James H. McLean

Tertiary Marine Pelecypods of California and Baja California: Nuculidae through Malleidae

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1228-A

Tertiary Marine Pelecypods of California and Baja California: Nuculidae through Malleidae

By ELLEN JAMES MOORE

PALEONTOLOGY OF CALIFORNIA AND BAJA CALIFORNIA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1228-A

A total of 233 species of pelecypods are illustrated, original descriptions quoted, taxonomy revised and updated, comparisons made with other species, geographic and geologic ranges given, occurrence by geologic formation cited, and habitat included when it can be confidently inferred

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TERTIARY MARINE PELECYPODS OF CALIFORNIA AND BAJA CALIFORNIA: NUCULIDAE THROUGH MALLEIDAE

By Ellen James Moore

ABSTRACT

Marine mollusks are the principal means of dating and correlating the shallow-water facies that have persisted in Cenozoic marine basins along the Pacific coast of North America. This study focuses on California, the standard of reference for Cenozoic sequences of the northeast sector of the Pacific Ocean basin.

Approximately 2,500 species of Tertiary marine mollusks were originally described from California, and about 50 from the Baja California Peninsula. A few additional species occur in the Californias that were originally described from other west coast localities. Descriptions of these species are spread through some 200 papers that span about 125 years of study. Some of these species are synonyms, and many are of doubtful status, never having been adequately illustrated. Consequently, research and practical utilization of Tertiary mollusks in geologic-age determination and biostratigraphy has often been difficult.

In this synthesis, all Tertiary marine mollusks from the Californias are illustrated, the original description quoted, the taxonomy revised and updated, comparisons made with other species, geographic and geologic ranges given, the occurrence by formation in the Californias cited, and the habitat described when known from living specimens of the species or inferred from related species. Tables for the larger families are incorporated to show geographic and age ranges of the included species.

This study is intended to improve the utility of marine mollusks in Cenozoic biostratigraphy of the Pacific coast of the conterminous United States and northern Mexico and, to a lesser extent, of Alaska, Kamchatka, and northern Japan.

The compilation begins with the pelecypods; this chapter describes 233 species of the families Nuculidae, Nuculanidae, Solemyidae, Arcidae, Parallelodontidae, Cucullaeidae, Noetiidae, Limposidae, Glycymerididae , Manzanellidae, Mytilidae, Pinnidae, Pteriidae, Isognomonidae, Pulvinitidae, and Malleidae. Other chapters will follow in systematic order.

INTRODUCTION

PURPOSE AND SCOPE

The literature pertaining to the Tertiary marine mollusks of California and the Baja California Peninsula spans about 125 years and includes descriptions of approximately 2,500 species in several hundred papers published in various journals. Many of these species have never been adequately illustrated.

This synthesis brings together systematically all the descriptions of species originally named from, or subsequently found in, the marine Tertiary rocks of California and the Baja California Peninsula and, to the extent that is practical, illustrates the holotypes of these species. Taxonomy is revised and updated; supplementary descriptions and comparisons are included; geographic, geologic-age, and ecologic ranges recorded; and reported occurrences in geologic formations in the Californias given. The goal is to improve the effectiveness and accuracy of utilizing mollusks in Cenozoic biostratigraphy.

The compilation is being published as a series of separate chapters of a Professional Paper. The arrangement is biologically systematic and the families are arranged as cited in the *Treatise On Invertebrate Paleontology* (Moore, 1969), beginning with the family Nuculidae. Subsequent chapters will deal with the remaining pelecypods and the gastropods, scaphopods, and cephalopods.

PROCEDURE

All Tertiary marine mollusks originally described from California and the Baja California Peninsula, and all species originally described from other geographic localities but known to occur in the Tertiary of the Californias, are included in this study. All positively identified species that have been found on faunal lists are also included. If a species is not positively identified or is questioned or only compared, it is generally not included. In genera that are extremely rare in the fossil record, however, I have included species that are only questionably identified.

In this work, species are arranged systematically following the order of families, genera, and subgenera given in the *Treatise* (Moore, 1969). Within the systematic groups, species are arranged by geologic age,

beginning with the oldest species and ending with the youngest. The order in which families are arranged and the generic and subgeneric catergories have generally not been modified, except in a few cases. Most modifications made reflect either definitive papers published after publication of the *Treatise* in 1969 or works published earlier but not cited in it.

Some of the names of genera and subgenera used in the *Treatise* and adopted in this paper have not been used before for west coast Tertiary species. Brief synopses of generic and subgeneric characters are given in the appropriate places; more complete synopses will be found in the *Treatise* (Moore, 1969), in Keen (1971), and in Olsson (1961). For genera and subgenera that are not included in the *Treatise,* complete descriptions are given in the text.

For large families, a distribution table is included to show graphically the geographic and geologic distribution of species within the family. To facilitate finding a specific taxon, the species are listed alphabetically under genus and subgenus in the tables.

The synonymy for each species includes the original citation and subsequent substantive references, with particular emphasis on papers published after the checklist of Keen and Bentson (1944). The accuracy of identifications cited in subsequent references in the synonymy has not been verified. No attempt is made to include all references to a species, but the reader is referred to any citations that include extensive synonymies.

The original description is quoted from the author of the species and is not modified; nor is it translated if in a language other than English.

The type is usually that of the author of the original description or of later workers who selected a lectotype or neotype. In some instances, where syntypes or cotypes are cited but only one figured, I have herein designated the figured specimen as the lectotype. Lectotypes have also been designated for species originally based on many unfigured syntypes. Where any confusion exists concerning the type specimen, the most logical specimen is selected as the lectotype.

Where the original locality description is so vague that it is of little use, the type locality is described as corrected or modified by other workers such as Keen and Bentson (1944) and the modifications given within brackets. All other localities are cited as originally described except that the formation given is that currently used.

Previously published supplementary descriptions and comparisons are included where this information adds to the original description of the species. Where such information is not available or inclusive, I have supplemented the original description in the section headed "Comments." For most descriptions, my comments are based only on examination of primary type material.

All available published data for each species have been included in the section on geographic and geologic age range, including that contained in faunal lists when the identification is unqualified. Range extensions into Alaska are based on written communications from Scott McCoy, Jr., Amoco Production Co., and Richard C. Allison, University of Alaska, on data not previously published. I am deeply indebted to them for making their material available to me.

Age ranges have not been refined within epochs. Where a stage name the same as a formation name is used, it is placed in quotation marks to distinguish it from the rock unit.

The divisions used here to indicate the approximate geographic range of species within California based on county distribution are northern, middle, and southern (fig. 1); the divisions for the Baja California Peninsula, norte and sur (fig. 2) (Tables 1-8).

An attempt has been made to include all citations to a species that are unqualified and every geologic formation in which it is reported to occur in the Californias. The assumption has been made that all identifications of species are correct unless there is a strong evidence to the contrary. The stratigraphic nomenclature used herein is that of the author(s) cited and does not necessarily agree with that of the U.S. Geological Survey. The age given for the stratigraphic units follows the classification of geologic time curently used by the U.S. Geological Survey. (See "Geologic Formations Cited for Occurrence of Pelecypods" at end of paper.) If the age of a formation is more than one epoch and a species is known to occur in only one part of that formation, this information is added. Except for the type locality of the species, each formation listed is followed by the name of the author and date of publication of the work from which it was obtained. More than one reference to a formation is given where it might be useful to the reader. The list of formations given for species occurrence should not be considered complete or necessarily accurate. Many western American Tertiary faunas have not been monographed, and their species content is not fully known. It is hoped that the list of formational occurrences reported will serve as a framework upon which the true distribution of each species can be built.

Most of the data on habitat have been compiled from Abbott (1974), Burch (1974), Hertlein and Grant (1972), Keen (1971), Smith and Gordon (1948), Stanley (1970), and Yonge and Thompson (1976).

The type specimens were all photographed by Kenji

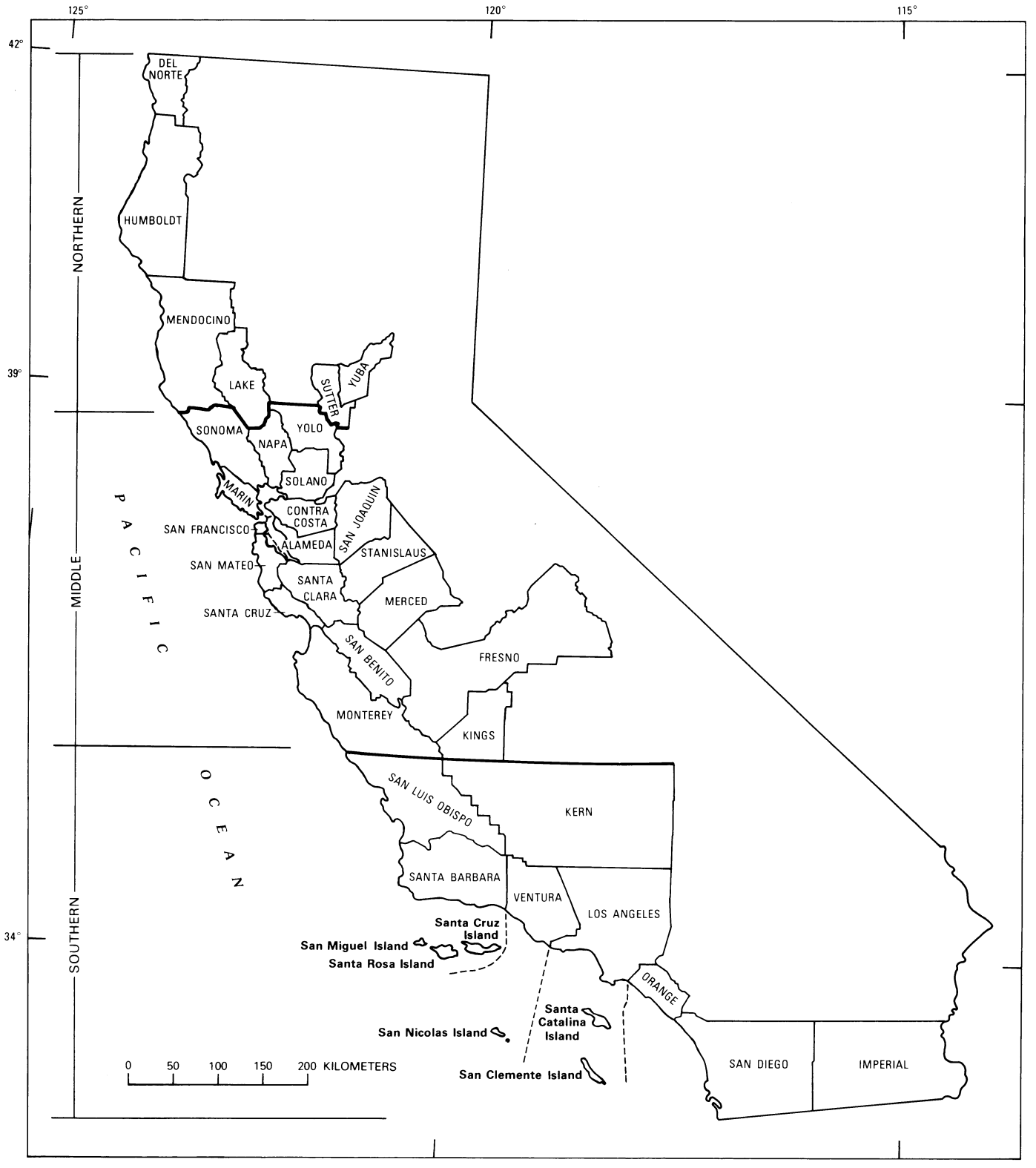

FIGURE 1.—Divisions used for geographic ranges of species of pelecypods, Nuculidae to Malleidae, reported from California. Heavy solid lines indicate Northern, Middle, and Southern divisions; dashed lines within southern region divide Channel Islands area.

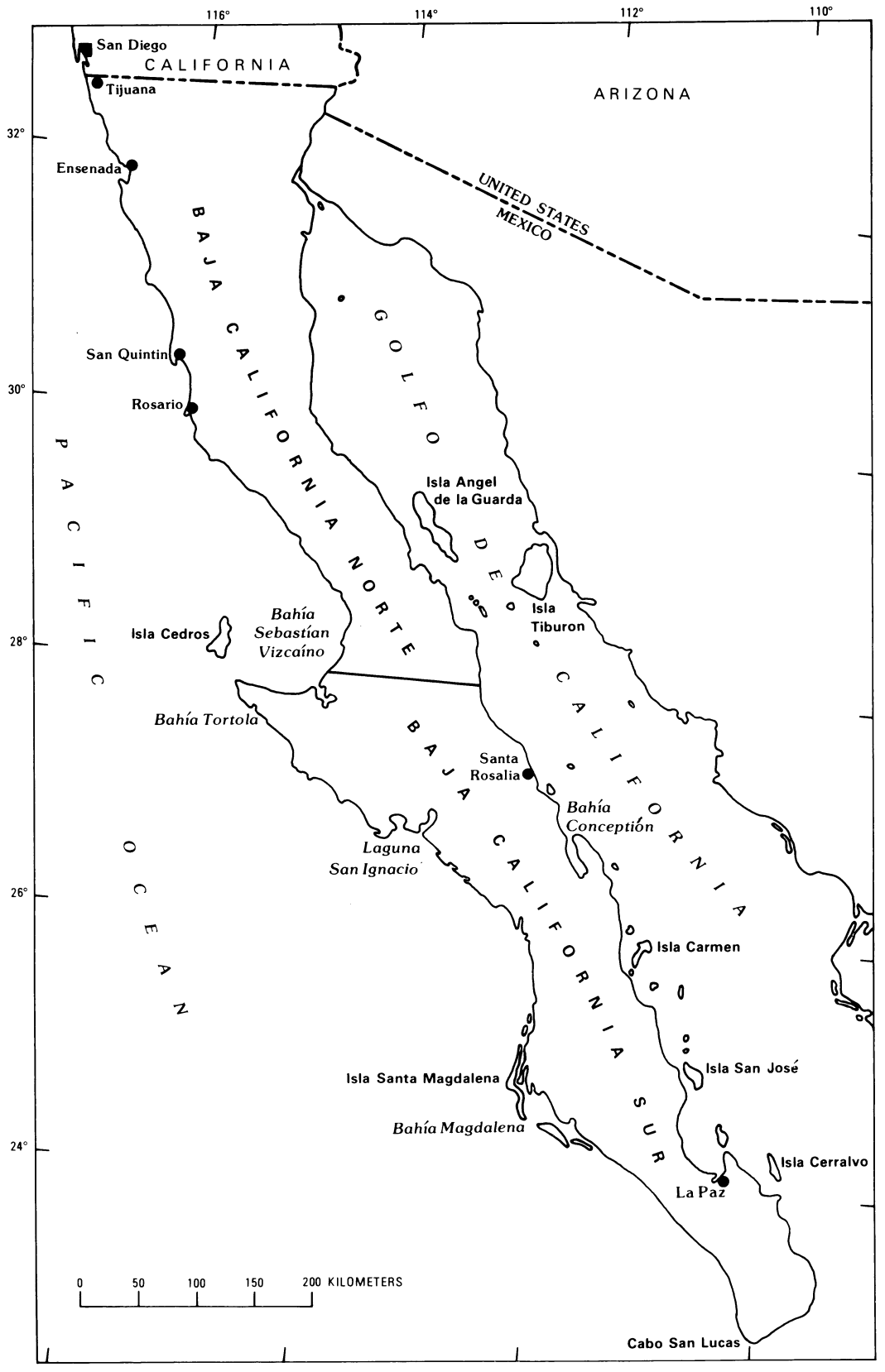

FIGURE 2.—Divisions used for geographic ranges of species of pelecypods, Nuculidae to Malleidae, reported from Baja California Peninsula.

Sakamoto, U.S. Geological Survey, with the exception of those housed in the National Museum of Natural History, which were photographed by Robert H. McKinney. Owing to the fact that the specimens photographed by Sakamoto were borrowed from other institutions, he did not use his usual technique of opaquing specimens for photography (Sakamoto, 1973). Photographs of a few specimens were furnished by other individuals or institutions; credit is given them on the plate explanations. The holotype of each Tertiary species is figured if the type is extant. Some Holocene type specimens retained in museums outside the United States have not been figured; specimens considered to be of the same species by authors such as Keen (1971) or Hertlein and Grant (1972), or Holocene specimens from the type locality, are used for these illustrations, and this information is included in the plate explanation. A few substitutions are made for missing Tertiary types, as noted in the plate explanations along with their source.

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Warren O. Addicott, U.S. Geological Survey, originally suggested this project, and since its inception has given me his wholehearted support, as has Louie Marincovich, also of the U.S. Geological Survey. They both also reviewed the manuscript, and their pertinent suggestions were most helpful.

A. Myra Keen, Stanford University, made available the files of the late Prof. Hubert G. Schenck, which contain many original descriptions of species and copies of original photographs. Professor Keen also gave generously of her time with many problems, in addition to reviewing the manuscript, and I owe her a debt of gratitude.

John G. Vedder, U.S. Geological Survey, assisted in pointing out pertinent references that included faunal lists and kindly checked all the sections on occurrence of species. Wendell P. Woodring, National Museum of Natural History, counseled me on the format to be used; his suggestions were most helpful.

Vida C. Kenk, San Jose State University, assisted me with generic and subgeneric allocation of the Mytilidae, and I am indebted to her for her advice. Takeo Susuki, University of California at Los Angeles, gave his faunal list from the Topanga Canyon Formation, Barry Roth, California Academy of Sciences, his faunal lists from the Wildcat Group, and William J. Zinsmeister, Ohio State University, his faunal list from the Paleocene of Simi Hills, Calif. I am indebted to them for letting me use their unpublished data.

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Mildred P. James made up cards for each species and its occurrences as noted on faunal lists. This was a time-consuming task, and I thank her for her patience and support.

ABBREVIATIONS

ANSP: The Academy of Natural Sciences of Philadelphia, Pa.

BM(NH): British Museum of Natural History, London, England.

CAS: California Academy of Sciences, San Francisco, Calif.

LAM: Los Angeles Museum of Natural History, Los Angeles, Calif.

MCZ: Harvard Museum of Comparative Zoology, Cambridge, Mass.

SDNM: San Diego Museum of Natural History, San Diego, Calif.

CAS/SU: Stanford University, Stanford, Calif. (The Stanford University collections are now housed at the California Academy of Sciences.)

CIT: California Institute of Technology, Pasadena, Calif. (The California Institute of Technology type collections are now housed at the Los Angeles Museum of Natural History.)

SU: Stanford University, Stanford, Calif.

UC: University of California, (Berkeley)

UCMP: University of California, Museum of Paleontology, Berkeley.

UCR: University of California at Riverside.

USCB: University of California at Santa Barbara.

USGS: U.S. Geological Survey, Washington, D. C., Cenozoic locality register.

USGS M: U.S. Geological Survey, Menlo Park, Calif., Cenozoic locality register.

USNM: National Museum of Natural History, Washington, D. C.

UW: University of Washington, Seattle, Wash.

SYSTEMATICS: PELECYPODS

Family NUCULIDAE Gray

Ovate; beaks opisthogyrate; internal ligament in a resilifer; inner shell material nacreous.

Habitat.—Cold-water forms in general, mostly offshore; tropical species apt to occur in very deep bathyal water; burrows superficially, living just beneath the sediment surface; moves slowly and sporadically.

Genus NUCULA Lamarck, 1799

Subgenus NUCULA s.s.

Inner margin of shell with small denticles.

Geologic range.—Cretaceous through Holocene (table 1).

Habitat.—Greatest number of species in temperate and boreal regions, intertidally (Marincovich, 1973, p. 7) to more than 3,660 m.

Nucula (Nucula) capayensis Schenck

Plate 1, figures 1, 2

Nucula (Nucula) capayensis Schenck, 1939, p. 34-35, pl. 6, figs. 16-18, 20.

Original description.—"Shell large for subgenus; dorsal margin gently convex; anterior extremity bluntly pointed dorsal to the convex ventral margin; posterior side truncate, but slightly inclined, giving a weak rostrate appearance to shell; numerous radial ribs up to about 560 microns in width, separated by narrow interspaces; inner ventral margin crenulate; chondrophore oblique, about 12 posterior, 26 anterior teeth; escutcheonal area set off by low sunken area; beaks opisthogyrate; length (dorsal margin horizontal), 32 mm, height, 22.5 mm, semithickness, 6.8 mm, umbonal angle, 115°."

Holotype.—UCMP 30196.

Type locality.—UC A-1319. Yolo County, Calif. Capay Formation, Eocene.

Comparisons.—This species has the general profile and sculpture of the smaller *Nucula cooperi* Dickerson, but the flat radial ribs of *N. cooperi* are much narrower, about 130 microns in width, and are separated by narrow interspaces. The largest reported specimen of *N. cooperi* is only 12.0 mm in length and even that individual may be immature. (Schenck, 1939, p. 35)

Comments.—Concentric ridges are fairly prominent near the anterior margin on the holotype; the radial ribs are barely perceptible near the ventral margin.

Geographic range.—Northern California.

Geologic range.—Eocene.

Occurrence in California.—Capay Formation.

Nucula (Nucula) cooperi Dickerson

Plate 1, figures 3, 4

Nucula cooperi Dickerson, 1913, p. 290, pl. 14, figs. 2a, 2b. Vokes, 1939, p. 40, pl. 1, figs. 1, 2.

Original description.—"Shell small, rounded triangular; small rather prominent beaks located about a third of the length from the anterior end and inclined forward. Cardinal margin nearly straight, sloping rapidly to the posterior margin; anterior end truncated, excavated under the beaks, slightly concave and united with the basal margin by a sharp angle; basal margin evenly rounded; posterior end narrowly rounded. Surface marked by many minute lines of growth and by small radiating ribs. Hinge robust, pit, very small."

Lectotype.—UCMP 11754a, herewith designated. Two specimens are in the type collection. The largest fits the dimensions of the specimen figured by Dickerson, although the valve has a large borehole not shown; this specimen is the lectotype.

Type locality.—UC 1853. Sutter County, Calif. Capay Formation, Eocene.

Supplementary description.—"The hinge of the left valve has 9 or 10 teeth in the posterior row and 16 or 17 in the anterior row, the rows being separated by a ligamental pit which is small, elongate-trigonal and directed anteriorly. The first tooth of the posterior row is large and trigonal in shape; the other teeth are straight. The inner margins of the valve are crenulate, and the muscle scars moderately large and rather deeply set; the pallial line is entire." (Vokes, 1939, p. 40)

TABLE 1.—*Geologic and geographic distribution of the family Nuculidae in the eastern Pacific region*
[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	Alaska	British Columbia	Washington	Oregon	California			Baja California		Central and/or South America
					Northern	Middle	Southern	Norte	Sur	
Genus *Nucula*:										
Subgenus Nucula:										
capayensis Schenck					E					
cooperi Dickerson					Pa and E	Pa and E	E			
vitis Anderson and Hanna							E			
Subgenus *Leionucula*:										
balboana Hertlein and Grant							Pl			
birchi Keen							M			
postangulata Clark						M?				
Subgenus *Lamellinucula*:										
exigua Sowerby							Pl and Ple		H	H
Genus *Nucula*?:										
bifida Clark						M?				
Genus *Acila*:										
Subgenus *Acila*:										
gettysburgensis (Reagan)	O and M	O and M	E? to M	O and M		E?; O and M				
semirostrata (Grant and Gale)						M and Pl	M to Ple			
Subgenus *Truncacila*:										
castrensis (Hinds)	H	H	H	H	Pl to H	M to H	M to H	H		
conradi (Meek)	M[1]		M	M		M	M			
dalli (Arnold)						E and O	O			
decisa (Conrad)	E[1]		E	E	Pa	Pa and E	E			
decisa, unnamed form, Vokes						Pa and E	E			
empirensis Howe	Pl[1]		Pl	M	Pl and Ple					
muta Clark						M?	O			
shumardi (Dall)	O		O	O	E and O	E and O	E and O			

[1]Scott McCoy, written commun., 1978

Comparisons.—*Nucula cooperi* closely resembles *Nucula solitaria* Gabb of the Cretaceous Chico Group, but is readily distinguished from it by radiating ribs (Dickerson, 1913). *N. cooperi* has the general profile and sculpture of the larger *Nucula capayensis* but has radial ribs that are much narrower (Schenck, 1939, p. 35). *N. cooperi* is smaller than *Nucula vitis* and has broader radial threads (Anderson and Hanna, 1925, p. 176).

Geographic range.—Northern and middle California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Marysville (Keen and Bentson, 1944) and Meganos (Clark, 1921) Formations; Paleocene and Eocene: Cerros Shale Member, Lodo Formation (Keen and Bentson, 1944); Eocene: Avenal Sandstone, Capay (Merriam and Turner, 1937), and Domengine (Vokes, 1939) Formations.

Nucula (Nucula) vitis Anderson and Hanna

Plate 1, figure 5

"*Nucula cooperi* Dickerson" of Dickerson, 1915, p. 42. Not *Nucula cooperi* Dickerson, 1913, p. 290, pl. 14, figs. 2a, 2b.

Nucula vitis Anderson and Hanna, 1925, p. 175, pl. 2, fig. 14, text fig. 8.

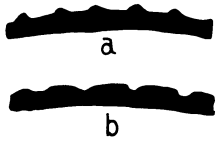
Original description.—"Shell trigonal in outline, rounded below; beaks full, turned gently backward; anterior slope convex, joining the basal margin with rounded angle; posterior slope flattened, almost straight, joining basal margin with abrupt angle of a little more than 90°, sculptured only with rather coarse lines of growth; remainder of surface marked by distinct lines of growth and numerous radiating threads which are very narrow, only about one-third as wide as the flat-bottomed grooves; boundary of posterior slope carinated, slightly convex when viewed horizontally; length 8.2 mm; height 6.9 mm." (Anderson and Hanna, 1925)

Holotype.—CAS 788.

Type locality.—CAS 245. Kern County, Calif. Tejon Formation, Eocene.

Comments.—In the original description, anterior and posterior are reversed.

Comparisons.—"The Tejon species is larger than *N. cooperi* Dickerson, in which the posterior slope is not convex; radial threads are broader in the last and are separated by narrow grooves as shown somewhat diagrammatically***.



(a) Diagrammatic cross section of *Nucula vitis* near center of marginal area, showing sculpture; (b) *Nucula cooperi*. In *Nucula vitis* the posterior and anterior slopes meet at the beak in an angle of 90°, whereas in *N. cooperi* the angle is 110°. All references to *N. cooperi* in the Type Tejon locality appear to have been based upon mistaken identity." (Anderson and Hanna, 1925, p. 176)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Type Tejon Formation.

Genus NUCULA?

Nucula? bifida Clark

Plate 1, figures 6, 7

Nucula bifida Clark, 1918, p. 122, pl. 12, figs. 10-12.

Original description.—"Shell small, subtrigonal in outline; beaks inconspicuous, recurved. Anterior dorsal slope gently convex; posterior dorsal slope very steep; apical angle a little more than 90°. Anterior end broadly and regularly rounded; ventral edge rather strongly and regularly arcuate. Surface of type sculptured by 22 fairly heavy, rounded, radiating ribs, a few of which are bifid or split near their lower ends; interspaces between the radiating ribs about equal to the width of the ribs. Escutcheon only very slightly depressed, but marked off by oblique radiating ribs which branch off from the last rib of the general surface; some of these are bifid distally. Lunule not depressed but marked by a sculpturing similar to that of the escutcheon. Hinge plate unknown. Length, 6 mm.; height, 4.5 mm.; greatest diameter of both valves, 3 mm."

Holotype.—UCMP 11184.

Type locality.—UC 331. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparisons.—"This beautiful species appears to be quite unique; the writer found nothing on the West Coast, either fossil or recent, with which to compare it. Though the hinge plate is not known, yet the general outline and sculpturing of the shell would seem to place it under the genus *Nucula*." (Clark, 1918, p. 122)

Comments.—If this species is indeed a *Nucula*, it probably can be assigned to *Nucula s.s.*, as it has radial ribs and therefore presumably has a crenulate inner margin. The shell is nuculid in outline, but the radial ribs are very heavy for a nuculid; a few are dichotomous on both valves near the ventral margin.

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—Miocene(?). San Ramon Sandstone (Keen and Bentson, 1944).

Subgenus LEIONUCULA Quenstedt, 1930

Inner margin of shell smooth.

Geologic range.—Cretaceous through Holocene (table 1).

Habitat.—15 to 2,275 m.

Nucula (Leionucula) birchi Keen

Plate 1, figures 8, 9

Nucula (Ennucula) birchi Schenck and Keen, 1940, p. 10, pl. 4, figs. 6, 7 [*nomen nudum*].

Nucula (Ennucula) birchi Keen, 1943, p. 41, pl. 3, figs. 9-12.

Original description.—"Shell small, solid, ovate, beaks low, opisthogyrate; lunule and escutcheon not marked; sculpture of incremental lines only; posterior end truncate, anterior produced and rounded, base arched; interior nacreous, adductor and auxiliary muscular impressions present, faint, basal margin smooth; hinge strong, chondrophore oblique, anterior teeth 15, posterior 6." (Keen, 1943)

Holotype.—CAS/SU 7527.

Type locality.—SU 2121. Kern County, Calif. Lowermost part of Round Mountain Silt, Miocene.

Comparisons.—From *Nucula nuculana* (Dall) of the Astoria Formation, Washington and Oregon (Moore, 1963, p. 52-53), the only other described West American Miocene *Nucula*, Keen (1943, p. 4) distinguishes this species by its smaller diameter, its more ovate outline, and its lack of impressed escutcheon. She adds that *Nucula postangulata* Clark is less attenuated anteriorly and has an impressed escutcheon, according to the original description.

Comments.—*Nucula postangulata* is similar to *N. birchi* Keen but is slightly flattened along the shell edge just below the anterior dorsal margin, is slightly less produced, and is more evenly rounded near the posterior ventral margin than *N. birchi*.

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Upper part of the Olcese Sand (Addicott, 1956) and lowermost part of the Round Mountain Silt.

Nucula (Leionucula) postangulata Clark

Plate 1, figure 12

Nucula postangulata Clark, 1918, p. 122, pl. 13, figs. 2-5.

Original description.—"Shell small, equivalved, inequilateral; subtrigonal to subovate in outline; beaks rather inconspicuous, opisthogyrous. Posterior dorsal slope abrupt, being a little more than at right angles to the anterior dorsal slope. Anterior end regularly rounded; posterior end subangulate. Escutcheon depressed and well-defined, lanceolate to subcordate, extending nearly to the posterior end, pouting rather sharply along its entire length. Lunule absent. Surface smooth except for fine, somewhat irregular incremental lines. Hinge plate unknown. Type 6.25 mm long; 4.75 mm high."

Holotype.—UCMP 11260.

Type locality.—UC 2754. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparisons.—See *Nucula (Leionucula) birchi.*

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—San Ramon Sandstone.

Nucula (Leionucula) balboana Hertlein and Grant

Plate 1, figure 10

Nucula (Ennucula) balboana Hertlein and Grant, 1972, p. 145-146, pl. 27, figs. 1-4.

Original description.—"Shell ovately triangular, smooth, beaks opisthogyrate, placed near posterior end, a lanceolate depressed area beneath them; the posterior margins of the valves slightly projecting; a narrow area along the anterior dorsal margin slightly depressed; anterior margin broadly rounded, the anterior end elliptically rounded, the posterior end slightly round and abruptly truncated; surface of valves with fine concentric lines of growth, toward the anterior margin with occasional minute constrictions; inner margin of shell smooth and devoid of denticles. Portions of two paratypes reveal the presence of about 18 teeth in the anterior series and about 8 or 9 in the posterior series. The chondrophore projects obliquely anteriorly. Dimensions of holotype: length, 13.4 mm; height 10.7 mm; convexity (both valves together slightly gaping due to enclosed sediment), 7.2 mm."

Holotype.—CAS 59684.

Type locality.—CAS 12099, San Diego County, Calif. San Diego Formation, Pliocene.

Comparison.—This species closely resembles the living species *Nucula (Leionucula) quirica* Dall but differs in that the shell is relatively more elongate and the anterior margin correspondingly less broadly rounded, and so far as known, there is no trace of fine radial striae on the interior of the valves. (Hertlein and Grant, 1972, p. 145-146)

Geographic range.—Southern California.

Geologic range.—Pliocene.

Occurrence in California.—Niguel (J. G. Vedder, written commun., 1978) and San Diego Formations.

Subgenus LAMELLINUCULA Schenck, 1944

Inner margin with small denticles; strong incised concentric sculpture; weak radial ribs.

Geographic range.—Europe, North America, South America, and Africa.

Geologic range.—Eocene through Holocene (table 1).

Habitat.—5 to 220 m, possibly deeper.

Nucula (Lamellinucula) exigua Sowerby

Plate 1, figure 13

Nucula exigua Sowerby, 1833, p. 198.

Nucula (Nucula) exigua Sowerby. Schenck, 1939, p. 36, pl. 6, figs. 1-8, 11.

Nucula (Nucula) exigua Sowerby. Hertlein and Grant. 1972, p. 146-147, pl. 27, figs. 5, 6.

Original description.—"Nuc. testa parva, oblique ovata, albicante, pellucida, concentrice sulcata; latere postico longiore, subacuminato, antico brevissimo: long. 0.2, lat. 0.1, alt. 0.15 poll."

Holotype.—BM(NH).

Type locality.—Bay of Caracas, probably the island of Curacao, west Colombia, South America (Schenck, 1939, p. 36). Holocene.

Supplementary description.—"This small trigonal species has strong, uniform concentric sculpture***" (Grant and Gale, 1931, p. 111).

"One left valve and two imperfect right valves*** retain traces of radial striae, crossing the stronger ribbing, over most of the surface of the valves. This feature, however, varies in a series of Recent specimens of this species as does the amount of escutcheonal projection." (Hertlein and Grant, 1972, p. 146)

Comparisons.—*Nucula suprastriata* Carpenter in Arnold (1903, p. 96, pl. 18, fig. 6), a similar species or subspecies, is said to differ from *N. exigua* by having a more impressed lunule and escutcheon and by radial sculpture that usually is present only near the base of the valves. (Hertlein and Grant, 1972)

Geographic range.—Living: Bahía Tórtolo, Baja California Sur, to the Golfo de California, and south to Ecuador; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: San Diego Formation (Hertlein and Grant, 1972); Pliocene and Pleistocene: Fernando(?) Formation (Kennedy, 1975); Pleistocene: unnamed strata in southern California (Kanakoff and Emerson, 1959).

Habitat.—16 to 1,895 m (Hertlein and Grant, 1972, p. 146).

Genus ACILA Adams and Adams, 1858

Shells with chevronlike sculpture.

Habitat.—Marine, does not occur in estuaries. Below intertidal zone to 1,465 m, usually at depths less than 915 m. Most abundant in cool and cold water with greatest diversity in temperate water between 4° and 20°C; in deep water, only south of the equator. Prefers mud or fine sand bottom; fossils abundant in siltstone, shale, and fine-grained sandstone. (Schenck, 1936, p. 9, 31-33)

Subgenus ACILA Adams and Adams

Shell with rostral sinus from umbo to ventral margin; usually one or more bifurcations of radial ribs in addition to primary one.

Geographic range.—Living off Hokkaido, Japan, to the Bay of Bengal and Arabian Sea.

Geologic range.—Eocene(?); Oligocene through Holocene (table 1).

Acilia (Acilia) gettysburgenis (Reagan)

Plate 1, figure 11

Nucula (Acila) gettysburgensis Reagan, 1909, p. 171, 175, 177, pl. 1, fig. 3. Clark, 1932, p. 804, pl. 14, fig. 12.

Nucula (Acila) gettysburgensis alaskensis Clark, 1932, p. 804-805, pl. 14, fig. 15.

Acila (Acila) gettysburgensis (Reagan). Schenck, 1936, p. 78-81, pl. 12, figs. 1-15; pl. 13, fig. 7; text fig. 8; *not* figs. 4, 7. Addicott, Kanno, Sakamoto, and Miller, 1971, p. C20, fig. 3, g, k, m. Addicott, 1976b, p. 121-123, 3 figs.

Original description.—"***Shell trigonal, convex, medium thickness; umbones considerably posterior to center, turned posteriorly, posterior end 16, anterior extremity 24.5 from umbones; posterior end short, truncated, concave back of umbones; anterior end rounded to arcuate, forming an acute angle with the anterior extremity; ventral and cardinal margins subparallel; lunule area large, slightly scooped out, sculptured same as rest of shell; a low ridge fronts each valve back of the lunule area, back of which there is a wide, flat, curved sinus extending from the umbo to the ventral margin, widening as it approaches that margin; surface divaricately sculptured, also ornamented with about seven concentric low ridges; inside of shell not seen. Dimensions: Lat, 28, alt, 19.5."

Holotype.—USNM 328302.

Type locality.—Clallam County, Wash., in sea cliffs near Gettysburg. Twin River Formation, Eocene to Miocene.

Supplementary description.—Shells smaller than 6 mm in length, truncate, primary bifurcation only, radial ribs about 200 microns wide, no rostral sinus. Shells 10 mm long have a well-developed sinus and show four or more concentric lines of growth. Shells 10-15 mm long are rostrate; secondary bifurcation sometimes present, radial ribs about 250 microns wide. Shells 15-20 mm long have distinct rostral sinus; secondary bifurcation present on some specimens. Specimens 25-30 mm long with rostral sinus, 11 or more well-defined concentric lines of growth; secondary bifurcation in area posterior to sinus generally present, on several a double bifurcation along line of primary bifurcation; radial ribs about 300 microns wide, interspaces narrower. Specimens between 30-36 mm long (the maximum length) may be gerontic individuals; 14 well-defined concentric lines of growth, narrow area of obsolete radial ribbing rarely present; secondary bifurcation posterior to sinus such that the trough of the sinus is the "V" of the bifurcating lines; radial ribs to 460 mincrons wide, separated by narrower interspaces. (Schenck, 1936, p. 79)

Comparisons.—*Acila gettysburgensis* typically has a stronger posterior sulcation, a larger apical angle, and a more prominent pout on the posterior area than *A. semirostrata*, a Pliocene species and the only other species in the eastern North Pacific Tertiary assigned to the subgenus *Acila*. (Grant and Gale, 1931, p. 115)

Geographic range.—Gulf of Alaska to San Francisco Bay area, California; possibly also in Japan, Kamchatka, and Sakhalin in the western north Pacific (Kristofovich, 1964).

Geologic range.—Eocene(?); Oligocene to Miocene(?) (Addicott, 1976b, p. 123). Peak abundance during Zemorrian Age.

Occurence in California.—Eocene and Oligocene: San Lorenzo Formation (Clark, 1918); Oligocene: Concord Formation of Clark (1918), Kirker Tuff; Miocene(?): San Ramon Sandstone.

Acila (Acila) semirostrata (Grant and Gale)

Plate 1, figures 23, 25

Nucula (Acila) semirostrata Grant and Gale, 1931, p. 113-115, text figs 2a, 2b, 3a, 3b.

Acila (Acila) semirostrata (Grant and Gale). Schenck, 1936, p. 94 pl. 13, figs. 2, 8, 10, text fig. 8.

Acila (Acila) gettysburgensis (Reagan). Schenck, 1936, p. 78-81, pl. 13, figs. 4, 9; *not* fig. 7. Not *Nucula (Acila) gettysburgensis* Reagan, 1909.

Original description.—"Shell relatively large, abruptly truncated posteriorly; ventral and dorsal margins broadly curved, anterior margin strongly curved, the ventral margin slightly and broadly insinuated about three millimeters from the abruptly curved posterior ventral end of the shell; posterior area rather broad, slightly concave and very little flared or pouted where the two valves meet; umbonal angle about 88 or 90 degrees; valves sculptured with numerous raised radial riblets which divaricate along an axis somewhat anterior to the lateral medial line of the valves; hinge with about 19 anterior and about 10 posterior teeth, those near the umbo closely appressed, the two series slightly separated by a small resilial pit; adductor scars prominent, variable in shape."

Holotype.—SDNM 370.

Type locality.—SDNM 442. Boundary line between Los Angeles and Ventura Counties, Calif. Pico(?) Formation, Pliocene.

Supplementary description.—Height is 80 percent or more of length (Schenck, 1935, p. 4). Rostral sinus weakly developed; about 15 concentric growth lines; primary bifurcation appears before 3-mm stage; secondary bifurcation especially noticeable on disk posterior to sinus; radial ribs separated by equal interspaces; escutcheonal area of holotype (a worn right valve) shows indistinctly on an area not crossed by radial ribs; area of obsolete radial ribs conspicuous. Largest right valve measures: length, 30.3 mm; height, 23.7 mm; semithickness, 9.6 mm; unbonal angle, 88°; number of anterior teeth about 19, posterior teeth about 10 (hinge worn). (Schenck, 1936, p. 94)

"A moderately large, short *Acila*. Posterior end truncated, slightly prolonged at the ventral margin. Posterior sinus moderately strong. The apex of the main chevron extends downward in an arc from the umbo. An inverted chevron lies in the posterior sinus, and a minor chevron on the rostrum back of the sinus***. The inverted chevron in the sinus and the minor chevron behind it are not mentioned in the original description and do not show on the figure***(Woodring, 1938, p. 28)

Comparisons.—*Acila gettysburgensis* typically has a stronger posterior sulcation, a larger apical angle, and a more prominent pout on the posterior area than *A. semirostrata* (Grant and Gale, 1931, p. 115). The similarity of these two species, though, has led to misidentification. (Addicott, 1976b)

"The Recent Japanese *A. mirabilis* (Adams and Reeve) has an inverted chevron and minor chevron, but large specimens have a double or multiple main chevron. This species also is larger, more elongate, and more strongly rostrate than *semirostrata*." (Woodring, 1938, p. 28)

Geographic range.—Middle and southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Santa Cruz Mudstone; Miocene and Pliocene: Capistrano Formation (Vedder, 1974); Pliocene: Pico(?)Formation; Pliocene and Pleistocene: Fernando Formation (Vedder, 1972).

Subgenus TRUNCACILA Schenck, 1931

Lacking the well-defined rostral sinus that characterizes *Acila s.s.*; one or more bifurcations of the radial ribs.

Geographic range.—Living from east Africa to the Bay of Bengal, the Philippine Islands, and Japan, and along the west coast of North America from Alaska to San Diego.

Geologic range.—Cretaceous through Holocene (Table 1).

Habitat.—Prefers a cool temperate habitat and depths of 10-915 m (Schenck, 1936, p. 9, 33-35).

Acila (Truncacila) decisa (Conrad)

Plate 1, figure 14

Nucula decisa Conrad, 1855, p. 11, 12; 1856, p. 322, pl. 3, fig. 19 Not *Nucula decisa* Dall, 1898, p. 573.

Acila (Truncacila) decisa (Conrad). Schenck, 1936, p. 53-56, pl. 3, figs. 1-9, 11-15; pl. 4, figs. 1, 2; text figure 7 (22, 23, 25).

Acila gabbiana Dickerson, 1916, p. 481, pl. 36, fig. 1.

Nucula (Acila) stillwaterensis Weaver and Palmer, 1922, p. 6, pl. 8, fig. 8.

Acila lajollaensis M. A. Hanna, 1927, p. 270, pl. 25, figs. 1, 3, 5, 7, 8, 12, 15.

Original descriptions.—"Suboval or subrhomboidal, posterior margin obliquely truncated; disk with divaricating striae." (*decissa*)

"Shell small, oval with straight anterior dorsal margin which slopes steeply to a sharp angle***broadly rounded ventral margin; posterior dorsal margin gently convex; posterior end, narrowly rounded; decoration consisting of delicate divaricate sculpture crossed by incremental lines; lunule fairly definite; escutcheon long and narrow." (*gabbiana*)

"Left valve: Shell of medium size, of moderate thickness, well inflated; beak nearly posterior; dorsal margin only slightly rounded; posterior slightly concave in outline except for a central convexity due to a ridge in the escutcheon; ventral straight near the posterior but rounded anteriorly; anterior rather sharply rounded to the dorsal and ventral margins; surface divaricately sculptured by prominent, elevated, rounded ribs which are separated by deep, round-bottomed interspaces of about the same width as the ribs; the shell is divided into nearly equal parts by this sculpturing; surface concentrically sculptured by growth lines which are most prominent in the interspaces, giving the interspaces a pitted appearance, a few growth lines are prominent over the whole surface; escutcheon large, sculpturing similar to the remainder of the shell except for more numerous ribs; a large prominent ridge runs through the center of the escutcheon causing a concavity on either side due to the inflation of the ridge; lunule not distinct except for change in direction of the ribbing, and a flattening of the surface; inner surface of the type not seen.

"Inner margin of paratype no. 31134 crenulate; muscle scars very unequal in size, the posterior the larger; hinge plate not wide; anterior surface bears about twenty large teeth which decrease in size toward the beak; posterior surface bears about ten large teeth, also decreasing in size toward the beak; pit under the beak elongate anteriorward. *Dimensions:* Altitude 8 mm., length 11 mm." (*lajollaensis*)

Neotype.—UCMP 31132, designated by Schenck (1936, p. 55), formerly the holotype of *Acila lajollaensis* Hanna. (The holotype of *Nucula decisa* Conrad is lost fide Dall, 1909.)

Type locality.—Five km north of La Jolla, San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—"Shell small, ovate-quadrangular, compressed; anterior dorsal margin straight; anterior extremity broadly rounded; ventral margin convex, not parallel to dorsal margin; posterior margin straight, giving truncate profile to shell; umbones inconspicuous; radial ribs 100± microns wide, separated by equal interspaces; no secondary bifurcation; concentric lines present, not conspicuous; no area of obsolete radial ribbing; interior nacreous, smooth; pallial line entire; teeth not available; no rostral sinus. Length up to 8 millimeters; height up to 6.8 millimeters; semithickness, 2.2 millimeters; umbonal angle, estimated, 98 degrees; angle of bifurcation, estimated, 65 degrees." (Schenck, 1936, p. 56)

Comments.—Concentric ridges are fairly prominent on part of the shell of the neotype. These ridges produce slight irregularities on the radial ribs.

Geographic range.—Kamchatka, Alaska to southern California.

Geologic range.—Paleocene and Eocene. In California, from the late Paleocene Meganos Stage to the late Eocene *Turritella schencki delaquerrae* Zone of Kleinpell and Weaver (Givens, 1974, p. 38).

Occurrence in California.—Paleocene: Martinez Formation (Weaver, 1949), Marysville Formation of Schenck (1936), Paleocene and Eocene: Santa Susana Formation (W. J. Zinsmeister, written Commun., 1978); Meganos Formation (Schenck, 1936), and Cerros Shale Member of Lodo Formation (Keen and Bentson, 1944); Eocene: Ardath Shale (M. A. Hanna, 1927), Avenal Sandstone (Stewart, 1946), Capay Formation (Merriam and Turner, 1937), Coldwater Sandstone, Domengine Formation (Schenck, 1936), Juncal Formation (in *Turritella uvasana infera* and *Turritella uvasana applinae* faunas, Givens, 1974), lower part of Llajas Formation of Schenck (1936), Muir Sandstone (Weaver, 1953), Tejon Formation (Schenck, 1936), and unnamed strata, San Nicolas Island (Vedder and Norris, 1963).

Acila (Truncacila) decisa (Conrad), unnamed form

Plate 1, figure 17

Acila (Truncacila) decisa (Conrad), var. Vokes, 1939, New York Acad. Sci., v. 38, p. 41, pl. 1, figs. 7-8.

Original description.—"Only four specimens referable to the genus *Acila* have been found in the collections from the Domengine [Avenal] formation. They all differ from the typical *Acila decisa* (Conrad) in being more inflated and in possessing a shallow groove bounding the edge of the lunule. Similar forms occur in beds of contemporaneous age in the Eocene of Oregon."

Figured specimen.—UCMP 15477.

Locality.—UC A-1165. Kings County, Calif. Avenal Sandstone, Eocene.

Comments.—The radial ribs on this form are separated by interspaces almost twice as wide as those on the neotype of *Acila decisa* and concentric ridges are not preserved.

Geographic range.—Oregon to southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Meganos Formation; Eocene; Avenal (Keen and Bentson, 1944) and Capay Formations, La Jolla Group, lower part of Llajas and Tejon Formations.

Acila (Truncacila) shumardi (Dall)

Plate 1, figures 15, 16

Nucula (Acila) decisa Conrad. Dall, 1898, p. 573. Not *Nucula decissa* (Conrad), 1855.

Nucula (Acila) shumardi Dall, 1909, p. 103.

Acila (Truncacila) shumardi (Dall). Schenck, 1936, p. 64-67, pl. 4, figs. 5-7, 9; pl. 6, figs. 1-11, text fig. 7 (18). Moore, 1976, p. 42-43, pl. 8, figs. 1-9, 11, 12, 14, 15, 18.

Original description.—"***Conrad described from the Eocene (called by him Miocene) of San Diego Mission, California, a *Nucula decisa* which he figured (very badly) and afterwards united with his Miocene Astoria species. In this he was followed by Gabb and others. None of the figures or descriptions of this *decisa* are sufficient to identify the species. A fine large species from the Eocene of Pittsburg, Oreg., collected by Diller, was identified by me with *decisa*. This identification was made because of the Eocene age of both, there being usually only one species of *Acila* in a single horizon. However, inasmuch as Conrad's original type specimen seems lost, and his figure and description are worthless,

it is probably best to apply a new name to the Oregonian Eocene species, which may be called *Nucula (Acila) shumardi* Dall."

Holotype.—USNM 406405.

Type locality.—USGS 2714. Columbia County, Oreg. Pittsburg Bluff Formation, Oligocene.

Supplementary description.—"*Acila shumardi* is large to moderate in size (largest specimen: 30 mm long, 22 mm high, and 16 mm thick) and is sculptured with many narrow ribs separated by small spaces which on some specimens are barely discernible and could be described as incised lines. Secondary bifurcation of the ribs may be present at the ventral margin either in the midportion of the anterior half of the shell or along the anterior side of the primary bifurcation. On one specimen (USGS 18681) the ribs split near the dorsal margin on the anterior portions of both valves of an articulated specimen. Although areas of secondary bifurcation, if present, usually occur on the largest specimens, such bifurcation has also been seen on specimens of only small to moderate size. The beaks are located at the sharply truncated posterior margin. The hinges exposed on two left valves***show 7-10 posterior teeth and 16-22 anterior teeth. The hinges exposed on six right valves***show 7-11 posterior teeth and 17-20 anterior teeth. One specimen***, at the anterior end of the posterior series of teeth, shows a deep irregular socket with an irregular toothlike projection at the ventral anterior edge. The number of teeth varies with the size of the individual shell, and the larger specimens have more teeth than the smaller ones." (Moore, 1976, p. 42-43)

Geographic range.—Alaska to middle California.

Geologic range.—Eocene and Oligocene.

Occurrence in California.—Eocene and Oligocene: Kreyenhagen (Watkins, 1974), San Emigdio (DeLise, 1967), and San Lorenzo Formations (Clark, 1918); Oligocene: Alegria Formation of Dibblee (1950), Concord Formation of Clark (1918), Kirker Tuff (Clark, 1918), Pleito Formation, and Tumey Formation of Atwill (1935).

Acila (Truncacila) dalli (Arnold)

Plate 1, figure 18

Nucula (Acila) dalli Arnold, 1908, p. 364-365, pl. 33, fig. 15.

Acila (Truncacila) dalli (Arnold). Schenck, 1936, p. 67-73, pl. 5, figs. 2, 9, 13; pl. 14, figs. 4, 6, 7,; text fig. 8.

Original description.—"Shell trigonal in outline, nearly as broad as long, large for a member of this genus, sometimes attaining a length of over 30 mm., rather compressed, strongly divaricately sculptured. Umbones prominent and turned backward, placed very near the posterior end, which is abruptly truncated and depressed, and forms a straight or slightly inwardly curved line from the umbones to the base, with which it makes a sharp angle of about 90°; base rounded becoming more and more so toward the anterior extremity, which region exhibits the sharpest curvature of any of the anterior portion of the shell; anterior dorsal margin nearly straight for a considerable distance in front of the umbones; a faint carina extends from the umbo to the posterior ventral angle; surface sculptured by numerous rounded, raised, divaricating lines; margins crenulate. Hinge as in other members of this genus."

Holotype.—USNM 165452.

Type locality.—On the headwaters of south fork of Waddell Creek, Big Basin, Santa Cruz quadrangle, Santa Cruz County, Calif. San Lorenzo Formation, Eocene and Oligocene.

Supplementary description.—"quadrangular, compressed; anterior dorsal margin gently sloping to rounded anterior extremity; ventral margin convex; straight posterior margin gives truncate appearance to profile; radial ribs 350± microns wide, separated by equal interspaces 200± microns deep; escutcheonal area crossed by radial ribs; primary bifurcation distinct, sometimes somewhat anterior to middle of shell at ventral margin; concentric lines of growth clearly shown on some specimens; secondary bifurcation, when present, situated near middle of disk; area of obsolete radial ribbing rarely present, never conspicuous; weakly developed rostral sinus present, but not conspicuous***. An imperfect specimen***shows a nuculid hinge with 15± anterior teeth." (Schenck, 1936, p. 67).

Comparisons.—*Acila (Truncacila) dalli* does not have the well-developed rostral sinus of *A. (A) gettysburgensis*, but the two species may be closely related and the postulation that *A. dalli* is ancestral to *A. gettysburgensis* may be a reasonable one. *Acila dalli* is also similar to *A. (T.) nehalemensis* Hanna but the shell of *A. nehalemensis* is more inflated than the compressed shell of *A. dalli.* (Schenck, 1935, p. 5, 68)

Geographic range.—Middle to southern California.

Geologic range.—Eocene and Oligocene.

Occurence in California.—Eocene and Oligocene: Rices Mudstone Member of San Lorenzo Formation (Brabb, 1964); Oligocene: Pleito Formation.

Acila (Truncacila) muta Clark

Plate 1, figures 19, 20

Acila muta Clark, 1918, p. 119-120, pl. 13, figs. 6, 12, 13.

Acila muta var. *markleyensis* Clark, 1918, p. 121, pl. 13, fig. 3.

Acila (Truncacila) muta B. L. Clark. Schenck, 1936, p. 74, 75, pl. 8, figs. 4, 11; text fig. 7, nos. 20, 21. Addicott, 1973, p. 22, pl. 1, figs. 4-15.

Original description.—"Shell subovate to subtrigonal, moderately convex; beaks strongly inturned; posterior end abruptly truncated, subangulate at point of junction between the posterior dorsal and the ventral edges. Anterior dorsal slope long and gently convex, posterior dorsal slope straight; apical angle about 90°; anterior end evenly rounded; posterior ventral edge regularly arcuate. Lunule obsolete, escutcheon large, well-defined by a circumscribed line, pouting in the middle. Surface of shell covered by fine, divaricating threads which extend onto the escutcheon; the line at which the divaricating threads cross, is near the middle of the shell; on some of the larger specimens, a duplication of the divarication may be seen near the ventral edge. Seventeen or eighteen fairly prominent cardinals anterior, and about ten posterior to the beaks, resilium pit narrow and deep, rather long."

Holotype.—UCMP 11196.

Type locality.—UCMP 1131. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Supplementary description.—"The radial ribs on the holotype (17.2 millimeters long) are 350± microns wide, separated by interspaces about half as wide. The smallest specimen (4.5 millimeters long) is ovate in profile; its broadly convex radial ribs are 220± microns wide, interspaces less than half as wide. The specimens have no marked area of obsolete radial ribbing. There is no rostral sinus. The interior of the holotype is sufficiently free of matrix to disclose nuculid dentition." (Schenck, 1936, p. 74)

Comparison.—"As indicated by Schenck (1936), the species that most closely resembles *Acila muta* is the middle Miocene *A. conradi* from the Temblor Formation ("Temblor Stage") of California and from the Astoria Formation of Oregon and Washington. Schenck differentiated these two species on the relatively greater thickness of the two valves of *A. muta.* They are differentiated here by the significantly smaller angle of bifurcation of *A. muta* evident from Clark's (1918) and Schenck's (1936) illustrated specimens. This difference is relfected by the fact that the primary line of bifurcation on specimens of *A. conradi* intersects the ventral

margin in a more anterior position than on specimens of *A. muta*." (Addicott, 1973, p. 22)

Geographic range.—California.

Geologic range.—Oligocene and Miocene(?).

Occurrence in California.—Oligocene: Wygal Sandstone Member of Temblor Formation (Addicott, 1973); Miocene(?): San Ramon Sandstone.

Acila (Truncacila) conradi (Meek)

Plate 1, figures 21, 22

Nucula divaricata Conrad, 1848, p. 432, figs. 1a, 1b, Not *Nucula divaricata* Hinds, 1843.

Nucula (Acila) conradi Meek, 1864, p. 27, *new name.*

Acila (Truncacila) conradi (Meek). Schenck, 1936, p. 82-85, pl. 8, figs. 1-3, 5-10, 12-14, text fig. 7. Moore, 1963, p. 54-55, pl. 12, figs. 2-4, 6-9.

Original description.—"Subovate, convex, with divaricating striae, extremities rounded, ligament margin very oblique, slightly curved; basal margin curved; beaks near the anterior extremity."

Neotype.—USNM 3526. (Moore, 1963, p. 55)

Type locality.—Astoria, Columbia County, Oreg. Astoria Formation, Miocene.

Supplementary description.—"Shell lacking a rostral sinus or possessing only an incipient sinus; no area of obsolete radial ribbing or such an area only weakly developed; usually less than 10 mm thick when more than 17 mm long." (Schenck, 1935, p. 4-5)

"Radial ribs about 220-350 microns wide, separated by narrower interspaces; line of primary bifurcation anterior to center of shell at ventral margin; angle of bifurcation 50 to 72 degrees; secondary bifurcation common; no rostral sinus; no apparent area of obsolete ribbing; interior ventral margin not markedly crenulate." (Schenck, 1936, p. 83)

"Young specimens have bifurcated radial ribs which extend to the ventral margin, whereas on mature specimens these ribs may be obliterated by concentric lines. Fine concentric lines are numerous on the entire surface of the shell and form concentric ridges when they are crowded together at irregular intervals." (Moore, 1963, p. 55)

Comparisons.—*Acila (Truncacila) conradi* resembles *A. (T.) muta* but is differentiated by the significantly greater angle of the bifurcation. The primary line of bifurcation intersects the ventral margin in a more anterior position on *A. conradi* than on *A. muta*. (Addicott, 1973, p. 22)

Geographic range.—Washington to southern California.

Geologic range.—Miocene. Occurs in Washington with *Vertipecten fucanus* (Dall), which is restricted to the Pillarian Stage, Miocene (Addicott, 1976d, p. 99). Occurs in Oregon and California with *Patinopecten propatulus* (Conrad), which is restricted to the Newportian Stage, Miocene, in Oregon (Addicott, 1976d, p. 102). Occurs in Kern County with foraminiferal assemblages of early Saucesian age (Addicott, 1970, p. 27).

Occurrence in California.—Cierbo Sandstone (Hall, 1960), Freeman Silt (Addicott, 1970), Neroly Sandstone (Hall, 1960), and upper part of the Temblor Formation (Stewart, 1946).

Acila (Truncacila) empirensis Howe

Plate 1, figure 26

Acila empirensis Howe, 1922, p. 96, pl. 9, figs. 4, 5, 8.

Acila (Truncacila) empirensis Howe. Schenck, 1936, p. 85-87, pl. 9, figs. 3, 4, 6-10, 12; text fig. 7. Weaver, 1942, p. 30-31, pl. 6, figs. 6, 16, 17.

Original description.—"Shell ovate, moderately convex, with fairly prominent adjacent beaks, lunule long, lanceolate, and separated from the rest of the shell by a distinct ridge, sculpture of lunule coarser than that of adjacent parts of shell; escutcheonal area not sharply defined, but separated from the rest of the shell by subangulation, on the anterior side of which, extending from the beaks to ventral margin, is a broad depression. Sculpture of escutcheon immediately below beaks tends to become obsolete; sculpture of escutcheon finer than rest of shell, and on some specimens tends to bifurcate.

"Ventral margin regularly arcuate; posterior dorsal edge convex, anterior dorsal edge fairly long and nearly straight; anterior end obliquely subtruncate; sculptured with coarse radial ribs, the sculpture being coarser on the posterior than on the anterior half of shell. Incremental lines heavy and irregular; the line of bifurcation meets the ventral edge anterior to the middle of shell; extending from beaks to posterior end and between ventral angulation and escutcheon, parallel to same, is a broad shallow depression which is more marked in adult specimens. Hinge teeth inaccessible. Length, 16 mm.; alt., 12 mm.; diam., 9 mm."

Holotype.—UCMP 30032.

Type locality.—UC 3323. Coos County, Oreg. Coos Conglomerate member of Empire Formation, Miocene.

Supplementary description.—Shell large for subgenus, truncate-quadrate, inflated; anterior dorsal margin straight, but profile changes abruptly toward the bluntly rounded anterior extremity; ventral margin convex; posterior margin straight except for a pouting in escutcheonal region; inturned beaks closely appressed; primary bifurcation distinct in umbonal area; secondary bifurcation on all shells; radial ribs to about 500 microns wide, separated by equal interspaces; concentric lines to about 12; no rostral sinus; area of obsolete radial ribbing well developed, to 5 millimeters in width; escutcheonal area indistinctly defined, crossed by radial ribs; lunule sometimes defined by an abrupt termination of radial ribs, producing the appearance of a lanceolate depression; interior poorly preserved, one specimen about 24 anterior, about 12 posterior teeth; shell nacreous, ventral margin lacks marginal plications. (Schenck, 1936, p. 86)

Comparison.—"This species is differentiated from its nearest relative, *Acila (Truncacila) conradi* (Meek), by the area of obsolete radial ribbing, generally larger size, and greater degree of inflation." (Schenck, 1936, p. 86)

Comments.—Faustman (1964) and Roth (1979) cite *Acila castrensis*, rather than *A. empirensis*, as occurring in the Wildcat Group.

Geographic range.—Alaska; Washington to northern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Pliocene and Pleistocene: Wildcat Group (Ogle, 1953).

