COSEWIC
Assessment and Status Report

on the

Yellow Lampmussel
Lampsilis cariosa

in Canada

SPECIAL CONCERN
2004

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC 2004. COSEWIC assessment and status report on the yellow lampmussel *Lampsilis cariosa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 35 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note: COSEWIC acknowledges Derek S. Davis, Kellie L. White and Donald F. McAlpine for writing the status report on the yellow lampmussel *Lampsilis cariosa* in Canada. The report was overseen and edited by Gerry Mackie, COSEWIC Molluscs Species Specialist Subcommittee Co-chair. COSEWIC also gratefully acknowledges the financial support of the New Brunswick Department of Natural Resources and the Nova Scotia Department of Natural Resources for partially funding the preparation of this status report and providing funding for field travel.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le lampsile jaune (*Lampsilis cariosa*) au Canada.

Cover illustration:
Yellow lampmussel — Provided by the author.

Catalogue No. CW69-14/389-2004E-PDF
ISBN 0-662-37335-9
HTML: CW69-14/389-2004E-HTML
0-662-37336-7

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – May 2004

Common name
Yellow lampmussel

Scientific name
Lampsilis cariosa

Status
Special Concern

Reason for designation
Populations quite large and apparently stable in Canada but found only in Sydney River, Nova Scotia and Saint John River watershed, New Brunswick. Threats are currently very limited but there are long-term concerns related to the potential for introduction of zebra mussels into the Saint John River, and maintaining habitat quality of the sole population in the Sydney River.

Occurrence
New Brunswick, Nova Scotia

Status history
Designated Special Concern in May 2004. Assessment based on a new status report.

COSEWIC
Executive Summary

Yellow Lampmussel
Lampsilis cariosa

Species information

The Yellow Lampmussel, *Lampsilis cariosa* (Say, 1817) is a bivalve mollusc up to 110 mm in length and almost oval in outline when viewed from the side. The exterior surface is glossy, bright yellow or reddish brown in colour, typically with several fine radiating lines on the upper posterior slope of the shell. The interior of the shell is white to pink in colour and there are several strong hinge teeth. In living animals, the soft parts of the body (called the mantle) are visible between the shell valves. The edges of the mantle that can be seen are smooth and pigmented with grey streaks and dots and, in the female, have a brightly coloured flap with an 'eye' spot.

Distribution

This is a species of the Northeast Atlantic Slope of North America, ranging from Georgia in the south to Nova Scotia in the north. Currently in Canada *L. cariosa* is known from only two localities: the Sydney River, Cape Breton County, Nova Scotia and the lower Saint John River and tributaries near Fredericton, New Brunswick. A historic record from the Saint François River, near Drummondville, Quebec is in need of confirmation. The range of the species is declining and all populations north of New York State are isolated.

Habitat

This species is typically found in faster flowing sections of larger rivers, especially on sand and gravel bottoms in riffles. However, in the north of its range it also occurs in lakes. The habitat in Sydney River includes a lake with wave-washed and vegetated shorelines and a lower river section dammed as a freshwater reservoir. Within this habitat the mussels live in water depths of 0.5 – 6.0 meters preferring areas of sandy substrate with low macrophyte cover. Generally they live in alkaline waters with pH above 7.0.

Biology

The soft parts of the body, inside the protective shell, include a muscular foot for anchorage and mobility, and paired gills for respiration, filter feeding and early larval development. The sexes are separate. Early larval development within females is followed by a period of parasitic life where the young develop while attached to the gills or fins of a host fish. White and Yellow Perch (*Morone americana* and *Perca flavescens*) have been identified as suitable hosts. After an undetermined period of development upon host fish, the young mussels drop into the bottom sediment where they grow to adult size. Yellow Lampmussels are filter feeders taking plankton and organic detritus from the water. The main predator of the adult mussels is muskrats.

Population sizes and trends

Base-line studies carried out in the Sydney River in 2001 and 2002 report a species density of 0.4 - 0.8 –individuals per m^2 with total usable habitat area estimated at 2.52 km^2. Preliminary studies in 2002 on the Canaan River, a tributary of the Saint John River, suggest population densities in the same range as Nova Scotia and adjacent Maine. Although the Yellow Lampmussel continues to have a wide distribution in the lower Saint John River system, there is some evidence that the species' range in New Brunswick has been reduced over the past century. Further work is needed to estimate overall abundance of Yellow Lampmussel in New Brunswick, but the large size of the lower Saint John River, the extensive area of suitable habitat, the results of recent surveys, and preliminary density estimates for the Canaan tributary, together suggest that the lower Saint John and tributaries harbor most of the Canadian population.

Limiting factors and threats

Location of the Nova Scotia population within a suburban environment, with associated pollution and development issues, is of concern. A dam constructed in 1902 maintains current water levels in the Sydney River. A dam breach would lead to a decline in *L. cariosa* habitat. *Lampsilis cariosa* populations in the lower Saint John River presently seem to have few threats (Sabine et al. In press). However, Sabine et al. (In press) suggest that further study on the effects of low, late summer, water levels on *L. cariosa* in terms of elevated water temperatures, exposure, and saline penetration are required. The current downstream limit of *L. cariosa* on the Saint John River coincides extremely closely with the current upstream limit for saltwater intrusion. During periods of low water the saline front penetrates farther inland. Sabine et al. (In press) observed some mortality in late August and early September 2001, a particularly dry year. They suggest that some of this mortality may have been due to low water levels and elevated water temperatures over sandbars during months in which lowest water levels occur in the river annually.

Special significance of the species

The Yellow Lampmussel is considered to be threatened throughout its range in the United States and in some watersheds it is believed to have been extirpated or is at least endangered. In Canada there are currently only two known populations, one occurring in the Sydney River, Nova Scotia, and the other occurring in the Saint John River, New Brunswick. The Sydney River population is disjunct from the Saint John River population with at least 500 km separation. The apparent size and presumed genetic integrity of these isolated *L. cariosa* populations, as well as current lack of zebra mussels (*Dreissena sp*.) in either the Saint John or Sydney River systems, suggests that these Yellow Lampmussel populations could play an important role in the future conservation of the species globally.

Existing protection or other status designations

There is no specific protection for the Yellow Lampmussel in Canada. Its habitat is only protected through general municipal, provincial and federal guidelines regarding the environment, fish habitat and domestic water supply areas. A long-term volunteer monitoring program aimed at detecting declines in the size and health of the Sydney River *L. cariosa* population is currently being developed by the Atlantic Coastal Action Program of Cape Breton.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species and include the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal organizations (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership, chaired by the Canadian Museum of Nature), three nonjurisdictional members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The committee meets to consider status reports on candidate species.

DEFINITIONS
(AFTER MAY 2004)

Species	Any indigenous species, subspecies, variety, or geographically or genetically distinct population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.
** Formerly described as "Not In Any Category", or "No Designation Required."
*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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SPECIES INFORMATION

Name and classification

The Yellow Lampmussel, *Lampsilis cariosa* (Say 1817) was originally described in 1817 by Thomas Say in a contribution to the *American Edition of the British Encyclopedia or Dictionary of Arts and Sciences* (Volume II) as *Unio cariosus*. It was later placed in the genus *Lampsilis*. The description was based on a limited number of specimens and did not adequately differentiate the species from others with similar morphology. This has led in the past to some confusion with *Lampsilis (Leptodea) ochracea* (Say 1817), *Lampsilis ventricosa* (Barnes 1823) and *Lampsilis ovata* (Say 1817).

PHYLUM Mollusca
- CLASS Bivalvia (Pelecypoda)
  - SUBCLASS Palaeoheterodonta
    - ORDER Unionoida
      - SUPER FAMILY Unionacea
        - FAMILY Unionidae
          - SUBFAMILY Lampsilinae
            - GENUS *Lampsilis*
              - SPECIES *cariosa*

The species name *cariosa* is Latin for 'corroded' and was applied by Say as the specimens that he examined were all heavily corroded around the area of the beaks.

Description

The Yellow Lampmussel is one of twelve species or subspecies of freshwater mussels found in Atlantic Canada. *L. cariosa* has been well described and figured in recent publications particularly Burch (1975), Clarke (1981), Smith (1986), Strayer and Jirka (1997) and Nedeau et al. (2000). These authors with the exception of Clarke (1981) and Nedeau et al. (2000) also provide keys for identification. The descriptions are based on both external and internal characters of the shell and mantle edge and are adequate for the identification of living animals as well as shells. It is not necessary to sacrifice animals in order to identify them properly.

The following description is based upon information provided in the publications mentioned above and personal observations of specimens from Sydney River, Nova Scotia. Figure 1 a, b and c show typical examples from Sydney River. Bivalve shells up to about 110 mm in length, but typically smaller, up to about 75 mm in length. When seen laterally almost oval in outline, but sexually dimorphic so that adult males appear more elongated than adult females, which are higher posterior to the beaks than they are anterior to the beaks. The beaks are moderately inflated and project beyond the hinge line. The shell is moderately thick, up to 4.0 mm in the largest specimens. The exterior surface is smooth except for concentric growth rest lines. The periostracum is normally bright yellow-orange, or reddish brown in some cases, and glossy. Specimens

Figure 1. *Lampsilis cariosa* from Blacketts Lake, Station 8, 25 August 1999. Top and middle exterior and interior, female length 60 mm. Bottom live specimens, male, length 75 mm. It is often not easy to distinguish small living specimens of *L. cariosa* from *Leptodea ochracea* which is generally occurring in the same habitat.

are usually without rays but when present these are well defined and restricted to the posterior slope of the shell. Specimens collected from Sydney River often have a mineral deposit on the posterior end, which may obscure the rays. Inside the shell the nacre is white with some pink colour in the area of the beaks. The hinge teeth are complete and well developed but may vary in form between individuals from different localities. Pseudocardinal teeth are often strong and conical. The lateral teeth are elevated, of medium length and straight or slightly curved, there being two in the left valve and one in the right valve. In juvenile shells the beak sculpture is composed of 5 or 6 moderately coarse, curved, singly or slightly double-looped concentric bars. These characteristics have been illustrated by Marshall (1890) and reproduced by Strayer and Jirka (1997). Most adult specimens are heavily corroded at the beaks and so these beak characters are not visible.

Soft parts of the living animals are visible along the shell margins. The mantle margin is smooth with grey streaks or dots and with a well developed and brightly pigmented flap-like extension and a dark eyespot. These characters are best developed in the female and are well illustrated by Smith (1986).

The larval stage, or glochidium is described in Hoggarth (1999). It is 0.22 mm long and 0.28 mm high, roughly elliptical in shape with a straight hinge line and no hooks.

DISTRIBUTION

Global range

The Yellow Lampmussel is a species of the Atlantic Slope drainage, occurring east of the Appalachian Mountains from Sydney River, Nova Scotia to Ogeechee River in Georgia. The general distribution is shown in Figure 2. There are records from the states of Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Massachusetts and Maine and the provinces of New Brunswick, Nova Scotia, and Quebec (Clarke 1981; Williams et al. 1993).

