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BIVALVE MOLLUSKS OF THE WESTERN BEAUFORT SEA

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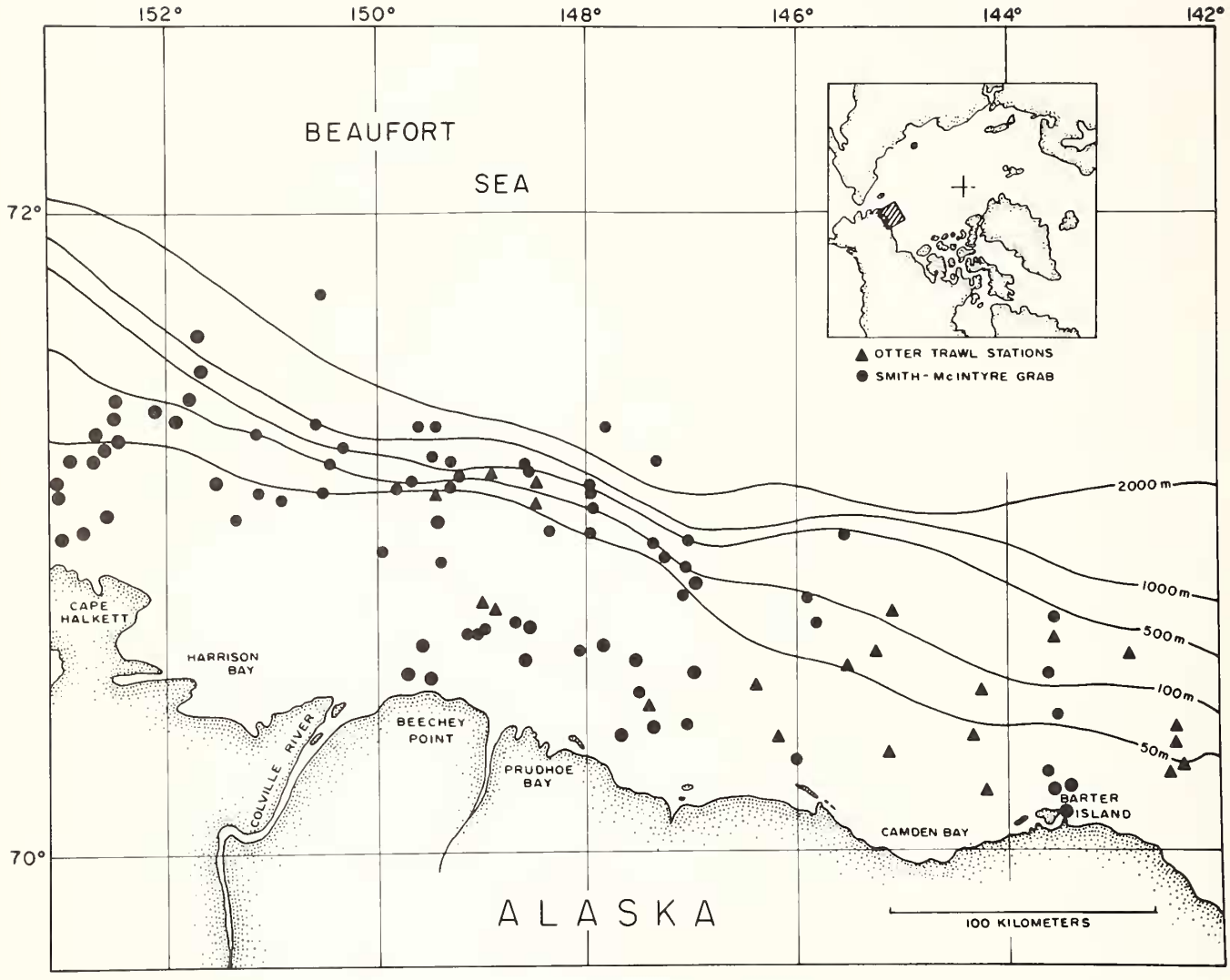

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BIVALVE MOLLUSKS OF THE WESTERN BEAUFORT SEA[1,2]

By F.R. Bernard[3]

ABSTRACT: This report is a systematic review and identification guide to 58 species of bivalve mollusks collected between 0–2560 m in the western part of the Beaufort Sea. Oceanographically the region is an integral portion of the Arctic Ocean, but faunally it consists of contributions from both the Atlantic and Pacific oceans. Six species are stenobathyal endemics with no close boreal relatives, their presence showing that at least a fraction of the deep-water benthic fauna survived the past several periods of glaciation. During these periods the shelf was emergent and ice-scoured and its fauna obliterated. As conditions ameliorated, adaptable species migrated from adjacent boreal seas, notably the Beringia refugium and also the Atlantic sector to colonize the newly submerged shelf. 24 species are of Atlantic and 20 of Pacific origin, a pattern probably largely dictated by the oligohaline region of the Mackenzie River estuary which is an effective barrier to many species. The fauna is not depauperated and is numerically comparable to temperate regions with similar limited habitat niches.

One new genus, *Boreacola* in the family Montacutidae, with the new species *B. vadosa* is described. A new species, *Axinulus careyi* in the family Thyasiridae is also proposed.

The many thousand specimens were collected by Oregon State University and supplemented with material collected by Western Washington State College and the United States Geological Survey.

INTRODUCTION

The marine biota of the Arctic Ocean is of particular significance as it provides a partial key to the complex evaluation of the northern boreal faunas. Mollusks, especially the Bivalvia, are important as they are abundantly represented in Tertiary and Quarternary deposits and may be used to follow periods of interchange and colonization between the Pacific and Atlantic oceans. The continental shelf of Arctic Alaska and Canada is a critical region for the interpretation of northern faunal distribution, as it is near the Bering Strait and is one of the two possible dispersal routes from adjacent regions.

The bivalve mollusks that are the subject of this report were largely collected by A. G. Carey, Jr., of the School of Oceanography, Oregon State University, supported by National Science Foundation grant GA-36679 and by Exxon, U.S.A., with a grant to the Smithsonian Institution, during the summers of 1971, 1972, and 1976. The series of bottom stations occupied by Smith-McIntyre Grab and Otter Trawl samples comprise the most comprehensive coverage to date of the Beaufort Sea from 10–2560 m (Frontispiece). A preliminary report on the general ecology of the benthos has already appeared (Carey et al., 1974). This material was supplemented by 16 quantitative and qualitative stations taken in 49–1289 m by United States Geological Survey with R/V Glacier in 1976, collected by A. Grant and R. Arnold, the bivalves submitted to me by the kindness of L. Marincovich, Jr. Additional material, particularly from shallow water, was examined at Western Washington State College.

The Beaufort Sea is an integral part of the Arctic Ocean, extending over 30° of longitude between Point Barrow, Alaska, and the westernmost islands of the Canadian Arctic Archipelago (Frontispiece). It encompasses the continental shelf of North America which extends on average 150 km northwards, and drops rapidly into the Laurentian or Canadian Basin. The Beaufort Sea is strongly influenced by the outflow of the Mackenzie River, the major drainage north from the American continent

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which results in an extensive superficial estuarine zone. This inflow of cold fresh water, coupled with the net eastwards current, make Point Barrow a boundary between the relatively warm saline Chukchi Sea, and the much colder, more brackish Beaufort Sea extending east to Banks Island where the salinity and temperature increase (Tully 1952). The oligohaline estuarine waters of the Mackenzie overlie the high salinity Arctic waters, but the high turbidity of the widespread river plume influences primary productivity, and the continuous settlement of sediments influences the character of the continental shelf bottom. A low annual primary production is indicated for the entire region (English 1961, Grainger 1975).

Many thousands of bivalves, representing 58 species were present in the survey area, and include virtually the entire known fauna of the region. This report describes the species, discusses the taxonomy, and presents illustrations. Outside the untranslated Soviet literature, no comprehensive reference to the regional fauna is available, so this effort is directed primarily as an identification guide for biologists monitoring the benthic ecology of the region. Quantitative aspects of the benthic ecology and its statistical treatment, will be published by others.

ACKNOWLEDGMENTS

The collection was made available through the auspices of the Natural History Museum of Los Angeles County, and I am indebted to J.H. McLean, curator of Malacology, for his kind assistance. The major part of the review was undertaken at the National Museum of Canada and I am grateful to the curator A.H. Clarke for permitting me access to the American Arctic and boreal collections. The extensive collections of the British Museum (Natural History), particularly material from the early Arctic explorations, and British Crag series of fossils, were examined. The MacGinitie and Dall specimens in the United States National Museum of Natural History were also consulted, as well as the relevant collections in the Redpath Museum, McGill University. At various times critical comparisons were made with the Arctic materials of the Universitets Zoologiske Museum, Copenhagen; the Zoologica Museum, Oslo; the Naturhistoriska Riksmuseet, Stockholm; the Museum d'Histoire Naturelle, Paris; and the Royal Scottish Museum, Edinburgh. I am very grateful to the curators and staff of these and other institutions for their assistance and advice during my visits and for various suggestions acknowledged in the text. I am indebted to A.H. Clarke, now of the U.S. National Museum of Natural History, for his kind criticism of the manuscript, to D.M. Hopkins, U.S. Geological Survey, for many helpful suggestions, and to R. Baxter of the Alaska Department of Fish and Game, for his comments and loan of material.

PREVIOUS RESEARCH

Knowledge of the existence of an ocean occupying the north polar region may be dated from Nansen's voyage of the Fram (1793–96), but some molluscan descriptions appeared earlier, for example Fabricius (1786) discussed and named a number of Arctic Greenland species. Despite this early biological interest, the difficulties of polar exploration, coupled with the high degree of morphological plasticity and the complex biogeography of a fauna subjected to numerous, sometimes catastrophic, environmental changes, result in the Arctic being one of the least understood biological regions. The fauna of the Eurasian Arctic is relatively well known (Zenkevitch 1963), and the bivalves of east Greenland have been thoroughly reviewed by Ockelmann (1958). The American Arctic is less known, particularly the Beaufort Sea area. The earliest published report is by Dall (1919), dealing with materials collected by the Canadian Arctic Expedition (1913–18). The western boundary of the Beaufort Sea was covered by the intensive studies of G. MacGinitie (1955) and the mollusks were reported by N. MacGinitie (1959), but the only published works dealing with the Beaufort Sea region proper are a brief report by Hulsemann (1962), listing 12 bivalve species from 15 shallow water (4–23 m) stations taken by the United States Coast and Geodetic Survey in 1953. The Canada Department of the Environment has supported studies in the Canadian portion of the Beaufort Sea, and after this paper was drafted, Wacasey (1975) published a preliminary report listing marine invertebrates, chiefly from the Mackenzie Bay area. The bivalve fauna appears sparser, but includes many of the species identified here, indicating a degree of homogeneity in the bivalve fauna. After completion of the present paper, I received a copy of a palaeobathymetic discussion and list of mollusks collected east of Herschel Island (Wagner 1977). I have not examined the specimens but have added them to the *Records* section and included additional species in the discussion.

BIOGEOGRAPHY

There is little doubt concerning the great age of the Arctic Ocean Basin (Eardly 1948), which was certainly established in the Cretaceous (Herron et al. 1974), but the contemporary fauna does not appear ancient, or even well-established. Substantial Mesozoic sedimentary features indicate a close affinity with the Pacific, but no evidence supports the assumption that the contemporary fauna is a Mesozoic relict. The origin of this fauna is subject of continuing debate, the majority of workers subscribing to a diverse boreal origin, but extreme schools exist. The one represented by Gur'yanova (1939), who considered it almost entirely derived from the Atlantic Pleistocene, the other by Gorbunov (1946b), who thought the present Arctic fauna to be exclusively of Pacific origin.

The Bering Strait opened and closed repeatedly in the late Miocene, Pliocene and Pleistocene; Hopkins (1973) reviewed and interpreted the sequence of fluctuating sea levels of the Bering Sea. These changes in climactic and geographic features were accompanied by periods of migration and local extinction of benthic invertebrates. Substantial faunal exchange between the Pacific-Arctic and Atlantic is evident after the Upper Pliocene, though the Arctic route was probably open long before this. This led Strauch (1970) to present convincing evidence to resurrect the hypothesis of the Thule Land Bridge. This body of land, now represented by the North Atlantic islands, separated the Atlantic Ocean and the Norwegian Sea, permitting only indirect and ephemeral channels until its submergence at the end of the Pliocene. The presence of this barrier allowed Pacific migrants to colonize only the American Atlantic and Greenland shelves.

At the peak periods of glaciation, it is doubtful that any open waters remained and the entire boreal continental shelf was ice-scoured. The scale and nature of these climatic changes probably resulted in the extermination of entire groups, and the rapidity of the change precluded local genetic adaptation. While it is probable that abyssal groups remained, it is almost certain that during these severest glacial episodes the Arctic continental shelf was a

tabula rasa, to which, as conditions ameliorated, migrated adaptable species from adjacent boreal seas, notably from an endemic Arctic fauna bordering the Beringia refugium (Hultén 1937) on the Alaskan or East Siberian Sector. According to Hopkins (pers. comm.) the initial opening of the Bering Strait is associated with the Beringian faunas in Northern Alaska and the European Red Crag, and by the subsequent appearance of numbers of Pacific migrants in the Pliocene and Pleistocene sediments of Iceland (Einarsson & Hopkins 1967). Evidence in Alaska shows this event to be older than 2.2 m.y., and the Iceland correlation between 3.0 and 3.5 m.y. ago.

Faunal interchange through the Arctic Ocean must be correlated with periods of benign climate in the Arctic, followed by more severe regimes. The important migrations of Pacific species to Iceland occurred at least 0.5 m.y. and perhaps > 1.0 m.y. prior to the widespread Pleistocene glaciation of Iceland (Einarsson, Hopkins & Doell 1967). Though a permanent ice-cover has persisted on the Arctic Ocean for the past 70,000 y. (Herman 1970), it is evident that during the last glaciation the Arctic continental shelf area was free of glacial ice, and may have supported much reduced fauna. It is during the Middle Pleistocene glaciation (Illinoian) that the Arctic Ocean was icebound (Herman 1970) and the shelf and much of the deepwater fauna eradicated. Accepting this interpretation makes it likely that the contemporary Beaufort Sea fauna invaded the shelf after the retreat of the ice, during the last interglaciation, less than 100,000 y. ago. Further evidence is provided by the occurrence over a large area of the submerged shelf of frozen sediments and permafrost (Hunter et al. 1976). Some 20 to 40,000 y. ago the sea level lowered approximately 100 m below its present level during a period when the climate was sufficiently severe to form permafrost which was inundated 5 to 20,000 y. ago (Lewellen 1974).

If the present Arctic fauna is a young colonizing bioceonosis with a very small endemic fauna as suggested by Clarke (1963), and with contributions from both the Atlantic and Pacific, it remains to discuss the relative importance of the contributing regions. The Atlantic species *Astarte alaskensis* Dall and *Hiatella arctica* (Linné) first appear in the Pacific in the Pliocene of the Gulf of Alaska (MacNeil 1965). The majority of transarctic migrants became extinct in the high Arctic, giving rise to isolated boreal populations, although a number did remain. Soot-Ryen (1932) listed 12 such species, but three did not become established in the Atlantic, and doubtfully even entered the Arctic (i.e. *Saxidomus giganteus* [Deshayes]; *Protothaca staminea* [Conrad]; and *Zirfaea gabbi* [Tryon]).

The appearance of the molluscan lists in the recent publications by Wacasey (1975) and Wagner (1977), covering that region of the Beaufort Sea extending approximately 128° to 140°W, are complementary to the present paper which covers 142° to 153°W. A synopsis of these collections and the species included by MacGinitie (1959) from Point Barrow (157°W), is given in Table 1.

TABLE 1.
Synopsis of bivalvia recorded in major collections from the Beaufort Sea area.

Species	MacGinitie 1959	Bernard	Wacasey 1975	Wagner 1977
Arctinula greenlandica		X	X	X
Astarte borealis	X	X	X	X
A. crenata		X	X	X
A. esquimalti		X		
A. montagui et form.	X	X	X	X
Axinopsida orbiculata	X	X		X
Axinulus careyi		X		
Bathyarca frielei				X
B. glacialis		X	X	X
B. raridentata		X		
Boreacola vadosa		X		
Cerastoderma echinatum				X
C. elegantulum				X
Chlamys pseudislandica	X	X		
Clinocardium ciliatum	X	X	X	X
Crenella decussata		X		
Cuspidaria glacialis		X		
C. subtorta		X		
Cyclocardia crassidens	X			
C. crebricostata	X	X		
Cyrtodaria kurriana		X	X	X
Dacrydium vitreum	X	X	X	
Diplodonta aleutica	X			
Hiatella arctica	X	X	X	X
Limatula hyperborea		X		X
Liocyma fluctuosa	X	X	X	X
L. viridis	X	X		
Lyonsia arenosa	X	X	X	X
L. norwegica				X
L. schimkewitsci				X
Lyonsiella uschakovi		X		
Lyonsiella sp.				X
Macoma balthica		X	X	X
M. calcarea	X	X	X	X
M. loveni		X		X
M. moesta	X	X	X	X
M. obliqua	X			
M. torelli			X	X
Malletia abyssopolaris		X		
Modiolus modiolus				X
Montacuta dawsoni		X		
M. maltzani			X	
Musculus corrugatus	X	X	X	X
M. discors	X	X	X	X
M. niger	X	X	X	X
Mya arenaria				X
M. pseudoarenaria	X	X	X	X
M. truncata	X	X	X	X
Mysella planata	X	X		X
M. tumida	X	X		
Mytilus edulis	X		X	
Nucula bellotii	X	X	X	X
N. zophos		X		
Nuculana minuta	X	X	X	X
N. pernula		X	X	X
N. radiata	X	X		
Pandora glacialis	X	X	X	X
Panomya ampla	X			
P. arctica	X			
Periploma abyssorum			X	
P. aleutica		X		
Portlandia arctica	X	X	X	X
P. fraterna		X	X	X
P. frigida		X	X	X
P. intermedia		X	X	X
P. lenticula		X	X	X
P. tamara		X	X	
Pseudopythina compressa	X			
Serripes groenlandicus	X	X		X
Tellina lutea	X			
Tellina sp.				X
Thracia adamsi	X			
Thracia devexa	X	X		X
T. myopsis	X	X	X	
Thyasira equalis		X		
T. gouldii	X	X	X	X
Yoldia hyperborea	X	X	X	X
Y. myalis	X	X		
Y. scissurata	X	X		

This table may serve as a check-list of the bivalve fauna of the Beaufort Sea. Until further collections are taken, particularly between Barter and Herschel Islands, distributional conclusions must be considered unreliable. From casual examination of Table 1 it is apparent that Point Barrow supports a fauna demonstrating close affinity with the Bering Sea, while the more eastern part of the Beaufort Sea has a stronger Atlantic connection, but the region west of Herschel Island has a more diverse bivalve fauna than that region influenced by the Mackenzie River. The record by Wagner (1977) of two species of *Cerastoderma* Poli 1795, typically a low Arctic and Atlantic genus is of particular interest and supports the notion that the oligohaline Mackenzie estuary is a potent barrier to westward penetration of shallow shelf fauna of Atlantic origin.

Of the 58 species in the OSU collection (Table 2), six are stenobathyal endemics with no close boreal relatives, and probably limited to the Laurentian Basin. Twenty-four are of Atlantic and 20 of Pacific origin. Seven are of unknown origin. This distribution is contrary to current concepts that Pacific elements are dominant (Durham & MacNeil 1967), supposedly due, in part, to the prevailing eastward currents of the American Arctic (MacNeil 1965), or the dispersive potential of the more diverse Pacific fauna (Ekman 1935). The eastward flowing currents have a dominant influence upon colonization patterns, especially for those species with planktonic larvae (rare in Arctic bivalves), but Huggett et al., (1975) emphasized the variability of the Beaufort Sea currents, featuring localized directional changes during ice-free periods, though the average trend is northeastern. There is no direct evidence to suggest that in the Pliocene and Pleistocene the dominant flow was easterly. Indeed, that most stable Arctic feature, the northward flow through the Bering Strait (Arsen'ev 1964), was reversed during the Kotzebuan Transgression (Mid-Pleistocene) with Arctic waters passing through the Bering Sea (Hopkins et al. 1972). This situation was certainly accompanied by a western flow along the shores of the Beaufort Sea, facilitating transmigration of Atlantic species.

The narrow and shallow Strait opening to the Bering Sea, compared to the wide Arctic-Atlantic connection, restricted colonization by Pacific species. The situation further favors Atlantic migrants by the massive influx deep into the Arctic of a northward extension of the Gulf Stream over the Faroe Island-Greenland Ridge. Brooding forms are relatively independent of prevailing currents, and in fact do colonize against them, though range extension is slow. An alternative path for Atlantic forms to the Beaufort Sea is via the Eurasian coasts, but it is likely that the Siberian Sea is an effective barrier to all except the most euryhaline forms, due to the presence of extensive oligohaline zones. The larval type will greatly influence the distributional ability of organisms. Planktotrophs are characterized by large dispersions from the established region when favourable conditions coincide with larval production. The majority of Arctic marine bivalves undergo lecithotrophic development (Thorson 1946, 1959), where metamorphosis is attained solely on nutrient matter in the egg. Mileikosky (1974) refined Thorson's scheme of classification and expanded it to include duration of pelagic life. If Arctic mollusks are separated into developmental groups, no overlying patterns are evident: some lecithotrophs have a limited distribution, while planktotrophs include some most successful colonizers. Chia (1974) advanced the view that, rather than the direct effect of limited availability of pelagic food for the larvae, the change is one of the metabolic partitioning of the resources of the adult. Under conditions of little available food for gamete production the reproductive strategy is shifted to greater efficiency in terms of per unit cost. The gamete index (vol. gametes/vol. animal) is higher in planktotrophic than lecitho-

TABLE 2.
Synopsis of bivalves collected in the Western Beaufort Sea, with their distributions and postulated areas of origin.

	Endemic	Arctic	Panarctic	Atlantic	Bering Sea	Pacific	Origin
Arctinula greenlandica			X	X			Atlantic
Astarte borealis			X	X	X	X	Atlantic
Astarte crenata			X	X			Atlantic
Astarte esquimalti		X			X	X	Pacific
Astarte montagui			X	X	X	X	Atlantic
Axinopsida orbiculata			X	X			Pacific
Axinulus careyi	X						
Bathyarca glacialis			X	X			Atlantic
Bathyarca raridentata			X	X			Atlantic
Boreacola vadosa	X	X					
Chlamys pseudislandica		X			X		Pacific
Clinocardium ciliatum			X	X	X	X	Pacific
Crenella decussata			X	X	X	X	Pacific
Cuspidaria glacialis			X	X	X		Atlantic
Cuspidaria subtorta			X?	X			Atlantic
Cyclocardia crebricostata		X			X	X	Atlantic?
Cyrtodaria kurriana			X	X			
Dacrydium vitreum			X	X			Atlantic
Hiatella arctica			X	X	X	X	Pacific
Limatula hyperborea			X	X			Atlantic
Liocyma fluctuosa			X	X	X	X	Pacific
Liocyma viridis		X			X		Pacific
Lyonsia arenosa			X	X	X		Pacific
Lyonsiella uschakovi	X						
Macoma balthica		X		X	X	X	Pacific
Macoma calcarea			X	X	X	X	Pacific
Macoma loveni			X	X	X		?
Macoma moesta			X	X	X	X	Pacific
Malletia abyssopolaris	X						
Montacuta dawsoni			X	X			Atlantic
Musculus corrugatus			X		X		Pacific
Musculus discors			X	X	X	X	Pacific
Musculus niger			X	X	X	X	Pacific
Mya pseudoarenaria		X		X			Atlantic
Mya truncata			X	X	X	X	Atlantic
Mysella planata		X			X		Pacific
Mysella tumida		X			X	X	Pacific
Nucula bellotii			X	X	X	X	Atlantic
Nucula zophos	X						
Nuculana minuta			X	X			Atlantic
Nuculana pernula			X	X	X	X	Atlantic
Nuculana radiata		X			X	X	?
Pandora glacialis			X	X	X	X	Atlantic
Periploma aleutica		X			X	X	Pacific
Portlandia arctica			X	X			Atlantic
Portlandia fraterna			X	X			Atlantic
Portlandia frigida			X	X			Atlantic
Portlandia intermedia			X	X			Atlantic
Portlandia lenticula			X	X	X		?
Portlandia tamara	X						
Serripes groenlandicus			X	X	X	X	Pacific
Thracia devexa		X		X			?
Thracia myopsis			X?	X	X		?
Thyasira equalis			X?	X			Atlantic
Thyasira gouldii			X	X	X	X	Atlantic
Yoldia hyperborea			X	X	X		Pacific
Yoldia myalis			X	X	X	X	Atlantic
Yoldia scissurata		X			X	X	Pacific

trophic organisms. However, my observations show that caloric reserves of lecithotrophic eggs are substantially higher per organism unit. In my opinion the determining factors are food availability for the larvae and ambient temperature which may be too low to maintain feeding activity, particularly in a discontinuous pelagic environment.

FAUNAL DIVERSITY

The Arctic has been considered to support only a depauperated fauna and a number of arguments have been advanced to account for this. These include difficulties of physiological adaptation to hypothermy, the low level of primary productivity, limited habitat variety, and the result of recent colonization. The OSU materials provide clear evidence that the Beaufort Sea bivalve fauna is richer than previously assumed, especially if the lack of an intertidal habit is considered. It is worthy of note that the total species present are numerically similar to the bivalves in other high boreal and subarctic seas (White Sea 38; Kara Sea 63; Laptev Sea 50; Eastern Siberian 54; Chukchi Sea 48 species, *fide* Filatova 1962). Limited habitat niches are certainly determining factors, as is the fact that the intertidal zone and shallow nearshore bottom is subject to ice-scour. However, by no means is the entire shallow habitat destroyed by the annual movement of ice. According to Brooks (1974), there is less ice-scour inside the 18 m contour than in deeper water.

The shallow habitat survey (0.5–5 m) by Western Washington State College collected many young and immature bivalves, but a number were in at least their 3rd year. It must be concluded that only part of the bottom is ice-scoured and limited regions may remain undisturbed for several years at a time. The presence of these young individuals, several hundred meters from deeper reproductive populations, nearly all producing lecithotrophic larvae or benthic young, suggests that transportation even of brooded young may be active. Sigurdsson et al. (1976) showed that dispersal of recently settled bivalves in a number of families may occur by current drifting using a byssal thread, analogous to the gossamer flight of young spiders.

The majority of specimens are smaller than those present in the Chukchi or Bering Sea, a fact that may be partially explained by the low primary production, low temperature, and ice cover during much of the year. The entire Arctic bivalve fauna demonstrates persistent morphological characters summarized by Nicol (1967). These include thin shells, lack of bright coloration and the absence of spines. Recently Vermeij & Veil (1978) have noted a higher proportion of bivalves with persistent posterior shell gapes and suggested this was attributable to higher predation in warmer waters. My view is that tightly closing shells are frequently found in stable, nearly static substrates that demand little movement from the infauna. Arctic forms are adapted to unstable substrates, subjected to current transportation, ice-scour, and high rates of deposition from adjacent rivers. In these conditions the ability to burrow rapidly and move freely may be important attributes. The lack of stable substrates is further demonstrated by the complete absence of cemented and pleurothetic (lying on the bottom on one valve) forms in Arctic waters (Nicol 1964). It is unlikely to be a direct result of low temperatures, as cemented genera such as *Hiatites* Defrance 1821 and *Crassostrea* Sacco 1897 are found in boreal waters.

FORMAT

Families are arranged according to the system used in Moore (1969). Inasmuch as a full classification is readily available in that work, supra-families are omitted here.

The generic accounts include remarks on the distribution and biology of the group as well as a morphological description. I have included original drawings of the type species of each of the genera, showing the interior of the right valve.

For each species the important systematic references are listed in chronological order. The *Description* paragraph is not the original description, but an expanded comparative statement which can be easily used to find the diagnostic features. The *Records* section lists the fossil and living records in chronological order, but no indication is given whether the record is under a synonymous name. Not all literature records were verified, but only those included where supported by contemporary distributions. Some difficulty was experienced citing Soviet Union palaeontological records, as they place the Pliocene/Pleistocene boundary at 1 m.y. b.p., rather than the accepted international 1.8 m.y. so I have altered Soviet citations to conform to the international stratigraphic usage.

Abbreviations

CAS	California Academy of Sciences
LACM	Natural History Museum of Los Angeles County
NMC	National Museum of Canada
OSU	Oregon State University
USGS	United States Geological Survey
USNM	United States National Museum of Natural History

SYSTEMATIC ACCOUNT

The key to the families is designed for Arctic and northern boreal species only, but attention must be drawn to the great variability in shape and frequent erosion of shell features, which may limit the usefulness of any key. A further difficulty is the evanescent character of hinge dentition in some representatives of the Hiatellidae and Cardiidae. In all cases, key identifications should be cross-checked with the text.

Artificial Key to the Families

1.	Hinge edentulous (ridges and tubercles may be present)	2
	Hinge with developed dentition	13
2.(1)	Shell with posterior calcareous siphonal tube	Cuspidariidae
	Shell without posterior siphonal tube	3
3.(2)	Beaks terminal	Mytilidae
	Beaks not terminal	4
4.(3)	Hinge with projecting chondrophore	5
	Hinge without projecting chondrophore	6

5.(4)	Chondrophore in left valve only	Myidae
	Chondrophore in both valves	Periplomatidae
6.(4)	Single adductor muscle scar	7
	Two adductor muscle scars	8
7.(6)	Valve with unsymmetrical ears, byssal notch present	Pectinidae
	Valve with small symmetrical ears, no byssal notch	Limidae
8.(6)	Valve with posterior radial ridge or flexure	Thyasiridae
	Valve without radial ridge or flexure	9
9.(8)	Ligament supported by lithodesma	10
	Ligament not supported by lithodesma	12
10.(9)	Shell inflated, oval to quadrate	Verticordiidae
	Shell elongated	11
11.(10)	One valve flat, other convex	Pandoridae
	Both valves convex	Lyonsiidae
12.(9)	Surface granular, sometimes with concentric lines	Thraciidae
	Surface smooth, sculpture radial	Cardiidae
13.(1)	Dentition taxodont	14
	Dentition not taxodont	17
14.(13)	Ligament mostly external	15
	Ligament mostly internal	16
15.(14)	Shell inflated, lateral teeth oblique	Arcidae
	Shell compressed, posterior teeth largest	Malletiidae
16.(14)	Shell rotund, no pallial sinus	Nuculidae
	Shell elongated, with pallial sinus	Nuculanidae
17.(13)	Hinge with developed cardinal teeth	18
	Hinge with no true cardinal teeth	Montacutidae
18.(17)	Hinge with two cardinal teeth in each valve	19
	Hinge with more than two cardinal teeth in one or both valves	21
19.(18)	Shell compressed, sculpture absent	Tellinidae
	Shell inflated, radial sculpture present	20
20.(19)	Posterior cardinal teeth elongated	Carditidae
	Posterior cardinal tooth peg-like	Cardiidae
21.(18)	Three cardinal teeth in each valve	Veneridae
	Three cardinal teeth in LV, two in RV	Astartidae

Family NUCULIDAE Gray 1824
Genus *Nucula* Lamarck 1799
Figure 1

Type species (monotypy): *Arca nucleus* Linné 1758. Recent. North Atlantic.

DESCRIPTION: Shell ovate to trigonal, surface unornamented or with concentric and radial striae. Beaks opisthogyrate, lunule and escutcheon obscure to prominent. Interior nacreous, margins plain or crenulate. Hinge with central oblique resilifer separating taxodont dentition into two series. Ligament internal. No pallial sinus.

RANGE: Jurassic to Recent. Recent distribution cosmopolitan, generally in cold or deep waters and well represented in boreal and Arctic regions. Shallow infaunal in fine-grained sediments, usually with high organic content.

DEVELOPMENT: Ova large, development lecithotrophic with reduced or no planktonic stage (Thorson 1946). Drew (1901) showed development in *N. delphinodonta* Mighels & Adams to be direct in an attached gelatinous egg capsule.

REMARKS: The group is structurally modified for deposit feeding, but at least some species are facultative filter-feeders (Casper 1940). Two subgenera are present in the study area.

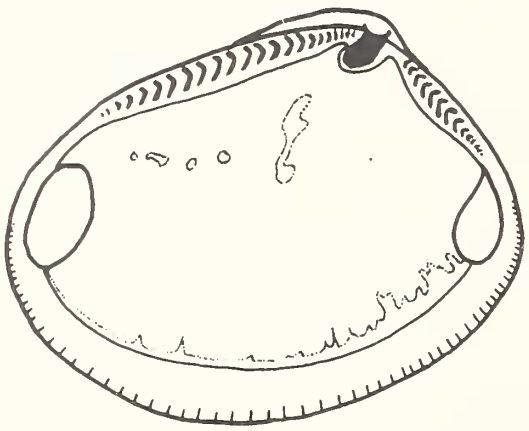


FIGURE 1. Interior of right valve of *Nucula nucleus* (Linné).

Key To Subgenera of *Nucula*

Margins crenated, sculpture including radial striae ..... *Nucula* s. str.
Margins smooth, surface smooth ..... *Leionucula*

Subgenus *Nucula* s. str.

Nucula (Nucula) zophos Clarke 1960

Figure 2

Nucula zophos Clarke 1960:5, pl.1, f.15–18; Clarke 1963:99; Paul & Menzies 1973:127.

DESCRIPTION: Shell length to 18 mm. Surface sculptured with numerous fine concentric ridges and intersecting radial lines giving a reticulated appearance. Periostracum thin and dehiscent. Interior brilliantly nacreous, with some of the radial lines carrying through. Shell margins strongly crenulated. Hinge line well developed with deep anteriorly directed chondrophore dividing dentition into two series, the anterior series having twice as many teeth as the posterior set.

COMPARISONS: The large size and curious reticulate sculpture is unlike any other boreal or Arctic representative of the genus. It is similar to the Panamic. *N. iphigenia* Dall 1896 which is larger and with a proportionally thicker and coarsely sculptured shell.

COLLECTION: Five single valves from 2377 m at 71°19.3′N, 147°47.1′W.

DISTRIBUTION: The type locality is 84°28′N, 148°28′W in approximately 1700 m, so the present record is an extension of over 1200 km south. This species is widely distributed in the archibenthal regions of the Laurentian Basin.

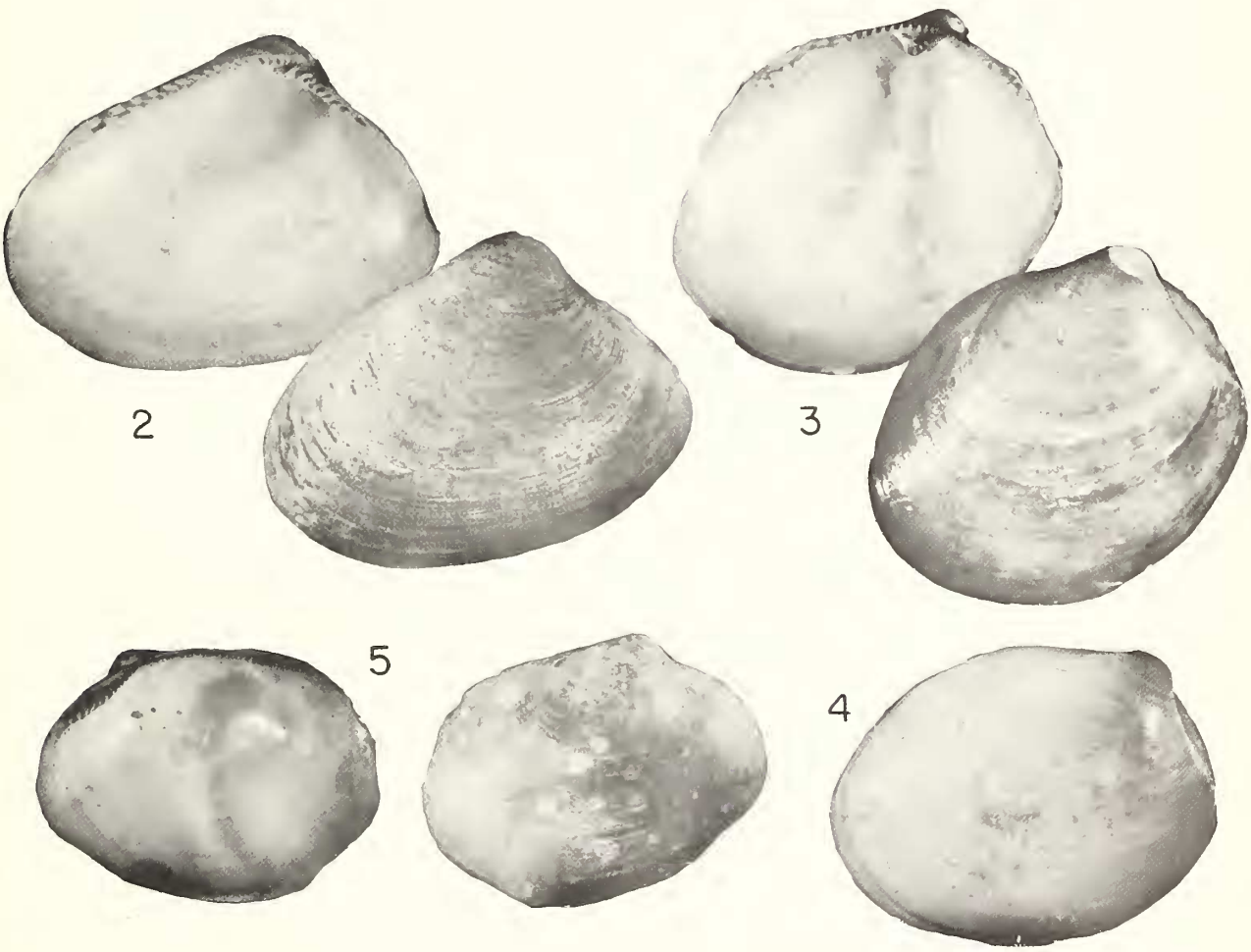
Subgenus *Leionucula* Quenstedt 1930.

Type species (original designation): *Nucula albensis* Orbigny 1844. Cretaceous. Europe.

Nucula (Leionucula) bellotii A. Adams 1856

Figures 3, 4

Nucula bellotii A. Adams 1856:51.
Nucula (Ennucula) bellotii A. Adams, Schenck 1939:30, pl.6, f.10, 11, 13, 16–20.



Figures 2–5. 2, *Nucula (Nucula) zophos* Clarke, length 12.9 mm; 3, *Nucula (Leionucula) bellottii* A. Adams, length 15.3 mm; 4, *N. (L). bellottii*, elongated form, length 10.4 mm; 5, *Malletia abyssopolaris* Clarke, length 11.6 mm.

Arca tenuis auctt [not Montagu 1808:56, pl. 29, f.1.]
Nucula tenuis (Montagu), Oldroyd 1925:13, pl.5, f. 12; Filatova 1948:415, pl.105, f.1; Scarlato 1955:186, pl.49, f.1.
Nucula tenuis typica G. Scars 1878:34.
Nucula inflata Hancock 1846:333, pl.5, f.13, 14, [not Sowerby 1827, not Wissmann & Munster 1841]; Hanley *in* Sowerby 1860:162, pl.229, f. 115, 116.
Nucula tenuis inflata (Hancock), Jeffreys 1863:151.
Nucula expansa Reeve *in* Belcher 1855:397, pl.33, f.2, [not Wissmann & Munster 1841]; Jeffreys 1863:152.
Nucula tenuis expansa (Reeve *in* Belcher), G. Sars 1878:33.

DESCRIPTION: Shell length to 20 mm, inflated, surface smooth, sometimes with incremental lirae and growth checkmarks. Periostracum yellow to dark-brown, brilliantly varnished. Shell tightly closing, margins smooth. Interior of shell nacreous. Hinge with large oblique resilifer and taxodont dentition in two series, the anterior teeth approximately twice as numerous. Pallial line entire, difficult to see.

COMPARISONS: This is a variable species, with two extreme varieties, a compressed form close to the type but with a light colored periostracum (*"N. expansa"*), and a larger, thin-shelled inflated form with a generally darker periostracum (*"N. inflata"*). Numerous transitional forms occur and there is no satisfactory way to separate them. The unsculptured exterior with brilliant periostracum and smooth shell margins distinguish *N. bellotii* from *N. zophos* Clarke.

COLLECTION: This species occurred at 132 stations for a total of 420 specimens and numerous dead valves. Living specimens were found from 10–2560 m, but were most abundant in less than 200 m.

RECORDS: *Pleistocene*—Wood 1851:84 (Britain); Wagner 1959:6 (British Columbia); Merklin et al. 1962:22, pl.1, f.1 (Chukotsk Peninsula); Petrov 1966:182, pl.10, f.1–8 (Chukotsk Peninsula); Petrov 1967:154 (Chukotsk Peninsula); Troitskiy, 1974:265 (Siberia). *Recent*—Møller 1842:17 (Greenland); M. Sars 1859:56 (European Arctic); Crosse 1877:118 (Bering and Chukchi Seas); E.A. Smith 1877:141 (European Arctic); D'Urban 1880:253 (Barents Sea); Leche 1883:449 (Novaya Zemlya); Krause 1885:21 (Bering Sea); Stuxberg 1886:149 (Novaya Zemlya); Jensen 1905:299 (Greenland); Dall. 1921:9 (Bering and Arctic Seas); Soot-Ryen 1939:8 (Franz Josef Land); Madsen 1949:11 (Iceland); Kuroda & Habe 1952:26 (Northern Japan); Filatova 1957b:51 (Eurasian Arctic); Ockelmann 1958:13 (Greenland); MacGinitie 1959:149, pl.18, f.4 (Point Barrow, Alaska); Ellis 1960:38 (Baffin Island and Greenland); Hulsemann 1962:70 (Beaufort Sea); McLaughlin 1963:24 (Bering Sea); Sparks & Pereyra 1966:834 (Chukchi Sea); Ishikawa 1969:49, pl.3, f.5 (Sea of Japan); Bernard 1970:86 (British Columbia); Clarke 1974:8 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal in shallow water but occasional specimens may be found down to 2400 m.

REMARKS: Schenck (1939) first proposed that the neglected name *N. bellotii* Adams should be applied to Arctic *Nucula* then included in *N. tenuis* (Montagu). It is possible that careful study will show that the two species intergrade, but I consider *N. bellotii* to be a closely related cold water species. *N. quirica* Dall, 1916, from Cook Inlet, Alaska has also been considered a synonym, but until its relationship with Californian material is elucidated I prefer to treat it as a separate taxon probably falling into the synonymy of Pacific *N. tenuis* and related to *N. balboana* Hertlein & Grant 1972, from the Pliocene of southern California.

Family MALLETIIDAE H.& A.Adams 1858
Genus *Malletia* Des Moulins 1832
Figure 6

Type species (monotypy): *Malletia chilensis* Des Moulins 1832. Recent. Southeast Pacific.

DESCRIPTION: Shell elongate, thin. Surface unornamented, but fine concentric striae and growth checkmarks may be present. Periostracum yellow to brown, brilliantly polished. Lunule and escutcheon absent or indistinct. Interior porcelaneous, shell margins smooth. Hinge with taxodont teeth in two series, the posterior teeth longer and more numerous. Ligament predominantly external. Pallial sinus small to extensive.

RANGE: Ordovician to Recent. Recent distribution cosmopolitan in archibenthal and abyssal seas. Malletiids are shallow burrowers in fine sediments.

DEVELOPMENT: No published description is available: a specimen of *M. fiora* Dall, 1916, from deep water off the Queen Charlotte Islands, contained large ova, indicating lecithotrophic development.

REMARKS: The anatomy of the soft parts of this family is poorly known, but appears to be closely related to the Nuculanidae. Malletids are probably detrivores and facultative filter feeders. Arctic representatives fall into two groups, those with and without the pallial sinus; although there appear to be intermediate forms, it is possible that anatomical work will result in separation at the subgeneric level.

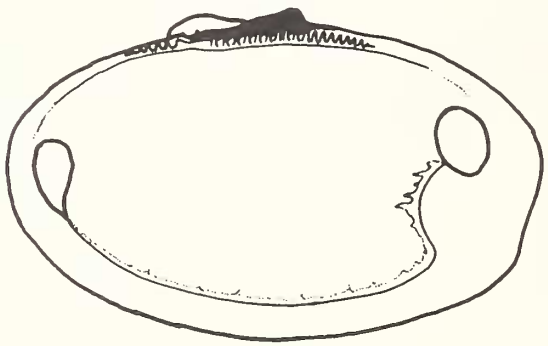


FIGURE 6. Interior of right valve of *Malletia chilensis* (Des Moulins).

Malletia abyssopolaris Clarke 1960
Figure 5

Malletia abyssopolaris Clarke 1960:7, pl.1, f.19–22; Paul & Menzies 1973:128.

DESCRIPTION: Shell outline commonly ovate, but may vary between subcircular to rhomboidal, length to 15 mm. Surface unornamented except for a few concentric lirae. Some specimens may have very fine radial lines which may carry through to the interior. Periostracum thin and dehiscent. Interior porcelaneous,

shell margins smooth. Hinge plate concave in front and convex posteriorly. Taxodont teeth short, V-shaped. Pallial line feebly impressed, no pallial sinus.

COMPARISONS: The species is easily distinguished by the dual curvature of the hinge line and the absence of a resilifer. Clarke (1960) compared his material to *M. abyssorum* Verrill & Bush 1898, from bathyal northwestern Atlantic, and *M. dunkeri* Smith 1855, from Japan, but these are both minute shells with a different surface pattern. The equivalent species from the Angara Basin is *M. kolthoffi* (Hägg 1904), thought by Soot-Ryen (1966) to be identical to *M. cuneata* Jeffreys 1876.

COLLECTION: Four single valves from 2560 m at 71°19.6′N, 147°48.2′W.

DISTRIBUTION: The type locality is 84°28′N, 148°28′W in 1690–1709 m. This new record extends the range some 1300 km south. The species is probably distributed throughout the Laurentian Basin in bathyal and archibenthal environments.

Family NUCULANIDAE H. and A. Adams 1858

Key to the genera of Nuculanidae

1. Shell tightly closing 2
   Shell with posterior gape ..... *Yoldia*

2.(1) Shell elongated, with concentric sculpture ..... *Nuculana*
   Shell with rostrum, surface unornamented ..... *Portlandia*

Genus *Nuculana* Link 1807

Figure 7

Type species (original designation): *Arca pernula* Müller 1771. Recent. North Atlantic.

DESCRIPTION: Shell elongate, usually rostrate. Surface smooth or with concentric sculpture. Periostracum polished, adherent. Lunule obscure, escutcheon well developed. Interior porcelaneous, shell margins smooth. Hinge with wide posteriorly directed resilifer. Ligament partly external. Taxodont dentition in two series, posterior teeth approximately twice as numerous as anterior series. Pallial line impressed, pallial sinus small.