Acila (Truncacila) castrensis (Hinds)

Plate 1, figure 24

Nucula castrensis Hinds, 1843, p. 98

Acila (Truncacila) castrensis (Hinds). Schenck, 1936, p. 96-99, pl. 10, figs. 1-5, text fig. 7 (2-5). Hertlein and Grant, 1972, p. 147-148, pl. 27, figs. 7-10.

Original description.—"Nuc. testa elliptica, antice rotundata, epidermide olivacea induta; lineis divaricatis; marginibus ventralibus crenulatis; cardine antice dentibus 5, postice 11. Long 3; lat 1½; alt. 2 lin."

Holotype.—Location unknown; not in British Museum *fide* Keen (1966a, p. 267).

Type locality.—Sitka, Alaska. A single specimen was dredged in the harbor, from 13 m, sand. (Hinds, 1843)

Supplementary description.—"Adult shell of medium size for subgenus, ovate-trigonal, compressed; anterior dorsal margin convex, sloping away from beaks to sharply rounded anterior extremity; ventral margin convex; posterior margin nearly straight, giving shell the 'abruptly truncated' appearance that has struck the attention of most writers; immediately below beaks, escutcheonal area outlined by a slight groove extending from beaks; inside this groove, which is crossed by radial ribs, is a slight pouting, giving posterior margin a gently convex outward profile; no rostral sinus; when shells are 1 to 2 millimeters in height, smooth, but with growth undulations; at height of 6.0 millimeters radial ribs well developed; when shells 12.0 millimeters high, radial ribs tend to become obsolete distally and concentric lines are more crowded; larger specimens show at least 18 annular growth undulations, area of obsolete radial ribbing well developed; radial ribs attain width of 400 ± microns, separated by interspaces about half as wide, crossed by concentric ribs about 10 microns wide; 60 percent of 50 specimens displayed secondary bifurcation; interiors***smooth; muscle scars slightly impressed; ventral margin smooth, except on small specimens; pallial line generally not clearly defined; posterior teeth vary in number from 7 (rare) to 12; anterior from about 14 to 20." (Schenck, 1936, p. 97)

Comparisons.—*A. castrensis* differs from *A. blancoensis* Howe by its more abruptly truncate posterior margin.

Geographic range.—Living: From Sitka, Alaska, to Isla de Cedros, Baja California Norte; fossil: northern to southern California and possibly on the Schmidt Peninsula, Kamchatka (Khomenko, 1938, p. 30, 66, 73, pl. 3, figs. 5-7) and in east Sakhalin (Simonova, 1941, p. 12, pl. 1, figs. 4, 4a). Fossil: northern to middle California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene and Pliocene: Capistrano (Vedder, 1974), Etchegoin (Arnold, 1909), Purisima (Arnold, 1908), Tahana Member of the Purisima (Addicott, 1969), and Towsley (Kern, 1973) Formations; Pliocene: Lomita Marl Member, San Pedro (A. Clark, 1931), Niguel (J. G. Vedder, written commun., 1978), and Ohlson Ranch (Peck, 1960) Formations, Pomponio Mudstone Member of the Purisima (Cummings and others, 1962), Rio Dell (Faustman, 1964), San Diego (Hertlein and Grant, 1972), and San Joaquin (*Acila* zone) Formations; Pliocene-Pleistocene: Fernando (English, 1914; Durham and Yerkes, 1964), Merced (Woodring and others, 1940) and Pico (W. O. Addicott and J. G. Vedder, written commun., 1978) Formations, and Wildcat Group (Roth, 1979); Pleistocene: Timms Point Silt Member of the San Pedro Formation (A. Clark, 1931).

Habitat.—Dredged in sandy mud from 7 to 1,280 m. Off California coast in 28 to 426 m (Woodring and others, 1946, p. 90).

Family MALLETIIDAE

Genus MALLETIA Des Moulins, 1832

No resilifer; ligament predominantly external.

Two Tertiary species, *"Malletia" chehalisensis* Arnold and *"M." packardi* Clark, were formerly assigned to the genus *Malletia*. *"M." chehalisensis* has been assigned to *Yoldia* because it has a resilifer, *"M." packardi* to *Portlandia*. Therefore, no Tertiary species representing this genus are known to occur in the Californias.

Family NUCULANIDAE

Geologic range.—Devonian through Holocene.

Habitat.—Most Holocene species are common on muddy bottoms.

Genus NUCULANA Link, 1807

Resilifer narrow, oblique; posterior end produced; concentric sculpture.

Geologic range.—Triassic through Holocene (table 2).

Habitat.—Abundant in cool water, usually on muddy bottom from 5 to 3,600 m.

Subgenus NUCULANA

Nuculana (Nuculana) fossa (Baird)

Plate 2, figures 1, 2

Leda fossa Baird, 1863, p. 71. Arnold, 1903, p. 96-97, pl. 17, fig. 7.

Nuculana fossa Baird. I. S. Oldroyd, 1924, p. 19, pl. 5, fig. 6. Grant and Gale, 1931, p. 120.

Original description.—"Shell small, elongate, convex, thin, umbones anterior, turning slightly toward the posterior end, which is elongated, narrow and truncated; anterior end short and evenly rounded, sculpture nearly obsolete, a few concentric lines discernible; escutcheon long, smooth and deep-set; an elongate process on the middle of interior of posterior end; hinge with a small internal cartilage-pit, and numerous teeth on each side. Length, 11; height, 6; diameter, 3.8 mm."

Holotype.—BN(NH) (A. M. Keen, oral commun., 1978).

Type locality.—Vancouver Island, British Columbia. Holocene.

Supplementary description.—1.8 to 2.5 cm in length; elongate, moderately fat and smooth except for small pronounced concentric ribs at the anterior end and on the beaks. Dorsal area of rostrum rather smooth, depressed, and bounded by two weak radial ribs. (Abbott, 1974, p. 414)

Comparison.—According to Arnold (1903, p. 97) *Nuculana fossa* is distinguished by its lack of sculpture. The escutcheon is wider on *N. fossa* than on *N. pernula*.

Geographic range.—Living: Alaska to Puget Sound, Washington; fossil: Alaska and southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: Rio Dell Formation (Faustman, 1964); Pliocene and Pleistocene: Fernando (J. D. Mount, written commun., 1971) and San Pedro (Arnold, 1903) Formations.

Habitat.—Dredged offshore in shallow water from 25 to 135 m.

Nuculana (Nuculana) fossa sculpta (Dall)

Plate 2, figures 3, 4

Leda fossa sculpta Dall, 1916, p. 396.

Original description.—"This form has regular concentric ripples on the beaks, behind a faint depressed ray near the anterior end and on the keels on either side of the escutcheon."

Holotype.—USNM 107688.

Type locality.—ALBATROSS sta. 2855, southeast of Alaska Peninsula, Alaska, in mud at 110 m.

Comments.—Concentric ridges are prominent posterior to the depressed area and on the keel, as noted by Dall (1916); the rest of the shell is almost smooth.

Geographic range.—Living: southeast of Alaska Peninsula; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando Formation (J. D. Mount, written commun., 1971).

Habitat.—110 to 125 m.

Nuculana (Nuculana) minuta praecursor (Arnold)

Plate 2, figure 5

Leda minuta Fabr. var. *praecursor* Arnold, 1903, p. 97-98, pl. 17, fig. 6.

Original description.—"Shell small, trigonal, convex, thin; umbones anterior to middle and turning slightly toward the posterior side; anterior portion from umbones short and rounded; posterior portion longer, slightly depressed, produced and slightly truncated; surface sculptured by prominent, raised concentric lines; escutcheon long, narrow, slightly striated with continuation of concentric ridges; a flat sculptured band runs around escutcheon from umbo to posterior end, and on the interior of the shell at the posterior end of this band is a little elongate ridge or process; hinge with prominent internal cartilage cup and about fifteen prominent sharp teeth on each side; pallial sinus small, narrow."

Holotype.—Alleged to be in USNM but not found.

Type locality.—Lower part of San Pedro Formation, Deadman Island, Calif. Pleistocene.

Geographic range.—Southern California.

Geologic range.—Pliocene and Pleistocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando (J. D. Mount, written commun., 1971) and San Pedro (Arnold, 1903) Formations.

TABLE 2.—*Geologic and geographic distribution of the family Nuculanidae in the eastern Pacific region*

[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	Alaska	British Columbia	Washington	Oregon	California			Baja California	
					Northern	Middle	Southern	Norte	Sur
Genus *Nuculana*:									
Subgenus *Nuculana*:									
fossa Baird	Ple[1] and H	H	H		Pl and Ple		Pl and Ple		
fossa sculpta (Dall)	H	H	H				Pl and Ple		
minuta praecursor (Arnold)							Pl and Ple		
pernula (Müller)	Pl to H	H					Pl and Ple		
Subgenus *Nuculana*?									
elongorostrata (Clark)						O			
Subgenus *Costelloleda*?:									
powersi Dickerson						Pa			
Subgenus *Saccella*:									
alaeformis (Gabb)					Pa	Pa			
cahillensis (Arnold)						E			
cellulita (Dall)	H	H	H	H	H	H	Pl to H		
chaneyi Vokes						E	E		
chehalisensis (Weaver)	M[2]	O	M			M	O and M		M
furlongi (Trask)						M			
gabbii (Gabb)				E	Pa	Pa and E	Pa to O?		
hondana Vokes						Pa and E			
hindsii (Hanley)	H	H	H	H	H	H	Pl to H	Ple and H	H
markleyensis (Clark)						M?			
merriami (Dickerson)			O				E and O		
ochsneri (Anderson and Martin)						M	M		
orcutti (Arnold)							M and Pl		
pulchrisinuosa (Clark)						E to M?			
taphria (Dall)						M to H	O to H	H	H
uvasana (Dickerson)							E		
washingtonensis (Weaver)	E[2]		E to M	O		E and O			
Subgenus *Saccella*?									
denominata Hanna						Pa			
fabata (Nelson)							Pa		
packardi (Dickerson)					Pa				
ramonensis (Clark)						M?			
Subgenus *Thestyleda*:									
hamata (Carpenter)	H	H	H	H	H	H	Pl to H	H	H
Genus Ledina:									
duttonae (Vokes)						Pa			
fresnoensis (Dickerson)				E		Pa and E	E		
Genus *Hilgardia*?:									
parkei (Anderson and Hanna)						E	E		
parkei coosensis Turner				E		E			
Genus *Litorhadia*:									
astoriana (Henderson)				M		E to M	O and M		
Genus *Yoldia*:									
Subgenus *Yoldia*?:									
temblorensis Anderson and Martin			M			M	M		
Subgenus *Kalayoldia*:									
cooperi Gabb						M to H	M to H	H	H
oregona (Shumard)	M	M	M	O and M			O and M		
submontereyensis Arnold						M	M		
supramontereyensis Arnold			M			M	M		
tenuissima Clark			M	O		E to M?	E to M		
Subgenus *Kalayoldia*?:									
carnarosensis (Clark)						M			
gesteri Dickerson					Pa				
Subgenus *Megayoldia*:									
beringiana Dall	H	H	H	H	H	H	Pl to H		
thraciaeformis (Storer)	Pl to H[2]	H	H			M and Pl			
Subgenus *Cnesterium*:									
ensifera Dall	M	H	H	H	Pl to H	H	H		
scissurata Dall	H	H	H	H	Pl to H	M to H?	Pl and Ple		
seminuda Dall	H	H	H	H	Pl to H	H	Pl and Ple		
strigata Dall	Pl[2]		M	M	Pl	M to Ple			
Genus *Yoldia*?:									
gala Woodring							M and Pl		
Genus *Portlandia*:									
Subgenus *Portlandia*:									
chehalisensis (Arnold)	O[2]		E to M			E and O			
markleyensis (Clark)						E			
mortuasusensis (Clark and Woodford)						Pa			
mosesi (Palmer)						E?			
packardi (Clark)			O			E to M?			
rosa (Hanna)							E		

[1]R. C. Allison, written commun., 1977.
[2]Scott McCoy, written commun., 1978.

Habitat.—The living species *Nuculana (Nuculana) minuta minuta* (Fabricus) occurs in mud at depths of 35 to 265 m.

Nuculana (Nuculana) pernula (Müller)

Plate 2, figure 6

Arca pernula Müller, 1779, p. 57. Oldroyd, 1924, p. 19, pl. 19, figs. 7, 7a.

Nuculana pernula Müller. Abbott, 1974, p. 413-414, fig. 4848.

Description.—"Shell oblong, rostrate, thick, olivaceous, sculptured with numerous raised concentric striae, more dense in the middle and slightly interrupted anteriorly; posterior side rostrated with a slight curve, depressed area circumscribed, inflated in the middle, apex obtuse; posterior side rather short, with an obscure ray, subacuminately rounded. Length, 17; height 10; diameter, 5.5 mm. of a specimen from Etah, Greenland." (Oldroyd, 1924, p. 19)

Holotype.—Location unknown.

Type locality.—North Sea.

Supplementary description.—1.2 to 2.5 cm in length, elongate and truncate posteriorly, moderately fat, slightly gaping at the rounded anterior end. Interior of rostrum (posterior end of shell) reinforced by a strong radial roundish low rib. Lunule long, prominent, with a sharp edge. (Abbott, 1974, p. 414)

Comparison.—"*N. conceptionis* Dall is much more elongate and smoother." (Abbott, 1974, p. 414)

Geographic range.—Living: northern Alaska to Chatlum Sound, British Columbia, and Arctic Ocean to Cape Cod, Mass.; fossil: Alaska and southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando Formation (J. D. Mount, written commun., 1971).

Habitat.—Cold water at depths of 15 to 100 m in clay.

Subgenus NUCULANA?

Nuculana (Nuculana?) elongorostrata (Clark)

Plate 3, figure 1

Leda elongorostrata Clark, 1918, p. 123, pl. 13, fig. 16.

Original description.—"Shell small, thin, elongate-ovate, narrow and abruptly attenuated. Anterior end rather narrow but regularly rounded; beaks inconspicuous, anterior to the middle; posterior dorsal margin long, straight, only sloping very slightly; anterior dorsal edge gently convex; ventral edge long and gently arcuate. Lunule and escutcheon both elongate-lanceolate. Surface covered by fine concentric, somewhat irregularly spaced lines of growth. On the rostrate end a shallow, rather broad sulcus extends from the beak to the lower side of the posterior end. Internal character of shell unknown."

Holotype.—UCMP 11206.

Type locality.—UC 2755. Contra Costa County, Calif. Kirker Tuff, Oligocene.

Comments.—On the basis of the outline of the holotype, this form is tentatively assigned to *Nuculana s.s.* Sixteen anterior teeth are preserved on the mold, but presumably there were more originally. This form is inflated and very elongate in proportion to its height (18 mm high; 7 mm long). The fine concentric sculpture described by Clark is not preserved on the holotype.

Geographic range.—Middle California.

Geologic range.—Oligocene.

Occurrence in California.—Kirker Tuff (Keen and Bentson, 1944).

Subgenus COSTELLOLEDA Hertlein and Strong, 1940

Shell elongate with strong concentric sculpture.

Geographic range.—North America.

Geologic range.—Paleocene(?); Holocene (table 2).

Subgenus COSTELLOLEDA?

Nuculana (Costelloleda?) powersi (Dickerson)

Plate 4, figures 4, 5

Yoldia(?) *powersi* Dickerson, 1919, p. 124-125, pl. 7, fig. 6.

Original description.—"Shell small, thin, elongated, slightly curved, shaped like a pruning knife. Beak, situated a fifth of the length from the anterior end, prominent. Anterior end, broadly rounded; posterior end, pointed sharply. Anterior dorsal margin, convex, short; posterior dorsal edge, concave, long. An impressed groove extends on the cast from the beak to the posterior end parallel to and just below the posterior dorsal edge. This groove divides the sharply pointed posterior end. Surface marked by rounded concentric lines which do not show in the type."

Holotype.—UCMP 11724.

Type locality.—UC 1556. Contra Costa County, Calif. Martinez Formation, Paleocene.

Comparison.—*Nuculana powersi* is readily distinguished from "*Yoldia*" *gesteri* Dickerson by its more prominent beaks, its concave dorsal posterior margin, and its short anterior margin; the knifelike form identifies it readily. (Dickerson, 1914)

Comments.—The holotype of this species is a mold, 10 mm long and 4 mm high. Its outline somewhat resembles the living Panamic species *Nuculana (Costelloleda) marella* Hertlein and Strong, as figured by Keen 1971, p. 28, fig. 17). *Costelloleda* has not been recorded in the fossil record. I have tentatively assigned this form to *Costelloleda* to call attention to its uniqueness and its similarity to that subgenus.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Subgenus SACCELLA Woodring, 1925

Rostrate, rostrum pointed; strong concentric rugae; posterior and anterior series of teeth mostly equal; resilifer triangular and symmetrical. A shallow groove extends from umbo to ventral margin at both ends of valve.

Geologic range.—Paleocene through Holocene (table 2).

Habitat.—Off southern California in shallow water (found in fish stomachs off Monterey) and off the west coast of America from Alaska south to Chile; in 7 to 1,000 m.

Nuculana (Saccella) alaeformis (Gabb)

Plate 2, figures 9, 10

Corbula alaeformis Gabb, 1869, p. 177, pl. 29, fig. 63. Not *Corbula aliformis* Conrad, 1866.

Corbula gabbii Dall, 1898, p. 840., new name for *Corbula alaeformis* Gabb. *Leda polynominata* Hana, 1924, p. 169, new name for *Corbula gabbi* Dall, not *Leda gabbii* Gabb, 1869.

"*Leda*" *alaeformis* (Gabb). Stewart, 1930, p. 58-59, pl. 7, fig. 13. [It seems from Article 58 of the International Code, Stoll and others, 1961, p. 55, item 1, that *C. alaeformis* and *C. aliformis*

are not homonyms and therefore the specific name *alaeformis* is reinstated following Stewart, 1930, p. 58].

Original description.—"Shell large, broadly rounded in advance, narrow, produced, and truncated behind; beaks about a third of the length from the anterior end, high; posterior cardinal margin nearly straight, bordered by a broad, deep groove, extending from the beaks to the posterior end; base prominently and broadly rounded in the middle, sinuous behind. Surface marked by small, regular, concentric ribs."

Type material.—Holotype missing and presumed lost. The specimen illustrated by Stewart (1930, pl. 7, fig. 13), MCZ 15049, has not been found. A specimen labelled, "paratype, UCMP 32515," is figured herein as well as a specimen originally figured by Stanton (1896, pl. 64, fig. 6, 7).

Type locality.—Near Lower Lake Village [NE¼ sec. 11, T. 12 N., R. 7 W.], Lake County, Calif. Martinez Formation, Paleocene.

Supplementary description.—"The escutcheon is very long and much impressed. The concentric lines are prominent and there are six to the two mm. interval near the posterior ventral margin. The posterior margin is sharply truncated but seems to be intact. Two taxodont teeth are visible on the cardinal region just anterior to the umbo. The ventral margin is incomplete." (Stewart, 1930, p. 58)

Geographic range.—Northern California.

Geologic range.—Paleocene.

Occurrence in California.—Las Virgenes Sandstone (W. J. Zinsmeister, written commun., 1978),Martinez Formation (Arnold, 1906; Waring, 1917).

Nuculana (Saccella) gabbii (Gabb)

Plate 2, figures 7, 8

Nuculana gabbii Conrad, 1866, p. 3, *nomen nudum.*
"*Leda gabbii* Conrad" of Gabb, 1869, p. 197-198.
Leda protexta? Gabb, 1869, p. 199.
Saccella gabbii (Gabb). Stewart, 1930, p. 55-58, pl. 7, fig. 3; pl. 10, fig. 4.
Nuculana (*Saccella*) *gabbii* (Gabb). Givens, 1974, p. 39, pl. 1, fig. 3.
Leda vogdesi Anderson and Hanna, 1925, p. 177, pl. 2, figs. 8, 9.

Original description.—"Shell small, elongated, narrow; anterior end produced, rounded; posterior end long, narrow, curved upwards; base broadly and pretty regularly convex; beaks small, subcentral, not prominent, with the cardinal margin somewhat convex in front, excavated behind. Surface marked by numerous, regular, concentric ribs." (Gabb, 1869)

Lectotype.—ANSP 4476 (Stewart, 1930).

Type locality.—Martinez, Contra Costa County, Calif. Tejon Formation of some authors, Eocene.

Supplementary description.—"there is considerable variation in length with an average slightly shorter than the length indicated in Gabb's figure***. The concentric sculpture is, in every case except one, that of ribs regularly overlapping toward the beak. At the posterior end, this type of ribbing may gradually grade into one of equilateral ribs***. The lunule and escutcheon are very long and well developed. The escutcheon is double***, being divided by a ridge on each valve. The outer escutcheon shows prominent divergent sculpture as though a feather had been distended and distorted by the insertion of an unsculptured area long its median line." (Clark and Woodford, 1927, p. 86)

Comparison.—*Nuculana gabbii* is much more slender than *N. alaeformis* Gabb, and the posterior cardinal margin is usually produced to a point where it joins the broadly convex basal margin. The surface is marked by many concentric lines, much finer than in *N. alaeformis.* (Waring, 1917, p. 76)

Geographic range.—Kamchatka; Southern Oregon and middle California.

Geologic range.—Paleocene to Oligocene(?). *Turritella delaguerrae* Zone of Kleinpell and Weaver (1963).

Occurrence in California..—Paleocene: Las Virgenes Sandstone (W. J. Zinsmeister, written commun., 1978), Martinez (Wilson, 1944) and Meganos Formations (Clark, 1921); Eocene: Avenal Sandstone (Stewart, 1946), Domengine (Wilson, 1944) and Llajas (Vokes, 1939) Formations, Matilija Sandstone (Dibblee, 1966), Muir Sandstone of Weaver (1953), Tejon Formation (Anderson and Hanna, 1925); Eocene and Oligocene: undifferentiated Sacate and Gaviota Formations of Weaver and Kleinpell (1963).

Nuculana (Saccella) hondana Vokes

Plate 2, figure 42

Nuculana (*Saccella*) *hondana* Vokes, 1939, p. 42-43, pl. 1, figs. 9, 10. Givens, 1974, p. 39, pl. 1, fig. 4.

Original description.—"Shell small, elongate, subtrigonal, moderately inflated; umbo nearly central; anterior and ventral margins broadly and regularly rounded; posterior margin rounded to the bluntly angulate rostrum; anterior dorsal margin varying from slightly concave to straight; posterior ventral margin slightly concave, the shell appearing distinctly equilateral; sculpture consisting of narrow, widely and regularly spaced concentric lines; a shallow, smooth groove extending from the beaks to the posterior point of the rostral margin; lunule and escutcheon long, narrow and well defined, the escutcheon crossed by a diagonal ridge."

Holotype.—UCMP 15561.

Type locality.—UC 1817. Fresno County, Calif. Cerros Shale Member, of the Lodo Formation, Paleocene.

Comparisons.—"*Nuculana hondana* may be distinguished from *N. gabbii*, with which it has heretofore been confused, by the bluntly rostrate posterior margin, the more equilateral outline, the straight rather than convex anterior dorsal margin, and the sculpturing of impressed lines rather than concentric ribbing; from *N. parkei* (Anderson & Hanna) by differences in shape and sculpturing, and in the absence of small, sharp ridges on the impressed area." (Vokes, 1939, p. 42)

Geographic range.—Southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Cerros Shale Member, Lodo Formation (Keen and Bentson, 1944); Eocene: Capay Formation, Juncal Formation (in *Turritella uvasana infera* fauna, Givens, 1974).

Nuculana (Saccella) chaneyi Vokes

Plate 2, figures 12, 13

Nuculana (*Saccella*) *chaneyi* Vokes, 1939, p. 43, pl. 1, figs. 11, 12.

Original description.—"Shell small, elongate; beaks low, opisthogyrate, slightly anterior; anterior dorsal margin slightly convex, sloping to the sharply rounded anterior end; ventral and posterior margins broadly rounded to the acute posterior end; posterior dorsal margin concave; escutcheon broad, incised, marked by a diagonal ridge from the beak nearly to the posterior end; lunule incised, narrower, and less well marked than the escutcheon; surface sculptured by broad, low, rounded ribbing separated by narrow incised interspaces; posterior area depressed, bounded by a well marked umbonal line to the posterior ventral margin, smooth except for coarse lines of growth."

Syntypes.—UCMP 15745 and 15746.

Type locality.—UC A-1165 and A-976. Kings County, Calif. Avenal Sandstone, Eocene.

Comparison.—"*N. chaneyi* somewhat resembles *N. hondana* in outline but differs in the depressed posterior area; it differs from *N.*

parkei (Anderson and Hanna) and *N. parkei coosensis* Turner in lacking posterior umbonal ridges; from *N. gabbii* it may be separated by shape and sculpturing." (Vokes, 1939, p. 43)

Comments.—The concentric sculpture on *Hilgardia? parkei coosensis,* discussed below under *Hilgardia?*, is slightly stronger and more prominent on the posterior depressed area than on *N. chaneyi.*

Geographic range.—Middle to southern California.

Geologic range.—Eocene.

Occurrence in California.—Avenal Sandstone, Domengine Formation and Muir Sandstone (Weaver, 1953).

Nuculana (Saccella) uvasana (Dickerson)

Plate 2, figures 11, 41

Leda uvasana Dickerson, 1915, p. 51-52, pl. 1, figs. 2a, 2b.

Original description.—"Shell of medium size, elongate, with a very small inconspicuous central beak; anterior dorsal margin slightly convex with a slight slope to a narrowly rounded anterior extremity; posterior dorsal margin concave, ending in a sharply pointed rostrum; ventral margin very broadly rounded; escutcheon lanceolate, distinct; lunule indistinct."

Holotype.—CAS 250.

Type locality.—CAS 244. Kern County, Calif. Tejon Formation, Eocene.

Comparison.—"This species has less thickness than *L. gabbi* Conrad and quite a different shape. Its ribbing is somewhat finer." (Dickerson, 1915, p. 52)

Comments.—The beak on *Nuculana uvasana* is slightly posterior to the midpoint of the shell. The escutcheon is divided by a ridge beginning at the beak and curving toward the dorsal margin where it terminates.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Tejon Formation.

Nuculana (Saccella) cahillensis (Arnold)

Plate 2, figure 34

Leda cahillensis Arnold, 1908, p. 375-376, pl. 34, fig. 9.

Original description.—"Shell attaining a length of only 6 or 7 mm, width about seven-ninths of length, oval, rounded in front, attenuate behind; well inflated, margin smooth; umbo small, subcentral, turned backward; anterior dorsal margin nearly straight, sloping steeply from umbo; anterior extremity regularly rounded; posterior dorsal margin concave, prominently excavated behind umbo; posterior extremity very attenuate; surface sculptured by numerous, equal, rounded concentric ribs, separated by moderately wide impressed lines; a trace of poorly developed carina extending from the umbo to the posterior extremity is discernible in the type."

Holotype.—CAS/SU 5386 (Keen and Bentson, 1944, p. 55).

Type locality.—Santa Cruz quadrangle, San Mateo County, locality No. 57, on road to Kings Mountain House, 3 km west of Woodside, in rather coarse, brownish-yellow sandstone. Butano(?) Sandstone, Eocene.

Comparison.—"This gibbous little *Leda* is easily distinguished from associated fossil forms by its small size, great convexity, broad outline, sharply attenuate posterior extremity, excavated margin posterior to umbo, and rather coarse sculpture. It resembles *L. acuta* Conrad (recent) in size but is relatively broader and more excavated behind. Distinguishable from the closely allied *L. taphria* Dall by much smaller size, more excavated dorsal posterior margin, and finer concentric sculpture." (Arnold, 1908, p. 376)

Comments.—This small form is very inflated, the posterior dorsal margin markedly concave, and the posterior extremity very rostrate.

Geographic range.—Middle California.

Geologic range.—Eocene.

Occurrence in California.—Butano(?) Sandstone.

Nuculana (Saccella) merriami (Dickerson)

Plate 2, figures 14, 15

Leda merriami Dickerson, 1917, p. 166, pl. 72, figs. 1a, 1b.

Nuculana merriami (Dickerson). Weaver, 1942, p. 37, pl. 8, figs. 21, 30.

Original description.—"Shell inflated, resembling *Leda alaeformis* Gabb in general shape; acutely rostrate, very inequilateral, very convex; beak prominent, high; anterior slope convex, ascending; posterior slope concave; anterior end bluntly rounded; base arcuate; escutcheon wide, nearly flat; incremental lines numerous, rounded; anterior teeth, 24; posterior teeth, 20 to 23; chondrophore sub-umbonal, not projecting. Dimensions: Length, 30 mm.; height, 22 mm.; convexity, 4.5 mm."

Holotype.—CAS 381.

Type locality.—UW 239. Cowlitz County, Wash. Gries Ranch Formation, Oligocene.

Comparison.—"*N. merriami* from the Gries Ranch beds***differs from *N. washingtonensis* of the Lincoln formation***in the proportionally lesser length of the area posterior to the umbo, the greater height, and the more pronounced concavity of the posterior dorsal margin. It is relatively higher and shorter than *N. cowlitzensis* of the***Cowlitz formation." (Weaver, 1942, p. 37)

Comments.—This form is very high in proportion to its length and also is acutely rostrate, as Dickerson has noted. It differs from *N. (S.) cowlitzensis* by having a more pronounced concave posterior dorsal margin.

Geographic range.—Southwestern Washington; southern California.

Geologic range.—Eocene and Oligocene.

Occurrence in California.—San Emigdio Formation (DeLise, 1967).

Nuculana (Saccella) washingtonensis (Weaver)

Plate 2, figures 16, 17

Leda washingtonensis Weaver, 1916, p. 34, pl. 3, fig. 25, 26.

Nuculana washingtonensis (Weaver). Weaver, 1942, p. 38-39, pl. 8, figs. 18, 20, 26. Watkins, 1974, p. 263-264, fig. 8.

Leda lincolnensis Weaver, 1916, 1916, p. 35, pl. 3, figs. 23, 24.

Original description.—"Shell of medium size, elongate and narrow; anterior dorsal margin two-fifths the length of shell, nearly straight and sloping downwards at an angle of 10° from the beaks; anterior end sharply rounded and merging into a slightly arcuate base; posterior dorsal margin slightly concave and deeply excavated; posterior end rostrate and obliquely truncate. On both valves a narrow but distinct groove extends from beaks to posterior end which becomes more deeply impressed near the latter. Surface of shell is sculptured by well marked concentric ribs which are flat topped and with interspaces of about equal width. Radiating ribs are absent. Beaks not very prominent; lunule linear and marked by very faint incised lines; escutcheon sunken, elongate-lanceolate, extending from beaks to posterior end and obliquely grooved with rounded outer edges. Hinge with 26 anterior and 21 posterior V-

shaped teeth. Chondrophore small and subumbonal. Adductor muscle scars small; pallial sinus short. Dimensions: Altitude 8 mm.; longitude 20 mm.; thickness 7 mm."

Lectotype.—CAS 451 (Moore, 1976); paratypes-CAS 450A-B.

Type locality.—UW 256. Lewis County, Wash. Lincoln Creek Formation, Eocene to Miocene.

Supplementary description.—"*Nuculana washingtonensis* is an elongate species terminating posteriorly in a sharply-pointed rostrum. The beaks are characteristically located two-fifths of the distance from the anterior end of the shell. The anterior dorsal margin is convex, and the anterior end is regularly curved. The ventral margin is long and broadly arcuate***. This sinus varies in prominence. There is also some variation in shape, degree of inflation, and relative position of the umbos. One of the most constant features is the sculpture, which consists of closely-spaced, well-developed, flat-topped concentric ridges***. Within the escutcheonal area the shell is produced at the dorsal margins. There is a slight posterior gape. The anterior hinge on a well-preserved***specimen contains about 26 V-shaped teeth, and the posterior hinge contains 20***." (Hickman, 1969, p. 27)

Comments.—This form is not as high in proportion to length as is *Nuculana (Saccella) uvasana.*

Geographic range.—Alaska to middle California.

Geologic range..—Eocene to Miocene.

Occurrence in California.—Eocene and Oligocene: Kreyenhagen Shale (Condit, 1930) and Rices Mudstone Member of San Lorenzo Formation (Cummings and others, 1962).

Nuculana (Saccella) pulchrisinuosa (Clark)

Plate 2, figures 18, 19

Leda pulchrisinuosa Clark, 1918, p. 123-124, pl. 11, figs. 5, 6.

Original description.—"Shell small, subovate; beaks near the middle. Dorsal slopes nearly equal, the posterior one, which is slightly the longer, being gently concave; anterior slope nearly straight. Anterior end regularly rounded; posterior end acutely rostrate. Lunule narrow, elongate-lanceolate, extending a little over half the length of the anterior dorsal edge. Escutcheon well defined, strongly depressed, lanceolate, extending from the beaks to the posterior end and enclosing a secondary escutcheon which is more sharply limited and more strongly depressed than the primary one. Surface of shell sculptured by numerous fine concentric ribs. On the surface near the posterior dorsal edge there is a shallow groove which extends from the beaks to a little anterior to the posterior end. Hinge plate unknown."

Holotype.—UCMP 11109.

Type locality.—UC 3081. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparison.—*Nuculana pulchrisinuosa* is somewhat like *Nuculana taphria* (Dall) but differs from that species in that it is slightly more elongate and the concentric sculpturing somewhat finer. The most important difference, however, is the presence of the double escutcheon; on *N. taphria*, the escutcheon is single (Clark, 1918, p. 124)

Nucula (Saccella) pulchrisinuosa somewhat resembles *N. gabbii* (Gabb). It differs from that species principally in that it is not so acute and elongate posteriorly, also in that the sculpturing is somewhat finer. (Clark, 1918, p. 124)

Nuculana pulchrisinuosa is also somewhat similar to *N. ochsneri* (Anderson and Martin). *N. ochsneri* differs from it by being more acute anteriorly and posteriorly; the sculpturing is coarser, and the lunule and escutcheon are larger. The escutcheon of *N. ochsneri* has the double area seen on *N. pulchrisinuosa*, but its secondary escutcheon is larger. (Clark, 1918, p. 124)

Comments.—The shell of the species has a poutlike escutcheonal margin.

Geographic range.—Middle California.

Geologic range.—Eocene to Miocene(?).

Occurrence in California.—Eocene: Muir Sandstone of Weaver (1953); Eocene and Oligocene; San Lorenzo Formation; Miocene(?): San Ramon Sandstone.

Nuculana (Saccella) chehalisensis (Weaver)

Plate 2, figures 20, 21

Leda chehalisensis Weaver, 1912, p. 56, pl. 12, figs. 104, 105.

Nuculana chehalisensis (Weaver). Weaver, 1942, p. 39, pl. 8, figs. 11, 15-17. Addicott, 1976a, p. 27.

Original description.—"Shell small, moderately convex, equivalve and nearly equilateral; beaks slightly elevated and curved forwards; lunule very large; cordate elongate and fairly deeply impressed; escutcheon long and narrow; anterior margin of shell concave, at first sloping steeply for a short distance from the beaks, and then straight to the anterior end; anterior end bluntly truncated upward; base broadly rounded; posterior margin very slightly convex and sloping downwards at a low angle; posterior end acutely rounded. Sculptured by equally spaced closely set concentric ribs with deeply grooved interspaces equal in width to the ribs. Dimensions: Altitude 10 mm.; longitude 15 mm.; thickness 3.5 mm."

Holotype.—CAS 539 (Weaver, 1942).

Type locality.—UW 63. Grays Harbor County, Wash. Astoria Formation, Miocene.

Comparison.—"*Nuculana*" *epacris* Moore is more elongate, more pointed at the posterior end, and more finely sculptured than *Nuculana chehalisensis* (Moore, 1963, p. 55).

Geographic range.—Alaska to Baja California Sur.

Geologic range.—Oligocene and Miocene.

Occurrence in California and Baja California Sur.—Oligocene and Miocene: Temblor Formation (Loel and Corey, 1932); Miocene: Briones Sandstone, Monterey Group, Sobrante Sandstone (Lutz, 1951), Tortugas Formation (Minch and others, 1976).

Nuculana (Saccella) markleyensis (Clark)

Plate 3, figure 2

Leda markleyensis Clark, 1918, p. 123, pl. 14, fig. 7.

Original description.—"Shell small, acutely rostrate posteriorly; beaks opisthogyrous, anterior to middle; posterior dorsal margin strongly concave, longer than anterior dorsal margin, which is gently convex; posterior end sharply pointed; anterior end regularly rounded. Surface covered by medium-fine, regular incremental lines; escutcheonal area flat, fairly broad, depressed nearly at right angles to the main outer surface of shell. Lunule and hinge plate not exposed."

Holotype.—UCMP 11272.

Type locality.—UC 3081. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparison.—*Nuculana markleyensis* resembles *Nuculana gabbii* (Gabb) in outline, but differs in being somewhat higher in proportion to the length; the beaks are more anterior, and the escutcheonal area is different. (Clark, 1918, p. 123)

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—San Ramon Sandstone.

Nuculana (Saccella) furlongi (Trask)

Plate 2, figures 35, 36

Leda furlongi Trask, 1922, p. 147, pl. 1, figs. 1a, 1b.

Original description.—"Shell small, subovate, moderately ventricose; beaks obscure, nearly central; slightly opisthogyrous; posterior dorsal edge gently concave; anterior dorsal edge nearly straight; anterior end regularly rounded; posterior end subacutely rostrate; lunule and escutcheon elongate, lanceolate, extending almost the entire length of the dorsal margins, and rather strongly pouting; surface sculptured with numerous fine regular concentric lines; hinge plate unknown."

Holotype.—UCMP 12362.

Type locality.—UC 15. Contra Costra County, Calif. Briones Sandstone, Miocene.

Comparison.—*Nuculana furlongi* somewhat resembles *Nuculana taphria* but differs from it by being narrower and more elongate posteriorly, by having finer concentric sculpturing, and by the lunule and escutcheon being more strongly pouting. It differs from *Nuculana ochsneri* by being less acutely elongate posteriorly, the posterior dorsal slope being less concave and the concentric ribs finer. It differs from *Nuculana whitmani* (Dall), described from the Empire Formation, Oregon, in that the ribs over the entire surface are finer and more evenly distributed, the posterior dorsal edge is less concave, and the shell appears much narrower. (Trask, 1922, p. 147)

Comments.—*Nuculana furlongi* is of moderate size and the margins of both the lunule and escutcheon pout markedly. Although the holotype is imperfectly preserved, neither the lunule nor the escutcheon is as wide or as well demarcated as on *Nuculana ochsneri* and *Nuculana taphria; N. taphria* is also more rostrate.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Briones Sandstone (Weaver, 1953; Hall, 1958).

Nuculana (Saccella) ochsneri (Anderson and Martin)

Plate 2, figures 24, 25

Leda ochsneri Anderson and Martin, 1914, p. 53, pl. 3, figs. 8a–8c.

Saccella ochsneri (Anderson and Martin). Moore, 1963, p. 55, 57, pl. 13, figs. 1–3, 7.

Original description.—"Shell small, slightly arcuate anteriorly, excavated behind the beaks, rostrate and acute with valves closed at the posterior extremity; basal margin strongly and regularly arcuate, or sometimes slightly truncated at the rear; surface marked with strong concentric lines, polished; posterior ends bearing a shallow oblique groove extending downward from the beaks. Length, 16 to 20 mm.; altitude, 9 to 10 mm.; thickness, 8 mm."

Holotype.—CAS 103.

Type locality.—CAS 68. Kern County, Calif. Round Mountain Silt, Miocene.

Comparisons.—*Nuculana ochsneri elmana* Etherington is more finely sculptured and has a second incised line on the escutcheon.

Nuculana ochsneri "***resembles *Leda taphria* Dall, of which it may be the precursor, but it is relatively thicker, less elevated, and less clearly truncated behind." (Anderson and Martin, 1914, p. 53)

"Nuculana" epacris Moore [Astoria Formation, Oregon] is higher in proportion to length and also more pointed at the posterior end than *N. ochsneri* and lacks the flattened area bordered by a slight ridge present at the posterior dorsal margin of *N. ochsneri.* (Moore, 1963, p. 55)

Nuculana (Saccella) amelga (Moore), described from the Astoria Formation, Oregon, differs from *N. ochsneri* by having sharp concentric ridges, not flattened as on *N. ochsneri* and more widely spaced. *N. amelga* is shorter anteriorly, the beaks are closer to the anterior margin, and it lacks the deeply incised, ridgelike lunule of *N. ochsneri.* (Moore, 1963, p. 57)

Geographic range.—Middle and southern California.

Geologic range.—Miocene.

Occurrence in California.—Buttonbed Sandstone Member of the Temblor, Castaic (Stanton, 1966), and McLure Shale Member of Monterey (Adegoke, 1969) Formations, Olcese Sand (Addicott, 1956), Round Mountain Silt (Keen, 1943), Sobrante Sandstone (Lutz, 1951), Tice Shale (Hall, 1958), and Topanga Formation (Takeo Susuki, written commun., 1978).

Nuculana (Saccella) taphria (Dall)

Plate 2, figures 22, 23

Leda taphria Dall, 1896, p. 70. New name for *Nucula coelata* Hinds, 1843, not *Nucula coelata* Conrad, 1833.

Saccella taphria (Dall). Moore, 1968, p. 50, pl. 23, figs. e–g.

Nuculana (Saccella) taphria (Dall). Hertlein and Grant, 1972, p. 150–151, pl. 27, figs. 11–13, 16–18.

Original description.—"Nuc. testa luteo-virente, oblonga, argute sulcata; antice arcuate rostrata, sulcis paululum obliteratis; umbonibus prominulis. Long 7; lat 3; alt 4 lin."

Holotype.—Missing (Keen, 1966a, p. 267; Hertlein and Grant, 1972, p. 150).

Type locality.—"California, between 38°18′ and 34°24′ north latitude; namely, at Russian Bodegas, San Francisco, and Santa Barbara, in from six to ten fathoms [11 to 18 m]." Holocene.

Supplementary description.—"The umbos of *Nuculana taphria* are nearly centrally situated, the rostrum is bluntly pointed and the exterior is sculptured with well developed, uniform, sharp, raised, concentric ribbing. A narrow lunular area is present and there is a long, narrow escutcheon concentrically striated. A narrow, shallow, depressed area extending from the umbos to the ventral margin is usually present just anterior to the dorsal margin. There are two gently curved rows (the anterior slightly the longer) of chevron-shaped teeth, about 20 in each series. A shallow pallial sinus is present. A typical specimen from off San Martin Island, Lower California, is 18 mm long, 11.2 mm high, convexity (both valves together), 8.9 mm***. Larger shells tend to be more globose with the posterior end more pointed and upturned. Some of these have been bored on the umbo by a gastropod." (Hertlein and Grant, 1972, p. 150)

Comparison.—"The shell of this species is less elongate, more inflated, and the surface is less polished than that of *Nuculana callimene* Dall from Panama and it has much coarser sculpture than that of *N. pontonia* Dall, originally described from the Galapagos Islands. The presence of an anterior lunular area on *N. taphria* serves to separate it from the similar *N. balboae* Brown and Pilsbry from mid-Miocene strata of Panama. Furthermore, the Panamanian species has a much greater number of teeth, 28 in the anterior and 18 in the posterior series." (Hertlein and Grant, 1972, p. 151)

Nuculana (Saccella) taphria resembles *N. calkinsi* (Moore, 1963, p. 56–57, pl. 13, figs. 10–13), described from the Astoria Formation, Oregon, but the rostrum of *N. calkinsi* is not as strongly recurved, and the escutcheon is longer, narrower, and has a secondary ridge.

In addition, the lunule of *N. taphria* is wider and more ovate in outline. (Moore, 1963, p. 57)

Geographic range.—Living: Bodega Bay, Calif., to Blanco de Arena, Golfo de California, Mexico; fossil: middle and southern California.

Geologic range.—Oligocene through Holocene.

Occurrence in California.—Oligocene and Miocene: Temblor Formation (Winterer and Durham, 1958); Miocene: Briones Sandstone (Hall, 1958), Santa Margarita Formation (Adegoke, 1969); Miocene and Pliocene: Capistrano (Vedder, 1974), Etchegoin (Adegoke, 1969), and Towsley (Kern, 1973) Formations; Pliocene: Cebada Member of Careaga Sand (Woodring, 1950), Niguel (J. G. Vedder, written commun., 1978), Ohlson Ranch (Peck, 1960), Pancho Rico (Durham, 1966), Purisima (Arnold, 1906), and San Diego (Hertlein and Grant, 1972) Formations; Pliocene and Pleistocene: Fernando (English, 1914), Pico (Winterer and Durham, 1958), Santa Barbara (Waterfall, 1929, as upper Pico), and Saugus (Waterfall, 1929) Formations; Pleistocene: lower part of San Pedro Series of Arnold (1903).

Habitat.—Occurs in sand and clay at depths of 5 to 145 m; found in fish stomachs off Monterey.

Nuculana (Saccella) orcutti (Arnold)

Plate 2, figures 28, 29

Leda orcutti Arnold, 1907b, p. 435, pl. 55, fig. 9.
Saccella orcutti (Arnold). Woodring, 1950, p. 80, pl. 8, figs. 5, 7, 8, 13; pl. 10, fig. 3

Original description.—"Shell averaging about 7 millimeters in longitude, solid, equivalve; beaks slightly anterior; anterior end rounded, shorter; posterior end rostrate, subacute; base arcuate; lunule long and very narrow, separated from shell by deeply impressed line; escutcheon much broader than lunule, its surface prominently concave and its carina well developed, especially toward the posterior end, sculpture consisting of several (7 in type) prominent wide spaced, narrow concentric riblets, this sculpture confined to the main portion of shell; lunule, escutcheon, and carinae ornamented only by fine concentric incremental lines; incremental lines also visible between the concentric riblets. Hinge and interior similar in a general way to *L. minuta* Fabr."

Holotype.—USNM 165271.

Type locality.—USGS 4473. Santa Barbara County, Calif. Careaga Sandstone, Pliocene.

Supplementary description.—*Nuculana orcutti* is characterized by its coarse, widely spaced concentric riblets. The umbones are nearly in the center of the dorsal margin, both anterior and posterior dorsal margins being approximately equal in length and nearly straight. The rostrum is not attenuated and comes to a blunt point. (Grant and Gale, 1931, p. 125).

"Twenty specimens are in collections from the type locality. They are elongate and strongly and coarsely sculptured except one, which is almost smooth aside from sculpture near the ventral margin. The few Careaga fossils also are elongate. The more numerous Sisquoc shells***show a greater range of variation. The outline varies from short***, the usual form, to elongate***. Some immature shells are coarsely sculptured***, but most immature and mature shells have strong moderately coarse sculpture. One immature shell, however, is almost smooth***." (Woodring, 1950, p. 80)

Comparison.—"The short form of *S. orcutti* resembles closely the Recent northern *S. penderi*, but has coarser and generally stronger sculpture." (Woodring, 1950, p. 81) *N. (S.) hindsii* has finer sculpture than *N. (S.) orcutti.*

Geographic range.—Southern California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Miocene and Pliocene: Sisquoc Formation (Woodring, 1950); Pliocene: Cebada Member of Careaga Sandstone and Foxen Mudstone.

Nuculana (Saccella) cellulita (Dall)

Plate 2, figures 26, 27

Leda cellulita Dall, 1896, p. 1. Dall, 1987, p. 7, pl. 2, figs. 5, 7.
Nuculana cellulita (Dall). Grant and Gale, 1931, p. 122.
Saccella cellulita (Dall). Woodring, 1950, p. 80, pl. 15, figs. 3, 26.

Original description.—"Shell solid, with a dull olive-gray epidermis, moderately convex, with subcentral, not prominent beaks, base profoundly arcuate, anterior dorsal slope rounded, posterior straight or slightly concave; posterior extreme bluntly pointed; escutcheon large, transversely striate; lunule not differentiated but similarly striate; sculpture of fine sharp, concentric grooves with wider interspaces, less arcuate than the incremental lines; chondrophore small, triangular, not projecting, with 22 anterior and 16 posterior hinge teeth on the cardinal border. Height 10.5; diameter 7.2; length 15.5 mm."

Lectotype.—USNM 107436a, here designated [from the syntypic lot] as the double-valved syntype figured by Dall (1897, pl. 2, fig. 7).

Type locality.—Puget Sound, near Port Orchard, Wash. Holocene.

Supplementary description.—The irregular *Acila*-like radial sculpture on the lunule and escutcheon is the most characteristic feature of *N. cellulita.* (Woodring, 1950, p. 80)

Comparison.—The shell of this species is less elongate and more bluntly pointed posteriorly than *Nuculana taphria.* The sculpture is not quite coincident with the growth lines (Grant and Gale, 1931, p. 123) The outline of *N. cellulita* suggests that of *N. taphria*, but the concentric rugae are finer. (Woodring, 1950, p. 80)

Geologic range.—Pliocene through Holocene.

Geographic range.—Living: Craig, Alaska to Redondo Beach, Calif.; fossil: southern California.

Occurrence in California.—Pliocene: Cebada Member of Careaga Sandstone (Woodring, 1950), lower part of San Pedro (Grant and Gale, 1931), and upper part of Sisquoc Formations; Pliocene and Pleistocene: Pico Formation (Winterer and Durham, 1958).

Habitat.—55 to 75 m, sandy mud.

Nuculana (Saccella) hindsii (Hanley)

Plate 2, figures 30, 31

Leda hindsii Hanley, 1860a, p. 440; 1860b, p. 135, sp. 51, pl. 229, fig. 102.
Nuculana redondoensis Burch, 1944, p. 9; text fig. p. 10.
Saccella redondoensis Burch. Woodring, 1950, p. 81, pl. 16, fig. 18.

Original description.—"Very small, subequilateral, pointed, ovate-oblong, more or less ventricose, only gaping at the hinder tip, with a conspicuous broad anterior indented ray and fold, white, concentrically costellated, except a smooth upper space before the keeled or sharply angulated umbonal ridge; riblets regular and numerous, scarcely as broad as their intervals, which are everywhere traversed by minute radiating lyrae. Anterior extremity attenuatedly rounded: posterior side, if either, the longer, simply and sharply acuminated, the tip subcentral, acutangular, scarcely, if at all, recurved. Dorsal slopes moderate; front one convex; hinder one straightish or subretuse. Ventral margin arcuated in the front and middle, rising at both ends, straighter behind. Lunule small, narrow, subgranosely cross-barred: escutcheon large, concave, crowded with longitudinal costellar striae, whose intervals appear punctulate either side of the minute cartilage-pit."

Holotype.—Location unknown.

Type locality.—Probably from the Gulf of Nicoya, Costa Rica, Holocene.

Supplementary description.—***Most of the fossils show microscopic punctae on the ventral side of the concentric rugae on the dorsal part of the shell, possibly due to slight corrosion, but not on the umbo. A few of the Recent shells examined show similar punctae***." (Woodring, 1950, p. 81)

Comparison.—"***N. acuta* Conrad, a name often given to this Pacific Coast species, has its rostral rib crossed by concentric ribs. *N. penderi* Dall and Bartsch is twice as fat, with a very ovate lunule and is more rounded at the ventral margin***." (Abbott, 1974, p. 415)

Nuculana hindsii is more pointed posteriorly than its Atlantic twin, *N. acuta* (Keen, 1971, p. 31). *Nuculana hindsii* has finer sculpture than *N. orcutti* and is shorter and more globose than *N. penderi.*

Geographic range.—Living: Nazan Bay, Alaska, to Panama; fossil: southern California to Baja California Norte.

Geologic range.—Pliocene through Holocene.

Occurrence in California and Baja California.—Pliocene: Cebada Member of the Careaga Sandstone (Woodring, 1950, as *N. redondoensis*); Pliocene and Pleistocene: Fernando Formation (Zinsmeister, 1970, as *N. acuta*); Pleistocene: unnamed sediments, San Quintin Bay, Baja California Norte (Jordan, 1926).

Habitat.—Dredged off the west coast of North America from 30 to 3,700 m in gravel, sand, sandy mud, mud, and shells.

Subgenus SACCELLA?

Nuculana (Saccella?) fabata (Nelson)

Plate 2, figure 39

Leda fabata Nelson, 1925, p. 404, pl. 49, fig. 1.

Original description.—"Shell small, suboval, moderately convex; beaks almost central, low. Anterior dorsal margin slightly concave, gently sloping; posterior dorsal margin almost straight, meeting anterior dorsal margin at beaks in very wide angle; ventral margin regularly and strongly arcuate, joining anterior dorsal margin in a rounded angle, merging into truncated posterior extremity; posterior extremity a trifle convex, meeting posterior dorsal margin in an angle slightly greater than 90°. Shell with maximum inflation just below beaks, slightly depressed toward anterior extremity, with broad, faint sulcation extending from behind beaks to posterior extremity. Surface of shell with fine concentric ribbing. Character of lunule and escutcheon obscure. Length of type specimen, 5 mm; height, 3.2 mm."

Holotype.—UCMP 30717.

Type locality.—UC 3752. Ventura County, Calif. Martinez Formation, Paleocene.

Comments.—The comparatively straight dorsal margin and near-central location of the beaks distinguish this species.

Geographic range.—Southern California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Nuculana (Saccella?) denominata G D. Hanna

Plate 2, figure 40

Leda milleri Dickerson, 1914, p. 123-124, pl. 7, fig. 4. Not *Nuculana milleri* Gabb, 1881.

Leda denominata G D. Hanna, new name, 1924, p. 169.

Original description.—"Shell small, moderately convex; beak, prominent, located one-third of the distance from anterior end. Posterior dorsal edge straight with a very slight slope to a blunt pointed posterior end. Anterior dorsal edge straight with a slightly greater slope than posterior dorsal edge. Ventral margin gently convex. This margin curves sharply toward the two pointed extremities of the shell."

Holotype.—UCMP 11663.

Type locality.—UC 1556. Contra Costa County, Calif. Martinez Formation, Paleocene.

Comparison.—This form resembles *N. packardi* but is much lower, its beak is more anterior and its length greater. It somewhat resembles *Yoldia chehalisensis* (Arnold) in shape. (Dickerson, 1914, p. 214)

Comments.—*Nuculana denominata* is more elongate in proportion to its height than *Portlandia chehalisensis*, and the holotype, though poorly preserved, resembles *Saccella* in outline.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Nuculana (Saccella?) packardi (Dickerson)

Plate 2, figure 32

Leda packardi Dickerson, 1914, p. 123, pl. 7, figs. 3a, 3b.

Original description.—"Shell thin, marked by fine rounded concentric lines, short, convex; beaks central, small but prominent; anterior dorsal margin, slightly sloping; posterior, straight; anterior end rounded; posterior end bluntly pointed with apex of point at end of straight posterior dorsal margin; base rounded from anterior to middle of posterior ventral margin; from this point the slightly curving posterior margin slopes abruptly upward to the posterior extremity. This species differs from all the other California ledas in shape and in the central position of its beaks. The oddly blunted rostrum is another distinguishing feature."

Holotype.—UC 11725.

Type locality.—UC 784. Lake County, Calif. Martinez Formation, Paleocene.

Comments.—The outline of this species is unique; it is quadrate and the apex of the posterior end is parallel with the dorsal margin.

Geographic range.—Northern California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Nuculana (Saccella?) ramonensis (Clark)

Plate 2, figure 33

Leda ramonensis Clark, 1918, p. 124-125.

Original description.—"Shell small; beaks nearly central, rather inconspicuous; angle of dorsal slopes fairly low, almost equal; both dorsal slopes straight and nearly equal in length. Posterior end acutely rostrate; anterior end regularly rounded. Lunule lanceolate, narrow and not very long; escutcheon elongate-lanceolate, reaching over two-thirds the length of the posterior dorsal edge, slightly pouting. Surface of shell covered by regular, well-marked concentric lines."

Holotype.—UCMP 11167.

Type locality.—UC 1131. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comments.—Concentric ridges are preserved near the ventral margin of the holotype.

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—San Ramon Sandstone.

Subgenus THESTYLEDA Iredale 1929

Posterior end drawn out into a spoutlike rostrum; strong concentric sculpture that curves at rostral sinus. Posterior end truncate, commonly with a keel at inflection of concentric ribs; chondrophore large.

Geographic range.—Western America.

Geologic range.—Pliocene through Holocene.

Nuculana (Thestyleda) hamata (Carpenter)

Plate 2, figures 37, 38

Leda hamata Carpenter, 1846b, p. 612, 644.

Nuculana (Thestyleda) hamata (Carpenter). Palmer, 1958, p. 61-62, pl. 2, figs. 4-6.

Original description.—"Santa Barbara; Cat. Is., 20-60 fms.; common. Like *Steenstrupi* and *pernuloides*, but very hooked, sculpture strong. 20-60 fm. c.*Cp.*"

Lectotype.—USNM 107420 (Palmer, 1958, p. 62).

Type locality.—Catalina Island, southern California, 35-110 m. Holocene.

Supplementary description.—"The long posterior rostrum is squarely cut off at the end, and the shell is strongly concentrically sculptured." (Keen, 1971, p. 31)

Geographic range.—Living: Puget Sound, Wash., to Baja California Sur; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: Niguel Formation (J. G. Vedder, written commun., 1978); Pliocene and Pleistocene: Fernando (Moody, 1916) and San Pedro (Arnold, 1903) Formations.

Habitat.—35 to 1,490 m, in mud and sand.

Genus LEDINA Dall, 1898

Ends of shell evenly rounded, valves smooth, equilateral.

Geographic range.—North America.

Geologic range.—Paleocene and Eocene.

Ledina duttonae (Vokes)

Plate 3, figure 3

Jupiteria (Ledina) duttonae Vokes, 1939, p. 44-45, pl. 1, fig. 6

Original description.—"Shell small, elongate, subtrigonal, moderately inflated; umbos central, high, prominent; anterior, posterior, and ventral margins broadly and regularly rounded; slightly rostrate posteriorly with the rostrum barely ridged; lunule and escutcheon prominent, long, narrow, high, smooth, set off from the rest of the shell by a shallow groove; surface sculptured by fine, regularly spaced, concentric striae, nine to the one mm. interval on the center of the valve; hinge consisting of a slightly convex anterior and a slightly concave posterior series of chevron-shaped teeth."

Holotype.—UCMP 15564.

Type locality.—UC 1817. Fresno County, Calif. Cerros Shale Member of the Lodo Formation, Paleocene and Eocene.

Comparison.—This unique little species is not likely to be confused with any previously described from the Western American Eocene. The high, centrally located umbos and the broad, rounded shape are distinctive. (Vokes, 1939, p. 44)

Comments.—The very high, central umbos are indeed distinctive, but this form is not as strongly inflated or corbuloid in shape as *Jupiteria*.

Geographic range.—Middle California.

Geologic range.—Paleocene to Eocene.

Occurrence in California.—Paleocene: Cerros Shale Member of the Lodo Formation (Keen and Bentson, 1944)

Ledina fresnoensis (Dickerson)

Plate 3, figures 4, 5

Leda fresnoensis Dickerson, 1916, p. 483, pl. 36, figs. 2a, 2b.

Calorhadia (Litorhadia) fresnoensis (Dickerson). Vokes, 1939, p. 43-44, pl. 1, fig. 5

Ledina fresnoensis (Dickerson). Givens, 1974, p. 39-40, pl. 1, fig. 2.

Original description."Shell long, rather robust for this genus; beak prominent and situated two-fifths of the length from the anterior end. Anterior dorsal margin straight with moderate slope; the posterior dorsal margin slightly concave with a gentle slope to a narrowly rounded rostrum; posterior end, narrowly rounded; ventral margin, broadly convex. Very fine growth lines decorate the shell. Dimensions.—Height of broken specimen, the type, 13 mm.; length, 22 mm."

Holotype.—UCMP 11790.

Type locality.—UC 1817. Fresno County, Calif. Lodo Formation, Paleocene and Eocene.

Supplementary description.—"The hinge of this species is that of typical *Calorhadia*; the anterior tooth-row is the shorter, containing 18+ chevron-shaped, narrow teeth, smaller near the umbo; the posterior row has 24 chevron-shaped teeth which are smaller near the beak but more robust than the teeth of the anterior row. The ligamental pit is trigonal in shape, moderately wide and symmetrically placed between the two rows of teeth. The impressed lunule is wide and long, extending to the anterior dorsal extremity; the escutcheon is wide and long and extends to the posterior dorsal extremity, being divided by a diagonal ridge from beneath the umbos to the posterior dorsal edge near the posterior end." (Vokes, 1939, p. 44)

"This species is referred to *Ledina* on the basis of its nearly smooth shell, equilateral shape, and evenly rounded anterior and posterior margins." (Givens, 1974, p. 40)

Geographic range.—Southern Oregon to southern California.

Geologic range.—Paleocene and Eocene: "Capay" to "Domengine" megafossil Stages (Givens, 1974, p. 40)

Occurrence in California.—Paleocene: Cerros Shale Member of the Lodo (Keen and Bentson, 1944) and Meganos (Clark, 1921) Formations; Eocene: Capay and Juncal (in *Turritella uvasana infera* fauna, Givens, 1974) Formations and lower part of Llajas Formation .

Genus HILGARDIA Harris and Palmer, 1946

Shell with radial ribs intersecting concentric sculpture as crenulations and nodes.

Geographic range.—North America. *Nuculana (Hilgardia) multilineata* (Conrad), the type species of the genus *Hilgardia*, occurs in the Eocene of Mississippi, Louisiana, and Arkansas. *Hilgardia* has not been reported from the Tertiary of the Western United States.

Geologic range.—Eocene (table 2).

Genus HILGARDIA?

Hilgardia? parkei (Anderson and Hanna)

Plate 3, figures 6, 7

Leda parkei Anderson and Hanna, 1925, p. 179-180, pl. 2, figs. 10, 11.

Nuculana (Saccella) parkei (Anderson and Hanna). Givens, 1974, p. 39.

Original description.—"Shell sculptured with uneven lines of growth, and therefore without the regular concentric ornamentation usually found in members of this genus; anterior end and basal margin gently rounded; posterior dorsal slope concave, bounded by an impressed area which is relieved by small sharp ridges, and crossed by distinct concentric sculpturing. The posterior dorsal margin and the basal margin meet in a sharp angle and point."

Holotype.—CAS 782.

Type locality.—CAS 244. Kern County, Calif. Tejon Formation, Eocene.

