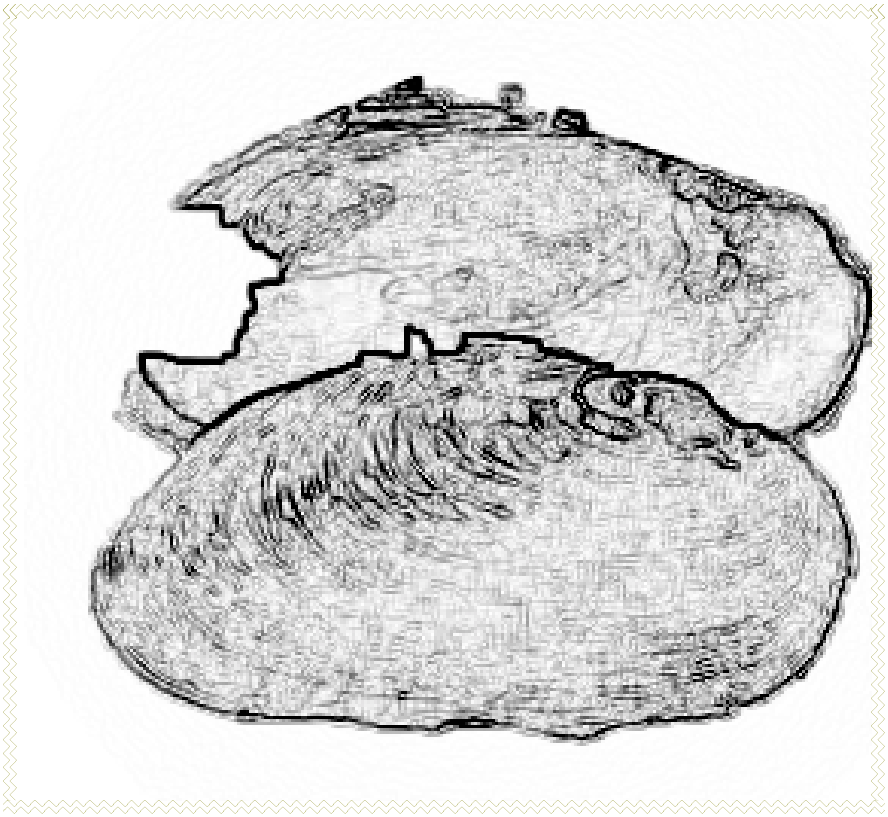
A species, distribution and abundance study of freshwater mussels of Richmond County, Nova Scotia



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May, 2000

Summary

The purpose of this project was to assess the species, distribution and relative abundance of freshwater mussels, their habitat preferences and host fish species within the study area.

This study took place from July – September 1999, within Richmond County, Nova Scotia (NS). Three locations were used, concentrating mainly on the Grand River watershed. This report summarizes data obtained from twenty sites, located in three main areas within Richmond County. The Grand River watershed contained the greatest concentration of sites. The study found five of the ten documented species of freshwater mussels in Nova Scotia:

1. *Margaritifera margaritifera*
2. *Elliptio complanatus*
3. *Anodonta cataracta*
4. *Anodonta implicata*
5. *Alasmidonta undulata*

The results indicated a relationship between the mussels and the habitat in which they prefer.

1. *Margaritifera margaritifera* – rocky bottom of a lake or river, and were most abundant in fast flowing rivers.
2. *Elliptio complanatus* - variety of substrates of various bodies of waters.
3. *Anodonta cataracta* - silty-loam, organic substrate in a lake or pond.
4. *Anodonta implicata* - sandy silty substrate found in lakes.
5. *Alasmidonta undulata* - sandy rocky bottom found in lakes.

Acknowledgements

I would like to thank Terry Power, wildlife biologist, with NS Department of Natural Resources for guiding my efforts and study. Derrick Davis of the Nova Scotia Museum of Natural History was very helpful in the identification of mussels. Mike Hill and Trevor Wilkie of the Department of Natural Resources, St. Peter's Nova Scotia assisted in Global Positioning Mapping Systems (GPS), and information on fish presence in the study area. Finally I would like to thank Gary Rosberg, fish biologist / Instructor at British Columbia Institute of Technology for guiding me throughout my report.

