at site C in Hay Bay.
Chronic sediment toxicity[2]	< Sites 5,6 and 35c had decreased survival (72%, 70% and 62% respectively)
Microtox[R] pore water toxicity[3]	< Mild toxicity at a majority of sites < No toxicity at sites B (Flowerpot Island), 35a and 35c (Fitzwilliam Island) < Significant toxicity at site 3 (Little Tub)-only in sediment collected in the fall

[1] - assessed uptake of lead, zinc and copper in body tissue of *Hyalella azteca*. Results may be biased, as sediments with adhered contaminants may have remained in the guts of *Hyalella*.

[2] -determined by feeding *Hyalella* in a controlled environment consisting of treated water and sediment from each site

[3] - evaluated toxicity by the concentration of sediment pore water required to reduce bioluminescence of bacterium

The zebra mussel contaminant study discussed above also included sediment sampling. Results indicated that nickel, chromium, and copper were elevated above the provincial LEL guideline at all sites. Lead, zinc and cadmium concentrations were elevated in sediments in Little Tub Harbour (cadmium also elevated at the Wetmore). Results are presented in the table and figures below.

	Cu	Ni	Cr	Pb	Zn	Cd
Wetmore (ZM-1)	**28.3**	**35**	**43.15**	21.1	78.5	**0.75**
Eagle Cove (ZM-2)	**23.2**	**39.1**	**42.3**	23.6	60.5	0.5
Sweepstakes (ZM-3)	**22.1**	**18**	**26.78**	28.8	16.8	0.18
Lighthouse (ZM-4)	**23.8**	**34.8**	**44.99**	27.3	60.3	0.34
Little Tub (ZM-5)	**54.2**	**24.8**	**60.36**	**237**	**201**	**0.79**
Background levels[1]	25	31	31	23	65	1.1
Provincial LEL[2]	**16**	**16**	**26**	**31**	**120**	**0.6**
Provincial SEL[2]	110	75	110	250	820	10

1 - Background for the Great Lakes based on pre-colonial sediment horizon

2 - Ministry of Environment and Energy, 1994.

Results exceeding guidelines shown in **bold**

Table 11. Mean contaminant concentrations in sediment (from Brand et. al, 1996).

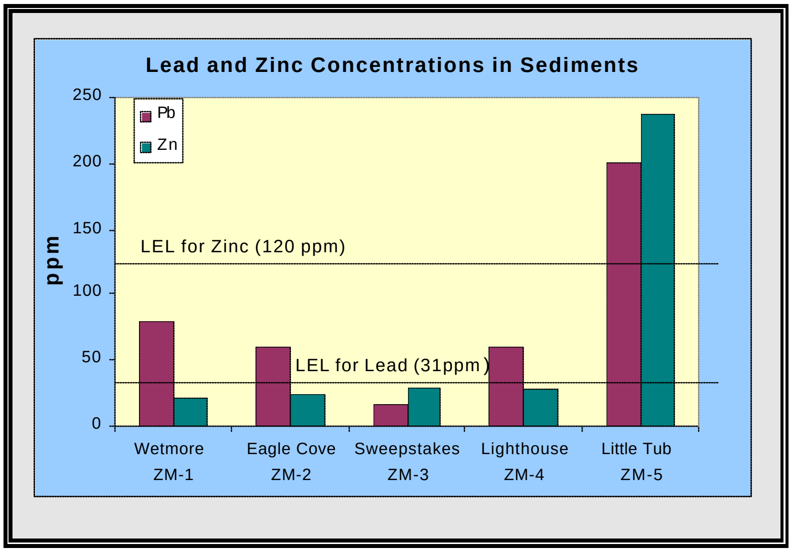


Figure 18. Lead and zinc concentrations in sediments (from Brand et. al, 1996).

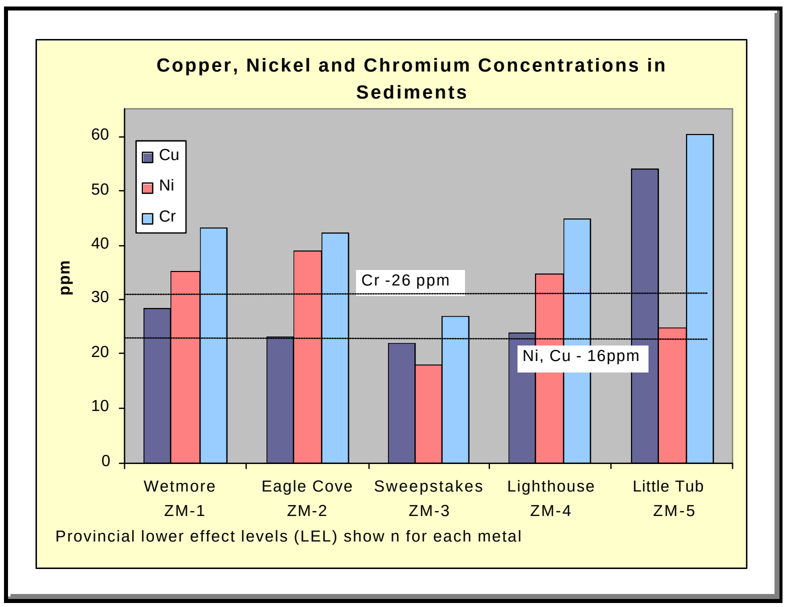


Figure 19. Copper, nickel and chromium concentrations in sediments (from Brand et al, 1996).

- < **Key message:** Contaminants in sediment are a threat to the aquatic food chain.
- < **Target:** Sediment contaminant levels meet (provincial) lower effect level guideline
- Y **Current status:** Cadmium, copper, chromium and nickel levels exceeded the LEL at most sites. Lead, manganese and zinc exceed the guideline at isolated sites.

3.0 Criteria: Biological Sustainability

3.1 Element: Lower Trophic Levels

Background

Lake-wide monitoring of lower trophic level (base of the food chain) species abundance and composition is performed to track long-term changes in the Great Lakes ecosystem. Planktonic organisms such as zooplankton and phytoplankton are used to discern the impacts of stresses throughout the food chain (e.g. nutrients, contaminants, fish populations and invasive species) as they are sensitive to water quality conditions and grazing by predators, and respond to changes in the lake ecosystem (Environment Canada and U.S. EPA, 2001; Edsall and Charlton, 1997).

Figure 20. *Cyclotella ocellata* (from GLNPO, 2002d)

Lower trophic level communities were studied within the marine park as part of the 1994 partnership study. Three sampling cruises were undertaken July, August and October, 1994, at both nearshore (<20 m depth) and offshore stations (>20 m). Results are presented below. Overall, the assessment revealed that Fathom Five is a healthy oligotrophic ecosystem (Munawar et. al., 2001).

Figure 21. *Tabellaria fenestrata* (from GLNPO, 2002d)

3.1.1 Indicator: Phytoplankton

Phytoplankton are microscopic plants that form the base of the aquatic food chain. Within Fathom Five, there is relatively high species diversity but a low concentration of biomass. Generally, the Fathom Five ecosystem harboured oligotrophic species consisting mainly of Diatomeae, Chlorophyta and Chrysophyceae (Munawar et. al, 2001). Species composition remained relatively constant during the three sampling cruises, as shown in Figure 22.

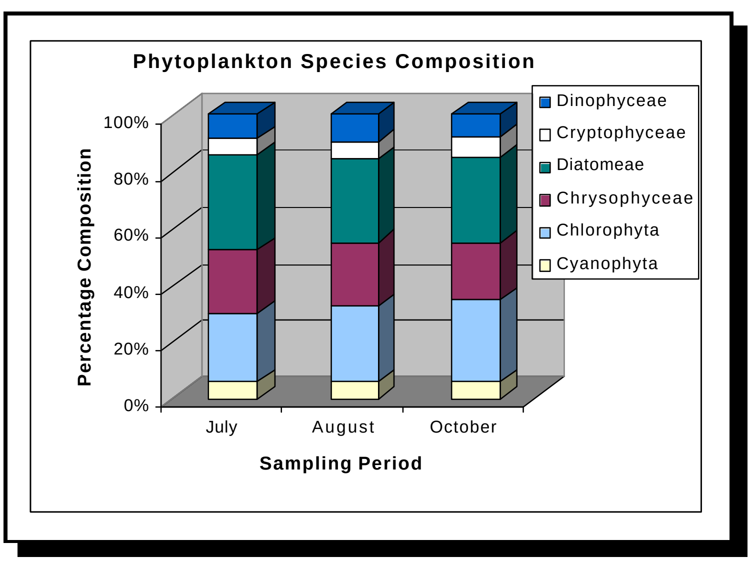


Figure 22. Phytoplankton species composition, Fathom Five National Marine Park.

Throughout the three cruises, nanoplankton (2-20um) dominated in terms of biomass at both nearshore and offshore sites, with picoplankton (<2 um) contributing the least (Munawar et. al, 2001; Environment Canada et. al., 1997). Fluctuations in biomass concentrations at each station are shown in Figure 23.

In terms of contribution to primary productivity, picoplankton dominated at all stations in July, despite its low biomass contribution. During August, the productivity rate was more moderate at nearshore stations and dominated by nanoplankton, and offshore productivity rate and relative contributions were low. The productivity rate declined at all stations during the fall cruise. In review, the offshore Fathom Five stations had similar productivity rates to those observed in Lake Huron, while the nearshore showed relatively high rates (Munawar et. al, 2001). Mean primary productivity rates for each size fraction at all sampling stations is shown below (refer to Figure 11 for sampling locations).

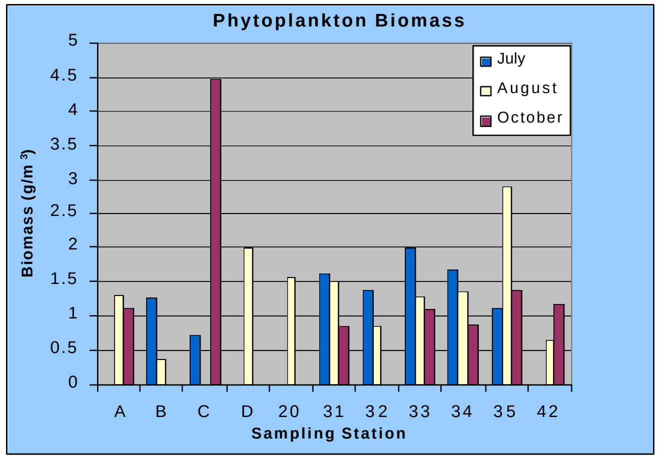


Figure 23. Phytoplankton biomass

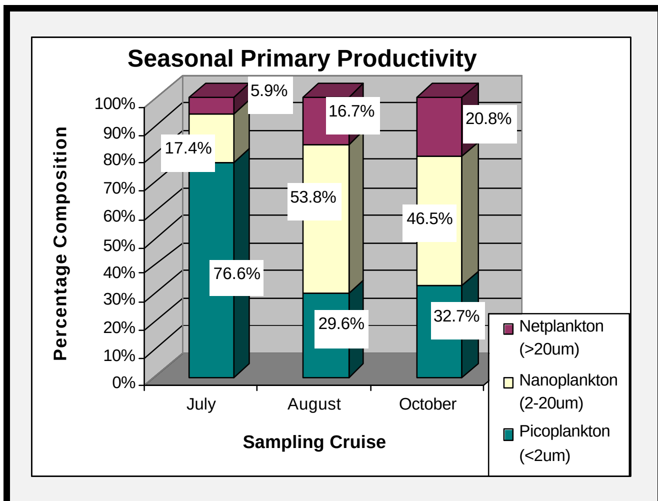


Figure 24. Seasonal primary productivity

< **Key Message:** Phytoplankton population monitoring is performed throughout the Great Lakes basin to assess aquatic ecosystem health.

< **Target**: Maintain diversity of species typical of healthy oligotrophic system.

T **Current status**: Indicative of a healthy oligotrophic system.

3.1.2 Indicator: Zooplankton

Zooplankton are the secondary producers of the aquatic food chain; they filter and eat algae and provide energy and nutrients to fish. Populations of zooplankton cycle up and down seasonally in response to temperature and food availability as well as to predation by fish (Edsall and Charlton, 1997). The zooplankton community of Fathom Five was typical of offshore Lake Huron in terms of biomass, abundance and species composition. Results were similar to earlier studies, with the addition of two recently introduced exotic species, *Dreissena* veligers (zebra mussel), and *Bythotrephes* (spiny water flea). Twenty-five species were observed, with rotifers and copepods the most abundant groups, followed by cladocerans. Large invertebrates were rare at most stations (Environment Canada et. al. 1997; Munawar et.al., 2001).