Canadian range

In Canada *L. cariosa* is currently known from only two localities: the Sydney River, Cape Breton Island, Nova Scotia and the Saint John River and tributaries near Fredericton, New Brunswick (Clarke, 1981, Sabine et al. In press) (Figure 3 & Figure 4). Some early reports from Madawaska River, Ontario and Lower St. Lawrence River (Burch 1975; LaRocque 1953) have been discounted as misidentifications of *Lampsilis* ovata (Say, 1817) = *Lampsilis ventricosa* (Barnes 1823) (Clarke 1981). However, Strayer and Jirka (1997) report that *L. cariosa* is widespread in the St. Lawrence River Basin in northern New York. This indicates the potential for occurrences in tributaries of the St. Lawrence River on the Canadian side. Supporting this further is an historic record represented by a specimen collected in the St. François River, 5.5 mi NW of Drummondville, Quebec, on 31 August 1952 by H.D. Athearn. This specimen is now in the collection of the Ohio State Museum of Biological Diversity, Ohio State University (OSM 24450). The identity of the collection as *L. cariosa* has been confirmed by G.T. Watters and D.H. Stansberry (Myers pers. comm. 2003), but more recently could not be located for examination. The current status of *L. cariosa* in Quebec remains uncertain but is in need of investigation.

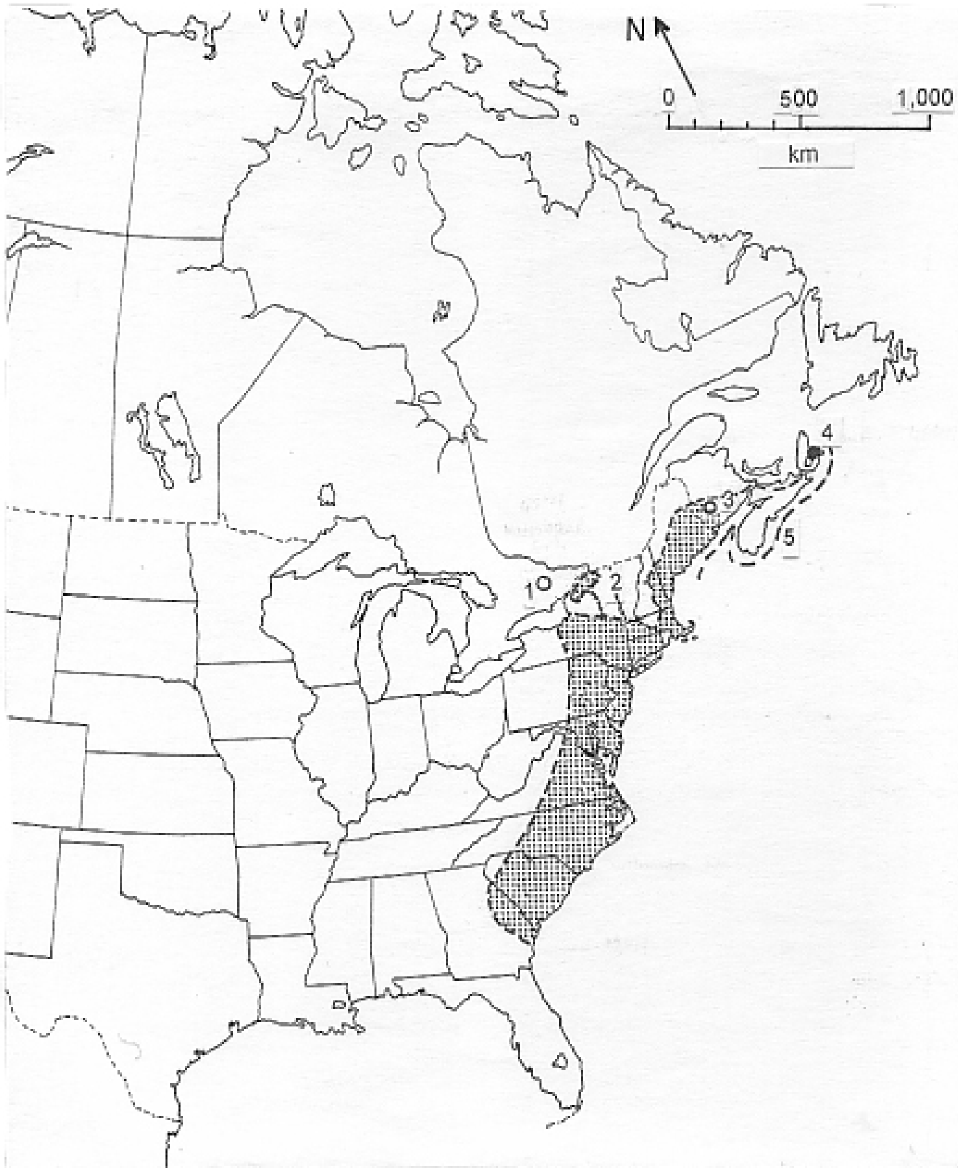

Figure 2. The general range of the Yellow Lampmussel, *Lampsilis cariosa*, on the Atlantic Slope of Eastern North America. Special features at the northern end of the range are: 1. Madawaska River, Ontario (*Lampsilis "cariosa"* = *L. cardium*) and not included in range calculation of *L. cariosa*; 2. Saint Lawrence Drainage Basin of New York State, *L. cariosa* populations; 3. McKinley Ferry site on Saint John River, New Brunswick; 4. Sydney River, Nova Scotia; 5. Speculative coastal plain connection about 7,000 ybp.

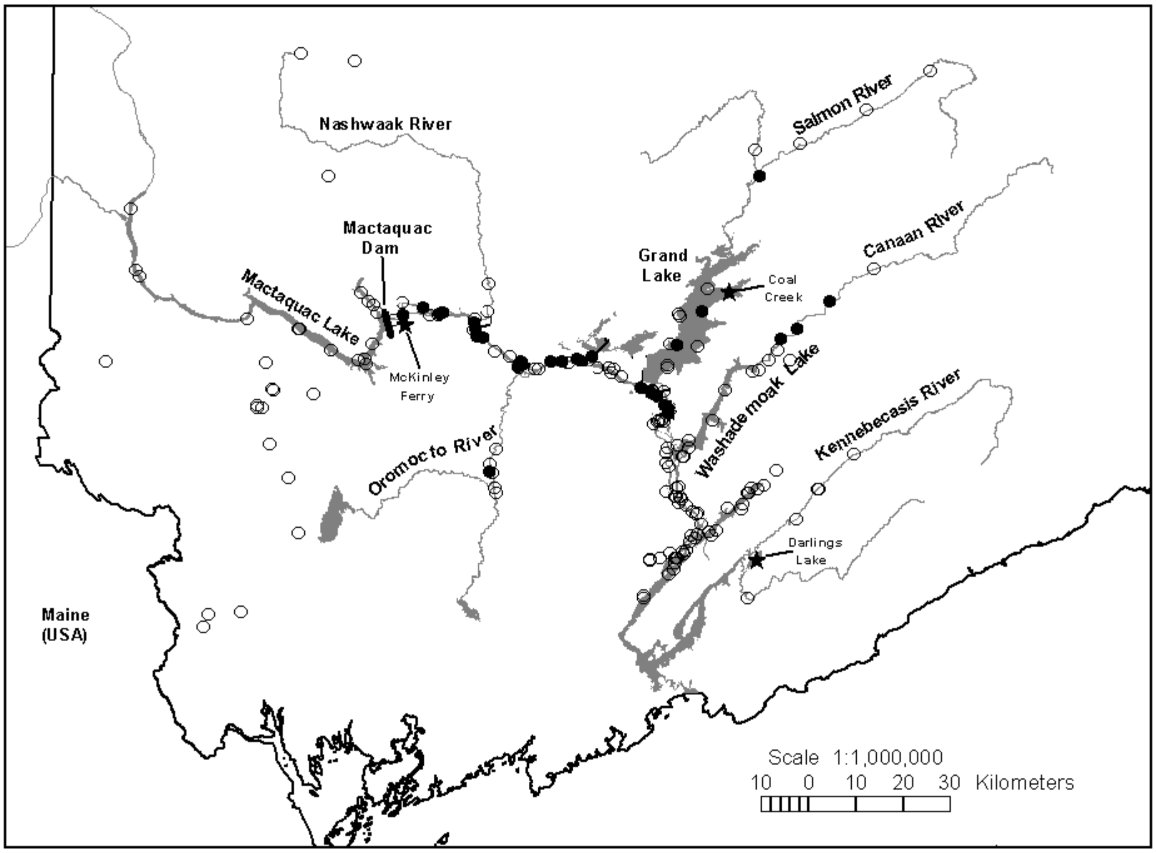

Figure 3. *Lampsilis cariosa* distribution in the lower Saint John River system, New Brunswick, showing all sites surveyed in 2001-2002. Solid circles show sites of *L. cariosa* occurrence, open circles show sites surveyed where *L. cariosa* was not present, stars mark historical occurrences (modified from Sabine et al. In press).

The Sydney River is a small system of about 14,000 hectares (140 km^2) that drains north to the Atlantic Ocean at Sydney Harbour (Figure 4). The length of the main stream is about 15 kms. Two lakes occur at the top of the river. The most significant lake is Blacketts Lake (187 hectares), which is the main centre of the *L. cariosa* population. Gillis Lake (11. 6 hectares) is connected to Blacketts Lake by a small stream. Nova Scotia has a variety of native plant and animal species with southern affinities that reached Nova Scotia from New England during the post-glacial warm (hypsithermal) period about 7,000 ybp (Davis and Browne (Eds.), 1996). The lower sea level provided a broad coastal plain with mature rivers suitable for *L. cariosa* populations. Two other disjunct freshwater mussels: *Leptodea ochracea* (Say 1818) and a rayed form of *Elliptio complanata*, also occur in the Sydney River along with a disjunct aquatic isopod *Caecidotea communis*. Rising sea level, past climatic cooling and geological factors such as bedrock type, which affect the quality of groundwater and landscape form, have contributed to the isolation of the Sydney River population. Counts et al. (1991) have provided a similar explanation for isolated mussel populations in the Delmarva Peninsula in the United States.