Comparison.—"The irregular sculpture and peculiar posterior slope distinguish this species from any other known to us. Only two specimens were found." (Anderson and Hanna, 1925, p. 180)

Hilgardia? parkei is distinguished from *Hilgardia? parkei coosensis* (Turner) by having a third intercalated umbonal line (Turner, 1938, p. 42, pl. 5, fig. 5).

Comments.—*Hilgardia? parkei* is higher in proportion to its length and not as coarsely or regularly sculptured concentrically as *H.? parkei coosensis*. The escutcheonal ridges of *H.? parkei* are slightly nodose.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Domengine Sandstone (M. A. Hanna, 1927), Juncal Formation (in *Turritella uvasana infera* and *T. uvasana applinae* faunas, "Capay" to "Tejon" megafossil Stages, Givens, 1974), La Jolla Group, Poway Group, and type Tejon Formation (M. A. Hanna, 1927).

Hilgardia? parkei coosensis (Turner)

Plate, 3, figure 8

Nuculana parkei (Anderson and Hanna), subsp. *coosensis* Turner, 1938, p. 42, pl. 5, fig. 5

Calorhadia? parkei coosensis (Turner). Stewart, 1946, table 1 (in pocket).

Original description.—"Shell small, elongate; beaks low, subcentral; anterior dorsal margin sloping; anterior sharply rounded; ventral margin gently convex; posterior extremity acute; posterior dorsal margin concave; ornamented by two posterior umbonal ridges, the upper terminating at the posterior extremity, and heavy concentric ribbing."

Holotype.—UCMP 33205.

Type locality.—UC A-838. Coos County, Oreg. Lower part of Umpqua Formation, Eocene.

Comparison.—*Hilgardia? parkei coosensis* does not have the third intercalated umbonal line that distinguishes *Hilgardia? parkei*. (Turner, 1938, p. 42) [See also *Nuculana* (*Saccella*) *chaneyi*.]

Comments.—The very heavy concentric ribs that continue across the posterior depressed area are distinctive.

Geographic range.—Southern Oregon to middle California.

Geologic range.—Eocene.

Occurrence in California.—Avenal Sandstone (Stewart, 1946).

Genus LITORHADIA Stewart, 1930

Shell with shape of *Nuculana* but hinge of *Calorhadia*; with wide ligamental pit.

Geologic range.—Eocene to Miocene (table 2).

Litorhadia astoriana (Henderson)

Plate 3, figure 9

Nucula impressa Conrad, 1849, p. 726, atlas pl. 18, figs. 7a-7c.

Yoldia (*Portlandia*) *astoriana* Henderson, 1920, p. 122, new name for *Nucula impressa* Conrad. Not *Nucula impressa* J. Sowerby, 1824.

Litorhadia astoriana (Henderson). Moore, 1963, p. 56, pl. 12, figs. 11, 14, 17, 21 [see for synonymy].

Original description.—"Oblong ovate, convex, with regular concentric impressed lines. Anterior extremity rostrate, slightly recurved, extremity truncated; ligament margin arcuate, slightly declining; rounded behind. Beaks submedial. Basal margin arcuate, slightly contracted near the anterior extremity. Astoria, Oreg. (Length 1 inch; breadth very nearly half an inch. Apical angle 155° to 160°. The fine lines of the surface are neat, but closely crowded)."

Lectotype.—USNM 3490 (Grant and Gale, 1931, pl. 32, fig. 46).

Type locality.—Astoria, Columbia County, Oreg. Astoria Formation, Miocene.

Supplementary description.—"The lectotype of *Litorhadia astoriana* (USNM 3490) is a double-valved specimen with the valves together and hinged but not completely closed. The shell of the right valve is broken along the ventral margin and covered by matrix at the posterior margin; only small patches of the original shell remain on the left valve. The anterior end is rounded, the posterior end is pointed and abruptly terminated; the beaks are slightly anterior of the middle of the shell. The lunule is long, incised, and flat; the escutcheon is wide, long, and deeply impressed, and the shell is produced at the dorsal margin within the escutcheonal area. There are concentric grooves on the shell separated by slight ridges. These grooves are particularly noticeable on the middle of the shell and near the ventral margins, but they seem to be missing from the umbonal area and the anterior and posterior ends of the shell. The type specimen is more than 18.9 mm long (posterior end covered), more than 9 mm high (ventral margin broken), and 6.7 mm wide***." (Moore, 1963, p. 56)

Geographic range.—Oregon to southern California.

Geologic range.—Eocene to Miocene.

Occurrence in California.—Eocene and Oligocene: San Lorenzo Formation (Arnold, 1906); Oligocene and Miocene: Temblor (Loel and Corey, 1932) and Vaqueros (Arnold, 1909) Formations; Miocene: Monterey Formation (Arnold, 1908).

Genus YOLDIA Möller, 1842

Somewhat similar to *Nuculana* but with thinner, subovate shell, slightly rostrate, usually gaping posteriorly; exteriorly sculptured by growth lines on concentric striae; hinge consists of two subequal series of small chevron-shaped teeth; resilifer large, symmetrically underlapping both rows of teeth; pallial sinus deep and wide, the apex broadly U-shaped.

Geologic range.—Cretaceous through Holocene (table 2).

Habitat.—Chiefly in boreal and temperate waters from 0 to 5,300 m; common in shallow water in the north Pacific; burrows vertically.

Subgenus YOLDIA?

Yoldia (Yoldia?) temblorensis Anderson and Martin

Plate 4, figure 14

Yoldia temblorensis Anderson and Martin, 1914, p. 54, pl. 3, fig. 3.

Original description.—"Shell small, oblong ovate, thin, arcuate on lower margin, nearly straight above; beaks central, inconspicuous; hinge margin bent only six degrees from a straight line; anterior end well rounded; posterior end rostrate, almost pointed, slightly open, angulated by an impressed line extending from the

beaks downward to the posterior end below the siphonal opening; anterior end similarly crossed by an impressed zone extending from the beaks obliquely downward and forward; surface sculptured by regular lines of growth."

Holotype.—CAS 106

Type locality.—CAS 68. Kern County, Calif. Round Mountain Silt, Miocene.

Comments.—The very straight anterior dorsal margin distinguishes this form.

Geographic range.—Western Washington, middle and southern California.

Geologic range.—Miocene.

Occurrence in California.—Monterey Formation, Olcese Sand (Addicott, 1956), Round Mountain Silt (Keen, 1943), Sobrante Sandstone, and Temblor Formation (Adegoke, 1969).

Subgenus KALAYOLDIA Grant and Gale, 1931

Posterior part of valves short, narrowed, recurved; strongly oblique resilifers, very deep pallial sinus; strong concentric sculpture.

Geologic range.—Eocene to Holocene (table 2).

Habitat.—*Kalayoldia* is restricted to western North America. The single living species, *Yoldia* (*Kalayoldia*) *cooperii* Gabb, ranges from middle California to Baja California Norte and Mexico, at depths of 10 to 25 mm.

Yoldia (Kalayoldia) tenuissima Clark

Plate 3, figure 10

"*Yoldia cooperii* Gabb," of Gabb, 1869, p. 31, pl. 9, fig. 4. Not *Yoldia cooperii* Gabb, 1865, p. 189.

Yoldia cooperi tenuissima Clark, 1918, p. 125-126, pl. 11, fig. 10; pl. 12, figs. 8, 14.

Yoldia (*Kalayoldia*) *tenuissima* Clark. Hickman, 1969, p. 32-33, pl. 1, fig. 18. Addicott, 1973, p. 22-23, pl. 1, figs. 2, 3, 5, 8.

Original description.—"This variety differs from the species *Y. cooperi* Gabb principally in that the distance from the beak to the anterior end is shorter in proportion to the length of the shell; also there is a less number of teeth in the hinge plate; in other respects the species and the variety are very similar. This difference, however, appears to be constant and when better and more specimens of the variety are obtained it may be found that the variety should be listed as a distinct species."

Holotype.—UCMP 11110.

Type locality.—UC 798. [No locality data available.] Lat 37.2° N., long 122.1° W., San Ramon Sandstone, Miocene(?) (Addicott, 1973, p. 23).

Geographic range.—Washington to southern California.

Geologic range.—Eocene to Miocene.

Occurrence in California.—Eocene and Oligocene: San Emigdio Formation (DeLise, 1967), San Lorenzo Formation (Clark, 1925); Oligocene: upper part of Gaviota Formation of Weaver and Kleinpell (1963), Wygal Sandstone Member, Temblor Formation (Addicott, 1973); Miocene: Gould Shale Member, Monterey Formation (Addicott, 1972), Olcese Sand (Addicott, 1956), Round Mountain Silt (Addicott, 1973); Miocene(?): San Ramon Sandstone (Weaver, 1953).

Yoldia (Kalayoldia) oregona (Shumard)

Plate 3, figures 11, 12

Leda oregona Shumard, 1858, p. 121-122 (reprinted in Dall, 1909, p. 187).

Yoldia (*Portlandia*) *oregona* (Shumard). Weaver, 1942, p. 49, pl. 9, figs. 8, 16.

Yoldia (*Kalayoldia*) *oregona* (Shumard). Trumbull, 1958, p. 900-901, pl. 115, figs. 2, 3. Hickman, 1969, p. 31-32, pl. 1, figs. 14, 15.

Original description.—"Shell rather large, ovate, compressed, convex; anterior extremity strongly arched; posterior extremity rostrate, slightly recurved, truncated; basal margin forming a broad curve, slightly contracted near the posterior extremity; ligament margin slightly concave; beaks situated a little in advance of the middle; surface neatly ornamented with regular, concentric, impressed lines, becoming more approximate above; hinge with a line of closely set oblique teeth on each side of the beak. Length 20 lines; height, 10 lines."

Lectotype.—USNM 562470 (Trumbull, 1958, p. 900).

Type locality.—A few kilometers south of Oregon City, Oreg. Scappoose(?) Formation, Oligocene and Miocene.

Supplementary description.—"The lectotype of *Yoldia* (*Kalayoldia*) *oregona* is of moderate size, slightly inflated, and the impression shows faint traces of concentric lines. The umbos are slightly anterior to the middle of the shell. The anterior end is evenly rounded; the posterior end is attenuated and recurved. The posterior hinge line is concave and consists of about 20 teeth; the anterior hinge line, which is convex, of about 25 teeth." (Trumbull, 1958, p. 900).

Comparisons.—"*Y. oregona* is easily distinguished from other Tertiary nuculid taxodonts. Its closest relative is probably the Recent species *Y. cooperi* Gabb of the southern California coast. The beaks of *Y. cooperi* are much more posterior in their placement, and hence the rostrum is shorter. Consequently the anterior dorsal margin has a much more prominent convex curve. *Y. tenuissima* Clark has a rostrum intermediate in length between that of *Y. oregona* and *Y. cooperi*, although it is probably more closely related to *Y. cooperi.*" (Hickman, 1969, p. 32)

Geographic range.—Alaska to southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Miocene: Temblor "Horizon" (Loel and Corey, 1932) and Round Mountain Silt (Keen, 1943).

Yoldia (Kalayoldia) submontereyensis Arnold

Plate 3, figure 13

Yoldia submontereyensis Arnold, 1908, p. 376-377, pl. 34, fig. 8.

Original description.—"Shell attaining a length of 32 mm., width about two-thirds of length, oblong, rounded in front, somewhat attenuated, angular, and slightly gaping behind, compressed; margin smooth; umbo central; anterior dorsal margin nearly straight, anterior extremity broad and evenly rounded; posterior dorsal margin concave, curving upward at posterior extremity, but not prominently excavated immediately in rear of umbo; basal margin curving up sharply behind and meeting dorsal margin in a right angle, although the extreme end is slightly posterior to the angle; a faint carina, separated from dorsal margin by impressed line or lunule, extends from umbo to posterior extremity; surface sculptured by numerous regular, narrow, incremental lamellae, which are abruptly truncated on the edge toward the umbo, slope off gently on the side toward the periphery, and become narrower posteriorly."

Holotype.—USNM 165459.

Type locality.—On San Francisquito Creek [below dam], 0.4 km below its confluence with Los Trancos Creek, Santa Cruz quadrangle [on San Mateo County line, 2 km southwest of Stanford University, Palo Alto quadrangle], California. Unnamed Miocene sandstone of Dibblee (1966).

Comparison.—*Yoldia submontereyensis* is closely allied to "*Nucu-*

lana" whitmani Dall from the Miocene and Pliocene of Oregon but differs from it by being less attenuate posteriorly and broader in outline; the excavation behind the umbo in *"N." whitmani* Dall is also more pronounced. *Yoldia submontereyensis* is smaller and less attenuated posteriorly than *Y. oregona* Shumard; is much smaller and much longer, but narrower posteriorly, than *Y. cooperi* Gabb; is much larger, broader and more closely sculptured than *Y. impressa* Conrad; is shorter and broader at the posterior end than *Y. supramontereyensis*. (Arnold, 1908, p. 376-377)

Geographic ranges.—Middle and southern California.

Geologic ranges.—Miocene.

Occurrence in California.—Upper part of Temblor Formation (Loel and Corey, 1932); unnamed Miocene sandstone near Stanford University of Dibblee (1966).

Yoldia (Kalayoldia) supramontereyensis Arnold

Plate 3, figure 14

Yoldia supramontereyensis Arnold, 1908, p. 382, pl. 35, fig. 9. Addicott, 1976a, p. 27, pl. 3, figs. 7, 15. Addicott and others, 1978, p. 58, pl. 1, fig. 5.

Yoldia cooperii supramontereyensis Arnold. Stewart, 1930, p. 62-64, pl. 15, fig. 2.

Original description.—"Shell attaining a length of 32 mm., width about two-thirds length, oblong, rounded in front, somewhat attenuated, angular and slightly gaping behind, compressed; margin smooth; umbo not prominent, curving backward, anterior, being about 48 percent of the length of the shell from the exterior extremity; anterior dorsal margin slightly convex, anterior extremity quite evenly rounded; posterior dorsal margin slightly concave and turned up at the extremity, meeting the ventral margin in a right angle slightly above and anterior to the curved extremity; a very faint carina, separated from the dorsal margin by a faint groove, extends from the umbo to the posterior extremity. Surface sculptured by numerous, regular, narrow, incremental lamellae, as in *Y. submontereyensis****. Hinge and teeth similar in a general way to *Y. cooperi.*"

Holotype.—CAS/SU 5362 (Keen and Bentson, 1944, p. 122).

Type locality.—Tusk Gully, near road, 4 km south of Mayfield [now part of Palo Alto] near Stanford University, Santa Cruz quadrangle, Santa Clara County, Calif. Unnamed Miocene sandstone of Dibblee (1966).

Comparison.—"*Y. supramontereyensis* is closely allied to *Y. submontereyensis****but is easily distinguishable by its long posterior extremity." (Arnold, 1908, p. 382)

"The beaks tend to be situated medially which permits this species to be differentiated from*** *Y. tenuissima* Clark." (Addicott, 1976a, p. 27)

Geographic range.—Washington and middle and southern California.

Geologic range.—Miocene. The record of *Yoldia supramontereyensis* in the Clallam Formation, Washington, "constitutes a range extension into the provincial lower Miocene; the holotype is from the unnamed sandstone of Dibblee (1966) which overlies the Page Mill Basalt that has been dated as 14.4±2.4 m.y. (Turner, 1970, p. 106). Benthonic foraminifers from this sandstone are of provincial middle Miocene (Relizian or Luisian) age (Clark, 1968, p. 177)." (Addicott, 1976a, p. 27)

Occurrence in California.—Hambre Sandstone (Hall, 1958), Monterey Formation (Lutz, 1951; Addicott and others, 1978), Oursan Sandstone, San Ramon Sandstone (Weaver, 1953), Sobrante Sandstone (Lutz, 1951), and Temblor Formation (Stewart, 1946); unnamed sandstone near Stanford University of Dibblee (1966).

Yoldia (Kalayoldia) cooperii Gabb

Plate 3, figures 19, 20

Yoldia cooperii Gabb, 1865, p. 189. Gabb, 1866, p. 31 (in part), pl. 9, fig. 54.

Yoldia (Kalayoldia) cf. *Y. (K.) cooperi* Gabb. Hertlein and Grant, 1972, p. 151-152 [See for synonymy].

Original description.—"Shell thin, somewhat compressed, very inequilateral, beaks placed about a third of the length from the anterior end, minute; anterior end narrow, sub-acuminate, posterior end broadly rounded; base most prominent just posterior to the middle of the shell; surface sculptured by numerous small concentric ribs, rarely dichotomous or anastomosing on the widest part of the shell; these ribs are flat and abruptly truncated on the side nearest the beak, giving the surface, under a glass, the appearance of an overlapping. Epidermis shining, olivaceous; internally a bluish white; muscular scars large, the anterior triangular, posterior a third the largest, broadly suboval. Long. 1.25, lat. 2.6, alt. .25 [inches]."

Holotype.—UCMP 30613.

Type locality.—"A single left valve was found on the beach at Santa Cruz, Cal., by Dr. Cooper." Santa Cruz County, Calif., Holocene.

Supplementary description.—"Shell large,***greatest height (distance between dorsal and ventral margins) anterior to the median line of the shell and far anterior to the umbones; anterior portion of valves broadly, evenly curved; posterior portion attenuated, produced into a rostrum concavely curved on its dorsal margin; posterior dorsal area somewhat depressed, definitely set off from adjacent surface of valves;***anterior dorsal margin curving gently into the regular anterior curve. Hinge a long, gently curving, anterior row of rather long, somewhat upcurved teeth, chevron-shaped at their bases, a depressed, somewhat roundly-trigonal ligament pit, and a short, slight-curved anterior [sic: posterior] row of teeth. Pallial sinus deep, u-shaped. Sculpture of concentric lamellae, occasionally slightly irregular in respect to incremental lines on portions of the valve but not regularly oblique. A large Recent specimen from Santa Cruz, California, in the Stanford collection, measures as follows: Total length, 76 mm.; umbo to end of rostrum 26 mm.; umbo to anterior margin of valve, 53 mm.; height (greatest dorsal-ventral distance), 37 mm.; thickness of one valve, about 7 mm." (Grant and Gale, 1931, p. 128)

Comparison.—"Compared to *Yoldia oregonensis* Conrad***the beaks of *Y. cooperii* are more posteriorly situated and the rostrum is shorter.

"*Yoldia supramontereyensis* Arnold***is less attenuated posteriorly than typical *Y. cooperii.*

"*Yoldia cooperii tenuissima* Clark***has the beak more anteriorly situated and a longer rostrum than *Y. cooperii.*" (Hertlein and Grant, 1972, p. 152)

Geographic range.—Living: from Point Reyes, Calif., to Todos Santos Bay, Baja California Sur; fossil: middle and southern California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene: Briones Sandstone (Weaver, 1953; Hall, 1958), San Pablo (Smith, 1912), Santa Margarita (Smith, 1912), and upper part of Temblor (Loel and Corey, 1932) Formations; Miocene and Pliocene: Etchegoin (Nomland, 1917a), Purisima (Addicott, 1969), and Tahana Member, Purisima (Addicott, 1969) Formations; Pliocene and Pleistocene: Fernando (English, 1914), Merced (Glen, 1959), San Pedro (Arnold, 1903), and Saugus (Waterfall, 1929) Formations, and Wildcat Group (Roth, 1979).

Habitat.—Usually in sand, from 10 to 125 m.

Subgenus KALAYOLDIA?

Yoldia (Kalayoldia?) gesteri Dickerson

Plate 4, figure 8

Yoldia gesteri Dickerson, 1914, p. 124, pl. 7, fig. 5

Original description."Shell thin, very compressed; anterior end, the shorter, and equally rounded above and below; posterior end, slightly longer, pointed; posterior dorsal margin very slightly concave; escutcheon, long, narrow; base, rounded and most prominent beneath beak, from which point it curves regularly to the pointed, posterior end; beaks, inconspicuous; sculpture consists of fine, rounded concentric threads."

Holotype.—UCMP 11685.

Type locality.—UC 790. Lake County, Calif. Martinez Formation, Paleocene.

Comparison.—"This species is not as convex as *Y. cooperi* Gabb of the Miocene, its posterior dorsal margin is not as concave as that of *Y. cooperi*, and the decoration is much finer." (Dickerson, 1914, p. 124)

Geographic range.—Northern California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Yoldia (Kalayoldia?) carnarosensis (Clark)

Plate 4, figure 17

Yoldia carnarosensis Clark, 1915, p. 446, pl. 48, fig. 6

Original description.—"Shell medium in size, beaks low and inconspicuous, situated about two-thirds the distance from the anterior to the posterior end. Anterior dorsal edge long and very gently convex; posterior dorsal edge gently concave. Posterior extremity subtruncate to bluntly rounded, the blunt subtruncate end being subangulate at the junction with the posterior dorsal edge and indistinctly separated from the ventral edge. Surface sculptured by somewhat irregular incremental lines or concentric ribs. On the surface near the posterior end there is a distinct sulcus which reaches from the beak to a little below the angulation on the posterior end. Hinge plate unknown."

Holotype.—UC 11539.

Type locality.—Carneros Creek [NW ½, sec. 4, T. 4 N., R. 4 W.], Napa County, Calif. Neroly Sandstone, Miocene.

Comparison.—"*Y. carnarosensis****somewhat resembles *Y. cooperi* Gabb, a recent West Coast species. It differs in the following respects: the posterior end is not so attenuated, the concentric ribbing is not so regular, the distinct sulcus on the posterior extremity is lacking on *Y. cooperi*." (Clark, 1915, p. 446).

Comments.—The bluntly rounded posterior end of this form is distinctive.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Briones, Cierbo, and Neroly Sandstones (Hall, 1958).

Subgenus MEGAYOLDIA Verrill and Bush, 1897

Broad, compressed, rostrum indefinite, with posterior marginal lobe; resilifer large, concave, striate within; pallial sinus large; ligament external, strongly developed.

Geologic range.—Oligocene through Holocene (table 2).

Habitat.—10 to 1,900 m, in sand and mud.

Yoldia (Megayoldia) beringiana Dall

Plate 3, figures 15, 16

Yoldia beringiana Dall, 1916, p. 399.

Original description.—"Shell large, thin, smooth, except for lines of growth, brilliantly polished, inequilateral, hardly rostrate, rounded at each end, less compressed behind than *Y. secunda*; color a rich yellowish brown, slightly olivaceous near the umbones; valves closing completely; escutcheon striated, narrower than in *secunda*; beaks very low, 24 anterior and 17 posterior teeth, the resilifer ample, cup-shaped, projecting. The pallial sinus is rather large and rounded. Length, 40; height, 22; diameter, 16 mm."

Lectotype.—USNM 226195a. The double-valved specimen from the syntypic lot, one valve of which is figured herein, is here designated the loctotype.

Type locality.—Bering Sea, off the Pribilof Islands, Alaska, in 1,805 m. Holocene.

Comparison.—Posterior end more evenly rounded and not turned upward as in *Megayoldia thraciaeformis*.

Geographic range.—Living: Bering Sea, off Pribilof Islands, Alaska, to Anacapa Island, southern California; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Pico Formation (Winterer and Durham, 1958).

Habitat.—280 to 1,905 m, in sand and mud.

Yoldia (Megayoldia) thraciaeformis (Storer)

Plate 3, figures 17, 18

Nucula thraciaeformis Storer, 1838, p. 122, text fig.

Yoldia thraciaeformis (Storer). Oldroyd, 1924, p. 27, pl. 5, fig. 1. Grant and Gale, 1931, p. 127-128, pl. 1, figs. 12a, 12b.

Yoldia (Megayoldia) thraciaeformis (Storer). Abbott, 1974, p. 418.

Original description.—"Shell ovate, transverse, equivalve, inflated, gaping at both extremities, with numerous, very distinct, concentric lines of increment, covered with a yellowish-green, polished epidermis in young specimens, concealed under a black pigment, which readily rubs off in the recent specimen, giving a sooty appearance to the fingers. In the adult shell the epidermis is rather a dirty brown. Beaks slightly prominent over hinge margin. An obtuse angle, more elevated and wider at its lower half, runs obliquely from the umbones to the posterior base of the shell, serving as a boundary to the anterior inflated portion. Posterior portion of the shell much compressed, its epidermis is of a lighter color, and the striae of increase are much more apparent, than upon the anterior portion. Anterior margin rounded; posterior somewhat truncated. Within perlaceous. Teeth, numerous and peculiar; those contiguous to hinge, small, those farther removed from fosset, very strong, sharp, angulated, higher than wide; the teeth of one valve shutting very closely into the excavated teeth of the opposite valve, form a very powerful hinge. Length, 57; height, 35 mm."

Holotype.—BM(NH).

Type locality.—Off Point Race, Atlantic [presumably Race Point, Mass.]. Holocene.

Supplementary description.—3.7 to 5.0 cm in length, oblong. Characterized by its squarish, upturned posterior end; large circular chondrophore; and the coarse, oblique rib running from beak to posterior ventral margin. (Abbott, 1974, p. 418.)

Geographic range.—Living: Greenland to South Carolina, Alaska to Puget Sound, Wash.; fossil: Alaska and middle California,

Pliocene; Japan, Oligocene to Pliocene (Masuda and Noda, 1976); possibly also in Kamchatka, USSR.

Geologic range.—Oligocene through Holocene.

Occurrence in California.—Miocene and Pliocene: Tahana Member of Purisima Formation (Addicott, 1969); Pliocene: Pomponio Mudstone Member of Purisima Formation (Cummings and others, 1962).

Habitat.—65 to 90 m; also found in fish stomachs.

Subgenus CNESTERIUM Dall, 1898

With oblique secondary incised sculpture, especially on anterior end.

Geographic range.—Living: eastern Pacific and Japan; fossil: Japan, Sakhalin Island, USSR, and west coast of the United States.

Geologic range.—Miocene through Holocene.

Habitat.—At depths of 15 to 250 m in mud and fine and coarse sand; common in fish stomachs off Pacific Grove, Calif.

Yoldia (Cnesterium) strigata Dall

Plate 4, figure 3

Yoldia (*Cnesterium*) *strigata* Dall, 1909, p. 104-105, pl. 14, figs. 9, 9a.

Yoldia scissurata Dall var. *strigata* Dall. Weaver, 1942, p. 51, pl. 9, figs. 14, 20.

Not *Yoldia scissurata strigata* Dall. Faustman, 1964, p. 114.

Original description.—"Shell thin, compressed, equivalve, inequilateral, polished; anterior end longer, equally arcuate above and below, anteriorly somewhat attenuated; posterior end a little shorter, subtruncate, slightly recurved, dorsal slope slightly concave, with the apposed margins compressed and projecting in the middle of the narrow escutcheon; lunule linear or nearly so; tuncate end a little concavely flexuous; posterior basal margin evenly convexly arcuate; base a little prominent toward the middle; beaks inconspicuous, flattish, not raised above the general arch of the dorsum; surface smooth except for obscure incremental lines, and numerous sharp, slightly elevated, somewhat flexuous, oblique, distant ridges with the long slope extending basally and the short slope abrupt and almost undercut; these ridges vary slightly in individuals but in general cover the sides of the shell nearly to the beaks, and are usually obsolete on the anterior dorsal areas and on the rostrum; the shell gets proportionately broader, vertically, with age. Longitude of figured specimen, 37 mm.; altitude, 19.5 mm.; diameter, 5.5 mm. An older but less perfect individual measures, longitude, 43.5 mm.; altitude, 23.0 mm.; diameter, 7.5 mm."

Holotype.—USNM 153951.

Type locality.—Coos Bay, Coos County, Oreg. Empire Formation, Miocene.

Supplementary description.—"a worn specimen indicates that there are at least 28 anterior and 22 posterior teeth on the hinge margin***." (Dall, 1909, p. 104-105)

Comparison.—"*Y. scissurata* Dall occurs in the lower Pleistocene of San Pedro, Cal.; it is a much smaller and proportionately more convex shell, with 20 anterior and about 14 posterior hinge teeth***." (Dall, 1909, p. 105)

Yoldia strigata is characterized by a more bluntly truncated posterior end than in *Y. scissurata* and the upward bending of the concentric growth lines is better developed on the posterior portion of the shell. (Weaver, 1942, p. 51)

Geographic range.—Alaska to northern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene and Pliocene: Tahana Member, Purisima Formation (Durham and Morgan, 1978); Pliocene: Falor Formation (Manning and Ogle, 1950); Pliocene and Pleistocene: Merced Formation (Glen, 1959).

Habitat.—The living species *Yoldia scissurata* occurs from the Arctic Ocean to San Diego, Calif., at depths of 15 to 135 m.

Yoldia (Cnesterium) ensifera Dall

Plate 4, figure 21

Yoldia ensifera Dall, 1897. p. 9, pl. 2, fig. 4.

Yoldia scissurata Dall. I. S. Oldroyd, 1924, pl. 5, fig. 2. Not *Yoldia scissurata* Dall, 1897.

Original description.—"Shell large, thin compressed, with a brilliant olivaceous periostracum, usually showing darker and lighter zones; valves nearly equilateral, moderately convex, rostrate, subarcuate; sculpture of fine lines of growth more or less evident, and on the anterior two-thirds of the shell numerous irregularly fluctuating, distant, incised grooves (like those of *Y. scissurata*) which are absent on the posterior third; base, arculate, anterior dorsal profile rounded evenly from the beaks; a slight inward wave of the margin is visible anteriorly near the pedal gape; lunule absent; the escutcheon impressed, and the posterior dorsal margins of the valves, projecting vertically, blade-like and slightly pouting; rostrum pointed, slightly recurved, beaks low, inconspicuous; valves internally whitish; pallial sinus deep, rounded; chondrophore wide, hardly projecting; teeth narrow, "Λ"-shaped, slender, about 30 in front of and 24 behind the chondrophore. Length, 35; height, 16; diameter, 6 mm."

Holotype.—USNM 107644.

Type locality.—Vancouver Island, British Columbia, 245 m. Holocene.

Comparison.—All of the specimens from Vancouver Island, B. C., south "which hitherto had been referred to *Y. scissurata* Dall, prove on examination to belong to this species. It differs from *scissurata* in being more equilateral, in having the grooved sculpture sparser and less extended, in being more compressed and more pointed but less recurved behind, and in the greater length, height and prominence of the blade-like extensions of the posterior dorsal margin." (Dall, 1897, p. 9) [See also *Yoldia scissurata.*]

Comments.—This species was placed in the synonymy of *Yoldia scissurata* Dall by Grant and Gale (1931, p. 131) and Abbott (1974, p. 418), but recent work by Barry Roth (1979) has led him to separate the two species following MacGinitie (1959, p. 154-155).

Geographic range.—Living: Vancouver Island, British Columbia, to San Diego, Calif.; fossil: Alaska and northern California.

Geologic range.—Miocene (Ariey, 1978); Pliocene through Holocene.

Occurrence in California.—Pliocene: Rio Dell Formation (Roth, 1979).

Habitat.—55 to 245 m.

Yoldia (Cnesterium) scissurata Dall

Plate 4, figures 1, 2

Nucula arctica Broderip and Sowerby, 1829, p. 359-360, pl. 9, fig. 1, Not *Yoldia arctica* Gray, 1824.

Yoldia scissurata Dall, 1895, p. 595, new name. Dall, 1897, p. 8, Arnold, 1903, p. 99-100, pl. 17, fig. 13. *Not* I. S. Oldroyd, 1924, pl. 5, fig. 2.

Original description.—"N. testa oblanga, postice subrostrata, antice subrotundata; epidermide crassa, olivacea; valvis striatis, striis obliquis lineas incrementi decussantibus; long. 1 5/8, alt. 6/8, lat. 7/16, poll."

Holotype.—Location unknown.

Type locality.—"Hab. in Oceano Arctico." "Two or three specimens were obtained in Vatcha Bay, Kamtschatka." [Vatyna Bay, Kamchatka]

Supplementary description.—"One of the largest of the Nuculae***. It is of an oblong shape, the anterior being longer than the posterior side; it is covered with a strong, shining olivaceous epidermis: the anterior side is somewhat rounded, and the posterior produced into a slightly recurved beak. The surface of each valve is covered with delicate concentric lines of growth, which are crossed on the central part, and towards the posterior side of the valves by stronger oblique striae. When the valves are closed, the upper posterior edge forms a sharp elevated ridge. The oblique striae are distinct on the epidermis as well as on the shell." (Broderip and Sowerby, 1829, p. 360)

"Shell rather small, oval***very thin, translucent, only slightly narrowed posteriorly; umbones minute, slightly anterior to middle, the anterior margin is evenly convex; a thin lamina runs along the anterior margin from the umbo to the end of the shell; a much narrower one also occurs on the posterior margin; surface sculptured concentrically as in *Y. cooperi* except that this incised sculpture is not in harmony with the incremental lines; hinge and teeth similar to *Y. cooperi.*" (Arnold, 1903, p. 99-100)

Comparison.—*Yoldia ensifera* "differs from *scissurata* in being more equilateral, in having the grooved sculpture sparser and less extended, in being more compressed and more pointed but less recurved behind, and in the greater length, height and prominence of the blade-like extension of the posterior dorsal margin." (Dall, 1897, p. 9)

"*Y. scissurata* is higher anteriorly and is proportionately longer from the umbos to the anterior end and proportionately shorter from the umbos to the posterior end than *Y. ensifera.* The posterior dorsal blades of the valves are longer and much higher in *Y. ensifera* than in *Y. scissurata*, so that a line from the beaks to the end of the rostrum always cuts across the blades in *Y. ensifera* but seldom does in *Y. scissurata.* The rostrum is more upturned in *Y. scissurata.* Even in specimens only 5 to 10 mm. long, these differences are apparent and consistent." (MacGinitie, 1959, p. 154-155)

Comments.—The specimen figured (pl. 4, figs. 1, 2) is one that was apparently handled by Dall (Joseph Rosewater, written commun., 1978).

Geographic range.—Living: Arctic Ocean to Monterey Bay, Calif.?; Vatyna Bay, Kamchatka; fossil: California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene and Pliocene: Purisima Formation (Arnold, 1906); Pliocene: Niguel (Vedder, 1972) and Rio Dell (Roth, 1979) Formations; Pliocene and Pleistocene: Fernando (Moody, 1916) and San Pedro (Arnold, 1903) Formations. [Some of the southern records may actually represent *Y. ensifera.*]

Habitat.—In coarse and fine sand and mud at depths of 15 to 255 m; common in fish stomachs.

Yoldia (Cnesterium) seminuda Dall

Plate 4, figures 7, 18, 19

Yoldia seminuda Dall, 1871, p. 153.
Yoldia imleri Waterfall, 1929, p. 85-86, pl. 5, fig. 7.
Yoldia scissurata strigata Dall. Faustman, 1964, p. 114. Not *Yoldia strigata* Dall, 1909.

Original description.—"Shell obscurely lozenge-shaped, elongate, covered with a polished, glossy, olivaceous epidermis. Valves compressed, umbones inconspicuous; lunule long, narrow, just evident; escutcheon long, narrow, indented, well defined. Ventral margin arcuated, widest about the middle of the shell; a slight obsolete groove or channel anteriorly bordered by two obscure ridges, terminates in a slight waved indentation in the anterior ventral margin, about the middle of the anterior fourth. Posterior end rising obliquely, rounded truncate posteriorly, forming an angle of 90° with the hinge margin, and slightly upturned. Posterior dorsal slope concave, anterior slightly upturned. Posterior dorsal slope slightly concave, anterior slightly convex, evenly rounded to the anterior end. Ligament pit large, roundly triangular. Teeth (anterior) 37, (posterior) 17. Pallial sinus reaching before the umbones, which are 14/35 of the whole length from the posterior end. Interior bluish white, with fine radiating lines. Exterior marked by lines of growth and obsolete radiating lines; sculptured by sharp grooves, which, beginning near the middle of the shell with a slight wave toward the umbones, pass backward and downward across the lines of growth, rising a little and ceasing abruptly at a distance of about 4/35 of the whole length from the posterior end. Long., 1.74; alt., .82; diameter, 7.2 in."

Holotype.—USNM 107678; holotype of *Y. imleri* UCMP 31420.

Type locality.—St. Paul's Harbor, Kodiak Island, Alaska, 30 m. Holocene.

Comments.—I am indebted to Barry Roth, California Academy of Sciences, who, during the course of his study of the fauna of the Wildcat Group, determined that *Yoldia imleri* Waterfall (pl. 4, fig. 7) is a synonym of *Y. seminuda* Dall.

Geographic range.—Living: Bering Sea to Monterey, Calif., 35 m; fossil: northern and southern California.

Geologic range.—Pliocene to Holocene.

Occurrence in California.—Pliocene: Rio Dell Formation (Roth, 1979); Pliocene and Pleistocene: Pico Formation (Waterfall, 1929).

Habitat.—40 m off Monterey, Calif., in sand; 15 to 90 m off Alaska.

Genus YOLDIA?

Yoldia? gala Woodring

Plate 4, figure 6

Yoldia gala Woodring, 1950, p. 81, pl. 8, figs. 1, 2; pl. 9, figs. 9, 10.

Original description.—"*Yoldia gala****, a new species, is the most characteristic megafossil in the diatomaceous strata of the Sisquoc formation. It is moderately large, elongate, and weakly sculptured, the sculpture consisting of low concentric rugae of varying width on the ventral half or less. Though this species is represented by numerous well-preserved molds, the only shell material consists of patches on a left valve***. The sculpture is generally impressed on internal molds. This *Yoldia* is the '*Nuculana* sp.' of the preliminary report on the Santa Maria district. The outline suggests *Yoldia* and the chondrophore is long and symmetrical, like that of *Yoldia.* It is not certain, however, that the chondrophore is as wide as that of *Yoldia.* The pallial sinus is not discernible on any of the fossils."

Holotype.—USNM 560024.

Type locality.—USGS 15020. Santa Barbara County, Calif. Todos Santos Claystone Member of the Sisquoc Formation, Miocene and Pliocene.

Comparison.—"*Yoldia gala* is perhaps related to *Yoldia astoriana*, from the Miocene Astoria formation of Oregon, but is larger and more elongate, its posterior end is not so abruptly upturned, and it evidently lacks the impressed lunule and escutcheon of *Y. astoriana****Yoldia gala* is also larger and more elongate than '*Leda*' *subimpressa,* from the Pliocene(?) Empire formation of Oregon. '*Leda*' *subimpressa* appears to be closely related to *Yoldia astoriana* and may be the same species, as had been claimed.

Arnold's *Yoldia impressa*, from the Monterey shale of the Santa Cruz Mountains, has strong regular concentric rugae and is probably a *Nuculana*. No recent California allies of *Yoldia gala* are recognized in the U.S. National Museum collections. *Y. limatula*, which has been dredged as far south as San Diego in deep water (417 fathoms), has a shallow ventral notch near the anterior end of the shell. Northern specimens of *Y. limatula* are much larger than *Y. gala*, but those from British Columbia to San Diego are not larger***." (Woodring, 1950, p. 81)

Geographic range.—Southern California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Todos Santos Member of the Sisquoc Formation.

Genus PORTLANDIA Mörch, 1857

Inflated, somewhat rostrate.

Subgenus PORTLANDIA

Posterior end set off by indistinct furrow.

Geologic range.—Paleocene through Holocene.

Habitat.—Living in boreal waters only; reported from 5 to 45 m. [Note that fossil species indentified as *Portlandia* occur in the Eocene of southern California.]

Portlandia (Portlandia) mortuasusenis (Clark and Woodford)

Plate 4, figure 15

Yoldia mortuasusensis Clark and Woodford, 1927, p. 86, pl. 14, fig. 3.

Original description.—"Shell short, plump, with moderately prominent, strongly inturned beaks which are anterior to the median line; anterior dorsal margin almost straight; posterior dorsal edge gently concave; anterior end broadly and regularly rounded; posterior end narrow and bluntly rounded. Lunule apparently absent; escutcheon long, narrow, slightly depressed. Surface of shell smooth and glistening, marked by very fine and fairly numerous faint concentric incremental lines; also the internal layer of the shell is covered by numerous very fine radial lines which can be seen only with the aid of a lens. *Dimensions*: Length 8.5 mm., height 5 mm., thickness of one valve about 2 mm."

Holotype.—UCMP 31337.

Type locality.—UC 3577. Contra Costa County, Calif. Meganos Formation, Paleocene.

Supplementary description.—"The type, which is very beautifully preserved, is the only specimen of this species found in our collection." (Clark and Woodford, 1927, p. 86)

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Meganos Formation.

Portlandia (Portlandia) markleyensis (Clark)

Plate 4, figure 16

Yoldia markleyensis Clark, 1938, p. 692, pl. 1, figs. 21, 22.

Original description.—"Shell smooth with beaks anterior to the median line and strongly inturned; anterior end regularly rounded; posterior dorsal edge straight or nearly so; escutcheon elongate-lanceolate in outline, smooth and somewhat depressed below the main surface of the shell; a somewhat smooth obscure lanceolate lunule; chrondrophore fairly large for this genus; taxodont teeth fairly high and peg-like, about twenty on each of the dorsal margins. Dimensions: holotype***30833, length 22.5 mm., height 12.6 mm., width of both valves 7.5 mm.; paratype, right valve, 30834, length 17.4 mm., height 10.3 mm."

Holotype.—UCMP 30833.

Type locality.—UC A-1297. Solano County, Calif. Markley Sandstone Member, Kreyenhagen Formation, Eocene.

Comparison.—The only form which *Portlandia markleyensis* closely resembles is *"Y." duprei* (Weaver and Palmer) from the Cowlitz Formation (Eocene) of southwestern Washington. *"Y." duprei* differs in that it is thicker than *P. markleyensis*, and, according to the description of Weaver and Palmer, the posterior end joins the posterior dorsal edge in a point—apparently meaning an angle—whereas on *P. markleyensis* the two edges merge gradually into one another. The two species are similar in outline, and future work may show that *P. markleyensis* should be considered a subspecies of *"Y." duprei*. (Clark, 1938, p. 692)

Comments.—This form has no pedal or siphonal gape and is moderately inflated in proportion to its size.

Geographic range.—Middle California.

Geologic range.—Eocene.

Occurrence in California.—Markley Formation.

Portlandia (Portlandia) rosa (M. A. Hanna)

Plate 4, figure 9

Leda rosa M. A. Hanna, 1927, p. 271, pl. 25, figs. 4, 6, 9, 16.

Portlandia (Portlandia) rosa (Hanna). Givens, 1974, p. 40.

Original description.—"Left valve; shell of medium size, moderately inflated, thin; ventral margin regularly broadly rounded; posterior dorsal margin nearly regularly concave to the rather sharply rounded rostrum; anterior dorsal margin straight to the broadly rounded anterior end; beak central, opisthogyrate, slightly anterior to the center; surface ornamented only by growth lines; no keel present; lunule narrow, linear; escutcheon linear, deep, wide, circumscribed by a ridge. *Dimensions. Type:* Altitude 8.5 mm., length 14.5 mm. *Paratype* 31092: Altitude 9.0 mm., length 15.5 mm."

"Hinge of paratype***narrow, twenty-one slightly V-shaped teeth present posterior to the large chondrophore, sixteen teeth remaining on the broken anterior portion of the hinge margin; interior of the shell not seen."

Holotype.—UCMP 31090.

Type locality.—UC 3993. San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—*Portlandia rosa* "is characterized by its wide shallow chondrophore, though it is not quite so extensive as shown in the original figure, for it has been slightly crushed downward away from the hinge. The chondrophore also shows***radiating lines." (Stewart, 1930, p. 62)

Comparison.—*Portlandia rosa* is closely related to *P. japonica* (Adams and Reeve), a living species, "which is so similar to it that it seems to be a direct descendant of the Eocene form. The posterior end of the Eocene species is a trifle higher, but considering the difference in time, they are remarkably alike." (Stewart, 1930, p. 62) *Portlandia rosa* does not have as straight a dorsal margin as *P. mosesi*.

Comments.—This species is the type of the genus *Portlandella* Stewart, (1930), now considered a synonym of *Portlandia*.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Juncal Formation in the *Turritella uvasana applinae* fauna (Givens, 1974) and the Ardath Shale (Hanna, 1927).

Portlandia (Portlandia) mosesi (Palmer)

Plate 4, figure 10

Yoldia mosesi Palmer, 1923, p. 301, pl. 55, fig. 2.

Original description.—"Shell small, thin; beaks anterior to middle, moderately prominent. Anterior dorsal margin short, straight; posterior dorsal margin slightly concave just under beak but nearly straight, and almost in line with anterior dorsal margin. Anterior end broadly and regularly rounded with only a very slight indication of an angulation at anterior end of dorsal margin. Posterior end bluntly rostrate. Ventral edge gently arcuate. Shell slightly inflated near middle. Hinge not exposed. Surface smooth except for occasional irregular growth lines. Dimensions of type (a left valve): Length 13.9 mm.; height 8.5 mm."

Holotype.—UCMP 30704.

Type locality.—UC 3573. Solano County, Calif. Capay(?) Formation, Eocene.

Comparison.—*Portlandia mosesi* has a straighter dorsal margin than *Portlandia rosa*.

Geographic range.—Middle California.

Geologic range.—Eocene(?).

Occurrence in California.—Capay(?) Formation.

Portlandia (Portlandia) chehalisensis (Arnold)

Plate 4, figures 12, 13

Malletia chehalisensis Arnold, 1908, p. 365-366, pl. 33, figs. 9, 9a.

Portlandia (Portlandella) chehalisensis (Arnold). Hickman, 1969, p. 30-31, pl. 1, figs. 9, 12, 13.

Original description.—"Shell attaining a length of 25 mm., oval, compressed, smooth; umbones rather inconspicuous, slightly anterior to middle, turned backward; anterior dorsal margin sloping straight from umbo; anterior extremity regularly rounded; posterior dorsal margin straight, depressed immediately in rear of umbones; posterior extremity above medial line, more attenuated than the anterior; posterior portion of base near extremity nearly straight, otherwise quite regularly curved. Surface smooth, except for faint concentric lines. Hinge consists of a row of sharp teeth flexed toward the umbo on each side of a prominent, projecting umbonal pit. Pallial sinus large and deep."

Holotype.—USNM 165447.

Type locality.—Porter, Chehalis County, Wash. Lincoln Creek Formation, Eocene to Miocene.

Supplementary description.—"Some of the specimens of this species from the type locality show distinct incised concentric sculpturing." (Clark, 1925, p. 79)

"*Portlandia chehalisensis* is a short, bluntly rostrate form with a relatively smooth shell. The inconspicuous and slightly opisthogyrous beaks are located slightly anterior—about 55 percent of the distance from the posterior end of the shell. The anterior end of the shell is evenly rounded, merging gradually with the broadly arcuate ventral margin. The posterior dorsal margin is slightly concave, almost forming a right angle with the abruptly truncate posterior margin. The ratio of length to width is about 1.7." (Hickman, 1969, p. 30)

Comparison.—[See *Portlandia packardi*.]

Geographic range.—Alaska to middle California.

Geologic range.—Eocene to Miocene.

Occurrence in California.—Eocene and Oligocene: Rices Mudstone Member of the San Lorenzo Formation.

Portlandia (Portlandia) packardi (Clark)

Plate 4, figure 11

Malletia packardi Clark, 1918, p. 125, pl. 12, fig. 3; pl. 14, figs. 5, 6.

Yoldia (Portlandia) packardi (Clark). Clark, 1925, p. 77, pl. 9, fig. 7. Weaver, 1942, p. 44-45, pl. 8, figs. 33, 34.

Original description.—"Shell rather small to medium in size; beaks anterior to the middle, opisthogyrous. Anterior dorsal slope straight; posterior dorsal slope rather strongly excavated; anterior end regularly rounded; posterior end regularly rounded but narrower than anterior end, the ventral margin sloping up more obliquely to it than to the anterior end. Surface smooth except for somewhat irregular incremental lines. As shown on one of the specimens obtained from the diatomaceous shale of the Markley formation (fig. 6), the escutcheon is well defined, long and narrow and depressed almost at right angles to the main outer surface of the shell. Lunule apparently absent. No well-defined chondrophore. Almost eighteen taxidont [Sic: taxodont] teeth posterior and about twenty-one anterior to the beak, the posterior and anterior rows of teeth meeting at the apex of the beaks."

Holotype.—UCMP 11154.

Type locality.—UC 2033. Contra Costa County, Calif. Kirker Tuff, Oligocene.

Comparison.—*Portlandia packardi* bears a very close resemblance to *P. chehalisensis* (Arnold) but the "umbones of the former are situated about 40 per cent of the length of the shell from the anterior end while in the latter they are nearly central. The anterior end of the former is more evenly rounded and the posterior dorsal margin more deeply concave, especially just below the umbo." (Weaver, 1942, p. 45)

Geographic range.—Western Washington to middle California.

Geologic range.—Eocene to Miocene(?).

Occurrence in California.—Eocene: Markley Sandstone Member of the Kreyenhagen Formation (Clark, 1918); Oligocene: Kirker Tuff; Miocene(?): San Ramon Sandstone (Clark, 1918).

Family SOLEMYIDAE

Geologic range.—Devonian through Holocene.

Habitat.—Shallow to deep water; moves by clapping valves together.

Solemya velum Say, a species living along the west Atlantic coast, lives in an open-ended, U-shaped burrow, in sandy mud, in shallow subtidal environments (Stanley, 1970, p. 120).

Genus ACHARAX Dall, 1908

Elongate-oval or subrectangular, compressed; umbones level with hinge margin, placed well toward posterior end of shell; valve margins with narrow anterior and posterior gapes; ligament wholly external, internal resilifer absent. Sculpture of irregularly arranged, depressed radial ribs; periostracum polished, consisting of radial sectors alternating in thickness and varying in width according to ribbing of shell; periostracum extends well beyond margins of calcareous part of valves, forming frill which, on death of animal, cracks along thinner sectors, producing series of rectangular or tonguelike projections separated by fissures.

Geographic range.—Eastern and western Pacific; Indian Ocean, western Atlantic.

Geologic range.—Miocene through Holocene, Japan and United States. (Probably also fossil from Devonian onward, if considered to include all *Solemya*-like forms with external ligament and without internal rib.)

Habitat.—Predominantly in deep water, although depth may be controlled by water temperature. *Acharax johnsoni* Dall has been found at 110 m in Puget Sound, 1,840 m off Baja California, and 3,180 m off northern Ecuador near the equator (Vokes, 1955, p. 537-538).

Acharax johnsoni (Dall)

Plate 4, figures 20, 23

Solemya johnsoni Dall, 1891, p. 189; 1895, p. 712, pl. 25, fig. 1.
Solemya (Acharax) johnsoni Dall. Olsson, 1961, p. 52-53 [See for synonymy]. Keen, 1971, p. 24.

Original description.—"Shell resembling *S. macrodactyla* Mabille and Rochenbrune, from Orange Harbor, Tierra del Fuego, but larger, longer in proportion, the shorter end more tapering and the opposite end more rounded. Length of shell 115, height 48, diameter 18, mm. The cartilage pit is 30 mm behind the shorter end, and the greatest length of the digitate epidermis beyond the edge of the shelly valve is 23 mm."

Holotype.—USNM 106886.

Type locality.—*Albatross* station 3010, 1,840 m, Baja California Norte. Holocene.

Supplementary description.—"The type lot of *Solemya johnsoni* Dall***labeled *johnsoni* in Dall's writing, consists of four paired shells that have a virtually intact periostracum. One that appears to agree with the figure is regarded as the holotype. The valves of this specimen are cracked, and a small part of the anterior end of the periostracum is missing. This shell has a length including the periostracum of about 112 millimeters. A lot of three paired shells, two of which have the periostracum intact, from *Albatross* station 3399 (off northern Ecuador, depth 1,740 fathoms) is labeled 'types' of *johnsoni* in Dall's writing (alcholic collection No. 3175). The largest of these shells has a length including a periostracum of about 73 millimeters." (Woodring, 1938, p. 27).

Comparison.—"*Solemya agassizi* Dall,***which was given a range from the Gulf of California to Peru, was differentiated from *johnsoni* on the grounds that it has 6 or 7 anterior radial channels, as compared with 9 to 12 on *S. johnsoni,* and that the periostracum of *johnsoni* has a subtriangular outline. The type of *agassizi* is a large shell (U.S. Nat. Mus. 106885) that has a length exclusive of the periostracum of about 143 millimeters and was dredged off Panama at a depth of 1,672 fathoms. The basal part has been broken since the drawing was made, or the drawing is a restoration. The anterior part of the shell has six grooves; some sculpture on the umbonal part of the shell is not shown on the drawing. It appears doubtful whether two species are represented in the National Museum collections. All the specimens in the dried collection, representing localities from Oregon to Ecuador, are labeled *agassizi* in Dall's writing, or were so labeled under his direction. They have five or six grooves bordered by flat or slightly raised edges, but on some there is a transition from deep grooves to shallow grooves and ribs, and the number of grooves is a matter of individual judgment. No specimen has the entire periostracum preserved. The specimens in the type lot of *johnsoni* have seven distinct grooves; those from station 3399 have seven to nine." (Woodring, 1938, p. 27)

Geographic range.—Living: Forbes Island, British Columbia, to Peru; fossil: northern and southern? California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: Rio Dell Formation (Roth, 1979); Pliocene and Pleistocene: Fernando(?) Formation (Woodring, 1938).

Habitat.—This species has been found at 110 m in Puget Sound, Wash., 1,840 m off Baja California, and 3,180 m off northern Ecuador. The depth of occurrence may be controlled by water temperature (Vokes, 195, p. 537-538). In Panama Bay at 3,270 m (Keen, 1971, p. 24).

Genus ACHARAX?

Acharax? dunnensis Palmer

Plate 4, figure 22

Solemya? dunnensis Palmer, 1923, p. 302, pl. 55, fig. 1
Solemya dunnensis Palmer. Vokes, 1955, p. 540.

Original description.—"Shell small, thin; dorsal margin slightly crushed. Elongate in outline. Beaks posterior to center. Posterior dorsal margin straight; anterior dorsal margin appears to be slightly concave; ends rounded; ventral edge evenly rounded. Hinge not exposed. Surface sculptured by very faint concentric growth lines and indistinct, rounded, rather widely spaced radiating ribs. Dimensions: Length 14.8 mm.; height 6.6 mm."

Holotype.—UCMP 30690.

Type locality.—UC 3573. Solano County, Calif. Capay(?) Formation, Eocene.

Geographic range.—Middle California.

Geologic range.—Eocene, "Capay" megafaunal Stage.

Occurrence in California.—Capay(?) Formation.

Family ARCIDAE

Geologic range.—Triassic(?); Jurassic through Holocene.

Habitat.—"Abundant in shallow, tropic, subtropic and warm temperate marine waters, but two genera, *Senila* [sic: *Senilia*] Gray and *Scaphula* Benson, occur in brackish water, the latter also occurs in fresh water." (Hertlein and Grant, 1972, p. 152) Burrows but employs a weak byssus for increased stability. (Stanley, 1970, p. 8)

Subfamily ARCINAE

Habitat.—Nestling or rock-boring forms. Epifaunal arcids, anchored by a byssus, have markedly thinner shells than infaunal species in which a byssus is weak or absent. (Stanley, 1970, p. 68)

Genus ARCA Linné, 1758

Elongate, subtrapezoidal to subrectangular, very inequilateral, commonly expanded or auriculate posteriorly; cardinal area broad; dental series long and nearly straight; surface sculpture radial, fine.

Geologic range.—Middle Jurassic through Holocene (table 3).

Habitat.—"Worldwide in tropical and subtropical marine waters, but some species ranging into the boreal zone. Mostly in intertidal zone to shallow neritic zone, occasionally to a depth of 146 meters***or deeper. *Arca tetragona* Poli reported from a depth of 2655 meters." (Hertlein and Grant, 1972, p. 153) Byssally attached.

Subgenus ARCA

Teeth small, numerous, transverse across middle of shell, becoming longer and convergent terminally.

Geologic range.—Late Cretaceous through Holocene (table 3).

Arca (Arca) hawleyi Reinhart

Plate 5, figure 1

Arca (Arca) hawleyi Reinhart, 1943, p. 21-22, pl. 2, figs. 19-22.

Original description.—"Narrow and elongate in outline, narrow-

TABLE 3.—*Geologic and geographic distribution of the family Arcidae*
[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	Alaska	British Columbia	Washington	Oregon	California			Baja California		Central and/or South America
					Northern	Middle	Southern	Norte	Sur	
Genus *Arca*:										
Subgenus *Arca*:										
hawleyi Reinhart						E	E			
leptogrammica Hall							M			
santamariensis Reinhart							M and Pl			
sisquocensis Reinhart							Pl and Ple			
terminumbonis Grant and Gale							M to Ple			
Genus *Barbatia*:										
Subgenus *Barbatia*:										
morsei Gabb						E	E			
Subgenus *Cucullaearca*:										
bramkampi Durham									Pl	
cliffensis M. A. Hanna							E			
reeveana (Orbigny)								H	Pl to H	H
Subgenus *Fugleria*:										
illota (Sowerby)							Pl	H	Ple and H	Ple and H
pseudoillota Reinhart							M to Ple			
Genus *Anadara*:										
Subgenus *Anadara*:										
calcarea (Grant and Gale)						M	Pl and Ple			
canalis (Conrad)					Pl	M and Pl	Pl			
carrizoensis Reinhart							M or Pl			
devincta (Conrad)	M?		M	M		M	M			
lakei (Wiedey)							M			
mediaimpressa (Clark)						M?	M			
montereyana (Osmont)	M[1]		M			M			M	
montesanoana (Etherington)			M			M				
osmonti (Dall)	O and M[2]						M			
submontereyana (Clark)						M?	O			
topangaensis Reinhart							M	M		
trilineata (Conrad)		M	M? and Pl	M and Pl		M to Ple	M to Pl			
Subgenus *Anadara*?:										
strongi (Loel and Corey)							M			
Genus *Larkinia*:										
camuloensis (Osmont)						M to Ple	Pl and Ple			
multicostata (Sowerby)							Ple and H	Ple and H	Pl to H	H
santana santana (Loel and Corey)							O and M	M?		
santana weddlei (Loel and Corey)						O and M				
Genus *Grandiarca*:										
grandis (Broderip and Sowerby)									Pl to H	M to H
Genus *Scapharca*?:										
Subgenus *Scapharca*?:										
obispoana obispoana (Conrad)			M?			M	M			
obispoana perdisparis (Wiedey)						M				
Subgenus *Cunearca*:										
hamelini (Wiedey)							O and M			
rivulata (Wiedey)							M			
santaclarana (Loel and Corey)							O and M			
vanderhoofi Durham									O	

[1]Hiroshi Noda, oral commun., 1978.
[2]Scott McCoy, written commun., 1978.

ing posteriorly, strongly inflated. Anterior margin evenly rounded, meeting dorsal margin at right angles; ventral margin indented by large byssal gape; posterior margin broken. (On paratype 5344, however, posterior margin is preserved; it is nearly straight, rounding sharply into the ventral margin, and meeting the dorsal margin at an angle of 50°.) Surface ornamentation poorly preserved; a few radial ribs visible on posterior slope, and above byssal gape are several prominent, indented growth lines. Ligamental area wide and flat, sculptured with three indistinct, chevron-shaped grooves, forming right angles under the beak. Dentition concealed on holotype. The paratype shows four posterior teeth lying transverse to the hinge line. Interior of shell not exposed."

Holotype.—CAS/SU 5343.

Type locality.—SU 834. Santa Barbara County, Calif. Tejon Formation, Eocene.

Comparison.—"Although it resembles in general *Arca washingtoniana* Dickerson from the Oligocene, this new species may be easily distinguished by its more elongate outline and relatively wider ligamental area." (Reinhart, 1943, p. 22)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Tejon and Ione(?) Formations and Cozy Dell Shale (Weaver and Kleinpell, 1963).

Arca (Arca) leptogrammica Hall

Plate 6, figure 4

Arca (Arca) leptogrammica Hall, 1964, p. 87-88, pl. 22, figs. 9, 10.

Original description.—"Moderately large, rhombic in outline, anterior extremity broadly rounded, ventral margin nearly straight, small byssal gape slightly posterior of center, and posterior margin sharply rounded below, gently rounded above. Numerous thin radial ribs crossed by extremely faint concentric growth lines. Ribs closely spaced, interribs approximately 4/10 mm. wide, ribs slightly bunched posteriorly. Hinge narrow."

Holotype.—UCLA 34997.

Type locality.—UCLA 4180. San Luis Obispo County, Calif., Phoenix Member of Hall (1962), Santa Margarita Formation, Miocene.

Comparison.—"*Arca washingtoniana* Dickerson, from the Oligocene of Washington and Oregon, is more elongate and the area dorsal of the prominent posterior ridge extending from the umbo to the ventral margin is more pronounced. *A. leptogrammica* is nearly two to four times larger than *A. washingtoniana*. The Pliocene *Arca santamariensis* Reinhart, although possessing fine radial ribs above the ridge from umbo to ventral margin, is smaller, has a depression at each end of the posterior slope, centrally located umbones, and a rounded posterior slope in comparison with *Arca leptogrammica*.

"*Arca sisquocensis* Reinhart is much smaller than *A. leptogrammica* and it has beaded and moderately coarse ribs for its size. Although the beaks of *A. mutabilis* are more centrally located, as they are in *A. leptogrammica*, the posterior ribs are distinctly coarser than those in the central portion of the shell. The only species, fossil or living, that seems to resemble *A. leptogrammica* is the Pliocene to Recent Japanese species *A. boucardi* Jousseaume.

However, the umbones of *A. boucardi* are more anterior and the shells are smaller. The bundles of ribs on the posterior slope of *A. boucardi* are more pronounced than those of *A. leptogrammica.*" (Hall, 1964, p. 88)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Phoenix Member of Hall (1962), Santa Margarita Formation.

Arca (Arca) terminumbonis Grant and Gale

Plate 5, figures 3, 4

Arca (Navicula) terminumbonis Grant and Gale, 1931, p. 142-143, pl. 1, figs. 18a-c, 19a-c, not 20a-c, 22.

Arca (Arca) terminumbonis Grant and Gale. Reinhart, 1943, p. 24-25, pl. 3, figs. 1-3.