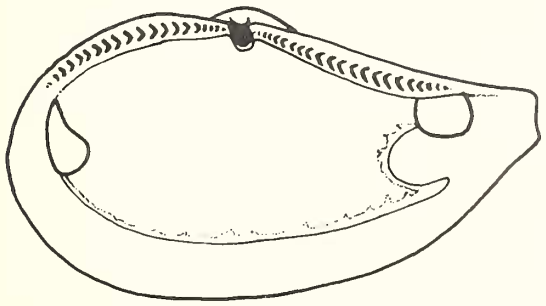


FIGURE 7. Interior of right valve of *Nuculana pernula* (Müller).

RANGE: Triassic to Recent. Recent distribution cosmopolitan, most numerous in boreal and temperate regions. The genus has an extended bathymetric range, from the shallow subtidal zone to hadal depths, and colonizes a wide range of sediments ranging from coarse sand and gravel to the finest silts. Nuculanids are generally medium depth infauna, depending upon the palp appendages to collect detritus, though at least some food may be obtained by filter feeding.

DEVELOPMENT: Ova large, development lecithotrophie with an abbreviated planktonic stage (Thorson 1946).

REMARKS: The anatomy of this group is well-known and conforms to the typical protobranchiate pattern with large palp appendages, a complete exhalant siphon and unfused inhalant siphon. The siphonal structures permit deeper burial in unconsolidated sediments, and they may be extended over the surface and used to sweep in epibenthic detritus.

Subgenus *Nuculana* s. str.
Nuculana (Nuculana) minuta (Fabricius 1776)

Figures 8, 9

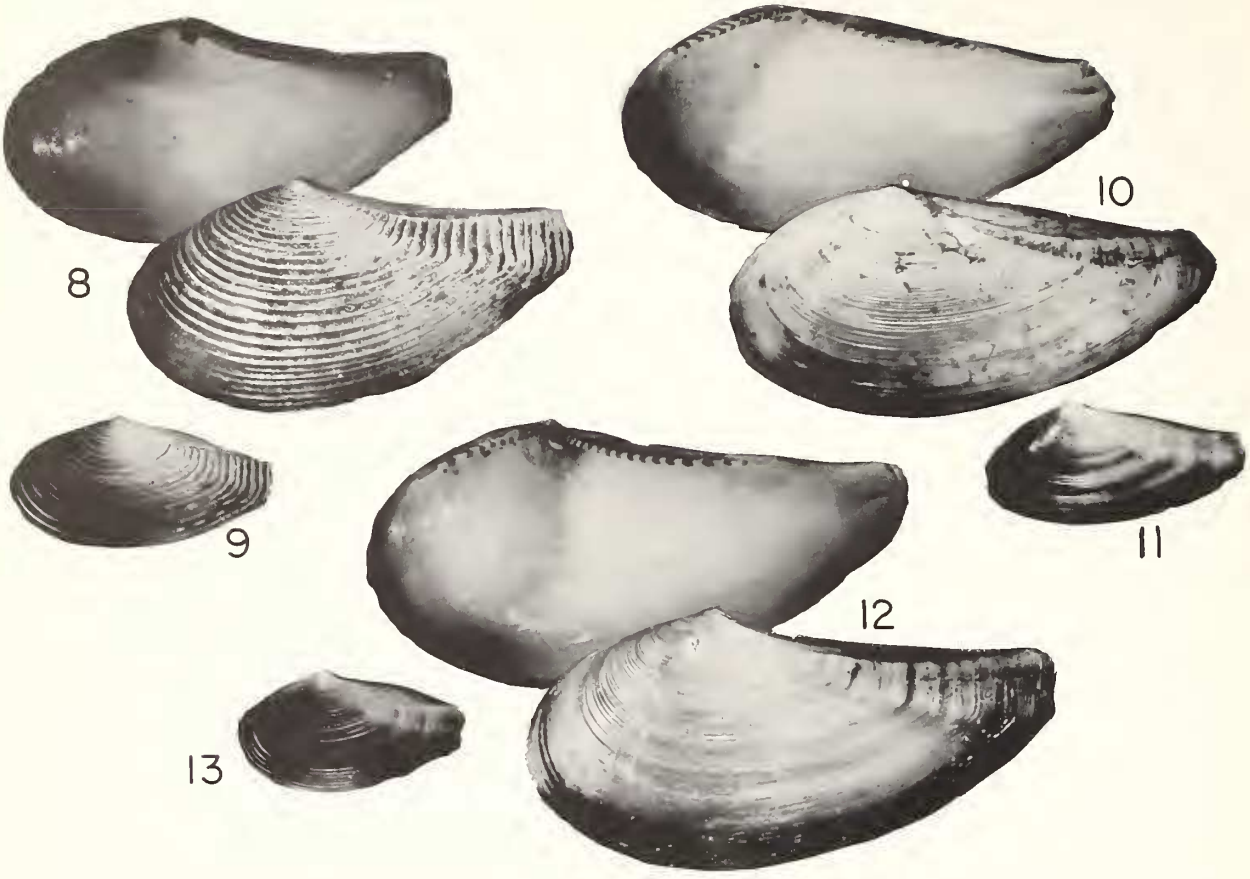
Arca minuta Fabricius 1776:414; Montagu 1803:140 (of "Gmelin"); Dillwyn 1817:245 (of "Müller").
Leda minuta (Fabricius) G. Sars 1878:36, pl.5, f.2a, 6; Oldroyd 1925:15, pl.5, f.5, pl.19, f.2, a; Filatova 1948:417, pl.105, f.6 (of "Müller"); Filatova and Barsonova 1964:34 (of "Müller"); Petrov 1966:184, pl.10, f.11 (of "Müller").
Nuculana minuta (Fabricius), MacGinitie 1959:150, pl.18, f.3.

DESCRIPTION: Shell elongate, inflated, with short obliquely truncated rostrum. Length to 20 mm. Surface ornamented with coarse concentric ribs. Periostracum light yellow to dark brown, strongly adherent. Escutcheon very prominent, bounded by a raised line. Interior polished, not nacreous. Hinge line nearly straight, resilifer narrow and posteriorly directed. Taxodont dentition in two series, more teeth in the posterior set. Pallial line not deeply impressed, pallial sinus well developed.

COMPARISON: This species may be confused with *N. pernula* (Müller), but it reaches only half the size and the rostrum is shorter. The radial sculpture is not as pronounced, and in *N. pernula* there is a tendency for the dorsal rostral margin to be concave and the rostrum to be ornamented with several radial lines, whereas in *N. minuta* the rostrum is straight and the radial ornamentation is absent.

COLLECTION: The species occurred at 24 stations for a total of 79 specimens and some single valves. Living representatives were found in 23–270 m.

RECORDS: *Pleistocene*—Richards 1962:52, pl.1, f.16 (Labrador, Quebec); *Recent*—Gould 1841:101 (Massachusetts); Jeffreys 1869:173, pl.29, f.6 (Britain); Gould 1870:164, f.470 (Massachusetts); Leche 1883:448 "Beck MS" (Novaya Zemlya); Krause 1885:22 (of "Müller") (Bering Sea); Whiteaves 1887:119 (British Columbia); Dautzenberg and Fischer 1910:16 (Novaya Zemlya); Massey 1930:238 (North Atlantic); Johnson 1934:16 (Labrador to Nova Scotia); Gorbunov 1946a: 46 (of "Müller") (Eurasian Arctic); Madsen 1949:14 (of "Müller") (Iceland); Filatova 1957b: 51 (of "Müller") (Eurasian Arctic); Ockelmann 1958:19,



FIGURES 8–13. 8. *Nuculana (Nuculana) minuta* (Fabricius), length 12.2 mm; 9, *N. (N.) minuta,* juvenile, length 7.7 mm; 10, *Nuculana (Nuculana) pernula* (Müller), length 19.9 mm; 11, *N. (N.) pernula,* juvenile, length 7.6 mm; 12, *Nuculana (Nuculana) radiata* (Krause), length 24.3 mm; 13, *N. (N.) radiata,* juvenile, length 6.1 mm.

pl.1, f.10 (Greenland); Ellis 1960:38 (Baffin Island and Greenland); Clarke 1962:53 (Canadian Arctic); Sparks and Pereyra 1966:834 (Chukchi Sea); Petersen 1968:5 (of "Müller") (Faroe Islands); Clarke 1974:8 (Baffin Bay); Wacasey 1974:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and north Atlantic. The species is represented in the Bering, and possibly the Okhotsk Sea. Records from Vancouver Island and California should be assigned to *N. pernula* (Müller).

Nuculana (Nuculana) pernula (Müller 1779)

Figures 10, 11

Arca pernula Müller 1779:55.
Leda pernula (Müller), G. Sars 1878:35, pl.5, f.1a–d; Oldroyd 1925:19, pl.19, f.7; Filatova 1948:417, pl.105, f.4–5; Petrov 1966:185, pl.10, f.12–15.
Nuculana pernula (Müller), Morch 1869:229.
Leda pernula costigera Leche 1883:447, pl.33, f.23–25 *(ex* Beck MS *Nuculana costigera).*
Leda pernula lamellosa Leche 1883:448, pl.33, f.26.
Leda rostrata Schumacher 1817:173, pl.19, f.4a–b [not Wood 1825]; Forbes 1846:420.
Nucula obsoleta Brown 1827:72, pl.25, f.17.
Nucula oblonga Brown 1845:84, pl.33, f.17
Leda pernuloides Dunker 1882:238.

DESCRIPTION: Shell elongate, inflated, with a long rostrum which tends to a concave curve on its upper surface, total length of shell to 38 mm. Surface with fine concentric lines, especially on dorsal part of disc. Periostracum light brown to black, polished and adherent. Valve with small anterior gape. Interior polished, porcelaneous, shell margins smooth. Pallial line slightly impressed, pallial sinus small.

COMPARISONS: This species appears less polymorphic than many Arctic bivalves. It may only be confused with *N. minuta* (Fabricius), but the latter is much smaller with a proportionately shorter rostrum and more pronounced sculpture.

COLLECTION: The species occurred at 57 stations for a total of 432 individuals in 23–455 m, but most abundant in less than 200 m.

RECORDS: *Miocene*—Yokohama 1925:9, pl.2, f.7–9 *lapsus "pennula"* (Northern Japan). *Pliocene*—Petrov 1966:185, pl.10, f.12–15 (Chukotsk Peninsula). *Pleistocene*—Wood 1851: 93, pl.10, f.13a, b (Britain); Meek 1923:414 (Alaska); Richards 1962:51 (Labrador to Maine). *Recent*—Loven 1846:34 (Norway); M. Sars 1850:173 (Norway); Jeffreys 1877a:232 (Britain); Leche 1878:27 (Novaya Zemlya); D'Urban 1880:253 (Barents Sea); Leche 1883:446 (Novaya Zemlya); Stuxberg 1886:149 (Novaya Zemlya); Hägg 1904:8 (Greenland);Dautzenberg and Fischer 1910:16 (Novaya Zemlya); Massy 1930:242 (North Atlantic); Mesjatsev 1931:46 (Barents Sea); Soot-Ryen 1939:8 (Franz Josef Land); Gorbunov 1946a:15 (Siberian Arctic); Madsen 1949:15 (Iceland); Kuroda and Habe 1952:26 (Northern Japan); Filatova 1957b:51 (Eurasian Arctic);

Ockelmann 1958:15, pl.1, f.9 (Greenland); Ellis 1960:38 (Baffin Island and Greenland); Merklin et al. 1962:23, pl.1, f.2 (Chukotsk Peninsula); Kuznetsov 1963:66 (Kamchatka); Filatova & Barsanova 1964:54 (Western Bering Sea); Soot-Ryen 1966:4 (Northeastern Atlantic); Petersen 1968:5 (Faroe Islands); Skalkin and Tabunkov 1969:1147 (Sakhalin Islands); Bernard 1970:86 (British Columbia); Kuroda et al. 1971:319, pl.66, f.13 (Japan); Clarke 1974:8 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal, throughout the North Atlantic, Bering Sea, Sea of Okhotsk, and in the North Pacific as far south as the Queen Charlotte Islands and northern Japan in 20–1400 m.

REMARKS: As this species is widely distributed throughout the Canadian Arctic Archipelago, the North Atlantic and Pacific oceans, its occurrence in the Beaufort Sea is not surprising. Arctic representatives are frequently referred to the subspecies *N. p. costigera* Leche, distinguished by an upturned rostrum. This character varies continuously however, and it cannot be given taxonomic status. Juvenile specimens, particularly from shallow water, frequently display a light color with concentric darker bands.

Nuculana (Nuculana) radiata (Krause 1885)

Figures 12, 13

Leda pernula radiata Krause 1885:23, pl.3, f.2a–c.
Leda radiata (Krause), Oldroyd 1925:25; Filatova 1948:418, pl.105, f.7.
Nuculana radiata (Krause), Kuroda and Habe 1952:62.

DESCRIPTION: Shell inflated, rostrum short. Length to 30 mm, generally smaller. Surface with prominent concentric ribs, crossed by fine radial ridges on periostracum: more pronounced in posterior region. Periostracum smooth and polished, light green to almost black, strongly adherent. Interior polished, margins smooth. Hinge line not well developed, resilifer small, elongated. Taxodont dentition in two series, teeth not numerous. Pallial line feebly impressed, pallial sinus small.

COMPARISONS: This species, with radial periostracal threads crossing the concentric ribs, is unlike any other Arctic nuculanid. The hinge resembles *N. minuta* (Fabricius), but the teeth are proportionally fewer.

COLLECTION: The species was represented at nine stations for a total of 280 specimens in 27–55 m.

RECORDS: *Pleistocene*—Petrov 1966: 186 (Chukotsk Peninsula). *Recent*—Soot-Ryen 1932:6, pl.1, f.7–8 (Pacific Arctic, Bering and Okhotsk seas); Gorbunov 1946a:46 (Siberia); Filatova 1957b:52 (Siberia), MacGinitie 1959:151, pl.18, f.2 (Point Barrow, Alaska); McLaughlin 1963:24 (Bering Sea); Sparks and Pereyra 1966:834 (Chukchi Sea).

DISTRIBUTION: Panarctic along the North American coast probably as far east as Union Strait and along the Siberian coasts of the Soviet Union. The species is distributed throughout the Bering Sea and extends to Northern Japan. It has not been collected south of the Aleutian Archipelago. All Beaufort Sea collections are in shallow water, usually less than 40 m.

REMARKS: Although proposed as a variety of *N. pernula* (Müller) it is more closely related to *N. minuta* (Fabricius) but is sufficiently and consistently distinct to warrant full separation. It probably arose in the eastern Bering Sea and only recently colonized the Chukchi Sea and adjacent Arctic.

Genus *Portlandia* Mörch 1857

Figure 14

Type species (subsequent designation ICZN 1966): *Nucula arctica* Gray 1824. Recent. North Atlantic.

DESCRIPTION: Shell solid, ovate to elliptical, with a small rostrum. Surface smooth, or with irregular incremental lirae. Periostracum thick, light brown to black, adherent. Interior porcelaneous, margins smooth. Hinge line well developed, resilifer large, taxodont dentition in two series, approximately equal in number, but anterior teeth slightly smaller. Pallial line impressed, pallial sinus small, in some cases absent.

RANGE: Miocene to Recent. Recent distribution cosmopolitan, usually in deep water, but also in shallow boreal and Arctic environments. The genus is a member of the shallow infauna of fine-grained sediments.

DEVELOPMENT: The ova are large, development is probably lecithotrophic with no planktonic phase (Bernard MS).

REMARKS: Anatomically the genus is closely related to nuculanids, and is characterized by short, often incomplete siphons, and large palp appendages. Members of the genus are probably entirely deposit feeders, actively plowing through the superficial sediments. Filatova (1951) has discussed the geographical distribution of the genus.

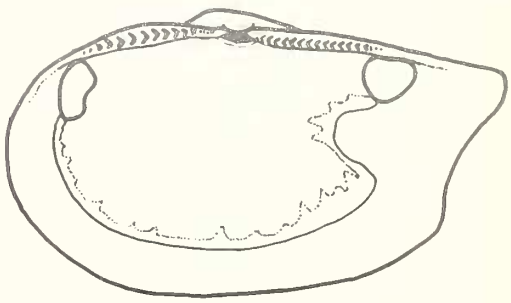


FIGURE 14. Interior of right valve of *Portlandia arctica* (Gray).

KEY TO THE SUBGENERA OF PORTLANDIA

1.	Pallial sinus small or absent	*Yoldiella*
	Pallial sinus developed	2
2.(1)	Resilifer large, subtriangular	*Portlandia* s. str.
	Resilifer small, rectangular	*Ledella*

Subgenus *Portlandia* s. str.
Portlandia (Portlandia) arctica (Gray 1824)
Figures 15, 16, 17

Nucula arctica Gray 1824:241.
Leda arctica (Gray), Dall 1874: 250 (of "Broderip"); Oldroyd 1925:26, pl.19, f.6, a.
Yoldia arctica (Gray), Mossewitsch 1928:1, pl.1; MacGinitie 1959:151, pl.18, f.8.
Portlandia arctica (Gray), G. Sars 1878:37, pl.4, f.7a–b; Filatova and Zenkevich 1957:67; Petrov 1966:190.
Nucula siliqua Reeve *in* Belcher 1855:396, pl.33, f.4; Crosse 1877:119.
Yoldia arctica siliqua (Reeve *in* Belcher), Petrov 1966:191, pl.11, f.1–7.
Leda (Portlandia) collinsoni Dall 1919:19A, pl.2, f.3, 4.

DESCRIPTION: Shell oval to elongate, total length to 30 mm, but usually half this. Posterior produced, set off by a radial sulcus to form a small pointed rostrum. Surface unsculptured, sometimes with feeble incremental lines and concentric wrinkles. Periostracum thick, color variable, ranging from light yellow-green to black but generally rich maroon. Interior of shell porcelaneous, margins smooth. Hinge line substantial, with large spoon-shaped resilifer, taxodont dentition in two series, with approximately the same number of teeth, the anterior series smaller. Pallial line clearly impressed, pallial sinus deeply indented.

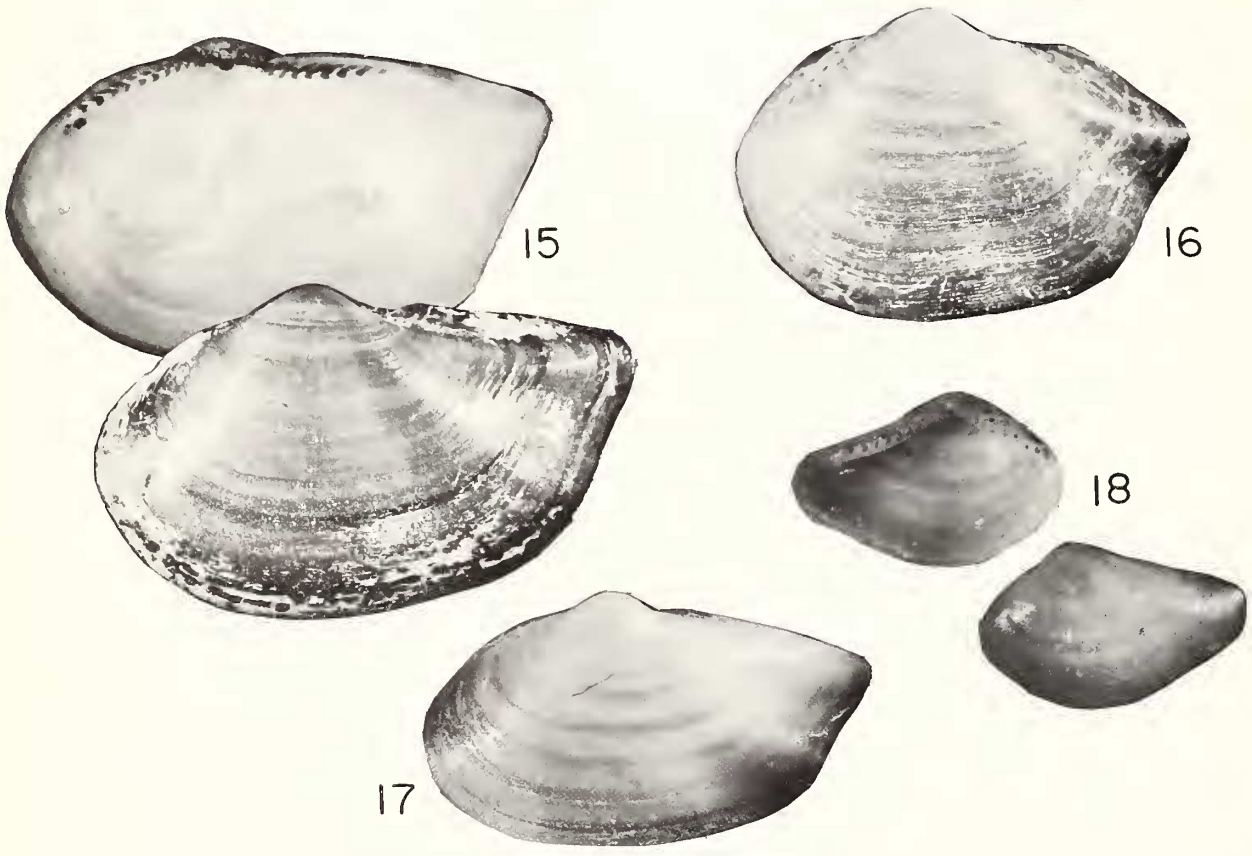
COMPARISONS: This species may be confused with *P. intermedia* (M. Sars), but the latter is a thinner-shelled, more inflated species and the posterior region is not set off by a radial sulcus, the resilifer is smaller and the pallial sinus only slightly indented.

COLLECTION: The species is abundantly represented in the collection, occurring at 85 stations for a total of 2944 specimens and numerous single valves. Living representatives were found between 10–2560 m, but were most abundant in shallow water.

RECORDS: *Pleistocene*—Jeffreys 1877:489 (Greenland and Spitzbergen); Lamplugh 1886:280 (British Columbia); Dall 1924:32A (Arctic Canada); Merklin et al. 1962:25 pl.1, f.4–8 (Chukotsk Peninsula); Richards 1962:52, pl.1, f.18–20, 27, 28 (Newfoundland to Vermont); Petrov 1967:190 (Bering Strait). *Recent*–Møller 1842:18 (Greenland); Crosse 1877:119 (Arctic); Leche 1878:27 (Novaya Zemlya); Leche 1883:444, pl.33, f.18, 19 (European Arctic); Stuxberg 1886:147 (Novaya Zemlya); Posselt 1898:68 (Greenland); Hägg 1904:14 (Greenland and Jan Mayen); Odhner 1915:60 (Spitzbergen); Mesjatev 1931:30 (Barents Sea); Soot-Ryen 1932:8 (Arctic); Gorbunov 1946a:42 (Siberia); Filatova 1951:119, f.1–3 (Eurasian Arctic); Filatova 1957b: 52 (Eurasian Arctic); Soot-Ryen 1958:8 (Greenland); Ockelmann 1958:23 (Greenland); Ellis 1960:38 (Baffin Island and Greenland); Hulsemann 1962:70 (Beaufort Sea); Wacasey 1975: 27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: This is the most characteristic high Arctic species, panarctic in distribution and also found in the northernmost Atlantic and south into Hudson Bay.

REMARKS: This is a variable species, with the elevated form



FIGURES 15–18. 15, *Portlandia (Portlandia) arctica* (Gray), length 17.9 mm; 16, *P. (P.) arctica*, abbreviated form, length 11.1 mm; 17, *P. (P.) arctica*, elongated form, length 11.2 mm; 18, *Portlandia (Ledella) tamara* (Gorbunov), length 2.7 mm.

referred to *P. collinsoni* (Dall), but as the proportions present a continuous spectrum, no systematic importance to the latter can be accorded. Dall (1919) stated his new species displayed a vermiculately wrinkled periostracum but type material lodged in the National Museum of Canada falls within the expected variability. Similarly, the Siberian *P. aestuariorum* Mossewitsch 1928 is probably also a morph. Remarks on feeding are given by Bubnova (1971, 1972) and the species is almost exclusively a detritus feeder. It is a member of the shallow-water fauna, so it is surprising that the OSU collection contained juvenile specimens from deepwater stations. The proportions of these representatives are slightly different from typical shallow *P. arctica,* but there is insufficient reason to separate them. I am grateful to R. Baxter for the loan of specimens collected in deep water from Prince William Sound, Alaska. They bear a close resemblance to *P. arctica,* but the profile of the rostrum and sculpture of the periostracum are different. It is my tentative opinion that the Gulf of Alaska representatives should be separated at the species level and will require a new name.

Subgenus *Ledella* Verrill and Bush 1897

Type species (subsequent designation Verrill and Bush 1897): *Leda messanensis* Seguenza 1877. Miocene. Europe.

Portlandia (Ledella) tamara (Gorbunov 1946)

Figure 18

Ledella tamara Gorbunov 1946b: 320, pl.3, f.4.

DESCRIPTION: Shell ovate, inflated, total length to 5 mm. Posterior with short rounded rostrum. Surface unornamented, except for sporadic feeble incremental striae. Periostracum thin, polished, strongly adherent. Shell interior porcelaneous, margins smooth. Hinge line straight in posterior region and convex anteriorly. Resilifer small, folded below beaks. Taxodont dentition in two series, approximately equal in number, but posterior teeth larger. Pallial line not impressed, pallial sinus not evident.

COMPARISON: This subgenus, with its *Portlandia*-like exterior and *Yoldiella*-like dentition, is separated from the latter by an internal ligament and is unmistakable. This is the sole Arctic representative of the taxon and its relationship to other members of group has not been elucidated.

COLLECTION: One right valve from 71°45.0′N, 150°35.0′W in 2130 m.

DISTRIBUTION: *Recent*—Wagner 1962:10 (Canadian Arctic Archipelago); Clarke 1963:100, pl.2, f.10, 11 (Laurentian Basin). The type locality is the New Siberian Islands (75°22′N, 135°00′E) in 3700–3800 m. Clarke (1963) reported numerous dead shells north of Point Barrow in 530–2278 m. Wagner's (1962) record from Eastern Arctic Canada, suggests that this species is widely distributed in the deeper waters of the Laurentian Basin.

REMARKS: *Ledella* was proposed by Verrill & Bush (1897) as a substitute name for the preoccupied *Junonia* Sequenza 1877, and placed as a subgenus of *Nuculana* by Moore (1960). It appears closer to *Yoldiella* on conchological grounds, but the internal ligament and shell shape suggest it should be accorded subgeneric status within *Portlandia.*

Subgenus *Yoldiella* Verrill and Bush 1897

Type species (original designation): *Yoldia lucida* Lovén 1846. Recent. North Atlantic.

Portlandia (Yoldiella) fraterna (Verrill & Bush 1897)

Figure 19

Yoldiella fraterna Verrill and Bush 1898:867, pl.80, f.5, pl.82, f.8.
Portlandia fraterna (Verrill and Bush), Odhner 1915:68, pl.1, f.26–29.
Portlandia frigida nana Jensen 1905:320 (*fide* Ockelmann, 1958), [not *Yoldia nana* M. Sars 1865.]

DESCRIPTION: Shell elliptical to elongate, total length to 5 mm but usually less than 3 mm. Surface smooth, rarely with fine incremental striae. Periostracum brilliantly varnished, light yellow to grey-brown in color, dehiscent. Interior polished, porcelaneous, margins smooth. Hinge line rather delicate, straight, with central small deep resilifer. Ligament mostly internal, with small protrusion just below the beaks. Teeth nearly equal in size. Pallial line obscure, pallial sinus feebly impressed.

COMPARISONS: This species may be confused with *P. frigida* (Torell) which is larger and the posterior end is set off from the disc by a radial flexure. *P. fraterna* has a thinner and more compressed shell.

COLLECTION: This species occurred at two stations, represented by three specimens and one valve, in 585–991 m.

RECORDS: *Pleistocene*–Merklin et al. 1962:27, pl.1, f.18 (Chukotsk Peninsula); Petrov 1967a:184 (Chukotsk Peninsula). *Recent*—Mesjatsev 1931:45 (Barents Sea); Filatova 1957b:52 (Eurasian Arctic); Filatova and Zenkevich 1957:65 (Kara Sea); Petrov 1967:184 (Chukotsk Peninsula); Ockelmann 1958:37, pl.1, f.15 (Greenland); Wacasey 1975:24 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and throughout the northern part of the Atlantic, into Hudson Bay and in deep water along the American eastern seaboard as far south as Georgia. The species has not been collected in the eastern Bering Sea and does not occur in the Pacific.

REMARKS: It is with some trepidation that I identify the OSU material with this species, there are small differences in the shell proportions, but within the range of polymorphism so characteristic of Arctic bivalves; however, there is too little material to make an extensive comparison. It is possible that *P. minuscula* Verrill & Bush 1898 is conspecific. The authors, in the original description, remark on the deep pallial sinus that is not visible in most specimens due to being weakly impressed. I am unable to detect a trace of a sinus in the material I have examined and consider this species to belong to the group of *Yoldiella* which lacks a pallial sinus.

Portlandia (Yoldiella) frigida (Torell 1859)

Figures 20, 21

Yoldia frigida Torell 1859:148, pl.1, f.3
Leda frigida (Torell), Jeffreys 1877a:232.
Portlandia frigida (Torell), G. Sars 1878:39, pl.4, f.11a, b.
Portlandia (Yoldiella) frigida (Torell), Filatova 1948:420, pl.106, f.6

DESCRIPTION: Shell ovate, inflation variable, but usually rather compressed. Total length to 8 mm, usually less than 4 mm. Posterior region sharply angulated, set off by a radial flexure. Surface unsculptured, sometimes with slight concentric lirae. Periostracum highly polished, color straw yellow to light brown, frequently with concentric bands of darker coloration. Interior porcelaneous, margins smooth. Hinge line with taxodont dentition in two nearly straight series of approximately equal numbers of teeth. Resilifer small, ligament partly external. Pallial

line slightly impressed, pallial sinus vestigial or absent.

COMPARISONS: This species is the most ovate of the subgenus, externally appearing very much like a small *P. arctica* (Gray), but is easily separated by the lack of a pallial sinus, the small resilifer and the external ligament. *P. fraterna* (Verrill & Bush) is a thinner shelled and more delicate species, and the hinge line is more nearly straight.

COLLECTION: This species is abundantly represented in the collection, occurring at 117 stations for a total of 1434 specimens and numerous single valves, in 27–2560 m.

RECORDS: *Recent*–Leche 1878:25, pl.1, f.62-d (Novaya Zemlya); Friele 1878:222 (North Atlantic); Friele and Grieg 1901:15 (Barents Sea); Jensen 1905:320 (Greenland); Odhner 1915:66, pl.1, f.20–32 (European Arctic); Mesjatsev 1931:44 (Barents Sea); Soot-Ryen 1939:9 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:18 (Iceland); Filatova 1957b:52 (Eurasian Arctic); Ockelmann 1958:34, pl.1, f.14 (Greenland); Wagner 1962:10 (Arctic Canada); Clarke 1963:100, pl.2, f.6–8 (Laurentian Basin); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and throughout the high latitudes of the Atlantic. Ockelmann (1958) has concluded that this species has a more limited distribution in the Atlantic than that suggested by the literature. I concur that the illustration given by Verrill and Bush (1898, pl.79, f.4) is not this species and is unlikely that it occurs as far south as New England. It is not present in the Bering Sea or Pacific.

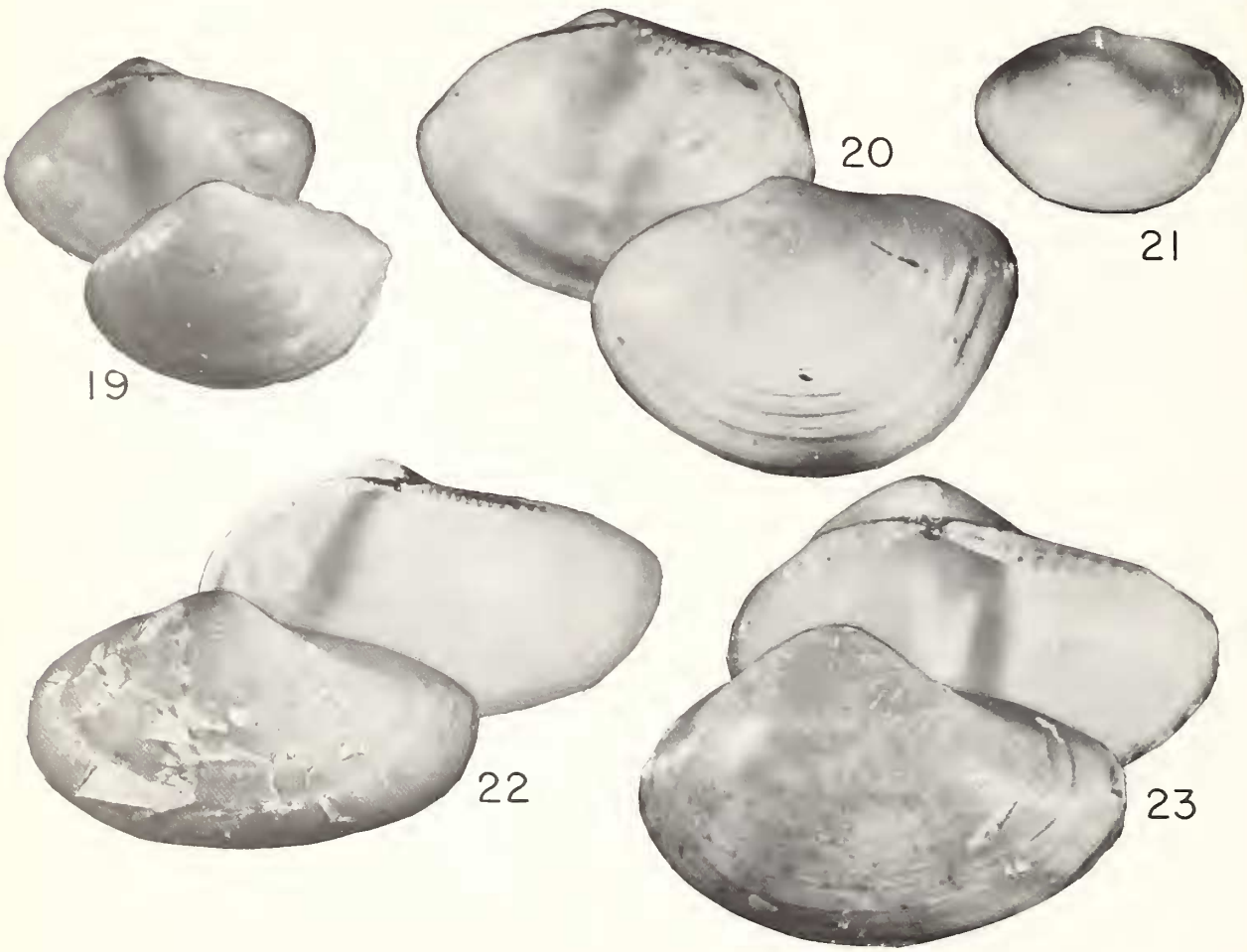
REMARKS: I am grateful to K.W. Ockelmann who identified this species for me.

Portlandia (Yoldiella) intermedia (M. Sars 1865)

Figure 22

Yoldia intermedia [M. Sars 1859:57, *nom. nud.*] M. Sars 1865:38, f.92–96; Oldroyd 1925:35, pl.1, f.1, 10.
Portlandia intermedia (Sars), Jensen 1905:319.
Portlandia (Yoldiella) intermedia (Sars), Filatova 1948:420, pl.106, f.3 (of "Møller").
Yoldiella intermedia (Sars), Petrov 1966:193, pl.11, f.11–14.
Yoldiella intermedia major Leche 1878:24, pl.1, f.5.

DESCRIPTION: Shell elongate, inflated, total length to 15 mm. Anterior margin rounded, posterior sharply angulate.



FIGURES 19–23. 19, *Portlandia (Yoldiella) fraterna* (Verrill and Bush), length 3.9 mm; 20, *Portlandia (Yoldiella) frigida* (Torell), length 4.6 mm; 21, *P. (Y.) frigida*, elongated form, length 4.5 mm; 22, *Portlandia (Yoldiella) intermedia* (Sars), length 12.3 mm; 23, *Portlandia (Yoldiella) lenticula* (Møller), length 5.6 mm.

Umbones prominent. Surface smooth, sometimes with weak incremental striae. Periostracum brilliantly varnished, often with an iridescent sheen, color a light straw yellow to a grey brownish. Interior porcelaneous, polished, margins smooth. Hinge line weak, taxodont dentition in two series, the posterior row straight, and the anterior series in curve parallel to shell margin. Resilifer small, deeply set in a vertical position below beaks. Ligament mostly internal, but small part protruding. Pallial line almost invisible, pallial sinus vestigial.

COMPARISONS: This large *Yoldiella* is easily distinguishable from others by the inflated and elongate shell and the small deeply set resilifer. The extensive peeling of the periostracum from dried shells to reveal the chalky shell surface is also characteristic.

COLLECTION: This species did not occur frequently in the collection, being present at four stations only for a total of 52 specimens and a few dead valves, in 270–455 m.

RECORDS: *Recent*—Dall 1874:250 (of "Carpenter") (Bering Sea); Friele 1878:222 (Greenland); Leche 1878:24 (Novaya Zemlya); D'Urban 1880:253 (Barents Sea); Leche 1883:446 (Novaya Zemlya); Hägg 1904:11 (Greenland); Jensen 1905:319 (Greenland); Dautzenberg & Fischer 1910:17 (Novaya Zemlya); Odhner 1915:60 (Spitzbergen); Massy 1930:244 (North Atlantic); Mesjatsev 1931:35 (Barents Sea); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:17 (Iceland); Filatova 1957b:52 (Eurasian Arctic); Ockelmann 1958:27, pl.1, f.12 (Greenland); Ellis 1960:38 (Baffin Island and Greenland); Clarke 1960:8, pl.1, f.6–8 (Laurentian Basin); Clarke 1963:100 (Laurentian Basin); Petrov 1967:184 (Bering Sea); Clarke 1974:9 (Baffin Bay); Wacasey 1974:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and widely distributed in the North Atlantic on the European side. This species has not been recorded in Hudson Bay or along the United States Atlantic seaboard. It extends into the northeastern part of the Bering Sea and has been collected several times in Norton Sound.

REMARKS: Ockelmann (1958) pointed out that, unlike other members of the genus, *P. intermedia* is rather uniform in its external morphology. It is possible that this species is a variety of *P. lucida* (Loven, 1846). It may be identical to *P. kolthoffi* Hägg 1904 from Jan Mayen, but that species is more compressed posteriorly and is ornamented with pronounced radial lirae.

Portlandia (Yoldiella) lenticula (Møller 1842)

Figure 23

Nucula lenticula Møller 1842:17.
Yoldia lenticula (Møller), Stuxberg 1886:148.
Portlandia lenticula (Møller), G. Sars 1878:39, p.4, f.10a, b.
Yoldiella lenticula (Møller), Petrov 1966:194, pl.11, f.15–20.
Yoldiella lenticula amblia Verrill & Bush 1898:866, pl.80, f.9, pl.81, f.4.
Yoldia abyssicola Torell 1859:149, pl.1, f.4a–b.
Portlandia (Yoldiella) persei Mesjatsev 1931:44; Filatova, 1957b: 52.

DESCRIPTION: Shell ellipticai to elongate, inflated, total length to 10 mm but usually smaller. Surface smooth, with fine concentric striae and growth checkmarks. Periostracum polished, straw yellow to dark brown in color. Interior porcelaneous, margins smooth. Hinge line narrow with two series of long taxodont teeth separated by a deeply set resilifer. Ligament mostly internal. Pallial line not discernible: pallial sinus absent.

COMPARISONS: This species may be confused with *P. intermedia* (M. Sars), but the posterior part is shorter, the shell less inflated, and the resilifer shallower.

COLLECTION: This species was abundantly represented at 56 stations for a total of 2271 specimens and numerous single valves, in 23–360 m.

RECORDS: *Pleistocene*—Merklin et al. 1962:26, pl.1, f.13–16 (Chukotsk Peninsula); Richards 1962:52, pl.1, f.23, 24 (James Bay to Maine); Troitskiy 1974:265 (Siberia) *Recent*—Hägg 1904:13 (Greenland); Jensen 1905:320 (Greenland); Odhner 1915:64 (Spitzbergen); Massy 1930:239 (North Atlantic); Soot-Ryen 1939:8 (Franz Josef Land); Gorbunov 1946a:46 (Siberian Arctic); Filatova 1957b:52 (Eurasian Arctic); Ockelmann 1958:30, pl.1, f.13 (Greenland); Soot-Ryen 1958:9 (Greenland); Clarke 1961:8, pl.1, f.4 (Laurentian Basin); Richards 1962:52, pl.1, f.23, 24 (Arctic Canada to Maine); Petrov 1967:184 (Northern Bering Sea); Petersen 1968:6(Faroe Islands); Clarke 1974:9 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and widely distributed throughout the Northern Atlantic and along the American coast as far south as Maine. It occurs sporadically in the northernmost Bering Sea, but not in the Pacific Ocean.

REMARKS: The taxon *P. lenticula amblia* (Verrill and Bush 1898) is merely a thicker shelled form typical of coarser sediments and occurs throughout the range.

Genus Yoldia Møller 1842

Figure 24

Type species (subsequent designation ICZN 1966): *Yoldia hyperborea* Torell 1859. Recent. Arctic.

DESCRIPTION: Shell thin, subovate to elongate, posterior produced, sometimes distinctly rostrate, with a posterior gape. Surface smooth or with predominantly concentric lirae. Periostracum brilliantly polished, thin and dehiscent. Interior porcelaneous, margins always smooth. Hinge line with large subumbonal resilifer, taxodont dentition in two subequal series. Pallial line feebly impressed, pallial sinus well developed.

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan in temperate and cold waters, from the high subtidal level to abyssal environments. Inhabiting a wide range of substrates, but usually with a high proportion of fine sediments. Long siphons permit the group to be deeply infaunal.

DEVELOPMENT: Ova large, development lecithotropic with a very abbreviated planktonic phase.

REMARKS: This genus includes the most developed protobranchs, all are active burrowers, rapidly moving through the substrate, or using the bifurcated foot to move the unburied animal. Three species are represented in the collection, but all are

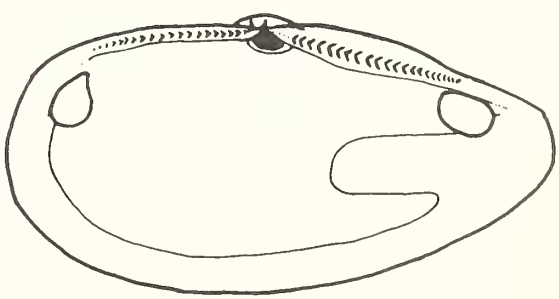


FIGURE 24. Interior of right valve of *Yoldia hyperborea* Torell.

scarce, as were those listed by MacGinitie (1959). It should be noted that *Y. thraciaeformis* (Storer 1838) was not found; it is circumboreal and abundantly represented in the Chukchi Sea and in Dolphin and Union Strait.

KEY TO THE SUBGENERA OF *YOLDIA*

Surface smooth, or with concentric lirae ..... *Yoldia* s. str.
Surface with oblique incised lirae ..... *Cnesterium*

Subgenus *Yoldia* s. str.
Yoldia (Yoldia) hyperborea Torell (Loven MS) 1859

Figures 25, 26

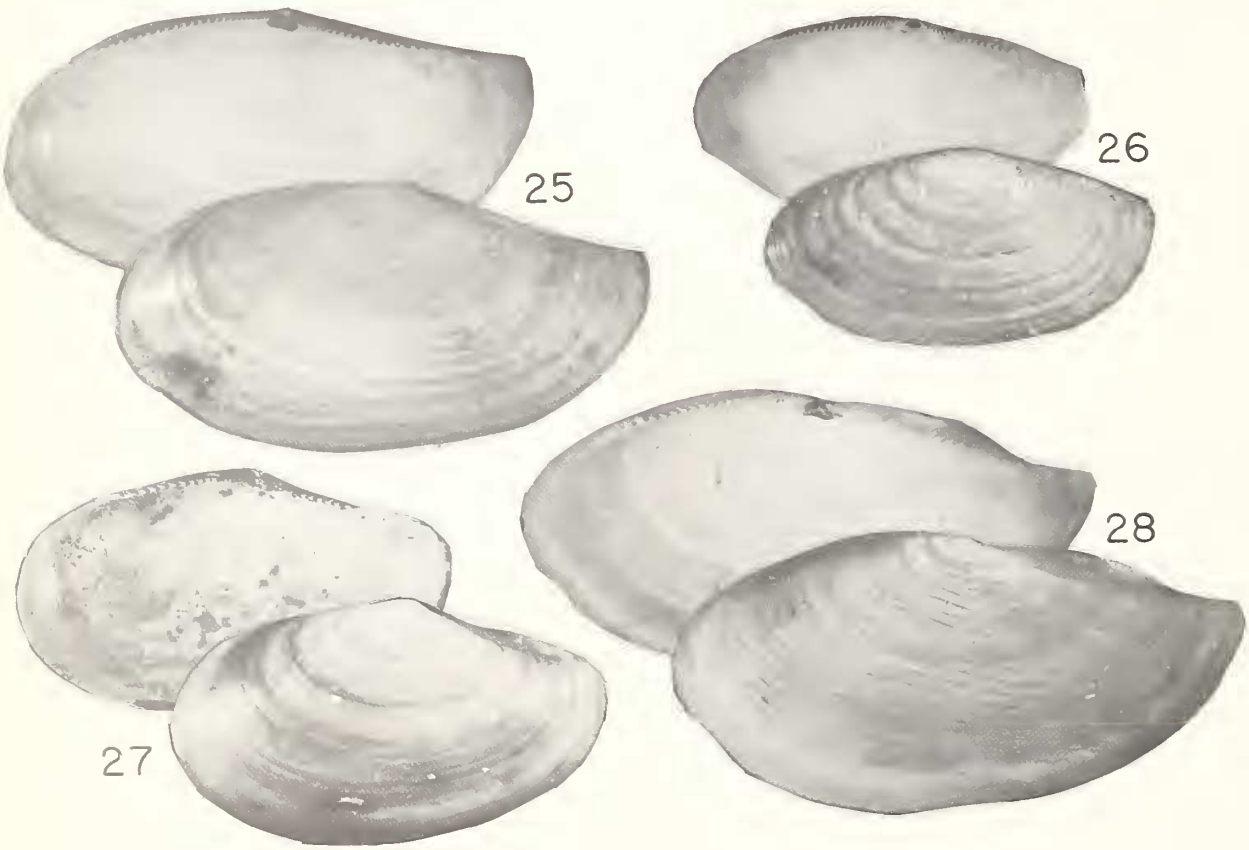
Yoldia hyperborea Torell (Loven MS) 1859:142, pl.2, f.6a–b; Filatova 1948:421, pl.106, f.8; Ockelmann 1954:8, pl.1, f.1, 2, pl.2, f.1–4; Cowan 1968:58, pl.5, f.6, 7.
Yoldia limatula hyperborea. Gorbunov 1946a:46.