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1.0 Introduction

1.1 Background

Freshwater mussels are bivalve molluscs found in the benthos of rivers, streams, lakes, and ponds of various sizes. Freshwater mussels belong to the Order *Unionoida*, and are represented by two families, the *Margaritiferidae* and the *Unionidae,* (Athearn and Clarke, 1962).

These molluscs are an integral part of the food chain in freshwater ecosystems. The longevity (beyond 100 years) for some of these species and their tendency to remain in the same locale create an abundant food source in the food chain. Unless dislodged by heavy currents or animal agents, freshwater mussels are important indicators of environmental quality. They accumulate heavy metals and exogenous organic chemicals in their soft tissues, and therefore are often used to monitor pollution levels, (Martin et al*, 1997).*

An association between certain fish species and mussels exists. Mussel larva are generally obligate parasites of fish. In order to reproduce, the mussel larvae require a host fish. A healthy reproducing mussel community signifies a high quality aquatic environment, with sufficient food and habitats for host fishes and other aquatic organisms. A diminishing mussel community may indicate the environment is in jeopardy. Contributing to biodiversity, mussels enhance the survivability and function of aquatic ecosystems, (Martin et al*, 1997).*

There is a relationship between the mussels found together and their habitat. This study indicates that certain mussels can live together, within the same body of water, as long as a varied substrate is present.

Due to the limited knowledge and the importance of mussels to aquatic ecosystems there is an interest for additional information regarding the ecology of freshwater mussels. The Department of Natural Resources St. Peter's Richmond County, NS, initiated this project during the summer of 1999.

Derrick Davis of the Nova Scotia Museum of Natural History, who has been studying mussels for over twenty years, has also expressed interest in the study. He hopes to gain a further understanding of mussel populations, species and localities for future work.

Mark F. Elderkin, Species at Risk Biologist for the Wildlife Division of NS Department of Natural Resources, has a long-term objective with NS Museum of Natural History to consolidate all the Eastern Region data into a single report.

1.2 Purpose

The purpose of this study was to establish a database for all of Nova Scotia and to have a record of where the molluscs are found. A draft report by the Department of Natural Resources will provide direction for any new inventory that may be required to identify gaps. Following this report, the data will go through a wildlife status review, prior to going to the Committee on the Status of Endangered Wildlife In Canada (COSEWIC) to determine if these species of molluscs are yellow, blue or red listed.

This study provides information on the species, distribution, relative abundance, habitat preference, life histories, and host fish of freshwater mussels found in a section of Richmond

County, Nova Scotia. Five of the ten species of freshwater mussels known in Nova Scotia were found within the study area. These include*: Margaritifera margaritifera, Elliptio complanatus, Anodonta cataracta, Anodonta implicata,* and *Alasmidonta undulata.*

1.3 Previous Studies

Only two comprehensive reports that deal exclusively with mussels of Nova Scotia currently exist. Willis (1857) in (Athearn and Clarke, 1962) found eight Unionids, and Jones (1877) who identified four Unionids. Both studies confirm four specific species: *(i) Elliptio complanatus (ii) Lampsilis radiata radiata (iii) Anodonta implicata (iv) Margaritifera margaritifera, in* (Athearn and Clarke, 1962).

Various persons between the years of 1914-1961 conducted additional studies that give information on freshwater mussels of Nova Scotia. Some examples are Clark and Berg (1959), Brooks (1936), Simpson (1914), Athearn and Clarke (1962).

1.4 Ecology of Freshwater Molluscs

Freshwater mussels retain their young for various lengths of time in modified portions of the gills. The glochidia are released by the parent when its light-sensitive mantle-spots are stimulated, for example by the shadow of a passing fish. The glochidia of each species of mussel, with a few exceptions, must attach to the gills or fins of a fish belonging to one, or a few, species for further development to take place. Most glochidia never accomplish this, but those that do succeed remain attached for a few weeks and metamorphose into tiny mussels. They then drop to the bottom and take up the normal life of a mussel, that is they travel around siphoning water for respiration and consuming phytoplankton as a source of nourishment and growth, (Athearn, 1981).