Original description.—"Shell of medium size and thickness, elongately trigonal; beaks near or at the extreme anterior end of the shell where the straight hinge line makes an acute angle with the area along the ventral margin; teeth divided near the middle by a slight internal thinning of the shell wall, outer teeth of the posterior series becoming rapidly elongated and very oblique, almost horizontal at the end of the hinge, continuing a short distance around the corner, teeth of the anterior series showing the same tendency but to a much less degree; cardinal area high, long, sculptured by many oblique grooves; beaks twisted forward but not sharply overhanging as in *Arca noae*; from the beaks an oblique fold running out the posterior ventral corner, dividing into two broad branches as it goes, separated from the cardinal area by a depression; shell near the ventral margin of the valve nearly perpendicular to the plane of the valve margins; ventral margin arched around a very large byssal gape; sculpture consisting of many fine wavy radial striations and a few concentric ripples."

Holotype.—SDNM 79.

Type locality.—SDNM 207. Los Angeles County, Calif. Fernando Formation, Pliocene and Pleistocene.

Supplementary description.—Arca (Arca) terminumbonis "has a distinctive, wedgelike form, with the broad end at the posterior, and an extremely large byssal gape. These features distinguish it from any other species of the genus." (Reinhart, 1943, p. 24).

Geographic range.—Southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene and Pliocene: Towsley Formation (Kern, 1973); Pliocene and Pleistocene: Fernando Formation.

Arca (Arca) santamariensis Reinhart

Plate 5, figures 2, 5

Arca (Arca) santamariensis Reinhart, 1937b, p. 183-184, pl. 28, figs. 4, 5, 7, 8, 11. Reinhart, 1943, p. 26, pl. 3, figs. 7-11.

Arca santamariensis Reinhart. Woodring, 1950, p. 81, pl. 14, figs. 6, 7.

Original description.—"Both valves of fairly well-preserved specimen, moderately large, elongate, equilateral, inflated. Profile of anterior margin evenly rounded; ventral margin roughly parallel to hinge; notched at center by byssal gape; posterior margin irregular, truncating ventral margin; umbones centrally placed, fairly large, but broken at top. Slightly curved umbonal ridge extends from umbo to posterior ventral margin; above this ridge is a groove. Medial sulcus extends upward a short distance from byssal gape. Sculpture, approximately 100 radial ribs, irregular in size and spacing, and having tendency to dichotomize; ribs larger at anterior and posterior ends of shell than elsewhere. Nodes on ribs inconspicuous, arranged in concentric bands; most prominent on posterior slope. Growth lines fairly prominent, following outline of shell. Ligamental area, with both valves together, resembles an arrowhead***, pointing anteriorly when viewed from above; inclined at anterior end, but nearly flat and wider toward posterior; four or five chevron-shaped grooves between beaks; in addition, ligamental area sculptured on exterior with a number of longitudinal lines, continuations of concentric growth lines. Hinge narrow, straight, slightly wider at extremities than at center; teeth about 44 in number; a few anterior and posterior teeth are V-shaped or curved; teeth converge ventrally at extremities of hinge. Muscle scars distinct, oval-shaped, nearly equal in size. Inner margin of shell nearly smooth, with feeble crenulations at posterior end; small byssal gape. Pallial line simple, prominent."

Holotype.—LAM 4072 (CIT 1381).

Type locality.—Pliocene asphalt beds at Fugler Point, 10.2 km southwest of Santa Maria, Santa Barbara County, Calif. Cebada Member of the Careaga Sandstone, Pliocene.

Supplementary description.—The posterior slope of this small-shelled species has a depression at each end, the intervening area being swollen. (Woodring, 1950, p. 81)

Comparison.—Arca santamariensis is somewhat similar to the living species *A. mutabilis* (Sowerby) from the Gulf of California and Panama, but the two species differ in ornamentation as well as in the shape of the ligamental area. (Reinhart, 1937b, p. 184)

Arca santamariensis "resembles***A. *mutabilis*, which lacks the depressions on the posterior slope." (Woodring, 1950, p. 81)

Geographic range.—Southern California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Miocene and Pliocene: Capistrano Formation (Vedder, 1974); Pliocene: Cebada Member of the Careaga Sandstone (Woodring, 1950).

Arca (Arca) sisquocensis Reinhart

Plate 5, figures 6, 8

Arca (Arca) sisquocensis Reinhart, 1937b, p. 182-183, pl. 28, figs. 1-3. Reinhart, 1943, p. 25, pl. 2, figs. 10-12. Hall, 1964, pl. 22, figs. 1, 2

Arca sisquocensis Reinhart. Kennedy, 1973, p. 124-125, fig. 3f.

Original description.—Small, well-preserved right valve, elongate in outline, moderately inflated, slightly inequilateral.

"Profile: Anterior margin evenly rounded; ventral margin straight, nearly parallel to hinge margin; posterior margin straight, forming acute angle where it intersects ventral margin, and meeting hinge margin at angle of 45°. Umbo located just anterior to center of shell, projecting slightly. An unusually sharp ridge extends from umbo to posterior ventral corner; above this ridge, shell is concave. A faint medial sulcus extends from byssal gape, upward a short distance toward umbo."

"Sculpture: About 40 radial ribs, with occasional small interribs. On posterior slope, ribs are large and dichotomizing; elsewhere, simple and ornamented with closely-spaced nodes. The five anteriormost ribs are as large as the posterior ones, but do not dichotomize. Concentric growth-lines are not prominent, but two distinct concentric bands may be distinguished, and several less distinct ones. Ligamental area narrow in front of umbo, wide behind, there becoming noticeably excavated. About two right-angled, chevron-shaped grooves directly beneath umbo. Hinge straight, narrow only slightly wider at extremities than at center; thirty-two teeth, small and granular at center, increasing regularly in size toward extremities of hinge; teeth converge ventrally, the anterior more sharply than the posterior. Muscle scars distinct, notable because of a raised flange bordering inner side of each scar, the posterior flange being the larger***. Inner margin of shell crenulated, especially at extremities. Narrow byssal gape near center. Pallial line simple; within this line, inner side of shell faintly striated by radial lines."

Holotype.—LAM 4073 (CIT 1382).

Type locality.—Pliocene asphalt beds at Fulger Point, 10.2 km southeast of Santa Maria, center of NE 1/4 sec. 35, T. 10 N., R. 33 W., S.B., Santa Barbara County, Calif. Cebada Member of the Careaga Sandstone, Pliocene.

Supplementary description.—The posterior slope of *A. sisquocensis* is practically flat or slightly concave. (Woodring, 1950, p. 81)

"*Arca sisquocensis* Reinhart is much smaller than *A. leptogrammica* and it has beaded and moderately coarse ribs for its size." (Hall, 1964, p. 88)

A fragment, which represents an individual probably 30 mm long, has about seven ligamental grooves on the cardinal area. This larger number of grooves is, no doubt, a result of the greater size of this shell in comparison to the holotype. (Hertlein and Grant, 1972, p. 154)

Comparison.—*Arca sisquocensis* "has no known Recent allies on the Pacific coast, but is closely related to the Recent Japanese *A. kobeltiana*. Adult shells of *A. sisquocensis* have a wider posterior slope than that of *A. kobeltiana*, the posterior ridge being more strongly curved. Both species have a flange on the muscle scars, indicating that they do not represent *Arca* in the restricted sense." (Woodring, 1950, p. 81)

Arca sisquocensis is similar in its general features to *A. washingtoniana* Dickerson from the Oligocene Gries Ranch Formation, Washington. In *A. washingtoniana* all of the ribs dichotomize and concentric growth lines are prominent, whereas in *A. sisquocensis*, only the ribs at the posterior end dichotomize and concentric bands are only feebly developed. (Reinhart, 1937b, p. 183)

Geographic range.—Southern California.

Geologic range.—Pliocene to Pleistocene.

Occurrence in California.—Pliocene: Foxen Mudstone, Cebada Member of the Careaga Sandstone (Woodring, 1950), and Niguel Formation (J. G. Vedder, written commun., 1978); Pliocene and Pleistocene: Fernando (Zinsmeister, 1970) and Santa Barbara Formations, and unnamed late Pliocene or early Pleistocene strata of Anacapa Island (Valentine and Lipps, 1963); Pleistocene: Lindavista Formation (Kennedy, 1973), unnamed strata of San Nicolas Island (Vedder and Norris, 1963) and of San Pedro.

Genus BARBATIA Gray, 1840

Shell small, elongate, ovoid, inequilateral; ornamentation costellate, commonly fine.

Geologic range.—Triassic(?); Jurassic through Holocene.

Habitat.—Living worldwide in tropical and subtropical water, some forms ranging into the warm temperate zone. From the littoral zone to 183 m; occasionally deeper. (Hertlein and Grant, 1972, p. 157). Byssally attached; characteristically live wedged in among coral colonies or rocks. (Stanley, 1970)

Subgenus BARBATIA

Cardinal area low, ligamental grooves closely spaced, costellae numerous, in some forms obsolescent.

Barbatia (Barbatia) morsei Gabb

Plate 5, figure 7

Barbatia morsei Gabb, 1864, p. 216, pl. 32, fig. 286.

Barbatia (Obliquarca) morsei Gabb. Vokes, 1939, p. 49-50, pl. 1, figs. 25, 26, 28, 29. Reinhart, 1943, p. 30-32, pl. 1, fig. 4 [See for synonymy].

Barbatia (Barbatia) morsei Gabb. Givens, 1974, p. 40-41.

Original description.—"Shell small, thin, subcompressed, oblique, broadest posteriorly; beaks small, approximate, anterior; area long and very narrow, shorter than the shell; anterior end short and broad; posterior end oblique above, rounded below; base sinuous, slightly gaping. Surface depressed in the middle and towards the ends, ornamented by numerous fine radiating ribs, alternating pretty regularly in size in the middle of the shell. Hinge slender, composed of numerous small, oblique teeth."

Lectotype.—UCMP 11984 (Reinhart, 1943, p. 31)

Type locality.—San Diego County, Calif. La Jolla Group, Eocene. M. A. Hanna (1927, p. 398) records *Barbatia morsei* Gabb from three stratigraphic units in the type area now designated the Torrey Sandstone, Delmar Formation, and Ardath Shale.

Supplementary description.—"Elongate***higher posteriorly than anteriorly; inequilateral, with umbo placed very near anterior extremity; umbonal ridge extends from beak to posterior ventral margin, in front of which is a shallow medial depression; in profile, hinge margin straight, scarcely interrupted by umbo, which projects slightly; anterior margin, partly concealed by matrix, slopes down immediately in front of umbo; ventral margin slightly broken in front, but growth lines show it to have been concave, with byssal gape at anterior third; posterior margin incomplete. Sculpture of numerous closely spaced radial ribs, inconspicuous posterior to umbonal ridge; more widely spaced in medial depression than elsewhere, in places separated by small inter-ribs; small nodes present on ribs on anterior half of shell; concentric growth lines fairly prominent posterior to umbonal ridge, but inconspicuous anterior to it.

"Although the entire ligamental area is not shown on any of the original specimens that I have seen, examination of other specimens from the type area shows the ligament to be restricted to the posterior of the umbo, the ligamental grooves extending up to the umbo, where they stop; the short dorsal margin anterior to umbo shows no trace of a ligamental area." (Reinhart, 1943, p. 31)

Comparison.—"Of the Pacific Slope species, *B. morsei* might be confused with *B. landesi* and *B. suzzalloi* (Weaver and Palmer), but differs from these by having the beaks placed farther anteriorly with the resulting anterior restriction of the ligament. Furthermore, *B. suzzalloi* possesses dichotomizing ribs, which *B. morsei* lacks." (Reinhart, 1943, p. 32)

Geographic range.—Middle and southern California. Reported occurrences in Washington and Oregon are probably *B. landesi* and *B. suzzalloi* (Reinhart, 1943, p. 31)

Geologic range.—Eocene.

Occurrences in California.—Ardath Shale, Delmar (M. A. Hanna, 1927), Domengine (Clark, 1929), Ione (Dickerson, 1916), and Juncal (in *Turritella uvasana applinae* fauna, Givens, 1974) Formations.

Subgenus CUCULLAEARCA Conrad 1865

Subequivalve but generally much distorted, dorsal margin deeply sinuated by large byssal gape; sculpture of fine to coarse, subequal costae.

Geologic range.—Cretaceous through Holocene.

Habitat.—In warm seas.

Barbatia (Cucullaearca) cliffensis M. A. Hanna

Plate 5, figures 9, 12

Barbatia cliffensis M. A. Hanna, 1927, p. 272, pl. 26, figs. 1-6.

Barbatia (Cucullaearca) cliffensis M. A. Hanna. Reinhart, 1943, p. 32-33, pl. 1, figs. 5-7.

Original description.—"Shell large, moderately inflated; anterior and posterior fairly regularly rounded; ventral slightly concave upward, due to a depression near the center of the shell; dorsal margin slightly convex; posterior dorsal somewhat expanded; beak prominent, nearly central; concentrically striated by growth lines; radially ornamented by prominent round-topped ribs, distinctly noded where crossed by the growth lines so that a rib may

appear throughout its length; central depression in the shell shallow, extending from the beak to the ventral margin; interior of the shell radially ribbed, a reflection from the outer surface; inner margin not distinct in the cotypes; hinge margin moderately wide; cardinal area widely triangular, bearing well defined ridges and grooves which meet at the center to form an inverted 'V'; teeth more definite near the margins, three to eight at either end, more or less V-shaped toward the beak, inclined near the hinge extremities but not parallel to the hinge line. *Dimensions. Cotype 31076*: Altitude 26 mm., length 47 mm. *Cotype 31077*: Altitude 30 mm., length 52 mm."

Lectotype.—UCMP 31077 (Reinhart, 1943).

Type locality.—UC 5062. San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—"Shell fairly large, inequilateral, subcompressed; in profile, anterior end rounded, ventral margin sloping downward posteriorly, posterior margin broadly rounded, meeting hinge margin at angle of 40°; large byssal gape just anterior to center of ventral margin; umbones broadly rounded, not conspicuous, variable in postition; in the lectotype***umbones are at anterior fourth, while in paratype***they are only slightly anterior to center. This last specimen is also more quadrate in outline than lectotype, which widens noticeably toward posterior end***. Although some of this widening is only apparent, due to part of the anterior ventral margin being broken, the actual widening, as shown by growth lines, is nevertheless considerable. A broad ridge extends from beak to posterior ventral margin; anterior to this ridge is a broad, shallow depression. Sculpture of about 40 ribs as wide as interspaces, ribs fairly uniform over most of surface except on and posterior to umbonal slope, where they are larger and more widely spaced than elsewhere; ribs crossed by numerous growth lines, accentuated by nodes on ribs which give surface of shell an imbricate appearance. Ligamental area narrow, triangular, highly inclined, bearing six chevron-shaped grooves, on the lectotype. Hinge wide at extremities, but very narrow at center; longer posteriorly than anteriorly, curved into a gentle arc; in the lectotype the posterior third of hinge bears 8 large teeth, straight at posterior end of hinge and V-shaped at anterior end, strongly convergent; anterior part of hinge of lectotype has about 6 somewhat smaller teeth, not V-shaped. Teeth in medial part of hinge small, granular. Muscle scars indistinct. Inner margin of shell crenulated, posteriorly at least; within pallial line these crenulations continue faintly toward the umbo; pallial line slightly impressed." (Reinhart, 1943, p. 33)

Comparison.—"This species may be distinguished from the other known species by its larger size, the concavity near the center of the shell, the noded character of the ribs, and by the general character of the hinge." (M. A. Hanna, 1927, p. 272)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Ardath Shale.

Barbatia (Cucullaearca) bramkampi Durham

Plate 5, figures 10, 11

Barbatia (Cucullaearca) bramkampi Durham, 1950, p. 55, pl. 1, 7, 9.

Original description.—"Shell large, rather flattened, beaks low, shape more or less irregularly subquadrate, similar in outline to *B. reeveana* (d'Orbigny); a low rounded angulation from the beak to ventral part of posterior margin; dorsal margin straight; posterior margin straight, making an angle of about 135° with dorsal margin, then rounding evenly into slightly curved ventral margin which slopes upward anteriorly to short rounded anterior margin; radial sculpture of 90-100 fine radial ribs, somewhat coarser and more nodose on anterior half of shell, posteriorly every fourth or sixth rib may be coarse, occasional fine secondaries intercalated; radial ribs crossed by fine growth lines which produce small nodes on anterior ventral margin; ligamental area with numerous inverted V-shaped chevrons; hinge with 5 coarse teeth and 10 finer ones inside them anteriorly, then a smooth area, followed by about 5 small teeth and 7 large ones posteriorly—on some specimens the smooth central area is also covered with fine teeth, and there may be 10 large ones posteriorly."

Holotype.—UCMP 15552.

Type locality.—UC A3519. Baja California Sur. Marquer Formation, Pliocene.

Comparison.—"The outline of different specimens varies considerably. *B. bramkampi* may readily be distinguished from *B. reeveana* by its finer and more numerous radial ribs, particularly on the anterior and posterior dorsal margins where the radial ribs on that species are rather coarse." (Durham, 1950, p. 55)

Geographic.—Baja California Sur.

Geologic range.—Pliocene.

Occurrence in Baja California Sur.—Marquer Formation.

Barbatia (Cucullaearca) reeveana (Orbigny)

Plate 6, figures 1, 2

Arca reeveana Orbigny, 1846, p. 635.

Barbatia (Cucullaearca) reeveana subsp. *reeveana* (d'Orbigny). Reinhart, 1943, p. 33-34, pl. 15, figs. 1-3.

Barbatia (Cucullaearca) reeveana (d'Orbigny). Durham, 1950, p. 56, pl. 1, figs. 3, 4, 8.

Original description.—"A. testa ovato-oblonga, compressa, radiatum inequaliter costata; epidermide squamosa versus marginem induta; latere buccali brevi, oblique rotundato; latere anali producto, externe arcuato, angulato; latere palleali hiante, alba, striis analibus duplicibus; area ligamenti angustata, sulcata."

Cotypes.—BM(NH) 54.12.478b (Keen, 1966b, p. 5).

Type locality.—Payta [sic: Paita], Peru. Holocene.

Supplementary description.—"Recent specimens of this subspecies***from the Galapagos Islands, show a large byssal gape, well-developed ligamental area, and hinge divided by a broad central edentulous gap, features which are characteristic of *Cucullaearca*." (Reinhart, 1943, p. 34)

"This is a fairly large, coarsely reticulate form, with a habit of attaching between rocks, so that the shell may be much distorted in shape or even worn smooth in spots by friction with its surroundings." (Keen, 1971, p. 40).

Geographic distribution.—Living: Laguna Manuela, Baja California Norte, Golfo de California, south to Zorritos, Peru; fossil: Baja California Sur.

Geologic range.—Pliocene though Holocene.

Occurrence in Baja California.—Pliocene: Marquer Formation (Durham, 1950); Pleistocene: unnamed strata, Gulf of California (Durham, 1950).

Habitat.—Intertidally to 120 m.

Subgenus FUGLERIA Reinhart, 1937a

Ovoid; cardinal area very narrow; sculpture of uniform costellae.

Geographic range.—Florida, California, and Central America.

Geologic range.—Pliocene through Holocene.

Habitat.—In tropical and subtropical seas.

Barbatia (Fugleria) pseudoillota Reinhart

Plate 6, figures 3, 5

Barbatia (Fugleria) pseudoillota Reinhart, 1937, p. 184-185, pl. 28,

figs. 6, 9, 10. Reinhart, 1943, p. 36, pl. 3, figs. 4-6. Woodring, 1950, p. 82, pl. 15, figs. 12, 13.

Original description.—"Fairly well-preserved right valve, elongate-oval in outline, inequilateral, little inflated. Beak placed near anterior end, prosogyrate. Profile of anterior margin of shell rounded; ventral margin nearly straight; byssal gape inconspicuous if present; posterior margin sharply-rounded ventrally, straighter dorsally; dorsal margin formed by large umbo, beyond which hinge margin projects only slightly on either side. A broad ridge extends from umbo to posterior ventral margin; in front of this is a very shallow medial depression. Sculpture of about 95 radial ribs, coarser on posterior slope than elsewhere; ribs spaced with fair regularity; small inter-ribs occasionally developed. Five prominent concentric growth lines present, as well as many inconspicuous ones. Ligamental area narrow, confined mainly to posterior of umbo, although extending slightly in front; about four chevron-shaped ligamental grooves present, of which the upper two do not extend anterior to beak. Hinge arched, very narrow; about 7 small, granular teeth, at anterior end of hinge only; no posterior teeth either on holotype or paratype. Interior of shell of holotype is mainly concealed by matrix, but in paratype (no. 1384), a young specimen, the interior of the shell is entirely exposed; this appears smooth, but under magnification is seen to have numerous fine radial striations. Muscle scars indistinct. Inner margin of shell smooth. Pallial line slightly indented."

Holotype.—LAM 4075 (CIT 1383).

Type Locality.—Pliocene asphalt beds at Fugler Point, 10.2 km southeast of Santa Maria, Santa Barbara County, Calif. Cebada Member, Careaga Formation, Pliocene.

Comparison.—*Barbatia pseudoillota* "is related to *Barbatia illota* (Sowerby), a Recent tropical Pacific Coast species***. However, although the posterior teeth on this species are not strongly developed, they are at least present." (Reinhart, 1943, p. 185)

Barbatia pseudoillota is less elongate than *B. illota* (Woodring, 1950, p. 82).

Geographic range.—Southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene and Pliocene: Towsley Formation (Kern, 1973); Pliocene: Cebada Member of the Careaga Sandstone (Woodring, 1950): Pliocene and Pleistocene: Fernando Formation (Vedder, 1972).

Barbatia (Fugleria) illota (Sowerby)

Plate 6, figures 6, 7

Byssoarca illota Sowerby, 1833, p. 18.

Fugleria illota (Sowerby). Olsson, 1961, p. 83-84, pl. 6, figs. 1, 1a, 1b.

Barbatia (Fugleria) illota Sowerby. Hertlein and Grant, 1972, p. 157-158, pl. 27, figs. 35, 36, 38-40.

Original description.—"Byss. testa ovata, alba, radiatim costata, costis numerosis, decussatis; epidermide fusca, foliacea induta; latere antico breviore, rotundato, postico declivi; area ligamenti angusta, brevi: long. 1.5, lat. 0.75, alt. 1, poll."

Holotype.—BM(NH) (A. M. Keen, oral commun., 1978).

Type Locality.—Found under stones in the Gulf of Nocoiyo [Nicoya, Costa Rica], Holocene.

Supplementary description.—"The shape is somewhat variable. On small specimens teeth are present along the entire hinge but on large specimens the posterior portion of the hinge is devoid of teeth except for four or five at the end***the teeth are striated. The ligamental grooves on small specimens are posterior to the beak, but larger specimens (35 mm long) have as many as seven ligamental grooves, the upper ones not extending beyond the beak but the three lower ones forming asymmetric angles extending anterior to the umbo. The largest Recent specimen which we have seen***is 39 cm long, 25 mm high, the convexity (both valves together), 18.6 mm." (Hertlein and Grant, 1972, p. 158)

"On fully adult shells of *B. illota* a narrow band of ligament extends in front of the umbo, as on small specimens of *Arca barbata*, the type of *Barbatia*. On such shells of *B. illota* the hinge is edentulous, except at the extremities." (Woodring, 1950, p. 82)

Comparison.—*Barbatia pseudoillota* Reinhart is a very similar species. The type specimen, a right valve, is 33.5 mm long and 31 mm high; the convexity is 9 mm. It was described as less elongate than *B. illota* and as having about seven granular teeth anteriorly but completely lacking teeth on the hinge posteriorly. Our observations on the hinge of adult Holocene specimens of *B. illota* show that although there is a long edentulous area in the subumbonal area, there are a few teeth at the posterior end. Perhaps a large series of *B. pseudoillota* may reveal specimens with teeth on the posterior end of the hinge but none have been reported. (Hertlein and Grant, 1972, p. 158)

Geographic range.—Living: Isla Angel de la Guarda, Golfo de California to Lobitos, Peru; fossil: southern California, to Panama and Ecuador.

Geologic range.—Pliocene through Holocene.

Occurrence in California and Baja California Sur.—Pliocene: Niguel (J. G. Vedder, written commun., 1978) and San Diego (Hertlein and Grant, 1972) Formations; Pleistocene: unnamed strata, Golfo de California (Durham, 1950).

Habitat.—Intertidal zone, attached to rocks; dredging records show an offshore occurrence to depths of 70 m. (Keen, 1971, p. 40)

Subfamily ANADARINAE Reinhart, 1935

Genus ANADARA Gray, 1847

Rotund, moderately heavy, sculptured with strong costae that correspond to interlocking crenulations of shell margins; equivalve in shape and sculpture; cardinal area elongate; dental series only slightly arched.

Geologic range.—Late Cretaceous through Holocene.

Habitat.—Littoral zone to 128 m but usually in less than 75 m. (Hertlein and Grant, 1972, p. 454) Usually burrowing but may attach by a weak byssus. (Stanley, 1970, p. 22-23)

Subgenus ANADARA

Subtrapezoidal; dental series continuous, consisting of similar and uniformly graded teeth.

Anadara (Anadara) osmonti (Dall)

Plate 6, figures 10, 11

"Arca microdonta Conrad" of Osmont, 1905, p. 90-91, p. 8, figs. 1-2; *not* fig. 3. Not *Arca microdonta* Conrad, 1855.

Arca osmonti Dall, 1909, p. 110, new name.

Anadara (Anadara) osmonti (Dall). Reinhart, 1943, p. 50-53, pl. 4, figs. 9, 11, 16; pl. 10, figs. 12, 15. [See for synonymy].

Arca barkeriana Clark, 1918, p. 128.

Arca impravida Wiedey, 1928, p. 130-131, pl. 14, figs. 2, 3.

Description of holotype.—"Large, subquadrate, inflated, equivalve, inequilateral. Anterior margin regularly and broadly convex in profile, ventral margin straight and almost parallel to hinge margin, posterior portion of shell mostly broken away, the upper part of posterior margin still remaining; umbones large and full, beaks prosogyrate; hinge margin projects scarcely at all in front of umbo, but does project a short distance behind it. Curvature of

shell fairly uniform, except from umbo to posterior ventral margin where it is greater, forming a broadly rounded ridge, from which, to posterior dorsal margin, shell is slightly concave. Twenty-eight radial ribs, badly worn so that on casual inspection they appear flat and unornamented; closer examination, however, shows, in the better preserved portions, a central longitudinal groove on each rib, on each side of which is a smaller secondary groove. Ribs uniform in size and distribution over surface; interspaces flat, narrower than the ribs; closely spaced growth lines cross ribs and interspaces. Cardinal area moderately wide and inclined. A few grooves may be seen on area, but these are very poorly preserved. Dentition and interior of holotype not visible." (Reinhart, 1943, p. 51)

Holotype.—UCMP 11927; of *A. barkeriana* UCMP 11924; of *A. impravida* CAS/SU 5162.

Type locality.—Unknown. Probably from Devils Den, Kern County, southern California (Reinhart, 1943, p. 50).

Supplementary description.—"Attention should especially be called to the variation in shape. Number of ribs is fairly uniform; an examination of many other specimens from Barker's ranch and Devils Den shows the number to range from 27 to 32, with 29 to 31 ribs on most of the mature specimens." (Reinhart, 1943, p. 51)

Comparison.—"From *A. devincta****(Conrad), *A. osmonti* differs by having the umbones placed farther anteriorly and by possessing beaded ribs, whereas those of *A. devincta* usually are not beaded. In addition, when viewed dorsally, the anterior end of most specimens of *A. osmonti* is more bluntly pointed than that of *A. devincta*, although some specimens of *A. osmonti*, particularly immature ones, are rather sharply pointed.

"*A. mediaimpressa****(Clark) greatly resembles *A. osmonti* but differs by having a slightly flattened area in the umbo, extending a short distance down toward the ventral margin. *A. mediaimpressa*, furthermore, has a sharply concave area on the dorsal posterior part of the shell which is not conspicuous in *A. osmonti*.

"*Andara lakei* (Wiedey), although similar in form to *A. osmonti*, has only about 25 ribs, which are broader and more deeply grooved." (Reinhart, 1943, p. 52-53)

Geographic range.—Alaska; southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Miocene: Branch Canyon Sandstone (Vedder, 1973), Olcese Sand and Round Mountain Silt (Addicott, 1956), Saltos Shale Member of the Monterey (Repenning and Vedder, 1961), and Topanga (Takeo Susuki, written commun., 1978) Formations.

Anadara (Anadara) submontereyana (Clark)

Plate 6, figure 12

Arca (Scapharca) submontereyana Clark, 1918, p. 128-129, pl. 16, fig. 2.

Anadara (Anadara) mediaimpressa subsp. *submontereyana* (Clark). Reinhart, 1943, p. 40-41, pl. 4, fig. 7.

Anadara (Anadara) submontereyana (Clark). Addicott, 1972, p. 23-24, pl. 1, figs. 6, 7, 11, 16, 17.

Original description.—"Shell plump, medium in size, fairly heavy, rhombic in outline; beaks rather prominent and anterior to the middle of the shell. Posterior end broadly rounded; anterior end regularly rounded, sloping down rather obliquely to the ventral edge. Ventral edge gently convex. Surface of shell radially sculptured by about twenty-three flat-topped ribs with interspaces averaging about the width of the tops of the ribs; on some specimens, there is a groove or channel down the middle of some of the ribs; this, however, appears to be due to weathering, not being apparent on the best preserved specimens. Incremental lines rather fine. Cardinal area large, crossed by well-defined multivincular grooves."

Holotype.—UCMP 11186.

Type locality.—UC 52. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Supplementary description.—"ventral margin broadly rounded, posterior margin rounded below, straight dorsally;***ribs nearly flat-topped, straight-sided, separated by interspaces slightly narrower than ribs; medial groove present on lower extremity of several posterior ribs of holotype. Concentric growth lines closely spaced, preserved only in interspaces***inner ventral margin crenulated." (Reinhart, 1943, p. 41)

"The number of ribs varies from as few as 21 or 22 to as many as 25. Both the ribs and interspaces are seen to be very finely noded on a few of the better preserved specimens." (Addicott, 1972, p. 23)

Comparison.—"*A. submontereyana* is not so large or inflated as *A. osmonti* and the number of radial ribs is not so great. The type specimen of *A. osmonti* Dall has twenty-seven ribs; the maximum number on any of the specimens of *A. submontereyana* examined by the writer is twenty-three." (Clark, 1918, p. 129)

Anadara submontereyana is "closely related to typical *A. mediaimpressa*, from which it differs in being slightly less convex and in having possibly fewer ribs. Typical *A. mediaimpressa* has 27 to 29 ribs, whereas on the holotype of *A. submontereyana* 24 can be counted, a number which would be increased if a well-preserved specimen were available." (Reinhart, 1943, p. 41)

"*A. submontereyana* differs from *A. strongi*, a somewhat similar species of early Miocene age, in having a few more radial ribs that are not strongly grooved." (Addicott, 1972, p. 24)

Geographic range.—Middle California.

Geologic range.—Oligocene and Miocene.(?).

Occurrence in California.—Oligocene: Wygal Sandstone Member of the Temblor Formation (Addicott, 1972); Miocene(?): San Ramon Sandstone.

Anadara (Anadara) lakei (Wiedley)

Plate 6, figures 8, 9

Arca lakei Wiedey, 1928, p. 127-128, pl. 13, figs. 4, 5.

Anadara (Anadara) lakei (Wiedey). Reinhart, 1943, p. 55-56, pl. 9, figs. 1-3, pl. 12, figs. 7, 8.

Original description.—"Shell subquadrate in outline and of moderate size, but distinctly inequilateral and quite gibbose. The anterior dorsal margin short and straight, gently sloping. The anterior dorsal extremity broadly rounded to the basal margin, which is less convexly rounded. The posterior dorsal extremity is quite sharply rounded, more narrowly below than above. Posterior dorsal margin short and straight to gently sloping. Umbones prominent, large, elevated, and incurved. The beaks are of moderate size, anteriorly situated, quite sharp, incurved and close-set. The cardinal area is not large and is only gently depressed. Sculpture consists of twenty-five ribs which are low and flattened. The ribs generally have on their surface three longitudinal striations which present the appearance of dividing the ribs into riblets, separated by thread-like channels. The interspaces between the ribs are slightly narrower than the ribs and are flatly channeled. Concentric lines of growth apparent but not prominent. Length, 38 mm.; breadth, 33 mm.; height of both valves, 32 mm."

Holotype.—SDNM 19.

Type Locality.—SU 432. San Luis Obispo County, Calif. Saltos Shale Member of the Monterey Formation, Miocene.

Comparison.—"The species with which *Anadara lakei* might be confused is *A. osmonti* (Dall), which it resembles in general form

and ornamentation. In *A. lakei*, however, the ribs are fewer in number (25 instead of about 29-31), and are broader and more deeply grooved. Until more specimens of *A. lakei* have been studied, it is not possible to decide whether this is a distinct species or merely a variety of *A. osmonti*." (Reinhart, 1943, p. 56)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Saltos Shale Member of the Monterey Formation.

Andara (Anadara) devincta (Conrad)

Plate 6, figures 15-17; plate 7, figure 1

Arca devincta Conrad, 1849, p. 726; atlas pl. 18, figs. 10, 10a.

Anadara (Anadara) devincta subsp. *devincta* (Conrad). Reinhart, 1943, p. 43-45, pl. 16, figs. 6, 8.

Anadara (Anadara) devincta (Conrad). Moore, 1963, p. 59-61, pl. 13, figs. 14, 15; pl. 14, figs. 1-13.

Arca (Scapharca) microdonta Conrad. Dall, 1909, p. 110. Not *A. microdonta* Conrad in Blake, 1855.

Arca procumbens Wiedey, 1928, p. 132, pl. 13, figs. 9-11.

Original description.—"Rhomboidal, ribs narrow, flattened, and little prominent anteriorly; on the posterior side wider, slightly convex, and longitudinally striated. Beaks distant."

Lectotype.—USNM 3499 (Moore, 1963).

Type locality.—Astoria, Columbia County, Oreg. Astoria Formation, Miocene.

Supplementary description.—"*Anadara devincta* includes forms quadrate to posteriorly elongate in outline, thin to highly inflated, possessing a narrow to very wide cardinal area, and forms that have smooth ribs, ribs medially split, or smooth ribs split at the ventral margin. On specimens preserved with the valves articulated and closed, the left valve is seen to overlap the right valve slightly along the ventral margin. The variations in outline, inflation, and ribbing bear no correlation to the size of the specimens, except that the thin forms become inflated as they mature and the cardinal area is coincidentally widened.

"There are three forms of *Anadara devincta* in the Astoria formation in Oregon; a thin, an inflated, and a split-rib form***.

"Young specimens of the split-rib form***are quadrate in shape (length 2.5 to 5 cm), thin to moderately inflated (thickness, 1.5 to 3 cm), have a narrow cardinal area, and have ribs split by one deep center groove. The mature forms are posteriorly elongated (length, 6 to 6.5 cm), are moderately to greatly inflated (thickness, 3.5 to 4.5 cm), have a wide cardinal area, and have ribs split by three grooves. The beaks are situated about two-thirds the distance from the posterior margin.

"The thin form***is usually moderate in size (length, 3 to 3.5 cm), subquadrate in shape, and thin (thickness, 1.5 to 2.5 cm) and has a narrow cardinal area and ribs split by 1 or 3 grooves.

"The inflated form***is subovate when young (length, 2.5 to 5 cm) and posteriorly elongated when mature (length, 5.5 to 7 cm), it is moderately to greatly inflated when small (thickness, 2 to 4 cm) and greatly inflated when large (thickness 4.5 to 5.5 cm). The beaks are three-fourths the distance from the posterior margin on young specimens and two-thirds this distance on mature specimens. The ribs are smooth on young specimens and split by 1 or 3 grooves at the ventral margin on large specimens." (Moore, 1963, p. 59-60)

Comparison.—*A. osmonti* (Dall) differs from *A. devincta,* on the basis of the poorly preserved topotype material available for comparison, by having a flattened ridge beginning beneath the anterior edge of the beak and extending to the anterior margin along the upper edge of the cardinal area. The cardinal area is inequilateral on all specimens, including the smallest, which possess a narrow cardinal area. The larger specimens of *A. osmonti* have a wide inequilateral cardinal area and resemble *Anadara devincta*, inflated form, in outline. However, the anterior cardinal ridge of *A. osmonti* is not found on *A. devincta*, inflated form; and the ribs of *A. osmonti* are split by 1 groove on small specimens and 3 grooves on larger specimens, whereas the ribs are smooth on *A. devincta,* inflated form, except on the ventral margin of large specimens.

"*Anadara trilineata* (Conrad) of Arnold (Woodring, Stewart, and Richards, 1940, p. 89)***differs from *A. devincta* by generally maintaining a moderately inflated shell throughout its growth, by usually having a fairly narrow cardinal area which is however wide on some large specimens, and by being higher usually in proportion to length. The ribs are grooved like *A. devincta*, split-rib form, but they seem to be consistently fewer in number *A. trilineata* averaging about 25 and *A. devincta*, split-rib form, about 32.

"*Anadara (Anadara) devincta montesanoana* (Etherington, 1931)***is trigonal rather than quadrate in outline and seems to be allied more closely to *Anadara (Anadara) trilineata* (Conrad) than to *A. devincta.*" (Moore, 1963, p. 61)

Geographic range.—Alaska(?) to southern California and Japan(?).

Geologic range.—Miocene.

Occurrence in California.—Briones Sandstone (Hall, 1958; Moore, 1963), Monterey Group (Weaver, 1949), Sobrante Sandstone (Lutz, 1951; Weaver, 1953), and upper part of Temblor Formation (Loel and Corey, 1932; Adegoke, 1969).

Anadara (Anadara) mediaimpressa (Clark)

Plate 7, figures 2, 3

Arca (Scapharca) mediaimpressa Clark, 1918, p. 126-127, pl. 7, figs. 7, 8; pl. 16, figs. 5-7.

Anadara (Anadara) mediaimpressa (Clark). Schenck and Reinhart, 1938, p. 34-37, pl. 1, figs. 1a-1d.

Anadara (Anadara) mediaimpressa subsp. *mediaimpressa* (Clark). Reinhart, 1943, p. 39-40, pl. 4, figs. 1, 5, 6.

Original description.—"Shell small to medium in size, rhombic in outline. Umbones rather broad, strongly inturned and anterior to middle of shell, depressed medially, the depression on the smaller specimens extending from the beak well down to the ventral edge; this character is best seen on the smaller specimens, being less noticeable on the larger ones. Posterior end broadly subtruncate to gently rounded, anterior end evenly rounded, narrower than posterior end. Surface sculptured by twenty-seven to thirty flat-topped, radial ribs with interspaces about as wide as the ribs. On one of the specimens figured***most of the ribs show a medium groove beginning about half way from the beaks and extending to the ventral edge; this groove is similar to that seen on *Arca montereyana* Osmont and on *Arca trilineata* Conrad. On this last, there is often a second and third groove bordering on each side of the medium groove which begin lower down from the beaks than does the medium groove. It is very possible that if larger specimens of *Arca mediaimpressa* are found, the second and third grooves may also appear on the lower part of the ribs. Apparently the ribs were originally somewhat spinose, due to the sharp, imbricating, incremental lines; this is to be seen on a few of the better preserved specimens. Surface rather strongly depressed posteriorly. Cardinal area very narrow; ligamental grooves obscure. Hinge plate narrow, slightly curved, with about thirty-five taxodont cardinals, which, beneath the beaks, are very small; distally they become larger and converge ventrally."

Holotype.—UCMP 11174.

Type locality.—UC 1131. Contra Costa County, Calif. San Ramon

Sandstone, Miocene(?).

Supplementary description.—"Sculpture of 27 to 29 radial ribs crossed by concentric growth lines; ribs flat-topped, beaded on anterior half of shell***ribs and interspaces crossed by closely-spaced concentric growth lines; medial groove present on ribs near ventral margin, becoming distinct at distance of 10 to 15 mm. from umbo***[on] a relatively large individual, an additional groove is present near ventral margin, on each side of medial groove; ligamental area, long, nearly flat, rather narrow, wider in front of than behind beaks, bearing three chevron-shaped grooves, only the posterior halves of which are well preserved; hinge exposed only on holotype***shorter anteriorly than posteriorly, wider at extremities than in medial area; teeth strong, regular, vertical at center, converging ventrally at extremities of hinge; inner margin of shell crenulated***" (Schenck and Reinhart, 1938)

Comparison.—"This species resembles *Anadara osmonti* (Dall)***. This comparison is based upon a small number of specimens of [*A.*] *mediaimpressa* and a large number of probable topotypes of [*A.*] *osmonti* ranging in length from 20 to 55 mm. and exhibiting considerable variation in outline and convexity. The similarity***is so great as to suggest the possibility that one rather than two species is present, but the meager representatives of [*A.*] *mediaimpressa* do not warrant making a definite decision as to specific identity." (Schenck and Reinhart, 1938, p. 37)

"*Arca mediaimpressa* differs from the typical *A. montereyana****in the following respects: The beaks are more prominent and broader, the latter lacking the depressed area just below the beaks, and the truncated posterior margin being more oblique; *A. montereyana* is the longer and is more strongly produced posteriorly, also the surface is not so strongly depressed near the posterior truncated end." (Clark, 1918, p. 127)

Geographic range.—Middle and southern California.

Geologic range.—Miocene.

Occurrence in California.—Miocene: Round Mountain Silt (Schenck and Reinhart, 1938) and upper part of Temblor Formation (Schenck and Reinhart, 1938); Miocene(?): San Ramon Sandstone.

Anadara (Anadara) montereyana (Osmont)

Plate 7, figure 4

Arca montereyana Osmont, 1905, p. 96-98, pl. 9, fig. 5; *not* figs. 5a, 5b.

Arca devincta var. *montereyana* (Osmont). Etherington, 1931, p. 69-70, pl. 3, figs. 1-5, 7, 8.

Anadara (*Anadara*) *montereyana* (Osmont). Reinhart, 1943, p. 47-49, pl. 10, figs. 1, 3, 4, 9.

Original description.—"Rhomdoidal, inequilateral, nearly two-thirds of the length being behind the beak, posterior margin making a very obtuse angle with hinge-line. Ratio of length to height about 1-1/2 to 1. Average size of adult about 51x33 mm. Beaks not prominent, turned rather sharply forward, narrow and close together, ligament area narrow. Hinge line long and straight. Basal margin nearly parallel to hinge line. Ribs 26-32, usually 27, prominent, square, flattened, a little wider than the interspaces and marked with a median groove. Occasionally, in the older specimens, two subsidiary grooves may appear toward the margin, as in *A. trilineata*. More or less distinct lines of growth often roughen the shell, especially in the larger individuals, and when these are fine and numerous they approach closely the beaded effect of *A. trilineata*."

Holotype.—UCMP 11925.

Type locality.—SU 1166. Selby, Contra Costa County, Calif. (Reinhart, 1943, p. 48). Monterey Group, Miocene.

Supplementary description.—"Moderately large, compressed*** elongate; dorsal margin straight, interrupted by umbo; anterior margin evenly rounded, merging into ventral margin which is gently convex, nearly parallel to dorsal margin; posterior margin sharply rounded below and nearly straight higher up, meeting hinge margin at angle of nearly 40°; umbo located one third of distance from anterior end; gentle ridge extends from umbo to posterior ventral margin, above which shell is slightly concave; no byssal gape apparent. Sculpture of 31 radial ribs, separated by nearly flat, narrower interspaces; ribs divided longitudinally by central grooves, which did not develop until shell had reached a length of about 30 mm; ribs and interspaces crossed by numerous, closely spaced growth lines***; ribs wider and more prominent on posterior part of shell than elsewhere; ligamental area, hinge, and interior of holotype concealed by matrix." (Reinhart, 1943, p. 49)

Comparison.—"This species resembles *Anadara devincta**** (Conrad) closely. The two species may be distinguished by the fact that *A. montereyana* is more elongate and more compressed than *A. devincta*, and typically has less deeply incised longitudinal grooves on the ribs.

"*A. montereyana* also resembles *A.**** *montesanoana* (Etherington), but differs in being more elongate and compressed, and in having 29 to 31 ribs whereas Etherington's subspecies has 25 to 28.

"The resemblance of *A. montereyana* to *A. osmonti* is fairly close, but *A. osmonti* is more inflated than *A. montereyana* and its umbones are located farther anteriorly.

"From *A. trilineata**** *A. montereyana* may be distinguished by being more elongate, with more bluntly rounded umbones, more ribs (*A. trilineata* usually has only 25 to 27), and by lacking the distinct beaded ornamentation of the ribs which characterizes *A. trilineata****.

"*A. montereyana* has been confused with *A. obispoana*, probably because *A. obispoana* is usually found as an internal mold, whereas *A. montereyana* is commonly better preserved, retaining its shell material. It is thus difficult to compare the two species, preserved differently; but if internal molds of *A. obispoana* are compared with internal molds of *A. montereyana*, the two are at once seen to be distinct because in the molds of *A. montereyana* the radiating ribs extend only for a short distance toward the umbo, while in *A. obispoana* they extend all the way up to the umbo. Other differences separate the two species, such as number of ribs. *A. obispoana* has about 26, fewer than *A. montereyana*." (Reinhart, 1943, p. 49)

Geographic range.—Alaska; Washington, middle California and Baja California Sur.

Geologic range.—Miocene.

Occurrence in California and Baja California Sur.—Briones Formation of Reinhart (1943), Monterey Formation (Ham, 1952), Oursan (Hall, 1958) and Sobrante (Lutz, 1951; Weaver, 1953), Sandstones and Tortugas Formation (Minch and others, 1976).

Anadara (Anadara) montesanoana (Etherington)

Plate 7, figures 6, 10

Arca devincta montesanoana Etherington, 1931, p. 69-70, pl. 3, figs. 1-5, 7, 8.

Anadara (*Anadara*) *devincta* subsp. *montesanoana* (Etherington). Reinhart, 1943, p. 45-46, pl. 11, figs. 13, 14.

Original description.—"Shell thick, subquadrate in outline; beaks elevated, subcentral; surface of the shell with 25-28 flattish channeled ribs varying in width from one-half to twice the width of the interspaces. Where the ribs are narrow they are bifurcated only once but usually develop four fine radial lines. On the adult the

cardinal area is wide, with four or five chevron-shaped threads; muscle scars deep; border coarsely crenate."

Holotype.—UCMP 31922.

Type locality.—UC 9069. Grays Harbor County, Wash. Montesano Formation of Weaver (1912), Miocene.

Comparison.—*Anadara devincta* has 29 to 32 ribs and *A. montesanoana* 26 to 28. This species approaches *A. trilineata* (Conrad) in outline and is similar in other respects, such as number of ribs, dentition, and ligamental area. *A. trilineata* is less convex, has a sharper umbo than *A. montesanoana*, and has beading on the ribs, which Etherington's species usually lacks. (Reinhart, 1943, p. 46)

Geographic range.—Washington and middle California.

Geologic range.—Miocene.

Occurrence in California.—San Pablo Formation (Etherington, 1931).

Anadara (Anadara) topangaensis Reinhart

Plate 8, figures 5, 6

Anadara (Anadara) topangaensis Reinhart, 1943, p. 53-54, pl. 10, figs. 10, 13, 14 [See for synonymy].

Arca microdonta Conrad. Osmont, 1905, p. 90-91, 100, pl. 8, figs. 3a-b, *not* figs. 1-2. Not *Arca microdonta* Conrad, 1855.

Original description.—"Moderate in size, ventricose, slightly inequilateral; in profile, anterior margin evenly rounded, ventral margin nearly straight, sloping upward slightly toward rear, posterior margin abruptly rounded ventrally, but straight above, meeting hinge margin at angle of 45°; distinct ridge extends from umbo to posterior ventral margin, above which shell is concave; beaks prosogyrate, located at anterior third; ventral margin without byssal gape. Ribs 28 to 30 in number, ornamented with distinct nodes; ribs not divided centrally by longitudinal groove; interspaces slightly concave, nearly as wide as ribs; concentric growth lines crossing ribs and interspaces at periphery of shell, but higher up, present only in interspaces. Cardinal area fairly wide, inclined, bearing 4 to 6 grooves, chevron-shaped on paratype 3259, but curved on holotype. Hinge straight, much wider at extremities than at center; teeth numerous and fine, ventrally convergent at extremities. Inner margin of shell crenulated; interior of shell not exposed on any available specimens."

Holotype.—~~UCMP~~ 3258.

Type locality.—UCLA 391. Los Angeles County, Calif. Topanga Formation, Miocene.

Comparison.—"This species resembles *Anadara osmonti* in general form, but whereas the ribs of *A. osmonti* are divided centrally by longitudinal grooves, those of *A. topangaensis* are not; furthermore, the nodes on *A. topangaensis* are much more prominent than on *A. osmonti*." (Reinhart, 1943, p. 54)

Geographic range.—Alaska; southern California to Baja California Norte.

Geologic range.—Miocene.

Occurrence in California.—Rosarito Beach (Minch and others, 1970) and Topanga Formations.

Anadara (Anadara) carrizoensis Reinhart

Plate 7, figures 5, 11

Anadara (Anadara) carrizoensis Reinhart, 1943, p. 56-57, pl. 5, figs. 1, 4, 10.

Original description.—"Large and thick-shelled, strongly inflated, inequilateral, equivalve, beaks prosogyrate, situated at anterior third of shell; shell elongate in outline, hinge margin long and straight, interrupted by prominent broad umbones, ventral margin broadly curved, anterior margin curved upward, meeting dorsal margin at angle of 90°; posterior margin sharply curved below, straight above, meeting dorsal margin at angle of about 45°. Sculpture similar on right and left valves, consisting of 40 radial, rather flat-topped ribs, each ornamented with three to four linear grooves; interspaces between ribs slightly concave, about half as wide as ribs; wavy concentric growth lines traverse ribs and interspaces, conspicuous toward ventral margin of shell. Ligamental area large, with about six ligamental grooves on each valve, not chevron-shaped, but curved under beaks. Hinge straight, rather narrow, slightly wider at extremities than at center of shell; taxodont teeth small and numerous; only a portion of dentition preserved on holotype, which has about 40 teeth***; these diverge ventrally near center of hinge, and converge at posterior extremity; anterior teeth not preserved on type specimens. Muscle scars not preserved. Inner margin of shell strongly crenulated."

Holotype.—LAM 4069 (CIT 3248).

Type locality.—CIT 738. Imperial County, Calif. Imperial Formation, Miocene or Pliocene.

Comparison.—"This species bears a strong resemblance to the Recent *Anadara formosa* (Sowerby), but differs from that species in profile and in lacking the medially sulcate anterior ribs of *A. formosa*. The Recent Atlantic Coast species *Anadara secticostata* (Reeve) likewise resembles *A. carrizoensis*, but is slightly inequivalve, and all of its ribs are medially sulcate." (Reinhart, 1943, p. 57)

Geographic range.—Southern California.

Geologic range.—Miocene or Pliocene.

Occurrence in California.—Miocene or Pliocene: Imperial Formation.

Anadara (Anadara) trilineata (Conrad)

Plate 7, figures 7-9

Arca trilineata Conrad, 1857a, p. 314.

Anadara (Anadara) trilineata subsp. *trilineata* Conrad. Reinhart, 1943, p. 57-60, pl. 5, fig. 9; pl. 6, figs. 1-3, 5, 7; pl. 7, fig. 1.

Anadara trilineata Conrad. Woodring and Stewart, 1940, p. 89-90, pl. 11, fig. 10, 19-24; pl. 14, fig. 7; pl. 20, figs. 15-17; pl. 29, figs. 2, 6. Woodring, 1950, p. 82, pl. 9, figs. 2, 5; pl. 11, fig. 4; pl. 16, fig. 19. Hertlein and Grant, 1972, p. 154-156, pl. 28, figs. 1-4, 6 [See for synonymy].

Original description.—"Trapezoidal, somewhat produced, inequilateral, ventricose; ribs 22-24, scarcely prominent, square, wider than the intervening spaces, ornamented with three impressed or four raised lines; disks concentrically wrinkled; summits prominent; beaks approximate. Length 3 inches."

Holotype.—Location unknown; presumed lost.

Type locality.—"*Arca trilineata* was said to have been collected by Newberry at Santa Barbara, but according to Newberry's itinerary he was nowhere near Santa Barbara, and this species has never been found near Santa Barbara. *Arca trilineata, Arca canalis,* and *Mulinia densata*, described at the same time and said to have been collected at Santa Barbara by Newberry, may have been collected at some locality farther north in the coastal region of California. It is possible but unlikely that they were collected by Blake in the Kettleman Hills or nearby; Blake mentioned only the *Arca*." (Woodring, 1938, p. 31)

Supplementary description..—"We have had a large number of specimens available for study including several hundred valves varying in length from 5 mm to*** 79 mm long. These specimens

vary somewhat in proportion of length to height but all are decidedly longer than high. The number of ribs varies, usually from 25 to 28***. The ribs on the anterior half of the shell are often deeply sulcated or almost bifid, those on the posterior half usually bear two, three, or occasionally four shallow grooves. The ribs usually begin to develop a medial sulcation after the shell attains a height of about 8 to 10 mm, occasionally earlier. The ribs are usually at least partially beaded." (Hertlein and Grant, 1972, p. 155)

Comparison.—"The fewer ribs as well as their beaded ornamentation and the slender umbos are features which serve to separate *Anadara trilineata* from two somewhat similar Miocene species, *A. devincta* Conrad*** and *A. montereyana* Osmont***. The less convex valves and more sharply projecting umbos as well as the usually beaded character of the ribs are shell characters differing from those of *A. devincta montesanoana* Etherington." (Hertlein and Grant, 1972, p. 156)

Geographic range.—Kamchatka and Sakalin; British Columbia to southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Briones Sandstone (Trask, 1922), Castaic Formation (Stanton, 1966), Cierbo Sandstone (Hall, 19580, Santa Margarita Formation (Adegoke, 1969); Miocene and Pliocene: Capistrano (Vedder, 1974), Tahana Member of Purisima (Addicott, 1969), Towsley (Kern, 1973) Formations; Pliocene: Cebada Member, Careaga Sandstone (Woodring, 1950), Etchegoin (Anderson, 1908) and Falor (Manning and Ogle, 1950) Formations, Foxen Mudstone (Keen and Bentson, 1944), Neroly (Weaver, 1949), Niguel (Vedder, 1960), Ohlson Ranch (Peck, 1960), Pancho Rico (Durham and Addicott, 1965), Pomponio Mudstone Member, Purisima (Cummings and others, 1962), Pullen (Roth, 1979), Tinaquaic Sandtone Member of the Sisquoc (Woodring, 1950), San Diego (Hertlein and Grant, 1972), and San Joaquin (Woodring and others, 1940) Formations; Pleistocene: Scotia Bluffs Sandstone (Roth, 1979).

Anadara (Anadara) trilineata calcarea (Grant and Gale)

Plate 8, figures 1, 2

Arca (Arca) trilineata var. *calcarea* Grant and Gale, 1931, p. 140-141, pl. 2, figs. 6a, 6b.

Anadara (Anadara) trilineata subsp. *calcarea* (Grant and Gale). Reinhart, 1943, p. 61-62, pl. 9, figs. 6-8.

Anadara trilineata calcarea Grant and Gale. Hertlein and Grant, 1972, p. 156, pl. 28, figs. 5, 7-10. [See for synonymy.]

Original description.—"Shell like that of typical *Arca trilineata* Conrad, but larger, much thicker, and with more numerous cardinal grooves."

Holotype.—CAS/SU 436.

Type locality.—Well in Balboa Park, San Diego, San Diego County, Calif. San Diego Formation, Pliocene.

Comparison.—"This subspecies differs from typical *A. trilineata* by having a larger, heavier shell and more grooves on the ligamental area. In addition, when viewed from above the anterior end of the shell of *A. trilineata calcarea* is bluntly pointed, differing from typical *A. trilineata*, which is sharply pointed. This blunt point was acquired at a late stage in the growth of the shell of *A. trilineata calcarea*, as shown by the growth lines." (Reinhart, 1943, p. 61)

Comments.—The holotype is a disarticulated, double-valved specimen.

Geographic range.—Middle to southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Briones Sandstone (Weaver, 1953); Pliocene: Niguel (Vedder, 1960) and San Diego (Hertlein and Grant, 1972) Formations; Miocene and Pliocene: Capistrano Formation (Vedder, 1974); Pliocene and Pleistocene: Fernando Formation (Schoellhamer and others, 1981).

Anadara (Anadara) trilineata canalis (Conrad)

Plate 8, figure 4

Arca canalis Conrad, 1847a, p. 314.

Anadara (Anadara) trilineata subsp. *canalis* (Conrad). Reinhart, 1943, p. 60-61, pl. 7, figs. 3, 4. [See for synonymy.]

Original description.—"Subtrapezoidal, ventricose; ribs 24-26, flattened, scarcely prominent, divided by a longitudinal furrow; disk concentrically wrinkled; umbo ventricose; summits prominent, remote from the center. Length 2 1/8 inches; height 1 3/4 inches."

Holotype.—Location unknown; presumed lost.

Type locality.—"Santa Barbara, Calif." The same uncertainty pertains to this locality as for *A. trilineata*.

Comparison.—"This subspecies differs from the typical subspecies in form; the subspecies *A. trilineata canalis* is almost equidimensional in profile, its height nearly the same as the length, whereas *A. trilineata trilineata* is elongate." (Reinhart, 1943, p. 60)

Geographic range.—Japan? (Reinhart, 1943, p. 60); northern to southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene. Pancho Rico Formation (Durham and Addicott, 1965); Miocene and Pliocene: Etchegoin (Arnold, 1909) and Purisima (Arnold, 1908; McLaughlin and Waring, 1915) Formations: Pliocene: Careaga Formation (Reinhart, 1943) and upper part of Towsley Formation (Winterer and Durham, 1962); Pliocene and Pleistocene: Fernando (W. O. Addicott and J. G. Vedder, written commun., 1968) and Pico (Winterer and Durham, and 1962) Formations.

Anadara (Anadara?) strongi (Loel and Corey)

Plate 6, figures 13, 14

Arca (Barbatia) strongi Loel and Corey, 1932, p. 183, pl. 7, fig. 11

Anadara (Anadara?) strongi (Loel and Corey). Reinhart, 1943, p. 42, pl. 12, fig. 6.

Original description.—"Shell small, thin, somewhat elongate; valves inequilateral, ovate-quadrate in outline, moderately convex; umbones low, moderately inflate [sic; inflated] and well anterior, beaks closely proximate, overhang above hinge line, area narrow and long; sculptured by about twenty pairs of narrow, sharply rounded double ribs between which pairs interspaces are about width of single rib. Length, about 17 mm.; width about 10 mm."

Lectotype.—UCMP 31762 (Reinhart, 1943).

Type locality.—UC A527. Orange County, Calif. Uppermost part of Vaqueros Formation, Miocene.

Supplementary description.—"umbones located at anterior third; shell evenly rounded, lacking medial depression or umbonal ridge; apparently no byssal gape. Ribs*** broad, flat, deeply grooved in center, grooves extending from margin to about 5 millimeters from beak; ribs separated by nearly flat interspaces slightly narrower than ribs; spacing and size of ribs fairly uniform over surface of shell. Sculpture appears to be equal on both valves. Ligamental area narrow*** an internal mold of three anterior teeth is preserved, showing these to converge ventrally; interior of shell not

known***. This species is assigned to *Anadara* on the basis of its regular, strong, *Anadara*-like radial ribs, which serve to separate it from *Barbatia*, as it was originally described. Preservation is not sufficiently good to permit its assignment to *Anadara s.s.*, however, except questionably, as it may be a *Scapharca*." (Reinhart, 1943, p. 42-43)

Comparison.—"This species is somewhat similar to *Anadara media-impressa**** which differs in having more ribs, in being more inflated, and in not possessing such well-developed longitudinal grooves on the ribs as *A. strongi*." (Reinhart, 1943, p. 43)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Uppermost part of Vaqueros Formation.

Genus GRANDIARCA Olsson, 1961

"Shell large, high trigonal, equivalve, solid, often becoming heavy and ponderous in the adult. Umbones wide and prominent, central, and usually feebly sulcate, bordered posteriorly by the umbonal ridge at first relatively sharp or angled, later becoming lower and rounded. Beaks small, curved in over a wide, triangular cardinal area. Ligament coarse and heavy, covering the cardinal area completely, the surface of the cardinal area striated with faint, vertical lines and marked with few to many deep, triangular to lozenge-shaped ligamental grooves. Ribs strong, rectangular in section between deeply grooved interspaces, the summit of the ribs smooth or concentrically wrinkled except on the most anterior ones which are crudely noded. Interior of shell widely and deeply fluted by the ribs around the ventral margin. Hinge teeth small, vertical, in a continuous series. Surface of shell protected by a thick, smooth, black periostracum.

"Like *Larkinia* but differing by its less truncated posterior side and fewer, plainer ribs." (Olsson, 1961).

Type species.—*Arca grandis* Broderip and Sowerby.

Comments.—This genus is reinstated following Keen (1971, p. 46), who says that *Grandiarca* is more oblique and massive than *Larkinia* and has fewer ribs.

Geographic range.—Magdalena Bay, Baja California Sur to Peru.

Geologic range.—Miocene to Holocene.

Grandiarca grandis (Broderip and Sowerby)

Plate 9, figures 8, 9

Arca grandis Broderip and Sowerby, 1829, p. 365

Anadara (Larkinia) grandis (Broderip and Sowerby). Reinhart, 1943, p. 65-66, pl. 13, figs. 4-6.

Anadara (Grandiarca) grandis (Broderip and Sowerby). Keen, 1971, p. 46, 48, fig. 89.

Original description.—"A testa oblique subquadrata, crassa, alba, radiatim costata, laevi, costis rotundatis, anticis crenulatis, reliquis muticis, epidermide coriacea; long 4 3/16, lat 3 3/40, alt 3 5/10, poll."

Holotype.—Location unknown.

Type locality.—None given.

