Status of the Northern Brook Lamprey, *Ichthyomyzon fossor*, in Canada*

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The Northern Brook Lamprey, *Ichthyomyzon fossor*, is a small, non-parasitic lamprey not particularly abundant in its endemic North American range. In Canada, it is found in the Hudson Bay drainage of Manitoba and in the Great Lakes drainage of Ontario and Quebec. These represent the northern limits of its range. It has never been the object of a directed survey in Canada; its precise status is thus unknown. The Northern Brook Lamprey is not specifically protected in Canada except for the general protection granted through the fish protection and pollution prevention sections of the Fisheries Act. The paucity of Canadian records supports a status of vulnerable for this species.

De petite taille et non parasite, la lamproie du Nord, *Ichthyomyzon fossor*, n'est pas très abondante dans son aire de répartition limitée à l'Amérique du Nord. Au Canada, elle est présente dans le bassin hydrographique de la baie d'Hudson, au Manitoba, et dans le bassin hydrographique des Grands Lacs, au Québec et en Ontario. Ces coordonnées représentent les limites septentrionales de son aire de répartition. Étant donné qu'elle n'a jamais fait l'objet d'un relevé orienté au Canada, on n'y connaît pas sa situation exacte. Elle n'est pas protégée de façon précise dans les eaux canadiennes, sauf pour ce qui est d'une protection générale en vertu des articles sur la protection de l'habitat des poissons et de la prévention de la pollution de la Loi sur les pêches. Sa rare capture dans les eaux canadiennes indique que l'espèce est vulnérable.

Key Words: Petromyzontidae, lampreys, Northern Brook Lamprey, lamproie du Nord, *Ichthyomyzon fossor*, vulnerable fishes.

The Northern Brook Lamprey, *Ichthyomyzon fossor* Reighard and Cummins 1916, is a non-parasitic lamprey endemic to North America where it is restricted to tributaries of Hudson Bay, the Great Lakes and the Mississippi River (Lanteigne 1981). The six species which comprise the genus *Ichthyomyzon*, probably the most primitive among the Northern Hemisphere lampreys (Hubbs and Trautman 1937), can be grouped into three species pairs each composed of a parasitic stem species and a non-parasitic satellite species. Thus, *Ichthyomyzon fossor* is the non-parasitic derivative of the parasitic stem species, *Ichthyomyzon unicuspis*. After metamorphosis, the parasitic species feed mainly on teleost fishes for one or more years (Scott and Crossman 1973) while the non-parasitic species spawn soon after transformation. All lampreys die soon after spawning.

Description

The adult Northern Brook Lamprey can reach a total length of 161 mm [Royal Ontario Museum (ROM) 177687]; Hubbs and Trautman (1937) reported a range of 94 to 146 mm (average 119 mm) and Lanteigne (1981) gave a range of 98 to 158 mm. In the streams of Michigan's Lower Peninsula, which yielded a more homogeneous sample, Morman (1979) found a range of 86 to 166 mm (average 115 mm). The number of trunk myomeres usually varies from 51 to 54 (average 52) (Lanteigne 1981) even though Hubbs and Trautman report a smaller range of 50 to 52 (average 51). Its body is definitely bicoloured: the dark slate of the back and sides contrasts with the pale grey or silvery white lower parts (Vladykov 1949). The ventral surface is somewhat tinted with orange, which is particularly noticeable in the sexually mature female where the eggs show through the body wall (Leach 1940). The lateral line organs are non-pigmented, a characteristic which readily separates it from its parasitic stem species, *Ichthyomyzon unicuspis*, (Vladykov 1949). All the disc teeth are blunt and degenerate in keeping with its non-parasitic lifestyle which is also evident in the non-functional nature of its intestine. All the endolateral teeth, a diagnostic character, are unicuspid (Figure 1).