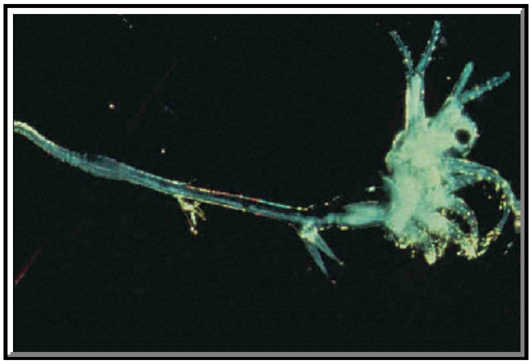


Figure 25. Spiny water flea (from GLNPO, 2002e).

Overall, the 1997 study shows a decline in crustacean zooplankton density and biomass in comparison with previous studies conducted in 1971, 1983 and 1988. There also appears to be a shift in cladoceran community composition to dominance by three species (*Bythotrephes, Bosmina* and *Daphnia g. mendotae*). This shift in community structure may reflect predation by *Bythotrephes*, which eats other zooplankton and is not a preferred prey for many fish. It therefore competes directly against young-of the year fish for energy. Predation by planktivorous fish such as alewife and young bloater may also be a factor in reduced zooplankton density and biomass (Munawar et al., 2001; Edsall and Charlton, 1997).

< **Key message**: Zooplankton population monitoring is conducted throughout the Great Lakes in order to track system-wide shifts at lower trophic levels.
< **Target**: Maintain species diversity typical of healthy oligotrophic system.
Y **Current status**: Lower biomass and density than previous studies. Shift in species dominance observed.

3.2 Element: Fish Population

Background

The marine park straddles the transition zone over the submerged portion of the Niagara Escarpment, a highly productive area that attracts many aquatic species. The deepwater fish community utilizes the profundal zone in open lake water as habitat within the park, while warmwater species are dependent on sheltered bays with associations of aquatic vegetation that provide food and refuge (Geomatics International 1993; ESP, 1993). Fish harvesting within the park boundary remains a source of livelihood for First Nations, as well as a recreational past time for sports fishing enthusiasts. Both warmwater and coldwater species are targeted for harvesting.

The indicators below examine the fish population of the marine park in terms of fish habitat, community structure and resource harvesting. To date, very little research has been undertaken on deepwater fish habitat within the park, although the use of new technology to access deep water fish habitat is currently being examined (Indicator 4.2.1). The indicator for fish habitat is therefore restricted to a discussion of the nearshore, or littoral zone of the marine park.

3.2.1 Indicator: Nearshore Fish Habitat

Nearshore areas of the Great Lakes provide critical habitat to virtually all species of Great Lakes fish during one or more of their life stages. Abundant food supply and protection from predators are provided by aquatic macrophyte communities along the shore. Higher water temperatures in these shoreline areas also provide favourable conditions for fish species (GLNPO, 2002b). Within the marine park, different littoral ecosystems are found on the Lake Huron and Georgian Bay shores. The eastern shore is exposed to high wave energy and the steep drop-off at the nearshore is largely unsuitable to aquatic vegetation communities. Nearshore fish habitat is therefore limited to relatively protected portions along the western shore, where suitable substrate for root establishment occurs (Geomatics International, 1993).

Species composition in the littoral zone is largely a function of the extent and complexity of the shoreline macrophyte communities. Nearshore habitat within the marine park has been ranked, primarily on the basis of plant species richness and density, to determine areas of significance. Hay Bay (considered the most important area for nearshore habitat), Cove Island and Russel Island were identified as areas of local and regional significance in terms of spawning, nursery and adult habitat (Geomatics International, 1993). The areas of local and regional significance are shown in Figure 26, and a survey of fish species found in these areas is shown in Figure 27.

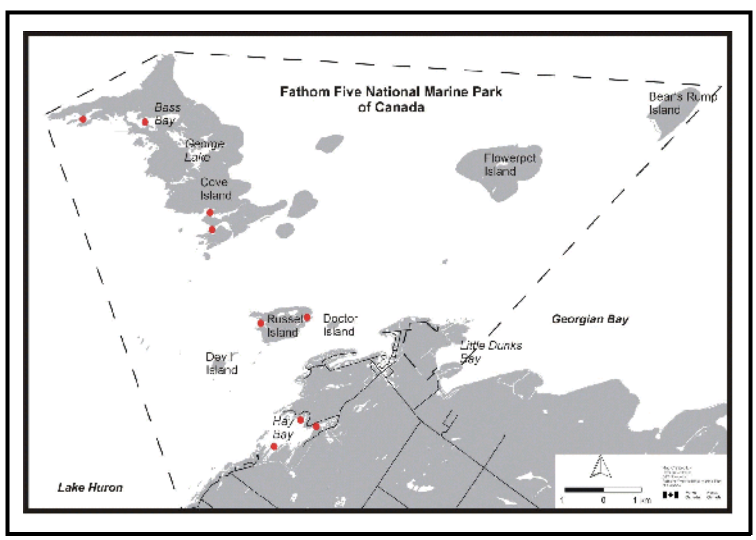


Figure 26. Nearshore fish habitat of local and regional significance.

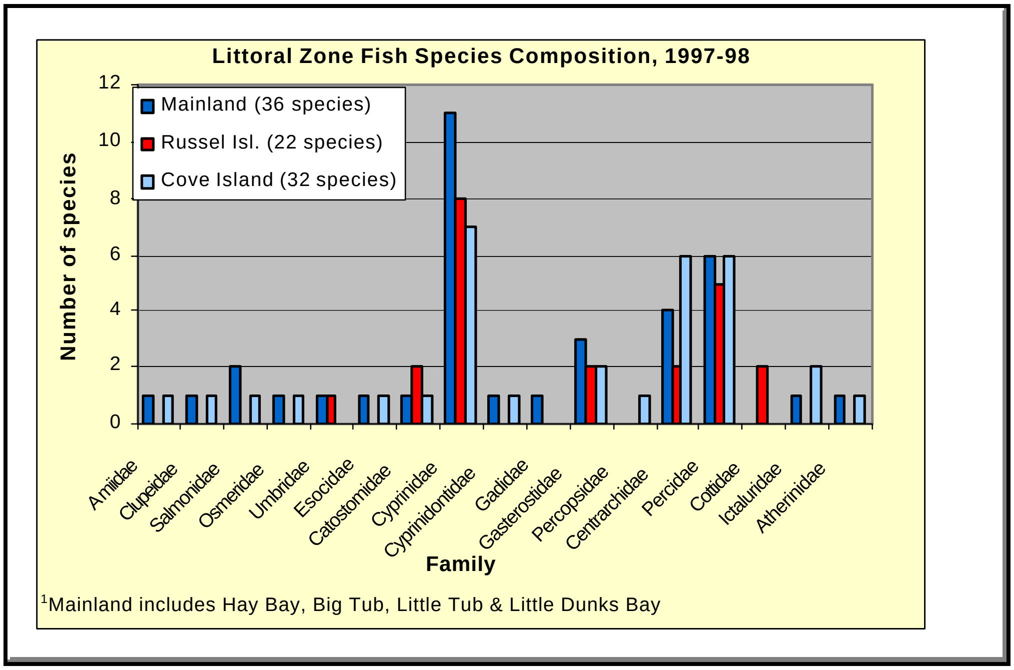


Figure 27. Littoral zone fish community, FFNMP (from Leslie and Timmins, 2001).

Overall, shoreline vegetation communities within the marine park are sparse, scattered and lacking in structural complexity. The situation for many species is tenuous, as there is no alternative habitat if existing areas are destroyed or degraded (Leslie and Timmins, 2001). Maintenance of macrophyte communities in significant areas will ultimately determine the health of the warm water fish community within the park (Geomatics International, 1993). In the future, satellite imagery and underwater mapping (Indicator 4.2.1) will be used to delineate critical nearshore habitat in Fathom Five. A monitoring protocol will be developed to quantify the areas of high macrophyte density and distribution.

- **Key message**: The extent, density and diversity of shoreline aquatic macrophyte communities determines the health of the warmwater fish community within and around the marine park.
- **Target:** Undeveloped.
- **Current status:** Critical habitat for warmwater species is found within Fathom Five.

3.2.2 Indicator: Fish Community Structure

The present fish community bears little resemblance to that originally found in Fathom Five. Overfishing and introduced species have resulted in extirpation or severe reductions in the abundance of native species, and as a result, food chains are highly unbalanced. Although the warmwater community has been little affected, the coldwater fish community has undergone dramatic changes, as shown below.

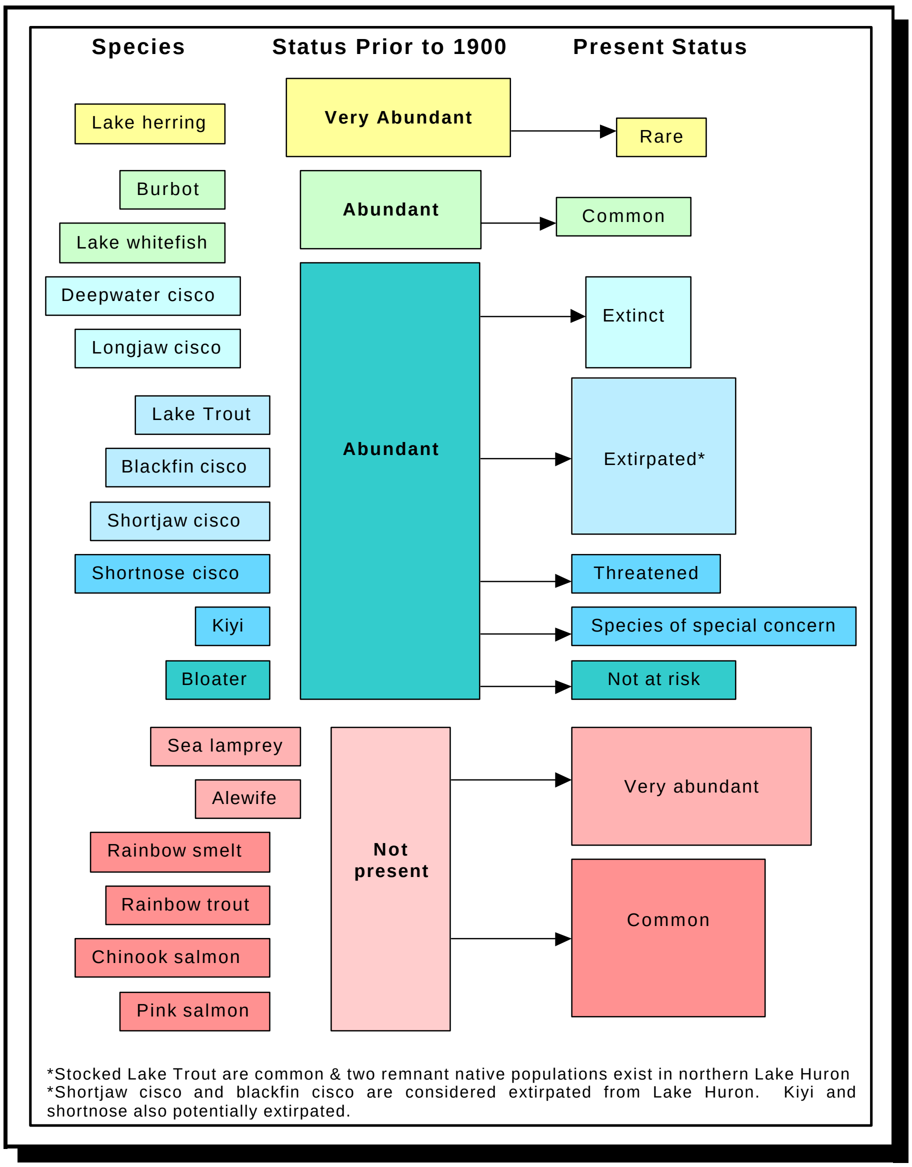


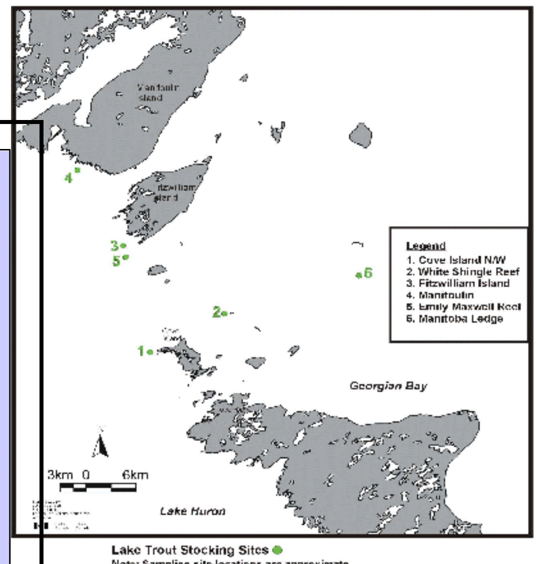
Figure 28. Historic coldwater fish community structure of Fathom Five (from Beak, 1990 and COSEWIC, 2000).