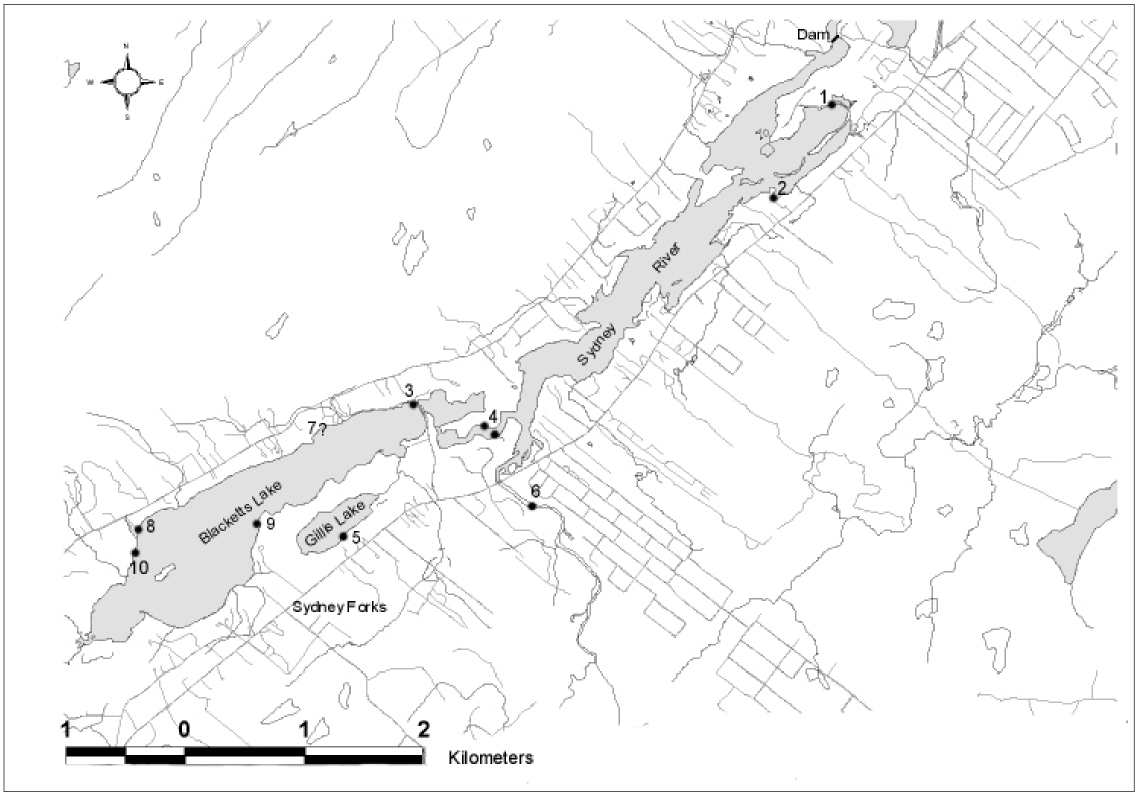

Figure 4. Sydney River, Cape Breton County, Nova Scotia, showing sampling sites for freshwater mussels including sites sampled by Clarke and Meachem Rick (1963), staff of Nova Scotia Museum of Natural History up to 1999 (1-8), and two high density mussel beds sampled by K. White in 2002 (9 and 10). See text for details.

The Saint John River is a much larger system, covering 55,000 km^2 with a main stream length of 700 km. *L. cariosa* is currently known only from the lower Saint John River (below head-of-tide) and its tributaries. That portion of the system includes the lower 140 km of main river as well as another 5 large tributary rivers, covering 15,000 km^2 (27%) of the entire drainage system. There are several large lakes in the lower Saint John System, including Grand Lake (17,100 ha), which is occupied by *L. cariosa.*

The occurrence of *L. cariosa* in the Saint John River is not unexpected as it is within the general range of the species and several locations are known from the nearby Mattawamkeag and Penobscot drainages in Maine (Nedeau et al. 2000). Nonetheless, 20^{th} Century malacologists overlooked an early Canadian reference to the Yellow Lampmussel in New Brunswick. Matthew and Stead (1903) reported the Yellow Lampmussel as occurring at “Grand Lake and elsewhere” in the province. This is supported by historical specimens recently discovered during databasing of the New Brunswick Museum mollusc collection taken at Darlings Lake on the Kennebecasis River, probably between 1895-1900, and material collected at Coal Creek, Grand Lake by W.D. Matthew, perhaps about 1900. Thus, there is evidence that the distribution of *L. cariosa* in New Brunswick had been historically well documented, though largely overlooked.

HABITAT

Habitat requirements

According to Clarke (1981), Strayer and Jirka (1997) and Nedeau et al. (2000) *L. cariosa* is predominantly a species of medium to large rivers. Strayer (1993) has made detailed studies of the macrohabitat of common mussel species, including *L. cariosa* in the middle of its range, in Pennsylvania and New York states. *L. cariosa* is common in this region and occurs in 26% of the streams examined. His results show that *L. cariosa* has a preference for hard water, stable low gradient, lowland rivers and streams and that stream size was probably the most important factor. It was generally most common in rivers with a drainage basin of more than 1200 km^2 and was much less frequent in smaller streams.

The habitats of *L. cariosa* in Northern Maine and the Maritime Provinces can be examined with respect to the above description. Figure 5 shows a section of Mattawamkeag Stream just south of Island Falls, Maine. Clarke and Meachem Rick (1963) reported the occurrence of *L. cariosa* in this section of the Penobscott River drainage. There was evidence, from fresh shell fragments, that the species was present in 1999. The habitat appears to be typical as described above, being a large river system with moderate flow, low gradient, riffles and sand/gravel bottom (Davis 1999).

The habitat of *L. cariosa* in the Sydney River, Nova Scotia is best described as a lake habitat (Figure 8). The river was dammed in 1902 creating a long lake habitat with imperceptible flow rates except at the constriction caused by the road causeway, at the bridge at Blacketts Lake and at the dam. At Blacketts Lake the water is alkaline with conductivity at 35.0 to 130.0 µmhos/cm and Ph at 7.2 to 7.5 (Alexander et al. 1986). No *L. cariosa* are found below the dam most probably due to the brackish water (2700 µS/cm recorded 200-m below dam). Salinity 100 m above is only (76 µS/cm). The Sydney River habitat above the dam is also suitable for freshwater fish and ten species have been reported (Table 1).

Figure 5. West Branch of Mattawamkeag Stream, 1.5 km south of Island Falls, Aroostook County, Maine, 9 August 1999. Freshwater shell fragments of *L. cariosa* were found. The occurrence of *L. cariosa* here was reported by Clarke and Meachem Rick (1963). The site is only a few kilometers west of the New Brunswick border, but the streams here are part of the Penobscot River draining directly to the Gulf of Maine.

Figure 8. Sydney River, below the outlet of Blacketts Lake, 21 June 1999. The stone causeway, bridge and shallows with emergent vegetation can be seen.

Microhabitat associations of the Sydney River population of *L. cariosa* were studied by K. White in 2001 and 2002. This consisted of an examination of mussel density in relation to substrate and macrophyte cover within 1-meter quadrats that were randomly placed around the 10 km perimeter of Blacketts Lake at a standardized depth of 0.75 m. Substrate composition was categorized using a modified Wentworth scale (Cummins 1962) with three categories of substrate identified: 1-mostly sandy (n=68), 2-mostly gravel (n=109) and

3-mostly silt (n=104). Macrophyte cover was coarsely categorized in each quadrat as greater than 50% (n=170) or less than 50% (n=111). This cover included emergent rushes (*Juncus spp*.), Pickerel weed (*Pontederia cordata* L.) and submerged pondweed (*Potamogeton robbinsii* Oakes). Mussel density across a depth range of 0.25-6.00 m was also examined by quadrat sampling using SCUBA. Relationships between habitat type and Yellow Lampmussel density were tested using analysis of variance (ANOVA). Tukey's method was used to make pair-wise comparisons with a Bonferroni correction made for multiple comparisons (Sokal and Rohlf 1995).

Table 1. Species of freshwater fish recorded from the Sydney River system, Cape Breton County, Nova Scotia.
Sources: Alexander et al. (1986) and Gilhen (1990)**.

Taxon		Habitat Strategy*	Reference
American Eel	*Anguilla rostrata*	catadromous	Alexander et al. (1986), Gilhen (1990)
Atlantic Salmon	*Salmo salar*	anadromous	Gilhen (1990)
Brook Trout	*Salvinus fontinalis*	freshwater	Alexander et al. (1986), Gilhen (1990)
Golden Shiner	*Notemigonus crysoleucas*	freshwater	Alexander et al. (1986), Gilhen (1990)
White Sucker	*Catostomus commersoni*	freshwater	Alexander et al. (1988)
Banded Killifish	*Fundulus diaphanus*	freshwater	Alexander et al. (1986), Gilhen (1990)
Brown Bullhead	*Ictolurus nebulosus*	freshwater	Gilhen (1990)
Threespine Stickleback	*Gasterosteus aculeatus*	freshwater to marine	Gilhen (1990)
Ninespine Stickleback	*Pungitius pungitius*	freshwater to marine	Gilhen (1990)
White Perch	*Morone americana*	freshwater	Alexander et al. (1986)

*From Natural History of Nova Scotia (1996), Vol. 1.

Significantly higher densities (68% greater) of *L. cariosa* occurred in sandy substrate than in silty substrate and quadrats with low macrophyte cover contained a significantly greater number of *L. cariosa* (77% greater) than quadrats with high macrophyte cover. The microhabitat associations observed here are similar to those reported for other related freshwater mussel species (e.g. Huebner et al. 1990). And the results are consistent with the explanation that heavier shelled species like *L. cariosa* tend to prefer sandy substrate over silty substrate due to the fact that they encounter difficulties maintaining filtering and reproductive positioning in loose silty substrate. Lighter shelled species like *Pyganodon cataracta,* (called "Eastern floater" for its ability to 'float' on top of silty substrate) do not encounter this problem and were found to thrive equally well in sandy or silty substrates.

L. cariosa density was also found to vary with depth in the Sydney River with lower densities occurring below 0.25 meters when compared to those at 0.75 – 6.0-m. However, no significant differences were found when comparing densities of Yellow Lampmussel at 0.75 m, 2.0 m, 4.0 m, and 6.0 m (n = 10). Mean *L. cariosa* densities within the study site ranged from 1.7/m^2 ($\pm$ 1.1) at 0.75-m to 2.3/ m^2 ($\pm$ 1.2) at 6-m. No individuals were found below the thermocline of Blacketts Lake which is estimated to occur at an approximate depth of 6 meters. Studies conducted on other freshwater mussel species have found similar relationships between depth and density, with lower density being found at depths below 50 cm and above 5.0 m (Ghent et al. 1978; Huebner et al. 1990; Haukiofa and Hakala 1974). No size, age or sex ratio differences were found among substrate type, macrophyte cover, or depth (P > 0.05).

It should be noted that causal interpretations of micro-habitat/density correlation should be made cautiously due to possible confounding factors. K. White found that substrate type and percent macrophyte cover are highly correlated with one another; with predominantly silty areas tending to be areas with greater macrophyte cover. Also, unmeasured factors, which may play a causal role in habitat associations, are likely also correlated with substrate, macrophyte cover and depth.

Figure 6 shows a section of the Saint John River, New Brunswick, about 13 km above Fredericton and 4 km below the Mactaquac Dam. *Lampsilis cariosa* was collected at this site in 1962, prior to the dam construction, which began in 1965. (Clarke 1981; Clayden et al.1984). The size of the Saint John River fits Strayers (1993) definition of sites most likely to host *L. cariosa* populations. Lampsilis cariosa has shown a preference for sand substrates elsewhere (Nedeau et al. 2000) and Strayer and Ralley (1993) have described the effect of impoundment in removing fine sediment from the riverbed for some distance below dams. Nonetheless, the low gradient and tidal nature of the lower Saint John River has resulted in the formation of extensive bars of almost pure sand, which Sabine et al. (In press) report appears to offer exceptional conditions for Yellow Lampmussels in the Saint John system. The tidal portion of the river and its lower tributaries are characterized by slow water flow, many large islands, and extensive bars with sparsely vegetated substrates of fine to coarse sand. The upper reaches of the lower tributaries of the Saint John are undammed and of moderate flow, with gravel/cobble substrates and only occasional sand bars. Although Sabine et al. (In press) reported occasionally finding *L. cariosa* on cobble substrates, they note that greatest numbers occurred on unvegetated bars of fine to coarse sand, and at depths ranging to 5.15 m.