Supplementary description.—The shell has about 26 ribs and thickens with age until it becomes impressively massive. A single valve, 145 mm long, weighs 680 grams. (Keen, 1971)

Comparison.—"The largest species of Arca we remember to have seen, growing even to a larger size than *A. sinilis*, which it also resembles very much; it is, however, longer, and the number of ribs greater." (Broderip and Sowerby, 1829, p. 365)

Geographic range.—Living: Magdalena Bay and the Golfo de California to Peru; fossil: Golfo de California to Ecuador.

Geologic range.—Miocene through Holocene.

Occurrence in Baja California.—Pliocene: unnamed strata, Carmen Island, Golfo de California (Hanna and Hertlein, 1927).

Habitat.—Found at extreme low tide on sand bars; common in mud around mangrove roots.

Genus LARKINIA Reinhart,

Subtrigonal, nearly as high as long, heavy with prominent, elevated umbones and small beaks; cardinal area high; costae narrow, steep-sided, smooth or beaded with coarse or scabrous nodes.

Geographic range.—Eastern Pacific; Caribbean.

Geologic range.—Oligocene through Holocene.

Habitat.—One species reported on sand bars at very low tide; to depths of 128 m.

Larkinia santana santana (Loel and Corey)

Plate 8, figures 3, 7

Arca (Anadara) santana Loel and Corey, 1932, p. 185, pl. 8, figs. 1a-3, 2, 3a, 3b.

Anadara (Larkinia) santana subsp. *santana* (Loel and Corey). Reinhart, 1943, p. 63-64, pl. 8, figs. 7, 8.

Anadara santana Loel and Corey. Squires and Fritsche, 1978, p. 17, pl. 3, fig. 1.

Original description.—"Shell heavy and rugose, fairly ventricose, equivalve, of medium size, exterior bell-shaped in outline, almost equilateral, interior subquadrate inequilateral, umbones very high and inflate [sic: inflated], medial; beaks prominent, strongly inturned, only slightly prosogyrous, and not greatly distant, just anterior to middle; cardinal area fairly broad, impressed, with inequal anterior-posterior lines; hinge plate narrow, straight, with about 30 fine slender teeth, vertical anteriorly, oblique posteriorly. The margins, which are fluted entirely around, are evenly rounded on the type specimen; (on most others the posterior extremity is more abruptly rounded and posterior margin is gently rounded). Surface sculptured by about 22 coarse, evenly rounded ribs with interspaces of almost equal width; prominent lines of growth give an irregularly constricted appearance to the shell which is of a dull brown color. Height, 40 mm.; length, 38 mm.; length of hinge plate, 30 mm.; diameter of valve, 20 mm."

Holotype.—UCMP 31768.

Type loclity.—UC 6128. Orange County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"Ligamental area broad, concave, indented at posterior end, sculptured by several indistinct grooves. Due to concavity, this area would appear U-shaped with both valves attached, if viewed end-on***. Hinge*** fairly heavy; teeth numerous, long and slender, converging slightly at extremities, but tending to diverge just posterior to center of hinge. Inner margin crenulated; no byssal gape." (Reinhart, 1943, p. 64)

Comparison.—"This species belongs to the subgenus *Larkinia*, resembling, in a general way, *Anadara chiriquiensis toroensis* (Spieker)***from the***Zorritos Formation,***Miocene, of Peru. The Peruvian species, however, may easily be distinguished by being more elongate in outline, and by having more ribs." (Reinhart, 1943, p. 64)

Geographic range.—Southern California; Baja California Norte?

Geologic range.—Oligocene and Miocene.

Occurrence in California and Baja California Norte.—Oligocene and Miocene: Vaqueros Formation (Loel and Corey, 1932), upper Sespe and Vaqueros Formations, undifferentiated (Schoellhamer and others, 1981); Miocene: questionably in unnamed Miocene strata near Purisima Nueva, Baja California Norte (Loel and Corey, 1932).

Larkinia santana weddlei (Loel and Corey)

Plate 9, figures 1, 2

Arca (Anadara) santana var. *weddlei* Loel and Corey, 1932, p. 185, pl. 8, figs. 4a, 4b.

Anadara weddlei (Loel and Corey). Schenck and Keen, 1940, pl. 31, figs. 1, 2.

Anadara (Larkinia) santana subsp. *weddlei* (Loel and Corey). Reinhart, 1943, p. 64-65, pl. 8, figs. 5, 6.

Original description.—"In the type section of the Vaqueros formation, Vaqueros Creek, Monterey County, occurs an *Arca* similar in all characters to *Arca (Anadara) santana* except that the umbones are less inflate [sic: inflated] and the ribs less prominent. These characters are constant in the eight specimens collected. Height of figured specimen, 39 mm.; length, 39 mm; diameter (both valves), 37 mm.; length of hinge plate, 34 mm."

Holotype.—UCMP 31771.

Type locality.—UC 3675. Monterey County, Calif. Vaqueros Formation, Oligocene and Miocene.

Comparison.—"This subspecies differs from typical *Anadara santana* only in having less inflated umbones, so that, when viewed from either side, the hinge margin projects noticeably beyond the umbo, whereas in the typical *A. santana* the hinge margin projects only slightly. The holotype of *A. santana weddlei* is equivalve; the beaks are prosogyrate, as in typical *A. santana*." (Reinhart, 1943, p. 64-65)

Geographic range.—Middle California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation.

Larkinia camuloensis (Osmont)

Plate 8, figures 8, 9

Arca camuloensis Osmont, 1905, p. 98, pl. 10, figs. 6, 6a; pl. 11, figs. 6b, 6c.

Arca (Arca) multicostata Sowerby var. *camuloensis* Osmont. Grant and Gale, 1931, p. 139, pl. 2, figs. 5a-c.

Anadara camuloensis (Osmont). Woodring, 1938, p. 29-30, pl. 6, figs. 10, 13-16.

Anadara (Larkinia) camuloensis (Osmont). Reinhart, 1943, p. 65, pl. 7, figs. 2, 8, 9.

Original description.—"Shell quadrate to circular, height only slightly less than length, (adult 90x98 mm.), almost equilateral, thickness through closed shell nearly equal to height. Beaks not widely separated, very slightly turned forward, and greatly incurved over a wide and flaring ligament area. Ribs about 32 in number, rounded and without grooves, considerably wider than the interspaces, and crossed by regular ridges, which give them a beaded structure. At about the ninth rib from the posterior end is a very distinct shoulder, from which there is a steep concave slope to the posterior margin."

Holotype.—UCMP 12006.

Type locality.—1.5 km north of Camulos, Ventura County, Calif. Fernando Formation, Pliocene and Pleistocene.

Supplementary description.—"A large, thick-shelled, moderately short *Anadara*. Sculpture consisting of strong ribs bearing heavy concentric ridges ('beads') that appear to be strongest on the anterior part of the shell and are not uniformly developed. Ribs and interspaces show indistinct radial threads. Cardinal area wide (from umbo to lower margin.)" (Woodring, 1938, p. 29)

Comparison.—"*A. camuloensis* is closely related to *A. multicostata* (Sowerby), but differs by possessing heavily beaded ribs, whereas those of *multicostata* are usually beaded slightly or not at all." (Reinhart, 1943, p. 65)

Geographic range.—Middle and southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Pancho Rico Formation (Durham and Addicott, 1965); Pliocene: Niguel Formation (J. G. Vedder, written commun., 1978); Pliocene and Pleistocene: Fernando (Arnold. 1907a; Durham and Yerkes, 1964) and Pico (Winterer and Durham, 1962) Formations.

Larkinia multicostata (Sowerby)

Plate 9, figures 4, 5

Arca multicostata Sowerby, 1833, p. 21

Anadara (Larkinia) multicostata (Sowerby). Reinhart, 1943, p. 66, pl. 8, figs. 9-11. Durham, 1950, p. 54, pl. 1, figs. 15-17. Keen, 1971, p. 48, fig. 90.

Original description.—"Shell squarely rhomboid, solid, equivalve; sides attenuated and angulated at the upper part, anterior side shorter, ventricosely rounded beneath, posterior angularly extended downward; ivory white, covered over with a brown horny epidermis, which is a little velvety between the ribs; radiately ribbed, ribs about six-and-thirty in number, rather narrow, rounded, smooth, anterior ribs slightly granulous; area of the ligament rather broad; umbones somewhat approximated. Length, 100; height, 80; diameter, 76 mm."

Holotype.—In BM(NH)?

Type locality.—Gulf of Tehuantepec, Central America. Holocene.

Supplementary description.—"This species varies greatly. There may be a sharp posterior ventral angle, or it may be nearly square, the chevrons for attachment of the ligament may be few or many, although they are commonly few. The specimens may attain a height of more than 85 mm." (Durham, 1950, p. 54)

Comparison.—"This has more ribs than *A. grandis* (31 to 36 rather than 25 to 27). The shell is thinner and more quadrate. Unlike *A. grandis*, it is a little inequivalve, the left valve overlapping the right, as in *Cunearca* and *Scapharca*." (Keen, 1971, p. 48)

Geographic range.—Living: Newport Bay, Calif., west coast of Baja California, Golfo de California, and south to Panama and the Galapagos Islands; fossil: Baja California Sur.

Geologic range.—Pliocene through Holocene.

Occurrence in Baja California Sur.—Pliocene: Carmen and Marquer Formations (Durham, 1950); Pleistocene: unnamed strata San Nicholas Island, Calif. (Vedder and Norris, 1963) and Bahía San Quintin, Baja California Norte (Jordan, 1926).

In regard to supposed Pliocene localities in the Puente Hills, Orange County, and the Third Street Tunnel, Los Angeles County, *L. camuloensis*, not *L. multicostata*, has been found. It therefore seems doubtful that *L. multicostata* occurs in the Pliocene. (Reinhart, 1943, p. 66)

Habitat.—In tropical waters in depths to 128 m; rarely, on sand bars at very low tide.

Genus SCAPHARCA Gray, 1847

Shell relatively thin, moderately convex; valves discordant, left

valve being larger, its margin overlapping that of right valve.

Geologic range.—Oligocene through Holocene (table 3).

Subgenus SCAPHARCA

Elongate, umbones flattened or slightly sulcate; sculpture similar on both valves, consisting of smooth or nodose, simple or bifurcating costae that are rectangular in cross section and separated by flattened interspaces; cardinal area narrow, elongate.

Genus SCAPHARCA?

Subgenus SCAPHARCA?

Scapharca? (Scapharca?) obispoana obispoana (Conrad)

Plate 9, figure 3

Arca obispoana Conrad, 1857c, p. 192, pl. 5, fig. 1. Grant and Gale, 1931, p. 955, pl. 32, fig. 49.

Anadara (Scapharca?) obispoana subsp. *obispoana* (Conrad). Reinhart, 1943, p. 70-72, pl. 10, figs. 6, 7, 11 [See for synonymy].

Anadara obispoana (Conrad). Addicott and others, 1978, p. 59, pl. 1, fig. 3.

Original description.—"Oblong, or trapezoidal; very inequilateral, ventricose; ribs about 26, little prominent, flattened; sides rectangular with the back; transversely rugose, or subcrenulated."

Lectotype.—USNM 13330 (Grant and Gale, 1931, p. 955; explanation of pl. 32, fig. 49).

Type locality.—A few kilometers southwest of San Luis Obispo, San Luis Obispo County, Calif. Santa Margarita(?) Formation, Miocene.

Supplementary description.—"Moderate in size, flat, *** quadrate in outline; hinge margin straight, slightly interrupted by umbones; ventral margin broadly rounded; anterior and posterior margins sharply rounded; umbones inconspicuous, located at anterior third. Ribs*** nearly flat, with a medial longitudinal groove faintly visible in each rib; ribs wider toward posterior than toward anterior part of shell; interspaces about as wide as ribs on anterior half of shell, but narrower in posterior half; concentric growth lines especially noticeable toward margins. Ligamental area apparently narrow; *** teeth *** strongly convergent." (Reinhart, 1943, p. 71)

Comparison.—"*A. obispoana s.s.* differs from *A.* (*A.*) *montereyana* by having fewer ribs and in being more compressed." (Reinhart, 1943, p. 72)

Geographic range.—Kamchatka(?); Washington(?) (Weaver, 1942); middle and southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Miocene: Monterey Formation (Arnold, 1908; Martin, 1912; Addicott and others, 1978), Oursan Sandstone (Hall, 1958), and Santa Margarita(?) Formations and upper part of Temblor Formation (Stewart, 1946; Adegoke, 1969).

Scapharca? (Scapharca?) obispoana perdisparis (Wiedey)

Plate 9, figure 6

Arca perdisparis Wiedey, 1928, p. 131-132, pl. 13, fig. 6; pl. 14, fig. 1.

Anadara (Scapharca?) obispoana subsp. *perdisparis* (Wiedey). Reinhart, 1943, p. 72-73, pl. 10, fig. 8.

Original description.—"Shell moderately small, elliptical in outline, with the posterior end broader than the corresponding anterior end. It is very inequilateral and only slightly convexly inflated. Anterior dorsal margin very short, passing in a gently rounded manner to the basal margin, which is very long and nearly straight, forming a low angle with the hinge line. Posterior dorsal extremity quite broadly rounded to the margin, which is but slightly rounded. Umbo narrow, distinctly elevated above the main body of the shell in a long, regularly rounded ridge. Beak small, sharp, but prominent, very near the anterior end of the shell and perceptibly prosogyrous. The shell is sculptured by about twenty-eight flattened ribs, of equal or of lesser width than the interspaces. The ribs apparently have little tendency to split. The hinge line is about two-thirds the length of the shell. Length, 36 mm.; breadth, 19 mm.; thickness of a single valve, 5 mm."

Holotype.—SDNM 23.

Type locality.—SD 443. Santa Cruz County, Calif. Monterey Formation, Miocene.

Comparison.—"This subspecies is similar to *Anadara obispoana obispoana* (Conrad), agreeing with it in the number of ribs *** dentition, and convexity. *A. obispoana perdisparis*, however, is more elongate than typical *A. obispoana*. No sharp line may be drawn between the subspecies and the typical species, both of which are variable in profile." (Reinhart, 1943, p. 73)

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Monterey Formation.

Subgenus CUNEARCA Dall, 1898

Subtrigonal, inflated, with full umbones and small, submedial beaks, high triangular cardinal area; sculpture of valves discrepant, costae of left valve larger and more coarsely nodose.

Geologic range.—Oligocene through Holocene (table 3).

Scapharca (Cunearca) vanderhoofi Durham

Plate 9, figure 7

Anadara (Cunearca) vanderhoofi Durham, 1950, p. 53, pl. 1, figs. 1, 2.

Anadara vanderhoofi Durham. Wilson, 1979, p. 25, fig.

Original description.—"Shell usually moderately thin, beaks rather high, of medium size, not too well preserved; dorsal margin straight, posterior margin slanting obliquely down and out, ventral margin evenly convex rounding into the decidedly convex anterior margin; right valve (holotype) with 28 medium-sized, square-sided ribs, interspaces of equal width; ribs apparently not noded; other right and left valves with about 24 ribs; all left valves with ribs wider than interspaces; ligamental area apparently with two broadly inverted V-shaped chevrons, widest anterior to beak but longest posterior; teeth eroded from all hinges available."

Holotype.—UCMP 30548.

Type locality.—UC A3595. Baja California Sur. San Gregorio Formation, Oligocene.

Geographic range..—Baja California Sur.

Geologic range..—Oligocene.

Occurrence in Baja California Sur.—San Gregorio Formation.

Scapharca (Cunearca) santaclarana (Loel and Corey)

Plate 9, figures 10, 11

Arca (Anadara) santaclarana Loel and Corey, 1932, p. 184, pl. 7, figs. 8, 9, 10a, 10b.

Anadara (Scapharca) santaclarana (Loel and Corey). Reinhart, 1943, p. 66-67, pl. 12, figs. 12-14.

Original description.—"Shell small, gibbose, fairly convex, subtrigonal and but slightly oblique, with prominent high umbones which are just posterior; beaks distant and only slightly prosogyrous; a strong angular posterior umbonal ridge extends to the posterior extremity; cardinal area wide, slightly concave, posterior margin straight to acute posterior extremity, ventral margin gently rounded to anterior, which is evenly curved to the hinge; surface sculptured by 18 flat ribs (prominently nodose as seen on other specimens) crossed by evenly spaced concentric lines. Height, 20 mm.; length, 22mm. On other specimens from same locality the hinge line is long, straight, with about 30 oblique teeth, the 3 extremities being almost horizonal. Diameter (both valves) 21 mm."

Holotype.—UCMP 31765.

Type locality.—UC A252. Ventura County, Calif. Vaqueros Formation, Oligocene and Miocene.

Comparison.—"This species resembles *Anadara* (*Cunearca*) *rivulata* (Wiedey) *** but differs in having broader umbones, wider ligamental area, and fewer ribs. *A. santaclarana* is a *Cunearca*, as shown by its short, high, inflated form. Better specimens than the ones available will probably show the species to be slightly inequivalve, as is typical *Cunearca*." (Reinhart, 1943, p. 67)

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Vaqueros Formation.

Scapharca (Cunearca) hamelini (Wiedey)

Plate 9, figure 12

Arca hamelini Wiedey, 1928, p. 126, pl. 13, fig. 2

Anadara (*Cunearca*) *hamelini* (Wiedey). Reinhart, 1943, p. 67-68, pl. 12, fig. 9.

Arca sespeensis Wiedey, 1928, p. 125, pl. 13, fig. 1.

Arca (*Anadara*) *sespeensis* Wiedey. Loel and Corey, 1932, p. 184, pl. 7, fig. 6.

Original description.—"Shell small, subtrapezoidal, distinctly inequilateral, equivalve, and convexly inflated. The anterior dorsal margin not long, moderately straight with the anterior extremity bluntly rounded. The basal margin is quite long and has a tendency toward parallelism with the hinge line. The posterior extremity more broadly rounded above than below. The posterior dorsal margin is short and nearly straight. The umbones are prominent, large, angular, and elevated, with the umbonal ridge quite well defined. Beak small, well anterior, prominent, sharply pointed, incurved, elevated, prosogyrous, and widely separated in combined valves. The sculpture consists of about sixteen ribs which are high, narrow, and rounded, separated by flattened channels which are distinctly much broader. Where the growth lines cross the ribs there is a tendency to form rugose sculpture, more markedly toward the extremity of the disk. The cardinal area is large, prominent, and moderately depressed. Length, 28 mm.; breadth, 20 mm.; height of one valve, 13 mm." (*hamelini*)

"Shell moderately small, trapezoidal, quite inequilateral and somewhat gibbose. Posterior dorsal margin short, dropping nearly straight down from under beak. It is quite sharply rounded at the extremity, and has a long, gently convex ventral margin. The posterior extremity is sharply rounded to the anterior dorsal margin which slopes approximately straight down from the beak. Umbo large, prominent, rather broad, and flattened. The beak is large, posterior, blunt, incurved, and pointed anteriorly. Cardinal area of moderate size, only gently depressed. Sculpture consisting of about nineteen ribs which are prominently elevated and sharply rounded. Concentric growth lines faint and indistinct. Length, 32 mm.; breadth, 25 mm.; height of one valve, 13 mm." (*sespeensis*)

Holotype.—*A. hamelini*, SDNM 18; *A. sespeensis*, SDNM 17.

Type locality.—SDNM 407. Ventura County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—A broad, rounded, inconspicuous ridge extends from umbo to posterior ventral margin. Ligamental area wide and flat. *Anadara sespeensis* is considered conspecific with *A. hamelini* because the holotypes of both species, collected from the same locality, are similar in size, number of ribs (17 ribs on the holotype of each), and shape, if one allows for distortion due to crushing, especially of the holotype of *A. sespeensis*. The beak of that specimen is crushed such as to appear opisthogyrate, this appearance is probably the reason for its being originally described as a right valve, although it is actually a left valve. Since *A. sespeensis* can hardly be considered recognizable, the name *A. hamelini* is used for this species. (Reinhart, 1943, p. 67)

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Vaqueros Formation.

Scapharca (Cunearca) rivulata (Wiedey)

Plate 9, figure 13

Arca rivulata Wiedey, 1928, p. 128, pl. 13, fig. 3.

Anadara (*Cunearca*) *rivulata* (Wiedey). Reinhart, 1943, p. 68-69, pl. 5, figs. 3, 5-8.

Arca galei Wiedey, 1928, p. 129-130, pl. 13, fig. 8.

Original description.—"Shell of small size, subquadrate in outline, quite inequilateral and rather convex. Anterior dorsal margin short, sloping quickly to the extremity, which is sharply rounded above, more so below. The basal margin gently convexly rounded to the posterior dorsal extremity which appears to be quite sharply rounded to its adjacent margin. The latter is moderately long and slopes down quite straight from the beak. Umbo prominent, elevated, and incurved. The beak is small, prominent, situated anteriorly, sharp, and distinctly prosogyrous. The sculpture consists of about twenty ribs which are rounded, prominently elevated, and separated by slightly narrower, flatly channeled interspaces. Ribs quite regularly rilled by concentric waves which do not sculpture the interspaces. Rilling is more marked toward the margins of the disk. The cardinal area is apparently small and only slightly depressed. Length, about 15 mm.; breadth, 13 mm.; height of a single valve, 7 mm." (*rivulata*)

"Shell of moderate size, subtrigonal in outline, distinctly inequilateral and quite convexly inflated. The anterior dorsal margin short and gently convexly curved to the anterior dorsal extremity, which is very sharply rounded to the basal margin. The latter is broadly convexly rounded. Posterior dorsal extremity angularly truncated to the posterior dorsal margin which is nearly straight and slopes abruptly. Umbo large, prominent, angular, elevated, and situated anteriorly. Beak slightly incurved, sharp, and prosogyrous. A distinct shoulder is formed at the posterior side of the umbo, extending from the beak to the posterior extremity, which causes the posterior dorsal area to be separated from the main body of the shell at nearly a right angle. The upper part of the posterior dorsal area appears distinctly folded under the beak. The sculpture consists of about twenty strong ribs, separated by narrower channeled interspaces. The ribs are rippled by concentric waves which are not apparent in the interspaces. Cardinal area inaccessible but apparently not large, sunken deeply below the beak. Length, 25 mm.; breadth, 18 mm.; thickness of a single valve, 9 mm." (*galei*)

Holotype.—*A. rivulata*: SDNM 20; *A. galei*: SDNM 21.

Type locality.—SU 432. San Luis Obispo County, Calif. Saltos Shale Member of the Monterey Shale, Miocene.

Supplementary description.—"Shell inequivalve, the right valve smaller than the left; sculpture of the two valves quite discrepant,

all of the ribs of the left valves nodulous, whereas, on right valve, only the anterior 10 are nodulous, the remaining ones being smooth; number of ribs on the two valves is the same—22. Ligamental area nearly flat, sculptured with two chevron-shaped grooves. Hinge straight, a little narrower at center than at extremities; about 36 small, closely spaced teeth interrupted by only a slight gap under the beak; these teeth are vertical at the center, but converge slightly at the extremities. Interior of the shell concealed by matrix, but enough of the inner margin is visible to show that it is strongly crenulated." (Reinhart, 1943, p. 69)

Comparison.—"This species resembles *Anadara* (*Cunearca*) *alcima* (Dall) *** from the Pliocene of Florida, but differs in having more prominent nodes and fewer ribs. *A. rivulata* is much closer to *Anadara* (*Cunearca*) *thalia* (Olsson)*** a Peruvian lower Miocene species***. Although the similarity between these two species is great, *A. thalia* differs in having two to three more ribs and in being slightly more elongate.

"This species also somewhat resembles *A. santaclarana* (Loel and Corey)*** but *A. rivulata* differs in having narrower umbones and ligamental area, and more ribs." (Reinhart, 1943, p. 69)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Upper part of Temblor Formation (Reinhart, 1943) and Saltos Shale Member of the Monterey Shale.

INDETERMINATE SPECIES

"Arca" clarki Dickerson

Arca clarki Dickerson, 1916, p. 481, pl. 37, fig. 12.

"Having exposed the hinge of the holotype, I find that this species does not belong to the Arcidae. The dentition consists of two heavy, ventrally-converging teeth on each side of the hinge plate; in the center of the hinge, directly beneath the beaks, is a deep central depression. The hinge, so far as can be seen, somewhat resembles that of *Limposis*, but externally this specimen resembles *Pteria* or *Pecten*."

Comments.—On the basis of the outline and poorly preserved hinge, I believe this species may be a young cardiid, and it will be illustrated in the chapter that includes that group.

"Anadara congesta (Conrad)"

Arca congesta Conrad, 1857a, p. 314

Anadara congesta (Conrad). Reinhart, 1943, p. 83.

"This name is evidently based upon an immature specimen; and since the type locality is unknown and the original figure and description are inadequate, this species must remain unrecognizable. As noted by Osmont, *Anadara congesta* might be the young of any one of half a dozen species. The holotype appears not to be in the U.S. National Museum***." (Reinhart, 1943, p. 83)

"Anadara (Anadara?) microdonta (Conrad)"

Arca microdonta Conrad, 1855, p. 13

Anadara (*Anadara?*) *microdonta* (Conrad). Reinhart, 1943, p. 46–47, pl. 6, figs. 9, 10.

"The type of *Arca microdonta* Conrad*** is a well-preserved right valve*** (***[USNM] 1844), said to be from the 'Tulare Valley(?)'***. California fossils have been identified as *Arca microdonta*, but no fossil or living species now known from California agrees with it, and whether it came from California is very doubtful. It shows no characters to differentiate it from 'non-winged' specimens of the Recent West Indian species identified by Dall as *Arca auriculata* Lamarck. Perhaps Blake collected it from Pleistocene deposits on the Atlantic coast of Panama near Colon (Aspinwall of Blake's time), where the species identified as *A. auriculata* is known to occur. Blake collected from the Miocene Gatun formation, but nothing is mentioned about other localities in Panama." (Woodring, 1938, p. 31)

Family PARALLELODONTIDAE

Subfamily GRAMMATODONTINAE

Genus PORTERIUS Clark, 1924

Ovoid, costellate, externally similar to *Barbatia* but with posterior lateral teeth and cardinals that converge ventrally.

Geographic range.—Western United States, Europe, and Japan.

Geologic range.—Eocene through Holocene. [Two species have been found in the Tertiary of the Western United States, one in the Eocene of southern California and one in the Oligocene of Washington and Oregon. The genus is not known to be living now off the coast of North or South America.]

Porterius woodfordi (Hanna)

Plate 10, figure 3, 4

Barbatia woodfordi M. A. Hanna, 1927, p. 273, pl. 27, figs. 1, 6, 8, 10.

Porterius woodfordi (Hanna). Reinhart, 1937a, p. 176–178. Vokes, 1939, p. 45, pl. 1, fig. 13.

Original description.—"Left valve; shell small, subrhomboidal, fairly thick, moderately inflated, inequilateral; beak fairly prominent, anterior to the center, projects a short way above the hinge margin; ventral margin regularly rounded; anterior regularly rounded; posterior rounded to obliquely truncated; hinge margin straight, about one-half the length of the shell; no umbonal ridge, surface slopes away regularly, being wider at the posterior; surface concentrically striated by fairly prominent growth lines; radially striated by fifty-five to sixty prominent rounded ribs which are separated by narrower interspaces; cardinal area short, narrow; hinge margin narrow, bearing at least four teeth anteriorly and six posteriorly, the portion directly below the beak broken away; teeth nearly parallel to the hinge line at either end; interior of the shell not seen. *Dimensions. Type*: Altitude 2.5 mm., length 3.5 mm. *Paratype* 31063: Altitude 9.0 mm., length 13.0 mm."

Holotype.—UCMP 31062.

Type locality.—UC 5062. San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—"Description of holotype (a young left valve): Shell minute, suboval *** moderately inflated, delicate. Umbo moderately prominent, located one-fourth of length of shell from anterior end; beak prosogyrate. In profile the anterior, ventral, and posterior margins are gently rounded; hinge margin nearly straight, except for interruption of umbo.

"Sculpture consists of about 58 radial ribs separated by narrower interspaces. Ribs simple throughout most of their length, but near ventral margin divided longitudinally by shallow grooves into two parts *** (In paratype no. 31063 *** a much larger specimen, this dichotomizing takes place at nearly the same distance from tip of umbo as in the small holotype; but in the larger specimen it is still high up in the umbo, so that throughout most of its length each rib is divided into two parts by a longitudinal groove. Toward the ventral margin each part resembles a separate rib. Hanna's figure does not show this detail.) Ribs are evenly spaced over most of shell, but the anterior and posterior ribs are larger and more widely

spaced. Regular concentric growth lines cut across the ribs.

"Ligamental area narrow, not well preserved, located posterior to umbo. Hinge exposed in holotype, but the remainder of interior of shell is unknown. Hinge gently arched, posterior part longer than anterior; wider at extremities than in mesial region *** three strong, regular, inclined anterior teeth, and five posterior teeth, the posteriormost three lying parallel to hinge." (Reinhart, 1937a, p. 177)

Comparison.—"this species resembles *Porterius gabbi* (Dickerson) in hinge structure; and inasmuch as these two species are also similar in shape and ornamentation (both species possess dichotomizing radial ribs), it seems evident that *P. woodfordi* likewise belongs to *Porterius*. The two species may be distinguished by the fact that the radial ribs are much coarser and more distinct on *P. gabbi* than on *P. woodfordi*." (Reinhart, 1937a, p. 178)

Geographic range.—Middle and southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Cerros Shale Member of the Lodo Formation (Keen and Bentson, 1944); Eocene: Ardath Shale, Domengine (Vokes, 1939) and Juncal (*Turritella uvasana infera* fauna, Givens, 1974) Formations.

Family CUCULLAEIDAE

Genus CUCULLAEA Lamarck, 1801

Subtrigonal, subtrapezoidal to ovoid, heavy shells, posterior margin obliquely truncated, surface radially sculptured with strong costae; middle series of teeth and crenulations of inner shell margin becoming obsolete in mature and old individuals; pseudolaterals diverging downward in adults.

Geographic range.—Living: Indo-Pacific; fossil: Europe and United States.

Geologic range.—Jurassic through Holocene.

Cucullaea mathewsonii Gabb

Plate 10, figures 1, 2

Cucullaea mathewsonii Gabb, 1864, p. 195, 235, pl. 31, fig. 266. Dickerson, 1914, p. 151, pl. 7, figs. 7a, 7b. Stewart, 1930, p. 77-78, pl. 8, fig. 8. Schenck and Keen, 1950, p. 27, pl. 19, fig. 4.

Arca biloba Weaver, 1905, p. 115, pl. 12, fig. 4 Not *Nucula biloba* Roemer, 1839.

"*Arca*" *biloba* Weaver. Reinhart, 1937a, p. 176, pl. 27, fig. 5.

Original description.—"Shell large, thin, gibbous, subquadrate, rounded in front and on the base, and truncated behind; beaks large, prominent, subcentral, incurved, and somewhat remote; area long, narrow; hinge-line nearly as long as the greatest length of the shell. Surface marked by a large number of small, regular ribs, rounded on the surface, sometimes grooved longitudinally and with acute interspaces; posterior to the umbonal angle these ribs are much smaller than on the rest of the surface; the whole surface is crossed by fine lines of growth. Inner margin of the valves crenulated; inner plate well marked, but not very elevated."

Lectotype.—ANSP 4559 (Stewart, 1930).

Type locality.—Martinez, Contra Costa County, Calif. Martinez Formation, Paleocene.

Supplementary description.—"basal margin of large specimens are truncated and marked by coarse lines of growth, probably due to age." (Waring, 1917, p.75)

Comments.—The preserved characters of the holotype bear resemblance to the Jurassic and Cretaceous subgenus *Idonearca*.

Geographic range.—Middle California to Baja California Sur.

Geologic range.—Paleocene and Eocene.

Occurrence in California and Baja California Sur.—Paleocene: Dip Creek Formation of Taliaferro (1944), Locatelli (Clark, 1968), and Martinez Formations; Paleocene and Eocene: Lodo (Smith, 1975) and Tepetate (Beal, 1948) Formations.

Cucullaea morani Waring

Plate 10, figures 5, 6

Cucullaea morani Waring, 1914, p. 784. Waring, 1917, p. 92, pl. 14, figs. 12-13.

Original description.—"Shell thick, oblique, very convex; beaks large, broad, prominent, and about one-third the distance from the anterior, incurved and somewhat remote; area oval in shape and about two-thirds the length of the shell. Altitude 36 mm.; longitude 60 mm. Anterior margin broadly rounded and more prominent above; base nearly straight; posterior produced and sharply rounded; umbonal ridge prominent and runs to posterior margin; cardinal margin sloping at an angle of about 45 degrees. Surface marked by alternating single and double radiating ribs which are crossed by fine to coarse lines of growth."

Holotype.—CAS/SU 166.

Type locality.—East of McCray wells 2.5 km. [Llajas Canyon, 6 km northeast of Santa Susana, Simi Valley, Camulos quadrangle], Ventura County, Calif. Llajas Formation, Eocene. (Keen and Bentson, 1944)

Geographic range.—Southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Meganos Formation (Clark, 1921); Eocene: Llajas Formation.

Family NOETIIDAE

Geologic range.—Cretaceous through Holocene.

Habitat.—Widespread in shallow seas.

Subfamily STRIARCINAE MacNeil, 1938

Geologic range.—Late Cretaceous through Holocene.

Genus ARCOPSIS Koenen, 1885

Barbatia-like costellate shells with ligament short, confined to shallow, triangular resilifer below beaks.

Geographic range.—Europe, North America, Indo-Pacific.

Habitat.—Attached to hard surface by byssus.

Subgenus ARCOPSIS

Surface costellate.

Geologic range.—Paleogene through Holocene.

Arcopsis (Arcopsis) eba (Hanna)

Plate 10, figures 17, 18

Arca eba M. A. Hanna, 1927, p. 271-272, pl. 26, figs. 7-13.

Arcopsis (Arcopsis) eba (Hanna). Reinhart, 1943, p. 37-38, pl. 11, figs. 15, 16.

Original description.—"Left valve. Shell small, rhomboidal, moderately heavy, fairly well inflated; ventral margin nearly straight to very broadly rounded; anterior moderately sharply rounded; posterior straight, obliquely truncated; dorsal margin straight; beak prominent, anterior to the center, incurved; posterior surface steeply inclined from an umbonal ridge which extends from the

beak to the posterior ventral point; surface concentrically banded by prominent flat placoid ridges of equal width; radial sculpturing consists of numerous rows of prominent rounded nodes which are steeply inclined on their upper surface and nearly normal to the shell on the side toward the margin; usually rows of larger and smaller nodes alternate; only one node of each radial row to each concentric ridge; nodes break off rather easily so the surface may appear to have been smooth; posterior slope noded in accordance with the general surface; inner margin smooth, bordered inside by a groove; cardinal area rather wide, nearly smooth; hinge margin narrow, bent downward at either end, bears about twenty prominent elongate teeth which are much inclined toward the hinge line at either end but not parallel with it. *Dimensions:* Altitude 3.25 mm., length 7.25 mm."

Holotype.—UCMP 31047.

Type locality.—UC 3990. San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—"In profile, anterior margin of shell rounded; ventral margin nearly straight; posterior margin sharply truncated, meeting dorsal margin at an angle of 45°, in holotype***numerous concentric growth lines, about 1/3 mm. apart, cover surface; these are crossed by radial ribs, formed of nodes (one node between each two growth lines)***. Nodes are larger (and consequently the radial ribs are more prominent) on the umbonal ridge than elsewhere. Spacing of ribs not uniform, but in most cases they are separated by interspaces wider than the ribs. About a quarter of the distance upward from the ventral margin, in the holotype, is a prominent growth line***; a similarly strong growth line, slightly higher up, is present on paratype***. Cardinal area long, narrow,***flat; two longitudinal grooves may be seen on***paratype***which join prominent growth lines at the extremities of cardinal area. Ligament apparently occupied only a small space between beaks, indicated by a shallow, transverse groove. Hinge slightly arched, thin in medial region; dentition observed in only two specimens, both imperfectly preserved***.

"On the holotype, the five posterior teeth and two anteriormost teeth converge ventrically; the intervening teeth are poorly preserved; an edentulous area is present beneath beak. Muscle scars not observed. Inner margin of shell smooth; pallial line simple, impressed. Inner surface of shell lacks radial striations." (Reinhart, 1943, p. 37-38)

Comparison.—"*Arca eba****may be separated from *Arca hornii* Gabb by shape, and in having a longer hinge line as well as a greater ratio of length to altitude. The sculpturing of the two is entirely different. *Arca hornii* is the only species with which *Arca eba* might be confused." (Hanna, 1927, p. 272)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Ardath Shale.

Subfamily TRINACRIINAE

Geographic range.—Europe, North America.

Geologic range.—Cretaceous to Eocene.

Genus PACHECOA Harris, 1919

(=HALOANUS Stewart, 1930)

Cardinal area small, situated entirely behind beaks; differs from *Noetia* in that sculpture consists of a few bifurcating costae, inner margin crenulate.

Geographic range.—North America.

Geologic range.—Eocene.

Subgenus PACHECOA

Elongate ovoid, cardinal area well defined.

Geographic range.—Southeast United States and California.

Geologic range.—Eocene.

Pachecoa (Pachecoa) hornii elusa (Clark and Woodford)

Plate 10, figure 8

Arca hornii elusa Clark and Woodford, 1927, p. 87, pl. 14, fig. 6

Trigonodesma hornii (Gabb) *elusa* (Clark and Woodford). Vokes, 1939, p. 49, pl. 1, fig. 22.

Original description.—"Shell small, gibbous, subequilateral; beaks central and very prominent; area short and narrow mostly anterior to the beaks. Anterior dorsal margin short and straight; posterior dorsal margin sharply curved down; anterior end broadly rounded; posterior end truncated, making a sharp angle with the ventral margin which is straight posteriorly and broadly rounded anteriorly. A large posterior escutcheon-like depression separated from the main surface of the shell by a distinct ridge, this depressed area pouting at the junction of the two valves. Surface ornamented by numerous radial ribs, with broader flat interspaces. Surface also covered by fine rounded incremental lines which give it a reticulated appearance. On the unweathered specimens, the rounded incremental lines are more prominent than the radial ribbing. The type***is a complete though immature specimen. *Dimensions*: Length 2.8 mm., height 2.3 mm., thickness of both valves 17 mm."

Type material.—The holotype, UCMP 31428, is missing and presumed lost. A hypotype, UCMP 15594 (Vokes, 1939, pl. 1, fig. 22) is figured herein.

Type locality.—UC 3579. Contra Costa County, Calif. Meganos Formation, Paleocene.

Comparison.—This form differs from the typical *Pachecoa hornii* (Gabb) in that the hinge line is shorter and the cardinal area is not so well developed. These differences seem to be constant on all the specimens at hand. (Clark and Woodford, 1927)

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Paleocene: Cerros Shale Member of the Lodo (Keen and Bentson, 1944) and Meganos Formations.

Pachecoa (Pachecoa) hornii (Gabb)

Plate 10, figure 7

Arca hornii Gabb, 1864, p. 194, pl. 30, fig. 263.

Holonanus hornii (Gabb). Stewart, 1930, p. 79-80, pl. 10, fig. 6.

Trigonodesma hornii (Gabb). Vokes, 1939, p. 49, pl. 1, figs. 24, 27.

Pachecoa (Pachecoa) hornii (Gabb) s.s. Givens, 1974, p. 41.

Original description.—"Shell minute, subequilateral; beaks subcentral, approximated; anterior end broadly rounded; basal most prominent below, or a little in advance of the beaks, nearly straight posteriorly, and inclined upwards towards the posterior, which is obliquely truncated; posterior side abruptly truncated behind the umbonal angle; area short and very narrow. Surface marked by very fine, radiating striae, somewhat undulated laterally and crossed by still finer lines of growth, with an occasional coarser line formed by a slight interruption in the growth."

Holotype.—ANSP 4460. [Holotype figured by Stewart, 1930, pl. 10, fig 6, is missing.]

Type locality.—Fort Tejon [NW ½ sec. 29, T. 10 N., R. 19 W., San Bernardino Base and Meridan, Kern County.] Calif. Tejon Formation, Eocene (Keen and Bentson, 1944).

Supplementary description.—The radiating lines on the holotype were about six per millimeter on the central region of the shell. The cardinal area is short and narrow, and the ligamental groove is apparently anterior to the umbo. Just enough of the hinge is exposed to show the taxodont character of the teeth. (Stewart, 1930, p. 79-80)

"The relative prominence of the radial and concentric striations on the surface of the shell varies somewhat in different specimens. Generally, but not always, the radial striations are slightly more prominent than the concentric ones on the right valve, and slightly less so on the left. On some specimens the concentric and radial sculpture seem about equal. The hinge is slightly arched, with small, convergent teeth. The ligamental area is transversely striated, and inclined, located anterior to the beak; the small posterior part of the cardinal area smooth, devoid of ligamental striations. The umbones are prominent, the beaks very slightly opisthogyrate." (Reinhart, 1943, p. 80-81)

Comparison.—The ventral margin of *Pachecoa hornii elusus* curves upward posteriorly instead of extending almost straight as in *P. hornii.* (Reinhart, 1943, p. 81)

Geographic range.—Middle and southern California.

Geologic range.—Eocene.

Occurrence in California.—Domengine, Juncal, and Matilija Formations (in *Ectinochilus supraplicatus* and *E. canalifer* faunas, Givens, 1974), La Jolla Group (Reinhart, 1943), Muir Sandstone of Weaver (1953), and Tejon Formation.

Family LIMOPSIDAE

Geologic range.—Triassic through Holocene.

Genus LIMOPSIS Sassi, 1827

Orbicular, nearly equilateral, commonly with slight forward obliquity.

Geologic range.—Jurassic through Holocene.

Subgenus LIMOPSIS

Surface without radial ornamentation; inner margins not crenulate.

Habitat.—Mostly cold water forms found in deep water, 35 to 7,350 m.

Limopsis (Limopsis) marysvillensis (Dickerson)

Plate 10, figures 9, 10

Glycimeris marysvillensis Dickerson, 1913, p. 290, pl. 14, figs. 1a, 1b; 1916, pl. 40, figs. 9a, 9b.

Limopsis (Limopsis) marysvillensis (Dickerson). Givens, 1974, p. 41, pl. 1, fig. 7.

Original description.—"Shell, small, subglobose, almost equilateral; beak small, incurved and central. Cardinal margin, straight; the anterior and posterior margins, regularly rounded. Surface marked by prominent concentric ribs. Hinge marked by eleven teeth. Area trigonal, small."

Holotype.—UCMP 11766.

Type locality.—UC 1853. Sutter County, Calif. Marysville Claystone Member of the Meganos Formation, Paleocene.

Geographic range.—Northern to southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Marysville Claystone Member of the Meganos Formation; Eocene: Capay (Merriam and Turner, 1937) and Juncal (in *Turritella uvasana infera* fauna, Givens, 1974) Formations.

Family GLYCYMERIDIDAE

Geologic range.—Cretaceous through Holocene (greatest development in Miocene.)

Habitat.—In tropical to temperate marine water from 0 to 640 m (one species collected at 1,846 m), usually at depths less than 110 m; probably restricted to coarse permeable substrata; strong tendency to lie on one side.

Subfamily GLYCYMERIDINAE

Geologic range.—Cretaceous through Holocene.

Genus GLYCYMERIS Da Costa, 1778

Subcircular to subquadrate, beaks orthogyre to opisthogyre, surface smooth or costate; ventral margins internally fluted.

Geologic range.—Early Cretaceous through Holocene.

Subgenus GLYCYMERIS

Subcircular, subequilateral, with small umbones and beaks; teeth relatively short, transverse, becoming obsolescent medially; surface smooth or costate.

Geologic range.—Early Tertiary though Holocene (table 4).

Glycymeris (Glycymeris) rosecanyonensis M. A. Hanna

Plate 10, figures 12, 13

Glycymeris rosecanyonensis M. A. Hanna, 1927, p. 273-274, pl. 27, figs. 4, 5, 9, 11. Givens, 1974, p. 42.

Original description.—"Shell small; general outline as figured; beak prominent, central; shell considerably inflated; outer surface ornamented by about forty rounded radial ribs which are approximately uniform in size except at the posterior and anterior extremities, separated by narrower rounded interspaces; outer surface also bears many concentric growth lines which are more prominent in the interspaces, giving the interspaces a pitted appearance; hinge line curving; cardinal area small, elongate trigonal; teeth separated from the cardinal area by a change in the surface; teeth arranged along the arc of a circle of smaller diameter than the diameter of the shell; teeth fourteen in number, seven to either side of a median line, nearly of uniform size, elongate, parallel sided, prominent, separated by sockets of equal width; long axes of the teeth not parallel to the radii of the circle of which they form an arc but to a point considerably above; ventral three-fourths of the inner margin prominently denticulate with some thirty teeth, denticulations do not correspond to the ribs of the outer surface, muscle scars large, pallial line distinct. *Dimensions. Type:* Altitude 5.75 mm., length 6.25 mm., diameter 2.75 mm. *Paratype:* Altitude 5.25 mm., length 5.5 mm., diameter 2.65 mm."

Holotype.—UCMP 30989.

Type locality.—UC 3990. San Diego County, Calif. Ardath Shale, Eocene.

Comparison.—"*Glycymeris rosecanyonensis****differs from *G. sagitatta* [sic; *sagittata*] ***which it most closely resembles, in size and shape. *G. sagitatta* flares out in front like two wings while *G. rosecanyonensis* slopes up forming an angle of slightly more than ninety degrees, and with only very narrow wings. Also the number of teeth is different. There are seven to nine teeth to the side of the median line in the new species while in Gabb's species there are fourteen. The row of teeth form an arc in the new species and not a

TABLE 4.—*Geologic and geographic distribution of the family Glycymerididae*
[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	Alaska	British Columbia	Washington	Oregon	California			Baja California		Central and/or South America
					Northern	Middle	Southern	Norte	Sur	
Genus *Glycymeris*:										
Subgenus *Glycymeris*:										
branneri Arnold						O and M	M			
buwaldi Clark						M?				
eocenica (Weaver)	M	M	E	E		E	E			
gabbi Dall	M		M	M		Pl				
gigantea (Reeve)							M or Pl		Pl to H	H
maculata (Broderip)							M or Pl	H	Pl to H	H
rosecanyonensis Hanna							E			
subobsoleta (Carpenter)	H	H	H	H	Pl to H	H	Ple and H	Ple		
viticola Anderson and Hanna							E			
Subgenus *Glycymeris*?										
swartsi Hertlein and Jordan									M?	
whaleyi Nicol							M			
Subgenus *Glycymerita*:										
major (Stanton)					Pa	Pa and E	Pa			
major meganosensis Clark and Woodford						Pa				
sagittata (Gabb)			E	E		E and O?	E			
Subgenus *Glycymerita*?:										
reefensis Vokes						E				
tecolotensis Hanna							E			
Subgenus *Tucetona*:										
evermanni Anderson and Hanna							E			
fresnoensis Dickerson			E	E		Pa and E				
multicostata (Sowerby)								Ple	Pl	H
perrini Dickerson				E		Pa and E	Pa and E			
ruckmani Dickerson							E			
teniumbricata Clark						M	M			
verticordia Anderson and Hanna							E			
Subgenus *Tucetona*?:										
maccrayi Waring							E			
septentrionalis (Middendorf)	H					M	Pl and Ple			
Subgenus *Axinola*:										
grewingki Dall	M? and Pl[1]			M and Pl		M and Pl	M to Ple			
profunda (Dall)						M	M to H			
Genus *Felicia*:										
phrear (Woodring)							Pl and Ple			

[1]Scott McCoy, written commun., 1978.

line bent down at either end. The radial ribs are crossed by narrow prominent growth lines. The radial ribs of *G. sagitatta* are flat and separated by narrow interspaces, while in *G. rosecanyonensis* they are rounded and separated by interspaces of nearly equal width.

"*Glycymeris rosecanyonensis****differs from *G. viticola****in the presence of the narrow wings, narrower but more prominent radial ribs, in the arrangement of the teeth, and in the much smaller size. The new species differs from *G. verticordia****in the less prominent and more uniform sculpturing. If differs from *G. evermanni****in the larger size, shape (presence of the narrow wings), and fine growth lines rather than flat-topped growth lines. If differs from *G. perrini****in that the radial sculpturing consists of only regular equal-sized ribs. It differs from *G. fresnoensis****in the much finer radial ribs. It differs from *G. hannibali****in the smaller apical angle as well as in sculpturing. It differs from *G. marysvillensis* in the presence of the prominent radial sculpturing. It differs from *G. ruckmani****in shape as well as sculpturing." (Hanna, 1927, p. 724)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Ardath Shale and Juncal Formation (in *Turritella uvasana applinae* and *Ectinochilus supraplicatus* faunas, Givens, 1974, p. 42).

Glycymeris (Glycymeris) viticola Anderson and Hanna

Plate 10, figures 14, 15

Glycymeris viticola Anderson and Hanna, 1925, p. 182-183, pl. 1, fig. 5; pl. 3, fig. 1.

Glycymeris (*Glycymeris*) *viticola* Anderson and Hanna. Givens, 1974, p. 42, pl. 1, fig. 6.

Original description.—"Shell small, equilateral, not inflated, with umbones rather low; apical angle about 95°; surface sculptured with 35 radial ribs, flattened on top, with interspaces crossed by fine lines of growth and by concentric grooves showing rest periods; hinge with seven anterior and seven posterior lateral teeth, and with four less distinct teeth in the median area; ligamental area marked by six inverted V-shaped ridges; basal margin bearing crenulations corresponding to the intercostal grooves; length of shell, 21.5 mm.; altitude, 21.5 mm."

Holotype.—CAS 777.

Type locality.—CAS 245. Kern County, Calif. Tejon Formation, Eocene.

Supplementary description.—"Several specimens are contained in the collections of the Academy of Sciences. They show that in its younger stages, the apical angle is greater than 95°, and that the ribs in unworn specimens are noded, due to the crossing of regularly spaced concentric grooves." (Anderson and Hanna, 1925, p. 183)

Comparison.—"In the details of its ornamentation this species does not closely resemble any other western form" (Anderson and Hanna, 1925, p. 183). [See *G. rosecanyonensis.*]

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Matilija Sandstone (*Ectinochilus canalifer* fauna, Givens, 1974, p. 42) and type Tejon Formation.

Glycymeris (Glycymeris) eocenica (Weaver)

Plate 12, figure 23

Pectunculus eocenica Weaver, 1912, p. 28, pl. 5, figs. 52, 53.

Glycymeris eocenica (Weaver). Clark, 1938, p. 693, pl. 1, figs. 1, 6, 10, 13, 18. Weaver, 1942, p. 56-57, pl. 10, figs. 2, 3, 8.

Original description.—"Shell subcircular, thin, equivalve, and nearly equilateral; base regularly convex; sides sloping down directly from the beak, the anterior side much more steeply rounded than the posterior, the latter being regularly convex; junction of the posterior end and the base very slightly truncated. Surface marked by forty broad nearly flat-topped radiating ribs with very narrow interspaces, between which are raised threads; four or five very prominent lines of interrupted growth are present with fainter intervening concentric lines. Hinge robust with radiating teeth; pallial line very distinct, inner margin coarsely crenulated. Dimensions.—Alt 23 mm.; long 25.; thickness 7 mm."

Holotype.—CAS 476. [The holotype is missing. The specimen figured, pl. 12, fig. 23, is the paratype according to Weaver (1942, pl. 10, fig. 2).]

Type locality.—UW 345. Cowlitz County, Wash. Cowlitz Formation, Eocene.

Geographic range.—Washington to southern California.

Geologic range.—Eocene.

Occurrence in California.—Markley (Clark, 1938) and type Tejon (Dickerson, 1914) Formations.

Glycymeris (Glycymeris) branneri Arnold

Plate 10, figures 11, 16

Glycymeris branneri Arnold, 1908, p. 377-378, pl. 34, fig. 1. Loel and Corey, 1932, p. 182, pl. 7, figs. 5a, 5b. Nicol, 1947, p. 346-347, pl. 50, figs. 12-15.

Original description.—"Shell averaging nearly 70 mm. in length, about as wide as long, suborbicular, equivalve, bilaterally unsymmetrical, considerably convex for one of this genus, thick and heavy; umbo somewhat anterior to center, protruding beyond hinge line and turned slightly toward the front; anterior dorsal margin straight, sloping steeply from umbo; anterior extremity quite sharply rounded, and located above center line of shell; posterior dorsal margin straight, sloping less steeply than anterior; posterior extremity protruding obliquely downward and backward, regularly rounded, located below center line of shell; posterior dorsal and ventral margins join in a faintly defined angle considerably above and in front of the extreme end of the shell. Surface sculptured by numerous flat to concave-topped, close-set, radiating ribs (about 55 discernible in the type), relatively much broader toward the middle of the shell and becoming narrower and less well defined toward either end; in the later stages of growth a raised beaded intercalary line occupies the interspace and (in the type) rises above the level of the ribs; prominent incremental lamallae cross the ribs, bowing convexly upward toward the umbo; they are straight on the sides and across the top of the ribs, and become less prominent and more closely set toward the periphery in the adult shell. Hinge with 5 or 6 boomerang-shaped teeth, with angle toward the umbo, on either side of a centrally divaricately striated broad ligamental area; the teeth in the young form a semicircle below and extending on either side beyond the ligamental area, but in the later stages of growth the centrally situated teeth are obliterated by encroachment of the ligament. Interior unknown, but interior of margins appear to be smooth."

Holotype.—USNM 165455.

Type locality.—Mindego Creek, 1.5 km above confluence with Alpine Creek, [sec. 24, T. 7 S., R. 4 W.] Santa Cruz quadrangle, San Mateo County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"Arnold's specimen was eroded so that he did not have a correct impression of some of the features of the shell, especially the ornamentation. The radial ribs are flat and are separated by lines or grooves. Secondary superimposed radial ribs do occur but are weakly developed and are only seen in certain areas of the shell. On some specimens***the shell is so eroded that the primary radial ribs are faintly marked, but the superimposed secondary radials are much more prominent. No concentric ornamentation is present.

"The interior ventral border is crenulated. The crenulations are long and slender with pointed ends and sunken centers.

"Contrary to Arnold's observation, the specimens seen by the writer usually have orthogyrate beaks; occasionally the beaks are slightly opisthogyrate.

"The ligamental area is large, and on well-preserved specimens the ligamental chevrons number from 6 to 9, are large, and are strongly marked." (Nicol, 1947, p. 347)

Comparison.—"This magnificent species is apparently one of the largest of the west coast forms, equaling in size but not in convexity the Cretaceous *Glycymeris veatchii* Gabb and its Eocene variety *G. veatchii major* Stanton. It also lacks the prominent groove which separates the dorsal posterior angle from the rest of the shell in the earlier forms. It is distinguishable from *Glycymeris gabbi* Dall from Coos Bay, Oregon, the next largest Miocene species, by its unsymmetrical outline, its much greater size, relatively greater convexity, closer set ribs, and peculiar wavy incremental sculpture." (Arnold, 1908, p. 378)

"The only closely related fossil species is Glycymeris swartsi Hertlein and Jordon [sic; Jordan] from lower Miocene beds of Lower California. *G. branneri* is a larger species, the crenulations on the inner ventral border are larger and have sunken centers, and the hinge teeth are larger and fewer in number than in *G. swartsi.*

"*Glycymeris gigantea* (Reeve)***is a close analogue to *G. branneri*, but the former is larger and has more prominent superimposed secondary ribs. The two species resemble each other in shell outline, ligamental area, and crenulations on the inner ventral border." (Nicol, 1947, p. 347)

Geographic range.—Middle and southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene. Vaqueros Formation (*Turritella inezana* zone); Miocene: Olcese Sand (Addicott, 1956) and Tierra Redonda Formation (Durham, 1970).

Glycymeris (Glycymeris) buwaldi Clark

Plate 12, figures 13, 14

Glycymeris buwaldi Clark, 1918, p. 129, pl. 7, figs. 10, 11.

Original description.—"Shell small, subcircular in outline; anterior dorsal slope gently convex; posterior dorsal slope short; posterior end subtruncated. Surface covered by fairly coarse, irregular incremental lines; also sculptured by numerous obscure radiating ribs, with interspaces which possibly average somewhat less than the width of the ribs; extending from the beak to the lower angle of the subtruncated end is an indistinct ridge, the narrow margin posterior to which is rather strongly depressed. Hinge plate heavy; cardinal area very narrow; posterior to the beak there are eight, and anterior to it, seven cardinals. A large part of the hinge plate is not covered by the cardinals both below and on the sides; ventral margin denticulate."

Holotype.—UCMP 11150.

Type locality.—UC 1131. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparison.—*Glycymeris buwaldi* is very similar in outline and sculpturing to *G. intermedia* Broderip, a Recent West Coast species, in fact so much so that the writer would have hesitated to separate the two had it not been that a good hinge plate was

obtained on the former, which is quite different from that of the latter. It is heavier; there is a less number of cardinals; there is a narrow interspace below the beak between the anterior and posterior cardinals, which is not present on *G. intermedia*; also the cardinal area on *G. buwaldi* is much smaller." (Clark, 1918, p. 130)

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—San Ramon Sandstone (Weaver, 1953).

Glycymeris (Glycymeris) gabbi Dall

Plate 13, figures 3, 4

Glycymeris gabbi Dall, 1909, p. 108, pl. 11, fig. 5. Weaver, 1942, p. 62, pl. 10, fig. 18.

Original description.—"Shell large, rather thin, compressed, suborbicular, nearly equilateral; beaks defective, probably rather elevated, separated by a narrower ligamental area with about half a dozen angular sulci divaricating from the vertical of the umbones; dorsal slopes straight, nearly smooth, the posterior slope somewhat flattened; disk uniformly sculptured with about 34 narrow, flat radial ribs, separated by somewhat narrower channeled interspaces, the interspaces wider and the ribs narrower toward the ends of the shell; concentric sculpture of narrow, flat ridges, narrower and closer together toward the basal margin, but on the central part of the disk forming with the radial ribs nearly square reticulations; interior, as in other cases, filled with a refractory matrix. Altitude of shell, 51 mm.; latitude, 53 mm.; diameter, about 20 mm."

Holotype.—USNM 153949b.

Type locality.—Coos Bay, Coos County, Oreg. Empire Formation, Miocene.

Comparison.—"It is possible***that this species may be synonymous with *G. grewingki* Dall. The differences in radiating and concentric sculpture are in part the result of weathering***. There seem to be differences in the number of radiating ribs and in their cross-sections as well as in the interspaces***. *G. gabbi* is more equilateral than *G. grewingki*." (Weaver, 1942, p. 62)

Geographic range.—Southern Oregon to middle California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Pliocene. Lower part of Merced Formation (Weaver, 1949).

Glycymeris (Glycymeris) gigantea (Reeve)

Plate 11, figures 1, 3

Pectunculus gigantea Reeve, 1843, pl. 1, figs. 3a, 3b.

Glycymeris gigantea (Reeve). Durham, 1950, p. 56, pl. 2, figs. 1, 8.

Glycymeris (Glycymeris) gigantea (Reeve). Olsson, 1961, p. 106. pl. 11, fig. 1.

Original description.—[Figured only.]

Holotype.—BM(NH) (A. M. Keen, oral commun., 1978).

Type locality.—Guaymas, West Mexico (Olsson, 1961, p. 106).

Supplementary description.—"One of the largest forms in the whole family. A large specimen may attain a height of 100 mm. The nearly smooth surface shows radial striae and the white ground color is mottled with reddish brown in zigzag patterns. There are about 30 hinge teeth." (Keen, 1971, p. 55)

Comparison.—The long oblique teeth of *G. gigantea* distinguish it from *G. maculata*, which has short, nearly vertical teeth. (Durham, 1950, p. 56)

Geographic range.—Living: Bahía de la Magdalena, Baja California Sur, to Acapulco, Mexico; fossil: southern California and both Pacific and Gulf sides of Baja California.

Geologic range.—Miocene through Holocene.

Occurrence in California and Baja California Sur.—Miocene or Pliocene: Imperial Formation (Hanna, 1926); Pliocene: Marquer (Durham, 1950) and San Marcos Formations (Durham, 1950); Pleistocene: unnamed strata of Laguna San Ignacio and Santa Rosalia, Baja California Sur (Minch and others, 1976).

Habitat.—Dredged in depths of 7 to 13 m.

Glycymeris (Glycymeris) maculata (Broderip)

Plate 11, figures 2, 4

Pectunculus maculatus Broderip, 1832, p. 126.

Glycymeris maculata (Broderip). Grant and Gale, 1931, p. 136. Keen, 1971, p. 55, fig. 112, Durham, 1950, p. 56, pl. 2, figs. 3, 5.

Glycymeris (Glycymeris) maculata (Broderip). Olsson, 1961, p. 106, pl. 11, figs. 2, 5.

Original description.—"Pect. testa orbiculata, subaurita, subaequilatera, convexa, albente castaneo-maculosa, striis radiantibus subdecussatis creberriensis; intus alba, marginibus crenatis; epidermide fusca villosa; long. 2 ⅝, alt. 2 ⅜, lat. 1 ⅝ poll."

Holotype.—BM(NH) (A. M. Keen, oral commun., 1978).

Type locality.—"Portu Portrero." [South America?; north of Zorritos, Peru.]

Supplementary description.—"This species attains a large size and has a strong, thick, very convex shell. The umbo protrudes prominently above the dorsal margin of the shell. The radial ribbing is reduced to very low relief or is obsolete, but the surface is finely and evenly radially striated. The hinge plate is heavy, with a curved series of stout chevron-shaped teeth which may be interrupted in the middle by the basal line of the ligamental area***. The variations in shape noticed in a series of specimens is partly due to the influence of a rocky habitat." (Grant and Gale, 1931, p. 136)

"The shell is often large (length 80 mm.), convex, heavy, nearly circular, the posterior side with a low, obscure angulation. Surface smoothish but when fresh showing a submicroscopic sculpture of low, rounded riblets on the umbones crossed by small, equidistant concentrics becoming gradually replaced ventrally by fine, raised radial threadlets which are evenly distributed and not bunched together in riblike groups. Hinge plate solid, the teeth relatively few, the laterals large, the middle series continuous or broken." (Olsson, 1961)

Geographic range.—Living: Northern Gulf of California and Bahía de la Magdalena, Baja California Sur, to Zorritos, Peru; fossil: southern California to Baja California Sur.