Like all other species in this world, freshwater molluscs follow a classification system.
The following section is summarized from, (Athearn and Clarke, 1962).

Phylum Mollusca- All invertebrates that are soft-bodied, non-segmented, have a muscular foot for burrowing or crawling, and possess a mantle (enveloping sheet of tissue that in most species secretes a calcareous shell).

Class Bivalvia– Clams and Mussels

Order Eulamellibranchia- Characterized by a hinge containing a few teeth of diverse shapes and sizes, and two large adductor muscles of about the same size, one anterior and one posterior, a partly closed mantle with well-developed siphons, and leaf-like gills within the mantle cavity.

Superfamily Unionacea- Freshwater Mussels

Family Margaritiferidae – Pearly River – Mussels
Subfamily Margaritiferinae – eastern pearlshell

1. *Margaritifera margaritifera* (Eastern River Pearl)

Figure 1: Picture of Eastern River Pearl
(Taken from Clark, 1981)

These mussels have a bivalve shell of medium thickness, with a pearly nacre, pseudocardinal hinge teeth well developed, lateral hinge teeth only partly developed or absent. All four gills are marsupial, however are less complex and more primitive than in *Unionidae*. The glochidia are oval shaped. The Family *Margaritiferidae* occurs only in North America and Eurasia. This species has been found in only streams, never in lakes or ponds. All streams found to contain this species have exhibited similar ecological characteristics, i.e., moderate to quite rapid current, and sand, gravel, or rocky substrate. This species sometimes lives to be over 100 years old. The probable host for *M.margaritifera* is the brook trout *(Salvelinus fontinalis)*.

This mussel is often found in quiet locations next to rushing water where it burrows in a vertical position. It prefers soft waters and occurs in coastal streams. Occasional hermaphorditism (having both male and female gonads) has been reported in *M. margaritifera.* The *Margaritiferids* are tachytictic (having a short breeding season). Mussels that are short – term breeders, that spawn in early spring and release glochidia in late summer to early fall (Martin *et al*, 1997).

Family Unionidae – Pearly Mussels
Subfamily Ambleminae – button shells and relative

1. *Elliptio complanata* (Eastern Elliptio)

Figure 2: Picture of Eastern Elliptio
(Taken from Clark, 1981)

These mussels have bivalve shells, which can be thin and fragile to thick and heavy, with pearly nacre. They may or may not have pseudocardinal hinge teeth and /or lateral hinge teeth. All four gills are marsupial, and the microstructure is more complex than in *Margaritiferidae*. *Amblemines* usually have thick shells with complete dentition (with both pseudocardinal and lateral teeth), and they are often found in coarse substrates with fast currents (Martin *et al*, 1997). The *Unionidae* family is worldwide but mostly occurs in Europe, Asia and North America.

This species is found in lakes, ponds, rivers, streams, and on nearly all kinds of substrates. Only brooks appear to be unsuitable. It is very common and is usually the dominant species where it occurs. Yellow perch, (*Perca flavescens)* is the host for *E. complanatus.*

The breeding period for *E. complanatus* in NS is June and July, and the glochidial infestation of a yellow perch lasts eighteen days. The yellow perch is the only known fish to carry the parasitic glochidia to full term. These mussels can be both hermaphrodites or dioecious (separate sexes). *E. complanatus* actively migrates and can be carried long distances by currents and has been known to clamp onto the feet of birds for dispersal. This mussel can live up to seventeen years old and its growth can be stunted by pollution.

Subfamily Anodontinae – Floater Mussels

Anodontines usually have thin shells with no or reduced dentition, and they typically occur in fine substrates and slow currents. *Anodontines* are bradytictic (having a long breeding season). Long – term breeders spawn in mid- summer to fall, hold glochidia over the winter, and release them in spring.