Figure 6. Saint John River at McKinley Ferry, York County, New Brunswick, 1999. The structure of Mactequac Dam can be seen in the far left of the picture, about 4 km upstream.

Trends

For the Sydney population the damming of the tidal river has led to increased habitat during the last century (Figure 7). In Nova Scotia suitable habitat may exist in upper parts of some larger streams such as River Inhabitants, St. Mary's River, Musquodoboit River, Tusket River and the Shubenacadie/Stewiacke rivers. No *L. cariosa* have been reported from these rivers. However, thorough surveys of these systems have not been done and few mussel specimens from them are present in museum collections. Thus the existence of *L. cariosa* in these rivers cannot be ruled out. However, the relatively high acidity of all but the Musquodoboit, Shubenacadie, and Stewiake Rivers would likely exclude *L. cariosa* (Elderkin pers. comm. 2004). Recent surveys within two federal parks in Nova Scotia: Cape Breton Highlands National Park and Louisburg National Historic site which included portions of the St. Mary's River and River Inhabitants drainage did not find any *L. cariosa* (Power and Gouthro 2002; Lambert et al. 2003).

In New Brunswick it is possible that damming may have reduced the area of habitat, as *L. cariosa* was not encountered in surveys of the headpond formed by the Mactaquac dam. However, further survey work effort is required to convincingly eliminate the possibility of extant populations within and upstream of the Mactaquac headpond (Sabine et al. In press). Additional suitable habitat may exist in other large (and unsurveyed) rivers in New Brunswick, such as the Miramichi and Magaguadavic rivers.

Protection/ownership

Most lake and river shorelines in Nova Scotia are privately owned which has led to extensive shoreline modification. In both New Brunswick and Nova Scotia protection of waterways is provided through regulation under Acts administered through provincial environment departments and federal Departments of Environment and Fisheries and Oceans. Protection through these Acts primarily focuses on the prevention of habitat

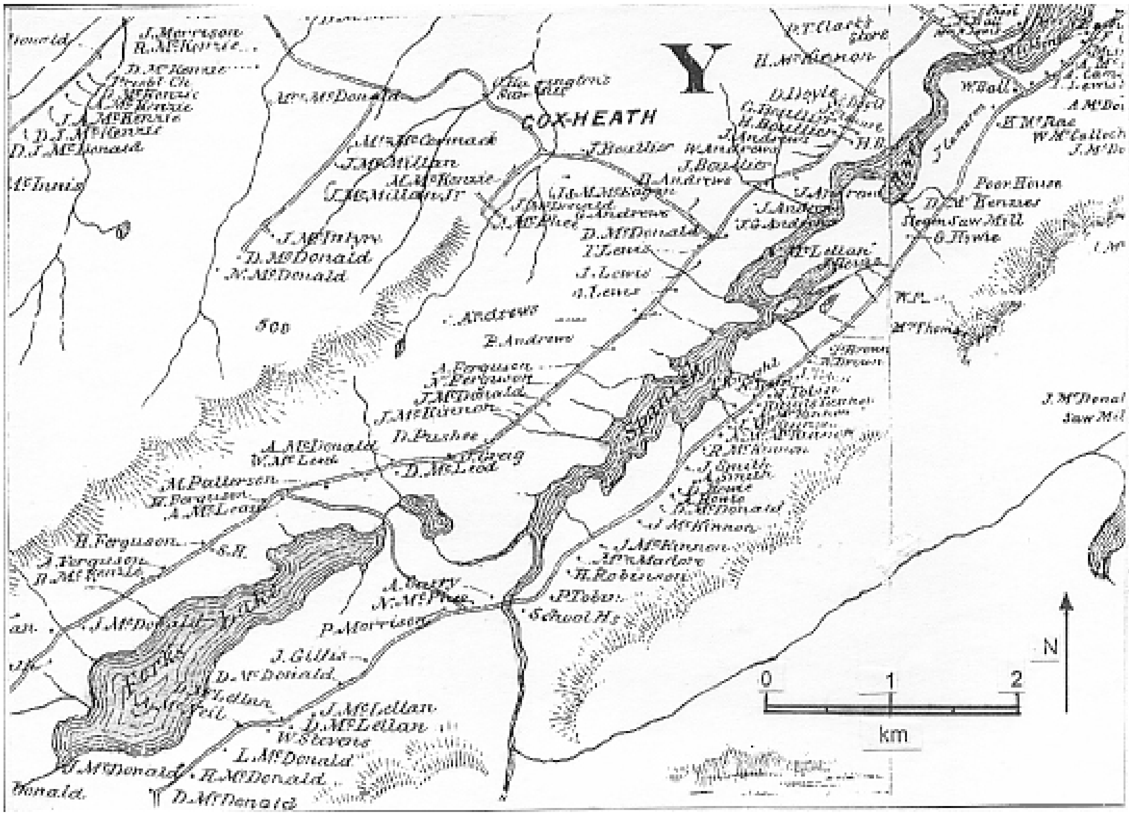

Figure 7. The Sydney River system as it was before flooding resulting from the 1902 dam. The river section (Spanish River) was probably all tidal, though dominated by freshwater. Forks Lake became Blacketts Lake and was entirely fresh and non-tidal. Little Gillis Lake was formed by flooding of a wetland near the property marked “J. Gillis”.
A section of the *Topographical Township Map of Cape Breton County, Nova Scotia* published by A.F. Church, Bedford, Halifax County, Nova Scotia in 1864.

loss for fishes which should provide protection for *L. cariosa* fish hosts. It is hoped that focusing on fish habitat will also make the regulations sufficient to protect against *L. cariosa* habitat loss and disturbance of the mussels themselves.

BIOLOGY

General

The biology of *L. cariosa* has been described by Johnson (1947) and summary information has also been provided by Clarke (1981) and Strayer and Jirka (1997). It is typical of most species of the Family Unionidae in terms of its general reproduction and habits; however, more detailed information is needed. There are paired gills or demibranchs, two on each side of the mid-line, which facilitate respiration, filter feeding and early larval development.

Reproduction

The sexes are separate and sexual dimorphism is seen in the shape of the adult shells and form of the mantle margin and other soft tissues. Sperm are released by the male and find their way to the female to fertilize eggs that are located and subsequently develop in modified posterior parts of the two outer demibranchs called the marsupium. The majority of unionids require a fish host for their parasitic larvae. And female *L. cariosa* like other species of Lamsilinae subfamily have modified their mantles to resemble fishes, possibly to act as lures to attract a piscivorous host fish (Kraemer 1970). When struck by a predatory fish, the lure releases the glochidia which then attach to the would-be predator. After an undetermined period of time on a fish host the glochidia transform into juvenile mussels and drop to the bottom sediment. Here they begin growth to the adult form.

All unionoids are divided into two behavioral groups based upon the duration that glochidia are brooded within female mussel before release onto a fish host. With spring or summer fertilization, bradytictic or long-term breeders hold larvae until the following spring or summer. Tachytictic or short-term breeders will release them later the same year, usually by July or August. Exact timing of fertilization and glochidial release is not known for *L. cariosa.* However, Wiles (1975) has shown that a related species, *Lampsilis radiata radiata* release glochidia onto fish hosts at least from spring to early autumn in Nova Scotia. In Lamsilinae species, release of glochidia is correlated with display of “mantle lure” and presence of swollen and darkened marsupia (Kraemer 1970). And, it is believed that only gravid females fully display their mantle lure. This characteristic was used as an indicator of gravidity of *L. cariosa* in the Sydney River.

K. White first observed *L. cariosa* with swollen marsupia and fully displayed mantle lures in the Sydney River on June 5, 2002 when the water temperature was 11.7 degrees Celsius. Mature glochidia (i.e. presumably ready to parasitize fish hosts) were found within these displaying females. Maturity was indicated by the observation that glochidia shells snapped shut when exposed to a 1 molar NaCl solution. Females ceased full display of mantle lures by August 15. After this date, only a small portion of the mantle lure could still be seen in females. However, mature glochidia were found within a non-displaying female collected in Blacketts Lake on November 15th, 2002. No further collections were made after this time. Based on this information, it appears that the *L. cariosa* in Sydney River are long-term breeders. With a period of gravidity occurring from at least June – November 15. More information is needed to determine the period of gravidity for the New Brunswick population.

Until recently the host fish for the parasitic glochidia of *L. cariosa* were unknown and there was no information available on the development of this stage or its duration. However, Wick and Huyrn (2003) investigated the fish hosts of *L. cariosa* occurring in Maine using laboratory infestations. Pumpkinseed sunfish (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*), and White perch (*Morone americana*) were used for host fish trials. Juveniles of *L. cariosa* transformed on *P. flavescens* and *M. americana*. Glochidial parasitic periods lasted 43 to almost 80 days for *M. americana* and an average of 42 days for *P. flavescens. P. flavescens* does not occur in Cape Breton, *M. americana* does (Davis and Browne 1996).

Field studies done on the Sydney River confirm that *M. americana* serves as a host fish for Yellow Lampmussel. In July of 2002, fish within an area of the Sydney River with a high density of female *L. cariosa* were sampled and examined for glochidial infestations (Table 1). Of the six species represented, only *M. americana* were found to contain *L. cariosa* glochidia. Average infestation rate of the twenty-two *M. americana* sampled was 44 glochidia/fish (± 16.7 SD). Average size of *M. americana* sampled was 128.6 mm (± 29.5 SD). No relationship was found between glochidial infestation rate and size of fish. Neither tank nor field studies have been carried out to identify fish host for the New Brunswick population. However, both *P. flavescens* and *M. americana* occur in the Saint John River (Gorham 1970), and therefore may serve as fish hosts for *L. cariosa* in New Brunswick.

Details on population structure and recruitment for the Sydney River *L. cariosa* population were gained through quadrat sampling carried out by K. White in 2001 and 2002. An average of 48.7 % of *L. cariosa* sampled were female with no significant deviation from a 1:1 sex ratio (n = 91, chi-squared 0.06). The minimum and maximum age of live *L. cariosa* found in the Sydney River was 1 and 17 years respectively with an average of 7.8 (± 2.7 SD) years. Both age and length frequency distributions of live *L. cariosa* were somewhat positively skewed with all age classes represented, suggesting recent recruitment. Age estimates were based on counts of external "annual" shell growth rings and therefore are only approximations. The use of external growth rings for aging has been criticized as underestimating ages of mussels due to inconsistent annulus formation (Downing et al.1992). Age of sexual maturity is not known for *L. cariosa;* however, it is estimated to occur ~ age 5 years in a related species of mussel with rate of survival to maturity estimated at 9-18% (Jansen and Hanson 1991).

