The North Pacific Miocene Record of *Mytilus* (*Plicatomytilus*), a New Subgenus of Bivalvia

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THE NORTH PACIFIC MIOCENE RECORD OF *MYTILUS (PLICATOMYTILUS)*, A NEW SUBGENUS OF BIVALVIA

By RICHARD C. ALLISON[1] and WARREN O. ADDICOTT[2]

ABSTRACT

A new subgenus of large plicate fossil mussels of the North Pacific, *Mytilus* (*Plicatomytilus*) n. subgen., includes three distinct species, *Mytilus* (*P.*) *middendorffi* Grewingk, 1850, *Mytilus* (*P.*) *gratacapi* n. sp., and *Mytilus* (*P.*) n. sp. This extinct subgenus ranged from central California to western Kamchatka during the Miocene.

Plicatomytilus is distinguished by strong plications of the shell which deflect the plane of commissure and by the foot retractor muscle scar which is separated from the posterior byssal retractor and posterior adductor muscle scar.

Mytilus middendorffi occurs in provincial middle Miocene deposits of (1) the Narrow Cape Formation, Kodiak Island, Alaska, (2) the upper part of the Astoria Formation, Tillamook County, Oreg., (3) an unnamed formation at Coos Bay, Oreg., (4) the lower (Miocene) part of Diller's (1903) Empire Formation near Cape Blanco, Oreg., (5) the Sobrante Sandstone near Castro Valley, Calif., (6) the Oursan Sandstone, Alameda County, Calif., (7) the Temblor Formation of Crittenden (1951), Santa Clara County, Calif., (8) the Sobrante Sandstone, Santa Clara County, Calif., (9) the Temblor Formation of Griswold Hills and the Vallecitos, San Benito County, Calif., and (10) the lower Temblor Formation, *Patinopecten* zone, Kings County, Calif. *Mytilus gratacapi* occurs on the Alaska Peninsula and at Unga Island, Alaska, in provincial middle(?) and late Miocene deposits of the upper part of the Unga Conglomerate Member of the Bear Lake Formation and upward into the overlying middle part of the Bear Lake Formation.

These two species have been lumped under *Mytilus middendorffi* Grewingk, but they do not co-occur. *Mytilus middendorffi* ranges throughout the "Temblor" Stage and from the upper part of the Saucesian Stage to the Luisian Stage of the microfaunal sequence. Much, if not all, of the range zone of *Mytilus gratacapi* seems to be of late Miocene age. The standard correlation of the Narrow Cape Formation with the Unga Conglomerate Member ("*Mytilus middendorffi* zone" of MacNeil and others) therefore is probably incorrect.

Mytilus (*Plicatomytilus*) n. sp. occurs in the middle and late Miocene Kakert and Etolon suites of the "Kavran Series" in western Kamchatka, U.S.S.R. Both *Mytilus* (*P.*) *gratacapi* and *Mytilus* (*P.*) n. sp. appear to have evolved from *Mytilus middendorffi* Grewingk.

The heavy plicate shell of *Plicatomytilus* was probably well adapted to life in high-energy environments in the shallow part of the inner sublittoral zone. *Mytilus gratacapi* may have been especially well adapted to heavy wave surge and surf conditions.

Another distinctive mytilid, *Mytilus* (subgenus?) n. sp., bearing two folds of the shell along the posterodorsal margin, occurs in the early Miocene Pyramid Hill Sand Member of the Jewett Sand, Kern River area, Calif., as well as in the early Miocene Clallam Formation of Washington, and the early middle Miocene Kuluven suite of western Kamchatka, U.S.S.R. This previously unrecognized taxon is not, however, referable to *Plicatomytilus*.

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INTRODUCTION

The existence of moderately large, heavy-shelled plicate mussels in the Tertiary beds of Kodiak and Unga Islands, Alaska, has been recognized since 1850 when Grewingk described *Mytilus middendorffi*. Following Grewingk (1850), many authors (Dall and Harris, 1892; Dall, 1896, 1904; Gratacap, 1912; Grant and Gale, 1931; Slodkevich [=Slodkewitsch], 1938; Hall, 1958; Burk, 1965; Addicott, 1967; and MacNeil, 1967) have repeated Grewingk's original records, or they themselves have assigned these plicate mytilids from Kodiak and many localities on the Alaska Peninsula and Unga to a single species, *M. middendorffi*. MacNeil, Wolfe, Miller, and Hopkins (1961) have indicated the correlation of Miocene strata on Kodiak Island, Unga Island, and the Alaska Peninsula that they assign to their "*Mytilus middendorffi* zone."

Recently, both of us have realized independently that the plicate mytilids that occur on the Alaska Peninsula and Unga Island in the Bear Lake Formation are in fact a distinctly different new species, and that this new species and *Mytilus middendorffi* belong to a new subgenus of *Mytilus* Linné. This paper therefore: (1) describes the new subgenus *Plicatomytilus*, (2) describes the new species *Mytilus* (*Plicatomytilus*) *gratacapi* from the Bear Lake Formation, (3) reviews the stratigraphic and paleozoogeographic distributions of *M.* (*P.*) *middendorffi* Grewingk and *M.* (*P.*) *gratacapi* n. sp., and (4) reviews the reported occurrences of *M.* cf. *middendorffi* [=*Mytilus* (*Plicatomytilus*) n. sp. of this paper] in Kamchatka.

Addicott is primarily responsible for the sections on chronologic and zoogeographic significance, and Allison is primarily responsible for the systematic sections of the paper. All the fossils, those illustrated and the type specimens, have been placed on deposit in the U.S. National Museum. The fossils were photographed by Kenji Sakamoto. We wish to thank Ellen J. Moore and

J. Wyatt Durham for their critical reviews of the manuscript.

Phylum Mollusca
Class Bivalvia
Subclass Pteriomorpha
Order Mytiloida
Superfamily Mytilacea
Family Mytilidae
Subfamily Mytilinae

Genus Mytilus Linné, 1758

Mytilus Linné, 1758, Systema Naturae, ed. 10, p. 704.

Type.—By subsequent designation (Gray, 1847), *Mytilus edulis* Linné, 1758.

Subgenus Plicatomytilus n. subgen.

Type.—*Mytilus middendorffi* Grewingk, 1850.

Description.—Shell moderate to large, heavy, mytiliform; beaks terminal; lunule grooved and sometimes incurved, forms two large teeth and several smaller ones; margins smooth; shell surface smooth, marked only by concentric growth lines and irregular undulations of growth; shell strongly plicate toward posterior and posterior ventral margin with two or three major plicae that strongly fold the plane of commissure; posterior dorsal area with or without irregular seminodulose divaricate branches of main posterior dorsal plica, little affecting plane of commissure; margin often alate at change in slope between anterior and posterior dorsal margins; resilial ridge compact; anterior adductor long, thin, and deeply sunken into shell, primarily on anterior ventral margin; posterior adductor and posterior byssal retractor continuous, may be poorly defined on shell; posterior byssal retractor usually narrow, continues to thin line near mid-dorsal break in margin slope where it occasionally is more deeply incised; foot retractor not continuous with posterior byssal retractor but placed inside pallial line and posterior byssal retractor at or near change in slope of dorsal margin; foot retractor large and elongate, but not usually deeply impressed into shell (fig. 1*A*); anterior byssal retractor small, divided into two or possibly three well-separated circular points of attachment on dorsal slope of umbo well above resilial ridge.

Discussion.—*Plicatomytilus* n. subgen. differs from all other mytilid genera and subgenera in possessing strong plications that clearly deflect the plane of commissure and in possessing a distinct foot retractor scar separated from the posterior byssal retractor and posterior adductor muscle scar (fig. 1*A*). The anterior byssal retractor is divided into two small circular scars, and the anterior adductor scar is narrow and deep. The shell margins of *Plicatomytilus* are noncrenulate, and the resilial ridge lacks pits (compact condition).

Grant and Gale (1931, p. 246) applied the subgeneric name *Mytiloconcha* Conrad, 1862, to several west coast species including *Mytilus middendorffi* because of their "peculiar heavy terminal hinge." Soot-Ryen (1955, p. 29) showed, however, that *Mytiloconcha* Conrad, 1862, is a junior subjective synonym of *Perna* Retzius, 1788. *Perna* Retzius differs from *Plicatomytilus* in possessing a pitted resilial ridge, in lacking an anterior adductor muscle, and in having a single elongate anterior byssal retractor scar. *Perna* does, however, have the foot retractor muscle placed anteriorly, separate from the posterior byssal retractor as in *Plicatomytilus*.

Mytilus s.s. (fig. 1*B*) differs from *Plicatomytilus* in possessing a pitted resilial ridge, in having an elongate anterior byssal retractor muscle scar or scars, and in having the posterior retractor muscles coalescent. The anterior adductor of *Plicatomytilus* is generally similar to that of the type species of *Mytilus, M. edulis* Linné, 1758, but may be longer and narrower.

Crenomytilus Soot-Ryen, 1955, differs from *Plicatomytilus* in possessing crenulate shell margins, in having an obliquely striated shell surface, in having a larger, more circular anterior adductor muscle scar, in lacking the double anterior byssal retractor scars of *Plicatomytilus*, and in having the posterior retractor muscles coalescent without a separate foot retractor scar.

Semimytilus Soot-Ryen, 1955, differs from *Plicatomytilus* in being edentate, in having a small, circular anterior adductor muscle scar, and in lacking the separated foot retractor muscle scar of *Plicatomytilus*. However, *Semimytilus* does possess a split anterior byssal retractor muscle scar, although, unlike *Plicatomytilus*, both halves of the scar are elongate.

Choromytilus Soot-Ryen, 1952, differs from *Plicatomytilus* in having the posterior byssal and foot retractor muscle scars continuous, although sometimes only narrowly so, and in having the anterior byssal retractor entire and not split as in *Plicatomytilus*. The anterior byssal retractor of *Choromytilus* is stronger and more posteriorly placed than in *Plicatomytilus*. *Choromytilus* possesses only one central tooth formed from the lunule, has "punctae" on the inside ventral half of the shell, and lacks the anterior adductor in large adult specimens although it is present in the young. The resilial ridge is compact as in *Plicatomytilus*.

Ischadium Jukes-Brown, 1905, possesses a radial surface sculpture with crenulated margins, lacks an anterior adductor, has the posterior foot and byssal retractors broadly united with the posterior adductor, and has a small, single muscle scar of the anterior byssal retractor.

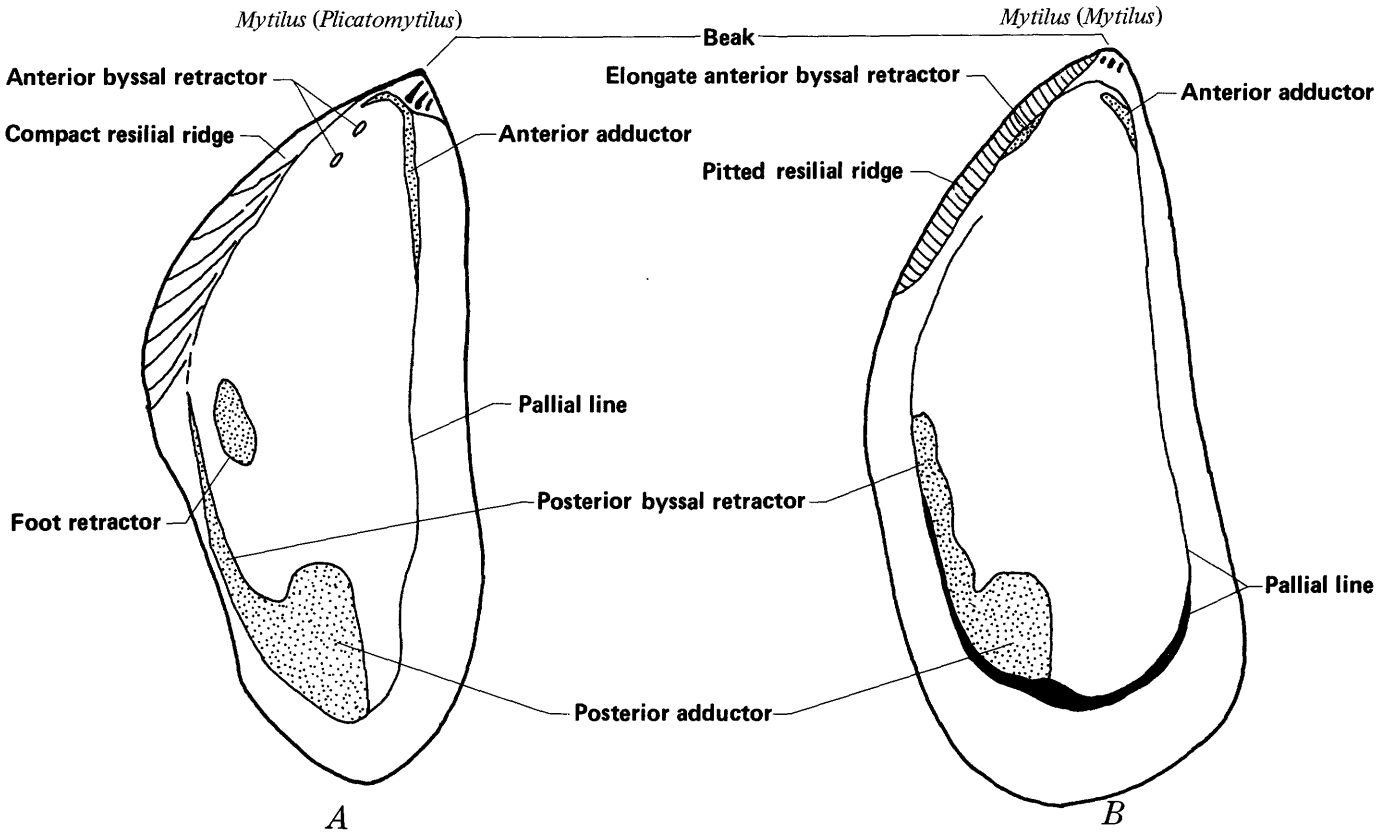

FIGURE 1.—Comparison of muscle scars of *Mytilus (Plicatomytilus)* n. subgen. and *Mytilus (Mytilus)*. *A*, Composite sketch of right valve of *Mytilu (Plicatomytilus)*. *B*, Sketch of right valve of *Mytilus (Mytilus) edulis* Linné, 1758. Four small paired scars, all beneath margin of shell and not directly visible in this view, mark earlier byssal retractor attachment and extend anteriorly to tip of beak. Specimen from Whale Island (Univ. Alaska loc. A–653), Katalla area, Alaska. Recent. University of Alaska figured specimen UA 2433. Variation in details of these scars is readily apparent when several individuals are examined.

Aulacomya Mörch, 1853, usually possesses radial surface sculpture, has only one tooth formed from the fold of the lunule, has the foot retractor coalescent with the posterior adductor, has an elongate single muscle scar of the anterior byssal retractor, and has the anterior adductor obsolete in larger individuals.

Hormomya Mörch, 1853, differs conspicuously from *Plicatomytilus* in having coarse radial sculpture dorsally and fine radial sculpture with unilaterally bifurcating ribs ventrally, in having crenulated margins, in having the foot retractor coalescent with the posterior byssal retractor and posterior adductor, and in having a single strong umbonal keel. *Hormomya* does, however, possess four or five teeth, of which the anterior are stronger, somewhat like *Plicatomytilus*.

Three North Pacific Miocene species, *M. middendorffi, M. gratacapi* n. sp., and a new species from the Kakert and Etolon suites of the "Kavran Series" of western Kamchatka are referable to *Plicatomytilus*. The subgenus apparently ranged from central California northward to the Alaska Peninsula, Kodiak Island, and westward to Kamchatka.