1. *Alasmidonta undulata* (Heavy-toothed Wedge Mussel)

Figure 3: Picture of Heavy-toothed Wedge Mussel
(Taken from Clark, 1981)

Occurs in lakes and in rivers usually on a sandy bottom. It is sporadic in its occurrence and almost never abundant. The host fish of this species is the blacknose dace (*Rhinichthys atratulus*).

2. *Anodonta cataracta cataracta* (Eastern Floater)

Figure 4: Picture of Eastern Floater
(Taken from Clark, 1981)

A.H. Clarke, Jr.1962, stated in the freshwater mussels of Nova Scotia-This species occurs in lakes, ponds and in large and small, usually slow-moving streams. Although sand and mud are the more frequently occupied substrates, gravel and rocky areas are also sometimes inhabited. In Nova Scotia it is usually the only *unionid* found in soft, muddy habitats. Host fish of *A.c. cataracta* are the common carp *(Cyprinus carpio*), white sucker *(Catastomus commersoni*) and pumpkinseed *(Lepomis gibbosus*).

3. *Anodonta implicata* (Alewife Floater)

Figure 5: Picture of Alewife Floater
(Taken from Clark, 1981)

Clarke, (1962) stated -The host fish for *A. implicata* is the alewife (*Alosa pseudoharengus*). This species of mussel occurs on sand or gravel substrattes, rarely on mud. This mussel is most easily identified by the distinct extra-thickening of the antero-ventral portion of the inner shell below the pallial line. The breeding period for *A.implicata* in NS is September to May.

1.5 MOLLUSCS AS POLLUTION INDICATORS

Three kinds of water pollution can affect mollusc populations – organic, inorganic, and thermal.

1. Organic pollution - Usually caused by sewage, insecticides and other biodegradable substances. Soft parts of molluscs can reveal recent pollution by insecticides through chemical analysis. In natural water, bacteria that use oxygen first attack sewage. Bacteria increase rapidly in the presence of biochemical oxygen demand (BOD), therefore all the oxygen dissolved in water may be used up. Gill-breathing molluscs are at a disadvantage in water with little oxygen, and are therefore the first to be killed by low oxygen concentrations.

A strong organic pollution indicator is a low diversity of molluscs, especially the presence of only one species. The presence of highly diverse communities of freshwater molluscs ensures there is clean water present. There are no freshwater molluscs found in highly polluted water. A mollusc's absence from mildly polluted habitats may be caused by the absence of their host fish, which may be more susceptible to low oxygen than the mussels.

This could also go the other direction, by having an unusual abundance of a certain species of mollusc because the species of fish that would normally prey upon it wouldn't be able to tolerate the polluted environment. The presence of dense mussel beds indicates clean (but not necessarily drinkable) water, partly because the substantial amount of oxygen required over the long term is available and because the mussels themselves filter and purify the water. A high diversity of mussels indicates high fish diversity.

2. Thermal pollution – River water is sometimes used for industrial cooling, this may heat the water enough to kill mussels outright, or adversely affect their reproductive cycles.

3. Inorganic pollution – Industry is the principle contributor to this pollution. A freshwater mussel can live for many years, and during each winter they form a distinct growth ring on their shells, which can be chemically analyzed. This chemical analysis can reveal if water pollution from radioactive materials or heavy metals has occurred, and when.

Many species of freshwater mussels need continuous waterways for migration. Glochidia of freshwater mussels may be carried long distances while attached to their host fish. Present distributions of freshwater mussels were largely brought about by postglacial stream confluences, for example the drainage pathways taken by glacial meltwater. Zoogeographic regions are areas, which have been isolated due to glaciation and have mussels, which have similar distribution limits. There are nine zoogeographic regions in Canada based on the occurrence of freshwater molluscs, and the area of study this report looks at covers the Atlantic Coastal Region, (Clarke, 1981).

Figure 6 details the parts of a freshwater mollusc, in order to understand the physical characteristics to follow in Table I on the following page.