Geologic range.—Miocene through Holocene.

Occurrence in California and Baja California Sur.—Miocene or Pliocene: Imperial Formation (Hanna, 1926); Pliocene: Marquer Formation (Durham, 1950); Pleistocene: unnamed strata Gulf of California and Laguna San Ignacio, Baja California Sur (Minch and others, 1976).

Habitat.—The holotype was found in fine gravel at a depth of 20 m.

Glycymeris (Glycymeris) subobsoleta (Carpenter)

Plate 12, figures 15, 16

Axinea (? *septentrionalis*, Midd. var.) *subobsoleta* Carpenter, 1864b, p. 644.

Glycymeris subobsoleta (Carpenter). Palmer, 1958, p. 63-64, pl. 1, figs. 8-10 [See for synonymy].

Original description.—"Shell similar to *G. septentrionalis,* slightly inequilateral, not tumid, umbones obtuse, broad, quite prominent; ash-colored, variegated with reddish chestnut; epidermis thick, somewhat laminated; ventral and posterior margins quite rounded, anterior margin produced, dorsal straight, sculptured by subobsolete radiating grooves, often disappearing dorsally; ventral margin strongly, and anterior and posterior internal margns slightly crenulated; cardinal plate subangular, with a few strong, compressed teeth; adductor scar chestnut colored; ligament furrowed." (Translation from Packard, 1918, p. 250)

Syntypes.—USNM 15594 (two; both figured).

Type locality.—Neah Bay, Wash. Holocene.

Supplementary description.—Ligament area short. Radial ribs flat with narrow interspaces. The flattest and most thin-shelled *Glycymeris* of the Pacific coast. (Abbott, 1974, p. 427)

Geographic range.—Living: Aleutian Islands, Alaska, to southern California [not living south of California, Keen, 1978, oral commun.]; fossil: California to Baja California Norte.

Geologic range.—Pliocene through Holocene.

Occurrence in California and Baja California.—Pliocene and Pleistocene: Wildcat Group (Ogle, 1953); Pleistocene: unnamed strata on San Nicolas Island (Vedder and Norris, 1963) and in Baja California Norte (Valentine, 1957).

Habitat.—10 to 25 m off Pacific Groove, middle California, in coarse granitic sand.

Subgenus GLYCYMERIS?

Glycymeris (Glycymeris?) whaleyi Nicol

Plate 11, figures 5, 6

Glycymeris whaleyi Nicol, 1947, p. 347-349, pl. 50, figs. 7-11.

Original description.—"Shell of medium size and thickness, outline of valves subcircular, with posterior side slightly produced; ratio of convexity to height 0.70; beaks orthogyrate and median in position; ligamental area amphidetic, short and high, with 6 to 8 delicate, distinct, chevron-shaped grooves; hinge teeth about 20 in number, central teeth may be absent on large specimens; hinge plate strongly arched; denticulations on inner ventral border large, few in number with sunken centers and blunt ends."

"The radial ribbing of this species varies with the size of the shell. On small specimens, or on the umbonal region and at either end of the shell, the radial ribs are raised, with well-rounded crests, separated by narrower interspaces. Toward the ventral margin on larger specimens these ribs become much wider and flatter and are secondarily grooved so that each rib may be divided into three parts. The interspaces remain linear. The number of radial ribs varies from 18 to 25, not including the secondary splitting of the ribs. No concentric ornamentation is present."

Holotype.—CAS 8584.

Type locality.—N. 71° W. 1.8 km from intersection of 119°45′ meridan and 35°00′ parallel as shown on U.S. War Department map of Caliente Mountain quadrangle [Caliente Mountain quadrangle, 1959], Caliente Mountain Range, San Luis Obispo County, Calif. Saltos Shale Member of the Monterey Shale, Miocene.

Comparison.—"The nearest related fossil species are all found in rocks of Miocene age in Columbia [Sic; Colombia] and Venezuela. *Glycymeris whaleyi* resembles *G. lloydsmithi* Pilsbry and Brown from the Miocene of Columbia but differs from the latter by having the chevron-shaped ligamental grooves present and by having flatter and more distinctly split radial ribs. *G. democraciana* F. and H. Hodson from the Miocene of Venezuela differs from the California species by having a higher arched hinge plate and by being more produced posteriorly. *G. whaleyi* differs from *G. usiacurii* Anderson from the Miocene of Columbia in lacking secondary intercalated ribs in the interspaces. The remainder of the split-ribbed species described from rocks of Miocene age in the Caribbean region generally have stronger ribs than *G. whaleyi.*

"The closest related living analogue to *Glycymeris whaleyi* is *G. bicolor* (Reeve) from the Gulf of California. *G. bicolor* has more numerous, narrower, and more prominent ribs; also more numerous and smaller denticulations on the inner ventral border of the shell." (Nicol, 1947, p. 348)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Saltos Shale Member of the Monterey Shale.

Glycymeris (Glycymeris?) swartsi Herltein and Jordan

Plate 11, figures 7, 8

Glycymeris swartsi Hertlein and Jordan, 1927, p. 620, pl. 17, figs. 1, 2.

Original description.—"Shell fairly large, obliquely ovate, rather strongly inflated; umbos high, subcentral, sculpture consisting of fine concentric lines of growth, and faint radial lines noticed on only a few unweathered parts of the shell and apparently developed mostly near base of shell; valves rounded in front, somewhat produced behind. Length approximately 40 mm.; height 38.2 mm.; width 29.8 mm."

Holotype.—CAS 5132.

Type locality.—SU 60. West side of Elephant Mesa, Laguna Scammon quadrangle, Baja California Sur. Isidro(?) Formation, Miocene.

Supplementary description.—"This species is unlike any other west coast *Glycymeris.* A row of taxodont teeth is present in one of the paratypes. The shape and sculpture of the valves and the circular row of teeth lead the authors to place this species under the genus *Glycymeris* although the shape is not similar to most other western North American species of that genus." (Hertlein and Jordan, 1927, p. 620)

Geographic range.—Baja California Sur.

Geologic range.—Miocene(?).

Occurrence in Baja California Sur.—Isidro(?)Formation.

Subgenus GLYCYMERITA Finlay and Marwick, 1937

Subquadrate, posterior subtruncate, with prominently projecting umbones, anterior and posterior teeth moderately elongate, curved or chevron-shaped with convexity directed toward beaks, medial teeth small, transverse, exterior costate.

Geographic range.—Europe, New Zealand, and California.

Geologic range.—Cretaceous to Oligocene(?) (table 4).

Glycymeris (Glycymerita) major meganosensis Clark and Woodford

Plate 11, figures 11, 12

Glycymeris major meganosensis Clark and Woodford, 1927, p. 86-87, pl. 14, figs. 4, 5.

Original description.—"Shell heavy, fairly large, ventricose, subcircular in outline; beaks prominent, strongly inturned; dorsal margins straight or nearly so, approximately at right angles to

vertical between the beaks and the ventral edge; posterior dorsal margin strongly depressed, or flexed. Main surface of shell sculptured by about 30 broad, flat-topped, low ribs with interspaces much narrower than the ribs. The ribbing becomes obsolete on a narrow, anterior dorsal margin, on the flexed posterior dorsal margin it is somewhat finer than on the main surface of the shell, becoming obsolete near the posterior dorsal edge. On the larger uneroded specimens the ribbing near the ventral edge tends to become obsolete and covered over by the heavy lines of growth. On adult specimens the ligamental area is wide and narrow, and there are about 20 taxodont teeth which extend continuously across the hinge plate and for about two-thirds the distance in the middle they are in a straight line curving gently downward on each end. *Dimensions.—Type:* Length 44 mm., height 43 mm., thickness of one valve 21 mm."

Holotype.—UCMP 31289.

Type locality.—UC 3152. Contra Costa County, Calif. Meganos Formation, Paleocene.

Comparison.—"The subspecies *meganosensis* differs from the typical form principally in the type of ribbing. On the majority of specimens of the latter the ribbing is more prominent and the interspaces are wider, and on the adult specimens the ribbing does not become obsolete as on *meganosensis.* Weathered specimens of the typical form are often hard to distinguish from the subspecies." (Clark and Woodford, 1927, p. 87)

Geographic distribution.—Middle California.

Geologic distribution.—Paleocene.

Occurrence in California.—Meganos Formation.

Glycymeris (Glycymerita) major (Stanton)

Plate 11, figures 9, 10

Pectunculus veatchi var. *major* Stanton, 1896, p. 1040, pl. 64, figs. 2, 3.

Glycymeris veatchii major (Stanton). Dickerson, 1914, p. 151, pl. 10, fig. 5.

Original description.—"Compared with the typical form of the species this variety is larger, less convex and proportionately longer; the ribs are broader than the interspaces and the posterior end is more sinuous. Length of a large specimen, 65 mm, height, 64 mm, convexity of one valve, about 22 mm."

Syntypes.—USNM 157830. [Not 157827 as cited by Keen and Bentson, 1944.]

Type locality.—One and one-half kilometers southeast of Lower Lake [NE ¼ sec. 11, T. 12 N., R. 7 W.] Lake County, Calif. Martinez Formation, Paleocene.

Comparison.—[See *G. major meganosensis.*]

Geographic range.—Northern to southern California.

Geologic range.—Paleocene to Eocene.

Occurrence in California.—Paleocene: Martinez and Silverado (Woodring and Popenoe, 1945) Formations; Paleocene and Eocene: Lodo Formation (Smith, 1975).

Glycymeris (Glycymerita) sagittata (Gabb)

Plate 12, figure 17

Axinaea (*Limopsis*?) *sagittata* Gabb, 1864, p. 197, 235, pl. 31, fig. 267, 267a.

Glycymeris sagittata (Gabb). Stewart, 1930, p. 71-73, pl. 12, fig. 10. Vokes, 1939, p. 45-46, pl. 1, figs. 18-20. Clark, 1938, p. 693. Stewart, 1946, table 1, pl. 12, fig. 3. Kleinpell and Weaver, 1963, p. 196-197, pl. 28, fig. 10; pl. 29, figs. 1, 2.

Glycymeris (*Glycymerita*) *sagittata* (Gabb). Givens, 1974, p. 42-43.

Glycimeris hannibali Dickerson, 1916, p. 483, pl. 36, figs. 8a, 8b.

Original description.—"Shell subcircular, thin, equivalve, very slightly inequilateral; base regularly convex, sides unequally so, the posterior being a little the most prominent. Surface marked by numerous faint, radiating lines, which, on weathered surfaces, develop into strongly impressed grooves; along these lines are small pits, from which proceed downwards fine, impressed diverging lines. Hinge composed of robust, radiating teeth. Inner margin finely crenulated." [*sagittata*]

"Shell of moderate size, inflated, with broadly rounded ventral margin and prominent beak. The anterior and posterior dorsal margins are practically straight and parallel to the axis of the shell. The anterior end is nearly straight except for a very slight central concavity at the end of a broad umbonal groove. The posterior end is broadly rounded with greatest arcuity near the dorsal margin. The decoration consists of about thirty flat radial ridges equal in width to their interspaces. The interspaces are decorated by arrow-like marks as in *G. sagittata* Gabb. Area long, narrow; interior of ventral margin dentate." [*hannibali*]

Lectotype.—ANSP 4422 (Stewart, 1930, p. 71).

Type locality.—Near Fort Tejon [N½ sec. 29. T. 10 N., R. 19 W., SB, Kern County], Calif. Tejon Formation, Eocene.

Supplementary description.—The hinge is exposed on one paratype, showing ten prominent widely spaced taxodont teeth anterior and eight posterior. The six central teeth are smaller and closer together and almost vertical, although the anterior three slope slightly posteriorly and the posterior three slope anteriorly. The coarse crenulations of the margin gradually disappear dorsally and are entirely absent at the extremities of the hinge. (Stewart, 1930, p. 71)

"The shell is smooth, radial ribbing on the surface being absent; upon weathering, the interspaces first appear as minute pitting, which rapidly deepens so that the radial ribs become prominent surface-features. The outline of the valves is variable; the most characteristic variations are figured.

"There seems to be a slight progressive loss of ribs during the evolution of this species. A count of several specimens from various Eocene horizons in California shows:

Horizon	*Average number of ribs*	*Minimum No.*	*Maximum No.*
Tejon	44	39	48
Domengine	48	43	52
Capay	49	46	52

(Vokes, 1939, p. 46)

"The hinge is almost, but not quite straight, with the line of the teeth bent downward at each end. There are 12 well-defined teeth on each side of the central area; in this they are small and indistinct. The ligamental area is long and narrow and contains about five wide-spreading, inverted V-shaped ridges. The outer surface is usually smooth to the unaided eye, but is marked on the umbones with about 35 narrow radiating grooves. These disappear above the margin of the shell in well grown specimens, while the flat ribs between the grooves, 12 in number, do not extend to the margin. The ribs are crossed by concentric lines of growth of equal size, which gives the surface a delicate cross-hatched appearance under the lens. The incised V-shaped lines shown in Gabb's figure appear on some specimens as pits caused by the wavy lines of growth around marginal crenulations." (Anderson and Hanna, 1925, p. 181-182)

"The specimens from the Santa Ynez Mountains have about 13 or 14 anterior and 12 posterior taxodont teeth. The disc is well preserved and has about 50-53 radiating ribs, considerably more than have been listed for this species; however, the types which the authors have been able to examine indicate that the previous literature cited may give too low an estimate because of poor

preservation of specimens. The posterior is sharply truncated and has a weak umbonal groove typical of this group of *Glycymeris* in its stratigraphically uppermost occurrences***." (Kleinpell and Weaver, 1963, p. 196-197)

Geographic range.—Washington to southern California.

Geologic range.—Eocene; Oligocene(?).

Occurrence in California.—Eocene: Avenal Sandstone (Stewart, 1946), Capay, Domengine (Vokes, 1939), and Llajas Formations, Markley Sandstone Member of the Kreyenhagen Formation (Clark, 1938), Muir Sandstone of Weaver (1953), Tejon (Anderson and Hanna, 1925), Juncal, and Matilija (in *Turritella uvasana applinae, Ectinochilus supraplicatus*, and *E. canalifer* faunas; Givens, 1974) Formations; Eocene and Oligocene: undifferentiated Sacate and Gaviota Formations (Weaver and Kleinpell, 1963).

Subgenus GLYCYMERITA?

Glycymeris (Glycymerita?) reefensis Vokes

Plate 12, figure 1

Glycymeris reefensis Vokes, 1939, p. 47-48, pl. 1, fig. 21.

Original description.—"Shell small, inflated; umbos central, prominent; cardinal area straight, slightly more than half the length of the shell; anterior, posterior, and ventral margins regularly and evenly rounded; posterior area not defined; surface smooth except for minute arrow-shaped pittings similar to those found in *G. sagittata*; interior of shell not seen."

Holotype.—UCMP 15571.

Type locality.—UC A-1165. Kings County, Calif. Avenal Sandstone, Eocene.

Comparison.—"*Glycymeris reefensis* may be distinguished from *G. sagittata* by its round outline and shorter cardinal area; from all other described West Coast Eocene species it may distinguished by its smooth shell with arrow-like pittings." (Vokes, 1939, p. 48)

Comments.—The somewhat quadrate outline and prominent high umbones suggest *Glycymerita.*

Geographic range.—Middle California.

Geologic range.—Eocene.

Occurrence in California.—Avenal Sandstone (Keen and Bentson, 1944).

Glycymeris (Glycymerita?) tecolotensis M. A. Hanna

Plate 11, figures 13, 14

Glycymeris tecolotensis M. A. Hanna, 1927, p. 274-275, pl. 27, figs. 2, 3, 7.

Original description.—"Shell of medium size, heavy, rounded except for the projection of the prominent centrally located beak beyond the margin of the general outline; hinge line slightly straightened as viewed from the outside, a character more prominent in smaller specimens; shell moderately inflated; outer surface ornamented by fine concentric growth lines, and numerous fine round-topped parallel-sided radial ribs which are separated by flat-bottomed interspaces of three to four times the width of the ribs; radial ribs become obscure near the perifery of the shell due to the increased prominence of the growth lines; outer surface of the type is weathered to some extent so the surface characters are not too clear in the figure; hinge of moderate width; cardinal area large, slightly impressed, trigonal, straight on its ventral side, crosses parallel to the anterior and posterior edges by fine ridges which meet in a depressed line in the center; six prominent teeth to each side separated by eight smaller teeth (four posterior and four anterior); dorsal margin of the toothed area is straight due to the truncation by the cardinal area, cardinal area and the toothed area are separated only by a cessation of the teeth and not by a line of any kind; inner margin crenulate; inner surface of the type not exposed."

Holotype.—UCMP 30987.

Type locality.—UC 5091. San Diego County, Calif. Ardath Shale, Eocene.

Supplementary description.—Hinge margin greater in proportion in smaller individuals. (Hanna, 1927, p. 275)

Comparison.—"*Glycymeris tecolotensis****differs from the heretofore described species [sic: *G. rosecanyonensis*] in the presence of the large cardinal area, straight hinge line with few teeth, and in the presence of the very fine radial sculpturing." (Hanna, 1927, p. 275)

Comments.—This species was placed in the synonymy of *G. perrini* Dickerson by Stewart (1930, p. 73).

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Ardath Shale.

Subgenus TUCETONA Iredale, 1931

Radial ribs well developed, interspaces narrow to moderately wide, ribs sometimes dividing terminally.

Geographic range.—Baja California to Ecuador; Australia.

Geologic range.—Paleocene through Holocene (table 4).

Comments.—*Tucetona* is reinstated as a subgenus following Keen (1971, p. 55).

Glycymeris (Tucetona) fresnoensis Dickerson

Plate 12, figures 2, 3

Glycimeris fresnoensis Dickerson, 1916, p. 483, pl. 36, fig. 7.

Glycymeris fresnoensis Dickerson. Turner, 1938, p. 44, pl. 5, fig. 9. Vokes, 1939, p. 48, pl. 1, fig. 17.

Original description.—"Shell small, cordate, with beak decidedly twisted; anterior and posterior dorsal margins nearly straight with steep slope to arcuate ventral margin; decoration consisting of sharp dichotomous ribs."

Holotype.—UCMP 11795.

Type locality.—UC 1817. Fresno County, Calif. Lodo Formation, Paleocene and Eocene.

Supplementary description.—"The type is an immature specimen in which the ribbing is sharper than is characteristic on adult individuals. The statement that the 'beak is decidedly twisted' is not borne out by a study of the type material, nor is it indicated in the figure accompanying the original description." (Vokes, 1939, p. 48)

Comparison.—[See *G. verticordia.*]

Geographic range.—Washington to middle California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene and Eocene: Cerros Shale Member of the Lodo Formation (Keen and Bentson, 1944); Eocene: Capay Formation.

Glycymeris (Tucetona) perrini Dickerson

Plate 12, figures 4, 5

Axinea cor Gabb, 1864, p. 198, 235, pl. 31, fig. 268. Not *Pectunculus cor* Lamarck, 1805.

Glycymeris instabilis Anderson and Hanna, 1925, p. 185, new name.

Glycimeris perrini Dickerson, 1916, p. 482-483, pl. 36, figs. 6a, 6b, 6c. Stewart, 1930, p. 73-74, pl. 7, fig. 5 [see for synonymy]. Turner, 1938, p. 44-45, pl. 5, figs. 10-12.

Glycymeris perrini Dickerson *instabilis* Anderson and Hanna.

Vokes, 1939, p. 47, pl. 1, figs. 14, 16.

Original description.—"Shell medium in size, nearly equilateral, cordate; beak small, prominent, slightly incurved, area very small; base broadly rounded; anterior end straight and slightly shorter than the posterior end. The base is denticulated on interior. Shell is decorated by numerous fine rounded radiating ribs which vary greatly in strength over various portions of the shell. Some of the ribs are dichotomous. Interspaces are very narrow. Concentric lines of growth cross these ribs and on weathered specimens are very prominent."

Holotype.—UCMP 11792.

Type locality.—UC 672. Fresno County, Calif. Domengine Formation, Eocene.

Supplementary description.—"This species is characterized by the presence of 'double ribs' which appear as ribs only after weathering; on unweathered specimens the ribbing appears as a difference in shell-texture on an almost smooth surface." (Vokes, 1939, p. 47)

Comparison.—The trigonal form of *G. perrini* is sufficient to distinguish it from *G. sagittatus*. (Dickerson, 1916, p. 483)

Geographic range.—Southern Oregon to southern California.

Geologic range.—Paleocene and Eocene.

Occurrence in California.—Paleocene: Cerros Shale Member of the Lodo (Keen and Bentson, 1944) and Martinez Formations; Eocene: Avenal Sandstone (Stewart, 1946), Llajas Formation (Vokes, 1939), and Muir Sandstone of Weaver (1953).

Glycymeris (Tucetona) evermanni Anderson and Hanna

Plate 12, figures 6, 7

Glycymeris evermanni Anderson and Hanna, 1925, p. 184-185, pl. 15, figs. 1-3.

Original description.—"Shell minute, circular, moderately inflated; umbones central; surface marked by about 26 rounded radial ribs which are closest together at the sides; in the center of the margin the interspaces are slightly wider than the ribs; ribs and interspaces crossed by coarse, equidistant, concentric grooves which extend uniformly form the beak to the lower margin, about 16 in number on the type specimen; hinge line curved, having only three teeth on each side of the beak in the best paratype; length 3.0 mm.; altitude 3.0 mm."

Holotype.—CAS 964.

Type locality.—CAS 711. Kern County, Calif. Tejon Formation, Eocene.

Supplentary description.—"This little species is beautifully cancellated on the outer surface. Three well-preserved specimens were extracted from very hard rock and the inner margin of one shows crenulations." (Anderson and Hanna, 1925, p. 185)

Comparison.—[See *G. rosecanyonensis*.]

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Type Tejon Formation.

Glycymeris (Tucetona) ruckmani Dickerson

Plate 12, figures 8, 9

Glycimeris ruckmani Dickerson, 1915, p. 52-53, pl. 1, figs. 5a, 5b. Anderson and Hanna, 1925, p. 184.

Original description.—"Shell of moderate size with acutely pointed beaks; dorsal margins sloping steeply to join a broadly rounded ventral margin; the posterior dorsal margin slightly convex and with a gentler slope than the straight anterior dorsal margin; decoration consisting of about 28 rounded radial ribs crossed by concentric growth lines; area semilunar and marked by impressed lines curving outward from the altitude line."

Holotype.—UCMP 11051.

Type locality.—UC 458. Kern County, Calif. Tejon Formation, Eocene.

Comparison.—"This species differs from *Glycimeris cor* [= *Glycymeris perrini*] in having a more pointed beak, in lack of hinge teeth in the central portion of its hinge and in general shape." (Dickerson, 1915, p. 53).

G. ruckmani has a smaller apical angle than *G. viticola* and also has fewer ribs. [See *G. rosecanyonensis*.]

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Type Tejon Formation.

Glycymeris (Tucetona) verticordia Anderson and G D. Hanna

Plate 12, figures 10, 11

Glycymeris verticordia Anderson and Hanna, 1925, p. 183-184, pl. 2, fig. 5; pl. 11, fig. 1.

Original description.—"Shell small, sub-triangular, lower margin rounded; beak nearer the anterior than the posterior end; surface sculptured with 16 high, slightly rounded ribs, with slightly rounded interspaces of about equal width; only the seventh rib from the posterior end dichotomous; hinge broad and flat, with seven strong teeth on each side of the central area; ligament area very narrow, and beak elevated but little above the hinge line. Length, 8 mm.; altitude, 7.5 mm."

Holotype.—CAS 776.

Type locality.—CAS 245. Kern County, Calif. Tejon Formation, Eocene.

Comparison.—"The beak in *G. fresnoensis* is centrally located, but in *G. verticordia* is much nearer the anterior end. In the former the anterior and posterior margins are almost straight, but in the latter they are much curved. Furthermore, the ribs in *G. verticordia* are more regular, sharper, and single, whereas, in *G. fresnoensis* they are irregular in size, and are often, but not always dichotomous." (Anderson and Hanna, 1925, p. 183-184) [See *G. rosecanyonensis*]

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Tejon Formation.

Glycymeris (Tucetona) tenuimbricata Clark

Plate 12, figures 24, 25

Glycimeris tenuimbricata Clark, 1918, p. 130, pl. 16, figs. 4, 8, 9, 10.

Original description.—"Shell subtrigonal, somewhat variable in outline and diameter, medium in size, equivalved, nearly equilateral, valves moderately convex. Apical angle about 90°; dorsal slopes straight, the anterior slope being a little the shorter; ventral edge strongly and regularly convex; posterior dorsal margin, as a rule, slightly more depressed than anterior dorsal margin. Surface sculptured by twenty-three to twenty-nine radiating ribs which become obsolete near the dorsal edges; ribs separated by interspaces which generally average a little less than their width; surface also covered by heavy incremental lines which, on unweathered specimens, are very strongly and beautifully imbricated. Hinge plate fairly heavy, with seven or eight teeth anterior to the beak, and ten

or eleven posterior to it. The teeth do not reach the ventral margin of the hinge plate; they are noticeably long and heavy near the ligamental area, which is narrow and ventrally is wedged in between the anterior and posterior rows of teeth; ligamental grooves numerous and well marked. Muscle impressions equal and fairly heavy."

Holotype.—UCMP 11183.

Type locality.—UC 1131. Contra Costa County, Calif. San Ramon Sandstone, Miocene.

Geographic range.—Middle California.

Geologic range.—Miocene(?).

Occurrence in California.—Miocene: Olcese Sand (Addicott, 1956) and San Pablo Formation; Miocene(?). San Ramon Sandstone (Clark, 1918)

Glycymeris (Tucetona) multicostata (Sowerby)

Plate 12, figures 18, 19

Pectunculus multicostatus Sowerby, 1933, p. 195-196.

Glycymeris multicostata (Sowerby). Grant and Gale, 1931, p. 133.

Glycymeris (Tucetona) multicostata (Sowerby). Keen, 1971, p. 57, fig. 116.

Original description.—"Pect. testa suborbiculari, alba, castaneo rubiginosa cinereoque variegata; costellis numerosis, ex umbone radiantibus, transversim striatis: long. 1.5, lat. 1.2, alt. 1.5 poll."

Holotype.—BM(NH) (A. M. Keen, oral commun., 1978).

Type locality.—Isla de Muerte, Golfo de Guayaquil, Ecuador.

Supplementary description.—"There are 35 to 40 flat-topped ribs on the grayish shell, and in occasional individuals these may divide, especially at the ends, into numerous riblets***. In the southern part of the range the shells seem to have fewer ribs, and some have been confused in collections with *G. canoa****." (Keen, 1971, p. 47)

"It is remarkable that in the young shells some of the radiating ribs are more prominent than others in the proportion of two large to one small." (Sowerby, 1833, p. 195-196)

Geographic range.—Living: Punta Peñasco, Sonora, Mexico, to Guayaquil, Ecuador; fossil: Baja California Peninsula and Golfo de California.

Geologic range.—Pliocene through Holocene.

Occurrence in Baja California Peninsula.—Pliocene: Marquer Formation (Durham, 1950); Pleistocene: Bahía de San Quintin (Minch and others, 1976).

Subgenus TUCETONA?

Glycymeris (Tucetona?) maccrayi Waring

Plate 12, figure 12

Glycimeris maccrayi Waring, 1917, p. 93, pl. 5, fig. 1.

Original description.—"Shell small, of medium thickness and moderate convexity; umbone prominent, central, incurved; cardinal margin slightly convex and flared; anterior margin slightly produced above, broadly rounded below; basal margin broadly convex; posterior slightly produced above, broadly rounded below; surface marked by medium-size rounded, radiating ribs, which are crossed by lines of growth."

Holotype.—CAS/SU 167.

Type locality.—SU 8. Ventura County, Calif. Llajas Formation, Eocene.

Comments.—The hinge area is not exposed on the holotype but the sculpture of rounded ribs suggests *Tucetona*.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Llajas Formation (Keen and Bentson, 1944).

Glycymeris (Tucentona?) septentrionalis (Middendorff)

Plate 13, figures 1, 2

Pectunculus septentrionalis Middendorff, 1849, p. 67, pl. 21, figs. 1-3.

Glycimeris septentrionalis Middendorff. Clark, 1915, pl. 48, fig. 4.

Original description.—"*Pectunculus septentrionalis* n. sp. Taf. XXI, fig. 1-3. Testa alba, extus maculis intense rubido-fuscis, intus macula ejusdem coloris magna ad impress. musc. antic.; subcordiformi, subaequilaterali, latitudine longitudinem aequante, gibbosa, umbonibus nonnihil antice inflexis; costis interstitia, ob incrementi strias squamulosa, latitudine bis ad ter superantibus, rotundo-applanatis, 37 (7 21 9); dentibus cardinis 22 ad 23; margine medio, dentibus subbifidis grosse dentato.

"Die Massverhältnisse sind: Long., 29 m.; Latit.; 30 m.; Diam. ventr., 20 m."

"Etwa 37 Rippen kommen vor, von denen ich 21 ausgebildetere auf dem Mittelfelde, nebst 7 und 9 etwas schwächeren auf dem sehr undeutlich begrenzten Vorder—und Hinterfelde zählte. Die rundrückigen scharfbegrenzten Rippen sind etwas flach, kaum halb so hoch als breit, und durch Furchen untereinander geschieden, welche zwei bis drei Mal schmäler sind; als die Rücken der Rippen. Den Rippen des Mittelfeldes entsprechend ist der Rand mit groben, der Länge nach gefurchten Zähnen besetzt."

Holotype.—Zoological Institute Leningrad, USSR.

Type locality.—Arctic.

Supplementary description.—"Shell of medium size, nearly circular, convex, thick; umbones central, not prominent; surface sculptured with rather faint ridges of growth and radiating grooves, which are more or less interrupted by the ridges; triangular ligamental area between umbones divaricately striated; hinge with a semi-circular row of transverse teeth; muscle impressions subequal; interior of margin crenulated. Length, 30; height, 32.2; diameter, 22 mm." (Arnold, 1903, p. 101)

Comparison.—Differs from *G. septentrionalis subobsoleta* by having a larger, thicker shell, greater convexity, and more pronounced sculpture. (Arnold, 1903, p. 101)

Geographic range.—Living: Aleutians to Forrester Island, Alaska; fossil: middle and southern California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene: Neroly (Weaver, 1949) and Santa Margarita (Gale, 1931) Formations; Miocene and Pliocene: Etchegoin (Anderson, 1905); Pliocene: San Joaquin Formation (Adegoke, 1969); Pliocene and Pleistocene: Fernando (Zinsmeister, 1970), San Pedro (Arnold, 1903), and Saugus (Kew, 1924) Formations.

Subgenus AXINOLA Hertlein and Grant, 1972

"Shell small to moderate size (5 to 50 mm long), subtrigonal to suborbicular in outline, often produced posteriorly, convexity of valves slight, thin, sometimes chalky, the Recent species covered with a velvety periostracum; the exterior is smooth or with faint rather narrow, flat-topped radial ribs which become strongly accentuated by erosion; beaks usually opisthogyrate but in some

species orthogyrate; cardinal area short, high, with ligamentary grooves forming asymetrical [asymmetrical] triangles, the anterior side the longer; hinge arcuate, the central teeth much finer than those at either end or sometimes nearly obsolete; interior ventral margin of valves crenulated, the crenulations with blunt ends." (Hertlein and Grant, 1972, p. 159)

Geographic range.—Northeastern Pacific; living from Baja California to Japan.

Geologic range.—Eocene through Holocene (table 4).

Glycymeris (Axinola) grewingki Dall

Plate 12, figure 20

Glycymeris grewingki Dall, 1909, p. 107, pl. 2, fig. 13. Stewart, 1940, p. 90, pl. 29, figs. 10, 11; pl. 33, figs. 7, 8.

Glycymeris (Axinola) grewingki Dall. Hertlein and Grant, 1972, p. 159-160.

Glycymeris coalingensis Arnold, 1909, p. 80, pl. 19, fig. 3.

Original description.—"Shell solid, suborbicular, subequilateral, equivalve; beaks prominent, moderately convex, slightly separated by the area, which is narrow, in each valve forming a wide, very obtuse triangle with deeply incised angular sulci, radiating from the vertical of the beak; anterior slope slightly shorter and more rounded than the posterior, which is somewhat produced toward the lower portion; there is no distinct lunule or escutcheon; but a feebly differentiated anterior dorsal area is characterized by radial threads much finer than those on the anterior half of the disk; on the latter are about a dozen flat, little-elevated, radial ribs, separated by much narrower, channeled sulci, the whole with more or less obsolete fine radial striation; these radial ribs are distinct when the surface of the shell is intact; the anterior half of the disk, except when decorticated, nearly smooth except for close-set uniform numerous radial threads which cover the entire surface; when decorticated the internal structure shows ribs much like those normally exposed on the anterior half of the disk. Altitude of figured specimen, 38 mm.; longitude, 38 mm.; diameter 20 mm."

Holotype.—USNM 107784. Holotype of *Glycymeris coalingensis* Arnold, USNM 165526.

Type locality.—Coos Bay, Coos County, Oreg. Empire Formation, Miocene.

Supplementary description.—"the incremental lines are imbricating, sharp and wavy, and where the surface is slightly worn, loop downward in more or less regular festoons in the interspaces, this being one of the unique characteristics of the species***" (Arnold, 1909, p. 80; as *G. coalingensis)*

Comparison.—*G. grewingki* differs from the living species *G. subobsoleta* Carpenter by having "higher umbos and correspondingly wider (dorsal-ventral) ligamental area and less prolongation posteriorly." (Hertlein and Grant, 1972, p. 160) [See also *G. gabbi.*]

Geographic range.—Alaska to southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Briones Sandstone (Weaver, 1953), Castaic (Stanton, 1966), Cierbo (Hall, 1960), and McLure Shale Member of the Monterey (Adegoke, 1969) Formations, Neroly Sandstone (Weaver, 1949), Oursan Sandstone (Hall, 1958), San Pablo (Clark, 1915) and Santa Margarita (Clark, 1915) Formations; Pliocene: Etchegoin (Woodring and others, 1941) and San Diego (Hertlein and Grant, 1972) Formations; Pliocene and Pleistocene: Fernando Formation (J. D. Mount, written commun., 1971); Pleistocene: Pico Formation (Waterfall, 1929; upper part of the Pico or basal Santa Barbara Formation of modern usage).

Glycymeris (Axinola) profunda (Dall)

Plate 12, figures 21, 22

Axinea profunda Dall, 1878, p. 11, 13.

Glycymeris (Axinola) profunda Dall. Hertlein and Grant, 1972, p. 160-161, pl. 27, figs. 15, 20, 21, 23, 25, 28-30, 34, 37, [See for synonymy].

Original description.—"Shell subtriangular, ventral margin rounded, umbos erect, rather small. Area narrow, deep; marked by five or six lines meeting at an angle in the vertical of the umbo, one above another; anterior lines somewhat the shortest; exterior marked by twenty-five or thirty flattened ribs, separated by deep channels one-fourth as wide as the ribs, and by which the interior margin is crenulated. The ribs are crossed by thread-like close lines of growth, which may be elevated or obsolete on the ribs, but are sharply defined in the channels, which they partially fill up in some specimens. Toward the anterior and posterior margins, the sculpture is nearly obsolete. In eroded examples, this sculpture may be entirely altered, and such are hardly striate, with a tendency to an elevated narrow ridge behind the anterior scar; hinge with teeth placed as if radiating from the centre of the valve, six to nine anteriorly, and ten to fourteen posteriorly, with some ten or twelve small, crowded teeth between the two radiating sets, and placed perpendicularly and parallel with one another. Height, 32 mm; length 30 mm; thickness, 20 mm; the last proportionally greater in the young."

Lectotype.—From type lot USNM 7935 (Woodring, 1946, p. 79). [The two remaining specimens in the original type lot have been assigned different USNM catalogue numbers.]

Type locality.—"The type material was collected evidently from the Pleistocene strata overlying the Pliocene San Diego Formation at Pacific Beach [San Diego County, Calif.]." (Woodring, 1946, p. 79)

Comparison.—"*Glycymeris subobsoleta* Carpenter***has a thin shell which is elongated posteriorly and has a narrow cardinal area. The shell characters of some young specimens of *G. profunda* approach those of *G. subobsoleta* and *G. grewingki.*

"*Glycymeris tenuimbricata* Clark***, a species with high slender umbos,***has an apical angle of about 90° and bears a general resemblance to some specimens of *G. profunda*, but it has a much narrower cardinal area.

"*Glycymeris keenae* Willett***from Alaska was described as a small (13.5 mm long) white shell with concentric sculpture and an angular hinge plate. Its general features are similar to those of *G. profunda* and allied species." (Hertlein and Grant, 1972, p. 161)

The specimens illustrated by Arnold (1903) as *G. barbarensis* (pl. 18, fig. 9) and *G. septentrionalis* (pl. 18, fig. 10) should be assigned to *G. profunda* (Hertlein and Grant, 1972, p. 161).

Geographic range.—Living: off Redondo and Catalina Island, California; fossil: middle and southern California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene: Cierbo and Neroly Sandstones (Hall, 1960); Miocene and Pliocene: Towsley Formation (Kern, 1973); Pliocene: Lomita Marl Member of the San Pedro Sand (Woodring, 1946), Niguel (J. G. Vedder, written commun., 1978) and San Diego Formations (Hertlein and Grant, 1972); Pliocene and Pleistocene: Fernando Formation (Zinsmeister, 1970).

Habitat.—At depths of 45 to 365 m off southern California (Willett, 1944, p. 112).

Genus FELICIA Mabille and Rochebrune, 1889

Oblique, with anterior end narrowly rounded; posterior slightly

quadrangular; exterior and inner margin smooth; dental series straight.

Geographic range.—Living: California to South America; fossil: California.

Felicia phrear (Woodring)

Plate 13, figures 5-7

Limopsis (Felicia) phrear Woodring, 1938, p. 31, pl. 5, fig. 9.

Original description.—"A large *Limopsis* allied to *dalli* and other deep-water species from the west coast of Central America and southern Chile. Obliquely elongate; some specimens, probably distorted, are short. Sculpture consisting of radial pits, between some of which faint or distinct narrow radial grooves extend. Near the upper posterior margin the grooves are generally replaced by narrow faint threads. Growth lines interrupt the grooves. Cardinal area and hinge plate moderately narrow. Hinge apparently symmetrical."

Holotype.—USNM 496077.

Type locality.—USGS 13900. Los Angeles County, Calif. Fernando Formation, Pliocene and Pleistocene.

Comparison.—"This species is closely allied to three large deep-water species from the west coast of Central America and southern Chile—'*compressus*' Dall (= *dalli* Lamy; southern Mexico, Panama), *zonalis* Dall (Panama); and *jousseaumi* (Mabille and Rochebrune) (Strait of Magellan) These three species were differentiated by Dall principally on characters of the periostracum. *L. phrear* is so far as now known smaller than these three species, elongate specimens are more elongate, and the radial grooves and pits are more widely spaced, except on the holotype. *L. zonalis* generally has a wider ligament area and hinge plate, and *jousseaumi* has slightly fainter sculpture. The fossils appear to be most closely allied to *dalli.*" (Woodring, 1938, p. 32)

Geographic range.—Southern California.

Geologic range.—Pliocene and Pleistocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando Formation.

Habitat.—The three living forms to which this species has been compared were dredged from 223 to 4,081 m (Woodring, 1937, p. 32).

"Glycymeris barbarensis (Conrad)"

Axinaea barbarensis Conrad, 1857a, p. 314; 1857b, p. 71, pl. 3, fig. 11. Not *Axinea barbarensis* Conrad, 1857b, p. 194, pl. 6, fig. 3.

Glycymeris barbarensis Conrad. Dall, 1909, p. 108-109. Hertlein and Grant, 1972, p. 161.

Original description.—"Lentiform, subequilateral, concentrically wrinkled; ribs about 37, scarcely prominent, flat, defined by an impressed line, wanting on the submargins and obsolete toward the base; summits slightly prominent. Length 1¾ inches; height rather more than 1¼ inches."

Holotype.—Presumed lost at ANSP (Woodring, 1946, p. 79).

Type locality.—Coast near Santa Barbara, Calif. Holocene.

Supplementary description.—"The high full umbo of Arnold's figure of *G. "barbarensis"* from the Palos Verdes sand suggests *G. profunda*, but the relative height is not great for the typical form. The specimen of *G. barbarensis* figured in volume 7 of the Pacific Railroad Reports is in the National Museum (13358). It is imperfect and poorly preserved in a matrix of hard sandy limestone and is probably a small specimen of the species Gabb later described as *G. veatchii.* It therefore is probably Paleocene (Eocene of Dall's nomenclature), as Dall thought, or Upper Cretaceous. A label glued to the rock reads '*Glossus* (*Pectunculus*) *collinus* Con., shore between San Luis and Santa Barbara.' Antisell, however, recorded it from the Simi Hills. The figured *G. barbarensis* of volume 6 of the Pacific Railroad Reports is not know to be exant [sic, extant]. It was listed from Santa Barbara, is presumably not conspecific with the *G. barbarensis* of volume 7, as Dall thought, and is presumably from the Pleistocene Santa Barbara formation. It has the relative dimensions of the Recent *G. subobsoleta.* The geologic reports, including the paleontology, of both volumes bear the date 1856. Volume 6 was transmitted for publication, however, May 6, 1857, and volume 7 February 9, 1857. Both were issued probably sometime during 1857. Until evidence establishing priority is found, the *G. barbarensis* of volume 6 is herewith arbitrarily given precedence. This action may dispose of the troublesome name, as the *G. barbarensis* of volume 6 is a probable synonym of *G. subobsoleta*, and the *G. barbarensis* of volume 7 is automatically a homonym." (Woodring, 1946, p. 79)

Family MANZANELLIDAE? Chronic

Geologic range.—Permian through Holocene.

Genus HUXLEYIA A. Adams, 1860

Ligamental fossette large and round, impinging on cardinal area; lateral tooth smaller than in *Nucinella.*

Geologic range.—Pliocene through Holocene.

Geographic range.—Living: Japan, Australia, Africa, western America; fossil: southern California.

Huxleyia munita (Dall)

Plate 13, figures 8-10

Cyrilla munita "Carpenter" Dall, 1898, p. 602.

Cyrilla munita (Dall). Schenck, 1939, pl. 6, figs. 14, 15.

Huxleyia munita (Dall). Keen, 1971, p. 36, fig. 65.

Original description.—"In this species the fossette has become still larger than in *Cyrilla sulcata.* None of the anterior cardinal teeth is left. The four posterior cardinals are of the bent or V-shaped variety, and the cardinal plate and shell have become more solid and heavy. The ligament is wholly internal and the cardinal plate solid and flat. The wing-like expansions of its outer margin, so notable in all true species of *Pleurodon* are gone."

Syntypes.—USNM 23243.

Type locality.—Off Catalina Island, Calif. Holocene.

Geographic range.—Living: southern California (records from Golfo de California are in error, Keen, 1971, p. 36); fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando Formation (Vedder, 1960, as "unnamed sandstone"); may be restricted to upper part.

Family MYTILIDAE

Subfamily MYTILINAE

Geologic range.—Devonian through Holocene.

Genus MYTILUS Linné, 1758

Wedge-shaped, elongate, beaks terminal; margins not crenulated, surface smooth or with radial ribs which are not bent dorsalward.

Geologic range.—Jurassic through Holocene.

Habitat.—Intertidal zone to about 90 m; attached by highly developed byssus to hard substrata, most commonly rocks, in areas of strong wave action; some clumps of *Mytilus* bind together pebbles and cobbles that serve as anchors for colonies.

TABLE 5.—*Geologic and geographic distribution of the family Mytilidae*

[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	Alaska	British Columbia	Washington	Oregon	California			Baja California		Central and/or South America
					Northern	Middle	Southern	Norte	Sur	
Subfamily Mytilinae:										
Genus *Mytilus*:										
Subgenus *Mytilus*:										
californianus Conrad	H	H	H	H	Pl to H	Pl to H	Ple to H	Ple		
condoni Dall			Pl		Pl and Ple	Pl and Ple				
edulis Linné	M? to H	H	H	M to H	Pl to H	M to H	Pl to H	H	H	
Subgenus *Mytilus*?:										
arnoldi Clark						O and M?	O			
ascia Gabb							E			
loeli Grant						O and M	O and M			
Subgenus *Crenomytilus*:										
coalingensis Arnold						M to Ple	M to Ple			
expansus Arnold						O and M	O and M			
kewi Nomland						M and Pl	M			
mathewsonii Gabb	M?[1]	O and M				M to Pl	O to M		M?	
sternbergi Hertlein and Grant							Pl	Pl		
trampasensis Clark						M				
Subgenus *Crenomytilus*?:										
perrini Clark						M				
schencki G D. Hanna and Hertlein						M	O and M			
Subgenus *Plicatomytilus*:										
middendorffi Grewingk	O? and M			M		M	M			
Genus *Brachidontes*:										
Subgenus *Brachidontes*:										
cowlitzensis (Weaver and Palmer)			E			Pa and E	E and O			
cooperi Moore, n. n.			E	E		E	E			
Genus *Brachidontes*?:										
Subgenus *Brachidontes*?:										
altiobliquus (Nelson)							Pa			
dichotomus (Gabb)			E				E			
kirkensis (Clark)						M?				
lawsoni (Nelson)						Pa	Pa			
susanaensis (Nelson)							Pa			
Genus *Brachidontes*:										
Subgenus *Scolimytilus*?:										
margaritana (Nomland)						M				
multiradiatus (Gabb)						Pa	E and O			
subconvexus (Trask)						M				
Subgenus *Aeidimytilus*:										
adamsianus (Dunker)							Pl to H	H	H	H
gabbi (Clark)						M				
Genus *Mytella*:										
inezensis (Conrad)							E and O			
Genus *Perna*:										
montana Conrad							M?			
Genus *Septifer*										
bifurcatus (Conrad)					H	H	Pl to H	Ple and H	H	
coalingensis Arnold						M and Pl				
elegans Waring							E			
Subfamily Crenellinae:										
Genus *Crenella*:										
decussata (Montagu)	H	H	H	H	H	H	Pl to H			
inflata Carpenter							Pl to H	H	H	H
Genus *Gregariella*:										
chenui (Récluz)						H	Pl to H	H	H	H
Genus *Musculus*:										
Subgenus *Musculus*:										
stalderi (Martin)					Pl					
Subfamily Lithophaginae:										
Genus *Lithophaga*:										
Subgenus *Lithophaga*:										
clarki M. A. Hanna							E?			
Subgenus *Diberus*:										
plumula (Hanley)							Pl and Ple		H	H
Genus *Adula*?:										
mcknighti M. A. Hanna							E			
Subfamily Modiolinae										
Genus *Modiolus*:										
Subgenus *Modiolus*:										
capax Conrad						M to H	M to H	H	H	H
carpenteri Soot-Ryen						M to H	Pl to H		Ple	
contracta Conrad						M? and Pl?				
directus Dall			M	M and Pl		M and Pl				
eugenensis Clark				O			E and O			
garzaensis Adegoke						M				
lagunanus Loel and Corey							O and M			
rectus Conrad		H	H	H		M to H	M to H	Ple and H	H	
veronensis temblorensis Adegoke						M				
veronensis veronensis Trask						M				
ynezianus Arnold						E and O	O and M			
Subgenus *Modiolus*?:										
merriami Weaver						Pa				
pittsburgensis Clark						O and M?				
Genus *Modiolus*?:										
Subgenus *Modiolus*?:										
clarki Moore, n.n.						M				
meganosensis Clark and Woodford						Pa				
sacculifer (Berry)						H	Pl to H			
Genus *Idasola*?:										
bakeri Dickerson						Pa				

[1]Scott McCoy, written commun., 1978.

Subgenus MYTILUS

Smooth or with radial ribs, margins smooth.

Geologic range.—Oligocene(?); Miocene through Holocene (table 5).

Habitat.—Temperature and boreal seas.

Mytilus (Mytilus) edulis Linné

Plate 13, figures 11, 12

Mytilus edulis Linné, 1758, p. 705. Soot-Ryen, 1955, p. 19-22, pl. 1, figs. 1-2; text figs. 1, 2, 10, 11 [see for synonymy]. Abbott, 1974, p. 428-429, fig. 5039. Hertlein and Grant, 1972, p. 162-163.

Mytilus (Mytilus) edulis Linnaeus. Grant and Gale, 1931, p. 244-245.

Mytilus ficus Dall, 1909, p. 113, pl. 9, figs. 1, 4.

Original description.—"M. testa laevinscula violacea, valvulis obliquis postice acuminatis."

Holotype.—In collection of Linnean Society, London, England (A. M. Keen, oral commun., 1978).

Type locality.—North Atlantic. Holocene.

Supplementary description.—"Relatively thin shelled, nearly smooth*** three small teeth at beaks. Length 70-100 mm." (McLean, 1978, p. 66)

Geographic range.—Living: Arctic Ocean to Baja California Sur; North Atlantic, South America, and Australia; fossil: Alaska to southern California.

Geologic range.—Miocene through Holocene.

Occurrence in California.—Miocene: Sobrante Sandstone (Lutz, 1951); Pliocene: Falor Formation (Manning and Ogle, 1950); Pliocene and Pleistocene: Fernando (Hertlein and Grant, 1972, p. 163), Merced (Glen, 1959), and Pico (Addicott and Vedder, written commun., 1968) Formations.

Habitat.—Usually found in intertidal zone attached in masses to pilings and rocks; at some places in deeper water to at least 35 m.

Mytilus (Mytilus) condoni Dall

Plate 13, figures 13, 14

Mytilus condoni Dall, 1890, p. 88-89. Addicott, 1974, p. 355-356, figs. 3-9. Yancey, 1978, figs. 5c, 5d.

Mytilus highoohiae Mandra, 1949, p. 104-105, fig. 1.

Mytilus aff. *middendorfi* Grewingk, n. sp. Manning and Ogle, 1950, pl. 8, fig. A.

Original description.—"The most remarkable, and only new form in this bed [at Shoalwater Bay, Washington] is a fine *Mytilus* as large as *M. californicus* but distinguished from all other species of the genus by its surface which resembles that of *M. edulis* superimposed upon which are a few strong divaricating ridges extending from about the middle of the valves toward the posterior extreme. Many species have the surface covered with fine divaricating lines but I believe there is none known in which there are a few strong distant ridges, perhaps not exceeding half a dozen on the surface of a shell six inches in length, and having otherwise the form and aspect of a giant *M. edulis*. For this interesting species I propose the name of *M. condoni* in honor of its discoverer."

Neotype.—USNM 647272 (Addicott, 1974, p. 355). Holotype of *Mytilus highoohiae* Mandra, UCMP 35518.

Neotype locality.—USGS M5219. Pacific County, Wash. Unnamed Pliocene strata.

Supplementary description.—"*Mytilus condoni* is characterized by a network of moderately fine, divaricating ribs that bifurcate along the median line of the valves. The ribs are of variable strength but are best developed on the medial and dorsal parts of the valves and tend to reach the ventral margin at a much later stage of growth than the dorsal margin. The ribs are relatively flat-topped and are much broader than the interspaces***. The early growth stages are characterized by a smooth surface; the divaricate rib pattern develops after a length of about 25 mm is attained. On a few specimens, however, the smooth surface is maintained until a much later stage in growth***. The shell margin is smooth except for the development of a few teeth in the umbonal region.

"Assignment to *Mytilus* is suggested by the similarity of internal morphology to that of the cosmopolitan species *M. edulis*. On the anterior part of the valve, the dentition, position of the anterior adductor muscle scar, and outline and position of the posterior retractors are all remarkably similar to *M. edulis****." (Addicott, 1974, p. 355)

Comparison.—"*Mytilus condoni* is characterized by a pattern of moderately fine divaricate ribbing, whereas *M. middendorffi* has a few rugose plicae that produce undulatory deflections of the plane of commissure. The sculpture of *M. middendorffi* consists of two main folds and, usually, finer folds that branch off of the main dorsal fold in the posterior dorsal area of the valves." (Addicott, 1974, p. 355)

Geographic range.—Washington to middle California.

Geologic range.—Pliocene and Pleistocene.

Occurrence in California.—Pliocene: Falor Formation (Manning and Ogle, 1950); Pliocene and Pleistocene: Carlotta (Ogle, 1953) and Merced (Addicott, 1974) Formations.

Habitat.—Presumed to have lived at low intertidal or uppermost inner sublittoral depths in embayed or otherwise protected environments (Addicott, 1974).

Mytilus (Mytilus) californianus Conrad

Plate 13, figures 15, 16

Mytilus californianus Conrad, 1837, p. 242, pl. 18, fig. 15. Oldroyd, 1924, p. 66, pl. 27, fig. 2. Soot-Ryen, 1955, p. 22-23, pl. 1, figs. 3-4, text figs. 3, 12 [see for synonymy].

Mytilus (Mytilus) californianus Conrad. Grant and Gale, 1931, p. 245, pl. 12, fig. 6.

Mytilus (Crenomytilus) californianus Conrad. Abbott, 1974, p. 429, fig. 5042.

Original description.—"Shell ovate elongated, inflated; anterior margin straight; posterior side emarginate; ribs not very numerous, slightly prominent, broad, rounded; lines of growth very prominent. Length, 2 1/8 inches."

Holotype.—In the Gould Collection, MCZ.

Type locality.—Off San Diego, Calif. Holocene.

Supplementary description.—"Thick shelled***showing strong radial ribs and irregular growth lines, the surface usually worn*** Length, 80-130 mm." (McLean, 1978, p. 66)

This species is usually easy to recognize by the radiating ribs. In shape, however, it varies from the broad bay form to the elongate irregular and worn form living in the surf. Some large specimens attain a length of 225 mm. (Soot-Ryen, p. 22)

Comments.—No posterior ligamental teeth are present on this form; it is therefore retained in *Mytilus s.s.*

Geographic range.—Living: Unalaska Island, Aleutian Islands, Alaska, to southern California [not living south of California, A. M. Keen, oral commun., 1978]; fossil: northern California to Baja California Norte.

Geologic range.—Pliocene to Holocene.

Occurrence in California and Baja California Norte.—Pliocene: Rio Dell Formation (Faustman, 1964); Pliocene and Pleistocene: Merced Formation (Arnold, 1906) and Wildcat Group (Ogle, 1953); Pleistocene: unnamed strata on San Nicolas Island (Vedder and

Norris, 1963) and at Bahía de San Quintin, Baja California Norte (Jordan, 1926).

Habitat.—Rocky intertidal zone to 38 m; seamounts (Paine, 1976). Especially common along the exposed coast in the intertidal zone (Soot-Ryen, 1955)

Subgenus MYTILUS?

The species here assigned to the subgenus *Mytilus*? could be placed in *Crenomytilus*?, as on the basis of external shell characters alone, the subgenera cannot be separated.

Mytilus (Mytilus?) ascia Gabb

Plate 14, figure 1

Mytilus ascia Gabb, 1864, p. 183, pl. 30, fig. 259. Anderson and Hanna, 1925, p. 186.

?*Mytilus humerus* Conrad, 1855, p. 10.

Original description.—"Shell long, narrow, oblique, convex; anterior margin nearly straight, abruptly truncated parallel with the border; cardinal margin slightly arched; anterior and posterior margins parallel, basal truncated somewhat convexly and at right angles to the two adjoining sides, uniting with them by rounded angles. Surface marked only by a few indistinct lines of growth."

Holotype.—UCMP 11989 is accepted as the holotype. It is the exact size of the original illustration and bears an old printed paper number indicative of the California State Survey collections.

Type locality.—Fort Tejon, Kern County, Calif. Tejon Formation, Eocene.

Comments.—The holotype is an internal mold with only patches of the inner shell layer preserved.

The holotype of *M. humerus* (Conrad) [see below] is missing and presumed lost. The original drawing is of a small (18-mm long) form that could have been an immature specimen of *M. ascia*.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Tejon Formation.

Mytilus (Mytilus?) humerus Conrad, nomen dubium

Mytilus humerus Conrad, 1855, p. 10. Conrad, 1857b, p. 2, fig. 10. Anderson and Hanna, 1925, p. 186, text fig. 9 [See for synonymy].

Original description.—"Ovate, ventricose, summit acute; anterior margin rectilinear; basal margin rounded; anterior extremity obtusely rounded; posterior extremity less obtuse; disk with minute radiating lines."

Holotype.—Not in USNM; missing and presumed lot.

Type locality.—Grapevine Canyon, Tejon quadrangle, Kern County, Calif. Tejon Formation, Eocene.

Comments.—Inasmuch as the holotype of this species is lost and the original drawing inadequate for identification, *M. humerus* is here considered to be a *nomen dubium. Mytilus humerus* may have been an immature specimen of *M. ascia*.

Mytilus (Mytilus?) arnoldi Clark

Plate 14, figure 2

Mytilus arnoldi Clark, 1918, p. 135, pl. 12, fig. 1.

Original description.—"Shell medium in size; beaks subacute; posterior end rather narrow, somewhat acutely rounded; base straight or nearly so; posterior dorsal margin straight, extending not quite to the middle of the shell; posterior to this, the margin converges very strongly to the posterior end, the converging margin being gently convex; the change from the posterior dorsal margin to the converging posterior margin is not marked by an angulation but by a broad, regular curve. Convexity of surface rather broad, the posterior slope being gentle, with the anterior slope slanting steeply though being considerable from vertical. Surface smooth except for medium coarse, somewhat irregular lines of growth."

Holotype.—UCMP 11153.

Type locality.—UC 78. Contra Costa County, Calif. Kirker Tuff, Oligocene.

Geographic range.—Middle California.

Geologic range.—Oligocene and Miocene(?).

Occurrence in California.—Oligocene: Kirker Tuff, lower part of Pleito and upper part of San Emigdio (Wagner and Schilling, 1923) Formations, and upper part of San Juan Bautista Formation of Addicott (1973); Miocene(?): San Ramon Sandstone (Weaver, 1949).

Mytilus (Mytilus?) loeli Grant

Plate 14, figure 3

Mytilus kewi Wiedey, 1949, p. 281, pl. 31, fig. 2 Not *Mytilus kewi* Nomland, 1917b, p. 314, pl. 14, fig. 1.

Mytilus loeli Grant, 1930, new name, p. 419.

Mytilus hamlini Loel and Corey, 1932, p. 205, pl. 34, fig. 3.

Original description.—"Shell of large size, highly inflated, with a prominent high, rounded elevation passing from beak to posterior extremity of shell; posterior margin long, evenly rounded, sharply so near beak with tendency toward straightening near extremity; beak low and sharply projected forward; entire shell of scimiter-shaped appearance; external surface sculptured only by inconspicuous lines of growth; interior unknown; in combined valves anterior dorsal portions form a broad flat area which merges into elevated portion, which is nearly vertical above suture. Height, 102 mm.; breadth, 53 mm.; thickness, single valve, 22 mm."

Holotype.—CAS/SU 515.

Type locality.—SU 200. Monterey County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"*Mytilus loeli* Grant*** is a broad, strongly arcuate species which may be related to *M.* (*Mytiloconcha*) *coalingensis* Arnold, a larger, less arcuate species ***. The latter belongs to the group with the umbo internally greatly thickened. The hinge characters of Wiedey's renamed species is***as yet unknown and it may prove to be subgenerically different from Arnold's species." (Grant, 1930, p. 419)

Comparison.—"The sharp and pointed beaks, together with the generally highly arcuate shape distinguish *M. kewi* from *M. mathewsonii* Gabb and *M. mathewsonii* var. *expansus* Arnold, *M. coalingensis* Arnold is less arcuate than this new species." (Wiedey, 1929, p. 281)

"This species is quite constant in the characters outlined and apparently is the precursor of *Mytilus mathewsoni* Gabb***to which species it is nearest related. It is different from the species in its more pronounced crescentic form and greater breadth. From *M. expansus* Arnold***it differs in its more crescentic form and in the lack of posterior angulation and ventral expansion." (Loel and Corey, 1932; as *M. hamlini*)

Geographic range.—Middle California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros and Temblor (Eaton and others, 1941) Formations.

Subgenus CRENOMYTILUS Soot-Ryen, 1955

Margins minutely serrated.

Geographic range.—Living: Japan and Philippines; fossil: western North America.

Geologic range.—Oligocene through Holocene (table 5).

Mytilus (Crenomytilus) expansus Arnold

Plate 15, figure 5

Mytilus mathewsonii Gabb var. *expansus* Arnold, 1907a, p. 528, pl. 43, fig. 2. Arnold, 1909, p. 116, pl. 5, fig. 3. Loel and Corey, 1932, p. 205, pl. 34, fig. 1.

Original description.—"Shell wedge-shaped, rounded behind, curved; posterior margin curved, semiangular in middle, anterior margin more nearly straight; beaks terminal, blunt; surface sculptured by irregular concentric lines and ridges of growth and by fine radiating striae."

Holotype.—USNM 164968.

Type locality.—Near Torrey Canyon oil wells, southwest of Piru [Piru quad.], Ventura County, Calif. Vaqueros Formation, Oligocene and Miocene.

Comparison.—"This variety differs from the typical form in being somewhat smaller, relatively broader, and with straighter anterior margins. The fine radial striation is also said to be lacking in the typical form." (Arnold, 1907a, p. 528)

Geographic range..—Middle to southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene: Wygal Sandstone Member of Temblor Formation (Addicott, 1973); Oligocene and Miocene: upper part of Sespe and Vaqueros Formations, undifferentiated (Schoellhamer and others, 1981), Vaqueros Formation (Loel and Corey, 1932; Bereskin and Edwards, 1969); Miocene: Buttonbed Sandstone Member of Temblor (Addicott, 1972), Los Tularicitos Member of Chamisal, McLure Shale Member of Monterey (Adegoke, 1969), Tierra Redonda (Durham, 1970), and Topanga (Takeo Susuki, written commun., 1978) Formations.

Mytilus (Crenomytilus) mathewsonii Gabb

Plate 14, figure 6

Mytilus mathewsoni Gabb, 1866, p. 30, pl. 8, fig. 51. Stewart, 1930, p. 96, pl. 13, fig. 2 [See for synonymy].

Mytilus (Mytiloconcha) mathewsonii Gabb. Clark, 1918, p. 135, pl. 18, figs. 1, 2. Clark and Arnold, 1923, p. 142, pl. 27, fig. 1. Weaver, 1942, p. 106, pl. 23, figs. 1, 10.