The historic structure of the coldwater fish community included herring/whitefish as primary consumers and lake trout as predators, or secondary consumers in the upper zone. In the deeper zone, five deepwater cisco species (chub) were primary consumers, and lake trout and burbot functioned as the secondary consumer level (Beak, 1990). Contributing factors to the shift in community composition are outlined below:

< During the 1940's -50's, lake trout were extirpated by selective overfishing and sea lamprey mortality. Cisco populations subsequently flourished in the absence of a predator, but larger cisco and whitefish were quickly depleted by commercial fishing.

< During the 1950's-60's, bloater (the smallest cisco) expanded due to lack of predation and competition, but was also targeted by commercial fishing and collapsed. Smelt and alewife, two non-native species became dominant due to the lack of predator.

Returning the Great Lakes to the biological communities of one hundred years ago is not feasible, and the loss of genetic diversity from extinctions and extirpation of local stock (lake trout, ciscoes) cannot be repaired. The coldwater fish community continues to be poorly represented at the predator level. Chinook salmon and rainbow trout (both non-native) are present, but numbers are too low to control smelt and alewife. Stocked lake trout have not shown successful reproduction, and appear to predate primarily on smelt and alewife, rather than bloaters and other ciscoes (Beak, 1990). Figure 29 indicates the number of lake trout stocked in the Greater Park Ecosystem (GPE) of Fathom Five in recent years, with locations shown on the accompanying map.



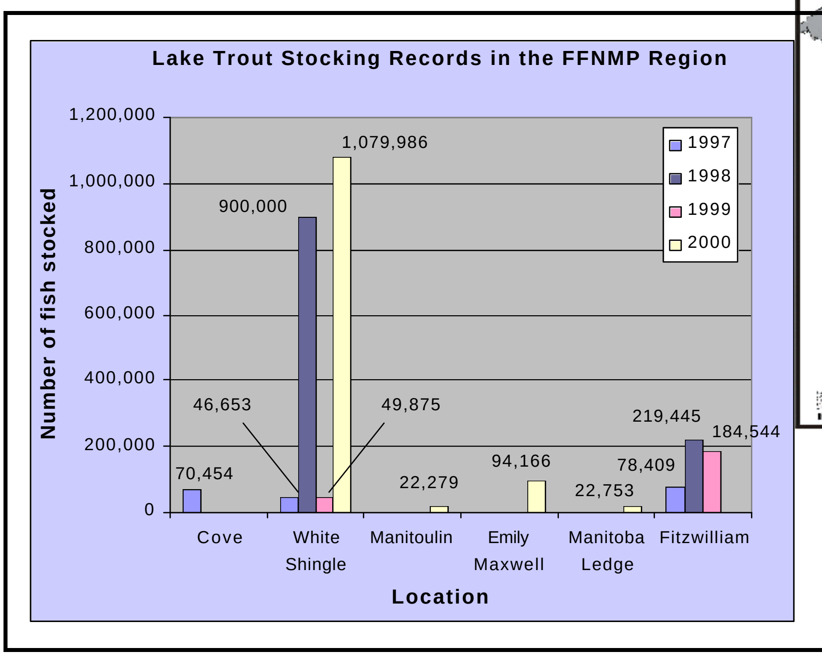


Figure 29. Lake trout stocking in Fathom Five GPE, 1997-2000 (from OMNR, 2002).

Restoration of native species and a stabilized community is desirable. The re-establishment of a self-sustaining lake trout population is an appropriate indicator for the health of the cold-water community.

- < **Key message**: The coldwater fish community of Fathom Five is unstable and altered from its historical state due to overfishing and non-native species introductions.
- < **Target:** Re-establishment of self-sustaining lake trout population genetically similar to original community.
- Y **Current status:** Stocked lake trout not yet successfully re-established within marine park.

3.2.3 Indicator: Resource Harvesting

The management focus of a marine park (ecological sustainability) allows harvesting of fish populations within the park boundary. Both commercial and sports fishing activities currently occur within the boundaries of Fathom Five. Under the terms of the federal-provincial agreement that established the marine park, the Province of Ontario manages both commercial and recreational fisheries through a fisheries management agreement with Parks Canada (Parks Canada, 1998a).

Commercial fishing became the primary economic activity in Tobermory in the early 1900s, when the timber industry declined. The viability of the commercial fishing industry declined as the result of over-fishing and the invasion/introduction of non-native species. Until recently, local inhabitants operated commercial fishing enterprises out of Tobermory. The Ontario Ministry of Natural Resources (OMNR) undertook a program of buy-outs of commercial fishing licenses in 1997, and commercial fish harvesting in the marine park is currently operated exclusively by the Chippewas of Nawash and Saugeen First Nations.

Currently, commercial harvesting efforts focus on whitefish, which has recovered well from fishing pressures in the 1950's and 1960's (Edsall and Charlton, 1997). The use of gill nets leads to incidental catch of (stocked) lake trout, which are caught in association with whitefish. Catch information from First Nations is not presently available, although the marine park has entered into a research agreement with First Nations which should provide more information on species harvested and level of catch within the park. Figure 30 indicates the level of harvesting of various species within the marine park during the late 1980's.

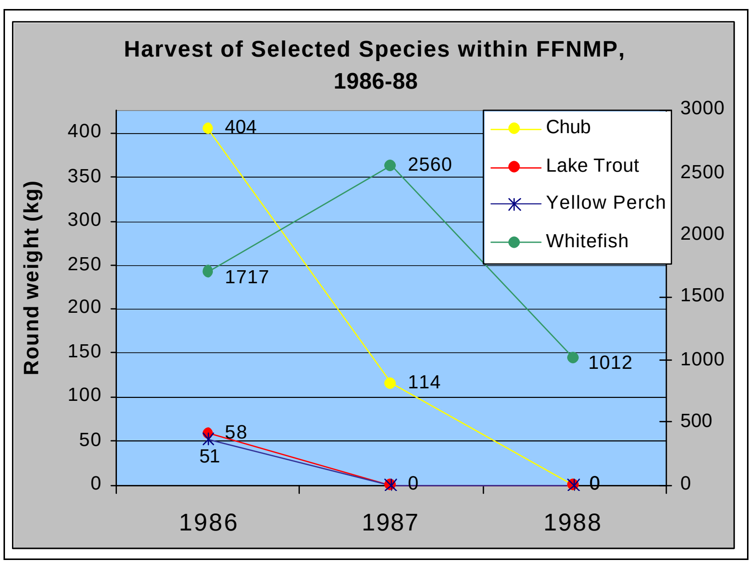


Figure 30. Fishing harvest in Fathom Five during the late 1980's (from Beak, 1990).

Sports fishing in Fathom Five is targeted at warmwater fish species (smallmouth bass and northern pike) in shallow littoral areas around the islands of the marine park and along the mainland shoreline of the park. Deepwater sports fishing in the open water offshore is based on stocked populations of trout and salmon (Parks Canada, 1998a; Beak 1990). Although deepwater sport fishing declined in the 1940's with the collapse of lake trout stocks, it has since gained popularity with the increasing abundance of rainbow trout and chinook salmon from fisheries management activities. There is currently no information available on the amount of sports fishing taking place in the marine park.

< **Key message**: Recreational and commercial fishing remain part of the cultural heritage of the marine park.
< **Target**: Harvesting done at sustainable level
Y **Current status**: No information on current level of harvesting.

3.3 Element: Invasive Species

<u>*Background*</u>

As mentioned above, the introduction of non-native species has had a significant impact on the ecosystem structure of Fathom Five, as it has elsewhere in the Great Lakes. Since the 1800's, over 160 organisms have been introduced into the Great Lakes basin, which is now considered one of the most highly disturbed systems in North America (Michigan DEQ, 2000; Crawford, 2001). Methods of introduction have included release of organisms from bait buckets and aquariums, escape from cultivation, and deliberate introduction of species for sports fishing. Transportation routes such as canals, railroads and highways have also provided vectors of introduction. The majority of species, however, have been introduced through the shipping industry, via ballast dumping (Mills et. al, 1993; Great Lakes Water Quality Board, 2001).

Figure 31 . Zebra mussel covering native mussel (from GLNPO, 2002e).

Introduced species displace native species, alter the existing food chain and change habitat characteristics. Approximately 10% of introduced species grow unabated due to a lack of natural controls and are considered "invasive" (Michigan DEQ, 2000). The ecological consequences of invasive species introductions are summarized in the table below.

Table 12. Ecological impacts of invasive species (from Crawford, 2001).

Diseases and parasites	< Exposure to new diseases and parasites leads to increased mortality of native species
Predation	< Prey species in the recipient ecosystem have not evolved to counter the predation style of non-natives < Abundance and diversity of native prey species is threatened
Competition	< Introduced species compete for the same, finite resources as native species (e.g. food, spawning habitat)
Genetic alteration	< Potential for wild hybridization of native and introduced species, producing sterile or viable hybrids < Transfer of genes may disrupt evolutionary adaptation of native species to its ecosystem < Loss of genetic diversity from extirpation
Environmental alteration	< Species affect their environment through interaction with it, and non-natives may alter the environment differently than native species
Community alteration	< Shifts in community composition are the inevitable outcome of alterations in predation, competition, and environmental conditions

3.3.1 Indicator: Invasive Species

Although the arrival of non-native species into the northern lakes tends to lag behind the southern lakes of the basin, many species have become established in Lake Huron (Mills et. al., 1993). Figures 32 and 33 present the number and diversity of invasive species introduced to the Great Lakes and Lake Huron in the past 200 years.

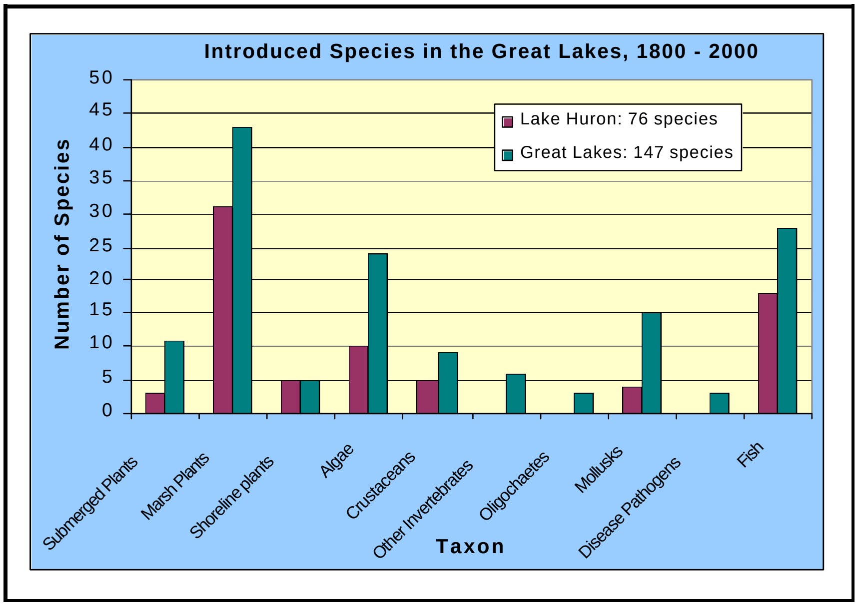


Figure 32. Species introductions into the Great Lakes (based on a review of Michigan DEQ, 2000 and Mills et.al., 1993).

