Cenozoic Pectinids of Alaska, Iceland, and Other Northern Regions

By F. STEARNS MacNEIL

GEOLOGICAL SURVEY PROFESSIONAL PAPER 553

Evolution of indigenous Alaskan pectinid stocks, of migrant stocks from other areas in the Pacific region, and of boreal Pacific species that subsequently migrated to the Arctic and northern Atlantic regions

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 66-321

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.00 (paper cover)

CONTENTS

ILLUSTRATIONS

[Plates follow index]

*Katalla district, Yakataga district, Malaspina district, and Lituya district are west to east in the outcrop of Tertiary rocks bordering the northern Gulf of Alaska.

CENOZOIC PECTINIDS OF ALASKA, ICELAND AND OTHER NORTHERN REGIONS

By F. STEARNS MACNEIL

ABSTRACT

Oligocene to Recent pectinids from Alaska contained in the collections of the U.S. Geological Survey are herein described and figured. New species from Iceland and the Queen Charlotte Islands, British Columbia, and a new subspecies from Greenland are included. This paper also contains the first published figure of the holotype of *Pecten (Chlamys) erythrocomatus* Dall and the first published photograph of the lectotype, herein designated, of *Pecten islandicus* var. *behringiana* Middendorff.

An attempt is made to determine the closest relatives of Alaskan species in other areas, as well as to determine the phylogenetic and geographic origin of Alaskan species. Several species or species groups are believed to have migrated from the Pacific to the Atlantic in late Cenezoic time, but so far no unequivocal case of an Atlantic pectinid entering the northern Pacific by way of the Arctic seas is known. Most Alaskan pectinids have older and more southern relatives in the Pacific, particularly in East Asia. At the same time, some Pacific middle Tertiary species have a striking similarity to European middle Tertiary species. It is suggested that some early and middle Tertiary pectinid stocks in the northern Pacific were of European origin but that they reached the northern Pacific by a Tethyan or Indian Ocean route rather than by way of the Arctic; subsequently, some of these stocks remigrated to northern Atlantic waters across the Arctic. Migration by a southern route has been demonstrated in the group of *Pecten jacobaeus*.

INTRODUCTION

This report, together with an earlier paper on the subgenus *Lituyapecten* (MacNeil, 1961), completes a study of the Cenozoic Pectinidae from Alaska contained in the collections of the U.S. Geological Survey. In addition to its own accumulation of the past 70 years, the Geological Survey is the repository for large collections made by the Gulf Oil Co., the Richfield Oil Co., and the British Petroleum Exploration Co. Several pectinids from Alaska were donated by the Shell Oil Co. A new Miocene species from the Queen Charlotte Islands in the collection of the University of California at Los Angeles is also described.

The Recent northern Pacific pectinids, both American and Asiatic, that range to Alaska or that have bearing on Alaskan species are included in the systematic treatment. Several subspecies of *Chlamys islandica* (Müller) are recognized in the Pacific, but typical *C. islandica* is not regarded as a living Pacific subspecies. This paper contains the first published illustration of the holotype of *Pecten (Chlamys) erythrocomatus* Dall from the Okhotsk Sea and the first published photograph of the lectotype, herein designated, of *Pecten islandicus* var. *behringiana* Middendorff. An attempt is made to rectify the nomenclature of northern Pacific pectinids in view of recent Japanese contributions, but admittedly a much better knowledge of the Russian Asiatic forms will be necessary before a wholly satisfactory integration can be made.

I am indebted to Dr. Leo G. Hertlein, of the California Academy of Sciences, for frequent consultations and advice during the preparation of this paper and for permission to figure several Recent specimens in the Academy collections. The photographs of the holotype of *P. (C.) erythrocomatus* Dall were obtained by him several years ago from Dr. Paul Bartsch, of the U.S. National Museum. Dr. A. O. Scarlato, Zoological Institute, Academy of Science, Leningrad, kindly supplied me with photographs of two specimens figured by Middendorff, one of which is here designated the lectotype of *Pecten islandicus behringianus* Middendorff. Dr. Willis P. Popenoe, of the University of California at Los Angeles, kindly gave me permission to describe the new species from the Queen Charlotte Islands. I am indebted also to Dr. Thorleifur Einarsson, of the University Research Institute, Reykjavik, Iceland, for specimens of *C. islandica* from Iceland. Kenji Sakamoto, of the U.S. Geological Survey, made all the photographs.

PECTINIDAE AS GUIDE FOSSILS

With the possible execption of the ammonites, no group of mollusks has been the subject of as many monographic studies as the Pectinidae. Comparatively few faunas, Recent or fossil, have been described in which there are no pectinids, and in many faunas the Pectinidae constitute the largest single group. Pectinids, like oysters, have a calcitic shell, and calcitic shells may be in evidence long after the aragonitic elements of a fauna have dissolved; it is fairly common for the oysters and pectens to be the only shells preserved in Tertiary strata.

While the modern technique of obtaining rubber casts from natural molds has obviated the difficulty of finding well-preserved shells—the pectens may even be dissolved purposely to obtain good molds—the durability of pectinid shells has probably been a large factor in determining the degree to which the group has been studied.

If all Tertiary stratigraphic studies were to be based on one group of mollusks and one alone, that group would undoubtedly be the pectens.

The Pectinidae exhibit a remarkable conformity to gross morphological plan. Unlike some other pelecypods, their family allocation is obvious from their external characteristics; both the Pectinidae and the supposedly ancestral Aviculopectinidae are instantly recognizable as pectinoid. Other related Paleozoic families are intermediate between the pectinids and the pteriids. So enormously complex is this group, however, that we still know very little of either its evolutionary pattern or its internal relationships. The comparatively narrow boundaries of diversification within the Pectinidae make it likely that similar morphological types evolved time and time again.

Distantly related genera such as *Chlamys* and *Propeamussium* probably represent groups that have been distinct since Paleozoic time, but it is not clear how far back most pectinid lineages must be traced to find a common ancestor. *Chlamys*-like forms are known in Mesozoic time. *Chlamys splendens* (Dollfus) (see Arkell, 1931, pl. 10, figs. 1–5) from the Jurassic is surprisingly like some late Tertiary and Recent *Chlamys*. While one is tempted to accept such forms as primitive *Chlamys*, few known Late Cretaceous or Eocene species are as similar to modern *Chlamys*. It is not at all certain, furthermore, that typical *Pecten* of the Tertiary, a genus having an externally convex right valve and a concave left valve, is descended from similar forms in the Cretaceous, such as *Neithea quinquecostatus* (Sowerby) (see Wade, 1926, pl. 21, figs. 1–5). Neither is it certain that all modern so-called *Pecten* (*Pecten*) are monophyletic. I cannot find an Eocene species that I would refer to *Pecten* (*Pecten*). *Pecten poulsoni* Morton from the Marianna Limestone (early middle Oligocene) of Alabama is *Pecten*-like, however, and it probably evolved from a late Eocene stock that was more equivalved and *Chlamys*-like.

Probably no other superfamily of Mollusca is as ubiquitous or spans as long a period of time as the Pectinacea. The Pectinidae come as close as any other family of mollusks to duplicating the complexity of the Mesozoic ammonites. In both the larval and adult stages, the pectinids are active swimmers; if dead shells had been dispersed as widely as those of the modern nautiloids, the pectinids might have exceeded the ammonites in their value as stratigraphic markers.

PECTINIDAE OF ALASKA

Alaska was the site of the first recorded observation (La Perouse, 1797, p. 189; Miller, 1961) of a fossil pectinid in western North America, the "manteau royal" seen by members of La Perouse's expedition of 1786 in the rocks of Cenotaph Island, Lituya Bay. Grewingk (1850, p. 99–100; Miller, 1961) cited this observation as evidence for the occurrence of Tertiary strata along the northeastern border of the Gulf of Alaska. The species was described by MacNeil (1961) as *Patinopecten* (*Lituyapecten*) *lituyaensis*. *Pecten propatulus* Conrad (1849), from Oregon, appears to have been the first western North American fossil pectinid to be described; the first fossil pectinid described from Alaska was *Pecten* (*Chlamys*) *lioicus* Dall (1907), a species from upper Pliocene or lower Pleistocene beds at Nome.

Two of the earliest described western American Recent species came from Alaska and Bering Sea: in 1845, Hinds described *Pecten rubidus* from Sitka, and in 1849 Middendorff described *Pecten islandicus behringianus* from somewhere in Bering Sea. The only species described earlier from western America were some tropical and subtropical species of Sowerby and d'Orbigny.

Before Dall (1898, p. 699–812) undertook the first systematic revision of all known pectinids of western America, numerous fossil and Recent species had been described, mostly by Conrad, Gould, and Dall. The literature was sparse at that time, some of it in papers now rare. Arnold (1906) published the first really important paper on western American pectinids, a paper that is still the primary reference. This paper describes many new species and figures most of the previously described species, including several type specimens not previously illustrated. The next significant revision of the fossil species was by Grant and Gale (1931), and a comprehensive treatment of the Recent species was much later undertaken by Grau (1959). Dall, Arnold, Grant and Gale, and Grau all included Alaskan species in their revisions. The large amount of Cenozoic material that has accumulated in the collections of the U.S. Geological Survey since Dall's time contains many new forms, however, and the much larger suites of shells make possible a study of varietal ranges that could not have been accomplished a few years ago.

In addition to American studies on Alaskan pectinids, there are several important Japanese papers

that deal directly or indirectly with Alaskan species. By far the greatest number of Japanese contributions are by Masuda, but other important papers have been published by Masuda and Hatai, Masuda and Sawada, Akiyama, Oyama, Kubota, and others. The long-continued practice of referring certain Recent Alaskan forms to *Chlamys islandica* (Müller) has dissuaded American authors from naming them. Consequently, some Alaskan species that range continuously along the eastern Asiatic coast have been named in Japan. However, several other American species names have many years' priority over Japanese names for very similar forms. Some of these Japanese species are here treated as subspecies of the earlier American species.

MIGRATION ROUTES

Theoretically, the direction of migration of mollusks that have pelagic larvae should be controlled by oceanic circulation. Throughout Tertiary time, new molluscan stocks have made abrupt and sometimes termporary appearances in the waters of western North America. Because most of these stocks have older representatives in Japan, it is presumed that they are immigrants from East Asia. These apparent first arrivals are found from the Alaska Peninsula to California. During Oligocene time the fauna of the Alaska Peninsula region was predominantly Asiatic.

It seems likely that these Asiatic faunas were brought to America by the Japan Current or some similar current that flowed eastward in Tertiary time. At the present time the Japan Current flows almost due eastward at about the latitude of Vancouver, and near the American coast it divides into northward and southward flowing branches. There are no known early Tertiary marine deposits north of the Alaska Peninsula, however, and it is suggested that all or most of the Bering Sea was land in early Tertiary time. Such a difference in basinal configuration, especially the absence of the basin that now accommodates the counterclockwise Subarctic Current, would almost certainly have had some effect on the main clockwise circulation in the northern Pacific, and especially on the terminal distribution of the main currents. It is suggested that the main Japan Current coursed the present Alaska Peninsula and the present northern shore of the Gulf of Alaska in early Tertiary time and that its present location is due in part to deflection by the modern Subarctic Current.

Migration patterns for most northern Pacific mollusks are still unknown. It is fairly well established, however, that many boreal and north temperate species range farther north on the Alaskan coast and that typically Arctic species range farther south along the Siberian coast. *Fortipecten* is known in upper Tertiary(?) beds at Kivalina, and *Natica janthostoma* occurs in upper Pleistocene beds at Cape Kruzenstern. *Chlamys* (*Swiftopecten*) occurs in middle Pleistocene beds at Nome. As far as is known, none of these forms is found in beds of comparable age in the Chukotsk Peninsula. Conversely, *Bathyarca glacialis*, an Atlantic and Arctic species, is reported from several localities near Kresta Bay in southwestern Chukotsk; these are only known occurrences south of Bering Strait. *B. glacialis* has been found only once in Alaska, in a test well near Cape Simpson east of Point Barrow where it occurs in about the middle part of the Gubik Formation (horizon probably about middle or upper Pleistocene).

How the counterclockwise circulation in Bering Sea could be responsible for this distribution of organisms when most of the flow in Bering Strait is north is not clear. According to Johnson (1956, p. 14), longshore currents along eastern Arctic Siberia have been reported to continue eastward to Kotzebue Sound on the Alaskan coast. If such a flow exists, it must merge with the northward flow through Bering Strait. Johnson concluded that the currents along northeastern Siberia more probably are deflected northwestward toward Herald Shoal. Some southward flow along the west side of Bering Strait is indicated, but whether it is seasonal and whether the anomalous distribution of the Pleistocene fossils is due to currents that no longer exist is not known.

The currents of Bering Sea and the Arctic Ocean, even when they are more accurately known, may not be a reliable model for currents of the past. Currents can and probably do increase, decrease, or shift their course with changes in basinal configuration. Seasonal variation in existing Arctic currents suggests that Arctic circulation could have been entirely different in past periods when the Arctic had less ice or was ice free. The distribution of species during the Pleistocene, particularly along the Arctic coast, is not what might be expected if existing currents prevailed. Judging from the molluscan faunas, at least one stage of the Pleistocene was characterized by two-way circulation in Bering Strait; there was a southward flow on the Asiatic side that rounded Chukotsk and entered the Anadyr Gulf and a northward flow on the American side that rounded Point Barrow and flowed eastward along the Arctic coast. At the present time (Johnson, 1956), the main plankton stream is due north from Bering Strait. A weak, possibly seasonal, eastward-flowing longshore

current may exist east of Point Barrow, but the main circulation in Beaufort Sea is clockwise.

SYSTEMATIC CONCEPT

A few decades ago it was fashionable and appropriate to categorize molluscan systematists as either "lumpers" or "splitters," depending on whether they favored broad taxonomic groupings or tended to recognize each morphological variant as an entity. From either viewpoint, the systematists of that era were typologists; their concept of species was based on type specimens or on figures which provided the only available knowledge of a taxon.

In recent years, the population concept of systematics has largely supplanted the type concept. The population concept is largely the concept of variability; in such a concept the type specimen is not necessarily typical of a species and could conceivably be the most atypical member of a species; types are often chosen solely on the basis of preservation. The type specimen has value in the population concept only as a nomenclatural reference; it is the bearer of the name that is given to the group within which it falls.

Paradoxically, the modern-day paleontologist is regarded by most contemporary neontologists as a typologist of the "old school." If paleontologists are typologists, it is only under those circumstances where typology is necessary; thousands of fossil species are known only from the type specimen. The space-time systematics with which the paleontologist works, however, leads him inevitably to the concept of variability as a constant. The neontologist by definition deals with the systematics of one instant of time. To him the variation within populations is deviation from a norm; at best it is an annoying circumstance that makes difficult the orderly demarcation of species. To a paleontologist the range of variation is the norm; deviation occurs at another instant of time when the range of variation is different.

The systematic categories of any past instant of time, if viewed alone, might differ in rank from those of another instant. Most paleontologists probably would agree that if they could be projected back in time and were to classify the fauna of the late Paleozoic as neontologists, the Recent Orders of mollusks would be no more than Families or Subfamilies. Two Recent species between which there is no present morphological continuum may be represented in Pleistocene time by geographical subspecies; each of the geographical subspecies might have an identical variant, but each would have other variants unlike variants in the other subspecies. In still earlier time, the two subspecies may be traceable to individual variants in a single population.

The limit of fertile breedability is known for very few Recent animals, and it will never be known for fossils. Nevertheless, the individuals in a given area that appear to be connected by an unbroken series of variants can be regarded, reasonably, as constituting a single taxon. Apparent morphological and geographical limits are still the soundest criteria for determining the boundaries of species and subspecies. Only those boundaries marked by a broad geographical hiatus are exempt from personal opinion. The systematist has the task, therefore, of determining the morphological and geographical boundaries of species, as well as the apparent varietal connectives between species. The position of the holotype within a species is of secondary concern. It becomes important only when a combination of taxa or the subdivision of a taxon is necessary, in other words, when the application of a name is involved.

In such a situation it is obvious that the final word on phylogeny cannot be had until the complete range of variation in all populations, in all areas, and at all instants of time is known. Every varietal series is potentially the ancestor of two or more species, depending on accidents of isolation due to migration or ecology or to possible genetic barriers a population might develop within itself. Nearly identical variants can occur in two or more populations which have different ranges of variation and which are separated in either space or time. It is to such nearly identical variants that we must look for evidence of both relationship and origin. The direction of evolution in closely related forms is often difficult to determine from morphology alone. An older population may reveal immediately, however, which variant in a younger population is more primitive.

Despite the large number of pectinids recorded thus far from both the American and Asiatic sides of the Pacific, it is still very difficult to see how they are interrelated. With very few exceptions, the statements made here concerning their relationships must be regarded as tentative.

The dependence of our taxonomic concept on nomenclatural priority has resulted in some unfortunate combinations of species and subspecies names. More or less provincial studies on opposite sides of the Pacific have complicated rather than clarified the picture. While the status of some American species is unsatisfactory and cannot be resolved yet with any degree of finality, their relationship to Asiatic forms involves even greater problems. I certainly am not convinced that the eastern Asiatic species are as endemic as Masuda (1963) suggested. Taxonomy could be made less cumbersome by the elimination of subspecies, but the resulting loss of nomenclature as a means of showing both relationships and trends in evolution would be undesirable. Many

relationships and most evolutionary and migrational patterns could be expressed with less confusion, however, if species and subspecies were not coordinate, that is, if the rules permitted the use of a junior name for the species and a senior name for the subspecies.

SYSTEMATIC PALEONTOLOGY

Genus DELECTOPECTEN Stewart, 1930

Palliolum (*Delectopecten*) Stewart 1930, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 118.

Type species (by original designation): *Pecten* (*Pseudamusium*) *vancouverensis* Whiteaves. Recent Sitka Harbor, Alaska, to Catalina Island, Calif.

Discussion.—Most recent authors have referred mud pectens of this kind to *Delectopecten*. The type species of *Delectopecten* has moderately strong radial sculpture on both valves. Some other species, such as *D. randolphi* (Dall), living from Washington to southern California, are hyaline and have concentric undulations only; Grau (1959, p. 44, pl. 16, figs. 4, 5) treated this species as *Cyclopecten* (*Delectopecten*) *randolphi* (Dall). As presently construed, the genus *Delectopecten* contains species with moderately strong radial or reticulate sculpture, species with radial rows of beads but no well-defined ribs, and species without radial sculpture on the disc; the species that have no radial sculpture on the disc may have moderately strong concentric undulations. The smooth species usually have radial threads on the anterior ear of the right valve. There are no internal ribs. The posterior ears of *Delectopecten* are not set off by an indentation; the margin of the ear is nearly tangential to the adjacent curved outline of the margin of the shell. The posterior ears of *Cyclopecten* are separated from the margin by an indentation.

If and until it can be shown that there is a close relationship, if not a morphological continuum, between *Cyclopecten* and *Delectopecten*, it might be better to regard them as separate genera. While some species of *Delectopecten*, such as *D. polyleptus* (Dall) (Grau, 1959, pl. 16, fig. 1), have radial rows of beads, these beads do not resemble the radial rows of hollow blisters found on the type species of *Cyclopecten* (*Pecten pustulosus* Verrill; Verrill and Bush, 1898, p. 839, pl. 85, figs. 5, 6, 10, 11). *C. pustulosus* has well-defined posterior ears set off by a moderately deep indentation. Verrill and Bush (1898, p. 839) stated that *C. pustulosus* does not have internal ribs as does *Propeamussium hoskynsi*, a species which is presumably the *Pecten hoskynsi* of Sars (1878, pl. 2, figs. 1a–c). If *P. hoskynsi* has internal ribs, it may prove to be a *Polynemamussium* and probably is not a synonym of *Cyclopecten imbriferum* (Lovén) (Ockelmann, 1958, p. 66, pl. 2, fig. 1). I cannot, however, find a figure of the interior of either *P. hoskynsi* or *C. imbriferum*, and until their internal shell features are clarified, the whole discussion might better be postponed.

Delectopecten maddreni MacNeil, n. sp.

Plate 4, figure 5; plate 5, figure 5

Description.—Shell small; disc has faint concentric growth lines and four or five crude concentric undulations; no radial sculpture. Anterior ear of right valve has 11 or 12 fine radial riblets; posterior ear unknown. Anterior ear of left valve slightly convex along its anterior border, the border nearly vertical; posterior ear smaller, the posterior border sloping at about 45°, weakly concave.

Discussion.—This species is closely related to *Delectopecten peckhami* (Gabb) as that species was interpreted by Arnold. (See Moore, 1963, p. 67.) The available figures of *D. peckhami* show about 4 to 6 riblets on the anterior ear of the right valve, whereas *D. maddreni* has 11 or 12 riblets. The California Academy of Sciences has some specimens identified as *D. pedroanus* (Trask) that have 10 to 12 riblets on the anterior ear. The distinction between *D. peckhami* and *D. pedroanus* is not clear, and some authors (Grant and Gale, 1931, p. 236) have combined them; certainly the type of *D. pedroanus* came from much younger beds than the type of *D. peckhami*.

According to Moore (1963, p. 67), the California occurrences of *D. peckhami* are all Miocene. Masuda (1962a, p. 164) recorded *D. peckhami* from late Oligocene to early Pliocene beds in Japan, and Slodkewitsch (1938, p. 113) gave a similar range for the species in Kamchatka.

Delectopecten maddreni occurs in beds that are probably of late Oligocene age. It is of about the same age, therefore, as the oldest of the Asiatic forms assigned to *D. peckhami*, and possibly these Asiatic Oligocene forms are closer to *D. maddreni* than to *D. peckhami*. *D. maddreni* appears to be more closely related to *D. peckhami* and *D. pedroanus* than to *D. lillisi* (Hertlein) (1934, p. 5, pl. 1, fig. 1, pl. 2, figs. 2, 3) from the Kreyenhagen Shale (late Eocene and early Oligocene) of California. *D. lillisi* has about 10 fine spinose riblets on the anterior part of the disc of the right valve. An apparently undescribed species of *Delectopecten* occurs in the lower part of the Moreno Formation (Late Cretaceous and Paleocene?) of California (the horizon probably of Maestrictian age).

Types: The holotype (USNM 644865) consists of a right and a left valve which may or may not belong to the same individual; the slab on which they occur has many specimens close together. The right valve has a height and length of about 22 mm. A figured specimen from the Poul Creek Formation is numbered USNM 644866.

Type locality: Upper part of the Burls Creek Shale Member of the Katalla Formation (horizon probably upper Oligocene), Burls Creek, Katalla district, Alaska, USGS 4321.

Locality of figured specimen: Middle part of the Poul Creek Formation (horizon probably upper Oligocene), north end of spur projecting into Bering Glacier, about due north of the mouth of Kulthieth River, Yakataga district, Alaska USGS 16898.

Genus POLYNEMAMUSSIUM Habe, 1951

Polynemamussium Habe, 1951, Genera of Japanese Shells, p. 72, figs. 136, 137.

Type species (by original designation): *Pecten intuscostatus* Yokoyama. Pleistocene, Miyata Formation. Kanagawa Prefecture, Japan.

Discussion.—Until Habe proposed the name *Polynemamussium*, there seems to have been no really appropriate taxon in which to include *Pecten* (*Pseudoamussium?*) *alaskensis* Dall. Arnold (1906, p. 133) referred it to the subgenus *Pecten* (*Propeamussium*). Since then *Propeamussium*, as a genus or subgenus, has been the most popular allocation of it. Grau (1959, p. 18) rejected the name *Polynemamussium* and treated Dall's species as *Propeamussium* (*Parvamussium*) *alaskense* (Dall). Both *Propeamussium* and *Parvamussium* have a few rather strong internal ribs that are widely spaced and appear, moreover, to be superimposed, calluslike, on a uniformly curved interior surface. The internal ribs of *Pecten alaskensis* are more numerous, are stronger toward the margin, and have interspaces that are round bottomed. While a few recent authors have used *Pseudamussium* and *Pseudamussium* (*Cyclopecten*) for this group, neither *Pseudamussium* nor *Cyclopecten* has internal ribs. Masuda (1962b, p. 154), in his discussion of *Polynemamussium*, said, "This genus differs from *Propeamussium* by its conspicuous imbricated sculpture of the left valve, distinct byssal notch, and the internal ribs which become distinct near the ventral margin."

Oyama (1944, p. 245) proposed *Squamamussium* (type species, *Amusium squamigerum* E. A. Smith, Recent, West Indies) as a subgenus of *Propeamussium*. He included both *Pecten alaskensis* Dall and *Pecten intuscostatum* Yokoyama in *Squamamussium* along with three species from the Indonesian region. No subsequent Japanese author has accepted *Squamamussium* for a northern Pacific species. The type species (see Küster and Kobelt, 1888, pl. 49, fig. 8) has fine radial ribs on the left valve, but without examining specimens I would hesitate to say whether it represents the same group as *Polynemamussium*.

Ômori (1955) regarded *Propeamussium* and *Parvamussium* as different genera, and he also recognized *Polynemamussium* (which he spelled *Polyneamussium*). His figures clearly show the nature of the internal ribs; they disappear distally in *Propeamussium* and *Parvamussium*, and they appear distally in *Polynemamussium*. According to Masuda (1962b, p. 155), the specimens Ômori figured as "*Polyneamussium*" *alaskense* (ibid., pl. 2, figs. 2–14) are *Polynemamussium intuscostatum*.

Polynemamussium alaskense (Dall)

Plate 5, figures 2–4

Pecten (*Pseudoamussium?*) *alaskensis*, Dall, 1872, Am. Jour. Conchology, v. 7, p. 155, pl. 16, fig. 4.

Pecten (*Propeamusium*) *alaskensis*, Dall, 1886, Mus. Comp. Zoology Bull., v. 12, no. 6, p. 215, pl. 5, figs. 7, 7a.

Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 133, pl. 53, figs. 2, 2a, 3 (with extended synonymy).

Pecten (*Propeamusium*) *alaskense*, Dall, 1921, U.S. Nat. Museum Bull. 112, p. 20, pl. 1, fig. 2.

Polynemamussium alaskense, Habe, 1951, Genera of Japanese Shells, p. 72.

Propeamussium (*Parvamussium*) *alaskense*, Grau. 1959, Allen Hancock Pacific Exped., v. 23, p. 18, pl. 3 (with extended synonymy).

Polynemamussium alaskense, Masuda, 1962, Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 33, no. 2, p. 155, pl. 18, figs. 5a, b, 6a, b (with extended synonymy).

Discussion.—Both the right and left valves of this species have weak internal riblets that become stronger distally, but only the left valve has riblets on the exterior. The number of external riblets is variable, ranging usually from 24 to 30. Some of the riblets tend to become weakly beaded or scabrous toward the margin. The riblets have little relief and tend to merge with the interspaces; usually they are lighter colored than the remainder of the disc. All the ears have weak radial riblets, but such riblets are stronger on the anterior ear of the right valve.

Polynemamussium intuscostatum (Yokoyama) (Masuda, 1962b, p. 156), a related species from the early Pliocene to Recent of Japan, is more coarsely sculptured than *P. alaskense* and the riblets are more beaded. Kanno (1962, p. 56, pl. 4, figs. 6, 7) reported *P. alaskense* from the Setana Formation (early Pliocene) of Hokkaido. Masuda recognized *P. alaskense* in several middle and late Pliocene formations in Japan. He also suggested that *Polynemamussium simanense* (Kuroda), a Recent species from Shimane Prefecture, Japan, may be a subspecies of *P. alaskense*.

Pecten (*Propeamusium*) *riversi* Arnold (1906, p. 126, pl. 44, figs. 8, 9), early Pleistocene from Deadman Island, near San Pedro, Los Angeles County, Calif., is closely related to *P. alaskense;* according to Arnold's figures the internal riblets are weaker and more closely restricted to the marginal area, and the external riblets of the left valve are stronger.

The earliest known American species of *Polynemamussium* is *Pecten* (*Propeamusium*) *levis* Moody (1916, p. 56, pl. 2, figs. 2a–d) (renamed *Pecten calamitus* Hanna, 1924, p. 176) from the Fernando Formation (late Pliocene) of Los Angeles. As noted by Moody, the internal riblets of *Polynemamussium calamitus* are more like those of *P. alaskense* than those of *P. riversi*. *P. alaskense* has been reported from Pleistocene beds in the Vancouver area (Wagner, 1959) and Alaska (Dall, 1898, p. 711). Regardless of the way in which the synonymy of this compact group may be resolved ultimately, its known distribution suggests that it is a migrant from East Asia.

Types: The holotype, in the U.S. National Museum, is from Port Etches, western Hinchinbrook Island, Prince William Sound, Alaska. It measures 19.5 mm in both height and length. Figured specimens, USNM 644867–644869.

Locality of figured specimens: Postglacial deposits in the vicinity of Juneau, Alaska, USGS M212, M218, M243.

Occurrence: According to Masuda, this species occurs in early Pliocene to Recent deposits in Japan, in Pleistocene (and postglacial) beds of southeastern Alaska and the Vancouver area, British Columbia, and is living from Bering Sea to Panama. Grau gave Lower California as the southern limit. Other specimens in the U.S. Geological Survey collections are from early Pleistocene beds on Middleton Island, Alaska, USGS 17744, and postglacial beds near Juneau, Alaska, USGS 5256, 12066.

Polynemamussium davidsoni (Dall)

Plate 5, figure 7

Pecten davidsoni Dall, 1897, Nautilus, v. 11, no. 8, p. 86.
Dall, 1902, U.S. Natl. Museum Proc., v. 24, p. 559, pl. 45, figs. 5, 6.
Pecten (*Pseudamusium*) *davidsoni*, Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 138, pl. 50, figs. 4, 4a.
Propeamussium (*Parvamussium*) *davidsoni*, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 20, pl. 4 (with extended synonymy).

Discussion.—If Grau (1959, p. 21) was correct in believing that the presence or absence of radial riblets on the right valve of this species is a matter of individual variation, such variation is unusually extreme. It would be difficult, furthermore, to assign a given right valve to either *P. davidsoni* or *P. alaskense*. Both Dall's and Arnold's figures show moderately strong irregularly spaced radial riblets on the lower part of the disc of the right valve, whereas Grau's figure shows the right valve to have concentric sculpture only. The left valve has moderately strong well-beaded riblets extending nearly to the beak and one or two interstitial riblets in the interspaces.

This species has not been reported previously as a fossil. A closely related species that differs mainly by having stronger and more coarsely beaded riblets on its left valve was described by Masuda (1962b, p. 156, pl. 18, figs. 9a, b, 10a, b, 11) as *Polynemamussium yasudae;* it occurs in the Oido Formation (early Miocene) of Miyagi Prefecture, northern Honshu, Japan.

Pecten (*Propeamusium*) *clallamensis* Arnold (1906, p. 57, pl. 3, figs. 1, 3, 3a; not fig. 2), probably from the Blakeley Formation of Weaver (1912) (late Oligocene and early Miocene), northwestern Washington, may be related to this species. It has similar radial rows of short curved scales, but they are not situated on raised ribs; there are no interstitial riblets. The right valve has no radial markings on the disc, but the ears have weak radial lirations. Arnold's figure 2 probably is the internal mold of his *Pecten* (*Propeamusium*) *waylandi* from the same locality.

Types: The holotype (USNM 107747) is from Davidson Bank north? of the entrance to Unimak Pass in the eastern Aleutian Islands, Alaska. Both the height and length measure 14 mm. Figured specimen, USNM 644870.

Locality of figured specimen: Postglacial deposits in the vicinity of Juneau, Alaska, USGS M243.

Occurrence: Dall (1902) reported that the species lives in Bering Sea, the Aleutian Islands, and eastward to Kodiak Island, Alaska; however, he later reported the locale to be (1921) only Davidson and Bowers Banks, Bering Sea. The fossil from near Juneau is well outside of its known Recent geographical range. *Polynemamussium davidsoni* also occurs in postglacial deposits near Juneau at USGS 5256.

Genus ARCTINULA Thiele, 1935

Propeamusium (*Palliolum* (*Arctinula*)) Thiele, 1935, Handbuch der systematischen Weichtierkunde, p. 806.

Type species (by monotypy): *Pecten greenlandicus* Sowerby/(=*Arctinula groenlandica* (Sowerby)). Recent. Greenland westward to Dolphin and Union Strait and southward to the Gulf of Saint Lawrence; Arctic except for the Beaufort and Chukchi Seas; Norway southward to northern Africa.

Discussion.—*Arctinula*, which was proposed as a section of the subgenus *Palliolum*, was raised to the rank of genus by Soot-Ryen (1958, p. 12), and it is here so regarded. The type species has been referred to the genus *Palliolum* by most modern authors.

Crosse (1885, p. 140) designated *Pecten incomparabilis* Risso as the type species of *Palliolum* Monterosato. If Roger's (1939, pl. 21, fig. 2a) figure of *Pecten incomparabilis* is correct, *Palliolum* has a sharp byssal notch and *Camptonectes*-like sculpture, characters very unlike those of *Arctinula groenlandica* (Sowerby). Stewart (1930, p. 118) made his *Delectopecten* a subgenus of *Palliolum* and stated that the type species of *Delectopecten*, *Pecten* (*Pseudamusium*) *vancouverensis*, has a weak *Camptonectes*-like microsculpture. Although he commented on the detached ear of *P. incomparabilis*, he did not mention its microsculpture.

Grau (1959, p. 57) concluded that *Palliolum* is a synonym of *Pseudamussium*. Even accepting, as did

Grau, the extremely tenuous reasoning of North (1951, p. 231) in determining the type species of *Pseudamussium* as *Ostrea hybrida* Gmelin, I am not convinced that it represents the same group as *Palliolum;* the type has since been determined as *Pecten septemradiatus* Müller.

Grau (1959, p. 53, pl. 20) further concluded that "*Pecten greenlandicus*" is a *Delectopecten;* he treats the species as *Cyclopecten* (*Delectopecten*) *groenlandica* (Sowerby). His photograph is probably the best figure of the species available. I cannot agree that *Arctinula groenlandica* is a *Delectopecten*, nor can I see any relationship between *A. groenlandica* and *Palliolum*, whatever the final deposition of that genus may be.

Despite its wide Arctic and Atlantic distribution, *Arctinula groenlandica* appears never to have gained access to Bering Sea or the northern Pacific Ocean.

Arctinula groenlandica (Sowerby)

Plate 4, figure 6

Pecten greenlandicus Sowerby, 1842, Thesaurus Conchyliorum, v. 1, p. 57, pl. 13, fig. 40.

Palliolum (*Arctinula*) *groenlandicum*, Thiele, 1935, Handbuch der systematischen Weichtierkunde, p. 806.

Palliolum groenlandicum, MacNeil, 1957, U.S. Geol. Survey Prof. Paper 294–C, p. 104, pl. 11, figs. 17, 18.

Arctinula groenlandica, Soot-Ryen, 1958, Norsk Polarinstitutt Skrifter, no. 113, p. 12.

Cyclopecten (*Delectopecten*) *greenlandicus*, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 53, pl. 20 (with extended synonymy).

Discussion.—Until Grau argued for a return to the original spelling, no author since Sowerby has spelled the name *greenlandicus*. Most authors have spelled it oe, and a few ø or ö.

Grau's excellent photographs of the species show clearly the smooth rounded anterior ear of the right valve and the very shallow byssal notch. Except for some faint radial striations and growth lines, both valves are smooth.

In all probability *Pseudamusium andersoni* Dall (1919, p. 19a, figs. 7, 8) (renamed *P. binominatus* Hanna, 1924, p. 175), Recent, from Dolphin and Union Strait, northern Canada, is a synonym. Ellis (1960, p. 39) reported *A. groenlandica* from Eclipse Sound in northern Baffin Island. Soot-Ryen (1932) said that the species lives along the Arctic coast from Norway to the East Siberian Sea but that it does not live in the Chukchi Sea or the Beaufort Sea.

The Alaskan beds containing *A. groenlandica* are the oldest marine Tertiary deposits in the Arctic Ocean area except for beds of approximately the same age in Spitzbergen. I have argued elsewhere (MacNeil, 1965) that these beds represent the first Tertiary marine invasion of the Arctic region and that the predominantly Atlantic affinities of the mollusks indicate that the first connection was with the Atlantic Ocean. Although many Pacific mollusks have escaped from the northern Pacific to the Arctic, and thence to the Atlantic, very few Atlantic species have entered the Pacific. Pacific to Atlantic migrations seem to have occurred periodically since late Miocene time but there is no evidence of migration during any earlier part of Tertiary time. The occurrence of *A. groenlandica* in Arctic Alaska may antedate the opening of Bering Strait. The species has not been found in any subsequent deposits on the Alaskan Arctic coast, and recent collecting has failed to reveal it living in the Beaufort and Chukchi Seas. If this species is ever found south of Bering Strait, it will have considerable stratigraphic significance.

Types: The whereabouts of the holotype is unknown. Grau's figured specimen measures 24 mm in height and 25 mm in length, probably about the maximum size. The figured specimen from the Nuwok Formation is numbered USNM 561876.

Locality of figured specimens: Lower part of the Nuwok Formation of Dall (1919) (horizon probably middle or upper Miocene), Carter Creek, a stream flowing into Camden Bay, northeastern Alaska, USGS D50 (T).

Genus CHLAMYS Roeding, 1798

Chlamys Roeding, 1798, Museum Boltenianum, p. 161

Type species (by subsequent designation, Herrmannsen, 1846): *Pecten islandicus* Müller. Recent. North Atlantic from Norway to Iceland, Greenland, and south to Cape Cod; Arctic Ocean between Greenland and the Laptev Sea. Not living in the Pacific.

Discussion.—Species included in the genus *Chlamys* are so similar morphologically that little division of the genus has been attempted. The genus contains, nevertheless, a very large number of species groups that appear to represent distinct phylogenetic lines. Many of the species groups have sculptural or other minor peculiarities that distinguish them. Ordinarily such characters are considered to be of specific rather than generic importance. In my opinion, however, *Chlamys* is one of the largest and most complex groups of mollusks, and it is not made less so by a lack of morphic types. I have no doubt that it will be divided eventually into several genera and subgenera on sound phylogenetic but relatively minor morphological grounds. While it is difficult to distinguish such groups in descriptive terms, trends in sculptural development are discernible. A certain amount of sculptural homeomorphy exists in *Chlamys*, but the value of sculpture cannot be minimized on that account. A well-defined phylogenetic series has as much validity in classification and as much value in stratigraphic work as a morphological oddity to which only a few known specimens can be assigned.

Subgenus LEOCHLAMYS MacNeil, n. subgen.

Type species: *Chlamys* (*Leochlamys*) *tugidakensis* MacNeil, n. sp. Pliocene. Alaska.

Description.—Shell of medium to moderately large size; moderately inflated, right valve more inflated than left valve; elongate dorsoventrally. Ears moderately large; recessed, the dorsal slope wider on left valve, anterior ear of right valve elongate and narrow, byssal sinus wide and deep with a moderately strong ctenolium. Ribs strong on both valves, interstitial ribs; present or absent; weakly to very strongly scabrous; many ribs have thick curved spines. Microsculpture reticulate or metal lathelike in juveniles, particularly on left valves, but consisting of fine continuous closely set raised lirations with a fanlike pattern in adults. Provinculum broad and gaping, extending nearly to the end of the ears; crurae moderately strong and weakly inclined. Muscle scars and umbonal callus inconspicuous.

Discussion.—The most distinguishing characters of *Leochlamys* are its long anterior ear, its deep, broad byssal notch, and its coarse, usually spiny ribs.

This subgenus is named in honor of Dr. Leo G. Hertlein, of the California Academy of Sciences, in recognition of his many contributions to the study of the Pectinidae.

Pectinids with deep, broad byssal notches and elongate or moderately elongate ears are known at least as early as Jurassic time. Such species as *Chlamys splendens* (Dollfus) (Arkell, 1931, pl. 10, figs. 1–5) and *C. nattheimensis* de Loriol (ibid., figs. 6–8) from the Jurassic, and *C. elongatus* (Lamarck) (Woods, 1902, pl. 32, figs. 1–3) from the Cretaceous resemble *C.* (*Leochlamys*) more closely in both auricular and sculptural characters than do the true *Chlamys* of the late Tertiary and Recent. These *Leochlamys*-like forms may prove to be the more archaic type of *Chlamys*.

Chlamys morphologically similar to the subgenus *Leochlamys* are known in the Atlantic-Mediterranean region throughout Miocene time. These include such forms as *C. multistriata* and *C. m. nimia* (Combaluzier, 1932, pl. 9, figs. 1–4) from the Burdigalian and Tortonian of Basse-Provence, France; *C. gloriamaris eggenburgensis* and *C. tauroperstriata alternicostata* (Schaffer, 1910, pl. 14) from the Burdigalian of the Vienna Basin; and both *C. justiana* and *C. varia* (Roger, 1939, pl. 22, figs. 19–23) from the Burdigalian to Calabrian beds in southern Europe.

Somewhat related Pacific species include *Pecten columbiana* Clark and Arnold (1923, pl. 23) from the Sooke Formation (early Miocene?) of Vancouver Island, and *Chlamys arakawai* (Nomura) (Masuda, 1954, pl. 19) from early and middle Miocene beds of Japan. Three Pliocene species are known from East Asia, *C. daishakensis* Masuda and Sawada (1961, p. 23, pl. 4, figs. 8, 9) and *C. iwakiana* (Yokoyama) from Japan, and *Pecten* (*Chlamys*) *tanassevitschi* Khomenko (see Slodkewitsch, 1938, pl. 20, fig. 5; pl. 21; pl. 22, fig. 1) from Sakahalin. *C. nipponensis* Kuroda and several related species (see Masuda, 1962b, p. 181) still live in Japan. The group is represented in the upper Mekran beds (Pliocene) of West Pakistan by *Pecten* (*Chlamys*) *alexandri* Vredenburg. Fleming (1948, p. 77, pl. 7, figs. 1–3) described a Recent species from New Zealand, *Chlamys suprasilis crespusculi*, that probably belongs to the same group, although the type is a juvenile shell.

At least two other Pacific groups have been recognized that appear to be more closely related to *C.* (*Leochlamys*) than to *C.* (*Chlamys*). One of these, *Scaeochlamys* Iredale (1929, p. 162), is based on *Pecten lividus* Lamarck (see Küster and Kobelt, 1888, pl. 52, figs. 1, 2) from Amboina, Indonesia, and it probably should also include *C. tegula* (Wood) and *C. squamata* (Gmelin). In my opinion the latter species does not belong in *Mirapecten* Dall, Bartsch, and Rehder (1938, p. 84; type *M. thaanumi* Dall, Bartsch, and Rehder, Recent from Hawaii), to which it was assigned by Kira (1955, p. 99). The other group, *Mimachlamys* Iredale (1929, p. 162) is based on *Pecten asperrimus* Lamarck from Australia. It probably includes *C. satoi* (Yokoyama) from the Byoritzu beds (Pliocene) of Formosa and the equivalent Naha Limestone of Okinawa.

Such a distribution for these supposedly *Leochlamys*-like forms, combined with their antiquity, might make it difficult to determine whether or not *C.* (*Leochlamys*) participated in any of the late Tertiary to Recent faunal migrations across the Arctic. The type species, *C.* (*L.*) *tugidakensis*, appears to be more closely related to a species occurring in the English Crags than to any known older Pacific species.

The apparent relative of *C.* (*L.*) *tugidakensis* in both the Coralline Crag (Pliocene) and the Red Crag (Pleistocene) of England was identified by Wood (1851, p. 33, pl. 6, figs. 4a–c) as *Pecten pusio* Pennant. According to Wood, the Crag species shows no evidence of attachment, but the Recent representatives of *P. pusio* attach themselves to rocks and stones by means of their spines. The latter description may be an allusion to *C. sinuosa* (Gmelin), a species included in *P. pusio* by several authors. Nyst (1878, pl. 16, figs. 1a–j), on the other hand, used the name *P. pusio* for a similar but more finely sculptured form from the Scaldesian of Belgium, which species Glibert (1957, p. 26) reidentified as *C. multistriata* (Poli).

223-848 O—67——2

Altena (1937, p. 60; see Heering, 1950, p. 43) proposed the name *Chlamys harmeri* to include both the Coralline Crag-Red Crag and Scaldesian forms. Actually *C. harmeri* is a substitute name for *Pecten striatus* J. Sowerby, non Müller, so that its type is a specimen from the Red Crag at Holywells near Ipswich, Suffolk. This is a finely ribbed form resembling *C. multistriata* and *C. tauroperstriata*, and it is not the species illustrated by Wood (1851, pl. 6, fig. 4a) as *Pecten pusio* var. *striatus* or as (ibid. fig. 4b) *P. pusio* var. *limatus*. The latter species is more closely related to *C.* (*L.*) *tugidakensis*. It may be the species figured by Wood (1874, pl. 8, fig. 7) as *P. varius*? from the Coralline Crag at Pettistree Hall near Sutton, Suffolk.

Despite the similarity of Wood's *Pecten pusio* to such European middle Tertiary species as *C. justiana* and *C. varia*, the actual succession of these forms has not been demonstrated. I am inclined to believe, however, that *P. pusio* of Wood and *C.* (*L.*) *tugidakensis* are approximately contemporaneous Atlantic and Pacific representatives of the same stock. It remains to be shown whether *C.* (*L.*) *tugidakensis* is a migrant from the northern Atlantic or whether the stock is one of European origin that reached the northern Pacific by way of the Tethys and reentered the northern Atlantic in late Pliocene or early Pleistocene time.

It has been shown quite conclusively by Fleming (1957) that the *Pecten jacobaeus* group migrated from the Atlantic-Mediterranean region to the Australia-New Zealand region in late Tertiary time. There is strong reason to believe that this group had a still earlier American origin and that it reached Europe in about middle Oligocene time. An undescribed species occurs in the Cooper Marl (Oligocene) of South Carolina (MacNeil in Malde, 1959, p. 15, 20); it was listed as *P.* n. sp. aff. *P. humphreysi* and has not been illustrated. A similar species was described by Von Koenen (1868, p. 232, pl. 26, fig. 12) from the Rupelian of Germany as *P. rupeliensis*. *Pecten humphreysi* Conrad occurs in the Calvert Formation (early Miocene) of Maryland, and a similar species, *P. borinquense* Hubbard (1920, p. 95, pl. 14, figs. 1, 2), was described from the Quebradillas Limestone (early? Miocene) of Porto Rico.

Fleming (1957, p. 16; p. 24, fig. 4), following Grant and Gale (1931, p. 222), suggested that the *P. jacobaeus* group is represented in Recent Japanese waters by *P. albicans* Schröter (Noda, 1961, pl. 3, figs. 1–4) and that the latter represents a branch of the group that reached Japan by way of California, where it is represented by the Pliocene *P. aletes* Hertlein (1925, p. 8, pl. 2, figs. 1, 4). At the time he wrote his paper, Fleming did not know, unfortunately, of *Pecten* (*Vola*) *byoritzuensis* Nomura (1933, p. 57, pl. 1, figs. 4a, b, 5a, b) from the Byoritzu beds (Pliocene) of Formosa. This species is much more closely related to *P. jacobaeus* and to its Australian and New Zealand relatives than to *P. albicans*. Since Numora's paper was published, *P. byoritzuensis* or a subspecies of it has been found to occur abundantly in the Naha Limestone (Pliocene) of Okinawa (U.S.G.S. collns., unpub.). The Okinawan Pliocene form is very closely related, in turn, to *P. aletes* Hertlein.

Morris (1952, p. 33, pl. 2) figured a specimen as *P. diegensis* Dall that definitely is not that species (see the photograph of the type in Arnold, 1906, pl. 51). If this shell came from California, it is a previously unrecorded species; it may be an incorrectly labeled specimen of *P. jacobaeus* from the Mediterranean.

As thus reconstructed, it seems likely that both *Leochlamys*-like forms and the group of *Pecten jacobaeus* followed migration routes similar to the routes Fleming (1957, p. 24, fig. 4*A*) postulated for the *P. benedictus* group. Both groups of *Pecten* migrated from Europe to Australia and New Zealand, as well as northward along the eastern Asiatic coast, and both seem to have crossed the equatorial Pacific to the American west coast. While the *P. jacobaeus* group seems to have accomplished its migration in Pliocene time, *Leochlamys*-like forms probably reached East Asia earlier. Whereas *Pecten* was confined to warm seas, *Leochlamys*-like forms invaded temperate and cool seas. A northern Pacific representative may have made a trans-Arctic migration to Europe in Pliocene time.

Chlamys (Leochlamys) tugidakensis MacNeil, n. sp.

Plate 7, figures 1–11; plate 8, figure 1

Description.—Shell of medium to moderately large size; medium inflated, the right valve more inflated than the left valve; dorsoventrally elongate. Anterior ear of right valve elongate and narrow; byssal sinus very broad and deep, byssal area wide with coarse growth lines; posterior ear of moderate size with a nearly vertical, slightly concave posterior margin. Anterior ear of left valve large and broad, anterior margin nearly vertical and slightly convex; posterior ear smaller with a weakly concave posterior margin. Dorsal margins weakly concave, dorsal slopes of right valve narrow with a shallow cleft, dorsal slopes of left valve broad and moderately undercut. Umbonal angle broader in young juvenile stage than in intermediate stage, flaring weakly again in adults. Ribs in juveniles definitely paired on the right valve, single with a well-defined interstitial riblet on left valve. Adult ribs more crudely paired, some paired ribs of equal size, others very unequal. Interstitial ribs rarely present on the right valve

of adults; interstitial ribs of left valve nearly as strong as primary ribs in adults. Adult ribs of both valves set with thick, broad, flattened or curved, irregularly spaced spines. Microsculpture consisting of fine raised *Camptonectes*-like lines that have a fanlike pattern within each interspace and rise along the sides of the adjacent ribs; the juvenile stage of the left valve has a reticulate or metal lathelike microsculpture. Interior of shell weakly corrugated.

Discussion.—Except for *C.* (*?L.*) *columbiana* (Clark and Arnold) (1923, pl. 23) from the Sooke Formation (early Miocene?) of Vancouver Island, British Columbia, no pectinids that have a long ear and a deep byssal notch have been described from the American west coast. *C.* (*?L.*) *columbiana* has much weaker spines on its ribs, and the right valve has fine interstitial riblets. Inasmuch as pectinids of this type are an ancient group, there is no assurance that *C.* (*L.*) *tugidakensis* is descended from *C.* (*?L.*) *columbiana.* Some poorly preserved specimens from the lower part of the Yakataga Formation reported by me as *Vertipecten* sp. indet. (MacNeil, 1961, p. 236) may belong to this group, but the known specimens are internal molds. *Leochlamys*-like forms appear to have been in the northwestern Pacific area from early Miocene? through Pliocene time.

Types: The holotype (USNM 644871), a right valve, measures height 70 mm, length 60 mm. The paratype (USNM 644872) is a left valve. Other figured specimens are numbered USNM 644873–644881, 645052.

Type locality: Near the center of the northwest side of Tugidak Island, Alaska, 320 ft below the top of a section computed to be 3,520 ft thick, 56°31″ N., 154°42″ W., USGS M1494.

Other occurrences: 1,900 ft above the base of the Tugidak Island section, USGS M1895; several horizons in the lower 2,500 ft of a section estimated to be nearly 4,000 ft thick, Middleton Island, Alaska, USGS 17746, M1746, M1751, M1754; upper part of Yakataga Formation (horizon probably Pliocene), along south side of Deadfall Creek north of La Perouse Glacier, Lituya district, Alaska, USGS M1851; upper part of the Yakataga Formation (horizon probably Pliocene) in the Chaix Hills, Malaspina district, Alaska, USGS M1878.

Subgenus SWIFTOPECTEN Hertlein, 1935

Pecten (*Swiftopecten*) Hertlein, 1935, California Acad. Sci. Proc., 4th ser., v. 21, no. 25, p. 319.

Type species (by original designation): *Pecten swifti* Bernardi. Recent. Japan.