Distribution

In the drainage basins of the Eastern United States (Figure 2), the Northern Brook Lamprey is found in the Western Great Lakes basin of Wisconsin and Michigan, in the Eastern Great Lakes basin of

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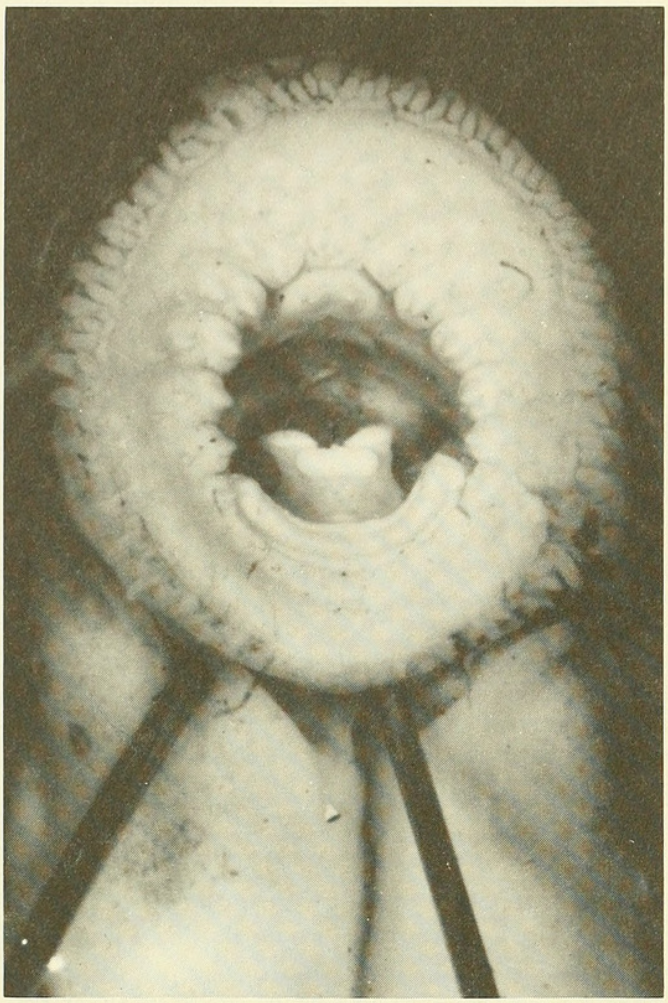

FIGURE 1. *Ichthyomyzon fossor:* female, 150 mm TL: Birch River, upstream of Prawda, Manitoba; May 13, 1977; J. Jyrkkanen; ROM 34264. Note blunt, degenerate and unicuspid disc teeth.

Michigan, Ohio and Pennsylvania (not present in Lake Ontario), in the Ohio basin of Illinois, Indiana, Ohio and Kentucky and in the Lower Missouri basin of Missouri where a disjunct population is found in the Ozark Uplands (Figure 3) [Pflieger 1971].

In Canada (Figure 4), the Northern Brook Lamprey occurs in the Great Lakes basin from Lake Superior to Lake Erie but appears to be absent in the Lake Ontario drainage (Scott and Crossman 1973) even though one transformed individual was captured in Tosorontio Creek (49°09'N, 79°58'W) in 1974 (ROM 30543). It has been captured in the Ottawa River at Ottawa (45°28'N, 75°37'W) [Canadian Museum of Nature (NMC) 82-0319] and it occurs in the St. Lawrence River down to the Nicolet River (Vladykov 1952). Its range in Canada has recently been extended further west to the Nelson River drainage of Manitoba (Jyrkkanen and Wright 1979) where it has been captured in the Whitemouth River (50°00'N, 96°00'W) and one of its tributaries, the Birch River (49°39'N, 95°47'W). This distribution represents the northern limits of the range of the Northern Brook Lamprey in North America.

Protection

The Northern Brook Lamprey is not listed as endangered, threatened or of concern in North America (Williams et al. 1989). In Canada, the species is not the object of any specific legal protection other than the general protection granted under habitat and pollution prevention sections of the Federal Fisheries Act. In Manitoba protection can be afforded through the provincial Endangered Species Act by regulation.