Figure 6: The Parts of a Freshwater Mollusc
(Taken from Clarke, 1981)

2.0 Study Area

The study area is located in Cape Breton, Nova Scotia, as shown in Figure 7.

Figure 7: Map of study area
Source: Map Insert Adapted from Nova Scotia Tourism (1995)
Scale: 1cm=150km (Approximate)

2.1 Study sites

The data were collected from twenty sites, located over three general areas within Richmond County, NS. Of the twenty study sites fifteen were concentrated in the Grand River drainage, four in River Tillard and one in Arichat following in Figure 8 and Figure 9.

Figure 8: Map of Study Sites 1-15 (Grand River area)
Source: Cartographic Division of Maritime Resource Management Service
Map # 39D4H8

Figure 9: Map of Study Sites 16-20 (St. Peter's and Arichat area)
Source: Cartographic Division of Maritime Resource Management Service
Map # 39D4H8

2.2 Site Locations

- Sites 1,2,5,6,7- Grand River at a minimum of 500 meter intervals, Grand River
- Sites 3,4 - Murchinson Brook, east and west side, Grand River
- Sites 8,9,11,13- Loch Lomond Lake at a minimum of 500 meter intervals, Loch Lomond
- Site 10- Benjamins pond, Loch Lomond
- Site 12- Brook off Chilholm Dam Lake, Loch Lomond
- Site 14- Barren Hill Lake, Barren Hill
- Site 15- Lake Uist, Lake Uist
- Site 16,19- Long Lake, west and east side, River Tillard
- Site 17- Cook Lake, St. Peter's
- Site 18- Cranberry Lake, St.Peter's
- Site 20- Pottie Lake, Arichat

2.3 Site Photos- Figures 10-13 depict conditions found in habitats examined during the study.

Figure 10: Photo of a midden represented at sites 5,6,7,19 and 20

Figure 11: Representative photo of the main Grand River sites 1,2,5,6,7 and 8.

Figure 12: Photo of a representative brook, which determined there to be absence/not-detected molluscs in, sites 3, 4, and 12.

Figure 13: Representative photo of lakes, which represents similar habitat qualities at sites 8-11 and 13-15.

3.0 Methods and Materials

3.1 Site Criteria / Establishment

Timed searches were used to examine the species, distribution, and relative abundance of the mussels. A random point was chosen and watercourses were sampled at intervals of at least 500 meters. At each site, a two-person crew searched the substrate for thirty minutes. Clear bottom buckets and eye goggles were used to increase visibility. On average, each site was approximately 100 meters in length, ten meters wide and three meters deep. In the brooks the average was approximately 7 meters in length, 8 meters wide and 0.5 meters deep.

3.2 Species Counts / Identification

A count of each mussel species was recorded for each site and representative specimens, (both alive and dead) were collected for identification. Two or three specimens from each site were kept as reference for further analysis. The specimens were frozen until they were required for analysis. The soft tissue was shucked and the shells were preserved with glycerin gel, numbered and stored in paper envelopes. Data were recorded on field sheets as follows: water body, location, habitat description (vegetation, animals, substrate, depth, etc.), water temperature, visibility and presence of middens. Identified mussel species along with relative abundance were also recorded. Appendix 1 includes the raw field data.

3.3 Research

Library research was used to establish life histories, and host fishes of the five mussel species found.

3.4 GPS Mapping

Maps of the three study areas were completed by a global positioning mapping system, providing the northing and easting co-ordinates of each site. These maps will be submitted at a later date following their interpretation, showing all three areas with their local features.

Figure 14: Sampling Stations 1-15 (Grand River area)

Geographically referenced through, Global Positioning Systems Mapping (GPS)

Figure 15: Sampling Stations 16-19(St. Peter's area)
Geographically referenced through, Global Positioning Systems Mapping (GPS)

Figure 16: Sampling Station 20 (Arichat area)

Geographically referenced through, Global Positioning Systems Mapping (GPS)

3.5 Materials

Following in Table II is a material and purpose list used in the study.