Discussion.—*Swiftopecten* is one of the most distinctive subgenera of *Chlamys.* Masuda (1959a, p. 87) used *Swiftopecten* as a subgenus of *Chlamys*, as do most recent authors; a few authors still include it under *Pecten.* At that time, Masuda discussed the apparent relationship of *Swiftopecten* to *Chlamys cosibensis* (Yokoyama). In 1960, however, Masuda (1960, p. 380) decided that *Pecten swifti* was related to and probably descended from *P. notoensis* Yokoyama, which species Hatai and Masuda (1953, p. 76) had earlier made the type of a new genus, *Nanaochlamys.* Inasmuch as *Swiftopecten* was thus presumed to have evolved from a group not part of *Chlamys*, he raised *Swiftopecten* to generic rank, a practice which he continued to follow in 1962 (Masuda, 1962b, p. 131, 195).

While there might be some justification for treating *Swiftopecten* as a genus because of its morphological pecularities, I doubt very much if it is closely related to *Nanaochlamys notoensis. C.* (*S.*) *swifti* appears to be rather closely related to *Pecten* (*Swiftopecten?*) *otutumiensis* Nomura and Hatai (see Masuda, 1960, pl. 39, figs. 6–8), from the Otsutsumi Formation (middle Miocene) of northern Honshu; but, here again, I can see no relationship with *N. notoensis;* Masuda treated this form as a subspecies, *Nanaochlamys notoensis otutumiensis.*

There is a striking similarity between *Nanaochlamys notoensis* and *Chlamys* (*Flexopecten*) *schafferi* Kautsky (see Roger, 1939, p. 200, pl. 27, figs. 1, 2) from the Tortonian of the Vienna Basin. If these two forms are related, as they certainly seem to be, either a Tethyan origin or the migration of the stock to East Asia by a Tethyan route seems most likely.

Nanaochlamys notoensis (Yokoyama) was described from the Nanao Formation (early Miocene) near Nanao, Ishikawa Prefecture, west-central Honshu. Specimens of the species collected by Dr. Kotora Hatai, and Dr. Shoshiro Hanzawa of Tohoku University, and by me from the Moniwa Formation (early Miocene), Miyagi Prefecture, northeastern Honshu, show the left valve to be flat or slightly concave in the juvenile stage. This condition suggests a relationship of *Nanaochlamys* with *Pecten* (*Pecten*) rather than with *Chlamys* or *Swiftopecten.*

Chlamys kitamurai Kotaka (1955, p. 26, pl. 2, fig. 2; Masuda, 1962b, p. 199, pl. 20, fig. 12), from the Isomatsu Formation (late Oligocene) of Aomori Prefecture, northern Honshu, may well be the earliest known *Swiftopecten;* Masuda treated the species as *Nanaochlamys kitamurai.*

If some of the forms figured by Masuda (1959b, pl. 13) as *Chlamys cosibensis*, or subspecies of it, are not related to *Swiftopecten*, as Masuda seems now to believe, they exhibit a remarkable amount of homeomorphy with *Swiftopecten.* The *Chlamys cosibensis* group may yet prove to have diverged from *Swiftopecten* in Oligocene time. The ribbing on juvenile right valves is very similar in *Swiftopecten* and the group of *Chlamys beringiana* (compare pl. 20, fig. 1 with Slodkewitsch, 1938, pl. 23, fig. 3).

Chlamys (*Swiftopecten*) *donmilleri*, here described from middle Miocene beds of Alaska, is the oldest Amer-

ican representative of the subgenus yet known. Several Pliocene species have been described from California. *C.* (*S.*) *kindlei* (Dall) is one of the most abundant species in the Intermediate Beach (middle Pleistocene) at Nome, Alaska, but no other American Pleistocene or Recent occurrences are known.

The existence of *Swiftopecten*-like forms in Europe poses some further problems of origin, descent, and name priority. *Manupecten* Monterosato, 1889 (type, *Ostrea pes-felis* Linné, Recent, Mediterranean) is remarkably like *Swiftopecten*. According to Roger (1939, p. 179), *C.* (*M.*) *pes-felis* has been in the Mediterranean from Calabrian (early Pliocene) to Recent time. Conceivably, it could be a migrant from the Pacific.

Until more is known of Tertiary migration routes and the place of origin of different pectinid stocks, it would be unwise to make a decision concerning the synonymy of *Manupecten* and *Swiftopecten*. To do so might obscure some very important morphic and phylogenetic trends, as well as some important avenues of migration. It is not known to what extent groups of central or southern Pacific origin may have migrated to the northern Pacific nor to what extent they may have migrated to Europe by a Caribbean route, and it is not known whether any groups migrated westward through the Tethys. There is a distinct possibility, however, that the modern European fauna is a mixture of stocks that originated in European waters and remained there throughout Tertiary time and of representatives of the same stocks that migrated to East Asia via a Tethyan route and back to Europe in late Tertiary or Quaternary time via an Arctic route. Other species of undoubted European origin lived in the extreme northern Pacific region from late Miocene to Recent time. Some such groups undoubtedly reached the Pacific by way of the Arctic.

Chlamys (Swiftopecten) donmilleri MacNeil, n. sp.

Plate 3, figures 1, 4, 6

Description.—Shell of medium size, moderately inflated; hinge of medium length; umbonal angle moderately narrow in juveniles but flaring strongly in adults; shell weakly asymetrical anteroposteriorly, strongly plicate and strongly varicate. Anterior ear of right valve moderately long, byssal area narrow, byssal notch moderately shallow; posterior ear of right valve short with a nearly vertical posterior margin. Ears of left valve unknown. Right valve has four strong medial plicae and an indistinct narrow plication at each end, interspaces about half as wide as plications, deepest between the growth varices; secondary sculpture consisting of low flattened lirations, 9 or 10 on the plications and 5 to 8 in the interspaces, strongest at the edge and on the forward slope of the growth varices. Left valve has five moderately strong plicae and wider interspaces that are more deeply sunken between the varices; secondary sculpture consists of raised lirations that tend to be weakest midway between the varices, although the crest of some varices may be nearly smooth. Interior features not known.

Discussion.—This species and the following doubtfully identified forms from the Alaska Peninsula are the oldest *Swiftopecten* to be recorded from America. *C.* (*S.*) *donmilleri* occurs in the part of the Yakataga Formation believed to be of middle and late Miocene age, and the Alaska Peninsula forms occur in association with *Mytilus middendorffi* Grewingk, believed to be a reliable indicator for the middle Miocene.

A *Swiftopecten* of comparable age and probably closely related to *C.* (*S.*) *donmilleri* was figured by Masuda (1959a, pl. 9, fig. 1) as *C.* (*S.*) *swifti*. It comes from the Otsutsumi Formation (middle Miocene; late early Miocene in a twofold division) of Miyagi Prefecture, northern Honshu. A right valve from the same locality was figured by Nomura and Hatai (1937, pl. 18, fig. 6).

Nomura and Hatai (1937, p. 130, pl. 18, fig. 7 (described another species from the Otsutsumi Formation as *Pecten* (*Swiftopecten?*) *otutumiensis*. Masuda (1960, pl. 39, fig. 8) figured another specimen from the same locality as *Nanaochlamys notoensis otutumiensis*. Whether or not this form proves to be a variant of the form assigned to *C.* (*S.*) *swifti* remains to be seen, but I doubt if it has any relationship to *Nanaochlamys notoensis*. Masuda (1960, pl. 39, figs. 6, 7) also figured two specimens from the Suenomatsuyama Formation (middle and late Miocene according to Masuda; late Miocene and early Pliocene according to Hatai and Nisiyama, 1952, p. 14) as *N. notoensis otutumiensis*. These are definitely a *Swiftopecten*, in my opinion, and the left valve strongly resembles a fragment figured here (pl. 3, fig. 2) from middle Miocene beds at Port Moller, Alaska Peninsula.

Types: The holotype (USNM 644882), a right valve, measures 69 mm in height and 64 mm in length. The paratype (USNM 644883) and a figured specimen (USNM 644884) are incomplete left valves.

Type locality: 1,500 ft above base of Yakataga Formation (horizon probably middle Miocene), south side of White River near foot of glacier, Yakataga district, Alaska, USGS 6694.

Other occurrences: Near base of Yakataga Formation (horizon probably middle Miocene), unnamed creek north of and parallel to Yakataga Ridge, Yakataga district, Alaska, USGS 15437; near base of Chaix Hills section of Yakataga Formation (horizon probably upper Miocene), south flank of Chaix Hills near margin of Malaspina Glacier, USGS 17817.

Chlamys (Swiftopecten) cf. C. (S.) donmilleri MacNeil

Plate 3, figure 3

Discussion.—A specimen collected by the Shell Oil Co. from the northwest side of Cape Aliaksin, Alaska Peninsula, differs from the holotype of *C.* (*S.*) *donmilleri* by having stronger and more continuous secondary riblets on its primary plicae; the plicae are broader and the interspaces correspondingly narrower. Whether or not this is a matter of individual variation is not certain on the basis of the few specimens at hand.

The only other fossil found with this specimen was a small barnacle, but other collections of similar lithology from the same region have yielded *Mytilus middendorffi*. The specimen is believed to be from the basal part of the Unga Conglomerate (horizon probably basal middle Miocene).

Figured specimen: (USNM 644885), consists of two fragments presumably of the same right valve. It has a height of approximately 62 mm.

Locality of figured specimen: Greenish gravelly sandstone, east side of Beaver Bay and along the southwest-northeast-trending coast at the northwest corner of Cape Aliaksin, Alaska Peninsula, USGS M2132.

Chlamys (Swiftopecten) sp.

Plate 3, figure 2

Discussion.—The mold of an incomplete left valve is present in a collection from the east side of Port Moller. It is associated with numerous specimens of *Mytilus middendorffi*, *Pododesmus* (*Monia*) sp., *Spisula*?, *Tellina*, and *Crytonatica*?, and presumably it comes from the lower part of the Unga conglomerate (middle Miocene).

The specimen has small, widely spaced radial plicae and numerous interstitial riblets. It compares most closely with a left valve figured by Masuda (1960, pl. 39, fig. 7) as *Nanaochlamys notoensis otutumiensis*.

Figured specimen: USNM 644886, a rubber cast of a fragment of a left valve, measures 41 mm in its longest dimension.

Locality of figured specimen: USGS 5046.

Chlamys (Swiftopecten) swifti kindlei (Dall)

Plate 3, figures 5, 7–9

Pecten (*Chlamys*) *kindlei* Dall, 1920, U. S. Geol. Survey Prof. Paper 125–C, p. 30, pl. 6, figs. 2, 7.

Pecten (*Pallium*) *swifti kindlei*, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 174, pl. 10, fig. 7.

Pecten (*Manupecten*) *kindlei*, MacNeil *in* MacNeil, Mertie, and Pilsbry, 1943, Jour. Palentology, v. 17, no. 1, p. 87, pl. 12, figs. 7, 8.

Chlamys (*Swiftopecten*) *swifti kindlei*, Masuda, 1959, Trans. Proc. Paleant. Soc. Japan, new ser., no. 34, p. 93.

Chlamys (*Swiftopecten*) *kindlei*, MacNeil *in* Hopkins, MacNeil, and Leopold, 1960, 21st Internat. Geol. Cong. Proc., pt. 4, p. 50.

Swiftopecten swifti kindlei, Masuda, 1962, Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 33, no. 2, p. 196.

Discussion.—*Chlamys* (*Swiftopecten*) *swifti* is certainly the closest known relative of this Alaskan form, regardless of whether they are considered one or separate species. *C.* (*S.*) *swifti kindlei* is less inflated than typical *C.* (*S.*) *swifti*, the plicae are less raised, and there is very little tendency for the shell to develop varices and nodes. From the stratigraphic and migrational standpoint, it probably is desirable for the nomenclature to emphasize the similarities rather than the differences.

The Mediterranean species, *C.* (*Manupecten*) *pesfelis*, has a narrower umbonal angle, narrower and higher plicae, and finer secondary riblets. In addition, it has a row of rounded nodes along the dorsal margin of both ears.

I am inclined to believe that *C.* (*S.*) *kindlei* is a Pleistocene offshoot from the typical *C.* (*S.*) *swifti* of Japan rather than a descendant of the Alaskan Miocene *C.* (*S.*) *donmilleri* or any of the California Pliocene species. *C.* (*S.*) *kindlei* is one of the most abundant species in the Intermediate Beach at Nome, and it certainly is the most conspicuous fossil. Unless it was brought to Nome from East Asia in a single pelagic transportation, it may yet be found elsewhere in an intervening area, possibly the Aleutians. Slodkewitsch (1938, p. 108) reports *C.* (*S.*) *swifti* from the Pomyr Series (late Pliocene?) of Sakhalin, and (ibid., p. 109) *C.* (*S.*) *swifti piltukensis* (Khomenko), a very weakly plicated form, from both the Pomyr Series of Sakahalin and the Upper Kavran Series (late Pliocene?) of Kamchatka. Merklin, Petrov, and Amitrov (1962), however, do not report *Swiftopecten* from any Pleistocene beds in the Chukotsk Peninsula. There is no evidence at present, therefore, that *Swiftopecten* reached Alaska by way of Chukotsk, the closest Asiatic region geographically.

Types: The specimens figured by Dall are designated the lectotype (right valve) and lectoparatype (left valve), respectively; both are numbered USNM 324301. The largest specimen figured here (USNM 644887), a right valve, measures height 115 mm, length 97 mm. A smaller left valve is numbered USNM 644888; two left-valve fragments are numbered USNM 644889, 644890.

Type locality: Intermediate Beach (middle Pleistocene), Nome, Alaska, USGS 7619? This may be USGS 5074 incorrectly numbered; at any rate, the species has been found only in the Intermediate Beach.

Other occurrences: Intermediate Beach, USGS 4537, 4538, 5313, 14866, M333, M1084, M1252.

Subgenus CHLAMYS Roeding

Discussion.—The species here treated as *Chlamys* ("*Chlamys*") belong to the large Jurassic to Recent group generally referred to the genus *Chlamys*, but not to the typical subgenus which consists of exclusively

northern Atlantic and northern Pacific species closely related to *Pecten islandicus* Müller. As thus restricted, typical *Chlamys* (*Chlamys*) ranges from late Miocene to Recent. Even as here treated the subgenus may be found ultimately to be polyphyletic. The *C. islandica* and *C. beringiana* groups may be found to be coordinate in rank and derived from different species of a still unnamed ancestral subgenus of *Chlamys*. Until much more is known of the actual phylogeny of these groups, it is probably best to combine them.

Group of C. ("C.") hastata (Sowerby)

Chlamys ("Chlamys") hastata (Sowerby)

Plate 24, figures 7, 10

Pecten hastatus Sowerby, 1843, Thesaurus Conchyliorum, v. 1, p. 72, pl. 20, fig. 236.

Pecten (Chlamys) hastatus, Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 108, pl. 42, figs. 1, 1a, 2, 2a (with extended synonomy).

Chlamys hastata, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 84, pls. 27, 28 (with extended synonomy).

Discussion.—Of the species here doubtfully referred to the subgenus *Chlamys* (*Chlamys*), *Pecten hastatus* Sowerby is probably the species most distantly related to the type species, *C.* (*C.*) *islandica*. It certainly falls within the genus *Chlamys* as construed by most authors and it probably shares with *Chlamys* (*Chlamys*) an ancestry in some Tertiary *Leochlamys*-like form; that is, both are derived from the more primitive type of *Chlamys*, which has a moderately high shell, a long anterior right ear, and a broad byssal notch.

Arnold (1906, pl. 11, fig. 4) figured a specimen from beds of late Pliocene or early Pleistocene age near San Pedro, Calif., as *Pecten* (*Chlamys*) *hastatus*. This specimen has broader scales on its ribs than the Recent *C. hastata*, and the drawing does not show the fine interstitial riblets. A more typical specimen of *C. hastata* (as *Pecten* (*Pecten*) *hastatus*) was figured by Grant and Gale (1931, pl. 11, figs. 6a, b) from supposed early Pleistocene beds in Ventura County, Calif.

One possible relationship of *C. hastata* is suggested by the similarity of the long ear, the broad byssal notch, and the juvenile sculpture to the corresponding parts of *C.* (*Leochlamys*) *tugidakensis* (compare Arnold's figures of *C. hastata* (1906, pl. 42, figs. 1, 1a, 2, 2a) with *C.* (*L.*) *tugidakensis* (pl. 7)). A very definite pairing of the ribs on juvenile right valves is apparent in both species. If *C. hastata* should prove to be derived from some Miocene representative of *Leochlamys*, it would, of course, have no close relationship to any of the other northern Pacific *Chlamys* (*Chlamys*) here discussed.

Grau (1959, p. 90) regarded *C. pugetensis* (Oldroyd) as a subspecies of *C. hastata*. Both of these species are equally remote from *C. islandica*. These forms are undoubtedly related, but I am inclined to regard them as separate species. *C. pugetensis* has a superficial resemblance to *C. multistriata* (see Sacco, 1897, pl. 1, figs. 12–19), a member of a group known throughout the middle and late Tertiary of southern Europe.

C. hastata is probably indigenous to the Pacific. An apparently undescribed species from the Pancho Rico Formation (early Pliocene) northeast of King City, Monterey County, Calif., UC A906, has a broad byssal notch and sculpture resembling that of *C. hastata hericius* although it is somewhat less scabrous. Juveniles of both this undescribed species and *C. hastata* are nearly identical for about the first 10 mm of growth. Adults of *C. pugetensis*, which usually do not exceed 30 mm in height, also resemble a comparable stage of the Pancho Rico species.

The stock of *C. hastata* may be represented in the Red Crag (early Pleistocene) of England by *Pecten disparatus* Wood (1882, p. 12, pl. 1, fig. 17). Wood was unable to find an undoubted relative of this single shell in Europe.

Types: The holotype, in the British Museum, is a juvenile shell; Sowerby gives its height as 1.15 in. (29 mm). Adults of the species average about 65 mm in height. Figured specimens, USNM 644891, 644892.

Type locality: Unknown. Grau (1959, p. 85) designated San Diego, Calif., as the type locality.

Locality of figured specimens: Santa Barbara County dump Foothill Boulevard, about three-fourths mile west of intersection with State Highway 150, NW¼ sec. 11, T. 4 N., R. 28 W., Santa Barbara County, Calif. Santa Barbara Formation (horizon lower Pleistocene).

Occurrence: Pliocene to Recent in southern California. The species now lives from San Diego to Monterey, Calif.

Chlamys ("Chlamys") hastata hericius (Gould)

Plate 21, figures 1, 3

Pecten hericius Gould, 1850, Boston Soc. Nat. Hist. Proc., v. 3, p. 345.

Gould, 1852, U.S. Exploring Exped., v. 12, p. 457, pl. 42, figs. 570a–c.

Pecten (Chlamys) hericeus, Dall, 1898, Wagner Free Inst. Sci. Trans., v. 3, no. 4, p. 708.

Pecten (Chlamys) hastatus var. *hericius*, Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 110, pl. 43, figs. 3, 3a.

Pecten (Pecten) hastatus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 166. (In part.)

Chlamys hastata hericia, Grau, 1959, Allan Hancock Pacific Exped. v. 23, p. 87, pl. 29 (with extended synonymy).

Discussion.—Typical *C. hastata* ranges from Monterey to San Diego, Calif., whereas *C. hastata hericius* ranges from the Gulf of Alaska to Santa Barbara, Calif. The more extreme variants of typical *C. hastata* have high, sharp crested ribs with moderately large spinelike scales, whereas the opposite extreme of *C. hastata hericius* has low bundles or fascicles of riblets with all the riblets finely and equally scabrous. Some

intermediate specimens might be difficult to assign to either subspecies. If living individuals of these forms do not constitute an entirely continuous series of variation, they come very close to it.

The more finely ribbed variants of *C. hastata hericius* are believed to be the more archaic form of the species. The type of *Pecten altiplicatus* Conrad (see Arnold, 1906, pl. 41, fig. 4) from beds of late Pliocene age near Santa Barbara, Calif., is closer to the borderline between typical *C. hastata* and *C. hastata hericius*. Much more will have to be known of the early history of the *C. hastata* group before it can be said with certainty that it is related to any known Alaskan or Japanese group.

Types: The holotype (USNM 5955) was figured by Gould (Johnson, 1964, p. 87). Arnold (1906, pl. 43, figs. 3, 3a) figured one of the coarsely sculptured variants. Figured specimen (CAS 12611), one of the more finely sculptured variants, measures 66 mm in height and 60.5 mm in length.

Type locality: Strait of Juan de Fuca, Wash. The subspecies lives from the Gulf of Alaska to Santa Barbara, Calif.

Locality of figured specimen: Puget Sound, CAS loc. 31879.

Chlamys ("Chlamys") pugetensis (Oldroyd)

Plate 22, figures 4, 5

Pecten islandicus pugetensis Oldroyd, 1920, Nautilus, v. 33, p. 136, pl. 4, figs. 5, 6.

Pecten (Chlamys) islandicus pugetensis, Dall, 1921, U.S. Natl. Museum Bull. 112, p. 19.

Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 55, pl. 12, figs. 4, 5.

Oldroyd, 1924, Puget Sound Biol. Sta. Pubs., v. 4, p. 18, pl. 9, figs. 5, 6.

Pecten (Pecten) hastatus var. *pugetensis*, Grant and Gale, 1931, San Diego Soc. Natl. History Mem., v. 1, p. 168.

Chlamys hastata pugetensis, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 90, pl. 10 (with extended synonymy).

Description.—Shell small, rarely exceeding 35 mm in height. Anterior ears large; anterior ear of right valve may be very long and straight; byssal sinus may be well rounded or angulate. Anterior dorsal margin usually a little longer than posterior dorsal margin. Ribs usually show a weak differentiation into primary, secondary, and even tertiary series. Ribs of right valve are bluntly rounded, but ribs of left valve tend to have a narrow rounded crest; small upright scales may be present. Primary ribs, and some other ribs, tend to become tripartite near the margin by the addition of minor riblets or ridges on the sides. The microsculpture is reticulate or metal lathelike and usually covers all the interspaces. Color is extremely variable. Some specimens have a nearly white right valve and brown radiating bands on the left valve. Other specimens have a reddish-orange left valve and a brownish right valve, sometimes with purple concentric bands; anterior ear of the right valve may be pure white. Still other specimens are uniformly reddish orange.

Discussion.—This small pectinid is sufficiently distinct to stand as a separate species. Middendorff's original figures of *C. beringiana* are reconstructed so as to give the impression of relationship to *C. pugetensis*. I am not aware of the occurrence of *C. pugetensis* in Bering Sea. Grant and Gale (1931, p. 168) and Grau (1959, p. 90) associated this form with *Pecten hastatus* and Burch (1944, p. 5) associated it with *P. hericius*. Its closest known relative probably is *C. hastata hericius*, but it diverged from the *hastata* stock in Pliocene time (see remarks under *C. hastata*, p. 14).

Types: The holotype is in the collections of Stanford University. The figured specimens (USNM 637739, 637740) are different individuals; the larger, a left valve, measures 31 mm in height and 26 mm in length.

Type locality: Recent, San Juan Island, Puget Sound, Wash.

Distribution: This species was identified from supposed Pliocene beds near Los Angeles (Grant and Gale, 1931, p. 168). It was collected by W. O. Addicott, of the U.S. Geological Survey, from a terrace deposit of late Pleistocene age about one-half mile southeast of Point Año Nŭevo, San Mateo County, Calif. The species is fairly abundant in the vicinity of Puget Sound. Grau (1959, p. 91) gave its Recent range as Newport Bay (near Los Angeles), Calif., to Hinchinbrook Island, Prince William Sound, Alaska. The specimen figured here is from Sitkalidak Island, USGS M2064, off eastern Kodiak, a further extension of its range.

Group of C. ("C.") tauroperstriata Sacco

Chlamys ("Chlamys") harmeri Altena

Plate 24, figures 4, 6

Pecten striatus J. Sowerby, Mineral Conchology of Great Britain, v. 4, pl. 394, figs. 2–4 (non Müller, 1776).

Pecten substriatus Orbigny, 1852, Prodrome de Paleontologie, v. 3, p. 129 (non Roemer, 1835).

Chlamys harmeri Altena, 1937, Bijdrage tot de kennis der fossiele, subfossiele en Recente Mollusken, die op de Nederlandsche stranden Aanspoelen, en hunner verspreiding, p. 60.

Discussion.—*Chlamys harmeri* is a substitute name for the preoccupied *Pecten striatus* J. Sowerby. I am inclined to agree with Altena (written commun., Nov. 5, 1964) that this species is not a synonym of *C. multistriata* (Poli), with which it and several related forms have been synonymized by several recent authors. As pointed out by Altena, *C. multistriata* is a small species, and *C. harmeri* is probably more closely related to *C. tauroperstriata* Sacco. Glibert (1957, p. 26), in one of the latest studies, of the species, stated that *C. multistriata* from the Burdigalian of the Vienna Basin and *C. harmeri* are of comparable size and that the two forms cannot be

separated on that basis. It would seem, however, that the bearing of a middle Miocene form on the relationship of two post-Tertiary forms must certainly be contingent on a much more thorough study of this group than has been undertaken so far.

This species is the *Pecten pusio* of Nyst (1878, pl. 16, figs. 1a–j), but it is not the *Pecten pusio* of Wood (1851, pl. 6, figs. 4a–c). Probably it is also the *C. multistriata* of Glibert (1957, p. 26), at least in part. According to Dodge (1952, p. 179), *Ostrea pusio* Linné is unidentifiable. He recommended that it be accepted as the valid name for *Pecten multistriatus* Poli because it was so used by virtually all writers of the last half of the 19th century. He quoted Bucquoy, Dautzenberg, and Dollfus, however, as saying that the name should be abandoned.

Types: The holotype of *Pecten striatus* J. Sowerby is presumably in the British Museum. As a stubstitute name, *C. harmeri* has the same type. Figured specimen (USNM 644895), a right valve, measures 52 mm in height and 47 mm in length. The figured left valve is numbered USNM 644896.

Type locality: Holywells, southeastern outskirts of the town of Ipswich, Suffolk. Red Crag (early Pleistocene), probably the Newbournian Stage.

Locality of figured specimens: Dredged from the Westerschelde, westernmost Netherlands, USGS M2519. Probably Scaldesian (early Pleistocene).

Chlamys ("Chlamys") breidavikensis MacNeil, n. sp.

Plate 25, figures 4–8

Description.—Shell moderately large, subrounded, left valve more inflated than right valve. Anterior ear of right valve moderately short and broad, byssal notch moderately shallow and V-shaped; posterior ear moderately short, posterior margin nearly straight and sloping at about 45°. Anterior ear of left valve moderately short and broad, anterior margin nearly vertical; posterior ear short and steeply sloping. Dorsal margins subequal or anterior margin slightly straighter and more elongate. Dorsal slopes of left valve broader and more undercut than on right valve. Ribs moderately fine with only 1 or 2 ribs showing any tendency to divide; right valve has about 90 ribs, 8 to 10 of which are on the dorsal slopes; a few of the terminal ribs might be regarded as interstitial riblets, but they are nearly as strong as the other ribs. Anterior ear of left valve has about 15 fine ribs. Ribs low, sculptured only by growth lines. Interspaces shallow and bearing reticulate microsculpture on the right valve; left valve interspaces may have reticulate microsculpture on early stages but in later stages they are smooth or have raised concentric lamellae.

Discussion.—*C.* ("*C.*") *breidavikensis* has about 30 more ribs than *C. islandica* on half-grown individuals. Large individuals of *C. islandica* may have about 90 riblets near the ventral margin, but many of the ribs divide once or twice to produce that number; very few of the ribs of *C. breidavikensis* bifurcate. Both of the posterior ears of *C. islandica* have a more sinuous margin and fewer and coarser ribs.

Both *C. breidavikensis* and *C. tjornesensis* have been reported in previous lists as *C. islandica*, but neither is that species, nor am I convinced that either is very closely related to *C. islandica*. In my opinion, *C. breidavikensis* is more closely related to the group of *C. multistriata* and *C. tauroperstriata;* typical *C. islandica* is more closely related to early Pleistocene forms in the northern Pacific. If an until intermediates are found, however, that definitely link *C. breidavikensis* with some other species, the exact relationships of all these species will remain in doubt.

Types: The holotype (USNM 644897), an incomplete right valve, has a length of 72 mm. The paratype (USNM 644898) is an incomplete left valve. Other figured specimens are numbered USNM 644899–901.

Type locality: Base of the highest fossiliferous bed in the Breidhavik section, beach southwest of lighthouse at Valadalstorfa, Tjörnes, northern Iceland (horizon probably early glacial Pleistocene), USGS M2153.

Group of C. ("C.") gloriamaris (Dubois)

Chlamys ("Chlamys") tjornesensis MacNeil, n. sp.

Plate 25, figures 1–3

Description.—Shell moderately large, subrounded to elongate dorsoventrally; left valve more inflated than right valve. Anterior ear of right valve large and moderately elongate; byssal notch broad and rounded at juncture with dorsal margin; posterior ear unknown. Anterior ear of left valve broad, margin nearly vertical to sinuous; posterior ear moderately short, margin vertical or slightly inclined. Dorsal margins slightly concave, anterior margin slightly longer. Dorsal slopes of left valve moderately broad, posterior slope weakly undercut, anterior slope concave but not undercut; anterior ear of right valve nearly flush with edge of disc. Ribs of right valve weakly divided into primary, secondary, and tertiary series; primary ribs weakly bifurcating in advanced growth stage, remaining usually as a split rib with a moderate median sulcus. Left valve tending to have more discrepant primary, secondary, and tertiary ribs in juvenile stage; in advanced stage the ribs tend to be more uniform and rounded. Ears with moderately coarse ribs.

Discussion.—The living species most nearly resembling *C. tjornesensis* probably is *C. wainwrightensis* from Arctic Alaska. The apparent morphological hiatus between *C. wainwrightensis* and any other Alaskan or Pacific species suggests that these forms may indeed be

related. Inasmuch as nothing is known of possible Pleistocene intermediates, however, it is not possible to demonstrate the derivation of *C. wainwrightensis* from *C. tjornesensis* at this time.

A possible antecedent of *C. tjornesensis* was figured by Schaffer (1910, pl. 14, figs. 8, 9) as *C.* aff. *C. longolaevis* Sacco. The fragments so figured may be extremely sculptured variants of the species Schaffer identified as *C. gloriamaris*. While *C. tjornesensis* has been identified by several past authors as *C. islandica*, there seems to be no close relationship with that species.

Types: The holotype (USNM 644902), an incomplete right valve, measures 85 mm in height. The paratype (USNM 644903) is an incomplete left valve. Another figured specimen, an incomplete left valve, is numbered USNM 644904.

Type locality: Sea cliff south of the mouth of Hallbjarnarstadhaá, Tjörnes district, northern Iceland, *Glycymeris* bed of the *Mactra* zone (horizon probably uppermost Pliocene), USGS M2203.

Other occurrences: Sea cliff north of the mouth of Hallbjarnarstadhaá Tjörnes district, northern Iceland, *Serripes groenlandicus* zone (horizon probably lower Pleistocene), USGS M2155.

Group of C. ("C.") cosibensis (Yokoyama)

Chlamys ("Chlamys") cf. C. ("C.") cosibensis (Yokoyama)

Plate 11, figures 9, 11, 12

?*Pecten cosibensis* Yokoyama, 1911, Geol. Soc. Tokyo Jour., v. 18, no. 208, p. 4, pl. 1, figs. 3, 4.

?*Pecten heteroglyptus Yokoyama*, 1926, Tokyo Imp. Univ. Fac. Sci. Jour., sec. 2, v. 1, pt. 8, p. 304, pl. 33, figs. 1–8.

Discussion.—The specimens from Tugidak here compared with *Chlamys* ("*Chlamys*") *cosibensis* are most like some of the specimens of C. *cosibensis heteroglypta* figured by Yokoyama (1926) from the Sawane Formation (early Pliocene) at Kaidate-no-sawa, Niigata Prefecture, northwestern Honshu. The right valve (pl. 11, fig. 9) has flat-topped but well-defined fascicles resembling those of the specimen in Yokoyama's plate 33, figure 5.

While the Tugidak form may be sufficiently distinct to have at least a separate varietal name, the wide range of variation shown by the available figures of *C. c. heteroglypta* and *C. c. cosibensis* appears to include variants similar to the form from Tugidak.

Two of the figures of *Pecten heteroglyptus* in Yokoyama's (1926, pl. 33, figs. 6, 7) original proposal of the species were treated as *P. heteroglyptus* var. *cosibensis* in violation of the priority of *cosibensis*. He appears to have acted on the assumption that *heteroglyptus* was the larger taxon. More recently, Masuda (1959b) placed *heteroglyptus* and *P. turpiculus* Yokoyama under *C. cosibensis* as subspecies. He also included a new Miocene subspecies, *C. cosibensis hanzawae*, in addition to the typical *C. cosibensis cosibensis*.

Figured specimens: The largest figured specimen (USNM 644905), a left valve, has a height of 40 mm and a length of 34 mm. Other figured specimens are numbered USNM 644906, 644907.

Locality of figured specimens: Near the center of the northwest side of Tugidak Island, Alaska, 320 ft below the top of a section computed to be 3,520 ft thick, 56°30″ N., 154°42″ W. USGS 1494. Horizon probably upper Pliocene.

Chlamys ("Chlamys") coatsi MacNeil, n. sp.

Plate 14, figures 6, 7; plate 15, figures 1, 2, 5–7

Pecten (*Chlamys*) *beringianus*, Stewart and MacNeil *in* Powers, Coats, and Nelson, 1960, U.S. Geol. Survey Bull. 1028–P, p. 543.

Description.—Shell of medium to moderately large size, rotund, moderately inflated. Anterior ear of right valve large and broad, byssal area broad; byssal sinus moderately broad, moderately deep, and angulate; posterior ear of right valve short, posterior margin sloping and weakly concave. Anterior ear of left valve moderately large and broad, anterior margin weakly sinuous. Dorsal margins of about equal length, straight or very weakly concave. Dorsal slopes moderately broad, those of the left valve broader than those of the right valve, weakly undercut. Sculpture consisting of broad plicae or fascicles centrally and finer riblets near the anterior and posterior margins; plicae nearly smooth in juveniles but breaking up into secondary riblets terminally; interplicae with secondary and tertiary riblets that develop earlier than the riblets on the plicae; plicae broader than interplicae on right valve, interplicae broader than plicae on left valve. Tops of plicae and riblets with concentric growth lines only; interspaces between riblets with reticulate or metal lathelike microsculpture.

Discussion.—The typical form of this species occurs with and may intergrade with *Chlamys coatsi middletonensis*, here described. Typical *C. c. middletonensis* comes from beds on Middleton Island that are believed at present to be older than the beds of Amchitka containing typical *C. coatsi*. Typical *C. coatsi* has not been found on Middleton Island; the only known occurrence of it outside of Amchitka is a single left valve from the Gubik Formation near Wainwright, Alaska, supposedly from a horizon of about middle Pleistocene age.

C. coatsi may be related through *C. c. middletonensis* to *C. pilicaensis* Kubota (see Masuda, 1962b, pl. 20, figs. 1, 2) from the Setana Formation (early Pliocene) of Hokkaido. *C. pilicaensis* has more regular ribs, especially on its right valve, but some specimens of *C. c. middletonensis* approach it in this respect. The more coarsely ribbed variants of *C. chaixensis* are similar to *C. c. middletonensis*, but the range of variation in *C. chaixensis* suggests that it was a stock already divergent from *C. coatsi* in late Pliocene time and that it was pro-

ducing variants wholly unlike any of the variants of *C. coatsi*. If *C. coatsi* is related to *C. pilicaensis*, as is suspected, it probably is related in turn to *C. chaixensis* through some early or middle Miocene species such as *C. otukae*. *C. otukae* is fairly closely related to the earliest known member of the *C. cosibensis* group, *C. c. hanzawae*, from the early Miocene.

Any attempt to determine the origin of *C. coatsi* at this time is complicated not only by a time and morphological gap in the Pacific, but also by the abrupt appearance in the Yorktown Formation (late Miocene) of Virginia of *C. decemnaria* (Conrad) (see Gardner, 1943, pl. 5, figs. 1, 2, 6, 7). I am inclined to doubt the descent of *C. decemnaria* from *Pecten (Chlamys) clintonius* Say and *P. (C.) clintonius rappahannockensis* Mansfield, as postulated by Mansfield (1936, p. 184). The last two forms belong to the genus *Placopecten*. I believe it likely, however, that *C. decemnaria*, *Placopecten clintonius*, and *Mya arenaria*, all of which occur in the Yorktown Formation, are migrants from the Pacific.

C. decemnaria appears to be related to *C. coatsi*, but its long anterior dorsal margin suggests that it may be related to *C. beringiana*. It is older than the earliest known Pacific members of either species, and it is younger than the possible Japanese early Miocene predecessors *C. otukae* and *C. cosibensis hanzawae*. Although late Miocene representatives of the *C. coatsi* stock have not yet been found in the Pacific region, I will suggest that the stock was present then and that it migrated to the Atlantic in late Miocene time; it gave rise there to *C. decemnaria*.

Pecten aratus Gmelin, a Recent deep-water species from the northern Atlantic, resembles both *C. coatsi* and *C. c. middletonensis*. Jensen (1912, pl. 1, figs. 5a–d) figured two specimens from south of Iceland at depths of 268 and 295 fathoms. His figures 5a and b have some ribs nearly as coarse as the large ribs of *C. coatsi*, whereas his figures 5c and d have finer ribs more nearly resembling those of the small specimen of *C. c. middletonensis* figured here (pl. 13, fig. 4). Presumably Jensen's two specimens represent the opposite extremes of variation. The anterior dorsal margin of Jensen's specimens is shorter than the posterior margin. In this respect, at least, it compares more with some variants of *C. coatsi* and with *C. trinitiensis*. *C. beringiana strategus* (Oldroyd, 1924b, pl. 41, figs. 1, 2), the only broad-ribbed living Pacific form with which it might be compared, has a longer anterior dorsal margin. I think it likely that *C. arata* is the only living representative of the *C. coatsi* stock.

Types: The holotype (USNM 644908), a left valve, has a height of 95 mm and a length of 90 mm. The paratype (USNM 644909), a right valve, measures 70 mm in height, 68 mm in length. Other figured specimens are numbered USNM 644910–644914.

Type locality: Poorly bedded loose sand and gravel forming a fill about 75 feet thick at the head of South Bight, Amchitka Island, Aleutian Islands, Alaska, USGS D46. Possibly from an upper horizon in the section; see discussion under *C. hanaishiensis amchitkana* (p. 31).

Other occurrences: South Bight, Amchitka Island, USGS 16908a (paratype); Gubik Formation (horizon probably middle Pleistocene), mouth of Kuk River near Wainwright, northern Alaska, USGS M1828.

Chlamys ("Chlamys") coatsi middletonensis MacNeil, n. subsp.

Plate 13, figures 3–5, 7; plate 14, figure 8; plate 15, figure 8

Discussion.—This subspecies differs from typical *C. coatsi* by having less discrepant juvenile and adult sculpture. The plications show less relief in *C. c. middletonensis*, almost none in some specimens, and the secondary riblets on the right valve usually extend to the beak; only an occasional plication is smooth. The left valve of *C. c. middletonensis* is more elegantly and more precisely sculptured; the ribs are divided into primary, secondary, tertiary, and quaternary ribs, the finest ribs tending to be neatly beaded towards the margins. Specimens from Amchitka show the original color; the left valve is bright red, the right valve pale pink or white. Typical *C. coatsi* from the same locality is mottled red or has irregular concentric red bands.

The possible relationships of this subspecies were discussed under typical *C. coatsi*.

Types: The holotype (USNM 644915), an unseparated pair of valves, measures 66 mm in height, 59 mm in length. Other figured specimens are numbered USNM 644916–644919.

Type locality: From about the top of Miller's measured section (1953, p. 23) on Middleton Island, Alaska, USGS M1741. The horizon is about 1,400 ft above the top of the *Chlamys (Leochlamys) tugidakensis* zone.

Other occurrences: South Bight, Amchitka Island, USGS D46; possibly from an upper horizon.

Chlamys ("Chlamys") cf. C. ("C.") coatsi middletonensis MacNeil

Plate 12, figure 4

Discussion.—A left valve from the upper part of the section on Middleton Island is probably closest to *C. coatsi middletonensis*. The texture and general plan of its ribs is intermediate between that subspecies and *C. pseudislandica plafkeri*. While it is possible that these forms are all part of one intergrading series, it seems fairly certain that the end members are foreshadowing quite different lines of development.

Figured specimen: USNM 644920, an incomplete left valve, has a height of 72 mm.

Locality of figured specimen: Upper part of the section on Middleton Island, Alaska, USGS 17745.

Chlamys ("Chlamys") chaixensis MacNeil, n. sp.

Plate 9, figures 2, 6–10; plate 10, figures 4, 5, 7, 8

Description.—Shell of medium size, suborbicular, usually longer than high. Hinge of moderate length. Anterior ear of right valve of medium length and moderately broad, byssal sinus moderately deep, narrow, and acute; posterior ear of medium length, posterior margin sloping gently and weakly concave. Anterior ear of left valve moderately small, margin moderately sloping and concave; posterior ear moderately long with a sinuous margin. Umbonal angle moderate to large. Dorsal margins nearly straight to moderately concave, dorsal slopes narrow and weakly undercut. Sculpture variable, ribs ranging from narrow and uniform to moderately broad and irregular, with or without fascicles; both valves may have moderately broad smooth ribs that divide terminally into several smaller riblets. The interspaces have reticulate or metal lathelike microsculpture.

Discussion.—This species occurs with and may intergrade with the form (pl. 10, figs. 1–3) identified as *Chlamys lioica* (Dall). Some unfigured fragments of the latter have no radial riblets on either valve. The specimens that come closest to connecting these two forms are the ones figured on plate 9, figure 8, and plate 10, figure 1. If these should prove to be one species, *C. chaixensis* could be treated as a variety of subspecies of *C. lioica*, the older name.

Chlamys cosibensis heteroglypta (see Nomura and Hatai, 1935, pl. 11, figs. 1, 2) may be the closest relative of this species in the Japanese Pliocene. The only other Japanese species that has much resemblance to it is *C. otukae* Masuda and Sawada (1961, pl. 4, figs. 1–5), described from the Oido Formation (early Miocene) of Miyagi Prefecture, northeastern Honshu. *C. otukae* may be the ancestral stock of *C. chaixensis;* at least I can find no other known Japanese Miocene species from which it could be derived.

Some specimens of *C. coatsi middletonensis* are close morphologically to the holotype of *C. chaixensis;* the latter probably is an extreme variant of the species. The general range of variation of the two forms is somewhat different, however; no varietal series similar to that found at the type locality of *C. chaixensis* has been found elsewhere in Alaska.

Of the older Alaskan species, *C. chaixensis* appears to be most closely related to some of the forms from the middle part of the Tugidak section here referred to *C.* aff. *C. trinitiensis* (pl. 8, figs. 2–5, 7–9). In all probability *C. chaixensis* was derived from some part of the middle Tugidak assemblage. Possibly the nearly smooth ribbed variant shown on plate 8, figure 9, is an end member of the Tugidak series analogous to the more coarsely ribbed variants of *C. lioica.*

Types: The holotype (USNM 644921), a specimen with paired valves, measures 59 mm in height and 60 mm in length. Two paratypes are numbered USNM 644922, 644923. Other figured specimens are numbered USNM 644924–644929.

Type locality: Highest part of the section in the Chaix Hills (horizon probably upper Pliocene), approximately 6,000 ft above a bed containing *Chlamys (Leochlamys) tugidakensis.* Malaspina district, Alaska, USGS M1875.

Chlamys ("Chlamys") lioica (Dall)

Plate 10, figures 1–3

Pecten (Chlamys) lioicus Dall, 1907, Am. Jour. Sci., serv. 4, v. 23, p. 457, text fig.

Dall, 1920, U.S. Geol. Survey Prof. Paper 125–C, p. 31.

Pecten (Pecten) lioicus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 165.

Pecten (Chlamys) lioicus, MacNeil, 1943, Jour. Paleontology, v. 17, no. 1, p. 87, pl. 13, fig. 5.

Discussion.—Until the discovery of this species in the Malaspina district along the northern Gulf of Alaska, it was known only from the holotype, a specimen collected from an indeterminate horizon at Nome; no other fossils were found with it. Grant and Gale suggested that it was merely an abnormal specimen of *Pecten islandicus*, as that species was interpreted by them.

The suite from the Chaix Hills shows the species to have considerable range in variation. One end of the series (pl. 10, fig. 1) has narrow but moderately strong ribs both anteriorly and posteriorly, and low rounded plicae medially. The interspaces have from one to four interstitial riblets, and the plicae divide terminally into several riblets. This variant approaches the less strongly plicated variants of *C. chaixensis;* additional specimens might show that the two forms intergrade. The middle part of the series (pl. 10, fig. 3) has a nearly smooth central disc. Several incised radial lines occur both anteriorly and posteriorly as well as sporadically on the central part of the disc. The marginal area of adults displays numerous closely spaced riblets of nearly equal size. The opposite end of the series has no radial sculpture although concentric growth lines and resting stages may be moderately strong. The holotype is close to the smooth end of the series, having only a few scattered and weakly incised lines close to the margin.

Two specimens from the Coralline Crag (late Pliocene) of England figured by Wood (1851, pl. 5, figs. 2a, b) as *Pecten tigrinus* var. *laevis* and *P. tigrinus* var. δ are surprisingly like the variants of *C. lioica* figured here; the former has a smooth disc and marginal riblets, the latter has weak plications. *P. gerardii* (Wood, 1851, pl. 5, figs. 5a, b), also from the Coralline Crag, is larger and more globose. I collected some fragmental specimens from the Coralline Crag in 1960 that probably are

P. gerardii, although one smaller, more inflated individual may be *P. tigrinus laevis*. All the fragments have a delicate diagonal *Camptonectes*-like microsculpture. The juvenile stage of *C. lioica* has similar microsculpture, especially near the dorsal margins.

The only nearly smooth *Chlamys* I find described from East Asia is *Pecten swifti piltukensis* Khomenko (see Slodkewitsch, 1938, p. 109, pl. 29, figs. 1–3) ; it occurs in the Pomyr Series of Sakhalin and the upper horizon of the Kavran Series of Kamchatka, both late Pliocene. While the plications and riblets of this form are subdued, they are present over the entire disc. In all probability this is a *Swiftopecten* and not very closely related to *C. lioica*.

Types: The holotype (USNM 110480), a right valve, measures 61 mm in height, 57 mm in width. The largest figured specimen (USNM 644930) is 68 mm high and 69 mm long. Two other figured specimens are numbered USNM 644931, 644932.

Type locality: "gravels under tundra near Nome, Alaska, at a depth of 50 feet," exact location and beach horizon unknown, USGS 4537.

Other occurrences: Highest part of the section in the Chaix Hills (horizon probably upper Pliocene), approximately 6,000 ft above a bed containing *Chlamys* (*Leochlamys*) *tugidakensis*, Malaspina district, Alaska, USGS M1875.

Chlamys ("Chlamys") trinitiensis MacNeil, n. sp.

Plate 8, figures 6, 10–12

Description.—Shell medium small, inflated, strongly plicate, gerontic stage tending to be less plicate and more inflated. Anterior ear of right valve moderately large and broad, terminal border rounded, byssal area of medium width, byssal sinus moderately shallow and angulate, ctenolium well defined; posterior ear of right valve short and narrow, posterior border slanting steeply. Posterior ear of left valve short with steeply sloping border; anterior ear unknown. Umbonal angle of moderate width, dorsal margins straight. Dorsal slopes of left valve and posterior dorsal slope of right valve moderately broad, undercut, and weakly concave; anterior dorsal slope of right valve narrow, forming a wide angle with the ear. Sculpture of right valve consisting of poorly to well-defined plicae which develop in the juvenile stage and tend to be obliterated in the gerontic stage. Left valve with medium to moderately broad, usually smooth plicae corresponidng to the interplicae of the right valve, likewise weak or absent in young juvenile and gerontic stages. Secondary sculpture of right valve consisting of moderately strong raised riblets, three to five on the plicae and four to five in the interplicae; riblets inequisized on some plicae with the larger riblets branching; at the beginning of the gerontic stage the riblets may split abruptly into two to four smaller riblets. Interplicae of left valve with three to six narrow but sharply raised riblets; smooth plicae splitting at beginning of gerontic stage into three to five small riblets. Microsculpture of both valves reticulate or metal lathelike, strongest in the secondary interspaces but covering riblets and plicae as well.

Discussion.—The closest known relative of this species is the form figured by Wood (1851, p. 27, pl. 5, figs. 2d–f) as *Pecten tigrinus* Müller var. γ. According to Wood, *P. tigrinus* occurs in both the Coralline Crag (late Pliocene) and the Red Crag (early Pleistocene) ; the horizon of his figured specimen is not given. Most recent lists of Crag fossils only record *P. tigrinus* from the Coralline Crag. The number of plicae is the most obvious difference between *C. trinitiensis* and the form figured by Wood; *C. trinitiensis* has five plicae on its right valve and four strong plicae (with two weaker terminal plicae) on its left valve; Wood's figure shows four plicae on the right valve and three on the left valve. This arrangement of plicae results in a median plication on the right valve of *C. trinitiensis* and a median furrow on the right valve of *C. tigrinus* var. γ.

Of the known Japanese species, *C. trinitiensis* most closely resembles *C. cosibensis* (Yokoyama). It is less like the Pliocene representatives of *C. cosibensis* (see Masuda, 1959b, pl. 13, figs. 1–9, 16–18) than the early Miocene form, *C. cosibensis hanzawae* (ibid., figs. 10–15). None of the Japanese forms exhibit the irregularity in the width of the secondary ribs seen in *C. trinitiensis*, nor do the secondary ribs show the abrupt splitting of the secondary ribs into several smaller riblets.

As matters now stand, a Pacific origin for *P. tigrinus* var. γ seems most likely. It is of interest to note that the gastropod *Molleria costulata* (Möller) occurs with *C. trinitiensis*. This minute but very characteristic gastropod has not been found elsewhere in the Pacific. MacGinitie (1959, p. 81) reported it living at Point Barrow, saying it had not been known previously outside the Atlantic. The occurrence of the species in Pliocene beds in the Gulf of Alaska strongly suggests communication with the Atlantic in Pliocene time.

Types: The holotype (USNM 644933) consists of a nearly complete right valve and an incomplete left valve, both belonging to the same individual. The right valve measures 41.5 mm in height and 38.5 mm in length. Two figured specimens are numbered USNM 644934, 644935.

Type locality: Near the center of the northwest side of Tugidak Island, Alaska, 320 ft below the top of a section computed to be 3,520 ft thick, 56°31'' N., 154°42'' W., USGS M1494.

Chlamys ("Chlamys") aff. C. ("C.") trinitiensis MacNeil

Plate 8, figures 2–5, 7–9

Discussion.—The middle part of the section on Tugidak Island contains an assemblage of pectinids, known thus far only from fragments, that appears to be very closely related to *C. trinitiensis*. If the fragments figured here actually represent one species, as is believed, the species is extremely variable. Some of the more uniformly ribbed individuals (figs. 2, 4) approach *C. cosibensis*. Other individuals with fine secondary ribs or with coarse secondary ribs that divide abruptly into several finer ribs (figs. 3, 8) appear to be more closely related to *C. trinitiensis*. Still other individuals show a high degree of coalescence of the secondary ribs (fig. 9), and these individuals with their large smooth plications have some resemblance to the more plicated variants of *C. chaixensis* (pl. 9, figs. 7–10), here described, as well as to the more plicated variants of *C. lioica* (pl. 10, fig. 1).

This series of forms may therefore have been derived from the *C. cosibensis* stock of Japan, but I am inclined to believe its immediate relationship is with *C. pilicaensis* Kukota. Several subsequent Alaskan species may be derived from it.

Figured specimens: The figured specimens are numbered USNM 644936–644942. They include fragments of both right and left valves.

