Fossils of Ontario
Part 2: Macroinvertebrates and Vertebrates of the Champlain Sea
with a listing of nonmarine species

Frances J. E. Wagner

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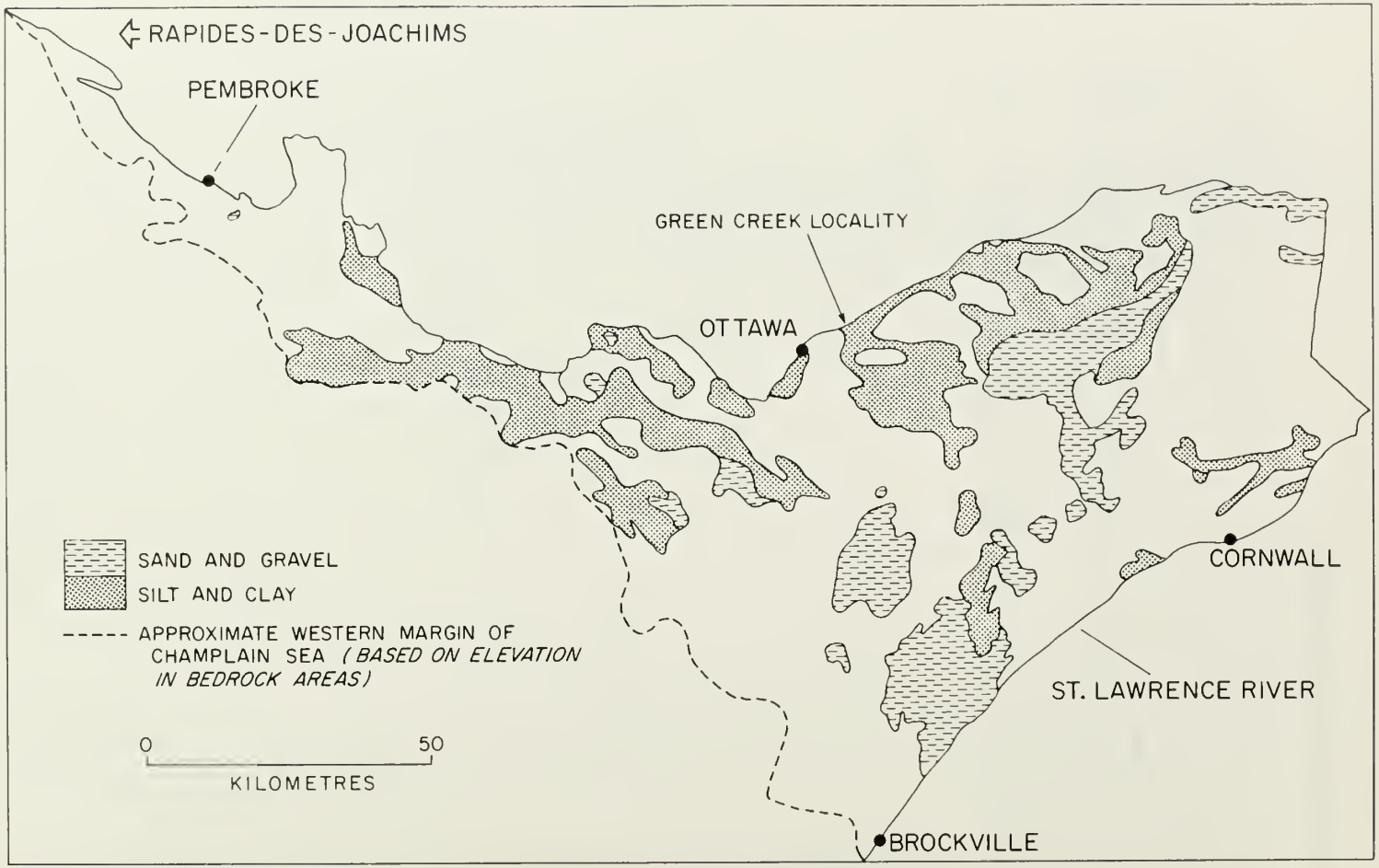


Fig. 1 Champlain Sea deposits, southeastern Ontario.

Introduction

The last continental glaciation in North America, the Wisconsinan, saw the major part of Canada covered by an extensive ice sheet. In eastern Canada the weight of the ice depressed the surface of the land by at least several hundred metres, and with the retreat of the glaciers, marine waters flowed inland to cover much of the Ottawa-St. Lawrence Lowland. The part of this marine inundation lying west of Quebec City has been named the Champlain Sea. In eastern Ontario dated marine sediments indicate that the waters of this sea extended up the Ottawa Valley to the vicinity of Rapides-des-Joachims, about 65 km upriver from Pembroke, and west at least as far as Brockville in the St. Lawrence Valley (Fig. 1).

During the Champlain Sea's geologically brief history, from about 12 500 years B.P. to 9 500 years B.P., various types of animals, ranging from microscopic foraminifera to whales, penetrated from the Atlantic Ocean into this inland sea. Their remains have been found embedded in the marine sediments of the area. This book emphasizes the groups of animals generally large enough to be visible to the naked eye; in other words, it excludes the microscopic foraminifera and ostracods, which are to be dealt with in a future volume of "Fossils of Ontario".

The types of animals that lived in the Champlain Sea and that are covered in this volume comprise sponges, bryozoans (moss animals), molluscs (gastropods and pelecypods, known otherwise as snails and clams), arthropods (a conchostracan or clam shrimp, barnacles, and an isopod, which is related to the terrestrial wood lice), an asteroid (starfish), ophiuroids (brittlestars), annelid worms, fish, whales, and seals. With the exception of one genus of barnacle, two genera of pelecypods, and one genus of seal, each genus is represented by only a single species. Nonmarine fossils found in concretions at Green Creek (Green's Creek of early literature), in the Ottawa area, are listed but not described.

Molluscs are the most common both in variety and numbers. White gastropod and pelecypod shells are easily visible in a variety of sediments. A branchiopod, several genera of fish, and the bones of a young seal are other marine fossils that have been found in the Green Creek concretions. These concretions offer very attractive and interesting specimens. Bones of whales and seals are of rare occurrence in the Champlain Sea deposits.

Champlain Sea fossil occurrences have been known since the late 1830s and their assemblages have been reported in various scientific journals and government publications. I recorded the Champlain Sea fossil references dating from 1837 in a Geological Survey of Canada paper (Wagner, 1967). I have abstracted the references pertinent to the Ontario scene from this and from other papers published after 1966. Earlier papers are often vague as to localities of fossil discoveries, citing occurrences such as "Ottawa and vicinity" or "right bank of Rideau River, near Manotick Road". More recent references are usually more specific and can lead the searcher to the exact sites where the fossils have been collected. New localities are continually being discovered, and a visit to such places as newly dug ditches, foundation excavations, fresh landslide scars, actively worked clay, and sand and gravel pits can reward the collector with interesting suites of fossils.

Species found in the Champlain Sea still exist, and those interested in the fascinating exercise of attempting to determine past environmental conditions and changes in these conditions can do so by comparing the fossil assemblages with their modern counterparts. Pelecypod fossils with their valves intact and in living position are abundant locally, as are apparently *in situ* gastropod shells. The specimens so preserved are those of species generally favouring a fine-grained substrate, and they are found in the clays and silts. The more widespread sands and gravels, being shallow-water deposits, were subject to wave action which, of course, affected the animal hard parts enclosed in them. Disarticulated pelecypod valves and barnacle plates, eroded gastropod shells, and fragments of all kinds are the common fossils in this type of deposit although complete specimens may be found. Fossils in the concretions are usually well preserved, but their occurrence is very localized. Detailed species descriptions and information pertaining to environmental factors favourable to the various species may be found in Abbott (1974), Bousfield (1960), Collins (1959), and Morris (1973).

Illustrations of complete specimens are the ideal for identification purposes because they give a whole against which fragmentary specimens can be compared. Unfortunately, many Ontario-collected specimens are incomplete, and therefore, specimens from the province are in the minority among the following figures. In addition, many specimens of the species reported in older literature could not be located, and sometimes even specimens from more recent collections were found to be missing. Where necessary, specimens (either existent or fossil) from elsewhere have been substituted or have been shown in addition to less than ideal Ontario material. For a few species, no substitute specimens could be obtained, and so drawings have been prepared.

Champlain Sea Deposits in Ontario

Unconsolidated deposits in the Ontario area of the Champlain Sea show a sequence of sediments of glacial, through freshwater, to brackish and marine, and back to freshwater origin. The brackish and marine materials relate to the Champlain Sea inundation. Sediment distributions shown in Figure 1 are based primarily on my own field observations. Fine-grained silts and clays are characteristic of the earlier, deeper phases of the sea, whereas sands and gravels were deposited during shallower intervals and along the shores. Boulder beaches were developed where till ridges projecting above the level of the marine waters allowed the waves to winnow out the fine-grained sediments.

The earlier names of *Leda* clay and *Saxicava* sand have been replaced by the more appropriate Champlain Sea clay and Champlain Sea sand (Gadd, 1960). *Leda* is a synonym of *Nuculana*; the pelecypod species characteristic of the clays is a *Portlandia*, namely *Portlandia arctica* (Gray). *Saxicava* is a synonym of *Hiatella*.

References for description and discussion of the Champlain Sea stratigraphy are given below.

GENERAL REFERENCES

Antevs (1925)
Chalmers (1907)
Coleman (1901a, 1901b, 1932, 1941)
Dawson, J. W. (1871, 1883b, 1893)
Logan (1863)
Murray (1852)

SPECIFIC REFERENCES

Ami (1887, 1892, 1906)
Ells (1898, 1907)
Gadd (1963a, 1963b, 1977, 1980)
Johnston (1917)
Keele and Johnston (1913)
Kindle (1918)
Owen (1951)
Richard (1975)
Terasmae (1960, 1965)
Wilson, W. J. (1898)

History of Champlain Sea Studies in Ontario

Observations of fossiliferous Champlain Sea sand and clay in Quebec (Beauport area) date back to 1837 when shells were collected there by H. W. Bayfield (1837). They were identified by Sir Charles Lyell (1841). The first record of Champlain Sea fossils in Ontario dates to 1845 when Lyell reported the occurrence of the capelin *Mallotus villosus*. The fish-bearing concretions had been obtained by William (later Sir William) Logan, founder and first director of the Geological Survey of Canada. They came from the shores of the Ottawa River near Ottawa (then called Bytown). Logan published subsequent reports on fossil finds from the Ottawa area and from north and west of Ottawa as far as Lake Coulonge, the major contribution appearing in the 1863 "Geology of Canada". Two other collectors of the 1850s who advanced the knowledge of the composition and distribution of Champlain Sea faunas in Ontario

were Alexander Murray of the Geological Survey of Canada and Joseph Leidy, an American palaeontologist.

An important collector in the period 1857 to 1895 was J. William (later Sir William) Dawson. In his later years he was principal of McGill College in Montreal. Dawson added considerably to the number of species known from the Champlain Sea and in 1893, he published the definitive work up to that time on the Pleistocene of Canada. His son, George Mercer Dawson, was third director of the Geological Survey of Canada, and his report on the operations of the Geological Survey for 1895 (published in 1897) makes reference to N. J. Giroux's collection of Champlain Sea fossils from the St. Lawrence area.

During the latter part of the 19th century and the first decade of the 20th Henry M. Ami published extensively on the Champlain Sea. He added significantly to the lists of both invertebrate and vertebrate species and recorded new localities, mainly in and around Ottawa. Ami was a palaeontologist with the Geological Survey at the time.

The 20th century saw the proliferation of people interested in the Champlain Sea and its faunas. Some of them merely repeated what was already known, sometimes adding a species or two or a new locality; others undertook detailed studies of a palaeoecologic or a stratigraphic nature. Major contributors of palaeoecologic interpretations include Winnifred Goldring of the State Museum at Albany, New York, and E. J. Whittaker and F. J. E. Wagner, the latter two invertebrate palaeontologists with the Geological Survey of Canada. Whittaker's observations were based on collections from along the St. Lawrence River between Prescott, Ontario and Lachine, Quebec. Goldring considered material from the Ottawa and Montreal areas although her main emphasis was on the area around Lake Champlain in Vermont and New York State. She studied the relationship of size differences in selected species to ecologic conditions, primarily to salinity. The full extent of the Champlain Sea was considered by Wagner, whose interpretation of ecologic conditions complemented and extended that of Goldring. She also added materially to the number of known fossiliferous sites in Ontario and Quebec.

Other contributors since the turn of the century to the knowledge of the Champlain Sea species and their distribution in Ontario include Ernst Antevs, Robert Bell, Robert Chalmers, R. W. Ells, W. A. Johnston, E. M. Kindle, Lawrence M. Lambe, C. M. Sternberg, Jaan Terasmae, and J. F. Whiteaves, all of whom were associated with the Geological Survey of Canada. Persons other than staff of the Geological Survey whose works on the Champlain Sea have been cited in the list of references include A. P. Coleman, C. R. Harington, J. W. Laverdière, G. H. Perkins, and H. G. Richards. All references relate to locality citations and not to taxonomic works.

Champlain Sea Fossils

Excluding the species of foraminifera and ostracods, at least 47 marine species have been identified from the area of the Champlain Sea in Ontario as opposed to a total of approximately 125 species from the Champlain Sea as a whole. No new marine species in addition to the 47 were collected from the parts of Quebec adjacent to Ontario. It is necessary to go as far as Montreal and south and east from there to find species other than those reported from Ontario.

The 47 marine species from Ontario are distributed among 40 genera of which 29 are invertebrates. A breakdown of the invertebrates shows one genus of Porifera (sponges), of Bryozoa (moss animals), of Conchostraca (clam shrimps), of Cirripedia (barnacles), of Isopoda, and of Asteroidea (starfish); two genera of Ophiuroidea (brittlestars) and of Polychaeta (worms); nine of Gastropoda (snails); and ten of Pelecypoda (clams). Among the vertebrates there are five genera of mammals and six genera of fish.

Organisms found in the Champlain Sea deposits may be classified as follows. The taxonomic categories under which the various forms are described appear in boldface.

PHYLUM	SUPERCLASS	CLASS	SUBCLASS	ORDER
Porifera		Demospongia		Epipolasida
Bryozoa				
Mollusca		**Gastropoda**		
		Pelecypoda		
Arthropoda	Crustacea	Branchiopoda		**Conchostraca**
		Cirripedia		
		Malacostraca		**Isopoda**
Echinodermata		Stelleroidea	**Asteroidea**	
			Ophiuroidea	
Annelida		**Polychaeta**		
Chordata	**Pisces**	Osteichthyes	Actinopterygii	**Clupeiformes**
				Gadiformes
				Gasterosteiformes
				Perciformes
		Mammalia		**Cetacea**
				Pinnipedia

Invertebrata

Porifera (Sponges) Figure 2A–D

Porifera are represented by only one genus, *Tethya*, a sponge belonging to the class Demospongia Solles, 1875, and the order Epipolasida Solles, 1888. These are sponges characterized by a complex structure of many chambers. The spicules may be either siliceous or of spongin, a flexible material related to horn. Spicules of both kinds may be present. Spicules are of two types, namely megascleres and microscleres (Fig. 2A–C). Megascleres make up the skeletal framework of the sponge, whereas microscleres are present in the flesh and do not form part of the framework. Microscleres are very rarely found in fossils. Epipolasids are typically radiate in form with a relatively thick external cover. The main spicules are strongyles (Fig. 2A) with swollen, spindlelike shafts.

Ami (1897, 1902) referred the single species from the Champlain Sea to the genus *Craniella* and Whittaker (1922) placed *Craniella* as a subgenus of *Tethya* (spelled

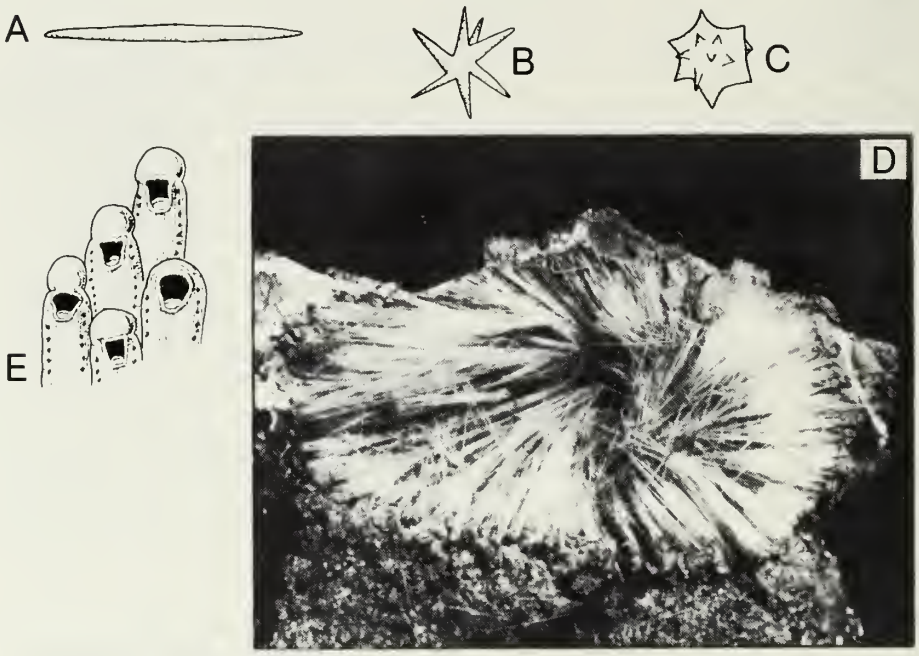


Fig. 2 **Porifera** (A–D) **Bryozoa** (E)
A Megasclere (a strongyle).
B Microsclere (a euaster).
C Microsclere (a sphaeraster).
Tethya logani Dawson
D Flattened rosettes of spicules, × 3.25, GSC 20130, Montreal, Quebec.
Porella elegantula d'Orbigny
E Schematic representation of several zooecia, × 2.5.