DESCRIPTION: Shell thin, compressed, total length to 45 mm. Surface smooth, sometimes with feeble incremental striae. Periostracum light brown to yellow, brilliantly polished and strongly adherent. Interior porcelaneous to chalky, shell margins smooth. Pedal and siphonal regions with pronounced gapes. Hinge line with large resilifer and taxodont dentition in two subequal series. Pallial line impressed, pallial sinus large.

COMPARISONS: This species is similar to the circumboreal *Y. amygdalea* Valenciennes 1846, but the posterior region is longer, more tapering and not pointed. The other representative of the genus also present in the Beaufort Sea is *Y. myalis* (Couthouy 1838) which is easily separated from *Y. hyperborea* by its more ovate outline, dull periostracum, and more posterior placement of the beaks.

COLLECTION: *Y. hyperborea* occurred at 13 stations for a total of 22 specimens and several single valves in a depth of 30–360 m.

RECORDS: *Pleistocene*—Merklin et al. 1962:24, pl.1, f.3 (Chukotsk Peninsula); Petrov 1966:188, pl.10, f.18–20 (Chukotsk Peninsula); Gladenkov 1972:207 pl.3, f.1–8 (Kamchatka). *Recent*—Leche 1883:444, pl.33, f.16, 17 (European Arctic); Krause 1885:25 (Bering Sea); Stuxberg 1886: 147 (Novaya Zemlya); Hägg 1904:10 (Greenland and Spitzbergen); Odhner 1910:18, pl.1, f.23 (Iceland); Odhner 1915:51 (Spitzbergen); Filatova 1957b:52 (Arctic); Ockelmann 1958:21 (Green-



FIGURES 25–28. 25, *Yoldia (Yoldia) hyperborea* (Torell), length 31.0 mm; 26, *Y. (Y.) hyperborea*, abbreviated form, length 24.8 mm; 27, *Yoldia (Yoldia) myalis* (Couthouy), length 17.1 mm; 28, *Yoldia (Cnesterium) scissurata* Dall, length 22.9 mm.

land); MacGinitie 1959:152, pl.18, f.5 (Point Barrow); Ellis 1960:38 (Baffin Island and Greenland); Sparks & Pereyra 1966:834 (Chukchi Sea); Petrov 1967a:184 (Northern Bering Sea); Gladenkov 1972:207, pl.3, f.1–8 (Kamchatka); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic, with discontinuous distribution. It is abundant in the Canadian Arctic Archipelago and Greenland and throughout the North Atlantic; also in the Chukchi and Northern Bering seas.

REMARKS: Ockelmann (1954) in a review of the various species proposed separation of North Atlantic more attenuated forms as *Y. hyperborea limatuloides* Ockelmann 1954. Cowan (1968) considered this stock distinct and conspecific with the circumboreal *Y. amygdalea* Valenciennes 1846.

Yoldia (Yoldia) myalis (Couthouy 1838)

Figure 27

Nucula myalis Couthouy 1838:62, pl.3, f.7.
Yoldia myalis (Couthouy), Oldroyd 1925:30, pl.5, f.8; Ockelmann 1954:18, pl.1, f.1, pl.2, f.5, 10.

DESCRIPTION: Shell inflated, ovate, anterior evenly rounded, posterior prolonged, subtriangular, maximum length to 30 mm. Surface with irregular concentric ridges. Periostracum olive green to dark brown, dull and dehiscent. Interior porcelaneous, margins smooth with prominent posterior and pedal gapes. Hinge line developed, taxodont dentition in two nearly equal series of short solid teeth. Resilifer large, shallow, and laterally produced. Pallial line deeply impressed, pallial sinus large.

COMPARISONS: Although the shell outline of this species tends to be variable, the more oval shape, posterior placement of the umbones, the full periostracum, and large elongated resilifer, readily distinguish this species from all other species of *Yoldia*.

COLLECTION: The species is represented by three specimens from one station in 79 m.

RECORDS: *Pleistocene*—Wood 1851:90, pl.10, f.17 a–c (Britain); Richards 1962:52, pl.1, f.26 (Maine); Petrov 1966:189, pl.10, f.21 (Chukotsk Peninsula). *Recent*—Gould 1841:99 (Massachusetts); Gould 1870:160 (Massachusetts); Crosse 1877:120 (Bering Sea); Johnson 1934:17 (Labrador to Massachusetts); Filatova 1957b:52 (Eurasian Arctic); MacGinitie 1959:152, pl.18, f.1 (Point Barrow, Alaska); Hulsemann 1962:71 (Beaufort Sea); Richards 1962:52, pl.1, f.26 (Labrador to Cape Cod); McLaughlin 1963:25 (Bering Sea); Filatova and Barsanova 1964:20 (Western Bering Sea); Sparks and Pereyra 1966:834 (Chukchi Sea); Bernard 1970:86 (British Columbia); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Limited Arctic distribution. The species is present along the North Atlantic American coast from Maine to Hudson Strait, but it is not found off Greenland. On the Pacific side it occurs from Washington State to Alaska and throughout the Bering Sea. It enters the Chukchi Sea and occurs sporadically on the adjacent continental margins as far west as the Siberian Sea and along the American coast to Point Barrow and the western Beaufort Sea.

REMARKS: Ockelmann (1954) is correct in regarding the distribution of this species as discontinuous, though Hulsemann (1962) extended the range some 250 km east of Point Barrow. There are consistent differences between the Pacific and Atlantic stocks, with Arctic representatives more closely connected to the Atlantic form. It is possible that living Arctic specimens are relicts of an earlier holoarctic distribution.

Subgenus *Cnesterium* Dall 1898

Type species (original designation): *Yoldia scissurata* Dall 1897. Recent. Northeast Pacific.

Yoldia (Cnesterium) scissurata Dall 1897

Figure 28

Yoldia scissurata Dall 1897:8, [new name for *Yoldia arctica* Broderip and Sowerby 1829 *not* Gray 1824]; Oldroyd 1925:31, pl.5, f.2.
Yoldia (Cnesterium) scissurata Dall, Filatova 1957b:52.
Yoldia ensifera Dall 1897a:9, pl.2, f.4; Oldroyd 1925:32, pl.5, f.3, pl.37, f.6.
Yoldia ensifera plena Dall 1908:256; Oldroyd 1925:33.
Yoldia (Cnesterium) strigata Dall 1909:18, 104, pl.14, f.9, a; Grant and Gale 1931:131.

DESCRIPTION: Shell compressed, elongate, maximum length to 40 mm. The anterior end is evenly rounded, posterior end with slightly recurved small rostrum. Posterior dorsal margins produced to form blade-like crest. Surface with feeble concentric lirae, crossed by oblique incised lines. Periostracum brilliantly varnished, adherent, color light brownish-yellow to black, frequently with concentric bands of different colors. Interior polished, shell margins smooth, with small pedal and siphonal gapes. Taxodont dentition in two series, the anterior rather more numerous than the posterior teeth. Resilifer wide, deeply set. Pallial line feebly impressed, pallial sinus deep and rounded.

COMPARISONS: This species is easily distinguished by the oblique sculpture which involves the shell layers and may carry through into the interior, in some specimens it may be more easily observed in transmitted light.

COLLECTION: Represented by four specimens only from one station in 64 m.

RECORDS: (?) *Miocene*—Dall 1909:104, pl.14, f.9, a (Oregon); Arnold and Hannibal 1913:590 (Oregon); Weaver 1916:32 (Washington). *Pliocene*—Grant & Gale 1931:131 (Oregon). *Pleistocene*—Grant and Gale 1931:131 (California); Zhidkova et al. 1972:97, pl.10, f.12–18 (Kurile Islands). *Recent*—Packard 1918:249, pl.14, f.6 (California); Grant & Gale 1931:131 (Arctic Ocean to British Columbia); Eyerdam 1938:100 (Aleutian Archipelago); Kuroda and Habe 1952:35 (Northern Japan); MacGinitie 1959:154 (Point Barrow, Alaska); McLaughlin 1963:25 (Bering Sea); Parker 1964:157 (Gulf of California, Mexico); Sparks and Pereyra 1966:834 (Chukchi Sea); Bernard 1970:86 (British Columbia).

DISTRIBUTION: Present throughout the Bering Sea, this species extends along the American coast possibly as far south as the Gulf of California, Mexico. It is present in the Sea of Okhotsk to Northern Japan. It passes through the Bering Strait into the Chukchi Sea as far west as the Siberian Sea and to the east including Point Barrow and the present range extension.

REMARKS: There is little doubt *Y. ensifera* Dall is the southern representative of this species and identical to *Y. strigata* Dall of the Miocene of Oregon. It is possible that *Y. vasiljevskii* Slodkevitch 1935 from Franz Josef Land is closely related. They may all have originated from *Y. (Cnesterium) yakatagensis* Kanno 1971 from the Alaskan Tertiary.

Family ARCIDAE Lamarck 1809
Genus *Bathyarca* Kobelt 1891
Figure 29

Type species (original designation): *Arca pectunculoides* Scacchi 1833. Eocene. Europe.

DESCRIPTION: Shell oval to elongate, inflated. Surface with incremental striae or small concentric riblets. Periostracum thick, dehiscent, hirsute, frequently with radial rows of short bristles. Interior porcelaneous, margins smooth. Hinge line with central edentulous space separating posterior and anterior series of pseudotaxodont teeth. In some species the hindermost teeth tend to be oblique and sometimes parallel the hinge margin. Ligament external, with small strands inserted in chevron-shaped grooves below the beaks. Pallial line entire, slightly impressed, no pallial sinus.

RANGE: Eocene to Recent. Recent distribution cosmopolitan, generally in deep and abyssal water, but may occur in 20 m or less in cold waters. The preferred habitat is gravel mixed with fine sediments and byssally attached to pebbles or other hard object. The habitat is superficially infaunal or nestling, often with only the anterior end buried, frequently resulting in the attachment to the shell of ascidians, actinians, and other small epizoae.

DEVELOPMENT: Ova are large, it is probable that development is lecithotrophic with a reduced, or absent planktonic phase (Thorson 1936, Ockelmann 1958).

REMARKS: Species presently included within *Bathyarca* fall into three distinct groups. The first comprise small, rather compressed types with few teeth that have a tendency to assume an oblique, or even horizontal, position. The shell is of medium thickness and the periostracum hirsute. The second group includes thin-shelled, highly inflated forms with concentric ribbing and overlying radial striae. The periostracum is thin and the teeth are more numerous. The last group is characterized by a thick chalky shell with irregular concentric striae and a thick very hirsute periostracum rather reminiscent of *Limopsis*. The interior between the adductor muscle scars is frequently colored red or brown. It is likely that careful comparison, particularly of the soft anatomy, will show that separate genera or subgenera should be erected. Two species are present in the collection.

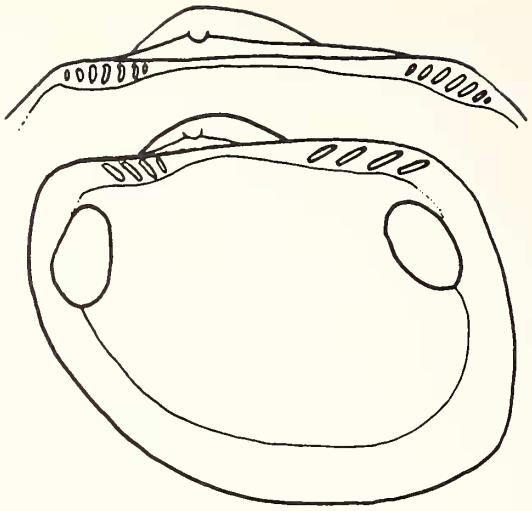
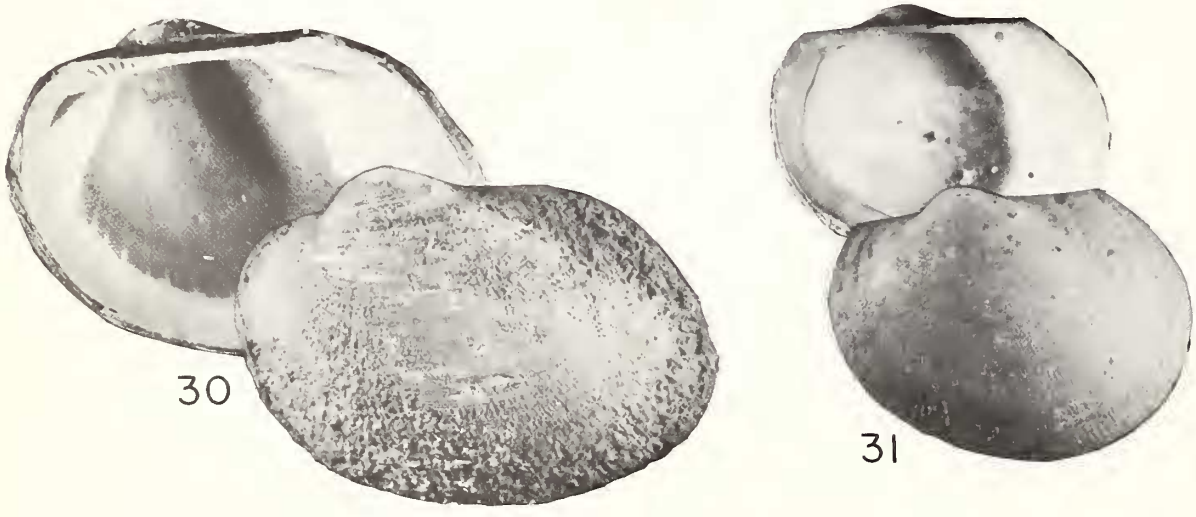


FIGURE 29. Interior of right valve of *Bathyarca pectunculoides* (Scacchi), *inset*, hinge of *B. glacialis* (Gray).

Bathyarca glacialis (Gray 1824)
Figure 30

Arca glacialis Gray 1824:244 (Appendix); G. Sars 1878:43, pl.4, f.1 a–c.
Arca (Bathyarca) glacialis Gray, Filatova 1948:422, pl.106, f.10.

DESCRIPTION: Shell thick, chalky, inflated, length to 25 mm. Outline elongate to ovate. Surface with feeble concentric striae. Periostracum thick, light brown, very hirsute. Beaks usually eroded and periostracum absent from most of the disc. Interior dull to chalky, except for marginal band. Region between the



FIGURES 30–31. 30, *Bathyarca glacialis* (Gray), length 19.9 mm; 31, *Bathyarca raridentata* (Wood), length 7.9 mm.

adductor muscles often deeply stained, either brown or reddish. Hinge line straight and narrow with central edentulous space separating two series of a few pseudotaxodont teeth, the exterior ones tending to be oblique, particularly in the posterior region. Ligament elongated, duplivincular, periligamental chevron-shaped grooves poorly developed. Pallial line feebly impressed, but pallial attachment point crenulated, no pallial sinus.

COMPARISONS: The massive chalky shell, hairy periostracum, and inflated shape distinguish this species.

COLLECTION: Specimens were found at 20 stations for a total of 60 specimens, and some single valves in 23–455 m.

RECORDS: *Pleistocene*—Merklin et al. 1962:27, pl.1, f. 19–24 (Chukotsk Peninsula); Richards 1962:52 (Maine); Troitskiy 1974:265 (Siberia). *Recent*—Leche 1878:29 (Novaya Zemlya); D'Urban 1880:253 (Barents Sea); Leche 1883:448 (Arctic); Stuxberg 1886:147 (Novaya Zemlya); Hägg 1904:17 (Greenland); Dautzenberg and Fischer 1910:15 (Novaya Zemlya); Odhner 1915:73 (Greenland); Massy 1930:248 (North Atlantic); Mesjatsev 1931:56 (Barents Sea); Soot-Ryen 1932:8, pl.1, f.12 (European Arctic); Johnson 1934:21 (Gulf of St. Lawrence); Gorbunov 1946a:46 (Arctic); Madsen 1949:22 (Iceland); Filatova 1957b:52 (Eurasian Arctic); Filatova and Zenkevich 1957:63 (Kara Sea); Ockelmann 1958:44, pl.1, f.18 (Greenland); Soot-Ryen 1958:11 (Greenland); Ellis 1960:38 (Baffin Island); Richards 1962:52 (Greenland to Gulf of St. Lawrence); Allen 1965:978 (Northwest Atlantic); Clarke 1974:9 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and boreal in the Atlantic. It is abundant from Baffin Island and Greenland, at least as far south as the Gulf of St. Lawrence and across the Atlantic to the Faroe Islands and Norway, though early reports that it is present in the Mediterranean are certainly erroneous. It is not present in the Pacific or Bering seas.

REMARKS: Several authors have taken the view that this species is closely allied to *B. raridentata* (Wood) through *B. pectunculoides* Scacchi 1834. Jeffreys (1863) rejected this, and it has not been accepted by the majority of workers.

Bathyarca raridentata (Wood 1840)

Figure 31

Arca pectunculoides, auctt., [not Scacchi 1834:82, pl.1, f.12a, b]; Philippi 1844:44, pl.15, f.3a–d.

Arca (Bathyarca) pectunculoides ("Scacchi"), Filatova 1948:422, p.106, f.12, 13.

Arca glacialis pectunculoides grandis Leche 1878:30, pl.1, f.9a–c.

Arca glacialis pectunculoides ("Scacchi"), Leche 1883:449; Gorbunov 1946a:46

Arca pectunculoides crenulata Verrill 1882:575; Lamy 1907:279.

Arca raridentata Wood 1840:232, pl.13, f.4; Forbes and Hanley 1848:241, pl.45, f.8; Jeffreys 1863:171, pl.5, f.3.

DESCRIPTION: Shell thin and delicate, outline ovate to rhomboidal, total length to 5 mm, usually rather smaller. Surface ornamented by radial and concentric riblets resulting in a reticulate appearance. Periostracum thin, light grey in color, hirsute and produced into concentric folds, especially in the ventral regions. Interior porcelaneous, sometimes with feeble radial striae, shell margins smooth, with projecting fringe of periostracum. Hinge lines straight, central portion edentulous, pseudotaxodont teeth few and weak, anterior series oblique, posterior series nearly parallel to hinge margin. Ligament duplivincular. Pallial line deeply impressed, no pallial sinus.

COMPARISONS: This species may be confused with *B. glacialis*, but the more delicate shell, smaller size, fewer teeth, and periostracum with concentric folds easily separate it.

COLLECTION: The species occurred at one station only represented by six specimens in 55 m.

RECORDS: *Pliocene*—Wood 1851:79, pl.10, f.3a, b (Britain) *Recent*—Loven 1846:34 (Greenland); Forbes and Hanley 1848:241, pl.45, f.8 (Hebrides); Wood 1852:79, pl.10, f.3a, b (Britain); M. Sars 1859:55 (European Arctic); Jeffreys 1863:171, pl.30, f.3 (Hebrides and Shetland Islands); G. Sars 1878:43 (Greenland); D'Urban 1880:253 (Barents Sea); Stuxberg 1886:146 (Novaya Zemlya); Hägg 1904:19 (Greenland); Jensen 1905:309 (Greenland); Dautzenberg and Fischer 1910:15 (Novaya Zemlya); Soot-Ryen 1925:5 (Spitzbergen); Massy 1930:247 (North Atlantic); Soot-Ryen 1939:9 (Franz Josef Land); Filatova 1957b:52 (Arctic); Filatova and Zenkevich 1957:67 (Kara Sea); Ockelmann 1958:39, pl.1, f.16 (Greenland); Allen 1965:978 (Northwest Atlantic); Soot-Ryen 1966:6 (North Atlantic); Petersen 1968:51 (Faroe Islands); Clarke 1974:9 (Baffin Bay).

DISTRIBUTION: Widely distributed in the North Atlantic from Greenland to Franz Josef Land and Novaya Zemlya, and south to Portugal and Canary Islands in deep water. Mediterranean records are probably in error. In the west Atlantic the species occurs from Baffin Island to Maine and possibly the Gulf of Mexico. It is probably panarctic with sporadic distribution. The species does not occur in the Bering Sea or Pacific Ocean.

REMARKS: I do not consider the Italian Miocene fossil *P. pectunculoides* Scacchi synonymous with the contemporary northern species. Scacchi's description is not adequate and the illustrations poor. However, they certainly do not represent the living Arctic and Atlantic bathyarciid so often referred to this species. I have examined several series of Wood's *Arca raridentata* from the Pliocene Coralline Crag of Britain presently in the British Museum (Natural History) Paleontological Collection, and conclude that it is identical to living material. Wood (1851) synonymized his *A. raridentata* with *A. pectunculoides* probably on the basis of Philippi's (1844) paraphrased and altered original description of the latter and his illustration which is not of Scacchi's species but most probably is *Arca pteroessa* E. A. Smith (1885). I consider *B. pectunculoides* a distinct species, essentially Mediterranean in distribution and extending to Belgium and Denmark. My examination of material from the Miocene of Belgium convinces me it is a markedly ovate form with three or four teeth on each side of the hinge, it is also more inflated than *B. raridentata* and the hinge appears to have a number of small denticles. It is with some reluctance that I reinstate Wood's taxon, but the conchological evidence supports this action. Clarke (1960, 1963) recognized *B. frielei* Jeffreys MS 1877 from the Laurentian Basin, and suggested this is the species recorded as *A. pectunculoides* by Scarlato in Brodskii and Nikitin (1955). Wagner (1977) identified *B. frielei* from the eastern Beaufort Sea. In my opinion *B. frielei* will prove to be a synonym of *B. raridentata*. *B. anomala* Verrill and Bush 1898, from the Atlantic coast of North America, is probably a gerontic specimen of *B. raridentata* with the dentition largely obliterated. *Arca pectunculoides orbiculata* Dall 1881 is not this species and I do not consider it closely related to *A. pectunculoides*.

Family MYTILIDAE Rafinesque 1815

This family is well represented throughout the Arctic, the present collection boasts three genera, but *Mytilus edulis* Linné was not collected. The latter is typically circumboreal and only sporadically panarctic. Its absence from the collection is probably attributable to the fact that no suitable inter- to subtidal habitat, protected from ice-scour, was sampled. Wagner (1977) recorded *Modiolus modiolus* (Linné 1750) from the eastern Beaufort Sea.

Key to the genera of Mytilidae

1. Shell with radial sculpture, reduced on shell posterior 2
   Shell sculpture absent, or evenly distributed .... *Musculus*
2.(1) Shell with strong radial ribs .... *Dacrydium*
   Shell not sculptured, transparent .... *Crenella*

Genus *Crenella* Brown 1827

Figure 32

Type species (monotypy): *Mytilus decussatus* Montagu 1808. Recent. North Atlantic.

DESCRIPTION: Shell oval, inflated, surface with numerous radial ribs which may bifurcate. Periostracum thin, polished, strongly adherent. Interior polished, shell margins crenulate. Hinge line weak, resilifer small, elongated. Two small groups of tiny dysodont teeth are present. Ligament internal. Pallial line almost invisible, no pallial sinus.

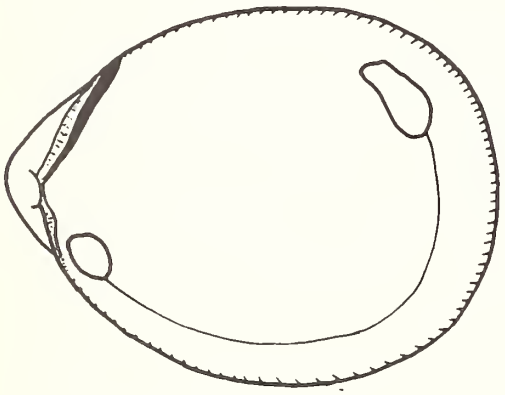


Figure 32. Interior of right valve of *Crenella decussata* (Montagu).

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan, from Arctic to tropical seas, and the low intertidal zone to 4500 m. The preferred habitat is fine sediment mixed with larger rock fragments, where individuals usually are byssally attached epifaunal nestlers.

DEVELOPMENT: Egg size varies widely, but the Arctic species have large ova, and lecithotrophic development (Ockelmann 1958).

REMARKS: The most striking feature of the soft anatomy is the vermiform foot with thickened end. It is protruded from the shell and actively moves the animal when not byssally anchored. Nutrition is entirely by suspension-feeding.

Crenella decussata (Montagu 1808)

Figure 33

Mytilus decussatus Montagu 1808:69; Lamarck 1819:120.
Crenella decussata (Montagu), Odhner 1915:80; Oldroyd 1925:79; Soot-Ryen 1955:81, pl.8, f.43, 45; Petrov 1966:204, pl.12, f.11–13.

DESCRIPTION: Shell subglobular to ovate, maximum diameter 5 mm. Beaks prominent, incurved and prosogyrous with a distinct smooth prodissoconch. Surface sculptured by numerous minute radial ribs and weaker concentric striae, producing a decussated surface. Ribs on central portion of disc bifurcated. Periostracum thin, translucent ash grey to light brown, strongly adherent. Interior nacreous, shell margins minutely denticulated. Hinge line thickened, with fine nearly vertical ridges giving the appearance of small denticles. A long narrow, deeply set resilifer accommodates the internal ligament. Pallial line feebly impressed, no pallial sinus.

COMPARISONS: The bifurcated sculpture and the inflated shell distinguish this species from other mytilids.

COLLECTION: *C. decussata* was present at one station only; one specimen and a single valve was collected in 27 m.

RECORDS: *Pleistocene*—Grant and Gale 1931:254 (California). *Recent*—Middendorff 1849:530, pl.11, f.22–24 (Siberia); Jeffreys 1863:133, pl.28, f.6 (Britain); Leche 1878:34 (Novaya Zemlya); G. Sars 1878:31, pl.3, f.4a, b (Greenland); Dunker 1882:225 (Northern Japan); Krause 1885:21 (Bering Sea); Stuxberg 1886:150 *(Novaya Zemtya);* Whiteaves 1887:120 (British Columbia); Massy 1930:250 (North Atlantic); Grant and Gale 1931:254 (Bering Sea to California); Mesjatsev 1931:68 (Barents Sea); Johnson 1934:29 (Greenland to North Carolina); Soot-Ryen 1939:10 (Franz Josef Land); Madsen 1949:24 (Iceland); Kuroda and Habe 1952:18 (Northern Japan); Filatova 1957b:52 (Eurasian Arctic); Ockelmann 1958:51 (Greenland); Ellis 1960:38 (Baffin Island); Kuznetsov 1963:109 (Kamchatka); Filatova and Barsanova 1964:34 (Eurasian Arctic); Petersen 1968:10 (Faroe Islands); Bernard 1970:87 (British Columbia).

DISTRIBUTION: Circumboreal and probably panarctic. This species occurs throughout the North Atlantic and sporadically in the Arctic. It has been recognized in the Bering Sea, the Sea of Okhotsk to Japan, and along the American Pacific coast as far south as California.

REMARKS: It is particularly significant finding a typical "European" morphotype in the Alaskan Arctic, as the Pacific representatives tend to have finer sculpture and more ponderous hinge that Atlantic *C. decussata*. Although Montagu's name has been applied to specimens from as far south as Baja California, it is probable that the circumboreal species only is found in the Pacific to northern Japan and central California.

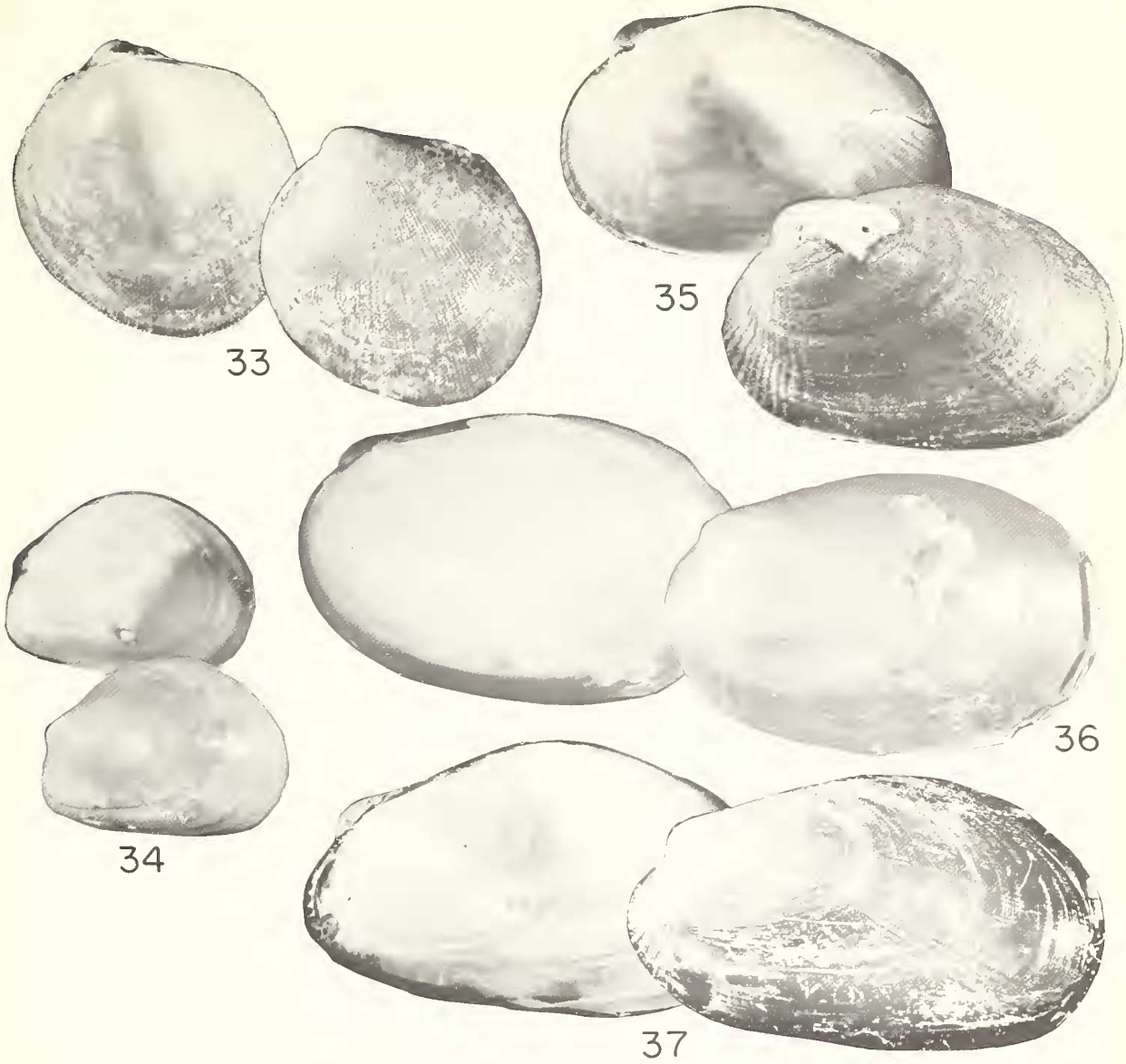
Genus *Dacrydium* Torell 1859

Figure 38

Type species (monotype): *Mytilus vitrea* Møller [Hölboll ms] 1842. Recent. Arctic.

DESCRIPTION: Shell hyaline, thin, very inflated, outline ovate. Surface smooth. Periostracum thin, adherent, sometimes with attached sand particles. Hinge edentulous, but with one or more areas of vertical striations on the thickened hinge margins.

RANGE: (?) Pliocene to Recent. Recent distribution cosmopolitan in cold waters, generally bathyal to abyssal and extending to hadal depths. The genus is a member of the superficial infauna of fine sediments mixed with boulders and gravel.



FIGURES 33–37. 33, *Crenella decussata* (Montagu), length 5.0 mm; 34, *Dacrydium (Dacrydium) vitreum* (Møller), length 4.1 mm; 35, *Musculus (Musculus) corrugatus* (Stimpson), length 13.1 mm, 36, *Musculus (Musculus) discors* (Linné), length 22.6 mm; 37, *Musculus (Musculus) niger* (Gray), length 15.0 mm.

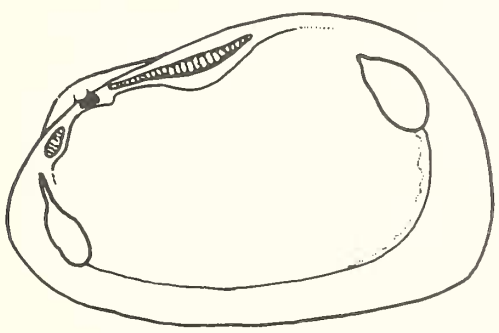


FIGURE 38. Interior of right valve of *Dacrydium vitreum* (Møller).

Though a developed byssal groove is present, there are no records of byssal attachment.

DEVELOPMENT: According to Ockelmann (1958) and Knudsen (1970), the ova of the species they examined are large, indicating lecithotrophic development, with a reduced or absent planktonic stage.

REMARKS: This genus displays a true amphiboreal distribution, being found in shallow water in the Arctic and Antarctic, but in deep water in the seas occupying lower latitudes. It is poorly represented in the Pacific by only two species, both in deep water. Ockelmann (1958) considers that further research will show the North Atlantic to possess several species presently lumped in *D. vitreum* (Møller). The subgenus *Quendreda* Iredale 1936, used by Soot-Ryen (1955) for a small species from the

Galapagos Islands, with vertical crenulations more pronounced than in *Dacrydium* s. str., probably deserves full generic separation.

Subgenus *Dacrydium* s. str.
Dacrydium (Dacrydium) vitreum (Møller [Hölboll MS] 1842)

Figure 34

Mytilus vitrea Møller [Hölboll ms] 1842:19.
Dacrydium vitreum (Møller), G. Sars 1878:28, pl.3, f.2a, b.

DESCRIPTION: Shell translucent and fragile with beaks on anterior end, total length to 6 mm. Anterior reduced, inflated, posterior region high and compressed. Surface smooth, with an oily iridescence in fresh specimens. Periostracum thin, polished, sometimes with adhering particles. Interior polished. Hinge dorsally thickened, with small rectangular resilifer below beaks. The hinge is edentulous, but two series of small vertical crenulations occur, more abundantly posterior to the resilifer. Anterior adductor muscle is attached to a thickened support. Pallial line feebly impressed, no pallial sinus.

COMPARISONS: This species cannot be confused with any other Arctic bivalve, as no other mytilid displays the hyaline shell and striated hinge line of *D. vitreum*.

COLLECTION: The species occurred at 19 stations for a total of 60 specimens in 34–455 m.

RECORDS: *Recent*—Torell 1859:139, pl.1, f.2 (Spitzbergen); Leche 1878:34 (Novaya Zemlya); Stuxberg 1886:151 (Novaya Zemlya); Jensen 1905:325 (Greenland); Dautzenberg and Fischer 1910:13 (Novaya Zemlya); Jensen 1912:53 (Greenland, Iceland, Faroes); Odhner 1915:80 (Spitzbergen); Massy 1930:249 (North Atlantic); Mesjatsev 1931:69 (Barents Sea); Soot-Ryen 1939:10 (Franz Josef Land); Gorbunov 1946a:46 (Arctic); Filatova 1948:430, pl.108, f.10 (East Siberian Sea, Kara Sea); Madsen 1949:22 (Iceland); Filatova 1957b:52 (Arctic); Filatova and Zenkevich 1957:63 (Kara Sea); Ockelmann 1958:48 (Greenland); Soot-Ryen 1958:14 (Greenland); Clarke 1960:3 (Arctic); Clarke 1963:101 (Arctic); Clarke 1974:9 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea).

DISTRIBUTION: Possibly panarctic, this species is present along the Eurasian coasts, and widely distributed in the North Atlantic, south to the Faroe Islands and doubtfully the Azores. It is present in the Bering Sea and the Gulf of Alaska (Bernard MS). Clarke (1963) published the initial record for this species in the Laurentian Basin.

REMARKS: The present collection comprises large specimens which tend towards *D. pacificum* Dall 1916 in outline. I have no hesitation at including them with *D. vitreum*, which displays some variability in shell proportions, but is possible that further research will show Dall's Pacific representative to be synonymous.

Genus Musculus Röding 1798

Figure 39

Type species (subsequent designation Iredale 1915): *Mytilus discors* Linné 1767. Recent. North Atlantic.

DESCRIPTION: Shell modioliform, surface ornamented with radial ribs in the anterior and posterior parts while the central portion is smooth, or with concentric striae and wrinkles. Periostracum dark, polished and strongly adherent. Interior iridescent, shell margins at least partly crenulated. Hinge edentulous, but with distinct small irregular crenulations, particularly on posterior

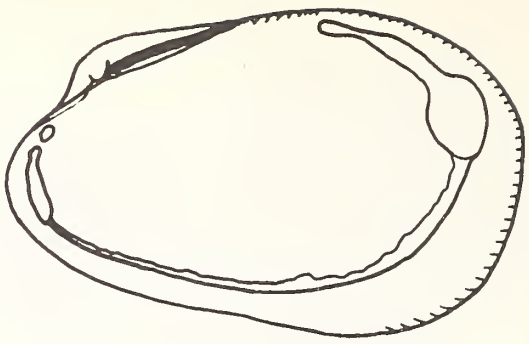


FIGURE 39. Interior of right valve of *Musculus discors* (Linné).

portion. Anterior adductor scar set well forward of the umbones and below large anterior pedal retractor muscles scar. Posterior adductor muscle scar subcircular, joined to elongated posterior retractor muscle scars. Pallial line not impressed, wide. No pallial sinus.

RANGE: Jurassic to Recent. Recent distribution cosmopolitan, in cold and temperate seas, and particularly in Arctic regions. Occurring from the intertidal zone to more than 1500 m, the genus is a member of the byssally attached epifauna, generally nestling in cavities or under rocks. Individuals may also attach to buried particles, becoming partially infaunal.

DEVELOPMENT: Eggs are large and attached within the byssal "nest" of the parent. Development continues within the gelatinous egg-mass and the planktonic stage is omitted (Ockelmann 1958).

REMARKS: The anatomy is typically mytilid, but the pallial current is anterior-posterior. Water is taken in through a funnel-like extension of the anterior mantle and expelled through a posterior extension forming an excurrent siphon. Nutrition is entirely by filter-feeding. The genus is notable for the construction of a "nest" or cylinder of byssus threads used as an egg-case. All species appear to be gregarious to some degree, generally being found in small groups mutually attached by byssal threads. Arctic representatives all belong to *Musculus* s. str. Three species are present.

Subgenus *Musculus* s. str.
Musculus (Musculus) corrugatus (Stimpson 1851)

Figure 35

Mytilus corrugatus Stimpson 1851:12.
Modiolaria corrugata (Stimpson), Dall 1874:250; Jensen 1912:62, pl.3, f.7 a–d; Oldroyd 1925:25.
Crenella corrugata (Stimpson), Stuxberg 1886:151.
Musculus corrugatus (Stimpson), Scarlato 1955:188, pl.5, f.1.
Musculus (Musculus) corrugatus (Stimpson), Scarlato 1960:86, pl.4, f.5, text-fig. 45.

DESCRIPTION: Shell irregularly ovate, inflated, total length to 20 mm, usually rather less. Surface ornamented with large rounded radial ribs on the anterior third of the shell. The central portion is not ribbed, but may display fine radial striae. The posterior part of the shell has finer and more numerous ribs. Periostracum greenish yellow to black, polished and strongly adherent. The periostracum may have fine concentric wrinkles on the cen-

tral portion of the shell. Beaks inflated, posterior hinge margin drawn out into a keel. Interior of shell iridescent, margins crenulated. Hinge edentulous, but irregular vestigial denticles may be present.

COMPARISONS: There is some doubt of the validity of this species, some workers regarding it as a form of *M. discors* (Linné). It displays coarser ribbing than either of the other two American Arctic species, and the shell is more robust, the beaks more inflated, and the smooth central portion slightly inset along the ventral margins.

COLLECTION: Eleven specimens were present at five stations in 27–70 m.

RECORDS: *Pleistocene*—Richards 1962:57, pl.5, f.5, 6 (Quebec and Maine); Petrov 1966:201, pl.12, f.8–9 (Chukotsk Peninsula). *Recent*—Crosse 1877:120 (Bering Sea); G. Sars 1878: 30, pl.19, f.2a, b (Greenland); Krause 1885:19 (Bering Sea); Hägg 1904:22 (Greenland and Spitzbergen); Dautzenberg and Fischer 1910:14 (Novaya Zemlya); Soot-Ryen 1939:9 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1948:429, pl.108, f.6 (Arctic); Filatova 1957b:53 (Arctic); MacGinitie 1959:158, pl.4, f.11, pl.18, f.7, pl.21, f.4 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island and Greenland); Kotaka 1962:146, pl.34, f.17 (Okhotsk Sea); Richards 1962:57, pl.5, f.5, 6 (Greenland to North Carolina); Filatova and Barsanova 1964:20 (Eurasian Arctic); Petrov 1967a:184 (Bering Sea); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Possiby panarctic. The species is recorded from the Canadian Archipelago, Hudson Bay and south to Maine, possibly to South Carolina. It is doubtful that it occurs in the Atlantic segment of the Arctic, but is present throughout the East Siberian Sea, the Chukchi Sea, and into the Bering Sea to Kamchatka and along the coast of Alaska. There are no substantiated records south of the Aleutian Islands.

REMARKS: The identity and distribution of this species remains uncertain. It is frequently considered a transitional form or subspecies of other *Musculus*, but Jensen (1915) thought the general outline and microscopic wrinkling of the periostracum of the central portion of the shell to be a constant feature. Ockelmann (1958) did not record *M. corrugatus* from Greenland, and believed it not to be present at Jan Mayen Land, but Jensen (1915) recorded it from Greenland, Spitzbergen, and the Kara Sea. A case may possibly be made to consider *M. corrugatus* a *nomen dubium*, as Stimpson (1851) gave no description or illustration, but merely equated it to the "*Modiola discors* Linné" of Gould 1841, recognizing that it differed from *M. discors* Linné of European authors.

Musculus (Musculus) discors (Linné 1767)

Figure 36

Mytilus discors Linné 1767:1159, Fabricius 1780:418; Dillwyn 1817:319.
Modiola discors (Linné), Lamarck 1819:114.
Musculus discors (Linné), Filatova 1948:429, pl.108, f.8; Scarlato 1955:189, pl.50, f.2.
Modiola laevigata Gray 1824:244.
Modiolaria laevis Beck 1851:208, pl.17, f.3a–f.
Modiolaria discors laevigata (Gray), Jensen 1912:57, pl.3, f.4a, b.
Modiolaria nigra laevigata (Gray), Gorbunov 1946a:46.
Modiola substriata Gray 1824:245.
Modiolaria substriata (Gray), Oldroyd 1925:76.
Modiolaria discors substriata (Gray), Jensen 1912:58, pl.3, f.5a, b.

DESCRIPTION: Shell ovate to elongate, thin and fragile, maximum length to 40 mm. Anterior and posterior thirds of shell ornamented with faint radial ribs and lirae. The central section is smooth, but may display irregular concentric growth lines. Periostracum ash yellow to dark brown, polished and strongly adherent. Interior brilliantly iridescent, shell margins crenulated, more prominently in the anterior and posterior ends. Hinge line and dentition as in genus.

COMPARISONS: This species may be confused with *M. corrugatus* (Stimpson) and it may be difficult to separate them during immature stages. Adult *M. discors* are characterized by the thin inflated shell, the much finer and sometimes absent radial ribbing, and the smooth central periostracum. Jensen (1912) showed that *M. laevigatus* and *M. substriatus*, both of Gray 1824 are merely varieties of *M. discors*. As the supposedly distinguishing characters form a continuous series, little purpose is served by retaining separate names.

COLLECTION: This species is represented at 16 stations in 27–101 m, with a total of 26 specimens.

RECORDS: *Pliocene*—Wood 1851:63, pl.18, f.5 (Britain); Wood 1874:111 (Britain); Petrov 1966:202, pl.12, f.10 (Siberia). *Pleistocene*—Knipowisch 1900:382 (Spitzbergen); Merklin et al. 1962:30, pl.2, f.7 (Chukotsk Peninsula). *Recent*—Montagu 1803:167 (Britain); Gould 1841:130, f.84 (Massachusetts); Møller 1842:19 (Greenland); Middendorff 1849:531, pl.12, f.11, 12 (Novaya Zemlya); Torell 1859:133 (Spitzbergen); Crosse 1877:120 (Bering and Arctic seas); Leche 1878:32 (Novaya Zemlya); G. Sars 1878:29, pl.3, f.3a, b (Greenland); D'Urban 1880:253 (Barents Sea); Krause 1885:18 (Bering Sea); Melvill and Standen 1900:3 (Franz Josef Land); Hägg 1904:23 (Greenland and Spitzbergen); Soot-Ryen 1932:9 (Greenland); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:27 (Iceland); Kuroda and Habe 1952:25 (Northern Japan); Filatova 1957b:52 (Arctic); MacGinitie 1959:159, pl.18, f.10, pl.21, f.5 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island and Greenland); Clarke 1961:7 (Gulf of St. Lawrence); McLaughlin 1963:25 (Bering Sea); Allen 1965:980 (Northwest Atlantic); Sparks and Pereyra 1966:834 (Chukchi Sea); Golikov and Scarlato 1967:88, f.77 (Sea of Japan); Petrov 1967:184 (Bering Sea); Habe and Igarashi 1967:31 (Northern Japan); Petersen 1968:51 (Faroe Islands); Bernard 1970:87 (British Columbia); Clarke 1974:9 (Baffin Bay); Scarlato and Ivanova 1974:301 (Kurile Islands); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is widely distributed through the North Atlantic from Greenland to the Kara Sea and south to Britain, Ireland and Norway. It is present in the Canadian Arctic Archipelago, Hudson Bay and south at least to New England. It is also represented in the Bering and Okhotsk seas south to Japan and along the American coast to Washington State and possibly Oregon.

REMARKS: *M. discors* is almost invariably collected with remnants of the byssal thread "nest" attached and with adhering epizoa and small nestling bivalves. Thorsen (1935) showed it to be a protandric hermaphrodite.

Musculus (Musculus) niger (Gray 1824)

Figure 37

Modiola nigra Gray 1824:244.
Crenella nigra (Gray), M. Sars 1859:55.
Modiolaria nigra (Gray), Crosse 1877:120.
Musculus nigra (Gray), Scarlato 1955:189, pl.50, f.5.
Musculus niger (Gray), Petrov 1966:203, pl.12, f.14–18.
Musculus niger obesus Dall 1916a:19 [nom. nud. not *Mytilus obesus* Reeve 1858]; Dall 1916b:405.
Musculus niger protractus Dall 1916a:19 (nom. nud.); Dall 1916b:405.
Modiola nexa Gould 1841:128, f.86.