Locality: Southwest side of Tugidak Island, south of Kodiak Island, Alaska, 1,900 ft above base of section estimated to be about 3,520 ft thick (horizon probably Pliocene), USGS M1895.

Group of C. (C.) rubida (Hinds)

Chlamys (Chlamys) rubida (Hinds)

Plate 20, figures 7, 9; plate 22, figures 7, 8

Pecten rubidus Hinds, 1845, Zoology of the Voyage of H.M.S. Sulphur, Mollusca, pt. 3, p. 61, pl. 17, fig. 5.

Pecten hericeus var. *navarchus* Dall, 1898, Wagner Free Inst. Sci. Trans., v. 3, no. 4, p. 708.

Pecten (Chlamys) hastatus var. *navarchus*, Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 112, pl. 43, figs. 1, 1a, b.

Pecten (Chlamys) hastatus var. *hindsii*, Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 111, pl. 43, figs. 2, 2a.

Pecten hindsii, Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 53, pl. 7, figs. 3, 4.

Pecten hindsii navarchus, Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 54, pl. 4, figs. 2, 3.

Pecten (Pecten) islandicus var. *hindsii*, Grant and Gale, 1931, San Diego Soc. Natl. History Mem., v. 1, p. 163. (In part.)

Chlamys rubida, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 76, pl. 24 (with extended synonymy).

Discussion.—As one of the earliest described species from the Pacific, *C. rubida* has figured prominently in the general confusion regarding the so-called Pacific *C. islandica*. Right valves of both *C. rubida* and *C. r. hindsii* have split ribs, suggesting an intergradation with *C. islandica*, to which *C. r. hindsii* has been referred by many authors. The left valve of typical *C. rubida*, however, has scabrous three-parted ribs and from one to three scabrous interstitial riblets, making it easily distinguishable from *C. r. hindsii*, which has coarser, more solid ribs. The specimens figured by Arnold as *hindsii* and *navarchus* very nearly represent the varietal extremes of typical *C. rubida*.

Superficially, the closest living species to *C. rubida* is *C. hastata hericius* (Gould); *C. hericius* probably forms a morphological continuum with the southern form, *C. hastata* (Sowerby), and most modern authors regard it as a subspecies of *C. hastata*. The morphological gap between *C. h. hericius* and *C. rubida* makes it unlikely, however, that there could have been any connection between these species since late Miocene or earliest Pliocene time.

I can find no authentic record of this species in East Asia. It has been reported from Hokkaido by Kuroda and Habe (1952, p. 16), Kira (1955, pl. 49, fig. 9), and Grau (1959, p. 79). The left valve figured by Kira has less-regular curved ribs (*?beringiana*); the ribs of *C. rubida* are straight. Furthermore, the left valve of *C. rubida* is rose or purplish; Kira's specimen is white. Neither *C. rubida*, *C. hericius*, or *C. hastata* is known in the Arctic or Atlantic regions.

Until recently the only problems concerning *C. rubida* were nomenclatural. Now that Martyn's "Universal Conchologist" (1784) has been declared invalid, *Pecten rubidus* Hinds is not a homonym of *P. rubidus* Martyn (= *C. islandica*). Most recent authors have presumed the species to be identical with *P. hindsii* Carpenter and *P. hericeus navarchus* Dall. Palmer (1958, p. 70) presented evidence of a further mixup involving *C. rubida*, *C. hindsii*, and *C. kincaidi*. According to Palmer, the name *Pecten hindsii* was given by Carpenter to a shell collected from Vancouver by H.M.S. *Plumper;* at that time Carpenter did not think it was the same species as *P. rubidus* Hinds. Unfortunately, the *Plumper* specimen (the type of *P. hindsii*) and the type of *P. rubidus*, which came from Alaska and was once in the British Museum, are now lost. It is not possible, therefore, to resort to the types for a solution.

Palmer further stated that the Carpenter collection in the Redpath Museum, Montreal, contains three specimens labeled by Carpenter as "*Pecten hindsii* Cpr. = *rubidus*, H. C. Sitka" and six specimens labeled "*Pecten* (?var.) *hindsii* Crp. = *rubidus* var. H. Cum. not Hinds. Neeah Bay. Swan" (Neah Bay is a village on the south shore of the Strait of Juan de Fuca). Here again is evidence that Carpenter had a form he thought was *rubidus* and a form he thought was not *rubidus*.

Through the courtesy of Dr. Vincent Conde of the Redpath Museum, Dr. Leo G. Hertlein and I have reexamined all these specimens. Our conclusion is that Hinds' figure is perfectly clear and that it is the form that Dall named *Pecten hericeus navarchus* and Grau accepted as *C. rubida;* this is the form that Carpenter had from Neah Bay. The Sitka specimens (Palmer, 1958, pl. 3, figs. 4–6), however, are the form which Grau (1959, p. 79) identified as *C. rubida jordani* and which probably includes among its variants the *C. kincaidi* of Oldroyd. This is the form that is commonly identified as *C. islandica* in southeastern Alaska. Inasmuch as Carpenter said his *P. hindsii* was more allied to *C. islandica*, whereas *P. rubidus* was more like *hericius* (in its more finely sculptured left valve), it would seem that the Sitka specimens represent the form Carpenter named *P. hindsii;* this is the reverse of Palmer's interpretation.

Large suites of specimens, both living and postglacial, from near Juneau, Alaska, show that these two forms merge through a continuous series of variants. They are here treated, therefore, as *C. rubida* and the subspecies *C. rubida hindsii* (=*kincaidi*). *C. rubida jordani* is regarded as a Pleistocene and more southern subspecies.

Types: The holotype, the specimen figured by Hinds, was in the British Museum (Carpenter, 1864, p. 606), but according to Grau (1959, p. 78) it is now missing; three other syntypes are present. The figured specimen (USNM 150220) measures 56 mm in height and 54.4 mm in length. Other figured specimens, USNM 644943, 644944.

Type locality: Alaska.

Locality of figured specimens: Recent, south side of the Alaska Peninsula, USNM 150220; postglacial deposits, Juneau area, Alaska, USGS M212.

Other occurrences: The species is reported living from Bering Sea to Monterey, Calif.

Chlamys (Chlamys) rubida jordani (Arnold)

Plate 22, figure 3; plate 24, figure 5

Pecten (*Chlamys*) *jordani* Arnold, 1903, California Acad. Sci. Mem., v. 3, p. 111, pl. 12, figs. 6, 7.

Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 114, pl. 44, figs. 1, 1a, b.

Oldroyd, 1924, Puget Sound Biol. Sta. Pubs., v. 4, p. 19, pl. 2, figs. 1, 2.

Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 55, pl. 28, figs. 5, 6.

Discussion.—The holotype of *C. r. jordani* has been suspected of being an abnormality. Woodring (in Woodring and others, 1946, pl. 32, fig. 16) illustrated a specimen from the Timms Point Silt (early Plestocene) of southern California as *Chlamys islandicus jordani.* This specimen is like one figured here (pl. 20, fig. 6) as *C. rubida hindsii.* Woodring (in Woodring and others, 1946, p. 80) stated that *C. i. jordani* is living in Puget Sound but is not known to be living farther south. Grau (1959, p. 79) combined *C. jordani* and the living *C. kincaidi* as one subspecies, *C. rubida jordani.* Oldroyd (1924a, p. 17, 19), on the other hand, thought both *C. jordani* and *C. kincaidi* were living in Puget Sound; she regarded *kincaidi* as a subspecies of *C. hindsii* (=*rubida*).

Until a very thorough study of the early Pleistocene fossils from San Pedro and Santa Barbara and the Recent species of Puget Sound is made, there will be some doubt as to the identity of *C. jordani* and the validity of *C. kincaidi.* I am indebted to Dr. Leo G. Hertlein, of the California Academy of Sciences, for pointing out to me that there is a small species in the upper part of the San Diego Formation (horizon late Pliocene) at Pacific Beach, San Diego, a locality listed for the species by Arnold, that matches the description and figure of *C. jordani.* It is higher than long, has a reticulate microsculpture that covers the ribs and interspaces alike, and has minor shelflike resting stages. Oldroyd's comments indicate that she had a similar concept of *C. jordani,* but apparently she did not find anything like this living in Puget Sound. At the same time, Woodring's (in Woodring and others, 1946, p. 81) discussion of *C. anapleus* sounds as though the small form with reticulate microsculpture all over the valves and shelflike resting stages is the young of that species.

I do not feel that a decision on *C. jordani* can be made without much more study, but I strongly suspect that *C. jordani* is a distinctive and identifiable subspecies and that it is typically southern. If this form should prove to be unidentifiable, all the specimens referred to it are referable to *C. rubida hindsii.*

I have not seen this subspecies from Alaska, or living anywhere, and as far as I am aware it is a southern Pliocene and early Pleistocene form.

Types: The holotype (USNM 162522) is a very large specimen for the subspecies, measuring 45 mm in height. Figured specimens USNM 644945, 644946.

Type locality: The holotype came from Deadman Island near San Pedro, Los Angeles County, Calif.; a locality that no longer exists. Whether it came from an upper Pliocene or a lower Pleistocene horizon is not known.

Other occurrences: Fernando Formation (horizon uppermost Pliocene), Orange County, Calif., USGS M2130 (figured); Santa Barbara Formation (horizon uppermost Pliocene), Santa Barbara County, Calif., USGS M1918 (figured); San Diego Formation (late Pliocene) at San Diego, Calif.; Lomita Marl, Timms Point Silt, San Pedro Sand (all early Pleistocene) near Los Angeles, Calif.

Chlamys (Chlamys) rubida hindsii (Carpenter)

Plate 18, figures 4, 6; plate 19, figures 1, 3, 4, 6; plate 20, figures 5, 6; plate 21, figure 4; plate 22, figures 1, 2; plate 24, figures 1, 8, 9

Pecten (?var.) *hindsii* Carpenter, 1864, British Assoc. Adv. Sci. Rept. 33, p. 645.

Pecten hindsii, Carpenter, 1872, Smithsonian Misc. Colln. No. 252, p. 606.

Pecten kincaidi Oldroyd, 1920, Nautilus, v. 33, p. 135, pl. 4, figs. 3, 4.

Pecten (*Chlamys*) *hindsii kincaidi*, Dall, 1921, U.S. Natl. Museum Bull. 112, p. 18.

Oldroyd, 1924, Puget Sound Biol. Sta. Pubs., v. 4, p. 17, pl. 9, figs. 3, 4.

Oldroyd, 1924[1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 53, pl. 12, figs. 1, 2.

Pecten (*Pecten*) *islandicus* var. *Jordani*, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 164, pl. 11, fig. 4.

Chlamys islandicus jordani, Woodring, 1946, U.S. Geol. Survey Prof. Paper 207, p. 80, pl. 32, fig. 16.

Chlamys rubida jordani, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 79, pl. 25 (with extended synonymy).

Discussion.—The holotype of *C. kincaidi* has smooth, broad, well-rounded ribs and narrow V-shaped interspaces. It does not compare in this respect with any other Recent specimen I have seen. There is little reason to doubt, however, that it is just an extreme variant of a species now living from Puget Sound to the Gulf of Alaska. The probability that *Pecten hindsii* Carpenter is an older name for this form was discussed under *C. rubida*.

Chlamys rubida hindsii is very closely related to and possibly descended from *C. hanaishiensis*. The most closely related form in early Pleistocene beds of Alaska is here described as *C. hanaishiensis amchitkana*, some variants of which are very similar to *C. r. hindsii*. In all probability the living American *C. r. hindsii* and *C. pseudislandica* are descended from different subspecies of *C. hanaishiensis*.

C. r. hindsii and *C. pseudislandica* are the two Pacific forms most commonly confused with *C. islandica* (Müller).

Types: The holotype of *C. rubida hindsii* is lost. The holotype of *Pecten kincaidi* Oldroyd (SU 89), deposited at Stanford University, measures 40 mm in height and 38 mm in length. The largest figured specimen (USNM 644947), a right valve, measures 62 mm in both height and length. Other figured specimens are numbered USNM 644948–644952, 644956, 644957, 637741–637744.

Type locality: Recent, Vancouver (Carpenter, 1864).

Other occurrences: Puget Sound to the northern Gulf of Alaska. A large suite of specimens is in the U.S. Geological Survey collection from Excursion Inlet, southeastern Alaska, USGS M234. The species is abundant in postglacial deposits near Juneau, southeastern Alaska, where both normal and very coarsely ribbed variants occur: USGS 5256, 5461, M212, M214, M216–M218, M243.

Chlamys (Chlamys) cf. C. (C.) rubida hindsii (Carpenter)

Plate 16, figure 3

Description.—Shell small, weakly inflated, higher than long; disc nearly symmetrical. Anterior ear of left valve of moderate length and broad, margin weakly sinuous; posterior ear short, margin moderately inclined and weakly concave. Dorsal margins nearly straight. Dorsal slopes narrow, the anterior slope slightly broader and less undercut than the posterior slope. Sculpture consisting of thin smooth weakly raised ribs and weakly concave interspaces about twice as wide as the ribs. Initial stage of juveniles smooth and glassy, followed by a short interval in which faint ribs appear and the interspaces have a microsculpture consisting of faint concentric undulations. Late juvenile stage marked by a moderately abrupt appearance of reticulate or metal lathelike microsculpture that continues to the margin. Shell is nearly white with irregular brown or chestnut maculations which are arranged in two poorly defined rings. This form is known only from a left valve.

Discussion.—I can find no previously described northern Pacific *Chlamys* with the extreme color pattern of this shell. The figured specimen is obviously juvenile. A large lot of *C. r. hindsii* from Excursion Inlet, southeastern Alaska, shows a tendency to have cream-colored maculations on a brownish-red background, but none of the shells are as nearly white as this specimen. The left valve of most specimens of *C. r. hindsii* of comparable size are brownish red; light-colored maculations or bands develop later. Furthermore, the beaks of young left valves of *C. r. hindsii* tend to be more inflated. This may be just a variety of *C. r. hindsii*, however, as that species is interpreted.

Figured specimen: USNM 637745, a left valve, measures 26 mm in height and 22 mm in length.

Occurrence: Recent, beach on Douglas Island, just north of bridge, near Juneau, Alaska, USGS M213.

Chlamys (Chlamys) rubida prerubida MacNeil, n. subsp.

Plate 11, figures 7, 8, 13

Description.—Shell moderately small, left valve more inflated than right valve. Anterior ear of right valve moderately large and broad, byssal notch shallow and angulate, byssal area moderately broad; posterior ear short, posterior margin concave, becoming nearly vertical at the hinge line. Anterior ear of left valve unknown; posterior ear short, posterior margin slanting and weakly concave. Posterior dorsal margins slightly longer than anterior dorsal margins. Dorsal slopes of left valve slightly wider than dorsal slopes of right valve. Young juvenile stage of right valve smooth and

weakly undulating, faint radial ribs appearing as growth continues. Adult sculpture consisting of moderately small and closely set ribs. Ribs of right valve slightly larger centrally, some of the central ribs splitting abruptly in adults, terminal ribs finer and weakly beaded or scabrous, interspaces evenly rounded and about the same width as the ribs, some interspaces having an interstitial riblet. Ribs of left valve finely scabrous, divided into primary, secondary, and tertiary ribs with finer interstitial riblets between them; primary and some smaller ribs double or three parted or irregularly divided. Microsculpture reticulate or metal lathelike and restricted to the interspaces of adult stage of the right valve and to very small patches on the left valve; not present in juveniles.

Discussion.—The microsculpture of the juvenile and adult stages of this subspecies is similar to that of both *C.* cf. *C. hanaishiensis* from the same locality (pl. 16, fig. 8) and Recent specimens of *C. rubida.* A large suite of specimens might show that *C. r. prerubida*, *C.* cf. *C. hanaishiensis*, and *C.* cf. *C. cosibensis* from this locality are all part of one intergrading series. Regardless of this possibility, they are regarded as the roots from which several subsequent species and subspecies were derived.

C. r. prerubida has finely scabrous ribs, as does *C. rubida*, and there is a similar tendency for the ribs of the left valve to be three parted. In both *C. r. prerubida* and *C. rubida*, the posterior dorsal margin is slightly longer than the anterior dorsal margin, the opposite of the condition in *C. beringiana.* In all probability *C. r. prerubida* is a direct ancestor of *C. rubida.*

While the exact relationship of the existing Pacific species *C. rubida* (Hinds), *C. hastata* (Sowerby), and *C. h. hericius* (Gould) is not fully understood and probably will not be until their Pliocene and Pleistocene history is better known, it seems likely that all of them originated in the Pacific. Arnold (1903, pl. 11, fig. 2) figured a specimen from the early Pleistocene of Deadman Island near San Pedro, Calif., as *P.* (*Chlamys*) *hericeus.* This specimen strongly resembles the fragment of *C. r. prerubida* shown here (pl. 11, fig. 8). *C. hericius*, which is regarded as a subspecies of *C. hastata* by most authors, may be the more archaic form of the species. *C. hastata* and *C. rubida* may prove, however, to belong to very distantly related sections of *Chlamys.*

Types: The holotype (USNM 644960), a right valve, has a height of 48 mm and a length of 42.5 mm. Two paratypes, both fragments of left valves, are numbered USNM 644961, 644962.

Type locality: Near center of the northwest side of Tugidak Island, Alaska, 320 ft. below the top of a section computed to be 3,520 ft thick, 56°31″ N., 154°42″ W., USGS M1494.

Group of C. (C.) beringiana (Middendorff)

Chlamys (Chlamys) beringiana (Middendorff)

Plate 20, figure 2; plate 21, figures 2, 5–7; plate 23, figures 3, 6; plate 24, figures 2, 3

Pecten islandicus var. *behringiana* Middendorff, 1849, Beitrage Malacozoologia Rossica, St. Petersbourg Imp. Acad. Sci. Mem., ser. 6, v. 6, p. 528, pl. 13, figs. 1–3.

Chlamys beringianus, Pavlovsky, 1959, Atlas Invertebrates Far Eastern Seas USSR, Acad. Sci. Zool. Inst., Moscow-Leningrad, pl. 50, fig. 10.

Chlamys islandica behringiana, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 73. (In part.)

Discussion.—The original drawings of this species are inadequate for positive identification; the ears as reconstructed in Middendorff's figures 1 and 2 are presumed to represent supposedly subjacent right valves. On the basis of the original figures, it would be difficult to distinguish this species from *C. pugetensis* (Oldroyd) (pl. 22, figs. 4, 5).

Dr. A. O. Scarlato, Zoological Institute, Academy of Science, Leningrad, has kindly supplied me with photographs of two specimens stated to be the types of *Pecten islandicus* var. *behringiana* Middendorff. One photograph (pl. 24, fig. 2) is of the largest of the three specimens figured by Middendorff (1849, pl. 13, fig. 1), and it is here designated the lectotype. The other photograph (pl. 24, fig. 1) is of the specimen figured by Middendorff (1849, pl. 12, fig. 9) as *Pecten rubidus* Hinds? Middendorff discussed both forms under *Pecten rubidus* in his text. The lectotype of *C. beringiana* comes presumably from Bering Sea, possibly from off Kamchatka. The larger specimen that Middendorff identified in his plate explanation as *P. rubidus* comes presumably from Sitka.

I am not entirely certain of the identification of either of these photographs. I am inclined to believe, however, that the larger specimen, a left valve, from Sitka (pl. 24, fig. 1) belongs to the species here identified as *C. rubida hindsii* and that it is close to the variant from postglacial deposits near Juneau here figured on plate 18, figure 4. Its ribs are slightly wider than on that specimen but otherwise the two specimens are very similar. A reticulate microsculpture covers both the ribs and interspaces on both specimens.

The identity of the lectotype of *C. beringiana* is much less certain. It has reticulate microscultpure on the early stages, but the interspaces of the later stages appear to be smooth. The primary ribs are of approximately the same size. Some of the interspaces have two interstitial riblets. The lectotype probably comes closest to the left valve of *C. beringiana* figured on plate 21, figure 5, but the latter has less-equisized ribs. Another left valve figured by Middendorff (1849, pl. 13, fig. 2)

has slightly curved inequisized ribs, and it may be the same species that Kira (1955, pl. 49, fig. 9) figured as *Chlamys islandica hindsii*. It would appear that the lectotype of *C. beringiana* is one of the less discordantly ribbed variants of the species. Possibly this variant is more common along the eastern Asiatic coast, where it ranges at least as far south as Hokkaido. The lectotype is fairly close to a left valve figured by Pavlovsky (1955, pl. 50, fig. 10) as *Chlamys beringianus*. A right valve with moderately uniform ribs (pl. 24, fig. 3) was collected from St. Lawrence Island.

The lectotype of *C. beringiana* (pl. 24, fig. 2) thus seems to represent the less extremely sculptured variants of the species. The opposite extreme of the species is represented by *C. b. graui* (Grau, 1959, pl. 23, fig. 2), which has crude high ribs that may or may not divide terminally and relatively narrow, deep interspaces that usually contain a single interstitial riblet.

Somewhat intermediate between these forms are the subspecies *C. b. strategus* and *C. b. unalaskae*. *C. b. strategus* (Oldroyd, 1924b, pl. 41, figs. 1, 2), which has broad, rounded, nearly smooth ribs that may divide terminally and broad shallow interspaces, is the variant that most modern authors have regarded as typical *C. beringiana*. *C. b. unalaskae* (pl. 20, figs. 1, 3–4) has broad, low, flattened fascicles with moderate broad, shallow interfascicular depressions on the right valve and moderately strong fascicles with broader interspaces on the left valve. The riblets are almost evenly distributed but slightly stronger on the fascicles, and they have little or no tendency to divide with growth.

The most likely Pliocene progenitor of *C. beringiana* in the northern Pacific region is *C. cosibensis* (Yokoyama). A species from the upper part of the section on Tugidak Island, here identified as *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *cosibensis* (pl. 11, figs. 9, 11, 12), is somewhat intermediate between *C. b. strategus* and the new subspecies, *C. b. unalaskae*. The peculiar flattening of the fascicles of the right valve that characterizes *C. b. unalaskae* is also found on some individuals of the Tugidak form (pl. 11, fig. 9). Typical *C. cosibensis* generally has more rounded fascicles, and on some individuals the fascicles are poorly developed.

Both rounded and flattened fascicles are found in *Swiftopecten*. If *Swiftopecten* shares a common ancestry with the *C. cosibensis* group, as is here maintained, variants with flattened fascicles might be expected in either group. Very little is known, however, of the late Oligocene and early Miocene history of either *Swiftopecten* or the *C. cosibensis* group. It is entirely possible that *Pecten* (*Chlamys*) *hastatus* var. *ingeniosa* Yokoyama (1929, p. 5, pl. 6, fig. 2), from the Nanao Formation (early Miocene) of the Noto Peninsula, west-central Honshu, is closer to being in the actual line of descent of *C. beringiana* than is the early Miocene *C. cosibensis hanzawae* (Masuda, 1959b, pl. 13, figs. 10–15).

Despite the apparent similarity of the more coarsely ribbed subspecies of *C. beringiana* to *C. tjornesensis* (pl. 25, figs. 1–3) from the late Pliocene and early Pleistocene beds of Iceland, I am inclined to believe these forms are not intimately related. Both *C. tjornesensis* and *C. breidavikensis* (pl. 25, figs. 4–8), although resembling *C. beringiana* and *C. islandica*, respectively, appear to be much more closely related to the European stocks of *C. gloriamaris* and *C. tauroperstriata*, and to be rather sharply delimited from *C. beringiana* and *C. islandica*. It may be found eventually that these forms do indeed have a common ancestry in early or middle Tertiary European species. I suspect at present, however, that representatives of these stocks migrated to East Asia by way of the Tethys and that species that developed subsequently in the northern Pacific reached the northern Atlantic secondarily by way of the Arctic. A much more complete knowledge of the intermediate forms will be necessary before such a migration pattern can be demonstrated.

The amount of the shell that is covered with reticulate or metal lathelike microsculpture varies geographically in *C. beringiana* if the specimens I have examined are consistently representative. Specimens of *C. beringiana* from Point Barrow to Point Hope and around Saint Lawrence Island have reticulate microsculpture over more of the shell, usually in all the interspaces, and sometimes on the ribs as well. Around Saint Paul Island, the microsculpture has not been observed on the ribs although it may cover all the interspaces. On some specimens, however, it is restricted to the early adult and even the juvenile stage. In the subspecies *C. b. unalaskae* from around Unalaska the microsculpture is usually found only on the juvenile stage of the shell and it may be absent entirely; in adults there are either fine radial lines or faint concentric undulations. The surface is excellently preserved on all specimens of *C. b. unalaskae* in the type lot.

Types: The type material is in the Akademiia Nauk USSR, Leningrad. The largest figured specimen (USNM 637749), an incomplete left valve, measures 63 mm in height and 55 mm in length. Other figured specimens are numbered USNM 637746–637748, 637750; CAS 12613–12614, 12746.

Type locality: Recent, Bering Sea.

Locality of figured specimens: Saint Paul Island, Pribiloff Islands, CAS 18493, USGS M1621; Saint Lawrence Island, USGS D373; Wainwright, CAS 34337; Point Barrow, CAS 34333; Point Hope, USGS 1339.

Grau (1959, p. 75) says the species ranges from Bering Sea to British Columbia, but all specimens of the typical form I have seen are from the area between the Pribiloff Islands and Point Barrow, Alaska. Possibly Grau's Gulf of Alaska and more southern records are based on *C. pugetensis*.

Chlamys (Chlamys) beringiana colvillensis MacNeil, n. subsp.

Plate 18, figures 5, 7

Pecten (Chlamys) n. sp., Dall, 1920, U.S. Geol. Survey Prof. Paper 125-C, p. 31.

Pecten sp., MacNeil, 1943, Jour. Paleontology, v. 17, no. 1, p. 86, pl. 12, fig. 4.

Chlamys hindsii, MacNeil, 1957, U.S. Geol. Survey Prof. Paper 294-C, p. 114, pl. 14, fig. 1.

Description.—Shell subrounded and medium inflated. Anterior ear of the right valve, the only one known, moderately narrow; byssal area correspondingly wide. Byssal sinus moderately broad and well rounded at its inner extremity, not angulate. Dorsal margins nearly straight and anterior margin slightly longer; dorsal slope very narrow. Ribs strongest medially where they are broad, straight sided, and crudely three crested; medial interspaces broad and round bottomed, about as broad as the ribs. Terminally the ribs are narrower and distinctly two parted; the most anterior and posterior ribs are smaller and single. Left valves, known only from scraps, have moderately high ribs that are slightly narrower than interspaces; ribs are usually three crested. Reticulate or metal lathelike microsculpture present between the smaller terminal ribs but not between medial ribs; medial interspaces have concentric lines only, and those of the left valve are slightly frilled or scaly.

Discussion.—This form is here made a subspecies of *C. beringiana*, but it could just as well stand as a distinct species. No other fossil pectinid from Alaska has the combination of characters exhibited by this form. The weakly inflated right valve and the three-crested nature of the medial ribs might suggest a relationship with *C. rubida*, as I believed originally. On the other hand, the slightly longer anterior dorsal margin suggests a relationship with *C. beringiana*. Until enough specimens have been found to show the full range of variation, it would be useless to speculate further on the exact relationships of this subspecies.

Types: The holotype (USNM 591912), an incomplete right valve, has a height of 62 mm and a length of 58 mm. The figured fragment from Nome is numbered USNM 644968.

Type locality: Colville River at Ocean Point, about 8 miles below the mouth of the Kikiakrorak River, northern Alaska, Gubik Formation (horizon probably early Pleistocene), USGS D306.

Other occurrences: Submarine Beach (late Pliocene or early Pleistocene), Nome, Alaska, USGS M1256; Submarine Beach or Intermediate Beach (middle Pleistocene), Nome, Alaska USGS 7477.

Chlamys (Chlamys) beringiana graui MacNeil, n. subsp.

Not figured

Chlamys islandica behringiana, Grau, 1959, Allan Hancock Pacific Exped. v. 23, pl. 23, fig. 2.

Discussion.—This is the most coarsely sculptured form of *C. beringiana.* It is closest to *C. b. strategus* and future collecting may show that it is only an extreme variant of that form. The ribs of *C. b. graui* are sharper and steeper sided than in *C. b. strategus*, and they extend more nearly to the beak. The interspaces of the left valve have a single strong interstitial rib. In *C. b. strategus* the ribs are broad and rounded and they break up near the margin into fasciclelike bundles. The interspaces are moderately broad and shallow, and they may contain several interstitial riblets.

It is presumed that the specimen figured by Grau from Saint Paul Island in the Pribiloffs, in the collections of the U.S. National Museum, is not one of the specimens on which Dall based his *Pecten hericeus* var. *strategus;* the latter form is stated to be from Unalaska.

The collection at Stanford University contains a left valve from Saint Paul that is almost identical with the left valve figured by Grau; it is bright red.

The most closely related known fossil form is *C. coatsi middletonensis. C. b. strategus* more nearly resembles *C. c. middletonensis*, however, than does *C. b. graui.*

Holotype: USNM 271731, measures 58 mm in height and 53 mm in length.

Type locality: Recent, Saint Paul Island, Pribiloff Islands, Alaska.

Chlamys (Chlamys) beringiana strategus (Dall)

Not figured

Pecten hericeus var. *strategus* Dall, 1898, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 709.

Pecten (Chlamys) islandicus beringianus, Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 55, pl. 41, figs. 1, 2.

Discussion.—This subspecies has the long anterior dorsal margin typical of *C. beringiana.* The ribs are smooth and rounded in young adults, but they break up into fascicular bundles of riblets at a more advanced growth stage.

Among the fossil forms, it is probably most like some of the variants of the Pleistocene *C. coatsi* (pl. 15, fig. 6), and, in turn, the Pliocene *C. chaixensis.* The exact varietal succession between all these forms is not known at present, but in all probability they stem from some part of the *C. hanaishiensis–C. cosibensis* complex.

The early Pleistocene form from Santa Barbara, Calif., that Arnold (1906, pl. 44, figs. 2, 2a, 3, 4) figured as *Pecten (Chlamys) hastatus* var. *strategus* is not this

subspecies. It does not have an elongate anterior dorsal margin, and the left valve has a pronounced flattening in the young stages. The juvenile ribs of the right valve are bifid. Specimens, especially juveniles, of this form that I have examined do not impress me as being very closely related to *C. b. strategus*. A specimen from beds of Pliocene age in Sulphur Canyon, Ventura County, Calif., figured by Grant and Gale (1931, pl. 11, fig. 2) as *Pecten (Pecten) beringianus* appears to be a precursor of the Santa Barbara species. If all Arnold's specimens are one species, I am inclined to agree with Woodring (in Woodring, Bramlette, and Kew, 1946, p. 81) that they are *Chlamys anapleus* Woodring (ibid., pl. 34, fig. 15). No species from Alaska that I have examined has a juvenile stage like *C. anapleus*.

Type: Dall never illustrated his *P. strategus* and in his later papers he appears to have placed it in the synonymy of *C. beringiana*. No type was designated, but presumably the specimens on which he based it are in the U.S. National Museum.

Occurrence: Dall (1898) reported the occurrence as Pleistocene of Alaska and Recent at Unalaska; I do not know to what Pleistocene specimens he refers. Oldroyd's specimen is from Bering Sea. If and until the type is clarified, Oldroyd's figure is the best indication of the subspecies.

Chlamys (Chlamys) beringiana unalaskae MacNeil, n subsp.
Plate 20, figures 1, 3, 4

Description.—Shell of medium size and moderately inflated, right valve more inflated than left valve. Anterior ear of right valve moderately long and narrow, byssal notch moderately wide, moderately deep, and angulate. Anterior ear of left valve of moderate length and very broad, anterior margin weakly sinuous; posterior ear short, steeply sloping margin. Anterior dorsal margin longer and more concave than posterior margin. Dorsal slopes of moderate width and very slightly undercut. Ribs, particularly of the left valve, gently curving toward the anterior with growth. Right valve with broad, flat-topped fascicles and narrower, shallow, rounded interspaces; both fascicles and interspaces with moderately strong riblets that are more or less evenly spaced. Left valve with moderately strong fascicles and wider interspaces, both the facicles and interspaces with strong riblets, usually with two to four riblets forming the crest of the fascicles. The riblets extend without convergence to the juvenile stage; a few are added interstitially in the adult stage. The riblets of both valves have small closely set scales or beads. The microsculpture of the juvenile stage is usually reticulate or metal lathelike, but in adults the surface between the riblets is usually either smooth, marked by concentric growth lines, or bears very fine radial lines.

The left valve shown on plate 20, figure 3, has no reticulate sculpture in the juvenile stage. An unfigured fragment of a left valve has reticulate microsculpture on both ribs and interspaces, well into the adult stage.

Discussion.—This is another of the peculiar forms that appears, on the basis of existing records, to be restricted to waters immediately surrounding Unalaska.

This form is made a subspecies of *C. beringiana* because of its longer anterior dorsal margin and because of the similarity of the right valve to right valves of typical *C. beringiana* from the Pribiloffs (pl. 21, figs. 2, 7). Pending further knowledge of this subspecies, it might with equal justification be combined with *C. islandica albida*. *C. islandica powersi* has its reticulate microscultpture restricted to the juvenile stage, but a left valve of *C. beringiana* subsp.? from Point Hope (pl. 20, fig. 2) has reticulate microsculpture over the entire shell except for the narrow crest of a few ribs.

The left valve of *C. b. unalaskae* is bright orange and the right valve is yellowish with several concentric orange bands. Specimens of *C. beringiana* from the Pribiloffs are mostly orange with narrow purple bands, and specimens from Saint Lawrence Island are mostly purple with orange bands. Specimens from Point Hope and Point Barrow are purple. There seems to be a color gradation in this species, therefore, from south to north. Grau (1959, p. 73) stated that *C. islandica albida*, the only living Alaskan form with which *C. b. unalaskae* might be confused, is white or very pale pink.

I can find no figures or descriptions of an Alaskan shell that could be this subspecies, and the type lot of 10 whole and incomplete specimens may be the only ones ever found. It is undoubtedly a very rare pectinid.

Types: The holotype (USNM 637751), a right valve, measures 55 mm in height and 42 mm in length. Two paratypes (USNM 637752, 637753) are both left valves.

Type locality: Recent, Usof Bay, southeastern Unalaska Island, Aleutian Islands, Alaska, USGS D53. Picked up on the tidal flat.

Chlamys (Chlamys) wainwrightensis MacNeil, n. sp.

Plate 18, figure 3; plate 19, figure 8, 9; plate 23, figures 4, 5

Description.—This species has a very inflated left valve and a very weakly inflated right valve. Shell relatively high for its width. Dorsal margins of unequal length with the anterior margin longer than the posterior margin, making shell slightly asymetrical. Dorsal slopes of right valve narrow, but those of the left valve broad, concave, and weakly undercut. Ribs of right valve low and rounded, straight sided; oc-

casional ribs are split, evenly or unevenly. The interspaces are gently rounded, and some interspaces have a small interstitial riblet. The left valve has higher and sharper ribs than the right valve; on some individuals nearly all ribs are split; other individuals have only one or two split ribs. Some individuals have a very weak tendency for the ribs to be differentiated into primary, secondary, and tertiary series. The interspaces are well rounded and usually roughened by growth lines. The microsculpture is reticulate or metal lathlike and covers most of the interspaces; it may or may not be present on the ribs. Right valves of living specimens have alternating broad orange and white bands, sometimes with a purple narrower band above the orange band; left valves are almost uniformly dark reddish purple.

Discussion.—This species is recognized with certainty only along the coast of Chukchi Sea between Point Hope and Wainwright, Alaska. Its closest known relative is a form from the Okhotsk Sea that Kotaka (1962, pl. 34, figs. 18–23) referred to *C. islandica erythrocomata.*

C. wainwrightensis resembles *C. beringiana* by having an elongate anterior dorsal margin, but it differs from *C. beringiana* and its subspecies by being less inflated; the right valve is very weakly inflated. A large suite of specimens of *C. rubida hindsii* from Excursion Inlet, southeastern Alaska, shows a gradation form individuals with more typical inflated equilateral right valves to individuals with abnormally flat right valves and longer anterior dorsal margins. None of the left valves in this suite, however, have the ribs divided into primary, secondary, and tertiary series as in *C. wainwrightensis.*

There is some resemblance between *C. wainwrightensis* and *C. tjornesensis* (pl. 25, figs. 1–3) from supposed late Pliocene beds of Iceland. The left valves also recall left valves of the Pliocene forms here referred to *C.* cf. *C. hanaishiensis* (pl. 9, fig. 4) and *C. chaixensis* (pl. 9, fig. 2). The exact relationship between all these forms is at present unknown, nor is it clear whether they originated in the Pacific Ocean or in the Atlantic Ocean. As was stated previously, stocks of European early Tertiary origin might have reached the northern Pacific by either an Arctic or a Tethyan route.

Types: The holotype (USNM 637756), a left valve, measures 69 mm in height anl 61 mm in length. The paratype (USNM 637757) is a right valve from the same locality. Other figured specimens are numbered USNM 637754–637755, 637758.

Type locality: Recent, Point Hope, Alaska, USGS M1339.

Other occurrences: Recent, Wainwright, Alaska, USGS M2056, M2062, D318.

Group of C. (C.) picoensis (Waterfall)

Chlamys (Chlamys) picoensis (Waterfall)

Not figured

Pecten (Chlamys) islandicus picoensis Waterfall, 1929, California Univ. Pubs. in Geol. Sci., v. 18, no. 3, p. 83, pl. 5, figs. 2, 4.

Pecten (Chlamys) venturaensis Waterfall, 1929, California Univ. Pub. in Geol. Sci., v. 18, no. 3, p. 84, pl. 6, fig. 4.

Pecten (Pecten) islandicus var. *hindsii*, Grant and Gale, 1931, San Diego Soc. Natl. History Mem., v. 1, p. 163. (In part.)

Chlamys rubida, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 77.

Discussion.—While this species is closely related to Recent *C. islandica* and the early Pleistocene subspecies such as *C. i. kanagae*, it is more intimately related to the substock of *C. chinkopensis* (Pliocene) and *C. kinoshitai* (Recent). The Japanese forms are here regarded as subspecies of *C. picoensis.* All these forms are less closely related to *C. rubida* and *C. r. hindsii* than to *C. islandica.*

Types: The holotype of *C. picoensis* (UC 31419), a right valve, is smaller than the paratype (UC 31417), a left valve; Waterfall gives the dimensions as, height 77 mm, length 82 mm, convexity of left valve 18 mm.

Type locality: Top of Pico Formation, northwest corner sec. 3, T. 3 N., R. 21 W., Ventura County, Calif., UC loc. 7100. The uppermost part of the Pico Formation may be of early Pleistocene age.

Other occurrences: Deadman's Island, San Pedro, Calif.

Chlamys (Chlamys) cf. C. (C.) picoensis chinkopensis Masuda and Sawada

Plate 11, figures 1–3, 5, 6, 10

?Chlamys chinkopensis Masuda and Sawada, 1961, Japanese Jour. Geology Geography, v. 32, no. 1, p. 21, pl. 4, figs. 6, 7.

Discussion.—This form is distinguished by its suborbicular, moderately inflated shell. It occurs with and may perfectly intergrade with the forms here identified as *C.* cf. *C. hanaishiensis*, *C.* cf. *C. cosibensis*, and *C. trinitiensis.* In Japan *C. chinkopensis* occurs in the Setana Formation (early Pliocene) in association with *C. hanaishiensis* Masuda, *C. pilicaensis* Kubota (see Masuda, 1962b, pl. 20, figs. 1, 2), and *C. cosibensis* (Yokoyama), forms that appear to be closely interrelated as are the members of the complex on Tugidak Island. Future collecting may show that all the above forms are one or, at the most, two species. Even so, the diversity of the complex and the possibility that it foreshadowed several subsequent species makes it desirable to recognize all the names applied to it, if only to designate varietal forms.

C. cosibensis is the oldest of the Japanese names. Masuda (1959b) made both *Pecten turpiculus* Yokoyama and *P. heteroglyptus* Yokoyama subspecies of

C. cosibensis. The extreme variants of both of these subspecies are less like typical *C. cosibensis* morphologically than are all the above-mentioned Setana and Tugidak forms, with the possible exception of *C. trinitiensis*.

No attempt is made here to combine any of the Japanese species, and it should not be done, in my opinion, until the complete range of variation of the Pliocene *Chlamys* in both Japan and Alaska is better known. In all probability enough names have been proposed already to cover any resolution of the synonymy on the species level. Two forms described from early Pleistocene deposits of California, *Pecten (Chlamys) islandicus picoensis* Waterfall (1929, p. 83, pl. 5, figs. 2, 4) and *Pecten (Chlamys) venturaensis* Waterfall (ibid., p. 84, pl. 6, fig. 4) are closely related to both *C. chinkopensis* and *C. hanaishiensis*, and it is thought to be desirable from the evolutionary standpoint, and for reasons of priority, to treat some of the younger Japanese species as subspecies or varieties of the previously named California species. The interests of the stratigraphic paleontologist are best served by stressing similarities in variation rather than minute and often individual morphological differences. A judicious use of species, subspecies, and varieties is the best means of showing evolutionary and migrational patterns, and it should be the goal of paleontologists to express these relationships in the nomenclature.

Figured specimens: The largest figured specimen (USNM 644977), a right valve, measures 56 mm in height and 54.4 mm in length. Other figured specimens are numbered USNM 644978–644982.

Locality of figured specimens: Near the center of the northwest side of Tugidak Island, Alaska, 320 ft below the top of a section computed to be 3,520 ft thick, 56°31″ N., 154°42″ W., USGS M1494; near the base of the section on Middleton Island, Alaska, approximately 2,000 ft below the top of the *Chlamys (Leochlamys) tugidakensis* zone, USGS M1753.

Chlamys (Chlamys) picoensis kinoshitai Kubota

Plate 24, figure 11

Chlamys erythrocomata, Kinoshita and Isahaya, 1934, Hokkaido Fish Exp. Sta. Rept. Aquatic Products, v. 33, no. 1, pl. 11, fig. 75.

Chlamys islandica var. *kinoshitai* Kubota, 1950, Shinsedai-no-Kenkyu (Cenozoic Research), no. 6, p. 16. [In Japanese.]

Chlamys islandica erythrocomata, Kira, 1955, Coloured illustrations of the shells of Japan, pl. 49, fig. 13.

Discussion.—Masuda (1962b, p. 167) combined this form with his *C. hanaishiensis* which he described from the Setana Formation (early Pliocene) of Hokkaido. I hesitate to take a firm stand on matters involving the identity of Asiatic species without access to specimens, but I am not convinced that Masuda was correct nomenclaturally in rejecting the name *kinoshitai*. According to Masuda, the name was only suggested and Kubota did not provide a figure or a description. The International Code of Zoological Nomenclature of 1961 states that prior to 1961 a variety name proposed conditionally is valid. Furthermore, Kubota's name is based on Kinoshita and Isahaya's figure, and he contrasted it with his *C. islandica osugii*. In my opinion, this meets all the requirements of the Code. Apparently Masuda felt that clarification could only be accomplished by rejecting *kinoshitai*.

C. p. kinoshitai is probably a direct linear descendent of *C. p. chinkopensis*. Inasmuch as *C. p. chinkopensis* occurs with *C. hanaishiensis* in the Pliocene beds of Tugidak Island, and the young of the two forms are not easily separable, a close relationship between them is indicated. It is my belief, however, that *C. p. chinkopensis* gave rise to the group of *C. islandica*, whereas *C. hanaishiensis* gave rise to the group of *C. pseudislandica* and probably had a common origin with the group of *C. rubida*. Of the known forms, the most likely connective between *C. p. chinkopensis* and *C. islandica* appears to be *C. i. kanagae*.

Judging from Recent specimens I have examined, a more nearly complete morphological continuum exists between *C. p. kinoshitai* and *C. pseudislandica* than between the former and *C. rubida* or *C. rubida hindsii*. The present geographical distribution of these forms shows a similar relationship; *C. p. kinoshita* and *C. pseudislandica* are distributed from Point Barrow to northern Bering Sea and along the northern Asiatic coast, whereas *C. rubida* ranges from the Gulf of Alaska to Puget Sound. *C. rubida* is believed to be related to *C. hanaishiensis* through *C. hanaishiensis amchitkana*, whereas *C. pseudislandica*, typical *C. hanaishiensis*, and *C. p. chinkopensis* form a more direct lineage.

Types: The holotype (in the collections of the Hokkaido Fish Experiment Station) is from Araito Island in the northern Kurile Islands, west of the southern tip of Kamchatka. The specimen figured by Kira is from "north of Chishima" (north of the Kuriles).

Group of C. (C.) hanaishiensis Masuda

Chlamys (Chlamys) cf. C. (C.) hanaishiensis Masuda

Plate 9, figures 1, 3–5; plate 10, figures 6, 9–11; plate 11, figure 4; plate 16, figure 8

?*Chlamys hanaishiensis* Masuda, 1962, Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 33, no. 2, p. 166, pl. 22, figs. 1, 2.

Discussion.—Masuda described *C. hanaishiensis* from the Setana Formation (early Pliocene) of Hokkaido. The specimens from Tugidak Island figured here are very similar to the Setana form. According to Masuda, the species still lives in the Okhotsk Sea, Bering Sea, and the northern Pacific. He thus made it include the

Pacific forms that previous authors had referred to either *C. islandica*, *C. kincaidi*, or *C. erythrocomata*. A revision as important as this warrants more explanation than Masuda gives.

As here interpreted, typical *C. hanaishiensis* is restricted to the Pliocene. One Pleistocene subspecies is described. *C. hanaishiensis* is closely related to *C. trinitiensis*, and it may have had a common origin with that species; the exact nature of their relationship is not known at present. *C. otukae* Masuda and Sawada (1961, p. 19, pl. 4, figs. 1–5), an early and middle Miocene species from Japan, may be the direct ancestor of *C. hanaishiensis*.

All the forms here recorded from Tugidak Island, *C. trinitiensis*, *C.* cf. *C. hanaishiensis*, and *C.* cf. *C. p. chinkopensis*, have nearly identical juvenile stages. Following an initial smooth stage that persists for about 2 mm of growth, there is a stage having very fine scarcely raised ribs with diagonal *Camptonectes*-like microsculpture in the interspaces. This stage is followed after about 10–12 mm of growth by an enlargement of the ribs to more or less their adult shape and by a transformation of the microsculpture from diagonal to reticulate. The change from diagonal to reticulate microsculpture takes place earlier and more gradually toward the margins and later and more abruptly on the central part of the disc. The juvenile stage of Recent *C. islandica* is similar except that the diagonal microsculpture is more subdued and may be absent on the central area; in such specimens the interspaces are smooth. It is inferred from the similarity of the juveniles that all these forms are closely related.

The ribs of the left valve of *C. hanaishiensis* tend to be of unequal size (not as fascicles or bundles of riblets). While the ribs are of more equal size in *C. hanaishiensis* than in some other species, such as *C. chaixensis* and *C. coatsi*, a rather close relationship between these species is indicated. The Pleistocene subspecies, *C. pseudislandica plafkeri* and *C. h. amchitkana*, both have variants with little or no difference in the size of the ribs on the left valve.

C. hanaishiensis and the related *C. rubida hindsii* and *C. picoensis kinoshitai* belong to a group of northern Pacific pectinids that is frequently included in but is clearly distinct from the Atlantic species, *C. islandica* (Müller). As here construed, typical *C. islandica* does not live in the Pacific Ocean area or along any part of Arctic Alaska. The *C. islandica* group probably originated in the Pacific, however, and two subspecies from Pleistocene beds are here described; the only surviving Pacific subspecies are *C. islandica albida* (Dall) (Arnold, 1906, p. 136, pl. 52, figs. 2, 2a) from Unalaska, and *C. i. erythrocomata* (Dall) (see pl. 21, figs. 8, 9) from the Okhotsk Sea. The situation is complicated by the fact that at least one related Pacific form, *C. pseudislandica*, also migrated to northern Europe in late Pleistocene time (see *Pecten islandicus*, Wood, 1851, p. 40, pl. 5, fig. 1); this species occurs in the Clyde beds of Scotland. The acceptance of Wood's specimen as a variant of *C. islandica* has given the impression that *C. islandica* is much more variable than it actually is.

Figured specimens: The largest figured specimen (USNM 644983) measures 67 mm in height and 57 mm in length. Other figured specimens are numbered USNM 644984–644990.

Locality of figured specimens: Near the center of the northwest side of Tugidak Island, Alaska, 320 ft below the top of a section computed to be 3,520 ft thick, 56°31″ N., 154°42″ W., USGS M1494; upper part of Yakataga Formation (horizon probably Pliocene), Lituya district, Alaska, USGS D184, D222, M1969.

Chlamys (Chlamys) hanaishiensis amchitkana MacNeil, n. subsp.

Plate 12, figures 3, 5; plate 13, figure 8; plate 14, figures 1, 2, 4, 5; plate 15, figure 4; plate 22, figure 6

Pecten (Chlamys) islandicus, Stewart and MacNeil in Powers Coats, and Nelson, 1960, U.S. Geol. Survey Bull. 1028–P, p. 543.

Description.—This subspecies ranges from forms in which the ribs of the right valve remain undivided throughout the life of the individual to forms in which the ribs divide at an early age. Left valves of the former type have ribs of nearly uniform size; left valves of the latter type have single, moderately strong interstitial riblets between the main ribs.

Discussion.—The variants with divided ribs and interstitial riblets are very closely related to *C. rubida jordani* (pl. 22, fig. 3; Woodring and others, 1946, pl. 32, fig. 16, as *C. islandicus jordani*). Typical *C. r. jordani* probably is a migrant of some part of this stock to southern waters. *C. h. amchitkana* grew to a much larger size than any known specimen of *C. r. jordani*.

This form resembles *C. pseudislandica plafkeri* except for a greater tendency for the ribs to split and a greater tendency for the ribs of the left valve to be of equal size. *C. h. amchitkana* may prove to be no more than a variant of *C. p. plafkeri*, but the prevalence of this form on Amchitka and *C. p. plafkeri* on Middleton suggests there may be a geographical sorting as well.

Two different collections of pectinids have been made from Pleistocene deposits at the head of South Bight, Amchitka Island. While no stratigraphic distinction has been made, the fossils suggest that more than one stage of the Pleistocene is represented. The collection containing *C. h. amchitkana* yielded Foraminifera that Cushman and Todd (in Powers and others, 1960, p. 543) compared with the fauna of the Timms Point Silt (early Pleistocene) of California. The pectinids in

this collection are leached and chalky. Another collection of fossils contains different pectinids, *C. coatsi*, *C. coatsi middletonensis*, and *C. islandica powersi*. The shells in this collection are comparatively fresh, and some specimens are brightly colored. While the bay head fill has small areal extent, more than one period of fill is likely.

Types: The holotype (USNM 644991), an incomplete right valve, measures 93 mm in height and 88 mm in length. Other figured specimens are numbered USNM 644992–644999.

Type locality: Poorly bedded loose sand and gravel forming a fill about 75 ft thick at the head of South Bight, Amchitka Island, Aleutian Islands, Alaska, USGS 16908.

Other occurrences: Middleton Island, USGS 17743, 17744.

Chlamys (Chlamys) pseudislandica MacNeil, n. sp.

Plate 19, figure 7; plate 20, figure 8; plate 23, figures 1, 2

Pecten islandicus, Wood, 1851, Palaeontographical Soc. London, v. 4, pt. 2, no. 1, p. 40, pl. 5, fig. 1.

Pecten (Chlamys) islandicus, Dall, 1898, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 735. (In part.)

Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 113. (In part.)

Pecten (Pecten) islandicus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 161. (In part.)

Chlamys islandica, Morris, 1952, A Field Guide to Shells of the Pacific Coast and Hawaii, p. 17, pl. 4, fig. 4.

MacGinitie, 1959, U.S. Natl. Museum Proc., v. 109, no. 3412, p. 155, pl. 19, fig. 4.

Grau, 1959, Allan Hancock Pacific Exped. v. 23, p. 69. (In part.)