Tethea in earlier publications). However, the two genera are distinct (Moore, 1955, p. E42). The specimen identified as *Craniella cranium* (Müller) by Whiteaves (1901) is probably *Tethya logani*.

***Tethya* Lamarck Figure 2D**

This is the one genus found in the Champlain Sea. *Tethya* is of spheroidal form with a warty, leathery surface. Megascleres in this genus are strongyles (Fig. 2A) and microscleres include sphaerasters and euasters (Fig. 2B, C). As fossils, only the megascleres have been reported. These spicules are found in clay as isolated individuals, in bundles resembling mouse fur, or clustered as flattened rosettes. The spicules are needlelike, hollow, gently curved, and tapering at both ends. Some are drawn out to very fine points, whereas others are more bluntly rounded. The megascleres measure up to 7.5 mm in length.

A specimen from the Montreal area of Quebec is illustrated.

SPECIES *Tethya logani* Dawson [recorded as *Craniella logani, Tethea logani, Tethea (Craniella) logani*]

REFERENCES Ami (1887, 1892, 1897, 1902), Wagner (1970), Whittaker (1922)

Bryozoa (Moss Animals) Figure 2E

Remains of these colonial animals are very scarce in the Champlain Sea deposits. Only one genus, *Porella*, which appears in the earlier literature as *Eschara*, has been identified positively from the Ottawa area. Fragments of bryozoan zoaria were reported from Stormont County but were not identifiable. The colonies may be free, branching forms or they may be encrusting on stones or shells. The zoaria can be seen readily with the naked eye but a hand lens is needed in order to see the details of the zooecia.

***Porella* Gray Figure 2E**

Porella is a foliate form. The apertural face may either be smooth or have a granulated calcareous covering over the smooth inner layer. There is a suboral avicularium. The ovicell is imperforate.

No specimen was available for illustration.

SPECIES *Porella elegantula* d'Orbigny

REFERENCES Ami (1892, 1897, 1902), Goldring (1922)

Gastropoda (Snails) Figures 3 to 5

Gastropods, commonly known as snails, are molluscs with a single calcareous shell that is closed at the apex and is not divided into regular chambers. Shell shapes and ornamentation are diverse. In most genera the shell is asymmetric.

Gastropods are one of the more common fossils in the Champlain Sea sediments, although their variety is smaller and their numbers far fewer than those of pelecypods. With the exception of *Neptunea*, all are small, ranging in length from 6 mm to about 25 mm. *Neptunea* may reach 120 mm in length. Many living gastropods have coloured shells, some of which are quite elaborately patterned. However, the genera represented here are dull, for the most part, ranging from amber to tan to brown and

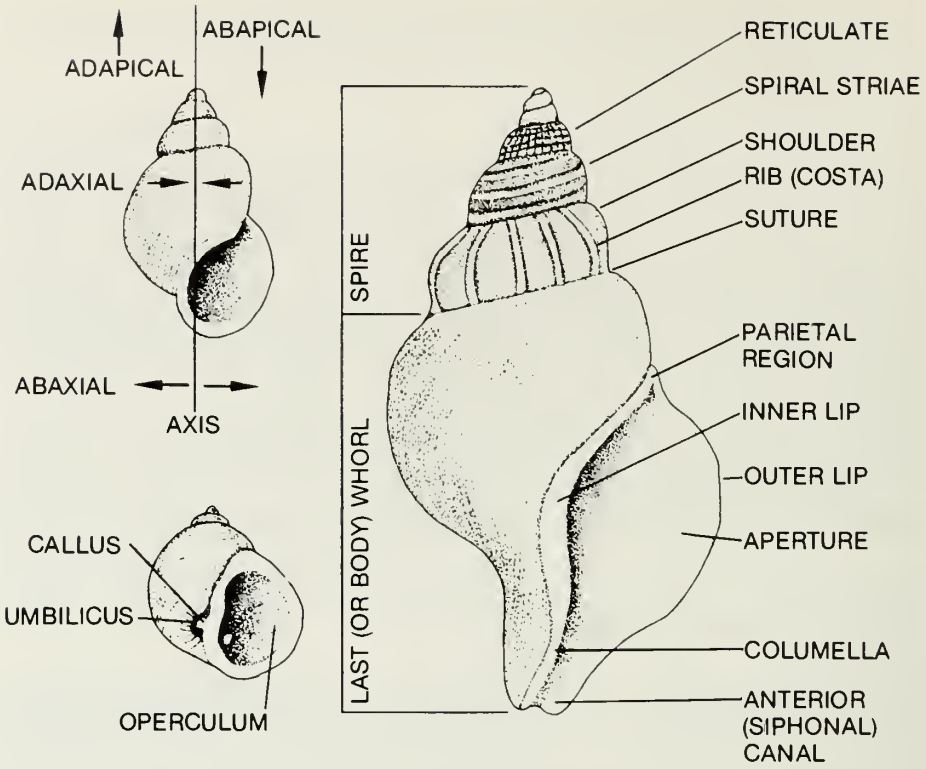


Fig. 3 Morphological terms applied to gastropods.

brownish grey in life. Some show colour banding. Fossil specimens are almost invariably bleached white, although occasionally they show a trace of colour or a colour pattern.

Shells may be found in clays and silts and in sands and gravels, but the best source is the former group, which are the finer-grained sediment. Most specimens reported during the period between 1897 and the present have been from the Ottawa area. This may reflect merely the fact that a growing city with its many excavations offered excellent chances for the discovery of these shells. However, my field program in the 1950s, which covered all of the area of Ontario that had been inundated by the Champlain Sea waters, brought to light extremely few samples of gastropods outside the Ottawa area. Their distribution is probably related to ecology. Most gastropod species identified favour a clay, silt, or fine sand substrate, and these sediments are best developed and exposed in the Ottawa Valley.

Figure 3 illustrates features of shell morphology and Figure 4 shows various gastropod shapes.

Margarites Gray Figure 5A

This is a small gastropod, generally less than 15 mm in length. It is trochiform in shape and has a rounded aperture with an interrupted peristome. The usually small, deep umbilicus is encircled by a spiral cord. A distinctive feature of the genus is the

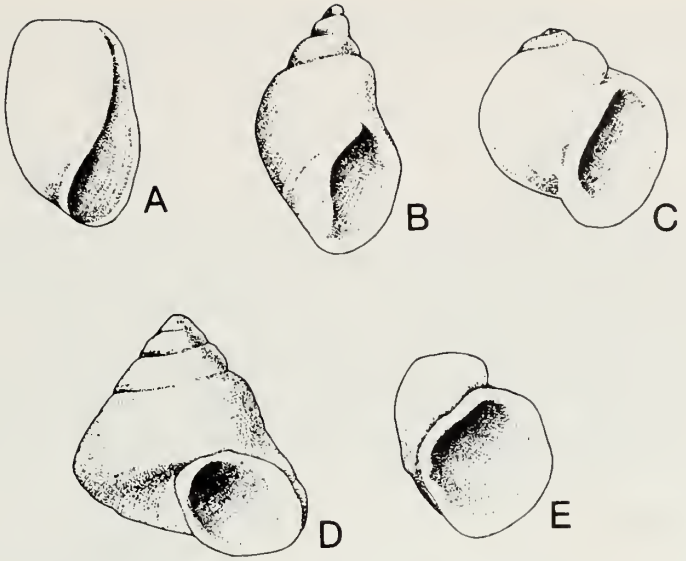


Fig. 4 Some common gastropod shapes.
A Cylindrical. C Globose. E Subglobose.
B Fusiform. D Trochiform.

nacreous interior of the aperture. The exterior of the shell may be smooth or spirally ribbed.

Two species have been identified from the Montreal area, but the single damaged specimen from Ottawa could not be identified as to species. Because the Ottawa fossil specimen was missing, a modern specimen representing one of the species reported from Quebec has been illustrated.

SPECIES *Margarites* sp.
REFERENCE Wagner (1970)

Velutina Fleming Figure 5B

Velutina is small, ranging up to about 20 mm in length. The shell is very thin and subglobose with two or three rapidly enlarging whorls that may be spirally striated or reticulately ornamented. The outer lip of the aperture is thin.

Finds in Ontario have been in and around Ottawa; the genus is more commonly represented in Quebec. A modern specimen is shown in place of the missing original fossil.

SPECIES *Velutina undata* Brown
REFERENCES Ami (1902), Whiteaves (1901)

Lunatia Gray Figure 5C

This is another gastropod scarce in Ontario, although it has been reported from several localities in Quebec. Shells of the genus may attain a length of 125 mm. However, the species found in the Champlain Sea does not grow more than 25 mm long. The globose shell has steadily enlarging, rounded whorls, and there is a small umbilicus, which may be almost closed. The aperture is long, between two-thirds and

three-quarters of the total length of the shell, and wide, but of variable proportions.

A specimen from Ontario was not available, and therefore a specimen from Quebec is illustrated.

SPECIES *Lunatia pallida* (Broderip and Sowerby)

REFERENCE Goldring (1922)

Natica Scopoli Figure 5D

Natica is similar in shape to *Lunatia* but is smaller (maximum length for the genus about 32 mm) and has its umbilicus almost or completely sealed with a callus. If the operculum is present, its composition is an important diagnostic feature; the operculum of *Natica* is calcareous, whereas that of *Lunatia* is horny.

Specimens have been collected from several localities in and around Ottawa and also from Farran Point, a site now inundated by the waters of the St. Lawrence Seaway. Like *Lunatia, Natica* is more widely recorded in Quebec. No specimen from Ontario could be found for illustration.

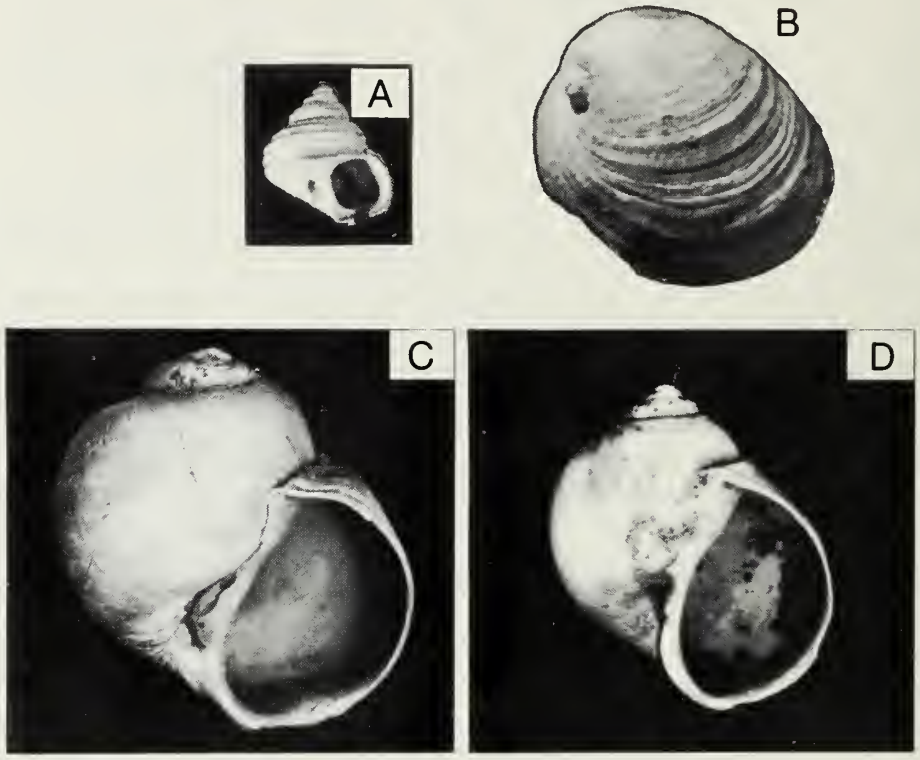


Fig. 5 ***Margarites Velutina Lunatia Natica***

Margarites costalis (Gould)

A A modern specimen, × 2, GSC 21096, Hudson Bay.

Velutina undata Brown

B A modern specimen, × 12, GSC 55158, Baie des Chaleurs.

Lunatia pallida (Broderip and Sowerby)

C Oral view, × 2, GSC 20136, near Ste-Geneviève, Quebec.

Natica clausa Broderip and Sowerby

D Oral view, × 2, GSC 20135, near Ste-Geneviève, Quebec.

SPECIES *Natica clausa* Broderip and Sowerby [*N. affinis* Gmelin is a synonym]
REFERENCES Ami (1897, 1902), Antevs (1925, 1939), Goldring (1922), Johnston (1916, 1917), Whittaker (1922)

Neptunea Röding Figure 6A

Representatives of this genus are the largest gastropods one is likely to find in the Champlain Sea deposits. Specimens from these deposits may reach 75 mm in length; the largest species of the genus reach about 125 mm. The fusiform shells generally have six to eight whorls. Sculpture is mostly spiral on the rounded or prominently shouldered whorls. The spiral ribs may be of two sizes. Some specimens have indistinct axial ribs. Sutures between adjoining whorls may be deep or shallow. The aperture is characterized by a short to long, usually twisted, siphonal canal.

In Ontario, this genus is apparently confined to the Ottawa district. A specimen from Quebec has been shown in place of the unavailable Ontario material.

SPECIES *Neptunea despecta* (Linné)
REFERENCES Ami (1902), Antevs (1925, 1939), Goldring (1922), Johnston (1916, 1917)

Admete Kröyer Figure 6B

Admete has a thin but strong shell about 25 mm long. The aperture is equal to about half the total length of the shell, which is basically fusiform in shape. The rounded whorls are sculptured with strong axial ridges and weak spiral threads. The aperture has a short, open, barely perceptible anterior canal. There are weak folds on the columella.

This gastropod is rare; it has been reported only once in Ontario, from Ottawa. Elsewhere in the Champlain Sea deposits, it has been collected from localities in Montreal and Quebec City. The whereabouts of Goldring's specimen is unknown to me; a sketch is presented because no suitable specimen of this species was available to be photographed.

SPECIES *Admete couthouyi* (Jay) [*A. viridula* (Fabricius) is a synonym]
REFERENCE Goldring (1922)

Cylichna Lovén Figure 6C

This and the following two genera are "bubble" shells and range from globose to cylindrical in shape. *Cylichna* is characterized by a small (9 mm or less in length), cylindrical shell that is generally smooth and glossy, although some species are ornamented with microscopic spiral scratches. The spire is involute, resulting in a small apical concavity. The lower end of the shell is truncate. The aperture is long and narrow, expanded below, and with a single oblique fold on the columella.

Only one of four species identified from the Champlain Sea has been found in Ontario. Several localities in and around Ottawa have been cited. A single specimen, which could not be identified to the species level, came from the Cornwall area. This gastropod has been collected from both sands and clays. A modern individual has been illustrated because no fossil material could be located.

SPECIES *Cylichna alba* (Brown)
REFERENCES Ami (1897, 1902), Antevs (1925, 1939), Goldring (1922), Johnston (1916, 1917), Wagner (1958)

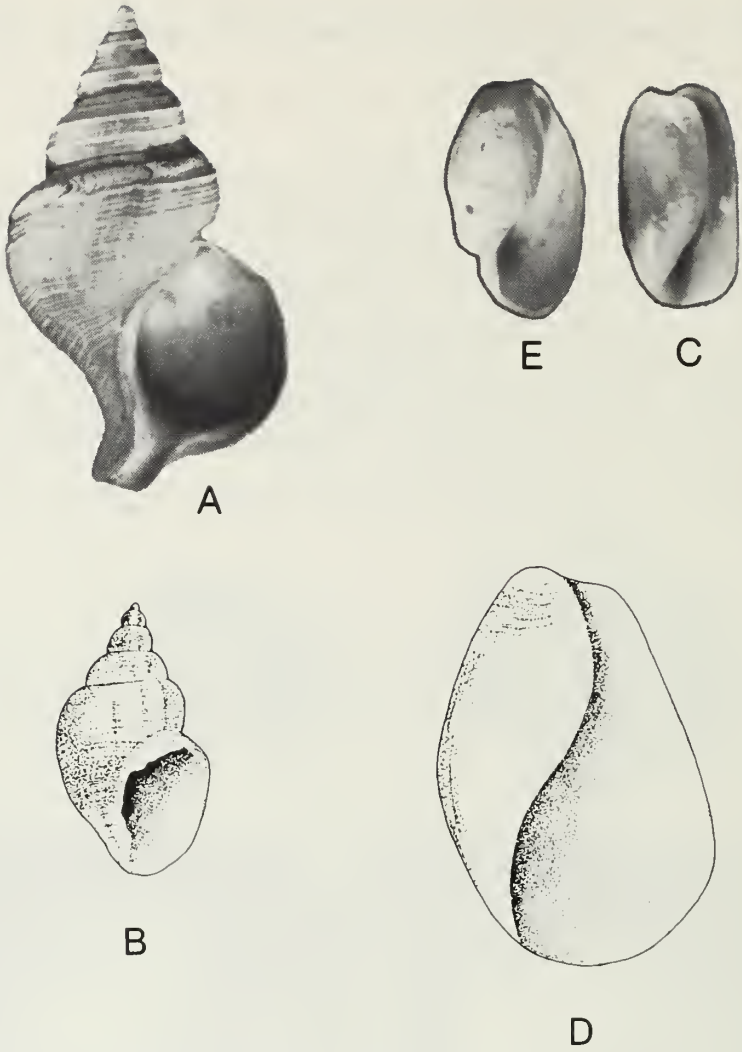


Fig. 6 ***Neptunea Admete Cylichna Philine Haminoea***

Neptunea despecta (Linné)

A Oral view of specimen previously referred to *N. despecta tornata* (Gould), × 1, GSC 20140, Grande-Rivière-du-Chêne, Quebec.

