

## 3.0 Biological Indicators - Introduction

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The health of our environment is dependent on healthy communities of wildlife. The definition of wildlife has recently been broadened by the Wildlife Ministers' Council of Canada to include invertebrates, plants, algae, fungi and bacteria, as well as mammals, birds, fish, reptiles and amphibians. These organisms play essential ecological roles, and also provide a wide range of economic and social benefits to humans.

In order to protect the integrity of natural ecosystems and healthy waters, it is necessary to protect biological diversity, or variety and variability in wildlife communities. Human settlement puts many stresses on wildlife communities, resulting in the loss of biological diversity. Pressures on wildlife result from the destruction of habitat by agriculture, forestry, and urbanization, from pollution in the form of industrial, urban and agricultural discharges and acid deposition, and through the introduction of non-native species.

Trends in wildlife diversity and abundance can be used as indicators of environmental health. In this report, a number of biological indicators are used. These include species diversity (for a number of different groups of organisms), species at risk, fish diversity and abundance, fish contaminant levels (indicated by restrictions on fish consumption), aquatic plant diversity and abundance, abundance of introduced plant species (indicated by plant harvesting), and exotic zebra mussel abundance and distribution.

## 3.1 Biological Indicator: Species Diversity

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### Background

Biological diversity or "biodiversity" refers to the variety of living organisms, which are found in a certain area. Biodiversity is important because it provides stability and balance in natural systems. Healthy ecosystems provide many benefits, including nutrient cycling, water purification, oxygen production, climate control, as well as natural resources such as fish and wildlife. Biodiversity is threatened by numerous human activities, including the destruction of habitat by agriculture, forestry and urban development, pollution, the introduction of non-native species, over-harvesting of plants and animals, and global problems such as ozone depletion and climate change.

Biodiversity may be measured at a variety of different scales, from genes to species, populations, communities, ecosystems and, even, entire landscapes. Species diversity is a good indicator of the state of an ecosystem. In river systems, species diversity typically declines in severe cases of cultural eutrophication (nutrient enrichment caused by human activities). For example, in highly eutrophic freshwaters, plant biomass may be extremely high, although few plant species are present. Higher species diversity would be expected in aquatic systems that are relatively natural or undisturbed, as well as in those where there are a variety of different

habitat types (such as riffles, pools, and wetland areas). A distinction should be made between native and non-native (introduced) species. Non-native species may lead to declines in biodiversity. The highly invasive zebra mussel is one well-known example of an introduced species that has led to decreased biodiversity in North American freshwaters.

Between 1998 and 2000, the Canadian Museum of Nature, along with the Rideau Valley Conservation Authority and the University of Ottawa, carried out the Rideau River Biodiversity Project (RRBP), a 3-year multidisciplinary community-based study of the environmental health of the Rideau. One objective of this study was to document biological diversity on the Rideau between Smiths Falls and Ottawa. The groups of organisms investigated include phytoplankton, aquatic plants, molluscs, amphibians, reptiles, fish and aquatic birds.

## Results

- **Phytoplankton** – microscopic algae were the most diverse organisms studied in the RRBP. Three hundred and fourteen species of phytoplankton were found in the Rideau River (Appendix 5a). This number underestimates the true diversity of algae, as some could not be identified to the species level. The most diverse group of algae was the green algae (chlorophytes), with 172 species. However, the most common algae in the Rideau were cryptophytes, bi-flagellated algae that are typically found in “clean” waters. However, in the lower section of the Rideau, a few species can be found that are more typical of nutrient-enriched systems such as in degraded European rivers.
- **Aquatic plants** - 59 species of submerged, floating and emergent plants were found in the Rideau River (Appendix 5b). By comparison, 45 species of aquatic plants have been found in the Point Pelee Marsh in southern Ontario. Four of the species found in the Rideau were non-native, invasive species: Eurasian water milfoil, curly pondweed, European frog’s bit and flowering rush. However, most shallow water sites have diverse communities of native plants. Beds of wild rice have even been found in some areas of the River.
- **Fish** – 31 species of fish from 11 families were found in the Rideau River during the study, and an additional 3 species were found in tributaries of the Rideau (Appendix 5c). In addition, Oscars, popular aquarium fish native to South America, were caught by anglers on two occasions in 1999. Black crappie, rock bass, pumpkinseed and bluegill, all members of the sunfish family, were found at most sites in the Rideau. Two species found during the study, the freshwater drum and the tadpole madtom, had never before been recorded in the Rideau River. The freshwater drum may be a recently introduced species. The common carp, another introduced species, was also found during this study. Rainbow trout and brown trout, non-native species previously stocked in the Rideau, have not been found for some years. The fish species diversity of the Rideau is similar to that of the Trent River, in which 32 species were found during a study in 1999-2000.
- **Aquatic birds** – 20 species of waterfowl and 3 other water bird species were found during the RRBP (Appendix 5d). Heavy use of the Migratory Bird Sanctuary at Merrickville was observed. Waterfowl