Population Sizes and Trends

No population estimates are available. In the St. Lawrence drainage of Quebec, Vladykov (1952) captured 63 adults and 849 ammocoetes between September 1946 and August 1951. The range extension of the species to Manitoba concerned 14 adult specimens (Jyrkkanen and Wright 1979). Collection records from the Royal Ontario Museum and the Canadian Museum of Nature reveal the paucity of specimens from the Great Lakes drainage as well as from other Canadian localities. It was formerly present in the Lake Ontario watershed but is now absent, or considered to be extremely rare. It is possibly present in a few scattered tributary creeks (Crossman and van Meter 1979) as in Tosorontio Creek. There is no indication that the species is in

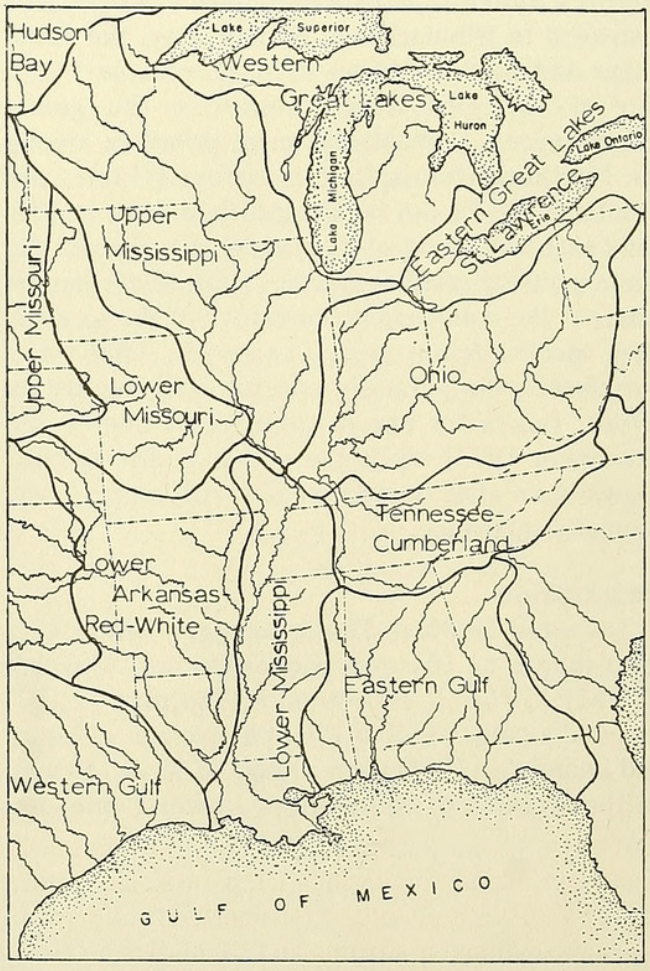

FIGURE 2. Principal drainage basins of the Eastern United States where the genus *Ichthyomyzon* is found.