Admete couthouyi (Jay)

B Schematic representation, × 2.

Cylichna alba (Brown)

C Oral view of a modern specimen, × 6, GSC 55112, Bay of Fundy.

Philine lima (Brown)

D Schematic representation, × 15.

Haminoea solitaria (Say)

E Oral view, × 7, GSC 20141, Apple Hill, Ontario.

***Philine* Ascanius Figure 6D**

This is the smallest of the gastropods that one is likely to find, ranging from 2 to 7 mm in length. The shell is thin and loosely coiled with a flaring aperture. In some species the top of the aperture is above the apex of the shell; in others it is below. The apex of the shell may be partly flattened or it may be rounded. Ornamentation is usually spiral and may consist of finely scalloped lines, or rows of small oblong rings, or microscopic punctations.

There is only one record of this genus in Ontario—near Ottawa. The only other record of the genus in the Champlain Sea deposits is from the Montreal area. In the absence of Goldring's specimen and suitable modern material, a drawing is presented.

SPECIES *Philine lima* (Brown) [*P. lineolata* Couthouy is a synonym]

REFERENCE Goldring (1922)

***Haminoea* Turton and Kingston Figure 6E**

This "bubble" shell is similar in shape to the others, *Cylichna* and *Philine*, being globose to broadly cylindrical. The shell of *Haminoea*, however, may be partly corneous and is often semitransparent and flexible. The apex of the shell is perforate; a diagnostic feature for species of this genus is the direction in which the lip of the aperture rises—to the right or to the left of the perforation, when viewed with the apex of the shell towards you and with the outer lip facing to the right. The sides of the whorls may be flattened or rounded. Ornamentation may be lacking or may consist of spiral grooves.

This genus was recorded earlier from the Ottawa area and from Kenyon Twp., Glengarry County.

SPECIES *Haminoea solitaria* (Say)

REFERENCES Goldring (1922), Wagner (1970)

Pelecypoda (Clams) Figures 7 to 15

Pelecypods are two-shelled organisms with wholly or partly calcified valves covering the right and left sides of the body. The hinge plate, with the distinctive pattern and shape of its teeth, is of diagnostic importance at the generic level. In some genera the hinge is edentulous. A dorsal ligament connects the valves that open and close along an anteroposterior axis. The surface of the valves may be smooth, with only faint concentric growth lines, or it may be highly sculptured concentrically, radially, or both. General features of shell morphology are shown in Figure 7.

Pelecypods are the most abundant macrofossils in the Champlain Sea deposits. Complete shells of infaunal species may be found in living position (Fig. 8), and it is not uncommon to see an exposure, particularly a gravel pit, liberally sprinkled with white pelecypod valves (Fig. 9). Separated valves may be concentrated, convex side up, by wave or current action. Living positions of several typical genera are shown in Figure 10.

***Nucula* Lamarck Figure 11A**

The valves of this small (less than 9 mm long), ovate-to-trigonal pelecypod close tightly all around the periphery. The outer surface of the shell is either smooth or

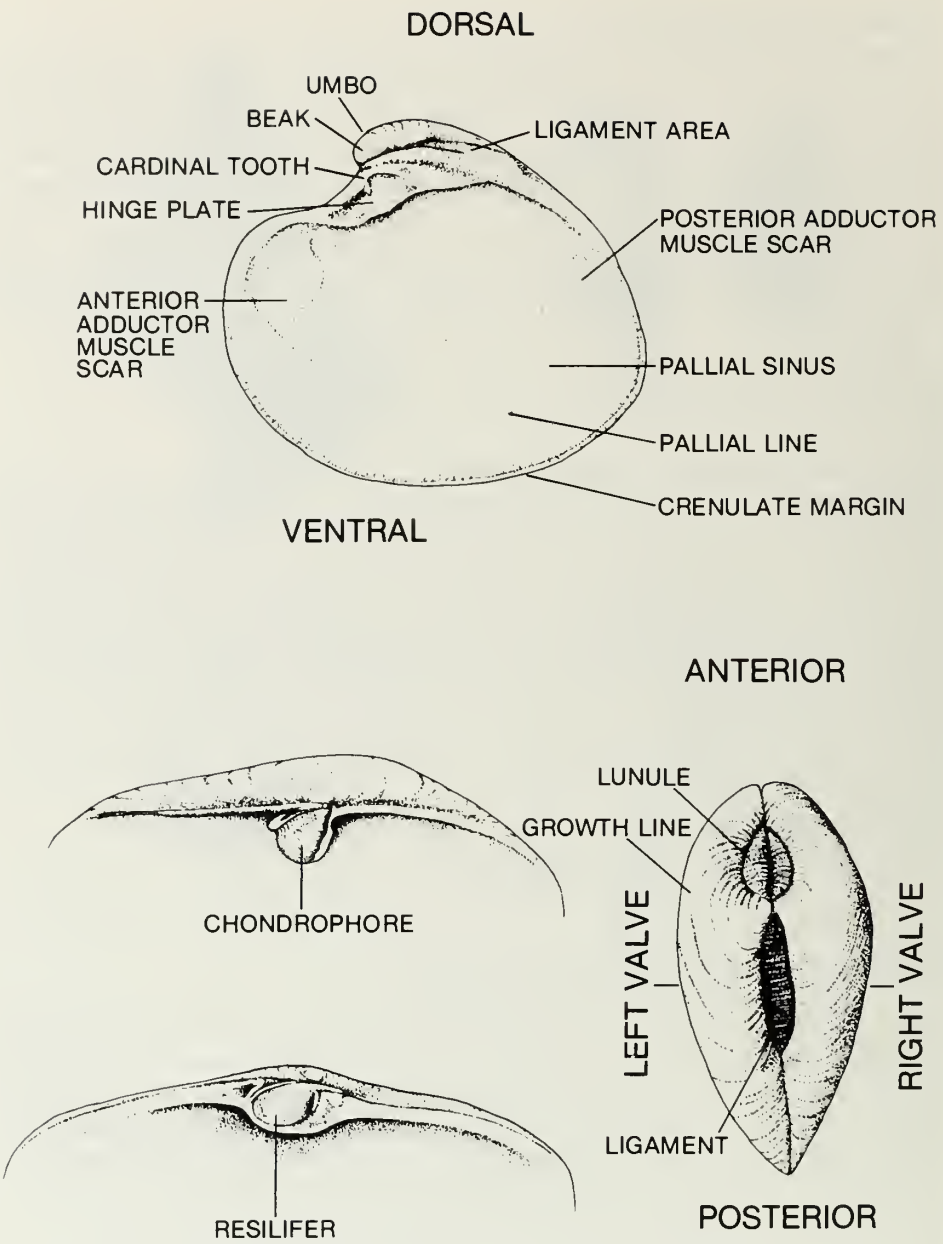


Fig. 7 Morphological terms applied to pelecypods.

ornamented with fine radial and concentric striae, and the interior of the shell is pearly. Interiorly, the ventral margins may be smooth or crenulate. Species identified from the Champlain Sea belong to the subgenus *Leionucula*, which has smooth inner ventral margins. A resilifer separates the anterior and posterior sections of the hinge with its closely interlocking, taxodont teeth. Beaks in this genus are opisthogyrate. There is no pallial sinus.

Fig. 8 Pelecypod shells (*Hiatella arctica*) in living position (above point of hammer), gravel pit 4.6 km south of Alexandria, Ontario (GSC Photo 144026).

Representatives of this genus have been found in the clays at various localities in the Ottawa Valley. Only one species has been identified, and it is apparently more common in Ontario than elsewhere. However, because the original material could not be found, a specimen from the Champlain Sea deposits in Quebec is shown.

SPECIES *Nacula tenuis* Montagu; *Nucula* sp. [the *N. expansa* listed by Coleman from Pakenham (?) is probably *N. tenuis*]

REFERENCES Ami (1902), Antevs (1925, 1939), Coleman (1901b), J. W. Dawson

Fig. 9 Exposure liberally sprinkled with pelecypod shells (foreground), gravel pit 4.6 km south of Alexandria, Ontario (GSC Photo 144027).

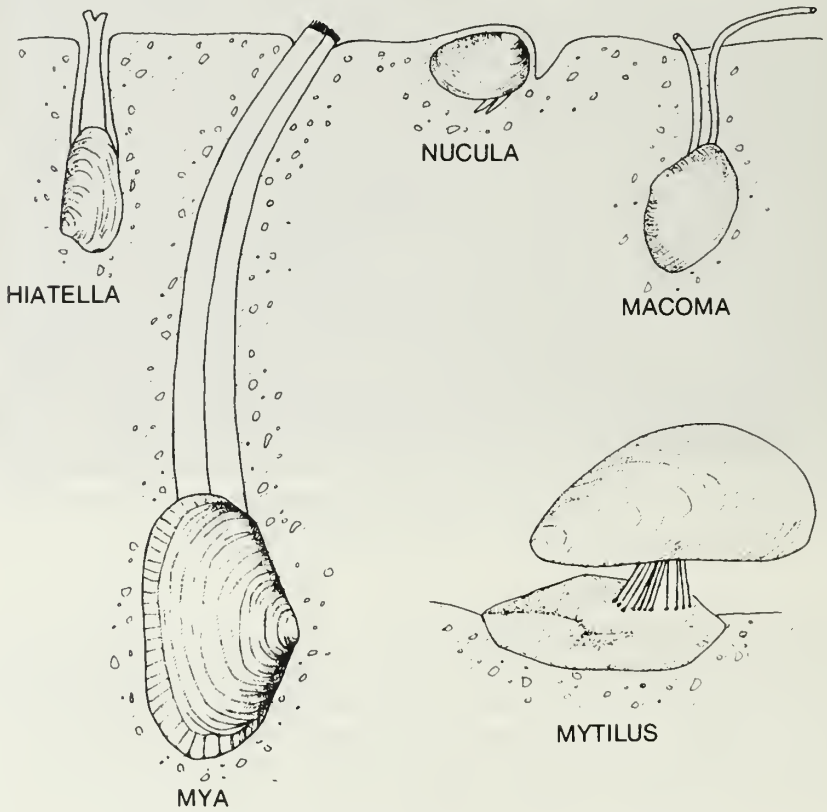


Fig. 10 Living positions of selected pelecypod genera.

(1857, 1871, 1893), Goldring (1922), Johnston (1916), Kindle (1918), Logan (1863), Whiteaves (1901), Whittaker (1922)

***Nuculana* Link Figure 11B, C**

Nuculana has an elongate, generally rostrate shell, either smooth or with concentric sculpture and with a polished periostracum. The interior of the shell is porcellaneous and the ventral margins are always smooth. Shells range from about 6 to 38 mm in length. The chevron-shaped hinge teeth are in two series separated by a wide, posteriorly directed resilifer. There are approximately twice as many teeth in the posterior series as in the anterior. There is a small pallial sinus.

Only one of the species of *Nuculana* recorded from the Champlain Sea has been found in Ontario and it is of limited occurrence. It has been reported from the Ottawa area and from near Farran Point, one of the communities obliterated by the St. Lawrence Seaway. No fossil material was available for illustration so a modern specimen has been substituted and the interior view has been sketched.

SPECIES *Nuculana minuta* (Fabricius)

REFERENCES Goldring (1922), Whittaker (1922)

***Portlandia* (Mörch) Figure 12**

Portlandia and *Nuculana* belong to the same family, Nuculanidae; however,

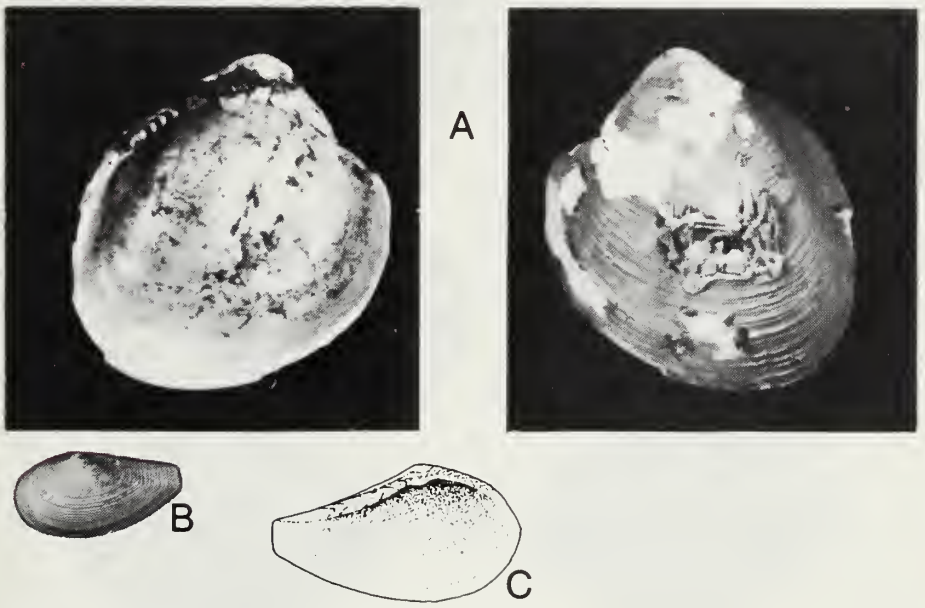


Fig. 11 ***Nucula Nuculana***

Nucula tenuis Montagu

A Interior and exterior views (part of hinge has been broken), × 4, GSC 20144, Lachevrotière River, Quebec.

Nuculana minuta (Fabricius)

B Exterior of left valve, × 2, GSC 22037, Hudson Bay.

C Diagram to show typical dentition.

Portlandia differs from the latter genus in that the surfaces of its valves are unornamented and in that the posterior end of its ovate-to-elliptical shell is dorsally produced. The interior of the shell of *Portlandia*, as of *Nuculana*, is porcellaneous, and the margins are smooth. A large resilifer separates the two series of chevron-shaped teeth. The number of teeth is approximately the same in both series, although there may be slightly fewer in the anterior series. If a pallial sinus is present, it is small. Specimens may reach 30 mm in length.

***Portlandia* sensu stricto Figure 12A, B**

The typical *Portlandia* has a well-developed, albeit small, pallial sinus. Its resilifer is large and subtriangular. The maximum length is 30 mm, but the length of most specimens is only about 15 mm. The one species in the Champlain Sea, *Portlandia* (*Portlandia*) *arctica*, is ubiquitous in the marine clays and is often found in silts and silty sands as well. It is the *Leda glacialis, Leda arctica,* or *Yoldia arctica* of the earlier authors and is the shell for which the *Leda* clay was named. Actually, *Leda* is a synonym of *Nuculana*, not of *Portlandia*.

SPECIES *Portlandia* (*Portlandia*) *arctica* (Gray)

REFERENCES Ami (1884, 1897, 1902), Antevs (1925, 1939), Coleman (1901b, 1941), J. W. Dawson (1857, 1871, 1893), Goldring (1922), Johnston (1916, 1917), Kindle (1918), Lowdon and Blake (1973, 1979), Lowdon, Fyles, and Blake (1967), Richards (1962), Terasmae (1960, 1965), Wagner (1958, 1970), Whiteaves (1901), Whittaker (1922), A. E. Wilson (1956), W. J. Wilson (1898)

***Portlandia* (*Yoldiella*) Verrill and Bush Figure 12C**

Species of this subgenus are small, from 2 or 3 mm to about 15 mm in length, with most less than 10 mm. The pallial sinus is very small and indistinct, or absent. The

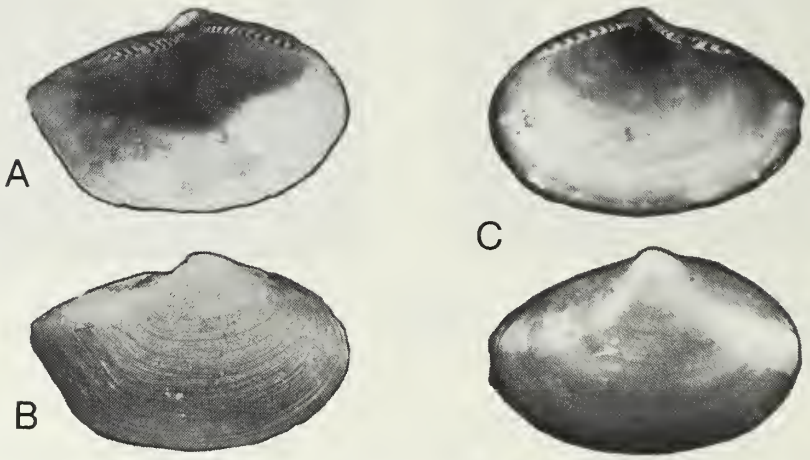


Fig. 12 ***Portlandia (Portlandia)*** ***Portlandia (Yoldiella)***
Portlandia (Portlandia) arctica (Gray)
A Interior of left valve, × 4, GSC 55116, Ottawa, Ontario.
B Exterior of right valve, × 4, GSC 55117, Ottawa, Ontario.
Portlandia (Yoldiella) lenticula (Möller)
C Interior and exterior views, modern specimen, × 6.75, GSC 55115, Beaufort Sea.

only species, *P.* (*Y.*) *lenticula*, is recorded from Green Creek, near Ottawa. *Leda pygmaea* of earlier authors is possibly this species. It has been necessary to use a modern specimen for illustration.