traffic at this sanctuary was similar to that seen at other migratory bird sanctuaries in Prince Edward County and in Lake Ontario around Wolfe Island.

- **Amphibians and reptiles** – 28 species of amphibians and reptiles have been found along the Rideau (Appendix 5e). These include 10 species of frogs, 6 species of turtles, 6 species of snakes and 6 species of salamanders. Nineteen of these species were found during the Rideau River Biodiversity Project. The most common were green frogs, bullfrogs, midland painted turtles and snapping turtles. In contrast to some studies in southwestern Ontario, the RRBP did not find many abnormalities, such as limb deformities in frogs.
- **Molluscs** – 8 species of native freshwater clams and one introduced species (the zebra mussel) were found in the Rideau River (Appendix 5f). Higher densities of live clams were found in the upper reaches of the River, between Smiths Falls and Burritts Rapids, while larger numbers of dead clams were found in the lower River, which is heavily colonized by zebra mussels.
- **Other invertebrates** – there is a diverse community of other aquatic invertebrates in the Rideau River (Appendix 5g). New species continue to be added as a result of ongoing research.

## Limitations

Species lists may reflect the degree of interest in certain groups of organisms, and may change with advances in knowledge. Measures of species richness do not provide information about the size or health of populations of each species.

## 3.2 Biological Indicator: Species at Risk

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### Background

Wildlife conditions and trends can be used as an indicator of the overall health of the environment. The occurrence of “species at risk” is one indicator of environmental problems. When a species is designated “at risk” it indicates there are problems with its populations or habitat, and that the species requires protection or some form of recovery action if it is to survive. In Canada, species at risk are identified at both national and provincial levels.

At the national level, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) produces an annual listing of species considered to be endangered, threatened, or of special concern. The numbers of species designated “at risk” nationally is likely greatly underestimated, however, as these numbers represent only the handful of species that have so far been reviewed. The Committee on the Status of Species at Risk in Ontario (COSSARO) evaluates species in Ontario, with the Ministry of Natural Resources (MNR) producing a list of species considered endangered, threatened or vulnerable in this province. In addition, the

Natural Heritage Information Centre (NHIC) assigns provincial ranks to species, in order to set protection priorities for rare species and natural communities.

Within Canada, almost half of the endangered and threatened species are found in the Great Lakes/St. Lawrence Life Zone, one of seven landscape units that reflect the terrestrial ecozones of Canada. The Rideau River is found within this Life Zone. Many of the endangered and threatened species in this zone (south of the Rideau River) are native to the Carolinian deciduous forest ecosystem, and are at the northernmost limit of their range in southeastern Ontario (hence their relative rarity). However, this zone has a long history of intensive agriculture, urbanization, manufacturing and transportation, which have put great stress on the natural environment. Aquatic environments in the Great Lakes and the St. Lawrence River have been particularly degraded, due to the introduction of non-native species, heavy pollution, and the manipulation of watersheds for transportation purposes. While the Rideau River has not been subject to the same intense industrialization as the Great Lakes and St. Lawrence, the stresses associated with increasing urbanization and shoreline development will increase risks to species in this area.

## Results

Several species found along the Rideau River are considered uncommon to extremely rare in Ontario (Table 4). Two bird species, the black tern and the least bittern are both considered rare and designated “vulnerable” in Ontario, although the black tern is not considered at risk nationally. Nine other species, including fish, birds, reptiles and molluscs, are considered rare to very rare in Ontario. No aquatic plant species, however, are considered at risk in the Rideau. One plant found during the Rideau River Biodiversity Project, the eastern mosquito-fern, is extremely rare in Ontario, but is thought to be an introduced (and not naturalized) species.