Animals such as *L. cariosa* living at low densities and employing direct fertilization are thought to improve reproduction by clumping (e.g. Anscombe 1950). Further clumping of *L. cariosa* likely occurs due to habitat preferences (see Habitat section for details). Sampling carried out by K. White in 2001 aimed at describing the spatial distribution of the Blacketts Lake *L. cariosa* suggests that there is significant spatial aggregation exhibited in this population. This was indicated by a high s^2/m ratio at 3.71. Chi-square test results indicated that this ratio is significantly different from one and that the spatial distribution is significantly different from a Poisson series ($P < 0.05$).

Survival

In related unionid species the estimated chances of a glochidium surviving to transform and drop from a host fish range from 0.0001% (Jansen and Hanson 1991) to 0.000001% (Young and Williams 1984). In a study of unionid reproduction and survivorship in an Alberta lake, Jansen and Hanson (1991) found that the mortality rate from the time of excystment (glochidia drops from fish host to the substrate) to the age of sexual maturity (~ age 5) is approximately 82-91%.

No specific details on survival patterns or rates are available for *L. cariosa* occurring in New Brunswick. Predation mortality patterns and rates for the Sydney River *L. cariosa* were examined by K. White in 2002. Evidence suggests that muskrats are the main predators of adult *L. cariosa* in the Sydney River with a total of six muskrat midden sites being actively used on Blacketts Lake (Figure 9). Three of these midden sites were randomly chosen for monitoring. Evidence of muskrat or other predator activity (e.g. trail from woods, tracks, scat, bite marks on shells) was noted at each site. All mussel shells located within middens were removed on June 25th, 2002 and subsequent collections of mussel shells at these sites were made bi-weekly until September 26th, 2002. The estimated predation rate of *L. cariosa* for this 8 week period was only 10.5 (± 8.7 SD) *L. cariosa* / week. If one assumes that this rate is maintained all year, it is estimated that an average of 546 *L. cariosa* are eaten by muskrats on Blacketts Lake annually. The length range of *L. cariosa* shells found at midden sites was 43.1 mm to 86.4 mm, with an average of 57.6 mm (± 10.5) suggesting that only adults are preyed upon. The sex ratio of *L. cariosa* at midden sites was not significantly different from 1:1 ratio (n = 54, chi-square = 0.91) suggesting that females and males are equally likely to be preyed upon by muskrats. Populations in the Saint John River appear to be nearly completely free of muskrat predation, although predation has been noted in the smaller tributary rivers (Sabine pers. comm. 2003)

Figure 9. Sydney River, showing muskrat midden beside the highway causeway, 20 June 1999. The muskrats live between the rocks and feed on mussels from the nearby shallows.

There was some concern that the human handling of mussels required for the research being carried out in the Sydney River population of *L. cariosa* could lead to mortality. This concern was addressed by K. White in 2002 through a field experiment designed to estimate mortality rates of *L. cariosa* due to human handling. During the course of this experiment Yellow Lampmussel (n = 20) were removed from their natural habitat and handled out of water for 45 minutes. These mussels were then placed in enclosures (1-meter wire mesh “corrals”) and the time it took for resumption of normal positioning in sediments was recorded. All mussels resumed normal filtering position in sediments and gravid females resumed mantle flap display within 1 hour of placement in enclosures and no mortality was observed in these mussels during an 18-week observation period. These results suggest that handling associated with species identification and shell measurement does not result in any significant disturbance or mortality.

Physiology

According to Strayer (1993) *L. cariosa* prefers larger rivers**,** presumably with good aeration and cooler temperatures as well as adequate calcium supply. As previously mentioned in the Habitat section of this report the water at Blacketts Lake is alkaline with a pH of 7.2 to 7.5 (Alexander et al. 1986), as a result of underlying calcareous bedrock. In normal winters much of the Sydney River is ice covered, with the exception of areas of higher flow at tributary stream outlets. No studies of the physiology of *L. cariosa* are known.

Movements/dispersal

Adult mussels are able to move locally using their muscular foot. Limited movements may achieve adjustments in orientation for feeding or to accommodate seasonal changes in water level. The main means of dispersal of *L. cariosa* is through the movement of the fish hosts of its glochidia larvae. As previously discussed in the Reproduction section, White Perch has been found to be a suitable fish host for Sydney River population of *L. cariosa*. And both Yellow and White Perch are likely fish hosts for Saint John River population. What follows is a description of the movements of White and Yellow Perch, which may also represent the movement and dispersal of attached *L. cariosa* larvae.

White Perch are found in fresh and brackish water (Scott and Crossman 1973). Sea-run populations are found in some coastal rivers and estuaries. However, sea-run populations are not common in the Maritime provinces. There are virtually no anadromous stocks in the Bay of Fundy. However, in the La Have River, Nova Scotia, provincial fishery survey workers have reported a seaward migration in summer. Spring spawning takes place when water temperatures become 11 to 16 degrees Celsius during late May or June in shallow water over many kinds of bottoms. Fresh and saltwater populations move to surface (or inshore) waters at night, retreating to deeper water during the day.

Yellow Perch are found in freshwater (Scott and Crossman 1973). However, it is occasionally found in brackish water along the Atlantic coast. Spawning occurs from April through July, but usually during May in the Maritime provinces, at water temperatures of 9 to 12 degrees Celsius. At this time, the adults move into shallow areas of lakes or up into tributary streams. Spawning takes place at night or in early morning, most often in areas where there is debris or vegetation on the bottom. Young perch grow quickly and remain near the shore during their first summer. Adults move in schools farther offshore than the young. They also move between deeper and shallow water in response to changing food supplies, seasons, and temperatures.

Nutrition and interspecific interactions

In the Sydney River *L. cariosa* is associated with, in order of frequency, eastern ellipto (*Elliptio complanata* both normal and rayed forms), eastern floater (*Pyganodon cataracta),* tidewater mucket (*Leptodea ochracea*)*,* and alewife floater (*Anodonta implicata*). *Margaritifera margaritifera* also occurs but not usually in association with *L. cariosa* (Clarke and Meachem Rick 1963, Davis 1999). The parasitic relationship with fish has been mentioned previously under Reproduction and predation by fish and muskrats under Survival

Freshwater mussels found in association with Yellow Lampmussel in the Saint John system include, in order of frequency, eastern elliptio (*Elliptio complanata*), alewife floater (*Anodonta implicata*), eastern lampmussel (*Lampsilis radiata*), tidewater mucket (*Leptodea ochracea*), eastern floater (*Pyganodon cataracta*), triangle floater (*Alasmidonta undulata*), and eastern pearlshell (*Margaritifera margaritifera*) (Sabine et al. In press). Sabine et al. (In press) also note that in the Saint John and tributaries they frequently found *Leptea ochracea* occupying habitat similar to *L. cariosa,* with the former a useful marker for the possible presence of Yellow Lampmussel. As with all freshwater mussels, *L. cariosa* is a suspension feeder filtering organic detritus and phytoplankton from the water. Suspended material is pumped into the mantle cavity of the mussel through the lower of two siphons and passes through the gills where food is separated from sediment particles. Food is passed anteriorly to labial palps at the mouth while the unwanted material is passed into the upper exhalent siphon and expelled as pseudofaeces.

Behaviour/adaptability

Apart from aspects previously mentioned under Reproduction and Movement, little is known about the behaviour of *L. cariosa*. The modification of the mantle edge of the female mussel to attract fish has been described in the Reproductive section along with observations on the timing of mantle lure display. No direct observations of glochidial release behavior have been made for *L. cariosa*.

Transformation of *L. cariosa* glochidia from larval to juvenile forms has been successfully carried in tank studies using White and Yellow Perch as host fish (Wick and Huryn 2002). Results of a field experiment carried out by K. White aimed at estimating *L. cariosa* mortality rates due to human handling, noted above, suggest that this species may respond well to transplanting.

POPULATION SIZES AND TRENDS

Since the discovery of the population of *L. cariosa* in Sydney River, Nova Scotia (Clarke and Meachem Rick, 1963), staff of the Nova Scotia Museum have made several visits to the area to check the occurrence and obtain specimens for their collection. Sites commonly visited are shown on the map, Figure 4. In 1977, 1978, 1987 and 1990 *L. cariosa* was found at Sites 1, 2 and 3; in 1999 it was also found at Sites 5 and 8. In 1999, S. Kavannagh (pers. comm.) reported *L. cariosa* throughout the system from the shore near the dam to Blacketts Lake. In 1999 the species appeared to be absent from the mud bottom and boggy shoreline at the southwestern end of Blacketts Lake and from the lower part of Meadows Brook (below Station 6 in Figure 4). Records of freshwater mussels made by S. Kavannagh will be published at sometime in the future with other records made in 1999 and 2000 by Nova Scotia Department of Natural Resources staff. In further surveys carried out by the Nova Scotia Department of Natural Resources staff in 1999 and 2000 studies throughout Cape Breton Island and northern Nova Scotia no additional sites for *L. cariosa* were found. A 2001 survey of the Fortress of Louisburg National Historic site and greater ecosystem and a 2002 survey of the Cape Breton Highlands National Park found no *L. cariosa* (Power and Gouthro 2002; Lambert et al. 2003).

A study aimed at providing quantitative estimates of the size of the Sydney River *L. cariosa* population was carried out by K. White in 2001 and 2002. This study focused on areas previously found to contain *L. cariosa*: the Sydney River above the dam including, Blacketts and Gillis Lake (Figure 4). All sampling for this study took place between July 1st and August 25th. Sampling methodology consisted of the collection of mussels from 310 1-m^2 quadrats randomly sampled from around the perimeter of Blacketts and Gillis Lake and 53 1-m^2 quadrats sampled along the shore of the Sydney River from the causeway at Blacketts Lake road to the dam. The majority of sampling (333 quadrats) was conducted through a glass-bottomed bucket, in wadeable water (< 1.5 m). Observation was visual or tactile depending on turbidity. As part of the search, fine sediment was brushed away, non-embedded material was lifted and loose sediment was raked with fingertips. A subset of thirty of these quadrats was double sampled with excavation (Smith et al. 2000). Excavation consisted of the removal of substrate to a depth of approximately 10 cm and sifting substrate through a mesh screen with openings of 6.4 mm. Additional sampling (30 quadrats) was also performed at depths ranging from 2-6 meters via SCUBA to determine if the estimates made at wadeable depths are representative of mussel density in deeper water. A total of 393 quadrats were sampled.

The majority of *L. cariosa* (with the exception of gravid females) observed in the Sydney River were completely buried in the sediments; however, their siphon opening was visible at the interface of sediment and water upon close inspection. Through double sampling, it was estimated that on average 87.5 % (± 31.0) of *L. cariosa* were visible through surface counts. Based on this finding and the finding that *L. cariosa* density at water depths of 0.5 m and 2.0 m was representative of densities at greater depths (see habitat section for details) it was decided that density estimates used to estimate total population size for the Sydney River would be made from surface counts of 363 randomly placed quadrats along wadeable (< 1.5 m) shoreline.