Table II: Materials Used and Their Purpose

MATERIALS	PURPOSE
Watch	**Time searches**
Thermometer	Water temperature
Clear bottom bucket	Search of substrate
Zip lock bags	Storage of molluscs
Catch net	Retrieval of molluscs from substrate
Chest waders	Water work
Specimen reference guide	Identification
Glycerin gel	Preservation of shells
Paper bags	Storage of shells
Knife	To shuck soft tissue
Eslon tape	To calculate pace for measuring distance of an average site
1.5 m walking pace	To pace the distance of an average site
Ruler	Measurement of substrate & molluscs
Global Positioning System (GPS)	Map of study area with geographic co-ordinates
Map of the study area	Orientation
Two way radio	Communication

Visual observations were made for water body type, water flow, aquatic vegetation, presence of middens and water clarity, which was out of ten (one being the worst and ten being the best).

4.0 Results and Discussion

Table III shows a detailed description of habitat for each site in order to note similarities and to compare results from one study site to another. The results of the study are also presented in Table III, which describes the relative abundance and the species found at each study site.

Major findings that resulted from this study are;

M. margaritifera was reported to be located only in small streams and rivers. (Athearn and Clarke, 1962). The results of this study contradict this as *M. margaritirfera* were found in many lakes. This indicates migration from rivers to lakes since the previous study.

Another finding worth noting, is the reproduction question at Long Lake, River Tillard (site # 16). The *Anodonta cataracta* varied from four to five inches in length. This mussel is at the adult stage at this size. The fact that there were no juveniles present may indicate a reproduction problem has occurred.

At site # 5, Grand River Falls there was an abnormal abundance of *M. margaritifera*. This species was discovered overlaying the entire substrate throughout the entire 30-minute survey. This suggests there is a strong population of host fish to meet conditions needed for this thriving reproduction.

This study indicated some limitations, which could have altered the results. These limitations include visibility problems and lack of human resources.

The visibility problems were due to cloudy water (naturally murky or from walking disturbances), sun reflection in some areas, and limited view with the equipment used i.e. clear- bottom bucket, goggles. To identify the mussels properly a specimen key would have proved both time saving and instructive.

The results indicated a relationship between the mussels and the habitat in which they live. The five mussels found are listed below with their preferred habitats:

6. *Margaritifera margaritifera* – prefers a rocky bottom of a lake or river, however most abundant in fast flowing rivers.
7. *Elliptio complanatus*- prefers a variety of substrates of various bodies of waters.
8. *Anodonta cataracta*- prefers a silty-loam, organic substrate in a lake or pond.
9. *Anodonta implicata* – prefers a sandy silty substrate found in lakes.
10. *Alasmidonta undulata* – prefers a sandy rocky bottom found in lakes.

There's a relationship between the mussels found together, and the habitat in which they live. This study indicates that certain mussels can together, within the same body of water as long as a varied substrate is present.

Table V shows species which can be found within the same habitat local.

Table V: Cohabitation of Mussels Within the Same Area

Site #	***Margaritifera margaritifera***	***Anodonta implicata***	***Anodonta Cataracta***	***Elliptio complanatus***	***Anodonta undulata***
8,15 (gravels & fines)	☆	☆			
16 (fines-gravels)			☆	☆	
19 (fines)		☆	☆		
20 (fines-gravels)			☆	☆	☆

5.0 Conclusion

From this study it is concluded that each of the five species of mussels require specific niches of habitat (the species which were cohabitating within the same area were in distinctive substrates), host fishes, and specific environmental conditions for survival.

6.0 Recommendations

Further studies are recommended at site # 16, Long Lake to examine why there is an apparent lack of juvenile recruitment. This could be due to an absence of required host fish or other environmental problems at this site.

Additional studies are also recommended on the fish located in the study area, in order to determine if they are potential hosts. Some of these fish were determined by (Clarke, 1981) and (Martin *et al*, 1997) as being host fish. Others however, were not identified as hosts such as; shad, eels, smelts, minnows and leeches.