Both terrestrial and aquatic invasive species are present in Fathom Five. Although the number of invasive species within the marine park is unknown, it can be assumed that many of the non-native species presently recorded in Lake Huron are also present in the marine park. A study of fish habitat within the marine park (including nearshore, deepwater, plateau and shoal locations) found 25% of fish species collected from sample sites were non-native (Crawford, 1994). As mentioned in the Indicator 3.1.2, spiny water flea and zebra mussel are known to be present and may be affecting the trophic structure of the Fathom Five aquatic ecosystem.

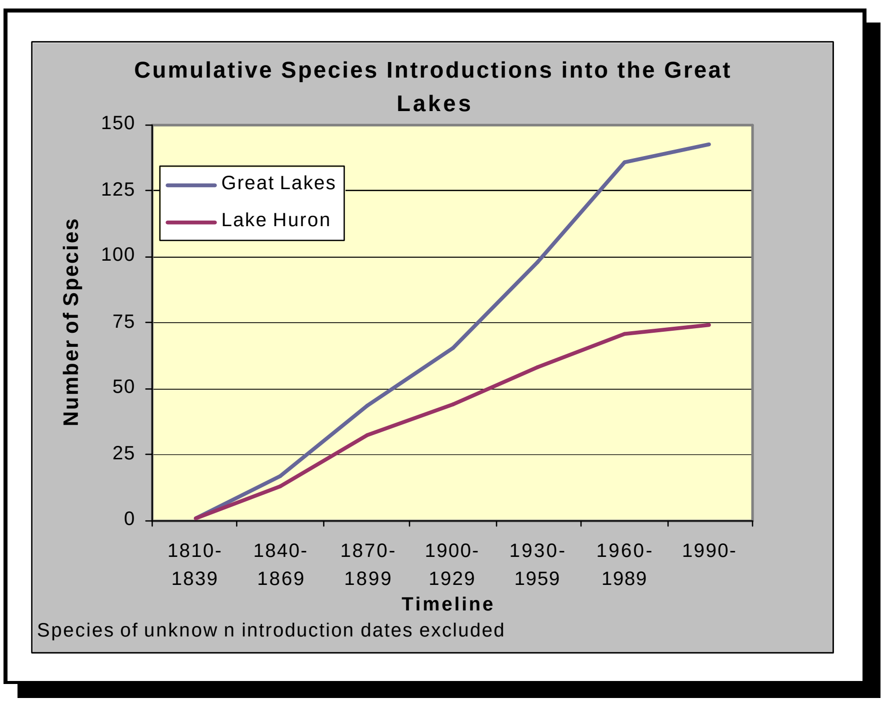


Figure 33. Cumulative Species Introductions into the Great Lakes (based on a review of Michigan DEQ, 2000 and Mills et.al., 1993).

< **Key message**: Non-native species cause irreparable damage to the biotic community.
< Target: 0 increase in non-native species
Y Current status: Approximately 76 non-native species in Lake Huron.

3.4 Element: Species at Risk

Background

The loss of native species has an irreversible affect on an ecosystem, and the protection of native species and their genetic diversity is a high priority in conservation efforts. In Canada, species populations undergo extensive research prior to designation as a "species at risk of extinction" by COSEWIC, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC status categories are presented in the Glossary, Table A). Both aquatic and terrestrial organisms at risk of extinction are found within the marine park. Several species, including deepwater ciscoes (herring-like, medium-sized fish) and Eastern Massasauga Rattlesnake, are currently the subject of park-sponsored research and are discussed below.

<u>*3.4.1 Indicator: Aquatic Species at Risk*</u>

Up until the 1950's, there were at least seven species of deepwater ciscoes (or chubs) in the Great Lakes, although research has suggested that there may have been many more locally evolved species and subspecies (Todd and Smith, 1992). Today, ciscoes are represented by a few closely related species or subspecies that are extinct, approaching extinction or merging their genetic identities by interbreeding . Much like the lake trout, overfishing and predation by sea lamprey are believed to have led to their decline. Predation of young ciscoes by alewife and rainbow smelt is also believed to have been a factor (Edsall and Charlton, 1997).

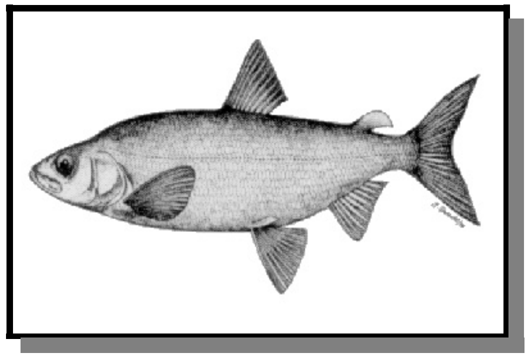


Figure 34. Blackfin Cisco (*Coregonus nigripinnis*)

Of the historically present deepwater ciscoes, two are now considered extinct, and all of the existing species are extirpated in one or more of the Great Lakes. The current status of three species is poorly known (the shortnose may be extinct, and the status of kiyi and shortjaw ciscoes is unknown in Lake Huron, although they are believed to have been extirpated) (Beak, 1990). The COSEWIC listing of cisco species is shown in Table 13.

Table 13. COSEWIC listings for cisco species (from COSEWIC, 2001).

Species	COSEWIC listing
Deepwater cisco *Coregonus johannae*	Extinct (1952)[1]
Longjaw cisco *Coregonus alpenae*	Extinct (1975)[1]
Shortjaw cisco *Coregonus zenithicus*	Threatened
Shortnose cisco *Coregonus reighardi*	Threatened
Blackfin cisco *Coregonus nigripinnis*	Threatened
Kiyi *Coregonus kiyi*	Special Concern
Bloater *Coregonus hoyi*	Not at risk

[1] Approximate date of extinction

Taxonomically, the ciscoes are very similar, and fishermen in the area who catch "chub" may potentially be catching threatened species. Two cisco species, (shortnose and kiyi) may still occur within the waters of Fathom Five (Beak, 1990). The park is undertaking a collaborative project with partners from

Department of Fisheries and Oceans and Chippewas of Nawash First Nations to sample reported locations of capture of cisco species, with the intention of determining their current status in Lakes Huron and Superior.

- **Key message**: Deepwater ciscoes are COSEWIC-listed species at risk.
- **Target:** 0 further extinctions of cisco species
- **Current status:** 2 cisco species extinct in Lake Huron; potentially 2 species at risk within the marine park (kiyi and shortnose) .

3.4.2 Indicator: Terrestrial Species at Risk

The Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*), Ontario's only venomous snake, is classified as a threatened species by COSEWIC. There is a resident population on Cove Island within Fathom Five (two other locations within the marine park have also been reported). Elsewhere in the province it has been decimated by persecution, and its habitat has been destroyed and fragmented by development. The few remaining populations in the province are geographically isolated from one another. The Cove Island sub-population, about which very little is known, remains largely undisturbed by human activities, as the island receives few visitors and most activity is restricted to the lighthouse area (Britton and Prior, 2001).

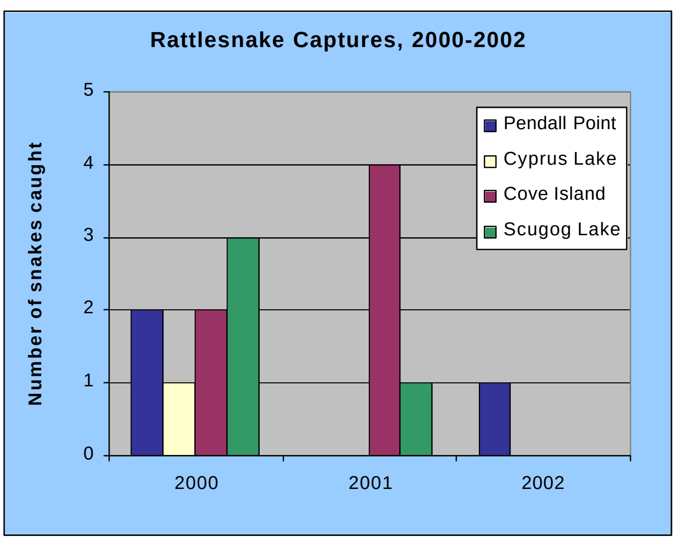


Figure 35. Rattlesnake capture numbers in BPNP and FFNMP, 2000-2002 (Shaw, 2002). According to protocol, the number of search hours is to remain consistent (10 hours/site) from year to year.

The snake is the subject of research focused on thermal ecology and habitat requirements (Weatherhead and Harvey), as well as a park-based long-term monitoring program. Park monitoring efforts are concentrated on baseline data collection, to enable future evaluation of population fluctuations and extinction, reproduction and recruitment rates. To date, monitoring of snakes on Cove Island has been limited by difficulty in accessing the site, although population sampling efforts on the island have resulted in the identification of one gestation/birthing site. Consistent monitoring of the Cove Island rattlesnake population over a long time frame will be necessary in order to assess population health. Figure 35 presents the number of snakes captured at sites in Bruce Peninsula National Park and Fathom Five National Marine Park since monitoring was undertaken.

< **Key Message**: The Eastern Massasauga Rattlesnake is a COSEWIC-designated threatened species.
< **Target:** 0 extirpations from marine park.
T **Current status:** Present in 3 known locations within the marine park**.**

4.0 CRITERIA: SOCIAL SUSTAINABILITY

4.1 Element: Education

Background

As described in the report of the Panel on Ecological Integrity of Canada's National Parks, parks can play a key role in educating about Canada's natural environment, ultimately becoming "centres of ecological understanding" at the core of a sustainably managed landscape (Parks Canada Agency, 2000). Park education programs are switching focus from traditional in-park programs aimed at out-of town visitors to outreach programs oriented towards residents of the "Greater Park Ecosystem" (GPE). Regardless of the audience, all education programs about the marine park incorporate messages about ecological sustainability, although requests are often for specific topics of interest (i.e. flowerpot formation and rattlesnakes). The challenge is to fulfill this type of request by placing it in the context of the ecosystem, rather than sticking to a narrow topical focus.

Education programming for Fathom Five is done in conjunction with programming for BPNP, and in the past the majority of education messages have focused on the terrestrial environment, (i.e. discussing the islands in the marine park) rather than the aquatic ecosystem. Although big news items such as zebra mussels and *e.coli* contamination generate a fair amount of interest, overall there is a lack of knowledge about marine ecosystems. Awareness of and appreciation for aquatic resources is low, as noted in a 1994 report about conserving biodiversity in the Great Lakes basin:

> It is commonly accepted that the biological elements that occur in tropical rain forests are important, highly threatened and need to be conserved. Unfortunately, the same understanding does not exist for the Great Lakes ecosystem (The Nature Conservancy, 1994).

Add to this the lack of awareness about the system of marine conservation areas in Canada, and the need for focused and expanded education programs becomes clear. Park wardens, biologists and interpretive staff at Fathom Five are co-ordinating communications to ensure a consistent approach in explaining the role of marine parks in sustaining the ecological health of the aquatic ecosystem.

<u>4.1.1 Indicator: Outreach Programs</u>

Education programs aimed at the local community are currently co-ordinated through a full time "outreach" position within Heritage Presentation. In the past two years, an annual open house has been instituted to provide a day when area residents can talk to park employees and learn about projects the park is involved in. Additional programs characterised as "outreach" (i.e. targeted at a local residential audience) include publications in the local newspaper, workshops on shoreline development, updates on the Visitor Centre (see below), and a park-sponsored orchid festival. Many of these programs are made possible by the contributions of partners in the local community.

Table 14. Average annual outreach programs at BPNP/FFNMP

Newspaper articles	20
Park radio	30
Local school programs	20
Community-wide events[a]	15

[a]: includes workshops, open-house and festivals

The park stands to gain significantly from improved communication with the local audience, not only in terms of generating support for and awareness of ecosystem sustainability initiatives, but also by accessing local knowledge. There is considerable local and First Nations knowledge about the local ecosystem and cultural heritage. Overall, improved communications between area residents and Parks Canada will help achieve the goal of ecological sustainability.

Case Study: Bruce Peninsula/Fathom Five Visitor Centre

The new park visitor centre (for which the funding is presently delayed) has been designed to act as a community resource and learning centre, rather than being simply geared towards out-of-town visitors. Environmental education programs for local schools will be run out of the new visitor centre, the park library and artifact collection will be more available, and the conference room will be open to area residents as well. In addition, local knowledge will be drawn upon in development of the Visitor Centre displays, particularly with regards to local cultural heritage.

< **Key message**: Outreach education is key to achieving park resource management goals.
< **Target:** 10 community-oriented Fathom Five events per year.
Y **Current status**: 15 events for both parks.