DESCRIPTION: Shell modioloform, compressed, maximum length to 45 mm. Surface ornamented with 10–15 strong radial

ribs on the anterior end, the central portion of the shell is not ribbed but may have obscure radial and concentric wavy lines and small tubercles. Anterior part of shell with radial ribs. smaller and more numerous than on the posterior end. Periostracum polished, strongly adherent, color olive green to black. Interior nacreous, often colored purple or reddish-brown. Shell margins with irregular crenulations. Hinge as in genus. Pallial line wide, feebly impressed.

COMPARISONS: This species is distinguished from other Arctic members of the genus by the generally more compressed shell, and the coarser ribbing on the anterior end. The ribs on both ends of the shell tend to be decussate.

COLLECTION: This species occurred at seven stations, for a total of 51 specimens collected between 27–64 m. Two small specimens were with a station label indicating 2560 m, probably the result of a collecting or labelling error as MacGinitie (1959) records this species to 200 m and Ockelmann (1958) gives 376 m as depth maximum.

RECORDS: *Pleistocene*—Slodkevitch 1938:94, pl.54, f.9–12 (Kamchatka); Merklin et al. 1962:30, pl.2, f.4–6 (Chukotsk Peninsula); Richards 1962:57, pl.5, f.12 (Quebec to Maine); Ilyina 1963:118; pl.51, f.10 (Kamchatka); Wagner 1970:38 (Northeastern Canada). *Recent*—Middendorff 1849:533 (Arctic); Torell 1859:130 (Spitzbergen); Jeffreys 1863:128, pl.28, f.4 (Britain); Gould 1870:190, f.487, 488 (Massachusetts); G. Sars 1878:31 (Greenland); Leche 1883:451 (European Arctic); Krause 1885:20 (Bering Sea); Stuxberg 1886:151 (Novaya Zemlya); Whiteaves 1887:120 (British Columbia); Melvill and Standen 1900:3 (Franz Josef Land); Hägg 1904:26 (Greenland); Dautzenberg and Fischer 1910:14 (Novaya Zemlya); Jensen 1912:63 (Arctic); Odhner 1915:75 (Greenland); Mesjatsev 1931:65 (Barents Sea); Soot-Ryen 1932:8 (European Arctic); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:28 (Iceland); Kuroda and Habe 1952:25 (Northern Japan); Filatova 1957b:53 (Eurasian Arctic); MacGinitie 1959:157, pl.18, f.6, pl.21, f.6 (Point Barrow, Alaska); Ockelmann 1958:58 (Greenland); Ellis 1960:39 (Baffin Island and Greenland); Scarlato 1960:78, pl.3, f.1, text-fig. 40 (Bering and Arctic seas); Clarke 1961:7 (Gulf of St. Lawrence); Kotaka 1962:140, pl.34, f.15, 16 (Okhotsk Sea); Richards 1962:57, pl.5, f.12 (Arctic Ocean to North Carolina); McLaughlin 1963:25 (Bering Sea); Filatova & Barsanova 1964:21 (Bering Sea); Sparks and Pereyra 1966:834 (Chukchi Sea); Hulsemann 1967:71 (Beaufort Sea); Petrov 1967b:150 (Northern Bering Sea); Habe and Igarashi 1967:31 (Northern Japan); Petersen 1968:11 (Faroe Islands); Bernard 1970:87 (British Columbia); Clarke 1974:9 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. The species is widely distributed throughout the North Atlantic and along the entire shallow bathyal zones of the Arctic Sea. It is well established in the Bering, Okhotsk and Sea of Japan. It is abundant off British Columbia and Washington and occurs sporadically as far south as Santa Barbara, California, from the low intertidal zone to 60 m.

REMARKS: This is the largest member of the genus and the shell morphology is fairly constant, although some variability in rib size and degree of shell inflation is present. The shell is frequently found with the anterior end only buried in the substrate. It does not construct a byssus "nest" like that of *M. discors* (R. Baxter pers. comm.).

Family PECTINIDAE Rafinesque 1815

The family is poorly represented in the collections. *Arctinula greenlandica* (Sowerby) is abundant, the other material present consists of a worn, probably fossil, fragment of a chlamid, and one recently dead *Chlamys pseudislandica* (MacNeil). *Hyalopecten frigidus* (Jensen 1912) was reported by Clarke (1962) from the central part of the Laurentian Basin, so it probably occurs in the deeper zones of the Beaufort Sea.

Key to the genera of Pectinidae

Shell with strong radial ribs, both valves convex .....
..... *Chlamys*

Shell sculpture weak, margins of right valve reflected ...
..... *Arctinula*

Genus *Arctinula* Thiele 1935

Figure 40

Type species (monotypy): *Pecten greenlandicus* Sowerby 1842. Recent. Arctic.

DESCRIPTION: Shell very thin, generally transparent, tightly closing. Auricles nearly symmetrical. Left valve may be unsculptured, but usually with radial rows of pustules or scales. Right valve smooth or with concentric lamellae; margins reflected against left valve. Byssal notch large, pectinidial teeth few and vestigial. Hinge line straight, resilifer triangular and deeply sunk. Interior smooth, monomyarian adductor scar hardly visible. Pallial attachment line wide, but difficult to see.

RANGE: Miocene to Recent. Recent distribution Arctic and boreal Atlantic to north Africa in deep water. Habitat preference is for fine sediments, often with mixture of boulders and large siliceous sponges. The genus is a member of the byssally attached epifauna occurring in 10 m to abyssal depths.

DEVELOPMENT: Ova large, development is lecithotrophic with a reduced planktonic phase (Thorson 1936).

REMARKS: The anatomy is typically pectinid, but the foot is particularly large, vermiform in shape with a flattened tip. The

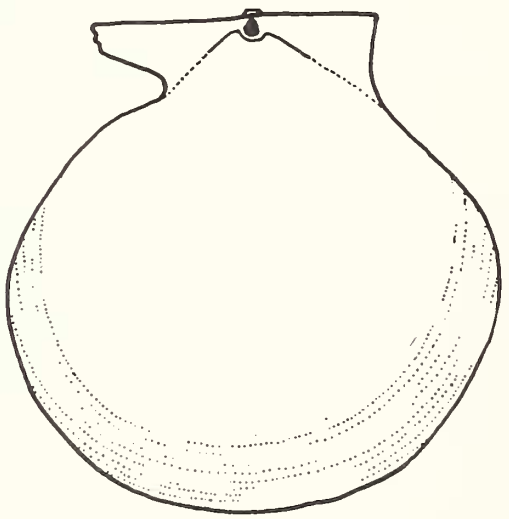


FIGURE 40. Interior of right valve of *Arctinula greenlandica* (Sowerby).

byssal apparatus is well developed; however, shells are attached by a few threads which are readily broken, the scallop moving actively prior to re-attachment. Nutrition is by filter feeding, but there are anatomical modifications for macrophagy. There is no agreement on the systematic placement of the small, thin-shelled pectinids. Several workers have identified American *Pseudamussium*, auctt., not Mörch1853, with *Pallioluu* Monterosato 1884. The type species of the latter is the Mediterranean *Pecten iucomparabilis* Risso 1826, a species with small but well developed cardinal crura and a pigmented shell pattern. *Arctinula*, originally proposed in *Propeamussium* Gregorio 1883, was first considered a genus by Soot-Ryen (1958) and so utilized by MacNeil (1967). The developed anterior auricles and reflected margin of the right valve distinguish it from *Cyclopecteu* and *Delectopecteu*.

Arctinula greenlandica (Sowerby 1842)

Figure 42

Pecten vitreus Gray 1824:245 [not *Ostrea vitrea* Dillwyn 1817]
Pecten greenlandicus Sowerby 1842:57, pl.3, f.40.
Pecten groelandicus (Sowerby), Middendorff 1849:529 (invalid emend.)
Pecten grönlandicus (Sowerby), G. Sars 1859:53 (invalid emend.).
Propeamussium (Arctinula) groenlandicum (Sowerby), Filatova 1948:425, pl.107, f.4.
Cyclopecten (Delectopecten) greenlandicus (Sowerby), Grau 1959:53, pl.20.
Arctinula groenlandica (Sowerby), MacNeil 1967:8, pl.4, f.6.
Pseudamusium andersoni Dall 1919:19A, pl.12, f.7, 8, [not *Pecten (Plagioctenium) andersoni* Arnold 1906.]
Pecten binominatus Hanna 1924:175, [new name for *P. andersoni* Dall 1919.]

DESCRIPTION: Shell very thin, transparent, outline ovate to circular, maximum length to 35 mm. Left valve ornamented with numerous minute irregular concentric striae with occasional fine radial threads. Right valve the smaller, with sporadic radial striae, but concentric growth checkmarks may be present. Prodissoconch and early shell often concentrically corrugated. Periostracum not visible, the shell surface with an oily violet iridescence when fresh. Hinge line straight, resilifer small and delicate. Auricles poorly developed, byssal notch deep, pectinidial teeth vestigial or absent. Interior polished, pallial or adductor muscle scars not visible.

COMPARISONS: This hyaline pectinid cannot be confused with any other Arctic species and is easily separated from *Hyalopecten frigidus* (Jensen 1912) by the latter's strong concentric undulations and pronounced radial striae.

COLLECTION: This species is extremely abundant in the Western Beaufort Sea, more than 50,000 specimens occurred at 42 stations in 19–2560 m.

RECORDS: *Miocene*—MacNeil 1957:104, pl.11, f.17, 18 (North Alaska). *Pliocene*—MacNeil 1957:104, pl.11, f.17, 18 (North Alaska). *Pleistocene*—Richards 1952:55, pl.3, f.15, 16 (Maine); Troitskiy 1974:265 (Siberia). *Recent*—Loven 1847:186 (Norway); Hanley 1856:274 (Greenland); Whiteaves 1872:348 (Gulf of St. Lawrence); Leche 1878:35 (Novaya Zemlya); G. Sars 1878:23, pl.2, f.4a–c (Greenland); D'Urban 1880:253 (Barents Sea); Stuxberg 1886:152 (Novaya Zemlya); Dautzenberg and Fischer 1910:12 (Novaya Zemlya); Jensen 1912:30 (Greenland); Soot-Ryen 1932:9 (Arctic); Johnson 1934:25 (Newfoundland); Soot-Ryen 1939:10 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:36 (Iceland); Richards 1952:55, pl.3, f.15, 16 (Greenland to Newfoundland); Filatova 1957b:53 (Eurasian Arctic); Filatova and Zenkevich 1957:68 (Arctic): Ockelmann 1958:68, pl.2, f.2 (Greenland); Soot-Ryen 1958:12 (Greenland); MacNeil 1967:8, pl.4, f.6 (Arctic Alaska); Clarke 1974:9 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic. The species is abundant off eastern Greenland and widely distributed throughout the boreal Atlantic. It does not occur in the Bering Sea or Pacific Ocean.

REMARKS: The original spelling "*greenlaudicus*" is acceptable and emendations by latter authors to the nordic diacritical form, or its diphthong approximation, are invalid. Sowerby was a British writer using the English form for the country of origin. Ockelmann (1958) has shown that specimens from more southerly parts of the Atlantic, considered a subspecies by Locard (1898), have anatomical differences and should be separated. It is intriguing that this most abundant species in the OSU collection was not recorded by Hulsemann (1967).

Genus *Chlamys* Röding 1798

Figure 41

Type species (subsequent designation Herrmannsen 1847): *Pecten islandicus* Müller 1776. Recent. North Atlantic.

DESCRIPTION: Valves convex. Auricles large, the anterior longer than posterior. Both valves with strong radial ribs. Byssal notch large, pectinidial teeth well developed. Hinge line straight. Adductor muscle scar clearly visible, pallial attachment scars obscure.

RANGE: Triassic to Recent. Recent distribution cosmopolitan, from the low intertidal zone to 500 m, but most abundant in warm shallow waters.

DEVELOPMENT: The larvae of a number of chlamids have been described and literature summarized by Thorson (1946). Ockelmann (1958) examined mature eggs and recently-settled *C. islaudica* (Müller), in all cases the evidence points to a fully planktotrophic development.

REMARKS: The genus contains a large number of superficially similar species distinguished by minor sculptural details, which may represent several separate phylogenetic lines (MacNeil 1967). It is poorly represented and sporadic in Arctic waters, but contains the most brightly colored northern shells.

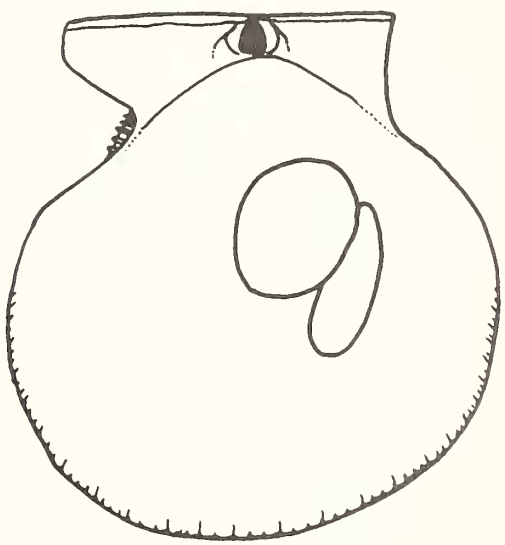


FIGURE 41. Interior of right valve of *Chlamys islandica* (Müller).

Subgenus *Chlamys* s. str.
Chlamys (Chlamys) pseudislandica MacNeil 1967

Figures 43, 44

Chlamys (Chlamys) pseudislandica MacNeil 1967:31, pl.19, f.7, pl.20, f.8, pl.23, f.1, 2.

DESCRIPTION: Shell subcircular to ovate, valves inflated. Maximum height 75 mm. Both valves ornamented with prominent radial ribs, wider and less prominent on the right valve. Ribs with sparse concentric scales, particularly on the left valve. Ribs divaricating in mature specimens. Interspaces with one prominent interstitial riblet. Interspace of right valve with minute latticed microsculpture. Left valve with latticed sculpture on early shell, replaced by concentric ridges on mature shell. Left valve mottled, reddish-brown to dark purple, frequently rayed with white or pink. Right valve white to light yellow-grey. Auricles broad and short. Byssal notch deep, pectinidial teeth strong, 6–8 in number. Interior polished, with radial plications conforming to external ribs. Adductor muscle scar and pallial line clearly impressed.

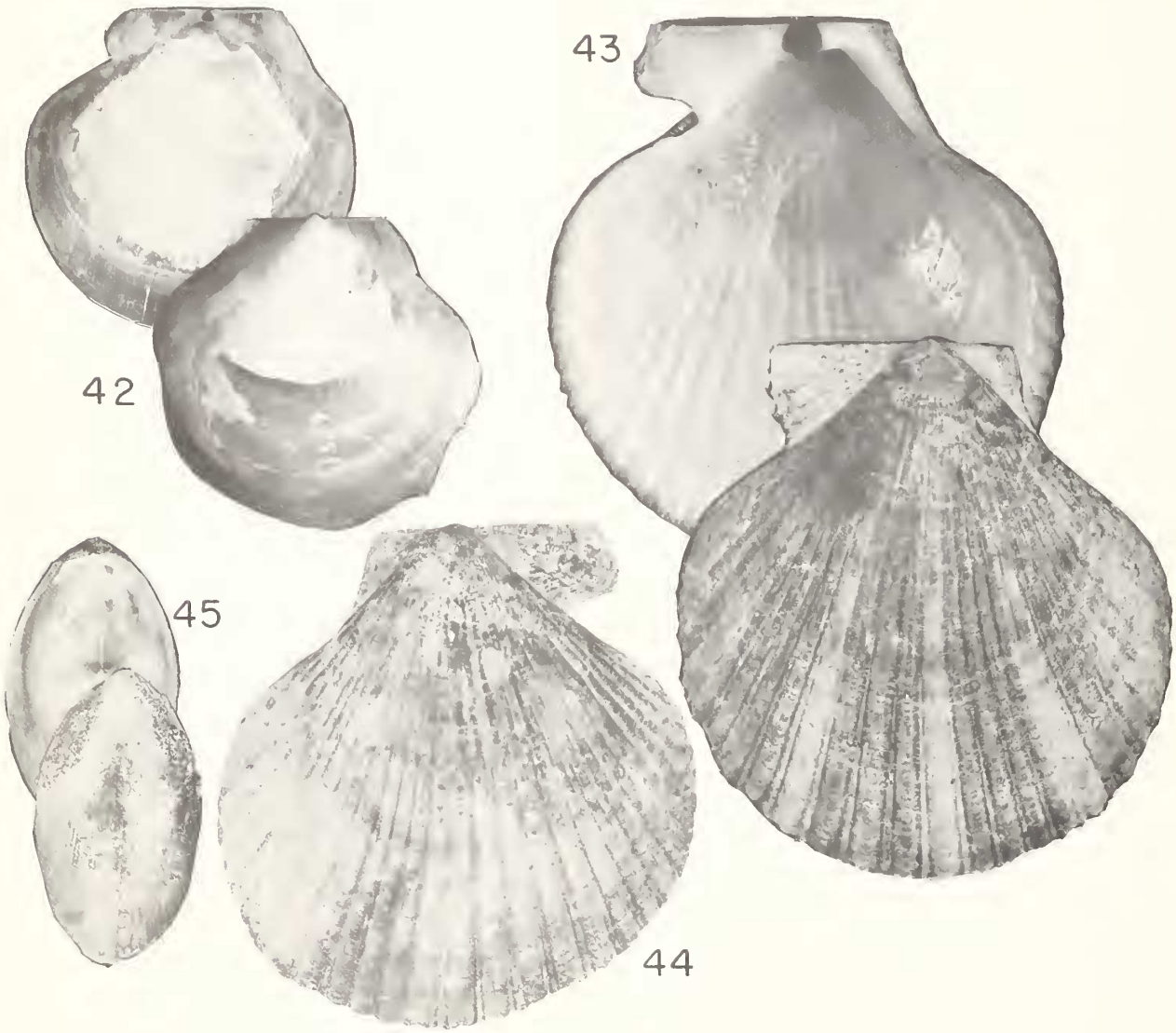
COMPARISONS: The species may be confused with C. *islandica* (Müller) which has more numerous and finer ribs that rarely divaricate near the shell margins. *C. rubida* (Hinds 1845) and its subspecies comprise thinner and less inflated shells.

COLLECTION: Represented by one recently dead and still articulated specimen, collected in 55 m at 71°18.1′N, 152°32.2′W.

RECORDS: *Pleistocene*—Wood 1851:40, pl.5, f.1 (Scotland). *Recent*—MacGinitie 1959:155, pl.19, f.4 (Point Barrow, Alaska); MacNeil 1967:31, pl.19, f.7, pl.20, f.8, pl.23, f.1, 2 (Arctic Alaska and Northern Bering Sea).

DISTRIBUTION: This species has the most restricted range of any Arctic shallow water form: Point Barrow, Alaska to St. Lawrence Island, Northern Bering Sea.

REMARKS: Grau (1959) concluded that *C. islandica* (Müller) is not living in the Pacific or Bering Sea, but did occur in the Arctic. MacGinitie (1959) referred 19 specimens from Point Bar-



FIGURES 42–45. 42, *Arctinula greenlandica* (Sowerby), length 20.6 mm; 43, *Chlamys (Chlamys) pseudislandica* MacNeil, length 56.7 mm; 44, *C. (C.) pseudislandica*, exterior of right valve, length 41.7 mm; 45, *Limatula hyperborea* Jensen, length 6.8 mm.

row to *C. islandica,* citing a range south through the Bering Sea to the Aleutian and Shumagin Islands. These southern records should be assigned to *C. rubida* (Hinds 1845). I follow MacNeil (1967) in separating the Arctic from the European stock, though this may be subject to revision following a comprehensive comparative study. Although the *islandica*-group had a Pacific origin, there are no American fossil records for *C. pseudislandica,* so it is probable that this form as well as the typical developed in the Atlantic. MacNeil (1967) identified *C. pseudislandica* in the late Pleistocene of Scotland. It is possible that further work will find living specimens in the Atlantic and the Canadian Arctic archipelago.

Family LIMIDAE Rafinesque 1815
Genus *Limatula* Wood 1839
Figure 46

Type species (subsequent designation Gray 1847): *Pecten subauriculata* Montagu 1808. Recent. North Atlantic.

DESCRIPTION: Shell ovate to elongate: maximum diameter dorsoventral. Surface with fine to coarse radial ribs. Periostracum thin, dehiscent. Interior polished. Hinge line straight, edentulous, and with small central resilifer.

RANGE: Triassic to Recent. Recent distribution cosmopolitan, generally in cold and temperate seas. Habitat preference is for coarse sediments, but includes fine substrates mixed with coarser particles. The genus is a member of the byssally temporarily attached epifauna.

DEVELOPMENT: Little information is available, but Thorson (1946) discussed the closely related *L. loscombii* (Sowerby 1824) and reported normal planktonic development.

REMARKS: The genus includes medium to small-sized shells most often found in deep and cold waters. Individuals are able to move and sometimes swim, by pulsating the extremely long tentacular fringe of the mantle edges. More usually, species are byssally attached, often in a 'nest' of matted byssal threads that may serve as a protection for the exposed tissues and delicate shell.

It is probable that the genus requires separation at the generic or subgeneric level, as it presently includes nearly equilateral to markedly oblique species, some with tightly closing valves and others with large gapes. Many species are superficially alike and the external ornamentation may vary with habitat. Useful distinguishing characters are found in the comparative height of the umbones and the length of the cardinal area just below the beaks.

L. subauriculata (Montagu 1803), though recorded in the early literature, does not occur in the high Arctic. It is widely distributed in the north Atlantic and also in the north Pacific. It is probable that research will result in separation of the Pacific representative.

Limatula hyperborea Jensen 1905
Figure 45

Limatula hyperborea Jensen 1905:329, f.1a–d.
Lima hyperborea (Jensen), Jensen 1912:41, pl.2, f.5a–e.

DESCRIPTION: Shell oval, very inflated, total height to 20 mm. Surface with numerous sharp elevated radial ribs, the two central ones larger and with a wider interspace than the others, which tend to become indistinct on the lateral shell margins. Periostracum brown, dehiscent. Interior polished, subnacreous. Shell margins crenulated by the larger ribs, the two prominent central ribs cause a corresponding furrow in the shell interior. Hinge line straight, edentulous, with a small central triangular resilifer. Pallial and adductor muscle attachment scars not obvious.

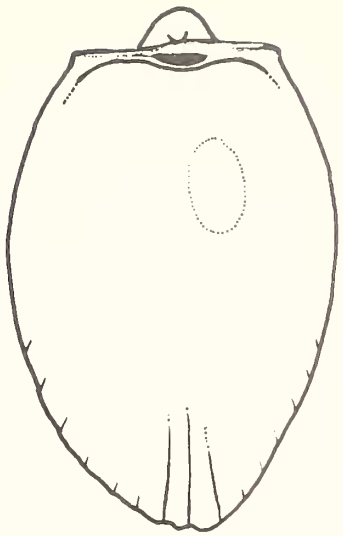


FIGURE 46. Interior of right valve of *Limatula subauriculata* (Montagu).

COMPARISONS: It is with some reservation that I assign this material to *L. hyperborea,* though it agrees well with Jensen's description and with specimens from east Greenland. The genus is poorly understood and probably overnamed, the last comprehensive published study of the North Atlantic-boreal species being by Jensen (1912). The present material is most easily confused with *L. subauriculata* (Montagu 1808) which is proportionately narrower and with more rounded ribs. It is also similar to the North Atlantic *L. subovata* Jeffreys 1876 (probably a synonym of *L. ovata* Wood 1848), which is more inflated and has more numerous radial ribs.

COLLECTION: Six specimens and 11 valves were collected from two stations in 79 and 455 m.

RECORDS: *Recent*—Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1957b:53 (Arctic); Ockelmann 1958:72, pl.2, f.3 (Greenland); Clarke 1963:102, pl.2, f.13 (Chukchi Sea); Clarke 1974:10 (Baffin Bay); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: The species is widely distributed in the north Atlantic from Greenland to Spitzbergen and the Kara Sea, and eastwards to the New Siberian Islands. Clarke (1963) first reported the species from the Laurentian Basin, the present collection extends the range approximately 1100 km south.

REMARKS: The relationship of this species, together with the two mentioned in the "comparisons" paragraph, to other North Atlantic species is not clear. A minority of authors have treated *L. hyperborea* as a subspecies of *L. gwyni* (Sykes 1903), a new name for *L. elliptica* Jeffreys 1863, not Whiteaves 1861. A review will have to consider at least 12 North Atlantic limatulids, several of them belonging to the *L. ovata* Jeffreys 1876 complex. At least two species occur in the Bering Sea and Eastern Pacific, the group is also well developed in the Subantarctic Region, with several species scarcely different from *L. subauriculata* (Montagu).

Family THYASIRIDAE Dall 1901

The family is cosmopolitan, but more abundantly represented in boreal waters where representatives may be found in often oxygen-poor environments with little other bivalve fauna. The family is a member of the eulamellibranch superfamily Lucinacea, that has adapted to an infaunal habitat without the development of long siphons. To provide communication with the surface, the long vermiform foot is thrust through the sediments and mucus-producing regions on the tip of the foot consolidate the particles to form a cohesive tube. Ventilation through the pallial cavities has been modified to utilize the pedal tube. Nutrition too, has been modified, the family tending to macrophagy as evidenced by the large mouth, reduced or vestigial labial palps, and only two, very large, ducts leading to the digestive diverticula. While identification of the family is readily made using shell structure, a useful cross-check is supplied by the very distinct digestive diverticula and gonad which form an arborescent mass connected to the body by a narrow band of tissue. A similar structure is only present in the septibranchs.

The three genera present in the collection are easily separable using external shell characters, but specific identification may be difficult due to a lack of strongly developed dentition and the marked variability of external proportions.

Key to the genera of Thyasiridae

1. Shell with concave lunule 2
   Shell without concave lunule ..... *Axinulus*

2.(1) Posterior of shell separated by radial fold ..... *Thyasira*
   Posterior area not separated by radial fold ..... *Axinopsida*

Genus *Axinopsida* Keen and Chavan *in* Chavan 1951

Figure 47

Type species (original description): *Axinopsis orbiculata* G. Sars 1878. Recent. North Atlantic.

DESCRIPTION: Shell suborbicular, lunule deeply concave. Surface smooth, sometimes with obscure concentric growth lines. Periostracum very thin, adherent. Interior dull to porcelaneous, shell margins smooth. Hinge line weak, edentulous, but with subumbonal internal shell margin upturned in each valve to form a peg-like pseudocardinal tooth. Adductor muscle scars elongated, pallial line wide.

RANGE: Pliocene to Recent. Recent distribution is limited to north boreal temperate and cold waters, and possibly the Mediterranean. The genus is a member of the deeply buried infauna, occurring in fine sediments.

DEVELOPMENT: Ockelmann (1958) found the type of the genus, *A. orbiculata* (G. Sars 1878) from Greenland, to have large ova, indicating lecithotrophic development.

REMARKS: The genus is closely related to *Thyasira,* and the mode of existence similar. The pallial current is modified to an anterior-posterior passage, and the vermiform foot is utilized to construct a mucus-lined inhalant tube, allowing burial to a depth generally limited to the long-siphoned bivalves.

Axinopsida orbiculata (G. Sars 1878)

Figure 49

Axinopsis orbiculata G. Sars 1878:63, pl.19, f.11a–d; Filatova 1948:438, pl.110, f.16.
Axinopsida orbiculata (G. Sars), Keen and Chavan in Chavan 1951:211.

DESCRIPTION: Shell orbicular, inflated, length to 5 mm. Surface smooth, brightly polished, sometimes with incremental striae and growth checks. Periostracum thin, varnished, adherent, but umbones frequently eroded. Beaks small, lunule deeply impressed, escutcheon obsolete. Shell interior polished, porcelaneous, margins smooth. Hinge edentulous, but with a subumbonal thickening to form a peg-like pseudocardinal tooth in each valve. Ligament attached to a small ill-defined groove. Adductor muscle scars elongated, subequal. Pallial line weakly impressed, no pallial sinus.

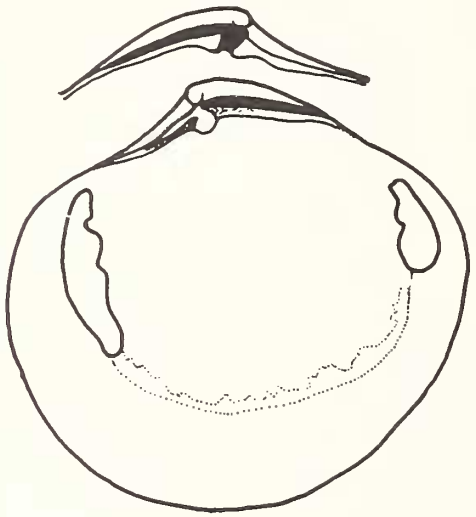


FIGURE 47. Interior of right valve and hinge of left valve of *Axinopsida orbiculata* (Sars).

COMPARISONS: The genus is readily recognized by the bilateral single pseudocardinal tubercle, and no other Atlantic-Arctic species resembles *A. orbiculata*. There is doubt as to the status of *A. viridis* (Dall 1901) from Alaska, which tends to have a deeper lunule and a more elongate outline. The other Pacific species is the Californian *A. serricata* (Carpenter 1864), which may be a senior synonym of *A. viridis*. It is possible that a careful review may unite these taxa and *A. orbiculata inaequalis* (Verrill and Bush 1898) into one polymorphic unit.

COLLECTION: This species occurred at 27 stations for a total of 206 specimens and numerous single valves, in 32–270 m.

RECORDS: *Pleistocene*—Merklin et al. 1962:39, pl.6, f.6 (Chukotsk Peninsula); Wagner 1970:40, pl.3, f.18a, b (Northeastern Canada). *Recent*—Hägg 1904:44 (Greenland); Jensen 1905:342 (Greenland); Odhner 1915:104 (Spitzbergen); Mesjatsev 1931:97 (Barents Sea); Johnson 1934:40 (Greenland to Maine); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:55 (Iceland); Filatova 1957b:55 (Arctic); Ockelmann 1958:111, pl.2, f.7, 8 (Greenland); Soot-Ryen 1958:23 (Greenland); MacGinitie 1959:172, pl.20, f.2 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island and Greenland); Clarke 1974:10 (Baffin Bay); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic. Abundant in the North Atlantic from Greenland to Norway and south at least to the Faroe Islands. In the western Atlantic it occurs from the Canadian Arctic Archipelago to Massachusetts. The species is not found south of Bering Strait, and records such as Petrov (1967a) should be referred to *A. viridis* (Dall).

REMARKS: In common with other thyasirids, this species is most easily assigned to family and genus by examination of the soft anatomy. The elongated adductors, vermiform bulb-ended foot, and arborescent digestive diverticula and gonad are all diagnostic.

Genus *Axinulus* Verril and Bush 1898

Figure 48

Type species (original designation): *Axinulus brevis* Verrill and Bush 1898. Recent. North Atlantic.

DESCRIPTION: Shell ovate to elongate, without a radial sulcus setting off the posterior end. Surface smooth, but with obscure concentric striae and growth checks. Periostracum very thin, often coated with ferruginous material. Shell interior polished, margins smooth. Hinge weak, edentulous, but with slight thickening of central part. Adductor muscle scars elongate, the posterior rather smaller. Pallial line wide, indistinct.

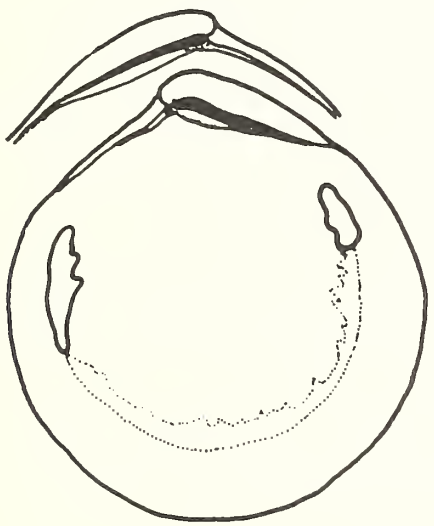


FIGURE 48. Interior of right valve and hinge of left valve of *Axinulus brevis* Verrill and Bush.

RANGE: Recent and possibly Pliocene. Recent distribution limited to North Atlantic and Arctic oceans and also the Mediterranean. The taxon is a member of the shallow infauna of fine sediments.

DEVELOPMENT: No observations.

REMARKS: The genus is close to *Thyasira*, displaying the same vermiform foot and arborescent gonad and digestive diverticula. Verrill and Bush (1898) proposed *Axinulus* as a new subgenus separated from *Thyasira* by the lack of the posterior radial plication and smaller posterior adductor muscle scar. The appearance of deposits cemented to the shell, and the frequently eroded umbones, suggest a superficially infaunal habitat.

Axinulus careyi NEW SPECIES

Figure 50

ORIGINAL DESCRIPTION: Shell minute, inflated, outline ovate. Umbones prosogyrous, not prominent. Surface earthy, white, with irregular concentric striae visible under high magnification. Periostracum thin, adherent. Shell coated with strongly cemented mud and debris, particularly in posterior and anterior portions. Interior smooth, polished. Hinge weak, edentulous, with a small thickening just below the umbone of each valve. Ligament small and external except for anterior end which occupies an obscure groove just behind the beaks. Adductor scars elongate, subequal. No pallial sinus.

TYPE LOCALITY: Western Beaufort Sea, Arctic Alaska. Oregon State University Station No. SMG 950 at 71°14.3′N, 149°22.9′W in 695 m, Collected by Smith-McIntyre Grab on September 5, 1971.

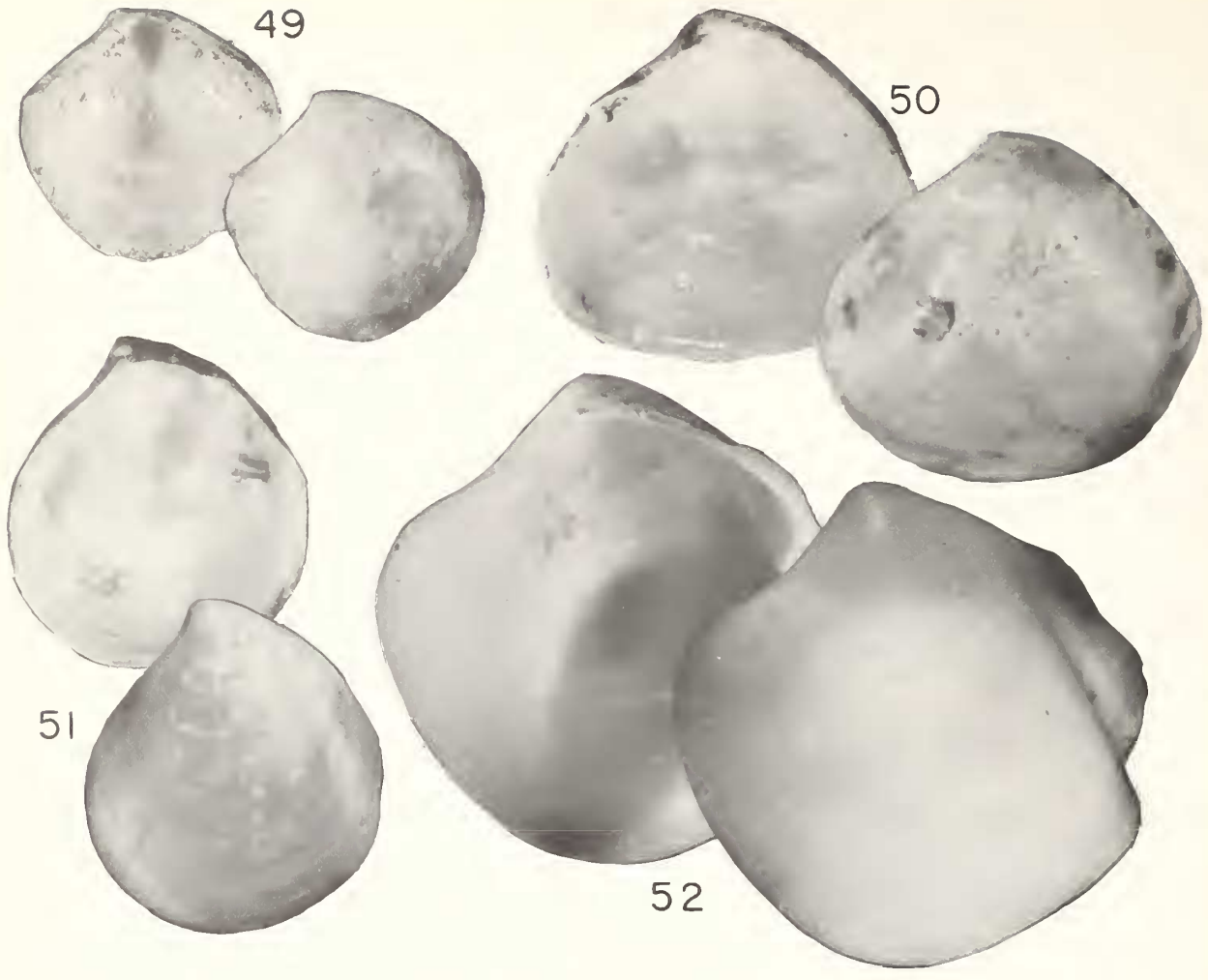
DIAGNOSIS: Shell to 3 mm, inflated, outline ovate. No depressed lunule, no radial sulcus, otherwise as in *Thyasira*. Separated from the related genus *Leptaxinus* Verrill and Bush 1898 by the rounded posterior margins.

ETYMOLOGY: This species is named for A.G. Carey, Jr. of Oregon State University in recognition of his important contributions to the study of Arctic benthic ecology.

Collection: This new species occurred at 12 stations for a total of 216 specimens in 585–2195 m.

MEASUREMENTS AND TYPE DEPOSITION:

	Measurements (mm)			
Type	L	H	W	Depository
Holotype	2.6	2.1	1.3	LACM No. 1900
Paratype 1	2.4	2.1	1.5	LACM No. 1901
Paratype 2	2.7	2.2	1.4	USNM No. 771436
Paratype 3	2.4	2.0	1.3	NMC No. 77001
Paratype 4	2.5	2.2	1.4	OSU No. 01047
Paratype 5	2.2	1.9	1.1	CAS No. 58994



FIGURES 49–52. 49, *Axinopsida orbiculata* (Sars), length 4.1 mm; 50, *Axinulus careyi* new species, HOLOTYPE, Length 2.6 mm; 51, *Thyasira (Thyasira) equalis* (Verrill and Bush), length 5.0 mm; 52, *Thyasira (Thyasira) gouldii* (Philippi), length 7.3 mm.

REMARKS: The generic assignment of this deep water species is difficult and possibly a new genus could be proposed to contain it. The new species appears intermediate between *Leptaxinus* and *Axinulus*, both of Verril and Bush 1898, combining the external characteristics of one and the hinge of the other. It is closest to *A. brevis* Verrill and Bush 1898, the type of the genus, but this species is proportionately higher and there is a small, but distinct radial posterior sulcus. Other related species include *A. ferruginosus* (Forbes 1844), characterized by a large posterior pseudocardinal process, and *A. pygmaeus* Verrill and Bush 1898, which has distinct posterior and anterior hinge tuberosities. There are several more related boreal Atlantic species, all distinguishable by shell outline or peculiarities of the pseudodental tuberosities, it is probable that *Axinulus* has been overnamed and the various sizes and shape of the hinge structures are a function of maturity.

Genus *Thyasira* Lamarck (Leach MS) 1818

Figure 53

Type species (original designation): *Tellina flexuosa* Montagu 1803. Recent. Mediterranean.

DESCRIPTION: Shell subglobular to oblique, posterior area set off by one or more radial sulci. Surface polished or chalky, smooth but sometimes with incremental concentric striae. Periostracum very thin, dehiscent in some species. Interior polished, shell margins smooth. Hinge line weak, edentulous, a small pseudocardinal tubercle may be present on left valve. Adductor muscle scars nearly equal, very elongated. Pallial line feebly impressed, wide. No pallial sinus.

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan especially in cold and deep waters. The group is deeply infaunal in fine sediments.

DEVELOPMENT: Published works on various species (Thorson 1936; Ockelmann 1958; Bernard 1972) indicate large ova with lecithotrophic development. Blacknell and Ansell (1974) report that the eggs of *T. gouldii* (Philippi) are large, sticky and attach to the substrate close to the parent. Development is direct within the capsule, a benthic juvenile hatching after a period of up to 2 months.

REMARKS: The anatomy of this group has been described by various authors, the points of interest including the long vermiform foot with a terminal bulb, the arborescent digestive diverticula, and the rotation of the body in the vertical plane, leading to elongation of the adductor muscles and their associated scars. The pallial current is anteroposterior, a secondary modification from the normal posterior exchange of most bivalves. A mucus-lined tube is formed through the substrate by the foot, permitting burial to a far greater depth than the respiratory apertures would allow. The genus is filter-feeding, but shows some modifications towards macrophagy. Arctic representatives are all assignable to *Thyasira* s. str.

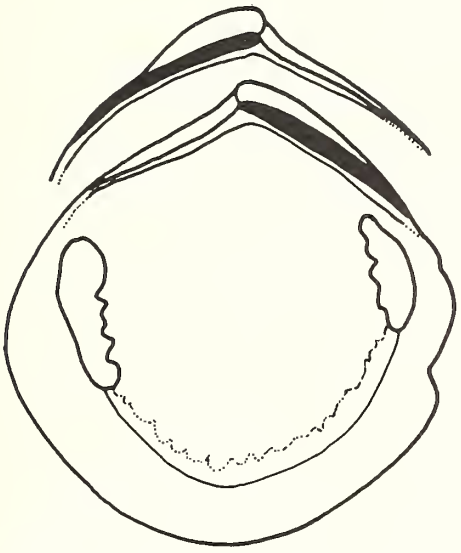


FIGURE 53. Interior of right valve and hinge of left valve of *Thyasira flexuosa* (Montagu).

Subgenus *Thyasira* s. str.
Thyasira (Thyasira) equalis
(Verrill and Bush 1898)

Figure 51

Cryptodon equalis Verrill and Bush 1898:788, pl.91, f.5, 6.
Thyasira equalis (Verrill and Bush), Soot-Ryen 1966:27, pl.1, f.11.
Cryptodon croulinensis altus Verrill and Bush 1898:787, pl.88, f.1, 2.

DESCRIPTION: Shell thin, inflated, maximum length to 10 mm, but usually not more than 5 mm. Surface smooth, chalky or polished, with faint incremental striae only. Periostracum thin, colorless, adherent. Posterior part of shell set off by a broad shallow radial flexure. Umbones prominent and markedly prosogyrous. Lunule not deeply impressed, forming a flat surface below the erect umbones. Ligamental marginal area sunken, circumscribed with an incised line. Interior of shell polished, margins smooth. Hinge weak and narrow, with an obscure subumbonal swelling, but no pseudocardinal tooth in either valve. Adductor muscle scars subequal, elongate but not deeply impressed. Pallial line not apparent.

COMPARISONS: This species may be confused with *T. croulinensis* (Jeffreys 1847), which is similar in hinge morphology and valve inflation, but has a greatly produced anterior region, and the posterior is set off by two radial plications forming a prominent ridge. There is also some resemblance to *T. gouldii* (Philippi 1845), which is rather more compressed and proportionately longer. Furthermore, the hinge of *T. equalis* is not as developed and lacks the pseudodental tubercle. *T. dunbari* Lubinsky 1976 from the central Canadian Arctic is more elongated and oblique.

COLLECTION: The species is represented at seven stations for a total of 95 specimens, collected between 923–1926 m. The majority of the delicate shells have been damaged by storage in formaldehyde solution.

RECORDS: *Recent*—Jensen 1905:341 (Greenland); Ockelmann 1958:104 Text-fig. 7 (Greenland); Clarke 1974:10 (Baffin Bay).

DISTRIBUTION: Probably panarctic in the deeper bathyal and abyssal regions. The species occurs frequently from northeastern America to Greenland and Massachusetts, then extends eastward to Iceland and the Kara Sea. This is the first record from the Beaufort Sea.

REMARKS: This is another Arctic Alaskan species identified with some doubt that only a full revision of the genus will remove. I am very grateful to K.W. Ockelmann who kindly examined representative specimens and agreed that they are close to *T. equalis* (Verrill and Bush), but pointed out that the prodissoconch is slightly larger. This certainly cannot be a sole differential feature, and is to be expected in specimens from separated populations at different latitudes. I find the OSU material so close to east American examples of *T. equalis* that it is best relegated to this taxon.

Thyasira (Thyasira) gouldii
(Philippi 1845)

Figure 52

Thyasira flexuosa, auctt., in part, [not *Tellina flexuosa* Montagu, 1803, new name for *Venus sinuosa* Donovan 1802 not Pennant, 1777]. Bernard 1972:382, f.5, 6, 12.
Lucina gouldii Philippi 1845:74, pl.2, f.7.
Axinus gouldii (Philippi), G. Sars 1878:60, pl.19, f.6a, b.
Thyasira flexuosa gouldii (Philippi), Soot-Ryen 1932:15, pl.2, f.7.
Thyasira wajampolkana Krishtofovich 1936:44, pl.3, f.3a, pl.6, f.3a.
Thyasira tokunagai Kuroda and Habe 1951:86.

DESCRIPTION: Shell subcircular to nearly trigonal, thin, often translucent. Maximum length 15 mm, usually smaller. Surface smooth with irregular concentric incremental striae. Periostracum very thin, dehiscent. Umbones prominent, beaks prosogyrous. Lunular area concave. Posterior region of shell set off by a deep radial groove. Interior polished, often with minute radiating lines inside the pallial line. Hinge considerably thickened, with a pseudocardinal tubercle in the left valve. Adductor muscle scars elongate, well defined. Pallial line wide and irregular. No pallial sinus.

COMPARISONS: This species has long been combined with *T. flexuosa* (Montagu), but Ockelmann (1958) considered it distinct, limiting *T. flexuosa* to the North Atlantic, a view supported by Miloslaskaja (1970). *T. gouldii* is separated from *T. flexuosa* by a larger prodissoconch (> 215μ across), a more shallow posterior radial fold, less inflated valves, and smaller size.

COLLECTION: This species occurred at 23 stations with a total of 60 specimens collected in 23–270 m. Thyasirid material from 11 other stations may be *T. gouldii*, but are too damaged to be identified with certainty.