7.0 Literature Cited

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8.0 APPENDIX 1

Raw field data

The following table compares the ecology, distribution and host fishes of the freshwater molluscs found within the study area from the 1999 Study, and of various studies by Clark, (1981) and Martin *et al*, (1997).

Table IV Ecology, Distribution Host fishes, and Possible Host Fishes of the Five Molluscs Studied

Common Name/Scientific Name	Distribution (same for both)	Ecology (known **)	Ecology (1999 Study)	Host Fish (known**)	Possible Host Fish (1999 Study) (Wilkie, Cotton, B
Eastern – River Pearl *(Margaritifera margaritifera)*	Atlantic drainage	Small – medium streams, sandy shoals. Never in lakes	Rivers and lakes (abundant in gravel-cobble bottoms, rarer in fines)	*Salvelinus fontinalis* (brook trout) *Salmo trutti* (brown trout) *Salmo salar* (Atlantic salmon) *Oncorhynchus mykiss* (rainbow trout) *O.kisutch* (coho salmon)	brook trout, brown salmon, rainbow tr shad, eels, smelts
Eastern Elliptio- *(Elliptio complanata)*	Atlantic drainage	Shallow water of lakes, rivers, and streams	Variety of water types with fine-gravel substrates	*Perca flavescens* (yellow perch) *Micropterus salmoides* (largemouth bass) *Fundulus diaphanus* (banded killifish)	suckers, brown tro perch, minnows
Heavy-toothed Wedge Mussel- *(Alasmidonta undulata)*	Atlantic drainage	Rivers, lakes especially on sand or gravel bottoms	Lakes with fines-gravel bottom	*Rhinichthys atratulus* (blacknose dace)	lake trout, perch
Eastern Floater- (*Anodonta cataracta cataracta)*	Atlantic drainage	Ponds, lakes and streams, small brooks (most abundant on mud, occurs on sand less frequently on gravel)	Lakes, ponds with fines-gravel substrate	*Cyprinus carpio* (common carp) *Catostomus commersoni* (white sucker) *Gasterosteur aculeatus* (threespine stickleback) *Lepomis gibbosus* (pumpkinseed)	brown trout, sucke perch, leeches
Alewife Floater- *(Anodonta implicata)*	Atlantic coastal plain	Coastal streams and lakes (occurs in sand and gravel, rarely in mud)	Lakes with fine substrate, occurred in gravel rare	*Alosa pseudoharengus* (alewife) *Catostomus commersoni* (white sucker) *Morone americana* (white perch) *Lepomis gibbosus* (pumpkinseed)	brook trout, brown salmon, rainbow tr shad, eels, smelts, Suckers

Information from this table was taken from **(Clark, 1981), (Martin *et al*, 1997) and the study undertaken in the summer of 1999.

This table shows a similarity in known host fish from previous studies compared to that of the possible host fish from the study undertaken in summer of 1999. This appears very obvious with the Eastern-River Pearl. The Eastern Floater also shows a strong similarity in its ecology. A key difference is in the Eastern-River Pearl, showing that it's never found in lakes from previous studies and from the study in 1999 it is shown to be located in lakes.

Table I: Physical Characteristics of the Studied Molluscs

Scientific name	Common name	Shell size	Periostracum color	Nacre color	Beak	Pseudocardinal teeth	Lateral tee
Margaritifera margaritifera	Eastern-River Pearl	Up to150mm long, 65mm high,10mm thick	Brown in juveniles, black in adults	White, with or without purple suffusions	Coarse ridges	1 in the right valve, 2 in the left	Poorly develop or absent
Elliptio complanata	Eastern Elliptio	Up to 125mm long, 40mm wide, 6mm thick	Brownish or blackish unrayed unless young or adults in sandy substrates	Purple in most pink-white in some	U-shaped ridges	1 in the right valve (small accessory tooth may be present in front of large one), 2 in the left	Narrow, 1 in th right valve, 2 i the left valve
Alasmidonta undulata	Heavy-toothed Wedge Mussel	Up to 75 mm long, 45mm high, 35mm wide,6mm thick	Yellowish, greenish, reddishbrown, or black with greenish blackish rays	Whitish at anterior, bluish at posterior	Sculpture very heavy	Strong and deeply grooved 1 in the right valve, 2 in the left valve	Vestigial or ab
Anodonta cataracta cataracta	Eastern Floater	Up to 150mm long, 75mm high, 665mm wide, 1.5 mm thick	Green, yellow-brown, shiny, green rays	Silvery - white	Sculpture	Absent	Absent
Anodonta implicata	Alewife Floater	Up to 125mm long, 65mm high, 40mm wide, 3.2 mm thick	Yellowish, brownish, blackish, heavy	Salmon - pinkish	Inflated and elevated	Absent	Absent