4.1.2 Indicator: Interpretive Programs

Programs for the general audience have been the mainstay of park education activities. These programs orient visitors to the marine park and establish a connection to the local environment, which is essential in developing visitor respect for and appropriate interaction with park resources. As with outreach programs, in the past these programs have been focused on the terrestrial ecosystem rather than the marine environment. Figure 37 presents visitor statistics for interpretive programs, including campfires, amphitheatre programs, hikes, stations (generally a display staffed by an interpreter in an accessible location) and roving talks. The program on board the Chi-cheemaun (ferry to Manitoulin Island) has been displayed separately, as it reaches a very large

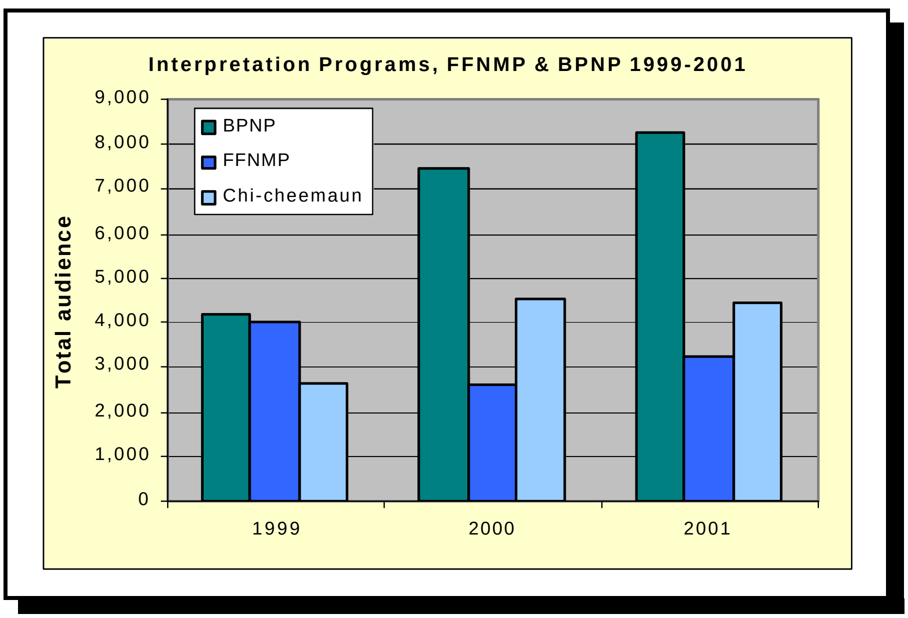


Figure 36. Interpretation contacts, FFNMP & BPNP 1999-2001

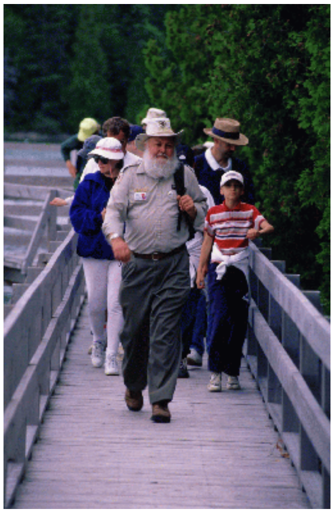


Figure 37. Parks Canada interpretive staff on Flowerpot Island.

audience, and both parks are discussed. The main focus of the talk, however, is aquatic.

It is anticipated that interpretive program delivery will improve with construction of the Visitor Centre. The new facility will help convey messages about the aquatic ecosystem and will serve as a centralized education resource, which is currently lacking. Many park visitors live within the Great Lakes basin and marine ecological information is therefore of local interest to them as well.

- **Key message**: Interpretive education increases awareness about the aquatic environment and the system of marine conservation areas.
- **Target:** 4,000 contacts per year, with increased focus on aquatic ecosystem.
- **Current status:** 3,204 contacts in 2001 (excluding ferry program).

4.2 Element: Partnerships

Background

Protected areas alone cannot succeed in conserving the ecological health of an area. Cooperation with other agencies is a necessity, as is the support and interest of the local community. Generally, the goals of partnerships can be categorized as either improving regional integration or science capacity.

Regional integration	< Establishing working relationships in the GPE facilitates conflict resolution < Sharing of knowledge and resources improves understanding of park goals and community needs < Leads to cooperation on mutually beneficial undertakings
Science capacity	< Links to the external science community enhance knowledge beyond what could be achieved with internal resources (fiscal and personnel) < Allows the park to draw from and contribute to research in the GPE

Table 15. Benefits of partnerships.

Ultimately, the goal of ecological sustainability will only be achieved through effective partnerships with adjacent landowners, business owners and local stakeholders. Research partnerships and working relationships are used as indicators of success in achieving the required collaborative approach.

4.2.1 Indicator: Research

There is continued research interest in Fathom Five, and in recent years the marine park has been the subject of significant research projects on both terrestrial and marine ecosystems. In 2001, a collection of research on the marine park was compiled and published as a book, entitled *Ecology, Culture and Conservation of A Protected Area: Fathom Five National Marine Park, Canada*. This milestone publication has provided much of the benchmark information for this report and indicates both the diversity of research in the park and the need for further study. Figure 38 illustrates the number of research permits at the marine park since 1994. Research projects that were undertaken in both parks are shown separately.

One significant multi-partner project which is currently ongoing in the marine park is detailed below.

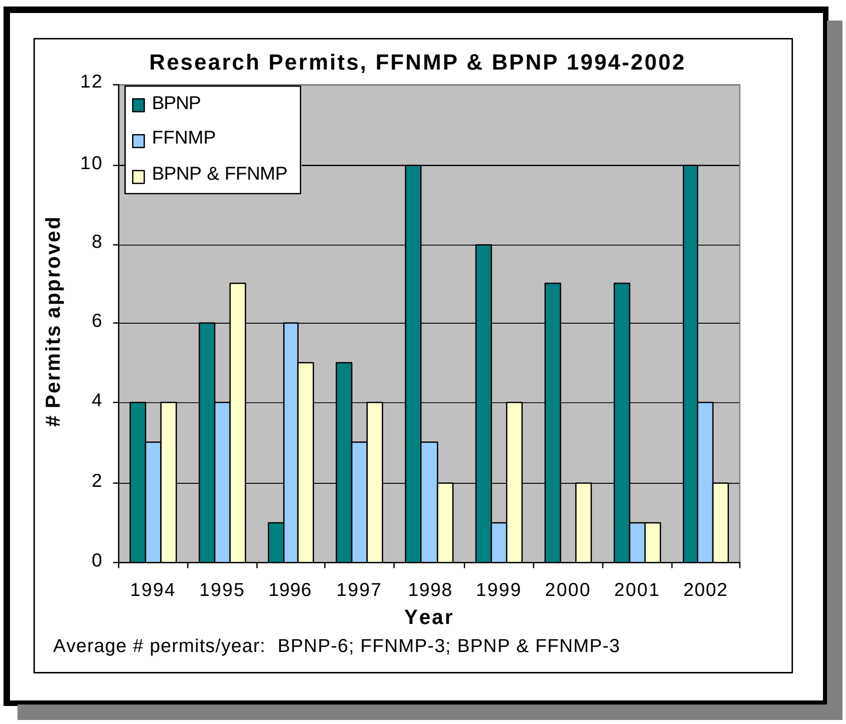
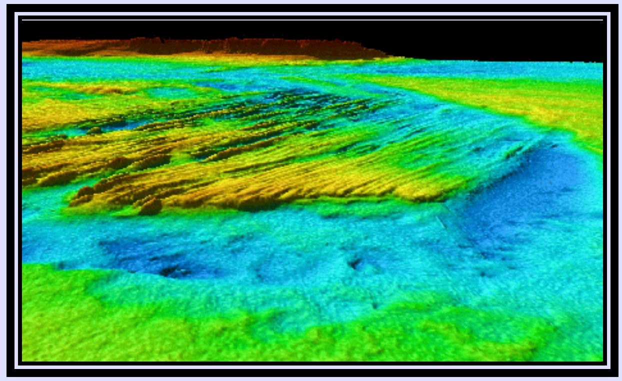


Figure 38**.** Research Permits in FFNMP and BPNP, 1994-2002..

Case Study: Underwater Mapping and Aquatic Habitat Classification

The objective of the underwater mapping project is to conduct a natural resource assessment and evaluation of the Fathom Five National Marine Park GPE. The project will generate a series of geo-referenced benthic terrain maps and associated digital databases. This will provide a basic inventory, fundamental to our understanding of the marine park ecosystem and necessary for assessment of bottom structure, critical habitat and unique, rare or representative features within the study area.

The project will be undertaken in two phases: initially, we would incorporate the use of a high-resolution multi-beam scanner (similar to satellite technology) to map the bottom structure of the lakebed. The second stage will be to develop a classification scheme to identify recurring ecological patterns on the lakebed, which will allow us to reduce complex natural variation to a reasonable number of meaningful ecosystem units. The project will focus on actual and potential habitat availability, rather than species-specific mapping.



The underwater mapping project will ultimately produce a series of high resolution, geo-referenced digital benthic terrain maps providing information on bathymetry, lakebed morphology and dynamics, sediment distribution, natural and anthropogenic features, geology, benthic habitat ecology, and lakebed resources. The product would be a seamless benthic terrain map extending from the shore to the deepest waters within the GPE, with a horizontal resolution of +/- 3m and vertical resolution of +/- 0.1m.

The project will enhance our ability to manage the aquatic ecosystem by improving our understanding of ecological structure and function as well as our knowledge of abiotic, biotic and cultural resources. The project will be driven by a partnership between Canadian Hydrographic Service, the Geological Survey of Canada, Defence Research and Development Canada, Department of Fisheries and Oceans, Chippewas of Nawash First Nation, and the Ontario Marine Heritage Committee.

< **Key message**: Research partnerships enhance scientific knowledge beyond in-park capabilities.
< **Target:** 6 research projects undertaken on Fathom Five each year.
T **Current status:** 6 FFNMP-related research permits in 2002.

4.2.3 Indicator: Working Relationships in the Greater Park Ecosystem

As discussed above, effective management for ecological sustainability requires work with partners in the GPE. There is a long list of target groups for improved working relationships, including provincial and municipal governments, First Nations bands, conservation groups, the business community, tourism agencies and local stakeholders. Currently, the main forum for involvement with park management is through the Park Advisory Committee (PAC), which was established to provide local stakeholder groups a voice in management decisions for FFNMP and BPNP. Other local liaison work is done through outreach programs, which are discussed above in Section 4.1.1, above. Some 15 groups are currently represented on the PAC (Table B in the glossary presents a full list of members), which meets every three months. Members provide feedback from their respective groups on tabled management issues, research projects and planning items. Three agencies on the PAC have a marine focus (Friends of Bruce District Parks, Ontario Underwater Council, and the Tobermory Maritime Association, which is currently not operational). Other working relationships are outlined below:

Figure 39. Friends of Bruce District Parks greeting visitors at Flowerpot Lightstation.

Table 16. Additional working relationships in the Greater Park Ecosystem

Agency	Interaction Basis
Department of Fisheries and Oceans	< fish habitat protection
Canadian Coast Guard	< marine rescue, navigable waters protection, shared facilities
Ontario Ministry of Natural Resources	< fisheries management, property transfer
First Nations groups (also represented on PAC)	< fisheries management, land use

< **Key message:** Working relationships in the GPE are critical to effective resource management.
< **Target:** 10 working relationships
< **Current status:** 6 working relationships (2 PAC + 4 Additional)

4.3 Element: Visitor Use

Background

Both the terrestrial and marine portions of the marine park are used by visitors (shoreline residents, who have direct access to the park, are not included here). Although some scale of impact is inevitable, the goal is to achieve sustainable use: a level of use without threat to ecological sustainability. Effective visitor management must therefore reflect an understanding of the impacts of visitation to the park ecosystem. These impacts include trampling of vegetation and soil, disruption of wildlife, and the introduction of wastes and invasive species. Impacts to cultural resources are also possible, whether inadvertent or intentional.

At the present time, there are minimal visitor facilities on the terrestrial holdings of the marine park. Only Flowerpot Island (where there are 6 campsites and a trail system) and the Land Base area on the mainland (accessible to visitors through the Bruce Trail) have formal visitor access points. However, even at these locations, where collection of visitor numbers is feasible, there has not been a formal and consistent effort to maintain visitor statistics. The aquatic portion of the park, which is inherently more accessible, is used by divers, boaters, and swimmers. Although records of locally registered vessels and seasonal dive tags have been maintained, they provide a very limited understanding of marine visitation. In the meanwhile, visitor management decisions must be made in the absence of any real understanding of visitor numbers and associated impacts.