**Table 4 Species at risk along the Rideau River.**

CATEGORY	COMMON NAME	SCIENTIFIC NAME	STATUS		
			COSEWIC	MNR	NHIC
Aquatic plants	Eastern mosquito-fern*	<i>Azolla caroliniana</i>			S1
Molluscs	Black sand-shell	<i>Ligumia recta</i>			S3
	Ridged wedge-mussel	<i>Alasmidonta marginata</i>			S3
Reptiles	Blanding's turtle	<i>Emydoidea blandingii</i>			S3
Birds	Black tern	<i>Chlidonias niger</i>	NAR	VUL	S3B,SZN
	Bufflehead	<i>Bucephala albeola</i>			S3B, SZN
	Greater scaup	<i>Aythya marila</i>			S2B,SZN
	Least bittern	<i>Ixobrychus exilis</i>	SC	VUL	S3B,SZN
	Redhead	<i>Aythya americana</i>			S2B,SZN
Fish	Eastern silvery minnow	<i>Hybognathus regius</i>	NAR		S2
	Greater redhorse	<i>Moxostoma valenciennesi</i>			S3
	Silver lamprey	<i>Ichthyomyzon unicuspis</i>			S3

See Appendices 6 – 8 for explanation of status categories

\* Considered introduced, not naturalized; NAR – not at risk; SC – special concern; VUL – vulnerable

S1 - Extremely rare in Ontario

S2B – Very rare in Ontario, breeding

S2 – Very rare in Ontario

S3B – Rare to uncommon in Ontario, breeding

S3 – Rare to uncommon in Ontario

SZN – Non-breeding migrants/vagrants

Sources: Canadian Museum of Nature Friends of the Rideau Bird Sanctuary

The black rat snake, which occurs near the Rideau River and is considered rare in Ontario and threatened both provincially and nationally, is a terrestrial species, and therefore not included in this listing of species at risk in the Rideau River.

## **Limitations**

Lists of species at risk reflect the degree of interest by researchers in certain groups of organisms. This indicator does not convey information about the size or health of the populations. Increases in knowledge about species and their habitats, or increased sampling effort could lead to increases in the number of species at risk that are identified along the River.

## **3.3 Biological Indicator: Fish Diversity and Abundance**

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### **Background**

Fish are important members of aquatic communities, and the health of fish communities is of great concern on rivers such as the Rideau, where recreational fishing is a popular activity. Fish communities are vulnerable to the effects of many human activities. The major stressors affecting freshwater fish populations are changes to fish habitat through human activities, the presence of toxic substances, over-harvesting, and the introduction of foreign species through deliberate or accidental means.

Aquatic habitat can be degraded or lost through channelization and the development of properties along the shoreline. Construction activities and agricultural land management practices can lead to soil erosion, which increases sediment transport into rivers, damages fish spawning areas, and reduces oxygen levels. Toxic substances entering the environment can accumulate in fish tissues, causing acute effects such as death, or other effects such as deformities, increased susceptibility to disease, and eventually the disappearance of the species. Over-harvesting by commercial and recreational fisheries can also lead to the loss of fish species in freshwater environments. The introduction of non-native species also threatens the diversity and abundance of fish communities.

The diversity and abundance of fish are commonly monitored as a means of assessing the condition of commercial and recreational fisheries, as well as the health of aquatic ecosystems. Standardized “index netting” allows researchers to observe trends in fish populations over time. The Kemptville District Office of MNR conducts Rideau River fisheries assessments, in partnership with the Water Environment Protection Section of the City of Ottawa (formerly RMOC). Six reaches are sampled between Smiths Falls and Ottawa (Table 5), with one or two reaches sampled each year on a 4-year rotational basis. During these index netting surveys, fish are sampled using hoop nets at a number of sites (ranging from 16 to 36) in each reach, and the “catch-per-unit-effort” (CUE) is calculated for each fish species. Index netting on the Rideau River has been conducted with hoop nets since

1997; prior to this, trap nets were used, so data cannot be compared between these two periods. However, the data collected between 1997 and 2000 can be used as a baseline, against which to compare results in future years.