Original description.—"Shell very large, thick, curved, width and thickness about equal in center, flatter towards the base; beaks terminal, blunt. Surface marked only by lines of growth and irregular concentric undulations."

Lectotype.—ANSP 4500 (Stewart, 1930).

Type locality.—South of Martinez [Conrad quadrangle, Contra Costa County], Calif. San Ramon Sandstone, Miocene(?).

Supplementary description.—"*M. mathewsonii* is distinguished by its comparatively large size, smooth surface, blunt beaks and straight base. The shell is noticeably high, rather narrow; the slopes from the line of highest convexity are steep both anteriorly and posterioly***the hinge plate just under the beak is thick and on this thickened area is a broad, deep, V-shaped groove. The ligamental groove is long, farily deep and heavy." (Clark, 1918, p. 135)

Comparison.—[See *Mytilus (Crenomytilus?) perrini.*]

Geographic range.—Alaska to Baja California Sur.

Geologic range.—Oligocene to Pliocene.

Occurrence in California and Baja California Sur.—Oligocene and Miocene: Temblor (Anderson, 1905) and Vaqueros Formations (Arnold, 1906); Miocene: McLure Shale member, Monterey Formation (Adegoke, 1969), Sobrante Sandstone (Merriam and Clark, 1914), Topanga Canyon (Takeo Susuki, written commun., 1978) and Isidro(?) (Beal, 1948) Formations; Miocene(?): San Ramon Sandstone (Clark, 1918; Weaver, 1953); Miocene and Pliocene: Purisima Formation (Arnold, 1906).

Mytilus (Crenomytilus) trampasensis Clark

Plate 14, figures 7, 8

Mytilus (Mytiloconcha) trampasensis Clark, 1915, p. 457-458, pl. 42, figs. 2, 3.

Crenomytilus trampasensis (Clark). Soot-Ryen, 1955, p. 23.

Original description.—"Shell medium to large, slender; beaks acute, not twisted; base nearly straight, on some specimens gently concave. Cardinal angle near the middle of the elongate axis. Posterior end evenly rounded; anterior slope steep; surface of shell posterior to the steep anterior slope slightly convex, with a very gentle posterior slope. Surface smooth except for fine incremental lines of growth. Hinge plate below the beaks heavy, with a deep groove anterior to the ligamental groove."

Syntypes. UCMP 11545, 11546.

Type locality.—UC 402. Contra Costa County, Calif. Neroly Sandstone, Miocene.

Comparison.—"This species differs from *Mytilus coalingensis* Arnold in being more slender, not so broad posteriorly; the beaks are not twisted; the surface is not so high or convex, the anterior slope not being so high but possibly steeper." (Clark, 1915, p. 458)

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Cierbo (Hall, 1960), Neroly (Hall, 1960), and Orinda (Richey, 1943) Formations.

Mytilus (Crenomytilus) kewi Nomland

Plate 15, figure 4

Mytilus kewi Nomland, 1916, p. 206, pl. 9, fig. 1. Not *Mytilus kewi* Wiedey, 1929, p. 281, pl. 31, fig. 2 [=*Mytilus loeli* Grant, 1930, p. 419].

Crenomytilus kewi (Nomland). Soot-Ryen, 1955, p. 23.

Original description.—"Shell elongate ovate, of moderate thickness. Surface sculptured by numerous unequal incremental lines and minute radiating striae. A wide depressed area passes from slightly above the beak to about middle of base. Beak terminal, somewhat curved. Posterior end regularly rounded. Posterior dorsal margin slightly arcuate, with small angulation a little more than one-half of the distance from the beaks to the anterior end. Base straight except slight arch where it meets the depressed area. Dimensions of type, which is a small specimen: length, 86 mm.; height, 45 mm.; maximum diameter, 34 mm."

Holotype.—UCMP 12061.

Type locality.—UC 2680. Fresno County, Calif. Etchegoin Formation, Miocene and Pliocene.

Comparison.—"This species seems to be rather closely allied to *Mytilus expansus* Arnold***. *M. expansus* Arnold has, however, a broader posterior outline and the depressed area is not as well marked. *M. kewi**** differs from *M. coalingensis* Arnold*** by being smaller, having less acute and not as much thickened beak, and in the depression extending from beak to basal margin."

(Nomland, 1916)

Geographic range.—Japan, Sakhalin, and Kamchatka; middle and southern California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Miocene: Santa Margarita Formation (Grant and Gale, 1931; Adegoke, 1969); Miocene and Pliocene: Etchegoin Formation (Wilson, 1944; Adegoke, 1969).

Mytilus (Crenomytilus) coalingensis Arnold

Plate 15, figures 1-3

Mytilus (Mytiloconcha) coalingensis Arnold, 1909, p. 73, pl. 19, fig. 5, pl. 22, fig. 6. Grant and Gale, 1931, p. 246 [See for synonymy].

Mytilus coalingensis Arnold. Stewart, 1940, p. 90, pl. 32, figs. 3, 4.

Crenomytilus coalingensis (Arnold). Soot-Ryen, 1955, p. 23.

Original description.—"Shell attaining an enormous size over 200 millimeters in length, elongate-ovate in outline, falcate toward beaks, gibbous, equivalve; surface comparatively smooth; shell moderately thick; beaks prominent, terminal, acute, curved sharply forward; posterior margin gently and regularly curved except for a faint suggestion of an angle a little above middle; base only very slightly curved; anterior margin gently and regularly concave; surface convex, the angle or region of greatest convexity being somewhat anterior to the middle of the shell, thus causing the anterior slope of the surface to be much steeper than the posterior; surface sculptured by numerous fine lines of growth, radiating striae, and more or less conspicuous concentric irregularities. Apical region thickened, extended; cardinal area exceedingly long, its width being two-thirds of its length, and carrying two ridges on the left valve and one on the right, each ridge representing teeth in the younger stages of growth; hinge area concentrically and radially sculptured; a deep triangular, longitudinally sulcated pit occupies the space immediately back of the ridged hinge area; a well-defined groove on the interior of the shell corresponds to the angle on the surface."

Holotype.—USNM 165551.

Type locality.—USGS 4656. Fresno County, Calif. Etchegoin Formation, Miocene and Pliocene.

Supplementary description.—"Fine transverse rows of pustules on the exterior of the anterior ventral end of *M. coalingensis* ***suggest that the inner margin of the valves of that species is crenulated." (Hertlein and Grant, 1972, p. 163)

Comparison.—"This magnificent species is easily recognized by its elongate falcate and longitudinally grooved and ridged apical region, where this is visible. It is closely allied to the type of the subgenus, *M. (M.) incurvus* Conrad***but may be distinguished from the latter by its greater size, broader outline, and prominent muscle pit just anterior to the beaks***. *M (M.) coalingensis* is broader and more falcate toward the beaks than *Mytilus mathewsonii* Gabb***, is relatively narrower and more falcate than *M. mathewsonii* var. *expansus* Arnold***, and lacks the corrugations of *M. californicus* Conrad***." (Arnold, 1909, p. 73)

"Specimens of *M. coalingensis* are as large as the living *M. californianus* Conrad but may be distinguished from the living species by the thicker hinge plate and by the absence of radiating ridges. The nearest living relative of *M. coalingensis* seems to be the large Japanese species *M. crassitesta* Lischke***, which, however, does not have so thick a hinge plate and the teeth of large specimens of which are more distinctly formed. Specific criteria distinguishing *M. coalingensis* from the many California Miocene forms that have been named have not yet been worked out." (Stewart, 1940, p. 90)

Geographic range.—Kamchatka; middle to southern California.

Geologic range.—Miocene to Pleistocene.

Occurrence in California.—Miocene: Castaic (Stanton, 1966) and Pancho Rico (Durham and Addicott, 1965) Formations; Miocene and Pliocene: Etchegoin (Arnold, 1906; Adegoke, 1969) and Towsley (Kern, 1973) Formations; Pliocene: Niguel (Vedder, 1960) and San Joaquin Formations (Woodring and others, 1940); Pliocene and Pleistocene: Fernando (Zinsmeister, 1970) and Merced (Martin, 1916; Yancey, 1978) Formations.

Mytilus (Crenomytilus) sternbergi Hertlein and Grant

Plate 16, figure 1

Mytilus (Crenomytilus) coalingensis sternbergi Hertlein and Grant, 1972, p. 163-164, pl. 41, figs. 10, 14 [See for synonymy].

Original description.—"Shell large, resembling *Mytilus coalingenesis* in general shape and trace of the line of growth. It differs from that species in that the valves are less convex. Dimensions: length, 238 mm, width, 134 mm, convexity near the umbonal area, 59 mm."

Holotype.—LAM 4470.

Type locality.—LAM 107. San Diego County, Calif. San Diego Formation, Pliocene.

Supplementary description.—"The presence of a large anterior adductor impression on some of the present specimens is similar to that on the type species of *Crenomytilus*. Minute crenulations on the anterior ventral margin, characteristic of *Crenomytilus* are not visible on our specimens." (Hertlein and Grant, 1972, p. 163)

Comparison.—"The shell of *Mytilus coalingensis sternbergi* is broader posteriorly and it is more curved toward the beaks than is that of *M. mathewsoni* Gabb***. The anterior ventral margin of the new subspecies is more curved than that of *M. mathewsonii expansus* Arnold***and *Mytilus kewi* Nomland***. *Mytilus schencki* Hanna and Hertlein*** is very much more broadly expanded posteriorly." (Hertlein and Grant, 1972, p. 164)

Geographic range.—Southern California to Baja California Norte.

Geologic range.—Pliocene.

Occurrence in California and Baja California.—Careaga Sandstone, Foxen Mudstone, and Niguel Formation (Vedder, 1960); San Diego Formation (Hertlein and Grant, 1972) and unnamed Pliocene strata between Ensenada and San Quintin, Baja California Norte (Hertlein and Grant, 1972).

Subgenus CRENOMYTILUS?

Mytilus (Crenomytilus?) schencki G D. Hanna and Hertlein

Plate 16, figure 2

Mytilus schencki G D. Hanna and Hertlein, 1938, p. 106, pl. 21, fig. 11.

Original description.—"Shell rather flat with the anterior part somewhat constricted, curved, but very broadly rounded and expanded posteriorly. Length (incomplete), about 138 mm."

Holotype.—CAS 4686.

Type locality.—In the southwest corner of the NW¼SW¼ sec. 23, T. 23 S., R. 13 E., Mount Diablo Base and Meridian, San Miguel quadrangle, Monterey County, Calif. Santa Margarita(?) Formation, Miocene.

Comparison.—"The broad expanded posterior part of this species is quite distinct from any of the described species from western

America, such as *M. expansus* Arnold*** and *M. loeli* Grant*** from the Vaqueros of California. Arnold's species bears a decided resemblance to *M. aquitanicus* Mayer***. Somewhat the same general shape of the new species seems to be indicated in the figure of the type of *M. vancouverensis* Clark and Arnold*** but it appears to be much less expanded." (Hanna and Hertlein, 1938, p. 106)

Supplementary description.—"*Mytilus schencki**** is probably referable to the subgenus *Crenomytilus* but we have not seen specimens in which uneroded margins could be observed." (Hertlein and Grant, 1972, p. 163)

Geographic range.—Middle to southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Temblor Formation of Page and others (1951); Miocene: Santa Margarita(?) Formation.

Mytilus (Crenomytilus?) perrini Clark

Plate 14, figures 4, 5

Mytilus perrini Clark, 1915, p. 456-457, pl. 42, figs. 5, 6.

Original description.—"Shell medium in size, somewhat variable in outline, elongate subovate; beaks subactue, slightly twisted; base straight or slightly concave. Posterior cardinal angle as a rule slightly anterior to the middle of the elongate axis, the angle being obscured on some of the larger specimens, the margin posterior to the point of angulation being nearly straight and parallel or slightly diverging from the anterior edge. Ventral edge broadly rounded to subtruncate. Surface of shell covered by heavy irregular undulations with finer incremental lines. Anterior slope of surface fairly abrupt; posterior slope gentle. There is a tendency for the surface of the shell to be depressed and flattened just in front of the posterior dorsal edge. Hinge plate heavy below the beak; on some specimens the thickened hinge plate resembles somewhat the myaphoric septum of a *Septifer* or *Dreissensia*; the anterior edge of the smaller specimens is denticulate immediately below the beaks; on the smaller specimen figured at least ten of these minute teeth may be counted. Ligamental groove broad and fairly heavy; anterior adductor scar long and narrow."

Holotype.—UCMP 11548.

Type locality.—UC 1617. Contra Costa County, Calif. Neroly Sandstone, Miocene.

Comparison.—"*M.* perrini***.differs from *M. mathewsonii* Gabb in that the latter is a larger form; the general outlines of the two shells are different; the highest point of convexity on the surface of *M. mathewsonii* Gabb is near the middle of the shell, on *M. perrini* it is in front of the middle; further, the posterior slopes of *M. mathewsonii* Gabb are steeper than on *M. perrini*. *M. perrini* ***resembles *M. californicus* Conrad in the fairly coarse concentric undulations; it lacks the heavy radial sculpture of *M. californicus*; the hinge plate and outline are also quite different. *M. perrini* differs from *M. expansus* Arnold***in that it is a smaller form; the posterior dorsal margin is shorter; the surface lacks the fine radiating striae seen on *M. expansus* Arnold. In other respects the two forms seem to be quite similar; both have a broad, subtruncate ventral edge and usually a straight base, the anterior slope of the surface being quite abrupt, with the highest point of convexity well in front of the middle of the shell." (Clark, 1915, p. 457)

Comments.—On the basis of Clark's statement (1915, p. 456) that the anterior edge below the beak is denticulate on small specimens of this species, it is tentatively assigned to *Crenomytilus*.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California—Briones (Weaver, 1953) and Neroly Sandstones.

Subgenus PLICATOMYTILUS Allison and Addicott, 1976

Geographic range.—Kamchatka, USSR, Alaska Peninsula, and Kodiak Island, Alaska, to middle California.

Geologic range.—Oligocene(?); Miocene (table 5).

Original 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 rectractor 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***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."

Mytilus (Plicatomytilus) middendorffi Grewingk

Plate 16, figures 3-6

Mytilus middendorffi Grewingk, 1850, p. 360-361, pl. 7, figs. 3a-c. Addicott, 1974, p. 355, figs. 1, 2.

Mytilus (Plicatomytilus) middendorffi Grewingk. Allison and Addicott, 1976, p. 3-9, pl. 1, figs. 1-10; pl. 3, figs. 2, 4, 6 [See for synonymy].

Original description.—"Testa subrhomboidali, tumida; valva altera plicis radialibus late et profunda plicato-sulcata; sulco maximo totam fere tumiditalis carinam summan concomitante, paullatim increscente et denique in ultimum marginem ventralem ob plicas hasce valde sinuatum, exeunte; sulcis reqliquis duobus multo minoribis, submarginalibus in ultimum marginem dorsalem, rectiusculum excurrentibus; valva altera obsoletissime plicato-sulcata."

Holotype.—Missing.

Type locality.—Probably at Narrow Cape, Kodiak Island, Alaska. Narrow Cape(?) Formation, Oligocene(?) and Miocene (Allison and Addicott, 1976, p. 5).

Supplementary description.—"*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***. 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.

"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." (Allison and Addicott, 1976, p. 4, 5)

Comparison.—Mytilus (Plicatomytilus) gratacapi Allison and Addicott (1976), described from the Bear Lake Formation, Alaska, "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." (Allison and Addicott, 1976, p. 11-12)

Geographic range.—Alaska to middle California.

Geologic range.—Oligocene(?); Miocene.

Occurrence in California.—Oursan and Sobrante Sandstones, and upper part of the Temblor Formation (Allison and Addicott, 1976, p. 6-7).

Genus BRACHIDONTES Swainson, 1840

Mytiliform, beaks terminal or nearly so; radially sculptured with bifurcating ribs.

Geologic range.—Jurassic through Holocene (table 5).

Subgenus BRACHIDONTES

Umbones subterminal, radial sculpture on ventral part simple or regularly bifurcating.

Habitat.—Intertidal on rocks and pilings to 30 m; some forms prefer slightly brackish water; both epifaunal and infaunal; some species with weak byssal attachment, partly or entirely buried in soft sediment; some species gregarious.

Brachidontes (Brachidontes) cowlitzensis (Weaver and Palmer)

Plate 17, figure 1

Modiolus (Brachydontes) cowlitzensis Weaver and Palmer, 1922, p. 16-17, pl. 9, fig. 9.

Brachidontes cowlitzensis? (Weaver and Palmer). Stewart, 1930, p. 100-104, pl. 8, fig. 12 (See for synonymy].

Brachidontes (Brachidontes) cowlitzensis (Weaver and Palmer). Givens, 1974, p. 43.

Volsella (Brachidontes) cowlitzensis (Weaver and Palmer). Weaver, 1942, p. 113-114, pl. 26, fig. 4.

Modiola ornata Gabb, 1864, p. 184, 234, pl. 24, fig. 166. Not *Mytilus ornatus* Orbigny, 1843.

Original description..—"Shell medium in size; subovate in outline; dorsal line straight, curving regularly into the posterior end which extends almost vertically downward; posterior end broad and inflated; anterior end short; beaks low; umbonal slope prominent and arching downward, convex above with a prominent concavity beneath; surface ornamented with radiating ribs which over the posterior and umbonal regions are large and flat with narrow interspaces; on the middle portion of the shell the ribs are very fine and delicate; on the anterior end of the shell, there are five or six radiating ribs which are enlarged with wide spaces between, the interspaces equal to the width of the ribs; cardinal margin denticulate, the series of teeth are larger on the anterior margin, diminishing in size beneath the beaks and becoming obscure on the posterior end; shell very thin and fragile. Dimensions.—Length 15 mm.; thickness, 7 mm." (Weaver and Palmer, 1922)

"Shell thin, broad, deep; beaks small, anterior, subterminal; anterior end narrow, rounded, produced; cardinal margin nearly straight, uniting by a broad curve with the posterior extremity; anterior basal edge broadly emarginate; umbonal ridge prominent, rounded, curved downwards and widening out posteriorly, until it becomes lost in the general swell of the surface. In advance of this the surface is gently concave; behind, it is nearly flat. Surface marked by numerous, fine dichotomous ribs, except on a small space under the beaks, where they sometimes become obsolete. Internal edge minutely crenulated. Figure, natural size, from an unusually large specimen. Generally from an inch to an inch and a quarter long." (Gabb, 1864)

Holotype.—CAS 7406. Lectotype of *Modiola ornata* Gabb, ANSP 4450, Stewart, 1930.

Type locality.—UW 329. Lewis County, Wash. Cowlitz Formation, Eocene.

Supplementary description.—"This species may be distinguished by its sharp umbonal ridge which is sharply deflected downward with less than one-fifth of the area of the surface of the shell beneath the ridge and the area above only very slightly swelled. The radial ribs are more marked above the umbonal ridge than below it." (Weaver, 1942, p. 113-114)

Comments.—A specimen from the Cowlitz Formation, when cleaned, showed no shelf in the umbonal cavity. Therefore, this species is indeed a *Brachidontes*.

Geographic range.—Washington to southern California.

Geologic range.—Paleocene to Oligocene.

Occurrence in California.—Paleocene: Martinez (Weaver, 1949) and Meganos (Clark, 1921) Formations; Eocene: Delmar (Hanna,

1927), Domengine (Clark and Woodford, 1927), Juncal, and Matilija (*Ectinochilus supraplicatus* and *E. canalifer* faunas, Givens, 1974) Formations, Poway Group (Hanna, 1927), and Tejon Formation (Anderson and Hanna, 1925); Eocene and Oligocene: Gaviota Formation (*Turritella variata lorenzana* zone, Weaver and Kleinpell, 1963).

Brachidontes (Brachidontes) cooperi Moore, new name

Plate 18, figure 8

Mytilus dichotomus Cooper, 1894, p. 49, pl. 5, fig. 64. Vokes, 1939, p. 58-59, pl. 3, fig. 14. Weaver, 1942, p. 107-108, pl. 23, fig. 14; pl. 26, fig. 10. Not *Septifer dichotomus* Gabb, 1864.

Septifer dichotomus Cooper. Stewart, 1946, tbl. 1 [in pocket].

Original description.—"Very similar to '*Septifer dichotomus*' Gabb, but without any trace of a septum inside the beaks. Outside also sculptured, as in *Modiola ornata* Gabb, and in several Tertiary or living species of this family. (Unfortunately the umbonal end of the specimen figured was broken off after it was arranged for drawing.) I illustrate this shell to show that such a *Mytilus* existed in the latest stage of the California coal-epoch, with a strong suspicion that it has already one or two names. Gabb's *Septifer* was described from one young specimen found at Tejon, very nearly in the same strata, and it is not unlikely that he was mistaken in the general character, but if proved correct the specific name suits this species as well. There is also Conrad's *Mytilus inezensis*, assigned to the Miocene Tertiary, which *prima facie* seems most probable, though there is some room for doubt. This has not lately been confirmed among large numbers of Miocene fossils handled by me, and if found in the Miocene will probably be found to be living *M. bifurcatus*, which also has its *Septifer bifurcatus* coexisting. In doubt as to the true value of the slight distinction between the two genera, I leave their correct names to be decided by future discoveries."

Holotype.—CAS 613.

Type locality.—California Coal Mine, near Huron [N½ sec. 16, T. 20 S., R. 17 E.], Fresno County, Calif. Domengine Formation, Eocene.

Supplementary description.—"This species is small, moderately inflated with a nearly straight ventral margin. The dorsal margin is strongly convex with a tendency to angulation about two-fifths the length of the shell from the anterior end. The posterior end is narrow, nearly straight, and forms rough angular junctions with both dorsal and ventral margins. The greatest thickness of the valves is attained about one-third the length of the shell from the anterior end. The radial sculpture is well marked and exhibits dichotomous branching on the posterior part of the shell." (Weaver, 1942, p. 107-108)

Comparison.—"A specimen in the collections of the University of California labelled *Septifer dichotomus* Gabb from the Tejon agrees with the original figure in size and shape and is presumably the holotype of that species. It is certainly a *Septifer*, and the form described by Cooper is distinct and differs from Gabb's species in having much finer sculpturing." (Vokes, 1939, p. 58)

Comments.—On the basis of Cooper's statement that this species has no septum inside the beaks, it is here assigned to *Brachidontes*.

Geographic range.—Washington to southern California.

Geologic range.—Eocene.

Occurrence in California.—Avenal Sandstone (Stewart, 1946), Domengine (Keen and Bentson, 1944), and Tejon (Anderson and Hanna, 1952) Formations.

Genus BRACHIDONTES?

Subgenus BRACHIDONTES?

Brachidontes (Brachidontes?) susanaensis (Nelson)

Plate 17, figure 2

Septifer susanaensis Nelson, 1925, p. 409, pl. 49, fig. 10

Original description.—"Shell small; beaks inconspicuous, terminal, semigyrate. Angle of margins at beaks about 50°. Base slightly concave; posterior dorsal edge almost straight for a trifle less than half the length of shell, posterior to which the edge is arcuate and approximately parallel to base; posterior extremity rounded with maximum curvature at junction with base. Rounded umbonal ridge extends from beaks to base of posterior extremity, most prominent near beaks. Posterior slope broad; anterior slope very steep. Surface of shell ornamented by about 40 radiating ribs. Many of these merge into a single rib near the beaks while some are bifid near the edge of the shell. Posterior edge internally crenulated. Length of type specimen, 8 mm.; width, 4 mm.; diameter of one valve, about 2.5 mm."

Holotype.—UCMP 30501.

Type locality.—UC 3776. Ventura County, Calif. Martinez Formation, Paleocene.

Comparison.—*Septifer elegans* Waring is less curved than "*Septifer*" *susanaensis* and differs somewhat in sculpture (Nelson, 1925, p. 409).

Comments.—*Brachidontes? altiobliquus* is somewhat more produced at the anterior dorsal margin and has a higher umbonal ridge and deeper ventral concavity than *B.? susanaensis*. These characters may not be sufficient to separate the two species. The radial ribs on *B.? susanaensis* are of almost equal width over the entire shell, which presumably distinguishes it from *B. cowlitzensis*.

Geographic range.—Southern California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Brachidontes? (Brachidontes?) altiobliquus (Nelson)

Plate 17, figures 3, 4

Modiolus altiobliquus Nelson, 1925, p. 408, pl. 49, fig. 5.

Original description.—"Shell small, subtrigonal; beaks inconspicuous. Posterior dorsal margin straight; posterior angle well developed, about halfway between beak and posterior extremity; posterior extremity broadly arcuate; basal margin regularly concave. Surface of shell with well-marked, rather sharp umbonal angulation extending in an almost straight line from beaks to juncture of posterior and ventral margins; posterior slope broad, gentle; anterior slope abrupt, slightly concave. Surface of shell ornamented by numerous small radiating ribs extending entire length of shell; ribs less conspicuous below umbonal angulation. Length of the type specimen, normal to dorsal margin, 13.2 mm.; length of dorsal margin 11.2 mm.; diameter of one valve, about 4.2 mm."

Holotype.—UCMP 30587.

Type locality.—UC 3809. Ventura County, Calif. Martinez Formation, Paleocene.

Comments.—This form has somewhat more prominent ribs along the ventral margin than *B. cowlitzensis* and is not as widely expanded on the posterior side. I do not know if the range in variation of *B. cowlitzensis* is sufficient to include this form, nor do I know if it is a *Brachidontes* or a *Septifer*.

Geographic range.—Southern California.
Geologic range.—Paleocene.
Occurrence in California.—Martinez Formation.

Brachidontes? (Brachidontes?) lawsoni (Nelson)

Plate 17, figure 5

Modiolus lawsoni Nelson, 1925, p. 408, pl. 50, figs. 3, 4.
Brachidontes lawsoni (Nelson). Keen and Bentson, 1944, p. 68.

Original description.—"Shell narrow, elongate, crescent-shaped rather high; beak almost terminal. Dorsal margin short, slightly convex; posterior lateral margin broadly arcuate, merging into a narrow, convex, subtruncate posterior extremity; base concave, with sharply reversed curvature at juncture with posterior extremity. Shell with prominent rounded umbonal ridge rising abruptly from beaks, curving backward and downward to juncture of posterior and basal margins, pinched at beaks, widening slightly posteriorly. Shell regularly rounded above and posterior to umbonal ridge; area below umbonal angulation steeply sloping, with a decrease in slope in anterior third above a line between beak and umbonal ridge. Surface of shell ornamented by numerous radiating ribs, uniform spacing of ribs maintained by insertion of new ribs as margin of shell is approached. Internal margin crenulated. Greatest length of type specimen (posterior extremity reconstructed from cotype 30652), 26.5 mm.; greatest width, 10.5 mm.; diameter of single valve, about 6 mm."

Holotype.—UCMP 30651.

Type locality.—UC 4004. Ventura County, Calif. Martinez Formation, Paleocene.

Comparison.—The almost terminal position of the beak of *B. lawsoni* is enough to separate it from *B. cowlitzensis*, which is also much wider. (Nelson, 1925, p. 408)

Comments.—The range in variation of *B. cowlitzensis* may be sufficient to include this form.

Geographic range.—Southern California.
Geologic range.—Paleocene.
Occurrence in California.—Lower part of the Lodo (Smith, 1975) and Martinez Formations.

Brachidontes? (Brachidontes?) dichotomus (Gabb)

Plate 17, figures 6, 7

Septifer dichotomus Gabb, 1864, p. 186, pl. 30, fig. 261. Arnold, 1909, p. 106, pl. 2, fig. 3. Anderson and Hanna, 1925, p. 187-188, pl. 1, fig. 2. Weaver, 1942, p. 115, pl. 25, fig. 6.

Original description.—"Shell small, oblique, subquadrate; cardinal margin straight, anterior and posterior margins subparallel, basal irregularly convex; anterior side abruptly truncated at an acute angle to the rest of the surface. Surface marked, posterior to this angle by a few large, irregular, radiating ribs, dichotomous, or with smaller ones interpolate."

Holotype.—UCMP 11993.

Type locality.—Fort Tejon, Tejon quadrangle, Kern County, Calif. Tejon Formation, Eocene.

Comments.—On the basis of the placement of the keel and the large radiating ribs, this species is assigned to *Brachidontes*?; the diagnostic internal characters are not exposed on the holotype.

Geographic range.—Washington; southern California.
Geologic range.—Eocene.
Occurrence in California.—Avenal Sandstone (Stewart, 1946) and Tejon Formation.

Brachidontes? (Brachidontes?) kirkerensis (Clark)

Plate 17, figure 9

Modiolus kirkerensis Clark, 1918, p. 133, pl. 9, fig. 8.

Original description.—"Shell medium in size; base straight or nearly so, on some specimens being slightly concave; anterior end rather strongly produced; posterior margin angulated back of middle of shell; posterior to this margin slopes in rather obliquely to the posterior end, which is regularly rounded but not very wide. Umbones prominent; umbonal ridge distinct but not extending to the posterior end of the shell. Surface rather acutely arched in the anterior third of the shell but gently rounded near the posterior end; anterior slope steep, slightly excavated in front of the umbonal ridge. Posterior slope not so steep as anterior; in the vicinity of the posterior angle, the surface is depressed or flattened, giving the shell an alate appearance similar to that seen on *Modiolus rectus* Conrad, a common Recent West Coast species. Surface, except for an elongate, smooth, triangular space between the base and the umbonal ridge, sculptured by numerous fine radiating dichotomous ribs, with interspaces averaging less than the width of the ribs. The dichotomous character of the ribbing is more marked toward the posterior margin."

Holotype.—UCMP 11121.

Type locality.—UC 3081. Contra Costa County, Calif. San Ramon Sandstone, Miocene(?).

Comparison.—"*M. multiradiatus* differs quite decidedly from *M. kirkensis*, both in outline and sculpturing; the anterior end is not produced as strongly as that of *M. kirkerensis* and there is no well-marked posterior angle; also the sculpturing is much coarser." (Clark, 1918, p. 133)

Geographic range.—Middle California.
Geologic range.—Miocene(?).
Occurrence in California.—San Ramon Sandstone (Weaver, 1953).

Subgenus SCOLIMYTILUS Olsson, 1961

Original descrption.—"Shell small, mytiliform or modioliform, the beaks placed almost terminal, the valves elongated with the longer, oblique axis lying along the convex or sharply arched umbonal slope, the ventral side commonly flattened or deeply impressed. The surface sculpture is formed by radial riblets which may be weak or coarse. The posterior adductor scar is fused with that of the retractor and with a part of the pallial impression forming a single, large, lobate-shaped or ribbon-like band within the posterior margin. Ligament, as in *Hormomya*, is nearly as long as the posterior-dorsal margin. Hinge with one to three, fairly large, strong, dysodont teeth under the beak. The valve margin is crenulated throughout except for a short space along the impressed ventral side where the fluting of the riblets is weak or obsolete."

Type species.—*Modiolus* (*Brachydontes*) *playasensis* Pilsbry and Olsson.

Geographic range.—California? to Peru.
Geologic range.—Paleocene(?) to Miocene(?); Holocene (table 5).

Subgenus SCOLIMYTILUS?

The forms here assigned to *Scolimytilus*? resemble that subgenus externally, but the internal shell characters of the fossil forms are not know.

Brachidontes? (Scolimytilus?) multiradiatus (Gabb)

Plate 17, figure 12, 17

Modiola multiradiata Gabb, 1866, p. 30, pl. 8, fig. 52.
Mytilus(?) *multiradiatus* (Gabb). Stewart, 1930, p. 96-97, pl. 14, fig. 3.

Original description.—"Shell moderate in size, variable in form, more or less curved; cardinal margin arched; posterior curved and descending more or less abruptly; anterior margin sinuated, more or less deeply excavated; beaks very small, subterminal. Surface marked by numerous fine radiating lines except on the anterior fourth, which is only marked by lines of growth."

Holotype.—ANSP 4482.

Type locality.—Martinez, Contra Costa County, Calif. Martinez Formation, Paleocene.

Supplementary description.—"The radial ribs are not well-preserved [on holotype]. They are absent and probably never were present on the anterior portion of the shell and they become very fine posteriorly and were apparently not developed on the posterior dorsal region***. The umbones and anterior ends of this specimen are too poorly preserved to permit an exact identification but teeth, suggesting *Mytilus*, are evident on the right valve and while the radial ribs suggest *Brachidontes*, they do not meet the dorsal posterior border at an angle as on that genus." (Stewart, 1930, p. 97)

Comments.—The right valve has heavy, slightly nodose ribs on the ventral half and much finer, somewhat nodose ribs on the dorsal half. The left valve has moderately heavy ribs on the mid-posterior region with much finer ribs closer to the ventral margin. Although no posterior ligamental teeth are visible on the exposed inner shell of the holotype, externally it resembles the subgenus *Scolimytilus*.

Geographic range.—Middle California.

Geologic range.—Paleocene to Oligocene.

Occurrence in California.—Paleocene: Martinez Formation; Eocene and Oligocene: San Emigdio and Pleito Formations, undifferentiated (Hammond, 1958).

Brachidontes? (Scolimytilus?) margaritana Nomland

Plate 17, figure 13

Septifer margaritana Nomland, 1917, p. 308-309, pl. 19, fig. 5.
Septifer margaritanus Nomland. Grant and Gale, 1931, p. 248.

Original description.—"Shell long, cuneate, rather thick; beaks pointed, terminal; with well-developed umbonal ridge extending to posterior ventral margin. Anterior dorsal margin slightly concave; posterior dorsal margin regularly convex; posterior end evenly rounded; ventral margin a little concave at middle but becoming convex about one-third of length of shell from anterior end. Surface ornamented by a large number of fine radiating ridges and well-developed growth lines. Dimensions: Length, 52 mm.; height, 22."

Holotype.—UCMP 11310.

Type locality.—UC 2276. Fresno County, Calif. Santa Margarita Formation, Miocene.

Comparison.—"This species is much larger than the Recent *Septifer bifurcatus* Conrad, the radiating ridges are more numerous, and the umbonal ridge is more marked." (Nomland, 1917, p. 309)

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Santa Margarita Formation.

Brachidontes? (Scolimytilus?) subconvexus (Trask)

Plate 17, figure 14

Modiolus gabbi subconvexus Trask, 1922, p. 149, pl. 3, fig. 2.

Original description.—"Shell very similar to *M. gabbi* Clark***but differs from the latter in that the umbonal ridge is less prominent; the shell is more convex, narrow, and tumid; the striations are slightly narrower and less prominent; and on the posterior slope the striations become much finer, closer together and more numerous."

Holotype.—UCMP 12372.

Type locality.—UC 793. [No locality data available. Trask (1922, p. 149) says that it is a common species in the Briones Formation.]

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Briones Sandstone.

Subgenus AEIDIMYTILUS Olsson, 1961

Original description.—"Shell small, mytiliform with ribbed sculpture, usually divided, the ribs on the posterior-dorsal side of the umbonal ridge much coarser. Ventral side usually strongly impressed resulting in a high, angular umbonal ridge and often a distorted appearance to the whole shell. Adductor and pallial impressions united, but smaller and narrower than in *Scolimytilus*."

Type species.—*Mytilus adamsiana* Dunker.

Geologic range.—Miocene through Holocene (table 5).

Habitat.—In temperate and tropical seas, predominantly intertidal; reported to a depth of 90 m.

Comments.—This genus was omitted by Soot-Ryen (1969) and was placed in synonymy with *Brachidontes* by Keen (1971). *Aeidimytilus* was used by Hertlein and Grant (1972) and seems to me, on the basis of external shell characters only, to be a useful category. Admitting that the classification of the mytilids needs to be resolved on the basis of soft-part anatomy and internal shell characters also, I feel that since these forms are different in external shell characters, they should be separated.

Brachidontes (Aeidimytilus) gabbi (Clark)

Plate 17, figure 8

Modiolus gabbi Clark, 1915, p. 458-459, pl. 48, fig. 1.

Original description.—"Shell medium to large, elongate, anterior end extending only slightly beyond the beak. Posterior dorsal edge subangulate posterior to the midlength of the valve. Base nearly straight with a tendency to concavity; posterior end evenly rounded. Surface sculptured by rather broad, flat-topped, dichotomous ribbing, except for an elongate, smooth, subtriangular space above the base near the anterior end; the dichotomous ribbing is more marked toward the posterior margin, while anteriorly the ribs are split only at their lower ends; interspaces slightly narrower than the tops or the ribs. Surface quite strongly convex, usually with a well-defined ridge marking the line of greater convexity extending from the beak toward the basal side of the posterior extremity; on the larger specimens this ridge is not so pronounced, the surface being more evenly rounded."

Holotype.—UCMP 11550.

Type locality.—UC 2040. Contra Costa County, Calif. San Pablo Group, Miocene.

Comparison.—"The radial ribbing on *M. multiradiatus* is much finer and closer together than on *M. gabbi*; also, on the former the anterior and extends much further beyond the beak than on the latter." (Clark, 1915, p. 459)

Geographic range.—Middle California.
Geologic range.—Miocene.
Occurrence in California.—Cierbo (Hall, 1958) and Neroly Sandstones (Weaver, 1949; Hall, 1958).

Brachidontes (Aeidimytilus) adamsianus (Dunker)

Plate 17, figures 10, 11

Mytilus adamsianus Dunker, 1856, p. 360.
Aeidimytilus adamsianus (Dunker). Hertlein and Grant, 1972, p. 164-165, pl. 42, figs. 4, 5 [See for synonymy].
Original description.—"M. testa ovato-trigona, utrinque obtuse carinata, solidula, costis mature bifidis eleganter granosis sculpta, fusco-purpurascente et albida; epidermide cornea vestita; umbonibus terminalibus; margine crenato."
Holotype.—Type lot in British Museum (Hertlein and Grant, 1972, p. 164).
Type locality.—Isthmus of Panama, Holocene.
Supplementary description.—"The beaks are small and nearly terminal and the umbonal ridge is high. The ribbing and general shell characters of the present valves agree exactly with specimens from west Mexico and Central America. The ribs on typical specimens of *Aeidimytilus adamsianus* are coarse on the dorsal area; they increase posteriorly by divarication or by addition. They are granulated as a result of successive step-like resting stages. The ribs on the ventral area are much finer. The dorsal area is brownish purple, the ventral area yellowish white. Interiorly the dorsal margin above the ligamental groove is strongly crenulated. The external appearance of this shell is remarkably similar to that of *Septifer bifurcatus*. Some specimens are sculptured with fine ribs but such forms agree in all other shell characters with the coarsely ribbed ones." (Hertlein and Grant, 1972, p. 165)
Geographic range.—Living: Santa Barbara, Calif., to Puerto Callo, Ecuador, and the Galapagos Islands; fossil: southern California.
Geologic range.—Pliocene through Holocene.
Occurrence in California.—Pliocene: San Diego Formation (Hertlein and Grant, 1972).

Genus MYTELLA Soot-Ryen, 1955

Mytiliform to modioliform or elongate; smooth or concentrically striated, rarely finely striated radially.
Geographic range.—Western North America to South America.
Geologic range.—Eocene through Holocene (table 5).

Mytella inezensis (Conrad)

Plate 17, figures 15, 16

Mytilus inezensis Conrad, 1857c, p. 194, pl. 8, figs. 2, 3. Woodring, 1931b, p. 380.
Mytella inezensis (Conrad). Soot-Ryen, 1955, p. 48
Original description.—"Subovate-oblong? ventricose anteriorly; compressed posteriorly ; ribs radiating, numerous, bifurcated, and trifurcated near the inferior margins."
Syntype.—USNM 13319 (Woodring, 1931b).
Type locality.—Santa Ynez Mountains and Santa Ynez River, Santa Barbara County, Calif. Gaviota Formation, Eocene and Oligocene.
Geographic range.—Southern California.
Geologic range.—Eocene and Oligocene.
Occurrence in California.—Eocene and Oligocene: Gaviota Formation of Keen and Bentson (1944).

Genus PERNA Retzius, 1788

Like *Mytilus* but without anterior adductor except in young specimens; surface and margins smooth.
Geologic range.—Eocene through Holocene (table 5).

Subgenus PERNA

Resilial ridge pitted, posterior retractor scars widely separated.
Habitat.—In tropic and subtropic seas.

Perna (Perna) montana Conrad

Plate 18, figure 4

Perna montana Conrad, 1857c, p. 195 [unfigured]. [Reprinted in Dall, 1909, p. 184.]
Original description.—"Elevated, anterior margin nearly straight; hinge line slightly incurved."
Holotype.—USNM 13329.
Type locality.—Santa Buenaventura, Santa Barbara County [Ventura, Ventura County], Calif. Formation and age unknown. [From the Eocene to Miocene sequence of the eastern Santa Ynez Mountains; presumably from the Miocene as stated by Conrad (1857c, p. 189).]
Supplementary description.—"An imperfect cast, about 4½ inches [11 cm] in height, allied to *P. marillata* of Virginia, from which it differs in having a straighter front and incurved cardinal margin." (Conrad, 1857c, p. 195)
Geographic range.—Southern California.
Geologic range.—Not known. Miocene?.
Occurrence in California.—Formation unknown.

Genus SEPTIFER Récluz, 1848

Externally similar to *Brachidontes* (*Brachidontes*), anterior adductor placed on internal septum beneath beaks.
Geologic range.—Triassic through Holocene (table 5).
Habitat.—In tropic and subtropic seas; from intertidal zone to about 55 m; attached by byssus; found on boulders at low tide.

Subgenus SEPTIFER

Radial sculpture strong, margins crenulated.

Septifer (Septifer) elegans Waring

Plate 18, figure 11

Septifer elegans Waring, 1917, p. 79, pl. 14, fig. 2.
Original description.—"Shell small, oblique, subquadrate; cardinal margin straight, anterior and posterior submargins subparallel, base irregularly convex; anterior side abruptly truncated, at an acute angle, to rest of surface; surface marked, posterior to this angle, by many fine radiating ribs. This species differs from *S. dichotomus* Gabb in having fine radial sculpture."
Neotype.—Here designated as CAS/SU 322. In the Stanford University type collection, there are two specimens of *S. elegans*. One is a small shell fragment in rock (CAS/SU 156) labelled "holotype?"; the other an entire specimen in rock (CAS/SU 322) labelled "paratype." This specimen labelled "paratype" is selected as the neotype.
Type locality.—SU 322. Ventura County, Calif. Llajas Formation, Eocene.
Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Llajas Formation (Keen and Bentson, 1944).

Septifer (Septifer) coalingensis Arnold

Plate 18, figure 10

Septifer coalingensis Arnold, 1909, p. 58-59, pl. 5, fig. 4.

Original description.—"Shell averaging about 45 millimeters in length, wedge-shaped, slender, convex, radially striate. Beaks subterminal, curved, sharp, anterior margin moderately concave, slightly angular at about middle; posterior margin considerably more curved than the anterior, slightly angulated opposite angle in the anterior margin; base slightly convex, moderately abruptly truncated at right angles to margins on both sides. Surface sculptured by numerous regular, close-set small rounded radiating ribs and a considerable number of prominent lines of growth; all of the specimens examined are more or less decorticated and show the radial sculpture around the periphery only; the sculpture in the younger stages of growth is believed to be coarser than that in the later stages. Hinge without teeth, furnished with a lamellar septum; ligamental pits linear, marginal."

Holotype.—USNM 165580.

Type locality.—USGS 4634. Fresno County, Calif. Etchegoin Formation, Miocene and Pliocene.

Supplementary description.—"This unique species is characterized by its slender form, regularly convex surface, and fine radial sculpture." (Arnold, 1909, p. 58)

Comparison.—*Septifer coalingensis* "is closely allied to the recent *S. bifurcatus* Reeve***but is narrower, more falcate, and more regularly but less markedly convex. It is much larger, narrower, less angulate, and finer sculptured than***S. *dichotomus* Gabb." (Arnold, 1909, p. 58)

Comments.—Arnold (1909) says that *S. coalingensis* has a lamellar septum; thus it does belong in *Septifer s.s.*

Geographic range.—Middle California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Etchegoin Formation (Keen and Bentson, 1944).

Septifer (Septifer) bifurcatus (Conrad)

Plate 18, figures 7, 9

Mytilus bifurcatus Conrad, 1837, p. 241, pl. 18, fig. 14.

Septifer bifurcatus Conrad. Soot-Ryen, 1955, p. 41-42, pl. 4, figs. 19, 20; text fig. 33. Hertlein and Grant, 1972, p. 165-166, pl. 42, figs. 6, 12, [See synonymy].

Original description.—"Shell narrowed, slightly arcuate; anterior margin much flattened; ribs narrow, prominent, bifurcated toward the base; color dark purple. Height 1 ½ inches."

Holotype.—ANSP 57920.

Type locality.—Unknown; believed to be California (Hertlein and Grant, 1972, p. 165). Age: Holocene.

Supplementary description.—"*Septifer bifurcatus* is here reported for the first time from strata of Pliocene age. One valve, somewhat eroded [is] 18.2 mm long and 10.8 mm wide***. The largest Recent specimen in the collections of the California Academy of Sciences [from]***San Diego, California, is 41.5 mm long and 18 mm high. Some large valves become partially or almost entirely smooth after attaining a length of about 25 mm. Shells similar to these with obsolete radial sculpture were described as *Septifer bifurcatus* var. *obsoletus* Dall." (Hertlein and Grant, 1972, p. 166)

"The outer form of this species is as variable as that of other intertidal mytilids. The keel from umbo to posteroventral angle is generally very pronounced and the ventral part flattened. The radiating sculpture is strong posterior to the keel, with the upper ribs bent dorsalward; the ventral ribs are weaker; all ribs are irregularly furcating. The periostracum is dark, blackish. The anteriorly placed umbones are strongly twisted, with the lunule bent inward, at least in large specimens, and furnished with radiating furrows which form the teeth. Generally there is a single strong tooth more or less furrowed; but the teeth seem to be so variable that it is nearly impossible to give an adequate description of them. The margins are crenulated, with especially strong crenulations behind the ligament. The crenulations on the posterior margins are extremely variable." (Soot-Ryen, 1955, p. 41-42)

Comparison.—"*Septifer margaritana* Nomland***was described as larger (52 mm long, 22 mm high) than *S. bifurcatus*, with more numerous radiating riblets and with a more acute umbonal angulation. We have examined a cast of the holotype which reveals the shell characters mentioned by Nomland." (Hertlein and Grant, 1972, p. 166)

Geographic range.—Living: Crescent City, Calif., to Cabo San Lucas, Baja California Sur; fossil: southern California and Baja California Norte.

Geologic range.—Pliocene through Holocene.

Occurrence in California and Baja California Norte.—Pliocene: San Diego Formation (Hertlein and Grant, 1972); Pleistocene: unnamed strata on San Nicolas Island (Vedder and Norris, 1963), Newport Bay area (Kanakoff and Emerson, 1959), San Pedro, Santa Barbara, and San Diego (Arnold, 1903), and in Baja California Norte (Valentine, 1957).

Habitat.—Usually intertidal and attached to underside of rocks; to 20 m.

Subfamily CRENELLINAE

Genus CRENELLA Brown, 1827

Small, round to ovate, beaks anterior; radiating sculpture, usually unilaterally bifurcate anteriorly and posteriorly, bifurcate or simple in middle; margins crenulate.

Geologic range.—Cretaceous through Holocene (table 5).

Habitat.—Most of the living species are found in cool seas but a few occur in tropical seas; 2 to 4,190 m (Hertlein and Grant, 1972, p. 170).

Crenella decussata (Montagu)

Plate 18, figures 1, 2

Mytilus decussata Montagu, 1808, p. 69.

Crenella decussata (Montagu). Grant and Gale, 1931, p. 254.

Original description.—"Shell longitudinally ovate, with the umbo at the smaller end; sides equal. It is very thin, pellucid, of a pearly white when divested of the epidermis, which is of a pale olive brown; and is finely striated longitudinally, crossed by more minute striae in a transverse direction, that give it a decussated appearance when examined under a microscope. The inside is smooth with a nacred gloss; at the hinge is a slight indenture, the margin contiguous and slightly denticulated; near the front margin is a singular, reflected transverse ridge, but whether this is a constant character, or accidental, cannot be determined; indeed only one valve of this curious little shell has come under examination, and that through the favor of Mr. Laskey, who found it in sand on the Scottish coast. Length about ⅛ of an inch; and not quite so broad."

Holotype.—In British Museum?

Type locality.—Scottish coast, British Isles. Holocene.

Geographic range.—Living: Bering Sea to San Pedro, Calif.; Greenland to North Carolina; British Isles; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando Formation (J. D. Mount, written commun., 1971; J. G. Vedder, written commun., 1978), San Pedro Formation (Oldroyd, 1924).

Habitat.—In sand or mud from 10 to 265 m.

Crenella inflata Carpenter

Plate 18, figures 3, 5, 6

?*Crenella inflata* Carpenter, 1864a, p. 313.

Crenella inflata Carpenter. Hertlein and Grant, 1972, p. 171, pl. 41, fig. 11 [See for synonymy].

Original description.—"C. testa valde inflata, minuta, albida, subrhomboideo-orbiculari; diagonaliter parum producta; marginibus subquadrangulatim rotundatis; umbonibus prominentibus, valde antice intortis; tota superficie ut in *C. decussata* sculpta, costulis crebris radiantibus aequidistantibus, hic et aliis intercalatis; lirulis concentricis decussantibus: intus margine dorsali brevissimo, arcuato, dentato; ligamento curtissimo, in fossa omnino interna, celata, lamina definiente, sito; lamina cardinali sub umtonibus intus porrecta, dentibus validis instructa; marginibus internis omnino crenatis; cicatr. adduct. subaequalibus, ventraliter sitis. Long. .1, lat. .2, alt. .09 poll."

Holotype.—USNM 3988 is considered to be the holotype (Hertlein and Grant, 1972, p. 171).

Type locality.—Cabo San Lucas, Baja California Sur. Holocene.

Comparison.—The shell of *Crenella decussata* is more symmetrical and the beaks more centrally located than on *C. inflata.*

Geographic range.—Living: Huntington Beach and San Miguel Island, Calif., to Golfo de California and south to Callao, Peru; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: San Diego Formation.

Habitat.—4 to 90 m.

Genus GREGARIELLA Monterosato, 1884

Elongated, inflated, beaks incurved, umbonal keel angulated; radially striated anteriorly and posteriorly where striae end along oblique line, median part concentrically striated; margins crenulated.

Geologic range.—Miocene through Holocene (table 5).

Habitat.—Living in 49 to 90 m; burrows in rocks and large shells.

Gregariella chenui (Récluz)

Plate 19, figures 1, 2

Mytilus (*Modiola*) *chenui* Récluz, 1842, p. 306.

Gregariella chenui Récluz. Hertlein and Grant, 1972, p. 168-169, pl. 41, figs. 1, 5; pl. 42, figs. 1, 8 [See for synonymy].

Original description.—"Soquille transverse, ovale, renflée, mince, marquée d'um angle obtus des sommets au bord postérieur et plane en dessus, arrondie, étroite et plus courte antérieurement qu'au côté postérieur, lequel est plus rétréci et presque anglueux. Sommets petits, saillants, obtusément arrondis, placés très-près du bord antérieur et décortiqués; l'extérieur est sculpté de très petits sillons longitudinaux, partant des crochets et rayonnant vers la base des valves: les sillons sont finement striés en dedans et ont un aspect presque onduleux; les antérieurs sont arqués et obliquent fortement en avant; les postérieurs ont une direction antérieure plus droit dans leur cours. Ces sillons et ces stries sont effacés sur le tiers antérieur des valves ou a'peine apparents, et à cette place règne une dépression qui part des crochets, où elle est peu sensible et se continue en augmentant graduellement d'intensité jusqu'a là base des valves, qu'elle rétrécit légèrement dans leur longeur. La couleur de cette couquille est roussâtre, peinte longitudinalement d'une large fascie marron sur la partie déprimée et lisse. Toute la portion postérieure est couverte de poils jaunâtres, comme agglutinés entre eux, et dont les postérieurs sont disposés en trois ou quatre filaments roides, velus et saillants d'un à deux millimètres. Interieur nacré et légèrement irisé. Charnière formée d'une série de denticules ou crenélures qui, très-saillantes antérieurement, se continuent sur toute la région supérieure des valves, et viennent finir sur le milieu du côté postérieur, en s'affaiblissant graduellement dans leur cours.—Larg. 16, diam, 10, convex. 10 mill."

Holotype.—Location unknown.

Type locality.—"Hab. les cotes du Bresil, province de Bahia."

Supplementary description.—"The radial sculpture on both the fossil and on the Recent shells is well developed and beaded posteriorly where crossed by coarse concentric lines of growth. The largest valve***from off Catalina Island is 0.4 mm long and 4.6 mm high." (Hertlein and Grant, 1972, p. 169)

"Shell***small, with the umbones anteriorly placed, of a broadly oval form with sloping curved anterior and posterior margins, broadest in the posterior half***. Sculpture consisting of a few radial anterior striae, a median part without radial sculpture, and distinct radial striae on the posterior part, the first not reaching to the ventral margin, the dorsal ones bent backward. The radiating striae crossed by distinct but somewhat irregular concentric lines, giving the posterior part a decussated sculpture. The anterior dorsal margin somewhat thickened and crenulated; the posterior dorsal margin with strong crenulations which become smaller on the posterior margin and hinder part of the ventral margin; the middle part of the ventral margin smooth. The ligament internal and descending backward, supported by a distinct nymphae." (Soot-Ryen, 1955, p. 78)

Comparison.—"The sculpture on the shell of *G. chenui* is much coarser, the posterior end more rounded and the umbonal slope is less angulated than that of *G. coarctata* Dunker in Carpenter***. Specimens of *G. coarctata* which we have seen are larger than those of *G. chenui.*" (Hertlein and Grant, 1972, p. 169)

Geographic range.—Living: Monterey Bay, Calif., to Bahía de la Independencia, Peru; also Brazil and Caribbean region; fossil: southern California.

Geologic range.—Pliocene.

Occurrence in California.—Pliocene: San Diego Formation (Hertlein and Grant, 1972).

Habitat.—Living in 2 to 90 m.

Genus MUSCULUS Röding, 1798

Modioliform with broadly rounded umbonal keel, posterodorsal part usually separated from remainder of valve by furrow, radiate sculpture separated in middle by concentrically striated area; margins crenulate.

Geologic range.—Jurassic through Holocene.

Habitat.—Moderately deep water; 10 to 230 m; some species occupy a bysally formed nest within shells or holdfasts or embedded within the nest of ascidians (sea-squirts).

Subgenus MUSCULUS

Shell rather flat.

Geologic range.—Jurassic through Holocene (table 5).

Musculus (Musculus) stalderi (Martin)

Plate 19, figures 3, 4

Modiolus stalderi Martin, 1914, p. 182-183, pl. 22, figs. 6a, 6b.
Volsella (Brachiodontes) stalderi (Martin). Grant and Gale, 1931, p. 252.

Original description.—"Shell small, thin, subelliptical, sculptured with numerous radiating ridges which are crossed by very fine concentric lines, producing a fine tessellated surface; valves nearly equal, very inequilateral; umbones conspicuous, almost terminal; umbonal ridge, prominent anteriorly broadening and less prominent posteriorly; hinge line nearly straight, about one-fourth the length of the shell; upper posterior margin broadly arcuate; posterior extremity sharply and evenly rounded; ventral margin nearly straight, slightly concave at the middle in some specimens; anterior end blunt, excavated in front of the beaks."

Holotype.—UCMP 12354.

Type locality.—UC 1859. Humboldt County, Calif. Rio Dell Formation, Pliocene.

Comparison.—"This species differs from the Recent *Brachidontes demissus* (Dillwyn), which has been introduced into San Francisco Bay from the Atlantic on seed oysters, in being less pointed anteriorly and less incurved ventrally." (Grant and Gale, 1931, p. 252)

Geographic range.—Northern California.

Geologic range.—Pliocene.

Occurrence in California.—Rio Dell Formation (Roth, 1979).

Subfamily LITHOPHAGINAE

Genus LITHOPHAGA Röding, 1798

Cylindrical, usually tapering posteriorly, beaks near anterior end; smooth or with vertical striae; hinge edentulous; margins smooth.

Geologic range.—Carboniferous(?); Eocene(?); Miocene through Holocene (table 5).

Habitat.—Mainly in tropical and subtropical seas; a few species extend into the temperate zone. Boring into calcareous rocks, coral, and shells, by means of a chemical process that is effective only in calcareous media; retains byssus.

Subgenus LITHOPHAGA

Shell with vertical striations.

Lithophaga (Lithophaga) clarki M. A. Hanna

Plate 19, figures 5, 6

Lithophaga clarki M. A. Hanna, 1927, p. 278-279, pl. 33, figs. 3-6, 9.

Original description.—"Shell small, very heavy, cylindrical, bluntly rounded in front, wedge-shaped behind, greatest altitude some distance behind the beaks, posterior margin somewhat sharply rounded; beaks not prominent, located near the anterior end, projecting only slightly above the bluntly rounded anterior; surface ornamented by small rounded growth lines; valves fit very closely together. *Dimensions:* Altitude 6 mm., length 13 mm., diameter of two valves 5 mm."

Holotype.—UCMP 31031.

Type locality.—UC 3981. San Diego County, Calif. Delmar Formation, Eocene.

Comments.—Fossiliferous marine sand of the Pleistocene Bay Point Formation unconformably overlies the Eocene Delmar Formation in the type locality of *Lithophaga clarki*. Fossil bivalve borings of Pleistocene age are associated with the wave-cut platform eroded into the Eocene Delmar Formation. The holotype of *L. clarki* is so well preserved that I suggest it may have been a Pleistocene species that burrowed into Eocene strata and shells. This suggestion is perhaps substantiated by Hanna's (1927, p. 279) comment that: "Some of the individuals lived in the soft sand which has since been cemented and consolidated." *Lithophaga* is not known from unconsolidated sediment.

*Geographic range.*Southern California.

Geologic range.—Eocene or Pleistocene.

Occurrence in California.—Delmar(?) Formation.

Subgenus DIBERUS Dall, 1898

Two or more posterior sulci with plumelike incrustation distinctly projecting beyond valves.

Geographic range.—Living: Western North America and Indo-Pacific; fossil: Florida and California.

Geologic range.—Miocene through Holocene (table 5).

Lithophaga (Diberus) plumula (Hanley)

Plate 19, figures 7, 8

Lithodomus plumula Hanley, 1844, p. 17.
Lithophaga plumula (Hanley). Arnold, 1903, p. 121.
Lithophaga (Diberus) plumula (Hanley). Grant and Gale, 1931, p. 253. Keen, 1971, p. 68, fig. 138.

Original description.—"Lit. testa L. canalifero simillima, sed extremitate antice minus obtusa; tegmine calcareo antico, crassiore, atque in parietibus confertis, subparallelis ordinato; parietibus corrugatis et (plumulae haud dissimilibus) versus marginem et marginem anticum utroque latere radiantibus."

Holotype.—BM(NH)? (A. M. Keen, oral commun., 1978).

Type locality.—Panama. Holocene.

Supplementary description.—"Anterior end rounded, two grooves extending from beaks to the tapered posterior end of the shell, area between the grooves bearing a ridged, feathery encrustation extending posteriorly beyond end of shell, encrustation is also thinly spread over the rest of shell***Length, 40-55 m." (McLean, 1978)

Comments.—*Lithophaga plumula kelseyi* Hertlein and Strong (1946), a species living along the coast of California, has been reported from the Pleistocene of Newport Bay, Calif., by Kanakoff and Emerson (1959).

Geographic range.—Living: Gulf of California to Peru; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene and Pleistocene: Fernando (Willett, 1946) and San Pedro (Arnold, 1903) Formations.

Habitat.—Specimens may be found boring into calcareous shale, into the pelecypod *Spondylus* or other large shells, or into masses of coral; low tide to 37 m.

Genus ADULA H. and A. Adams, 1857

Elongate, cylindrical, beaks behind anterior margin, anterodorsal margin thickened, surface smooth or with irregular wrinkles.

Geographic range.—Pacific.

Geologic range.—Eocene(?); Holocene (table 5).

Habitat.—Usually boring in soft rocks with the exception of *Adula diegensis* (Dall), which is free-living on mud flats or pilings.

Genus ADULA?

Adula? mcknighti (M. A. Hanna)

Plate 19, figures 9, 10

Lithophaga mcknighti M. A. Hanna, 1927 p. 279, pl. 33, figs. 2, 7, 8, 10, 11 [Figure 2 is not of the holotype. I assume it was an impression of the mold not retained with the type specimen.]

Original description.—"Shell of moderate size, elongate, well inflated, heavy; beaks anterior, elongate due to the length of the shell, prominent; ventral margin straight to slightly concave; anterior short, rounded to the beak; posterior somewhat flattened, well rounded; posterior dorsal margin broadly rounded; only concentric sculpturing present, which consists of heavy placoid ridges which project out over the later formed ones for a considerable distance; both the concentric ribs and the interspaces sharp. *Dimensions:* Altitude 8 mm., length 19 mm., diameter of the two valves 9 mm."

Holotype.—UCMP 31151.

Type locality.—UC 5062. San Diego County, Calif. Delmar Formation, Eocene.

Comparison.—"*Lithophaga mcknighti****differs from *Lithophaga clarki****not only in shape and size but also in the coarse placoid character of the concentric sculpturing." (Hanna, 1927, p. 279)

Comments.—The strong placoid ridges illustrated by Hanna (1927, pl. 33, fig. 2) and the overall outline of this form exclude it from the lithophagids. The shell is mytiloid in shape with large, rounded umbos and somewhat resembles the living species *Adula diegensis* (Dall). If it is indeed *Adula,* this is the only known fossil species.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Delmar Formation.

Subfamily MODIOLINAE

Genus MODIOLUS Lamarck, 1799

More or less inflated, rounded anteriorly, umbones obtuse, distinctly behind anterior end.

Geologic range.—Devonian through Holocene (table 5).

Habitat.—Intertidal zone to 3,270 m (Knudsen, 1970); most abundant at depths less than 90 m; usually semi-infaunal or infaunal in marsh grass, sand, and gravel, but some species live attached to piling; some species gregarious.