SPECIES *Portlandia* (*Yoldiella*) *lenticula* (Möller)

REFERENCES Richards (1962); for *Leda pygmaea*—Coleman (1901b), J. W. Dawson (1857, 1871, 1893), Goldring (1922), Logan (1863)

***Mytilus* Linné Figure 13A**

The shell is roughly wedge-shaped with the beaks forming a pointed apex and with the other end wider and rounded. The colour of the shell is distinctive, being bluish black on the exterior, but pearly white on the interior, with a deep purple-blue margin. The surface may be smooth or may have radial ribs. There is a shiny

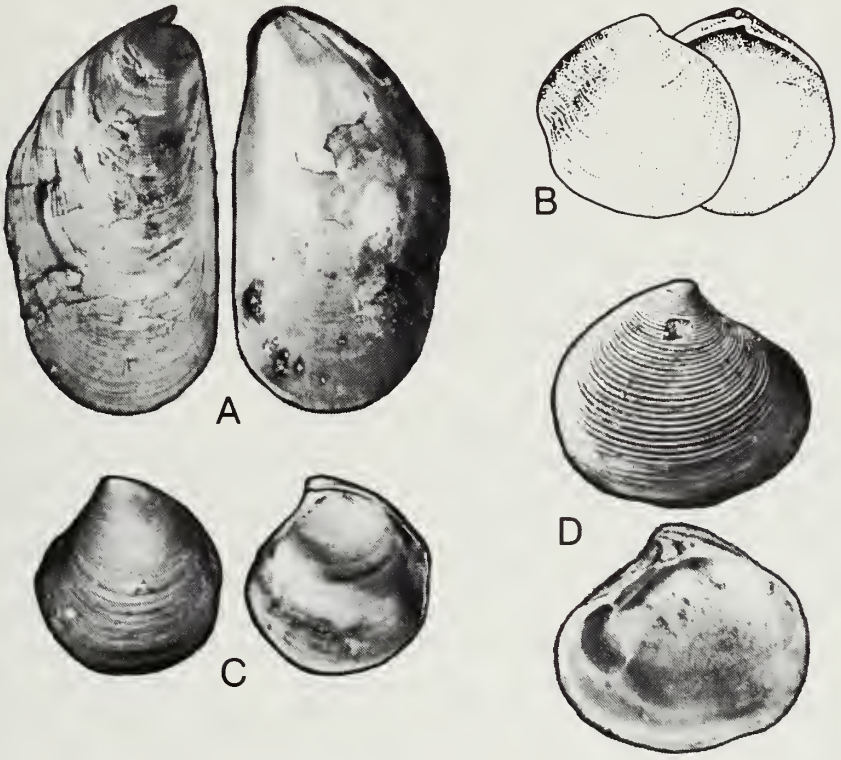


Fig. 13 ***Mytilus Thyasira Axinopsida Astarte***

Mytilus edulis Linné

A Interior and exterior views of a worn specimen, × 2, GSC 20149, St-Joseph-du-Lac, Quebec.

Thyasira flexuosa (Montagu)

B Schematic representation of right and left valves, × 1.75.

Axinopsida orbiculata (Sars)

C Interior and exterior views, × 4, GSC 20154, Cornwall area, Ontario.

Astarte montagui (Dillwyn)

D Interior and exterior views of specimen previously referred to *A. montagui striata* (Leach), × 2, GSC 20151, St-Janvier-de-Joly, Quebec.

periostracum. Four to six small, weak teeth are located close to the beaks. Some species may attain a length of 250 mm, but the species encountered in the Champlain Sea ranges in length between about 25 and 75 mm.

Mytilus is widely distributed and is found mainly in coarser sediments (pebbles to cobbles and boulders) because it is an attached form. Although complete specimens may be found, most occurrences are of fragments only. Two tiny pearls (0.35 mm and 0.4 mm in diameter) were found with well-preserved *Mytilus* shells in a gravel pit east of Winchester. Unfortunately, the good shells from Winchester were missing, as were the older collections. Therefore a specimen from Quebec has been shown.

SPECIES *Mytilus edulis* Linné

REFERENCES Ami (1884, 1892, 1897, 1902), Antevs (1925, 1939), Coleman (1901a, 1901b, 1941), Dawson (1857), Goldring (1922), Johnston (1917), Kindle (1918), Leidy (1856), Lowdon and Blake (1979), Terasmae (1960, 1965), Wagner (1958, 1970), Whiteaves (1901), Whittaker (1922), A. E. Wilson (1956)

Thyasira Lamarck Figure 13B

Most representatives of this genus are small, usually less than 15 mm in length. The posterior area of the subglobular-to-oblique shell is characterized by one or more radial furrows. The weak hinge is edentulous, although there may be a small pseudocardinal tubercle in the left valve. The pallial line is without a sinus. Externally the shell may be chalky or polished and is possibly ornamented with concentric growth lines but otherwise smooth.

Only a single species has been collected from Ottawa, and because no specimens were available to be photographed a sketch has been substituted.

SPECIES *Thyasira flexuosa* (Montagu)

REFERENCES Antevs (1925, 1939)

Axinopsida Keen and Chavan Figure 13C

This genus is similar in shape to *Thyasira*, but is smaller, being not more than 5 mm long. The two genera differ also in that *Axinopsida* does not have a posterior radial furrow, or furrows, and has a deeply impressed, concave lunule, a feature lacking in *Thyasira*. The shell surface is smooth and shiny, sometimes with incremental lines, and with a thin periostracum. Interiorly, the shell is porcellaneous and polished; the margins are smooth. The hinge is without teeth, although there may be a thickening below the beak in each valve forming a peglike pseudocardinal. There is no sinus in the weakly impressed pallial line.

The Cornwall area has yielded the only representative of this genus so far identified from the Champlain Sea.

SPECIES *Axinopsida orbiculata* (Sars)

REFERENCE Wagner (1970)

Astarte Sowerby Figure 13D

The shape of this genus may be quadrate, trigonal, or rounded. The surface may be smooth but more commonly has fine-to-coarse, rounded, concentric ridges. The thick periostracum ranges from yellow through shades of brown to almost black. Interior margins of the shell may be smooth or crenulated; in the subgenus recorded from the Champlain Sea they are smooth. Hinge teeth are variable in shape, development, and number, but there are always three in the left valve. The pallial line is without a sinus.

Some species of *Astarte* attain a length of at least 50 mm; *A. montagui*, found in the Champlain Sea deposits in Ontario, reaches a maximum length of about 20 mm.

One of two species of *Astarte* from the Champlain Sea has been found in Ontario, primarily in and around Ottawa. Earlier authors recorded it as *Astarte compressa, A. banksi*, or *A. laurentiana*. Varieties have been named on the basis of height to lengthen ratios; however, since the ratios intergrade, it is better to disregard these varieties.

A specimen from Quebec is illustrated in place of the unavailable material from Ontario.

SPECIES *Astarte montagui* (Dillwyn)

REFERENCES Antevs (1925, 1939), Goldring (1922), Johnston (1916, 1917)

***Macoma* Leach Figure 14A–D**

One species of *Macoma* reaches a length of more than 100 mm, but the two species found in the Champlain Sea attain a maximum length of about 50 mm and are usually much smaller than that. Shells are ovate to subtrigonal, with a posterior flexure that is usually to the right. The exterior of the shell is generally white, porcellaneous to chalky, and smooth or with faint concentric growth lines. The hinge line has cardinal teeth only, two in each valve. A characteristic feature is the configuration of the pallial sinus, which is of a different size and shape in each valve.

One species, *Macoma balthica*, is particularly abundant throughout the area; the other, *M. calcarea*, is less common but still of widespread occurrence. Both are generally associated with the sand and gravels, although a few specimens have come from the clays of the area.

SPECIES *Macoma balthica* (Linné) [listed as *Tellina groenlandica, Macoma groenlandica,* or *Macoma fragilis* in the earlier literature]; *Macoma calcarea* (Gmelin)

REFERENCES Ami (1884, 1892, 1897, 1902, 1906), Antevs (1925, 1939), Bell (1906), Chalmers (1907), Coleman (1901a, 1901b, 1941), G. M. Dawson (1897), J. W. Dawson (1871, 1893), Dyck and Fyles (1963, 1964), Goldring (1922), Johnston (1916, 1917), Keele and Johnston (1913), Kindle (1918), Leidy (1856), Logan (1863), Lowdon and Blake (1970, 1973, 1979), Richards (1962), Terasmae (1960, 1965), Wagner (1958, 1970), Whiteaves (1901), Whittaker (1922), A. E. Wilson (1956), W. J. Wilson (1898)

***Mya* Linné Figure 15A, B**

This is one of the largest pelecypods to inhabit the Champlain Sea, with specimens as long as 150 mm possible although individuals of 50 to 75 mm in length are more usual. The chalky shell is ovate to elongate in shape, rounded anteriorly, and either produced or truncated posteriorly. The right valve is slightly larger than the left, the valves closing with either an anterior or a posterior gape. Sculpture is lacking, but there may be irregular growth lines. The edentulous hinge has a large, projecting, spoon-shaped chondrophore in the left valve and a recessed ligamental cavity in the right valve. There is a well-developed pallial sinus that is variable in size and shape.

This pelecypod burrows deeply, as much as 30 cm below the sediment-water interface, and thus is often preserved intact, in living position. All records for the genus in Ontario are for *Mya arenaria* and are from the Cornwall area. In Quebec the genus is widely represented by *M. arenaria* and two other species. Most occurrences are in sand.

SPECIES *Mya arenaria* Linné

REFERENCES Chalmers (1907), Terasmae (1960, 1965), Wagner (1970), Whiteaves (1901), Whittaker (1922)

***Hiatella* Bosc (Daudin ms) Figure 15C, D**

The shell is highly variable in form because the animal nestles among pebbles,

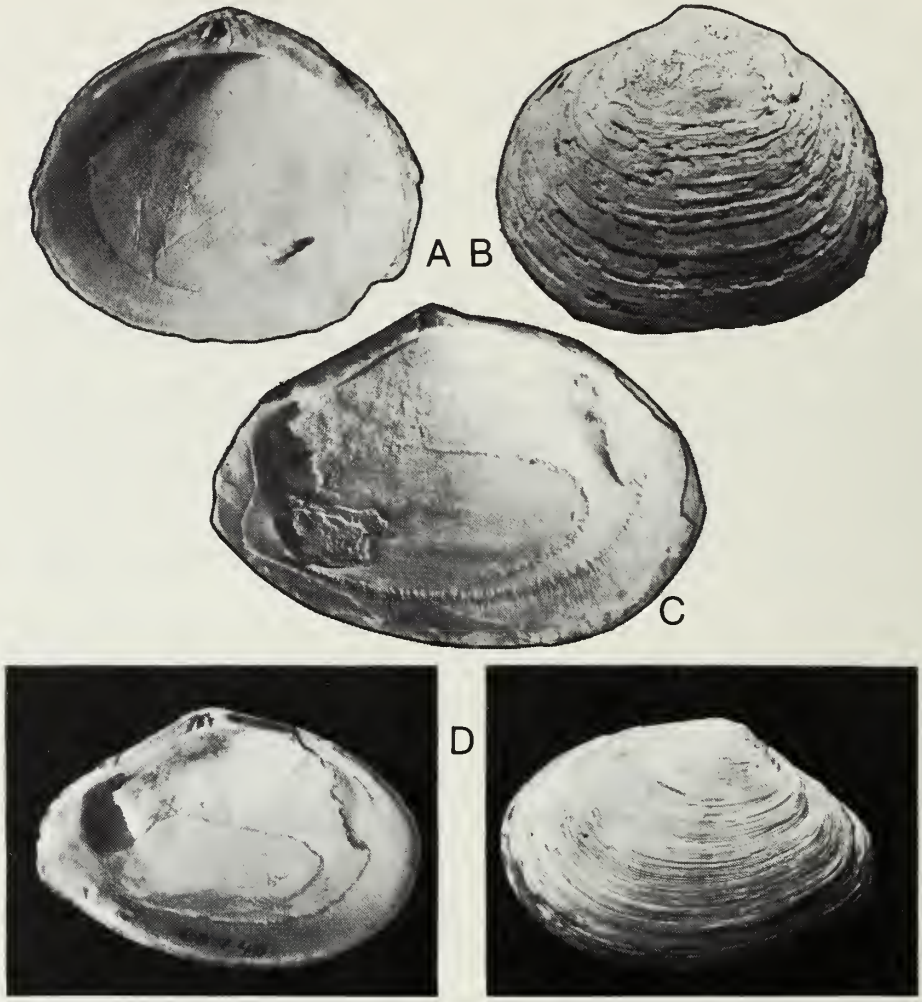


Fig. 14 ***Macoma***

Macoma balthica (Linné)

A Interior of right valve, × 3, GSC 55118, Harrisons Corners, Stormont County, Ontario.

B Exterior of left valve, × 3, GSC 55119, Harrisons Corners, Stormont County, Ontario.

Macoma calcarea (Gmelin)

C Interior of left valve, × 1.5, GSC 55120, Cornwall area, Ontario.

D Interior and exterior view, × 1, GSC 20158, St-Maurice, Quebec. This specimen shows detail of the pallial sinus more clearly.

cobbles, and even boulders, and often burrows into soft rocks. The shape may be quadrate, trapezoidal, or irregular, with a posterior gape. Usually the shell is chalky and heavy and has irregular growth striae. It may reach a length of 75 mm, although most individuals are much less than that. Adults characteristically have an edentulous hinge, but juveniles sometimes have a single, small, ephemeral cardinal tooth in the right valve and two teeth in the left valve. The pallial line is discontinuous and the sinus is small.

The one species encountered is the *Saxicava arctica* of earlier authors, the source of the name for the *Saxicava* sand. Juveniles of this species have two rows of spines running from the umbones to the posterior margin; these spines normally disappear with age. This common species is often found in sand and gravel pits or other exposures of these materials.

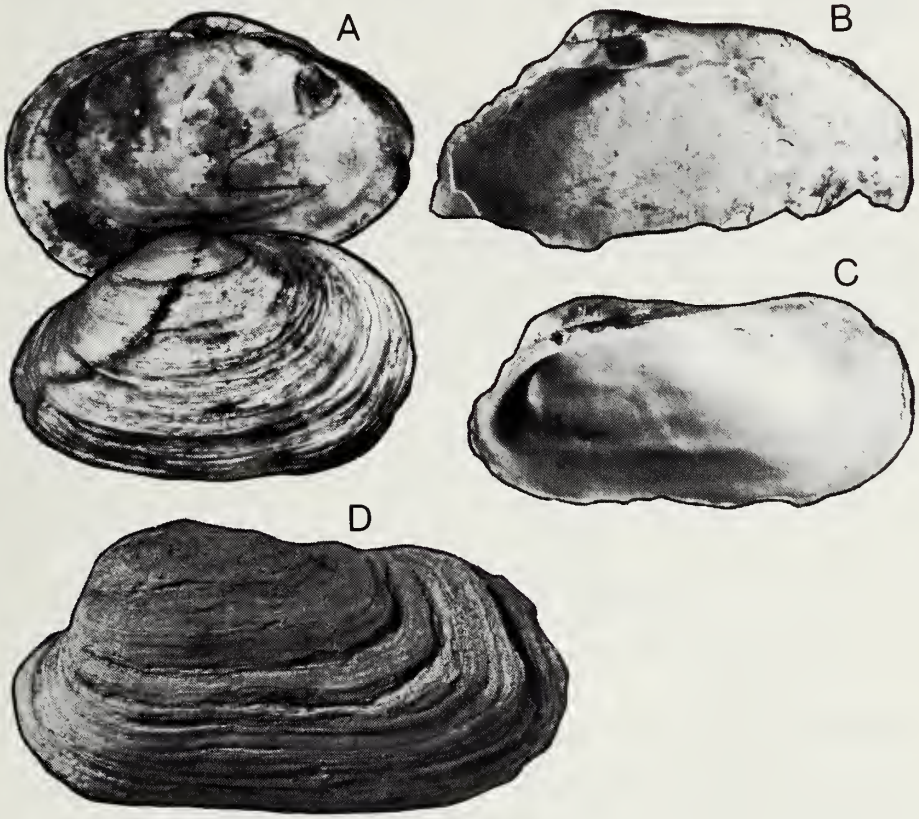


Fig. 15 ***Mya Hiatella***

Mya arenaria Linné

A Interior and exterior views of a right valve, × 1, GSC 20160, St-Rémi, Quebec.