4.3.1 Indicator: Marine Visitation

Fathom Five is renowned as the "dive capital of Canada." The Diver Registration Program currently in place at the marine park was established by the province in 1980, and adopted by Parks Canada with the transfer to federal jurisdiction. Divers are required to register individually for an annual permit prior to their first dive of the year. Park staff (assisted by volunteers from the Ontario Underwater Council) ensure that each diver is advised of safety rules and made aware of park rules and regulations (McClellan, 2001). Although return visitors are encouraged to drop into the centre to sign the guest log, there are no records of the number of dives per season or the location of dives. On average, approximately 6,200 divers purchase permits each year, with the majority of use condensed between the months of June and August (Coady, 2002).

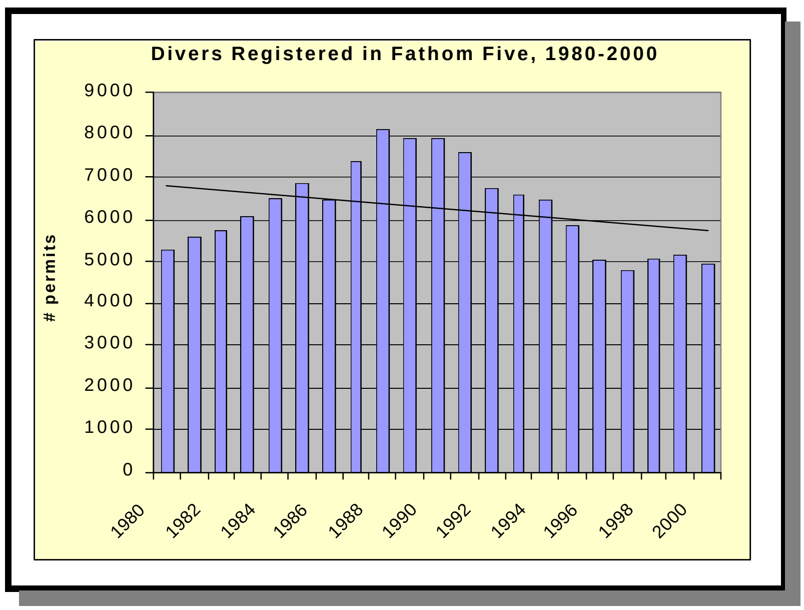


Figure 40. Registered divers, Fathom Five 1980-2001

< **Key message**: At certain levels of use, park visitors may threaten ecological sustainablility.
< **Target:** Undeveloped.
Y **Current status:** Level of use and impacts unknown.

4.3.2 Indicator: Terrestrial Visitation

Campers and day users impact the environment through their interaction with it. In particular, the thin soil of the peninsula is highly impacted by visitor use. Soil structure and nutrient cycling is effected by trampling, and incision of the trail path leads to ponding of water. Cumulatively, this leads to widening of trail paths and an inability of the soil to support plant life. In addition, trampled areas provide ideal habitat for many invasive species, which may be carried into the parks by visitors. Measures to mitigate visitor impacts include boardwalks over wet areas and clearly defined trail borders. However, monitoring of visitor impacts is also essential in order to prevent worsening conditions.

There are no accurate statistics for day users in the terrestrial portion of the marine park (Flowerpot and the Land Base are the two accessible areas, as mentioned above). Figure 40 presents the amount of camping on Flowerpot Island in terms of *camper nights* (the number of users multiplied by the number of nights on a site). On average, there are 650 camper nights per year on Flowerpot (Coady, 2002).

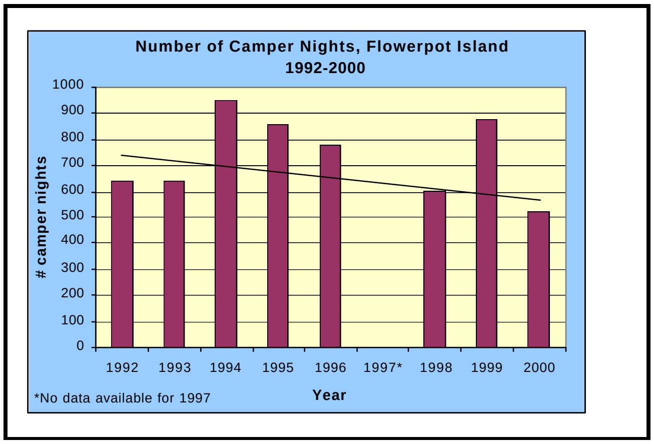


Figure 41. Number of camper nights on Flowerpot Island, 1992-2000.

As mentioned above, there is currently no monitoring program to tie the number of visitors to impacts; however a monitoring protocol recently developed and implemented for BPNP should be applicable to the terrestrial portion of the marine park.

< **Key message:** Visitors to the terrestrial portion of the park impact the health of the park ecosystem.
< **Target:** More accurate statistics required for target
Y **Current status:** Average of 650 camper nights per year on Flowerpot Island. Average day use unknown.

4.4 Element: Cultural Resources

Background

Cultural resources within the marine park include shipwrecks, heritage buildings (the lighthouses within the marine park are in fact managed by Canadian Coast Guard) and sites of importance to First Nations. At the present time, monitoring of cultural resources is limited to study of shipwrecks. A shipwreck monitoring program was undertaken in 1992, with a series of site monitoring initiatives utilizing scientific, visual, photographic and video monitoring techniques. The program was designed to record, identify and evaluate environmentally-induced change and the impacts of human intervention. Studies have included an assessment of zebra mussel impacts and an examination of wreck stability, as well as a study of corrosion rates in conjunction with the Canadian Conservation Institute. Findings of the shipwreck stability study are presented below.

4.4.1 Indicator: Shipwreck Stability

In 1992, Parks Canada undertook an annual monitoring program to determine the long-term stability of the cultural resources that have made the park so well-known. Four wrecks, all with wooden hulls, were chosen as indicators of the 27 wrecks found within the marine park (Figure 42). Fathom Five staff divers completed a series of dives to record measurements of the wrecks' hulls with the assistance of Marine Archaeological Services staff from the Parks Canada Ontario Service Centre. Measurements were designed to monitor the physical stability of the hulls, determine the rate of spread or collapse and indicate any incremental tilting or sagging (Stewart, 1998; Stewart and Murdock, 1997). Results are summarized below.

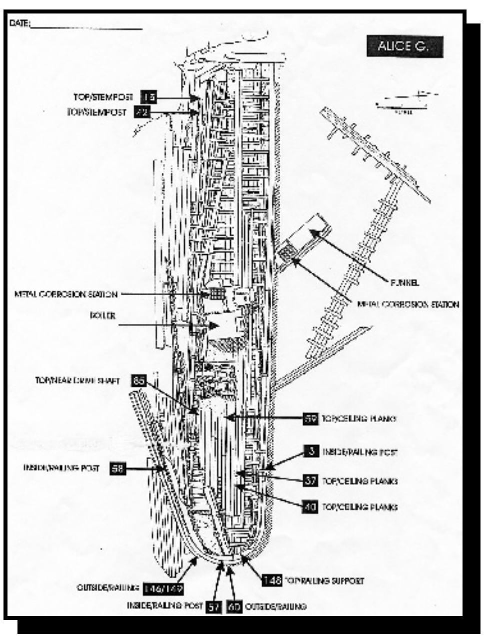


Figure 42. Shipwreck "Alice G"

Table 17. Shipwreck monitoring program (from Stewart and Murdock, 1997).

Sweepstakes	< a shallow water, well-protected wreck; almost complete hull < highly visited by divers and glass-bottomed tour boats	< measurable flex over time which may or may not result in structural instability < the small scale of movement exhibited over time indicates a dynamic stability
Arabia	< a deep water (~110 feet), exposed wreck < almost complete hull	< measurements reveal that the hull is showing signs of instability and possible collapse
Alice G	< a shallow water, shore-accessible wreck < relatively protected, partial hull	< the hull appears to be shifting (tilting) relative to the lake bottom < the structure is still internally stable
James C. King	< a mid-depth (25-95 feet), exposed wreck < partial hull	< the hull has undergone varying periods of change < overall, there has been a shift from instability towards a more stable position

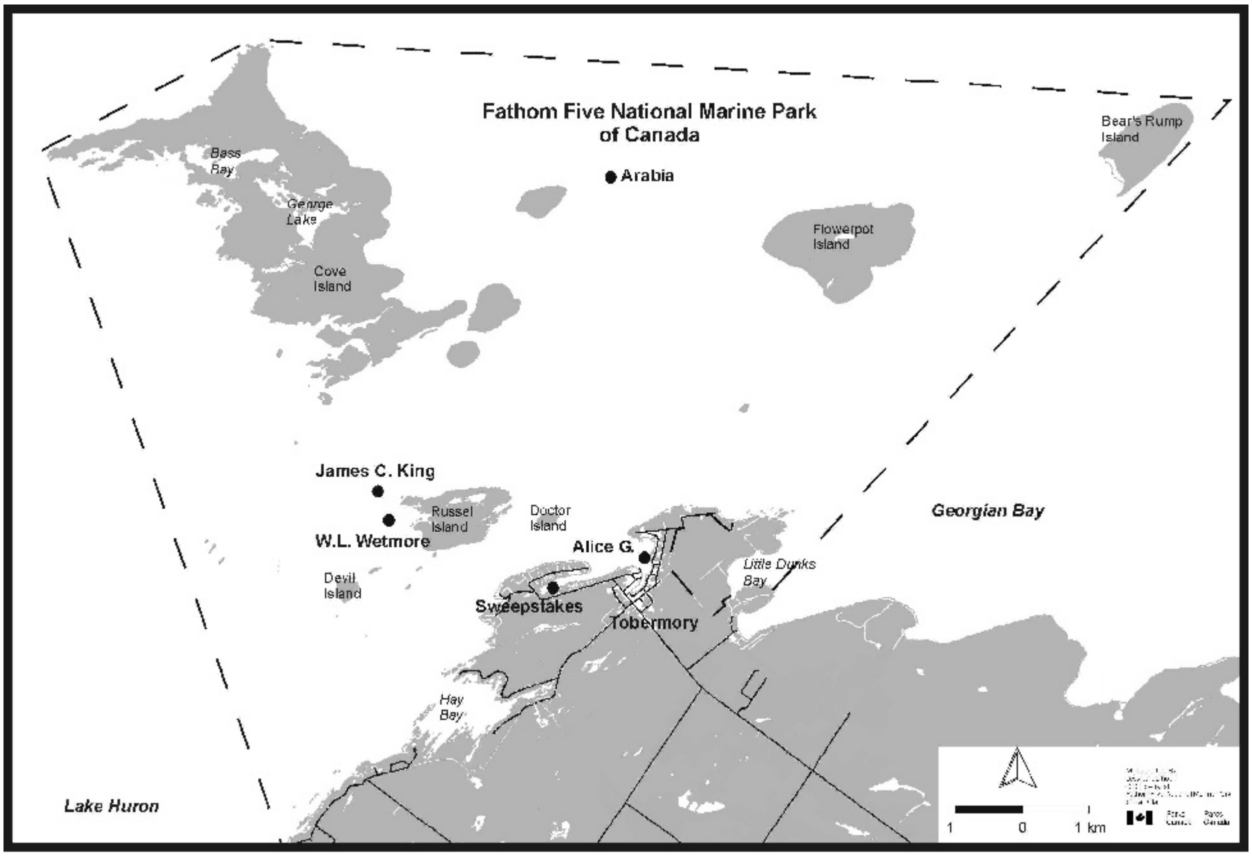


Figure 43. Shipwreck monitoring locations, Fathom Five National Marine Park.

Each wreck revealed a different pattern of change over time, making prediction of change at other wrecks difficult. To date, change appears to be slow. The small scale of movement makes accurate measurement a priority.

Case Study: Zebra Mussel Impacts on Submerged Archaeological Resources

Fathom Five is renowned for its cultural resources, namely the 27 shipwrecks found within the boundaries of the marine park. The introduction of the zebra mussel (*Dreissena polymorpha*) to the Great Lakes exposed the submerged archaeological resources of the park to a new threat. In 1995, Parks Canada and the Ontario Ministry of Citizenship, Culture and Recreation initiated a multi-year study to examine the impacts of the zebra mussel on submerged archaeological resources and to investigate ways to mitigate impacts.