Geologic range.—Middle to late Miocene.

Mytilus (Plicatomytilus) middendorffi Grewingk, 1850

Plate 1, figures 1–10; plate 3, figures 2, 4, 6

1850. *Mytilus middendorffi* Grewingk, Verhandlungen der Russischkaiserlichen Mineralogischen Gesselschaft zu St. Petersburg, Jahrgang 1848 and 1849, no. 6, p. 167, 360–361, pl. 7, figs. 3a–c; reprinted 1850, p. 94, 287–288, pl. 7, figs. 3a–c; not *M. middendorffi*, Unga, p. 171 and 361; reprinted 1850, p. 98 and 288 [=*M. gratacapi* n. sp.].

1871. *Modiola (Mytilus) Dufrenoyi* d'Orbigny. Eichwald, E., Geog.-palaeon. bemerk. über die Halbinsel Mangischlak und die Aleutischen Inseln, p. 128, St. Peterburg [incorrectly synonymizes *M. middendorffi* with a Cretaceous species from France]; Kodiak; not Unga [=*M. gratacapi* n. sp.]; not *M. dufrenoyi* d'Orbigny, France.

1892. *Mytilus middendorffi* Grewingk. Dall, W. H., and Harris, G. D., Correlation Papers, Neogene: U.S. Geol. Survey Bull. 84, p. 253, Kodiak; not *M. middendorffi*, Unga [=*M. gratacapi* n. sp.].

1896. *Mytilus middendorffi* Grewingk. Dall, W. H., U.S. Geol. Survey 17th Ann. Rept., Pt. I, p. 844, Kodiak; not *M. middendorffi*, Unga [=*M. gratacapi* n. sp.].

1904. *Mytilus middendorffi* Grewingk. Dall, W. H., Neozoic invertebrate fossils, a report on collections made by the expedition, *in* Harriman Alaska Expedition, v. 4 (Geology and Paleontology), p. 113, Kodiak; not *M. middendorffi*, Unga [=*M. gratacapi* n. sp.], New York, Doubleday, Page and Co. (Reprinted by Smithsonian Institution, 1910).

1912. *Mytilus middendorffi* Grewingk. Gratacap, L. P., Am. Mus. Nat. History Bull., v. 31, art. VI, p. 69–70, pl. VII, figs. 4–6, Kodiak; not *M. middendorffi*, Unga, pl. VII, figs. 1–3 [=*M. gratacapi* n. sp.].

1913. *Mytilus middendorffi* Grewingk. Arnold, Ralph, and Hannibal, Harold, Am. Philos. Soc. Proc., v. 52, p. 590.

1925. *Mytilus middendorffi* Gmelin. Hertlein, L. G., and Crickmay, C. H., Am. Philos. Soc. Proc., v. 66, no. 2, p. 266, 267.

1931. *Mytilus middendorffi* Grewingk. Grant, U.S., IV, and Gale, H. R., San Diego Soc. Nat. History Mem., v. 1, p. 247, Kodiak; not *M. middendorffi*, Unga [=*M. gratacapi* n. sp.].

1934. Not *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., On the stratigraphy of the Tertiary deposits of the western coast of Kamchatka: Academie des Sciences de L'Union des Republiques Sovietiques Socialistes (Akademiya Nauk), C. R. (Dokl.), T. 3, no. 1, p. 60 and 62 [=*M.* (*Plicatomytilus*) n. sp. of this report].

1936. Not *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., The stratigraphy and fauna of the Tertiary deposits of the western coast of Kamchatka: Trudy neftyanogo geologo razvedochnogo instituta, Seriya A, Vypusk 79, p. 125–126, pl. XV, figs. 5, 5a, Leningrad, Moscow [=*Mytilus* (*Plicatomytilus*) n. sp. of this report].

1937. *Mytilus middendorffi* Grewingk. Woodring *in* Capps, S. R., U.S. Geol. Survey Bull. 880–C, p. 155.

1938. *Mytilus middendorffi* Grewingk. Slodkevich, V. S., Paleontology of U.S.S.R., v. 10, pt. 3, fasc. 19, Tertiary Pelecypoda from the Far East, Pt. II, p. 231, pl. L, figs. 2, 2a, re-illustration of Grewingk's figures of *M. middendorffi* s.s.; Kodiak; not *M. middendorffi*, Unga, p. 231 [=*M. gratacapi* n. sp.

1938. Not *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., Paleontology of U.S.S.R., v. 10, pt. 3, fasc. 18 and 19, Tertiary Pelecypoda from the Far East; fasc. 18, p. 237, 238; fasc. 19, p. 119, 231, pl. L, figs. 3, 3a [=*Mytilus* (*Plicatomytilus*) n. sp. of this report].

1943. *Mytilus midendorfi* Grewingk. Gilbert, C. M., Am. Assoc. Petroleum Geologists Bull., v. 27 (5), p. 645.

1946. *Mytilus middendorffi* Grewingk. Stewart, Ralph, U.S. Geol. Survey Prof. Paper 205–C, p. 100, 102.

1946. *Mytilus* cf. *M. middendorffi* Grewingk. Stewart, Ralph, U.S. Geol. Survey Prof. Paper 205—C, table 2, loc. 14393; ? loc. 14385.

1953. *Mytilus middendorffi* Grewingk. Durham, J. W., Geol. Soc. America Bull., v. 64, no. 12, pt. 2, p. 1504–1505.

1958. *Mytilus middendorffi* Grewingk. Hall, C. A., California Univ. Pubs. Geol. Sci., v. 34, no. 1, p. 49, 52, pl. 5, fig. 6, Kodiak and California; not *M. middendorffi*, Unga, p. 52 [=*M. gratacapi* n. sp.].

1963. *Mytilus* cf. *M. middendorffi* Grewingk. Moore, E. J., U.S. Geol. Survey Prof. Paper 419, p. 62 [MacNeil's report from the "Oligocene of Alaska" seems invalid].

1963. Not *Modiolus* cf. *middendorffi* Grewingk. Il'ina, A. P., Mollusks of the Neogene of Kamchatka, pl. XXXVI, fig. 2 (same individual illustrated by Slodkevich, 1936, pl. XV, figs. 5, 5a and 1938, pl. L, figs. 3, 3a) [=*M.* (*Plicatomytilus*) n. sp. of this report].

?1965. *Mytilus middendorffi* Grewingk. Addicott, W. O., U.S. Geol. Survey Prof. Paper 525–C, in part, p. C108 [field identification] not p. C104 [=*Mytilus* (subgenus?) n. sp.].

1965. *Mytilus middendorffi* Grewingk. MacNeil, F. S., U.S. Geol. Survey Prof. Paper 483–G, p. G36.

1965. *Mytilus middendorffi* Grewingk. Burk, C. A., Geol. Soc. America Mem. 99, p. 93 and 104 (Kodiak Island); not p. 91, 92, 93, 116, 213, 214, 215, 228 (Alaska Peninsula) [=*M. gratacapi* n. sp.].

1967. *Mytilus middendorffi* Grewingk. Addicott, W. O., U.S. Geol. Survey Prof. Paper 593–D, p. D7, in part, not Kern River area, California [=*Mytilus* (subgenus?) n. sp.]; not Alaska Peninsula [=*M. gratacapi* n. sp.].

1967. Not *Mytilus middendorffi* Grewingk. MacNeil, F. S., U.S. Geol. Survey Prof. Paper 553, p. 13 [=*M. gratacapi* n. sp.].

?1969. *Mytilus* cf. *middendorffi* Grewingk. Pronina, I. G., Middle Miocene mollusks from deposits in the Kronotskiy region of the eastern shoreline of Kamchatka, p. 254, pl. III, fig. 3.

1972. *Mytilus middendorffi* Grewingk. Addicott, W. O., Am. Assoc. Petroleum Geologists, Pacific Sec., 1972 Guidebook, Geology and oilfields, west side central San Joaquin Valley [Calif.], p. 67.

1972. Not *Mytilus middendorffi* Grewingk. Gladenkov, Y. B., Petrov, O. M., and Sinel'nikova, V. N., Pliocene-Pleistocene boundary in the northwest Pacific *in* International Colloquium on the boundary between Neogene and Quaternary, coll. papers III, Moscow, p. 58. [Incorrect synonymy of *Mytilus middendorffi* Grewingk with *Mytilus tichanovitchi* Makiyama, 1934.]

1973. *Mytilus middendorffi* Grewingk. Allison, R. C., and Addicott, W. O., Geol. Soc. America, Abstracts with programs, v. 5, no. 1, p. 2–3.

1974. *Mytilus middendorffi* Grewingk. Addicott, W. O., Veliger, v. 16, no. 4, p. 354–358, figs. 1 and 2.

Mytilus middendorffi is characterized by the broad plications of the shell that strongly deflect the plane of commissure. The sulcus of one valve meets the fold of the opposite valve producing two or three undulatory deflections of the plane of commissure posteriorly. The species may reach a fairly large size (largest specimen at hand is about 102 mm long) and may become strongly inflated (one articulated individual measuring about 95 mm long has a height of about 51 mm). The shell is always elongate, usually with a gentle arch in the longitudinal profile in contrast to *M. gratacapi* n. sp. which is usually strongly contorted along the longitudinal axis. The dorsal margin is frequently alate at the break in slope between the anterior and posterior dorsal margins. The shell is typically mytiliform but readily distinguished by the several strong plications. With the exception of *M. gratacapi* n. sp. and the western Kamchatka Kakert and Etolon suite taxon, we know of no other North Pacific fossil mytilid with which *M. middendorffi* may be easily confused.

As might be expected, various shells of the species display individual variation. Most of the shells are moderately inflated, as is typical in *Mytilus*, although a few are greatly inflated. A few specimens remain compressed even in the large adult stage. The amount of alation along the dorsal margin is variable, but it does not appear to be directly related to the size of the individual shell. A few individuals have very modest alar development, many have a moderate alation at the break in slope, and about an equal number have rather pronounced alation. The shape of the dorsal margin of

the shell above the alate flange varies considerably from vertical or even overhanging to gently merging with the dorsal alation. This variation seems to be governed both by the degree of inflation of the shell and the amount of alation. The apical angle of the shell varies to a moderate extent; it becomes larger with more pronounced alation and more pronounced arching of the anterior-posterior axis of the shell. In general, this anterior-posterior arch of the shell is fairly constant, as defined by the umbonal ridge along the dorsal edge of the shell; the latter culminates in the main posterior dorsal flexure of the shell, which usually terminates at the posteriormost point on the shell margin. Some individuals, however, display a sharper flexure in this umbonal ridge above the dorsal alation than do others. The ventral margin may be either perfectly straight or very gently concave but it is never prominently arched.

Perhaps the greatest variation is in the rib or fold development. Two main ribs or folds appear when the shell has reached 35 to 45 mm in length; the anterior-ventral is the more prominent of the two. Several individuals, however, possess a weaker third fold placed still more anteroventrally. This anterior fold is faintly visible on many individuals; rarely it becomes strengthened to produce a three-ribbed variant (pl. 1, figs. 3 and 9) in which it weakly deflects the plane of commissure. Three-ribbed variants occur in the Miocene of California at USGS localities 5765 and M3614, but they are associated with other typical individuals and apparently are nothing more than individual variants of *M. middendorffi*.

The strength of the main folds and sinuses is also variable and may affect the amount of deflection in the plane of commissure, but the plications never approach obsolescence. The main anteroventral fold is normally strongly flexed ventrally as it approaches the posterior end of the shell. The ventral curvature of this rib, which is variable, seems to be related to the degree of anterior-posterior arching of the shell. The main anterior-ventral rib never bends through more than about 60 degrees of rotation, whereas the same rib may be bent through a 90-degree turn in *Mytilus gratacapi* n. sp.

In addition to the main folds, smaller irregular folds or ribs that branch off of the main dorsal fold may occur along the posterior dorsal area. This posterior dorsal area particularly displays marked variation. Most well-preserved individuals have two or three poorly defined irregular nodulose branches in this area. The posteriormost of these dorsal secondary ribs, usually the most clearly defined, branches off in a dorsal direction near the terminus of the main rib. These secondary dorsal ribs do not seriously deflect the plane of commissure, although they may cause mild undulations of it. A few individuals have only one secondary rib branching dorsally near the terminus of the main dorsal rib. On several individuals the main dorsal rib is crowded against the dorsal margin, and the secondary terminal rib is directed ventrally off of it into the sinus between the two main folds. A few individuals have little or no development of secondary ribs along the posterior dorsal margin.

Figured specimens.—USNM 647057, 647058, 647059, 647060, 647061, 647062, 647063, 647064, 647065, 647076.

Discussion.—*Mytilus middendorffi* was described by Grewingk in 1850 from collections of Wosnessensky, Fischer, and Kupreanof from the Alaska Peninsula, Kodiak Island, and the Aleutian Islands. Grewingk (1850, p. 167, 171, 361; reprinted 1850, p. 94, 98, 288) reported *M. middendorffi* from Kodiak Island (Igatskoj Bay = Ugak Bay, and Tonky Cape = Narrow Cape) and Unga Island at "Sacharowschen" Bay (= Zachary Bay). Unfortunately, Grewingk did not designate the type locality of the species, and his type specimens have not been found (see MacNeil, 1965, p. G12). Were it not for the fact that Grewingk's original description and illustrations of *M. middendorffi* are unmistakably clear, there might be some difficulty in recognition of his species, for we consider the Unga *Mytilus* to be a distinct species, though closely related to the one found at Narrow Cape. Grewingk's illustrations (1850, pl. 7, figs. 3a–c) leave no doubt that Kodiak Island, probably at Narrow Cape, is the type locality and that *M. middendorffi* properly applies to the abundant and characteristic *Mytilus* found there in the Miocene Narrow Cape Formation. The species from the Unga Conglomerate Member of the Bear Lake Formation, *Mytilus gratacapi* n. sp., we have named in honor of L. P. Gratacap who first illustrated it in his 1912 paper "An unusual specimen of *Mytilus middendorffi* Grewingk, from Alaska" (hills above Cape Seniavin). The morphologic differences between *M. middendorffi* and *M. gratacapi* are discussed under *M. gratacapi*.