B Interior of a broken left valve showing the chondrophore, × 3, GSC 55121, Cornwall area, Ontario.

Hiatella arctica (Linné)

C Interior of right valve, × 3, GSC 55122, northwest of Moulinette, Ontario.

D Exterior of left valve, × 3, GSC 55123, northwest of Moulinette, Ontario.

SPECIES *Hiatella arctica* (Linné) [*Saxicava arctica* and *Saxicava rugosa* are synonyms]

REFERENCES Ami (1884, 1892, 1897, 1902, 1906), Antevs (1925, 1939), Chalmers (1907), Coleman (1901a, 1901b, 1941), G. M. Dawson (1897), J. W. Dawson (1857, 1871, 1883b, 1893), Goldring (1922), Johnston (1916, 1917), Keele and Johnston (1913), Kindle (1918), Leidy (1856), Logan (1847, 1863), Lowdon and Blake (1973, 1976, 1979), Murray (1852), Richards (1962), Terasmae (1960, 1965), Wagner (1958, 1970), Whiteaves (1901), Whittaker (1922), A. E. Wilson (1956), W. J. Wilson (1898)

Conchostraca (Clam Shrimps) Figure 16

Conchostracans belong to the crustacean class Branchiopoda. The body is enclosed within a translucent bivalve shell which may show various forms of ornamentation in addition to growth lines. Genera are 2 to 16 mm in length and inhabit both freshwater and marine environments.

Cyzicus Audoin Figure 16

This genus is characterized by a thin, pellucid, laterally compressed, subovate shell. The umbonal area is small. There are numerous growth lines. Representatives of the genus attain a length of about 12 mm.

Several incomplete specimens have been found in concretions from Green Creek, near Ottawa. The whereabouts of this material is unknown, and so a diagrammatic presentation of the genus is shown instead.

SPECIES *Cyzicus dawsoni* (Packard) [the original listing is *Estheria dawsoni*]

REFERENCES Coleman (1932), J. W. Dawson (1893)

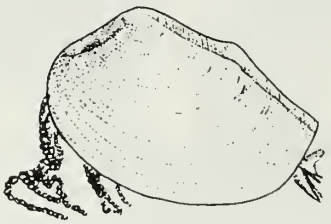


Fig. 16 Diagrammatic presentation of the genus *Cyzicus*, ×3.

Cirripedia (Barnacles) Figures 17 and 18

Anyone who has visited the seacoast will be familiar with the myriads of barnacles encrusting any suitable base of attachment from high-tide level down to the sea floor.

Complete fossils of this crustacean are rarely found. The usual remains are isolated individual wall plates, opercular valves, or opercular plates. Less commonly wall plates are attached to a calcareous basis (basal disc) and are intact. Often only the basal disc will be found, adhering to a stone. Barnacle shell morphology is illustrated in Figure 17.

Three species have been identified in Ontario, only one of which, *Balanus crenatus*, is at all common. It is most abundant in the eastern part of the province, in

the Cornwall area. *B. balanus* has been reported only from the Ottawa district, and *B. hameri*, although more widely distributed, is also rare.

***Balanus* da Costa**

The wall of *Balanus* is formed of six usually rigidly articulated plates. Externally the wall plates may be either ribbed or merely rough. The basis is calcareous.

***Balanus* sensu stricto Figure 18A–D**

The central section (paries) of each wall plate has parietal tubes, whereas the radii (overlapping flanges on either side of the paries) are solid. Species attain a length of about 40 mm.

No complete fossil specimens were available, and so modern ones have been substituted for illustration.

SPECIES *Balanus* (*Balanus*) *balanus* (Linné); *Balanus* (*Balanus*) *crenatus* Bruguière

REFERENCES Ami (1892, 1897, 1902, 1906), Antevs (1925, 1939), Coleman (1901b), Goldring (1922), Kindle (1918), Terasmae (1960, 1965), Wagner (1958, 1970), Whittaker (1922), A. E. Wilson (1956), W. J. Wilson (1898)

***Balanus (Chirona)* Gray Figure 18E–G**

In this subgenus both paries and radii are thin and solid. Specimens may reach a length of about 65 mm.

SPECIES *Balanus* (*Chirona*) *hameri* (Ascanius)

REFERENCES Ami (1906), Wagner (1970), Whittaker (1922)

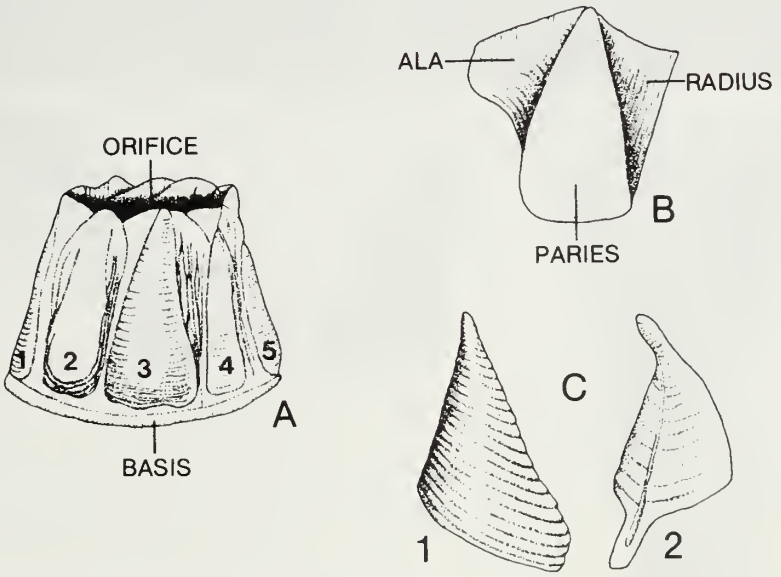
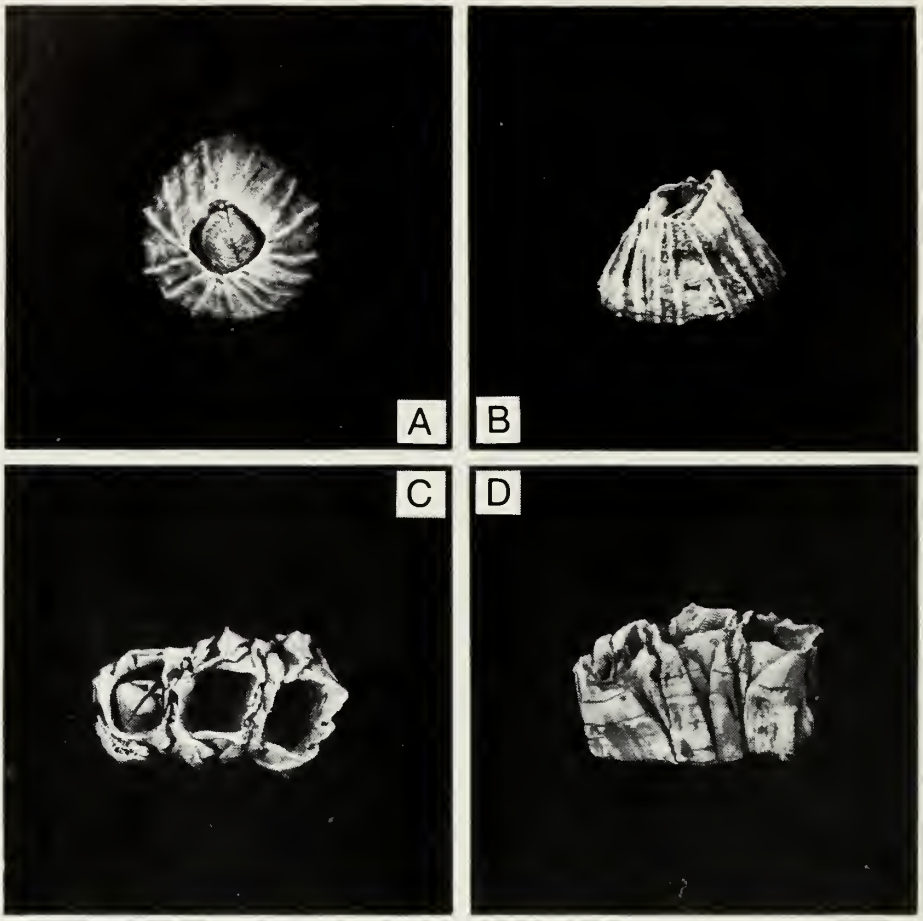
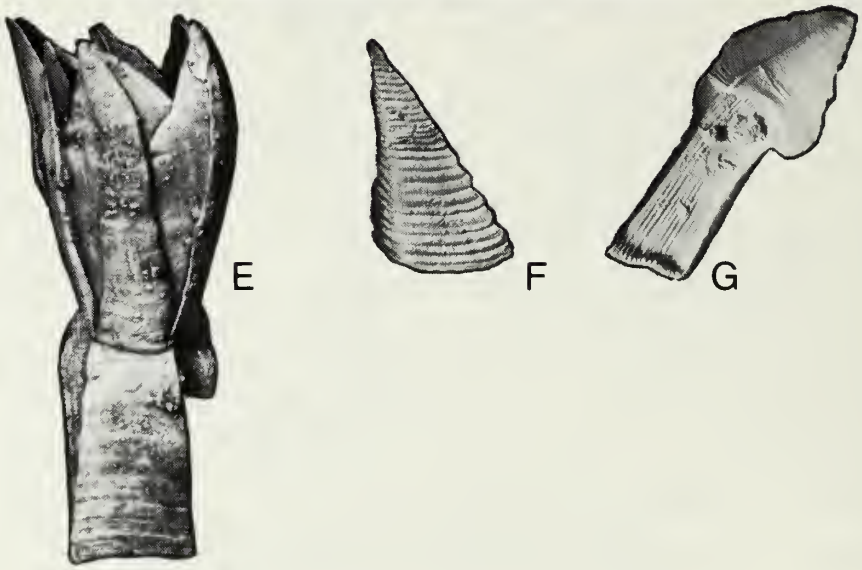


Fig. 17 Morphological terms applied to barnacles.
A 1. Rostrum, 2. Rostrolateral, 3. Lateral, 4. Carinolateral, 5. Carina.
B Compartment with ala on one side and radius on the other.
C 1. Scutum, 2. Tergum.


A
B
C
D


E
F
G

Isopoda (Isopods) Figure 19

These malacostracan crustaceans are often, but not always, shrimplike. The isopod body is elongate, flattened, and made up of a cephalon with seven thoracic and six abdominal somites. The last abdominal somite, or telson, is broad. A familiar terrestrial member of this group is the sow-bug, or pill-bug, common under leaves or piles of decaying vegetation. Other isopods are found in freshwater or marine habitats.

Mesidotea Richardson Figure 19

This form attains a length of about 120 mm. The first thoracic somite envelopes the cephalon laterally; the other thoracic somites are folded downwards laterally. The eyes are dorsal. The length of the pleotelson is more than one quarter that of the body.

A single specimen was discovered in a concretion from the bank of the Ottawa River east of Ottawa.

SPECIES *Mesidotea sabini* Kröyer

REFERENCE Kindle (1928)

Asteroidea (Starfish) Figure 20

These echinoderms have relatively broad, hollow arms that are not normally separated from the central disc. The number of arms may vary from five to many. The arms and disc have a skeleton of calcified ossicles. The ossicles frequently bear spines or have granules distributed over the surface. There is an ambulacral groove on the oral (downward-facing) side of each arm. Asteroids are free-moving. They are capable of regenerating an arm where one has been thrown off to escape capture. General features of asteroids are depicted in Figure 20A.

Crossaster Müller and Troschel Figure 20B

In this genus the arms, which are half as long as the breadth of the disc, may number as many as 15. Individual specimens range between 200 and 300 mm in diameter. At the points of union of the ossicles on the upper (aboral) surface there are club-shaped tubercles that bear smaller spines, giving the arms a distinctive tufted appearance.

Starfish remains are not common. Specimens have been reported only from Green Creek in Ontario and from Montreal in Quebec. No specimen of *C. papposus* was available, and so a sketch has been prepared.

Fig. 18 ***Balanus (Balanus)*** ***Balanus (Chirona)***

Balanus (Balanus) balanus (Linné)

A Top view of adult specimen, × 1, GSC 20190, Atlantic Coast.

B Side view of GSC 20190.

Balanus (Balanus) crenatus Bruguière

C Top view of cluster of three individuals, × 1, GSC 20191, Atlantic Coast.

D Side view of GSC 20191.

Balanus (Chirona) hameri (Ascanius)

E Side view of adult specimen attached to a wall plate of another individual of *B. hameri*, × 1, GSC 20192, St-Philomène, Quebec.

F An opercular plate (scutum), × 1, GSC 55124, Russell County, Ontario.

G A wall plate (or compartment), × 1, GSC 55125, Russell County, Ontario.

Fig. 19 *Mesidotea*
Mesidotea sabini Kröyer
Specimen preserved in a concretion, × 1, GSC 9368, Ottawa River, east of Ottawa, Ontario

SPECIES *Crossaster papposus* (Linné)
REFERENCES Dawson (1893), Goldring (1922), Whiteaves (1901)

Ophiuroidea (Brittlestars) Figures 21 and 22

Ophiuroids are related to the starfish but are distinct in that the arms and central disc are strongly differentiated. Also, the arms are slender and elongate. An individual may throw off pieces of an arm or may completely dismember itself without permanent injury; the lost parts are readily reproduced. Figure 21 illustrates a typical brittlestar.

Four genera have been identified from the Champlain Sea, only two of which have been found in Ontario. Isolated ossicles are sometimes found in the silts and clays; more complete specimens are much rarer.

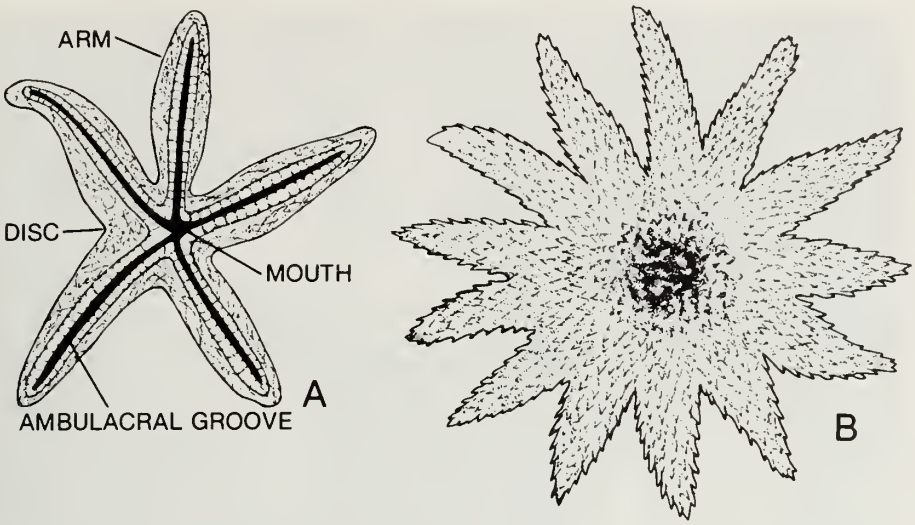


Fig. 20 **Asteroidea** *Crossaster*

A Morphological terms applied to starfish (oral view).

Crossaster papposus (Linné)

B Schematic presentation of a typical specimen (aboral view).

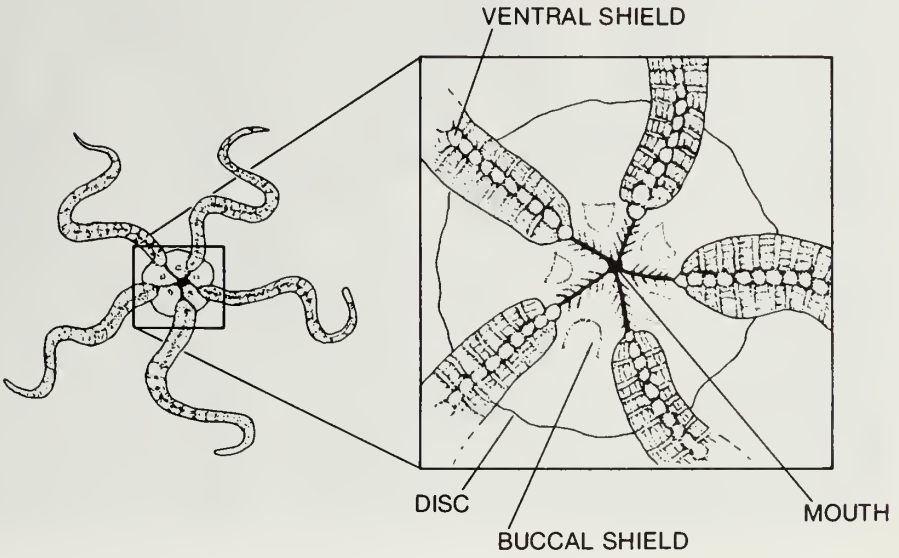


Fig. 21 Morphological terms applied to brittlestars (oral view).

Fig. 22 ***Ophiura***
Ophiura sarsi Lütken
Impression in clay, × 3, Ottawa, Ontario.

Ophiocoma **Agassiz**

This genus has comparatively stout arms that are widest at a distance away from the base. The arm spines are long and solid and the disc is granulate.