**Table 5 Location of fisheries assessment reaches on the Rideau River.**

SAMPLING REACH	LOCATION
Kilmarnock Reach	Smiths Falls to Merrickville
Andrewsville Reach	Merrickville to Burritts Rapids
Long Reach	Burritts Rapids to Long Island Locks
Eccolands Reach	Long Island Locks to Black Rapids
Mooney's Bay Reach	Black Rapids to Hog's Back Dam
Ottawa Reach	Hog's Back Dam to Rideau Falls (natural river channel)

## Results

The Rideau River is home to a diverse fish community. Since 1883, 57 fish species have been reported in the Rideau River and canal. By comparison, 64 species have been reported in the Ottawa River. However, not all of the fish species reported in this historical record are still found in the Rideau, and some are rare. A fish survey carried out in 1998 as part of the Rideau River Biodiversity Project identified 31 species of fish in the Rideau River. This fish community is similar to that found in another similar canal system, the Trent Canal, where 32 species were found in 1999-2000. Twenty-four of these species were found in both the Trent and the Rideau Rivers.

Index netting results between 1997 and 2000 indicate that the highest total fish abundance was found in the Kilmarnock reach (CUE = 48.0) (Table 6). The Andrewsville reach had the lowest abundance (9.2) and the Long, Eccolands, Mooney's Bay and Ottawa reaches had similar total fish abundance (19.8, 16.3, 16.3 and 18.6, respectively). A total of 21 species of fish were netted during this program, with 13 or 14 species found within each reach.

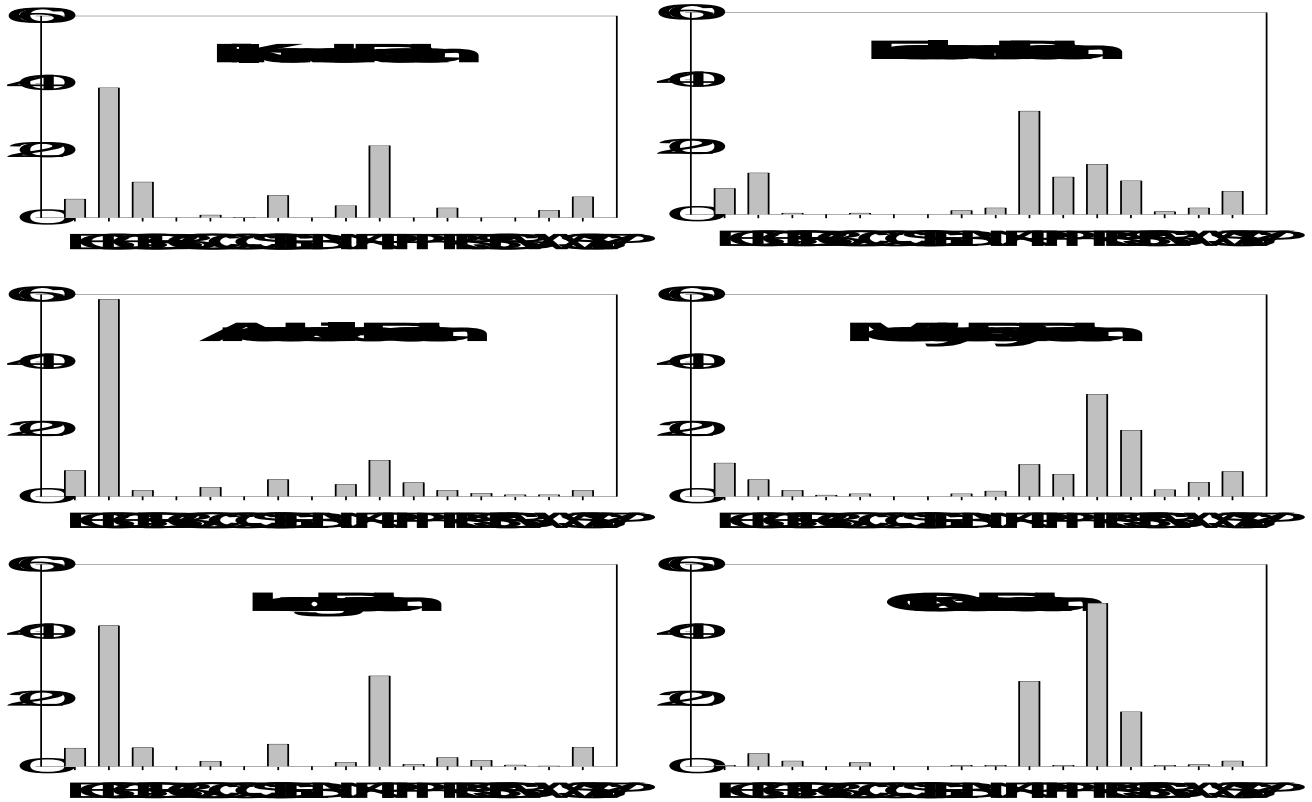
Overall, the three most abundant fish species in the Rideau River were bluegill, pumpkinseed and rock bass. Bluegill were the most commonly sampled fish at the three upstream reaches (Kilmarnock, Andrewsville and Long Reach), followed by pumpkinseed (Figure 11). In the lower three reaches (Eccolands, Mooney's Bay and Ottawa), pumpkinseed, rock bass and smallmouth bass were the most abundant.