The first valid report of *M. middendorffi* outside the type region in Alaska was by Arnold and Hannibal (1913, p. 590) from localities in the basal (= middle Miocene) sandstone of the Empire Formation near Cape Blanco, Oreg. Since 1913 a number of reports have been published that extend the known geographic range of *M. middendorffi* from central California to Alaska and doubtfully to Kamchatka (fig. 2). However, the species remains little known, perhaps owing to the paucity of illustrations of it in easily accessible literature. Grewingk's original figures were redrawn by Gratacap (1912); he also included three illustrations of the long-confused species here named *M. gratacapi* from the Unga Conglomerate Member. Slodkevich (1938) repro-

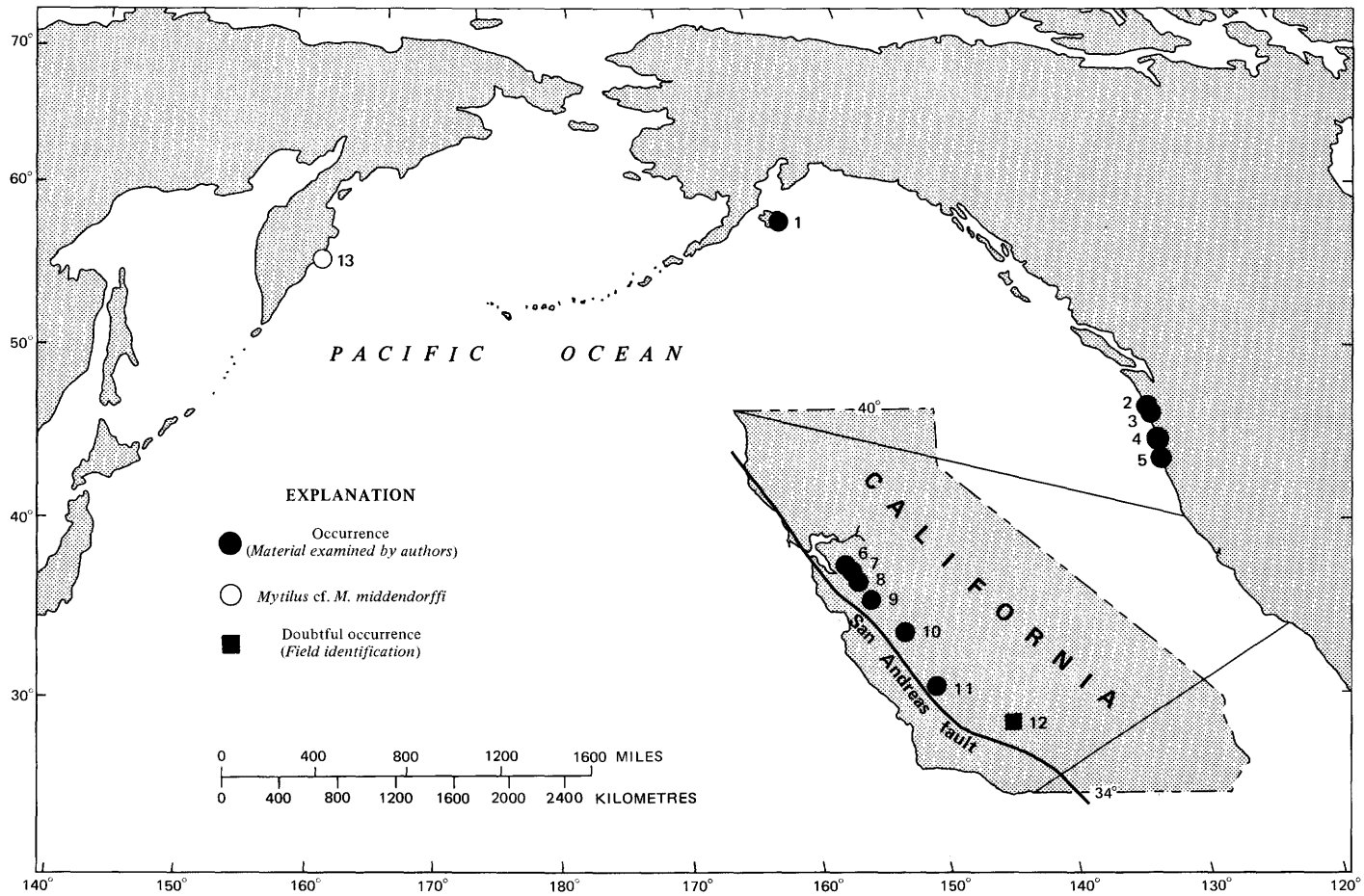

FIGURE 2.—Middle Miocene distribution of *Mytilus middendorffi* Grewingk. 1, Kodiak Island, Alaska. 2, Svenson quadrangle, Clatsop County, Oreg. 3, Cannon Beach quadrangle, Tillamook County, Oreg. 4, Coos Bay, Oreg. 5, Cape Blanco, Oreg. 6, Eden Canyon, near Castro Valley, Calif. 7, Sunol Valley Regional Park, Alameda County, Calif. 8, Milpitas-Calaveras Road, Santa Clara County, Calif. 9, Henry W. Coe State Park, Santa Clara County, Calif. 10, Griswold Hills and the Vallecitos, San Benito County, Calif. 11, Reef Ridge, Kings County, Calif. 12, Tejon Hills, Kern County, Calif. 13, Kronotskiy area, eastern Kamchatka, U.S.S.R. (Pronina, 1969). Records of a new *Plicatomytilus* species from probable Miocene rocks on west coast of Kamchatka (Slodkevich, 1934, 1936, 1938; Il'ina, 1963) are not shown.

duced Grewingk's original figures and illustrated another taxon now referable to *Plicatomytilus* that we consider to be a new species from the "Kavran Suite" of the west coast of Kamchatka (Slodkevich, 1936, 1938). More recently, Hall (1958) illustrated individuals of *M. middendorffi* from California, and Il'ina (1963) reproduced Slodkevich's 1936 and 1938 illustration of the new species from western Kamchatka. Pronina (1969) illustrated a poorly preserved internal mold from the "Ratitin suite, middle Miocene" of eastern Kamchatka that may be referable to *Plicatomytilus* but that cannot be adequately compared to *M. middendorffi*.

Occurrence.—Narrow Cape Formation, Kodiak Island, Alaska (USGS Cenozoic loc. 13372, D227, M1735; University of Alaska loc. A–180, A–181, A–183, A–204, A–255, A–256, A–257, A–258, A–260, A–264, A–266, A–268, A–269, A–271, A–273, A–275, A–276, A–278; Stanford University loc. 43952, 43953); Astoria Formation of middle Miocene age, Clatsop County, Oreg. (USGS Cenozoic loc. M6382); Astoria Formation of middle Miocene age, Tillamook County, Oreg. (USGS Cenozoic loc. M5807); unnamed formation of middle Miocene age, Coos Bay, Oreg. (USGS Cenozoic loc. 18284); lower part of Diller's (1903) Empire Formation near Cape Blanco, Oreg. (USGS Cenozoic loc. 3334, 7901, M2142, M3637, M4126, M4129, M4130, M4132, M4135, M4136, M4687, M4690, M5737; University of Oregon loc. F–2011; University of California, Berkeley loc. A8711; Stanford University loc. NP23, NP26; California Academy of Sciences loc. CAS 17, CAS 19, CAS 22); Sobrante Sandstone, near Castro Valley, Calif. (University of California, Berkeley loc. B4162); Oursan Sandstone, Sunol Valley Regional Park, Alameda County, Calif. (Stanford University loc. 3248); Temblor Formation of Crittenden (1951), Milpitas-

Calaveras Road, Santa Clara County, Calif. (Stanford University loc. 2982); Sobrante Sandstone, Henry W. Coe State Park, Santa Clara County, Calif. (USGS Cenozoic loc. M4756, M5162); Temblor Formation, Griswold Hills, San Benito County, Calif. (USGS Cenozoic loc. 5765, 5766, M3614; Stanford University loc. 49046); Temblor Formation, Vallecitos, San Benito County, Calif. (Stanford University uncatalogued collection); lower part of the Temblor Formation, Reef Ridge, Kings County, Calif. (USGS Cenozoic loc. 14385, 14393).

Range.—Middle Miocene.

Doubtful occurrences.—A record of *Mytilus middendorffi* from middle Miocene strata exposed in the Tejon Hills area along the southeast margin of the San Joaquin basin, Calif. (Addicott, 1965, p. C108), was based upon a field identification that is considered doubtful. If this record is verified, this occurrence of *M. middendorffi* will be the most southerly along the Pacific coast.

Incorrect records of Mytilus middendorffi.—Records of *Mytilus middendorffi* from the Alaska Peninsula and Unga Island, Alaska (Grewingk, 1850; Dall, 1896, 1904; Gratacap, 1912; Grant and Gale, 1931; Slodkevich, 1938; Hall, 1958; MacNeil and others, 1961; Moore, 1963, p. 62; Burk, 1965; Addicott, 1967; MacNeil, 1967) are of the strongly arched, plicate species herein named *Mytilus gratacapi* n. sp. Many of these are secondary citations of Grewingk (1850) and Dall (1896, 1904).

Dall (1904, p. 113) commented that *Mytilus middendorffi* "is represented in the Pliocene of Oregon [southwestern Washington] by *Mytilus condoni* Dall which is somewhat similarly sculptured." The late Tertiary species from Washington was described by W. H. Dall in a letter to the editor of "Nautilus" printed under the title "Conchological Notes from Oregon" (Dall, 1890). The type locality of *M. condoni* was given as "marine Pliocene *** at [Shoalwater] Willapa Bay, Wash.," but the species was neither adequately described nor illustrated. Addicott (1974) collected a *Mytilus* from the north shore of Willapa Bay (USGS Cenozoic loc. M5219) that fits Dall's original description, and it is presumed to be topotypic material (pl. 3, fig. 10). We consider this *Mytilus* to be conspecific with the later named species *M. highoohiae* Mandra 1949, from the Pliocene of Humboldt County, Calif. It is not clear whether Dall (1904) intended to include *M. condoni* as a synonym of *M. middendorffi* or merely to indicate supraspecific relationship. Dall's meaning is not critical, however, because *M. condoni* is a slender species characterized by fine divaricate ribbing (pl. 3, fig. 10), and it is both specifically and subgenerically distinct from *M. middendorffi*.

Mytilus ficus Dall (1909, p. 113, pl. 9, figs. 1, 4), from the Empire Formation at Coos Bay, Oreg., has been treated as a possible synonym of *M. condoni* Dall (Grant and Gale, 1931). The Empire species, however, does not possess radial or bifurcating sculpture and is therefore clearly separable from both *M. condoni* and *M. middendorffi*.

A rather small (length 68 mm), plicate *Mytilus* (pl. 3, fig. 9) from the early Miocene Jewett Sand of the Kern River area, Calif., has been incorrectly identified as *M. middendorffi* (Addicott, 1965, p. C104; 1967, p. D7). This species has a pronounced dorsal alation and strongly inflated valves; its strong umbonal ridge extends from the beak to the posterior extremity, and a distinctive parallel ridge of secondary strength is located at the base of the dorsal alation. This Jewett Sand taxon differs from *M. middendorffi* in that the folds are not staggered on opposing valves. Consequently, the plane of commissure remains perfectly flat without any gape although the marginal outline of the shell protrudes slightly where the folds of the two valves meet (pl. 3, fig. 9).

We found that well-preserved specimens of this Jewett Sand species also occur in the lower Miocene Clallam Formation (Addicott, 1975) of the northern Olympic Peninsula, Wash. (USGS Cenozoic loc. M4051, M4679; Stanford University loc. NP87, 89, 160; Portland State University loc. PSU–A0008). The same species has also been illustrated by Il'ina (1963, pl. 10, figs. 1 and 6), under the name "*Mytilus ochotensis* Slodkewitsch." Il'ina's (1963) specimen came from beds of the Kuluven suite ("zone of *Thyasira disjuncta* var. *ochotica*") exposed along the seashore 4.35 km south of the mouth of the Polovinka River, western Kamchatka. Through the courtesy of Academician V. V. Menner and Dr. V. N. Sinel'nikova, both of the Geological Institute in Moscow, we have recently received a well-preserved specimen of this same taxon from the Kuluven suite of the Shainaga River area, western Kamchatka. We consider the Kamchatkan specimens to be conspecific with the specimens from the Clallam Formation and the Jewett Sand. This distinctive mytilid, *Mytilus* (subgenus?) n. sp., cannot, however, be assigned to *Mytilus ochotensis* Slodkevich, 1936, because the latter species lacks the characteristic pair of ribs or plications of the dorsal part of the shell. Gladenkov (1974) considered the Kuluven suite to be of early middle Miocene age.

Dr. Saburo Kanno of Tokyo University of Education has recently sent us specimens of *Mytilus tichanovitchi*, Makiyama, 1934 (Makiyama, 1934, p. 134–135, pl. IV, figs. 11 and 12; Uozumi, 1966, p. 129–130, pl. 9, figs. 2–4, 8), a similar species from the lower part of the Ashai Formation of Hokkaido Island, Japan, and Neogene strata in Sakhalin. This Japanese species, however, also lacks the paired ribs or plications of the dorsal area of

the shell that characterize the species from the Jewett Sand-Clallam Formation-Kuluven suite.

We conclude that this distinctive taxon from the Jewett Sand-Clallam Formation-Kuluven suite is as yet undescribed and that it is not referable to *Plicatomytilus*.

Reports of Mytilus middendorffi *in Kamchatka.*—Although *Plicatomytilus* is clearly recognizable in the deposits of the Kakert and Etolon suites of the "Kavran Series" of western Kamchatka, we are not aware of any Asian material that can be confidently assigned to *Mytilus middendorffi* sensu stricto. Slodkevich (1934, 1936, 1938) and Il'ina (1963) discussed and (or) illustrated this "Kavran Series" taxon that we consider to be specifically distinct from *M. middendorffi*. Further discussion of this taxon is included under *Mytilus* (*Plicatomytilus*) n. sp. of this paper.

Pronina (1969) reported *"Mytilus* cf. *middendorffi"* from the "Ratitin suite, middle Miocene" of the Kronotskiy area, eastern Kamchatka. She also summarized the distribution of *Mytilus middendorffi* as: Alaska (Miocene), Oregon (Pliocene) [presumably the middle Miocene occurrence in the lower part of the Empire Formation near Cape Blanco], western coast of Kamchatka, lower part of the Kavran Series (upper Miocene) [our *Mytilus* (*Plicatomytilus*) n. sp.]. Unfortunately, Pronina's (1969) illustration is of a poorly preserved internal mold that is inadequate for species determination.

Gladenkov, Petrov, and Sinel'nikova (1972) considered *Mytilus tichanovitchi* Makiyama, 1934, from the lower part of the Ashai Formation of Japan and the Neogene of Sakhalin and Kamchatka, to be synonymous with *Mytilus middendorffi* Grewingk. We believe *M. tichanovitchi* to be distinct, however, because this Japanese species lacks any convolution of the plane of commissure in association with folds of the shell (see Uozumi, 1966).

Mytilus (*Plicatomytilus*) therefore does occur in Kamchatka in rocks of probable middle to late Miocene age [see discussion of age of the "Kavran Series" taxon under *Mytilus* (*Plicatomytilus*) n. sp. of this report], but the presence of *Mytilus middendorffi* Grewingk there is yet to be demonstrated.

Age and correlation.—The biozone of *Mytilus middendorffi* is an important index to the provincial middle Miocene of the eastern North Pacific. Many of the occurrences of this species have been recognized only during the past 10–15 years, and a few are recorded here for the first time. Occurrences of this species in the California Coast Ranges and southwestern Oregon can be confidently assigned to the middle Miocene "Temblor" Stage of Weaver and others (1944) and, in some places, can be correlated with the provincial benthonic foraminiferal chronology. The high-latitude occurrence in the Narrow Cape Formation on the northeast coast of Kodiak Island, Alaska, is also of provincial middle Miocene age although correlation of the associated fauna with sequences in the conterminous United States is difficult.

Occurrences of *Mytilus middendorffi* in the Diablo Range of central California indicate that it ranges throughout the "Temblor" Stage and that its range includes the upper part of the Saucesian Stage as well as the Relizian and Luisian Stages of the microfaunal sequence of Kleinpell (1938). The earliest occurrence of *M. middendorffi* is in the lower part of the "Temblor" Stage at Reef Ridge (lat 35.9° N.) in Stewart's (1946) *Vertipecten* [*Patinopecten*] zone of the Temblor Formation. This part of the "Temblor" Stage can be defined, in central California, by the concurrent range zone of *Lyropecten miguelensis* and *Patinopecten propatulus*; and it is coeval with the upper part of the Saucesian foraminiferal stage (Addicott, 1972). The latest occurrences of *M. middendorffi* are farther north in the Diablo Range near San Jose, Calif. (lat 37.3° N.). In this area it occurs in the Sobrante and Oursan Sandstones which are assigned, respectively, to the middle Miocene Relizian and Luisian Stages of the foraminiferal chronology (Kleinpell, 1938).

Occurrences in southwestern Oregon near Cape Blanco and at Coos Bay are within the concurrent range zone of *Bruclarkia* and *Patinopecten* and, therefore, are referable to the "Temblor" Stage. There are also several stratigraphically restricted "Temblor" species such as *Crepidula rostralis* (Conrad), *Molopophorus matthewi* Etherington, *Nassarius arnoldi* (Anderson), and *Acila conradi* (Meek) associated with *M. middendorffi* in southwestern Oregon.