RECORDS: *Pliocene*—Dall 1874b:297 (California); Cooper 1888:237 (California); Slodkevich 1938:952, pl.70, f.5a, b, (Kamchatka); Petrov 1966:217, pl.16, f.6, 7 (Chukotsk Peninsula); Hertlein and Grant 1972:255, pl.43, f.17, 21 (California); *Pleistocene*—Arnold 1903:135 (California); Richards 1962:60, pl.7, f.6, 7 (Newfoundland to Maine); Wagner 1970:40, pl.3, f.17a, b (Eastern Canada). *Recent*—G. Sars 1878:51, pl.19, f.4a, b (Greenland); Krause 1885:33 (Bering Sea); Stuxberg 1886:143 (Novaya Zemlya); Odhner 1915:103 part (Greenland); Oldroyd 1925:120, pl.34, f.5 (Bering Sea to California); Grant and Gale 1931:282 (Bering Sea to California); Johnson 1934:39 (Greenland to Connecticut); Gorbunov 1946a:46 (New Siberian Islands); Filatova 1957b:55 (Eurasian Arctic); Ockelmann 1958:100, pl.2, f.4, 5 (Greenland); MacGinitie 1959:171, pl.4, f.12 (Point Barrow, Alaska); Richards 1962:60, pl.7, f.6, 7 (Labrador to North Carolina); Kuznetsov 1963:96 (Kamchatka); Petersen 1968:19 (Faroe Islands); Bernard 1970:88 (British Columbia); Clarke 1974:10 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and probably circumboreal. The species occurs from northern Greenland and south to at least North Carolina, and eastwards to Iceland and Norway. It is abundant along the entire Arctic coast of America, the Bering Sea, and extends to the Sea of Okhotsk and northern Japan. On the Pacific coast it is present to southern California.

REMARKS: Gould (1841) in his *Invertebrata of Massachusetts* identified a small thyasirid with the European *T. flexuosa* (Montagu). Philippi (1845), in a paper reviewing this work, expressed the opinion that the species merited separation and proposed calling it *T. gouldii*. Jeffreys (1863) questioned its validity, but it was fully accepted by Binney (1870) in the revised edition of Gould's work. The status of *T. gouldii* has never been clear, and for nearly a century it has been considered a subspecies or junior synonym of *T. flexuosa* (Jeffreys 1877; Soot-Ryen 1932; MacGinitie 1959). Ockelmann (1958), followed by Miloslavskaja (1970) considered *T. flexuosa* a boreo-lusithanian species, distinct from the panarctic and amphi-american *T. gouldii*. The entire taxon is in need of a full review to elucidate distribution, particularly in the Western Pacific as *T. gouldii* was recorded from the Japanese Tertiary by Yabe and Nomura (1925), but latter renamed *T. tokunagai* by Kuroda and Habe (1951). I believe this species to be identical to *T. wajampolkana* Krishtofovich 1936, from the Pliocene of Kamchatka, and clearly a synonym of *T. gouldii*.

Family UNGULINIDAE H. and A. Adams 1857

This family is not represented in the collections, although MacGinitie (1959) reported a single specimen of *Diplodonta aleutica* Dall 1901 from Point Barrow. This species, originally proposed as a subspecies of *D. torelli* Jeffreys 1876, is distinct from the North Atlantic representatives and probably the same as *D. orbellus* (Gould 1852) distributed throughout the North Pacific and Bering Sea, with Point Barrow the easternmost location.

Family MONTACUTIDAE Clark 1885

MacGinitie (1959) recognized a single specimen of *Pseudopythina compressa* Dall 1899 in the Point Barrow material. This species, presently placed in the genus *Neaeromya* Gabb 1873, is commensal with burrowing invertebrates and found in the North Pacific Ocean and Bering Sea ranging to the Chukchi Sea. It appears that Point Barrow is the eastern limit on the American coast.

Key to the genera of Montacutidae

1.	Resilifer small, vertical	*Montacuta*
	Resilifer developed, not vertical	2
2.(1)	Resilifer deep, oblique	*Mysella*
	Resilifer shallow, wide and horizontal	*Boreacola*

Genus *Boreacola* NEW GENUS

Figure 54

Type species (original designation): *Boreacola vadosa* new species.

ORIGINAL DESCRIPTION: Shell minute, thick, ovate, inflated; posterior truncated, anterior rounded. Surface with fine regular concentric lirae. Periostracum thin, adherent, highly polished. Umbones not prominent; prodisoconch large, white, clearly separable from later shell. Left valve with long anterior lamella bent ventrally to form small subumbonal pseudocardinal tooth. Posterior lamella vestigial, not hooked. Right valve with smaller anterior lamella, not hooked; posterior lamella absent. Resilifer wide and shallow. Shell interior lustrous, partially punctate. Adductor muscle scars elongated, subequal. Pallial line narrow, no pallial sinus.

RANGE: Arctic Alaska in shallow water.

ETYMOLOGY: The name is derived from the Latin northern *(Borealis)* and the suffix a dweller in *(-cola)*.

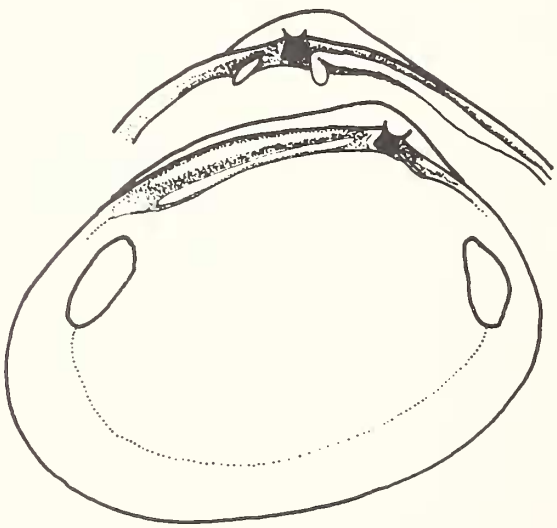


FIGURE 54. Interior of right valve and hinge of left valve of *Boreacola vadosa* N.GEN., N.SP.

REMARKS: The thick translucent shell is quite different from the opaque and chalky shells of *Montacuta* and *Mysella*. The prominent ventrally flexed umbonal end of the anterior lamina in the left valve, the vestigial dentition of the right valve, and the wide resilifer contrasts to the two stout lateral teeth in the right valve and edentulous left valve of *Mysella*. In *Montacuta* the hinge is weaker and the umbonal hooks, though small, are present on both the anterior and posterior lamella of the right valve.

I have no hesitation in proposing this new genus of Montacutidae. The dentition of the group, although small and difficult to observe, is perfectly consistent and unlike other genera. There is little doubt that several separate phylogenies are included in the family. The new genus is closest to *Montacuta*, but in this group the subumbonal hooks are formed by the *lateral* flexure of a vertical lamella, whereas in *Boreacola* it is formed by the rotation of a horizontal ridge.

Boreacola vadosa NEW SPECIES
Figure 56

ORIGINAL DESCRIPTION: Shell thick, minute, inflated, ovate to elliptical. Maximum length 3 mm. Anterior produced, rounded; posterior truncated. Surface smooth, with regular concentric lirae. Periostracum pale yellow to grey, adherent, highly polished. Umbones prominent, prodisoconch nearly horizontal in adult specimens, frequently coated by dark deposits. Interior polished, translucent. Right valve with obscure dentition, left valve with long anterior lamella and subumbonal pseudocardinal tooth. Resilifer wide and shallow. Ligament entirely internal. Muscle and pallial scars clearly impressed; no pallial sinus.

TYPE LOCALITY: Western Beaufort Sea, Arctic Alaska. Western Washington State College station M12 at Pitt Point, 70°55′44″N, 153°12′44″W, Collected in 0.5 m with the Smith-McIntyre Grab.

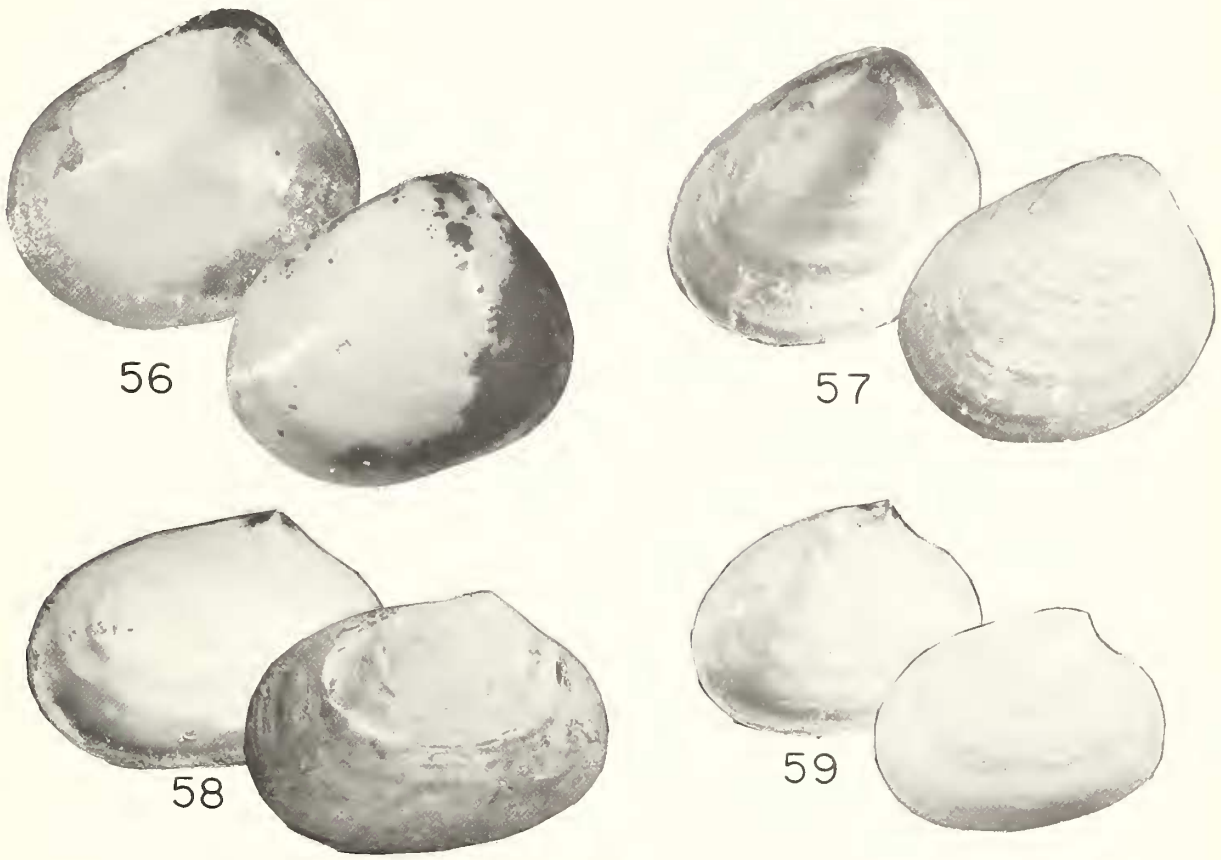
DIAGNOSIS: Shell to 3 mm, thick, subhyaline. Anterior produced, posterior truncated. Left valve with two teeth-like lamellae and subumbonal pseudocardinal. Right valve with corresponding vestigial dentition.

ETYMOLOGY: The specific name is derived from *vadosus*, the Latin for shallows and refers to the shallow water habitat.

COLLECTION: 354 specimens from 15 stations in 0.5–30 m.

MEASUREMENTS AND TYPE DEPOSITION:

	Measurements (mm)			
Type	L	H	W	Depository
Holotype	2.3	2.0	1.3	LACM No. 1902
Paratype 1	1.9	1.6	1.1	LACM No. 1903
Paratype 2	2.3	1.9	1.2	USNM No. 771437
Paratype 3	2.1	1.7	1.3	NMC No. 77002
Paratype 4	1.9	1.7	1.1	OSU No. 01048
Paratype 5	2.0	1.5	1.0	CAS No. 58995



FIGURES 56–59. 56, *Boreacola vadosa* new genus, new species, HOLOTYPE, length 2.3 mm; 57, *Montacuta dawsoni* Jeffreys, length 1.9 mm; 58, *Mysella (Mysella) planata* (Dall *in* Krause), length 4.4 mm; 59. *Mysella (Rochefortia) tumida* (Carpenter), length 2.6 mm.

COMPARISONS: The salient differences are given under the generic discussion. This species may only be confused with *Mysella tumida* (Carpenter), but the two large divergent teeth of the right valve of the latter species clearly separate it.

REMARKS: The species is very abundant in favored areas, particularly the extremely shallow subtidal regions that have had little sampling effort. A number of specimens of a montacutid turned up in the shallow (< 30 m) stations of the 1970–72 OSU collections, but I was unable to assign to genus due to extensive formaldehyde damage. Examination of the Western Washington State College material collected at Pitt Point, Alaska (<1 m), revealed abundant representatives in excellent preservation.

Genus *Montacuta* Turton 1822

Figure 55

Type species (subsequent designation Herrmannsen 1846): *Ligula substriata* Montagu 1808. Recent. North Atlantic.

DESCRIPTION: Shell thin, ovate to subquadrangular, inflated. Surface usually with concentric lirae and growth checkmarks, occasionally with fine radial threads. Periostracum thin and polished. Interior of shell chalky, margins smooth. Hinge weak, with anterior lamina terminating in a minute cardinal hook in each valve, but larger in the right valve. Posterior lamina weak, sometimes vestigial. Ligament mostly internal, resilifer a small oblique channel posterior to the umbones. Adductor muscle scars irregular, elongated. Pallial line wide. No pallial sinus.

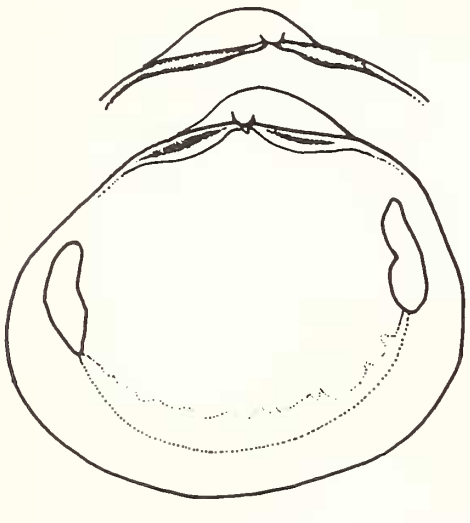


FIGURE 55. Interior of right valve and hinge of left valve of *Montacuta substriata* (Montagu).

RANGE: Eocene to Recent. Recent distribution Arctic and circumboreal. Commensal with larger burrowing invertebrates, particularly echinoderms and polychaetes.

DEVELOPMENT: Eggs are retained in the mantle cavity in at least some species and released for a short planktonic phase (Oldfield 1961; Thorson 1946; Loven 1848). The planktonic larva has been described by Lebour (1938).

REMARKS: Nutrition in the genus is by filter feeding. The anatomy points to a shallow infaunal existence, but specimens are usually collected in the deeper sediments. Most are commensals byssally attached to their infaunal partners, or to the walls of burrows, allowing existence at a greater buried depth.

Montacuta dawsoni Jeffreys 1863

Figure 57

Montacuta dawsoni Jeffreys 1863:216; Jeffreys 1869:178, pl.31, f.7
Mysella sovaliki MacGinitie 1959:173, pl.4, f.10.

DESCRIPTION: Shell obliquely triangular to subelliptical, maximum length 3 mm. Surface smooth with occasional concentric incremental striae and growth checks. Periostracum thin, light brown, dehiscent. Umbones not prominent, usually eroded. Interior polished, with faint radiating lines, margins smooth. Hinge with an anterior and smaller posterior lamina in each valve, but obscure in left valve. Resilifer triangular, subumbonal. Adductor muscle scars and pallial line not apparent.

COMPARISONS: The species is readily separated from others in the genus by the triangular outline that is due to the extension of the anteroventral margins. The low beaks separate it from the New England species *M. elevata* Stimpson 1851.

COLLECTION: *M dawsoni* occurred at three stations for a total of five specimens collected in 23–29 m.

RECORDS: *Recent*—Johnson 1934:44 (Greenland to Newfoundland); Gorbunov 1946a:46 (New Siberian Islands); Filatova 1957b:55 (Arctic). MacGinitie 1959:173, pl.4, f.10 (Point Barrow, Alaska); Clarke 1962:66 (North Atlantic and Mediterranean).

DISTRIBUTION: Probably panarctic, the species is widely distributed through the North Atlantic from Greenland to Norway, south to Britain, and along the American eastern seaboard from Baffin Island to New Brunswick; and from the Canadian Arctic Archipelago to Point Barrow, Alaska. It does not occur in the Bering Sea or Pacific Ocean.

REMARKS: I consider *Mysella sovaliki* MacGinitie 1959 a synonym. MacGinitie gave an abbreviated description, comparing it only to the northeast Pacific *Tellimya tumida* Carpenter 1864, and stated that three specimens (USNM 170490) labelled *Montacuta dawsoni* should be referred to the new species. After examination of the type of *M. sovaliki* and numerous specimens of *M. dawsoni*, I conclude that MacGinitie's species falls within the expected variation of high Arctic bivalves. I have been unable to arrive at a firm conclusion, but am of the opinion that *Mysella maltzani* Verkrüzen 1876 is also a probable synonym. This species is sporadically distributed from Norway to the Siberian Sea (Filatova 1948), Novaya Zemlya (G. Sars 1878), and Spitzbergen (Odhner 1915), thus completing the panarctic distribution of *M. dawsoni*.

Genus *Mysella* Angas 1877

Figure 60

Type species (original designation): *Mysella anomala* Angas 1877. Recent. Australia.

DESCRIPTION: Shell subtrigonal to elliptical. Surface smooth or with obscure concentric lirae. Periostracum polished, light to dark brown, dehiscent. Umbones prominent, beaks small. Interior glossy, shell margins smooth. Hinge well developed, with two stout teeth bordering the central resilifer in the right valve. Left valve edentulous, but with shell margins inserted into a

groove above teeth of right valve. Adductor muscle scars weakly developed. Pallial line irregular and obscure. No pallial sinus.

RANGE: Miocene to Recent. Recent distribution cosmopolitan, generally in fine sediments and commensal with burrowing echinoderms, polychaetes, sipunculids, and mollusks (Boss 1965).

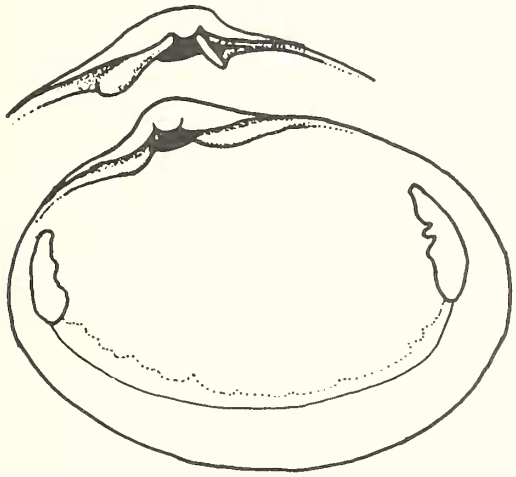


FIGURE 60. Interior of right valve and hinge of left valve of *Mysella anomala* (Angas).

DEVELOPMENT: Thorson (1946) observed the species *M. bidentata* (Montagu 1803) brooding its eggs, which are released at an advanced stage of development.

REMARKS: The genus contains filter feeding bivalves that attach directly to larger invertebrates, or afix the byssus to the burrow wall of deep infauna, probably benefiting from the water circulation generated by the host. A review of the many species currently placed within *Mysella* will probably show that the northern boreal representatives should be placed in several genera and separated from the antipodal *Mysella*.

KEY TO THE SUBGENERA OF *MYSELLA*

Resilifer narrow, oblique ..... *Mysella* s. str.
Resilifer wide, vertical ..... *Rochefortia*

Subgenus *Mysella* s. str.

Mysella (Mysella) planata (Dall *in* Krause 1885)

Figure 58

Tellimya planata Dall *in* Krause 1885:34, pl.3, f.6a–d.
Mysella planata (Dall *in* Krause), Dall 1899:892, pl.88, f.12.
Rochefortia planata (Dall *in* Krause), Oldroyd 1925:132.
Montacuta planata (Dall *in* Krause), MacGinitie 1959:974, pl.20, f.1, 3–7, 9–11.

DESCRIPTION: Shell compressed, subquadrate to ovate, maximum length 10 mm, usually less than 5 mm. Surface smooth, sometimes with incremental lirae. Periostracum dark brown, dehiscent, with concentric wrinkles and folds. Umbones situated nearer the posterior end of shell, not prominent and usually eroded. Interior polished, frequently with faint radial lines. Shell margins smooth. Hinge developed, with two prominent diverging teeth on either side of the resilifer of the right valve. Left valve edentulous, but dorsal margins of shell slightly produced to fit into corresponding grooves in the right valve. Adductor muscle scars subequal, narrow and irregular. Pallial line wide and indistinct. No pallial sinus.

COMPARISONS: This species may be confused with *M. tumida* (Carpenter 1864) a species with a more triangular outline, weaker dentition, and a polished periostracum.

COLLECTION: *M. planata* occurred at six stations for a total of 39 specimens and a few single valves from 270–717 m.

RECORDS: *Pliocene*—Durham and MacNeil 1967:331 (North Pacific). *Recent*—Paetel 1890:134 (Bering Sea); Dall 1921:37 (Arctic Ocean to Southern Alaska); Filatova 1957b:55 (Siberian Arctic); MacGinitie 1959:174, pl.20, f.1, 3–7, 9–11 (Point Barrow, Alaska); Eyerdam 1960:37 (Aleutian Islands); Scarlato and Ivanova 1974:306 (Kurile Islands); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: The species is limited to the Chukchi Sea and adjacent Arctic Ocean from the Beaufort to the Siberian Sea, and south to include the Bering Sea and the Kurile Islands. It has not been identified south of the Aleutian Archipelago, or in the Atlantic segment of the Arctic.

REMARKS: MacGinitie (1959) following Dall (1899) identified *M. planata* with *M. elevata* Mörch *in* Jones 1875 *(not* Stimpson, 1851), and with *M. moelleri* Mörch (Holboll MS) *in* Jones 1875. According to Dall, the latter was not validly proposed, so the taxon dates from Posselt 1898, and therefore falls into the synonymy of *M. planata*. However, I believe the Mörch taxon to be valid; furthermore, it is a distinct species synonymous with *M. elevata* Mörch *in* Jones 1875. Rejection of Dall's (1899) synonymy removes the North Atlantic records of *M. planata* cited by MacGinitie (1959).

Subgenus *Rochefortia* Velain 1877

Type species (monotypy): *Rochefortia australis* Velain 1877. Recent. Indian Ocean.

Mysella (Rochefortia) tumida (Carpenter 1864)

Figure 59

Tellimya tumida Carpenter 1864:602, 611, 643; Tryon 1872:229.
Mysella tumida (Carpenter), Dall 1899:881, pl.87, f.7; Palmer 1958:88, pl.7, f.8–12.
Rochefortia tumida (Carpenter), Oldroyd 1925:132, pl.54, f.11–14.

DESCRIPTION: Shell ovate to subtriangular, compressed, maximum length 5 mm. Surface smooth, with irregular incremental striae. Periostracum dark brown, sometimes with bands of darker color. The surface of the periostracum is polished, but microscopic concentric wrinkles are present. Umbones inflated, eroded, placed near truncated posterior margins. Interior glossy, shell margins smooth, very tightly closing. Hinge strong, two large teeth in right valve, left valve with hinge margins produced into two laminar pseudolaterals, otherwise edentulous. Adductor muscle scars elongated. Pallial line wide, indistinct. No pallial sinus.

COMPARISONS: The subtriangular outline and truncated posterior end of the shell, and the heavy dentition of the hinge distinguish this species from *M. planata* (Dall *in* Krause 1885).

COLLECTION: Eight specimens from two stations were collected in 29 and 71 m.

RECORDS: *Pliocene*—Hertlein and Grant 1972:239, pl.44, f.2–5, 7, 8, 12, pl.45, f.5, 8, 9, 12 (California). *Pleistocene*—Grant and Gale 1931:301, pl.14, f.16, 17 (Lower California, Mexico); Kanakoff and Emerson 1959:24 (California); Addicott 1966:4, pl.4, f.12, 13 (California); Allison 1973:20 (Aleutian Islands, Alaska). *Recent*—Krause 1885:36 (Bering Sea); Newcombe 1893:4 (British Columbia); Baker 1910:47 (Alaska); Willett 1918:68 (Alaska); Grant and Gale 1931:301, pl.14, f.16, 17 (Alaska to California); Eyerdam 1960:44 (Aleutian Islands, Alaska); Bernard 1970:88 (British Columbia); Wacasey 1975:27 (Beaufort Sea).

DISTRIBUTION: Widely distributed in the Bering Sea and the American coast as far south as Tillamook, Oregon and possibly California.

REMARKS: This species was not recorded by MacGinitie (1959), however, I have no hesitation assigning the few OSU specimens to *M. tumida*. I have not seen material collected south of central Oregon.

Family CARDITIDAE Fleming 1828
Genus *Cyclocardia* Conrad 1867

Figure 61

Type species (subsequent designation Stoliczka 1871): *Cardita borealis* Conrad 1831. Recent. North Atlantic.

DESCRIPTION: Shell rounded to trigonal, thick and solid. Surface ornamented with strong radial ribs, which may be beaded. Periostracum dark brown to black, frequently velvety. Beaks prosogyrous, not prominent. Interior porcelaneous, shell margins coarsely crenulated. Hinge ponderous, with peg-like, often bifid, anterior cardinal tooth and curved elongate posterior cardinal in the left valve. Right valve with large central cardinal and narrow laminar subligamental posterior cardinal tooth.

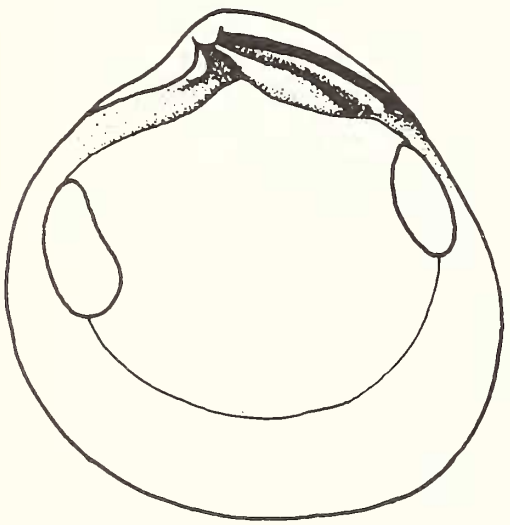


FIGURE 61. Interior of right valve of *Cyclocardia borealis* (Conrad).

Adductor muscle scars nearly equal in size, deeply impressed. Pallial line width irregular. No pallial sinus.

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan in temperate and boreal waters. The genus is a member of the shallow infauna of coarse sediments. Large specimens frequently have sessile invertebrates attached to the posterior end of the shell.

DEVELOPMENT: The family is generally incubatory with the young released as benthic juveniles (Dall 1903; Jones 1963).

REMARKS: MacGinitie (1959) obtained a number of specimens of *C. crassidens* (Broderip and Sowerby 1829), at Point Barrow and Coan (1977) recorded the species at Cape Simpson (CAS 35058). It is not represented in the present collection, so it is possible this northeastern Pacific species is not firmly established in the Arctic. The anatomy of *Cyclocardia* has been reported by Pelseneer (1911) and Pacific species were examined by Yonge (1969) who also summarized the salient features of the superfamily. Coan (1977) published a review of the Northwest American species.

Subgenus *Cyclocardia* s. str.
Cyclocardia (Cyclocardia) crebricostata (Krause 1885)

Figures 63, 64

Cardita borealis crebricostata Krause 1885:70, pl.3, f.4.
Venericardia crebricostata (Krause), Oldroyd 1925:114, pl.13, f.12.
Venericardia (Cyclocardia) crebricostata (Krause), Kotaka 1962:150, pl.35, f.5–7.
Cyclocardia crebricostata (Krause), Coan 1977:378, f.6–7.
Venericardia (Cyclocardia) alaskana Dall 1903a:710, 715; Dall 1903b: pl.63, f.7.

DESCRIPTION: Shell circular to nearly ovate, inflated, thick, maximum length 40 mm. Surface ornamented with 18–30 rounded ribs with equal interspaces crossed by numerous small concentric folds resulting in a scalariform appearance. Periostracum dark brown, velvety. Beaks small, erect, usually eroded. Interior polished, shell margins crenulated. Hinge delicate for the genus. Left valve with large central bifid cardinal and curved, elongated posterior cardinal tooth. Right valve with large central cardinal and thin laminar posterior cardinal tooth. External ligament placed on well-developed nymphs. Adductor muscle scars equal, deeply impressed. Pallial line impressed. No pallial sinus.

COMPARISONS: This species is allied to the North Atlantic *C. borealis* (Conrad 1831) but is distinguishable by the thinner shell, more delicate ribs, and weaker hinge.

COLLECTION: This species occurred at 19 stations for a total of 29 specimens from 30–101 m.

RECORDS: *Pliocene*—MacNeil et al. 1943:75, pl.14, f.16, 17 (Alaska); Hopkins and MacNeil 1960:B341 (Northwest Alaska); Petrov 1966:215, pl.10, f.3 (Chukotsk Peninsula); Zhidhova et al. 1968:94, pl.23, f.4, 5 (Sakhalin Islands). *Pleistocene*—Miller 1953:29 (Alaska); Barth 1956:119 (Pribiloff Islands, Alaska); Merklin et al. 1962:36, pl.15, f.7 (Chukotsk Peninsula); Hopkins et al. 1972:126 (St. Lawrence Island). *Recent*—Kinoshita and Isaka 1934:15, pl.11, f.81 (Northern Japan); Kuroda and Habe 1952:34 (Northern Japan); Habe and Igarashi 1957:35 (Northern Japan); Filatova 1957b:54 (South Chukchi Sea); MacGinitie 1959:169 (Point Barrow, Alaska); Merklin et al. 1962:36, pl.5, f.7 (Chukotsk Peninsula); McLaughlin 1963:26 (Bering Sea); Bernard 1970:88 (British Columbia).

DISTRIBUTION: Widely distributed throughout the Bering Sea, the species extends westward into the Okhotsk Sea and to Northern Japan. Along the American coast it is found from Point

Barrow to central Oregon (Bernard MS) and has been recorded from the Chukchi Sea.

REMARKS: This is a northern species and records south of central Oregon are in error. It appears to have originated in the Western Bering Sea and only recently entered the high Arctic, probably after the Pleistocene Kotzebuan Transgression (Hopkins et al. 1972). *C. alaskana* (Dall 1903) is certainly this species which Dall separated from the Atlantic *C. borealis* auctt (in part Conrad 1890). Localized high-count rib populations, identified as *C. crebricostata nomensis* MacNeil 1943, are present in both the Bering and Chukchi seas (D.M. Hopkins, pers. comm.), and may be considered morphs of the typical form. The relationship to *Venericardia granulata rjabininae* Scarlato 1955 from the Chukotsk Peninsula is unresolved. The latter appears to be more elongated and with wider interspaces between the ribs.

Family ASTARTIDAE d'Orbigny 1844
Genus *Astarte* J. Sowerby 1816
Figure 62

Type species (original designation): *Pectunculus sulcatus* Da Costa 1778. Recent. North Atlantic.

DESCRIPTION: Shell trigonal, quadrangular, or rounded. Surface smooth or with concentric lirae or ribs. Periostracum thick, varnished, adherent. Interior porcelaneous, shell margins smooth or finely crenulated. Hinge well developed, with three teeth in the left valve. Adductor muscle scars subequal, deeply impressed. Pallial line uniform. No pallial sinus.

RANGE: Jurassic to Recent. Recent distribution cosmopolitan, especially in boreal and cool waters, extending to low latitudes in deeper water. The genus is a member of the superficial infauna, with the shell frequently covered with various small sessile invertebrates.

DEVELOPMENT: Reproduction is non-pelagic according to the species examined by Thorson (1946). Ova are large and adhesive, attaching to the substrate or shell near the parent (Ockelmann 1958).

REMARKS: The limited distribution of juveniles may be the primary cause of the great polymorphism displayed by the genus. All observed species are active movers over the substrate, especially at night, they are shallow burrowers, often leaving the posterior end of the shell, with its small pallial aperture, exposed. It is interesting to note that Stanley (1970) reported an exception in *A. castanea* (Say 1822), which exposes the anterior end. As it is commonly present in coarse sediments, it is probable that this species utilizes the interstitial water for respiration and nourishment.

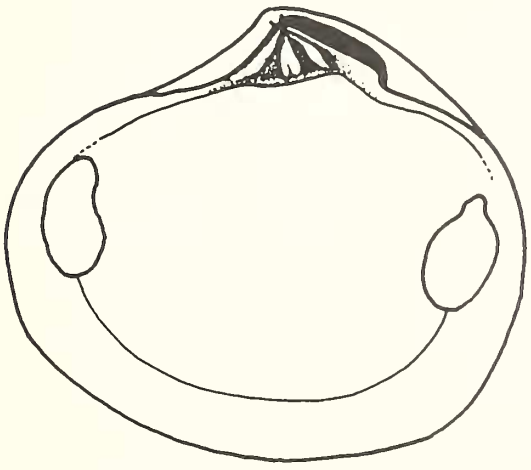


FIGURE 62. Interior of right valve of *Astarte sulcata* (Da Costa).

KEY TO THE SUBGENERA OF *ASTARTE*

1. Shell smooth, or with regular concentric ribs 2
   Shell with broad irregular, sometimes broken concentric ribs ..... *Rictocyma*

2.(1) Lunule rounded, depressed, ligamental nymph narrow ..... *Astarte* s. str.
   Lunule elongate, superficial, ligamental nymph broad ..... *Tridonta*

Subgenus *Astarte* s. str.
Astarte (Astarte) crenata (Gray 1824)
Figure 65

Nicania crenata Gray 1824:119.
Astarte crenata (Gray), Smith 1881:23; Jensen 1912:113, pl.4, f.5a–m; Soot-Ryen 1932:14, pl.1, f.15–18.
Astarte crenata inflata Hägg 1904:f.4–6; Jensen 1912:113, pl.4, f.5h–i.
Astarte crenata quadrata Filatova 1957b:54 [*nom. nud.*].
Crassina elliptica Brown 1827:96, pl.38, f.3 [not *Astarte elliptica* Sibirgokova, 1961].
Astarte elliptica (Brown), Smith 1881:204.
Astarte semisulcata Möller 1842:19 [not *Crassina semisulcata* Leach *in* Ross 1819].

DESCRIPTION: Shell ovate to rhomboidal, posterior end truncated. Surface ornamented with strong rounded equidistant concentric ribs. Periostracum with a silken sheen, yellow to brown. Umbones prominent, beaks usually eroded. Interior porcelaneous, polished, shell margins finely crenated in mature specimens, smooth in immature individuals. Hinge delicate for the genus. Right valve with three cardinal teeth. Left valve with posterior cardinal obsolete. Ligamental nymph vestigial, ligament in sunken groove. Adductor muscle scars subequal. Pallial line impressed. No pallial sinus.

COMPARISONS: The regular and equidistant concentric ribbing of most of the disc and the wide lunule distinguish this species from all other Arctic representatives of the genus. The crenulation of the shell margins is age-dependent and can not be used as a basis for identification.

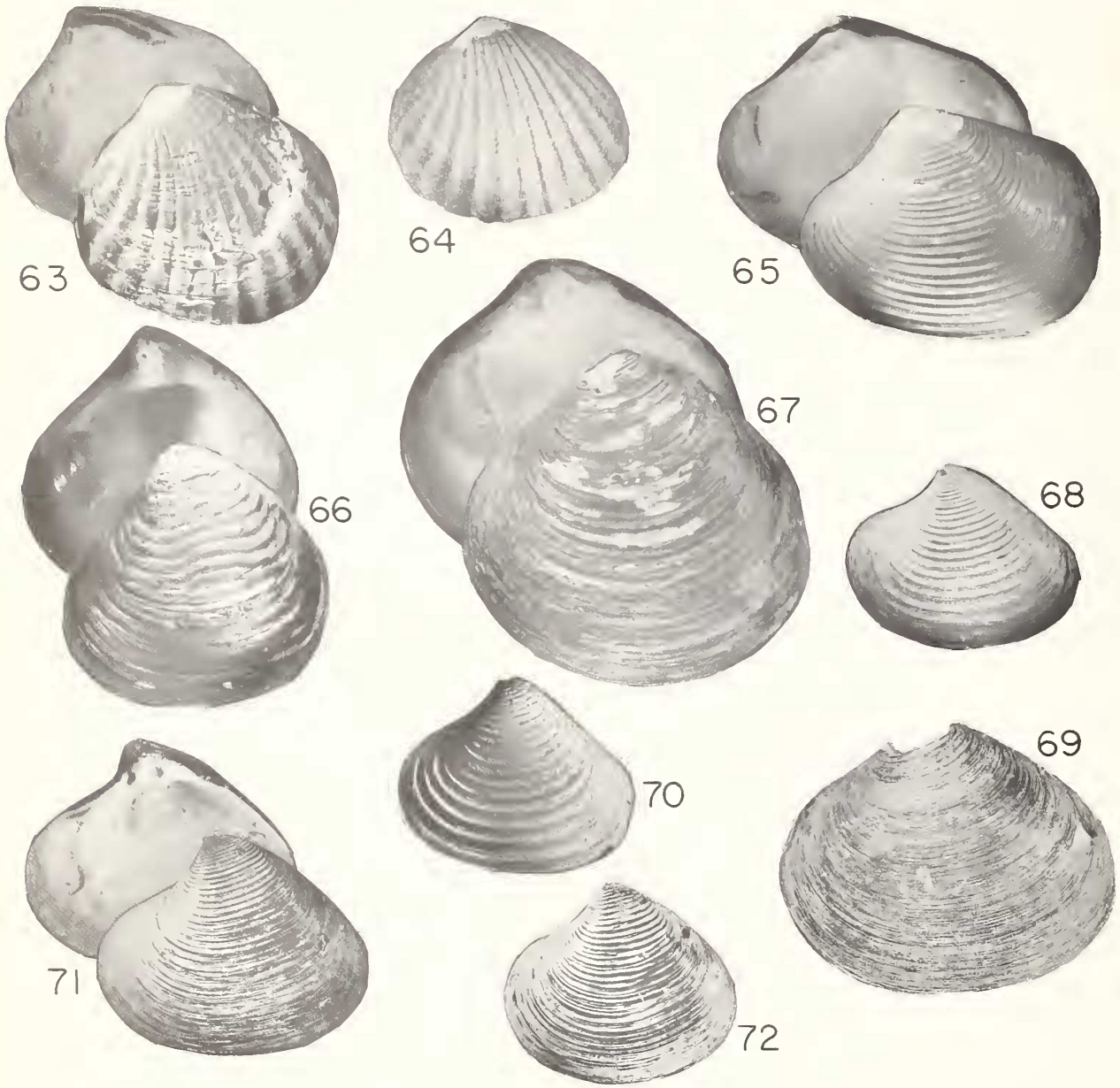
COLLECTION: This species occurred at two stations for a total of 56 specimens from 357 and 455 m.

RECORDS: *Pliocene*—Wood 1853:181, pl.16, f.7 (Britain); Schlesh 1924:11 (Iceland); Glibert and Van De Poel 1970:74 (Scotland). *Pleisto-*

cene—Richards 1962:58, pl.6, f.6, 7 (Labrador to Massachusetts). *Recent*—D'Urban 1880:253 (Barents Sea); Petersen 1893:75 (Denmark); Melville and Standen 1900:4 (Franz Josef Land); Hägg 1904:36 (Greenland); Mesjatsev 1931:84 (Barents Sea); Johnson 1934:36 (Greenland to Gulf of St. Lawrence); Soot-Ryen 1939:14 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1948:434, pl.109, f.5–8 (Arctic); Madsen 1949:48 (Iceland); Filatova 1957b:65 (Kara Sea); Filatova and Zenkevich 1957:66 (Kara Sea); Ockelmann 1958:89 (Greenland); Soot-Ryen 1958:20 (Greenland); Richards 1962:58, pl.6, f.6, 7 (Arctic to Massachusetts); Kuznetsov 1963:66 (Kamchatka); Petersen 1968:52 (Faroe Islands); Clarke 1974:10 (South Greenland); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Probably panarctic, the species is widely distributed from Greenland eastwards to Norway and south to the Faroe Islands. It occurs in the Canadian Arctic Archipelago, Hudson Bay, and south to Massachusetts. It is present in the Siberian Sea, but does not extend into the Eastern Bering Sea or Pacific Ocean.

REMARKS: This is a highly polymorphic species, with numerous varietal and subspecific forms, a selection of the more important ones are presented in the systematic citation section above. It is easily distinguishable in its "typical form" but varieties may be confused, particularly with *A. borealis* (Schumacher 1817). Distinguishing points are the comparative thinness of the shell, the regular concentric ribbing over most of the disc, and the light colored periostracum which is thin and never fibrous or decorticated as in *A. borealis*. Under the microscope the peri-



FIGURES 63–72. 63, *Cyclocardia (Cyclocardia) crebricostata* (Krause), length 16.5 mm; 64, *C. (C.) crebricostata*, length 18.4 mm; 65, *Astarte crenata* (Gray), length 21.0 mm; 66, *Astarte (Rictocyma) esquimalti* (Baird), length 11.2 mm; 67, *Astarte (Tridonta) borealis* (Schumacher), length 29.2 mm; 68, *A. (T.) borealis*, length 24.0 mm; 69, *A. (T.) borealis*, length 33.1 mm; 70, *A. (T.) borealis*, juvenile, length 10.9 mm; 71, *Astarte (Tridonta) montagui* (Dillwyn), length 17.2 mm; 72, *A. (T.) montagui*, juvenile, length 4.1 mm.

ostracal folds are more regular and less numerous than in the latter species. Care must be exercised in utilizing the fine structure of the periostracum as an identification aid suggested by Ockelmann (1958). Although useful, microscopic appearance is not absolutely consistent.

Subgenus *Rictocyma* Dall 1872

Type species (monotypy): *Rictocyma mirabilis* Dall 1872. Recent. Northeast Pacific.

Astarte (Rictocyma) esquimalti (Baird 1863)

Figure 66

Crassatella esquimalti Baird 1863:70.
Astarte esquimalti (Baird), Oldroyd 1925:108 [not pl.13, f.19].
Rictocyma zenkevitchi Filatova 1957a:300 f.4.

DESCRIPTION: Shell quadrate to subtrigonal, compressed, maximum length 20 mm. Surface with numerous irregular concentric ribs. In large individuals ribs may be absent from ventral part of disc. Periostracum light to dark brown, with microscopic striae and wrinkles. Umbones prominent. Beaks erect and generally eroded. Lunule long and flat. Escutcheon elongated. Interior porcelaneous, sometimes with pearly luster, margins smooth. Hinge carved, left valve with prominent anterior tooth, a central laminar and a vestigial subligamental tooth. Right valve with three teeth, the central one large. Adductor muscle scars equal, deeply impressed. Pallial line narrow. No pallial sinus.

COMPARISON: *A. esquimalti* is the only Arctic representative of the subgenus and is easily separated from the inflated trigonal *A. mirabilis* (Dall 1871), of the Bering Sea, by the more numerous and narrower concentric ribs.

COLLECTION: Twelve specimens from six stations were collected in 34–270 m.

RECORDS: *Pleistocene*—Miller 1953:29 (Alaska). *Recent*—Lord 1866:368 (Vancouver Island); Whiteaves 1887:121 (Queen Charlotte Islands to Vancouver Island); Paetel 1890:138 (Vancouver Island); Newcombe 1893:4 (Vancouver Island); Taylor 1895:35 (British Columbia); Willett 1918:67 (Alaska); Eyerdam 1960:43 (Alaska); Bernard 1970:88 (Alaska to Puget Sound, Washington).

DISTRIBUTION: The species occurs throughout the Bering Sea and south to Puget Sound, Washington. Dall (1885) reported this species from Cape Franklin, but this is the first record from the Beaufort Sea.

REMARKS: Dall (1871) proposed *Rictocyma* as a subgenus to contain his new species *A. mirabilis*. The description is diagnostic, but the illustration is poor, and Dall was apparently unaware of Baird's *Crassatella esquimalti*, although it was included in the catalogue of West American mollusks by Carpenter (1864) and Lord (1866). In 1885 Dall, without explanation, synonymized his species with Baird's, and in 1903 Dall stated that *A. mirabilis* was a juvenile *A. esquimalti* and illustrated (Dall 1903b, pl.63, f.11, 12) a large specimen from the Shumagin Islands, reproduced by Oldroyd (1925, pl.13, f.19). I consider *A. mirabilis* a valid species as Dall apparently based his concept of Baird's species entirely upon the brief Latin diagnosis because the holotype (BM[NH] no number) has not been figured. Dall's difficulty is apparent from his MS name *A. esquimalti limata* on the specimen label (USNM 169565) that I consider to be *A. esquimalti* s. str. I hold *R. zenkevitchi* Filatova 1957a, from the Western Bering Sea and Kamchatka to be synonymous to *A. esquimalti* as Filatova based her comparison upon Dall's illustration of "*A. esquimalti*" which in fact is *A. mirabilis*. *A (Gonilia?) diversa* Dall 1920 from the Alaskan Pliocene is probably also a synonym of *A. mirabilis*.

Subgenus *Tridonta* Schumacher 1817

Type species (monotypy): *Tridonta borealis* Schumacher 1817 ex *Venus borealis* Chemnitz 1784. Recent. Arctic.

Astarte (Tridonta) borealis (Schumacher 1817)

Figures 67, 68, 69, 70

Venus borealis Chemnitz 1784 (of "Linné") invalid binom. ICZN [not *Venus borealis* Linné 1767].
Tridonta borealis Schumacher 1817:47, pl.17, f.1.
Astarte borealis ("Chemnitz"), Jensen 1912:92, pl.4, f.1a, b; Oldroyd, 1925:106; Scarlato, 1955:192, pl.51, f.8.
Astarte (Tridonta) borealis (Linné), Filatova 1948:435, pl.109, f.11.
Astarte borealis ovata Filatova 1957b:54 [not *Crassina ovata* Brown 1827].
Astarte (Tridonta) borealis pseudoactis Merklin and Petrov *in* Petrov et al. 1962:33, pl.4, f.1–3.
Crassina semisulcata Leach *in* Ross 1819 [not *Astarte semisulcata* Møller 1842].
Crassina withami J. Smith 1839:105, pl.1, f.21.

DESCRIPTION: Shell ovate to quadrangular, compressed, total length to 55 mm. Surface sculptured with concentric ribs usually limited to first 6–8 mm of the disc. Periostracum thick, yellow to black, adherent. In some individuals the periostracum is compact and polished with microscopic concentric striae, in others it is fibrous and decorticated. Umbones subcentral, not prominent. Interior polished, margins smooth, valves tightly closing. Hinge strong, right valve with two diverging teeth, left valve with large central cardinal and two smaller lateral teeth. Ligament supported by prominent nymphs. Adductor muscle scars deeply impressed, anterior pedal retractor scar prominent. Pallial line narrow. No pallial sinus.

COMPARISONS: This species is very variable, the proportions and the appearance of the periostracum are not consistent, but it is separated from other astartids by the always uncrenulated shell margins, the nearly central umbones, and the concentric ribs limited to the umbonal region.

COLLECTION: Twenty-six specimens and numerous single valves were collected from 16 stations between 28–270 m.