Description.—Valves moderately inflated, ranging from subrounded to higher than long. Anterior ear of right valve moderately short and broad; byssal notch narrow and angulate. Anterior ear of left valve moderately short with sinuous anterior margin. Both posterior ears short with moderately sloping concave margins. Anterior dorsal margins shorter than posterior margins. Anterior slopes moderately broad, those of left valve broader and more undercut than those of right valve. Sculpture moderately coarse, the ribs ranging from moderately broad to medium sized, roughened by crude growth lines. Ribs of right valve usually splitting evenly in adult stage and strongly divided at margin in full-grown specimens, interspaces usually with a single moderately strong interstitial riblet. Ribs of left valve narrower, split, and with a strong interstitial riblet; usually three ribs are slightly stronger and lighter colored than the rest. A reticulate or metal lathelike microsculpture is present in interspaces, both primary and secondary; tops of ribs have concentric sculpture.

Discussion.—Ribs of this subspecies are coarser, higher, and have a greater tendency to split, especially on the left valve, than do the ribs of *C. rubida hindsii*. *C. r. hindsii* tends to be longer and less inflated, whereas *C. pseudislandica* tends to be higher and more inflated. The left valve of *C. pseudislandica* is usually dark reddish purple.

The most apparent difference between *C. islandica* and *C. pseudislandica* lies in the ribs; the ribs of *C. pseudislandica* are coarser, plainer, and have a strong tendency to divide toward the margin; the ribs of *C. islandica* are finer, more frilled, and have less tendency to divide terminally, although some ribs may divide in an early growth stage.

Grau seems to have been the first author to exclude *C. islandica* from the Pacific and Bering Sea, but he recognized the species in Arctic Alaska. In my opinion, the typical form of the species is not known living or fossil in the Pacific, Bering Sea, Chukchi Sea, or the Beaufort Sea. It probably does not live east of Novaya Zemlya.

C. islandica probably had a Pacific origin, but the typical form developed in Atlantic waters. The facts that *C. pseudislandica* has until quite recently been identified as *C. islandica* and the probability that *C. pseudislandica* also migrated to the northern Atlantic region in late Pleistocene time have contributed to the almost universal combination of these two forms.

The specimen figured by Wood (1851, pl. 5, fig. 1) from the Clyde beds (late Pleistocene) of Scotland could well have come from Point Barrow; it is typical of *C. pseudislandica* in every respect. According to MacGinitie (1959, p. 155), a specimen examined by her from Vadsø, Norway, has broad primary ribs that divide. Norwegian specimens should be reexamined to see whether there actually is a form living there that can be distinguished from typical *C. islandica*. MacGinitie mentioned a specimen from Massachusetts Bay that resembles the Point Barrow form, and Grant and Gale (1931, pl. 11, figs. 1 a, b) figured one from Eastport, Maine. While MacGinitie gave measurements for 19 specimens from Point Barrow, the specimen she figured appears to be a young adult. The holotype figured on plate 23, figures 1, 2, was dredged by Dr. G. D. Hanna, of the California Academy of Sciences.

C. pseudislandica is now living as far south as Saint Lawrence Island in northern Bering Sea, but it is not known to be living farther south. It has not been found fossil in Alaska. At the present time there is a geographical and morphological gap between this subspecies and *C. rubida*. Specimens from Point Barrow exhibit considerable range in the width of the ribs. The narrow ribbed subspecies, *C. p. arconis* (pl. 23, figs. 7, 8) probably comes as close to *C. picoensis kinoshitai* as any Alaskan specimen I have seen. Its relationship to *C. islandica* is also apparent, but in my opinion the

stocks of *C. islandica* and *C. picoensis* became distinct in early Pleistocene time.

C. pesudislandica probably is the form Masuda (1962b, p. 167) had in mind when he said *C. hanaishiensis* is living in Bering Sea; however, he made the type of *C. hanaishiensis* a specimen from the Setana Formation (early Pliocene). Masuda also included *C. picoensis kinoshitai* (Kubota, 1950, p. 16; based on the *C. erythrocomata* of Kinoshita and Isahaya, 1934, pl. 11, fig. 75) in *C. hanaishiensis*. To justify the name *C. hanaishiensis*, Masuda maintained that the name *C. kinoshitai* was invalid. In my opinion, the name *C. kinoshitai* is valid, but I do not believe the form so named should be combined with the early Pliocene *C. hanaishiensis*.

Types: The holotype (CAS 12612) measures 73.5 mm in height and 69.5 mm in length. Figured specimens, USNM 637759, 637760.

Type locality: Recent, off Point Barrow, Alaska, CAS loc. 34358.

Other occurrences: Known to be living from Point Barrow, Alaska, to Saint Lawrence Island, northern Bering Sea USGS D373.

Chlamys (Chlamys) pseudislandica plafkeri MacNeil, n. subsp.

Plate 12, figures 1, 2, 6, 7; plate 13, figures 1, 2

Pecten islandicus, MacNeil *in* Miller, 1953, Jour. Geology, v. 61, no. 1, p. 29.

Description.—Shell moderately large, left valve more inflated than right valve, valves higher than long. Ribs of right valve moderately wide to moderately narrow, or of unequal width, rounded and somewhat crude, entire or divided into two and rarely three parts toward the margin, interspaces opposite primary ribs of left valve wider, deeper, and sometimes with an interstitial riblet. Ribs of left valve weakly divided into primary, secondary, and tertiary ribs, the tertiary ribs numbering one or two between different secondary and primary ribs, higher and sharper than on right valve.

Discussion.—Specimens from Middleton Island referred to this subspecies are larger and more rounded than specimens of *C.* cf. *C. hanaishiensis* from supposed Pliocene beds on Tugidak Island.

The specimens of *C.* cf. *C. hanishiensis* from Pliocene beds in the Lituya district (pl. 10, figs. 6, 9–11) are also smaller than *C. p. plafkeri* and some of the specimens are lopsided. If this lopsidedness proves to be a characteristic that is not due to distortion, this variant is in need of a name. They occur both above and below other beds containing *Clinocardium meekianum* (Gabb), a species believed to be restricted to the Pliocene.

C. hanaishiensis amchitkana occurs with *C. p. plafkeri* on Middleton Island, but so far only the former has been found on Amchitka Island in the Aleutians. *C. h. amchitkana* has narrower ribs, and they have more of a tendency to split toward the margin; the ribs of the left valve are all nearly the same size.

C. p. plafkeri appears abruptly in the Middleton Island section; its first occurrence is in a bed immediately above the highest bed, USGS 17746, containing *C.* (*Leochlamys*) *tugidakensis*. Miller's (1953, p. 23) stratigraphic section for Middleton Island shows that within some 3,675 feet of glacial marine sediments there are numerous beds of cobble-sized conglomerate. The conglomerate in which *C. p. plafkeri* first appears, USGS 17745, is the only one of these conglomerates, or the only part of the section for that matter, that marks a change in the pectinid fauna. The top of the range of *C.* (*L.*) *tugidakensis* is taken tentatively as the top of the Pliocene. Typical *C. p. plafkeri* is taken to mark the beginning of the Pleistocene. *C. coatsi middletonensis*, which appears for the first time with *C. p. plafkeri*, is also known from supposed Pleistocene beds on Amchitka Island.

The more coarsely ribbed variants of *C. p. plafkeri* approach the less coarsely ribbed variants of *C. coatsi middletonensis*. Possibly not enough specimens are at hand to show beyond all question that these two forms do not merge, but I do not believe they do. *C. pilicaensis* Kubota (see Masuda, 1962b, pl. 20, figs. 1, 2), described from the Setana Formation (early Pliocene) of Hokkaido, is intermediate bewteen these two forms, however, and they are either descended from *C. pilicaensis* or all three forms descended from a common immediate ancestor. Masuda said that *C. pilicaensis* still lives in the northern Pacific; this is probably an allusion to *C. beringiana* or the subspecies *C. b. graui*.

It must be recognized that the abrupt appearance of *C. pseudislandica plafkeri* and *C. coatsi middletonensis* in the Middleton Island section is due to a migration from elsewhere. While it is possible that these are Atlantic migrants, I believe they are more like preexisting Japanese species than any known forms in northern Atlantic or European beds.

Types: The holotype (USNM 645002) has a height of 88 mm and a length of 81 mm. A large incomplete unfigured specimen has a height of 100 mm. Other figured specimens are numbered USNM 645003–645006.

Type locality: Conglomeratic sandy mudstone 2,185–2,695 ft above base of a 3,675-ft section, near north end of Middleton Island, Alaska, USGS 17745 (for description of section, see Miller, 1953, p. 23).

Other occurrences: Middleton Island, same bed as above and higher beds in section, USGS 17743, M1742, M1743, M2054.

Chlamys (Chlamys) pseudislandica arconis MacNeil, n. subsp.

Plate 23, figures 7, 8

Discussion.—This subspecies differs from typical *C. pseudislandica* by its finer ribs, of which only a few have any tendency to divide, and by its longer ear and broader byssal notch. Since only one specimen like this has been seen, it may be no more than an extreme variant of *C. pseudislandica*. This specimen, dredged from a depth of 300 feet, was alive when taken.

Holotype: The holotype (CAS 12747) measures 71 mm in height and 66.5 mm in length; the double convexity is 30 mm.
Type locality: Arctic Ocean about 17 miles west of Arcon Beach, 71°21'30" N., 157°23'00" W., CAS 34347.

Group of C. (C.) islandica (Müller)

Chlamys (Chlamys) islandica islandica (Müller)

Plate 18, figure 8; plate 19, figures 2, 5; plate 24, figures 12, 13

Pecten islandicus Müller, 1776, Prodromus Zoologiae Danicae, v. 32, p. 248.
Fabricius, 1780, Fauna Groenlandica, v. 16, p. 415.
Pecten rubidus, Martyn, 1784, Universal Conchologist, v. 4, p. 153, fig. 1, (non Hinds, 1845).
Chlamys islandica, Roeding, 1798, Museum Boltenianum, p. 161.
Pecten (Chlamys) islandicus, Dall, 1898, Wagner Free Inst. Sci. Trans., v. 3, no. 4, p. 735.
Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 113, pl. 45, figs. 1, 1a.
Pecten (Pecten) islandicus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 161, pl. 11. (In part.)
Chlamys islandica, Grau, 1959, Allan Hancock Pacific Exped., v. 23, p. 69, pl. 22 (with extended synonymy).

Discussion.—Other names proposed for this species include *Ostrea cinnabarina* Born, *Ostrea demissa* Solander, *Pecten pealeii* Conrad, *Pecten fabricii* Philippi, *Chlamys islandica* var. *insculpta* Verrill, and *Chlamys costellata* Verrill and Bush. It is perhaps remarkable that Linné did not have a clear concept of this species. According to Dodge (1952, p. 178–179), the box which bears the name *Ostrea pusio* in Linné's collection contains a right valve of *C. islandica*, as well as odd valves of several other species.

Other unsegregated valves of *C. islandica* were in Linné's collection. The types of *Lepas balanus* Linné (=*Balanus balanus*) (Pilsbry, 1916, pl. 33, fig. 1) are attached to a fine left valve of *C. islandica*. Pilsbry identified the substrate valve as *Pecten opercularis* Linné, but whether the misidentification is his or Linné's is not clear; at least Dodge did not mention an association of *C. islandica* and *C. opercularis* in Linné's collection. No better evidence of the general confusion concerning *C. islandica* needs to be cited.

The so-called *Chlamys islandica* in the northern Pacific have troubled systematists for years. While typical *C. islandica* belongs to the same section of *Chlamys* as the northern Pacific forms, the stocks have been distinct since early Pleistocene time and possibly earlier. Several authors (Arnold, 1906, pl. 45, figs. 1, 1a; Oldroyd, 1924b [1925], pl. 8, figs. 1, 2; Grant and Gale, 1931, pl. 11, figs. 1, 1a; Grau, 1959, pl. 22) have figured specimens from the Atlantic coast and Greenland with discussions of northern Pacific species referred to *C. islandica*. While the locality of these specimens has been clearly stated, the illustration of Atlantic rather than Pacific specimens has given an entirely false impression of the Pacific species. Several species or subspecies have been described from the northern Pacific region, based, unfortunately, on unusual or juvenile specimens. Without access to large suites of the taxa involved, it might be difficult to determine beyond all question which taxa the named species represent. I am inclined to believe that the valid species have been named, however atypical the holotypes might be.

Several distinct species of *Chlamys* that either in whole or in part have been included in *C. islandica* are now living in the area between Puget Sound and Point Barrow. One type has valves of nearly equal inflation and dorsal margins of nearly equal length. The ribs range from broad and rounded to sharp and high and from moderately split to strongly split, sometimes multiple. This type includes *C. rubida*, the subspecies *C. rubida hindsii*, and a new species, *C. pseudislandica*. The other type has a longer anterior dorsal margin. It includes two subtypes. One has valves of nearly equal inflation and a wide range in the width of the ribs, particularly in the development of fascicular bundles; this subtype probably includes typical *C. beringiana* of Middendorff. The other, known from a single species, has a very weakly inflated right valve, a moderately inflated left valve, and a moderate division of the ribs on the left valve into wider primary ribs and weaker secondary and tertiary ribs; the primary ribs are not appreciably higher than the other ribs. This latter species is here named *C. wainwrightensis;* a possible representative of this group is living in the Okhotsk Sea (Kotaka, 1962, pl. 34, figs. 18–23; identified as *C. islandica erythrocomata*).

Despite longstanding confusion over the point, typical *C. islandica* does not live in Alaskan waters or anywhere in the northern Pacific region. The species probably descended, however, from the stock of *C. picoensis chinkopensis* Masuda and Sawada (1961, pl. 4, figs. 6, 7) and *C. imanishii* Masuda and Sawada (ibid., figs. 10a–c, 11), both from the early Pliocene of Japan. Very closely related forms are here recorded from supposedly late Pliocene beds of Tugidak Island, Alaska. A related but somewhat more advanced form was described by Waterfall (1929, p. 83, pl. 5, figs. 2, 4) from the

223-848 O—67——4

upper (early Pleistocene?) part of the Pico Formation as *Pecten (Chlamys) islandicus picoensis*, and (ibid., p. 84, pl. 6, fig. 4) *Pecten (Chlamys) venturaensis;* these supposedly different species probably are identical. *C. chinkopensis* is here regarded as a subspecies of *C. picoensis*. At any rate, *C. picoensis* is close to the borderline morphologically between *C. chinkopensis* and the earliest known subspecies of *C. islandica*. It is not entirely clear at present, however, just how *C. p. chinkopensis*, *C. cosibensis*, and *C. hanaishiensis* are related.

The oldest subspecies of *C. islandica* here recognized is *C. i. kanagae*, from beds of early Pleistocene age on Kanaga Island in the Aleutians. This subspecies ranges from strongly fasciculate to nonfasciculate. Both of the living Pacific subspecies, *C. i. albida* and *C. i. erythrocomata*, are moderately fasciculate.

Chlamys islandica now lives in the northern Atlantic region. It has been confused in that area, however, with at least two older fossil species from Iceland, *C. tjornesensis*, n. sp., and *C. breidavikensis*, n. sp., and with the late Pleistocene and Recent *C. pseudislandica*, another migrant from the Pacific.

C. tjornesensis occurs in both the "*Mactra*" and "*Cardium*" [*Serripes*] zones of Iceland; Askelsson (1960) indicated that the Pliocene-Pleistocene boundary is between the *Mactra* and *Cardium* zones. *C. breidavikensis* occurs in the uppermost fossiliferous bed of the Breidhavik sequence at Tjörnes, Iceland, a horizon within the early part of the glacial Pleistocene.

C. breidavikensis is the only one of these Icelandic species that resembles *C. islandica*, but it has many more ribs than the latter. Furthermore, the anterior ear of the left valve more nearly resembles that of *C. harmeri* Altena (pl. 24, fig. 6) and *C. tauroperstriata* (Sacco) (1897, pl. 1, figs. 20, 21), species related to *C. multistriata* (Poli) from the Mediterranean. Sacco (1897, p. 9) though *C. islandica* diverged from *C. multistriata* in post-Pliocene time. I am inclined to believe that *C. breidavikensis* belongs to the *C. tauroperstriata* group, but I have not seen any specimens that convince me that *C. islandica* is derived from *C. breidavikensis*. *C. islandica* appears to be much more closely related to some early Pleistocene forms in the Pacific.

Roger (1939, p. 168, pl. 22, figs. 3, 4) figured a specimen from Sicilian (early glacial Pleistocene) beds of Sicily that is very similar to the two Pacific early Pleistocene subspecies, *C. i. kanagae* and *C. i. powersi*. The Sicilian occurrence is both the earliest in Europe and the most southern. Presumably the species reached the Mediterranean region from the Arctic, but the exact route is not clear; the species is not known in early Pleistocene beds in either England or the Netherlands. It did not survive the early Pleistocene in the Mediterranean region.

A living variant of *C. islandica* (pl. 24, figs. 12, 13) from northern Iceland has some resemblance to both the typical form and *C. i. kanagae*. Its ribs, while slightly coarser than in either of these forms, are not as coarse as in *C. pseudislandica* and *C. wainwrightensis*, nor is its left valve more inflated as in *C. wainwrightensis*.

Typical *C. islandica* occurs in late Pleistocene (or postglacial) beds at Bohuslan, Sweden, at Reykjavik, Iceland (pl. 18, fig. 8; pl. 19, figs. 2, 5), and probably in Greenland and northern Canada. All northern Atlantic records for *C. islandica* however, need, to be reexamined. Recent specimens from eastern North America show clearly and consistently that two distinct species are involved: one species with fine nonbifurcating ribs on both valves lives from Newfoundland northward; another species with coarse bifurcating ribs on the right valve and inequisized ribs on the left valve lives along the coast of Maine and Massachusetts. A specimen of the latter from Eastport, Maine, was figured by Grant and Gale (1931, pl. 11, figs. 1a, b); in my opinion this is typical *C. pseudislandica*. MacGinitie (1959, p. 155) mentioned a specimen with broad primary ribs that divide from Vadsø, Norway, suggesting that *C. pseudislandica* is living on both sides of the Atlantic. The same species occurs in the Clyde beds (late Pleistocene) of Scotland (Wood, 1851, pl. 5, fig. 1). Richards (1962) recorded *C. islandica* from beds of late Pleistocene and postglacial age from Labrador to Long Island, but it now seems likely that both *C. islandica* and *C. pseudislandica* are included among the forms so identified.

Figured specimens: The specimens here figured are numbered USNM 645007–645009, 637761, 637762.

Locality of figured specimens: Raised terrace deposits (postglacial; radiocarbon dated at 10,200 yrs B.P.), Reykjavik Airport, Iceland, USGS M2055.

Doubtful identifications: Two specimens that may represent an undescribed subspecies of *C. islandica* are from the Recent beach at Tjörnes, northern Iceland, USGS M2464.

Chlamys (Chlamys) islandica thulensis MacNeil, n. subsp.

Plate 18, figure 2

Discussion.—The form so named comes from late Pleistocene deposits of northern Greenland. It is distinguished from typical *C. islandica* by weak fascicles which, toward the beak, become single ribs that are higher and stronger than the adjacent riblets.

While this may be just an individual variation of *C. islandica*, it is intermediate morphologically and geographically between typical *C. islandica* and *C. islandica albida*. It has some resemblance to *C. i. kanagae*. More specimens from this locality will have to be ex-

amined before its validity as a subspecies can be confirmed. Several scraps of other individuals have similar fasciciles.

Holotype: USNM 645010, an incomplete left valve, has a greatest dimension of 81 mm.

Type locality: Raised beach, probably postglacial, Narssurssuk, northwestern Greenland, USGS D386.

Chlamys (Chlamys) islandica kanagae MacNeil, n. subsp.

Plate 13, figure 6; plate 15, figure 3; plate 17, figures 1–8; plate 18, figure 1

Pecten n. sp. *B.* aff. *P. albidus*, MacNeil *in* Fraser and Barnett, 1959, U.S. Geol. Survey Bull. 1028–I, p. 218.

Description.—Shell of medium size, subrounded, medium inflated. Ears similar or slightly shorter than in typical *C. islandica.* Sculpture of right valve ranging from uniformly nonplicate or nonfasciculate to moderately fasciculate; fascicles are flat topped and bear from three to six riblets; interspaces are concave and shallow, about the same width as the fascicles, and contain from three to six riblets. Left valve ranges from moderately strongly fasciculate to weakly fasciculate; some fascicles or plicae are rounded and solid, dividing weakly near the margin; some fascicles are moderately high and divided into three to four riblets throughout most of their length; other fascicles are narrow and low, with a single riblet along the crest; interspaces are moderately broad and may contain from four to nine riblets that may be of subequal size or divided into secondary and tertiary series. Riblets of both valves are finely beaded or scabrous, the closely set scales adding considerably to the apparent thickness. Microsculpture of adults nonreticulate and where seen consists of very fine straight radial lines. Some juvenile left valves have reticulate or metal lathelike microsculpture over the riblets and interspaces alike; this microsculpture terminates abruptly in the late juvenile stage and is followed by radial microsculpture.

Discussion.—Some of the variants of this subspecies approach *C. pseudislandica plafkeri.* Right valves have similar flat-topped fascicles, and many left valves have moderately large smooth primary ribs or plications. The riblets of *C. i. kanagae* are finer and more scabrous, however, and the primary interspaces or interplicae of the left valve have more riblets. One specimen (pl. 13, fig. 6) from the upper part of the Middleton Island section is tentatively identified as *C. i. kanagae.*

C. islandica powersi from Pleistocene beds on Amchitka is undoubtedly the closest known relative of *C. i. kanagae.* The shell of *C. i. powersi* tends to be more inflated and twisted, and the riblets are finer, more widely spaced, and less scabrous. The two living Pacific subspecies of *C. islandica*, *C. i. albida* (Dall) (see Arnold, 1906, pl. 52, figs. 2, 2a) from Unalaska and *C. i. erythrocomata* (Dall) (pl. 21, figs. 8, 9) from the Okhotsk Sea probably are descended directly from the *C. i. kanagae-powersi* stock. All these forms have similar microsculpture, reticulate in juveniles and finely radial in adults.

Of all the known Pleistocene pectinids in the Pacific, *C. i. kanagae* is the most likely ancestor of typical *C. islandica.* The typical form of *C. islandica* has no fascicles and the riblets are subequal in size. *C. i. thulensis* (pl. 18, fig. 2), here described from late Pleistocene or postglacial beds of Greenland, has weak fascicles, however, and it is intermediate both morphologicaly and geographically between *C. i. kanagae* and *C. islandica islandica.*

Types: The holotype (USNM 645011), a right valve, measures 73 mm in height and 67.5 mm in length. The paratype (USNM 645012) is a left valve. Other figured specimens are numbered USNM 645013–645021.

Type locality: Green tuffaceous sandstone along west side of the northeastern peninsula of Kanaga Island, north of coastal lakes and about 4.5 miles south southwest of Kanaga Volcano, ceneral Aleutian Islands, USGS D3.

Other occurrences: Unnamed Pleistocene formation on Adak Island, central Aleutian Islands, USGS 16907; upper part of section (early Pleistocene) on Middleton Island, Alaska, USGS M1742.

Chlamys (Chlamys) islandica powersi MacNeil, n. subsp.

Plate 16, figures 1, 2, 4–7

Discussion.—This subspecies is closely related to *C. i. kanagae.* It differs from it by having a more inflated shell and a slight twist to the shell. The riblets of the left valve are smaller, more delicate, and more widely spaced in *C. i. powersi*, and the riblets of the right valve are correspondingly larger and broader. While both subspecies have fascicular bundles or plications on the left valve, the range of variation differs; *C. i. kanagae* has variants with fused riblets of moderately broad solid ribs, and even the most weakly fasciculated specimens have a heavier riblet along the crest of the fascicle; *C. i. powersi* has little or no tendency for the riblets to be fused or enlarged on the fascicles. Both subspecies have similar microsculpture.

While it will not be possible to describe the exact line of descent of this and the other subspecies of *C. islandica* until the complete range of variation of all intermediate forms is known, it seems fairly certain that this subspecies and *C. i. kanagae* are two of the oldest known forms that can be included in *C. islandica.* They are clearly related to the late Pliocene forms here referred to *C. cosibensis*, *C. picoensis chinkopensis*, and *C. hanaishiensis.* All these species and subspecies are variable, but it is still not possible to say which variants are more primitive, which are more advanced, which species are

successional, or which are coderivatives from older varietal series.

This subspecies probably is the closest known fossil relative of *C. i. albida* (Dall) and *C. i. erythrocomata* (Dall).

Types: The holotype (USNM 645022), a right valve, measures 96 mm in height and 86 mm in length. Two paratypes (USNM 645023, 645024) are left valves. Three other figures specimens are numbered USNM 645025–645027.

Type locality: Poorly bedded loose sand and gravel forming a fill about 75 ft thick at the head of South Bight, Amchitka Island, Aleutian Islands, USGS D46. Possibly from an upper horizon in the section (middle Pleistocene?).

Chlamys (Chlamys) islandica erythrocomata (Dall)

Plate 21, figures 8, 9

Pecten (Chlamys) erythrocomatus Dall, 1907, Smithsonian Misc. Colln., v. 50, pt. 2, p. 170.

Discussion.—The photographs reproduced here are the first illustrations of the holotype of this species to be published. They were sent to Dr. L. G. Hertlein, of the California Academy of Sciences, by Dr. Paul Bartsch, of the U.S. National Museum, several years ago. I do not believe any subsequent reference to this species by either an American or Japanese author is correct. H. A. Rehder (written commun., Grau, 1959, p. 73) thought from an examination of the holotypes that *C. i. albida* and *C. i. erythrocomata* were close enough to be united; certainly they are very close.

The species figured by Kotaka (1962, pl. 34, figs. 18–23) from the Okhotsk Sea as *C. islandica erythrocomata* has a weakly inflated right valve, and the anterior dorsal margin is longer than the posterior dorsal margin. This form is closest to *C. wainwrightensis*, here described. Unless a careful comparison should justify a new subspecific name, it probably should be referred to that species.

As far as I can determine, this subspecies has not been found since the original discovery, and, like *C. i. albida*, it is a rare form.

Holotype: The holotype (USNM 110462) measures 69 mm in height and 70 mm in length.

Type locality: Recent, Albatross Sta. 5021, Okhotsk Sea.

Chlamys (Chlamys) islandica albida (Dall)

Not figured

Pecten (Chlamys) hericius var. *albidus* Dall, MS., 1904 (cited in Arnold, 1906, p. 136).

Pecten (Chlamys) hastatus var. *albidus* Dall in Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 136, pl. 52, figs. 2, 2a.

Pecten (hericius Gould var.?) *albidus*, Oldroyd, 1924 [1925], Stanford Univ. Pubs., Geol. Ser., v. 1, no. 1, p. 52, pl. 12, figs. 8, 9.

Pecten (Pecten) hastatus albidus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 168.

Chlamys islandica albida, Grau, 1959, Allan Hancock Pacific Expd., v. 23, p. 72, pl. 23, fig. 1.

Discussion.—Grau combined this eastern Aleutian subspecies with *C. i. erythrocomata* from the Okhotsk Sea. While these two forms are more closely related to one another than either is to any other known form, I prefer to regard them as separate subspecies. *C. i. erythrocomata*, judging solely from the illustrations of the holotype (pl. 21, figs. 8, 9), is more elongate and the byssal notch is deeper and more angulate. *C. i. albida* is higher and the byssal notch is shallower and less angulate. The specimen of *C. i. albida* figured by Grau has the same height in proportion to its length and the same type of byssal notch as the holotype; it shows a small amount of variation, however, in the number and spacing of the fascicles. In all probability both subspecies are descended directly from *C. i. powersi.*

Holotype: USNM 150207, has a height of 45 mm.

Type locality: Recent, Illiukliuk Harbor, Unalaska Island, eastern Aleutian Islands, Alaska.

Other occurrences: Albatross sta. 3322, off Markoffski Bay (Grau); probably Morkovskoi Bay, now known as Pumicestone Bay, west side of Unalaska Island.

Other species assigned to Chlamys

Chlamys sp.

Plate 14, figure 3

Discussion.—The impression of an incomplete left valve from the upper beds on Middleton Island is unlike any of the other pectinids found there. Its narrow but well-defined fascicles and fine riblets suggest a relationship to *C. islandica kanagae* and *C. i. powersi.* Until better specimens of this form are obtained, it would be difficult to determine its relationships more precisely. If this is a subspecies of *C. islandica*, it is the only record of the species in a section in which fossiliferous beds of both Pliocene and Pleistocene age are recognized.

Figured specimen: USNM 645028, a fragment of a left valve, has a longest dimension of 55 mm.

Locality of figured specimen: Unnamed formation, upper beds (horizon probably early Pleistocene), Middleton Island, Alaska, USGS M1742.

Chlamys (?) washburnei (Arnold)

Plate 1, figure 2

Pecten (Chlamys) washburnei Arnold, 1906, U.S. Geol. Survey Prof. Paper 47, p. 119, pl. 45, fig. 2.

Chlamys washburnei, MacNeil *in* Powers, Coats, and Nelson, 1960, U.S. Geol. Survey Bull. 1028–P, p. 537.

Discussion.—Very little concerning the age of this species can be added to my previous statement (MacNeil in Powers and others, 1960, p. 537) that "*Chlamys washburnei* was described from beds on the Yachates

River, Oregon, which have been assigned variously to the Pliocene (Arnold, 1906, p. 119–120), middle Miocene(?) (Weaver, 1942, p. 86), and to the early Oligocene (Vokes, personal commun., 1954). It is associated, according to Vokes, with two crinoids, *Isocrinus oregonesis* and *I. nehalemensis*, which Moore and Vokes (1953, p. 116) described from beds correlated with the Keasey Formation (early Oligocene)."

Chlamys washburnei and *Isocrinus oregonensis* occur together on Rat Island in the Aleutians (MacNeil in Lewis and others, 1960, p. 560). The specimen figured here is from nearby Amchitka Island, presumably from beds of the same age as those on Rat Island. A poorly preserved mold from the south side of Attu Island may be the same species.

Chlamys washburnei is one of the earliest members of the *C. islandica* group, and it could be the radicle for several subsequent genera, including *Placopecten*.

Nagao (1928, p. 39) described *Pecten (Chlamys) ashiyaensis* from late Oligocene beds of Japan. Illustrations of this species by Oyama, Mizuno, and Sakamoto (1960, pl. 28) strongly suggest that this is a *Vertipecten*, or at least a *Chlamys* very closely related to *Vertipecten*. Masuda (1962b, p. 179) decided, after studying Nagao's specimens, that two species were involved. The second species was named *Chlamys nagaoi* Masuda. His figures of the species (1962b, pl. 20, figs. 4–6) show it to be very similar to *C. washburnei*. Both the Alaskan and Oregon beds containing *C. washburnei* are believed, however, to be older than late Oligocene, the age assigned to the Japanese species.

Another species that probably is related to *C. washburnei* was described by Makiyama (1934, p. 133, pl. 3, figs. 7, 8) from the Asagai Formation (late Oligocene and early Miocene) at Matchgar, northern Sakhalin as *Chlamys matchgarensis*. This species has heavier and broader ribs than *C. washburnei*.

Types: The holotype (USNM 164843) has a height of 108 mm. Figured specimen numbered USNM 645029.

Type locality: Mouth of Yachates River, Lincoln County, Oreg., in beds now referred to the Keasey Formation (horizon probably early Oligocene), USGS 3593.

Locality of figured specimen: Banjo Point Formation (Oligocene?), south side of Amchitka Island at 51°24′32″ N., 179° 09′44″ E., Aleutian Islands, Alaska, USGS D47.

Other occurrences: Gunners Cove Formation (Oligocene?), Rat Island, Aleutian Islands, Alaska, USGS M337; volcanic conglomerate along Nevidiskof Bay, south side of Attu Island, Aleutian Islands, Alaska (49–P–67).

?Chlamys sp.

Plate 6, figure 9

Discussion.—An unidentified fragment of a pectinid is present in a collection of possible early Miocene age from Tanaga Island in the central part of the Aleutian Islands (Fraser and Barnett, 1959, p. 220–221, loc. 12). It occurs in association with a large *Spondylus*?, resembling *S. perrini* Wiedey, *Platyodon* sp., *Acmaea* sp., and a large heavily fluted barnacle that according to V. A. Zullo (oral commun., 1962) is wholly unlike any known northern Pacific barnacle.

The fragment, probably of a right valve, bears some resemblance to a fragment of *Patinopecten (Lituyapecten) poulcreekensis* MacNeil figured by me (McNeil, 1961, pl. 35, fig. 4), and it is of comparable age.

Figured specimen: USNM 645030, a fragment of a right valve, measures 36 mm in its longest dimension.

Locality of figured specimen: A 5 to 20-foot lens of tuffaceous coquina conglomerate overlying an andesite flow, Tanaga Island, lat 51°41′25″ N., long 177°50′30″ W., Aleutian Islands, USGS D26 (T).

Chlamys? nuwokensis MacNeil

Plate 6, figures 1–3

Chlamys nuwokensis MacNeil, 1957, U.S. Geol. Survey Prof. Paper 294–C, p. 120, pl. 11, figs. 4–6, 12.

Discussion.—This species has a very thin translucent shell. The umbonal angle is narrow but flares rapidly, making the dorsal margins strongly concave. The ribs are narrow with a rounded top in juveniles but they become indistinct towards the margin in adults; the point at which they become indistinct varies in different individuals. The interspaces are broad and gently rounded, and they are sculptured with fine radial riblets. The surface is finely scabrous but not with the metal-lathe type of microsculpture. The byssal sinus is moderately deep and the byssal area of the anterior ear of the right valve is wide.

The relationships of this species are unknown. As pointed out at the time of its description, it has at least a superficial resemblance to *Chlamys sayana* (Dall) from the middle Miocene of Florida (see Tucker-Rowland, 1938, pl. 2, fig. 6). Nothing described from the northern Pacific area thus far has much resemblance to it. The species has a vague similarity to some variants of *C. opercularis* (Linné) from nothern Europe but not enough for definite identification.

Pecten glyptus Verrill (Dall, 1889, p. 248, pl. 8, figs. 2, 3; Abbott, 1954, p. 366, pl. 33, fig. a), a Recent species from moderately deep water in the western Atlantic, has a thin shell with somewhat similar shape and sculpture. Dall's figure shows, however, that it has well-defined *Amusium*-like internal ribs. *C. nuwokensis* has not the slightest indication of internal ribs; the interior surface undulates gently in conformance with the exterior ribs.

There is at least a superficial similarity between *C. nuwokensis* and *C. hastata*. Both species have very concave dorsal margins and sharp-crested ribs separated

by broad rounded interspaces. Furthermore, the interspaces are sculpture by moderately fine regular radial riblets. I am inclined to regard whatever similarity there is between these forms as homeomorphic.

If and until it can be shown that this species is clearly related to some Tertiary form, it might be suspected of being a relict of some very old group. It has as much resemblance to *Pecten assiniboiensis* Landes (1940, p. 142, pl. 3, fig. 9) from the Bearpaw Formation (Cretaceous) of Saskatchewan as to the above-mentioned Tertiary and Recent species. The possibility exists that there was a landlocked or nearly landlocked sea in the polar region throughout early Tertiary time.

Types: The holotype (USNM 561866), an incomplete left valve, has a length of 60 mm. Two paratypes are figured, a fragment of a left valve (USNM 561867), and a fragment of a right valve (USNM 561869).

Type locality: Beds below the type Nuwok Formation of Dall (1919) (210–258 ft below the top of the Nuwok Formation, the upper 210 ft of which constitutes the type Nuwok), Carter Creek, a stream flowing into Camden Bay, northeastern Alaska, USGS D50 (T). The horizon is believed to be of middle or late Miocene age (see remarks under *Arctinula groenlandica*, p. 8).

Genus VERTIPECTEN Grant and Gale, 1931

Pecten (*Vertipecten*) Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 188.

Type species (by original designation): *Pecten nevadanus* Conrad. Early and middle Miocene. Southern California.

Discussion.—The outstanding peculiarity of *Vertipecten* is the much greater inflation of its left valve over its right valve. This characteristic is rare but not unknown in other pectinids; *Vertipecten* certainly seems to be the largest pectinid to have it.

While the more advanced species of *Vertipecten* have highly inflated left valves and very coarse ribs, rivaling *Patinopecten* in coarseness, the earliest and more primitive species had less inflated left valves and finer ribs. The more finely ribbed *Vertipecten* are clearly related to *Chlamys*, and the genus appears to have diverged from *Chlamys* in late Eocene or early Oligocene time. The known *Vertipecten* that have fine ribs and that appear to be most closely related to *Chlamys* are of Oligocene and possibly earliest Miocene age. Species with medium to moderately coarse ribs also occur in Oligocene beds, however, suggesting that coarsely ribbed stocks appeared early in the evolution of the genus and that both fine and coarsely ribbed stocks were coexistent for a time. The last known species of *Vertipecten* have coarse ribs. Left valves of *Vertipecten* usually have finely reticulate or metal lathelike microsculpture, as do most groups of *Chlamys*.

Chlamys grunskyi (Hertlein) (new name for *Pecten branneri*, Dickerson, 1917, pl. 28, fig. 2), from the Gries Ranch Formation (early Oligocene), near Vader, Wash., is closely related to *Vertipecten* and may actually be a *Vertipecten*. Only the right valve of this species has been found. *C. grunskyi* is one of the closest known relatives of *V. lachenbruchi* here described, from middle Oligocene beds of Alaska.

Weaver and Kleinpell (1963, p. 197) identified *Pecten* (*Chlamys*) *sespeensis* Arnold, a Vaqueros species, in both the so-called Coldwater Sandstone (late? Eocene) and the upper part of their Gaviota Formation (?horizon middle Oligocene) of southern California. One of the specimens they figured (pl. 29, fig. 10, pl. 30, fig. 1) from the Gaviota Formation is very close to the boundary between *Chlamys* and *Vertipecten*, morphologically. Weaver and Kleinpell (1963, p. 198) also recorded *Vertipecten yneziana* (Arnold) from early (?) to late Oligocene beds in the same region. This is certainly a *Vertipecten*, and I see no reason to doubt the specific identification.

At the same time, Weaver and Kleinpell (1963, p. 198, pl. 31, figs. 2, 3, 7) described a new subspecies, *Pecten* (*Vertipecten*) *yneziana subyneziana* which they recorded from both the so-called Coldwater Sandstone (late? Eocene) and the undifferentiated Sacate-Gaviota Formation (late Eocene or early Oligocene). They say, "With this previously undescribed subspecies the very phylogenetic radicle of the subgenus *Vertipecten*, as described by Grant and Gale (1931, p. 188–189), is now recognized." Unless *Vertipecten* as presently construed is polyphyletic, I am inclined to doubt this conclusion. Assuming the age assigned to this subspecies is correct, it does not conform morphologically to what I would expect the prototype species of *Vertipecten* to be. It is possible, of course, that *Vertipecten* is polyphyletic and that finely ribbed species such as *V. porterensis* (Weaver) and coarsely ribbed species such as *V. fucanus* (Dall) belong to different genera.

If *Vertipecten* as presently construed is polyphyletic, the coarsely ribbed type probably had a much earlier origin than the finely ribbed type. A possible ancestor of the coarsely ribbed type might be found in *Pecten* (*Chlamys*) *fissicosta* Etheridge (Woods, 1902, p. 163, pl. 30, figs. 3–8) from the Cretaceous of England. According to Woods, the right valve of this species is less inflated than the left valve. If and until some intermediate forms are discovered, and it can be shown how this stock might have reached the northern Pacific, this possible relationship is little more than an interesting speculation.

The genus *Vertipecten* is peculiar to western North America. The fact that no member of this group has been found on the Asiatic side of the Pacific is in harmony with the thesis that few, if any, mollusks having

pelagic larvae have migrated from the American to the Asiatic side of the Pacific. In contrast, many Asiatic forms have migrated to the American side. Such a distribution for forms with pelagic larvae may result from the major oceanic current circulation, which is clockwise in the northern hemisphere. The Subarctic Current of Bering Sea circulates counterclockwise, and it could carry some pelagic larvae towards East Asia by a far northern route, but so far little is known of such migrations. The few mollusks that appear definitely to have originated on the American side of the Pacific and to have appeared subsequently in East Asia have benthonic larvae. These forms, while having a temperature preference that may restrict them to a current or other water of favorable temperature, may, nevertheless, migrate with or against currents.

Vertipecten lachenbruchi MacNeil, n. sp.

Plate 1, figures 3–8; plate 2, figures 4, 7

Description.—Shell of medium size and moderately inflated, the left valve more inflated than the right valve; beaks moderately sharp; dorsal margins weakly concave; hinge line moderately long and straight. Ears prominent and moderately broad; anterior ear of right valve moderately broad with a broad strongly sculptured byssal area, byssal notch broad but moderately shallow; posterior ear of right valve moderately long with a concave moderately sloping posterior margin; anterior ear of left valve with a weakly concave but nearly vertical anterior margin; posterior ear of left valve moderately short and strongly sloping along its posterior margin. Sculpture consisting of moderately small and closely set ribs that are variable in shape and spacing and ornamented with beadlike to scabrous projections; left valve (holotype) with a maximum of 47 ribs, of which about 20 might be considered primaries, the secondaries are variable in size and in the number between pairs of primaries; right valve ribs sharper and irregularly paired, especially near the beaks, scabrous to bluntly spined; ears strongly sculptured with primary and secondary riblets, growth lines on byssal area strongly raised and irregular.

Discussion.—This species is based on specimens from two localities, the holotype, a left valve and the largest specimen, from McGinty Point on the mainland, and several scraps of right valves from Unga Island. *Acila shumardi* occurs at both localities.

I cannot say on the basis of the material at hand whether this species is very close to any others described. Its sculpture resembles that of *Pecten (Chlamys) proavus* Arnold (1906, p. 52, pl. 2, figs. 6–8) from a locality between Pescadero Creek and the San Lorenzo River, San Mateo County, Calif. Arnold thought its age was Eocene, but Keen and Bentson (1944, p. 93) said "Oligocene or Miocene." Earl Brabb, of the U.S. Geological Survey (oral commun., June 8, 1964) thought the horizon of *P. proavus* was within the Zemorrian foraminiferal stage.

V. lachenbruchi may be fairly closely related to *Pecten (Chlamys) grunskyi* Hertlein (*Pecten branneri*, Dickerson, 1917, pl. 28, fig. 2) from which it differs mainly by having weak spines or scales on its ribs. The ears of the right valve are very similar on the two species.

Types: The holotype (USNM 645031), an incomplete left valve, has a length of 58 mm and if complete probably would be about 80 mm. Three paratypes (USNM 645032, 645033, 645034) are smaller fragmental right valves. Two figured scraps are numbered USNM 645035 and 645036.

Type locality: An unnamed formation within and possibly near the top of the *Acila shumardi* zone (middle Oligocene), east tributary to Mud Bay, south of Port Moller, Alaska Peninsula, USGS M1025.

Other occurrences: Paratypes and figured specimens are from an unnamed formation south of West Head, northeastern Unga Island, Alaska, probably the same stratigraphic horizon as the type locality near Mud Bay, USGS 5037.

Vertipecten popofensis MacNeil, n. sp.

Plate 1, figure 1; plate 2, figures 1, 3, 5, 6, 8

Description.—Shell of medium size and moderately thin. Left valve more inflated than right valve, especially near the beak. Anterior ear of left valve larger than posterior ear, anterior margin weakly S-shaped, posterior ear with a convex margin, ears of right valve not well known, anterior ear broad with a broad byssal area. Left valve sculpture consists of moderately broad rounded ribs over most of the disc; the ribs become smaller and weakly beaded posteriorly. Weaker interstitial ribs present in some interspaces on the disc and in most posterior interspaces. Right valve with low rounded to flattened ribs and interspaces of nearly equal width; posteriormost ribs weak and irregular. Reticulate or metal lathelike microsculpture present on ears, the upper part of the disc, and persisting to the margin on the posterior part of the shell, posteriorly having a diagonal strike as in *Camptonectes*.

Discussion.—Although the material on which this species is based is fragmental and the fragments belong to different individuals, it is presumed that the fragments all belong to the same species. Several nearly complete internal molds are present in the same collections.

The shell of this species is thin for a pectinid of this size, a factor contributing to the rarity of large pieces of test; the fragments figured were freed from matrix in the laboratory. The test apparently crumbled and was lost on free specimens collected in the field.

Vertipecten popofensis is probably most closely related to two Miocene species, *V. fucanus* (Dall) from the Astoria Formation of Washington and *V. bowersi* (Arnold) (=*V. nevadanus* (Conrad)) from the Temblor Formation of central California (for both see Arnold, 1906). This group of *Vertipecten* has moderately strong to strong ribs; the ribs of the right valve are broadly rounded or flat topped. *V. porterensis* (Weaver) (see Clark and Arnold, 1923, pl. 24, fig. 1), from the Blakeley Formation of Weaver (1912) (late Oligocene and early Miocene) of Washington, appears to belong to a different group of *Vertipecten*, a group that is more primitive morphologically and that retains more of the characters of the ancestral *Chlamys*. *V. porterensis* is more closely related to *V. lachenbruchi* and may be derived from that species.

The oldest known *Vertipecten*, *V. yneziana* (Arnold) (see Weaver and Kleinpell, 1963, pl. 30, fig. 7; pl. 31, figs. 1, 4), and *V. sespeensis* (Arnold) (ibid., pl. 29, fig. 10; pl. 30, fig. 1), both from late Eocene or early Oligocene beds of southern California, may also represent two groups; *V. sespeensis* the group of *V. porterensis*, and *V. yneziana* the group of *V. fucanus*.

V. popofensis occurs in association with *Acila shumardi* (Dall), *Ostrea tigiliana* Slodkewitsch, *Arca* cf. *A. merriami* (Van Winkle), and numerous other probably undescribed species.

A fragment of a pectinid (pl. 1, fig. 1) from the upper part of the Tokun Formation (Eocene and Oligocene) in the Katalla district, Alaska, may be referable to *V. popofensis*. The specimen is an internal mold with a little shell material adhering; it does not show the external character of the ribs. The horizon in the Oligocene from which this fragment was obtained may be older than the horizon of the type of *V. popofensis*.

The species of *Vertipecten* here described are the first undoubted *Vertipecten* to be reported thus far from Alaska. Some internal molds from the Yakataga district reported previously (MacNeil, 1961, p. 236) may be a *Chlamys* related to *Chlamys tugidakensis*, here described. *Vertipecten* may have originated in Alaskan waters.

Types: The holotype (USNM 645037), an incomplete left valve, measures 48 mm in its longest preserved dimension; it is a half-grown specimen. The paratype from the same locality (USNM 645038), a large fragment of the disc of a left valve, would have a restored length of about 90 mm. Two paratypes and two figured specimens are numbered USNM 645039, 645041, 645051.

Type locality: An unnamed formation within the *Acila shumardi* zone (middle Oligocene), seacliff near the northwest corner of Popof Island, Shumagin Islands, Alaska, USGS 3563.

Other occurrences: Same horizon, northeastern Unga Island south of West Head, USGS 5037.

Doubtful occurrence: Upper part of Tokun Formation, "Split Creek, 100–200 yards above branch that heads against the Redwood Creek divide," Katalla district, USGS 4323.

Vertipecten n. sp.?

Plate 2, figure 2

Discussion.—A mold of a left valve of a *Vertipecten* is present in one of the collections of the Harriman Expedition from the east side of Chichagof Bay, a small cove on the south side of the Alaska Peninsula, west of Stepovak Bay and about due north of Korovin Island. It occurs in a partly metamorphosed rock containing *Acila shumardi*, *Ostrea tigiliana* Slodkewitsch, *Epitonium atwoodi* Dall, and other mollusks.

The specimen appears, on the basis of its ribbing, to be intermediate between *V. lachenbruchi* and *V. popofensis*, possibly closer to the former. The interspaces have a reticulate or metal lathelike microsculpture. The ears are more coarsely ribbed than on either of the above species.

Figured specimen: USNM 164892, a fragment of a left valve, measures 47 mm along its most complete dimension.

Locality of figured specimen: USGS 3373.

Genus PATINOPECTEN Dall, 1898

Patinopecten Dall, 1898, Wagner Free Inst. Sci. Philadelphia Trans., v. 3, p. 695.

Type species (by original designation): *Pecten caurinus* Gould. Recent. California to Alaska.

Discussion.—Prior to 1962, most of the large pectinids, Tertiary to Recent, on both sides of the northern Pacific were assigned to the genus *Patinopecten*. Then Masuda (1962b, p. 216) separated a group of *Patinopecten*-like species under the name *Kotorapecten*, and Akiyama (1962) proposed the name *Masudapecten* for three other species. Masuda (1963) decided that none of the Japanese species previously assigned to *Patinopecten* belonged to that genus, and for another large group of species he proposed the new genus *Mizuhopecten*, having as its type the Recent *Pecten yessoensis* Jay. No Japanese species are retained in *Patinopecten* as a result of these revisions. Inasmuch as Masuda regarded *Mizuhopecten*, *Kotorapecten*, and *Masudapecten* as being more closely related to *Fortipecten* Yabe and Hatai than to *Patinopecten* and because *Fortipecten* was the oldest of the Japanese names, he proposed Fortipectininae as a new subfamily name to include the newly proposed genera. *Nipponopecten* Masuda (1962b, p. 194) was also included in the Fortipectininae.

Masuda's classification, which is based on selected characters, does not relate the American *Patinopecten* to the Japanese forms. In my opinion, the status of the newly proposed Japanese genera and subfamily must be considered tentative until the exact relation-

ship of all the American and Japanese stocks is better understood than at present. The fact remains that the large American pectinids referable to *Patinopecten* and to the subgenus *Patinopecten* (*Lituyapecten*) MacNeil appeared in America abruptly and without any known American antecedents. In all probability, the stock or stocks came from East Asia. I find it difficult to believe that some of the species included under *Mizuhopecten* by Masuda will not be restored to *Patinopecten* or that *Patinopecten* will not have some suprageneric priority in a subfamily or family name.

Subgenus PATINOPECTEN Dall

Patinopecten (Patinopecten) cf. P. (P.) caurinus (Gould)

Plate 4, figures 3, 4

Discussion.—Beds high in the Yakataga Formation in the vicinity of the Pinnacle Hills in the Malaspina district have been known to contain *P. caurinus* or a species closely related to it (Dall in Russell, 1891, p. 171–173; MacNeil, 1961, p. 236; Miller, 1961, p. 243). The figures of this form given here are the first to be published. They are photographs of rubber casts obtained from molds prepared by the acid solution of shell material in slabs of a highly indurated sandstone. The shells themselves were deeply pitted by the enclosing sand grains so that little or no surface detail shows on the casts. The ears and ribbing, however, show that the species is very similar to *P. caurinus*.

Patinopecten caurinus has not been identified with certainty in pre-Pliocene beds; the supposed Miocene records of Grant and Gale (1931, p. 195) are based on *P. propatulus* Conrad and *P. oregonensis* Howe, which they placed in the synonymy of *P. caurinus*. The species has been found in the Coos Conglomerate (early Pliocene) of Oregon and in the Rio Dell Formation of Ogle (1953) (part of the Wildcat Series of Lawson, 1894) (Pliocene) of Humboldt County, Calif. A specimen from the so-called Wildcat Series was figured by Masuda (1963, pl. 23, figs. 1a, b).

Figured specimens: The largest figured specimen (USNM 645042), a right valve, has a height of 94 mm and a length, slightly compressed, of 96 mm. A left valve is numbered USNM 645043.

Locality of figured specimens: Yakataga Formation, upper part (horizon probably Pliocene), south side of Point Glorious at the western end of the Pinnacle Hills, a spur projecting into the eastern side of Seward Glacier, Malaspina district, Alaska, USGS R263 (T).

Subgenus LITUYAPECTEN MacNeil, 1961

Patinopecten (*Lituyapecten*) MacNeil, 1961, U.S. Geol. Survey Prof. Paper 354–J, p. 227.