Specimens have been reported from several Champlain Sea localities, from Quebec City in the east to Ottawa in the west, but none was identifiable as to species.

SPECIES *Ophiocoma* sp.

REFERENCES Dawson (1871, 1893)

Ophiura **Lamarck Figure 22**

The central disc in this genus is covered with scales. Rudimentary dorsal arm plates fill the notches around the edge of the disc at the bases of the arms. Ventral shields on the arms are usually triangular and are more broad than long. Spines on the arms are vestigial.

The genus has been identified from Montreal and from the Ottawa area; specimens are rare.

SPECIES *Ophiura sarsi* Lütken; *Ophiura* sp.

REFERENCES J. W. Dawson (1857), Wagner (1954)

Polychaeta (Polychaete Worms) Figure 23

The Annelida, the phylum to which the polychaete worms belong, have a distinct head, a segmented trunk, and an unsegmented pygidium. In the class Polychaeta the trunk segments have lateral bundles of bristles termed chaetae. The chitinous jaws are distinctive and are often the only part to be fossilized, although the burrows and calcareous tubes formed by some families are also preserved. Most of these worms are marine, with a comparatively small number of representatives living in fresh or brackish waters.

Two of the three genera recognized in the Champlain Sea deposits have been reported from Ontario.

Nereis **Linné Figure 23A**

Some species may attain a length of 450 mm or more; the species *N. pelagica*, recorded only from Green Creek, reaches a maximum of about 125 mm for females and 50 mm for males. The first segment of the body usually has four tentacles on each side, and the last segment has a pair of long cirri that give the impression of a divided tail.

It has been necessary to provide a sketch for this genus.

SPECIES *Nereis pelagica* Linné

REFERENCES Dawson (1891, 1893), Goldring (1922), Whiteaves (1901)

Serpula **Linné Figure 23B**

This is a tube-building polychaete. The irregularly tapering calcareous tubes are coiled and contorted and have fine concentric ridges on the surfaces. They are attached at the lower end, usually to a shell or rock, and are more or less erect above their point of attachment. The tubes may reach a length of about 100 mm.

Only two localities are known for this genus in Ontario, both in the Ottawa district. Neither specimen was available for illustration, and therefore a drawing has been substituted.

SPECIES *Serpula vermicularis* Linné
REFERENCES Goldring (1922), Wagner (1970)

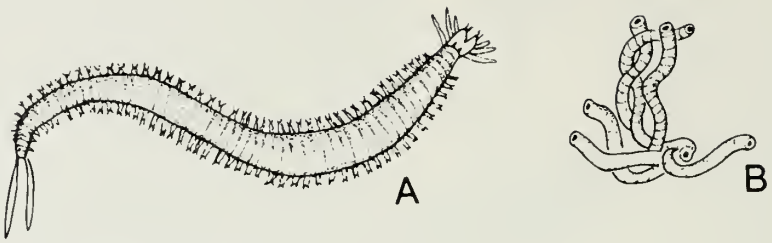


Fig. 23 ***Nereis Serpula***
Nereis pelagica Linné
A Diagrammatic presentation, × 1.
Serpula vermicularis Linné
B Diagrammatic presentation of several calcareous tubes, × 0.7.

Vertebrata

Chordata Figures 24 to 32

A vertebrate find is an exciting experience. The most rewarding locale is the area between Green Creek and Hiawatha Park on the south side of the Ottawa River, where concretions bearing relatively complete fish skeletons are commonly eroded out of the clays. The concretions have yielded six genera of fish and, as well, some limb bones and part of the lower jaw of a young seal. Seal and whale bones are rare in the Champlain Sea; they have been found in sand and gravel deposits near Ottawa.

Pisces

Figure 24 illustrates various terms related to fish morphology.

Clupeiformes

This is the order of fish to which the capelin and smelts belong. They have a short dorsal fin, the base of which is shorter than one-third of the total length of the body (the total body length is the distance from the tip of the snout to the end of the vertebral column). The dorsal fin is situated at about the midpoint of the body, and the base of the pelvic fin is below the dorsal fin.

***Mallotus* Cuvier Figure 25**

Capelin may grow as long as about 230 mm but are usually shorter. The body is elongate and compressed. The length of the head (the distance from the tip of the snout to the most posterior part of the opercular membrane) is about one-quarter of the total length. The dorsal fin, inserted about midway between the snout and the tip of the tail, has 12 to 15 rays. The anal fin, with 18 to 23 rays, has a longer base than that of the dorsal fin. The two pelvic fins are inserted below the dorsal fin, and the

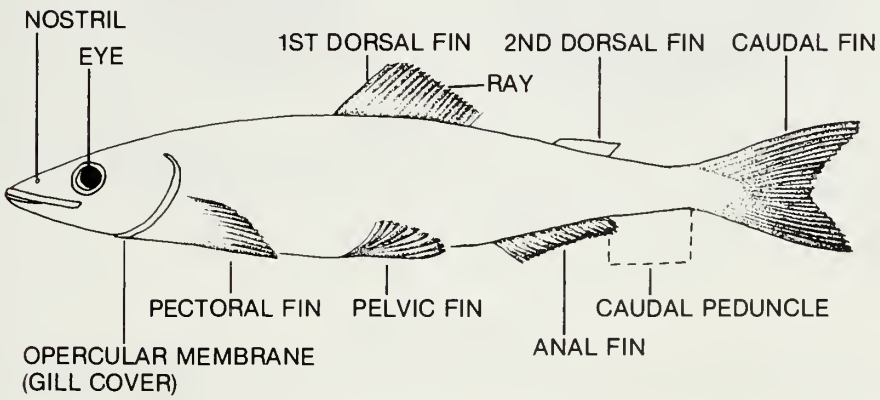


Fig. 24 Morphological terms applied to fish.

pectoral fins are just behind the gill openings. The pectoral fins are broadly based. The scales on this genus are small.

Specimens have been collected from the Ottawa River drainage area above Ottawa, as well as from the classic Green Creek locality.

SPECIES *Mallotus villosus* (Müller)

REFERENCES Ami (1884, 1887, 1897, 1902), Champagne, Harington, and McAllister (1979), Coleman (1901b), J. W. Dawson (1871, 1878, 1891, 1893), Ells (1907), Goldring (1922), Harington (1971, 1972, 1977), Johnston (1917), Lambe (1914), Leidy (1856), Logan (1863), Lyell (1845), McAllister, Cumbaa, and Harington (1981), Murray (1852), Wagner (1970)

***Osmerus* Lacépède Figure 26**

Smelts are slender fish; their body is deepest anterior to the dorsal fin and tapers towards the head and tail. The head is pointed, with the lower jaw projecting slightly beyond the upper. Individuals may reach a length of 350 mm, but most range between 200 and 250 mm in length. The dorsal fin, with 9 to 11 rays, is situated at about the middle of the back; this fin is higher than long. The anal fin has 15 to 18 rays and is longer than it is high. The caudal fin is deeply forked. Pectoral fins lie immediately behind the gill openings, and the abdominally placed pelvic fins are below the anterior part of the dorsal fin.

Like *Mallotus, Osmerus* has been found in a concretion from Green Creek. In *Osmerus* the mouth opening extends behind the eyes, whereas in *Mallotus* the mouth extends posteriorly only to about the middle of the eye. There are also differences in the numbers of the rays in the dorsal and anal fins and in body proportions.

SPECIES *Osmerus mordax* (Mitchill)

REFERENCES Champagne, Harington, and McAllister (1979), Coleman (1901b), J. W. Dawson (1891, 1893), Harington (1971, 1972, 1977), McAllister, Cumbaa, and Harington (1981)

Gadiformes

Specimens of this order from Ontario are of the tomcod (genus *Microgadus*).

***Microgadus* Gill Figure 27A**

The tomcod is slender, reaching a maximum length of about 300 mm. The mouth is short and there is a small barbel hanging from the lower jaw. This genus differs from most in having three dorsal fins rather than the usual two. The caudal fin is rounded. The anal fin is divided into two parts. Pectoral fins reach backwards as far as the vent, but the pelvic fins below them are shorter.

Two specimens were found in concretions east of Ottawa in 1979. A sketch illustrating a whole fish has been substituted for the line drawing of part of an individual that accompanied the report of the presence of this genus in Ontario.

SPECIES *Microgadus tomcod* Walbaum

REFERENCE McAllister, Cumbaa, and Harington (1981)

Gasterosteiformes

Fish belonging to this order are usually small, 150 mm or less in length. The dorsal, anal, and pelvic fins have sharp spines. Sticklebacks are members of this order.

Fig. 25 ***Mallotus***
Mallotus villosus (Müller)
Specimen in a concretion, × 1,
GSC 6597a, Green Creek, Ontario.

Fig. 26 ***Osmerus***
Osmerus mordax (Mitchill)
Skeleton preserved in a concretion,
× 1.1, NMC 35801 B, Green Creek
area, Ontario.

Gasterosteus **Linné Figure 27B**

Sticklebacks have a rather stout body with a very slim caudal peduncle. Maximum length is 100 mm, but most individuals do not exceed about 75 mm. The lower jaw of the small mouth protrudes beyond the upper. A characteristic feature is the presence of three, on rare occasion four, isolated serrated spines in front of the dorsal fin. The dorsal fin has 10 to 14 (usually 12) rays. The caudal fin is truncate, not forked. Origin of the anal fin is behind that of the dorsal. The pelvic fin has one soft ray plus a single strong spine, and the pectoral fins are large and are situated a short distance behind the gill opening.

The concretions of Green Creek and vicinity have provided the only remains of this fish known in the Champlain Sea deposits.

SPECIES *Gasterosteus aculeatus* Linné; *Gasterosteus* sp.

REFERENCES Ami (1902), Champagne, Harington, and McAllister (1979), Coleman (1901b), J. W. Dawson (1871, 1878, 1891, 1893), Goldring (1922), Harington (1971, 1972, 1977), McAllister, Cumbaa, and Harington (1981)

Perciformes

Two of the fish identified from the Champlain Sea, the sculpins (*Artediellus*) and lumpsuckers (*Cyclopterus*), belong to this large order.

Artediellus **Jordan**

The body is elongate but stout. Sculpins are generally small, and the possible species from the concretions does not reach more than 100 mm in length. The large head, with prominent eyes placed high, is distinguished by a long, hooklike spine on each cheek. The gill coverings end in a covered spine high on each side. The mouth is terminal and ends under the middle of the eye. Two dorsal fins are present: a soft anterior one beginning over the gill opening, followed by a spinous one with 12 to 14 rays. The caudal fin is small and spade-shaped. The anal fin, with 10 to 12 rays, is situated under the second dorsal fin. The pectoral fins are large, reach back as far as the beginning of the anal fin, and have 20 to 22 rays. The long, slender pelvic fins are on the ventral edge under the forward edge of the pectorals.

In the Champlain Sea deposits *Artediellus* has been found only in the Green Creek area. This specimen should properly be referred to as *Artediellus* sp. until it can be confirmed whether it is *A. uncinatus* or *A. atlanticus*. The whereabouts of the specimen is unknown and no illustration was available.

SPECIES *Artediellus* sp. [recorded previously as *Cottus* sp., *Cottus uncinatus*, *Cottus* (*Centrodermichthys*) *uncinatus*, and *Artediellus uncinatus* (Reinhardt)]

REFERENCES Ami (1897, 1902), Champagne, Harington, and McAllister (1979), Coleman (1901b), J. W. Dawson (1878, 1891, 1893), Harington (1971, 1972, 1977), Johnston (1917), Logan (1863), McAllister, Cumbaa, and Harington (1981)

Cyclopterus **Linné**

The lumpsucker has a stout, thick body with a small head. The eye is small, as is the mouth; the angle of the mouth is in front of the eye. Maximum length for specimens of the species from the Champlain Sea, as recorded by J. W. Dawson (1871), is 610 mm, but specimens found in concretions would be much smaller than this. The anterior dorsal fin is visible only in small specimens (less than 30 mm long); in larger specimens it is enclosed in a hump that is covered in hard, wartlike tubercles. The

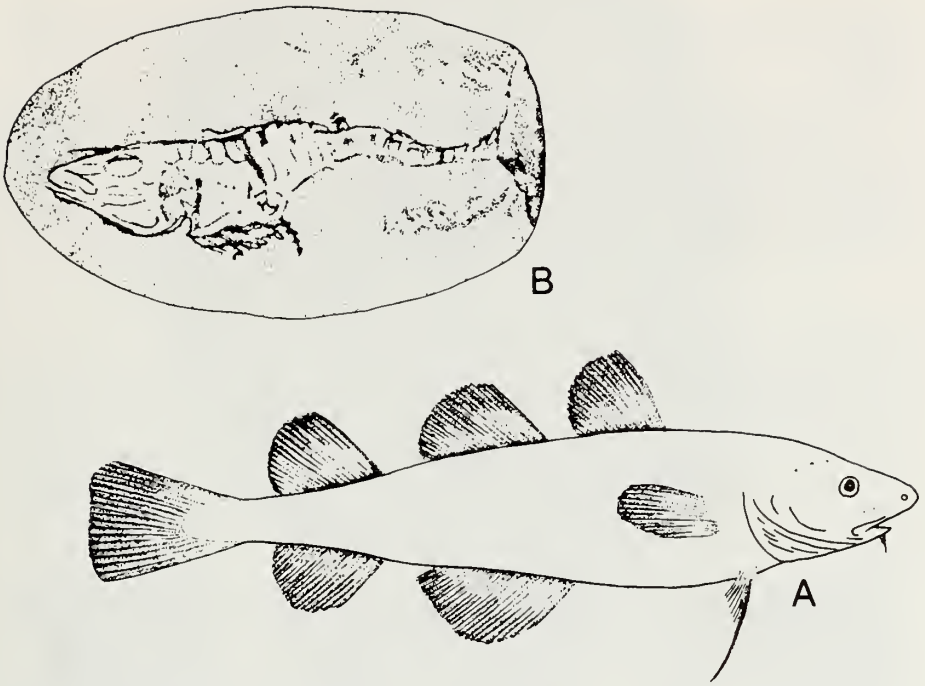


Fig. 27 ***Microgadus Gasterosteus***
Microgadus tomcod Linné
A Sketch to show general features of the species.
Gasterosteus aculeatus Linné
B Drawing of a specimen in a concretion, from J. W. Dawson (1893), × 0.6.

posterior dorsal fin has 10 or 11 rays and is located behind the hump. The caudal fin is slightly rounded. The anal fin, with 9 to 11 rays, is below the posterior dorsal fin and is similar in size to it. Pectoral fins are large and extend along the lower two-thirds of the gill opening; they have 20 or 21 rays. Pelvic fins, situated on the ventral side between the bases of the pectorals, are reduced to fleshy knobs, which, with a surrounding circular flap of skin, form sucking discs, a feature not likely to be preserved in fossil specimens.

Like the other genera of fish, *Cyclopterus* has been identified from a concretion from Green Creek. The whereabouts of this specimen is unknown and no illustration was available.

SPECIES *Cyclopterus lumpus* Linné [one early record shows it as *Cyclopteris*]

REFERENCES Ami (1884, 1897), Champagne, Harington, and McAllister (1979), Coleman (1901b), Dawson (1871, 1878, 1891, 1893), Goldring (1922), Harington (1971, 1972, 1977), Leidy (1856), Logan (1863), McAllister, Cumbaa, and Harington (1981), Murray (1852)

Mammalia

Two orders of marine mammals, namely Cetacea (whales) and Pinnipedia (seals), are represented. Most finds have been of isolated bones or incomplete skeletons,

although essentially complete seal skeletons were found at Montreal and Tétreauville, Quebec, and whale skeletons were unearthed at Cornwall, Ontario, and Daveluyville, Quebec.

Identification of bones would need the services of an expert, and I will not attempt to describe whale and seal skeletons here. The larger museums [Royal Ontario Museum (ROM) in Toronto and the National Museum of Natural History (NMC) in Ottawa] have vertebrate palaeontologists on staff, and vertebrate specialists may be contacted in some of the universities in the province.

Cetacea

***Delphinapterus* Lacépède Figure 28**

This is the white whale, or beluga, a small whale that may reach a length of 5 m but that usually has a maximum length between 3 and 4 m. White whales are common on the Gulf of St. Lawrence at present and often travel up the St. Lawrence River as far as Quebec City. Bones have been found in the Champlain Sea sands in the vicinity of Ottawa (Jock River, Ottawa East, Rideau Junction, Uplands) and at Pakenham, Cornwall, and Williamstown.

SPECIES *Delphinapterus leucas* Pallas [recorded as *Beluga catodon, Beluga vermontana, Delphinapterus catodon, Delphinapterus* (*Beluga*) *catodon,* and *Delphinapterus vermontanus*]

REFERENCES Billings (1870), Coleman (1901a), J. W. Dawson (1871, 1893), Dyck et al. (1966), Harington (1971, 1972, 1977, 1981), Lambe (1910, 1914), Laverdière (1950), Lowdon and Blake (1979), Perkins (1908), Selwyn (1872), Sternberg (1951), Whiteaves (1907)

***Megaptera* Gray**

Part of a skeleton of a humpback whale was found in a gravel pit at an elevation of about 128 m (420 ft) at Warwick, near Smiths Falls, Ontario, in 1882. The female humpback whale averages about 15 m in length; males are smaller.