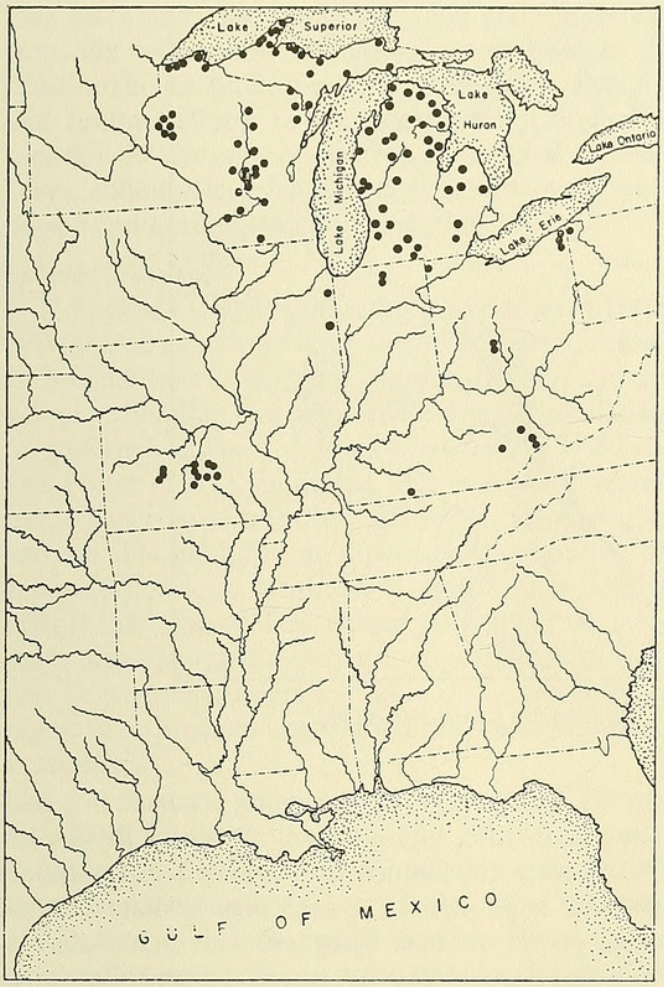

FIGURE 3. Distributional records of *Ichthyomyzon fossor* in Eastern United States.

danger of extinction but the state of our knowledge is such that no predictions can be made. The better fish sampling methods used in the last two or three decades, as well as the major research effort expanded in the Great Lakes in the wake of the sea lamprey invasion, may be in part responsible for the greater number of endemic lampreys appearing in fish collections. This increase should, therefore, not be viewed as a real increase in abundance.

Habitat

The ammocoetes of the Northern Brook Lamprey require a fairly soft bottom in which to make their burrows; as a rule, they are not found in firm sand or in the extremely soft mud of backwaters (Churchill 1947). In a given area with suitable bottom, they are most numerous in water 15 to 61 cm deep, amongst the vegetation. Maximum silt content and total volatile organic content of occupied sediments in an Ohio creek were 77% and 65%, respectively (Anderson and White 1988). Small ammocoetes were less tolerant of silt than large ones. The highest density of ammocoetes are usually found in the warmer sections of streams and tributaries receiving large surface flow of warm water from lakes, swamps and marshes (Morman 1979).

In Quebec, adult Northern Brook Lampreys are found in brooks tributary to small rivers. In the Yamaska River, where it was most abundant at St. Césaire where the river spans from 30 to 130 m, the current was moderate, the water was turbid and the banks were composed of clay (Vladykov 1952). In the Lake Superior watershed, *Ichthyomyzon fossor* was most common in medium-to-large streams with average summer flows of 0.3 to 28.3 cubic meters per second (Schuldt and Goold 1980). It was also common in several turbid streams. Along the western half of the United States shoreline, the preferred streams were generally warmer than eastern streams. In the lower peninsula of Michigan, the Northern Brook Lamprey was rarely found in small stream systems; it was most frequently collected in small, isolated segments of moderate-sized to large streams characterized by summer low flows (Morman 1979). It typically lived in the warmer, less rapid lower reaches of streams and tributaries that received large surface flow of warm water from lakes, swamps or marshes. It was also less commonly found in cold-water environments where mean daily temperatures during mid-June to August ranged from 14° to 20°C. In Manitoba, *Ichthyomyzon fossor* has been collected in the Birch River, a tributary of the Winnipeg River (Jyrkkanen and Wright 1979). The Birch River is a small river with a maximum flow of 5.7 to 8.5 cubic meters per second (cm/s) and a low flow of less than 0.15 cm/s. The substrate is highly varied with silts and sediments in the quieter reaches of the stream, gravel and cobble riffles and several small waterfalls.