Type species (by original designation): *Patinopecten* (*Lituyapecten*) *lituyaensis* MacNeil. Late Miocene(?). Lituya Bay district, Alaska.

Discussion.—At one time (see MacNeil, 1961, p. 228) I did not feel that the origin of typical *Patinopecten* was clear; however, I have become convinced on the basis of further study that *Patinopecten* (*Patinopecten*) is derived from the older subgenus *Patinopecten* (*Lituyapecten*). The closest known relative of *P. caurinus* may be *P.* (*L.*) *purisimaensis* (Arnold).

It still remains to be shown how the American *Patinopecten* and *Patinopecten* (*Lituyapecten*) are related to the early so-called *Patinopecten* of Japan, all of which Masuda (1963) now places in different genera. I am not prepared to accept Masuda's (1963, p. 152) suggestion that *Patinopecten* is more closely related to typical *Pecten* and the Amusiinae than to the large Japanese pectinids or that it is a migrant from the Mediterranean region rather than from East Asia.

Patinopecten (Lituyapecten) n. sp.

Plate 6, figures 6, 8, 10

Discussion.—MacNeil, 1961, p. 231, pl. 41, fig. 2) figured a specimen from the Icy Point section at the south end of the outcrop of Tertiary beds in the Lituya district, Alaska, as *Patinopecten* (*Lituyapecten*) *yakatagensis*? Clark. A few additional scraps of this species have been collected since that time. While these scraps indicate that a still-undescribed species lived in the area, they do not provide enough of the shell to justify a description. It is presumed that one of the scraps recently collected is part of a left valve, but, if so, the left valve does not have the frills along the edges of the ribs that characterize the other Alaskan species of *Lituyapecten*. This species closely resembles *P.* (*L.*) *coosensis* (Shumard).

Figured specimens: USNM 645044,–645046 are all scraps, two of them right valves and one a possible left valve.

Locality of figured specimens: Beds of probably late Miocene age in the vicinity of Icy Point, Lituya district, Alaska, USGS M1144, M1154, and M1842. A larger fragment figured previously is from USGS D187 (T).

Subgenus MIZUHOPECTEN Masuda, 1963

Mizuhopecten Masuda, 1963, Trans. Proc. Palaeont. Soc. Japan, new ser., no. 52, p. 151.

Type species (by original designation): *Pecten yessoensis* Jay. Recent. Northern Japan.

Discussion.—Masuda separated *Mizuhopecten* from *Patinopecten* because of its longer ears, much shallower byssal notch, and the lack of a distal denticle on its auricular crurae. He also states that *Mizuhopecten* has broader and more rounded ribs, but both groups are variable in that respect. The size of the ears and the depth of the byssal notch seem to be the most reliable charatcers for distinguishing typical *Patinopecten* and

Mizuhopecten. The ears of the respective type species, *P. caurinus* and *P. yessoensis*, are joined to the dorsal margins somewhat differently; in *P. caurinus* the ears are flush with or even slightly raised above the margins, and there is no open cleft; in *P. yessoensis* the ears are set back from the margins, and there is a moderate cleft between the ears and margins.

Another character that seems to be consistent, one that Masuda did not mention, is the nature of the umbonal callus that fills the area between the muscle scar and the cardinal plate. *P. caurinus* has a thin callus that appears to be crystallographically more similar to the rest of the interior of the shell. *P. yessoensis* has a thick coarsely crystalline callus that shows numerous reflecting surfaces on individual crystals.

Patinopecten (Mizuhopecten) skonunensis MacNeil, n. sp.

Plate 4, figure 2; plate 6, figure 7

Description.—Only the right valve of this species is known. Shell of medium size, suborbicular, moderately inflated. Beaks moderately overturned, sloping moderately steeply toward the hinge. Dorsal margins very weakly concave, outer margins evenly curved. Hinge line of medium length and ears of medium size; anterior ear moderately broad with about three faint radial riblets, byssal area swollen and sculptured by growth lines only; posterior ear moderately broad, posterior margin sloping at about 45°, radial sculpture hardly discernible; byssal notch shallow; ears nearly flush with dorsal margins and with no open cleft between the ear and margin. Sculpture consists of about 20 moderately prominent radial ribs of variable width, some of the anterior ribs having a tendency to split; interspaces rounded and slightly narrower than the ribs. The shell of the holotype is slightly worn, but there appears to be no clearly defined microsculpture. Muscle scar of medium size. Area between muscle scar and hinge plate with a moderately heavy coarsely crystalline callus. Auricular crurae moderately strong, swollen distally, and diverging weakly from the hinge line terminally. Ligament pit with strong lateral ridges. No ctenolium.

Discussion.—The ears of this species are appressed to the dorsal margins as in *P. caurinus*, but in practically all other characters it is more closely related to *P. yessoensis*. The posterior ear slopes even more than in *yessoensis;* in *caurinus* the posterior margin of the ear is nearly vertical.

Judging from available figures of Japanese species, *P. skonunensis* is most closely related to the *P. hashimotoi* group of Akiyama (1962, p. 115), particularly to the *P. yamasakii* subgroup. Both *P. hashimotoi* Akiyama (1962, pl. 2, figs. 1, 5) from the Nakatombetsu Formation (early? Pliocene) of Hokkaido and *P. yamasakii ninohensis* Masuda (see Akiyama 1962, pl. 5, fig. 2) from the Suenomatsuyama Formation (lower part, probably late Miocene according to Hatai and Nisiyama, 1952) of northern Honshu resemble this species. Masuda (1963, p. 149), however, assigned these two species to different genera, *P. hashimotoi* to *Mizuhopecten* and *P. yamasakii* to *Kotorapecten*.

Of the American species commonly referred to *Patinopecten*, I am inclined to believe *P. healeyi* (Arnold) (1906, pl. 37, figs. 1, 2) from the Pliocene of California is most closely related to *P. skonunensis*. *P. healeyi* has a shallow byssal notch, the posterior margin of the posterior ear slopes strongly, and the umbonal callus is coarsely crystalline and thick. *P. healeyi* has two-parted ribs on its right valve, but this division into two ribs is restricted to the anterior ribs of *P. skonunensis*.

The deep byssal notch of *P. caurinus* indicates that typical *Patinopecten* is closely related to and probably descended from the older American subgenus *Lituyapecten*. *P. healeyi* and *P. skonunensis* have a shallow byssal notch, and in this respect, at least, they are more like *Mizuhopecten*.

Addicott (1965) identified a *Nassarius* found with *P. skonunensis* as *N. whitneyi* (Trask), a species described from the Briones Sandstone (early late Miocene) of central California and reported from supposed middle Miocene beds in the same area.

Holotype: UCLA 39474, an incomplete right valve, measures 72 mm in longest dimension; its complete length would be comparable.

Type locality: Skonun Point, about 5 miles east of Masset on the north coast of Graham Island, Queen Charlotte Islands, British Columbia, UCLA 4674. Skonun Formation (probably late Miocene). (See MacKenzie, 1916, p. 73.)

Genus FORTIPECTEN Yabe and Hatai, 1940

Pecten (*Fortipecten*) Yabe and Hatai, 1940, Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 21, no. 2, p. 149.

Type species (by original designation): *Pecten takahashii* Yokoyama. Maruyama Formation (early Pliocene). Southern Sakhalin. Reported from several formations of early Pliocene age in Hokkaido and northern Honshu.

Discussion.—Masuda (1962b, p. 222) is, so far as I am aware, the first author to raise *Fortipecten* to the rank of genus, and it is here so regarded. Masuda (1963, p. 149–150) proposed the new subfamilial name Fortipectininae to include all the so-called *Patinopecten* of Japan which he transferred to other genera. *Fortipecten* is characterized by a very large adductor muscle, and in this character alone it is very distinct from

Patinopecten. It is equally distinct on this basis from the other Japanese genera, *Masudapecten*, *Kotorapecten*, *Mizuhopecten*, and *Nipponopecten*, that Masuda included in the Fortipectininae. I am not convinced that *Masudapecten*, *Kotorapecten*, and *Mizuhopecten* are sufficiently removed from *Patinopecten* to be included in a different subfamily. If a subfamily name is required, I would prefer to place these four genera in a subfamily Patinopectininae. *Fortipecten* is so unique that, pending further knowledge of its ancestry, it could stand in a subfamily of its own. Fortipectininae would, of course, have priority as a subfamily name for the group of *Fortipecten*.

According to Chinzei (1960, p. 68), *Fortipecten takahashii* occurs in beds of early and middle Pliocene age, and a new species, *F. kenyoshiensis* (ibid., p. 64), occurs in the Togawa Formation of late Pliocene age. Chinzei dated the Togawa Formation as late Pliocene, partly because it is overlain unconformably by Pleistocene beds. Masuda (1962b, p. 222), on the other hand, assigned both species to the early Pliocene (in a twofold division).

If the known Japanese *Fortipecten* are confined to the lower half of the Pliocene, the genus may be a migrant to Japan from elsewhere in the northern Pacific. The new species from Alaska described here, *F. mollerensis*, is believed to be of late Miocene age, and, as *F. hallae* (Dall), the genus is known from both near Nome, Alaska, south of Bering Strait, and at Kivalina, Alaska, north of Bering Strait, in beds of very late Pliocene or possibly earliest Pleistocene age. *F. piltunensis* (Khomenko) (see Slodkewitsch, 1938, pls. 39, 40, figs. 2, 3) was described from the Supra-Nutovo series of Sakahalin, beds believed by Russian geologists to be of very late Pliocene age. *Fortipecten* may thus occur in Alaska in beds both older and younger than those of Japan.

Fortipecten mollerensis MacNeil, n. sp.

Plate 4, figure 1; plate 5, figures 1, 6

Description.—Shell large, thick, medium inflated, slightly elongate anteroposteriorly, hinge line moderately long. Ears of left valve large and moderately elongate, the anterior ear slightly larger, terminal margins nearly vertical, anterior margin of anterior ear slightly sinuous. Sculpture of left valve consisting of about 16 low, rounded, moderately broad ribs, separated by shallow, rounded interspaces nearly twice as broad as the ribs. No secondary riblets or microsculpture discernible on type. Interior of left valve with moderately deep, rounded grooves opposite ribs that extend only a short distance from the margin, probably being filled with callus centrally. Adductor muscle scar very large and deep, probably made deeper than originally by the solution of an aragonitic attachment layer. Pedal retractor scar also large and deep. Subumbonal callus area well defined and sunken. Right valve ears unknown. Sculpture consisting of moderately strong broad ribs that may range from rounded to flattened to medially grooved on the central part of the disc, and finer irregularly spaced ribs terminally; some terminal interspaces have a moderate interstitial riblet. The central ribs of the right valve are broader than the interspaces.

Discussion.—This species has a shorter hinge than either *F. takahashii* or *F. kenyoshiensis*, the ribs are considerably stronger and broader, and there is no apparent tendency for every third or fourth rib to be stronger. There is no tendency for the ribs of *F. mollerensis* to form nodes or bumps at regular intervals as in the Japanese species and in *F. hallae* from Alaska. *F. mollerensis* and *F. hallae* both have wider and stronger ribs and a shorter hinge line than the Japanese species. If *F. mollerensis* has any fine radial markings between the primary ribs of the left valve, they are not visible on the type; it differs in this respect from the other known species of *Fortipecten*.

The antecedents of this species, and, for that matter, the origin of the genus *Fortipecten* remains unknown. There is at least a superficial resemblance between *F. mollerensis* and some large pectinids from the Miocene of the Vienna basin. One such species, *Amussiopecten gigas plana* Schaffer (1910, pl. 22, figs. 1, 2) has very large ears and somewhat similar sculpture. The muscle scars are not figured. Relationship is suggested between *Fortipecten* and both *Pecten* and *Amussiopecten* by the fact that the dorsal marginal areas of the left valve of both *F. takahashii* and *F. hallae* are more swollen than the dorsal central part of the disc. An outside origin for *Fortipecten* is only a possibility at present, however, and an early Tertiary Japanese origin cannot be ruled out entirely.

F. mollerensis occurs with *Clinopegma* cf. *C. stantoni* (Arnold), *Turritella* aff. *T. sagai* Kotaka, *Acila* cf. *A. empirensis* Howe, *Cyclocardia*, *Siliqua*, *Spisula*, *Macoma*, *Panomya*, and *Mya*. The fauna is dated, tentatively, as late Miocene.

Types: The holotype (USNM 645047), a left valve, measures 118 mm in height and 125 mm in length. The paratype (USNM 645048) is a fragment of a right valve.

Type locality: A small knob extending above the level of the Recent terrace on the south shore of Port Moller, approximately 3 miles southeast of Point Divide, USGS M2131.

Fortipecten hallae (Dall)

Not figured

Pecten (Plagioctenium) hallae Dall, 1921, Nautilus, v. 34, p. 76.
Pecten (Patinopecten) rhytidus Dall, 1921, Nautilus, v. 34, p. 77.
Pecten (Aequipecten) hallae, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 220.
Pecten (?Vertipecten) rhytidus, Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 191.
Pecten (Fortipecten) hallae, MacNeil *in* MacNeil, Mertie, and Pilsbry, 1943, Jour. Paleontology, v. 17, no. 1, p. 86, pl. 12, figs. 1, 2; pl. 13, fig. 1.
Patinopecten (Fortipecten) hallae, MacNeil *in* Hopkins and MacNeil, 1960, U.S. Geol. Survey Prof. Paper 400-B, p. B341.

Disscussion.—The only available figures of this species (MacNeil and others, 1943) show the exteriors of two right valves and a left valve. The muscle scar is extremely large, and the shell has a thick subumbonal callus. The left valve is swollen both medially and along the dorsal margins, leaving shallow, broad, but distinct sulci both anterior and posterior of the medial area; it resembles *Pecten (Pecten)* in this respect. The shell is thick and it weathers soft and chalky with a silklike sheen. The left valve has fine radial riblets between the primary ribs and the surface retains remnants of a metal lathelike microsculpture.

Fortipecten hallae is most closely related to *F. kenyoshiensis* (Chinzei) from the middle Pliocene of Japan. The left valve of *F. kenyoshiensis* is very similar, both in gross features and in the texture of its interstitial riblets (see Chinzei, 1960, p. 66, fig. 2). The right valve of *F. kenyoshiensis* has narrower and more prominent ribs and may be more inflated, and these characteristics make it intermediate between *F. hallae* and *F. takahashii*.

The inclusion of *F. hallae* in the fauna of the so-called Submarine Beach at Nome and in a similar fauna at Kivalina, north of Kotzbue Sound, is open to some question. Until the summer of 1961, when an old mine dump near the Solomon River was rediscovered, the exact locality of *F. hallae* was not known. Unfortunately, only a few unidentifiable scraps of other mollusks were found to occur with it, although *F. hallae* itself seems to have been fairly abundant. Not even fragments of *F. hallae* have been found in the Submarine Beach at Nome. The possibility certainly exists that the beds on Solomon River are a pre-Submarine Beach deposit not represented at Nome. A nearly complete but highly polished left valve of *F. hallae* from Kivalina, now in the California Academy of Sciences, and fragments of the species in Geological Survey collections apparently came from fossiliferous beds now exposed, but they have a preservation different from that of the rest of the fauna, and they could have been reworked into the beds now containing them from a submarine deposit. Until this species can be shown with certainty to have lived in the Submarine Beach, I am inclined to regard its inclusion in the fauna of the Submarine Beach as tentative.

Types: The lectotype (USNM 499059), a right valve labeled the type of *P. hallae*, has a height of 120 mm and a length of 126 mm. A left valve (USNM 499061) labeled *P. rhytidus* is the best preserved known specimen.

Type locality: Immediately above bedrock and about 20 ft below sea level in a prospect mine shaft, 0.8 mile east of Solomon townsite, and about 1 mile inland on the delta of the Solomon River, USGS 9250, M1267.

Other occurrences: Small valley on north side of Kivalina River about 1.3 miles above its mouth on Kivalina Lagoon and about 5.3 miles north-northwest of Kivalina Village, Alaska, USGS M1817.

Genus MIYAGIPECTEN Masuda, 1952

Miyagipecten Masuda, 1952, Trans. Proc. Paleont Soc. Japan, new ser., no. 8, p. 251.

Type species (by original designation): *Miyagipecten matsumoriensis* Masuda. Nanakita Formation (middle Miocene). Miyagi Prefecture, Japan.

Discussion.—Miyagipecten has a smooth *Amusium*-like right valve. The left valve has numerous fine radial ribs that do not extend to the margin in adult specimens. The Alaskan species, here described, has a smooth right valve and fine ribs on its left valve. In addition, its left valve has a strong metal lathelike microsculpture. I am assigning the Alaskan species to *Miyagipecten* because of its ribless right valve.

Although its ribs are more numerous, the fine ribs and microsculpture of the Alaskan species are similar to the ribbing and microsculpture of the left valve of two Japanese Pliocene species, *Pecten plebejus* Yokoyama (see Akiyama, 1962, pl. 1, fig. 5), and *Pecten tokunagai* Yokoyama (see Masuda, 1962b, pl. 24, fig. 9b). Akiyama (1962, p. 109) recognized both species and included them in *Patinopecten (Masudapecten)*, but Masuda (1963, p. 149) combined them under *P. tokunagai*, which he made the type of a new genus, *Yabepecten*. Both species have moderately small or weak radial ribs on the right valve. The ribs of *P. plebejus*, however, are very weak, and the upper part of the disc is nearly smooth.

Inasmuch as Masuda (1962b, p. 210) thought *P. plebejus* and *P. tokunagai* were one species, and the species so construed has ribs on its right valve that range from moderately strong to nearly obsolete, it would be possible for a related species to have a smooth right valve. The smooth right valve of *Miyagipecten* led Masuda (1957, p. 31) to assign it to the subfamily Amusiinae. In my opinion, this assignment is debata-

ble. I am inclined to believe that *Miyagipecten alaskensis*, here described, is much more closely related to *Yabepecten* and to some species of *Masudapecten* than it is to *Amusium*.

Miyagipecten alaskensis MacNeil, n. sp.

Plate 6, figures 4, 5

Description.—Shell of medium size and suborbicular, medium to weakly inflated. Right valve *Amusium*-like sculpture well developed with two apparent resting stages shown on the holotype. Anterior ear of right valve moderately broad and of moderate length, no well-defined byssal area; byssal notch shallow. Posterior ear of right valve moderately short with a steeply sloping posterior margin. Left valve with numerous small, rounded radial ribs, increasing in number by the addition of intercalary ribs ventrally, the intercalary ribs rapidly becoming as strong as the primary ribs. Microsculpture reticulate or metal lathelike, covering the interspaces and ribs alike. Ears of left valve unknown.

Discussion.—This species is known from the external and internal mold of several right valves and one incomplete external mold of a left valve. It occurs in a hard gravelly sandstone in association with a large unidentified fragment of *Patinopecten* (*Lituyapecten*). It is not absolutely certain that the two incomplete valves here figured belong to the same species. The ventral half of the internal mold of a specimen with attached valves show that neither valve has internal ribs; the internal mold comes from the external mold of a right valve. The probability is, therefore, that this is not an *Amusium*, but the possibility exists that the fragment of a ribbed left valve is a *Chlamys*.

No pectinid like this has been reported previously from America. It is presumed to be related to *Miyagipecten*, although I cannot find a description of a species of that genus that refers to a microsculpture like that of *M. alaskensis*. *M. alaskensis* may be closely related to *M. saromensis* Hasimoto and Kanno (1958, p. 287, pl. 42, figs. 1–5) from the Chirai Formation (middle Miocene) of Kitami Prefecture, nothern Hokkaido. The right valve of *M. saromensis* has faint radial ribs, unlike the present species, but the radial ribs of the left valve are of similar texture.

Types: The holotype (USNM 645049), an incomplete right valve, has an estimated height of about 55 mm, although another incomplete right valve probably was closer to 85 mm. The paratype is numbered USNM 645050.

Type locality: Nunatuk north of the east end of the Pinnacle Hills, lat 60°09′40″ N., long 140°16′40″ W., Malaspina district, Alaska, USGS M1321. The horizon is probably early Pliocene.

223-848 O—67——5

LOCALITIES

U.S. National Museum catalog numbers (Recent mollusks accessioned by the Division of Mollusks, U.S. National Museum, are cataloged by species lot; no separate locality number is given. New catalog numbers are not assigned to specimens subsequently made types or to figured specimens):

110462. Albatross sta. 5021, Okhotsk Sea, 73 fathoms. Recent.
150220. Alaska Peninsula, Alaska. Recent.

California Academy of Sciences localities (the California Academy of Sciences maintains both a locality register and a specimen catalog for types and figured specimens):

18493. St. Paul Island, Pribiloff Islands, Alaska. Recent. G. D. Hanna, collector.
31879. Puget Sound, Wash. Recent.
34333. Two miles off Arcon Camp, Point Barrow, Alaska, 71°21′10″ N., 156°46′45″ W., 140 ft. G. D. Hanna, collector.
34337. Three and one-half miles off Wainwright, Arctic coast of Alaska, 70°40′45″ N., 160°06′40″ W., 63 ft. G. D. Hanna, collector.
34347. Seventeen miles magnetic west of Arcon Beach, Arctic coast of Alaska. 71°21′30″ N., 157°23′00″ W., ?300 ft. G. D. Hanna, collector.
34358. Five miles off Point March, Arctic coast of Alaska. 70°38′30″ N., 160°19′00″ W., 69 ft. G. D. Hanna, collector.

University of California (Berkeley) locality (the University of California at Berkeley maintains both a locality register and a catalog of types and figured specimens):

A906. North wall of Wild Horse Canyon, 1,000 ft south of the E. cor. sec. 8, T. 20 S., R. 9 E., 100 ft below base of barren gravels of Paso Robles Formation. King City quad., Monterey County, Calif. J. Kirby, collector.

University of California (Los Angeles) locality:

4674. Skonun Point, 5 miles east of Masset on the north coast of Graham Island, Queen Charlotte Islands, Canada. Skonun Formation (probably late Miocene). Richfield Oil Co., collector.

U.S. Geological Survey Cenozoic localities (Washington register) (the U.S. Geological Survey maintains a locality register for Cenozoic mossusks at Washington and for Cenozoic mollusks at Menlo Park, Calif. Collections and records once at Denver are now at Menlo Park. Types and figured specimens are given U.S. National Museum catalog numbers and deposited in the U.S. National Museum, Washington):

3373. East side of Chichagof Bay, Alaska Peninsula, Alaska. *Acila shumardi* zone, Stepovak Series of Palache (1904) (Oligocene). Harriman Expedition, 1899, G. Palache, collector.
3363. Near northwest corner of Popof Island, Shumagin Islands, Alaska. *Acila shumardi* zone, upper part (*Oligocene*). W. H. Dall, collector.
4321. Burls Creek, 3.58 miles, 152.5° E. of N. from mouth of Split Creek on Bering Lake, Katalla district, Alaska. Burls Creek Shale Member (late? Oligocene) of Katalla Formation. A. G. Maddren, collector.
4323. Split Creek, 1.98 miles, 152.5° W. of N. from mouth of Split Creek on Bering Lake, Katalla district, Alaska. Tokun Formation, upper part (Oligocene). A. G. Maddren, collector.

4537. "Gravels under tundra near Nome, Alaska, at a depth of 50 ft" (?near Center Creek, about 2 miles from shore of Bering Sea). Intermediate Beach (middle Pleistocene). F. H. Moffit, collector.

4538. Otter Creek, about 2 miles from shore of Bering Sea. Shells said to come from 54 ft below surface and 20 ft above sea level, near Nome, Alaska. Probably Intermediate Beach (middle Pleistocene). Given to F. L. Hess by J. J. Beaver, collector.

5037. East side of Unga Island about one-fourth mile from northeast corner, 70 ft above mean tide level. Shumagin Islands, Alaska. *Acila shumardi* zone, upper part (Oligocene). W. W. Atwood, collector.

5046. North side of Port Moller, about due east from Hot Springs, Alaska Peninsula, Alaska. *Mytilus middendorffi* zone, Unga Conglomerate (middle Miocene). W. W. Atwood, collector.

5074. Mine dumps on Center Creek near Nome, Alaska. Gravels worked in these mines lie 18–21 ft above sea level. Intermediate Beach (middle Pleistocene). E. M. Kindle, collector.

5256. Postglacial deposits on Douglas Island, near Juneau, Alaska. A. Spencer, collector.

5313. Mine on Center Creek 1½ miles from coast and 32 ft below surface, Nome area, Alaska. Intermediate Beach (middle Pleistocene). Alaska Yukon Exposition, 1909, collectors.

5461. Mouth of Eagle River on Lynn Canal, north of Juneau. Postglacial deposits. A. Knopf, collector.

6694. Mouth of large gulch on south slope of White River valley at foot of glacier [1913], 2.40 miles 14° E. of N. from mouth of Fulton Creek, Bering Glacier A–4 quad., Yakataga district, Alaska. About 1,500 ft above base of Yakataga Formation (horizon probably middle Miocene). A. G. Maddren, collector.

7477. Dump of mine shaft 80 ft deep, 1 mile from coast between Dry and Bourbon Creeks, Nome area, Alaska. Probably Intermediate Beach (middle Pleistocene). F. L. Hess, collector.

7619. (=5074?) Mine dumps half a mile west of Nome, Alaska. Submarine Beach (late Pliocene or early Pleistocene). E. M. Kindle, collector.

9250. Prospect mine shaft about 1 mile inland and about 0.8 mile east of Solomon townsite on the delta of the Solomon River, immediately above bedrock and about 20 ft below sea level. Submarine Beach or possibly beds older than the Submarine Beach at Nome (late Pliocene or early Pleistocene). Otto Halla, collector.

12066. Glacier Highway along north side of Auke Bay, about about midway between Point Louisa and Auke Lake, Juneau area, Alaska. Postglacial deposits. M. L. Merritt, collector.

14866. Dumps of a line of old drift mines trending 60° W. of N., between Center and Bourbon Creeks about 2 miles north of the mouth of Snake River, Nome area, Alaska. Intermediate Beach (middle Pleistocene). J. B. Mertie, Jr., collector.

15437. Unnamed creek on the north flank of and parallel to Yakataga Ridge, 0.3 mile 16° E. of N. from peak 2430 near west end of Yakataga Ridge. Bering Glacier A–4 quad., Yakataga district, Alaska. Probably in basal part of Yakataga Formation (horizon lower middle Miocene). E. M. Spieker, collector.

16898. North end of spur projecting north into Bering Glacier, 12.8 miles, 58° E. of N. from north end of Hanna Lake. Bering Glacier A–4 quad., Yakataga district, Alaska. Near middle of Poul Creek Formation (horizon probably upper Oligocene or lower Miocene). D. J. Miller, collector.

16907. One and one-half miles, 14° west of northeast corner "clam lagoon," on sea cliff 280 ft above sea level. Adak Island, Aleutian Islands, Alaska. Early Pleistocene. R. R. Coats, collector.

16908. Floor of quarry at garbage dump, 3 miles west of East Cape at elevation 125 ft. Amchitka Island, Aleutian Islands, Alaska. Early or middle Pleistocene. R. R. Coats, collector.

16908a. Same as USGS 16908.

17743. West side of Middleton Island, Alaska, approximately 3.34 miles, 153° W. of N. from northern tip of island, 270–870 ft below top of exposed section in massive medium-gray to greenish- and olive-gray conglomeratic sandy mudstone; contains rock fragments as much as 4 ft in diameter. Probably early Pleistocene. D. J. Miller, collector.

17744. Bay near center of west side of Middleton Island, Alaska, approximately 2.34 miles, 160° W. of N. from northern tip of island, 870–980 ft below top of exposed section in conglomeratic sandy mudstone containing thin interbeds of conglomerate, coarse sandstone, and coquina. Probably early Pleistocene. D. J. Miller, collector.

17745. Northeast side of Middleton Island, Alaska, approximately 0.68 miles, 147° E. of N. from northern tip of island, 980–1,490 ft below top of exposed section in conglomeratic sandy mudstone; rock fragments in gravel are mainly of pebble and cobble size. Probably earlyPleistocene. D. J. Miller, collector.

17746. South tip of Middleton Island, Alaska, 1,490–1,535 ft below top of exposed section in conglomeratic sandy mudstone; contains rock fragments as much as 3 ft in largest dimension and thin beds of coquina at top and base of unit. Probably uppermost Pliocene. D. J. Miller, collector.

17817. South flank of Chaix Hills near margin of Malaspina Glacier [1947], 3.68 miles, 45° W. of S. from north end of Crater Lake, Bering Glacier quad., Malaspina district, Alaska. Yakataga Formation (horizon probably upper Miocene). D. J. Miller, collector.

U.S. Geological Survey Cenozoic localities (Denver register; transferred to Menlo Park):

D3 (T). High west-facing side of Kanaga Island, north of coastal lakes and about 4½ miles south-southwest of Kanaga Volcano, Kanaga Island, Aleutian Islands, Alaska. Horizon early or middle Pleistocene. G. L. Snyder, collector.

D26 (T). Lens of tuffaceous coquina conglomerate 5–20 ft thick and overlying an andesite flow, 51°41′25″ N., 177°50′30″ W., southeastern Tanaga Island, Aleutian Islands, Alaska. Early Miocene(?) G. L. Snyder, collector.

D46 (T). Loose sandy beach deposit about 135 ft above sea level at the head of South Bight, south side of Amchitka Island, Aleutian Islands, Alaska. 51°22′50″ N., 179°28′58″ E. Horizon early or middle Pleistocene. H. A. Powers, collector.

D47 (T). *Isocrinus*-bearing beds, 51°24′32″ N., 179°09′44″ E., Amchitka Island, Aleutian Islands, Alaska. Banjo Point Formation (Oligocene?). H. A. Powers, collector.

D50 (T). 210–258 ft below top of measured section on Carter Creek a stream flowing into Camden Bay, NE¼ NW¼ quad. 681, Arctic coast, northeastern Alaska. Overlain by the type Nuwok Formation of Dall (1919) and underlain by nearly 7,000 ft of non-fossiliferous beds. Horizon probably middle or upper Miocene. R. H. Morris, collector.

D53 (T). Tidal flat in Usof Bay, Unalaska Island, Aleutian Islands, Alaska. Recent, E. H. Meitzner and R. P. Platt, collectors.

D184 (T). Ocean beach reef, 1.03 miles, 57° E. of S. from mouth of Dagelet River, Mount Fairweather quad., Lituya district, Alaska. Upper part of Yakataga Formation (horizon probably Pliocene). D. J. Miller, collector.

D187 (T). Ocean beach reef, Icy Point measured section, 1.04 miles, 22° W. of S. from mouth of Kaknau Creek (Palma Bay, Mount Fairweather quad.), Lituya district, Alaska. Upper part of Yakataga Formation (horizon probably upper Miocene or lower Pliocene). J. F. Seitz, collector.

D222 (T). Steelhead Creek, probably from reefs at mouth of creek, about 4.5 miles southeast of entrance to Lituya Bay. Mount Fairweather C–5 quad., Lituya district, Alaska. Upper part of Yakataga Formation (horizon probably Pliocene). C. E. Kirschner and J. E. Heppert, collectors.

D263 (T). South side of Point Glorious, about 0.1 mile east of the westernmost part of the point, Mount St. Elias quad., Malaspina district, Alaska. Upper part of the Yakataga Formation (horizon probably Pliocene). G. Plafker, D. J. Miller, and D. L. Rossman, collectors.

D306 (T). Coleville River at Ocean Point, about 8 miles below mouth of Kikiakrorak River, northern Alaska. Lower part of Gubik Formation (horizon probably lower or middle Pleistocene). R. Stefanson, collector.

D318 (T). Beach at Wainwright, Arctic coast of Alaska. Recent. U.S. Coast Guard, collectors.

D373 (T). Beach at Cape Kialegah, St. Lawrence Island, Alaska. Recent. E. H. Muller, collector.

D386 (T). Raised beach at Narssurssuk, Greenland, terrace lies 10–35 ft above sea level. Probably post-glacial. W. E. Davies, collector.

U.S. Geological Survey Cenozoic localities (Menlo Park register):

M212. End of highway north of Douglas Island bridge, Douglas Island, Juneau area, Alaska. Postglacial deposits. D. J. Miller, collector.

M213. Beach at end of Douglas Island north of bridge, near Juneau, Alaska. Recent. D. J. Miller, collector.

M214. South side of Fish Creek on road north of bridge, Douglas Island, Juneau area, Alaska. Postglacial deposits. D. J. Miller, collector.

M216. Cut on Glacier Highway at Lena Cove, Juneau area, Alaska. Postglacial deposits. D. J. Miller, collector.

M217. Cut on Glacier Highway at Point Louisa, Juneau area, Alaska. Postglacial deposits. D. J. Miller, collector.

M218. Cut on Glacier Highway along north shore of Auke Bay, north to northwest of Indian Point. Postglacial deposits. D. J. Miller and W. H. Condon, collectors.

M223. East arm of Excursion Inlet, north side of Icy Strait between Lynn Canal and Glacier Bay. Dredged from depth of 150 ft. D. J. Miller, collector.

M234. East arm of Excursion Inlet on small bay 1.5 miles north of point between two arms. Dredged 500 ft offshore at depth of 50 ft. D. J. Miller, collector.

M243. Cuts on both sides of road 0.8 mile northeast of Fish Creek bridge, Douglas Island, Juneau area, Alaska. Postglacial deposits. D. J. Miller, collector.

M333. Tailing piles about 1½ to 2 miles north of Nome, Alaska. Intermediate Beach (middle Pleistocene). D. M. Hopkins, collector.

M337. Rat Island, Aleutian Islands, Alaska. 51°48′58″ N., 178°19′02″ E. Gunners Cove Formation (Oligocene?). H. A. Powers, collector.

M1025. Flats of east tributary to Mud Bay along east upstream fork, about 3.7 miles a little east of south from Jerk Triangulation Station, Port Moller quad., Alaska Peninsula, Alaska. Probably in upper part of *Acila shumardi* zone (Oligocene). M. C. Lachenbruch, collector.

M1084. Tailing piles about 1.6 miles north of north edge of Nome, Alaska. Intermediate Beach (middle Pleistocene). D. M. Hopkins, collector.

M1144. Topsy Creek, Lituya district, Alaska, approximately 58°36′15″ N., 137°27′45″ W. Upper part of Yakataga Formation (horizon upper Miocene or lower Pliocene). British Petroleum Exploration Co., collectors.

M1154. Icy Point, Lituya district, Alaska, approximately 58°22′45″ N., 137°05′00″ W. Upper part of Yakataga Formation (horizon upper Miocene or lower Pliocene). British Petroleum Exploration Co., collectors.

M1252. Tailings of prospect shafts on northeast slope to Otter Creek below Florence Gulch, east of Nome, Alaska, about 64°29′30″ N., 165°17′10″ W. Intermediate Beach (middle Pleistocene). D. M. Hopkins, collector.

M1256. Dredge tailings near oil tanks in F. A. A. warehouse on west side of Snake River, Nome, Alaska, 63° 30′00″ N., 165°25′30″ W. Submarine Beach (late Pliocene or early Pleistocene). D. M. Hopkins, collector.

M1267. Tailings of prospect shaft of Otto Halla. On delta of Solomon River a mile inland and 0.8 mile east of Solomon townsite, 64°33′45″ N., 164°24′40″ W., about 25 miles east of Nome, Alaska. D. M. Hopkins, collector. Same locality as USGS 9250.

M1321. Nunatuk north of the east end of the Pinnacle Hills, east of the Seward Glacier, 60°09′40″ N., 140°16′40″ W., Malaspina district, Alaska. Upper part of Yakataga Formation (horizon probably lower Pliocene). British Petroleum Exploration Co., collectors.

M1339. Beach near Point Hope, Alaska, 68°25′00″ N., 166° 24′00″ W. Recent. G. W. Moore, collector.

M1494. About 320 ft below top of glacial-marine sequence estimated to be about 3,520 ft thick, Tugidak Island, Trinity Islands, Alaska, 56°31′ N., 154°42′ W. Probably late Pliocene. G. W. Moore, collector.

M1621. St. Paul Island, Pribiloff Islands, Alaska. Recent.

M1622. Same as M1621.

M1741. Cliff near southwestern end of Middleton Island, Alaska; close to the top of Miller's (1953, p. 23) measured section, and about 550 ft below the top of the exposed section as determined by Plafker. Horizon probably lower Pleistocene. G. Plafker, collector.

M1742. Cliff on west side of Middleton Island, Alaska; about 1,080 ft below top of exposed section as determined by Plafker. Horizon probably lower Pleistocene. G. Plafker, collector.

M1743. Cliff on west side of Middleton Island, Alaska; about 1,200 ft below top of exposed section as determined by Plafker. Horizon probably lower Pleistocene. G. Plafker, collector.

M1744. Cliff on west side of Middleton Island, Alaska; about 1,250 ft below top of exposed section as determined by Plafker. Horizon probably lower Pleistocene. G. Plafker, collector.

M1746. Cliff at south end of Middleton Island, Alaska; about 1,800 ft below top of exposed section as determined by Plafker. Horizon probably uppermost Pliocene. G. Plafker, collector.

M1751. Extreme southeast tip of Middleton Island, Alaska; about 3,550 ft below top of exposed section as determined by Plafker. Horizon probably upper Pliocene. G. Plafker, collector.

M1752. Extreme southeast tip of Middleton Island, Alaska; about 3,650 ft below top of section as determined by Plafker. Horizon probably upper Pliocene. G. Plafker, collector.

M1753. Extreme southeast tip of Middleton Island, Alaska; about 3,700 ft below top of section as determined by Plafker. Horizon probably upper Pliocene. G. Plafker, collector.

M1754. Extreme southeast tip of Middleton Island, Alaska; about 50 ft above base of section determined by Plafker to be about 3,900 ft thick. Horizon probably upper Pliocene. G. Plafker, collector.

M1817. North bank of Kivalina River, about 67°49′00″ N., 164°37′12″ W., between Kotzebue Sound and Point Hope, Alaska. Late Pliocene or early Pleistocene. D. S. McCulloch, collector.

M1828. First high bluff on southwest side of Kuk River at its mouth, 70°44′51″ N., 160°07′54″ W., Arctic coast of Alaska near Wainwright. Gubik Formation (horizon probably middle Pleistocene). D. S. McCulloch, collector.

M1842. Approximately 2,700 ft above base of measured section at Icy Point, Mount Fairweather quad., Lituya district, Alaska. Upper part of Yakataga Formation (horizon probably upper Miocene or lower Pliocene). G. Plafker, collector.

M1851. Approximately 4,750 ft above base of measured section along east side of Deadfall Creek, west of La Perouse Glacier, Mount Fairweather quad., Lituya district, Alaska. Measured section extends 58°29′54″ N., 58°30′18″ N. to 58°30′18″ N., 137°20′54″ W. Upper part of Yakataga Formation (horizon probably Pliocene). G. Plafker, collector.

M1869. Reef west of Deadfall Creek, west side of La Perouse Glacier, Mount Fairweather quad., Lituya district, Alaska. Upper part of Yakataga Formation (horizon probably Pliocene). G. Plafker, collector.

M1875. Near top of measured section in Chaix Hills, Bering Glacier quad., Malaspina district, Alaska. Uppermost part of Yakataga Formation (horizon probably upper Pliocene). G. Plafker, collector.

M1878. In lower part of measured section in Chaix Hills, Bering Glacier quad., Malaspina district, Alaska, approximately 6,000 ft lower stratigraphically than M1875. Yakataga Formation (horizon probably about basal Pliocene). G. Plafker, collector.

M1895. About 1,900 ft above the base of a glacial-marine section estimated to be about 3,520 ft thick, west side of Tugidak Island, Trinity Islands, Alaska, 56°27′25″ N., 154°46′10″ W. Probably Pliocene. G. W. Moore, collector.

M2054. Upper part of section on Middleton Island. G. Plafker, collector. Probably from M1742.

M2055. Raised beach deposit at Reykjavik Airport, 13 meters above sea level; radiocarbon dated at 10,200 yrs B.P. Iceland. T. Einarsson, Univ. Research Inst., Reykjavik, Iceland, collector.

M2056. Beach about 1 mile north of Wainwright, Alaska. Recent. O. W. Geist and P. Sellman, collectors.

M2062. Beach at Wainwright, Alaska. Recent. D. S. McCulloch, collector.

M2064. Beach of Sitkalidak Island, off southeast coast of Kodiak Island, Alaska. Recent. E. J. Moore, collector.

M2130. Quarry now filled by housing subdivision, about 1¾ miles south of the northeast end of runway of Orange County Airport and near the head of Newport Bay, Tustin quad., Orange County, Calif. Fernando Formation (horizon upper Pliocene). J. G. Vedder, collector.

M2131. East coast of Point Divide, approximately 3 miles southeast of Point Divide, between Herendeen Bay and Port Moller, Alaska Peninsula. Late Miocene(?). Shell Oil Company, collectors.

M2132. West coast of Cape Aliaksin, approximately 2 miles northeast of Point Aliaksin, south side of Alaska Peninsula, Port Moller, quad., Alaska. Unga Conglomerate (middle Miocene). Shell Oil Company, collectors.

M2133. West side of spit, Punak Islands, St. Lawrence Island, Alaska. Recent. H. B. Allen, collector.

M2153. Beach exposure southwest of lighthouse Valadalstorfa, Breidhavik, Tjörnes district, northern Iceland. Base of bed 14 at Stapavik, the uppermost fossiliferous bed of the Breidhavik section (early glacial leistocene). D. M. Hopkins, collector.

M2155. Bed 21 of Tjörnes section, 100 miles south of Baejarlaekur, Húsavik quad., Tjörnes district, northern Iceland (*Cardium* zone, early Pleistocene). D. M. Hopkins, collector.

M2164. Bed 20 of Tjörnes section at Kambgja, Húsavik quad., Tjörnes district, northern Iceland (*Cardium* zone, early Pleistocene). Carlie Bjarnisson, collector.

M2203. Bed 10 of Tjörnes section, Svarthamar and Stori Svarthamar south of Hallbjarnastadhaá, Húsavik quad., Tjörnes district, northern Iceland (*Mactra* zone, late Pliocene). D. M. Hopkins, collector.

M2464. Recent, beach at Tjörnes, Iceland. D. M. Hopkins, collector.

M2519. Dredged from the Westerschelde, westernmost Netherlands. Probably from beds of Scaldesian (early Pleistocene) age. Obtained from C. O. van Regteren Altena, Rijksmuseum van Natuurlijke Historie, Leiden.

REFERENCES

Abbott, R. T., 1954, American seashells: New York, D. Van Nostrand Co., 541 p., 32 pls., 100 figs.

Addicott, W. O., 1965, Some western American Cenozoic gastropods of the genus *Nassarius:* U.S. Geol. Survey Prof. Paper 503–B, 21 p.

Akiyama, Masahiko, 1962, Studies on the phylogeny of *Patinopecten* in Japan: Tokyo Kyoiku Daigaku Sci. Repts., Sec. C, v. 8, no. 74, p. 63–122, pls. 1–8.

Altena, C. O. van Regteren, 1937, Bÿdrage tot de kennis der fossiele, subfossiele en recente mollusken, die op het nederlandsche strand aanspoelen, en hunner verspreiding: Rotterdam, Neiuwe Verh. Bataffsch Genoot. der Proefondervindel. Wijsbegeerte (Philosophy).

Arkell, W. J., 1931, British Corallian Lamellibranchiata, pt. 3: Palaeont. Soc. London Mon., v. 83, no. 1, p. 105–132, pls. 9–12.

Arnold, Ralph, 1903, The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California: California Acad. Sci. Mem., v. 3, 420 p., 37 pls.

——— 1906, The Tertiary and Quaternary Pectens of California: U.S. Geol. Survey Prof. Paper 47, 264 p., 53 pls.

Askelsson, Johannes, 1960, Pliocene and Pleistocene fossiliferous deposits; on the Geology and Geophysics of Iceland: Internat. Geol. Cong., 21st, Copenhagen 1960. Guide to Excursion A–2, p. 28–32.

Burch, J. Q., ed., 1944, Pelecypoda, pt. 1 *of* Distributional list of the west American marine mollusks from San Diego, California, to the Polar Sea: Conchol. Club of Southern California, Proc., no. 33–45, text figs.

Carpenter, P. P., 1864, Supplementary report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America: British Assoc. Adv. Sci. Rept. 1863, p. 517–686 (reprinted Smithsonian Misc. Colln., no. 252, 1872).

Chinzei, Kiyotaka, 1960, A new *Fortipecten* from the Pliocene Sannohe Group in Aomori prefecture, northeast Japan: Japanese Jour. Geology Geography, v. 31, no. 1, p. 63–69, pl. 7.

Clark, B. L., and Arnold, Ralph, 1923, Fauna of the Sooke Formation, Vancouver Island: California Univ. Dept. Geology Bull., v. 14, no. 5, p. 123–234, pls. 15–42.

Combaluzier, Charles, 1932, Le Miocene de la Basse-Provence: Bull. des services de la carte géologique de la France, v. 35, no. 182, 171 p., 12 pls.

Conrad, T. A., 1849, Fossils from northwestern America, *in* Dana, J. D., Geology, V. 10 *of* U.S. Exploring Expedition, 1838–1842, under Charles Wilkes: Philadelphia, Pa., app. p. 723–728; atlas, pls. 17–21.

Crosse, J. C. H., 1885, Review of Monterosato's Nom. gen. e spec. d. alcune Conch. Medit., 1884: Jour. Conchyliologie, v. 33, p. 139–142.

Dall, W. H., 1889, Scientific results of explorations by the U.S. Fish Commission steamer *Albatross*, no. 7, Preliminary report on the collection of Mollusca and Brachiopoda obtained in 1887–1888: U.S. Natl. Mus. Proc., v. 12, no. 773, p. 219–362, pls. 5–14.

Dall, W. H., 1898, Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Philadelphia Trans., v. 3, pt. 4, p. 571–947, pls. 23–25.

——— 1902, Illustrations and descriptions of new, unfigured, or imperfectly known shells, chiefly American, in the U.S. National Museum: U.S. Natl. Mus. Proc., v. 24, p. 499–566, pls. 27–40.

——— 1904, Neozoic invertebrate fossils [of Alaska]: Harriman Alaska Expedition, v. 4 (Geology and Paleontology), p. 99–122 (reissued by Smithsonian Inst. 1910).

——— 1919, The Mollusca of the Arctic coast of America collected by the Canadian Arctic Expedition west of Bathurst Inlet, with an appended report on a collection of Pleistocene fossil Mollusca: Canadian Arctic Exped. Rept., v. 8, pt. A, p. 1–29, pls. 1–3.

——— 1921, Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United States National Museum, with illustrations of hitherto unfigured species: U.S. Natl. Mus. Bull. 112, p. 1–217, pls. 1–22.

Dall, W. H., Bartsch, Paul, and Rehder, H. A., 1938, A manual of the Recent and fossil marine pelecypod mollusks of the Hawaiian Islands: Bernice P. Bishop Mus. Bull. 153, 233 p., 58 pls.

Dickerson, R. E., 1917, Climate and its influence upon the Oligocene faunas of the Pacific coast, with descriptions of some new species from the *Molopophorus lincolnensis* zone: California Acad. Sci. Proc., ser. 4, v. 7, no. 6, p. 157–192, pls. 27–31.

Dodge, Henry, 1952, The classes Loricata and Pelecypoda, pt. 1 of historical review of the mollusks of Linnaeus: Am. Mus. Nat. History Bull., v. 100, art. 1, 263 p.

Ellis, D. V., 1960, Marine infaunal benthos in Arctic North America: Arctic Inst. N. America Tech. Paper 5, 53 p.

Fleming, C. A., 1948, New species and genera of marine Mollusca from the southland fiords: Royal Soc. New Zealand Trans., v. 77, pt. 1, p. 72–92, pls. 4–8.

——— 1957, The genus *Pecten* in New Zealand: New Zealand Geol. Survey Palaont. Bull. 26, 69 p., 15 pls.

Fraser, G. D., and Barnett, H. F., 1959, Geology of the Delarof and westernmost Andreanof Islands, Aleutian Islands, Alaska: U.S. Geol. Survey Bull. 1028–I, p. 211–248.

Gardner, Julia, 1943, Mollusca from the Miocene and lower Pliocene of Virginia and North Carolina: U.S. Geol. Survey Prof. Paper 199–A, 144 p., 23 pls.

Glibert, Maxime, 1957, Pelecypodes du Diestien, du Scaldasien, et du Merxemien de la Belgique, premiere note: Inst. Royal des Sci. Nat. de Belgique Bull., v. 33, no. 9, 40 p., 1 pl.

Gould, A. A., 1852, Mollusca and shells: United States Exploring Expedition during the years 1838–1842 under the command of Charles Wilkes, U.S.N., Boston, 510, p., pls.

Grant, U. S., 4th, and Gale, H. R., 1931, Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions: San Diego Soc. Nat. History Mem., v. 1, 1036 p., 32 pls.

Grau, Gilbert, 1959, Pectinidae of the eastern Pacific (Allan Hancock Pacific Expeditions, v. 23): Los Angeles, Calif., Univ. Southern California, 308 p., 57 pls.

Grewingk, Constantin, 1850, Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West-Kuste Amerikas mit den anliegenden Inseln: Russisch-kaiserlichen mineralog. Gesell. St. Petersburg Verh. 1848–49, p. 76–424, pls. 1–7.

Hanna, G. D., 1924, Rectifications of nomenclature: California Acad. Sci. Proc., ser. 4, v. 13, no. 10, p. 151–186.

Hasimoto, Wataru, and Kanno, Saburo, 1958, Molluscan fauna from the Tertiary formation of Chirai, Kamisaroma, Kitamino-Kuni, Hokkaido: Trans. Proc. Palaeont. Soc. Japan, new ser., no. 32, art. 349, p. 285–289, pl. 42.

Hatai, Kotora, and Masuda, Kôichirô, 1953, On the *Pecten notoensis* Yokoyama: Trans. Proc. Palaeont. Soc. Japan, new serv., no. 11, art 237, p. 75–82, pl. 7.

Hatai, Kotora, and Nisiyama, Syozo, 1952, Checklist of the Japanese Tertiary marine Mollusca: Tohoku Univ. Sci. Repts., 2d ser. (Geology), Spec. Volume 3, 464 p.

Heering, J., 1950, Pelecypoda (and Scaphopoda) of the Pliocene and older Pleistocene deposits of the Netherlands: Mededeel. Netherlands Geol. Stichting, ser. C, v. 4, pt. 1, no. 9, 225 p., 17 pls.

Hertlein, L. G., 1925, Pectens from the Tertiary of Lower California: California Acad. Sci. Proc., 4th ser., v. 14, no. 1, 35 p., 6 pls.

——— 1934, New oysters and a new pecten from the Tertiary of California: Southern California Acad. Sci. Bull., v. 33, no. 1, p. 1–6, 2 pls.

Hubbard, Bela, 1920, Tertiary Mollusca from the Lares District, Porto Rico: New York Acad. Sci. Scientific Survey of Porto Rico and the Virgin Islands, v. 3, pt. 2, p. 79–164, pls. 10–25.

Iredale, Tom, 1929, Mollusca from the continental shelf of Eastern Australia, no. 2: Rec. Australian Mus., v. 17, no. 4, p. 157–189, pls. 38–41.

Jensen, A. S., 1912, Lammellibranchiata, pt. 1: [The Danish] Ingolf-Expedition 1895–1896, v. 2, pt. 5. København.

Johnson, M. W., 1956, The plankton of the Beaufort and Chukchi Sea areas of the Arctic and its relation to the hydrography: Arctic Inst. North America Tech. Paper 1, 32 p., 11 figs., 15 tables.

Johnson, R. I., 1964, The Recent Mollusca of Augustus Addison Gould: U.S. Natl. Mus. Bull. 239, 182 p., 45 pls.

Kanno, Saburo, 1962, Molluscan fauna from the so-called Setana Formation, southwestern Hokkaido, Japan: Toyko Kyoiku Daigaku Sci. Rept., Sec. C, v. 8, no. 73, p. 49–62, 5 pls.