SPECIES *Megaptera novaeangliae* Borowski [*M. longimana* Gray is a synonym]

REFERENCES Coleman (1901a, 1901b, 1941), J. W. Dawson (1883a, 1883b, 1893), Harington (1971, 1972, 1977, 1981), Laverdière (1950)

***Balaena* Linné Figure 29**

A characteristic of the bowhead whale is that the length of its head is more than one-third that of its body. Total length is about 20 m. The baleen plates, of which there are approximately 360 on each side of the mouth, measure 35 cm wide by 3 m long. Bones of a right pectoral flipper, ribs, and part of a jaw, all probably from one individual, were collected near White Lake, Ontario.

SPECIES *Balaena mysticetus* Linné

REFERENCES Harington (1977, 1981), Lowdon and Blake (1979)

Pinnipedia

***Phoca* Linné**

This is a genus of aquatic mammals in which the limbs have developed as flippers. Generally the females are much smaller than the males. Two subgenera are represented in the Champlain Sea.

Fig. 28 ***Delphinapterus***
Delphinapterus leucas Pallas
Cranium (top view showing blow hole) and mandibles, × 0.3, NMC 21336, near Pakenham, Ontario.

Fig. 29 ***Balaena***
Balaena mysticetus Linné
Right humerus, × 0.3, NMC 29414, near White Lake, Renfrew area, Ontario.

Phoca (Pagophilus) **Gray Figure 30**

Harp seals attain a maximum length of just under 2 m. Isolated bones that may be of this genus have been reported from the clays in and around Ottawa. The only specimen that can be referred definitely to a harp seal is part of the lower jaw of a young individual preserved in a concretion at Green Creek.

SPECIES *Phoca (Pagophilus) groenlandica* (Erxleben) [listed in earlier records as *Phoca groenlandica, Pagophilus groenlandicus,* and *Phoca* sp.]

REFERENCES Ami (1884, 1892, 1897, 1902), Coleman (1910b), J. W. Dawson (1878, 1893), Grant (1883), Harington (1971, 1972, 1977, 1981), Laverdière (1950), Sternberg (1951)

Phoca (Pusa) **Scopoli Figure 31**

The ringed seal is the smallest of the pinnipeds, with an average length of 1.4 m. At present, it is seldom found south of the Strait of Belle Isle. A single bone was found in 1975, in a sand pit near Uplands (now Ottawa International) Airport, Ottawa. However, the almost complete specimen from Tétreauville (now in the western part of Hull), Quebec, is much more impressive and has therefore been used to illustrate this form.

SPECIES *Phoca hispida* Schreber

REFERENCE Harington (1977, 1981)

Erignathus **Gill Figure 32**

Bearded seals reach a maximum length of just under 2 m when adult. These seals usually feed in shallow water, and molluscs form an important part of their diet. Part of a cranium, minus teeth, was collected near Finch, Ontario.

SPECIES *Erignathus barbatus* Erxleben

REFERENCES Harington (1977, 1981)

Fig. 30 ***Phoca (Pagophilus)***
Phoca (Pagophilus) groenlandica (Erxleben)
Drawing of a part of the lower jaw of a young harp seal in a concretion from Green Creek, from J. W. Dawson (1893).

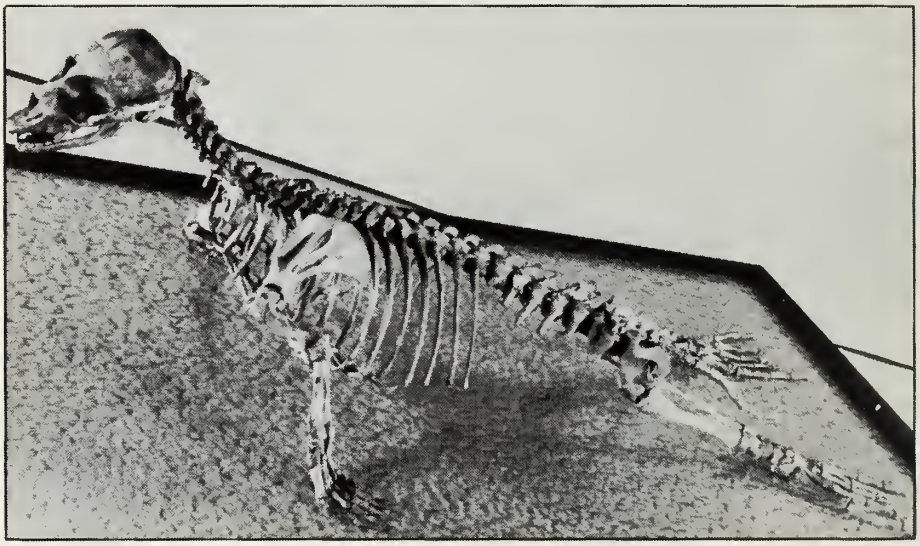


Fig. 31 ***Phoca (Pusa)***
Phoca (Pusa) hispida Schreber
Ringed seal skeleton (NMC 6830) on display in the National Museum of Natural Sciences, Ottawa. Specimen from Tétreauville, in the western part of Hull, Quebec. NMC Photo 72–1540.

Fig. 32 ***Erignathus***
Erignathus barbatus Erxleben
View of top of skull, × 0.8, ROM 985, near Finch, Ontario. NMC Photo 75-5772.

Nonmarine Species

Figure 33

Concretions from the Green Creek deposits have yielded a number of species of nonmarine origin (both fauna and flora), suggesting that, at this point in time, the area formed the margin of the retreating Champlain Sea. Among the species identified are insects, freshwater fish, a small terrestrial mammal, birds (several feathers discovered, Fig. 33A), and a variety of plants (Fig. 33B). Although these are not species that owed their presence to the Champlain Sea, they are ones that apparently had become fossilized in the marginal environment of the sea. The most comprehensive list is given by Ami (1902). Harington (1971, 1972, 1978) and Harington and Occhietti (1980) mention the more recent discoveries.

A paper by Gadd (1980) gives an up-to-date discussion of the conglomeration of marine, freshwater, and terrestrial species found in the concretions at Green Creek and vicinity, and of their possible relative ages.

Insecta

Trichoptera (caddisflies)

Phryganea ejecta Scudder Ami (1902), Coleman (1932)

Coleoptera (beetles)

Tenebrio calculensis Scudder Ami (1902), Coleman (1932), Scudder (1895)

Fornax ledensis Scudder Ami (1902), Coleman (1932), J. W. Dawson (1893), Scudder (1895)

Byrrhus ottawensis Scudder Ami (1902), Coleman (1932), Scudder (1895)

Pisces (freshwater fish)

Myoxocephalus thompsoni (Girard) [deepwater sculpin] Champagne, Harington, and McAllister (1979), McAllister, Cumbaa, and Harington (1981)

Salvelinus (*Cristivomer*) *namaycush* (Walbaum) [lake char] Champagne, Harington, and McAllister (1979), Harington (1971, 1972, 1978), McAllister, Cumbaa, and Harington (1981)

Coregonus cf. *C. artedii* Le Sueur [cisco] McAllister, Cumbaa, and Harington (1981)

Mammalia

Martes americana (Turton) [marten] Harington (1971, 1972)

Aves

Feathers of "small wading birds", according to J. W. Dawson, plus a single bird vertebra from the sands near Uplands (now Ottawa International) Airport, Ontario. J. W. Dawson (1893), Harington (1971, 1972, 1978), Harington and Occhietti (1980).

Fig. 33 Nonmarine fossils
A Impression of a feather in a concretion, × 1, GSC 6600, Green Creek, Ontario.
B Leaf impression in a concretion, × 1, GSC 32381, Green Creek, Ontario.

Plantae (listed alphabetically)

Ami (1902), J. W. Dawson (1893), Penhallow (1900)

Descriptions and illustrations of species for which common names are given can be found in McKay and Catling (1979) or Niering and Olmstead (1979). Names, and

therefore identity, of the other plants could not be confirmed.

Acer saccharinum (silver maple)
Acer spicata (mountain maple)
Algae spp.
Alnus sp. (alder)
Arctostaphylos uva-ursi (bearberry)
Betula lutea (yellow birch — now known as *B. alleghaniensis*)
Brasenia peltata
Bromus ciliatus ?
Carex magellanica
Carices or Gramineae spp.
Cyperaceae (sedges)
Drosera rotundifolia (round-leaved sundew)
Elodea canadensis [=*Anacharis canadensis*] (common waterweed)
Encyonema prostratum ?
Equisetum limosum ?
Equisetum scirpoides ?
Equisetum sylvaticum (woodland horsetail)
Fontinalis sp.
Fucus digitatus
Fucus sp. or *Ulva* sp.
Gaylussacia resinosa [=*G. baccata*] (black huckleberry)
Gaylussacia sp. (huckleberry)
Hypnum fluitans
Graminea resinosa ?
Oryzopsis asperifolia
Populus balsamifera (balsam poplar)
Populus grandidentata (large-toothed aspen)
Potamogeton natans
Potamogeton pectinatus ?
Potamogeton perfoliatus ?
Potamogeton pusillus ?
Potamogeton rutilans
Potentilla anserina (silverweed)
Potentilla canadensis (Canadian dwarf cinquefoil)
Potentilla norvegica (rough cinquefoil)
Potentilla tridentata
Thuja occidentalis (eastern white cedar)
Trifolium repens (white clover)
Typha latifolia (common cattail)
Valisneria spiralis ?
Valisneria sp. (tape grass)

Repositories of Illustrated Specimens

GSC Geological Survey of Canada
NMC National Museums of Canada
ROM Royal Ontario Museum

Glossary of Morphological Terms

abaxial (Gastropoda)—outwards away from the shell axis.

adapical (Gastropoda)—towards the apex of the shell, along the axis or slightly oblique to the axis.

adaxial (Gastropoda)—inwards towards the shell axis.

adductor muscle (Pelecypoda)—a muscle, commonly one of two, connecting the two valves and tending to draw them together.

ambulacral groove (Asteroidea)—an axial depression along the oral surface of the arm and covered by a series of ambulacral ossicles.

ambulacrum (Asteroidea)—one of the radial areas bearing the tubular protrusion by which locomotion is accomplished.

anal fin (Pisces)—a median unpaired fin on the ventral margin between the anus and the caudal fin.

anterior canal (Gastropoda)—see **siphonal canal**.

anteroposterior (Pelecypoda)—in a front-to-back direction.

aperture (Gastropoda)—an opening at the last-formed margin of the shell, providing an outlet for the head and foot.

apex (Gastropoda)—top of the shell.

apical (Gastropoda)—referring to the apex.

aster (Porifera)—microsclere rays diverging from a central point.

avicularium (Bryozoa)—a specialized zooid with smaller polypide but with strong muscles that operate a mandiblelike operculum; resembles the head of a bird.

axial (Gastropoda)—parallel or subparallel with the axis of the shell.

axis (Gastropoda)—an imaginary line through the apex of the shell and about which the whorls are coiled.

baleen (Cetacea)—one of the fibrous plates in the mouth through which food is strained.

barbel (Pisces)—a slender, whiskerlike tendril on the head of certain fishes.

basis; pl. bases (Cirripedia)—a calcareous or membraneous plate serving to attach the barnacle to the substrate or to a foreign body.

beak (Pelecypoda)—a noselike angle located along or above the hinge margin and marking the point where growth of the shell started.

calcareous (general)—composed of calcium carbonate.

callus (Gastropoda)—a smooth, shelly layer on the parietal region or extending from the inner lip over the base or into the umbilicus.

cardelle (Bryozoa)—same as **condyle**.

cardinal tooth (Pelecypoda)—a hinge tooth situated close to the beak.

carina (Cirripedia)—a single compartment plate situated at the end of the shell where the cirri are protruded.

caudal fin (Pisces)—a terminal vertical fin; tail.

caudal peduncle (Pisces)—a slender posterior portion of the body situated between the anal and caudal fins.

centrum (Porifera)—the middle part of a spicule from which rays diverge irregularly.

cephalon (Isopoda)—head.

chaeta; pl. chaetae (Polychaeta)—a bristle.

chamber (Porifera)—a cavity containing the operative flagellate cells.

chitinous (Polychaeta)—horny.

chondrophore (Pelecypoda)—a process with a hollowed-out surface for attachment of the internal ligament.

cirrus; pl. cirri (Polychaeta)—a filament.

collabral (Gastropoda)—conforming to the shape of the outer lip, as shown by growth lines.

columella (Gastropoda)—a solid or hollow pillar surrounding the axis of a coiled shell and formed by the adaxial walls of the whorls.

concentric (Pelecypoda)—having a direction coinciding with that of the growth lines.

condyle (Bryozoa)—a rounded protuberance for hingement of the operculum.

corneous (Gastropoda)—consisting of a horny substance.

crenate (Pelecypoda)—with notches along the edge or crest (as of ribs).

crenulate (Pelecypoda)—minutely crenate.

disc (Asteroidea, Ophiuroidea)—the central part of the body, more or less distinctly separable from the arms.

dorsal (Pelecypoda)—referring to the region of the hinge.

dorsal fin (Pisces)—a fin developed on the back.

edentulous (Pelecypoda)—lacking hinge teeth.

euaster (Porifera)—an aster lacking a centrum.

foliate (Bryozoa)—of thin, leaflike layers.

fusiform (Gastropoda)—a slender spindle shape tapering almost equally towards both ends.

globose (Gastropoda)—more or less spherical, rounded.

groove (Asteroidea)—see **ambulacral groove**.

growth line (Pelecypoda, Gastropoda)—a line on the surface of the shell marking the position of the shell margin at some stage of growth.

helicocone (Gastropoda)—a distally expanding coiled tube that forms most gastropod shells.

hinge plate (Pelecypoda)—a shelly internal platform bearing hinge teeth and situated below the beak, adjacent to parts of the dorsal margin.

hinge tooth (Pelecypoda)—a shelly structure, usually one of a series, adjacent to the dorsal margin, and received by a socket in the opposite valve; hinge teeth serve to hold the closed valves in position.

imperforate (Bryozoa)—lacking perforations.

infaunal (Pelecypoda)—living burrowed into the substrate.

inner lip (Gastropoda)—the adaxial margin of the shell aperture, extending from the foot of the columella to the suture.

involute (Gastropoda)—having the last whorl enveloping the earlier ones, so that the height of the aperture corresponds to the height of the shell.

ligament (Pelecypoda)—a horny, elastic structure, or structures, joining the two valves of the shell dorsally and serving as a spring, causing the valves to open when the adductor muscles relax.

longitudinal septum (Cirripedia)—a wall of tubes disposed at right angles to the inner and outer laminae of the compartment plate and separating them.

lunule (Pelecypoda)—a depression, commonly heart-shaped, situated anterior to the beaks in many bivalves.

megasclere (Porifera)—a spicule that is an element of the framework of the organism.

microsclere (Porifera)—a spicule that is loose in the flesh and does not form a part of the skeletal framework; microscleres are rare in fossils.

nacreous (Gastropoda, Pelecypoda)—lustrous, pearly.

opercular membrane (Pisces)—a gill cover.

opercular valve (Cirripedia)—a moveable plate in the orifice.

operculum (Bryozoa)—a small calcareous or chitinous lamina articulating on condyles (cardelles) that project from the edge of the orifice.

operculum (Gastropoda)—a corneous or calcareous structure borne by the foot and serving for closure, wholly or in part, of the aperture.

opisthogyrate (Pelecypoda)—curved so that the beaks point posteriorly; a term applied to the umbones.

oral (Asteroidea, Ophiuroidea)—referring to the surface of the animal that contains the mouth and that is directed downwards.

orifice (Bryozoa)—the primary opening of the zooecium, for extrusion of the polypide.

orifice (Cirripedia)—an opening in the upper part of the barnacle shell, containing the opercular valves.

ossicle (Asteroidea, Ophiuroidea)—any individual calcified element of the skeleton, usually referring to the larger of such elements.

outer lip (Gastropoda)—abaxial margin of the aperture, extending from the suture to the foot of the columella.

ovate (Pelecypoda)—shaped like the longitudinal section of an egg.

ovicell (Bryozoa)—any structure serving to contain the larvae during their development.

pallial line (Pelecypoda)—a line or narrow band on the interior of the valve, close to the margin, and marking the line of attachment of the marginal muscles of the mantle.

pallial sinus (Pelecypoda)—an embayment of the pallial line, forming the line of attachment of the siphonal retractor muscle.

paries; pl. parietes (Cirripedia)—the median, triangular part of the compartment (wall) plate, with the lower edge attached to the basis.

parietal region (Gastropoda)—an area of the basal surface of the helicocone, just inside and just outside the aperture.

parietal tube (Cirripedia)—one of the myriad porelike canals in the longitudinal septum.

pectoral fin (Pisces)—either of a pair of fins usually situated behind the head, one on each side; pectoral fins correspond to the forelimbs of higher vertebrates.

pellucid (Conchostraca)—translucent.

pelvic fin (Pisces)—either of a pair of fins on the lower surface of the body; these fins correspond to the hind limbs of higher vertebrates.

perforate (Gastropoda)—with a cavity or depression.

periostracum (Pelecypoda)—a thin coat of horny material that covers the exterior of the calcareous shell.

peristome (Gastropoda)—the margin of the aperture.

pleotelson (Isopoda)—a structure formed by the fusion of one or more abdominal somites with the telson.

polypide (Bryozoa)—the soft parts of the zooid.