RECORDS: *Pliocene*—Wood 1853:175, pl.16, f.3a–d (Britain); Yokoyama 1922:163 pl.10 f.11a, b (Northern Japan); Nomura and Hatai 1935:85 (Japan); Slodkevich 1938:759, pl.59, f.5a, b (Chukotsk Peninsula); Petrov 1966:206 (Chukotsk Peninsula); Glibert and Van De Poel 1970:73 (Belgium); Zhidkova et al. 1972:119, pl.23, f.2 (Kurile Islands). *Pleistocene*—Knipowisch 1900:379 (Spitzbergen); Filatova 1957b:59 (Eurasian Arctic); Merklin et al. 1962:32, pl.2, f.8–13 (Chukotsk Peninsula); Richards 1962:59, pl.6, f.10, 11 (Labrador to Maine); Glibert and Van De Poel 1970:73 (Belgium); Hopkins et al. 1972:126 (St. Lawrence Island); Allison 1973:20 (Aleutian Islands). *Recent*—M. Sars 1850:170 (Norway); Crosse 1877:123 (Arctic and Bering seas); G. Sars 1878:50, pl.5, f.8a, b (Greenland); Melvill and Standen 1900:4 (Franz Josef Land); Mesjatsev 1931:71 (Barents Sea); Soot-Ryen 1932:12 (Greenland); Johnson 1934:37 (Greenland to Massachusetts); Soot-Ryen 1938:10, pl.1, f.1–3 (Franz Josef Land); Gorbunov 1946a:46 (Arctic); Madsen 1948:43 (Iceland); Kuroda and Habe 1952:14 (Northern Japan); Ockelmann 1958:74 (Greenland); Soot-Ryen 1958:19 (Greenland); MacGinitie 1959:166, pl.22, f.1–6 (Point Barrow, Alaska); Clarke 1960:11 (Arctic); Ellis 1960:39 (Baffin Island); Hulsemann 1962:71 (Beaufort Sea); Kotaka 1962:148, pl.34, f.24, 25, 28, 29 (Okhotsk Sea); Richards 1962:59, pl.6, f.10, 11 (Arctic Ocean to Massachusetts); Kuznetsov 1963:6 (Kamchatka); Sparks and Pereyra 1966:834 (Chukchi Sea); Petrov 1967a:184 (Bering Sea); Golikov and Scarlato 1967:99, pl.9, f.4 (Northern Japan);

Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal, this species is widely distributed throughout the North Atlantic from the Canadian Arctic Archipelago to Norway and Denmark, and south to Massachusetts. It is not represented in the Pacific south of Prince William Sound, but is abundant in the Bering Sea and extends into the Sea of Okhotsk and the Sea of Japan. It is essentially a shallow water species, but drift shells have been recorded in more than 1600 m (Clarke 1960).

REMARKS: The shell outline and proportion of the hinge teeth are of little use in identification, but the microscopic appearance of the periostracum is constant for this particular species. Ockelmann (1958) showed it to be plain with fine concentric folds that may be prolonged into a fibrous mat, particularly on the ventral part of the disc. MacGinitie (1959) has pointed out that the dentition of high Arctic specimens may be rather coarser than that found on individuals from lower latitudes.

Astarte (Tridonta) montagui (Dillwyn 1817)

Figures 71, 72

Venus compressa Montagu 1808:43, pl.26, f.1 [not Linné 1767].
Venus montagui Dillwyn 1817:167.
Astarte montagui (Dillwyn), Jensen 1912:97, pl.4, f.2a, b; Filatova 1948:435, pl.110, f.5–8; Filatova and Barsanova 1964:20.
Nicania banksii Leach *in* Ross 1819: Appendix 62.
Astarte banksii (Leach *in* Ross), Gray 1839:152, pl.44, f.10.
Nicania striata Leach *in* Ross 1819: Appendix 62.
Astarte striata (Leach *in* Ross), Gray 1839:152, pl.44, f.9.
Astarte multicostata MacGillivray 1843:211 [not *Crassina multicostata* J. Smith 1839; not *Astarte multicostata* Filatova 1957a].
Astarte warhami Hancock 1846:336, pl.5, f.15, 16.
Astarte fabula Reeve *in* Belcher 1855:398, pl.33, f.5a, b; Oldroyd 1925:107, pl.19, f.4a.

DESCRIPTION: Shell trigonal to ovate, occasionally elongate. Maximum length 25 mm, rarely more than 15 mm. Surface with numerous concentric narrow sharp riblets, evenly spaced on the early shell, and tending to become irregular in the ventral regions. Periostracum thick, straw-yellow to maroon. The polished surface covered with numerous microscopic wrinkles. Umbones prominent, beaks usually eroded. Lunule wide, deeply impressed. Escutcheon flattened, not demarcated. Interior polished, translucent. Hinge well developed, curved. Right valve with prominent cardinal, posterior and anterior teeth vestigial. Left valve with two large, and one small tooth. Ligament on a large nymph. Adductor muscle scars and anterior and posterior pedal muscle scars deeply impressed. Pallial line wide. No pallial sinus.

COMPARISONS: This is one of the most variable members of the genus as testified by its numerous synonyms. It may be distinguished from other Arctic astartids by the wide and deeply concave lunule, the elongated shallow escutcheon and the slight protuberance of the ligament, which does not project as far as in *A. borealis* (Schumacher 1817). The interior of *A. montagui* is more polished than in other species and may display a bluish alabasterine depth, particularly on the adductor muscle scars. The region above the pallial line and between the adductor scars is generally opaque and less polished.

COLLECTION: This is the most abundant astartid in the collection, 641 specimens and many single valves occurred at 129 stations between 10–455 m.

RECORDS: *Pleistocene*—Fielden 1877:489 (Greenland); Knipowisch 1900:379 (Spitzbergen); Laursen 1950:86 (Iceland); Merklin et al. 1962:34, pl.4, f.4, 8 (Chukotsk Peninsula); Richards 1962:58, pl.6, f.14, 15 (Arctic); Petrov 1966:210, pl.15, f.8–15 (Eurasian Arctic); Glibert and Van De Poel 1970:76 (Belgium); Wagner 1970:39, pl.3, f.14a, b, 15a, b, (Eastern Canada); Troitskiy 1974:265 (Siberia). *Recent*—Mørch 1869:233 (Iceland); Crosse 1877:123 (Bering and Arctic seas); Leche 1878:17 (Novaya Zemlya); D'Urban 1880:256 (Barents Sea); Krausé 1885:31 (Bering Sea); Melvill and Standen 1900:4 (Franz Josef Land); Dall 1903b:942, 945 (Arctic and Bering seas); Odhner 1915:96 (Spitzbergen); Soot-Ryen 1925:5 (Spitzbergen; Spärck 1929:13 (Iceland); Grant and Gale 1931:268 (Herschel Island, Arctic and Bering Sea); Mesjatsev 1931:76 (Barents Sea); Soot-Ryen 1939:11, pl.1, f.4 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:44 (Iceland); Filatova 1957b:54 (Arctic); Ockelmann 1958:80 (Greenland); Soot-Ryen 1958:19 (Greenland); MacGinitie 1959:167, pl.22, f.11, 12 (Point Barrow, Alaska); Clarke 1960:2, 11, pl.1, f.5 (Arctic); Hulsemann 1962:68 (Beaufort Sea); Richards 1962:58, pl.6, f.14, 15 (Arctic); McLaughlin 1963:26 (Bering Sea); Kuznetsov 1963:66 (Kamchatka); Sparks and Pereyra 1966:834 (Chukchi Sea); Clarke 1966:11, pl.1, f.5 (Arctic); Petrov 1967:167, 184 (Bering and Chukchi seas); Golikov and Scarlato 1967:100, f.84 (Northern Japan); Bowden and Heppell 1968:248 (Britain); Petersen 1968:52 (Faroe Islands); Clarke 1974:10 (Baffin Bay); Wacasey 1974:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. The species is widely distributed in the North Atlantic from Greenland to Norway and Sweden and south to Faroe and Shetland islands and Northern Britain. It occurs along the American coast from Nova Scotia through the Arctic shores and into the Bering Sea. It does not occur south of the Aleutian Islands. It is the most common astartid present on the Eurasian Arctic coast from the Kara Sea to Siberia and extends into the Sea of Okhotsk to Northern Japan.

REMARKS: A number of authors have retained form names such as *warhami* Hancock, but as no geographic pattern is discernible and a continuous series of intergrades occur, there is little benefit in naming extremes. Jensen (1912) suggested the environment influences morphology, the shell becoming less tumid and more elongate in colder waters. This is the pattern for Greenland (Ockelmann 1958); however, it does not hold for the Pacific high latitudes, as the most elongated and tumid forms of *A. montagui* occur in the Bering Sea.

Family CARDIIDAE Lamarck 1809

The collection contained a few specimens belonging to genera *Clinocardium* and *Serripes*. Wagner (1977) recorded both *Cerastoderma echinatum* (Linné 1758) and *C. elegantulum* (Beck *in* Møller 1842) from the eastern Beaufort Sea, so it is possible that the low-salinity area of the Mackenzie estuary forms an effective barrier to westward penetration of the typically European Arctic genus.

Key to the Genera of Cardiidae

Shell with strong radial ribs, dentition developed ..... *Clinocardium*

Shell with obscure radial channels, dentition vestigial ..... *Serripes*

Genus *Clinocardium* Keen 1936

Figure 73

Type species (original designation): *Cardium nuttallii* Conrad 1837. Recent. Northeast Pacific.

DESCRIPTION: Shell elliptical to subtrigonal, surface with numerous uniform radial ribs, overlaid by fine concentric threads. Periostracum thin, ciliated in some species. Beaks recurved, prosogyrate. Interior porcelaneous, margins coarsely crenulate. Hinge strong, arched. Each valve with two cardinal and a posterior and anterior lateral teeth. Ligament on a short nymph. Adductor muscle scars nearly equal, not impressed. Pallial line shallow, uniform width. No pallial sinus.

RANGE: Miocene to Recent. Recent distribution Arctic circumboreal, intertidal to 500 m, not a typically high Arctic genus, but one or two species numerically abundant.

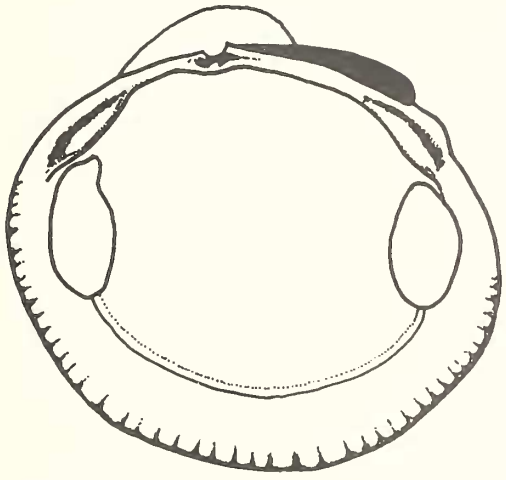


FIGURE 73. Interior of right valve of *Clinocardium nuttallii* (Conrad).

DEVELOPMENT: The type of the genus undergoes planktonic development (Bernard MS) and Ockelmann (1958) stated that *C. ciliatum* (Fabricius) also has a long pelagic phase.

REMARKS: Although widely distributed in the Arctic, the genus does not appear fully adapted, and is usually found only sporadically. It is probable that the requirement for a lengthy planktonic larval existence may hinder distribution.

Clinocardium ciliatum (Fabricius 1780)

Figure 75

Cardium ciliatum Fabricius 1780:410; Lamarck 1819:6 [as *"ciliare"*]; Jensen 1912:79, pl.3, f.10.
Cardium (Cerastoderma) ciliatum (Fabricius), Oldroyd 1925:142, pl.19, f.8, a; Filatova 1948:432, pl.109, f.1.
Clinocardium ciliatum (Fabricius), Keen 1936:120.
Cardium (Clinocardium) ciliatum (Fabricius), Clench and Smith 1944:15, pl.10.
Laevicardium (Cerastoderma) ciliatum (Fabricius), Grant and Gale 1931:310, pl.19, f.11.
Cardium arcticum Sowerby 1840:106.

DESCRIPTION: Shell subcircular to ovate, inflated, length to 70 mm, usually smaller. Surface with 28–40 radial triangular ribs, less prominent in the lateral part of disc. Periostracum yellow to greyish-brown, thin, adherent, with numerous concentric folds especially produced over the ribs, giving them a ciliated appearance. Umbones prominent, beaks prosogyrate. Lunule and escutcheon obscure. Interior porcelaneous, margins coarsely crenulate. Hinge plate arched. Two cardinal and two lateral teeth in each valve, but the posterior lateral and cardinal almost vestigial. Ligament weak, attached to small nymph. Adductor muscle scars nearly equal. Pallial line indistinct. No pallial sinus.

COMPARISONS: The species is easily distinguished by the thin shell, the numerous narrow sharp ribs, and the periostracal fringe on the radial ribbing which may, however, be absent from gerontic and abraded specimens. The dentition, particularly the lateral teeth, is weaker than in other members of the genus.

COLLECTION: Eight specimens and some fragments occurred at seven stations between 26–159 m.

RECORDS: *Pleistocene*—Meek 1923:414 (Alaska); Wagner 1959:5 (British Columbia); Merklin et al. 1962:38, pl.6, f.1 (Chukotsk Peninsula); Richards 1962:63, pl.8, f.8, 9 (Hudson Bay to Massachusetts); Petrov 1966:221, pl.17, f.1–3 (Eurasian Arctic). *Recent*—Montagu 1803:79 (England); Leche 1878:21 (Novaya Zemlya); G. Sars 1878:46, pl.5, f.4a, b (Greenland); Leche 1883:443 (Arctic); Hägg 1904:51 (Greenland and Spitzbergen); Mesjatsev 1931:107 (Barents Sea); Kinoshita and Isaka 1934:15, pl.12, f.84 (Northern Japan); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:63 (Iceland); Soot-Ryen 1951:3 (Norway); Kuroda and Habe 1952:17 (Northern Japan); Filatova 1957b:55 (Arctic); Ockelmann 1958:118 (Greenland); MacGinitie 1959:176, pl.26, f.4 (Point Barrow, Alaska); Clarke 1961:7 (Gulf of St. Lawrence); Ellis 1960:39 (Baffin Island); Kotaka 1962:151, pl.35, f.4 (Sea of Okhotsk); Richards 1962:63, pl.8, f.8, 9 (Arctic to Massachusetts); McLaughlin 1963:26 (Bering Sea); Filatova and Barsonova 1964:34 (Bering Sea); Allen 1965:983 (Northwestern Atlantic); Sparks and Pereyra 1966:834 (Chukchi Sea); Habe and Igarashi 1967:36 (Northern Japan); Petrov 1967:184 (Bering Sea); Clarke 1974:11 (Baffin Bay); Kafanov 1974:1469 (North Atlantic and Arctic); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. The species is distributed throughout the North Atlantic from Greenland to Norway and south to England and Ireland. It is abundant from Cape Cod, Massachusetts to Hudson Bay and Baffin Island. It has been reported from all the Arctic coasts, the Bering Sea, Sea of Okhotsk and south to northern Japan. In the eastern Pacific it ranges into the northern portion of the Gulf of Alaska.

REMARKS: The species has been named several times, these synonyms, listed by Dall (1901) should be re-examined when the limits of variability have been established. Though the dentition is reduced there is no doubt that the species should be assigned to *Clinocardium*. Kafanov (1974) proposed the genus *Ciliatocardium* with *C. ciliatum* as type species and sole living representative of the taxon, which apparently arose from Miocene *Clinocardium* stock. The value of this generic separation has not been established. Andrews (1972) discussed fossil and living growth rates.

Genus *Serripes* Gould 1841

Figure 74

Type species (monotypy): *Cardium groulandicum* Bruguière1789. Recent. Arctic.

DESCRIPTION: Shell ovate, inflated and brittle. Surface with weak radial channels, especially on anterior and posterior slopes. Periostracum thin, adherent. Interior polished or dull, margins smooth. Hinge narrow and poorly developed. Right valve with two cardinals and anterior and posterior lateral teeth. Left valve with corresponding laterals and single cardinal tooth. Dentition is

evanescent and many specimens, irrespective of size, are edentulous. Ligament large, on wide nymph. Adductor muscle scars equal. Pallial line uniform. No pallial sinus.

RANGE: Miocene to Recent. Recent distribution includes the Arctic Ocean and northern circumboreal regions. Shallow and intertidal infauna of mixed sediments.

DEVELOPMENT: According to Thorson (1936) the ova of *S. groenlandicus* (Bruguière 1789) are small and poor in yolk, accordingly, development is planktotrophic.

REMARKS: This genus includes the largest high Arctic bivalves and the only one of major significance as food for walrus.

Serripes groenlandicus (Bruguière 1789)

Figures 76, 77

Venus islandica (of "Linné") Fabricius 1780:411 [not *Venus islandica* Linné 1767].
Cardium grönlandicum Chemnitz 1782:pl.19, f.198 [non binom. ICZN.]
Cardium grönlandicum Bruguière 1789:222; Gmelin 1791:3252; Jensen 1915:115.
Aphrodite groenlandica (of "Chemnitz"); Leche 1883:443.
Cardium (Serripes) groenlandicum (of "Chemnitz"), Jensen 1912:85, p.3, f.12a, b.
Serripes grönlandicus (of "Chemnitz"), Gould 1870:145, f.454; Oldroyd 1925:145, pl.8, f.3; Filatova 1948:431, pl.108, f.12.
Serripes groenlandicus (of "Chemnitz"), Soot-Ryen 1932:14; Clench and Smith 1944:28, pl.13, f.5–7; Scarlato 1955:143, pl.51, f.11; Petrov 1966:222, pl.17, f.4–9, pl.18, f.1–3.
Serripes grönlandicus protractus Dall 1900:1112.

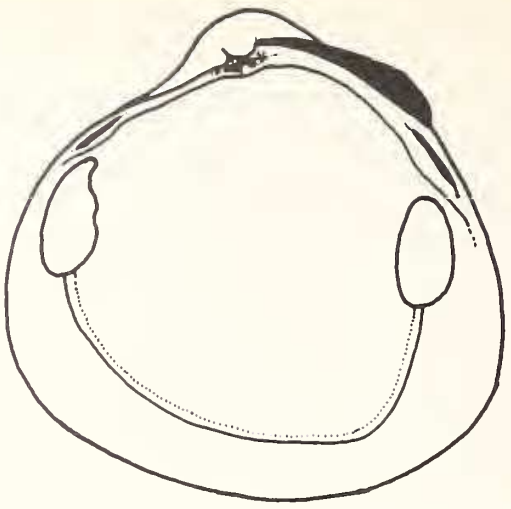
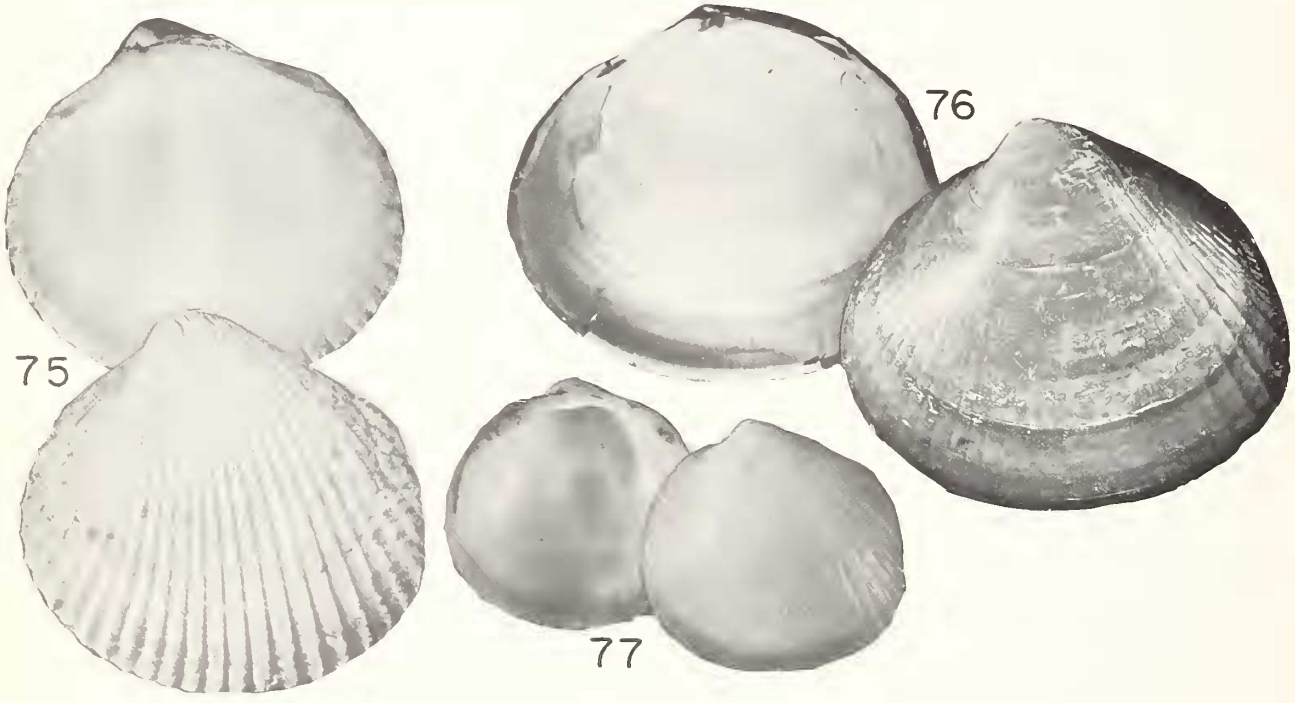


FIGURE 74. Interior of right valve of *Serripes groenlandicus* (Bruguière).

DESCRIPTION: Shell thin, inflated, subquadrate with rounded anterior and truncated posterior, length to 95 mm, usually less than 45 mm in the high Arctic. Surface with narrow radial channels, absent from the central part of the disc. Concentric growth lines and checks may be present. Periostracum thin, light pinkish-brown to dark-brown, often with concentric bands of darker color. Interior polished, margins smooth except for lateral zones that may be obscurely crenulate. Hinge narrow, frequently edentulous with obscure tuberosities, but some specimens with a small central cardinal and weak anterior and posterior lateral teeth in each valve. Adductor muscle scars nearly equal. Pallial line weakly impressed. No pallial sinus.

COMPARISONS: Although this species is rather variable, it is easily distinguished by the thin, brittle shell, the obscure dentition, and the radial channels between the wide and shallow ribs confined to the anterior and posterior of the shell. It is surprising



FIGURES 75–77. 75, *Clinocardium ciliatum* (Fabricus), length 20.6 mm; 76, *Serripes groenlandicus* (Bruguière), length 27.7 mm; 77, *S. groenlandicus*, juvenile, length 2.9 mm.

that a number of synonyms have been proposed, most of them merged by Wood (1853). Another species, *S. laperousii* (Deshayes 1839), limited to the Gulf of Alaska, Bering, Okhotsk and Sea of Japan, is separable by the elongated posterior which has a marked gape, and the much heavier shell.

COLLECTION: Ten juvenile specimens and four larger valves occurred at 10 stations between 10–101 m.

RECORDS: *Pliocene*—Wood 1853:160, pl.13, f.1a–d (Britain); Hopkins and MacNeil 1960:B41 (Alaska); Zhidkova et al. 1968:104 (Sakhalin Islands); Zhidkova et al. 1972:127, pl.9, f.1 (Kurile Islands). *Pleistocene*—Wood 1853:160, pl.13, f.1a–d (Britain); Wagner 1959:5 (British Columbia); Merklin et al. 1962:38, pl.6, f.3–5 (Chukotsk Peninsula); Richards 1962:63, pl.8, f.12, 13 (Labrador to Maine); Hopkins et al. 1972:126 (St. Lawrence Island). *Recent*—Gould 1841:92 (Massachusetts); Middendorff 1849:557, pl.16, f.6–9 (Novaya Zemlya); Leche 1878:21 (Novaya Zemlya); G. Sars 1878:49, pl.5, f.3a–b (Greenland); Krause 1885:27 (Bering Sea); Melvill and Standen 1900:4 (Franz Josef Land); Dautzenberg and Fischer 1910:20 (Novaya Zemlya); Soot-Ryen 1939:15 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:59 (Iceland); Soot-Ryen 1951:2 (Norway); Kuroda and Habe 1952:31 (Northern Japan); Filatova 1957b:55 (Eurasian Arctic); Ockelmann 1958:113 (Greenland); MacGinitie 1959:176, pl.26, f.5 (Point Barrow, Alaska); Clarke 1961:7 (Gulf of St. Lawrence); Richards 1962:63, pl.8, f.12, 13 (Greenland to Massachusetts); McLaughlin 1963:27 (Bering Sea); Allen 1965:983 (Northwestern Atlantic); Golikov and Scarlato 1967:107 (Northern Japan); Petrov 1967:167 (Arctic); Bernard 1970:88 (British Columbia); Clarke 1974:10 (Baffin Bay); Scarlato 1976:103 (Bay of Peter the Great); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is found throughout the north Atlantic from Greenland to Norway and south to Iceland, the Faroe Islands, and Britain. Along the American coast it occurs from Baffin Island to Cape Cod, Massachusetts. It has been reported from all regions of the shallow high Arctic, into the Bering Sea, west to northern Japan and along the Alaskan coast south to northern Oregon.

REMARKS: This is a shallow water species, but shells may be transported to great depths, Clarke (1960) reported fragments from 2200 m in the Laurentian Basin. It may be noted that the diacritic mark of the first vowel in the original combination is deleted in current nomenclature and the letter "e" inserted.

Family TELLINIDAE Blainville 1814

There were no representatives of *Tellina* in the collection. MacGinitie (1959) noted abundant fossil *Tellina lutea* Wood (Gray MS) 1828 (= *Tellina lutea alternidentata* Broderip and Sowerby 1829) at Point Barrow, and the species is recognized in the Pliocene and Pleistocene of Alaska. Living representatives, however, appear limited to the Chukchi, Bering and Okhotsk seas, and do not occur east of Cape Lisburne, Alaska. There is British Museum material (BM[NH] 1860. 1. 23.5) cited by Coan (1971) and labelled Cape Kruzenstern, Arctic coast of Mackenzie, Canada (vicinity of Dolphin and Union Strait). I believe this locality to be mistaken for Cape Krusenstern (formerly spelled with a "z") on the north side of Kotzebue Sound, Alaska, which is well within the known distribution of *T. lutea*. The species is not known to occur live in the Arctic, but does occur fossil at several locations in Arctic Alaska. The *"Herald"* (the vessel which collected the B.M. *Tellina*) did obtain material from the Canadian Arctic (Seemann 1853), but the majority of the described material originated in the Pacific and Bering seas. Forbes (1850) discussing American Pacific shells and lack of precise location data states "a few specimens of considerable interest were taken by the *"Herald"* at Cape Krusenstern." Wagner (1977) recorded an unidentified species of *Tellina* from the eastern Beaufort Sea.

Genus *Macoma* Leach 1819

Figure 78

Type species (monotypy): *Tellina calcarea* Gmelin 1791. Recent. North Atlantic.

DESCRIPTION: Shell ovate to subtrigonal, compressed. Surface white, chalky, smooth with faint incremental striae and growth checkmarks. Posterior of shell produced, frequently twisted to the right. Periostracum thin, light brown to colorless. Interior porcelaneous to chalky, shell margins smooth. Hinge weak, two cardinal teeth in each valve, lateral teeth absent. Ligament external, seated on nymph. Adductor muscle scars irregular. Pallial line narrow, not joining posterior adductor scar. Pallial sinus conjoined with pallial line, with a different configuration in each valve.

RANGE: Miocene to Recent. Recent distribution cosmopolitan, preferring fine sediments from the intertidal to the abyssal zones. The group is shallow to deeply infaunal, usually lying in the horizontal plane on the left valve (Stanley 1970).

DEVELOPMENT: There appears to be a range of developmental types within the genus. *M. moesta* (Deshayes 1854) produces large, adhesive ova undergoing a reduced, or totally absent, planktonic phase, while *M. calcarea* (Gmelin 1791) undergoes a normal planktonic development (Ockelmann 1958, 1962).

REMARKS: The genus has long been considered totally deposit feeding, as is *M. calcarea* (Reid and Reid 1969), but this is not universal, Braefield and Newell (1961) showed *M. balthica* may also function as a filter feeder. Four species are represented in the collection; however, there is a high probability that further exploration, particularly in sheltered nearshore environments, will yield additional species. As an aid to those using this text to identify macomids from the study area, the most likely additional species are listed below. Identifications of these and other species may be found in Coan (1971). I am most grateful to E.V. Coan for confirming my identifications.

Macoma brota Dall 1916b. This was proposed as a new name for *Tellina edentula* Broderip and Sowerby 1829 [*not* Spengler 1798]. It is widely distributed in the Chukchi and Bering seas and

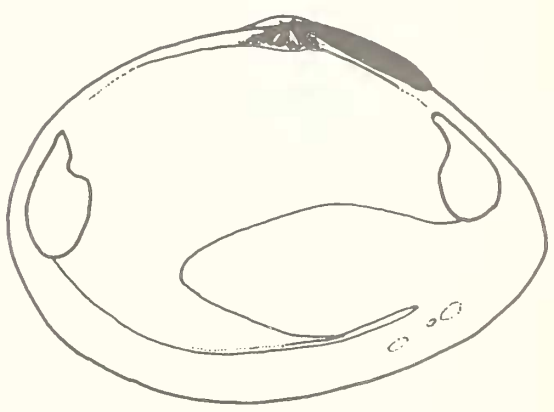


FIGURE 78. Interior of right valve of *Macoma calcarea* (Gmelin).

south to Washington State. In the North Atlantic it has been reported living from several locations in the Canadian Arctic Archipelago and in Bathurst Inlet. Though it is well represented in the Arctic Pleistocene, it is rare in the Beaufort Sea and probably may not occur east of Dease Inlet (USNM 363169).

Macoma crassula (Deshayes 1855). This is the *Macoma torelli* (Jensen [Steenstrup MS] 1905), a typically high Arctic species discussed and synonymized by Coan (1971). It occurs at Point Barrow and Nunivak Island, and Wacasey (1974) reported it from Mackenzie Bay and Wagner (1977) from the eastern Beaufort Sea. The distribution is probably panarctic.

Macoma lama Bartsch 1929. Together with its synonym, *M. planuiscula* Grant and Gale 1931, is represented in the northeastern Pacific, Bering and Chukchi seas, extending eastward to Point Barrow. The USNM contains material from Dease Inlet (USNM 363166) to the east of Point Barrow, so the species may extend some way into the Beaufort Sea.

Macoma middendorffi Dall 1884. This is the *Tellina edentula* auctt. not Broderip and Sowerby 1829. It is distributed throughout the Bering and Chukchi seas and along the Siberian coast. It has been collected at Point Barrow (USNM 207073), but is not recorded by MacGinitie (1959).

Macoma obliqua (Sowerby 1817). This is not *Tellina obliqua* Wood 1815 but ICZN Opinion 948:1971 (application by Coan and Sealey 1969) conserves the junior name. Coan (1969) showed that the common North Pacific *Tellina incongrua* (von Martens 1865) is conspecific with the British Coralline Crag (Pliocene) fossil *Tellina obliqua* Sowerby 1817, presently extinct in the North Atlantic. The species occurs throughout the Bering Sea and Japan and south along the American coast to Washington State. It was recorded living from Point Barrow by MacGinitie (1959), who found a single specimen, and Coan (1969) referred to material in the USNM (207073) from the same locality. Though distributed throughout the Pleistocene facies of Arctic America, it has not been found living in the Beaufort Sea.

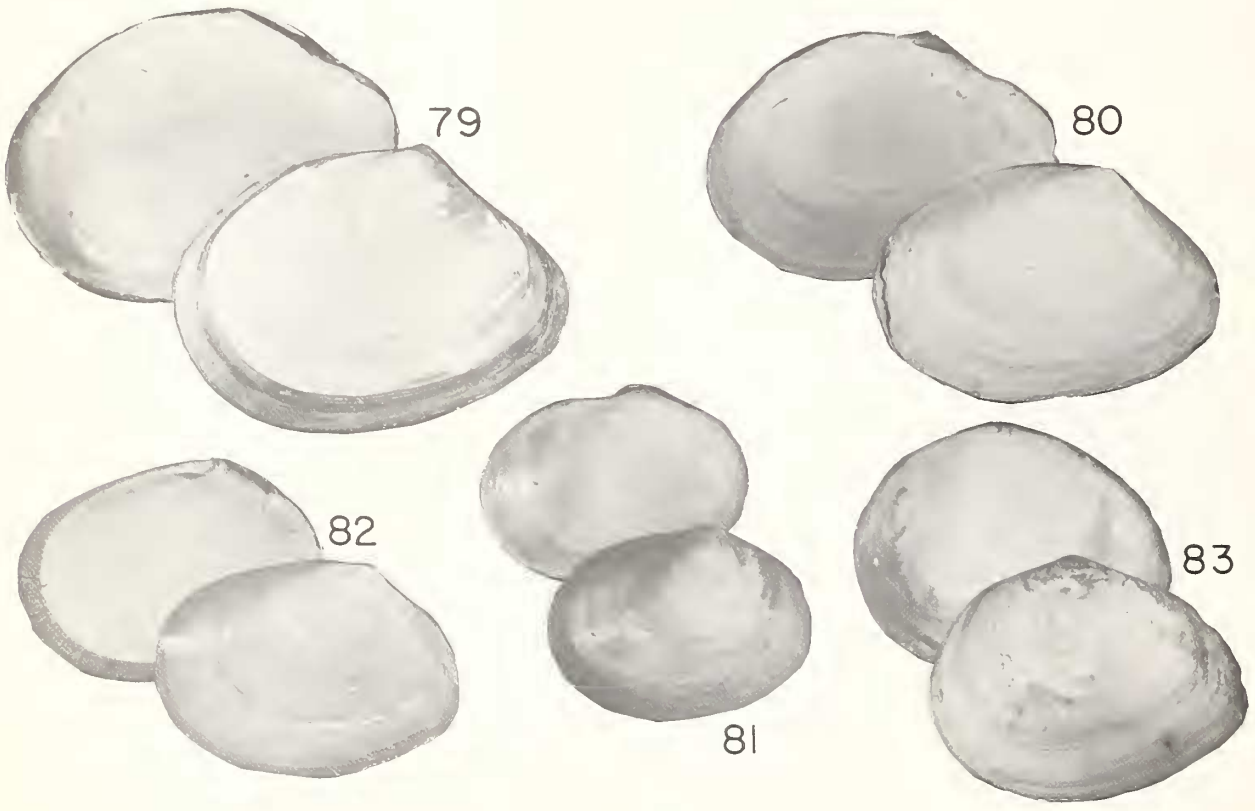
Subgenus *Macoma* s. str.

Macoma (Macoma) calcarea (Gmelin 1791)

Figures 79, 80

Tellina calcarea Chemnitz 1782:140, pl.13, f.136 [not binom.]; Gmelin 1791:3236.
Tellina (Macoma) calcarea (of "Chemnitz"), Jensen 1905:342, f.2a, b.
Macoma calcarea (Gmelin), Oldroyd 1925:173 [not pl.42, f.5]; Soot-Ryen 1932:15, pl.2, f.1–6; Filatova 1948:440, pl.111, f.2; Scarlato 1955:196, pl.53, f.1; Dunnill and Ellis 1969:10, f.4, 1a–d, 9e; Afshar 1969:78, pl.30, f.8–12.
Macoma (Macoma) calcarea (Gmelin), Coan 1971:20, pl.3, f.20, pl.4, f.21–*24, pl.5, f.25, text-fig. 9.*
Macoma calcarea obliqua Soot-Ryen 1932:15, pl.2, f.4a, b [not *Tellina obliqua* Sowerby, 1817].
Macoma calcarea longisinuata Soot-Ryen 1932:17, pl.2, f.1, 3.
Macoma sitkana Dall 1900:307, 323, pl.4, f.6, 7.

DESCRIPTION: Shell ovate, posterion elongated, flexed to the right. Length to 54 mm, shell thin chalky. Surface smooth with incremental striae and growth checks. Periostracum thin,



FIGURES 79–83. 79, *Macoma (Macoma) calcarea* (Gmelin), length 37.2 mm; 80, *M. calcarea,* length 22.6 mm; 81, *Macoma (Macoma) loveni* Jensen, length 13.3 mm; 82, *Macoma (Macoma) moesta alaskana* Dall, length 20.7 mm; 83, *Macoma balthica* (Linné) length 17.6 mm.

dark grey, dehiscent, generally absent except for marginal band. Umbones not prominent, beaks usually eroded. Interior chalky to porcelaneous, shell margins smooth. Hinge weak, two small cardinal teeth in each valve. Ligament strong and elongate, partly buried in escutcheon. Adductor muscle scars subequal, irregular. Pallial line not distinct, not connecting adductor muscle scars. Pallial sinus large, partly conjoined with pallial line, of different size in each valve.

COLLECTION: 120 specimens and many single valves were found at 54 stations between 10 and 360 m.

COMPARISONS: Although this is a polymorphic species, the produced and rostrated posterior, with its characteristic flexure and weak dentition distinguish *M. calcarea*. Stocks of this species in the Arctic and Atlantic appear fairly stable, but in the Bering and Pacific areas there is a degree of plasticity. Dunnill and Coan (1968) showed that at least two species were included in northeastern Pacific populations previously assumed to be *M. calcarea*.

RECORDS: *Miocene*—Arnold and Hannibal 1913:590 (Oregon); Ilyina 1963:8, pl.24, f.8, pl.27, f.4, pl.49, f.2 (Kamchatka). *Pliocene*—Arnold and Hannibal 1913:590 (California); McNeil et al. 1943:75, pl.15, f.19 (Aleutian Islands); Petrov 1966:228, pl.19, f.3–11 (Siberia); Zhidhova et al. 1968:118, pl.11, f.4–6 (Sakhalin Islands); Zhidhova et al. 1972:132, pl.18, f.16 (Kurile Islands). *Pleistocene*—Wood 1857:229 (Britain); Arnold and Hannibal 1913:590 (Washington); Newcombe 1914:107 (British Columbia); Meek 1923:414 (Alaska); Grant and Gale 1931:369 (California); Slodkevich 1938:1273, pl.94, f.1–3 (Chukotsk Peninsula); Wagner 1959:5 (British Columbia); Richards 1962:66, pl.10, f.17–19 (Labrador to South Carolina); Merklin et al. 1962:41, pl.7, f.5–10 (Chukotsk Peninsula); Wagner 1970:42, pl.4, f.5a, b (Eastern Canada); Hopkins et al. 1972:126 (St. Lawrence Island); Troitskiy 1974:265 (Siberia). *Recent*—Møller 1842:120 (Greenland); D'Urban 1880:253 (Barents Sea); Hägg 1904:46 (Greenland and Spitzbergen); Dautzenberg and Fischer 1910:24 (Novaya Zemlya); Odhner 1915:111 (Greenland) Massy 1930:270 (North Atlantic); Johnson 1934:52 (Greenland to Long Island Sound); Slodkevich 1938:1273, pl.94, f.1–3 (Northern Japan); Soot-Ryen 1939:16 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1957b:56 (Arctic); Filatova and Zenkevich 1957:64 (Kara Sea); Ockelmann 1958:125, pl.2, f.10 (Greenland); MacGinitie 1959:181, pl.24, f.5–7, pl.26, f.6–9 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island and Greenland); Clarke 1962:67 (Arctic); Hulsemann 1962:72 (Beaufort Sea); Richards 1962:66, pl.10, f.17–19 (Arctic to New Jersey); Kuznetsov 1963:66 (Kamchatka); McLaughlin 1963:27 (Bering Sea); Filatova and Barsanova 1964:31 (Bering Sea); Allen 1965:983 (Northwestern Atlantic); Sparks and Pereyra 1966:834 (Chukchi Sea); Okutani 1966:12 (Northern Japan); Golikov and Scarlato 1967:112, f.104 (Sea of Japan); Dunnill and Coan 1968:12 (British Columbia); Petersen 1968:53 (Faroe Islands); Ishikawa 1969:49 (Northern Japan); Bernard 1970:89 (British Columbia); Kuroda et al. 1971:457, pl.100, f.9 (Japan); Okutani 1972:96 (Northern Japan); Clarke 1974:11 (Baffin Bay); Scarlato and Ivanova 1974:311 (Kurile Islands); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is found throughout the North Atlantic and Pacific. It is well represented in the Canadian Arctic Archipelago, Hudson Bay and south to New Jersey, and across the Atlantic from Greenland to Iceland, the Faroe Islands, and Britain. It may occur as far south as the Azores in deep water. The range includes the Bering and Okhotsk seas to Northern Japan, and along the coast of America as far as central Washington.

REMARKS: The species probably originated during the late Miocene in the North Pacific and is first recorded on the Atlantic side in the Pleistocene (Wood 1855), under the synonym *Tellina lata* Gmelin 1791.

Macoma (Macoma) loveni (Jensen [Steenstrup MS] 1905)

Figure 81

Tellina (Macoma) loveni Jensen (Steenstrup MS) 1905:45, pl.1, f.5a–h.
Macoma loveni (Jensen), Filatova 1948:440, pl.111, f.6.
Macoma (Macoma) loveni (Jensen), Coan 1971:31, pl.8, f.42, 43, text-fig. 19.

DESCRIPTION: Shell oval, inflated, thin and fragile. Maximum length 20 mm, usually smaller. Anterior rounded, posterior slightly truncated. Surface smooth with occasional checkmarks. Periostracum thin, light-brown with an iridescent sheen, dehiscent. Interior polished, shell margins smooth. Hinge weak, with two minute cardinals in each valve. Ligament short, projecting substantially on the exterior. Adductor muscle scars nearly equal. Pallial line deeply impressed. Pallial sinus deep, larger in the left valve.

COMPARISONS: This is the most inflated of Arctic macomids and is easily separable from *M. moesta* (Deshayes) on that basis, and from *M. calcarea* (Gmelin) by the lack of a posterior rostration, and the pallial sinus of the left valve is only slightly confluent with the pallial line.

COLLECTION: The species only occurred at one station (70°34.8′N, 144°23.1′W) in 71 m where 12 specimens were collected.

RECORDS: *Recent*—Soot-Ryen 1938:16, pl.1, f.10 (Franz Josef Land); Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1957b:56 (Arctic); Ockelmann 1958:132, pl.2, f.11 (Greenland); Soot-Ryen 1958:25 (Greenland); Filatova and Barsanova 1964:31 (Bering Sea); Kuznetsov 1963:114 (Kamchatka); Golikov and Scarlato 1967:125, f.108 (Sea of Japan); Clarke 1974:11 (Baffin Bay); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Possibly panarctic in distribution. This species occurs from Baffin Island and Greenland across the Atlantic to the Kara Sea. It is present throughout the Bering Sea, extending to northern Japan and Siberia and has been collected from Point Barrow, Alaska.

REMARKS: It is with some doubt that I assign material to this species, but general characters conform to Greenland specimens. Coan (1971) showed that *M. inflata* Dawson 1872 is not a synonym.

Macoma (Macoma) moesta alaskana Dall 1900

Figure 82

Tellina moesta Deshayes 1855:361.
Tellina (Macoma) moesta (Deshayes), Jensen 1905:346, f.4a–c *in part*.
Macoma moesta (Deshayes), Filatova 1948:440, pl.111, f.4.
Macoma alaskana Dall 1900b:309, pl.3, f.5.
Macoma (Macoma) moesta alaskana (Dall), Coan 1971:29, pl.7, f.38, text-fig. 17.
Macoma krausei Dall 1900:322, pl.4, f.8 [*in part Tellina lutea* auctt. not Gray 1828].
Macoma oneilli Dall 1919:20A, pl.2, f.1.

DESCRIPTION: Shell thin, compressed, oval with rounded anterior and broadly truncated posterior. Maximum length 40 mm. Surface smooth, sometimes with minute concentric striae and growth checkmarks. Periostracum greenish-grey to yellow, polished and adherent. Umbones not prominent, beaks usually eroded. Interior chalky, more rarely polished. Shell margins smooth. Hinge poorly developed, two small cardinals in each valve, the anterior left cardinal bifid. Ligament external, on well developed nymph. Adductor muscle scars nearly equal. Pallial

line not deeply impressed. Pallial sinus of left valve largest.

COMPARISONS: This is the most oval and compressed of Arctic macomids and is easily separated from other species.

COLLECTION: This species occurred at 24 stations between 10–64 m for a total of 74 specimens.

RECORDS: *Pleistocene*—Smith 1919:138 (British Columbia). *Recent*—Odhner 1915:112 (Spitzbergen); Grant and Gale 1931:370, pl. 20, f.3 (Arctic and Bering seas); Kuroda and Habe 1952:24 (Northern Japan); Filatova 1957b:56 (Eurasian Arctic); Filatova and Zenkevich 1957:67 (Kara Sea); Ockelmann 1958:129, pl.2, f.13 (Greenland); MacGinitie 1959:182, pl.21, f.1–3, pl.23, f.10, pl.24, f.1–3 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island); Hulsemann 1962:73 (Beaufort Sea); Kotaka 1962:153, pl.35, f.20, 21 (Okhotsk Sea); Kuznetsov 1963:107 (Kamchatka); McLaughlin 1963:28 (Bering Sea); Filatova and Barsanova 1964:20 (Bering Sea); Sparks and Pereyra 1966:834 (Chukchi Sea); Habe and Igarashi 1967:41 (Northern Japan); Clarke 1974:11 (Baffin Bay); Wacasey 1974:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is found from the Canadian Arctic Archipelago to Greenland and east to Spitzbergen and the Kara Sea. It is abundant throughout shallow water of the Bering and Okhotsk seas to Northern Japan, and along the American coast as far south as Washington state.

REMARKS: Coan (1971) retained Dall's *M. alaskana* as a subspecies of *M. moesta* for specimens from Shelikof Strait and south to Puget Sound. He considered the nomenclatural question not solved and commented on the continuous nature of the variation. I am of the opinion that material in the OSU collection is similar to specimens from British Columbia, rather than the very compressed form of *M. moesta* from the north Atlantic and Arctic, so favor the use of Dall's taxon as a subspecies. However, a critical comparison, based on an adequate series of representatives is required, as the compressed form is widely distributed in the Arctic, the Bering Sea and along the Alaska Peninsula.

Macoma balthica (Linné 1758)

Figure 83

Tellina balthica Linné 1758:677; Gmelin 1791:3241; Dillwyn 1817:102.
Macoma balthica (Linné), G. Sars 1878:72; Oldroyd 1925:172, pl.44, f.1, 2, 9; Scarlato 1935:196, pl.52, f.12; Golikov and Scarlato 1967:126, f.109 [as *"baltica"*]; Coan 1971:44, pl.11, f.65, pl.12, f.66–69, text-fig. 30.
Tellina inconspicua Broderip and Sowerby 1829:363.
Macoma inconspicua (Broderip and Sowerby), Dunnill and Ellis 1969:20, f.6, 9.