**Table 6 Catch per unit effort (CUE, fish/net night) of fish species in the Rideau River, 1997-2000.**

FISH SPECIES	KILMARNOCK 1998	ANDREWSVILLE 1999	LONG REACH 2000	ECCOLANDS 1998	MOONEY'S BAY 1997	OTTAWA 1999	TOTAL CUE
Alewife	0	0.04	0	0	0	0	0.04
Black Crappie	2.72	0.75	1.03	1.25	0.38	0.05	6.18
Bluegill	18.5	5.33	7.94	2	0.62	0.7	35.09
Brown Bullhead	5.11	0.17	1.06	0.06	0.38	0.3	7.08
Carp *	0.39	0.25	1.08	0.06	0.15	0.2	2.13
Channel Catfish	0.06	0	0	0	0	0	0.06
Golden Shiner	0.06	0	0	0	0	0	0.06
Greater Redhorse	0	0	0.11	1.5	0.23	0.05	1.89
Largemouth Bass	3.17	0.46	1.25	0	0	0	4.88
Muskellunge	0	0	0	0.19	0	0	0.19
Northern pike	1.72	0.33	0.22	0.31	0.31	0.05	2.94
Pumpkinseed	10.17	1	5.11	5	1.92	4.7	27.90
Rock Bass	1.39	0.17	0.50	2.44	5.54	9	19.04
Shorthead Redhorse	0	0.38	0	0	0	0	0.38
Silver Redhorse	0	0	0	0.31	0.15	0	0.46
Smallmouth Bass	0	0.08	0.33	1.63	3.62	3	8.66
Tiger Muskie **	0	0	0	0	0	0.05	0.05
Walleye	0	0.04	0.08	0.13	0.23	0.05	0.53
White Sucker	1.06	0.04	0.03	0.31	0.46	0.1	2.00
Yellow Bullhead	0.67	0	0	0	0	0	0.67
Yellow Perch	3	0.17	1.08	1.13	2.31	0.3	7.99
TOTAL CUE	48.02	9.21	19.83	16.32	16.3	18.55	128.23

\* non-native species    \*\* pike-muskellunge hybrid

Sources: MNR 2000; RMO 2000



Legend	
BC – black crappie	NP – northern pike
BG – bluegill	P – pumpkinseed
BB – brown bullhead	R – redhorse species
CC – channel catfish	RB – rock bass
C – common carp	SB – smallmouth bass
GS – golden shiner	W – walleye
LB – largemouth bass	WS – white sucker
M – muskellunge	YP – yellow perch

**Figure 11 Percent abundance of fish species in 6 reaches along the Rideau River (1997-2000 sampling period).  
Sources: MNR, 2000; RMO, 2000**

**Limitations**

Sampling methods may be biased for certain species of fish. Comparison of CUE between different systems is not possible unless identical methods are used. Different reaches are sampled in different years; results may reflect conditions such as water levels in a given year.



## 3.4 Biological Indicator: Restrictions on Fish Consumption

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### Background

Many contaminants in freshwaters accumulate in the flesh of fish, although the amounts are variable depending on the contaminant, the species of fish and their position in the food chain. The fish most likely to contain high contaminant concentrations are predatory species and large fish. The Ontario Ministry of the Environment, in partnership with the Ministry of Natural Resources, monitors the concentrations of harmful pollutants in sport fish across Ontario, and publishes the results every 2 years in the Guide to Eating Ontario Sport Fish. Changes in this indicator over time may indicate changes in overall environmental health.