In the Yamaska River of Quebec, the Northern Brook Lamprey spawned in May when the water temperature ranged from 12.8° to 17.2°C. Spawning activity peaked at water temperatures of 13.3° to 15.6°C (Vladykov 1949). In Michigan, spawning activities were observed from 23 May to 27 May and were most vigorous at water temperatures ranging from 20° to 22°C; spawning seldom took place at water temperatures inferior to 18°C (Reighard and Cummins 1916). All the spawners were observed on a bottom of coarse gravel and shingle which contained stones from 2.5 to 15.2 cm in diameter, and in water from 20.3 to 45.7 cm deep. At that point, the stream was less than 10 m wide with a strong current (Reighard and Cummins 1916).

General Biology

Reproductive Capability

Like all lampreys, the Northern Brook Lamprey breeds only once. According to Leach (1940), the ammocoete period lasts six years and is followed by a short transformation period of two or three months and an immature adult period of a semi-sedentary nature. The latter lasts until mid-February. The active early adult period follows and leads to sexual

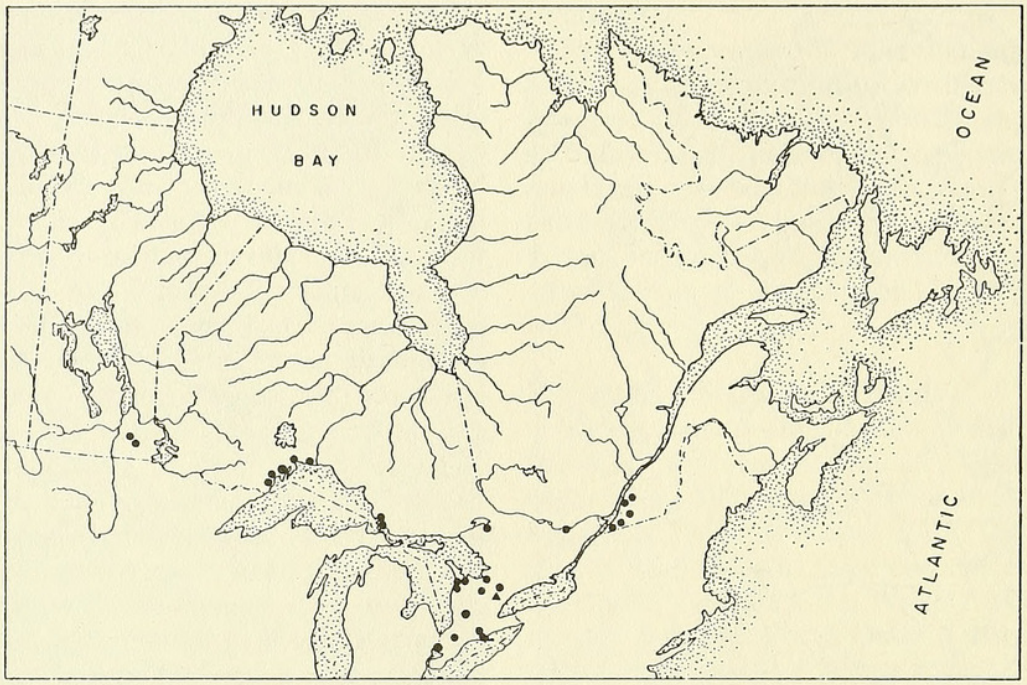

FIGURE 4. Distribution records of *Ichthyomyzon fossor* in Canada.

maturity around mid-May. The post-spawning period probably lasts only a few days, after which all spawners die. Since degeneration of the alimentary canal occurs at the beginning of transformation, there is a period of eight or nine months during which no food is taken (Churchill 1947).

Three physical factors in streams are essential for successful spawning: first, for nest building, a suitable substrate of gravel is required that includes at least a small amount of silt-free sand or other fine material to which the eggs can adhere, thereby increasing the probability of their retention in the nest. Second, a current must be flowing uni-directionally over the nest. Third, the water temperatures must be suitable.