DESCRIPTION: Shell ovate, irregularly inflated, anterior rounded, posterior produced. Maximum length 35 mm, usually not more than 20 mm. Surface smooth, chalky, with concentric checkmarks. The shell may be white or stained pink or yellow. Periostracum thin, brownish-red to grey, thrown into numerous small concentric wrinkles, strongly adherent, but usually eroded from most of the disc. Interior of shell dull, colored white to pink, shell margins smooth. Hinge weak, with two cardinal teeth in each valve, the left anterior and right posterior tooth bifid. Adductor muscle scars irregular. Pallial line deeply impressed. Pallial sinus large, confluent with pallial line for most of its length.

COMPARISONS: This species is readily distinguishable from other northern macomids by the large pallial sinus, of nearly equal size in each valve, which fuses with the pallial line near its anterior end. The tendency of the shell to pink or yellow coloration is unique, the lack of a lateral flexure of the posterior end is a further distinguishing character.

COLLECTION: The species is represented by nine specimens and some single values collected from six stations in 10–270 m.

RECORDS: *Pleistocene*—Henderson 1927:1 (Washington); Merklin et al. 1962:42, pl.8, f.1 (Chukotsk Peninsula); Richards 1962:66, pl.10, f.15, 16 (Labrador to South Carolina); Spaink and Norton 1967:39, pl.2, f.6a–e (Holland); Wagner 1970:41, pl.4, f.3a, b (Eastern Canada); Hopkins et al. 1972:127 (St. Lawrence Island). *Recent*—Krause 1885:36 (Bering Sea); Peterson 1888:147 (Denmark); Hägg 1904:45 (Spitzbergen) Yocum and Edge 1929:50 (Oregon); Massy 1930:270 (North Atlantic); Grant and Gale 1931:371, pl.4, f.6a, b (Arctic to California); Mesjatsev 1931:103 (Barents Sea); Johnson 1934:52 (Arctic Ocean to Georgia); Kuroda and Habe 1952:24 (Northern Japan); Eyerdam 1960:44 (Kodiak Island, Alaska); Troitskiy 1961:449 (Laptev Sea); Merklin et al. 1962:42, pl.8, f.1 (Chukotsk Peninsula); Richards 1962:66, pl.10, f.15, 16 (Arctic to Georgia); Filatova and Neiman 1963:1038 (Bering Sea); Allen 1965:983 (Northwestern Atlantic); Segerstrale 1965:195 (Baltic Sea); Golikov and Scarlato 1967:126 (Northern Japan); Petersen 1968:53 (Faroe Islands); Bernard 1970:89 (British Columbia); Scarlato 1974:104 (Bay of Peter the Great); Wacasey 1974:24 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Circumboreal in distribution, *M. balthica* is abundant in the North Sea, including England, Norway and Denmark. It is present in the waters of the Faroe Islands and north to Iceland, but has not been recorded from Greenland. On the Atlantic American coast it occurs from Labrador to South Carolina. It is present in the Bering and Okhotsk seas to Japan, and along the American coast to Monterey, California.

REMARKS: While this species has invaded the Arctic coasts adjacent to the Atlantic and Pacific oceans, it cannot be counted a true high Arctic member. This may, in part, be a reflection of its preference for low salinity near-brackish environments. Mokievskii (1960) lists this species from the Sea of Japan as *M. baltica solidula* (Pultney 1799). Coan (1971) gives a partial synonymy, including the Japanese *M. takahokoensis* Yamamoto and Habe 1959.

Family VENERIDAE Rafinesque, 1815

It is intriguing that such a large and cosmopolitan family should be so poorly represented in the Arctic, a situation first noted by Filatova (1962). Soot-Ryen (1932) listed four genera from the Arctic *(Liocyma, Turtonia, Saxidomus,* and *Paphia),* only the first is truly Arctic. *Turtonia* is a boreal genus, extending as far north as the west coast of Greenland, and the latter two generic identifications are certainly in error.

Genus *Liocyma* Dall 1870

Figure 84

Type species (original designation): *Venus fluctuosa* Gould 1841: Recent. North Atlantic.

DESCRIPTION: Shell ovate to trigonate, sometimes elongate. Surface with obscure concentric lirae, or large concentric ribs. Periostracum thin, polished, adherent. Interior porcelaneous. Shell margins smooth. Hinge well developed, three cardinal teeth in each valve. Ligament external. Adductor muscle scars subequal. Pallial line uniform. Pallial sinus small and rounded.

RANGE: Pleistocene to Recent. Recent distribution limited to north boreal Atlantic and Pacific Arctic. The genus is a shallow infaunal filter feeder, typically in sandy substrates in shallow water.

DEVELOPMENT: Thorsen (1936) has shown the ova of *L. fluctuosa* (Gould 1841) to be very large, indicating lecithotrophic

development.

REMARKS: This is the only venerid clam found in the high Arctic. In common with Arctic bivalves species it demonstrates wide morphometric variability. Following MacGinitie (1959) the current trend is to recognize a single species complex. However, after examination of all type material, I consider that two species are represented in the collection.

Liocyma fluctuosa (Gould 1841)

Figure 85

Venus fluctuosa Gould 1838:107 [*nom. nud.*]; Gould 1841:87, f.50.
Tapes fluctuosa (Gould), Deshayes 1853:176.
Liocyma fluctuosa (Gould), Dall 1874:249; Filatova 1948:441, pl.112, f.1; Scarlato 1955:193, pl.57, f.14; Fischer-Piette and Metivier 1971:74, pl.15, f.6, 7.
Gomphina (Liocyma) fluctuosa (Gould), Ockelmann 1958:123, pl.2, f.9.
Venus astartoides Middendorff (Beck MS) 1849:252, pl.20, f.5–13.
Liocyma beckii Dall 1870:257.
Liocyma scammoni Dall 1871:145, pl.14, f.9.
Liocyma schefferi Bartsch and Rehder 1939:111, pl.8, f.1a, b.

DESCRIPTION: Shell ovate to trigonal, compressed to inflated. Maximum length 33 mm, usually less than 15 mm. Surface with numerous small concentric ridges. Periostracum varnished, thin, grey to yellowish, strongly adherent. Umbones prominent, beaks frequently eroded. Interior porcelaneous, more rarely chalky. Shell margins smooth. Hinge not strong, three cardinal teeth in each valve, the central one bifid, others lamellar. Ligament external. Adductor muscle scars subequal. Pallial line irregular. Pallial sinus small, sharply angulate.

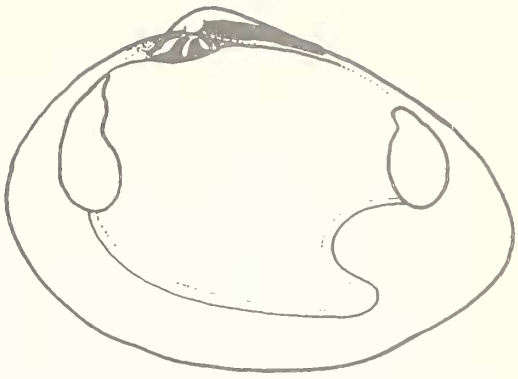
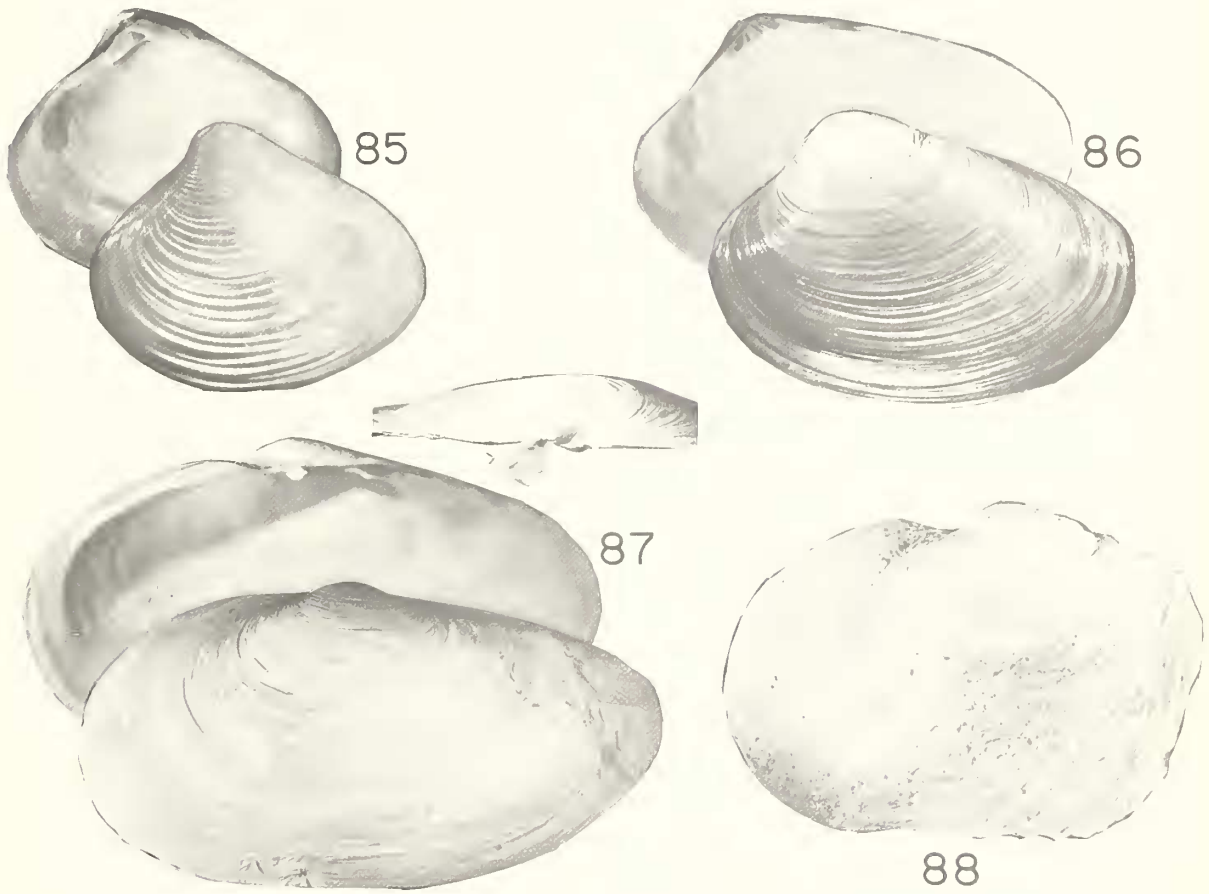


FIGURE 84. Interior of right valve of *Liocyma fluctuosa* (Gould).

COMPARISONS: This is a highly variable species, but is easily separated from *L. viridis* Dall 1871 by the more ponderous dentition, deeper pallial sinus and thinner periostracum.



FIGURES 85–88. 85, *Liocyma fluctuosa* (Gould) length 10.6 mm; 86, *Liocyma viridis* Dall, length 28.8 mm; 87, *Mya (Mya) pseudoarenaria* Schlesch, length 41.7 mm; *inset* chondrophore of left hinge; 88, *Mya (Mya) truncata* Linné, fossil ?, length 31.6 mm.

COLLECTION: This species is represented by 154 specimens and numerous single valves collected from 34 stations between 10 and 101 m.

RECORDS: *Pliocene*—Wood 1874:144, pl.9, f.8 (Britain); Khomemko 1931:76, pl.15, f.3–5 (Kamchatka); Slodkevich 1938:147, pl.86, f.4, 5, 6, a, 7, 8 (Kamchatka); Ilyina 1963:78, pl.18, f.7, pl.26, f.10, 11a (Kamchatka); Petrov 1966:225, pl.18, f.6–16 (Chukotsk Peninsula). *Pleistocene*—Knipovitsch 1900:379 (Spitzbergen); Merklin et al. 1962:40, pl.7, f.1–4 (Chukotsk Peninsula); Allison 1973:20 (Aleutian Islands). *Recent*—Gould 1841:87, f.50 (Massachusetts); Crosse 1877:123 (Bering Sea); Leche 1878:14 (Novaya Zemlya); Leche 1883:440 (Kara Sea); Krause 1885:32 (Bering Sea); Stuxberg 1886:143 (Novaya Zemlya); Melvill and Standen 1900:5 (Franz Josef Land); Hägg 1904:49 (Greenland); Jensen 1905:309 (Greenland); Dautzenberg and Fischer 1910:20 (Novaya Zemlya); Odhner 1910:20 (Iceland); Odhner 1915:114 (Greenland); Grant and Gale 1931:336 (Arctic); Mesjatsev 1931:105 (Barents Sea); Johnson 1934:49 (Greenland to Nova Scotia); Soot-Ryen 1939:16, pl.1, f.8 (Franz Josef Land); Madsen 1949:67 (Iceland); Kuroda and Habe 1952:23 (Northern Japan); Filatova 1957b:55 (Eurasian Arctic); Ockelmann 1958:123, pl.2, f.9 (Greenland); Soot-Ryen 1958:23 (Greenland); MacGinitie 1959:177, pl.23, f.1–8 (Point Barrow, Alaska); Kotaka 1962:152, pl.35, f.14–17 (Okhotsk Sea); Hulsemann 1962:72 (Beaufort Sea); Kuznetsov 1963:83 (Kamchatka); McLaughlin 1963:27 (Bering Sea); Filatova and Barsanova 1964:20 (Bering Sea); Sparks and Pereyra 1966:834 (Chukchi Sea); Golikov and Scarlato 1967:110, f.92 (Sea of Japan); Ishikawa 1968:49, pl.3, f.3 (Northern Japan); Bernard 1970:89 (British Columbia); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal in distribution. This species is sporadically abundant across the North Atlantic from the Canadian Arctic Archipelago and Greenland to Iceland and Norway. On the American Atlantic seaboard it occurs throughout Hudson Bay and Labrador to Nova Scotia. The Pacific distribution includes the Bering and Okhotsk seas to Northern Japan and along the American coast as far south as Washington state. The species has been recorded along the Eurasian Arctic coast to Siberia and the Chukchi Sea.

REMARKS: MacGinitie considered all boreal and Arctic species proposed in the literature to be merely variants of *L. fluctuosa*. There is no doubt that a very variable group is involved, neither the height or spacing of the concentric ribs, nor the shell outline, form a basis for nomenclature, but I conclude that at least two species are involved, and have assigned the various junior synonyms to these, basing my opinion on hinge dentition structure, appearance of the periostracum, and prolongation of the shell posterior. Johnson (1934) listed *L. fluctuosa brunnea* Dall 1902 from the Gulf of St. Lawrence. La Rocque (1953) repeated the name and cited the Proceedings of the United States National Museum, volume 24, page 378. This reference is not correct, and Boss et al. (1968) do not include this species among those proposed by Dall. I have been unable to locate material in the USNM that may support a manuscript name, and do not believe it appears as a *nomen nudum* in Dall's writings. It may best be considered a *nomen nudum* of Johnson (1934).

Liocyma viridis Dall 1871

Figure 86

Liocyma viridis Dall 1871:146; Oldroyd 1925:159, pl.1, f.3; Fischer-Piette and Metivier 1971:76.
Liocyma aniwana Dall 1907:172; Fischer-Piette and Metivier 1971:76.
Liocyma subanivana Khomenko 1931:78, pl.5, f.6–8.
Liocyma hokkaidoensis Habe 1953:179, f.412–414.

DESCRIPTION: Shell thin, moderately inflated, posterior elongate, almost rostrate. Maximum length 25 mm. Surface with numerous sharp concentric ridges. Periostracum brilliantly varnished, color grey to greenish-yellow. Umbones not prominent, beaks eroded. Interior of shell with polished margin, but area between muscle scars and pallial line is chalky and pustulate. Shell margins smooth, usually with fringe of periostracum extending from shell exterior. Hinge weak, each valve with three diverging cardinal teeth, the central tooth bifid, others lamellar. Ligament external, seated on a small nymph. Adductor muscle scars subequal. Pallial line irregular. Pallial sinus very small, apex forming a right angle.

COMPARISONS: The species may only be confused with *L. fluctuosa* (Gould 1841), especially the attenuated variant, but the dentition in this species is nearly equal, while in *L. viridis* the central tooth is the largest, and the posterior cardinal tooth of the right valve is vestigial. Other distinguishing characters are the pustulate interior of the shell and the shallow pallial sinus, forming a more obtuse angle than that of *L. fluctuosa*.

COLLECTION: Five specimens and four valves were collected at two stations in 34 and 64 m.

RECORDS: *Recent*—Crosse 1877:123 (Bering Sea); Kuroda and Habe 1952:23 (Northern Japan); Eyerdam 1960:44 (Aleutian Islands).

DISTRIBUTION: The center of distribution is the Bering Sea, with sporadic occurrences along the Arctic Alaskan coast to Point Barrow and the western Beaufort Sea. The species has been collected in the Sea of Okhotsk, south to Hokkaido, Japan.

REMARKS: I consider *L. aniwana* Dall 1907 from Sakhalin Island to be identical to *L. subanivana* Khomenko 1931, from the Pleistocene of that island and that both prove to be synonyms of *L. viridis*. The Japanese representative was named *L. hokkaidoensis* by Habe 1952.

Family MYIDAE Lamarck 1809
Genus *Mya* Linné 1758

Figure 89

Type species (subsequent designation Children 1822): *Mya truncata* Linné 1758. Recent. North Atlantic.

DESCRIPTION: Shell ovate to elongate, chalky. Surface unsculptured, usually with irregular incremental lirae and growth checkmarks. Periostracum thin, adherent. Interior chalky to por-

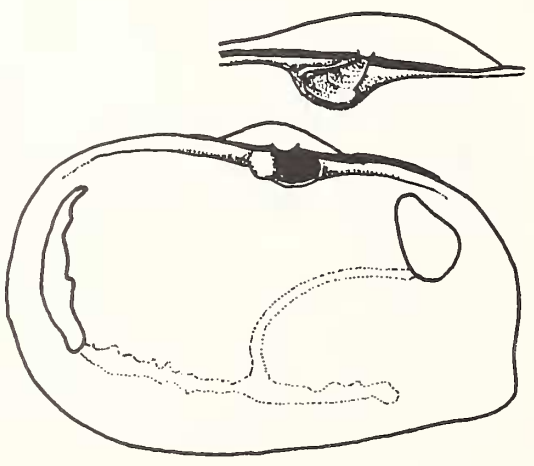


FIGURE 89. Interior of right valve and hinge of left valve of *Mya truncata* (Linné).

celaneous, shell margins smooth, valves closing with a posterior and anterior gape. Hinge edentulous, with a large projecting chondrophore in the left valve, projecting obliquely across a recessed ligamental cavity in the right valve. Posterior adductor muscle scar small, anterior scar elongate. Pallial line broad, rather irregular. Pallial sinus well developed.

RANGE: Oligocene to Recent. Recent distribution northern boreal and Arctic, in muddy and sandy substrates generally in less than 50 m. The long siphons enable the genus to be a deeply infaunal filter feeder.

DEVELOPMENT: Thorsen (1936) and others have shown that all species examined produce small eggs that undergo a prolonged planktonic development phase.

REMARKS: Although the genus is distributed in the Arctic, it is poorly represented in the present collections, both species collected were long dead, possibly fossil. This may be attributed to insufficient penetration of the substrate by the collecting apparatus to capture large deep burrowers. Wagner (1977) recorded *Mya arenaria* Linné 1758 from the eastern Beaufort Sea.

Subgenus *Mya* s. str.

Mya (Mya) pseudoarenaria Schlesch 1931

Figure 87

Mya intermedia Dall 1898:857 [in part; not *Mya intermedia* Sowerby 1814]; Oldroyd 1925:199, pl.15, f.5.

Mya truncata forma ovata Jensen 1900:139, f.3, 4 [not *Mya ovata* Donovan 1802]; Laursen 1966:406, f.2.

Mya pseudoarenaria Schlesh 1931:136, pl.13, f.10–12.

Mya (Mya) pseudoarenaria Schlesh, MacNeil 1965:37, pl.7, f.9–11, 13, 14, pl.9, f.4; Strauch 1972:141, pl.10, f.10.

DESCRIPTION: Shell ovate to elongate, inflated, maximum length 95 mm. Anterior end rounded, inflated, posterior produced, more compressed. Siphonal gape large, anterior gape small. Surface chalky, unornamented except for small irregular concentric striae and coarse growth checkmarks. Periostracum thin, dehiscent, folded and wrinkled and connected to the siphonal sheath on the posterior part of the shell. Interior chalky, sometimes polished in young specimens. Hinge edentulous with large projecting subtrigonal chondrophore in the left valve, and a sunken subumbonal pit-like chondrophore in the right valve. Ligament internal, inclined to the right so that it lies entirely within that valve. Anterior adductor muscle scar narrow and elongate, posterior scar smaller and subcircular. Pallial line wide and irregular. Pallial sinus large, anterior margin rounded, ventrally confluent with pallial line.

COMPARISONS: Externally, this species most closely resembles *M. arenaria* Linné 1758, but is separated by the nearly trigonal chondrophore. Further, *M. arenaria* does not occur in the Arctic. Internally, *M. pseudoarenaria* is close to *M. truncata* Linné 1758, but the pallial sinus is proportionately larger, and the chondrophore outline a right angled triangle, rather than the equilateral triangle of the latter species.

COLLECTION: One dead specimen and three valves were collected at one station in 64 m. The entire specimen was not articulated, but retained part of the ligament. These may represent fossil or transported material.

RECORDS: *Pliocene*—Merklin et al. 1962:48, pl.10, f.5–8 (Chukotsk Peninsula); Petrov 1966:237, pl.21, f.3–6, pl.22, f.1–9 (Chukotsk Peninsula). *Pleistocene*—Dall 1898:857 (Alaska); Jensen 1900:139, f.3, 4 (Greenland); Crickmay 1924:206 (British Columbia); Filatova 1948:442 (Arctic); MacNeil 1965:38 (Britain); Wagner 1970:43, pl.5, f.2a–c (Eastern Canada). *Recent*—Odhner 1915:123 (Spitzbergen); Madsen 1949:76 (Iceland); Soot-Ryen 1951:3 (Norway); MacGinitie 1959:186, pl.19, f.7, pl.25, f.4 (Point Barrow, Alaska); McLaughlin 1963:28 (Bering Sea); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Probably panarctic. This species is found from the Canadian Arctic Archipelago to Greenland, Iceland, Spitzbergen and Norway. It has not been recorded from Hudson Bay or the Atlantic coast of America. It is present in the Arctic Alaskan coast, the Chukchi Sea and the Siberia Sea. It extends into Norton Sound in the northern Bering Sea.

REMARKS: The distinctness of the Arctic species was not recognized for a long time, the majority of authors referring it to *M. arenaria* or *M. truncata* and sometimes *M. japonica* Jay 1856; the situation is so confused that early bibliographic records are best discarded. Dall (1898) recognized the intermediate morphology of Arctic species and proposed *M. intermedia*, but the taxon may only be accepted in part as it included southern Bering Sea and Gulf of Alaska material. Furthermore, it is preoccupied by Sowerby 1814 for a British Eocene fossil. Jensen (1900) saw the close connection to *M. truncata* and proposed the form name *ovata* to denote the *M. arenaria*-like outline. The diagnosis is accurate but unfortunately the name is preoccupied by Donovan (1802), so Schlesh (1931) proposed a substitute name. Much remains to be done to untangle the systematic position of this taxon. It is possible that an earlier name will be recognized; for instance, the British *M. ovalis* Turton 1822 which MacGillivray (1843) considered to be related to *M. truncata*.

Mya (Mya) truncata Linné 1758

Figure 88

Mya truncata Linné 1758:670; Dillwyn 1817:42; Oldroyd 1925:197, pl.10, f.4; Filatova 1948:442, pl.112, f.4; Petrov 1966:238, pl.21, f.7, pl.23, f.1–9.

Mya (Mya) truncata (Linné), MacNeil 1965:38, pl.8, f.1–12, pl.9, f.1–3, 5–20; Strauch 1972:138, pl.10, f.5, 7, 8.

Mya praecisa Gould 1850:215.

Mya truncata uddevalensis Forbes 1846:407; MacGinitie 1959:184, pl.25, f.1–3.

DESCRIPTION: Shell with rounded anterior and truncate posterior with large siphonal gape. Length to 90 mm, generally less than 50 mm. Shell thin to ponderous, inflated, frequently distorted. Surface with irregular incremental striae and coarse growth checkmarks. Periostracum thin, grey-brown, dehiscent, thicker in posterior regions where it merges with the siphonal sheath. Umbones prominent, beaks opisthogyrate. Interior chalky, polished and porcelaneous in juvenile specimens. Hinge edentulous, with large projecting chondrophore in left valve, opposed to an inset subumbonal pit-like chondrophore in the right valve. Ligament internal. Anterior adductor muscle scar elongate, posterior scar nearly circular. Pallial line irregular, not continuous. Pallial sinus wide, not deep, ventral margin confluent with the pallial line.

COMPARISONS: This species is readily distinguished by the abruptly truncated posterior end, the large siphonal gape, and the nearly symmetrical triangular chondrophore in the left valve. *M. truncata* has the shortest pallial sinus of any living *Mya*, the pallial sinus scar joining the pallial line at an almost vertical inclination.

COLLECTION: Only two worn valves were present at one station in 64 m. No periostracum or trace of the ligament remain, so

it is likely this material is fossil.

RECORDS: *Miocene*—Arnold and Hannibal 1913:590, 596 (Oregon); Ilyina 1963:9 (Kamchatka); MacNeil 1965:38, pl.8, f.1–12, pl.9, f.1–3, 5–20 (California). *Pliocene*—Feilden 1877:438, 486 (Greenland); Schlesch 1924:15 (Iceland); Merklin et al. 1962:47, pl.10, f.3, (Chukotsk Peninsula); MacNeil 1965:38, pl.8, f.1–12, pl.9, f.1–3, 5–20 (Oregon); Zhidkova et al. 1968:133, pl.49, f.1 (Sakhalin Islands). *Pleistocene*—Grewinck 1850:171 (Alaska); Feilden 1877:438, 486 (European Arctic); Knipovitsch 1900:380 (Spitzbergen); Arnold and Hannibal 1913:590, 596 (British Columbia); Newcombe 1914:107 (British Columbia); Laursen 1950:86 (Greenland); Miller 1953:29 (Alaska); Fujie 1957:399, pl.3, f.1–4 (Japan); Merklin et al. 1962:47, pl.10, f.3 (Chukotsk Peninsula); Richards 1962:70, pl.13, f.1, 2 (Newfoundland to Massachusetts); MacNeil 1965:38, pl.8, f.1–12, pl.9, f.1–3, 5–20 (California); Hopkins et al. 1972:126 (St. Lawrence Island); Allison 1973:20 (Aleutian Islands). *Recent*—Montagu 1803:32 (Britain); Gould 1841:42 (Massachusetts); Møller 1842:21 (Greenland); Middendorff 1849:585, pl.14, f.13–15 (Arctic and Bering Sea); Middendorff 1851:266, pl.25, f.11–14 (Sea of Okhotsk); M. Sars 1859:61 (Arctic); Crosse 1877:126 (Bering Sea); Leche 1878:9 (Novaya Zemlya); M. Sars 1878:92 (Norway); Dunker 1882:176 (Northern Japan); Krause 1885:39 (Bering Sea); Stuxberg 1886:140 (Novaya Zemlya); Hägg 1904:55 (Greenland); Dautzenberg and Fischer 1910:21 (Novaya Zemlya); Grant and Gale 1931:414 (circumboreal); Mesjatsev 1931:122 (Barents Sea); Johnson 1934:56 (Greenland); Soot-Ryen 1939:17 (Franz Josef Land); Gorbunov 1946a:46 (Arctic); Madsen 1949:76 (Iceland); Kuroda and Habe 1952:25 (Northern Japan); Filatova 1957b:56 (Arctic); Ockelmann 1958:144 (Greenland); MacGinitie 1959:184 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island); Richards 1962:70, pl.13, f.1, 2 (Arctic to Massachusetts); Kuznetsov 1963:108 (Kara Sea); Sparks and Pereyra 1966:834 (Chukchi Sea); Petersen 1968:36 (Faroe Islands); Bernard 1970:90 (British Columbia); Clarke 1974:11 (Baffin Bay); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Circumboreal and probably panarctic. This species is widely distributed throughout the Northern Pacific, the Chukchi Sea, the Siberian Sea, and along the Eurasian shallow continental shelf to Norway. It occurs as far south as England and the British Channel probably to the Iberian Peninsula. The species has been found at Novaya Zemlya, Iceland and Greenland and the Canadian Arctic Archipelago. Along the eastern coast of America it occurs south to Nantucket, Massachusetts, and on the Pacific coast to Puget Sound, Washington.

REMARKS: *M. truncata* is rather variable in outline, and is greatly influenced by substrate size and consistency. As the synonyms have been fully treated by MacNeil (1965), mention here is only made to *M. truncata uddevalensis* Forbes 1846, which is merely a frequently occurring abbreviated form. The species probably did not reach European seas until the Lower Pleistocene, and records of it from the English Coralline Crag (Pliocene) are doubtful. I have been unable to locate the specimen figured by Wood (1857) and could not identify with certainty *M. truncata* in the Crag collection of the British Museum (Natural History). I agree with MacNeil (1965:39) that Pliocene Crag specimens should be referred to *M. pseudoarenaria* Schlesh 1931.

Family HIATELLIDAE Gray 1824

No representatives of *Panomya* Gray 1857 were present in the collection, although MacGinitie (1959) recorded *P. arctica* (Lamarck 1818) and *P. ampla* Dall 1898 at Point Barrow. The former has a circumboreal distribution, but it is not a true high Arctic species, merely one of the Bering Sea elements carried into the southern Chukchi Sea by the Bering current.

Key to the genera of Hiatellidae

Beaks anterior; pallial sinus small but distinct .... *Hiatella*
Beaks posterior; no pallial sinus ..... *Cyrtodaria*

Genus *Cyrtodaria* Reuss 1801

Figure 90

Type species (Subsequent designation Vokes and Cox 1961): *Mya siliqua* Spengler 1793. Recent. Arctic.

DESCRIPTION: Shell thick, elongate. Surface smooth with occasional growth checkmarks. Periostracum thick, dark brown to black, dehiscent, exposing the chalky shell. Shell interior usually chalky, sometimes porcelaneous in young specimens. Margins smooth, thick, with large posterior and anterior gapes. Hinge edentulous, with subumbonal thickening. Ligament external. Pallial line weakly to deeply impressed, entire. No pallial sinus.

RANGE: Pliocene to Recent. Recent distribution limited to North Atlantic and circumarctic including the Chukchi Sea, to Kuskodwim Bay, northern Bering Sea.

DEVELOPMENT: No information available.

REMARKS: The genus is limited to shallow boreal and Arctic waters and consists of only two species. Nesis (1965) reviewed the genus and thought its occurrence as characteristic of brackish water environments. Yonge (1971) published on the morphology and concluded species were adapted for horizontal burrowing through the substrate by anchoring the anterior end by dilation of the siphons and associated tissues, while forcing the wedge shaped anterior end forward and extending the large foot. The stomach is large and the intestine very long. The gills and palps suggest the taxon is a filter-feeder in regions of high turbidity. The periostracum is particularly thick and developed.

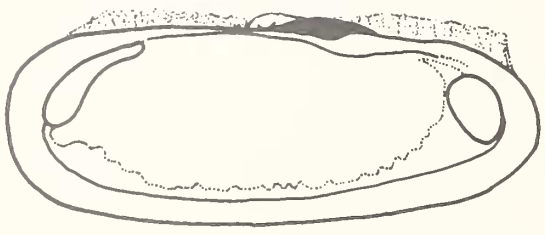


FIGURE 90. Interior of right valve of *Cyrtodaria siliqua* (Spengler).

Cyrtodaria kurriana Dunker 1862

Figures 92, 93, 94

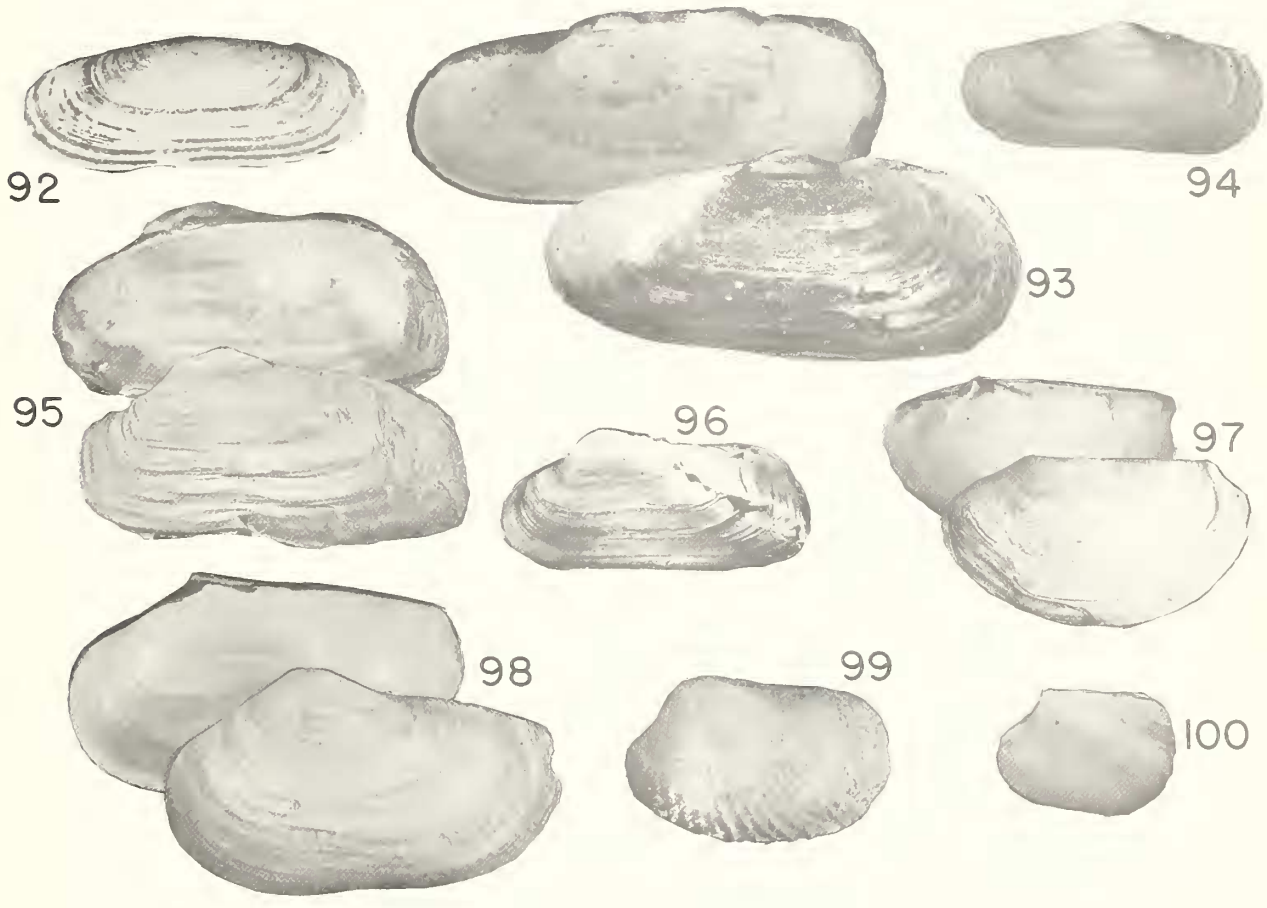
Cyrtodaria kurriana Dunker 1862:38; Oldroyd 1925:208; Filatova 1948:444, pl.113, f.1; Strauch 1972:90, pl.9, f.13–16.

DESCRIPTION: Shell usually thick, very elongate. Maximum length 40 mm., generally less than 30 mm. Surface smooth, except for incremental striae and growth checkmarks. Periostracum thick, polished, brown to black, dehiscent to reveal the chalky shell. The periostracum is fused to the siphonal sheath, and bridges the dorsal shell margins. Umbones not prominent, beaks often eroded. Interior of shell chalky, sometimes polished in young specimens. Margins plain, meeting only ventrally with large posterior and anterior gapes. Adult hinge edentulous, but with subumbonal tuberosity. Ligament external, supported by a substantial nymph. Adductor muscle scars deeply impressed, anterior elongate, posterior nearly oval. Pallial line with irregular upper margin, widening near adductor muscles. No pallial sinus.

COMPARISONS: This species may be confused with the northeastern American *Cyrtodaria siliqua* (Spengler 1793) the only other representative of the genus, but is separable by its smaller size and untwisted valves. The height-length ratio in *C. siliqua* is approximately 1:2, while in *C. kurriana* it is around 1:3. Worn valves may superficially resemble *Hiatella,* but the posterior position of the beaks and the continuous pallial line separate *Cyrtodaria.* A further useful distinguishing character is the ligament which is amphidetic (on either side of beaks) in *Cyrtodaria* and opisthodetic (posterior to beaks) in *Hiatella.*

COLLECTION: One decomposed valve from 270 m. The presence of fresh periostracum shows the specimen to have been recently living, but the friable and worn appearance is suggestive of transportation. The species was abundant in less than 2 m at Kaktovic Lagoon (70°4.9′N, 143°38.7′W), collected by Western Washington State College.

RECORDS: *Pleistocene*—Dall 1919:29A (Arctic); Merklin et al. 1962:45, pl.8, f.5 (Chukotsk Peninsula); Petrov 1966:234, pl.20, f.7, 10 (Chukotsk Peninsula); Petrov 1967:184 (Bering Sea); Hopkins et al. 1972:125 (St. Lawrence Island). *Recent*—Leche 1878:9 (Novaya Zemlya); Leche 1883:437 (Novaya Zemlya); Stuxberg 1886:139 (Novaya Zemlya); Hägg 1904:62 (Jan Mayen Land); Gorbunov 1946a:46 (Eurasian Arctic); Kuroda and Habe 1952:18 (Northern Japan); Ushakov 1952:61 (Chukchi Sea); Filatova 1957b:56 (Arctic); Ockelmann 1958:142, pl.2, f.14 (Greenland); Soot-Ryen 1958:26 (Greenland); Hulsemann 1962:68 (Beaufort Sea); Merklin et al. 1962:45, pl.8, f.5 (Chukotsk Peninsula); Wagner 1962:10 (Canadian Arctic); Clarke



FIGURES 92–100. 92, *Cyrtodaria kurriana* Dunker, fossil ?, length 27.1 mm; 93, *C. kurriana,* length 19.0 mm; 94, *C. kurriana,* juvenile, length 12.4 mm; 95, *Hiatella (Hiatella) arctica* (Linné), length 27.8 mm; 96, *H. (H.) arctica,* juvenile, length 8.1 mm; 97, *Pandora (Pandorella) glacialis* Leach *in* Ross, length 21.0 mm; 98, *Lyonsia (Lyonsia) arenosa* (Møller), length 26.4 mm; 99, *L. (L.) arenosa,* juvenile, 7.2 mm; 100, *L. (L.) arenosa,* juvenile, length 2.1 mm.

1963:103 (Arctic); Wacasey 1974:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and high latitude North Atlantic, this species is most abundant in the Canadian Arctic Archipelago and Greenland and into Hudson Bay. It occurs in the Siberian and Chukchi Sea, and into the northern part of the Bering Sea.

REMARKS: Although not recorded by MacGinitie (1959), Baxter (pers. comm.) retrieved *Cyrtodaria* mixed with the *Hiatella* of the MacGinitie collection. *C. kurriana* was abundant in the stations worked by Hulsemann (1962), especially just east of Point Barrow. Nesis (1965) considered this species adapted to oligohaline conditions, so it should be well represented in the shallow Mackenzie estuary. The muscular foot and wedge-shaped anterior end are modifications for rapid and active burrowing, indicative of unstable shallow water habitat.

Genus *Hiatella* Bosc (Daudin MS) 1801

Figure 91

Type species (subsequent designation Winckworth 1932): *Mya arctica* Linné 1767. Recent. North Atlantic.

DESCRIPTION: Shell irregular, inflated. Surface with incremental striae. Periostracum brown, thin, dehiscent, frequently with attached sand particles. Interior polished, often nacreous. Margins plain, with large posterior gape. Hinge edentulous in the adult, but with ephemeral small cardinal in the right valve and two small teeth in the left valve of some juveniles. Ligament external, opisthodetic. Anterior adductor muscle scar elongate, posterior rounded, frequently deeply impressed. Pallial line in sections, Pallial sinus small, demarcated by large siphonal retractor muscle scars.

FIGURE 91. Interior of right valve of *Hiatella arctica* (Linné).

RANGE: Oligocene to Recent. Recent distribution cosmopolitan, especially in temperate zones, generally in shallow water in a variety of substrates, including boring into soft rock, or nestling in silicious sponge.

DEVELOPMENT: *H. arctica* (Linné) produces small eggs with prolonged planktonic development (Thorson 1936). This appears common to all species of the genus (Bernard MS).

REMARKS: The genus includes some of the most widely distributed bivalve species. All representatives have remarkably plastic shells, which are profoundly influenced by substrate, and the taxonomy is not understood. There are at least three northern species, but high Arctic dwellers are best referred to *H. arctica* (Linné).

Subgenus *Hiatella* s. str.
Hiatella (Hiatella) arctica (Linné 1767)

Figures 95, 96

Mya arctica Linné 1767:1113.
Saxicava arctica (Linné), M. Sars 1859:62; Oldroyd 1925:208, pl.9 f.6, pl.5, f.4; Filatova 1948:443.
Hiatella arctica (Linné), Lamarck 1819:30; Hanley 1843:150.
Didonta bicarinata Schumacher 1817:125, pl.6, f.2a, b.
Saxicava ungana Grewingk 1850:354, pl.6, f.1a–c; Dall 1904:117.
Saxicava orientalis Yokoyama 1920:106, pl.7, f.2, 3; Kuroda and Habe 1952:21; Yamamoto and Habe 1959:111, pl.12, f.16, 17.
Hiatella sakhalinensis Oyama, Mizuno and Sakamoto 1960:207, pl.63, f.1a–d.

DESCRIPTION: Shell elongated, rugose, frequently deformed. Moderately inflated with beaks towards the anterior end. Maximum length 75 mm, generally smaller. Surface chalky, with irregular incremental striae and large checkmarks. Periostracum thin, grey to light brown, dehiscent, wrinkled in posterior region. Juvenile specimens with two radial spinose ribs from umbones to posterior margin. In some rare individuals the ribs and spines may persist. Interior polished, frequently with central patch of brown or yellow. Hinge edentulous in adult, juveniles with two teeth in the left and one in the right valve. Ligament external, entirely posterior to the beaks. Adductor muscle scars deeply impressed, anterior elongate, posterior rounded. Anterior pedal retractor muscle scar large. Pallial line in several interrupted segments. Pallial sinus wide and shallow with two large pedal retractor muscle scars.

COMPARISONS: In spite of the extreme plasticity of outline and tendency to xenomorphic growth, the genus is easily recognized and all high Arctic representatives are referable to *H. arctica*. *H. pholadis* (Linné, 1767) occurs with this species in the North Atlantic and Bering Sea but has a more cylindrical outline and, according to Dodge (1952) is edentulous and spineless in the juvenile phase. It has not been reported from the Arctic Ocean.

COLLECTION: Sixty specimens together with numerous fragments and single valves were present at 13 stations between 27 and 159 m.

RECORDS: *Miocene*—Cossmann and Peyrot 1909:131, pl.3, f.20–27 (France); Sorgenfrei 1958:125, pl.20, f.66a–e (Denmark). *Pliocene*—Wood 1857:287, pl.29, f.4a, b (England); Tokunaga 1906:36, pl.2, f.21a, b (Japan); McNeil et al. 1943:75, pl.15, f.16 (Alaska); Hopkins and McNeil 1960:341 (Alaska); Merklin et al. 1962:44, pl.8, f.6, 7 (Chukotsk Peninsula); Petrov 1966:233, pl.20, f.5, 6 (Chukotsk Peninsula); Hertlein and Grant 1972:326, pl.56, f.15, 17, 18 (California); Zhidkova et al. 1968:129, pl.23, f.8, a (Sakhalin Islands); Zhidkova et al. 1972:141, pl.28, f.5 (Kurile Islands). *Pleistocene*—Arnold and Hannibal 1913:598 (Washington); Orcutt 1921:24 (Mexico); Johnstone 1923:50 (British Columbia); Hoots 1931:122 (California); Armstrong and Brown 1954:356 (British Columbia); Emerson 1956:339 (Mexico); Wagner 1959:5 (British Columbia); Merklin et al. 1962:44, pl.8, f.6, 7 (Chukotsk Peninsula); Richards 1962:71, pl.12, f.17–20 (Labrador to North Carolina); Zullo 1969:350 (Oregon); Hopkins et al. 1972:126 (St. Lawrence Island); Allison, 1973:20 (Aleutian Islands); Troitskiy 1974:265 (Siberia). *Recent*—Møller 1842:21 (Greenland); Carpenter 1857:16 (Mexico); Lischke 1869:134 (Northern Japan); Gould 1870:89 (Massachusetts); Jeffreys 1877:234 (Britain); G. Sars 1878:95, pl.20, f.8a–d (Greenland); Dunker 1882:175 (Japan); Melvill and Standen 1900:5 (Franz Josef Land); Baker 1902:42 (Mexico); Hägg 1904:58 (Greenland and Spitzbergen); Jensen 1905:357 (Greenland); Odhner 1915:129 (Greenland); Soot-Ryen 1925:6 (Spitzbergen); Yocum and Edge 1929:50 (Oregon); Massy 1930:276 (North Atlantic); Hatai and Nomura 1935:19 (Japan); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:73 (Iceland); Kuroda and Habe 1952:21 (Northern Japan); Scarlato 1955:196, pl.53, f.9 (Kara Sea); Filatova 1957b:56 (Arctic); Ockelmann 1958:135

(Greenland); Soot-Ryen 1958:27 (Greenland); MacGinitie 1959:190, pl.26, f.1–3 (Point Barrow, Alaska); Clarke 1960:12 (Canadian Arctic); Clarke 1961:7 (Gulf of St. Lawrence); Ellis 1960:39 (Baffin Island); Merklin et al. 1962:44, pl.8, f.6, 7 (Chukotsk Peninsula); Richards 1962:71, pl.12, f.17–20 (Arctic to West Indies); McLaughlin 1963:28 (Bering Sea); Filatova and Barsanova 1964:20 (Bering Sea); Sparks and Pereyra 1966:835 (Chukchi Sea); Petersen 1968:54 (Faroe Islands); Bernard 1970:70 (British Columbia); Kuroda et al. 1971:466, pl.102, f.11 (Japan); Clarke 1974:11 (Baffin Bay); Scarlato 1974:99 (Bay of Peter the Great); Scarlato and Ivanova 1974:304 (Kurile Islands); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is probably the most cosmopolitan of continental shelf bivalves. It ranges through the North Atlantic, the Mediterranean and along the west coast of Africa to Gabon. In the Western Atlantic it occurs from Greenland to the Gulf of Mexico and probably Argentina. It is ubiquitous in the Bering Sea and Sea of Okhotsk and into the Sea of Japan. On the West American coast it is present from Alaska to Panama and probably to Patagonia.