The density of *L. cariosa* in Blacketts Lake was 0.8(± 1.7 SD) individuals per m^2. At Gillis Lake the density was 0.8 (± 1.1 SD) individuals per m^2, and the lower Sydney River density was estimated at 0.4 individuals per m^2 (± 1.2 SD). Translating these density estimates into total population abundance estimates for the Blacketts Lake and Gillis Lake requires an assumption about the area of the usable habitat within our sampling area. Based on the examination of density in relation to water depth we assume all area within depths of 0.5 and 5.0 meters of water represent usable habitat for *L. cariosa* within the Sydney River. Arc view software was used to estimate this area from GIS and bathymetric maps. Blacketts Lake, Gillis Lake and the Lower Sydney River were estimated to contain 0.564 km^2, 0.145 km^2 and, 1.81 km^2 of usable habitat respectively. Multiplying these numbers by the density estimates we come up with a total abundance estimate of 434,401 (± 953,425 SD) for Blacketts Lake, 108,636 (± 165,128 SD) for Gillis Lake and 723,600 (± 2,225,070 SD) for the lower section of Sydney River to the dam. Total population size estimate for the Sydney River population is 1,266,637 (± 3,343,623 SD). Obviously, the high error associated with these estimates renders them somewhat meaningless. The high degree of spatial aggregation seen in the Sydney River *L. cariosa* population is similar to that seen in other populations of unionids and it results in a high variance to mean ratio which in turn results in highly imprecise density estimates and difficulties in examining population dynamics (Kat 1983). In 2002 in an attempt to provide more precise estimates of minimum population size for the Sydney River, K. White carried out stratified sampling within two areas of high *L. cariosa* density within Blacketts Lake (marked sites 9 and 10 on Figure 4). Density at these sites was 3.5 individuals per m^2 (± 2.4 SD) and 3.9 individuals per m^2 (± 2.7 SD). The area of these 'clumps' was estimated at 12,500 m^2 and 23,200 m^2 with estimated population sizes of 39,875 (± 25,375 SD) and 81,896 (± 56,144 SD) respectively.

Although the Yellow Lampmussel continues to have wide distribution in the lower Saint John River system, there is some evidence that the species range in New Brunswick has been reduced over the past century (Sabine et al. In press). The Yellow Lampmussel may once have occurred in the now-dammed portions of the Saint John River above head-of-tide. The species currently exists immediately below the Mactaquac dam, and is found above head-of-tide on the Canaan River, occasionally on cobble substrates that were typical of the upper Saint John River prior to dam construction. Excellent Yellow Lampmussel habitat appears to be abundant in the shallow waters of the Mactaquac headpond (Sabine et al. In press). Although it remains possible that the Yellow Lampmussel still exists upstream from the Mactaquac headpond, the disappearance of *L. cariosa* from such areas above the Mactaquac dam would represent a reduction in the New Brunswick range and population. Additionally, two *Lampsilis cariosa* valves now in the New Brunswick Museum mollusc collection were taken at Darlings Lake on the Kennebecasis River, probably between 1895-1900. Mussel surveys in 2001 and 2002 failed to record *L. cariosa* from the Kennebecasis River. Likewise, species specific searches of several km of Darlings Lake shoreline in

2002 were also unsuccessful. Sabine et al. (In press) note that although the portion of the Saint John River between the lower limits of the current range of *L. cariosa* and the mouth of the Kennebecasis River appears to be too brackish to support the species; the disappearance of the Yellow Lampmussel from the Kennebecasis River itself would represent a considerable reduction in the range of the species in New Brunswick, and hence in the extent of occurrence and the area of occupancy.

Until Davis (1999) investigated the status of several species of freshwater mussels in New Brunswick and Nova Scotia in 1999, the Yellow Lampmussel was completely ignored in New Brunswick, save the brief comments on Canadian distribution provided by Clarke (1981) made on the basis of 2 worn valves collected by A.M. Rick near Fredericton in 1962 (Clayden et al. 1982). These specimens could not be located in the CMN collection for re-examination in October 2000. Davis (1999) was unable to locate *L. cariosa* in New Brunswick during his searches, and given the long interval since previous collections, as well as subsequent changes to the river with the operation of the 670 megawat Mactaquac hydroelectric dam starting in 1968, concluded that the Yellow Lampmussel was likely extirpated in New Brunswick. Considering that Rick's 1962 collection site is only about 2 km downstream from the dam, this was perhaps not an unreasonable conclusion.

Nonetheless, surveys in New Brunswick in 2001 and 2002 indicate that a significant Yellow Lampmussel population continues to exist in the lower Saint John River and tributaries. While surveys to date have been directed largely at confirming the presence of *L. cariosa* in New Brunswick and delineating distribution in the Saint John system, it is clear that the lower Saint John and tributaries harbor most of the Canadian population (Sabine et al. In press). For example, Sabine et al. (In press) report that one of 30 sites on the Saint John system where *L. cariosa* occur consists of approximately 2.4 km^2 of ideal habitat. Should densities of *L. cariosa* at this site approach those of the neighbouring Nova Scotia (0.4 - 0.7/m^2) or Maine populations (0.4 –2.8/m^2; Wick and Huryn 2002) numbers at this site alone would approach 2 million individuals. Even assuming densities an order of magnitude lower than these would indicate a total population in the lower Saint John River system well into the millions. Preliminary density estimates collected for the Canaan River in 2002 based on the excavation of over 500 0.25 m^2 quadrats, suggest that densities in the Canaan are in the same range as those recorded in the Sydney River, Nova Scotia and in Maine (Sabine et al. In press).

LIMITING FACTORS AND THREATS

The location within a suburban environment presents several threats to the Sydney River population. A dam constructed in 1902 for industrial and domestic freshwater supply maintains current water levels in the Sydney River. A breach of this dam would lead to a decline in *L. cariosa* habitat due to both a reduction of shore habitat covered by water and an increase saltwater intrusion upstream of dam. Fish and mussel populations benefit from environmental controls required for maintenance of water quality standards. Nonetheless, the shorelines along the Sydney River are progressively being subjected to residential and service industry development and there is increasing risk of pollution and siltation from property maintenance, transportation accidents, and recreational activities. There are reports of “swimmers itch”, which is caused by the cercariae of various species of trematode parasites, in Blacketts Lake. Cercaria are carried by a variety of freshwater pulmonate snails, but particularly the freshwater snail *Stagnicola catascopium catascopium* (Say, 1817), a common species throughout eastern Canada (Scott and Burt 1976; Clarke 1981). Depending on the compound used, attempts to control snail populations with molluscicides may be detrimental to mussel populations (Waller et al. 1993).

Lampsilis cariosa populations in the lower Saint John River presently seem to have few threats (Sabine et al. In press). The largest populations, situated in mid-river in the large lower sections of the river, appear to be relatively unexposed, even to muskrat predation, which has been identified as a threat to endangered mussel populations elsewhere (Zahner-Meike and Hanson 2001). While there is some agricultural, residential, and industrial development along the river corridor through most of its length, much of the Saint John River drainage consists of undeveloped forestland. Issues of sedimentation, eutrophication due to agricultural run-off and sewage, and riparian development are problems in some areas within the Saint John watershed, and are increasing in some areas (Harvey et al. 1998). The portion of the Kennebecasis River from which historical records for *L. cariosa* exist, but in which they have been unable to relocate the species, was recently judged to one of the most heavily encroached riparian zones in New Brunswick (Brillant pers. comm. 2002).

Sabine et al. (In press) suggest that further study on effects of low, late summer, water levels in the lower Saint John River on *L. cariosa* mortality, in terms of elevated water temperatures, exposure, and saline penetration, are required. The current downstream limit of *L. cariosa* on the Saint John River coincides closely with the current upstream limit for saltwater intrusion. However, during periods of low water the saline front penetrates farther inland. Sabine et al. (In press) observed some mortality on the Saint John River in late August and early September 2001, a particularly dry year. They suggested that some of this mortality may have been due to low water levels and elevated water temperatures over sand bars.

The introduced zebra mussel (*Dreissena polymorpha*) poses a severe threat to native freshwater mussel populations elsewhere in North America (Ricciardi et al. 1998; Martel et al. 2001). Although White (2001) suggested that there was a low risk of establishment of *D. polymorpha* in the Sydney River, Sabine et al. (In press) identified the zebra mussel as a potential threat to *L. cariosa* in New Brunswick. While *D. polymorpha* has not been recorded in New Brunswick to date, its ability to colonize freshwaters with non-unidirectional flow, such as lakes or tidal rivers, indicates that it could potentially spread throughout the lower Saint John River if accidentally introduced.

SPECIAL SIGNIFICANCE OF THE SPECIES

Bailey (1887) reports shell beads of local manufacture produced from unionids in a native Indian grave on the Tobique, northern New Brunswick. There is also literature suggesting that an informal unionid pearl fishery, focusing on *Margaritifera*, operated in some of the southern counties of New Brunswick in the late 19th C (Ganong 1889). However, as far as is known, neither the Saint John or Sydney River *L. cariosa* had any traditional, cultural or commercial uses. Currently, the Yellow Lampmussel is considered to be threatened throughout its range in the United States and in some watersheds it is believed to have been extirpated or is at least endangered.

Further work is needed to estimate overall abundance of *L. cariosa* in the Saint John River system, but it is clear that the lower Saint John and tributaries harbor most of the Canadian population. Both the Saint John and Sydney River populations are disjunct, the latter being at least 500 km from the nearest population in the main part of the range. The apparent size and presumed genetic integrity of these isolated *L. cariosa* populations, as well as the current lack of zebra mussels (*Dreissena* sp.) in either the Saint John or Sydney River systems, suggests that these Yellow Lampmussel populations could play an important role in the future conservation of the species. Furthermore, relatively easy access to *L. cariosa* and associated freshwater mussels in the Saint John and Sydney Rivers provides an important research and educational resource.

EXISTING PROTECTION OR OTHER STATUS

Lampsilis cariosa is listed as threatened throughout its range in the United States (Williams et al. 1993) and is protected in some states such as Massachusetts and Maine (D. Smith 1999; Nedeau et al. 2000). It may be extirpated in some watersheds (Counts et al. 1991; Strayer and Jirka 1997). The species is being considered for listing under the US federal Endangered Species with current evidence of vulnerability but more research needs to be done before species can be listed (U.S. Fish and Wildlife Service 2004).

TECHNICAL SUMMARY

Lampsilis cariosa

Yellow Lampmussel lampsile jaune

Range of Occurrence in Canada: known from only two localities: the Sydney River, Cape Breton County, Nova Scotia and the lower Saint John River and tributaries near Fredericton, New Brunswick.