In Manitoba, fourteen mature individuals were captured in the Birch River in mid-May 1977 (Jyrkkanen and Wright 1977). Of these, 10 were males and four were females. They were assumed to be spawning at the time of collection. No details on the reproductive behavior were reported. Two more sexually mature individuals, a male and a female whose eggs were free in the body cavity, were captured in the Whitemouth River (into which the Birch River empties) in mid-July 1977 (Lanteigne 1981). For two nests in which sex ratio was determined in a Michigan river, 11 males and two females were in one and three males and one female in the other (Morman 1979). In a tributary of southern Lake Superior, Purvis (1970) noted that 97% of the metamorphosed specimens collected in August were males and in June, 75% of the spawners were also males.

In a Michigan river, *Ichthyomyzon fossor* was observed in seven nests on 13 June when water temperatures ranged from 16.5° to 20.5°C (daily mean 18°C) [Morman 1979]. Spawning occurred in a shallow, pool-riffle, high-gradient stretch of the stream. Nests were inconspicuously located in interstices beneath large stones (18 to 36 cm in diameter) and were poorly defined. Spawners were unobtrusive as had been observed by Reighard and Cummins (1916).

The number of eggs laid is roughly in proportion to the size of the female. The actual fecundity of nine *Ichthyomyzon fossor* females from Quebec (128 to 150 mm TL) averaged 1524 eggs (range 1115 to 1979 eggs) (Vladykov 1951) whose average diameter was 1.01 mm. Leach (1940) recorded 780 eggs in a 92 mm TL ripe female. The eggs are demersal (Fuiman 1982) and seem to develop in an extremely adhesive glue-like mass under artificial conditions (Leach 1940) where the incubation period lasted 9 days at 18°C (Smith et al. 1968).

After fertilization, the eggs become covered by the substrate in and around the nests (Hardisty and Potter 1971). After hatching, the proammocoetes emerge from the substrate and drift downstream where they burrow into silt beds, especially along protected banks (Piavis 1971).

Behavior/Adaptability

The young larvae settle down into the soft bottom of slowly flowing waters where they are carried by the current. According to Sawyer (1959), the mouth is directed towards the current, with the upper section of the burrow sloping obliquely towards the mud surface. For several years, they lie concealed in the silt deposits, feeding on desmids, diatoms and protozoans (Scott and Crossman 1973) strained from the water. Since their burrows at the substrate sur-

face are sometimes closed off, food may be drawn from the sediments, depending on environmental conditions and activity of the ammocoetes (Moore and Mallatt 1980). In fact, detritus is frequently reported in the gut contents of all species of lampreys, although its relative abundance may vary with season and locality (Hardisty and Potter 1971).

Species Movement

It appears that ammocoete movement differs between streams owing probably to variations in such conditions as flow and bottom stability, current velocity, flooding and ammocoete density in relation to preferred habitat (Morman et al. 1980). Hardisty and Potter (1971) suggested that in some streams, particularly those with low gradients, stable flows and suitable habitats, the downstream migration of lamprey larvae is minimal. It appeared to Leach (1940) that ammocoetes moved only when the substrate was disturbed or when food was in short supply. Downstream migration takes place primarily at night; thus, predation by diurnal birds and mammals is minimal.

Limiting Factors

Lowering of water levels is probably a significant ammocoete mortality factor (Scott and Crossman 1973). Such is the case in the Yamaska River, where severe low water levels are regularly recorded in summer; these are generally followed by degradation of the aquatic environment (Mongeau et al. 1988). Siltation and pollution are a threat to successful spawning which requires a suitable substrate of clear gravel (Bailey 1959; Starrett et al. 1960). General deterioration in river habitat may reduce the available food supply of larvae and increasing levels of toxic chemicals may cause direct mortality.