On Kodiak Island, Alaska, *Mytilus middendorffi* is associated with a large but poorly known fauna in the Narrow Cape Formation that is currently being studied by the authors. Preliminary analysis of this fauna suggests that it is coeval with the fauna of the Astoria Formation of Oregon and Washington, on the basis of specimens of *Anadara, Dosinia, Ficus,* and *Molopophorus* that appear to be conspecific with species whose range zones are restricted to the Astoria Formation.

Zoogeographically, *Mytilus middendorffi* has an unusually broad distributional pattern for a shallow-water Miocene mollusk (fig. 2) although many modern mytilids have an equally extensive, or even greater, latitudinal distribution (Soot-Ryen, 1955). Its known range during the middle Miocene was from the San Joaquin basin of central California (lat 36° N.) to the Gulf of Alaska (lat 58° N.); this range makes it an extremely useful species for stratigraphic correlation. If

verified, the doubtful occurrence in the middle Miocene of eastern Kamchatka (Pronina, 1969) would significantly extend its range westward across the North Pacific rim.

The *Plicatomytilus* species of western Kamchatka (Slodkevich, 1934, 1936, 1938; Il'ina, 1963) seems to be of middle to late Miocene age (Sinel'nikova and Drushchits, 1971; Gladenkov and others, 1972; Gladenkov, 1974) but it does not appear to be *Mytilus middendorffi*. These records confirm the presence of *Plicatomytilus* in Kamchatka without confirming the occurrence of *M. middendorffi* there. The absence of this species in most faunal assemblages of the middle Miocene Astoria Formation of the central and northern Oregon coast (Moore, 1963) can be explained by the fact that these assemblages represent relatively deep sublittoral environments from which the shallow-water genus *Mytilus* was excluded. Assemblages from the early Miocene Clallam Formation (Addicott, 1975) of northwestern Washington contain *Mytilus* (subgenus?) n. sp. (a taxon from the Jewett Sand-Clallam Formation-Kuluven suite); its presence suggests a generally shallower sublittoral environment, but to date, *Mytilus middendorffi* has not been recorded from the Clallam Formation. The absence of *M. middendorffi* from probable middle Miocene beds of the lower Yakataga Formation of the Gulf of Alaska (Kanno, 1971; Miller, 1971) may be due to the deeper water environment represented by many lower Yakataga faunules (Kanno, 1971, p. 21–24). Kanno (1971, p. 22) reported fragments of "*Mytilus* sp." from shallow-water faunules in the eastern part of the Yakataga Formation exposure belt, but to date *M. middendorffi* has not been recorded there.

Ecology.—Nothing is known directly of the ecological tolerances of *Plicatomytilus* inasmuch as the subgenus is extinct. Many specimens at hand seem to show some wear or abrasion of the juvenile part of the shell on the umbos, but the shell as a whole is often very well preserved even retaining parts of the heavy periostracum. It does not seem probable that *Plicatomytilus* lived in the intertidal zone where sand abrasion caused by wave surge and surf severely corrodes the umbonal area of living *Mytilus californianus* Conrad. *Mytilus* characteristically lives in extremely shallow water although it may live at depths down to 40 or 50 fathoms and has been dredged from as deep as 120 fathoms (Soot-Ryen, 1955, p. 105–110). Berry (1954) reported a maximum known depth of 48 fathoms for *M. californianus*, taken alive off the coast of Humboldt County, Calif. This individual was very large (228 mm by 89.5 mm by 69.2 mm) but quite thin shelled. These data suggest that a thin shell may be correlated with a deeper water habitat or conversely that *M. middendorffi*, with its heavy plicate shell, was well adapted to life in high-energy environments in the shallow part of the inner sublittoral zone.

Mytilus middendorffi has been found associated with a number of other shallow-water molluscan genera including *Acila, Anadara, Diplodonta, Glycymeris, Macoma, Siliqua, Solen, Spisula, Securella, Cancellaria, Crepidula, Olivella, Dosinia, Mya* (*Mya*), and *Pseudocardium* (see Arnold and Hannibal, 1913, p. 590–591; University of Alaska Kodiak Island Miocene collection). With the exception of *Acila, Macoma, Cancellaria,* and *Glycymeris*, which range downward into the upper bathyal zone, these genera range from intertidal or shallow subtidal depths to various depths between about 33 and 120 fathoms. The extinct genus *Pseudocardium* also possesses a very heavy shell that probably was adapted to the high-energy environments of the inner sublittoral zone.

Mytilus (Plicatomytilus) gratacapi n. sp.

Plate 2, figures 1, 3, 4, 6–10; plate 3, figures 1, 3, 5, 7, 8

1850. *Mytilus middendorffi* Grewingk. Verhandlungen der Russichkaiserlichen Mineralogischen Gesellschaft zu St. Petersburg, Jahrgang 1848 and 1849, No. 6, p. 171 and 361, Unga; reprinted 1850, p. 98 and 288; *not M. middendorffi*, Kodiak, p. 167, 360–361, pl. 7, figs. 3a–3c; reprinted 1850, p. 94 and 287–288, pl. 7, figs. 3a–3c.

1871. *Modiola* (*Mytilus*) *Dufrenoyi* d'Orbigny. Eichwald, E., Geog.-palaeon. bemerk. über die Halbinsel Mangischlak und die Aleutischen Inseln, p. 128, St. Petersburg [incorrectly synonymizes *M. middendorffi* with a Cretaceous species from France], Unga; *not* Kodiak [=*M. middendorffi* Grewingk]; not *M. dufrenoyi* d'Orbigny, France.

1892. *Mytilus middendorffi* Grewingk. Dall W. H., and Harris, G. D., Correlation Papers, Neogene: U.S. Geol. Survey Bull. 84, p. 253, Unga; *not M. middendorffi*, Kodiak.

1896. *Mytilus middendorffi* Grewingk. Dall, W. H., U.S. Geol. Survey 17th Ann. Rept., pt. I, p. 844, Unga; *not M. middendorffi*, Kodiak.

1904. *Mytilus middendorffi* Grewingk. Dall, W. H., Neozoic invertebrate fossils, a report on collections made by the expedition, *in* Harriman Alaska Expedition, v. 4 (Geology and Paleontology), p. 113, Unga; *not M. middendorffi*, Kodiak; New York, Doubleday, Page & Co. (reprinted by Smithsonian Institution, 1910).

1912. *Mytilus middendorffi* Grewingk. Gratacap, L. P., Am. Mus. Nat. History Bull. 31, art. VI, p. 69–70, pl. VII, figs. 1–3, Unga; *not M. middendorffi*, pl. VII, figs. 4–6, Kodiak.

1931. *Mytilus middendorffi* Grewingk. Grant, U.S., IV, and Gale, H. R., San Diego Soc. Nat. History Mem., v. 1, p. 247, Unga; *not M. middendorffi*, Kodiak.

1938. *Mytilus middendorffi* Grewingk. Slodkevich, V. S., Paleontology of U.S.S.R., v. 10, pt. 3, fasc. 19, Tertiary Pelecypoda from the Far East, Pt. II, p. 231, Unga; *not M. middendorffi*, p. 231, pl. L, figs. 2, 2a, Kodiak.

1938. Not *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., Paleontology of U.S.S.R, v. 10, pt. 3, fasc. 18 and 19, Tertiary Pelecypoda from the Far East; fasc. 18, p. 237, 238; fasc. 19, p. 119, 231, pl. L, figs. 3, 3a [=*Mytilus* (*Plicatomytilus*) n. sp. of this report].

1958. *Mytilus middendorffi* Grewingk. Hall, C. A., California Univ. Pubs. Geol. Sci., v. 34, no. 1, p. 52, Unga; *not M. middendorffi*, California and Kodiak, p. 49, 52, pl. 5, fig. 6.
1965. *Mytilus middendorffi* Grewingk. Burk, C. A., Geol. Soc. America Mem. 99, p. 91, 92, 93, 116, 213, 214, 215, 228, Alaska Peninsula; *not M. middendorffi*, Kodiak, p. 93, 104.
1967. *Mytilus middendorffi* Grewingk. Addicott, W. O., U.S. Geol. Survey Prof. Paper 593–D, p. D–7, Alaska Peninsula; *not M. middendorffi*, central California, Oregon, Pleasanton area, Santa Clara County, Griswold Hills, Reef Ridge and Kern River areas.
1967. *Mytilus middendorffi* Grewingk. MacNeil, F. S., U.S. Geol. Survey Prof. Paper 553, p. 13.
1973. *Mytilus* n. sp. Allison, R. C., and Addicott, W. O., Geol. Soc. America, Abstracts with programs, v. 5, no. 1, p. 2–3.

Description.—The shell is moderate sized, variable, heavy and ventricose for genus, often is strongly curved along anterior-posterior axis, and occasionally approaches the shape of *Crepidula*. The heavy shell is much thickened from within during growth; the breaks are terminal, pointed, and situated well above the plane of commissure above a large prominent lunule. A deep groove extends postero-dorsally from the beak on each valve becoming the broadly concave surface of the heavy thickened nymphae. A sharply incised groove that arches from the beak ventrally to the shell margin below the beak strongly marks the edge of the lunule; the lunule is semispade shaped (two valves together), the posterior dorsal point is attenuated, and the other two points beneath the beaks are strongly uncinate. The surface of the lunule has one or occasionally two strong ribs immediately dorsal to the incised ventral margin, and occasionally it has several additional very weak ribs dorsally; the lunule is not turned under such that ribs become hinge teeth; the hinge is normally edentate although some less inflated individuals may have valve margins slightly overlapped beneath beaks so that the ridges and grooves of the lunule barely interlock; the overall aspect of the shell is strongly governed by the variable degree of curvature of the anterior-posterior axis; the juvenile shell is mytiliform; large adults are usually bent posteriorly, inflated, and have one or two prominent bends in the dorsal margin. The dorsal margin is usually bent sharply between 20–30 mm in length marking the end of the juvenile mytiliform shape; occasionally there is another rather sharp bend toward the ventral between 50–60 mm in length; this posterior bend may be more evident on the dorsal umbonal ridge than on the dorsal shell margin which may become somewhat alate posteriorly. The bend between 20 and 30 mm in length may give the appearance of a modioliform shape. The ligament is long, heavy anteriorly, thin posteriorly; it reaches to the angulation between the dorsal and posterior slopes. Rapid growth on the posterior and ventral margins of the shell may cause marked bending of the shell along the posterior-anterior axis such that the plane of commissure diverges continually from the juvenile plane through a twisting rotation. The angle between the adult plane of commissure and the juvenile mytiliform plane (angle measured in elevation view) may reach about 95° in large old individuals; the angle between the ventral shell margin of the adult and juvenile shell (measured as seen from above with shell resting on plane of commissure = plan view) may reach up to 110°. The ventral shell margin is usually slightly concave but may be nearly straight or strongly concave. The shape of the posterior end of the shell is extremely variable; it ranges between broadly rounded or subquadrate-angulate to slightly pointed or rarely very pointed; the posterodorsal margin is either alate or nonalate. The valves are sharply tumid or relatively thin posteriorly, and either broader or narrower than the medial part of the shell. The shell varies from very weakly plicate, hardly deflecting the plane of commissure, to very strongly plicate; however, the intermediate condition is the most common. The shell is usually modestly sulcate anterior to the main anteroventral fold. The shells have either two or three folds separated by sinuses; the posterior dorsal fold usually is less distinct in those with three folds. The folds cross the shell from the beak to the posteroventral and posterior margin; the folds often are sharply bent ventrally toward the posterior end of the shell; this bend is sometimes associated with a posteroventral production of the shell margin. The posterior dorsal area shows no evidence of branching secondary folds. The surface of the shell has prominent growth lines and constrictions (rugose) that may break up the continuity of the folds by forming a line of ill-defined ovate nodes. The juvenile mytiliform shell is often set off by a prominent growth constriction. The shell is covered with a heavy periostracum, which is often preserved as a tough black carbonaceous layer. The weathered specimens frequently display numerous parallel wavy lines internally between the umbonal ridge and the dorsal margin;

R, right valve; L, left valve; ‡, specimen incomplete; M, internal mold without shell; C, crushed specimen.

Specimen	Measurements		
	Length (mm)	Height (mm)	Thickness (mm) one valve
USNM 647066 (R)[1]	70	47	31
(L)	71	46	29
USNM 647067 (both)	72	47	16R; 15L
USNM 647068 (both)	82	42	~19R; 21L
USNM 647069 (L)	53	‡	23
USNM 647070 (both)	56L; 57R	35R; 39L	25L; 27R
USNM 647071 (both)	72	46	20R; 19L
USNM 647072 (both)	70	47	23L; 20R (M)
USNM 647073 (R)	70	40	~20‡
USNM 647074 (both)	63	34	19R; ~17L‡
USNM 647075 (both)	52	37	19L; 19R
USNM 647079 (both)	82	51	18L; 22R
USNM 647080 (R)	~71‡	46	20
USNM 647081 (both)	67	49	~16L; ~19R‡
USNM 647082 (both)	65R; 65L	47	~17R; ~14L (C)
USNM 647083 (both)	76	39	23R; ~19L‡

[1]Holotype.

these lines mark the successive posterior migration of the posterior adductor and retractor muscles and their scars. The musculature is as described for *Plicatomytilus*.

Holotype.—USNM 647066.

Type locality.—U.S. Geol. Survey M5182.

Discussion.—*Mytilus gratacapi* n. sp. has long been confused with *M. middendorffi* Grewingk, probably owing in part to Grewingk's (1850) report of *M. middendorffi* from both Kodiak and Unga Islands, Alaska, as well as to subsequent repetitions of Grewingk's locality records by Dall and Harris (1892) and Dall (1896, 1904). In 1904 Dall (p. 113) included *M. middendorffi* in a listing of Miocene fossils from the Shumagin Islands collected by himself in 1865, 1872, 1874, and 1880, and by Mr. Trevor Kincaid in 1899; he gave the distribution as "Unga Island, and on Kadiak Island near Cape Tonki, Igatskoi Bay (Grewingk)". It seems likely, however, that this citation is merely a repetition of Grewingk's original record rather than a new confirmation of the Unga Island occurrence by recollection of mytilid fossils there. The paucity of easily accessible published illustrations of *M. middendorffi*, the much repeated early locality record of Grewingk's, the uniquely folded or plicate shells of both the Kodiak and the Alaska Peninsula Miocene mytilids, and finally Gratacap's (1912) concurrence that the same species occurs at Kodiak Island and on the Alaska Peninsula have prevented recognition of the Alaska Peninsula fossil mytilids as a distinct species.