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* calculated from GIS maps using Arc view	Sydney River - 20 km² Saint John River – approx 245 km²
• *Specify trend in EO*	Sydney River – Stable; Saint John River – evidence of a reduction in historic range- current trend unknown
• *Are there extreme fluctuations EO?*	Probably not
• *Area of occupancy (AO) (km²)* **see Population Size and Trends section for calculation methods**	Sydney River – approximately 2.6 km² Saint John River - Unknown but considerably less than EO
• *Specify trend in AO*	Sydney River – unknown Saint John River – unknown
• *Are there extreme fluctuations AO?*	Unknown for both populations
• *Number of known or inferred current locations*	2, consisting of the Sydney River (including 2 small lakes) and about 30 sites on the Saint John River
• *Specify trend in #*	Evidence of historic decline on the Saint John River, current status unknown
• *Are there extreme fluctuations in number of locations?*	Probably not
• *Specify trend in area, extent or quality of habitat*	Stable in Sydney and Saint John River
Population Information	
• *Generation time (average age of parents in the population)*	Unknown
• *Number of mature individuals*	Unknown
• *Total population trend:*	Unknown
• *% decline last/next 10 years or 3 gen.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	Unknown
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	Stable
• *Are there extreme fluctuations in number of populations?*	Probably not
List populations with number of mature individuals in each: *Sydney River ~ 0.4 – 0.8 individuals per m^2; Saint John River ~ 0.4 – 0.8 individuals per m^2*	
Threats (actual or imminent threats to populations or habitats)	
Residential alteration of shore in Sydney River	

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Global Heritage Status Rank: G3G4; Rounded Global Heritage Status Rank: G3; Global Heritage Status Rank Reasons: Range and abundance have contracted somewhat. United States National Heritage Status Rank: N3N4. Connecticut (SH), Delaware (SH), District of Columbia (SH), Georgia (S2), Maine (S2S3), Maryland (S1), Massachusetts (SH), New Hampshire (SX), New Jersey (S1), New York (S3), North Carolina (S1), Pennsylvania (S3S4), South Carolina (S?), Vermont (SR), Virginia (S2), West Virginia (S1). International Union for the Conservation of Nature (IUCN): endangered. American Fisheries Society Status: Threatened (NatureServe 2003 – See Appendix 1. For code definitions)	
• *Is immigration known or possible?*	Not possible for Sydney River Possible for Saint John River
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Unknown
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	
Other Status	

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Populations quite large and apparently stable in Canada but found only in Sydney River, Nova Scotia and Saint John River watershed, New Brunswick. Threats are currently very limited but there are long-term concerns related to the potential for introduction of zebra mussels into the Saint John River, and maintaining habitat quality of the sole population in the Sydney River.	

Applicability of Criteria

Criterion A (Declining Total Population): No data available on population decline rates.

Criterion B (Small Distribution, and Decline or Fluctuation): Extent of occurrence and area of occupancy both small and meet endangered but “continuing declines” either not present, unknown, or population is stable.

Criterion C (Small Total Population Size and Decline): Number of mature individuals unknown, but probably much larger than criteria for threatened (e.g. total population estimated at > 1,000,000).

Criterion D (Very Small Population or Restricted Distribution): Number of mature individuals unknown, but probably much larger than criteria for threatened (e.g. total population estimated at > 1,000,000. If area of occupancy < 20 km^2 it would qualify for threatened under D2, but AO unknown for St. John River.

Criterion E (Quantitative Analysis): No data available for quantitative analysis:

ACKNOWLEDGEMENTS

Preparation of this status report and associated travel costs were supported by a contract with Canadian Wildlife Service, Environment Canada, and grants from New Brunswick Department of Natural Resources and Nova Scotia Department of Natural Resources. The authors would also like to thank Andrew Hebda, Curator of Zoology, Nova Scotia Museum of Natural History, and Jerry Leary, Director, The Nylander Museum for kindly providing access to collections under their charge. Staff of the Nova Scotia Department of Natural Resources made the results of their freshwater mussel surveys of 1999 available for reference. Also Ms. Sana Kavanagh of University College of Cape Breton, Sydney provided initial results of her 1999 study of mussels of Sydney River. The Atlantic Coastal Action Program of Cape Breton through Environment Canada's Science Linkage Program provided funding for Kellie White's 2001-2002 study on the Sydney River. Technical consultation for that study was provided by Diane Amirault (Canadian Wildlife Services), Janice Smith (National Water Research Institute) and Jim Foulds (University College of Cape Breton). Edgar Barrington and Mike Joseph of the Community Employment Innovation Project carried out the data collection for K. White's study of the Sydney River. We are also grateful to Dwayne Sabine and Scott Makepeace, Fish and Wildlife Branch, New Brunswick Department of Natural Resources and Energy, who permitted extensive use of their submitted manuscript (prepared with McAlpine) on the Yellow Lampmussel in the Saint John River and tributaries. Dwayne Sabine also provided very helpful comments on a draft of this report.

LITERATURE CITED

Anscombe, F.J. 1950. Sampling theory of the negative binomial and logarithmic series distributions. Biometrika 37: 358-382

Alexander, D.R., J.J. Kerekes and B.C. Sabean. 1986. Description of selected lake characteristics and occurrence of fish species in 781 Nova Scotia lakes. Proceedings of the Nova Scotian Institute of Science 36:63-106.

Athearn, H.D. 1961. Additions to the list of New Brunswick non-marine Mollusca. Sterkiana 4:33- 34.

Athern, H.D., and A.H. Clarke. 1962. The freshwater mussels of Nova Scotia. National Museum of Canada, Contributions to Zoology 1960-61, Bulletin 183:11-41.

Bailey, L.W.1887. On the relics of the stone age in New Brunswick. Bulletin of the Natural History Society of New Brunswick. 6: 3-16.

Burch, J.B. 1975. Freshwater Unionacean Clams (Mollusca, Pelecypoda) of North America. Malacological Publications, Hamburg, Michigan. 204 pp.

Brilliant. S. pers. comm. Correspondence to D. McAlpine. 2003. Program Manager, Atlantic Coastal Action Program – Saint John. [Personal Communication]

Clarke, A.H. 1981. The Freshwater Molluscs of Canada. National Museum of Natural Sciences, National Museums of Canada, Ottawa. 446 pp.

Clarke, A.H., and A. Meachem Rick. 1963. Supplementary records of Unionacea from Nova Scotia with a discussion of the identity of *Anodonta fragilis* Lamarck. National Museum of Canada, Bulletin 199, Paper 2:15-27.
Clayden, S.R., D.F. McAlpine and C. Guidry. 1984. Rare and Vulnerable Species of New Brunswick. Publications in Natural Science, 2. New Brunswick Museum. 95 pp.
Counts, L.C., T.S. Handwerker and R.V. Jesien. 1991. The Naiades (Bivalvia, Unionidae) of the Delmarva Peninsula. American Malacological Bulletin 9:27-37.
Davis, D.S. 1985 Synopsis and Distribution Tables of Land and Freshwater Molluscs of Nova Scotia. Curatorial Report 54, Nova Scotia Museum, Halifax. 30 pp.
Davis, D.S. 1999. Proposed study of the Yellow Lampmussel, *Lampsilis cariosa* in the Maritime Provinces of Canada. Triannual Unionid Report 17: May 1999.
Davis, D.S. 1999. Reports of Museum Visits and Field Collections Related to Studies of the Freshwater Mussels, *Lampsilis cariosa* (Say, 1817) and *Leptodea ochracea* (Say, 1817), Mollusca, Unionidae, in New Brunswick and Nova Scotia in 1999. 23 pp. Privately printed.
Davis, D.S. and S. Browne (Editors). 1996. Natural History of Nova Scotia. Two volumes. Nova Scotia Museum and Nimbus Publishing, Halifax. 821 pp.
Downing, W. L, J. Shotsell, J. A. Downing. 1992. Non-annual external annuli in the freshwater mussels *Anodonta grandis grandis* and *Lampsilis radiata siliquoidea*. Freshwater Biology 28:309-317.
Elderkin, M. pers. comm. Phone conversation with K. White. 2004. Biologist, Nova Scotia Department of Natural Resources. [Personal Communication]
Fuller, S. 1998. (Draft). Atlas of Rare, Threatened and Infrequent Fauna of Nova Scotia. Nova Scotia Museum of Natural History, Halifax. 290 pp.
Ganong, W.F. 1889. The economic mollusca of Acadia. Bulletin of the Natural History Society of New Brunswick. 8: 3-116
Ghent, A.W., Singer, R. and Johnson-Singer, L. 1978. Depth distributions determined with SCUBA, and asociated studies of the freshwater unionid clams *Elliptio complanata* and *Anodonta grandis* in Lake Bernard, Ontario. Canadian Journal of Zoology. 56:1654-1663.
Grigg, U. 1972. Freshwater Mussels in the Nova Scotia Museum Collection. Curatorial Report 8. Nova Scotia Museum, Halifax. 18 pp.
Gorham, S.W. 1970. Distributional checklist of the fishes of New Brunswick. New Brunswick Museum, Saint John, 32 pp.
Haukioja, E., and Hakala, T. 1974. Vertical distributions of freshwater mussels (Pelecypoda, Unionidae) in southwestern Finland. Ann. Zool. Fenn. 11: 127-130.
Hanson, J.M. and A. Locke. 1999. (Draft). Status of the Dwarf Wedgemussel, *Alasmidonta heterodon* (Lea, 1830) in Canada. Committee on Status of Endangered Wildlife in Canada, Ottawa. 28 pp.
Harvey, J., D. Coon, and J. Abouchar. 1998. Habitat Lost: Taking the Pulse of Estuaries in the Canadian Gulf of Maine. Conservation Council of New Brunswick, Fredericton, New Brunswick.
Hoggarth, M.A. 1999. Descriptions of some of the glochidia of the Unionidae (Mollusca : Bivalvia). Malacologia 41(1):1-118.

Huebner, J.D., Malley, D.F., and Donkersloot, K. 1990. Population ecology of the freshwater mussel *Anodonta grandis* in a Precambrian Shield Lake. Can. J. Zool. 68: 1931-1941

Isnor, W. 1981. Provisional Notes on the Rare and Endangered Plants and Animals of Nova Scotia. Curatorial Report 46, Nova Scotia Museum, Halifax. 71 pp, 135 maps.

Jansen, W. A. & J. M. Hanson. 1991. Estimates of the number of glochidia produced by clams (*Anodonta grandis simpsonianus* Lea), attaching to Yellow Perch (*Perca flavescens*), and surviving to various ages in Narrow Lake, Alberta. *Canadian Journal of Zoology* 69**:** 973-977.

Johnson, R.I. 1947. *Lampsilis cariosa* Say and *Lampsilis ochracea* Say. Occasional Papers on Mollusks, Harvard University Museum of Comparative Zoology, 1:145-156.

Johnson, R.I. 1980. Zoogeography of North American Unionidae (Mollusca: Bivalvia) north of the maximum Pleistocene glaciation. Bulletin of the Museum of Comparative Zoology, 149:7-189.

Kat, P. W. 1983. Sexual selection and simultaneous hermaphroditism among the Unionidae (Bivalvia: Mollusca). Journal of Zoology*,* London 201: 395-416.

Kramer, L. R. 1970. The Mantle Flap in Three Species of Lamsilis (Pelecypoda: Unionidae). Malacologia, 10(1):225-282

Lambert, S., Adams, J., Ross, S. 2003. 2002 Cape Breton Highlands National Park Freshwater Mussel Survey. Unpublished Internal Report. Parks Canada: Ingonish Beach, NS.

LaRocque, A. 1953. Catalogue of the Recent Mollusca of Canada. Bulletin 129 (Biology Series 44) National Museum of Canada, Ottawa. 406 pp.

Marshall, W.B. 1895. Geographical Distribution of New York Unionidae. 48th Annual Report of the New York State Museum: 47-99.