Results of the study revealed no evidence of direct physical damage from zebra mussel attachment, provided the mussels are left undisturbed. Because their lifetime is short, the clumps detach when the mussel below dies, without loss of surface material. The mussels do impair visual examination of the wrecks and therefore impede archaeological recording or recovery activities. However, the greatest threat to the wrecks may be the well-intentioned efforts of divers to remove the mussels.

All methods used to remove mussels (hand-scraping, dive knifes, scrapers, water jetting) have the potential to cause direct, visible damage to the artifact surface. This damage is significant and irreversible, and can literally wear away or destabilise surfaces. No permanent control strategies emerged from the study. The results made it clear that mussels should not be removed from shipwreck surfaces.

(from Binnie et. al, 2000)

< **Key message**: Cultural resource sustainability is vital to management decisions about public access and visitor safety.
< **Target:** Sustainability of resource
T **Current status:** Dynamic stability, with slow change over time.

5.0 CONCLUSION

Generally, Fathom Five National Marine Park is considered a healthy oligotrophic environment, with above standard water quality capable of supporting a healthy ecosystem. However, the ecosystem is under stress by non-native species and isolated areas of sediment contamination (although toxicity and bioavailability to aquatic organisms is limited). Impacts to nearshore habitats are anticipated to grow due to increasing development pressure and the projected decline in water levels. Throughout this document, key messages have been summarized for each indicator, along with indicator performance in relation to a target. But what do the indicators tell us, in relation to ecosystem health?

In order to provide a holistic perspective of ecosystem health in Fathom Five, the information from the 23 indicators must be integrated into a concise and meaningful summary. In the table below, a report card format is used, with the overall status for each element summarized graphically as either worsening, improving, or unchanging/showing little evidence of change. Where there is insufficient information to determine element status, the overall status is shown as unknown. Of the 11 elements, only two (water quality and education) are listed as improving. The three elements with declining conditions (water levels, fish populations and invasive species) suggest priorities for management action, as do the three with insufficient information to determine status (visitor use, species at risk and shoreline development).

Table 18. Fathom Five Ecological Health Report Card

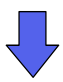
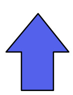
Criterion	Element & Overall Status	Indicator Assessment
Physical Sustainability	Water Level 	T Water levels remain within historical range; Y However a long-term decline in lake levels is projected.
	Shoreline Development ?	Y Shoreline development (in terms of docks and properties) continues to increase. Y Cumulative impacts are unknown. T Ecological concerns are being incorporated into dock facility development.
Chemical Sustainability	Water Quality 	T Overall, a healthy oligotrophic system. Ionic chemistry and nutrient loadings have stabilized lake-wide, and Fathom Five levels fall within lake-wide range. T Fathom Five phosphorus loadings meet the IJC guideline & nuisance algae are not present in nearshore areas. T Contaminants in the water column meet guidelines. Y A fish consumption advisory is in effect within marine park. Elevated heavy metals are found in zebra mussels within the park. Y There is sediment contamination within the marine park and in Little Tub Harbour, although toxicity to wildlife appears minimal.

Table 18. Fathom Five Ecosystem Health Report Card, continued

Criterion	Element & Overall Trend	Indicator Assessment
Biological Sustainability	Lower Trophic Levels ↔	**T** The phytoplankton community is representative of a healthy oligotrophic community. **Y** A shift in zooplankton community is evident, with lower biomass & species abundance than in previous studies. Dominance by 3 species (two non-native).
	Fish Population ↓	**T** Nearshore fish habitat within the marine park is of regional significance. Offshore habitat unknown but being studied. **Y** Hay Bay, considered the most significant area of nearshore fish habitat, is subject to high development pressure. **Y** The coldwater fish community is unstable. Stocked lake trout are not reproducing successfully. **Y** Levels of commercial and sports fish harvesting are unknown.
	Invasive Species ↓	**Y** Invasive species are present in the park and impacting community structure. The number of species locally present is unknown.
	Species at Risk **?**	**T** Eastern Massasauga Rattlesnake sub-populations are present on islands, although population viability is unknown. **Y** Presence of deepwater cisco species at risk unknown, but a joint research project has been undertaken.
Social Sustainability	Education ↑	**T** Interpretive education programs focused on the marine park are increasing. All staff participate in education programs. **T** Outreach programs focused towards area residents are increasing. One full time staff person is dedicated to outreach program development.
	Partnerships ↔	**T** There is continued research interest in the marine park, although the number of permits lags behind the number for BPNP. The underwater mapping project, an innovative and multi-partner project that will increase understanding of the marine ecosystem, is underway. **Y** Minimal partnership projects with agencies and groups from the GPE.
	Visitor Use **?**	**Y** Levels of visitor use and associated impacts are poorly understood.
	Cultural Resources ↔	**T** Shipwrecks show progressive but minor deterioration.

Some causes of concern (flagged with an "x" in the indicator assessment column) reflect long-term deterioration in the lake-wide ecosystem (e.g. the change in fish community structure and corresponding increase in invasive species). However, in many instances the issues of concern stem in large part from our lack of knowledge about specific topics. Our ability to manage Fathom Five is clearly compromised by our poor understanding of the levels and impacts of visitor use, the impacts of shoreline development, and the presence of species at risk and invasive species within the marine park.

6.0 MANAGEMENT IMPLICATIONS

Although the data presented in this report does permit a general perspective of Fathom Five's ecological health, the lack of an in-park monitoring program impedes our ability to understand stressors and ecosystem change in the park. Data collection efforts to date have succeeded only in establishing baseline conditions, with no information on trends. This results in a lack of information that can effectively influence overall management direction. Ultimately, the ecosystems of Fathom Five will only be ecologically sustainable if management decisions are based on a solid understanding of ecosystem processes. In the interim, a lack of knowledge is no excuse for inaction. As we work towards establishing our own ecological monitoring program, management actions must focus on addressing knowledge gaps and on taking concrete steps to mitigate the impacts and concerns outlined above.

Management and science partnerships are clearly important, and there are many opportunities to join existing initiatives while our own are under development. Although invasive species and sources of contamination may not be found within the boundaries of Fathom Five, they are of immediate concern to ecosystem sustainability. It is no longer acceptable to assume that broad-scale ecological issues are the responsibility of other government agencies. This report clearly identifies the need for Parks Canada to broaden its scope of involvement beyond park boundaries, particularly in the National Marine Conservation Area program. At Fathom Five, Parks Canada must define its role as the steward of an interlinked complex of aquatic and terrestrial environments within the Great Lakes ecosystem. Participation in lake and basin-wide planning exercises such as the Canada-Ontario agreement may be the only area where we can aid or influence other organizations to work towards ecological sustainability, for example by taking action to reduce the numbers of invasive species entering Lake Huron or to remediate sources of pollution. It is only through partnerships that we will achieve our desired goal of ecological sustainability.

The recommendations of the Fathom Five State of the Park Report are mirrored in the 11th Biennial Report on Great Lakes Water Quality by the International Joint Commission (IJC), released in September 2002. The IJC report likewise states that the integrity of Great Lakes waters continues to be compromised:

> Pollution endangers human health and restricts the fish we can safely eat. Habitat continues to be destroyed or spoiled, and the rich diversity of our native fish and wildlife remains threatened (IJC, 2002).

The IJC report goes on to urge a balanced but aggressive approach to restoration and protection of Great Lakes resources. Governments and citizens are encouraged to recognize the benefits of Great Lakes ecosystems and boldly take necessary action. The Fathom Five State of the Park Report is a small step in the right direction.

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APPENDIX A: GLOSSARY OF TERMS & ACRONYMS

Benthic: Bottom-dwelling Organisms that live on the bed of a water body, anywhere from the high water mark to the deepest areas, are benthic.

Bioaccumulation: The increasing concentration of a substance such as a pesticide in organisms from their predecessors in the *food chain* (also "biomagnification").

Bioavailability: Available for uptake by organisms.

Dieldrin - Formerly used as a pesticide and now banned throughout North America. Aldrin, another formerly used pesticied transforms into dieldrin through natural breakdown processes.

DCB (dichlorobenzene): Widely used as a moth killer in space deodorizers and in the production of polyphenylene sulfide. Also used in the manufacture of certain resins, in the pharmaceutical industry and as a general insecticide in farming. Believed to damage unborn fetus, lungs, liver, kidney, blood cells, nervous system. May cause skin allergy.

Dioxins and furans - There is no known use of dioxins and furans; they are byproducts of processes involving chlorine, organic chemicals and heat, including incineration of medical and solid waste, pulp and paper bleaching and chemical manufacturing. Dioxins are highly toxic, carcinogenic and considered a potential endocrine disrupter.

Eutrophic: Rich in organic and mineral nutrients, either naturally or by fertilization.

Eutrophication: Process of nutrient over-enrichment. Once a body of water is over-rich in organic and mineral nutrients, algae will grow rapidly and deplete the oxygen supply required by other aquatic life.

Extirpated: A species no longer existing in one location but occurring elsewhere. The scale varies and is generally specified, as in "locally extirpated" from Lake Huron, or "extirpated from North America".

Food chain: The transfer of food energy from plants through herbivores to carnivores. For example, algae - zooplankton - small fish - large fish - heron/human.

HCH (alpha and gamma): hexachloro-cyclohexane (also known as BHC or benzene hexachloride). This is a manufactured chemical that does not occur naturally in the environment. One chemical form, or isomer, is gamma-HCH, also known as lindane, which was used as an insecticide on fruit and vegetable and forest crops (e.g. greenhouse vegetables, tobacco and Christmas trees). HCH is still used in ointments to treat lice and scabies.

Heavy metal: Term applied to metals of high density.

Heptachlor epoxide: A by-product of heptachlor, a man-made chemical commonly used by exterminators and homeowners to control and kill termites. Used by farmers to kill insects in seed grains and in crops. Toxic to animals and humans (linked to kidney and liver damage, infertility and improper development of offspring).Since late 1978, most uses have been phased out and the chemical is no longer available to the general public . Use for termite control phased out as of 1988.

Hyallela azteca: a 1/4 inch-long freshwater amphipod, or shrimp-like crustacean, common in aquatic systems and found clinging to vegetation and burrowing in bottom-sediments. It is used to determine toxicity*** an invertebrate

Lowest Effect Level (LEL): Level of contamination used by the Province of Ontario in reporting sediment contamination. Indicates the level of contamination which has no effect on the majority of sediment-dwelling organisms. The sediment is clean to marginally polluted.

Lindane: see HCH

Littoral zone: the nearshore area where light penetrates to the bottom. In this zone, light provides energy and structure required by algae and aquatic macrophytes which in turn, provide food for fish, amphibians and insects.

Macrophyte: A large plant with roots and differentiated tissues. May be emergent (e.g. cattails), submergent (e.g. water milfoil) or floating (e.g. lily pads).

Mercury: Widely used in batteries, electrical equipment, medical equipment, thermometer, thermostats and preservatives. Former uses (as a fungicide, pesticide and in latex paint) have been discontinued, but it is still used at chlor alkali plants to produce chlorine gas and caustic soda. Small concentrations of mercury exist in nattural materials such as coal, wood and metal ore, and are released when these materials are processed. Mercury is also released when garbage is burned, and vaporises from landfills.

Mirex/photomirex: Mirex was used as a pesticide and as a flame retardant in a variety of industrial, manufacturing and military applications.

Nearshore: Generally considered the band of water from the shoreline edge out to the lake bed contour where the thermocline (thermal gradient) intersects with the lake bed in late summer or early fall. Although defined differently than littoral zone, both terms have been used in this document to indicate the area of aquatic habitat close to shore.

Oligotrophic: Poor in the mineral nutrients required by green plants; pertaining to an aquatic habitat with low productivity.

Organochlorine pesticides - Man-made organic chemicals that have been used to control pests ranging from fungus to grasshoppers. DDT was the first organsochlorine pesticide used on a large scale in the US. Most organochlorine pesticides are no longer sold for use in the U.S. Other organochlorine pesticides mentioned in this report include mirex, DDT, dieldrin, heptachlor epoxide, and DCB.

Organic: Substances which contain carbon atoms and carbon-carbon bonds.