In 1912, Gratacap described and illustrated a *Mytilus* from the divide of the Alaska Peninsula near Cape Seniavin, presumably in the vicinity of Bear Lake (fig. 3). The specimen came to Gratacap from a Mr. Dunham of Nome, Alaska, who had obtained it from a Spanish sea captain named de Soto. Both valves of the single specimen are embedded in a conglomerate matrix, presumably the Unga Conglomerate Member of the Bear Lake Formation. Dall (in Gratacap, 1912, p. 69) identified this specimen as *M. middendorffi* Grewingk and commented on it being a much distorted specimen with exaggerated resting stages, an exaggerated dental ridge, and an arcuate shape. Although Dall regarded this individual as gerontic and distorted by a "hard life," Gratacap's illustrations (1912, pl. 7, figs. 1–3) show the strong arching of the anterior-posterior axis, the prominent umbonal rib beneath the beak, and the strong growth constrictions. These characteristics, together with our examination of several mytilid collections from the Miocene of the Alaska Peninsula, make it clear that Gratacap's (1912, p. 69) individual is not "an unusual specimen of *Mytilus middendorffi*," but a representative of a very distinctive undescribed species herein named *M. gratacapi*. *M. gratacapi* is

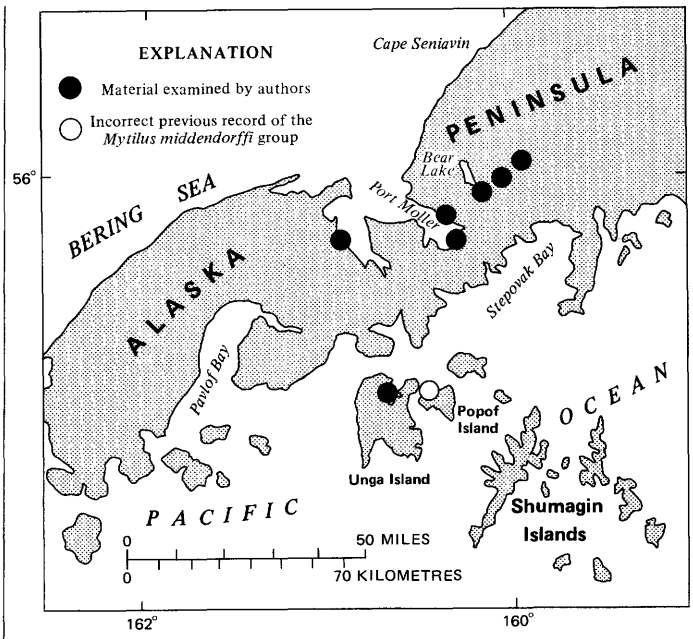

FIGURE 3.—Geographic distribution of *Mytilus gratacapi* n. sp.

abundant in the upper part of the Unga Conglomerate Member of the Bear Lake Formation (Burk, 1965, p. 91 and 116) and ranges upward into the middle part of the formation; we have seen no specimen of *M. middendorffi* from the Miocene beds on the Alaska Peninsula. As far as we know now, the two mytilids do not co-occur, for we do not know of any record of *M. gratacapi* aside from those on the Alaska Peninsula and Unga Island (fig. 3) in the Bear Lake Formation. Although *M. gratacapi* and *M. middendorffi* are doubtless related, the standard correlation of the Narrow Cape Formation of Kodiak Island with the Unga Conglomerate Member of the Bear Lake Formation ("*Mytilus middendorffi* zone" of MacNeil and others, 1961, and Burk, 1965, p. 90) merits careful review, because the probability is that much, if not all, of the range zone of *M. gratacapi* is of late Miocene age.

Mytilus gratacapi n. sp. is characterized by its prominently ribbed lunule, edentate hinge, lack of secondary folds on the posterodorsal surface, strong arching of the anteroposterior axis of the shell, strong ventral bending of the main folds of the shell toward the posterior margin, and by the usual presence of numerous semiregular constrictions of the shell along growth lines. Although the species exhibits great individual variation, it may be readily distinguished from *M. middendorffi*: (1) the adult *M. gratacapi* possesses a large ribbed lunule with beaks situated well above the plane of commissure and has a sharp groove running posterodorsally from beneath the beaks, whereas the lunule of *M. middendorffi* is small, externally indistinct, and turned under to form the

hinge teeth; (2) *M. middendorffi* usually possesses secondary folds on the posterodorsal surface that branch off of the main dorsal fold; *M. gratacapi* does not possess secondary branch folds; (3) *M. middendorffi* has a regular elongate mytiliform shell, whereas adult *M. gratacapi* typically has a strongly arched and twisted shell that has a trapezoidal or subquadrate shape; (4) the main shell folds of *M. gratacapi* are usually more sharply bent ventrally toward the posteroventral margin than those of *M. middendorffi*; this bend may accompany a posteroventral production of the shell margin by giving it a broader blunter aspect than that of *M. middendorffi;* (5) the main fold and sinuses of *M. gratacapi* are weaker and, accordingly, deflect the plane of commissure less severely than those of *M. middendorffi;* (6) *M. gratacapi* usually bears well-marked semiregular constrictions along growth lines (rugae) that tend to give the main folds of the shell an indistinct nodose appearance; such constrictions are not as common or well marked on shells of *M. middendorffi*, and as a result the main folds do not appear nodose, and; (7) *M. gratacapi* usually has three primary folds; if present, the third fold develops posterodorsally of the main folds, whereas in *M. middendorffi,* the third fold, if present, apparently develops anteroventrally of the main folds.

The large number of specimens at hand show much individual variation even among specimens collected from a single locality. Accordingly, we have chosen a number of paratypes in order to depict the range of variation of this species. Were it not for many intermediate forms in the collections, one might easily regard some of the more extreme variants as distinct taxa. This variation affects a number of characteristics of the shell. The lunule, although external and large in most specimens, may occasionally be slightly turned under, producing a very weak dentition. The wide variation in the arching and twisting of the shell, along the anteroposterior axis, greatly affects the overall aspect of the shell as well as its component parts such as the dorsal, ventral, and posterior margins. The shape of the posterior end of the shell is in fact perhaps the most singly variable characteristic. The dorsal margin may be strongly alate or almost nonalate as it is in *M. middendorffi.* The strength of the plicae or shell folds too may vary from strong to nearly absent on rare individuals. The development of the posterior dorsal fold is especially variable, and some shells may wholly lack this fold.

Occurrence.—Unga Conglomerate Member of the Bear Lake Formation, Unga Island (Grewingk, 1850; Dall, 1896, 1904), Alaska Peninsula (USGS Cenozoic loc. 5046, M805, M806, M1192, M1904, M1905, M3586, M5180, M5738); middle part of the Bear Lake Formation stratigraphically above the Unga Conglomerate Member, Alaska Peninsula, Alaska (USGS Cenozoic loc. M1022, M5182, M5185); unnamed marine rocks of "Pliocene" age of Burk (1965) [Bear Lake? Formation] (USGS Cenozoic loc. M5174).

Range.—Middle(?) to late Miocene.

Incorrect record of Mytilus gratacapi.—*Mytilus gratacapi* is present in a collection that was supposedly acquired from beds exposed on the north shore of Popof Island (USGS Cenozoic loc. 7905). The collection appears, however, to have been derived from several collecting stations, and it is very doubtful if the *M. gratacapi* specimens actually came from Popof Island. Subsequent mapping of Popof Island indicates that the marine Tertiary strata exposed along the shore eastward from East Head are referable to the Stepovak Formation of Burk (1965). All the other records of *M. gratacapi* are from the stratigraphically higher Bear Lake Formation. None of the several modern collections of mollusks from exposures of the Stepovak on Popof Island (USGS Cenozoic loc. M1160, M1162, M1164, M1167, M1654, M1655, M1656) contains *M. gratacapi*; rather they contain a shallow-water fauna characterized by *Ostrea tigiliana* Slodkevich that is considered (MacNeil in Burk, 1965) to have western North Pacific affinities and is roughly coeval with the fauna of the Oligocene "Lincoln" Stage of the eastern North Pacific. Burk (1965, p. 226) noted that this collection (USGS Cenozoic loc. 7905) contains species from both an Oligocene and a "middle" Miocene fauna, and that the faunal elements are associated with two different lithologies. Accordingly, the specimens of *M. gratacapi* and large *Crepidula* labeled USGS Cenozoic loc. 7905 are believed to have been collected from exposures of the Unga Conglomerate Member of the Bear Lake Formation either on neighboring Unga Island or on the Alaska Peninsula to the north of Popof Island. The mixing of fossils from two formations in the collection labeled 7905 was indirectly noted by MacNeil, Wolfe, Miller, and Hopkins (1961, p. 1804, annotation 2c).

Age and correlation.—Occurrences of *Mytilus gratacapi* are limited to a relatively small area on the Alaska Peninsula near Port Moller and in the adjacent Shumagin Islands (fig. 3). The age and correlation of the lowest strata bearing *M. gratacapi* (in terms of Gulf of Alaska and conterminous United States sequences) are problematic owing to the fact that associated mollusks are rare and poorly preserved. The highest occurrences, however, can be confidently assigned to the provincial late Miocene.

The lowest stratigraphic occurrence of *Mytilus gratacapi* is in the Unga Conglomerate Member of the Bear Lake Formation where it is associated with a commonly occurring *Crepidula* that is characterized by

a large internal septum with nearly parallel insertions. This species is considered distinct from *Crepidula ungana* Dall from the underlying Stepovak Formation of Burk (1965) (MacNeil in Burk, 1965, p. 92, 226). Other mollusks from the Unga include poorly preserved tellinid and venerid bivalves (USGS Cenozoic loc. 5046, M3587) that cannot be identified specifically. Plant fossils collected by W. H. Dall from "just beneath [the] *Crepidula* bed" on Zachary Bay, Unga Island, were considered by Wolfe (in Burk, 1965, p. 234) to be of no younger than middle Miocene age. Wolfe (1972, p. 203) assigned this Unga Island flora to the late Seldovian paleobotanical stage.

Although the floral evidence suggests that the lowest occurrence of *Mytilus gratacapi* could be as old as middle Miocene, a collection from the middle part of the Bear Lake Formation on the Alaska Peninsula about 50 miles to the northeast is clearly of late Miocene age (USGS Cenozoic loc. M5182). This locality, about 2½ miles southeast of Bear Lake (fig. 3), is stratigraphically above a collection of well-preserved mollusks that has been correlated with the late Miocene fauna of the Montesano Formation of western Washington (MacNeil in Burk, 1965, p. 228). A chronologically significant species in this collection is *Clinocardium pristinum* Keen. So far as is known, this occurrence and possibly an occurrence near Milky River (USGS Cenozoic loc. M1022) a few miles to the northeast are the highest stratigraphic occurrences of *M. gratacapi*. This species had not previously been recorded from above the Unga Conglomerate Member of the Bear Lake Formation.

Another important record of *Mytilus gratacapi* is from beds exposed inland from the west shore of Herendeen Bay (USGS Cenozoic loc. M5174) in strata mapped as unnamed marine rocks of Pliocene age by Burk (1965, geologic map; p. 94). Associated with *M. gratacapi* at this locality are a species of *Clinocardium* with crested ribs similar to *Clinocardium yakatagense* (Clark) and *Clinocardium ciliatum* (Fabricius) and specimens of a large *Mya* of the *Mya elegans* group. The occurrence of *Mytilus gratacapi* in this unit suggests that it may be in part coeval with the middle(?) and upper part of the Miocene Bear Lake Formation, rather than with the unnamed Pliocene beds as earlier supposed (Burk, 1965, p. 94). Pliocene strata do crop out on the west shore of Herendeen Bay north of Village Spit, but the coastal exposures of "marine Pliocene" beds south of Village Spit (Burk, 1965, geologic map) probably belong to Burk's (1965) Upper Cretaceous Coal Valley Member of the Chignik Formation. The nearest known exposures of the Bear Lake Formation are located about 8 miles to the northwest near the mouth of Port Moller.

It seems probable that *Mytilus gratacapi* evolved from *Mytilus middendorffi* during or near the end of the middle Miocene and that it represents the last occurrence of rugose, coarsely plicate species of *Plicatomytilus* in western North America. *Mytilus (Plicatomytilus)* n. sp. from western Kamchatka is clearly distinct from *M. gratacapi*.

Ecology.—*Mytilus gratacapi* usually occurs in shell beds by itself without the preserved remains of other mollusks. It is known, however, to co-occur with *Crepidula* sp., *Clinocardium* sp., and *Mya* (*?Arenomya*) cf. *M.* (*?A.*) *elegans* (Eichwald), 1871 (USGS Cenozoic loc. M5174). Although *Crepidula* and *Clinocardium* are known to range in depth from the intertidal zone to 90 fathoms and 125 fathoms respectively, we have not been able to find any record of members of the *Arenomya* stock ranging below the shallow subtidal zone. This association seems to indicate a habitat in the intertidal to very shallow subtidal range. The very heavy shell and considerable variation in shape also suggest that *M. gratacapi* may have lived on exposed coastlines where it was especially well adapted to heavy wave surge and surf conditions.

Mytilus (Plicatomytilus) n. sp.

Plate 2, figures 2, 5

1934. *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., On the stratigraphy of the Tertiary deposits of the western coast of Kamchatka: Academie des Sciences de L'Union des Republiques Sovietiques Socialistes (Akademiya Nauk), C. R. (Dokl.), T. 3, no. 1, p. 60 and 62 (Russian and English).

1936. *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., The stratigraphy and fauna of the Tertiary deposits of the western coast of Kamchatka: Trudy neftyanogo geologo razvedochnogo instituta, Seriya A, Vypusk 79, p. 125–126, pl. XV, figs. 5, 5a, Leningrad, Moscow.

1938. *Mytilus* cf. *middendorffi* Grewingk. Slodkevich, V. S., Paleontology of U.S.S.R., v. 10, pt. 3, fasc. 18 and 19, Tertiary Pelecypoda from the Far East; fasc. 18, p. 227, 238; fasc. 19, p.119, 231, pl. L, figs. 3, 3a [not figs. 2, 2a=*Mytilus middendorffi* Grewingk, Kodiak].

1963. *Modiolus* cf. *middendorffi* Grewingk. Il'ina, A. P., Mollusks of the Neogene of Kamchatka, pl. XXXVI, fig. 2 (same individual illustrated by Slodkevich, V. S., 1936 and 1938).

Discussion.—Slodkevich (1934) seems to have first recognized the similarity of a plicate shelled mytilid from the "Kavran Series" of western Kamchatka to *Mytilus middendorffi* Grewingk. Later, in 1936, and again in 1938, he described this east Asiatic taxon and illustrated a single specimen from the "River Reel'nye-vayam" area. Il'ina (1963) re-illustrated Slodkevich's (1936, 1938) specimen and reported it as "*Modiolus* cf. *middendorffi* Grewingk."

Slodkevich's (1936, 1938) descriptions of "*Mytilus* cf. *middendorffi*" indicate that he had only a single steinkern of one valve from the River Reel'nye-vayam area available for study. He clearly discussed the characteristic folding of the shell, reflected by the steinkern, and noted (1938) that the holotype of *M.*

middendorffi is lost. In order to describe the external features of the shell, he offered a short quotation from Grewingk (1850) dealing with the folding of the shell. These descriptions are somewhat confusing until one realizes that Slodkevich has incorrectly considered the beak of the shell to be posterior and the opposite folded end of the shell to be anterior. In the discussion, Slodkevich follows Dall's (1904) and Grant and Gale's (1931) views on the relationships of *M. middendorffi* to *M. condoni* Dall and *M. ficus* Dall. The tentative identification was offered because of the poor preservation of the single specimen. Although this much illustrated specimen is poorly preserved, Slodkevich's descriptions and the illustrations clearly indicate the characteristic folding of the shell and the plane of commissure that typifies *Plicatomytilus*.

Through the kindness of the Academician V. V. Menner and Dr. V. N. Sinel'nikova, both of the Geological Institute of Moscow, we have recently received a specimen of *Plicatomytilus* from the Kakert suite of the "Kavran Series" at the mouth of the Kavran River (Geological Institute, Moscow, loc. 69), western Kamchatka (pl. 2, figs. 2, 5). We consider this specimen to be synonymous with *Mytilus* cf. *M. middendorffi* of Slodkevich (1934, 1936, 1938) and *Modiolus* cf. *middendorffi* of Il'ina (1963), but not with *Mytilus middendorffi* Grewingk, 1850.