Keen, A. M., and Bentson, Herdis, 1944, Check list of California Tertiary marine Mollusca: Geol. Soc. America Spec. Paper 56, 280 p.

Kinoshita, Toraichiro, and Isahaya, Takao, 1934, Catalogue of shells in Hokkaido owned by the H.F.E.S.: Hokkaido Fish Expt. Sta. Rept. Aquatic Products, no. 33, 19 p., 15 pls.

Kira, Tetsuaki, 1955, Coloured illustrations of the shells of Japan: Hoikusha, Osaka, 204 p., 67 colored plates. [In Japanese].

Koenen, Adolph von, 1868, Das marine Mittel-Oligocän Norddeutschlands und seine Mollusken-Fauna, II Theil: Palaeontographica, v. 16, fasc. 6, p. 223–294, pls. 26–30.

Kotaka, Tamio, 1955, Molluscan fauna from the Oligocene Isomatsu Formation, Aomori prefecture, northeast Japan: Saito Ho-on kai Mus. Res. Bull., no. 24, p. 23–30, pl. 31.

——— 1962, Marine Mollusca dredged by the "S.S. *Hokuhomaru*" during 1959 in the Okhotsk Sea: Tohoku Univ. Sci. Repts., 2d ser. (Geology), Spec. Volume 5 (Kon'no Memorial Volume), p. 127–158, pls. 33–35.

Kubota, Kaoru, 1950, Fossil Pectinidae of the Setana Series; Explanation of Cenozoic fossils from Northern Japan, 9: Shinseidai-no-Kenkyu (Cenozoic Research), no. 6, p. 12–18, pls. 8, 9. [In Japanese.]

Kuroda, Tokubei, and Habe, Tadashige, 1952, Check list and bibliography of the Recent marine Mollusca of Japan: Tokyo, Hosokawa Printing Co., 210 p.

Küster, H. C., and Kobelt, Wilhelm, 1888, Die Gattungen *Spondylus* und *Pecten:* Systematisches Conchylien-Cabinet von Martini und Chemnitz, v. 7, pt. 2, 296 p., 72 pls.

Landes, R. W., 1940, Geology of the southern Alberta Plains; Palaeontology of the marine formations of the Montana Group: Geol. Survey Canada Mem. 221, pt. 2, p. 129–201, 8 pls.

La Pérouse, J. F. de G., 1797, Voyage de la Perouse autour du monde, publié conforément au décret du 22 avril 1791, et rédigé par M. L. A. Milet-Mureau: Paris, Imprimerie de la République, v. 2, 398 p.

Lawson, A. C., 1894, The geomorphology of the coast of northern California: California Univ. Dept. Geology Bull., v. 1, p. 241–271.

Lewis, R. Q., Nelson, W. H., and Powers, H. A., 1960, Geology of Rat Island, Aleutian Islands, Alaska: U.S. Geol. Survey Bull. 1028–Q, p. 555–562.

MacGinitie, Nettie, 1959, Marine Mollusca of Point Barrow, Alaska: U.S. Natl. Mus. Proc., v. 109, no. 3412, p. 59–208, 27 pls.

MacKenzie, J. D., 1916, Geology of Graham Island, British Columbia: Geol. Survey Canada Mem. 88, 221 p.

MacNeil, F. S., 1961, *Lituyapecten* (new subgenus of *Patinopecten*) from Alaska and California: U.S. Geol. Survey Prof. Paper 354–J, p. 225–237, pls. 35–46.

——— 1965, Evolution and distribution of the genus *Mya* with a discussion of Tertiary faunal migrations: U.S. Geol. Survey Prof. Paper 483–G, 51 p.

MacNeil, F. S., Mertie, J. B., Jr., and Pilsbry, H. A., 1943, Marine invertebrate faunas of the buried beaches near Nome, Alaska: Jour. Paleontology, v. 17, no. 1, p. 69–96, pls. 10–16.

MacNeil, F. S., Wolfe, J. A., Miller, D. J., and Hopkins, D. M., 1961, Correlation of Tertiary Formations of Alaska: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 11, p. 1801–1809, 2 figs.

Makiyama, Jiro, 1934, The Asagaian mollusks of Yotukura and Matchgar: Kyoto Imp. Univ. Coll. Sci. Mem., ser. B, v. 10, no. 2, art. 6, p. 121–167, pls. 3–7.

Malde, H. E., 1959, Geology of the Charleston phosphate area, South Carolina: U.S. Geol. Survey Bull. 1079, 105 p.

Mansfield, W. C., 1936, Stratigraphic significance of Miocene, Pliocene, and Pleistocene Pectinidae in the southeastern United States: Jour. Paleontology, v. 10, no. 3, p. 168–192, pls. 22, 23.

Masuda, Kôichirô, 1954, On "*Pecten*" *arakawai* Nomura, pt. 5 *of* On the Miocene Pectinidae from the environs of Sendai: Trans. Proc. Palaeont. Soc. Japan, new ser., no. 14, p. 149–152, pl. 19.

——— 1957, A note on *Miyagipecten matsumoriensis* Masuda: Saito Ho-on Kai Mus. Res. Bull. 26, p. 31–39, pl. 4.

——— 1959a, On *Pecten swifti* Bernardi, pt. 14 *of* On the Miocene Pectinidae from the environs of Sendai: Trans. Proc. Palaeont. Soc. Japan, new ser., no . 34, art. 362, p. 86–95, pl. 9.

——— 1959b, *Pecten cosibensis* Yokoyama and its related species, pt. 15 *of* On the Miocene Pectinidae from the environs of Sendai: Trans. Proc. Palaeont. Soc. Japan, new ser., no. 35, art. 366, p. 121–132, pl. 13.

——— 1960, On the morphogenesis of *Nanaochlamys:* Tohoku Univ. Sci. Repts., 2d ser. (Geology), Spec. Volume 4 (Hanzawa Memorial Volume), p. 371–383, pl. 39.

Masuda, Kôichirô, 1962a, Notes on the Tertiary Pectinidae of Japan: Tohoku Univ. Sci. Repts., 2d ser. (Geology), Spec. Volume 33 (Kon'no Memorial Volume), p. 117–238.

——— 1962b, Tertiary Pectinidae of Japan: Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 33, no. 2, p. 117–238, pls. 18–27.

——— 1963, The so-called *Patinopecten* of Japan: Trans. Proc. Palaeont. Soc. Japan, new ser., no. 52, art. 461, p. 145–153, pls. 22, 33.

Masuda, Kôichirô, and Sawada, Yoshio, 1961, Some new Tertiary pectinids from southwestern Hokkaido, Japan: Japanese Jour. Geology Geography v. 32, no 1, p. 19–29, pl. 4.

Merklin, R. L., Petrov, P. M., and Amitrov, O. V., 1962, Atlas-guide of mollusks of the Quaternary deposits of the Chukotsk Peninsula: U.S.S.R. Acad. Sci., Comm. Study of the Quaternary Period, 56 p., 12 pls. [In Russian.]

Miller, D. J., 1953, Late Cenozoic marine glacial sediments and marine terraces of Middleton Island, Alaska: Jour. Geology, v. 61, no. 1, p. 17–40, 2 pls.

——— 1961, Stratigraphic occurrence of *Lituyapecten* in Alaska: U.S. Geol. Survey Prof. Paper 354–K, p. 241–248.

Moody, C. L., 1916, Fauna of the Fernando of Los Angeles: California Univ. Dept. Geol. Sci. Bull., v. 10, no. 4, p. 39–62, 2 pls.

Moore, E. J., 1963, Miocene marine mollusks from the Astoria Formation in Oregon: U.S. Geol. Survey Prof. Paper 419, 109 p., 10 pls.

Moore, R. C., and Vokes, H. E., 1953, Lower Tertiary crinoids from northwestern Oregon: U.S. Geol. Survey Prof. Paper 233–E, p. 113–147, pls. 14–24.

Morris, P. A., 1952, A field guide to shells of the Pacific coast and Hawaii: Boston, Houghton Mifflin Co., 220 p. 40 pls.

Nagao, Takumi, 1928, Palaeogene fossils of the island of Kyushu, Japan: Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 12, no. 1, 140 p., 17 pls.

Noda, Hiroshi, 1961, The geological significance of the genus *Pecten* from the Pliocene Haizume formation, Niigata prefecture, Japan: Japanese Jour. Geology Geography, v. 32, no. 1, p. 9–17, pl. 3.

Normura, Sitihei, 1933, Pelecypoda, pt. 1 *of* Catalogue of the Tertiary and Quaternary Mollusca from the island of Taiwan (Formosa) in the Institute of Geology and Paleontology, Tohoku Imperial University, Sendai, Japan: Tohoku Univ. Sci. Repts., 2d ser. (Geology), v. 16, no. 1, 108 p. 4 pls.

Nomura, Sitihei, and Hatai, Kotora, 1935, Pliocene Mollusca from the Daisyaka shell-beds in the vicinity of Daisyaka, Aomori-ken, northeast Honsyu, Japan: Saito Ho-on Kai Mus. Research Bull., no. 6, p. 83–142, 5 pls.

——— 1937, A list of the Miocene Mollusca and Brachiopoda collected from the region lying north of the Nanakita River in the vicinity of Sendai, Rikuzen Province, Japan: Saito Ho-on Kai Mus. Research Bull., no. 13, p. 121–145, pls. 17–21.

North, F. K., 1951, On the type of *Pseudamussium* and other notes on pectinid nomenclature: Jour. Paleontology, v. 25, no. 2, p. 231–236.

Nyst, P. H., 1878, Terrain Pliocene Scaldisien, pt. 1 *of* Conchyliologie des terrains Tertiaires de la Belgique: Ann. Mus. Royal d'Hist. Nat. de Belgique, ser. Paléont., v. 3, 265 p., 28 pls.

Ockelmann, W. K., 1958, Marine Lamellibranchiata [pt. of] Zoology of East Greenland: Meddelelser om Grønland, v. 122, no. 4, 256 p., 3 pls.

Ogle, B. A., 1953, Geology of Eel River Valley area, Humboldt County, California: California Div. Mines Bull. 164, 128 p.

Oldroyd, I. S., 1924a, Marine shells of Puget Sound and vicinity: Washington Univ. Puget Sound Biol. Sta. Pubs., v. 4, 272 p., 49 pls. [1925].

——— 1924b, The marine shells of the west coast of North America: Stanford Univ. Pubs. Geol. Sci., v. 1, no. 1, 247 p., 57 pls.

Ômori, Masae, 1955. On some fossil new species of the genus *Propeamussium* from Japan: Tokyo Kyoiku Daigaku Sci. Repts., sec. c, v. 4, no. 27, p. 7–22, 2 pls.

Oyama, Katura, 1944, Taxonomy of the genus *Propeamussium:* Malac. Soc. Japan Jour., v. 13 (5–8), p. 240–254. [In Japanese.]

Oyama, Katura, Mizuno, Atsuyuki, and Sakamoto, Toru, 1960, Illustrated handbook of Japanese Paleogene molluscs: Japan Geol. Survey, 244 p., 71 pls.

Palache, Charles, 1904, Geology about Chichagof Cove, Stepovak Bay, with notes on Popof and Unga islands [Alaska]: Harriman Alaska Exped., v. 4, p. 69–88.

Palmer, K. V. W., 1958, Type specimens of marine Mollusca described by P. P. Carpenter from the West Coast (San Diego to British Columbia): Geol. Soc. America Mem. 76, 376 p., 35 pls.

Pavlovsky, E. N., 1955, Atlas of the invertebrates of the Far Eastern Seas: Akad. Nauk SSSR, Zool. Inst. Leningrad, 243, p., 66 pls.

Pilsbry, H. A., 1916, The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species: U.S. Natl. Mus. Bull. 93, 366 p. 76 pls.

Powers, H. A., Coats, R. R., and Nelson, W. H., 1960, Geology and submarine physiography of Amchitka Island, Alaska: U.S. Geol. Survey Bull. 1028–P, p. 521–554.

Richards, H. G., 1962, Studies on the marine Pleistocene: Am. Philos. Soc. Trans., v. 52, pt. 3, 141 p., 21 pls.

Roger, Jean, 1939, Le genre *Chlamys* dans les formations Néogènes de l'Europe: Soc. Géol. de France Mem. 40, 294 p., 28 pls.

Russell, I. C., 1891, An expedition to Mount St. Elias, Alaska: Natl. Geog. Mag., v. 3, p. 53–191.

Sacco, Federico, 1897, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 24 (Pectinidae): Turin, 73 p., 21 pls.

Sars, G. O., 1878, Mollusca Regionis Arcticae Norvegiae: Universitets program, 1878, Christiana.

Schaffer, F. X., 1910, Das Miocan von Eggenburg: Austria Geol. Bundesanst., v. 22, no. 1, 126 p., 48 pls.

Slodkewitsch, W. S., 1938, Tertiary Pelecypoda from the Far East, pts. 1 and 2: USSR Acad. Sci., Paleont. Inst., Paleontology of USSR, v. 10, pt. 2, fasc. 19, 275 p., 106 pls.

Soot-Ryen, Tron, 1932, Pelecypoda with a discussion of possible migrations of Arctic pelecypods in Tertiary times: Norwegian North Polar Expedition with the "*Maud*," 1918–1925, Sci. Results (pub. by Geofysisk., Bergen), v. 5, no. 12, 35 p., 2 pls.

——— 1958, Pelecypods from East-Greenland: Norsk Polarinstitutt Skrifter, no. 113, 33 p.

Stewart, R. B., 1930, Gabb's California Cretaceous and Tertiary type lamellibranchs: Philadelphia Acad. Nat. Sci. Spec. Pub. 3, 314 p., 17 pls.

Tucker-Roland, H. I., 1938, The Atlantic and Gulf Coast Tertiary Pectinidae of the United States, sec. 3: Mus. Royal d'Hist. Nat. de Belgique Mem., ser. 2, v. 13, 76 p., 6 pls.

Verrill, A. E., and Bush, K. J., 1898, Revision of the deep water Mollusca of the Atlantic coast of North America, with descriptions of new genera and species: U.S. Natl. Mus. Proc., v. 20, no. 1139, p. 775–901, pls. 71–97.

Wade, Bruce, 1926, The fauna of the Ripley Formation on Coon Creek, Tennessee: U.S. Geol. Survey Prof. Paper 137, 272 p., 72 pls.

Wagner, F. J. E., 1959, Palaeoecology of the marine Pleistocene faunas of southwestern British Columbia: Canada Geol. Survey Bull. 52, 67 p., 1 pl.

Waterfall, L. N., 1929, A contribution to the paleontology of the Fernando Group, Ventura County, California: California Univ. Dept. Geology Bull., v. 18, no. 3, p. 71–92, pls. 5, 6.

Weaver, C. E., 1912, A preliminary report on the Tertiary paleonotology of western Washington: Washington Geol. Survey Bull. 15, 80 p.

——— 1942, Paleontology of the marine Tertiary formations of Oregon and Washington: Washington Univ. Geology Pub., v. 5, pt. 1–3, 789 p., 104 pls.

Weaver, D. W., and Kleinpell, R. M., 1963, Oligocene biostratigraphy of the Santa Barabara Embayment, California: California Univ. Pubs. Geol. Sci., v. 43, 250 p., 38 pls.

Wood, S. V., 1851, Bivalves, pt. 2, no. 1 *of* The Craig Mollusca: Palaeontographical Soc. London Mon.,, v. 4, 150 p., 12 pls.

——— 1874, Supplement to the Crag Mollusca, Bivalvia: Palaeontographical Soc. London Mon., v. 27, p. 99–231, pls. 8–11.

——— 1882, Third supplement to the Crag Mollusca: Palaeontographical Soc. London Mon., v. 36, 24 p., 1 pl.

Woodring, W. P., Bramlette, M. N., and Kew, W. S. W., 1946, Geology and Paleontology of Palos Verdes Hills, California: U.S. Geol. Survey Prof. Paper 207, 145 p., 37 pls.

Woods, Henry, 1902, The Cretaceous Lamellibranchiata, pt. 4: Palaeontographical Soc. London Mon., v. 56, p. 145–196, pls. 27–38.

Yokoyama, Matajirō, 1926, Fossil shells from Sado: Tokyo Imp. Univ. Fac. Sci. Jour., sec. 2 (Geology Mineralogy Geography Seismology), v. 1, no. 8, p. 249–312, pls. 32–37.

——— 1929, Pliocene shells from near Nanao, Noto: Imp. Geol. Survey Japan Rept. 104, 7 p., 6 pls.

INDEX

[Italic page numbers indicate descriptions]

223-848 O - 67 - 6

PLATES 1-25

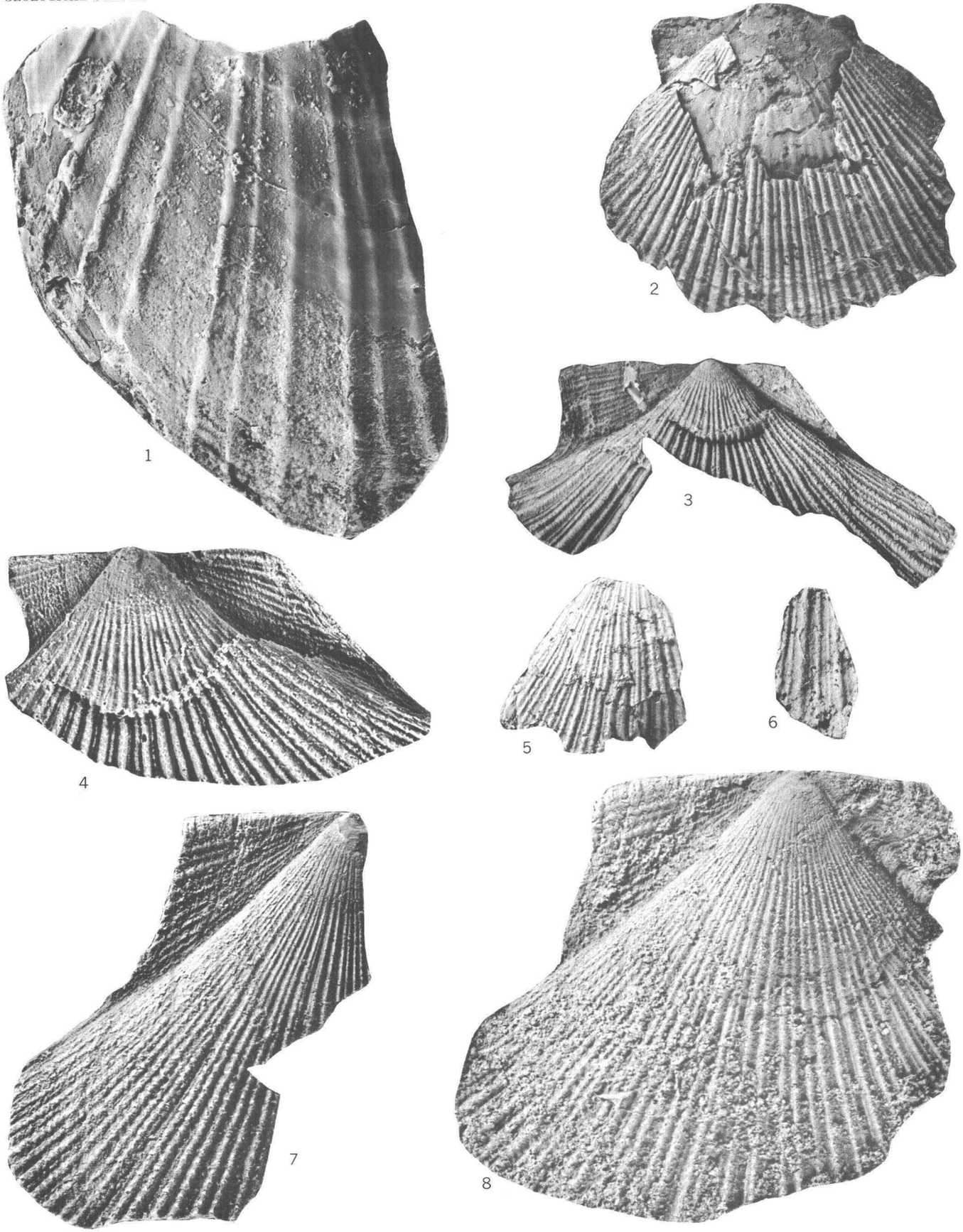
PLATE 1

FIGURE 1. ?*Vertipecten* cf. *V. popofensis* MacNeil (p. 40).
Figured specimen (USNM 645051, fragment of ?right valve, internal mold, × 2. Tokun Formation, upper part (Oligocene), Katalla district, Alaska, USGS 4323.

2. *Chlamys*(?) *washburnei* (Arnold) (p. 36).
Figured specimen (USNM 645029), incomplete left valve, × 1. *Isocrinus*-bearing beds (early Oligocene), Amchitka Island, Aleutian Islands, Alaska, USGS D47.

3–8. *Vertipecten lachenbruchi* MacNeil, n. sp. (p. 39).
Unnamed formation, *Acila shumardi* zone (middle Oligocene).

3. Holotype (USNM 645031), incomplete left valve, rubber cast, × 1½. East tributary to Mud Bay, Alaska Peninsula, USGS M1025.
4. Another cast of holotype, different illumination, × 2.
5, 6. Fragments (USNM 645035–36), × 1½. Near northeast corner of Unga Island, Alaska, USGS 5037.
7. Paratype (USNM 645032), fragment of right valve, rubber cast, × 2½. USGS 5037.
8. Paratype (USNM 645033), incomplete right valve, rubber cast, × 2½. USGS 5037.



PECTINIDS FROM ALEUTIAN ISLANDS, ALASKA PENINSULA
KATALLA DISTRICT (ALASKA)

PLATE 2

FIGURES 1, 3, 5, 6. *Vertipecten popofensis* MacNeil, n. sp. (p. 39).

Unnamed formation, *Acila shumardi* zone (middle Oligocene).

1. Holotype (USNM 645037), incomplete left valve, × 2. Near northwest corner of Popof Island, Alaska, USGS 3563.
3. Paratype (USNM 645039), fragment of ?left valve showing ear, × 2½. Near northeast corner of Unga Island, Alaska, USGS 5037.
5. Paratype (USNM 645040), fragment of right valve, × 1½. USGS 5037.
6. Paratype (USNM 645038), fragment of left valve, rubber cast, × 1. USGS 3563.

2. *Vertipecten* n. sp.? (p. 40).

Figured specimen (USNM 164892), incomplete left valve, rubber cast, × 1½. East end of Chichagof Bay in *Acila shumardi*-bearing beds (middle Oligocene), Alaska Peninsula, USGS 3373.

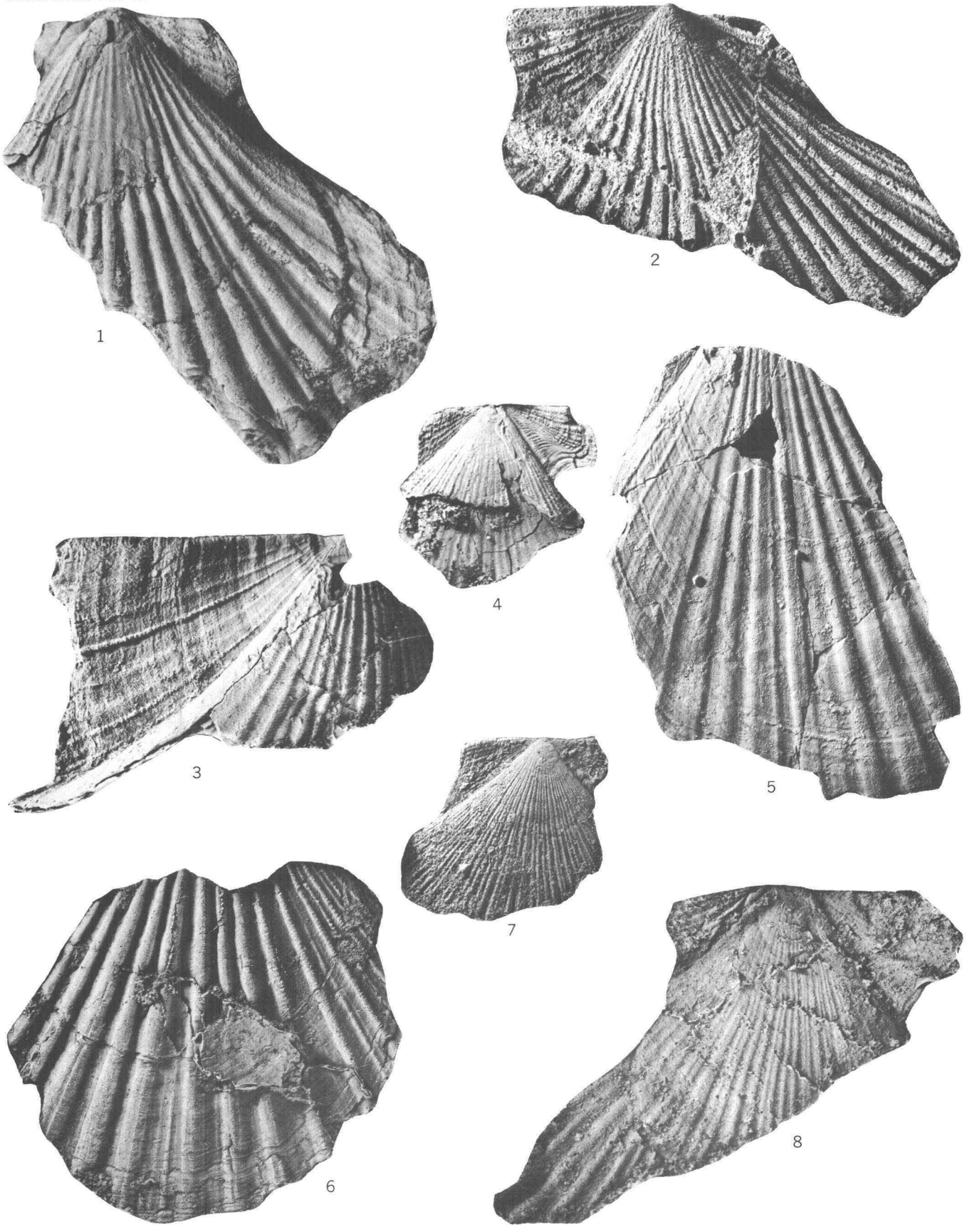
8. ?*Vertipecten popofensis* MacNeil.

Figured specimen (USNM 645041), fragment of right valve, rubber cast, × 2½. USGS 5037.

4, 7. *Vertipecten lachenbruchi* MacNeil, n. sp. (p. 39).

Unnamed formation, *Acila shumardi* zone (middle Oligocene), near northeast corner of Unga Island, Alaska, USGS 5037.

4. Paratype (USNM 645034), dorsal fragment of right valve showing ears, × 2½.
7. Paratype, same specimen as pl. 1, fig. 8, × 1, USGS 5037.



PECTINIDS FROM ALASKA PENINSULA, SHUMAGIN ISLANDS (ALASKA)

PLATE 3

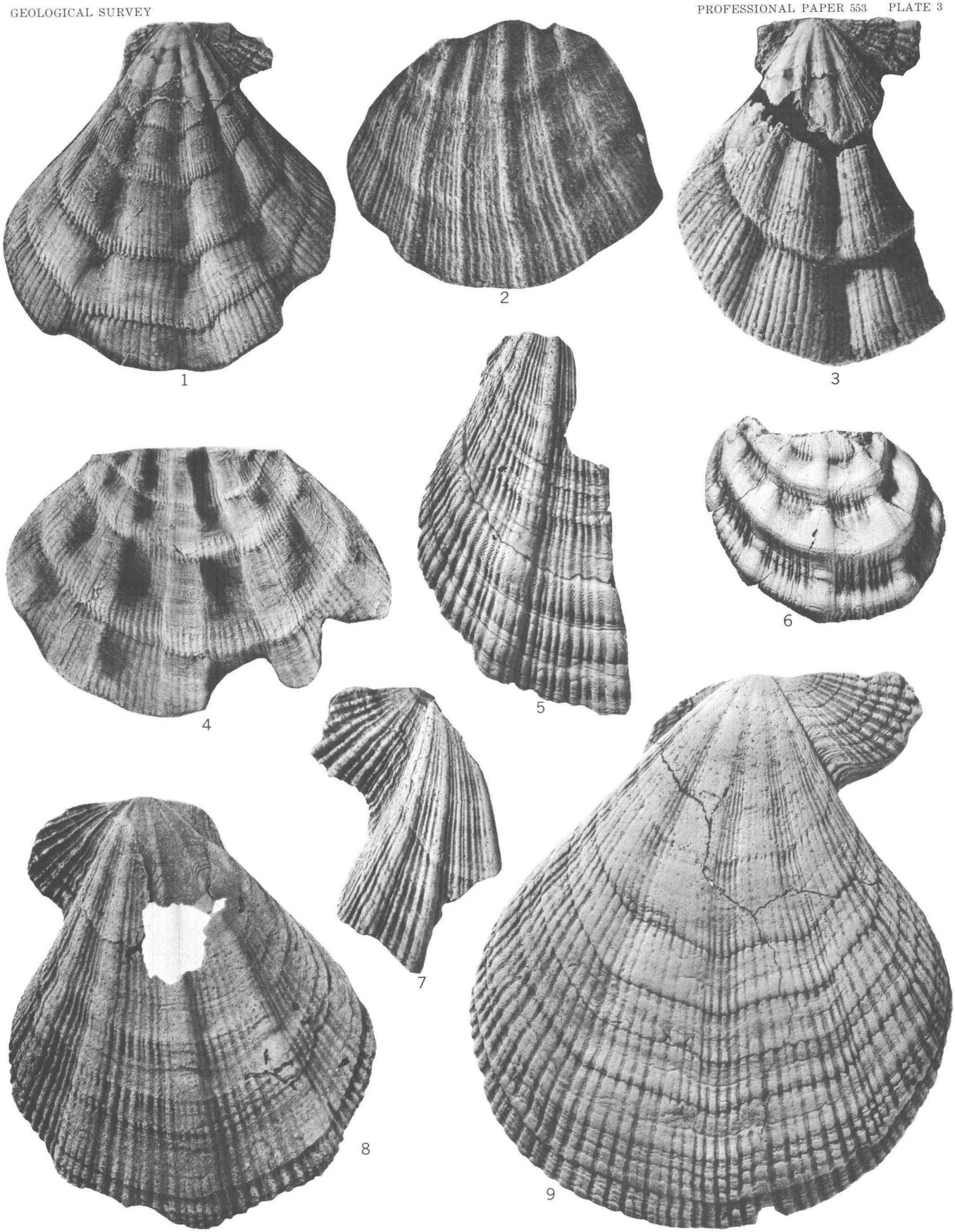
[All figures × 1]

FIGURES 1, 4, 6. *Chlamys* (*Swiftopecten*) *donmilleri* MacNeil, n. sp. (p. 12).

1. Holotype (USNM 644882), right valve, rubber cast. 1,500 ft above base of Yakataga Formation (horizon probably middle Miocene), USGS 6694.
4. Paratype (USNM 644883), incomplete left valve, rubber cast. Near base of Yakataga Formation (horizon probably middle Miocene), USGS 15437.
6. Figured specimen (USNM 644884), incomplete left valve. Near base of Chaix Hills section of Yakataga Formation (horzion probably upper Miocene), USGS 17817.

2. *Chlamys* (*Swiftopecten*) sp. (p. 13).
   Figured specimen (USNM 644886), incomplete left valve, rubber cast. Unga Conglomerate *Mytilus middendorffi* zone (middle Miocene), east side of Port Moller, Alaska Peninsula, USGS 5046.
3. *Chlamys* (*Swiftopecten*) cf. *C.* (*S.*) *donmilleri* MacNeil (p. 13).
   Figured specimen (USNM 644885). Unga Conglomerate, *Mytilus middendorffi* zone (middle Miocene) northwest side of Cape Aliaksin Alaska Peninsula, USGS M2132.

5, 7–9. *Chlamys* (*Swiftopecten*) *swifti kindlei* (Dall) (p. 13).
   Figured specimens. Intermediate Beach (middle Pleistocene), Nome, Alaska.
   5, 7. Fragments of left valves (USNM 644889–644890), USGS 5074.
   8. Left valve (USNM 644888), USGS 14866.
   9. Right valve (USNM 644887), USGS 5313.



PECTINIDS FROM ALASKA PENINSULA, SEWARD PENINSULA
YAKATAGA DISTRICT (ALASKA)

PLATE 4

[All figures × 1 unless otherwise noted]

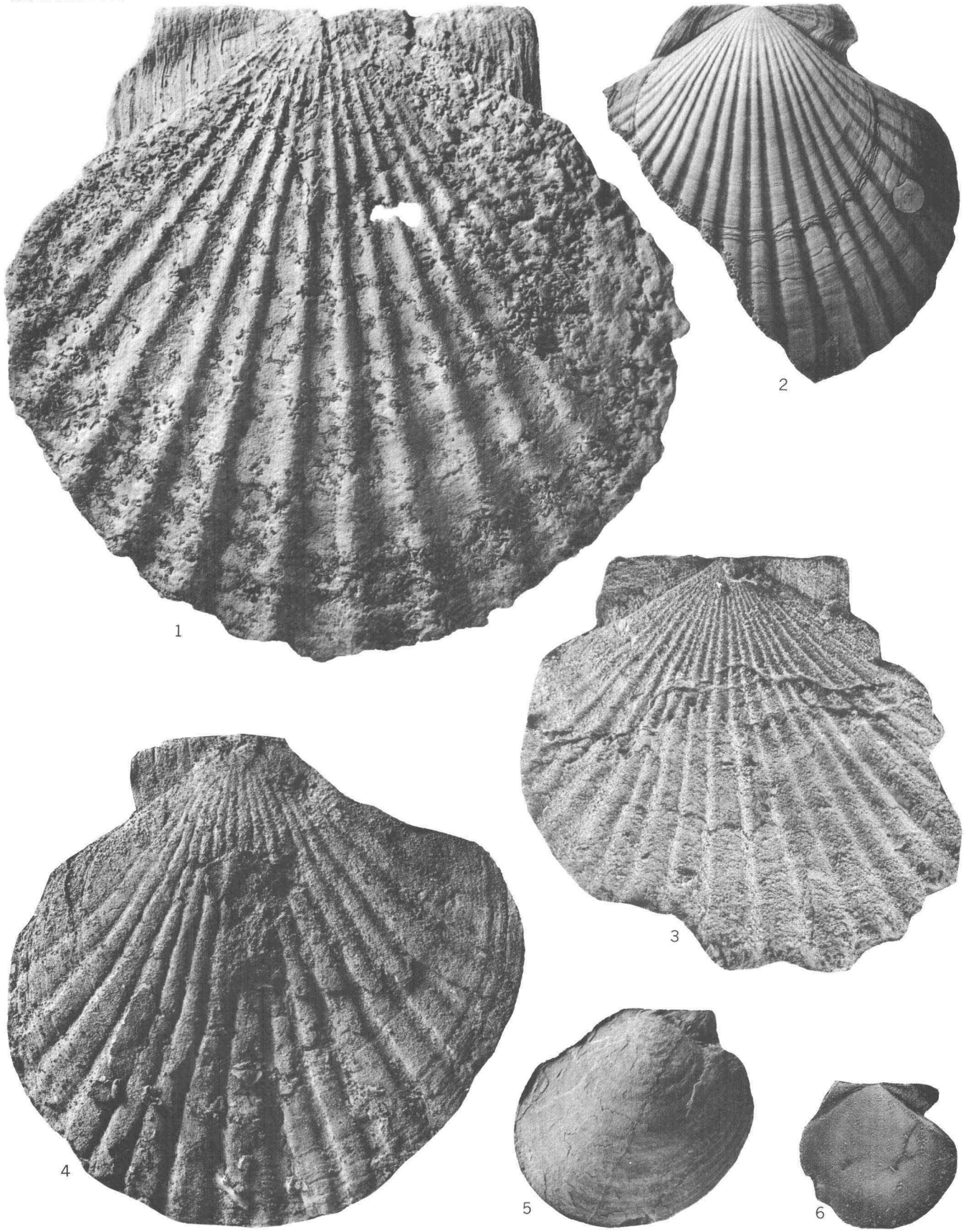
FIGURE 1. *Fortipecten mollerensis* MacNeil, n. sp. (p. 43).
Holotype (USNM 645047), exterior of left valve. Unnamed formation (horizon probably upper Miocene or lower Pliocene), southeast of Point Divide, Herendeen Bay, Alaska Peninsula, USGS M2131.

2. *Patinopecten* (*Mizuhopecten*) *skonunensis* MacNeil, n. sp. (p. 42).
Holotype (UCLA 39474), exterior of right valve. Skonun Formation (probably late Miocene), Skonun Point, north side of Queen Charlotte Island, British Columbia. UCLA loc. 4674.

3, 4. *Patinopecten* (*Patinopecten*) cf. *P.* (*P.*) *caurinus* (Gould) (p. 41).
Figured specimens. Upper part of Yakataga Formation (horizon probably Pliocene), Point Glorious, Malaspina district, Alaska, USGS D263 (T).
3. Left valve (USNM 645043), rubber cast.
4. Right valve (USNM 645042), rubber cast.

5. *Delectopecten maddreni* MacNeil, n. sp. (p. 5).
Figured specimen (USNM 644866), left valve. Near middle of Poul Creek Formation (horizon probably late Oligocene), north end of Hanna Lake, USGS 16898. Poul Creek Formation (late Oligocene and early Miocene), Yakataga district, Alaska.

6. *Arctinula groenlandica* (Sowerby) (p. 8).
Figured specimen (USNM 561876), right valve, × 4. Lower part of Nuwok Formation of Dall (1919) (horizon probably upper Miocene), Carter Creek, Artic coast of Alaska, USGS D50 (T). Nuwok Formation of Dall (1919) (late Miocene and Pliocene), Camden Bay region, northeastern Alaska.



PECTINIDS FROM ALASKA PENINSULA, YAKATAGA DISTRICT, MALASPINA DISTRICT
ARCTIC COAST (ALASKA), QUEEN CHARLOTTE ISLANDS (BRITISH COLUMBIA)

PLATE 5

FIGURES 1, 6. *Fortipecten mollerensis* MacNeil, n. sp. (p. 43).

1. Holotype (USNM 645047), interior of left valve (same specimen as pl. 4, fig. 1), × 1. Unnamed formation (horizon probably upper Miocene or lower Pliocene), southeast of Point Divide, Herendeen Bay, Alaska Peninsula, USGS M2131.
6. Paratype (USNM 645048), incomplete right valve, × 1. USGS M2131.

2–4. *Polynemamussium alaskense* (Dall) (p. 6).

2. Figured specimen (USNM 644867), right valve, × 2. North side of Douglas Island, east of Entrance Point, USGS M243.
3. Figured specimen (USNM 644868), incomplete right valve, × 2. Glacier Highway, north shore of Auke Bay, USGS M218.
4. Figured specimen (USNM 644869), left valve, × 2. End of highway, north of Douglas Island bridge, USGS M212. Postglacial deposits, Juneau area, southeastern Alaska.

5. *Delectopecten maddreni* MacNeil, n. sp. (p. 5).

Holotype (USNM 644865), incomplete right valve and left valve, rubber cast, × 2. Burls Creek Shale Member of the Katalla Formation (horizon probably upper Oligocene), Burls Creek, Katalla district, Alaska, USGS 4321.

7. *Polynemamussium davidsoni* (Dall) (p. 7).

Figured specimen (USNM 644870), left valve, × 2. North side of Douglas Island, east of Entrance Point, USGS M243. Postglacial deposits, Juneau area, southeastern Alaska.

PECTINIDS FROM ALASKA PENINSULA, SOUTHEASTERN ALASKA, KATALLA DISTRICT (ALASKA)

223-848 O - 67 - 7

PLATE 6

[All figures × 1 unless otherwise noted]

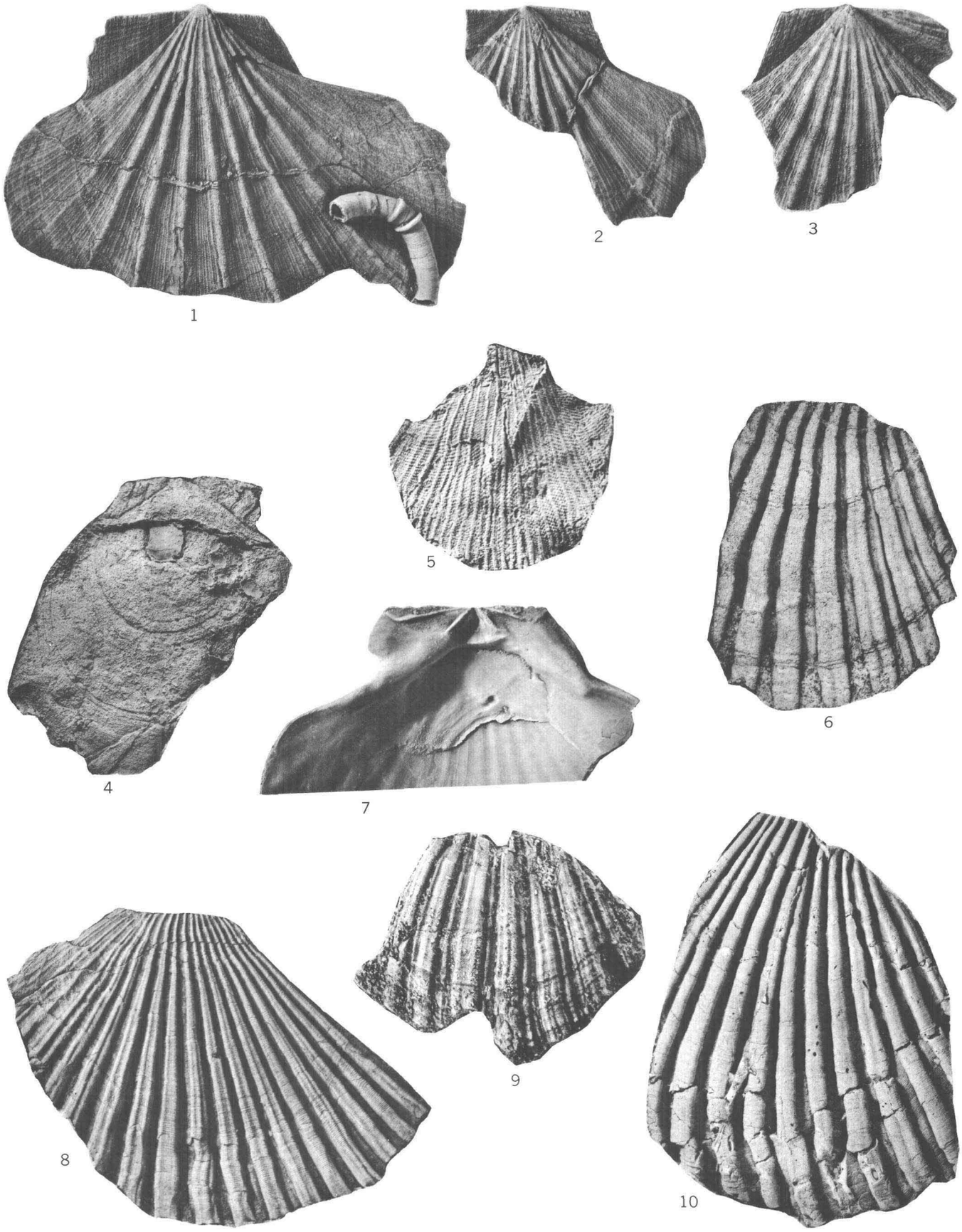
FIGURES 1–3. *Chlamys*? *nuwokensis* MacNeil (p. 37).
Nuwok Formation of Dall (1919) (horizon probably upper Miocene), Carter Creek, Camden Bay region, northeastern Alaska, USGS D50 (T).
1. Holotype (USNM 561866), incomplete left valve, × 1½.
2. Paratype (USNM 561867), incomplete left valve, × 1½.
3. Paratype (USNM 561869), incomplete right valve, × 2.

4, 5. *Miyagipecten alaskensis* MacNeil, n. sp. (p. 45).
Nunatuk north of east end of Pinnacle Hills, Malaspina district, Alaska. Upper part of Yakataga Formation (early Pliocene), USGS M1321.
4. Holotype (USNM 645049), incomplete right valve, rubber cast.
5. Paratype (USNM 645050), fragment of left valve showing sculpture, rubber cast, × 1½.

6, 8, 10. *Patinopecten* (*Lituyapecten*) n. sp. (p. 41).
Figured specimens. Upper part of Yakataga Formation (horizon probably upper Miocene or lower Pliocene), Icy Point area, Lituya district, Alaska. This probably is the species figured as *P.* (*L.*) *yakatagensis*? (Clark) by MacNeil (1961, pl. 41, fig. 2).
6. Fragment of right valve (USNM 645044), USGS M1144.
8. Fragment of ?left valve (USNM 645045), USGS M1154.
10. Fragment of right valve (USNM 645046), USGS M1842.

7. *Patinopecten* (*Mizuhopecten*) *skonunensis* MacNeil, n. sp. (p. 42).
Hinge of holotype (pl. 4, fig. 2). UCLA loc. 4674.

9. ?*Chlamys* sp. (p. 37).
Figured specimen (USNM 645030), fragment of ?left valve, × 1½. Unnamed formation (early? Miocene), Tanaga Island, Aleutian Islands, USGS D26 (T).



PECTINIDS FROM ALEUTIAN ISLANDS, MALASPINA DISTRICT, LITUYA DISTRICT
ARCTIC COAST (ALASKA), QUEEN CHARLOTTE ISLANDS (BRITISH COLUMBIA)

PLATE 7

[All figures × 1]

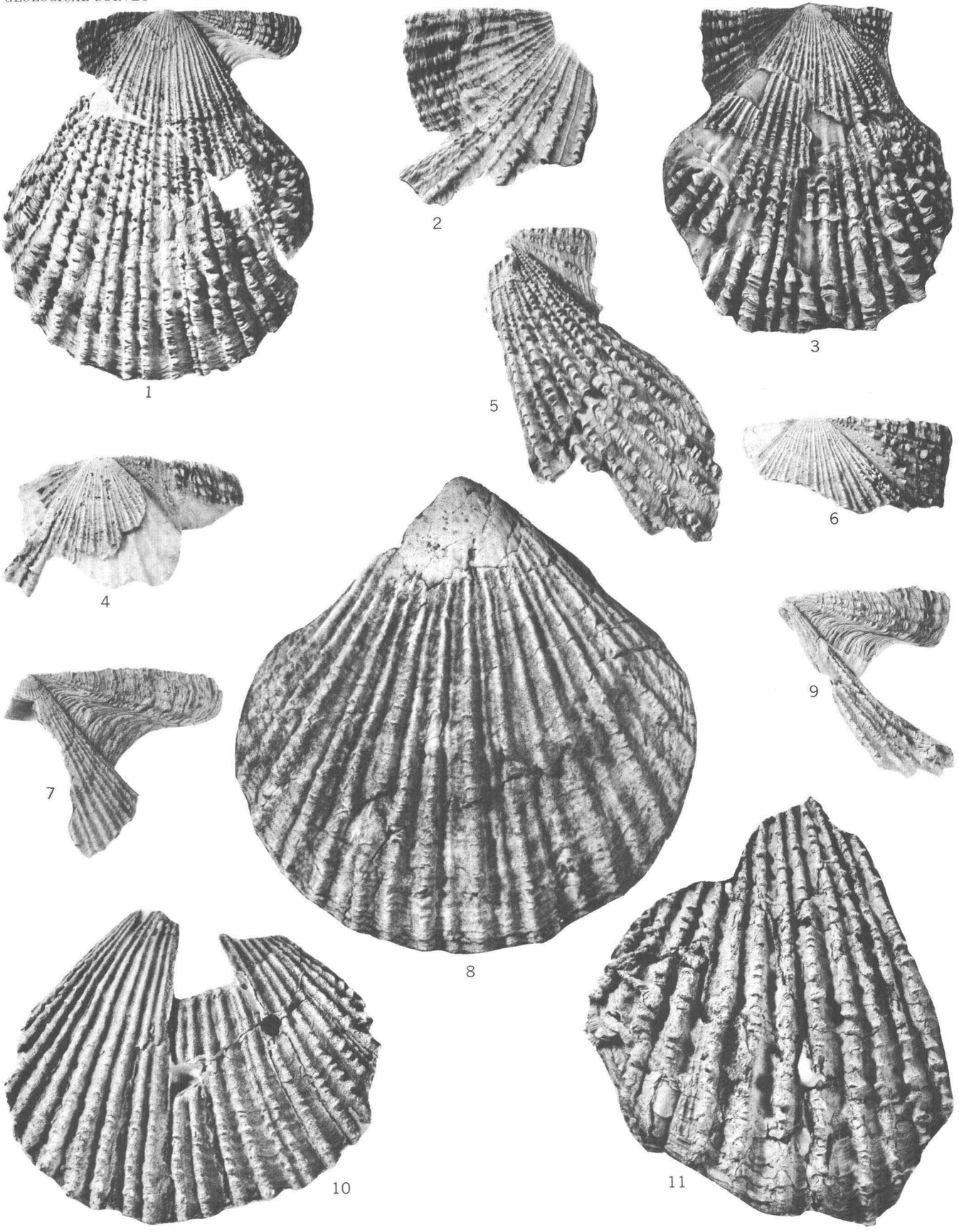
FIGURES 1–11. *Chlamys* (*Leochlamys*) *tugidakensis* MacNeil, n. sp. (p. 10).
Tugidak and Middleton Islands and the Lituya district, Alaska, all probably Pliocene.

Uppermost beds, Tugidak Island, USGS M1494:
1. Holotype (USNM 644871), a right valve.
2. Figured specimen (USNM 644873), anterior ear of a large left valve.
3. Paratype (USNM 643872), a left valve.
5. Figured specimen (USNM 644874), fragment of a left valve.

Middle beds, Tugidak Island, USGS M1895:
4, 6. Figured specimens (USNM 644875, 644876), dorsal fragments of left valves.
7, 9. Figured specimens (USNM 644877, 644878), dorsal fragments of right valves.
11. Figured specimen (USNM 644879), fragment.

Lower beds, Middleton Island, USGS M1753:
8. Figured specimen (USNM 644880), incomplete left valve.

Upper part of Yakataga Formation, La Perouse Glacier section, Lituya district, USGS M1851:
10. Figured specimen (USNM 644881), fragment of ?right valve.