porcellaneous (Pelecypoda)—of translucent, porcelainlike appearance.

pseudocardinal (Pelecypoda)—an irregularly formed tooth situated close to the beak.

punctations (Gastropoda)—minute pits.

pygidium (Polychaetia)—tail section.

quadrate (Pelecypoda)—square, or almost so.

radial (Pelecypoda)—a direction of growth outwards from the beak, commonly indicated by the direction of ornamentaiton.

radiate (Porifera)—with spicules radiating outwards from a central point.

radius; pl. radii (Cirripedia)—the lateral part of a compartment plate adjoining the paries and marked off from it by a change in the direction of growth lines and by a depressed exterior surface.

resilifer (Pelecypoda)—a recess or process for the attachment of an internal ligament.

reticulate (Gastropoda)—ornamentation consisting of a network of obliquely intersecting linear ridges.

rib (Gastropoda)—a round-topped elevation of moderate width and prominence, disposed collabrally on the shell surface.

rostrate (Pelecypoda)—having a pointed, beaklike posterior end.

shoulder (Gastropoda)—angulation on the whorl forming the abaxial edge of the sutural ramp or shelf.

siphonal canal (Gastropoda)—a tubular or troughlike extension of the anterior (abapical) part of the apertural margin.

somite (Isopoda)—a division of the body in the cephalon, thorax, and abdomen; the exoskeleton of each somite comprises a body-ring that is generally divisible into a dorsal and a ventral portion.

sphaeraster (Porifera)—an aster with a globular centrum.

spicule (Porifera)—a unit of the mineral skeleton of a sponge.

spiral (Gastropoda)—as applied to ornamentation, passing continuously round the whorls almost parallel with the suture.

spire (Gastropoda)—the adapical, visible part of all the whorls exclusive of the last (or body) whorl.

spongin (Porifera)—an organic, tough, flexible material related chemically to horn and hair.

stria; pl. striae (Pelecypoda)—a narrow linear furrow or raised line on the surface of the shell.

striate (Gastropoda)—with a narrowly incised shallow groove, or grooves.

strongyle (Porifera)—a type of megasclere with a single axis and with both ends bluntly rounded.

subglobose (Gastropoda)—almost rounded.

substrate—the base or material on, or in, which an organism lives.

sutural shelf (Gastropoda)—a horizontal flattened band in some shells that adjoins the adapical suture of the whorls.

suture (Gastropoda)—a continuous line on the shell surface, where the whorls adjoin.

taxodont (Pelecypoda)—with numerous, short hinge teeth, some or all of which are transverse to the hinge margin.

telson (Isopoda)—the last somite of the body; tail.

trapezoidal (Pelecypoda)—with four straight sides, no two of which are parallel.

trigonal (Pelecypoda)—three-sided.

trochiform (Gastropoda)—with a flat-sided conical spire and an almost flat base.

umbilicus (Gastropoda)—a cavity or depression formed round the shell axis between the faces of the adaxial walls of the whorls where these do not coalesce to form a solid columella.

umbo (Conchostraca)—the apical portion of either valve.

umbo; pl. umbones (Pelecypoda)—the region of the valve surrounding the point of maximum curvature of the longitudinal dorsal profile and extending to the beak when not coinciding with it.

valve (Pelecypoda)—one of the calcareous structures (two in most pelecypods) of which the shell consists.

ventral shield (Ophiuroidea)—an ossicle of secondary origin on the oral side of the arm.

whorl (Gastropoda)—any complete coil of the helicocone.

zoarium (Bryozoa)—an assemblage of many zooids forming a bryozoan colony.

zooecium (Bryozoa)—a chitinous, double-walled sac, chamber, or tube containing the soft parts or polypide.

zooid (Bryozoa)—a single bryozoan animal, consisting of soft parts and a skeleton.

Literature Cited

ABBOTT, R. T.

1974 American seashells. 2nd ed. New York, Van Nostrand Reinhold. 663 pp.

AMI, H. M.

1884 List of fossils from Ottawa and vicinity. Transactions of the Ottawa-Naturalist Club 2:54–62.

1887 The great ice age and subsequent formations at Ottawa, Ontario. Ottawa Naturalist 1:65–74, 81–88.

1892 Additional notes on the geology and paleontology of Ottawa and its environs. Ottawa Naturalist 6:73–78.

1897 Contributions to the post-Pliocene deposits of the Ottawa Valley. Ottawa Naturalist 11:20–26.

1902 List of fossils to accompany report of Dr. R. W. Ells on the City of Ottawa map. Geological Survey of Canada, Annual Report (n.s.) 12 (1899):51G–56G.

1906 Report of the geology of a portion of eastern Ontario to accompany map-sheet 119. Geological Survey of Canada, Annual Report (n.s.) 14 (1901) pt. J:Appendix.

ANTEVS, E.

1925 Retreat of the last ice sheet in Eastern Canada. Geological Survey of Canada, Memoir 146:66–73.

1939 Late Quaternary upwarpings of northeastern North America. Journal of Geology 47:707–720.

BAYFIELD, H. W.

1837 Notes on the geology of the north coast of the St. Lawrence. Transactions of the Geological Society of London, ser. 2, 5:89–103.

BELL, R.

1906 Summary report of the operations of the Geological Survey for the year 1901. Geological Survey of Canada, Annual Report (n.s.) 14 (1901) pt. A:257A–258A.

BILLINGS, E.

1870 [On the bones of a whale lately discovered in Cornwall, Ont.] Canadian Naturalist (n.s.) 5:438–439.

BOUSFIELD, E. L.

1960 Canadian Atlantic sea shells. Ottawa, National Museum of Canada. 72 pp.

CHALMERS, R.

1907 Artesian borings, surface deposits and ancient beaches in Ontario. Geological Survey of Canada, Annual Report (n.s.) 15 (1902–1903) pt. A:207A–281A.

CHAMPAGNE, D. E., C. R. HARINGTON, and D. E. McALLISTER

1979 Deepwater sculpin, *Myoxocephalus thompsoni* (Girard) from a Pleistocene nodule, Green Creek, Ontario, Canada. Canadian Journal of Earth Sciences 16:1621–1628.

COLEMAN, A. P.
1901a Marine and freshwater beaches in Ontario. Geological Society of America, Bulletin 12:129–146.
1901b Sea beaches in eastern Ontario. 10th Report of the Ontario Bureau of Mines: 215–227.
1932 An interglacial Champlain Sea. American Journal of Science, ser. 5, 24:311–315.
1941 The last million years. Toronto, University of Toronto Press. 216 pp.

COLLINS, H. H., Jr.
1950 Complete field guide to American wildlife, east, central and north. New York, Harper and Row. 683 pp.

DAWSON, G. M.
1897 Summary report on the operations of the Geological Survey for the year 1895. Geological Survey of Canada, Annual Report (n.s.) 8 (1895) pt. A:73A–74A.

DAWSON, J. W.
1857 On the newer Pliocene and post-Pliocene deposits of the vicinity of Montreal. Canadian Naturalist and Geologist 2:401–426.
1871 Notes on the post-Pliocene geology of Canada. Canadian Naturalist (n.s.) 6:19–42, 166–187, 241–259, 369–416.
1878 Note on a fossil seal from the *Leda* clay of the Ottawa Valley. Canadian Naturalist (n.s.) 8:340–341.
1883a On portions of the skeleton of a whale from gravel on the line of the Canadian Pacific Railway, near Smith's Falls, Ontario. Canadian Naturalist (n.s.) 10:385–387.
1883b Canadian Pleistocene. Geological Magazine 10:111–113.
1891 Note on a fossil fish and marine worm found in the Pleistocene nodules of Green's Creek on the Ottawa. Canadian Record of Science 4:86–88.
1893 The Canadian ice age. Montreal, William V. Dawson. 301 pp.

DYCK, W. and J. C. FYLES
1963 Geological Survey of Canada radiocarbon dates I and II. Geological Survey of Canada, Paper 63-21:20.
1964 Geological Survey of Canada radiocarbon dates III. Geological Survey of Canada, Paper 64-40:2.

DYCK, W., J. A. LOWDON, J. G. FYLES, and W. BLAKE, Jr.
1966 Geological Survey of Canada radiocarbon dates V. Geological Survey of Canada, Paper 66-48:8.

ELLS, R. W.
1898 Sands and clays of the Ottawa Basin. Geological Society of America, Bulletin 9:211–222.
1907 Report on the geology and natural resources of the area included in the northwest quarter-sheet, number 122, of the Ontario and Quebec series, comprising portions of the counties of Pontiac, Carleton and Renfrew. Geological Survey of Canada, Publication 977:1–71.

GADD, N. R.
1960 Surficial geology of the Bécancour map-area, Quebec. Geological Survey of Canada, Paper 59-8:1–34.

1963a Surficial geology of the Ottawa map-area, Ontario and Quebec. Geological Survey of Canada, Paper 62-16:1–4.
1963b Surficial geology of the Chalk River area, Ontario and Quebec. Geological Survey of Canada, Map 1132A.
1977 Offlap sedimentary sequence in Champlain Sea, Ontario and Quebec. Geological Survey of Canada, Paper 77-1A:379–380.
1980 Maximum age of a concretion at Green Creek, Ontario. Géographie physique et Quaternaire 34:229–238.

GOLDRING, W.
1922 The Champlain Sea. New York State Museum Bulletin 239-240:135–187.

GRANT, J. A.
1883 On the inferior maxilla of *Phoca Groenlandica* from Green's Creek, Gloucester, Russell Co., Ontario. Royal Society of Canada, Transactions 1:286.

HARINGTON, C. R.
1971 The Champlain Sea and its vertebrate fauna; Part I, The history and environment of the Champlain Sea. Trail and Landscape 5:137–141.
1972 The Champlain Sea and its vertebrate fauna; Part II, Vertebrates of the Champlain Sea. Trail and Landscape 6:33–39.
1977 Marine mammals in the Champlain Sea and the Great Lakes. Annals of the New York Academy of Science 288:508–538.
1978 Quaternary vertebrate faunas of Canada and Alaska and their suggested chronological sequence. Syllogeus 15:1–105.
1981 Whales and seals of the Champlain Sea. Trail and Landscape 15:32–47.

HARINGTON, C. R. and S. OCCHIETTI
1980 Pleistocene eider duck (*Somateria* cf. *mollissima*) from Champlain Sea deposits near Shawinigan, Québec. Géographie physique et Quaternaire 34:239–245.

JOHNSTON, W. A.
1916 Late Pleistocene oscillations of sea-level in the Ottawa Valley. Geological Survey of Canada, Museum Bulletin 24 (Geological Series 33):1–14.
1917 Pleistocene and Recent deposits in the vicinity of Ottawa, with a description of the soils. Geological Survey of Canada, Memoir 101:1–69.

KEELE, J. and W. A. JOHNSTON
1913 The superficial deposits near Ottawa. Geological Survey of Canada, Guide Book 3:126–134.

KINDLE, E. M.
1918 An Ottawa beach of the Champlain Sea. Ottawa Naturalist 32:83–86.
1928 A crustacean new to the Pleistocene fauna of Canada. Canadian Field-Naturalist 42:211–212.

LAMBE, L. M.
1910 Palaeontology and zoology. Geological Survey of Canada, Summary Report for 1909:269–273.
1914 Report of the vertebrate palaeontologist. Geological Survey of Canada, Summary Report for 1913:293–299.

LAVERDIÈRE, J. W.
1950 Baleine fossile de Daveluyville, Québec. Naturaliste canadien 77:271–282.

LEIDY, J.
1856 Note on the remains of a species of seal, from the Post-Pliocene deposit of the Ottawa River. Proceedings of the Academy of Natural Sciences of Philadelphia 8:90–91.

LOGAN, W. E.
1847 Tertiary deposits. *In* Report [on a part of the Ottawa River district]. Geological Survey of Canada, Report of Progress for 1845–46:71.
1863 Stratified clays and sand of eastern Canada. *In* Report on the geology of Canada. Geological Survey of Canada, Report of Progress for 1863:915–930.

LOWDON, J. A. and W. BLAKE, Jr.
1970 Geological Survey of Canada radiocarbon dates IX. Geological Survey of Canada, Paper 70-2(B):60.
1973 Geological Survey of Canada radiocarbon dates XIII. Geological Survey of Canada, Paper 73-7:19.
1976 Geological Survey of Canada radiocarbon dates XVI. Geological Survey of Canada, Paper 76-7:6–7.
1979 Geological Survey of Canada radiocarbon dates XIX. Geological Survey of Canada, Paper 79-7:12–13.

LOWDON, J. A., J. G. FYLES, and W. BLAKE, Jr.
1967 Geological Survey of Canada radiocarbon dates VI. Geological Survey of Canada, Paper 67-2 (B):6.

LYELL, C.
1841 Remarks on some fossil and Recent shells, collected by Captain Bayfield, R. N., in Canada. Transactions of the Geological Society of London (ser. 2) 6 (pt. 1):135–141.
1845 Travels in North America in the years 1841–1842, with geological observations on the United States, Canada, and Nova Scotia. New York, Wiley and Putnam. 2 vols.

McALLISTER, D. E., S. L. CUMBAA, and C. R. HARINGTON
1981 Pleistocene fishes (*Coregonus, Osmerus, Microgadus, Gasterosteus*) from Green Creek, Ontario, Canada. Canadian Journal of Earth Sciences 18:1356–1364.

McKAY, S. and P. CATLING
1979 Trees, shrubs and flowers to know in Ontario. Don Mills, J. M. Dent. 208 pp.

MOORE, R. C., ed.
1955 Treatise on invertebrate paleontology; part E, Archaeocyatha and Porifera. Lawrence, Geological Society of America and University of Kansas Press. 122 pp.

MORRIS, P. A.
1973 A field guide to shells of the Atlantic and Gulf coasts and the West Indies. 3rd ed. Boston, Houghton Mifflin. 330 pp.

MURRAY, A.
1852 On the geology of the region between the Ottawa, the St. Lawrence, and the Rideau

rivers, with notes on economic minerals. Geological Survey of Canada, Report of Progress for 1851–52:57–91.

NIERING, W. A. and N. C. OLMSTEAD
1979 The Audubon Society field guide to North American wildflowers, eastern region. New York, Knopf. 863 pp.

OWEN, E. B.
1951 Pleistocene and Recent deposits of the Cornwall-Cardinal area, Stormont, Dundas, and Grenville Counties, Ontario. Geological Survey of Canada, Paper 51-12:1–25.

PENHALLOW, D. P.
1900 The Pleistocene flora of the Don Valley [Canada]. British Association for the Advancement of Science, Report for 1900:334–339.

PERKINS, G. W.
1908 Fossil Cetacea of the Pleistocene of the United States and Canada, with special reference to *Delphinapterus vermontanus* Thompson. Report of the State Geologist of Vermont, 1907–1908:76–112.

RICHARD, S. H.
1975 Surficial geology mapping: Ottawa Valley lowlands (Parts of 31G, B, F). Geological Survey of Canada, Paper 75-1(B):113–117.

RICHARDS, H. G.
1962 Studies of the marine Pleistocene. Transactions of the American Philosophical Society (n.s.) 52(3):10–11, 44, 51–141.

SCUDDER, S. H.
1895 Canadian fossil insects. Geological Survey of Canada, Contributions to Canadian Palaeontology 2(1):27–56.

SELWYN, A. R. C.
1872 Summary report of the director. Geological Survey of Canada, Report of Progress for 1870–71:10.

STERNBERG, C. M.
1951 White whale and other Pleistocene fossils from the Ottawa Valley. National Museum of Canada, Bulletin 123:259–261.

TERASMAE, J.
1960 Surficial geology of Cornwall map-area, Ontario and Quebec. Geological Survey of Canada, Paper 60-28:1–4.
1965 Surficial geology of the Cornwall and St. Lawrence seaway project areas, Ontario. Geological Survey of Canada, Bulletin 121:1–54.

WAGNER, F. J. E.
1954 Report on a fossil from Ottawa, Ontario, collected by Miss Nancy Graves, July 1954, and submitted by Dr. T. L. Tanton, November 1954. Geological Survey of Canada, Fossil Report P1-2-54/55. (Unpublished)

1958 Unusual Pleistocene fossils from southeastern Ontario. Transactions of the Royal Society of Canada (ser. 3) 5 (sec. 4):5–11.

1967 Published references to Champlain Sea faunas 1837–1966 and list of fossils. Geological Survey of Canada, Paper 67-16:1–82.

1970 Faunas of the Pleistocene Champlain Sea. Geological Survey of Canada, Bulletin 181:1–104.

WHITEAVES, J. F.

1901 Catalogue of the marine invertebrates of Eastern Canada. Geological Survey of Canada, Publication 772:1–272.

1907 Palaeontology and zoology. Geological Survey of Canada, Summary Report for 1906:170–177.

WHITTAKER, E. J.

1922 Pleistocene and Recent fossils of the St. Lawrence Valley from Prescott to Beauharnois. *In* J. Keele and L. H. Cole, Report of structural material along the St. Lawrence River. Canada Department of Mines, Mines Branch Publication 549:103–108.

WILSON, A. E.

1956 A guide to the geology of the Ottawa district. Canadian Field-Naturalist 70:1–68.

WILSON, W. J.

1898 Notes on the Pleistocene geology of a few places in the Ottawa Valley. Ottawa Naturalist 11:209–220.

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