REMARKS: Strauch (1968) considered this species to have a cosmopolitan distribution since the Early Tertiary. Material from the Pacific coast of South America is indistinguishable from Arctic and North Atlantic representatives; however, Olsson (1961) preferred to use *H. solida* (Sowerby 1834) for species from the Panamanic Province. I believe a single Eastern Pacific species is involved, including *Saxicava antarctica* Philippi 1845 and its numerous synonyms described from the Chiloe Archipelago, extending into the Magellanic Province and collected at the West Falkland Islands (Melvill and Standen 1914). The wide distribution and plasticity of this species has resulted in a large synonymy, first consolidated by Hägg (1904). I consider the Miocene species *H. sakhaliensis* Oyama, Mizuno and Sakamoto 1960 to be the earliest Pacific representative of *H. arctica*. *H. arctica* has not developed the boring habit of other members of the genus, but is frequently found in vacated burrows. The long siphons permit an infaunal habit, but this species is usually a byssally attached epifaunal nestler, often in crevices between rocks, or in siliceous sponges, or dead shells. Yonge (1971) described the functional morphology and drew attention to the hypertrophied pallial musculature, reflected by the wide and segmented pallial line. Strauch (1968) suggested that paleotemperatures could be estimated using fossil shell lengths, but Rowland and Hopkins (1971) found no such relationship for contemporary Pacific populations where shell length is chiefly governed by mode of life.

Family PANDORIDAE Rafinesque 1815
Genus *Pandora* Bruguiére 1797
Figure 101

Type species (subsequent monotypy Lamarck 1799): *Solen inaequivalvis* Linné 1758. Recent. North Atlantic.

DESCRIPTION: Shell compressed with crescent-shaped outline. Left valve convex, frequently larger than the flattened right valve. Surface smooth, sometimes with incremental striae. Periostracum thin, grey, dehiscent. Interior polished, nacreous, margins plain. Hinge not developed, but with two or more diverging ridges bordering the resilifer. Resilium sometimes with a lithodesma.

RANGE: Oligocene to Recent. Recent distribution cosmopolitan in shallow water to 1000 m. The genus is epifaunal or shallowly infaunal, particularly in coarse and shifting sediments.

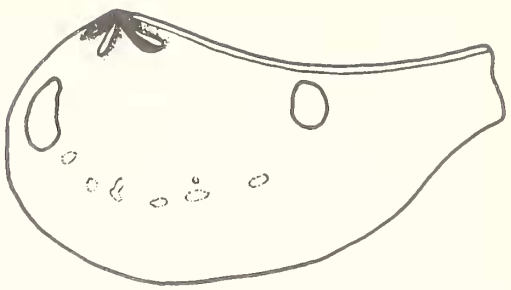


FIGURE 101. Interior of right valve of *Pandora inaequivalvis* (Linné).

DEVELOPMENT: All northeastern Pacific species produce large ova similar to *P. glacialis* Leach *in* Ross, described by Thorsen (1936) as surrounded by a thick gelatinous layer. The eggs probably adhere to the substrate near the parent and development is lecithotrophic but may undergo a short planktonic phase (Allen 1961).

REMARKS: *Pandora* has a short siphon and the frequent occurrence of epifauna on the flat right valve, supports the statement by Allen (1955) that *P. inaequivalvis* Linné is epifaunistic and lies on the cupped left valve. Stanley (1970) considered *P. gouldiana* (Dall) to be a shallow infaunal species with frequent periods on the substrate surface. *Pandora* s. str. although circumboreal, is not represented in the high Arctic, but the subgenus *Pandorella* Conrad (= *Kennerlia* Carpenter, 1864), characterized by radial striae or ribbing on the right valve and a lithodesma supporting the ligament, is widely distributed.

Subgenus *Pandorella* Conrad 1863

Type species (monotypy) *Pandora arenosa* Conrad 1834. Miocene. Eastern United States.

Pandora (Pandorella) glacialis Leach *in* Ross 1819
Figure 97

Pandora glacialis Leach *in* Ross 1819:174; Oldroyd 1925:89, pl.15, f.11, pl.42, f.3, 4.
Pandora (Kennerlia) glacialis (Leach), Filatova 1948:444, pl.13, f.4.
Calopodium (Kennerlia) glacialis (Leach), Soot-Ryen 1939:18.
Kennerlyia glacialis eutaenia Dall 1915:449.

DESCRIPTION: Shell very inequivalve, left valve convex, overlapping the smaller flat right valve, Posterior slightly rostrate. Maximum length 30 mm. Surface of left valve with irregular striae and growth marks. Right valve with fine indented radial lines. Periostracum thin, dehiscent, wrinkled in posterior ventral region. Umbones not prominent, beaks frequently eroded to expose nacreous shell. Interior nacreous, shell margins smooth. Hinge not developed, left valve edentulous, but with an oblique resilifer. Right valve edentulous. Left valve with peg-like anterior and lamellar posterior crura. Ligament internal with a small lithodesma. Pallial line represented by obscure isolated attachment scars. No pallial sinus.

COMPARISONS: This species is separated from boreal members of the genus by the radial lines of the right valve, which often appear on the inner side of the shell as slightly raised ribs.

In juveniles the left valve may also have two narrow radial ribs from umbones to posterior margin.

COLLECTION: One hundred sixteen specimens and 31 single valves were present at 11 stations between 10 and 270 m.

RECORDS: *Pliocene*—Waterfall 1929:78 (California); Petrov 1966:241, pl.23, f.10, 11 (Chukotsk Peninsula). *Pleistocene*—Bailey 1935:495 (California); Richards 1962:58, pl.6, f.1, 2 (Labrador to Maine). *Recent*—Leche 1878:11, pl.1, f.1a, b (Novaya Zemlya); Leche 1883:439 (Kara Sea); Krause 1885:38 (Bering Sea); Stuxberg 1886:141 (Novaya Zemlya); Melvill and Standen 1900:5 (Franz Josef Land); Jensen 1905:361 (Greenland); Odhner 1915:130 (Spitzbergen); Mesjatsev 1931:111 (Barents Sea); Soot-Ryen 1932:11 (Greenland); Grant and Gale 1931:262 (Arctic to Washington); Johnson 1934: (Arctic to Massachusetts); Gorbunov 1946a:46 (Eurasian Arctic); Filatova 1957b:57 (Arctic); Ockelmann 1958:152 (Greenland); Hulsemann 1962:68 (Beaufort Sea); Richards 1962:58, pl.6, f.1, 2 (Arctic to Massachusetts); Bernard 1970:90 (British Columbia); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species occurs sporadically through its range which includes the extreme North Atlantic, and along the American coast as far south as Massachusetts. It is present in the Bering Sea and Sea of Okhotsk and south to Northern Japan and the Kurile Islands. In the eastern Pacific it occurs south to Washington.

REMARKS: Shells closely resembling *Pandora* s. str. except for the radial straitions on the right valve, and the presence of a lithodesma strengthening the ligament, were placed in a new subgenus, *Kennerlia* by Carpenter (1864). Vokes (1956) showed that an earlier name was *Pandorella* Conrad 1863, for which the type, *P. arenosa* Conrad (by monotypy), has a developed lithodesma. It may be concluded that the presence of this structure is the chief diagnostic character of *Pandorella;* it is therefore surprising that Keen in Moore (1969) states the lithodesma to be wanting. It must be surmised that this is a *lapsus calami*.

Family LYONSIIDAE Fischer 1887
Genus *Lyonsia* Turton 1822
Figure 102

Type species (monotypy): *Mya norwegica* Gmelin 1791. Recent. North Atlantic.

DESCRIPTION: Shell thin, brittle, elongate. Posterior produced and truncate with siphonal gape. Surface ornamented with radial threads and striae. Periostracum thin, adherent. Interior nacreous. Hinge edentulous, resilium situated in an elongate oblique resilifer. The ligament is supported by a wide, posteriorly bifid lithodesma. Adductor muscle scars obscure. Pallial line wide, barely impressed. No pallial sinus.

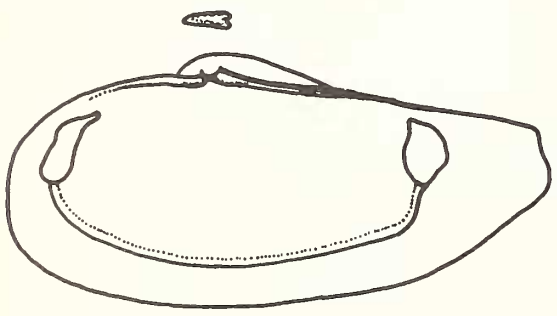


FIGURE 102. Interior of right valve and lithodesma of *Lyonsia norvegica* (Gmelin).

RANGE: Eocene (?) to Recent. Recent distribution northern circumboreal in shallow water, usually in sand or sandy mud substrata, or as byssally attached nestlers. A few species are present in warm waters.

DEVELOPMENT: According to Ockelmann (1958), *L. arenosa* (Møller) produces eggs with plentiful yolk that undergo lecithotrophic development with a curtailed, or absent, planktonic stage. *L. hyalina* Conrad 1831 has a similar development (Chanley and Castagna 1966).

REMARKS: Because of the shortness of the siphons, most species occur in the superficial infauna, anchored with several byssal threads, there is also a tendency for sand particles to be cemented to the periostracum, or for the shell to be covered with a coating of sediment mixed with mucus. Wagner (1977) recorded *Lyonsia schimkewitschi* Derjurgin and Gurjanova 1926 from the eastern Beaufort Sea. The original description was not very specific, so it may be considered a *nomen dubium*, and I believe it to be a morph of *L. norvegica* Gmelin 1791.

Subgenus *Lyonsia* s. str.
Lyonsia (Lyonsia) arenosa (Møller 1842)
Figures 98, 99, 100

Pandorina arenosa Møller 1842:20.
Lyonsia arenosa (Møller), Oldroyd 1925:92; Lamy 1928:250; Filatova 1948:444, pl.13, f.2.
Lyonsia (Pandorina) flabellata Gould 1861:23.
Lyonsia ventricosa Gould 1861:23.
Lyonsia arenosa sibirica Leche 1883:439, pl.32, f.3, 4.

DESCRIPTION: Shell thin, brittle, inflated. Anterior rounded, posterior end produced, truncated with narrow siphonal gape. Maximum length 50 mm, but usually less than 25 mm. Surface with irregular incremental striae and fine radial threads. Periostracum light brown to dark grey, adherent, often with attached sand grains and mucus-bound sediment. Interior nacreous, shell margins smooth. Hinge edentulous. Ligament internal, supported by a large, posteriorly bifid lithodesma. Adductor muscle scars not impressed. Pallial line wide, entire. Pallial sinus barely present.

COMPARISONS: This species may be confused with *L. norvegica* (Gmelin 1791), which is distributed through the European Atlantic and Mediterranean, and in the eastern Beaufort Sea according to Wagner (1977). It is distinguished by a thicker shell and coarser, less numerous, radial threads. The periostracum is thicker and concentrically wrinkled between the radial threads, but in *L. norvegica* the interstial spaces are closely punctated.

COLLECTION: Twenty specimens and 14 separated valves occurred at 15 stations between 15–101 m.

RECORDS: *Pleistocene*—Laursen 1950:83 (Greenland); Richards 1962:57, pl.5, f.17 (Quebec to Maine); Petrov 1966:240, pl.23, f.12, 13 (Chukotsk Peninsula); Wagner 1970:44, pl.5, f.3a, b (Eastern Canada). *Recent*—Gould 1870:65 (Massachusetts); G. Sars 1878:81, pl.34, f.2a, b (Greenland); Leche 1878:11 (Novaya Zemlya); Stuxberg 1886:141 (Novaya Zemlya); Hägg 1904:62 (Greenland); Jensen 1905:359 (Greenland); Odhner 1915:131 (Spitzbergen); Grant and Gale 1931:264 (Arctic to Japan); Mesjatsev 1931:117 (Barents Sea); Johnson 1934:31 (Greenland to Massachusetts); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:80 (Iceland); Kuroda and Habe 1952:24 (Northern Japan); Filatova 1957b:56 (Arctic); Ockelmann 1958:149 (Greenland); Soot-Ryen 1958:16 (Greenland); Ellis 1960:39 (Baffin Island); Hulsemann 1962:64 (Beaufort Sea); Richards 1962:57, pl.5, f.17 (Greenland to Maine); McLaughlin 1963:26 (Bering Sea); Filatova and Barsanova 1964:31 (Bering Sea); Wacasey 1975:27 (Beaufort Sea); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: Panarctic and circumboreal. This species is represented in the shallow water off Northeastern America, Greenland and the Canadian Arctic Archipelago. It occurs sporadically at Spitzbergen and Novaya Zemlya, and eastwards to Siberia. It enters the Bering Sea, Sea of Okhotsk and northern Japan. The range south of Kodiak Island has not been confirmed.

REMARKS: The shell outline and number of radial striae are variable, as evidenced by the synonyms *L. (Pandorina) flabellata* Gould 1861, which is merely a thin-shelled inflated morph with more numerous striae; and *L. ventricosa* Gould 1861 from Hakodadi, Japan, which is the shorter, more rotund form. A greater difficulty is the confusion with the Atlantic *L. norvegica* (Gmelin). Middendorff (1849) considered the two species synonymous, a conclusion apparently accepted by Carpenter (1857). MacGinitie (1959) used the Gmelin name for a specimen and broken valve from Point Barrow. I have been unable to locate this material in the USNM as MacGinitie did not illustrate her specimen, but I feel confident in concluding that in fact it should be assigned to *L. arenosa,* as MacGinitie did not discuss the relationship of high Arctic to Atlantic representatives, nor give a reason for her nomenclature. A number of authors cited an Eastern Pacific range for *L. arenosa* as far south as northern Washington. I consider this to be in error, and have not seen specimens south of the northern part of the Gulf of Alaska.

Family PERIPLOMATIDAE Dall 1895
Genus *Periploma* Schumacher 1817
Figure 103

Type species (monotypy): *Periploma inaequivalvis* Schumacher 1817. Recent. North Atlantic.

DESCRIPTION: Shell thin, ovate to quadrangular; right valve more convex than left valve. Surface smooth, frequently with minute pustules or concentric lirae. Periostracum very thin, dehiscent. Umbones prominent, beaks opisthogyrate, fissured. Interior smooth, subnacreous. Hinge edentulous, resilium in two chondrophores supported by an oblique rib running from beaks towards posterior margin of shell. Usually with lithodesma. Adductor muscle scars elongated, narrow. Pallial line feebly impressed; pallial sinus small and rounded.

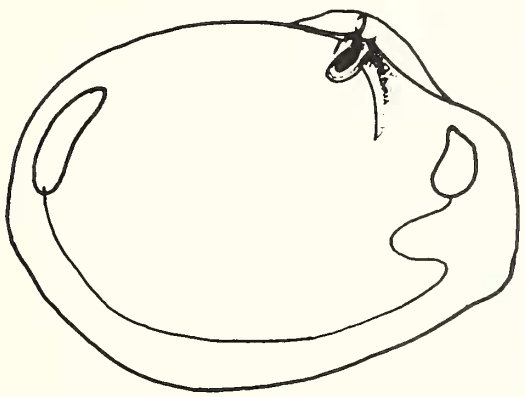


FIGURE 103. Interior of right valve of *Periploma inaequivalvis* Schumacher.

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan, from the subtidal zone to 2500 m, mostly in warmer waters.

DEVELOPMENT: I have been unable to locate any references to development in the literature.

REMARKS: The genus is unrepresented in OSU and Washington State College collections but a recently dead valve and some fragments were present at USGS location M6936 in the Beaufort Sea at 709 m.

Subgenus *Periploma* s. str.
Periploma (Periploma) aleutica (Krause 1885)
Figure 104

Anatina ? aleutica Krause 1885:38, pl.3, f.7.
Periploma alaskana Williams 1940:37, f.1; Rosewater 1968:38.

DESCRIPTION: Shell thin, extremely fragile; ovate. Maximum length 30 mm. Surface smooth or with irregular incremental lirae. Posterior truncated, set off by shallow radial sulcus. Periostracum thin, with fine wrinkles on posterior and ventral shell margins. Beaks prominent, with apex divided by a vertical slit. Interior subnacreous. Hinge edentulous with prominent chondrophore supported by posteriorly directed buttress in each valve. The umbonal slit is prolonged ventrally as a furrow with inserted ligamental band. Lithodesma small. Adductor muscle scars unequal, pallial line obscure. Pallial sinus small.

COMPARISONS: The species bears a superficial resemblance to the Atlantic *P. papyraceum* (Say 1822), but is readily distinguished by the narrower, nearly vertical chondrophore.

COLLECTION: Two valves and several fragments collected by the United States Geological Survey at location M6936 (71°28.9′N, 151°40.9′W) in 709 m.

RECORDS: *Recent*—Williams 1940:37, f.1 (Chukchi Sea and Montagu Island, Alaska).

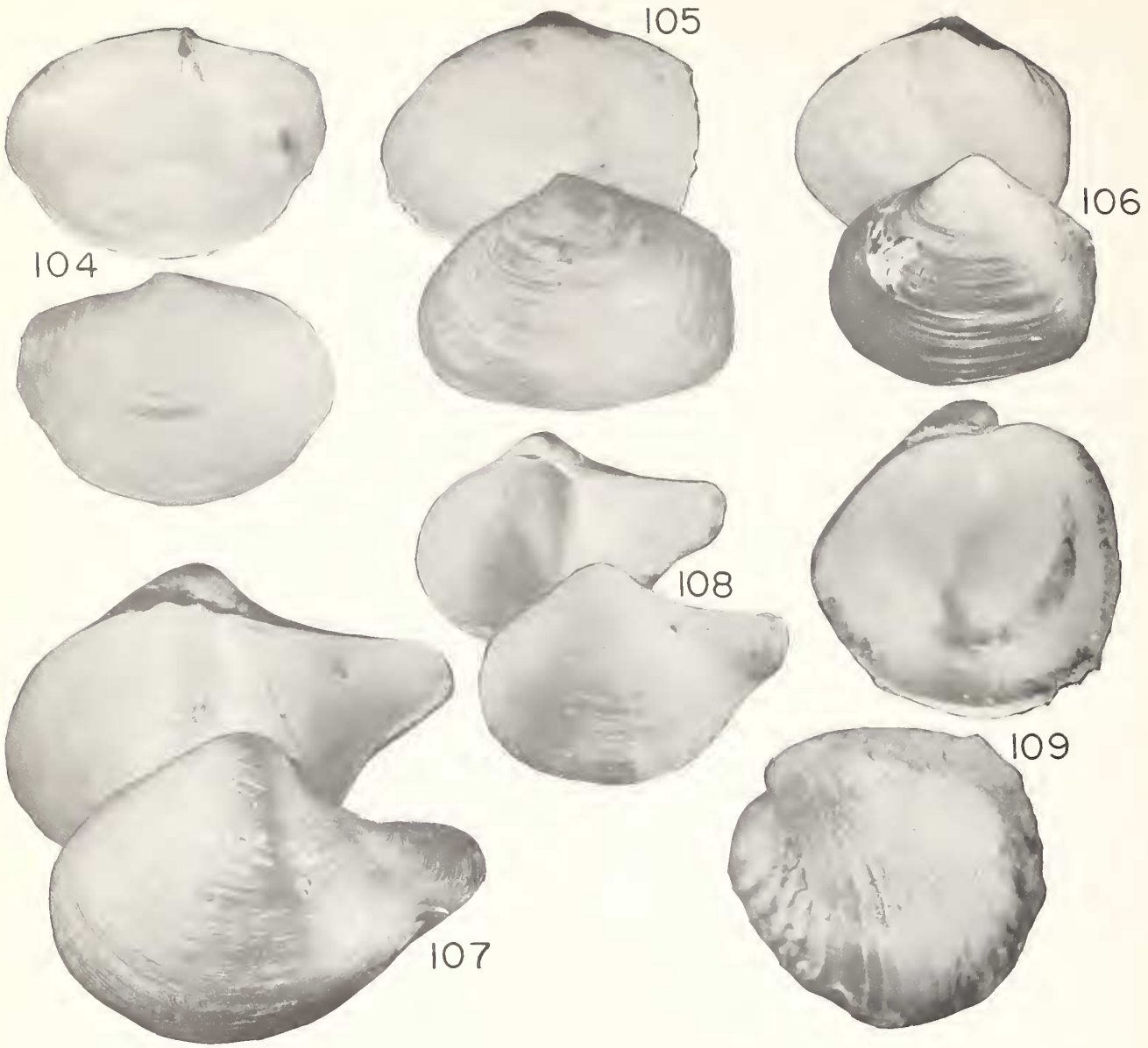
DISTRIBUTION: The species occurs in the Beaufort, Chukchi, and eastern Bering Sea and in the northern portion of the Gulf of Alaska. This is the initial record from the Beaufort Sea.

REMARKS: Krause's description of this species from the southern Bering Sea was overlooked by Williams (1940) who redescribed it from the Chukchi south to the Gulf of Alaska. This bivalve is probably descended from the Pacific discoidal *Periploma* and may be a comparatively recent migrant to the Arctic. In view of this, and the present distribution, it is puzzling that no representatives of the genus are found from British Columbia to southern Oregon, but in central and southern California a number of species occur. On the other hand, the genus is well represented in boreal Atlantic waters.

Family THRACIIDAE Stoliczka 1870
Genus *Thracia* Sowerby (Leach MS) 1823
Figure 110

Type species (subsequent designation Anton 1839): *Mya pubescens* Pulteney 1799. Recent. North Atlantic.

DESCRIPTION: Shell ovate, posteriorly produced and truncate. Surface with obscure concentric striae and many small granules. Umbones prominent, beak of right valve frequently abraded and perforated by opposite valve. Interior chalky. Hinge edentulous. Ligament partly external. Resilium attached to elongate narrow, nearly horizontal resilifer. A small lithodesma may be present.



FIGURES 104–109. 104, *Periploma (Periploma) aleutica* (Krause), length 36.8 mm; 105, *Thracia (Thracia) devexa* Sars, length 27.0 mm; 106, *Thracia (Thracia) myopsis* Møller, length 7.0 mm; 107, *Cuspidaria glacialis* (Sars), length 28.8 mm; 108, *Cuspidaria subtorta* (Sars), length 4.7 mm; 109, *Lyonsiella (Policordia) uschakovi* Gorbunov, length 4.0 mm.

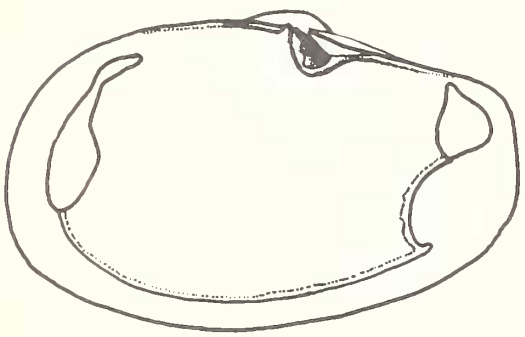


FIGURE 110. Interior of right valve of *Thracia pubescens* (Pultney).

RANGE: Jurassic to Recent. Recent distribution cosmopolitan from the low intertidal zone to 1000 m, usually in sandy substrates. The genus belongs to the deeply infaunal filter-feeding group of bivalves.

DEVELOPMENT: According to Thorson (1936), *T. devexa* G. Sars 1878 produces larges yolk-rich eggs, so development is lecithotrophic with a reduced, or absent, planktonic stage.

REMARKS: Two species are in the present collection, but it is unlikely that further collecting will include *T. septentrionalis* Jeffreys 1872, of the North Atlantic and westward to Greenland and the Canadian Arctic Archipelago. *T. adamsi* MacGinitie 1959, from Point Barrow, was not collected. This interesting species, with a massively buttressed resilifer, was placed by MacGinitie in a new subgenus, *Lampeia*, but it is probably referable to *Asthenothaerus* Carpenter 1864 (Baxter pers. comm.)

Subgenus *Thracia* s. str.
Thracia (Thracia) devexa G. Sars 1878
Figure 105

Thracia truncata devexa G. Sars 1878:84, pl.6, f.11a, b.

DESCRIPTION: Shell ovate, anterior rounded, posterior broadly truncate. Maximum length 40 mm, usually less than 25 mm. Surface ornamented with irregular concentric striae and numerous fine granules. Periostracum yellow to grey, adherent. Umbones prominent, eroded in large specimens. Interior polished. Hinge edentulous, with central notch and two elongated tubercles in right valve. Resilifer small, oblique to nearly horizontal. Adductor muscle scars subequal, not impressed. Pallial line entire. Pallial sinus shallow and broad.

COMPARISONS: This species is readily distinguished from *T. myopsis* Møller by the more inflated umbones, shorter resilifer, and less numerous surface granulations.

COLLECTION: Eleven specimens and three single valves were present at nine stations between 28–101 m.

RECORDS: *Recent*—Jensen 1905:360 (Greenland); Odhner 1915:134 (Spitzbergen); Soot-Ryen 1941:23, pl.2, f.5, 6, pl.6, f.4, pl.9, f.5 (Norway); Ockelmann 1958:156, pl.3, f.5 (Greenland); Wagner 1977:2015 (Eastern Beaufort Sea).

DISTRIBUTION: A discontinuous panarctic species present in the Atlantic sector from Greenland to Northern Norway and Spitzbergen and Novaya Zemlya, then the Beaufort and Chukchi seas.

REMARKS: This is the second record for the species from the Beaufort Sea. I have also examined material from the Chukchi Sea collected by the United States Geological Survey. It is probable that a wider distribution will be established when confusion with the following species has been purged from the literature. It was originally proposed as a subspecies of *T. myopsis* Møller, which Sars thought was a junior synonym of *T. truncata* Brown 1827

Thracia (Thracia) myopsis Møller (Beck MS) 1842
Figure 106

Thracia myopsis Møller (Beck MS) 1842:21; Filatova 1948:445, pl.13, f.6.
Thracia truncata typica G. Sars 1878:84, pl.6, f.10a, b.

DESCRIPTION: Shell ovate to elongate, anterior rounded, posterior truncated. Maximum length to 35 mm. Surface with concentric striae and irregular incremental lines. The entire shell is covered with coarse and densely packed granules giving a shagreened appearance. Periostracum ash brown to gray, adherent. Umbones not prominent, frequently eroded. Interior polished, sometimes iridescent in young specimens. Hinge edentulous, with central notch and obscure tubercles. Resilifer long and narrow. Adductor muscle scars subequal, not deeply impressed. Pallial line entire, barely visible. Pallial sinus shallow.

COMPARISONS: This species is readily distinguished from *T. devexa* G. Sars 1878 by the more closely spaced surface granulations, the less inflated umbones and the much longer resilifer.

COLLECTION: Twenty specimens were collected from 12 stations in 29–357 m.

RECORDS: *Recent*—Gould 1870:71 (Massachusetts); Verrill and Smith 1873:673, pl.27, f.196 (Massachusetts); Leche 1878:12 (Novaya Zemlya); Stuxberg 1886:140 (Novaya Zemlya); Jensen 1905:360 (Greenland); Odhner 1915:132 (Spitzbergen); Mesjatsev 1931:116 (Barents Sea); Johnson 1934:30 (Greenland to Massachusetts); Soot-Ryen 1939:18 (Franz Josef Land); Soot-Ryen 1941:22, pl.2, f.1–4, pl.6, f.3a, b, pl.8, f.4a–e (Norway); Gorbunov 1946a:46 (European Arctic); Filatova 1957b:57 (Eurasian Arctic); Ockelmann 1958:155, pl.3, f.4 (Greenland); Soot-Ryen 1958:17 (Greenland); MacGinitie 1959:162, pl.23, f.9, pl.24, f.4 (Point Barrow, Alaska); Ellis 1960:39 (Baffin Island); McLaughlin 1963:26 (Bering Sea); Petersen 1968:40 (Faroe Islands); Clarke 1974:11 (Baffin Bay); Wacasey 1975:27 (Beaufort Sea).

DISTRIBUTION: Probably panarctic and circumboreal in the Atlantic sector only. The species has been recorded in the Canadian Arctic Archipelago and along the American coast to Massachusetts. In the North Atlantic it occurs from Greenland to Norway, Spitzbergen, Novaya Zemlya, and south to the Faroe Islands and possibly Iceland. The species is rare in the Bering Sea and possibly extends into the Sea of Okhotsk.

REMARKS: MacGinitie (1959) synonymized this species in part with the Northeastern Pacific *T. curta* Conrad 1837, thus extending the range circumboreally. The latter is a larger, thicker shelled species with the posterior region set off by a radial sulcus, and is closely allied to the Atlantic *T. conradi* Couthouy 1838.

Family CUSPIDARIIDAE Dall 1886
Genus *Cuspidaria* Nardo 1840
Figure 111

Type species (monotypy): *Tellina cuspidata* Olivi 1792. Recent. Mediterranean.

DESCRIPTION: Shell globose with a narrow, tapering shell-covered siphonal sheath or rostrum. Surface unornamented, chalky, with occasional incremental lines. Interior polished. Hinge edentulous, sometimes with small peg-like tubercle in right valve. Resilifer small, spoon-shaped. Ligament supported by a lithodesma. Adductor muscle scars subequal, feebly impressed. Pallial line irregular. No pallial sinus.

RANGE: Cretaceous to Recent. Recent distribution cosmopolitan in cold and deep water. The genus is well represented in Arctic and abyssal to hadal environments. Shallow infaunal in friable substrates, where many species of the genus actively move around.

DEVELOPMENT: Eggs of all species examined (Ockelmann 1958; Knudsen 1970; Bernard 1974) are large and development is lecithotrophic with a reduced or absent planktonic stage.

REMARKS: The group is remarkably modified for macrophagy and feeding is entirely carnivorous, the gills are absent,

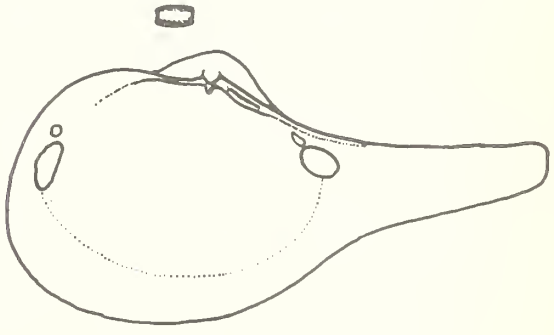


FIGURE 111. Interior of right valve and lithodesma of *Cuspidaria cuspidata* (Olivi).

the pallial cavity is divided by a muscular septum that functions as a powerful pump, drawing small crustaceans and other small benthic organisms into the inhalant opening. The alimentary system is invested with a muscle layer and the interior of the stomach is lined with a greatly extended gastric shield. No member of the closely related genus *Cardiomya* was collected although they are well established circumboreally at high latitudes (Scarlato 1972).

Cuspidaria glacialis (G. Sars 1878)
Figure 107

Neaera glacialis G. Sars 1878:88, pl.6, f.8a–c; Smith 1885:35.
Cuspidaria glacialis (G. Sars), Verrill and Bush 1898:800; Oldroyd 1925:98, pl.19, f.3a; Knudsen 1970:155, pl.16, f.4, 5.

DESCRIPTION: Shell thin, globular with tube-like posterior rostrum. Surface unornamented except for fine incremental lirae. Periostracum thin, ash-grey, concentrically wrinkled on posterior part of shell. Interior polished or chalky, with numerous fine radial striae. Hinge weak, edentulous. Right valve with small tooth-like tubercle and posteriorly directed resilifer. Left valve with smaller resilifer. Adductor muscle scars subequal, scarcely visible. Pallial line irregular, weakly impressed. No pallial sinus.

COMPARISONS: This species is closely related to *C. arctica* G. Sars 1878; however, *C. arctica* displays a more globular shell and a shorter, more abrupt rostrum.

COLLECTION: Twenty-five specimens and 12 single valves were collected from 9 stations between 23–455 m.

RECORDS: *Recent*—Leche 1883:437 (Kara Sea); Jensen 1905:310 (Greenland); Odhner 1915:135 (Spitzbergen); Johnson 1934:33 (Quebec to Florida); Soot-Ryen 1939:18 (Franz Josef Land); Filatova 1957b:57 (Eurasian Arctic); Ockelmann 1958:164, pl.3, f.10 (Greenland); Clarke 1962:71 (Arctic); Bernard 1974:36, pl.13, f.3, 4 (Bering Sea); Clarke 1974:12 (Baffin Bay).

DISTRIBUTION: Panarctic and throughout the North Atlantic from Greenland to Norway, Spitzbergen, and Novaya Zemlya. The range includes the Canadian Arctic Archipelago south to Massachusetts. It is present in the Bering Sea and probably the Sea of Okhotsk to Northern Japan, but does not occur south of the Aleutian Islands.

REMARKS: Dall (1886) recorded this species in the Gulf of California but Bernard (1974) showed that Eastern Pacific, excluding the Bering Sea material should be assigned to *C. subglacialis* Dall 1913, which differs by the less inflated beaks, straighter rostrum, and the subtriangular tubercle in the right valve. Likewise, Atlantic records south of Massachusetts are probably referable to *C. media* Verrill and Bush 1889.

Cuspidaria subtorta (G. Sars 1878)
Figure 108

Neaera subtorta G. Sars 1878:87, pl.6, f.6a–c; Jeffreys 1877a:235; Smith, 1885:35.
Cuspidaria subtorta (G. Sars), Verrill and Bush 1898:806, pl.73, f.1, pl.74, f.4, 5.

DESCRIPTION: Shell thin, translucent, ovate, rostrum short, tapered, upturned and twisted to the left. Maximum length 10 mm. Surface unornamented, but with irregular concentric lirae and growth marks. Periostracum ash-grey, thin, adherent. Umbones inflated, beaks prominent. Interior polished. Hinge edentulous, right valve with obscure tubercle arising from posterior margin of the small resilifer. Ligament supported by a lithodesma. Adductor muscle scars not visible. Pallial line obscure. No pallial sinus.

COMPARISONS: This species is readily distinguished by the short, tapered and twisted rostrum. It may be confused with *C. obesa* (Loven 1846), but that species is more globular and lacks the lateral ridge in the right valve.

COLLECTION: Four specimens were collected from two stations in 71 and 360 m.

RECORDS: *Recent*—Stuxberg 1886:140 (Novaya Zemlya); Odhner 1915:136 (Spitzbergen); Johnson 1934:33 (Nova Scotia); Gorbunov 1946a:46 (Eurasian Arctic); Madsen 1949:85 (Iceland); Filatova 1957b:57 (Arctic); Ockelmann 1958:161, pl.3, f.9 (Greenland); Soot-Ryen 1958:18 (Greenland); Clarke 1974:12 (Baffin Bay).

DISTRIBUTION: Probably panarctic. This species is abundant off Greenland and extends throughout the North Atlantic to Spitzbergen and Novaya Zemlya. It has been recorded off Iceland and Nova Scotia. It occurs in the Siberian Sea, but not in Chukchi or Bering Sea. It is absent from the Pacific.

REMARKS: This is the initial record from the Alaskan Arctic. Ockelmann (1958) comments on the similarity to *C. pellucida* (Stimpson 1853) from the western North Atlantic. Although *C. subtorta* rarely attains more than 4 mm in length and sports a wide, untwisted rostrum, it is likely that careful comparison will show it to be a synonym of *C. obesa* (Loven 1846).

Family VERTICORDIIDAE Stoliczka 1871
Genus *Lyonsiella* G. Sars (M. Sars MS) 1872
Figure 112

Type species (monotypy): *Pecchiolia abyssicola* G. Sars 1872. Recent. North Atlantic.

DESCRIPTION: Shell thin, fragile, inflated. Surface ornamented by radial lines or ribs, sometimes with minute granules. Periostracum thin, often with adherent sand particles. Interior nacreous, shell margins plain. Hinge edentulous, left valve with obscure thickening of shell margin below beak. A small resilifer

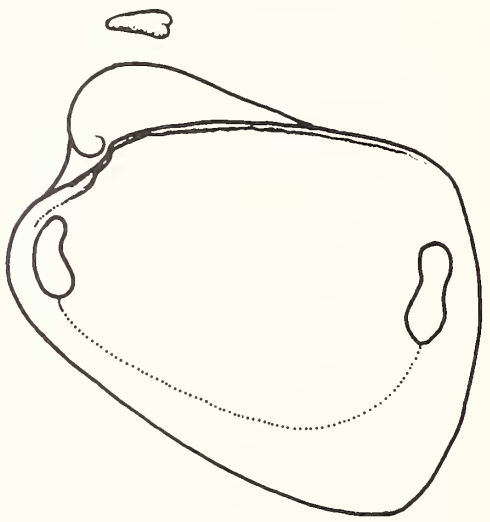


FIGURE 112. Interior of right valve and lithodesma of *Lyonsiella abyssicola* (Sars).

present in each valve. Ligament almost entirely internal, supported by large bifid lithodesma. Adductor muscle scars subequal, not impressed. Pallial line feebly impressed. No pallial sinus.

RANGE: Pliocene to Recent. Recent distribution cosmopolitan, typically in abyssal and hadal depths, generally in mixed to coarse sediments where the genus is nestling or shallowly infaunal.

DEVELOPMENT: The eggs of all species examined are large (Dall 1895; Knudsen 1970; Bernard 1974; Allen and Turner 1974), so development is lecithotrophic with a curtailed planktonic stage.

REMARKS: This genus is a member of a group of carnivorous bivalves, usually grouped with the Cuspidariidae into the superfamily Poromyacea, formerly the Order Septibranchia. I consider the phylogenies separate and any similarities the product of adaptive convergence during assumption of macrophagy and the progressive loss of the gill filter apparatus. I believe the verticordiids represent a terminal phase of a trend shown by typical anomalodesmacean genera such as *Lyonsia* and *Mytilimeria*, but are in no way transitional to the true septibranch genera of the poromyiids, *Cuspidaria* and *Cardiomya*, which demonstrate affinity to the Palaeotaxodonta. The siphons of Verticordiids are vestigial and there appears to be no burrow constructing ability as in the thyasirids, so the group is restricted to the shallow infauna. The foot is well developed and the animal is capable of active movement over the substrate. There is a developed byssal apparatus, so at least some representatives may be epifaunal nestlers. Wagner (1977) recorded an unidentified member of the genus from the eastern Beaufort Sea.

Subgenus *Policordia* Dall, Bartsch and Rehder 1939 *Lyonsiella (Policordia) uschakovi* Gorbunov 1946

Figure 109

Lyonsiella uschakovi Gorbunov 1946:32, pl.1, f.4a–c.

DESCRIPTION: Shell suborbicular, inflated, translucent. Maximum length 6 mm. Surface with widely spaced thin radial lirae. Periostracum thin, ash-grey, with adherent particles and mucus-bound sediment. Umbones inflated, beaks prominent, area in front of beaks deeply sunken. Interior brilliantly nacreous. Hinge narrow, edentulous. Left valve with thickened posterior margin interlocking with right valve. There is an inconspicuous resilifer in each valve. Ligament almost entirely internal, supported by large cylindrical lithodesma. Adductor muscle scars not impressed. Pallial line weak, irregular. No pallial sinus.

COMPARISONS: This rotund little species is unlike any other north boreal *Lyonsiella*. It may be separated from *L. alaskana* Dall 1895 by the more globular outline and proportionately larger lithodesma. The other Arctic representative is *L. abyssicola* (G. Sars 1872) which is markedly trapezoidal in shape with the free edge of the valves sinuous, and the surface ornamented by numerous radial rows of short hexagonal spines.

COLLECTION: One broken specimen occurred at 71°19.3′N, 147°47.1′W in 2377 m.

RECORDS: *Recent*—Filatova 1957b:57 (Siberia); Clarke 1962:69 (Laurentian Basin); Clarke 1963:93, pl.2, f.3 (Laurentian Basin); Soot-Ryen 1966:21, pl.2, f.21 (Siberia).

DISTRIBUTION: Endemic in the Laurentian Basin and adjoining bathyal zones.

REMARKS: It is with some doubt that I identify this specimen with Gorbunov's species, which was collected off the New Siberian Islands (80°58′N, 142°50′E in 1475–1510 m, however Clarke (1960) has recorded the species from the northern Beaufort Sea (84°34′N, 146°24′W in 2210 m), and again (1963) from 77°42′N, 167°50′W in 711 m, firmly placing it in the Beaufort fauna. It appears to be one of the few endemic species, but doubtless others will be located when the deeper reaches of the Laurentian Basin are adequately collected.

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APPENDIX

LOCATIONS AND DEPOSITION OF ILLUSTRATED SPECIMENS

Figure	Geographical coordinates		Depth (M)	Station No.	Depository
2	70°19.3′N	147°47.1′W	2377	OSU SMG 890	LACM 71-415
3	70°19.8′N	146°26.5′W	34	OSU OTB 460	LACM 72-252
4	70°43.0′N	149°02.0′W	50	OSU OTB 419	LACM 71-363
5	71°19.6′N	147°48.2′W	2560	OSU SMG 891	LACM 71-416
8	71°12.0′N	149°15.0′W	64	OSU SMG 956	LACM 71-457
9	71°22.5′N	152°22.6′W	88	OSU SMG 1320	LACM 76-60
10	70°34.8′N	144°23.1′W	71	OSU OTB 450	LACM 72-243
11	71°31.0′N	156°02.2′W	110	OSU SMG 1272	LACM 76-58
12,13	70°10.2′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
15	70°10.2′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
16	71°08.2′N	152°57.5′W	26	OSU SMG 1360	LACM 76-61
17	70°37.6′N	148°32.0′W	29	OSU SMG 1295	LACM 76-59
18	71°45.1′N	150°35.0′W	2130	OSU SMG 1023	LACM 71-491
19	71°15.2′N	149°28.8′W	991	OSU SMG 948	LACM 71-452
20,21	70°34.8′N	144°23.1′W	71	OSU OTB 450	LACM 72-243
22	70°51.5′N	145°17.0′W	357	OSU OTB 457	LACM 72-250
23	71°05.7′N	148°41.0′W	55	OSU OTB 467	LACM 72-256
25	71°50.5′N	153°10.7′W	384	USGS PPB 42	USGS M6936
26	71°12.0′N	148°35.0′W	360	OSU OTB 418	LACM 71-362
27	70°41.6′N	145°23.8′W	79	OSU OTB 450	LACM 72-243
28	71°04.1′N	151°21.5′W	64	OSU SMG 972	LACM 71-464
30	70°56.1′N	147°50.6′W	47	OSU OTB 833	LACM 36528
31	71°05.7′N	148°11.0′W	55	OSU OTB 467	LACM 72-256
33	70°10.3′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
34	71°05.7′N	148°11.0′W	55	OSU OTB 467	LACM 72-256
35	70°31.7′N	147°33.5′W	29	OSU OTB 463	LACM 72-254
36	70°10.2′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
37	70°10.2′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
42	70°43.0′N	149°06.0′W	31	OSU OTB 420	LACM 71-364
43,44	71°18.1′N	152°32.2′W	55	USGS PPB 55	USGS M6936
45	70°51.5′N	145°17.0′W	357	OSU OTB 453	LACM 72-246
49	71°01.0′N	148°22.7′W	48	OSU SMG 933	LACM 71-445
50	71°14.3′N	149°22.9′W	695	OSU SMG 950	LACM 71-454
51	71°22.0′N	150°38.0′W	997	OSU SMG 1022	LACM 71-490
52	71°14.3′N	149°22.9′W	695	OSU SMG 950	LACM 71-454
56	70°55.8′N	153°12.8′W	0.5	WWSC M12	LACM 36529
57	70°31.8′N	147°33.5′W	29	OSU OTB 463	LACM 72-254
58	71°14.1′N	149°21.7′W	603	OSU SMG 952	LACM 71-456
59	70°30.3′N	144°21.6′W	46	OSU OTB 451	LACM 72-244
63	70°50.0′N	147°21.6′W	47	OSU SMG 879	LACM 71-406
64	71°17.6′N	152°43.4′W	53	OSU SMG 1495	LACM 36530
65	70°43.1′N	143°42.8′W	464	OSU OTB 449	LACM 72-242
66	71°12.0′N	149°15.0′W	65	OSU SMG 954	LACM 71-457
67	71°10.0′N	149°18.9′W	51	OSU SMG 958	LACM 71-458
68	71°10.1′N	152°32.2′W	55	OSU SMG 1341	LACM 36531
69	71°12.0′N	152°49.0′W	30	OSU SMG 1502	LACM 36532
70	70°48.5′N	145°56.1′W	270	OSU SMG 855	LACM 71-402
71	71°12.0′N	148°36.0′W	80	OSU SMG 932	LACM 71-444
72	71°13.0′N	152°42.0′W	37	OSU SMG 1187	LACM 36533
75	71°04.1′N	151°21.5′W	64	OSU SMG 972	LACM 71-464
76.77	71°21.5′N	149°32.2′W	48	OSU SMG 946	LACM 71-450
79	70°43.0′N	149°00.0′W	23	OSU SMG 967	LACM 71-459
80	71°50.4′N	153°10.7′W	384	USGS PPB 78	USGS M6941
81	70°34.8′N	144°23.1′W	71	OSU OTB 450	LACM 72-243
82	70°31.7′N	147°33.5′W	29	OSU OTB 463	LACM 72-254
83	70°34.6′N	143°38.0′W	21	OSU SMG 839	LACM 71-399

85	70°14.7′N	143°23.6′W	28	OSU OTB 446	LACM 72-239
86	70°15.5′N	143°39.6′W	35	OSU SMG 821	LACM 36534
87	71°04.1′N	151°21.5′W	64	OSU SMG 972	LACM 71-464
88	71°04.1′N	151°22.2′W	21	OSU SMG 969	LACM 71-461
92	70°25.0′N	147°05.0′W	47	OSU SMG 872	LACM 71-405
93,94	70°04.9′N	143°38.7′W	2	WWSC CP 38	LACM 36535
95	70°10.2′N	144°33.0′W	27	OSU OTB 453	LACM 72-246
96	70°19.8′N	146°26.5′W	34	OSU OTB 460	LACM 72-252
97	70°19.8′N	146°26.5′W	34	OSU OTB 460	LACM 72-252
98	70°31.7′N	147°33.5′W	29	OSU OTB 463	LACM 72-254
99,100	71°19.0′N	152°38.5′W	55	OSU SMG 1159	LACM 36536
104	71°28.9′N	151°40.9′W	709	USGS PPB 42	USGS M6936
105	70°55.7′N	149°23.2′W	64	OSU SMG 998	LACM 71-482
106	71°05.7′N	148°41.0′W	55	OSU OTB 467	LACM 72-256
107	70°43.1′N	143°42.8′W	455	OSU OTB 449	LACM 72-242
108	70°34.8′N	144°23.1′W	71	OSU OTB 450	LACM 72-243
109	71°19.3′N	147°47.1′W	2377	OSU SMG 890	LACM 71-415

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