This specimen from the Kavran River area is a left valve that measures 77 mm in length (incomplete), about 43 mm in maximum height, and about 17 mm thick (one valve). A moderate umbonal ridge extends from the umbo to the posterior end of the shell, gently diverging from the posterodorsal margin. A well-marked sulcus, immediately anteroventrally of the umbonal ridge, extends from the umbo to the posteroventral corner of the shell where it clearly deflects the plane of commissure. Immediately anterior of this sulcus, a moderate fold extends from near the center of the shell to the ventral margin where it weakly deflects the plane of commissure. The characteristics of the beak, hinge, and lunule are not known because the shell is broken. The umbonal ridge is prominently undercut near the center of the dorsal margin where a moderately marked alation occurs between the anterodorsal and the posterodorsal edges of the shell. The convexity of the shell, which is moderate but not great, is greatest along the dorsal margin. Well-marked growth lines occur on the surface of the shell.

Although *Mytilus (Plicatomytilus)* n. sp. is quite similar in outline to *Mytilus middendorffi* Grewingk and is clearly related to it, we believe that the "Kavran Series" taxon should be recognized as a distinct species. *Mytilus (P.)* n. sp. appears to differ from *M. middendorffi:* (1) by being slightly smaller in fully adult size, (2) by having the major folds of the shell and plane of commissure much less pronounced and therefore weaker than in *M. middendorffi,* (3) by totally lacking the secondary bifurcated folds of the posterodorsal surface area that are characteristic of *M. middendorffi,* and (4) by being slightly less inflated and tumid than typical adult individuals of *M. middendorffi.*

Mytilus (P.) n. sp. also differs markedly from *Mytilus gratacapi* n. sp.: (1) by lacking the strong arching and twisting of the anteroposterior axis of the shell of *M. gratacapi,* (2) by lacking the strong ventral bending of the main folds of the shell toward the posterior margin as seen in the Alaska Peninsula species, (3) by lacking the prominent growth constrictions and nodose surface tendency of *M. gratacapi,* and (4) by probably lacking the prominently ribbed lunule of *M. gratacapi.*

Figured specimen.—USNM 647084.

Occurrence.—Etolon suite of the "Kavran Series," River Reel'nye-vayam area, and Kakert suite of the "Kavran Series," at the mouth of the Kavran River, western Kamchatka, U.S.S.R. The Etolon suite overlies the Kakert suite.

Range.—Middle to late Miocene.

Stratigraphic distribution and age.—The specimen of *Mytilus (P.)* n. sp. that was considered to be *Mytilus* cf. *middendorffi* by Slodkevich (1934, 1936, 1938) and to be *Modiolus* cf. *middendorffi* by Il'ina (1963) has been referred to the "Kavran Series" (Slodkevich, 1934), the "Kavran suite" (Slodkevich, 1936, 1938), and to the "Etolon Suite, zone of *Swiftopecten swiftii* var. *etchegoini*" (Il'ina, 1963). The label with the specimen donated to us by V. V. Menner and V. N. Sinel'nikova (pl. 2, figs. 2, 5) indicates it to be from the "Kakert Suite." The Kakert and Etolon suites are considered to be parts of the "Kavran Series" (see Gladenkov, 1974). The former specimen comes from the "River Reel'nye-vayam" area, and the latter specimen is from the "mouth of Kavran River" area, western Kamchatka.

Slodkevich (1934 and 1936) considered the "Kavran Series" or "Kavran Suite" to be middle and late Pliocene in age. In 1938, Slodkevich revised his view by referring the "Kavran Suite" to the "Miocene-Pliocene." Il'ina (1963) considered "the zone of *Swiftopecten swiftii* var. *etchegoini*" (Etolon suite) to be of middle Pliocene age.

More recently, Sinel'nikova and Drushchits (1971) and Gladenkov, Petrov, and Sinel'nikova (1972) considered the "Kavran Series" and the Etolon suite of western Kamchatka to be of middle to late Miocene age. Gladenkov (1972, 1974) considered the Kakert suite to be of middle Miocene age and the Etolon suite to be of middle and late Miocene age. Gladenkov's (1972, 1974) age interpretations seem to agree well with what may be inferred from the presence of *Mytilus (Plicatomytilus)* n. sp.; its nearest relative, *Mytilus middendorffi,* is

restricted to deposits of middle Miocene age in western North America.

LOCALITY REGISTER

[Localities from which *Mytilus middendorffi* and *M. gratacapi* have been collected. Age and formational assignments in brackets are those of the present authors]

Locality	Description
	USGS localities (Washington, D. C., register)
3334	Base of beach bluff half a mile north of Blacklock Point [Curry County], Oreg. Same description as loc. 7901. [Lower part of Diller's (1903) Empire Formation.]
5046	North side of Port Moller, Alaska Peninsula, Alaska [same as loc. M805 according to notation on locality label written by F. S. MacNeil]. Collected by W. W. Atwood and H. M. Eakin, July, 1912. [Bear Lake Formation.]
5765	East end of Vallecitos, 500 ft southeast of New Bedford well, in bed of Silver Creek just below where branch road to well crosses creek, San Benito County, Calif. From basal sand of lower Miocene [Temblor Formation, middle Miocene]. Collected by R. W. Pack, 1909.
5766	East end of Vallecitos, 1.1 miles almost due north of New Bedford well, on north side of first large gully draining into Silver Creek north of well. Near center of W½ sec. 32, T. 16 S., R. 12 E., San Benito County, Calif. From sandstone underlying shale of loc. 5789 and directly above Oligocene(?) diatomaceous shale. Basal Miocene [Temblor Formation, middle Miocene]; same horizon as loc. 5765. Collected by R. W. Pack, 1909.
7901	Base of beach bluff half a mile north of Blacklock Point [Curry County], Oreg. Same description as loc. 3334. [Lower part of Diller's (1903) Empire Formation.]
7905	North side of Popof Island, Shumagin Islands, Alaska. Collected by W. H. Dall [Collection mixed, specimens of *Mytilus gratacapi* probably from Unga Island or Alaska Peninsula (p. 12)].
13372	Southwest corner of Narrow Point, entrance to Ugak Bay, Kodiak Island, Alaska. [Narrow Cape Formation, middle Miocene.] Collected by S. R. Capps, 1934.
14385	On east side of ridge between Garza and Baby King Canyons about 300 ft south of road, 1,150 ft S., 250 ft W. of NE cor. sec. 10, T. 23 S., R. 17 E., Reef Ridge 15-minute quad., Kings County, Calif. Lower part of Temblor Formation [middle Miocene]. Collected by Ralph Stewart.
14393	Southeast and southwest sides of Roundtop, in sec. 12, T. 23 S., R. 16 E., Reef Ridge 15-minute quadrangle, Kings County, Calif. Pebble beds near top of lower part of Temblor Formation [middle Miocene]. Collected by Ralph Stewart.
18284	Dredging from between mile 3.5 and mile 4 in Coos Bay opposite pulp mill, Empire 15-minute quadrangle, Coos County, Oreg. Unnamed formation of middle Miocene age. Collected by E. J. Moore, 1949, 1951, 1952.
	USGS localities (Denver, Colorado, register)
D227	Sea cliff at east margin of beach south of Twin Lakes about 0.2 mile N. 5° W. of southwesternmost projection at Narrow Cape, Kodiak Island, Alaska (coordinates on Kodiak 1:250,000 quadrangle: 15.60, 7.48). [Narrow Cape Formation.] Collected by C. E. Kirschner and J. E. Heppert, 1953.
	USGS localities (Menlo Park, California, register)
M805	Northeast shore of Left Head, 5.4 miles N. 31° E. of Jerk triangulation station, Port Moller quadrangle, Alaska Peninsula, Alaska. Collected by M. C. Lachenbruch, 1959.
M806	Northeast shore of Right Head, 4 miles N. 84° E. of Jerk triangulation station, Port Moller quadrangle, Alaska Peninsula, Alaska. Collected by M. C. Lachenbruch, 1959.
M1022	17.3 in. N., 19.8 in. E. of SW cor. Port Moller 1:250,000 quadrangle, Alaska Peninsula, Alaska. Unga Conglomerate Member of Bear Lake Formation. Collected by M. C. Lachenbruch.
M1192	East shore of Port Moller between Left Head and Right Head, lat 55°49′ N., long 160°18.5′W., Port Moller 1:250,000 quadrangle, Alaska Peninsula, Alaska. Unga Conglomerate Member of Bear Lake Formation. Collected by C. A. Burk, 1959–61.
M1735	From 1,250 ft above base of section at Narrow Cape, lat 57°26′ N., long 152°19′ W., Kodiak 1:250,000 quadrangle, Alaska. Narrow Cape Formation. Collected by G. W. Moore, 1963.
M1904	Six miles N. 85° E. of southernmost tip of Bear Lake and 1 mile S., 0.9 mile W. of NE cor. Port Moller 1:250,000 quadrangle, Alaska Peninsula, Alaska. Collected by Mobil Oil Co., 1963.
M1905	On north coast of Left Head, Port Moller Bay, 9.5 miles S. 72° E. of Harbor Point and 8.8 miles S., 13.4 miles W. of NE cor. Port Moller 1:250,000 quadrangle, Alaska Peninsula, Alaska. Collected by Mobil Oil Co., 1963.
M2142	Seacliff exposure southeast of Cape Blanco in E ½ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Unnamed sandstone and conglomerate of middle Miocene age exposed below unconformity within Diller's (1903) Empire Formation. Collected by W. O. Addicott, 1964.
M3586	Northeast shore of Right Head, approximately 600 ft E., 2,300 ft S. of NW cor. sec. 32, T. 50 S., R. 71 W., Port Moller (D–1) 15-minute quadrangle, Alaska Peninsula, Alaska. Collected by Standard Oil Co., 1965.
M3614	Concretionary sandstone in cliff on west side of Silver Creek, 1,700 ft N., 900 ft E. of SW cor. sec. 5, T. 17 S., R. 12 E., New Idria 15-minute quadrangle, San Benito County, Calif. About 50 ft above base of Vaqueros Formation of Anderson and Pack (1915) [Temblor Formation]. Collected by W. O. Addicott, 1967.
M3637	Seacliff exposure about halfway between Blacklock Point and Floras Lake, 1,000 ft N., 2,400 ft W. of SE cor. sec. 18, T. 31 S., R. 15 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Empire Formation of Diller (1903). Collected by W. O. Addicott, R. J. Janda, and H. E. Clifton, 1967.
M4126	Seacliff exposure of *Mytilus middendorffi*-bearing conglomerate lenses stratigraphically below prominent tuff bed southeast of Cape Blanco, in E ½ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Lower part of Diller's (1903) Empire Formation. Same as USGS loc. M2142. Collected by W. O. Addicott and R. J. Janda, 1969.
M4129	Seacliff exposure east of waterfall on north side of Blacklock Point, 2,500 ft N., 200 ft W. of SE cor. sec. 24, T. 31 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Lower part of Diller's (1903)

Locality	Description
	Empire Formation. Collected by W. O. Addicott and R. J. Janda, 1969.
M4130	Seacliff exposures about 1 mile northeast of Blacklock Point, in S½ sec. 18, T. 31 S., R. 15 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. *Mytilus*-bearing concretions from 50-ft-thick unit in lower part of Diller's (1903) Empire Formation. Collected by W. O. Addicott and R. J. Janda, 1969.
M4132	North bank of small draw near Floras Lake, in SE¼ NE¼ sec. 18, T. 31 S., R. 15 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. 1,650 ft S., 1,000 ft W. of NE cor. sec. 18. Concretions in massive sandstone of lower part of Diller's (1903) Empire Formation. Collected by W. O. Addicott and R. J. Janda, 1969.
M4135	Seacliff exposure of massive gray, micaceous silty sandstone containing large (2- to 5-ft-thick) concretions with minute *Spisula*, 3,650 ft S., 100 ft E. of NW cor. sec. 1, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Near top of lower part of Diller's (1903) Empire Formation and stratigraphically above tuff. Collected by W. O. Addicott, 1969.
M4136	Seacliff exposure of *Mytilus middendorffi*-bearing beds, 40 to 50 ft stratigraphically above tuff bed, in E½ SE¼ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Lower part of Diller's (1903) Empire Formation. Collected by W. O. Addicott, 1969.
M4687	Seacliff exposure southeast of Cape Blanco in E½ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Lower part of Diller's (1903) Empire Formation. Same as USGS loc. M2142. Collected by W. O. Addicott, 1971.
M4690	Seacliff exposure stratigraphically above M4689, 2,700 ft S., 950 ft W. of NE cor. sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Collected by W. O. Addicott and R. J. Janda, 1971.
M4756	Bench mark north of head of Samson Ridge, 850 ft S., 2,700 ft W. of NE cor. sec. 5, T. 9 S., R. 4 E., Mt. Sizer 7½-minute quadrangle, Santa Clara County, Calif. Sobrante Sandstone. Collected by Susan Bartsch, 1971.
M5162	Cut along Steeley Road near north line of sec. 5, T. 9 S., R. 4 E., Mt. Sizer 7½-minute quadrangle, Santa Clara County, Calif. Sobrante Sandstone. Collected by K. J. Murata, 1972.
M5174	North of Village Spit on west side of Herendeen Bay, from measured section along shoreline between 2,700 ft N., 1,800 ft W. of SW cor. sec. 31 and 1,200 ft N., 2,700 ft E. of SW cor. sec. 25, T. 50 S., R. 75 and 76 W., Port Moller (D–3) 15-minute quadrangle, Alaska. Collected by Union Oil Co., 1971 [probably coeval with upper Bear Lake Formation].
M5180	South of Sundean triangulation station on northeast shore of Right Head, Port Moller, 200 ft N., 2,500 ft W. of SE cor. sec. 30, T. 50 S., R. 71 W., Port Moller (D–1) 15-minute quadrangle, Alaska. Collected by Union Oil Co., 1971.
M5182	From measured section about 2½ miles southeast of Bear Lake, section extends from 1,500 ft N., 1,800 ft W. of SE cor. sec. 9 to 600 ft N., 1,000 ft W. of SE cor. sec. 4, T. 49 S., R. 69 W., Port Moller (D–1) 15-minute quadrangle, Alaska Peninsula, Alaska. Collected by Union Oil Co., 1971.
M5185	Measured section on northeast side of Milky River, section extends from 1,500 ft N., 2,000 ft E. of SW cor. sec. 16, to 1,900 ft S., 800 ft W. of NE cor. sec. 16, T. 48 S., R. 68 W., Chignik (A–6) 15-minute quadrangle, Alaska Peninsula, Alaska. Collected by Union Oil Co., 1971.
M5737	Seacliff exposure 130 ft stratigraphically above lowest exposure of Diller's (1903) Empire Formation southeast of Cape Blanco in NE¼ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle, Curry County, Oreg. Collected by W. O. Addicott and R. J. Janda, 1971.
M5738	Seacliff exposure at westernmost point of peninsula between Right Head and Left Head, Port Moller, Alaska Peninsula, Alaska. Collected by A. W. Schlottman, 1961.
M5807	Roadcut on west side of logging road spur in SE¼NE¼ sec. 4, T. 3 N., R. 10 W., Cannon Beach 15-minute quadrangle, Tillamook County, Oreg. [Astoria Formation.]
M6381	Cut on south side of logging road in NE¼NE¼SW¼ sec. 23, T. 6 N., R. 9 W., Cannon Beach 15-minute quadrangle, Tillamook County, Oreg. Approximately 380 ft above base of Astoria Formation. Collected by A. Niem, D. M. Cooper, J. W. Miller, and W. O. Addicott, 1974.
M6382	Bank on east side of Big Creek, 150 ft S., 1,100 ft W. of NE cor. sec. 10, T. 7 N., R. 7 W., Svenson 15-minute quadrangle, Clatsop County, Oreg. Astoria Formation. Collected by A. Niem, D. M. Cooper, J. W. Miller, and W. O. Addicott, 1974.
	University of Alaska Museum localities
A–180	Massive blue-gray fine- to medium-grained sandstone unit about 85 ft thick including several concretionary beds. A large landslide from this unit has produced a rubble cone at head of beach and toe of seacliff. Includes concretionary lenses rich in *Mytilus middendorffi, Clinocardium, Pseudocardium, Kewia kannoi, Dosinia, Mya,* and *Acila*. Below this bed is a massive black chert and white quartz pebble to granule conglomerate. Top of unit marked by a 2-ft-thick concretionary bed rich in *Pseudocardium* and *Mytilus middendorffi*. Locality A–180 includes fossils from lower half of this 85-ft-thick unit. Locality approximately 700–800 ft southeast of southwest end of south Twin Lake in seacliff at Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison, 1969 and 1970, C. W. Allison, 1969, and J. W. Durham, 1970.
A-181	Locality in seacliff about 125 ft southeast of start of seacliff exposure at northeast end of south Twin Lake, Narrow Cape, Kodiak Island, Alaska. Locality in a 2-ft-thick concretionary bed rich in *Mytilus middendorffi, Pseudocardium,* and *Kewia kannoi*. Fossil bed overlain by massive medium-grained gray buff-weathering sandstone and underlain by fine-grained massive gray sandstone. Locality exposed on rock promontory projecting out from seacliff on southeast side of small doubly reentrant cove on beach. Narrow