Table III: Detailed Site Description, Relative Abundance, Species and Distribution

	Site # 1	Site # 2	Site # 3	Site # 4	Site # 5	Site # 6	Site # 7	Site # 8
Location	Grand River, Grand River	Grand River, Grand River	Murchinson Brook, Grand River	Murchinson Brook, Grand River	Grand River Falls, Grand River	Grand River, Grand River	Grand River, Grand River	River off Narrow, Head of Loch Lomond
Date surveyed	July, 21 1999	July, 22 1999	July 22, 1999	July 22, 1999	July, 22 1999	July 28, 1999	July 28, 1999	August 4, 1999
Water body / flow	River / medium	River / medium	Brook / slow	Brook / slow	River / medium	River / fast	River / medium	River / slo
Substrate	Cobble	Cobble	Gravel	Gravel	Cobble	Gravel	Gravel	Gravel
Water visibility	8/10	8/10	9/10	8/10	8/10	2/10	5/10	6/10
Aquatic vegetation	No	No	No	No	No	No	No	Yes
Water temperature	15 C	15 C	13 C	13 C	20 C	20 C	20 C	21 C
Midden presence	No	No	No	No	Yes	Yes	Yes	No
Mollusc occurrence								
M.m	Common	Occurred			Abundant	Occurred	Common	Abundant
E.c								
A.i								Common
A.c								
A.u								

Relative Abundance Key

1-10	Occurred	
10-100	Common	
100-500+	Abundant	

Mollusc codes

M.m	*Margaritifera margaritifera*
E.c	*Elliptio complanatus*
A.i	*Anodonta implicata*
A.c	*Anodonta cataracta*
A.u	*Anodonta undulata*

Substrate Key

< 2mm	Fines
2-64mm	Gravel
64-256mm	Cobble

Table III: Continued

	Site # 11	Site #12	Site #13	Site #14	Site # 15	Site #16	Site # 17	Site # 18
Location	Loch Lomond Lake, Loch Lomond	Brook off Chilolm Dam Lake, Loch Lomond	Loch Lomond Lake, Loch Lomond	Barren Hill Lake, Barren Hill	Lake Uist, Lake Uist	Long Lake, River Tillard	Cook Lake, St. Peter's	Cranberry Lake, St. Peter's
Date surveyed	August 5, 1999	August 5, 1999	August 5, 1999	August 8, 1999	August 12, 1999	August 16, 1999	August 17, 1999	August 17, 1999
Water body / flow	Lake/very little	Brook/ medium	Lake/ very little	Lake/ very little	Lake/ very little	Lake/very little	Lake/ very little	Lake/very little
Substrate	Fines	Gravel	Cobble	Organic/ Cobble	Fines	Fines-Gravel	Fines	Fines
Water visibility	8/10	9/10	9/10	1/10	1/10	2/10	2/10	1/10
Aquatic vegetation	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Water temperature	22 C	19 C	26 C	26 C	22 C	23 C	22 C	22 C
Midden presence	No	No	No	No	No	No	No	No
Mollusc occurrence								
M.m					Common			
E.c						Common		
A.i	Occurred			Common	Common			
A.c						Occurred		
A.u								

Relative Abundance Key

1-10		Occurred
	M.m	Margaritifera margaritifera
10-100		Common
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