Richards (1976) demonstrated a reduction in numbers of *Ichthyomyzon fossor* larvae and other warmwater fishes in a Michigan basin concurrent with the trend toward an increase in the relative abundance of coldwater species between the 1920s and 1972; he hypothesized that these changes were caused by a decrease in average water temperatures after that particular Michigan river basin was reforested and low-head impoundments were removed.

It is assumed that larval lampreys are largely immune from predation because of their burrowing sedentary habits (Churchill 1947; Hardisty and Potter 1971). However, evidence that ammocoetes are readily eaten by predatory fish is found in their formerly common and widespread use as bait (Vladykov 1949; Scott and Crossman 1973). In the course of field work carried out in the Ottawa River at Ottawa in the spring of 1979 and 1980, I observed unidentified predatory fishes capture ammocoetes swimming at the surface away from the electrical field generated by an electroshocker.

Lampreys on nests are probably most vulnerable to predators because they are more exposed in relatively shallow water and are not cautious. Therefore, in streams with few spawners, predators could reduce or prevent successful spawning (Morman et al. 1979).

Starting in 1958, Sea Lamprey (*Petromyzon marinus*) control programs in the upper three Great Lakes – Huron, Michigan and Superior – were carried out in Canadian and American streams with the help of a non-selective lampricide (Smith and Tibbles 1980). These programs were extended to Lake Ontario in 1971. In the process, native lampreys were inadvertently destroyed and their distribution throughout the Great Lakes watershed was greatly reduced. For example, 64% of the Lake Superior streams inhabited by native lampreys required treatment (Schuldt and Goold 1980). Lampricide was thus applied to 81 of the 105 streams inhabited by *Ichthyomyzon* larvae and the genus subsequently disappeared from 41 of the treated streams. They were readily eliminated from watersheds where they were confined to short stretches and where few sources of recruitment were available. Native lampreys disappeared from most streams unless they inhabited areas above barriers, in lentic environments, in tributaries in which Sea Lamprey did not spawn, or in difficult to treat areas such as oxbows, beaver ponds, long estuaries and springs. These changes reflect, in general, the results in the other Great Lakes where Sea Lamprey control programs were carried out.

Fecundity of a species is important in its recovery after lampricide treatment. In *Ichthyomyzon fossor*, fecundity was found to be twelve times less than its parasitic stem species, *Ichthyomyzon unicuspis* (Vladykov 1951). Its low fertility and mobility due to its non-parasitic nature suggest that it would be more vulnerable to chemical treatment than would parasitic lampreys.

Special Significance of the Species

All species, lampreys included, are part of our biodiversity heritage. While some may feel that all lampreys should be eradicated, it must be remembered that they are one of the oldest and most successful groups of living fishes (Beamish 1987). As such, they offer an excellent opportunity to study evolution in fishes and the reasons for their continued success in a changing environment. Even though the Northern Brook Lamprey has scientific interest, it is doubtful that the general public would support its protection.

Concern over the loss of non-parasitic lampreys was expressed by Vladykov (1973). According to him, a large concentration of ammocoetes in a brook is very favorable to its ecosystem. As prey of the Rainbow Trout (*Oncorhynchus mykiss*), Smallmouth Bass (*Micropterus dolomieui*), Grass Pickerel (*Esox*

americanus) [Vladykov 1949], American Eel (*Anguilla rostrata*) [Perlmutter 1951], Northern Pike (*Esox lucius*) [McPhail and Lindsey 1970] and Rock Bass (*Ambloplites rupestris*) [Hubbs and Trautman 1937], they represent an important link in the food chain. They also function as filter feeders and detritivores and so play a role in recycling dead organic matter into living tissue (Vladykov 1973).

Evaluation

Due to its restricted distribution in Canada, and eradication from some sites by the Sea Lamprey control program, the Northern Brook Lamprey can be considered a vulnerable species according to COSEWIC definitions. Its occurrence as disjunct populations and its affinity for areas of poor natural drainage and warmwater habitats suggest that this species may have been more abundant and widespread in an earlier period (Morman 1979).

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