PCBs: an organochlorine compound used widely in electrical equipment such as transformers and capacitors. Manufactured between 1929 and 1978, PCB oils were used as non-flammable electrical insulating fluid. PCBs bioaccumulate and are carcinogens and probable endocrine disrupters. PCBs are not pesticides but have many of the same properties.

Plankton: microscopic organisms that float freely with currents in a body of water. Plankton is made up of tiny plants (phytoplankton) and tiny animals (zooplankton). The word plankton comes from the Greek word planktos, which means drifting.

Phytoplankton: Microscopic organisms that are the primary producers at the base of the food web. They use chlorophyll to convert energy from sunlight, chemicals and dissolved carbon dioxide gas into carbohydrates.

Profundal zone - deep zone of water

PEL: Probable Effect Level. Designated level of contamination (used by the federal government) to indicate level above which toxic effects frequently occur.

Severe Effect Level (SEL): - Designated level of contamination (used by Province of Ontario). Sediment contaminated at this level is considered heavily polluted and likely to affect the health of sediment-dwelling organisms. If level of contamination exceeds the SEL then acute toxicity testing is required.

Trace metal: A metal found in low concentration, in mass fractions of ppm or less, in a specified source.

Trophic level: The aquatic food chain is made up of several trophic levels. At the base of the food chain are the lower trophic levels, phytoplankton and zooplankton. Zooplankton feeds on phytoplankton and form the second link in the food chain of the open waters. Planktivorous fish form the third link in the open water food chain, and feed on the lower trophic levels. They include smelts, herring, shad, lake whitefish, sunfish and numerous species of minnows. These fish, in turn, fall prey to the larger piscivorous "fish-eating" fishes. This group includes lake trout, lake sturgeon, northern pike and muskellunge.

Trophic state: Describes the level of biological activity of a body of water. Includes the categories eutrophic, oligotrophic, and mesotrophic.

Zooplankton: Microscopic animals that feed primarily on phytoplankton by filtering water. forming Zooplankton form the second level of the food chain. Some are larval or immature stages of larger animals, others are single-celled animals or tiny crustaceans.

Definitions from: Environment Canada and US EPA, 2001; GLNPO 2002c; USGS, 2002c.

Table A: COSEWIC status categories

Extinct	A species that no longer exists.
Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at risk	A species that has been evaluated and found to be not at risk.

From COSEWIC, 2000.

Table B: PAC committee:

< Niagara Escarpment Commission	< St. Edmunds Property Owner Association
< Upper Bruce Peninsula Sportsmen Association	< Bruce Trail Association
< Tobermory Chamber of Commerce	< Chippewas of First Nation
< Bruce Peninsula Tourist Association	< Saugeen First Nation
< Municipality of the Upper Bruce Peninsula	< Canadian Parks and Wilderness Society
< Federation of Ontario Naturalists	< Tobermory Maritime Association
< Friends of Bruce District Parks	< Tobermory Snowmobile Club
< Ontario Underwater Council	

Acronyms

BPNP: Bruce Peninsula National Park
Cd: Cadmium
CHS: Canadian Hydrographic Service
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
CCFM: Canadian Council of Forest Ministers
CCREM: Canadian Council of
CCME: Canadian Council of Ministers of the Environment
Cr: Chromium
Cu: Copper
DEQ: (Michigan) Department of Environmental Quality
DFO: Department of Fisheries and Oceans (Fisheries and Oceans Canada)
EA: Environmental Assessment
EPA: Environmental Protection Agency
ESP: Ecological Services for Planning
FFNMP: Fathom Five National Marine Park
GLIN: Great Lakes Information Network
GLNPO: Great Lakes National Program Office
GLWQA: Great Lakes Water Quality Agreement
GPE: Greater Park Ecosystem
Hg: Mercury
IGLD: International Great Lakes Datum
IJC: International Joint Commission
ISGQ: Interim Sediment Quality Guidelines
LEL: Lowest Effect Level
Mn: Manganese
Ni: Nickel
ng/L: nanograms/Litre
NMCA: National Marine Conservation Area
OMNR: Ontario Ministry of Natural Resources
P: Phosphorus
PAC: Park Advisory Committee (See Table B, above)
Pb: Lead

PEL:	Probable Effect Level
ppm:	parts per million
SEL:	Severe Effect Level
SOLEC:	State of the Lakes Ecosystem Conference
TP:	Total Phosphorus
USGS:	United States Geological Survey
ug/L:	micrograms/Litre
Zn:	Zinc

APPENDIX B: PARKS CANADA NATIONAL MONITORING FRAMEWORK

Although the Fathom Five State of the Park Report is based on the SOLEC/GLWQA framework of biological, chemical and physical indicators, there is an existing Parks Canada framework that employs an alternate model to provide information on ecosystem health or ecological integrity (Table C). The Parks Canada framework was designed around terrestrial ecosystems, whereas the Fathom Five reporting structure was designed to integrate ecological information with other agencies reporting on aquatic ecosystem health in the Great Lakes.

Table C: Parks Canada National Monitoring Framework

BIODIVERSITY	ECOSYSTEM FUNCTION	STRESSORS
Species richness • change in species richness • number and extent of exotics	**Succession/Retrogression** • disturbance frequency and size (fire, insects, flooding) • vegetation age class distribution	**Human Land Use Patterns** • land use maps, road densities, population densities
		Habitat Fragmentation • patch size, interpatch distance, forest interior
Population Dynamics • mortality/natality rates of indicator species • immigration/emigration rates of indicator species • population variability of indicator species	**Productivity** • remote or by site	**Pollutants** • sewage, petrochemicals, etc. • long-range transportation
	Decomposition • by site	**Climate** • weather data • frequency of extreme events
Trophic Structure • size class distribution of al taxa • predation levels	**Nutrient Retention** • Ca, N by site	**Other** • park specific issues

Parks Canada, 1998.

As with the SOLEC/GLWQA structure, which refers solely to physical, chemical and biological integrity, the social or "human dimensions" type indicators do not fit into this model. An additional category is required to encompass issues such as regional integration, cultural resource monitoring, and stewardship. Table D, below, cross-references the Parks Canada monitoring structure with the reporting structure used for Fathom Five, to illustrate how comprehensive the Fathom Five framework is in terms of assessing the aspects of ecosystem health outlined in Table C above. As would seem logical, most of the physical indicators in the Fathom Five structure can be characterized as stressors, and most of the biological indicators fit in the "biodiversity" category. In some cases, indicators fit more than one category, depending on what unit of measure or target is used (e.g. invasive species fits in the biodiversity and stressor categories). The social indicators aren't cross-referenced as there is no corollary in the Parks Canada (Table C) framework.

Table D. Assessment Framework Comparison

Criterion	Element	Indicator	Parks Canada Framework Comparison
Physical Sustainability	Water Level	Water levels	Stressor: climate
	Shoreline Development	Shoreline residential development	Stressor: human land use patterns
		Dock facility development	Stressor: human land use patterns
Chemical Sustainability	Water Quality	Ionic chemistry	Stressor: pollutants
		Nutrient concentrations	Stressor: pollutants
		Contaminants in the water column	Stressor: pollutants
		Contaminants in wildlife	Stressor: pollutants
		Contaminants in sediment	Stressor: pollutants
Biological Sustainability	Lower Trophic Levels	Phytoplankton	Ecosystem Function: productivity, Biodiversity: species richness
		Zooplankton	Biodiversity: species richness
	Fish Population	Nearshore fish habitat	Ecosystem Function: productivity, Biodiversity: species richness
		Fish community structure	Biodiversity: trophic structure, species richness
	Invasive Species	Invasive species	Biodiversity/Stressor: species richness
	Species at Risk	Aquatic species at risk	Biodiversity: species richness
		Terrestrial species at risk	Biodiversity: species richness, population dynamics
Social Sustainability	Education	Outreach programs	Stewardship capacity
		Interpretive programs	Stewardship capacity
	Partnerships	Research	Social integration, science capacity
		Working relationships in the G.P.E.	Stewardship capacity, social integration
	Visitor Use	Marine visitation	Stressor: human use
		Terrestrial visitation	Stressor: human use
	Cultural resources	Shipwreck stability	Stressor: environmentally-induced change

APPENDIX C: INTERNET RESOURCES

Table E: Web sites

General Great Lakes Information	Reports & Publications
• Great Lakes Information Network: www.great-lakes.net • Great Lakes Information Management Resource: www.on.ec.gc.ca/glimr/intro.htm • Great Lakes Commission: http://www.glc.org/ • International Joint Commission: www.ijc.org/ijcweb-e.html • Great Lakes United: www.glu.org/ • Lake Huron Initiative: www.deq.state.mi.us/ogl/huron.html • Lake Huron Centre for Coastal Conservation: http://www.lakehuron.on.ca/ • State of the Lakes Ecosystem Conference: http://www.on.ec.gc.ca/solec/intro.html • Michigan Department of Environmental Quality http://www.michigan.gov/deq/0,1607,7-135-3313_3677---,00.html • The Nature Conservancy: http://www.tnc.org/greatlakes • Environment Canada: http://www.on.ec.gc.ca/water/greatlakes/intro-e.html • Understanding lake ecology: http://wow.nrri.umn.edu/wow/under/primer/page17.html	• Two reports on the Great Lakes by The Nature Conservancy (*The Conservation of Biological Diversity in the Great Lakes* and *Great Lakes in the Balance*) are available at: http://www.epa.gov/glnpo/ecopage/issues.html • The *11th Biennial Report on Great Lakes Water Quality*, by the IJC is available at: http://www.ijc.org/comm/11br/english/report/index.html • SOLEC Background Papers on Nearshore Waters of the Great Lakes, Coastal Wetlands, Land Use, etc. are available at: http://www.epa.gov/glnpo/solec/96/ • The *Great Lakes Environmental Atlas and Resource Book*: http://www.on.ec.gc.ca/great-lakes-atlas/intro.html • SOLEC *State of the Great Lakes 2001:* http://binational.net/sogl2001/download.html • The *Lake Huron Initiative Action Plan Update*: http://www.michigan.gov/deq/0,1607,7-135-3313_3677---,00.html
Stewardship	**Invasive Species**
• Lake Huron Centre for Coastal Conservation: http://www.lakehuron.on.ca/ • Caring for shorelines: http://www.caringforshorelines.ca/ • Living by Water: http://fanweb.ca:8080/LBW/forms_folder/faq/popup/forms_folder/index_html?audiencetype=G	• Aquatic Nuisance Species Task Force: http://anstaskforce.gov/index.htm# • Great Lakes Commission: http://www.glc.org/ans/ • Invasive species in the Great Lakes region: http://www.great-lakes.net/envt/flora-fauna/invasive/invasive.html • Michigan Department of Environmental Quality: • http://www.michigan.gov/deq/0,1607,7-135-3313_3677_8314---,00.html

Water Levels	Species at Risk
• Great Lakes Environmental Research Laboratory: http://www.glerl.noaa.gov/data/now/wlevels/lowlevels/ • Great Lakes Information Network water level info: http://www.great-lakes.net/envt/water/levels/hydro.html • Canadian Hydrographic Service: http://chswww.bur.dfo.ca/danp/wlgraphs_e.html • US Army Corps of Engineers: http://www.lrd.usace.army.mil/gl/gl_news.htm#levels	• Environment Canada: http://www.speciesatrisk.gc.ca/species/index_e.cfm • Parks Canada: http://www2.parkscanada.gc.ca/sar/english/index_e.html • Search for information on cisco species at risk in the Great Lakes: http://www.speciesatrisk.gc.ca/species/search/SearchRequest_e.cfm • Great Lakes Info Net: http://www.great-lakes.net/envt/flora-fauna/endanger.html
Water Quality & Contaminants	**Parks Canada**
• Environment Canada, water quality in the Great Lakes: http://www.on.ec.gc.ca/monitoring/water-quality/greatlakes-e.html • Lake Huron GLIN site: http://www.great-lakes.net/humanhealth/lake/huron.html • OMNR Guide to eating Ontario Sports fish: http://www.ene.gov.on.ca/envision/guide/index.htm • Great Lakes Water Quality monitoring : http://www.epa.gov/glnpo/monitoring/plankton/mich83-92/index.html	• Fathom Five National Marine Park of Canada: http://www.parkscanada.gc.ca/amnc-nmca/on/fathomfive/index_E.asp • Bruce Peninsula National Park of Canada: http://www2.parkscanada.gc.ca/parks/ontario/bruce_peninsula/bruce_peninsula_e.htm • Parks Canada General Information: http://www.parkscanada.gc.ca/index_e.asp