Locality	Description
	Cape Formation, middle Miocene, U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–183	Fossil locality in 25-ft-thick light-gray massive fine- to medium-grained sandstone, 14 ft. below prominent 2-ft-thick concretionary bed rich in *Pseudocardium* which bounds top of unit. Another 1-ft-thick concretionary unit occurs 5 ft above base of unit and has a 6-in.-thick discontinuous concretionary bed directly above it. Bedding shown by laminae of shell detritus. Base of unit bounded by a 1-ft to 6-in.-thick hard concretionary bed that is rich in *Mytilus middendorffi* (loc. A–273). Locality A–183 is 125 ft east of loc. A–181. Locality includes mollusks and echinoids. Site located in seacliff on northwest side of small slotlike cave about 800 ft southeast of start of seacliff exposures (southeast of Twin Lakes Valley) on northeast side of Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–204	Outcrop of very fine to fine-grained gray soft buff-weathering blocky fossiliferous sandstone with *Mya, Mytilus middendorffi*, and fossil bone debris. *Mya* upright in life position. Outcrop consists of the stratigraphically highest bed that is exposed immediately southeast of east Twin Lake on southwest shore of Narrow Cape (northeast entrance to Ugak Bay), Kodiak Island, Alaska. Outcrop exposed in bluffs at head of beach and a short distance to northeast along southeast valley slope of east Twin Lake. This bed, about 50 ft thick, immediately overlies a thin calcareous concretionary bed of fine-grained gray unfossiliferous sandstone. Stratigraphic interval immediately above this bed is covered beneath surficial deposits of east Twin Lake. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison, 1969 and 1970, C. W. Allison, 1969, and J. W. Durham, 1970.
A–255	Bulk collection of fossils from about 290 ft of strata exposed in seacliff immediately southeast of south Twin Lake, on southwest shore of Narrow Cape, Kodiak Island, Alaska. Top of locality includes highest stratigraphic unit exposed southeast of Twin Lakes, a very fine to fine-grained gray soft buff-weathering blocky fossiliferous sandstone with *Mya, Mytilus middendorffi*, and some fossil bone debris (= loc. A–204). Bottom of locality just northwest of large landslide debris cone on beach, stratigraphically in the middle of a massive blue-gray fine- to medium-grained sandstone unit about 85 ft thick (= unit of loc. A–180). Fossil locality in interval primarily of sandstone, with some mudstone and marked by several conspicuous concretionary beds and discontinuous concretionary horizons. A conspicuous unfossiliferous concretionary bed occurs about 50 ft below top of locality; another conspicuous 2-ft-thick concretionary bed rich in *Pseudocardium* and *Mytilus middendorffi* occurs about 40 ft above base of locality. This second bed is a fine- to medium-grained calcareous pebbly shell fragment sandstone. Locality continues along beach for about 600 ft. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison, 1969 and 1970, C. W. Allison, 1969, and J. W. Durham, 1970.
A–256	Collection from float boulders on beach below loc. A–255. Narrow Cape Formation, middle Miocene, Kodiak Island, Alaska. Coll. R. C. Allison and C. W. Allison, 1969.
A–257	Fossils from buff-weathering massive gray fine- to very fine-grained sandstone that includes occasional concretions 4–5 ft in diameter. Unit exposed in high seacliff and about a quarter of a mile northwest along beach on southwest side of Narrow Cape from small point which is last of proximal beach visible to northwest from end of road on hill between two Twin Lakes. Locality near base of this massive sandstone which forms cliff and near axis of a syncline and highest strata in section exposed at beach level. Narrow Cape Formation, middle Miocene, Kodiak Island, Alaska. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison, 1969.
A–258	Collection from 100-ft-thick unit of massive gray brownish-weathering medium-grained sandstone with minor concretions and a few lenses of *Mytilus middendorffi*. Irregular lenses of conglomerate scattered throughout unit. *Mytilus* lenses at base of unit in 3-ft-thick pea gravel to pebble conglomerate. *Mytilus* bed at top of unit just below massive white quartz and black chert granule to pebble conglomerate. Base of unit about 25 ft stratigraphically above base of this seacliff, almost to southwest tip of cape. Base of unit about 1,500 ft southeast along beach from southwest end of south Twin Lake, Narrow Cape, Kodiak Island, Alaska. Exposures in high seacliff. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison and J. W. Durham, 1970.
A–260	Collection from beach boulder float at top of landslide of locality A–180, on beach approximately 800 ft southeast of southwest end of south Twin Lake, Narrow Cape, Kodiak Island, Alaska. *Mytilus middendorffi, Dosinia, Mya,* and *Acila*. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–264	Bulk collection of fossils from uppermost 180 ft of strata exposed in seacliff immediately southeast of northeast end of south Twin Lake, Narrow Cape, Kodiak Island, Alaska. Base of collection 25 ft below conspicuous 2-ft-thick concretionary bed, rich in *Pseudocardium*. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. R. C. Allison, J. W. Durham, and W. O. Addicott, 1970.
A–266	Fossils from 40-ft-thick unit of massive hard gray medium-grained sandstone with concretions up to 5 ft in diameter. Locality in seacliffs immediately southeast of small stream that crosses beach on northeast side of Narrow Cape, Kodiak Island, Alaska. Fossils located in concretions or concretionary lenses. Unit without pebbles. Top of unit is a 1-ft-thick unfossiliferous concretionary bed. *Priscofusus, Dentalium, Macoma, Mytilus middendorffi, Tellina,* and *Lucino-*

Locality	Description
	ma. Base of unit about 35 ft stratigraphically above a 4-ft-thick sandy granule to pebble conglomerate bed. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. W. O. Addicott, 1970.
A–268	Concretionary bed forming rock rib on beach platform at northeast corner of Narrow Cape, Kodiak Island, Alaska. Bed located about 25 ft stratigraphically above basal unconformity of Narrow Cape Formation. Three concretionary zones below this bed and above base of formation are unfossiliferous. Concretionary beds in fine-grained light-gray buff-weathering massive sandstone. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Kodiak Island, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–269	Fossils from a 45-ft-thick unit of fine- to very fine-grained massive red-brown-weathering fossiliferous sandstone. Twenty feet above base of unit 1- to 2-ft-thick hard concretionary bed bears gastropods and bivalves. Top of unit is 1-ft-thick conglomerate lens and concretionary bed with *Mytilus middendorffi* and *?Fulgoraria*. Bottom of unit marked by concretionary bed which is loc. A–268. Locality A–276 is about 20 ft stratigraphically higher than top of this unit. Locality A–269 in seacliff and beach platform that runs for about 100 ft along coast immediately northwest of northeast tip or point of Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970. [No *Mytilus middendorffi* collected = field identification.]
A–271	Collection from basal 2 ft of a 40-ft-thick massive buff-weathering gray fine- to medium-grained sandstone with scattered rare pebbles, several pebble lenses, and a concretion up to 5 ft in diameter at tip of small point. Fossil bed immediately underlain by 4-ft-thick pebble to cobble conglomerate bed. Locality A–271 about 80 ft stratigraphically below loc. A–266. Locality A–271 in seacliff exposures on northeast shore of Narrow Cape, Kodiak Island, Alaska, between promontories or points in small cove southeast of stream which crosses beach. Small point immediately to southeast impassible on foot at high tide. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–273	Fossil collection from 2 ft stratigraphically below top of 25-ft-thick unit of sandstone. Lower 5 ft of unit composed of pebbly medium-grained sandstone; remainder of unit of fine- to medium-grained massive gray sandstone. Bottom of unit a 1-ft-thick unfossiliferous concretionary bed; top of unit a 1-ft- to 6-in.-thick hard concretionary bed bearing *Mytilus middendorffi*. *Mytilus middendorffi* also occurs in lenses 2, 10, and 15 ft above base of unit. *Kewia* occurs with *Mytilus middendorffi* at locality A–273. Locality A–273 about 25 ft stratigraphically below conspicuous 2-ft-thick concretionary bed rich in *Pseudocardium*. Base of unit about 25 ft stratigraphically above 10- to 25-ft-thick granule to fine pebble conglomerate. Locality A–273 in seacliff approximately 900 ft southeast of start of seacliff exposures (southeast of Twin Lakes valley) on northeast side of Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970.
A–275	Fossils from massive blue-gray fine- to medium-grained sandstone unit about 85 ft thick including several concretionary beds (= unit of A–180). Fossils collected from 10–15 ft stratigraphically below conspicuous 2-ft-thick fine- to medium-grained calcareous pebbly shell fragment sandstone bed rich in *Pseudocardium, Mytilus middendorffi,* and *Dosinia*. Locality in seacliff approximately 600–700 ft southeast of southwest end of south Twin Lake, at Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360,edition of 1949. Coll. W. O. Addicott, 1970.
A–276	Concretionary lens with *Mytilus middendorffi* within 40-ft-thick fine-grained gray sandstone unit. Top of unit marked by 2-ft-thick concretionary bed of fine-grained gray unfossiliferous sandstone. Base of unit (top of loc. A–269) marked by 1-ft-thick fossiliferous conglomerate lens and concretionary bed with *Mytilus middendorffi* and *?Fulgoraria*. Locality A–276 is 100 ft northwest of loc. A–269 in the seacliff on northeast coast of Narrow Cape, Kodiak Island, Alaska. Next 100-ft distance along beach to northwest with red staining on rock in small cove where small fault strikes N. 33° W., dips 53° N. Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949. Coll. J. W. Durham, 1970. [No *Mytilus middendorffi* collected=field identification.]
A–278	"Fossil cliffs, Pasagshak Pt., Pasagshak Bay, off Ugak Bay, Kodiak Island, Alaska. Found in sandstone cliffs about 20–25 ft above sea level in 6-in-thick bed. Total cliff height above sea level about 100 ft. Collected by Everett W. Stone, Jr. of Kodiak, 1973." [This may come from Narrow Cape rather than Pasagshak Point; precise locality considered unknown—R. C. Allison.] Narrow Cape Formation, middle Miocene. U.S. Geol. Survey Kodiak B–1 and B–2 quadrangles, Alaska, 1:63,360, edition of 1949.
	University of Oregon locality
F–2011	Cape Blanco and south for about 1½ miles. Lower part of Empire Formation. Collected by Ellen James.
	University of California, Berkeley, localities
A8711	Fossils from limy lens in sandstone that is about 100 ft lower than A8710 below unconformity at base of Empire Formation and below pumiceous tuff beds. A8711 about 400 yards nearer the Cape Blanco light than loc. A8710. Astoria Formation, Curry County, Oreg. SW¼NE¼ sec. 2, T. 32 S., R. 16 W., Cape Blanco 15-minute quadrangle. [Lower part of Diller's (1903) Empire Formation.]
B4162	Cut on east side of Canyon Road 0.2 mile above Dublin Highway at Eden Creek, in NW¼ sec. 6, T. 3 S., R. 1 W., Hayward 7½-minute quadrangle, Alameda County, Calif. Sobrante Sandstone. Collected in 1956.

Locality	Description
	Stanford University localities
2982	Summit of Milpitas-Calaveras Road (just south of north line of sec. 2, T. 6 S., R. 1 E., Calaveras Reservoir 7½-minute quadrangle), Santa Clara County, Calif. Temblor Formation of Crittenden (1951). Collected by Harold Hannibal.
3248	Along road in NE¼NE¼NE¼ sec. 14, T. 5 S., R. 1 E., 554 mm [21.8 in.] S., 181 mm [7.1 in.] E. of NW cor. La Costa Valley 7½-minute quadrangle, Alameda County, Calif. Oursan Sandstone of Hall (1958) [locality is incorrectly plotted near base of Tice Shale in SW¼SE¼ sec. 25, T. 4 S., R. 1 W., on Hall's (1958) geologic map]. Collected by Stanford Geological Survey and W. G. Cooper.
43952	On coast 5,500 ft north-northwest of northeast tip of Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation. Collected by Union Oil Company.
43953	Along coast 3,800 ft north-northwest of northeast tip of Narrow Cape, Kodiak Island, Alaska. Narrow Cape Formation. Collected by J. C. Hazzard.
49046	In SE¼SW¼ sec. 18, T. 17 S., R. 12 E., Priest Valley 15-minute quadrangle, San Benito County, Calif. Temblor Formation. Collected by R. H. Vaughn, 1957.
NP23	Seacliff between Blacklock Point and Floras Lake, north of Cape Blanco, Curry County, Oreg. Basal sandstone of Empire Formation. Collected by Harold Hannibal, 1911 or 1912. [Lower part of Diller's (1903) Empire Formation.]
NP26	Seacliffs southeast of [Cape Blanco] lighthouse for mile along shore, Curry County, Oreg. Basal sandstone of Empire Formation. Collected by Harold Hannibal, 1911 or 1912. [Lower part of Diller's (1903) Empire Formation.]
Uncataloged collection	Near well in SW¼ sec. 14, T. 17 S., R. 11 E., New Idria 15-minute quadrangle, San Benito County, Calif., from unit in Temblor Formation striking east-west through S½ sec. 14 and SW¼ sec. 13, and near S¼ corner. South side of Vallecitos.
	California Academy of Sciences localities
CAS 17	In sea cliff about 1¼ to 1½ miles southeast of Cape Blanco, Oreg. Empire Formation. [Lower part of Diller's (1903) Empire Formation]
CAS 19	In sea cliff about 1¼ to 1½ miles southeast of Cape Blanco, Oreg. Empire Formation. [Lower part of Diller's (1903) Empire Formation.]
CAS 22	In sea cliff about 3 miles northeast of Cape Blanco, Oreg., or about half a mile northeast of Blacklock Point, Empire Formation. [Lower part of Diller's (1903) Empire Formation.]