Fish consumption restrictions are based on concentrations of a variety of contaminants, and vary depending on the species and size of fish. More than 99% of restrictions on the consumption of sport fish from inland locations, such as the Rideau River, are due to contamination with mercury. In contrast to the Great Lakes, very few inland locations have been exposed to discharges of pesticides or other organic compounds in sufficient quantities to cause fish consumption restrictions.

Mercury occurs naturally but is usually found at very low levels in water. Additional inputs from industry have declined since the 1970s when actions to reduce mercury entering aquatic systems were initiated. Consumption restrictions are put in place when the concentration of mercury in fish flesh exceeds 0.45 ppm, and total restriction is recommended at 1.57 ppm. Children under 15 and women of childbearing age are advised to eat no fish containing over 0.45 ppm mercury, and only 4 meals per month of fish with less than 0.45 ppm mercury.

The fish used to calculate consumption restrictions for the Rideau River are collected during fisheries assessments conducted by the Surface Water Quality Branch of the City of Ottawa (formerly RMOC) and the Kemptville District Office of the MNR. Separate fish consumption advisories are provided for fish from 3 reaches of the Rideau River: from Smiths Falls to Merrickville, from Merrickville to Manotick, and from Manotick to Ottawa. Some fish species were tested for mercury only, while others were tested for mercury, PCBs, mirex/photomirex and pesticides.

### Results

For most species tested, the maximum recommended number of meals per month was 8, regardless of fish size (Table 7). However, restrictions of 4 or fewer meals per month were applied to larger specimens of northern pike, largemouth bass, walleye, smallmouth bass, rock bass and yellow perch in some or all of the reaches of the Rideau.

Overall, these consumption guidelines are similar to (or in some cases slightly more restrictive than) those for fish of the same species and size in Upper Rideau Lake and the Trent River. For example, a maximum of 4 meals per month is recommended for northern pike (18" or larger) in the lower Rideau River, while the same restriction does not apply to pike of any size in the Trent River, and only to larger pike (over 22") in Upper Rideau Lake. However, the consumption guidelines for the Rideau River are less restrictive than those for the Ottawa River below Arnprior. For example, in the Ottawa River, restrictions of 4 meals per month are recommended for 12-14" walleye, smallmouth bass and black crappie, while in the Rideau, the same restrictions only apply to larger smallmouth bass and walleye (and never to black crappie).

Trends in mercury concentrations in fish from the Rideau River vary between species. There appears to have been a decrease in mercury concentrations in northern pike and smallmouth bass since the mid-1970s (RMOC 1999). However, mercury levels in brown bullhead, walleye and largemouth bass have not declined during this period.

**Table 7 Fish consumption recommendations for the Rideau River, 2000-2001.**

Reach	Species	Maximum recommended number of monthly meals								
		Fish Size (inches)								
		6 - 8	8 - 10	10 - 12	12 - 14	14 - 18	18 - 22	22 - 26	26 - 30	>30
<b>Smiths Falls to Merrickville</b>	Northern Pike (1)					8	4			
	Largemouth Bass (2)		8	8	4	4				
	Rock Bass(1)	8	8							
	Yellow Perch (1)	8	8							
	Pumpkinseed (1)	8								
	Brown Bullhead (2)	8	8	8	8	8				
<b>Merrickville to Manotick</b>	Walleye (2)					8	4	4	4	
	Northern Pike (2)					8	8	8	4	
	Smallmouth Bass (2)	8	8	8	8	4	2			
	Largemouth Bass (2)		8	8	8	4				
	Rock Bass (2)	8	4							
	Yellow Perch (2)	8	8	8	4					
	Pumpkinseed (1)	8								
	Bluegill (1)	8	8							
	Black Crappie (2)	8	8	8						
	Brown Bullhead (2)	8	8	8	8					
	Carp (2)				8	8	8	8	8	8
<b>Manotick to Ottawa</b>	Walleye (1)		8	8	8	8	4			
	Northern Pike (2)				8	8	4	4	4	
	Smallmouth Bass (2)	8	8	8	8	4	2			
	Rock Bass (2)	8	8							
	Yellow Perch (1)	8	8	8						
	Bluegill (1)	8								
	Black Crappie (2)	8	8	8						
	Brown Bullhead (2)	8	8	8	8	8				
	Carp (2)							8	8	8

(1) tested for mercury only (2) tested for mercury, PCBs, mirex/photomirex and pesticides

Source: Guide to Eating Ontario Sport Fish, 2000-2001 (MOE, 2001)