Martel, A. L., Pathy D.A, Madill J.B., Renaud C.B, Dean S.L, & Kerr S.J. 2001. Decline and regional extirpation of freshwater mussels (Unionidae) in a small river system invaded by *Dreissena polymorpha*: the Rideau River, 1993-2000. *Canadian Journal of Zoology,* 79, 2181-2191.

Martin, S.M. 1997. Freshwater Mussels (Bivalvia:Unionidae) of Maine. Northeastern Naturalist, 4:1-34.

Matthew, W.D. & Stead, G. (1903) Land and freshwater shells collected near St. John, N.B. *Proceedings of the Miramichi Natural History Association,* 3: 48-49.

Metcalfe-Smith, J., S.K. Staton, G.L. Mackie and N.M. Lane. 1998. Selection of candidate species of freshwater mussels (Bivalvia:Unionidae) to be considered for National Status Designation by COSEWIC. Canadian Field Naturalist, 112:425-440.

Myer, C. pers. comm 2003. Email correspondence to D. McAlpine. May 2003. Staff member of Ohio State Museum of Biological Diversity, Ohio State University. [Personal Communication]

NatureServe. 2003. NatureServe Explorer: An online encyclopedia of life [web application]. Version 1.8. NatureServe, Arlington, Virginia. Website: http://www.natureserve.org/explorer. [accessed March 2004].

Nedeau, E.J., M.A. McCollough and B.I. Swartz. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta. 118 pp.

New Brunswick, NB Power. c. 1990. Hydropower in New Brunswick. NB Power Corporation, Fredericton. 10 pp.
Nova Scotia. 1980. Nova Scotia Special Places Protection Act. Statutes of Nova Scotia 1980, Chapter 17.
Nova Scotia. 1987. Abandoned Waste Disposal Sites Study. Department of Environment, Province of Nova Scotia, Halifax. 59 pp.
Power, T. and D. Gouthro. 2002. A Survey of Freshwater Mussels (Order Unionoida) within Fortress of Louisbourg National Historic Site and Greater Ecosystem, Cape Breton, Nova Scotia.
Ricciardi, A., Neves, R.J. and Rasmussen J.B. (1998) Impending extinctions of North American freshwater mussesl (Unionida) following the zebra mussel (*Dreissena polymorpha*) invasion. Journal of Animal Ecology, 67, 613-619.
Sabine, D. L., S. Makepeace and D. F. McAlpine. In press. The Yellow Lampmussel (*Lampsilis cariosa*) in New Brunswick: a population of significant conservation value. Northeastern Naturalist.
Scott, M.E. and M.D.B. Burt. 1976. Swimmer's itch in New Brunswick: distribution and description of the causative agent, *Cercaria carascopii* n. sp. Canadian Journal of Zoology 54: 2200-2207.
Scott, W. B. and E. J. Crossman 1973. Freshwater Fishes of Canada. Fisheries Bulletin 184. Research Board of Canada, Ottawa.
Shore, V. 1977. Endangered Wildlife in Canada, Invertebrates: Molluscs. International Wildlife 7:24.
Sokal, R. R. and F. J. Rohlf. 1995. Biometry: The Principles and Practice of Statistics in Biological Research. Third Edition. W. H. Freeman and Company, New York. 887 pp.
Smith, D.G. 1986. Keys to the Freshwater Macroinvertebrates of Massachusetts. No. 1. Mollusca, Pelecypoda (Clams and Mussels). Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, Westborough. 53 pp.
Smith, R. F. R. F. Villella, D. P. Lemarie, and S. von Oettingen 2000. How much excavation is needed to monitor freshwater mussels? Proceedings of the First Freshwater Mollusk Conservation Society Symposium. 1999 203-218.
Strayer, D.L. 1993. Macrohabitats of freshwater mussels (Bivalvia: Unionacea) in streams of the northern Atlantic slope. Journal of the North American Benthological Society 12: 236-246.
Strayer, D.L., S. Claypool and S.J. Sprague. 1997. Assessing unionid populations with quadrats and timed searches, pp. 163-169. *In* K.S. Cummings, A.C. Buchanan, C.A. Mayer and T.J. Naimo, Conservation and Management of Freshwater Mussels II: initiatives for the future. Proceedings of an Upper Mississippi River Conservation Committee Symposium, October 1995, St. Louis, MO.
Strayer, D.L. and K.J. Jirka. 1997. The Pearly Mussels of New York State. New York State Museum, New York State Education Department, Albany. 113 pp. 27 plates.
Strayer, D.L. and J. Ralley. 1991. The freshwater mussels (Bivalvia: Unionidae) of the Upper Delaware drainage. American Malacological Bulletin, 19:21-25.
Strayer, D.L. and J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling Unionaceans (Bivalvia), including two rare species of *Alasmidonta*. Journal of the North American Benthological Society, 12: 247-258.

U.S. Fish and Wildlife Service. 2004. Watershed Rarity Ranks For Species of Special Emphasis. Website: http://www.fws.gov/r5soc/sose.htm#codekey. [accessed March 2004]

Wick, P. C. (In prep). Fish hosts and population demographics of *Lampsilis cariosa* and *Leptodea ochracea*, two threatened unionid bivalves in Maine.

Wick, P.C. and A.D. Huryn. 2002. Biology and natural history of *Lampsilis cariosa* and *Leptodea ochracea* (Unionidae) in Maine. Abstracts of the 2002 North American Benthological Society Annual meeting, Pittsburg, Pennsylvania.

Waller, D.L., J.J. Rach, W.G. Cope, L.L. Marking, S.W. Fisher, H. Dabrowska. 1993. Toxicity of candidate molluscicides to zebra mussels (*Dreissena polymorpha*) and selected nontarget organisms. Journal of Great Lakes Research 19: 695-702.

Wiles, M. 1975. The glochidia of certain Unionidae (Mollusca) in Nova Scotia and their fish hosts. Canadian Journal of Zoology, 53:33-41.

Williams, J.D., M.L. Warren Jr., K. Cummings, J.L. Harris and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.

Young, M. & J. Williams. 1984. The reproductive biology of the freshwater pearl mussel *Margaritifera margaritifera* (Linn.) in Scotland. I. Field studies. *Archiv für Hydrobiologie* 99: 405-422.

Zahner-Meike, E. and J.M Hanson.2001. Effect of muskrat predation on naiads. In *Ecology and evolution of the freshwater mussels Unionida* (eds G. Bauer & K. Wachtler), pp. 163-184. Ecological Studies, 145, Springer-Verlag, Berlin.

BIOGRAPHICAL SUMMARY OF THE REPORT WRITERS

Derek Davis has had a life long interest in natural history and landscape and has a particular interest in molluscan diversity and zoogeography. He was educated in London, England and received his BSc. in Geology, Zoology and Botany from the University of London in 1960. In the following five years he carried out marine surveys of electricity generating sites in the United Kingdom, continued his interest in natural history, participated in 10 km^2 mapping census of non-marine Mollusca and organized nature conservation activities for youth in Britain and Northwest Europe. He immigrated to Canada in 1965 and received a PhD. in biology from Dalhousie University, Halifax, NS. in 1972 for studies on the ecology of the Rough Periwinkle. He joined the Nova Scotia Museum in 1968 as Chief Curator of Science. His work included administration, management, research and interpretive projects. Through the provincial government Committee on Land Use Policy he participated in preparation of policy and legislation related to the provincial park system, the Special Places Protection Act and wildlife habitat protection. A product of this work was the major two-volume resource document, *The Natural History of Nova Scotia*, first published in 1984 and revised in 1996. He managed the non-arthropod invertebrate collections of the museum and made significant additions of molluscs and other invertebrates from marine, freshwater and terrestrial habitats, mostly from Nova Scotia. He has published many papers and reports. He retired from the Nova Scotia Museum in 1994 but remains a Research Associate with them. Derek Davis is a member of the Ecology Action Centre, the

American Malacological Society, the Marine Biological Association of the United Kingdom, the Malacological Society of London and other scientific societies.

Kellie White received her BSc. in Ecology & Evolution in 1994 and her Masters in Zoology in 1997 from the University of Western Ontario where her thesis research focused on freshwater mussel ecology. She then went on to Boston University's Center for Ecology and Conservation Biology where she coordinated their Tropical Ecology Program from 1998 until 2000. In 2001 she began working with the Atlantic Coastal Action Program – Cape Breton as a research Ecologist. In this capacity, she has focused on wildlife conservation, education and, habitat restoration. This work has included research on the *Lampsilis cariosa* in the Sydney River, the assessment and restoration of over 100 km of freshwater fish habitat and the development of volunteer monitoring programs for freshwater mussels, estuaries and migratory waterfowl in Cape Breton.

Donald McAlpine received his PhD from the University of New Brunswick and is currently Curator of Zoology in the Natural Sciences Department of the New Brunswick Museum. He also holds adjunct appointments at the University of New Brunswick and Dalhousie University. Prior to joining the NBM in 1981 he worked for various scientific and conservation organizations in Canada, the United Kingdom, Iceland, and Panama.

AUTHORITIES CONTACTED

A notice about the study of the status of *L. cariosa* was put in the May 1999 edition of the Triannual Unionid Report 17 (Davis, 1999). This generated only one general inquiry requesting information about local freshwater mussels. Information about *L. cariosa* in New England was obtained from a web-site set up by D.G. Smith, Massachusetts: http://www.bio.umass.edu/biology/conn.river/lampmussel.html. Lori Small, Environment Librarian, Nova Scotia Department of the Environment, Halifax was contacted for information on water quality in Sydney River, N.S. URL:http://www.gov.ns.ca/envi. Discussions about the project were also held with Mark Elderkin, Terry Power and other Nova Scotia Department of Natural Resources staff during a freshwater mussel workshop held at Coxheath, Cape Breton County on 21 June 1999.

Other authorities contacted include:

Caroline Pollock, IUCN/SSC, Redlist Programme, Cambridge, U.K.
Isabelle Picard
Dwayne Sabine, Scott Makepeace, Fish and Wildlife Branch, New Brunswick Department of Natural Resources and Energy.
Carol Myers, Ohio State Museum of Biological Diversity, Ohio State University.
Shawn Brillant, Atlantic Coastal Action Plan, Saint John, New Brunswick.
Chip Wick, Ecology and Environmental Sciences, University of Maine at Orono.

COLLECTIONS EXAMINED OR CONSULTED

The following collections were examined or consulted for *L. cariosa* material:

Canadian Museum of Nature, 1740 Pink Road, Aylmer, Quebec, J9H 5EI. (Curator, Dr. André Martel).

New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick, E2K 1 E5. (Curator of Zoology, Dr. D. MacAlpine).

Nova Scotia Museum of Natural History, 1747 Summer St., Halifax, Nova Scotia, B3H 3A6. (Curator of Zoology, Andrew Hebda).

The Nylander Museum, 657 Main Street, Caribou, Maine, 04736. (Director, Jerry Leary).

Ohio State Museum of Biological Diversity, Ohio State University, 1315 Kinnear Road, Columbus, OH, 432212 (Research Assistant, Ms. Carol Myers).

Appendix 1. Status Code Definitions

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure, 5 = demonstrably widespread, abundant, and secure, X = presumed extirpated, H = possibly extirpated, R = reported,? = unranked.