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PLATES 1–3

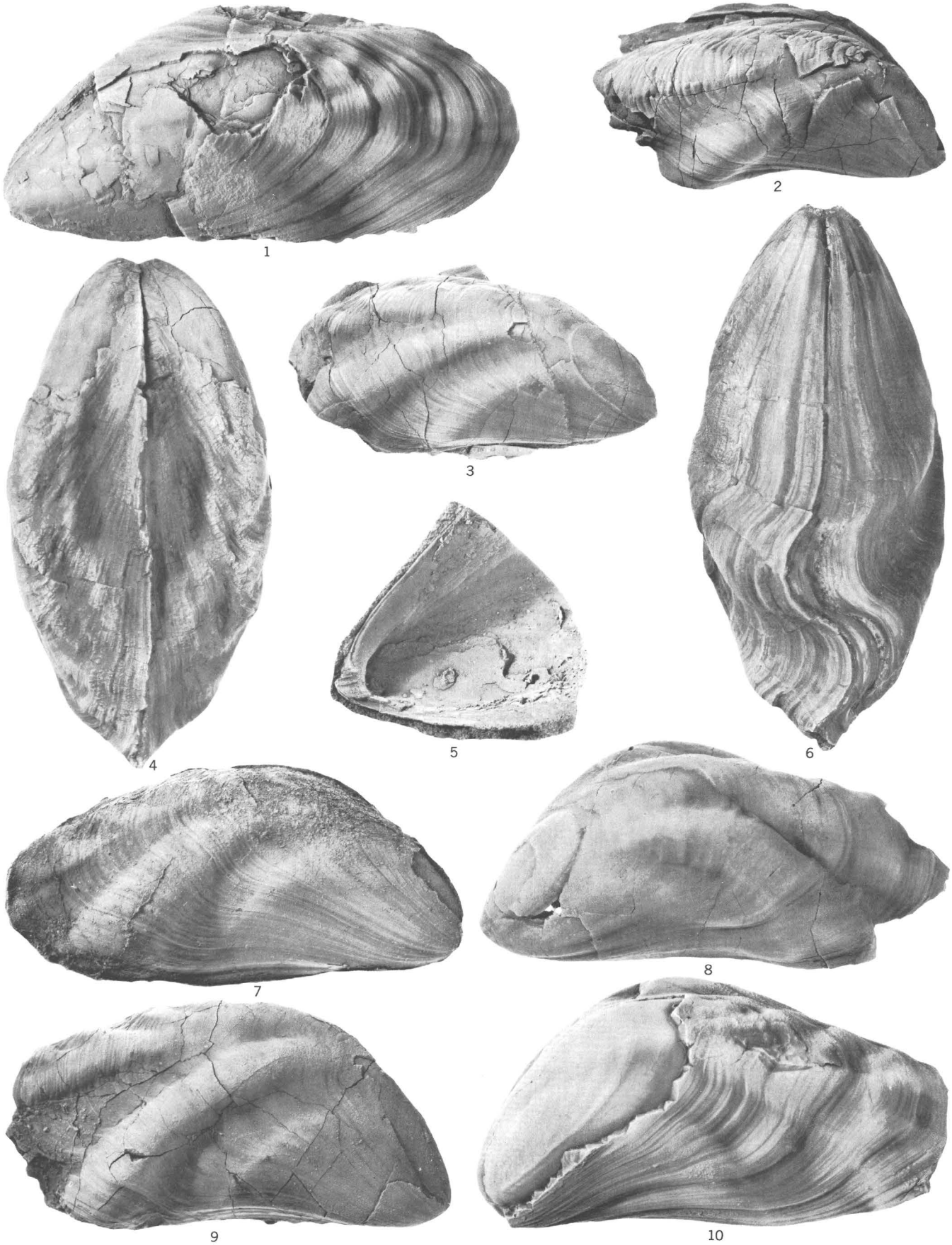
[Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colo. 80225]

PLATE 1

[All figures × 1]

FIGURES 1–10. *Mytilus* (*Plicatomytilus*) *middendorffi* Grewingk, 1850 (p. 3).

1. USNM 647057. Length 100 mm. Narrow Cape Formation, Kodiak Island, Alaska. UA loc. A–268.
2. USNM 647058. Length 70 mm. Temblor Formation, Griswold Hills, California. USGS Cenozoic loc. M3614.
3. USNM 647059. Length 70 mm. Temblor Formation, Griswold Hills, California. USGS Cenozoic loc. M3614.
4, 6. USNM 647060. Length 102 mm. Lower part of the Empire Formation of Diller (1903), near Cape Blanco, Oregon. USGS Cenozoic loc. M5737.
5. USNM 647061. Length 47 mm, a rubber cast. Lower part of the Empire Formation of Diller (1903), near Cape Blanco, Oregon. USGS Cenozoic loc. M4130.
7. USNM 647062. Length 86 mm, a rubber cast. Lower part of the Empire Formation of Diller (1903), near Cape Blanco, Oregon. USGS Cenozoic loc. M4130.
8. USNM 647063. Length 90 mm. Narrow Cape Formation, Kodiak Island, Alaska. UA loc. A–183.
9. USNM 647064. Length 87 mm. Temblor Formation, Griswold Hills, California. USGS Cenozoic loc. M3614.
10. USNM 647065. Length 92 mm. Narrow Cape Formation, Kodiak Island, Alaska. UA loc. A–256.



MYTILUS (PLICATOMYTILUS) MIDDENDORFFI

PLATE 2

[All figures × 1]

FIGURES 1, 3, 4, 6–10. *Mytilus* (*Plicatomytilus*) *gratacapi*, n. sp. (p. 9).

1, 3, 9, 10. Holotype USNM 647066. Length: right valve 70 mm, left valve 71 mm. Bear Lake Formation, Alaska Peninsula, Alaska. USGS Cenozoic loc. M5182.

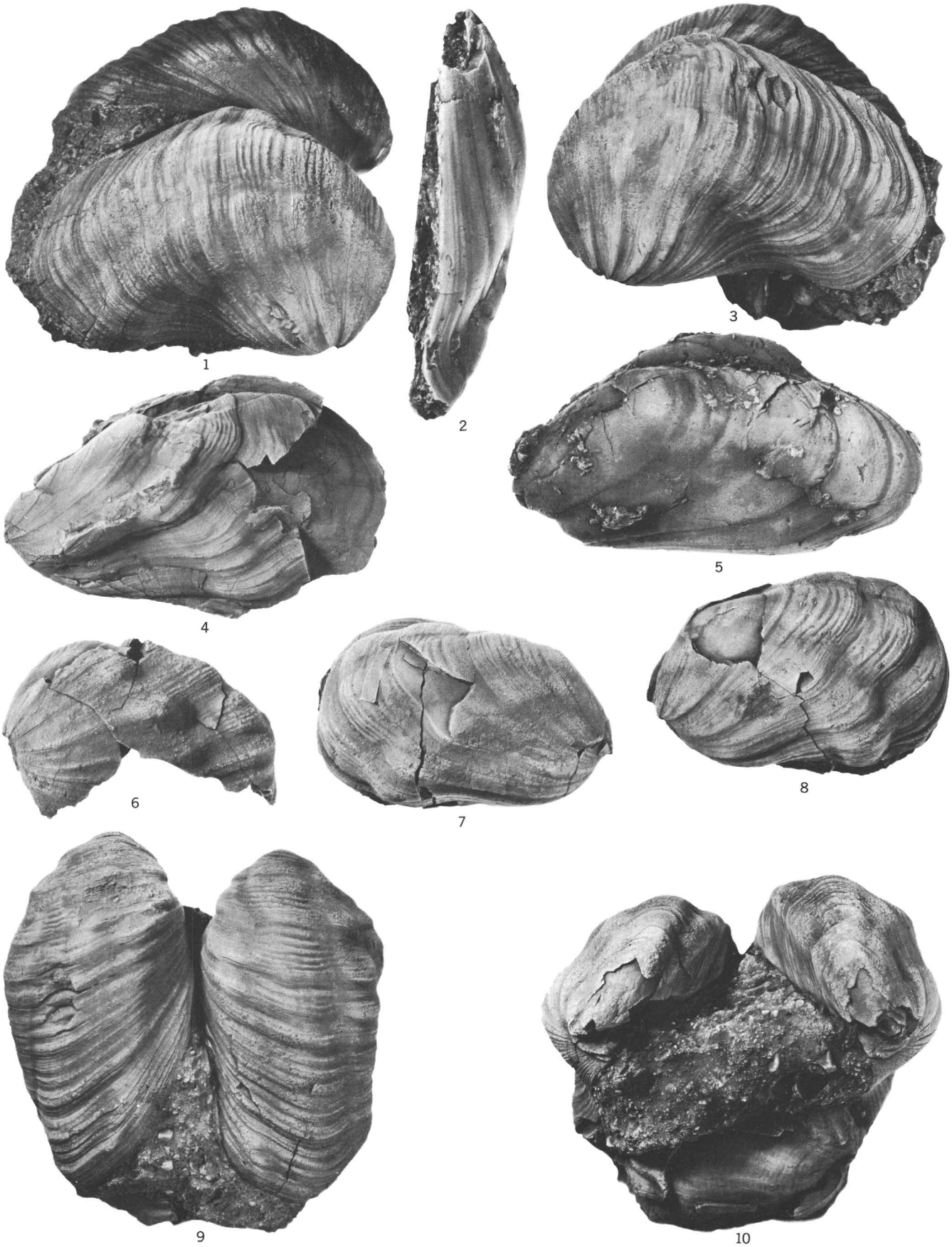
4. USNM 647067. Length 72 mm. Unga Conglomerate Member of the Bear Lake Formation, Alaska Peninsula, Alaska. USGS Cenozoic loc. M1022.

6. USNM 647069. Length 53 mm. Bear Lake Formation, Alaska Peninsula, Alaska. USGS Cenozoic loc. M5182.

7, 8. USNM 647070. Length: right valve 57 mm, left valve 56 mm. Bear Lake Formation, Alaska Peninsula, Alaska. USGS Cenozoic loc. M5182.

2, 5. *Mytilus* (*Plicatomytilus*) n. sp. (p. 13).

USNM 647084. Length 77 mm. Kakert suite of the "Kavran Series", mouth of the Kavran River, western Kamchatka, U.S.S.R. Geological Institute, Moscow, loc. 69.



MYTILUS (*PLICATOMYTILUS*) *GRATACAPI* AND
MYTILUS (*PLICATOMYTILUS*) N. SP.

PLATE 3

[All figures ×1]

FIGURES 1, 3, 5, 7, 8. *Mytilus* (*Plicatomytilus*) *gratacapi* n. sp. (p. 9).

1. USNM 647071. Length 72 mm. Bear Lake (?) Formation, Herendeen Bay, Alaska. USGS Cenozoic loc. M5174.
3. USNM 647072. Length 70 mm. Bear Lake Formation, Port Moller, Alaska. USGS Cenozoic loc. M805.
5. USNM 647073. Length 70 mm. Bear Lake Formation, Port Moller, Alaska. USGS Cenozoic loc. M805.
7. USNM 647074. Length 63 mm. [Bear Lake Formation.] North side of Port Moller, Alaska. USGS Cenozoic loc. 5046.
8. USNM 647075. Length 52 mm. Bear Lake Formation, Port Moller, Alaska. USGS Cenozoic loc. M805.

2, 4, 6. *Mytilus* (*Plicatomytilus*) *middendorffi* Grewingk, 1850 (p. 3).

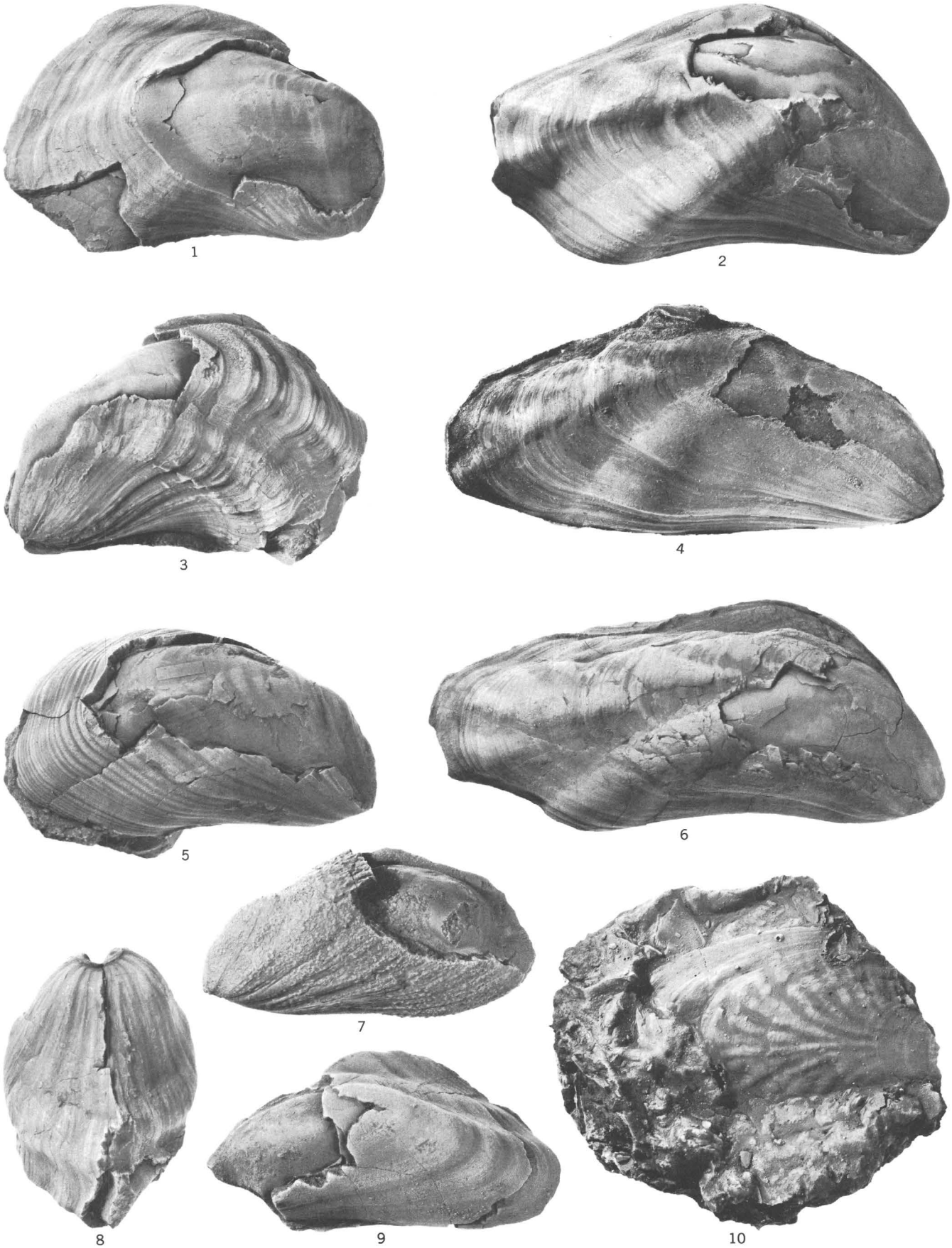
2. USNM 647065. Length 92 mm. Narrow Cape Formation, Kodiak Island, Alaska. UA loc. A–256.
4. USNM 647076. Length 95 mm. Lower part of the Empire Formation of Diller (1903), near Cape Blanco, Oregon. USGS Cenozoic loc. M4130.
6. USNM 647060. Length 102 mm. Lower part of the Empire Formation of Diller (1903), near Cape Blanco, Oregon. USGS Cenozoic loc. M5737.

9. *Mytilus* (subgenus?) n. sp. (p. 7).

USNM 647077. Length 68 mm. Pyramid Hill Sand Member of the Jewett Sand, Kern River area, California. USGS Cenozoic loc. M1591. Although this undescribed species is not referable to *Plicatomytilus*, it is found in the Jewett Sand of California, the Clallam Formation of Washington, and the Kuluven suite of western Kamchatka.

10. *Mytilus* (*Mytilus*) *condoni* Dall, 1890 (p. 7).

USNM 647078. Length 55 mm. Unnamed strata of late Pliocene age, Willapa Bay, Washington. USGS Cenozoic loc. M5219.



MYTILUS (PLICATOMYTILUS) GRATACAPI, MYTILUS (PLICATOMYTILUS) MIDDENDORFFI, MYTILUS (SUBGENUS?) N. SP., AND *MYTILUS (MYTILUS) CONDONI*