PECTINIDS FROM TRINITY ISLANDS, MIDDLETON ISLAND, LITUYA DISTRICT (ALASKA)

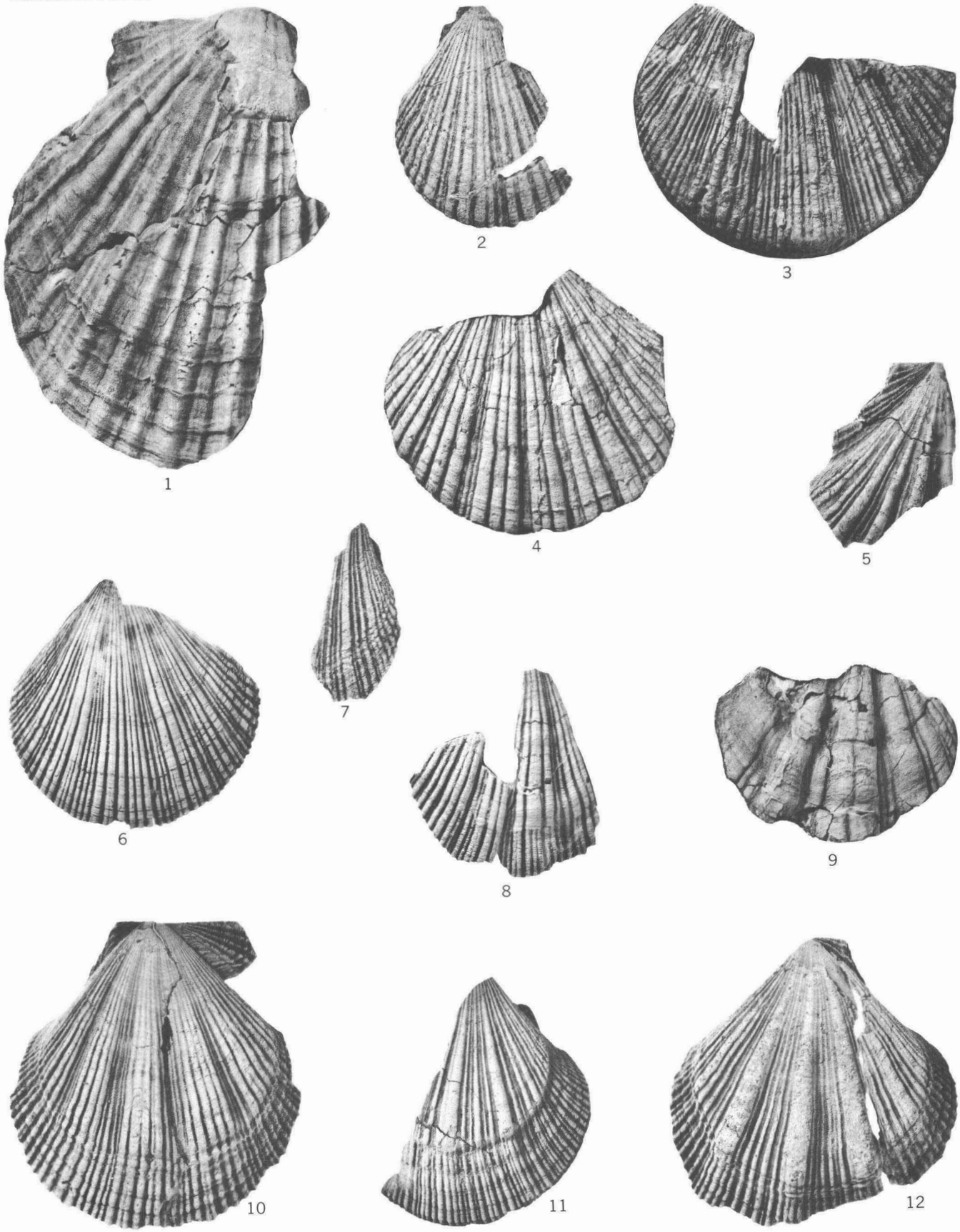
PLATE 8

[All figures × 1 unless otherwise noted]

FIGURE 1. *Chlamys* (*Leochlamys*) *tugidakensis* MacNeil, n. sp. (p. 10).
Figured specimen (USNM 645052), an incomplete, partly decorticated large left valve. Lower beds (horizon probably upper Pliocene), Middleton Island, Alaska, USGS M1752.

2–5, 7–9. *Chlamys* (*"Chlamys"*) aff. *C.* (*"C."*) *trinitiensis* MacNeil (p. 21).
Figured specimens. Middle beds (Pliocene), Tugidak Island, Alaska, USGS M1895.
2. Incomplete right valve (USNM 644936).
3. Incomplete left valve (USNM 644937).
4. Incomplete right valve (USNM 644938).
5. Fragment of left valve (USNM 644939).
7. Fragment of left valve (USNM 644940).
8. Fragment of right valve (USNM 644941).
9. Fragment of right valve (USNM 644942).

6, 10–12. *Chlamys* (*"Chlamys"*) *trinitiensis* MacNeil, n. sp. (p. 20).
Upper beds (probably late Pliocene), Tugidak Island, Alaska, USGS M1494.
6. Figured specimen (USNM 644934), an incomplete right valve.
10. Holotype (USNM 644933), right valve, × 1½.
11. Figured specimen (USNM 644935), an incomplete left valve.
12. Holotype, left valve, × 1½.



PECTINIDS FROM TRINITY ISLANDS, MIDDLETON ISLAND (ALASKA)

PLATE 9

[All figures × 1 unless otherwise noted]

FIGURES 1, 3–5. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis* Masuda (p. 29).

Figured specimens. Unnamed formation, upper part (horizon probably upper Pliocene), Tugidak Island, Alaska, USGS M1494.

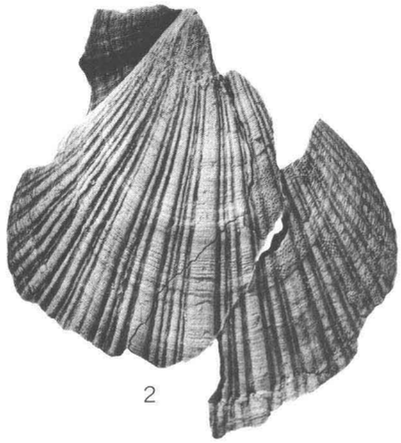
1. Right valve (USNM 644983).
3. Left valve, same individual as above.
4. Left vavle (USNM 644984), × 1½.
5. Right valve, same individual as above, × 1½.

2, 6–10. *Chlamys* (*"Chlamys"*) *chaixensis* MacNeil, n. sp. (p. 19).

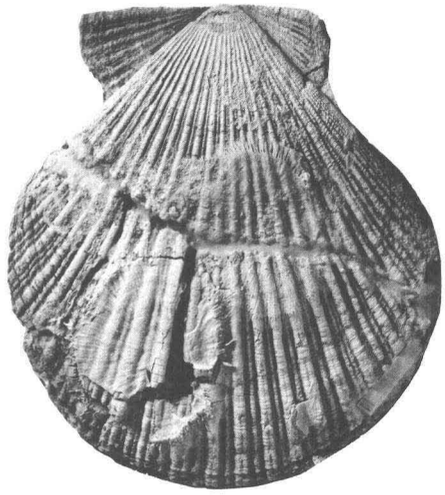
Top of Chaix Hills section, upper part of the Yakataga Formation (horizon probably upper Pliocene), Yakataga district, Alaska, USGS M1875.

2. Figured specimen (USNM 644924), incomplete left valve.
6. Figured specimen (USNM 644925), incomplete right valve.
7. Figured specimen (USNM 644926), incomplete left valve.
8. Holotype (USNM 644921), right valve.
9. Figured specimen (USNM 644927), fragment of left valve.
10. Holotype, left valve.

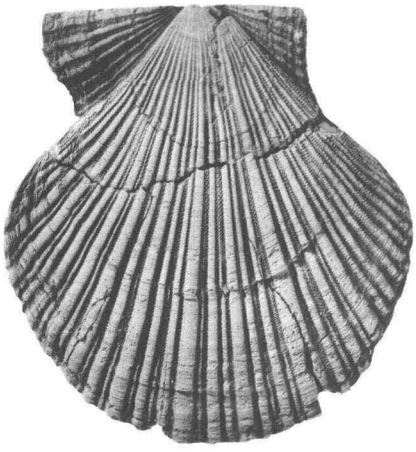
1



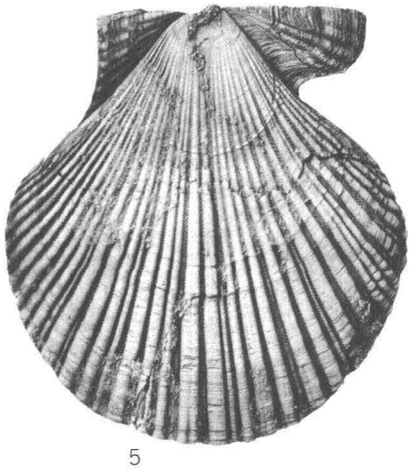
2



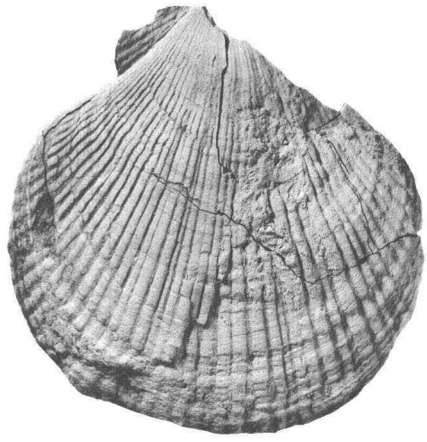
3



4

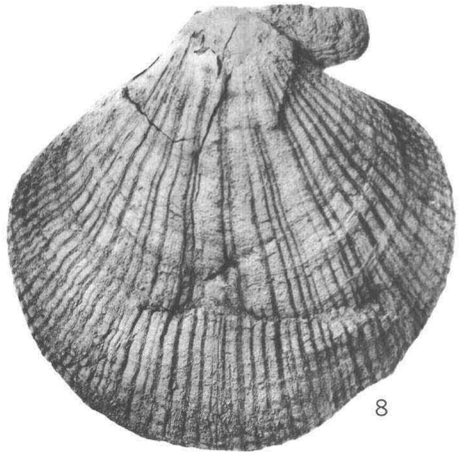


5

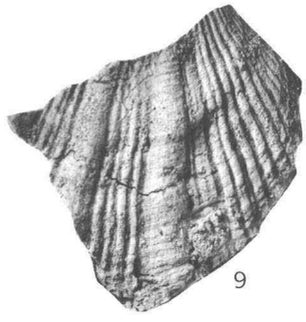


6

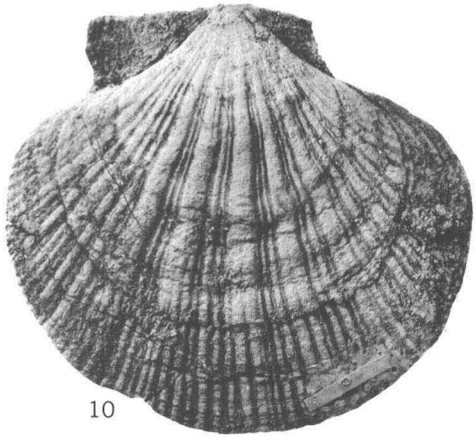
7



8



9



10

PECTINIDS FROM TRINITY ISLANDS, YAKATAGA DISTRICT (ALASKA)

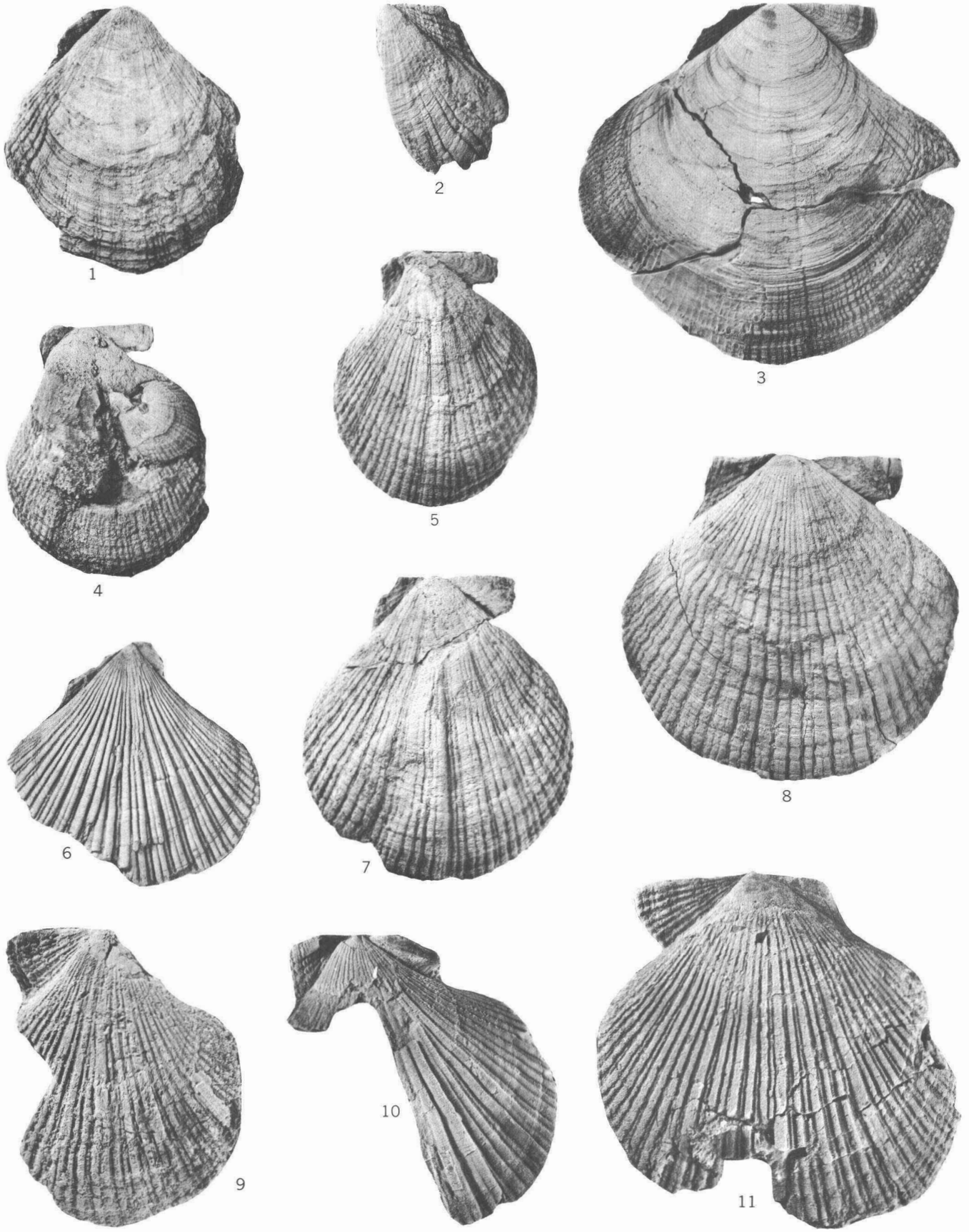
PLATE 10

[All figures × 1 unless otherwise noted]

FIGURES 1–3. *Chlamys* (*"Chlamys"*) *lioica* (Dall) (p. 19).
Figured specimens. Top of Chaix Hills section, upper part of Yakataga Formation (horizon probably Pliocene), Yakataga district, Alaska, USGS M1875.
1. Incomplete right valve (USNM 644931).
2. Fragment of left valve (USNM 644932).
3. Right valve (USNM 644930).

4, 5, 7, 8. *Chlamys* (*"Chlamys"*) *chaixensis* MacNeil, n. sp. (p. 19).
Top of Chaix Hills section, upper part of Yakataga Formation (horizon probably upper Pliocene), Yakataga district, Alaska, USGS M1875.
4. Paratype (USNM 644922), right valve of narrow ribbed variant.
5. Figured specimen (USNM 644928), right valve.
7. Figured specimen (USNM 644929), right valve.
8. Paratype (USNM 644923), right valve of a broad ribbed variant.

6, 9–11. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis* Masuda (p. 29).
Figured specimens. Upper part of Yakataga Formation (horizon probably Pliocene), Lituya district, Alaska.
6. Incomplete right valve (USNM 644985), USGS M1969.
9. Incomplete left valve (USNM 644986), USGS D222 (T).
10. Incomplete right valve (USNM 644987), USGS D184 (T).
11. Left valve (USNM 644988), × 1½, USGS D184 (T).



PECTINIDS FROM YAKATAGA DISTRICT, LITUYA DISTRICT (ALASKA)

PLATE 11

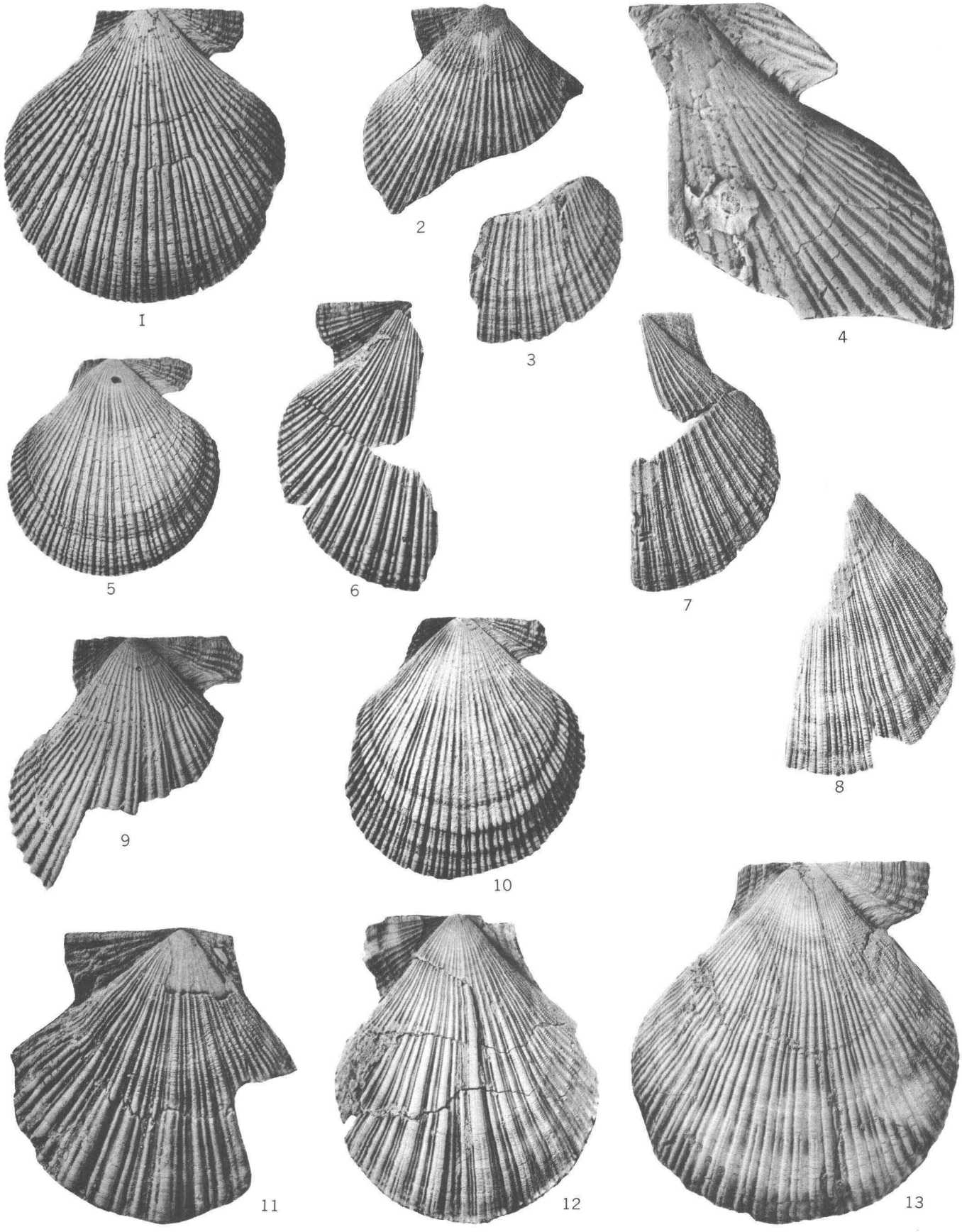
[All figures × 1 unless otherwise noted]

FIGURES 1–3, 5, 6, 10. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *picoensis chinkopensis* Masuda and Sawada (p. 28).
Figured specimens. Unnamed formations on Tugidak and Middleton Islands (horizons probably upper Pliocene), Alaska.
1. Right valve (USNM 644977), upper beds, Tugidak Island, USGS M1494.
2, 3. Fragments of left valves (USNM 644978, 644979), lower beds, Middleton Island, USGS M1753.
5. Right valve (USNM 644980), USGS M1494.
6. Fragment of left valve (USNM 644981), USGS M1494.
10. Right valve (USNM 644982), USGS M1494.

4. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis* Masuda (p. 29).
Figured specimen (USNM 644989), fragment of right valve, × 2. Upper part of the Yakataga Formation (horizon probably Pliocene), Lituya district, Alaska, USGS D222.

7, 8, 13. *Chlamys* (*Chlamys*) *rubida prerubida* MacNeil, n. subsp. (p. 23).
Unnamed formation, upper part (horizon probably upper Pliocene), Tugidak Island, Alaska, USGS M1494.
7. Paratype (USNM 644961), fragment of left valve.
8. Paratype (USNM 644962), fragment of left valve, × 1½.
13. Holotype (USNM 644960), right valve, × 1½.

9, 11, 12. *Chlamys* ("*Chlamys*") cf. *C.* ("*C.*") *cosibensis* (Yokoyama) (p. 17).
Figured specimens, × 1½. Unnamed formation, upper part (horizon probably upper Pliocene), Tugidak Island, Alaska, USGS M1494.
9. Incomplete right valve (USNM 644906).
11. Incomplete left valve (USNM 644907).
12. Left valve (USNM 644905).



PECTINIDS FROM TRINITY ISLANDS, MIDDLETON ISLAND, LITUYA DISTRICT (ALASKA)

223-848 O - 67 - 8

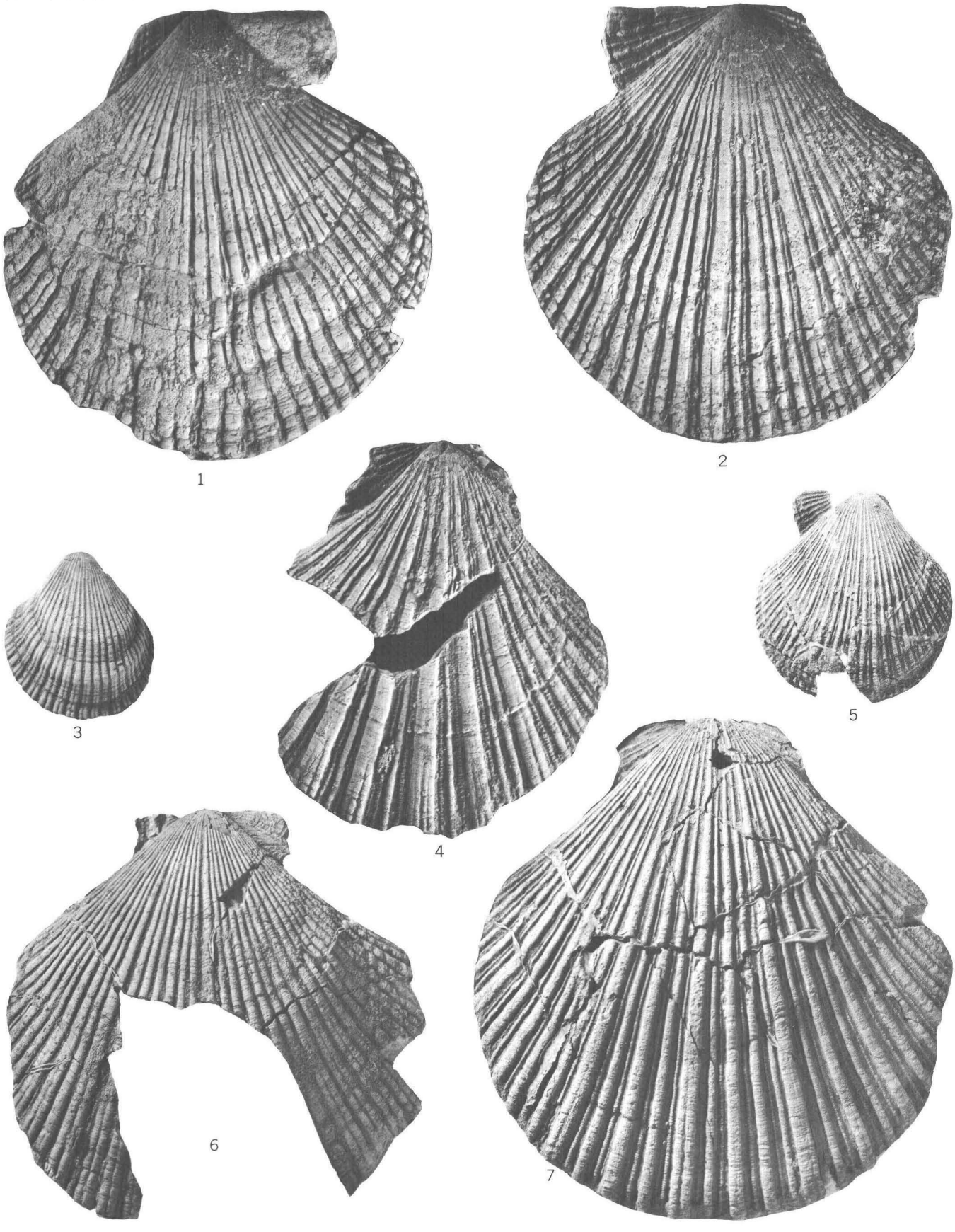
PLATE 12

[All figures × 1]

FIGURES 1, 2, 6, 7. *Chlamys* (*Chlamys*) *pseudislandica plafkeri* MacNeil, n. subsp. (p. 32).
Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska.
1. Holotype (USNM 645002), right valve, USGS 17745.
2. Holotype, left valve, USGS 17745.
6. Figured specimen (USNM 645003), right valve, ?opposite valve of individual on pl. 12, fig. 7, USGS M1724.
7. Figured specimen (USNM 645004), left valve, USGS M1742.

3, 5. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis amchitkana* MacNeil (p. 30).
Figured specimens. Unnamed formation, upper beds (horizon probably Pleistocene), Middleton Island, Alaska, USGS 17744.
3. Incomplete right valve (USNM 644993), juvenile.
5. Left valve (USNM 644994), juvenile.

4. *Chlamys* ("*Chlamys*") cf. *C.* ("*C.*") *coatsi middletonensis*. MacNeil, n. subsp. (p. 18).
Figured specimen (USNM 644920), incomplete left valve. Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska, USGS 17745.



PECTINIDS FROM MIDDLETON ISLAND (ALASKA)

PLATE 13

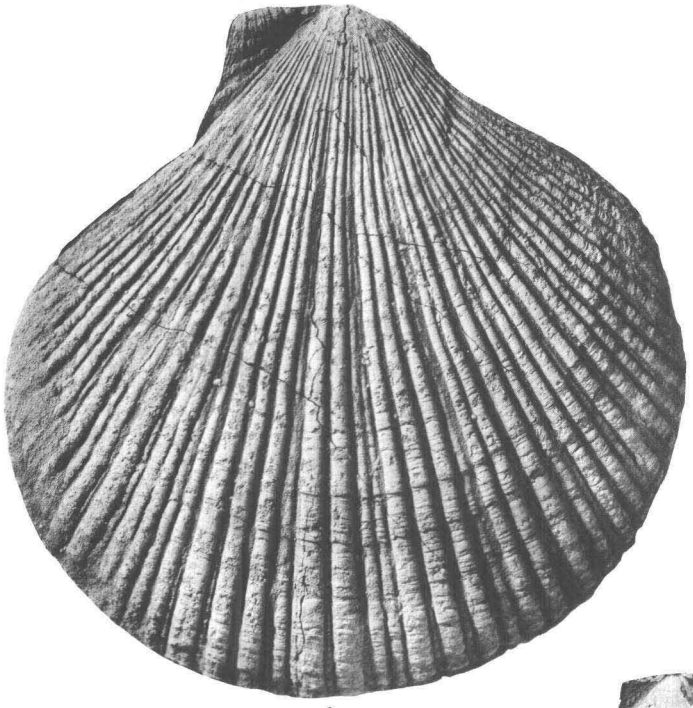
[All figures × 1]

FIGURES 1, 2. *Chlamys* (*Chlamys*) *pseudislandica plafkeri* MacNeil, n. subsp. (p. 32).
Figured specimens. Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska.
1. Incomplete right valve (USNM 645005), USGS M1743.
2. Left valve (USNM 645006), USGS M2054.

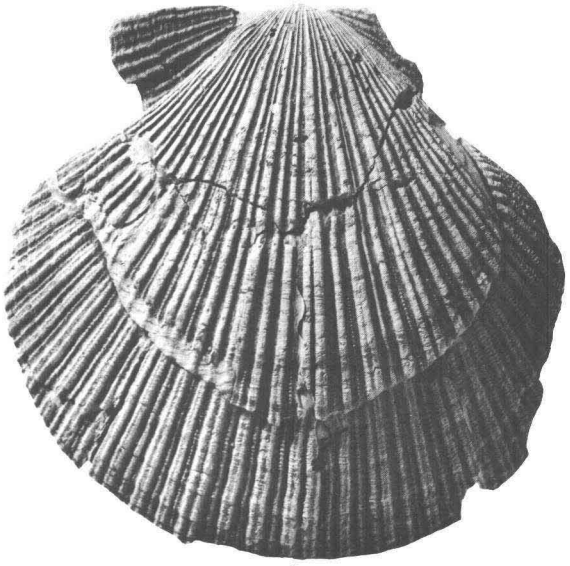
3–5, 7. *Chlamys* (*"Chlamys"*) *coatsi middletonensis* MacNeil, n. subsp. (p. 18).
Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska, USGS M1741.
3. Holotype (USNM 644915), right valve.
4. Figured specimen (USNM 644916), incomplete right valve of fine ribbed variant.
5. Holotype, left valve.
7. Figured specimen (USNM 644917), incomplete right valve of coarse ribbed variant.

6. *Chlamys* (*Chlamys*) *islandica kanagae* MacNeil, n. subsp. (p. 35).
Figured specimen (USNM 645013), incomplete right valve. Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska, USGS M1742.

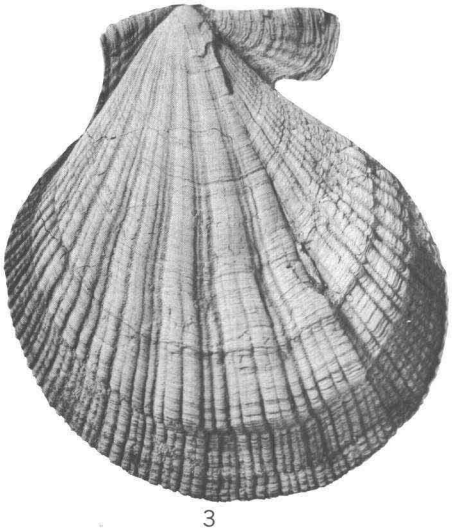
8. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis amchitkana* MacNeil, n. subsp. (p. 30).
Figured specimen (USNM 644995), right valve, juvenile. Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska, USGS M1744.



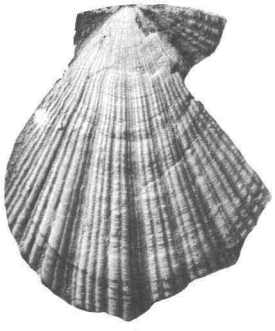
1



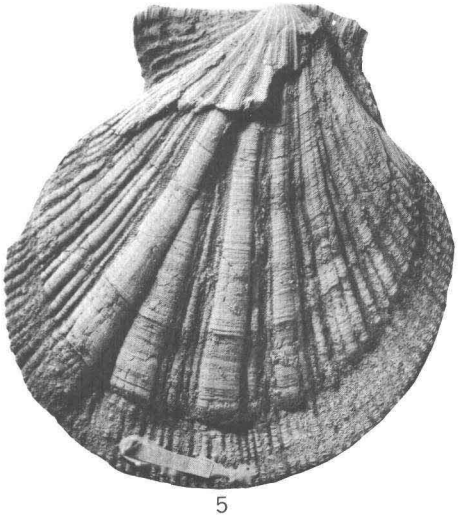
2



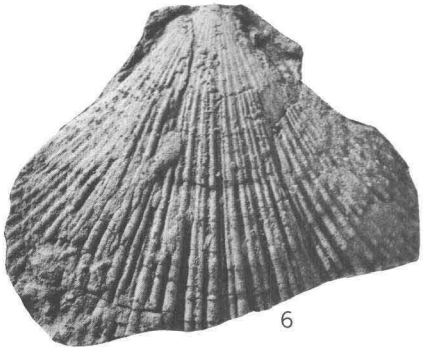
3



4

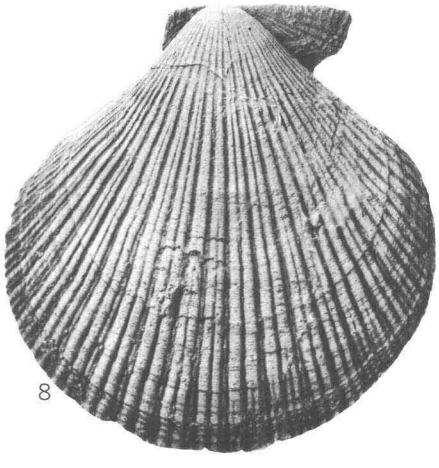


5



6

7



8

PECTINIDS FROM MIDDLETON ISLAND (ALASKA)

PLATE 14

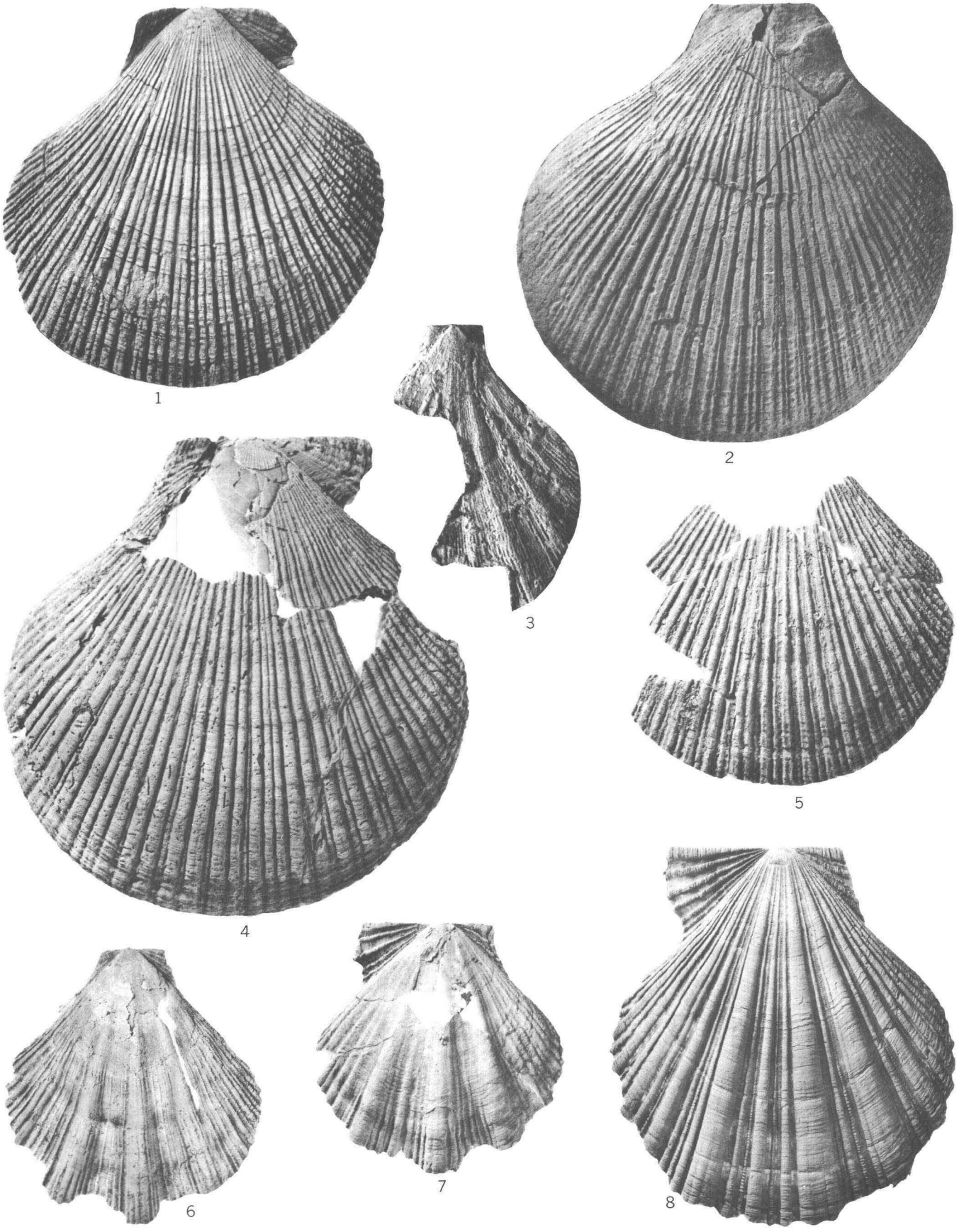
[All figures × 1]

FIGURES 1, 2, 4, 5. *Chlamys* (*Chlamys*) *hanaishiensis amchitkana* MacNeil, n. subsp. (p. 30).
Unnamed formations (horizons probably lower Pleistocene) on Middleton Island and Amchitka Island, Aleutian Islands, Alaska.
1. Figured specimen (USNM 644996), right valve. Middleton Island, upper beds, USGS 17743.
2. Figured specimen (USNM 644997), right valve. Middleton Island, upper beds, no locality data.
4. Holotype (USNM 644991), right valve. Amchitka Island, lower(?) beds, USGS 16908.
5. Paratype (USNM 644992), fragment of left valve. Amchitka Island, lower(?) beds, USGS 16908.

3. *Chlamys* sp. (p. 36).
Figured specimen (USNM 645028), fragment of left valve, rubber cast. Unnamed formation, upper beds (horizon probably lower Pleistocene), Middleton Island, Alaska, USGS M1742.

6, 7. *Chlamys* (*"Chlamys"*) *coatsi* MacNeil, n. sp. (p. 17).
Figured specimens. Unnamed formation, upper(?) beds (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska.
6. Left valve (USNM 644913), juvenile, USGS D46 (T).
7. Left valve (USNM 644914), juvenile, USGS 16908a.

8. *Chlamys* (*"Chlamys"*) *coatsi middletonensis* MacNeil, n. subsp. (p. 18).
Figured specimen (USNM 644918), left valve. Unnamed formation, upper(?) beds) (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska, USGS D46 (T).



PECTINIDS FROM ALEUTIAN ISLANDS, MIDDLETON ISLAND (ALASKA)

PLATE 15

[All figures × 1 unless otherwise noted]

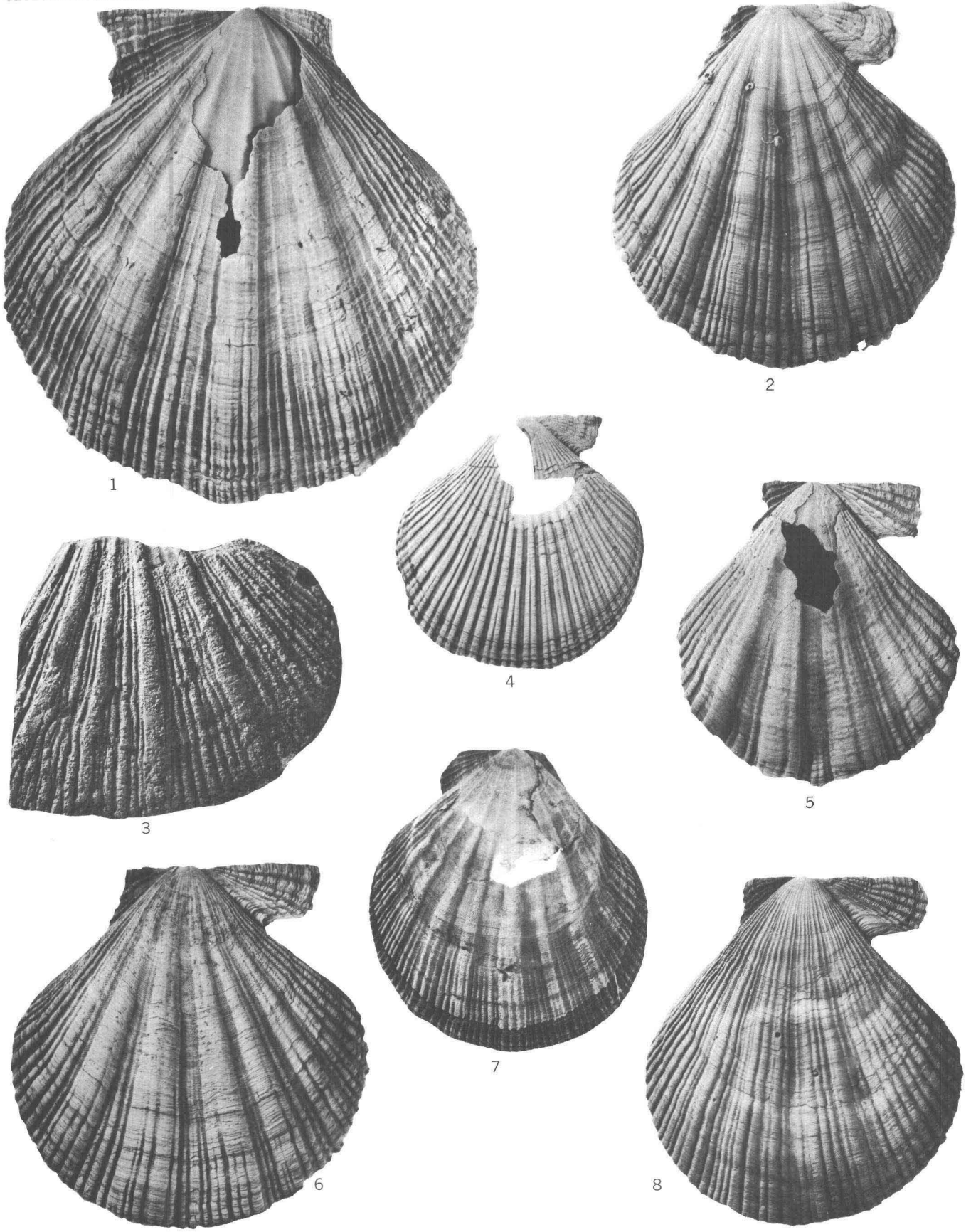
FIGURES 1, 2, 5, 6. *Chlamys* (*"Chlamys"*) *coatsi* MacNeil, n. sp. (p. 17).
Unnamed formation, upper(?) beds (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska.
1. Holotype (USNM 644908), left valve, USGS D46.
2. Figured specimen (USNM 644910), right valve, USGS D46.
5. Figured specimen (USNM 644911), right valve, slightly enlarged, USGS 16908a.
6. Paratype (USNM 644909), right valve, USGS 16908a.

3. *Chlamys* (*Chlamys*) *islandica kanagae* MacNeil, n. subsp. (p. 35).
Figured specimen (USNM 645014), fragment of left valve.
Unnamed formation (early or middle Pleistocene), Kanaga Island, Aleutian Islands, Alaska, USGS D3.

4. *Chlamys* (*Chlamys*) *hanaishiensis amchitkana* MacNeil, n. subsp. (p. 30).
Figured specimen (USNM 644998), right valve, juvenile. Unnamed formation, upper beds (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska, USGS 16908a.

7. *Chlamys* (*"Chlamys"*) *coatsi* MacNeil, n. sp. (p. 17).
Figured specimen (USNM 644912), left valve. Gubik Formation (horizon probably middle Pleistocene), mouth of Kuk River, near Wainwright, northern Alaska, USGS M1828.

8. *Chlamys* (*"Chlamys"*) *coatsi middletonensis* MacNeil, n. subsp. (p. 18).
Figured specimen (USNM 644919), right valve. Unnamed formation, upper(?) beds (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska, USGS D46.



PECTINIDS FROM ALEUTIAN ISLANDS, ARCTIC COAST (ALASKA)

PLATE 16

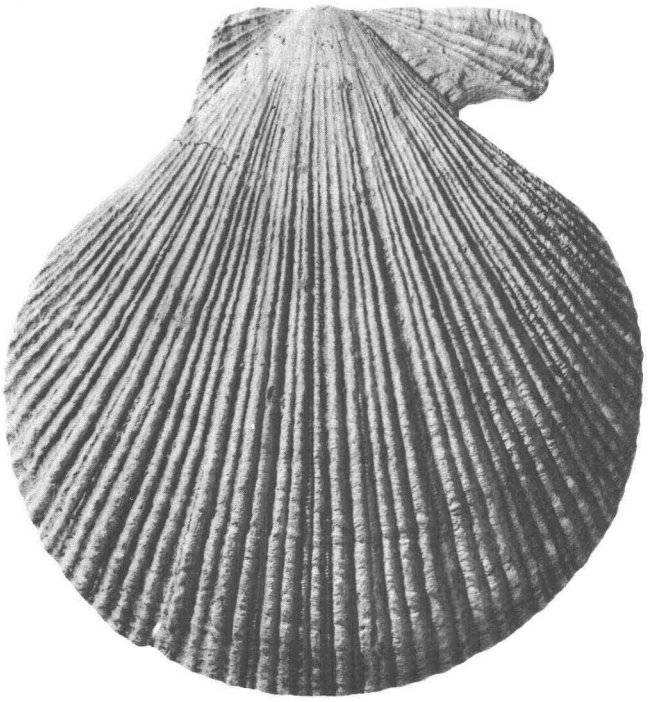
[All figures × 1 unless otherwise noted]

FIGURES 1, 2, 4–7. *Chlamys* (*Chlamys*) *islandica powersi* MacNeil, n. subsp. (p. 35).
Unnamed formation, upper(?) beds (early or middle Pleistocene), Amchitka Island, Aleutian Islands, Alaska, USGS D46 (T).

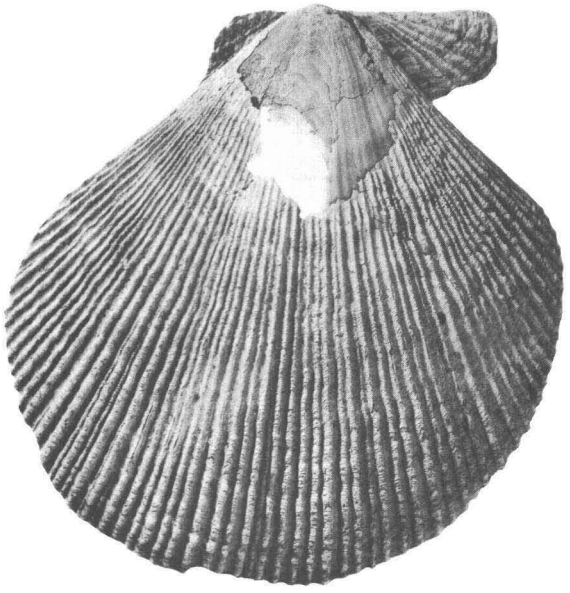
1. Holotype (USNM 645022), right valve.
2. Figured specimen (USNM 645025), right valve.
4. Figures specimen (USNM 645026), right valve.
5. Figures specimen (USNM 645027), left valve.
6. Paratype (USNM 645023), left valve.
7. Paratype (USNM 645024), left valve.

3. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *rubida hindsii* (Carpenter) (p. 23).
Figured specimen (USNM 637745), left valve, × 1½. Recent, Douglas Island, near Juneau, southeastern Alaska, USGS M213.

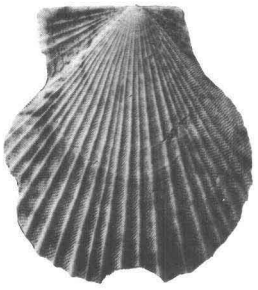
8. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *hanaishiensis* Masuda (p. 29).
Figured specimen (USNM 644990), right valve, juvenile, ×2½. Unnamed formation, upper part (horizon probably upper Pliocene), Tugidak Island, Alaska, USGS M1494.



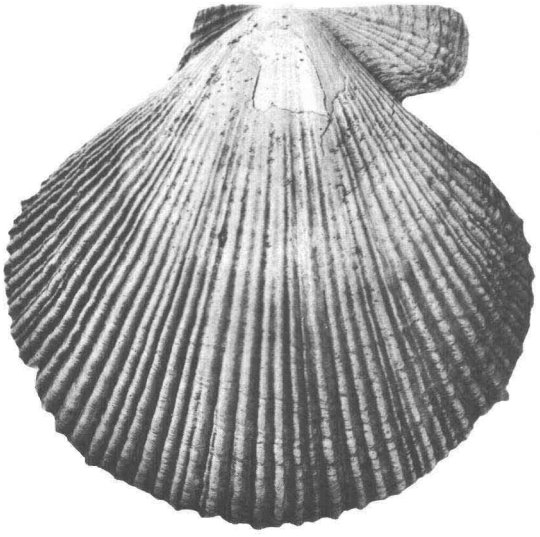
1



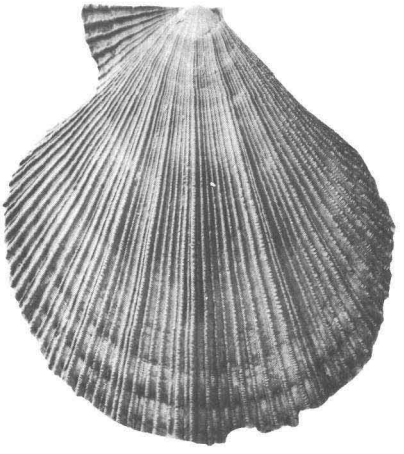
2



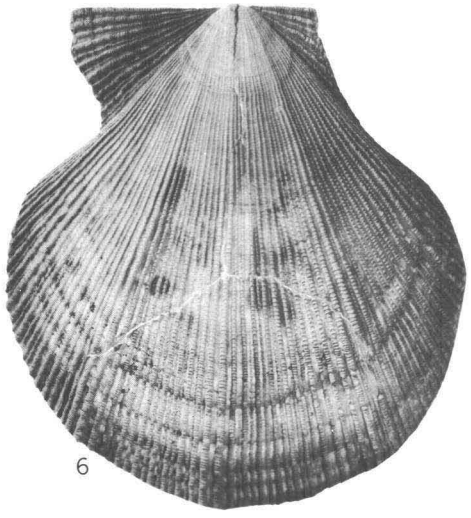
3



4

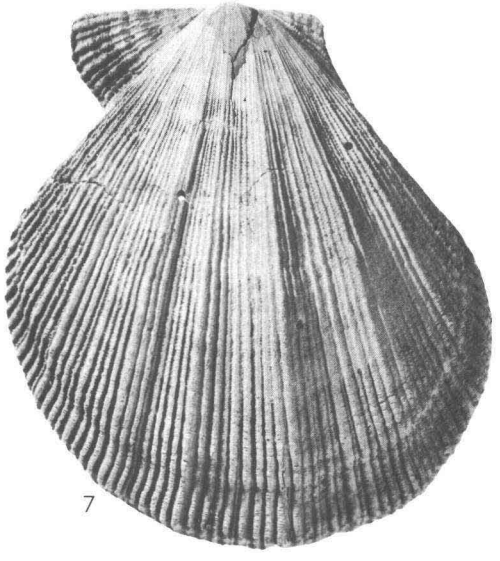


5



6

8



7

PECTINIDS FROM ALEUTIAN ISLANDS, TRINITY ISLANDS, SOUTHEASTERN ALASKA (ALASKA)

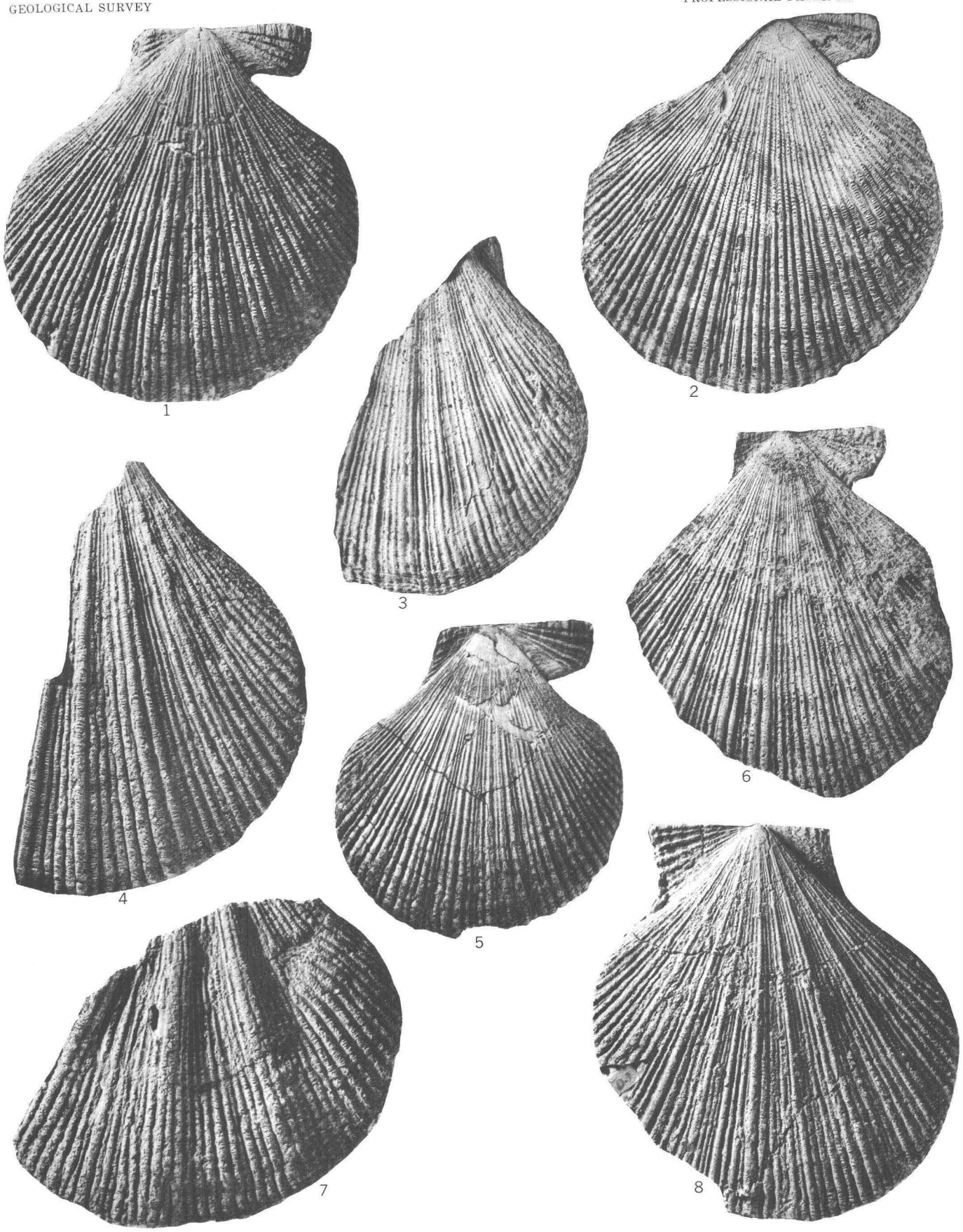
PLATE 17

[All figures × 1]

FIGURES 1–4, 6–8. *Chlamys* (*Chlamys*) *islandica kanagae* MacNeil, n. subsp. (p. 35).
Unnamed formation (early or middle Pleistocene), Kanaga Island, Aleutian Islands, Alaska, USGS D3 (T).

1. Holotype (USNM 645011), right valve.
2. Figured specimen (USNM 645015), right valve.
3. Figured specimen (USNM 645016), fragment of left valve.
4. Figured specimen (USNM 645017), fragment of left valve.
6. Figured specimen (USNM 645018), incomplete right valve.
7. Figured specimen (USNM 645019), fragment of left valve.
8. Paratype (USNM 645012), left vlave.

5. *Chlamys* (*Chlamys*) *islandica kanagae* MacNeil, n. subsp. (p. 35).
Figured specimen (USNM 645020), right valve. Unnamed formation (horizon probably lower Pleistocene), Adak Island, Aleutian Islands, Alaska, USGS 16907.



PECTINIDS FROM ALEUTIAN ISLANDS (ALASKA)

223-848 O - 67 - 9

PLATE 18

[All figures × 1 unless otherwise noted]

FIGURE 1. *Chlamys* (*Chlamys*) *islandica kanagae* MacNeil, n. subsp. (p. 35).
Figured specimen (USNM 645021), incomplete right valve. Unnamed formation (early or middle Pleistocene), Kanaga Island, Aleutian Islands, Alaska, USGS D3.

2. *Chlamys* (*Chlamys*) *islandica thulensis* MacNeil, n. subsp. (p. 34).
Holotype (USNM 645010), incomplete left valve. Raised beach (probably postglacial), Narssurssuk, northwestern Greenland, USGS D386.

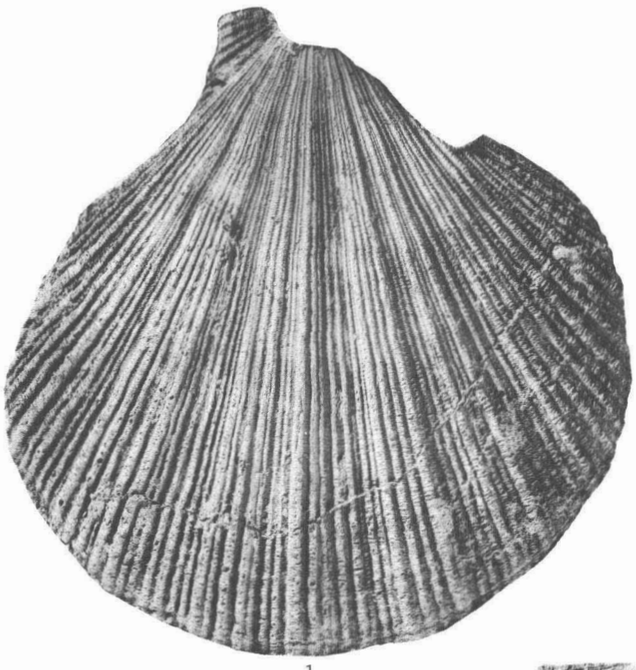
3. *Chlamys* (*Chlamys*) *wainwrightensis* MacNeil, n. sp. (p. 27).
Figured specimen (USNM 637754), right valve. Recent, Wainwright, northern Alaska, USGS M2062.

4, 6. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) (p. 23).
Postglacial deposits, Juneau area, southeastern Alaska.
4. Figured specimen (USNM 644948), left valve, Glacier Highway, north shore of Auke Bay, USGS M218.
6. Figured specimen (USNM 644947), right valve, × 1½, north side of Douglas Island, east of Entrance Point, USGS M243.

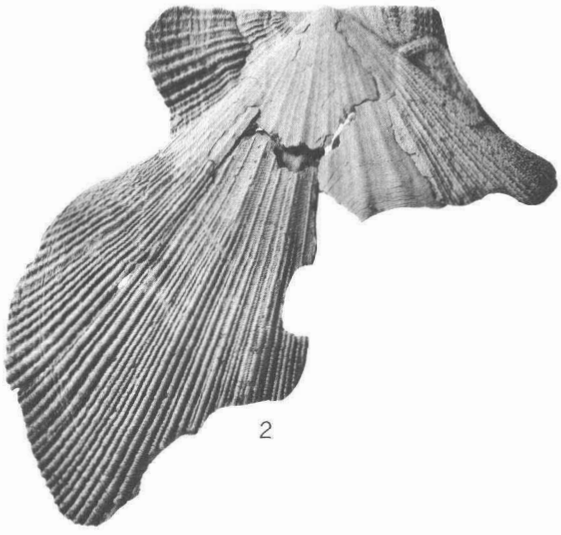
5. *Chlamys* (*Chlamys*) *beringiana colvillensis* MacNeil, n. subsp. (p. 26).
Holotype (USNM 561912), incomplete right valve. Gubik Formation, lower part (horizon probably lower Pleistocene), Colville River at Ocean Point, northern Alaska, USGS D306.

7. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *beringiana colvillensis* MacNeil (p. 26).
Figured specimen (USNM 644968), fragment of left valve, Submarine Beach (late Pliocene or early Pleistocene), Nome, Alaska, USGS M1256.

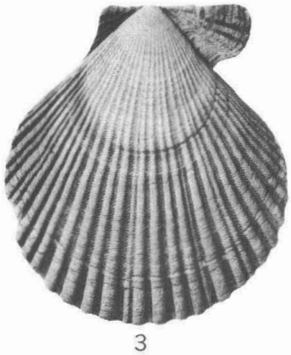
8. *Chlamys* (*Chlamys*) *islandica islandica* Müller) (p. 33).
Figured specimen (USNM 645007), left valve. Raised terrace deposit (postglacial; radiocarbon dated at 10,200 yrs B.P.), Reykjavik Airport, Iceland, USGS M2055.



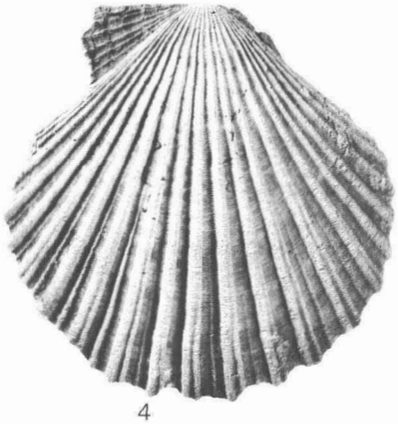
1



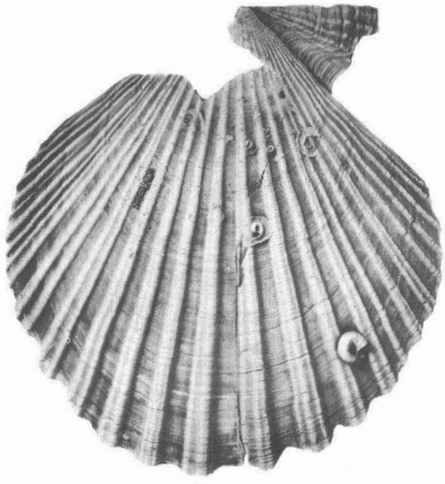
2



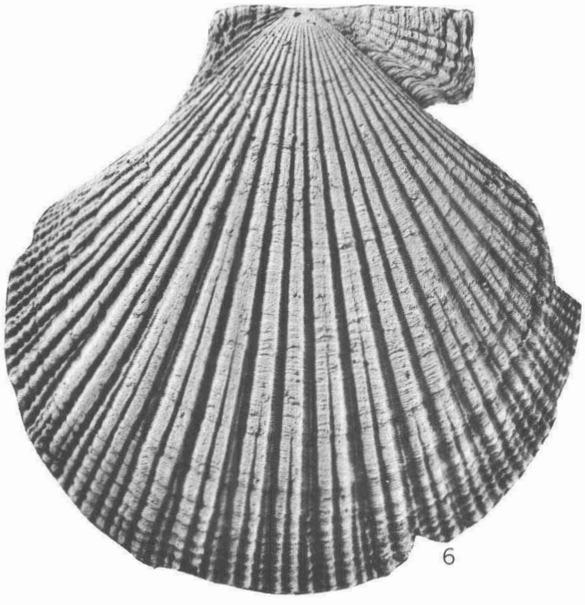
3



4

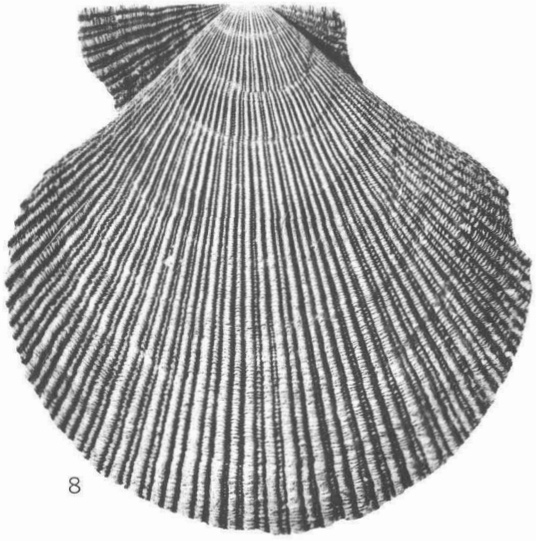


5



6

7



8

PECTINIDS FROM ALEUTIAN ISLANDS, SOUTHEASTERN ALASKA, SEWARD PENINSULA
ARCTIC COAST (ALASKA), GREENLAND, ICELAND

PLATE 19

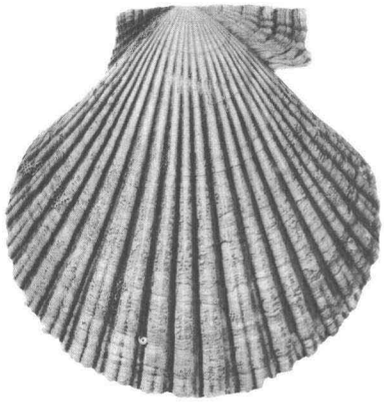
[All figures × 1]

FIGURES 1, 3, 4, 6. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) (p. 23).
Figured specimens. Postglacial deposits, Juneau area, southeastern Alaska.
1. Right valve (USNM 644949), south of Fish Creek on road north of bridge, Douglas Island, USGS M214.
3. Left valve (USNM 644950), USGS M214.
4. Left valve (USNM 644951), USGS M214.
6. Left valve (USNM 644952), north side of Douglas Island east of Entrance Point, USGS M243.

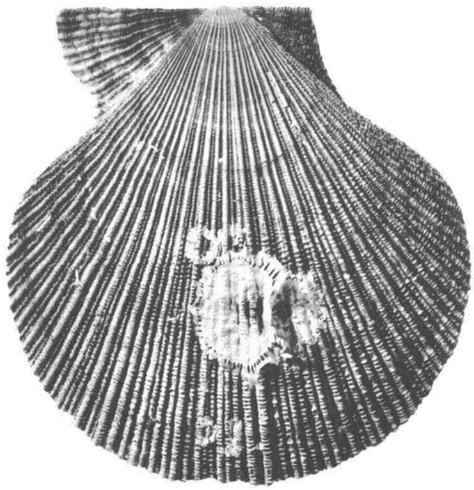
2, 5. *Chlamys* (*Chlamys*) *islandica islandica* (Müller) (p. 33).
Figured specimens. Raised terrace deposits (postglacial; radiocarbon dated at 10,200 yrs B.P.), Reykjavik Airport, Iceland, USGS M2055.
2. Left valve (USNM 645008).
5. Right valve (USNM 645009).

7. *Chlamys* (*Chlamys*) *pseudislandica* MacNeil, n. sp. (p. 31).
Figured specimen (USNM 637759), right valve. Recent, St. Lawrence Island, northern Bering Sea, USGS D373.

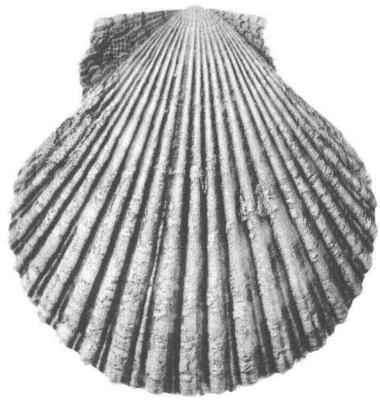
8, 9. *Chlamys* (*Chlamys*) *wainwrightensis* MacNeil, n. sp. (p. 27).
Recent, northern Alaska.
8. Figured specimen (USNM 637755), a right valve, Wainwright, USGS M2056.
9. Holotype (USNM 637756), a left valve, Point Hope, USGS M1339.



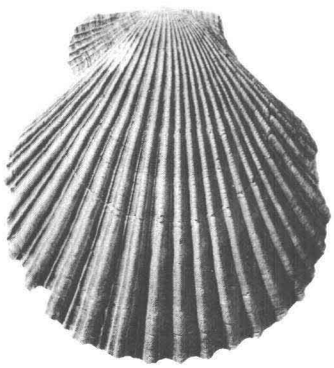
1



2

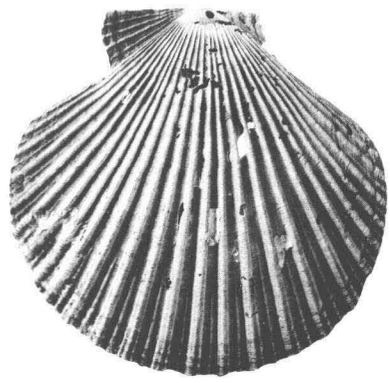


3

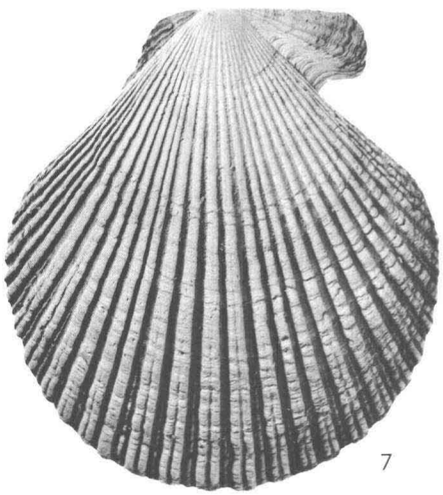


4

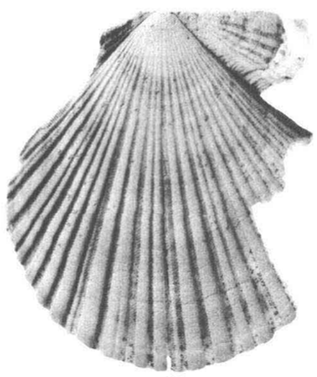
5



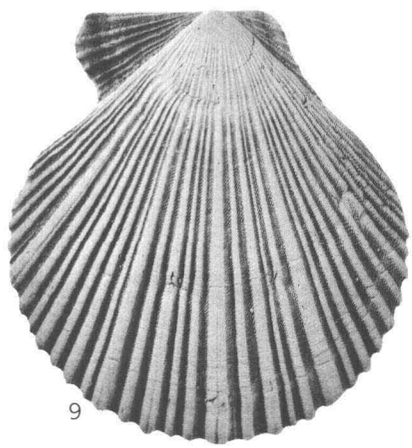
6



7



8



9

PECTINIDS FROM SOUTHEASTERN ALASKA, ST. LAWRENCE ISLAND
ARCTIC COAST (ALASKA), ICELAND

PLATE 20

[All figures × 1 unless otherwise noted]

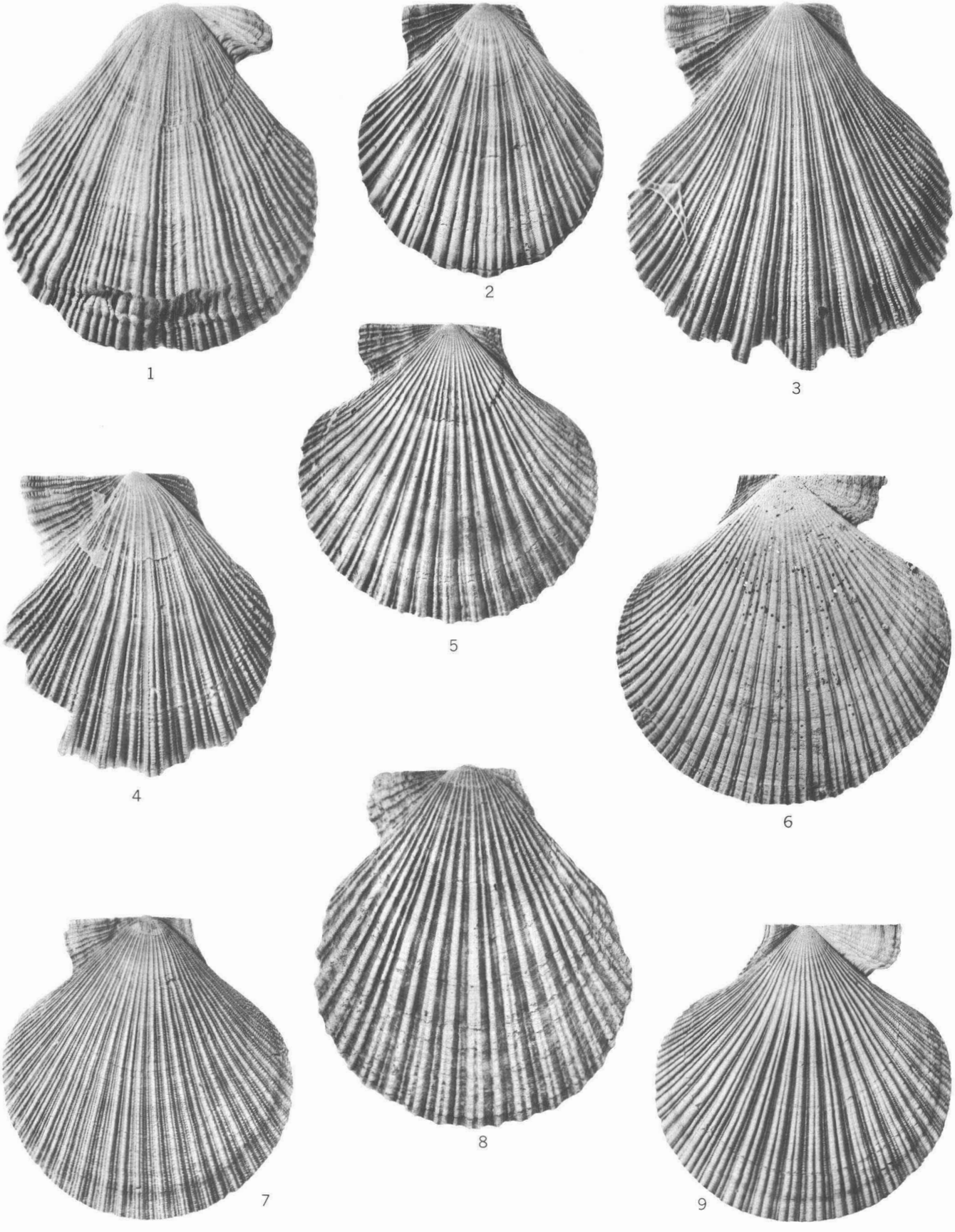
FIGURES 1, 3, 4. *Chlamys* (*Chlamys*) *beringiana unalaskae* MacNeil, n. subsp. (p. 27).
Recent, Unalaska Island, Aleutian Islands, Alaska, USGS D53.
1. Holotype (USNM 637751), right valve, × 1½.
3. Paratype (USNM 637752), left valve, × 1½.
4. Paratype (USNM 637753), left valve, × 1½.

2. *Chlamys* (*Chlamys*) *beringiana* (Middendorff) subsp. ?(p. 24).
Figured specimen (USNM 637746), left valve. Recent, Point Hope, northwestern Alaska, USGS M1339.

5, 6. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) (p. 23).
Figured specimens. Recent, Excursion Inlet, southeastern Alaska, USGS M223.
5. Left valve (USNM 637741).
6. Right valve (USNM 637742).

7, 9. *Chlamys* (*Chlamys*) *rubida* (Hinds) (p. 21).
Figured specimen (USNM 150220), both valves of same individual. Recent, Alaska Peninsula.
7. Left valve.
9. Right valve.

8. *Chlamys* (*Chlamys*) *pseudislandica* MacNeil, n. sp. (p. 31).
Figured specimen (USNM 637760), left valve. Recent, Wainwright, northern Alaska, USGS M2056.



PECTINIDS FROM ALEUTIAN ISLANDS, ALASKA PENINSULA, ARCTIC COAST
SOUTHEASTERN ALASKA (ALASKA)

PLATE 21

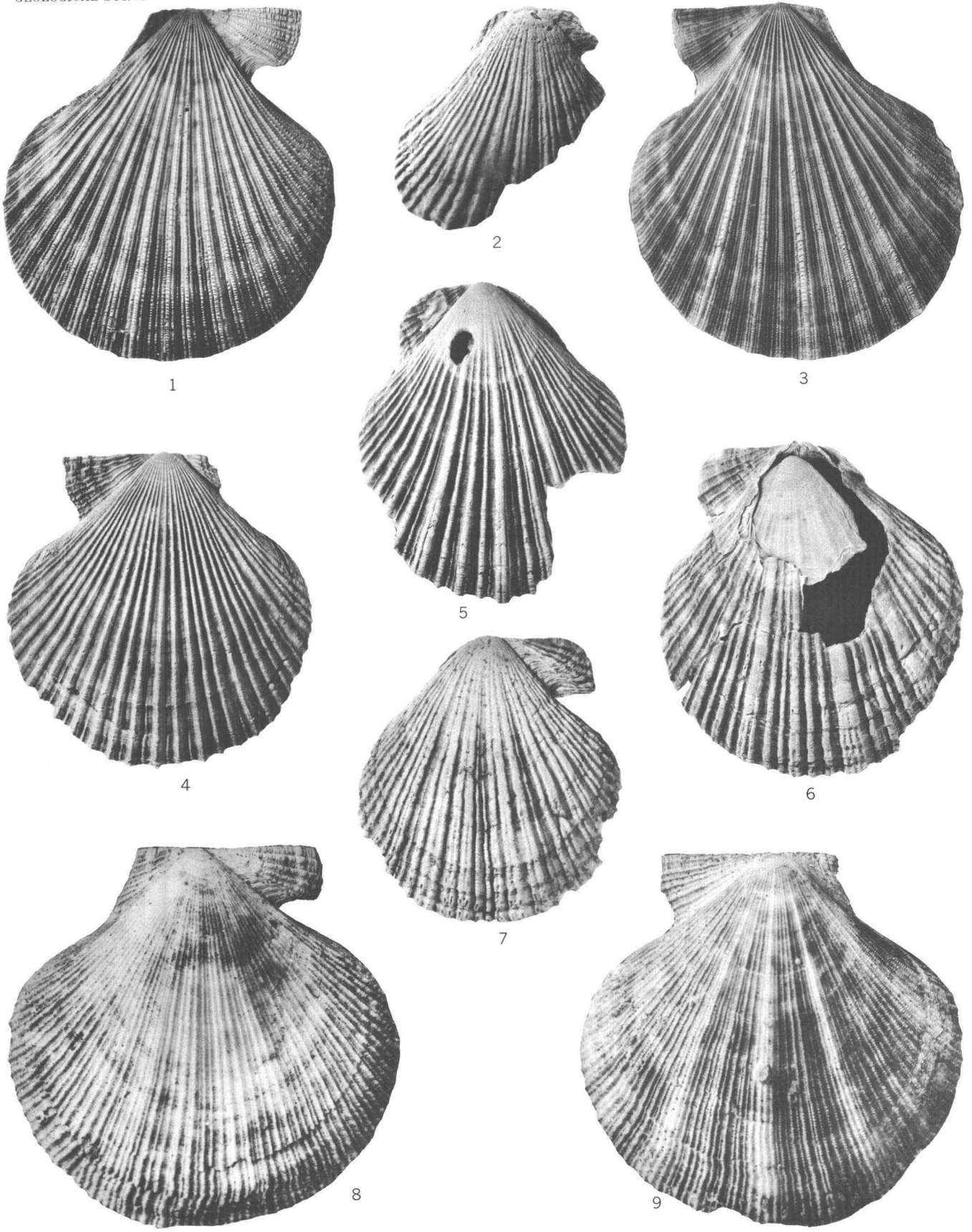
[All figures × 1]

FIGURES 1, 3. *Chlamys* ("*Chlamys*") *hastata hericius* (Gould) (p. 14).
Figured specimen (CAS 12611), both valves of the same individual. Recent, Puget Sound, Washington, CAS loc. 31879.

2, 5–7. *Chlamys* (*Chlamys*) *beringiana* (Middendorff) (p. 24).
Figured specimens. Recent.
2. Incomplete right valve (USNM 637747), St. Paul Island, Pribiloff Islands, USGS M1622
5. Incomplete left valve (USNM 637748), St. Paul Island, Pribiloff Islands, USGS M1621.
6. Incomplete left valve (USNM 637749), St. Lawrence Island, northern Bering Sea, USGS D373.
7. Right valve (CAS 12746), St. Paul Island, Pribiloff Islands, CAS loc. 18493.

4. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) (p. 23).
Figured specimen (USNM 637743), a left valve of the variant with sharp-topped ribs. Recent, Excursion Inlet, north side of Icy Strait, southeastern Alaska, USGS M234.

8, 9. *Chlamys* (*Chlamys*) *islandica erythrocomata* (Dall) (p. 36).
Holotype (USNM 110462), both valves. Recent, Albatross sta. 5021, Okhotsk Sea, depth 73 fathoms. This is the first published illustration of the holotype.



PECTINIDS FROM PUGET SOUND (WASHINGTON), SOUTHEASTERN ALASKA
PRIBILOF ISLANDS (ALASKA), OKHOTSK SEA

PLATE 22

[All figures × 1 unless otherwise noted]

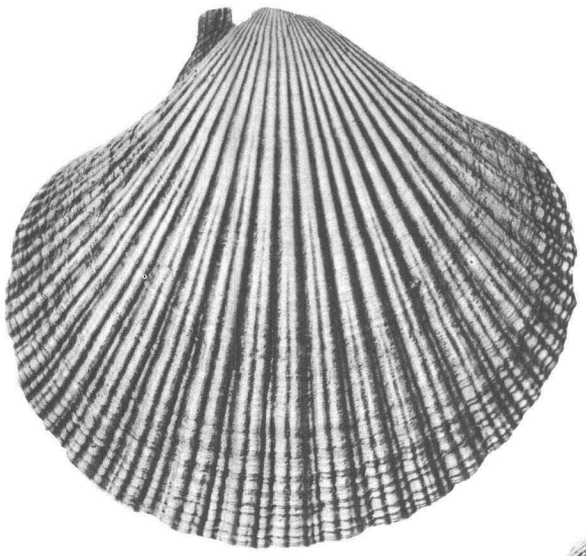
FIGURES 1, 2. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) var.? (p. 23).
Figured specimens. Postglacial deposits, Juneau area, southeastern Alaska.
1. Incomplete large right valve (USNM 644956), south of Fish Creek on road north of bridge, Douglas Island, USGS M214.
2. Right valve (USNM 644957), mouth of Eagle River on Lynn Canal, USGS 5461.

3. *Chlamys* (*Chlamys*) *rubida jordani* (Arnold) (p. 22).
Figured specimen (USNM 644945), right valve. Fernando Formation (horizon uppermost Pliocene), about 1¾ mile south of northeast end of Orange County Airport and near head of Newport Bay, Orange County, Calif., USGS M2130.

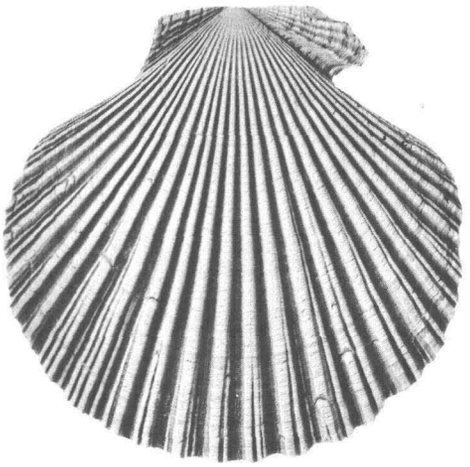
4, 5. *Chlamys* (*"Chlamys"*) *pugetensis* (Oldroyd) (p. 15).
Figured specimens. Recent, Sitkalidak Island, east side of Kodiak Island, Alaska, USGS M2064.
4. Right valve (USNM 637739), × 2.
5. Left valve (USNM 637740), × 2.

6. *Chlamys* (*Chlamys*) *hanaishiensis amchitkana* MacNeil, n. subsp. (p. 30).
Figured specimen (USNM 644999), incomplete right valve. Unnamed formation, lower (?) beds (horizon probable lower Pleistocene), Amchitka Island, Aleutian Islands, Alaska, USGS 16908.

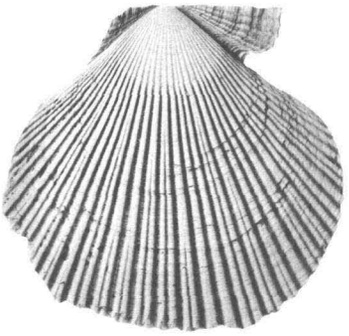
7, 8. *Chlamys* (*Chlamys*) cf. *C.* (*C.*) *rubida* (Hinds) (p. 21).
Figured specimens. Postglacial deposits, Juneau area, Alaska, end of highway north of Douglas Island bridge, USGS M212.
7. Right valve (USNM 644943).
8. Fragment of a left valve (USNM 644944).



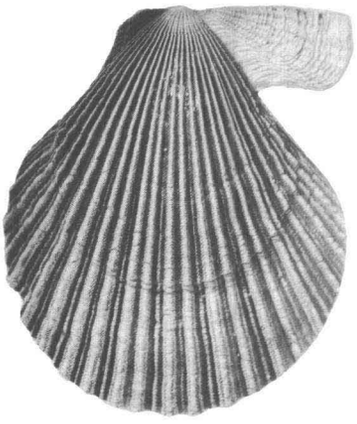
1



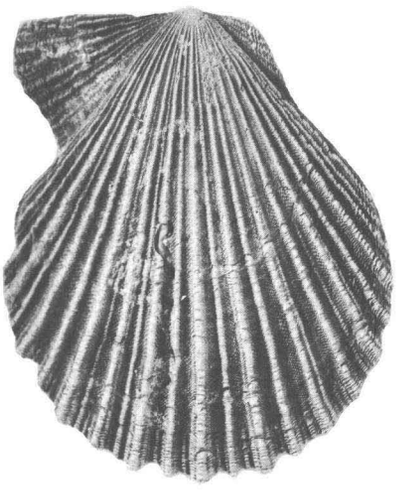
2



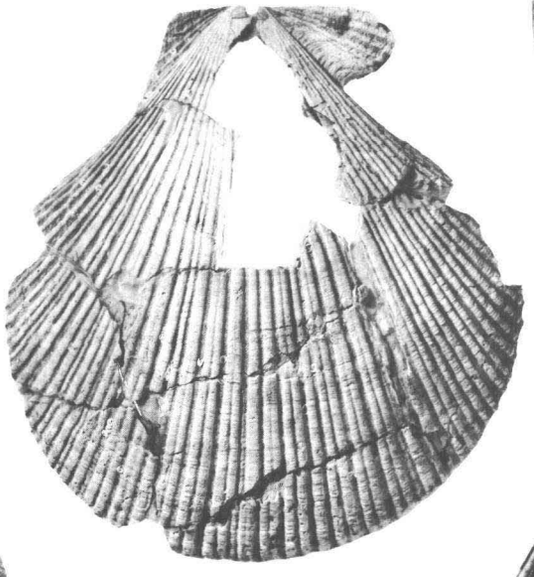
3



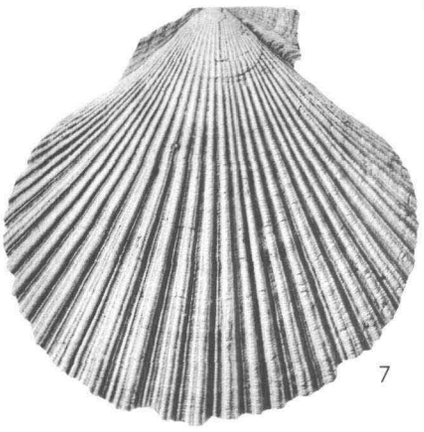
4



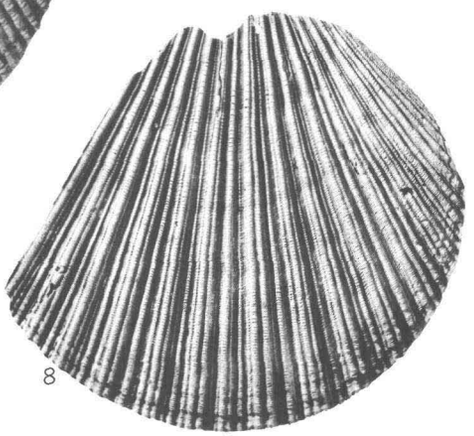
5



6



7



8

PECTINIDS FROM ALEUTIAN ISLANDS, SITKALIDAK ISLAND OFF KODIAK
SOUTHEASTERN ALASKA (ALASKA), CALIFORNIA

PLATE 23

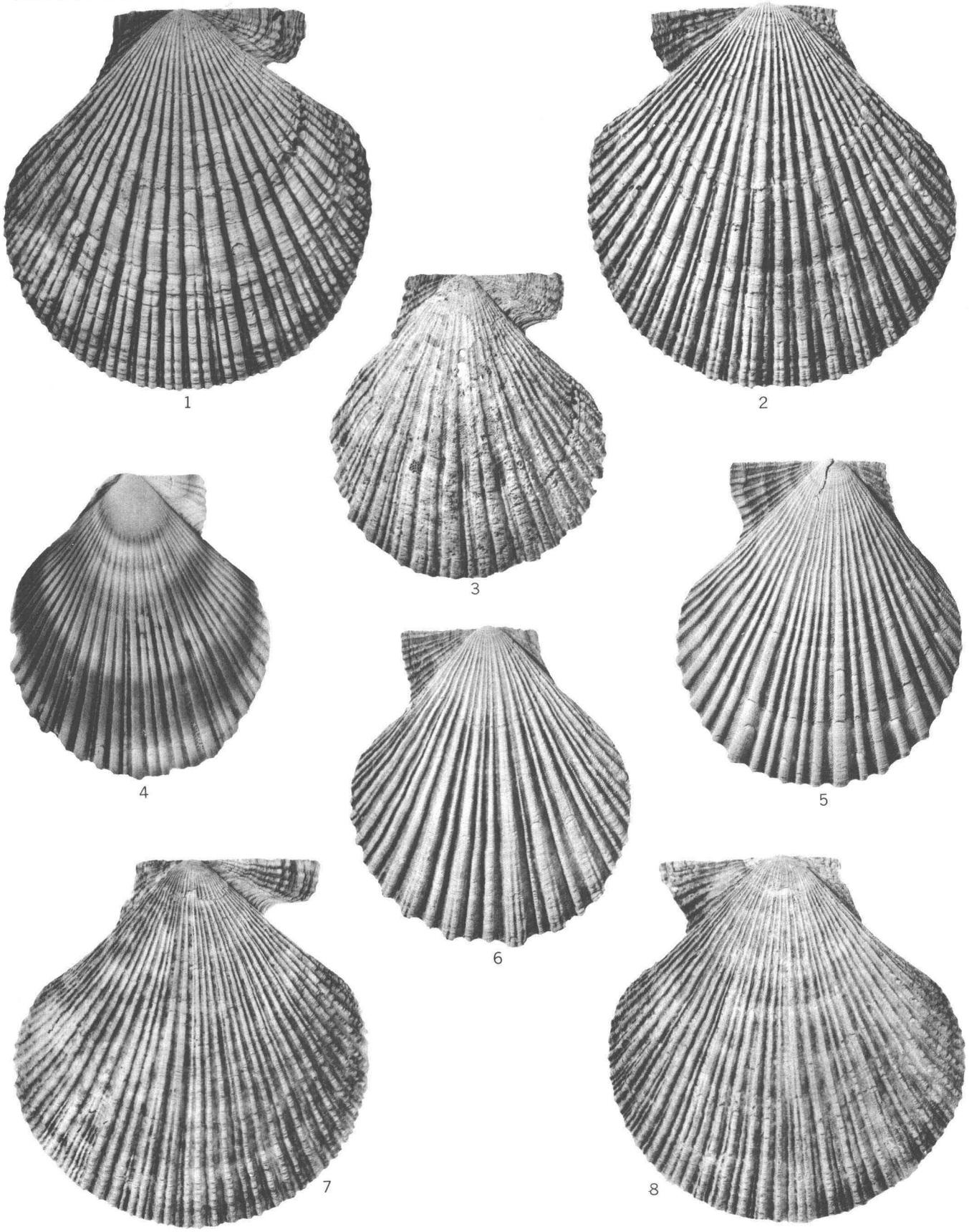
[All figures × 1 unless otherwise noted]

FIGURES 1, 2. *Chlamys* (*Chlamys*) *pseudislandica* MacNeil, n. sp. (p. 31).
Holotype (CAS 12612), both valves. Recent, 5 miles off Point Marsh, near Wainwright, Arctic coast of Alaska, CAS loc. 34358.

3, 6. *Chlamys* (*Chlamys*) *beringiana* (Middendorff) (p. 24).
Figured specimens. Recent, Arctic coast of Alaska.
3. Right valve (CAS 12614), 2 miles off Arcon Camp, Point Barrow, northern Alaska, CAS loc. 34333.
6. Left value (CAS 12613), 3½ miles off Wainwright, Artic coast of Alaska, CSA loc. 34337.

4, 5. *Chlamys* (*Chlamys*) *wainwrightensis* MacNeil, n. sp. (p. 27).
Recent, northern Alaska.
4. Paratype (USNM 637757), a right valve, Point Hope, USGS M1339.
5. Figured specimen (USNM 637758), a left valve, × 1½, Wainwright, USGS D318.

7, 8. *Chlamys* (*Chlamys*) *pseudislandica arconis* MacNeil, n. subsp. (p. 33).
Figured specimen (CAS 12747), both valves. Recent, 17 miles west of Arcon Beach, near Point Barrow, northern Alaska, CAS loc. 34347.



PECTINIDS FROM ARCTIC COAST (ALASKA)

223-848 O - 67 - 10

PLATE 24

FIGURE 1. *Chlamys* (*Chlayms*) *rubida hindsii* (Carpenter) (p. 23).
The specimen figured by Middendorff (1849, pl. 12, fig. 9) as *Pecten rubidus* Hinds?. Probably from Sitka, Alaska. Recent. In Zoological Institute, Leningrad.

2. *Chlamys* (*Chlamys*) *beringiana* (Middendorff) (p. 24).
Lectotype. The largest of three specimens figured by Middendorff (1849, pl. 13, fig. 1) as *Pecten islandicus* var. *behringiana*. Probably from Bering Sea. Recent. In Zoological Institute, Leningrad.

3. *Chlamys* (*Chlamys*) *beringiana* (Middendorff) (p. 24).
Figured specimen (USNM 637750), an incomplete right valve. Recent, St. Lawrence Island, northern Bering Sea, USGS D373.

4, 6. *Chlamys* (*"Chalmys"*) *harmeri* Altena (p. 15).
Figured specimens. Probably Scaldesian (early Pleistocene). Dredged from the Westerschelde, western Netherlands, USGS M2519.
4. Right valve (USNM 644895).
6. Left valve (USNM 644896).

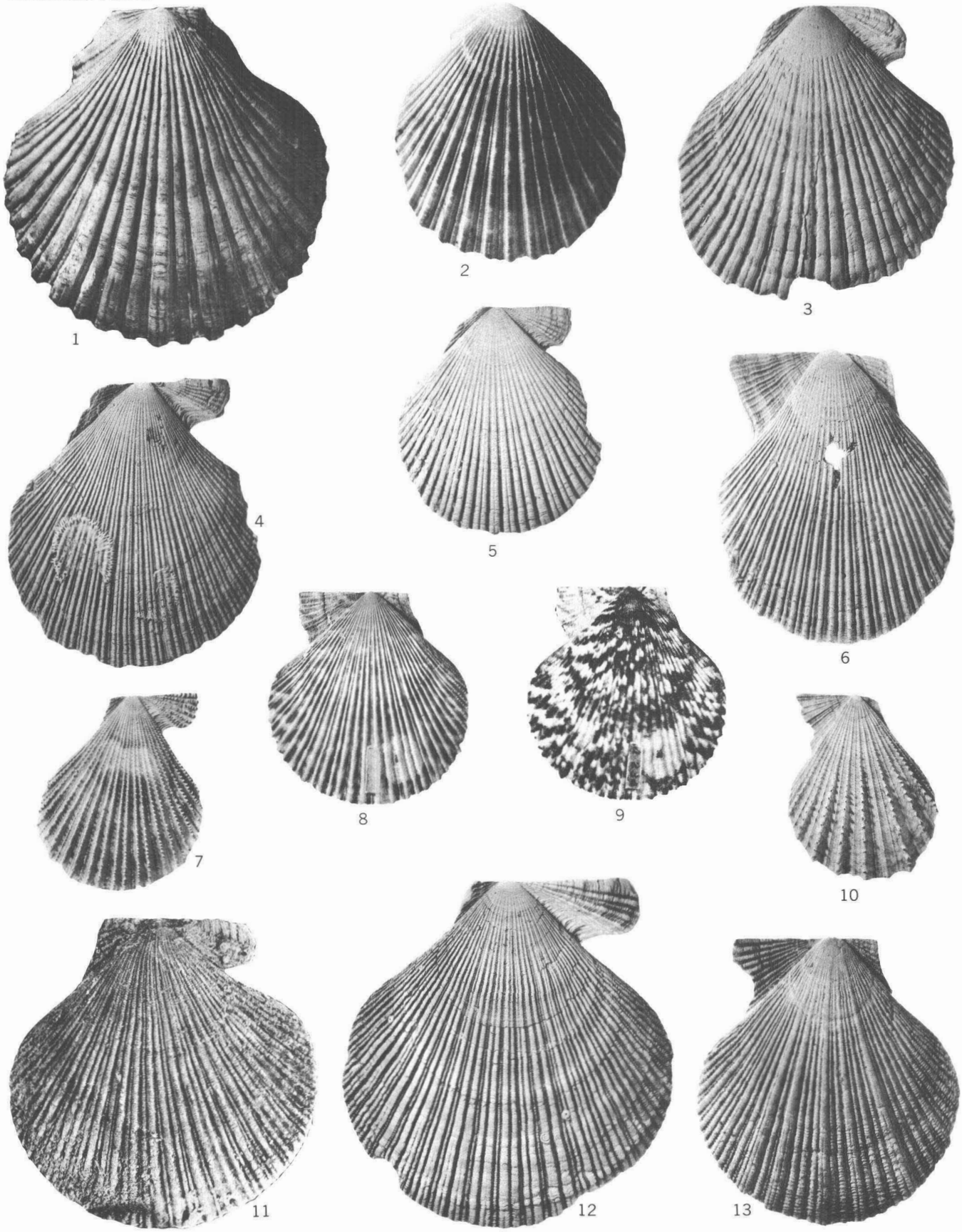
5. *Chlamys* (*Chlamys*) *rubida jordani* (Arnold) (p. 22).
Figured specimen (USNM 644946), × 1½. Santa Barbara Formation (horizon upper Plicoene), Santa Barbara County, Calif., USGS M1918.

7, 10. *Chlamys* (*"Chlamys"*) *hastata* (Sowerby) (p. 14).
Figured specimens. Santa Barbara Formation (horizon uppermost Pliocene), Santa Barbara County, Calif., USGS M1717.
7. Right valve (USNM 644891).
10. Left valve (USNM 644892), × 1½.

8, 9. *Chlamys* (*Chlamys*) *rubida hindsii* (Carpenter) (p. 23).
Figured specimen (USNM 637744). Recent, Excursion Inlet, southeastern Alaska, USGS M234.
8. Left valve, coated with ammonium chloride.
9. Same specimen, uncoated to show color markings.

11. *Chlamys* (*Chlamys*) *picoensis kinoshitai* Kubota (p. 29).
Holotype (in collections of Hokkaido Fish Experiment Station), right valve. Recent, Araito Island, northern Kurile Islands.

12, 13. *Chlamys* (*Chlamys*) *islandica* (Müller) subsp.? (p. 34).
Figured specimens. Recent, Tjörnes, northern Iceland, USGS M2464.
12. Right valve (USNM 637761).
13. Left valve (USNM 637762).



PECTINIDS FROM ST. LAWRENCE ISLAND, SOUTHEASTERN ALASKA (ALASKA),? BERING SEA CALIFORNIA, KURILE ISLANDS, ICELAND, NETHERLANDS

PLATE 25

[All figures × 1]

FIGURES 1–3. *Chlamys* (*"Chlamys"*) *tjornesensis* MacNeil, n. sp. (p. 16).

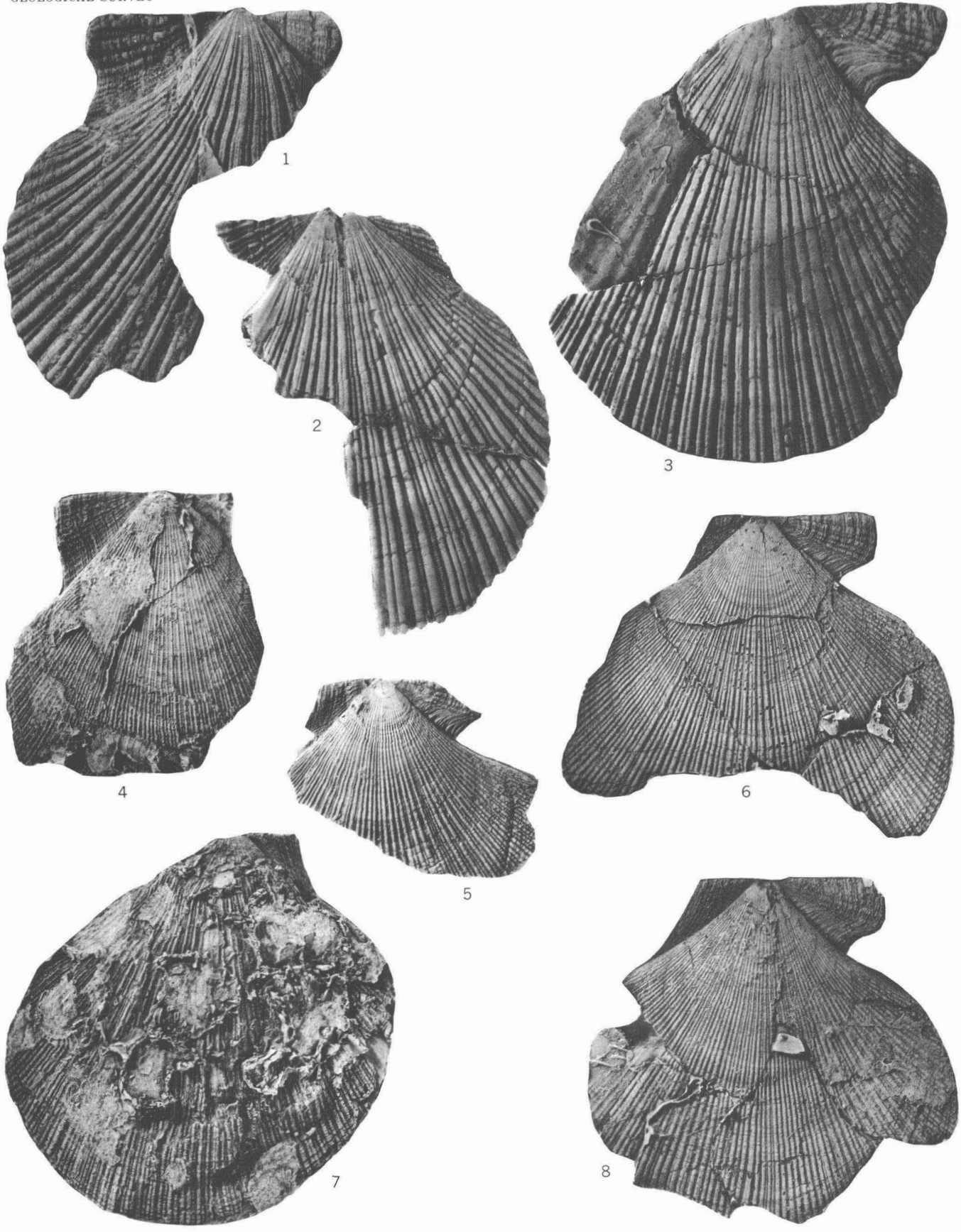
Tjörnes beds near Hallbjarnarstadhaá, northern Iceland.

1. Figured specimen (USNM 644904), incomplete left valve, rubber cast. *Serripes groenlandicus* zone (early Pleistocene), USGS M2155.
2. Paratype (USNM 644903), incomplete left valve. Upper part of *Mactra* zone (late Pliocene), USGS M2203.
3. Holotype (USNM 644902), incomplete right valve. Upper part of *Mactra* zone (late Pliocene), USGS M2203.

4–8. *Chlamys* (*"Chlamys"*) *breidavikensis* MacNeil, n. sp. (p. 16).

Tjörnes beds near Breidhavik, northern Iceland. Base of highest bed in Breidhavik section, USGS M2153.

4. Paratype (USNM 644898), incomplete left valve, rubber cast.
5. Figured specimen (USNM 644899), incomplete right valve.
6. Holotype (USNM 644897), incomplete right valve, rubber cast.
7. Figured specimen (USNM 644900), incomplete left valve, rubber cast.
8. Figured specimen (USNM 644901), incomplete right valve, rubber cast.



PECTINIDS FROM ICELAND