Subgenus MODIOLUS

Inflated, smooth.

Modiolus (Modiolus) eugenensis Clark

Plate 19, figure 12

Modiolus eugenensis Clark, 1925, p. 86, pl. 9, fig. 4. Hickman, 1969, p. 34, pl. 2, figs. 1-5.

Volsella eugenensis (Clark). Weaver, 1942, p. 111-112, pl. 24, fig. 8.

Original description.—"Shell fairly large; base usually slightly concave; anterior end moderately produced; posterior margin angulated well back of middle of valve; posterior to angulation, the edge turns in rather abruptly to posterior end, which is broadly rounded; umbones only moderately prominent; umbonal ridge very prominent; distinct to the posterior end. Surface of shell strongly arched; posterior and anterior slopes about equal in width, both fairly steep. Surface, except for a smooth elongated triangular space between base and umbonal ridge, sculptured by fairly coarse, radial ribbing, which apparently does not extend on to depressed anterior dorsal margin. Dimensions: Greatest length, about 67 mm.; greatest width, 33 mm."

Holotype.—UCMP 30319.

Type locality.—UC 4182. Eugene, Lane County, Oreg. Eugene Formation, Oligocene.

Supplementary description.—"*Modiolus eugenensis* is a large, elongate form ranging from 48 to 95 mm in length and from 23 to 39 mm in altitude. The rounded anterior end extends for a short distance in front of the small inconspicuous beaks. The hinge margin is longer than the posterior dorsal margin, and the two meet to form an angle of about 125°. The posterior ventral margin is straight to broadly convex, and the area of maximum convexity corresponds to the angulation in the posterior dorsal margin. The umbonal ridge, which distinguishes this genus from *Mytilus*, is prominent and convex, extending obliquely from the beaks to the rounded posterior end. The posterior dorsal and ventral slopes are slightly depressed on either side of the umbonal ridge. Surface sculpture is formed by threads radiating from the beak. These threads are prominent dorsal to and along the umbonal ridge and are only faintly developed ventrally. Generally only the pearly inner shell layers are preserved, but fragments of the outer layer indicate that the surface was a golden brown." (Hickman, 1969, p. 34)

Comparison.—"*M. eugenensis**** is closely related to *M. sookensis* (Clark and Arnold) from the upper Oligocene of Vancouver Island. *M. sookensis* may be distinguished by a less prominent umbonal ridge, lack of prominent radial ornamentation, and by the equal length of the posterior and dorsal slopes on either side of the angulation." (Hickman, 1969, p. 34)

Geographic range.—Oregon; southern California.

Geologic range.—Eocene and Oligocene.

Occurrrence in California.—Eocene and Oligocene: San Emigdio Formation (Delise, 1967).

Modiolus (Modiolus) ynezianus Arnold

Plate 19, figure 11

Modiolus ynezianus Arnold, 1907b, p. 429, pl. 52, fig. 2. Arnold and Anderson, 1907, p. 132, pl. 15, fig. 2. Loel and Corey, 1932, p. 206, pl. 33, figs. 7, 9.

Original description.—"Shell averaging about 60 mm in altitude, elongate-ovate in outline, convex, equivalve; beaks nearly terminal, protruding forward and slightly beyond margin; base not regularly rounded, curving sharper anteriorly; anterior margin curving sharply around attenuate extremity just in front of beak and then straight for nearly entire length of shell, with the exception of a slight contraction near middle caused by a sulcation extending obliquely backward from beaks; posterior dorsal margin straight, bending around a moderately angular extremity into the slightly arcuate ventral margin; the shell bulges in the middle in such a way as to suggest a broad rounded ridge bowing over obliquely backward from the anterior part of the base to the beak; surface sculpture consists of fine incremental lines."

Holotype.—USNM 165324.

Type locality.—USGS 4504. Santa Barbara County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"This species attains much larger size than is indicated by Arnold's figured specimen. When the beaks and part of the umbones are missing, it is difficult to separate from *Mytilus expansus* Arnold." (Loel and Corey, 1932, p. 206).

Geographic range.—Southern California.

Geologic range.—Eocene to Miocene.

Occurrence in California.—Eocene and Oligocene: San Lorenzo Formation (Arnold, 1908); Oligocene and Miocene: Vaqueros Formation.

Modiolus (Modiolus) lagunanus Loel and Corey

Plate 19, figures 13, 14

Modiolus ynezianus (Arnold) *lagunanus* Loel and Corey, 1932, p. 206, pl. 34, fig. 2.

Original description.—"Shell elongate-quadrate bowed in outline; very convex; beaks blunt, nearly terminal; anterior and posterior margins nearly parallel, tapering suddenly dorsally and rounded sharply to the ventral margin, the anterior margin being evenly concave and the posterior evenly convex; a prominent, broad umbonal ridge extends from anterior extremity obliquely bowing to the umbone. Surface marked by fine incremental lines. Height, 1.10 mm.; width (or antero-posterior length at widest point), 40 mm.; diameter (single valve), 36 mm."

Holotype.—UCMP 31788.

Type locality.—UC A543. Orange County, Calif. Vaqueros Formation, Oligocene-Miocene.

Comments.—This form is distinctive in being very slender with almost no posterior enlargement and very wide and in having a strong umbonal ridge and concave anterior ventral surface.

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation.

Modiolus (Modiolus) ynezianus garzaensis Adegoke

Plate 20, figure 1

Modiolus ynezianus Arnold *garzaensis* Adegoke, 1969, p. 93, pl. 1, figs. 5, 7.

Original description.—"Shell small, thin, relatively short and wide, roughly triangular in outline; beak prominent, subacutely pointed; anterior end extends only slightly beyond beaks; umbonal ridge well developed, its main axis runs from posterior dorsal margin of beak to posterior edge of 'straight' anterior dorsal margin; shell sloping with high angle from top of umbonal ridge to anterior dorsal margin but more gradually to posterior dorsal margin; posterior dorsal margin straight, about two-thirds length of shell, merges sharply into the rounded basal margin at an angle of about 50°; anterior dorsal margin slightly convex, more than three-fourths length of shell; surface of shell ornamented by concentric lines of growth, often accompanied by overlap of shell layers giving a distinct banded appearance especially near ventral margin."

Holotype.—UCMP 36601.

Type locality.—UC D-1065. Fresno County, Calif. Upper part of Temblor Formatiôn, Miocene.

Comparison.—"This species may be readily distinguished from other described Miocene species of *Modiolus* by its relatively small size. It is smaller, less crescentic in shape, and has a straighter and more prominent umbonal ridge than in typical *Modiolus ynezianus* Arnold*** and has a gently convex, straight, or slightly concave anterior dorsal margin whereas this margin is markedly concave in *M. ynezianus, s.s.* From *M. veronensis* Trask, the new subspecies is separated by its smaller size, its higher umbonal ridge and its 'convex' anterior dorsal edge." (Adegoke, 1969, p. 93)

Comments.—The small size of this form is not especially distinctive. The umbonal ridge on the holotype of *M. veronensis temblorensis* is higher and more arcuate than on *M. ynezianus garzaensis* Adegoke, but the variation within living species is so great that I believe *M. ynezianus garzaensis* and *M. veronensis temblorensis* may be conspecific.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Upper part of Temblor Formation.

Modiolus (Modiolus) veronensis veronensis Trask

Plate 20, figure 3

Modiolus veronensis Trask, p. 150, pl. 3, fig. 4

Original description.—"Shell small to medium in size, flat and elongate; anterior end extending only slightly beyond beak; posterior dorsal edge straight and not separated from the posterior end by any well defined angle; anterior dorsal edge slightly concave; base evenly rounded; surface smooth, except for concentric lines of growth."

Holotype.—UCMP 12373.

Type locality.—UC 3529. Alameda County, Calif. Briones Sandstone, Miocene.

Comments.—The holotype is moderately inflated in proportion to its size.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Briones Sandstone.

Modiolus (Modiolus) veronensis temblorensis Adegoke

Plate 20, figure 2

Modiolus veronensis Trask *temblorensis* Adegoke, 1969, p. 94, pl. 1, figs. 6, 8.

Original description.—"Shell small, narrow, elongate, convex anteriorly, less so in posterior half; lateral profile arcuate; anterior end extends slightly beyond beaks; posterior dorsal margin straight, about half the length of shell, gently merging into the rounded ventral margin; anterior dorsal margin slightly concave; conspicuous umbonal ridge on anterior third of shell; surface smooth except for concentric lines of growth."

Holotype.—UCMP 36606.

Type locality.—UC D-1065. Fresno County, Calif. Upper part of Temblor Formation, Miocene.

Comparison.—"This subspecies differs from *Modiolus ynezianus* Arnold and *Modiolus ynezianus* Arnold *garzaensis* Adegoke*** by its narrower and more elongate outline, evenly rounded ventral margin and shorter and less inflated umbonal ridge. From typical *Modiolus veronensis* Trask, the new subspecies can be distinguished by its greater convexity and higher and more distinct umbonal ridge." (Adegoke, 1969, p. 94)

Comments.—It is doubtful that the higher umbonal ridge and greater convexity of this form are characters sufficiently unique to warrant separating it from either *M. ynezianus garzaensis* or *M. veronensis veronensis*.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Upper part of Temblor Formation.

Modiolus (Modiolus) contracta Conrad

Plate 20, figure 5

Modiola contracta Conrad, 1855, p. 14. Conrad, 1857c, pl. 5, fig. 35.

Original description.—"Elongated, narrowed anteriorly, contracted submedially, basal margin widely contracted; disk with numerous minute radiating lines."

Holotype.—USNM 1853.

Type locality.—Twenty-five or thirty km south of Tres Pinos, Monterey County, Calif. Etchegoin(?) Formation.

Geographic range.—Middle California.

Geologic range.—Miocene(?) and Pliocene(?).

Occurrence in California.—Etchegoin(?) Formation.

Modiolus (Modiolus) directus Dall

Plate 20, figure 4

Modiolus directus Dall, 1909, p. 113-114, pl. 12, figs. 11, 12. Clark, 1915, pl. 42, fig. 4. Etherington, 1931, p. 73, pl. 4, fig. 4.

Original description.—"Shell thin, elongate, covered with a brown periostracum of which the remaining portions show alternating zones of darker and lighter color; umbones low, inconspicuous, not very close to the posterior end of the valves, as figured; dorsal margin straight anteriorly, arcuate posteriorly, obliquely descending to the hinder end of the shell, which is bluntly rounded; umbonal ridge broad, prominent, extending from the beaks to the lower posterior end of the shell, the part of the disk immediately in front of it slightly excavated; basal margin slightly concave, arching anteriorly toward the subangulate anterior extremity, surface smooth or distally slightly concentrically wrinkled. Longitude, 105 mm.; altitude, 40 mm.; diameter, 26 mm."

Lectotype.—USNM 153947, here designated. (Figured by Dall, 1909, pl. 12, figs. 11, 12.)

Type locality.—Coos Bay, Coos County, Oreg. Empire Formation, Miocene and Pliocene.

Comparison.—According to Dall (1909, p. 114), the anterior end of *Modiolus directus* is proportionately much shorter than that of *M. rectus*, the posterior end even more so.

Geographic range.—Washington to middle California.

Geologic range.—Miocene and Pliocene.

Occurrence in California.—Miocene: Cierbo and Neroly (Hall, 1960) Sandstones; Miocene and Pliocene: Etchegoin (Arnold, 1909) and Tahana Member, Purisima (Cummings and others, 1962) Formations.

Modiolus (Modiolus) capax (Conrad)

Plate 20, figure 6

Modiola capax Conrad, 1837, p. 242.

Modiolus capax (Conrad). Keen, 1971, p. 72, fig. 149.

Volsella capax (Conrad). Grant and Gale, 1931, p. 249 [See for synonymy].

Original description.—"Shell much inflated; anterior margin slightly retuse in the middle; umbo broad; summit obtusely rounded; posterior margin salient in the middle; epidermis chestnut brown, fibrous at base; within bluish, tinged with yellow. Length, 3 inches."

Holotype.—Not found at Philadelphia Academy of Natural Sciences; missing and presumed lost.

Type locality.—San Diego, Calif. Holocene.

Comparison.—*Modiolus capax* has a rounded, bulbous dorsal margin that distinguishes it from *M. recta*; the nearly straight ventral margin distinguishes it from *M. flabellata*. *Modiolus capax* differs from both *M. recta* and *M. flabellata* by having umbos at, but separate from, the anterior end. (Fitch, 1953, p. 47)

This species is similar to *M. modiolus*, but heavier shelled and more inflated and has a more depressed region between the umbones. (Grant and Gale, 1931, p. 249)

Geographic range.—Living: Santa Cruz, Calif. to Paita, Peru; fossil: middle California to Baja California Sur.

Geologic range.—Miocene through Holocene.

Occurrence in California and Baja California Sur.—Miocene: Briones (Hall, 1958), Cierbo (Hall, 1960), Neroly (Weaver, 1949), and Santa Margarita Formations (Grant and Gale, 1931); Miocene and Pliocene: Etchegoin (Clark, 1915) Formation; Pliocene: Marquer Formation (Durham, 1950); Pliocene and Pleistocene: Fernando (J. D. Mount, written commun., 1971) and Saugus(?) [upper part of Pico of Waterfall, 1929] Formations.

Habitat.—Intertidally on rocks or boulders or in mud to 45 m. Solitary individuals occur in protected areas along the open coast.

Modiolus (Modiolus) rectus Conrad

Plate 20, figure 9

Modiola recta Conrad, 1837, p. 234, pl. 19, fig. 1.

Modiolus rectus Conrad. Arnold, 1903, p. 120-121. Arnold, 1909, p. 146, pl. 20, fig. 4. Hertlein and Grant, 1972, p. 166-167, pl. 42, fig. 7 [See for synonymy].

Mytilus (Modiola) flabellatus Gould, 1850, p. 343.

Original description.—"Shell produced, smooth, thin; anterior margin elevated; posterior side cuneiform; color brown, with a broad pale stripe extending from the beak toward the posterior margin; within very glossy and irridescent. Length, 2 inches."

Holotype.—In Gould Collection, MCZ.

Type locality.—Sandy shores near Santa Barbara, Calif. Holocene.

Supplementary description.—"Specimens are often found that are 120 mm to 130 mm in length but huge forms are reported to attain a length of 230 mm." (Hertlein and Grant, 1972, p. 167)

Comparison.—*Modiolus rectus* is always more elongate than *M. neglectus* Soot-Ryen (1955) and never shows the distinct posterodorsal angle of that species. The straight dorsal margin extends over to the posterior margin in a long arch without angulation. (Soot-Ryen, 1955, p. 63) [See *M. directus* Dall.]

Geographic range.—Living: Vancouver Island, British Columbia, to Bahía Concepción east coast of Baja California Sur; fossil: middle California to Baja California Norte.

Geologic range.—Miocene to Holocene.

Occurrence in California and Baja California Norte.—Miocene: Pancho Rico (Durham and Addicott, 1965) and Santa Margarita (Nomland, 1917) Formations; Miocene and Pliocene: Etchegoin (Arnold, 1909); Nomland, 1971a; Wilson, 1944), Purisima (Martin, 1916), and Towsley (Kern, 1973) Formations; Pliocene: San Diego Formation (Hertlein and Grant, 1972); Pliocene and Pleistocene: Merced (Martin, 1916; Glen, 1959), San Pedro (Arnold, 1903), Santa Barbara (Arnold, 1903), and Saugus (Waterfall, 1929) Formations; Pleistocene: unnamed Pleistocene strata, San Diego, Calif. (Arnold, 1903), and Bahía de San Quintin, Baja California Norte (Jordan, 1926).

Habitat.—"At the present time this mollusk lives on a muddy bottom with the anterior portion embedded in a nest in the mud but with the posterior portion of the shell exposed above the surface of the bottom. (Hertlein and Grant, 1972, p. 167)

Living singly on mud flats at low water or submerged with the posterior end slightly protruding. Intertidal to about 45 m.

Modiolus (Modiolus) carpenteri Soot-Ryen

Plate 20, figures 7, 8

Modiola fornicata Carpenter, 1846b, p. 643. Not *Modiola fornicata* F. A. Roemer, 1836.

Modiolus fornicatus (Carpenter). Palmer, 1958, p. 73, pl. 4, figs. 10-12 [See for synonymy].

Modiolus carpenteri Soot-Ryen, new name, 1963, p. 127.

Original description.—"Short, swollen, like large *M. marmorata*; but smooth, not crenated."

Holotype.—Redpath Museum 3133.

Type locality.—Santa Barbara, Santa Barbara County, Calif. Holocene.

Supplementary description.—"In this species the beaks curve strongly forward, downward and backward so that a portion of their curve projects considerably beyond the anterior margins of the valves*** a Recent specimen from Monterey which is unusually large and swollen*** has the following measurements: extreme anterior-posterior length, 32 mm.; dorsal-ventral height, 16 1/2 mm.; thickness of both matched valves together 20 mm." (Grant and Gale, 1931, p. 251)

Comparison.—[See *M. sacculifer.*] *Modiolus trinominata* "is much larger, does not have such a pronounced curvature of the umbones, is less ventricose, and is broader posteriorly." (Grant and Gale, 1931)

Geographic range.—Living: Monterey to San Pedro, Calif.; fossil: middle California to Baja California Sur.

Geologic range.—Miocene through Holocene.

Occurrence in California and Baja California Sur.—Miocene and Pliocene: Etchegoin Formation (Nomland, 1917a); Pliocene and Pleistocene: Santa Barbara Formation (Arnold, 1903); Pleistocene: unnamed strata, Bahía de la Magdalena, Baja California Sur (Jordan, 1924).

Habitat.—25 to 45 m.

Subgenus Modiolus?

Modiolus (Modiolus?) merriami Weaver

Plate 21, figure 2

Modiolus merriami Weaver, 1905, p. 114-114, pl. 12, fig. 2.

Modiolus merriami Weaver. Dickerson, 1914, p. 151, pl. 9, fig. 7.

Original description.—"The shell is thin, elongated, and moderately convex. The beaks are broad and not very prominent. The umbonal ridge is prominent, rounded, and curved only slightly downward. The surface is marked by several rather prominent concentric wrinkles. There is no radial ornamentation."

Holotype.—UCMP 11892.

Type locality.—UC 333. Contra Costa County, Calif. Martinez Formation, Paleocene.

Comments.—The holotype is very small (28 mm long) with only patches of the internal shell layer preserved. The mold from which it came does not reveal the external shell characters, but it is modiolid in outline.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Paleocene: Martinez Formation.

Modiolus (Modiolus?) pittsburgensis Clark

Plate 21, figures 3, 4

Modiolus pittsburgensis Clark, 1918, p. 134, pl. 9, fig. 9.

Original description.—"Shell rather small, thin; umbones not prominent; umbonal ridge indistinct, unseen in the anterior third of the shell; anterior end strongly produced beyond the beaks; base straight; posterior margin long, with no distinct posterior angulation; posterior end broad and regularly rounded, the base and the posterior margin diverging in approaching the posterior end. Surface rather strongly arched, the highest point of convexity being posterior to the middle of the shell. Anterior slope broad and fairly steep; posterior slope shorter but more steep than the anterior. Surface smooth except for medium fine incremental lines."

Holotype.—UCMP 11122. [The specimen illustrated herein is a plaster cast of the two-part mold.]

Type locality.—UC 1895. Contra Costa County, Calif. Kirker Tuff, Oligocene.

Comparison.—"This species appears to be quite distinct in outline from any of the known Recent or fossil species of the West Coast. In outline it somewhat resembles *Modiolus inflatus* Dall; both have the broadly rounded posterior end; on the former the anterior end is more strongly produced and the shell is more slender just back of the beaks." (Clark, 1918, p. 134)

Comments.—The cast is small, inflated, and the posterior end enlarged.

Geographic range.—Middle California.

Geologic range.—Oligocene and Miocene(?).

Occurrence in California.—Oligocene: Kirker Tuff; Miocene(?): San Ramon Sandstone (Weaver, 1949).

Modiolus (Modiolus?) sacculifer (Berry)

Plate 21, figure 1

Volsella sacculifer Berry, 1953, p. 407, pl. 28, figs. 1, 2, text fig. 1.

Modiolus sacculifer (Berry). Hertlein and Grant, 1972, p. 167-168, pl. 41, fig. 2-4 [See for synonymy].

Original description.—"Shell of but moderate size for the genus, in outline broadly almond-shaped; highest at about the mid-point, thin, smooth, moderately inflated; hinge-line nearly straight to very slightly arcuate. Valves well rounded behind, more or less distinctly swollen ventrally in the byssal region and produced abruptly into a small obtuse lobe-like flare or pocket just under the umbones, the rounded angle of this pocket forming the anterior end of the shell; postero-dorsal area subalate, its angle obtuse. Hinge toothless except for a short, sharply conical, posteriorly directed process set off by a notch at the anterior insertion of the ligament. Periostracum light to deep brown (near Buckthorn Brown to Mummy Brown), smooth, polished, under the more or less dehiscent traces of some fairly considerable posterior shagginess."

Holotype.—CAS/SU 7853.

Type locality.—San Pedro Harbor, Los Angeles County, Calif. Holocene.

Supplementary description.—"The anterior lunular part, so characteristic in most of the specimens, is not so well defined in small specimens, which often look very like small *M. modiolus.* The lunule is dull and usually distinctly set off from the rest of the shell. The inside is margaritaceous, white or reddish-white; the shell is thin compared to *M. capax* and *M. fornicatus*. The ligament is short, and the umbones nearly touch in the middle." (Soot-Ryen, 1955, p. 66)

Comparison.—"The shell of *M. sacculifer* is readily separable from that of *Modiolus carpenteri* Soot-Ryen***a new name for *Modiola fornicata* Carpenter***, in that the lobe-like anterior end extends beyond the beaks whereas in Soot-Ryen's species it does not." (Hertlein and Grant, 1972, p. 167)

Geographic range.—Living: Monterey to Long Beach and Beechers Bay, Santa Rosa Island, and San Clemente Island, Calif.; fossil: southern California.

Geologic range.—Pliocene through Holocene.

Occurrence in California.—Pliocene: San Diego Formation.

Habitat.—Living in nests of sand or among holdfasts; low intertidal zone to 100 m.

Genus MODIOLUS?

Subgenus MODIOLUS?

Modiolus (Modiolus?) meganosensis Clark and Woodford

Plate 21, figure 5

Modiolus? meganosensis Clark and Woodford, 1927, p. 88, pl. 14, fig. 9.

Original description.—"Shell elongate subtrapezoidal in outline; beaks rather prominent, strongly inturned. Anterior end broadly rounded, posterior dorsal edge long and straight, separated from the posterior end by a fairly well developed angulation; base long and straight, parallel with the posterior edge; a well-defined umbonal ridge between the beaks and the point of junction of the base and posterior end; slope of surface between this ridge and the posterior dorsal edge rather abrupt; anterior slope broader and more gentle, slightly depressed between the beaks and the middle of the ventral edge. *Dimensions:* Greatest length 15 mm.; greatest width about 7 mm."

Holotype.—UCMP 31363.

Type locality.—UC 3155. Contra Costa County, Calif. Meganos Formation, Paleocene.

Supplementary description.—"Only one specimen of this species was found in our collection; a cast but fairly well preserved. It appears to be referable to the genus *Modiolus*, and if so it is very different in outline from any of the other known species from the west coast of North America." (Clark and Woodford, 1927, p. 88)

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Meganos Formation.

Modiolus? (Modiolus?) clarki Moore, new name

Plate 21, figures 8, 9

Mytilus merriami Clark, 1915, p. 455-456, pl. 48, figs. 7, 8. Not *Modiola merriami* Weaver, 1905.

Original description.—"Shell thick, very ventricose. Beaks heavy, bluntly pointed. Hinge plate below the beaks very heavy. Base sometimes straight, sometimes gently concave. Posterior edge angulated, the point of angulation being situated anterior to the middle. Posterior extremity evenly rounded. Surface of shell covered by irregular coarse incremental undulations. Highest point of convexity of surface anterior to the middle of the valve; anterior slope high and nearly perpendicular; posterior slope steep, dropping at an angle of nearly 30° as measured at the point of angulation on the posterior edge; to the rear of this point the shell is not so convex; no teeth on thickened hinge plate. Thickened area below the beaks obscurely grooved; deep elongate anterior adductor muscle scar just below the thickened hinge plate."

Holotype.—UCMP 11544.

Type locality.—UC 118. Contra Costa County, Calif. Neroly Sandstone, Miocene.

Comments.—On the basis of the position of the umbonal ridge, strong inflation, and assumed beak location, this species is tentatively assigned to *Modiolus*. The holotype has an exceptionally thick shell perhaps indicating response to wave shock. The assignment of this species to *Modiolus* necessitates a new name owing to the prior existence of *Modiola merriami* Weaver, 1905.

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Neroly Sandstone (Weaver, 1949).

Genus IDASOLA Iredale, 1915

Small, thin-shelled, with rounded anterior and posterior margins, beaks in front of middle.

Geographic range.—Atlantic; California?

Geologic range.—Paleocene(?); Holocene (table 5).

Habitat.—In bathyal water.

Genus IDASOLA?

Idasola? bakeri (Dickerson)

Plate 21, figures 6, 7

Modiolus bakeri Dickerson, 1914, p. 128, pl. 9, fig. 8.

Original description.—"Shell medium in size, thick; beak small but prominent, about a sixth of the length from the anterior end, which is narrowly rounded; posterior end, broadly rounded; cardinal margin, straight; ventral margin, slightly rounded; umbonal ridge prominent, rounded, and extending to the posterior end below its center. A marked concavity in larger specimen figured extends from the beaks to the middle of the ventral margin. Surface marked by lines of growth."

Holotype.—UCMP 11686.

Type locality.—UC 1556. Contra Costa County, Calif. Martinez Formation, Paleocene.

Comments.—The holotype is an internal mold of a left valve with the beak broken off and only patches of internal shell preserved. It is markedly inflated in proportion to its size with prominent beaks, is not elongate or modiolid in shape, and is somewhat enlarged posteriorly. On the basis of the holotype, I am not even certain that this form should be assigned to the Mytilidae; it could be an arcid. Within the mytilids, it somewhat resembles *Idasola*, a bathyal form.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Family PINNIDAE

Genus PINNA Linné, 1758

Equivalve, wedge- to ham-shaped; umbones at extreme anterior end; valves carinate medially, at least in early growth stages; mostly with radial ribs, some forms with growth undulations on ventral region; nacre of interior divided medially into two lobes.

Geologic range.—Carboniferous through Holocene (table 6).

Subgenus PINNA

Wedge-shaped, ventral margin straight to concave; median ridge well defined; sculpture of radial ribs or rows of scales.

Habitat.—Living worldwide in tropical or subtropical shallow seas. Sedentary, generally found buried, with the rounded posterior margins above the sediment surface, in mud, sand, or gravel with

TABLE 6.—*Geologic and geographic distribution of the Family Pinnidae*

[Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	California		Baja	
	Middle	Southern	Norte	Sur
Genus *Pinna*:				
Subgenus *Pinna*:				
barrowsi Dickerson	Pa			
latrania G D. Hanna		M or Pl		Pl
lewisi Waring		E		
mendenhalli G D. Hanna		M or Pl		
stocktoni Loel and Corey		O and M		
n. sp. Vokes	E			
Genus *Atrina*:				
alamedensis (Yates)	O and M	M		
bicuneata (Nomland)	M			
stephensi G D. Hanna		M or Pl		
venturensis (Yates)		O and M		

the anterior end downward and anchored in a vertical position by the byssus; occasionally found epifaunally attached to hard substrata. (Olsson, 1961, p. 143; Yonge and Thompson, 1976, p. 171) Lives buried in the mud of a quiet bay. (Keen, p. 74)

Pinna (Pinna) barrowsi Dickerson

Plate 22, figures 5, 6

Pinna barrowsi Dickerson, 1914, p. 125, pl. 8, fig. 3. Anderson and Hanna, 1925, p. 189.

Original description.—"The shape of the shell is elongate-cuneate. The cross section of the shell is quadrate-oval. The valves meet on their dorsal margins at a sharp angle which increases from sixty degrees near the base to ninety degrees near the beak. The ventral portions of the valves are rounded. Each valve presents two slopes; a flat, dorsal and a slightly convex, ventral which meet along a radial line. This line divides the shell so that the flat dorsal slope is one-third and the rounded ventral, two-thirds of the total surface. The rounded ventral slope is marked in its central half by approximately eight compressed and slightly elevated radial ribs whose interspaces are twice their width, and by eight to ten concentric rounded ribs in its marginal portion as well as radial ribs, thus further dividing the convex slope into equal parts. These ribs do not show on figured specimen. The flat dorsal slope of the shell is ornamented by about ten compressed radial ribs which are separated by interspaces two times as wide. The nearly straight posterior end makes a right angle with the ventral margin."

Holotype.—UCMP 11728.

Type locality.—UC 1547. Contra Costa County, Calif. Martinez Formation, Paleocene.

Comparison.—According to Waring, (1917, p. 94), *Pinna barrowsi* has a narrower apical angle than Eocene species *P. lewisi* Waring and has fewer radiating ribs.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Pinna (Pinna) lewisi Waring

Plate 21, figure 10

Pinna lewisi Waring, 1917, p. 94, pl. 15, fig. 24.

Original description.—"Shell thin, pearly, mytiliform, equivalve, truncate and wholly open behind; hinge line long; valves triangular, the apical angle being about 45 degrees; convex along the center line and flaring at the margins; base of shell notched in the middle and convex on either side; surface marked by fine indistinct radiating ribs and concentric lines of growth."

Holotype.—CAS/SU 5194.

Type locality.—SU 2696. Ventura County, Calif. Llajas Formation, Eocene.

Comparison.—"Differs from *Pinna barrowsi* Dickerson***by having a wider apical angle and fewer radiating ribs." (Waring, 1917, p. 94)

Geographic range.—Southern California.

Geologic range.—Southern California.

Occurrence in California.—Llajas Formation.

Pinna (Pinna) n. sp. Vokes

Plate 22, figure 1

Pinna n. sp. Vokes, 1939, p. 50, pl. 2, fig. 14.

Original description.—"A single crushed individual representative of the genus *Pinna* occurs in the collections. The shell is elongate-cuneate, ornamented with 23 rounded radial ribs separated by interspaces of approximately equal width."

Figured specimen.—UCMP 32595.

Locality.—UC 2287. Fresno County, Calif. Domengine Formation, Eocene.

Geologic range.—Eocene.

Occurrence in California.—Domengine Formation.

Pinna (Pinna) stocktoni Loel and Corey

Plate 22, figures 2, 3

Pinna (Pinna) stocktoni Loel and Corey, 1932, p. 186, pl. 8, figs. 5, 6.

Original description.—"Shell large, very convex, elongate-cuneate in outline, subdiamond shape in cross-section; valves flattened and gaping ventrally, umbonal shoulder subangular to rounded, extending almost to ventral margin, carina about one-third of height in width, flat or concave; dorsal margin being evenly, broadly arcuate, and the ventral part of shell somewhat flattened near this margin; dorsal surface ornamented by 5 or 6 longitudinal round ribs with a longitudinal groove above shoulder, ventral portion with about 14 weaker ribs which become concentric on the posterior third. Length (incomplete), 85 mm.; width, 105 mm.; diameter (both valves), 55 mm. Cotype, length (incomplete), 63 mm.; width, 36 mm.; diameter (both valves), 22 mm."

Syntypes.—UCMP 31778 and 31779.

Type locality.—UC A-252. Ventura County, Calif. Vaqueros Formation, Oligocene and Miocene.

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation.

Pinna (Pinna) latrania G D. Hanna

Plate 22, figure 4

Pinna latrania G D. Hanna, 1926, p. 475, pl. 27, fig. 1, text fig. 1.

Pinna (Pinna) latrania Hanna. Grant and Gale, 1931, p. 145.

Original description.—"Shell thin, long and slender, apical angle acute (27°); surface apparently unmarked externally by ridges, ribs or spines, except for a heavy longitudinal mid-rib in each valve; this is rounded convex, internally and apparently sharply carinate externally and divided longitudinally, the two parts being united by cartilage; the length of this rib is unobtainable from available material, but in other species it does not extend entirely to the beak; each valve is deeply sulcate at the mid-rib so that in looking down upon it, it is double-looped. Length of type specimen, 135 mm.; width from hinge line down, 63 mm.; gape

posteriorly, 51 mm.; length of hinge line, 116 mm.; length of byssal scar, 85 mm."

Holotype.—USNM 324593.

Type locality..—USGS 3922. Imperial County, Calif. Imperial Formation, Miocene or Pliocene.

Comments.—See *Pinna mendenhalli* below.

Geographic range.—Southern California and Baja California Sur.

Geologic range.—Miocene to Pliocene.

Occurrence in California and Baja California.—Miocene or Pliocene: Imperial Formation; Pliocene: unnamed strata, Baja California Sur (Durham, 1950).

Pinna (Pinna) mendenhalli G D. Hanna

Plate 23, figure 1

Pinna mendenhalli G D. Hanna, 1926, p. 476, pl. 27, fig. 2.
Pinna (Pinna) mendenhalli Hanna. Grant and Gale, 1931, p. 146.

Original description.—"Shell thick and heavy; apical angle obtuse (47°); outer surface without sculpture or distinct ribs; there is a low longitudinal ridge, however, on the ventral half of each valve; mid-rib exceedingly heavy (7 mm. thick in a fragment preserved on one specimen); rounded on the interior and apparently sharply carinate on the exterior. Each valve appears to be divided through this rib for at least a portion of its length because in the remnants of the shell preserved on the casts, there are ligament scars as shown in the figure. The gape extends the full length of the shell and the byssal scar appears to do the same; beak and posterior margins not seen. Greatest length of type, 167 mm.; greatest breadth, 98 mm.; thickness, 58 mm.; full dimensions were: length about 200 mm. and breadth 100 mm.; thickness of the paratype is 66 mm."

Holotype.—USNM 324593a.

Type locality.—USGS 3922. Imperial County, Calif. Imperial Formation, Miocene or Pliocene.

Comments.—*Pinna latrania* is distinguished from *P. mendenhalli* primarily on the basis of its smaller apical angle: 27° compared to 47°. The holotypes of both species, collected from the same locality in the Imperial Formation, are poorly preserved. I am not certain that two species are actually represented.

Geographic range.—Southern California.

Geologic range.—Miocene or Pliocene.

Occurrence in California.—Miocene or Pliocene: Imperial Formation.

Genus ATRINA Gray, 1842

Equivalve, ham-shaped, posterior end rounded, no median ridge; smooth or with radial rows of ribs or scales; internal nacre not divided into two lobes.

Geologic range..—Jurassic through Holocene (table 6).

Habitat.—Living in tropical and warm-temperate, shallow seas; vertically embedded in the substratum.

Atrina venturensis (Yates)

Plate 23, figure 2; plate 27, figure 2

Pinna venturensis Yeates *in* Cooper, 1888, p. 259
Pinna venturensis Yates. Cooper, 1894, p. 56, pl. 4, fig. 54.
Pinna (Atrina) venturensis Yates. Dall, 1898, p. 665.

Original description.—"From the hinge side about two thirds of the width of this shell is marked by nine well-developed, narrow ribs, radiating from the apex to the basal margin; the other portion shows rounded, concentric inequidistant ribs, extending only to the line of the radiating ribs, so that about two thirds of the surface is covered by the radiating smaller ribs, and one third by the curved, concentric, rounded ribs or wrinkles, very like *Pinna pectinata*, figured in 'Brown's Recent Conchology.' *Pinna venturensis* is short and thick compared with its length. The largest specimen found was about five and one half inches long, three and one half in width, and one and three fourths in thickness, the hinge side considerably shorter than the other. Locality, several specimens collected by the writer in Casitas Pass, Ventura County."

Holotype.—UCSB-Y3096.

Type locality.—Casitas Pass [Ventura quadrangle], Ventura County, Calif. Vaqueros Formation (Keen and Bentson, 1944).

A specimen of *Atrina venturensis* (pl. 27, fig. 2) was found in the collections at the University of California at Santa Barbara by Eugene V. Coan (oral commun., 1979). This specimen is presumably the holotype described by Yates in 1888. It is not the specimen subsequently illustrated (pl. 4, fig. 54) in 1894 (pl. 23, fig. 2 in this report). The specimen was surely handled by Yates as his signature is on the old label as well as a notation, also in his own hand, stating, "Described in 7th Annual Report of Cal. State Mineralogist for 1889. Illustration in same Report for 1891-2." Camp (1963, p. 384) briefly discussed *A. venturensis* and *Atrina alamedensis* and said that, "The University of California, Santa Barbara, has what are presumably the types of these shells."

Geographic range.—Southern California.

Geologic range.—Oligocene to Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation.

Atrina alamedensis (Yates)

Plate 23, figure 3; plate 27, figures 1, 3

Pinna alamadensis Yates *in* Cooper, 1888, p. 259 [*Lapsus* for *P. alamedensis*].
Pinna alamedensis "Yates." Cooper, 1894, p. 56, pl. 4, fig. 53. Clark, 1915, p. 446-447, pl. 48, fig. 3.
Pinna alamedensis Yates. Clark, 1915, p. 446-447, pl. 48, fig. 3.
Pinna (Atrina) alamedensis Yates. Grant and Gale, 1931, p. 146.

Original description.—"This species has nine concentric inequidistant rounded wrinkles emanating from the open side, and turning toward the hinge at nearly right angles, the entire shell marked by longitudinal narrow ribs (about forty), which, radiating from apex, extend to the basal margin, becoming more indistinct as they approach the lower margin. These ribs, at their intersection with the lines of growth, are ornamented by slight elevations, forming zigzag markings along the lines of growth. The hinge side is straight the entire length, the opposite side running parallel for about one half the distance from base to apex, where it makes a sharp curve, thence at an angle of about forty-five degrees to the apex. Length nine, width five, and thickness about two inches. Locality, Alameda Creek, Alameda County. Only one specimen found, and that a very fine one, in the center of a round sandstone bowlder. Miocene."

Holotype?.—UCSB-Y474.

Type locality.—In sandstone boulder, Alameda Creek, Alameda County, Calif. San Pablo(?) Group, Miocene.

A specimen of *Atrina alamedensis* (pl. 27, figs. 1, 3) was found in the collections at the University of California of Santa Barbara by Eugene V. Coan (oral commun., 1979). This specimen is presumably the holotype described by Yates in 1888. It is not the specimen subsequently illustrated (pl. 4, fig. 53) in 1894 (pl. 23, fig. 3 in this report). It is the approximate size given by Yates and better fits Yates' (1888, p. 259) statement that it was "a very fine one" than does the less complete specimen figured later (1894, pl. 4, fig. 53).

Supplementary description.—*Pinna alamedensis* "is noticeable for its large size and the thickness of the prismatic outer layer. Some of the specimens collected have a maximum antero-posterior length of ten inches, with a maximum width at right angles to that of about five and one-half inches." (Clark, 1915, p. 447)

Comparison.—[See *A. bicuneata.*]

Geographic range.—Middle and southern California.

Geologic range.—Oligocene to Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation (Arnold, 1908); Miocene: Monterey Formation (Nomland, 1917b, Cierbo and Neroly Sandstones (Hall, 1960), and Santa Margarita Formation (Nomland, 1917b).

Atrina bicuneata (Nomland)

Plate 23, figure 4

Pinna bicuneata Nomland, 1917b, p. 308, pl. 15, figs. 1a, 1b.

Pinna (Atrina) bicuneata Nomland. Grant and Gale, 1931, p. 146.

Original description.—"Shell elongate-cuneate; in cross-section thin, acutely elliptical. Hinge line long, nearly straight; ventral margin slightly concave near beaks; posterior end evenly rounded. Sculptured by approximately ten distinct radiating ridges which appear to be absent on lower one-third of shell."

Holotype.—UCMP 11307.

Type locality.—UC 2284. Fresno County, Calif. Santa Margarita Formation, Miocene.

Comparison.—"This form may be distinguished from *Pinna alamedensis* Yates, which also occurs in the same beds, by its smaller size, long, straight hinge-line and ventral margin, less number of radiating ridges, and in being thinner in cross-section." (Nomland, 1917b, p. 308)

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Santa Margarita Formation and San Pablo Group (Nomland, 1917b).

Atrina stephensi G D. Hanna

Plate 24, figure 4

Atrina stephensi G D. Hanna, 1926, p. 461, pl. 27, figs. 3, 4.

Original description.—"Shell robust, inflated, beaks acutely pointed; both margins concave toward beaks; growth ridges rough but not scaled or spinose; radial ridges on posterior two-thirds of shell; these are wavy in cross section, but not spinose; byssal area flat, the opening 3.5 mm. wide; valves gape broadly. Length 200 mm.; thickness, 60 mm.; width, 112 mm."

Holotype.—SDNM 2.

Type locality.—S. ½ sec. 10, T. 16 S., R. 10 E., SB, Coyote Mountain, Imperial County, Calif. Imperial Formation, Miocene or Pliocene.

Comparison.—"This species appears to be more closely related to *A. oldroydi* than any other; comparison has been made with the type of that species in Stanford University and it is found to have a convex swelling on the ventral margin; the radial ridges do not extend on the ventral half of the shell and the byssal area is not so flattened." (Hanna, 1926, p. 461)

Geographic range.—Southern California.

Geologic range.—Miocene or Pliocene.

Occurrence in California.—Miocene or Pliocene: Imperial Formation.

Family PTERIIDAE

Genus PTERIA Scopoli, 1777

Obliquely ovate, moderately inflated, slightly inequivalve; elongate posterior wing commonly present; exterior commonly smooth except for growth lines, but with radial rows of lamellar processes in some species.

Geographic range.—Triassic through Holocene (table 7).

Habitat.—Living in warm seas, most common in sandy sediment; on mud flats and in shallow subtidal water, seldom more than a few meters deep; byssally attached; some species gregarious on alyconarians (octocoral).

Pteria howei Nelson

Plate 24, figure 2

Pteri howei Nelson, 1925, p. 406, pl. 49, figs. 6, 7.

Original description.—"Shell medium-sized, thin, submytiliform, oblique; beaks fairly prominent, anterior; hinge line long, straight. Anterior ear almost one-third the length of posterior ear, margin of ear convex below hinge; posterior ear narrow, rear margin straight, curved to meet posterior margin of shell. Posterior margin of shell produced, rounded, with greatest curvature at junction with ventral margin; ventral margin broadly arcuate, roughly parallel to hinge line; anterior extremity continuous with ventral margin with reversed curvature where joined to anterior ear. Anterior ear joined to body in a rounded angle along a convex line between the anterior extremity and front of beak; posterior ear similarly joined along a slightly concave line between posterior end of shell and rear of beak. Byssal notch in right valve rather large, rounded, corresponds to a depression between ear and body of shell. Surface of shell smooth. Length of type specimen, 33 mm.; height, 13 mm. Length of cotype specimen, 19 mm.; height, 8.4 mm.; diameter of one valve, about 3.3 mm."

Holotype.—UCMP 30515.

Type locality.—UC 3767. Ventura County, Calif. Martinez Formation, Paleocene.

Comparison.—"*Pteria howei* is more elongate and has a less

TABLE 7.—*Geologic and geographic distribution of the family Pteriidae*

[H = Holocene; Ple = Pleistocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene]

Species	California		Baja California		Central and/or South America
	Middle	Southern	Norte	Sur	
Genus *Pteria*:					
berryi Adegoke	M				
hertleini Wiedey	O and M	O and M			
howei Nelson		Pa			
jordani Wiedey		M			
pellucida (Gabb)	E	E			
rositae Hertlein		O and M			
sp. Clark and Woodford	Pa				
Genus *Pinctada*:					
mazatlanica (Hanley)			H	Pl to H	H

prominent beak than *P. pellucida* (Gabb), and is much lower than *Pteria clarki* Weaver and Palmer." (Nelson, 1925, p. 406)

Geographic range.—Southern California.

Geologic range.—Paleocene.

Occurrence in California.—Martinez Formation.

Pteria sp. Clark and Woodford

Plate 24, figure 1

Pteria sp. Clark and Woodford, 1927, p. 88, pl. 14, fig. 7.

Description.—"An imperfect specimen of a *Pteria*, not determinable specifically."

Figured specimen.—UCMP 31321.

Locality.—UC 3152. Contra Costa County, Calif. Meganos Formation, Paleocene.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Meganos Formation.

Pteria pellucida (Gabb)

Plate 24, figure 3

Avicula pellucida Gabb, 1864, p. 186, pl. 25, fig. 172.

Pteria pellucida (Gabb). Anderson and Hanna, 1925, p. 188-189, pl. 1, fig. 1. Vokes, 1939, p. 50-51, pl. 2, figs. 1, 4, 7, 8. Kleinpell and Weaver, 1963, p. 197, pl. 29, fig. 5. Givens, 1974, p. 43, pl. 1, fig. 10.

Not *Pteria pellucida* (Gabb). Anderson and Hanna, 1925, p. 188-189, pl. 1, fig. 1.

Original description.—"Shell oblique, subcompressed, broad-lingulae-form; ears very unequal; beaks moderate, anterior; cardinal line straight; anterior ear short angular, posterior ear broad, acuminate; anterior and posterior margins nearly parallel for a short distance below the ears; base forming an excentric curve, most produced behind; there is no distinct division between the body of the shell and the ears. Surface polished, and exhibiting only faint, concentric undulations, corresponding to lines of growth, and a few microscopic, radiating lines, posteriorly."

Lectotype.—UCMP 11983 (Vokes, 1939, p. 50)

Type locality.—Near Martinez, Contra Costa County, Calif. Domengine(?) Formation, Eocene (Keen and Bentson, 1944).

Comparison.—"The specimen figured by Anderson and Hanna (1925: *pl. 1, f. 1*) as *Pteria pellucida* differs from Gabb's species in having the dorsal edge of the anterior ear at an angle to the hinge-line rather than forming a straight line, and in the umbonal ridge forming an angle of approximately 55 degrees with the hinge-line." (Vokes, 1939, p. 51)

Geographic range.—Middle and southern California.

Geologic range.—Eocene.

Occurrence in California.—Avenal (Stewart, 1946) and Coldwater (Weaver and Kleinpell, 1963, p. 197) Sandstones, Domengine Formation, Matilija Sandstone (*Ectinochilus canalifer* fauna, Givens, 1974), and Tejon Formation (Anderson and Hanna, 1925).

Pteria hertleini Wiedey

Plate 24, figure 6

Pteria hertleini Wiedey, 1928, p. 133. pl. 2, fig. 1. Loel and Corey, 1932, p. 188, pl. 10, figs. 1, 4.

Original description.—"Shell large, very oblique, lingulaeform, nearly equivalve, very inequilateral, and highly inflated. Anterior dorsal margin quite straight and nearly vertical to the hinge line. This dorsal extremity is terminated in a sharp curve. The basal margin is broadly rounded and seems generally somewhat parallel to the hinge line. The posterior dorsal extremity is more sharply rounded; being quite distant from the beaks, it accentuates the oblique form of the shell. The posterior dorsal margin is very long and nearly straight. The umbones are very prominent, highly elevated, very regularly rounded, and acutely angular. The beaks are small, sharp, not conspicuous, and quite distant from one another. The hinge length is about three-fourths the width of the shell and is straight with a broad, moderately deeply excavated ligamental area. The anterior ear is the sharper and the more extended. Length, about 110 mm.; breadth, about 99 mm.; thickness of combined valves, about 70 mm.; length of hinge line, about 75 mm."

Holotype.—CAS/SU 5160.

Type locality.—SU 200. Monterey County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"This species is distinct in its inflation and acute umbonal angle. The shell is thin and not commonly preserved. On a few specimens the surface is seen to be smooth, with faint concentric incremental lines, strongest on umbos." (Loel and Corey, 1932, p. 188)

Comparison.—"This new species is very distinctive and is resembled but slightly by any of the yet recorded West Coast Tertiary forms of this genus. From *Pteria jordani* Wiedey***it differs in being more convexly inflated, more elongate and extended in outline, and in possessing higher, sharper, and more prominent umbones***" (Wiedey, 1928)

Comments.—See *Pteria rositae.*

Geographic range.—Middle and southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation (Eaton and others, 1941); Miocene: Temblor "horizon" (Loel and Corey, 1932), Topanga Formation (Takeo Susuki, written commun., 1978).

Pteria berryi Adegoke

Plate 24, figure 5

Pteria berryi Adegoke, 1969, p. 95-96, pl. 1, figs. 10, 12.

Original description.—"Shell moderately large, oblique, nearly equivalve, inflated, inequilateral; anterior dorsal margin fairly long, nearly straight, merges into broadly rounded ventral margin with sharp angulation; posterior dorsal margin very long, nearly straight, merges into ventral margin with no marked angulation; extreme ventral margin broadly rounded; umbones prominent, convexly rounded; beaks small, acutely pointed and bent anteriorly; hinge line straight, about two-thirds length of shell; posterior ventral margin of shell conspicuously depressed and flattened behind hinge line; shell surface smooth."

Holotype.—UCMP 36611.

Type locality.—UC D-1063. Fresno County, Calif. Upper part of Temblor Formation, Miocene.

Comparison.—"This new species is closely similar to *Pteri hertleini* Wiedey from the Vaqueros Formation but may be distinguished from it by its relatively smaller size, its shorter and more broadly rounded posterior ventral margin and by the more prominent depression and flattening of the posterior dorsal margin. It differs from *P. jordani* Wiedey from the Temblor of Santa Monica Mountains by its wider and more convexly inflated valves, and by the more prominent umbones." (Adegoke, 1969, p. 96)

Geographic range.—Middle California.

Geologic range.—Miocene.

Occurrence in California.—Upper part of Temblor Formation.

Pteria jordani Wiedey

Plate 25, figure 1

Pteria jordani Wiedey, 1928, p. 134-135, pl. 4, fig. 4; pl. 15, fig. 3.

Original description.—"Shell quite large, moderately oblique, lingularform, slightly inequivalve, inequilateral, and well inflated. Anterior dorsal margin above the hinge line rounded concavely, the anterior dorsal extremity very broadly convexly rounded. The basal margin is a little more sharply rounded toward the posterior dorsal extremity, which is but gently rounded. The posterior dorsal margin slopes nearly straight and is only slightly re-entrant into the main body of the shell adjacent to the hinge line. Umbones large, prominent, broad, convexly well inflated with a poorly defined umbonal ridge passing from the beaks toward the base of the shell, about 45° to the hinge line. Beaks situated at the anterior end of the shell, small, sharp, slightly elevated, and incurved. Since most of the shell has been broken away, the external sculpture is unknown. The hinge line is generally about the length of the shell and is straight, marked in the ligamental area by long, narrow, longitudinal grooves. The posterior ear is the broader, while the anterior ear appears to be the more extended and sharper, being very acutely angular. The shell attains a length of over 100 mm.; a breadth of over 95 mm, and a thickness in combined valves of over 55 mm."

Holotype.—SDNM 25.

Type locality.—SU 425. Los Angeles County, Calif. Topanga Formation (Keen and Bentson, 1944), Miocene.

Comparison.—"This new species differs from other known fossil forms in its very much greater size and in its more rounded and regular outine. It is approached in similarity by***Pteria hertleini* Wiedey***The latter species is of similar size, but shows greater sharpness of the umbones, which are themselves much more inflated. In some respects it is resembled by *Pteria peruviana* Reeve, which ranges from the Gulf of California to Ecuador. The fossil species has not the subquadrate outline nor the short posterior ear much separated from the shell found in the living form." (Wiedey, 1928, p. 135)

Geographic range.—Southern California.

Geologic range.—Miocene.

Occurrence in California.—Topanga Formation (Takeo Susuki, written commun., 1978).

Pteria rositae Hertlein

Plate 24, figure 7

Pteria rositae Hertlein, 1928, p. 150, pl. 25, fig. 3. Loel and Corey, 1932, p. 188, pl. 9, fig. 3.

Original description.—"Shell oblique triangular, with long produced wing; hinge line long and straight; surface ornamented by incremental lines of growth. Beak near anterior fourth, prominent, oblique; shell slopes rather rapidly posteriorly from beak; anteriorly the beak slopes abruptly to a small byssal fold, forming a groove which separates the anterior auricle from shell; auricle triangular, obliquely truncate; byssal notch small, but pronounced. Height, 26.9 mm; length of hinge line (incomplete at both ends), 43 mm."

Holotype.—CAS 4142.

Type locality.—CAS 1156. Santa Barbara County, Calif. Rincon Shale, Oligocene and Miocene.

Comparison.—"This species differs from *P. sterna* Gould in that the anterior ventral part of the shell drops abruptly and is directly in line with the byssal sinus while in *P. sterna* Gould, the anterior ventral part of the shell extends broadly anterior and the byssal groove runs obliquely anterior from the beak. It is much broader ventrally and much more extended posteriorly than *P. peruviana* Reeve." (Hertlein, 1928, p. 150)

"The small form figured and described by Hertlein may possibly be a young specimen of *P. hertleini* Wiedey***, to the young of which it is very similar in outline." (Loel and Corey, 1932, p. 188)

Comments.—The anterior margin of *P. rositae* is nearly straight, as is a groove that continues to the dorsal edge. *P. hertleini* Wiedey, though much larger, has a deeply concave anterior margin, and, in proportion to its size, a shorter dorsal margin. *P. rositae* has a short posterior wing and a large anterior ear. The living species, *Pteria sterna* (Gould), includes a short-winged form that occurs in clusters on mud flats (Keen, 1971, p. 77).

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Rincon Shale.

Genus PINCTADA Röding, 1798

Less oblique and usually thicker shelled than *Pteria*, subquadrate, commonly slightly higher than long, nearly equivalve; posterior wing and indentation lacking or nearly so; surface lamellose.

Geographic range.—Pantropic, especially Indo-Pacific.

Geologic range.—Miocene through Holocene (table 7).

Habitat.—Attached by byssal threads; the flattened shell is usually secured almost at right angles to the surface but always inclined somewhat to the right. (Yonge and Thompson, 1976, p. 173)

Pinctada mazatlanica (Hanley)

Plate 25, figure 2

Meleagrina mazatlanica Hanley, 1855, p. 388, pl. 24, fig. 40.

Pteria (Pinctada) mazatlanica (Reeve). Grant and Gale, 1931, p. 148 [See synonymy].

Pinctada mazatlanica Hanley. Hertlein and Strong, 1943, p. 164-165.

Pinctada mazatlanica (Hanley). Durham, 1950, p. 58, pl. 2, fig. 6. Keen, 1971, p. 79, fig. 162.

Original description.—"Large, solid, subventricose, more or less oblique, more or less projecting behind ventrally, longer than broad, squarish above in front; rounded ventrally, yellowish olive, with rather faint pallid rays; the rather distant concentric lamellae somewhat closely fringed with moderately large peaked concave vandyked scales; ventral edge much arcuated, rising in front; anterior margin not retuse, but either straightish or convex, forming nearly a rectangle with the rather short straight and rising dorsal line; hinder gape ample, the posterior dorsal incurvation being full, and the auricle rather large and deep; nacre bluish white, broadly edged with the external colouring. 5***4½. *Mazatlan. Distinguished from margaritifera by its scales, obliquity, colour, and by not being retuse in front.*"

Holotype.—Location unknown; not in BM(NH) (A. M. Keen, oral commun., 1978).

Type locality.—Mazatlan, Mexico.

Geographic range.—Living: Pacific coast of Baja California and Golfo de California to Peru; fossil: Baja California Sur.

Geologic range.—Pliocene through Holocene.

Occurrence in Baja California Sur.—Pliocene: Carmen and Marquer Formations (Durham, 1950); Pleistocene: unnamed strata Punta San Telmo and Isla Carmen, Baja California Sur (Durham, 1950).

Habitat.—In shallow water offshore; attached by byssus.

Family ISOGNOMONIDAE

Genus ISOGNOMON Lightfoot, 1786

Shell subequivalve, usually higher than long, more or less compressed, of various shapes; umbo directed anteriorly and not protruding above hinge margin; ligamental area broad and flat, scarcely undercut; ligamental grooves numerous, regularly arranged; narrow byssal gape present below beaks with corresponding reflection of anterior margin.

Geologic range.—Triassic through Holocene (table 8).

Habitat.—Attached to byssus that passes between the two valves; commonly wedged in among coral colonies, mangrove roots, or rocks with a distorted shell conforming to the constricting cavity.

Subgenus ISOGNOMON

Rhomboidal to pyriform, beak at anterior end of hinge margin, produced and pointing anteriorly; lower part of anterior margin in some species strongly convex and extending well forward of beak, entire margin in other species straight or almost so and inclined so as to form a slightly acute angle with hinge margin; hinge margin rather short, posterior wing obtuse and seldom well differentiated; ligamental grooves subequal, intervals between them lying in general plane of ligamental area; surface lamellose.

Isognomon (Isognomon) panzana (Loel and Corey)

Plate 25, figures 3, 6

Pedalion panzana Loel and Corey, 1932, p. 187, pl. 9, figs. 1a, 1b, 2-6.

Original description.—"Shell large, rugose and thick, of a dark brown material, valves equivalve, very inequilateral and high, fairly convex, and subquadrate in outline; umbones prominent—produced beyond anterior margin in continuation of dorsal margin, beaks acute, proximate, inturned; dorsal margin gently curved, joining posterior margin in a short curve (in paratype this extremity is angular) ventral margin evenly rounded to the anterior which is gently convex in lower half and gently concave in upper part of beak. The upper part of the anterior margin is deeply inturned; a fairly prominent ridge extends along this convexity from the beak, inside of which ridge is a groove, deepest under beaks. Interior of valves quadrate, produced toward beaks; cardinal area straight, broad, with deep straight, perpendicular pits which are wider posteriorly. No byssal notch on right valve. Muscle scars not seen. Surface ornamented by a number of irregular, divaricate-radial plications, triangular in shape, which become more numerous and stronger toward the crenulate posterior ventral margins."

Holotype.—UCMP 31780.

Type locality.—UC A-498. San Luis Obispo County, Calif. Vaqueros Formation, Oligocene and Miocene.

Supplementary description.—"This interesting species is the first *Pedalion* found in the Post-Eocene Tertiary of the West Coast. It occurs in large numbers at the type locality, forming a hard reef bed." (Loel and Corey, 1932, p. 187)

Geographic range.—Southern California.

Geologic range.—Oligocene and Miocene.

Occurrence in California.—Oligocene and Miocene: Vaqueros Formation.

Isognomon (Isognomon) janus Carpenter

Plate 25, figures 4, 5

Isognomon janus Carpenter, 1857, p. 151-152. Keen, 1971, p. 79, fig. 163.

Pedalion janus (Carpenter). Durham, 1950, p. 58, pl. 3, figs. 1, 4.

Original description.—"I. t. rhomboideâ, tenui, planatâ, pallidâ; valvâ inferiori laevi, superiori costis gracillimis, interdum obsoletis, testâ juniore spinis semitubulis imbricatâ; haud auritâ, angulo ad umbones acuto; marginibus ant. et post. subparallelis, subrectis: cardine ligamento ut in Avicula longo, fossibus perpaucis, minimis, irregulariter dispositis; imp. musc. haud magno."

Holotype.—BM(NH), Carpenter collection, tablet 690.

Type locality.—Off Mazatlan, Mexico.

Comparison.—"The principal distinction that Carpenter noticed in this shell was that there are fewer pits along the hinge margin—as many as 10 to 12 in *I. recognitus*, only 7 to at most 9 in *I. janus*.***The shell tends to be higher for the length or more tongue-shaped. Radial sculpture may be more pronounced in *I. janus*, and concentric lamellae are lacking. *Perna anomoides* Reeve was described as from 'California,' but the present label on the type specimen in the British Museum says 'Torres Straits' (i.e. northern Australia). Reeve's figure does not resemble *I. janus* in outline." (Keen, 1971, p. 79)

Geographic range.—Living: Laguna San Ignacio, Baja California Sur, to Oaxaca, Mexico; fossil: Baja California Sur.

Geologic range.—Pliocene through Holocene.

Occurrence in Baja California Sur.—Pliocene: Marquer Formation (Durham, 1950).

Habitat.—"on *I. chemnitzii* and *Spondylus calcifer****" (Carpenter, 1857, p. 152)

Isognomon sp. (Clark and Woodford)

Plate 26, figure 3

Pedalion sp. Clark and Woodford, 1927, p. 88, pl. 14, fig. 8.

Description.—"Two fragmentary specimens are referred to this

TABLE 8.—*Geologic and geographic distribution of the family Isognomonidae.*
[H = Holocene; Pl = Pliocene; M = Miocene; O = Oligocene; E = Eocene; Pa = Paleocene.]

Species	California		Baja California		South America
	Middle	Southern	Norte	Sur	
Genus *Isognomon*:					
Subgenus *Isognomon*:					
janus Carpenter				Pl to H	H
panzana (Loel and Corey)		O and M			
Subgenus *Isognomon*?:					
n. sp.? Givens		E			
sp. (Clark and Woodford)	Pa				
Genus *Pachyperna*?:					
goniglensis (M. A. Hanna)		E			
joaquinensis (Vokes)	E				

genus, one of which is figured. The material is not good enough for specific identification."

Figured specimen.—UCMP 31301.

Locality.—UC 3609. Contra Costa County, Calif. Meganos Formation, Paleocene.

Geographic range.—Middle California.

Geologic range.—Paleocene.

Occurrence in California.—Meganos Formation.

Isognomon n. sp.? Givens

Plate 26, figure 1

Isognomon n. sp.? Givens, 1974, p. 43-44, pl. 2, fig. 6.

Description.—"Five poorly preserved specimens of a large *Isognomon* were collected from locality 4752. They represent the first record of this genus in the Eocene of the Pacific Coast and, therefore, probably represent a new species. The small size of the sample and poor preservation of the specimens, however, do not justify the naming of a new species at this time. The description of the figured specimen is as follows: shell subquadrate in outline, about 6 in high and 4 in long, moderately convex, equivalve, inequilateral; umbo situated at anterior end of hinge margin, produced and directed anteriorly; anterior margin of shell nearly straight, becoming concave near the beak and forming an acute angle with the hinge margin; posterior and ventral margins of shell evenly rounded; narrow byssal gape present below beaks; hinge area with at least 11 narrow, subequal ligament grooves; surface of shell concentrically lamellose."

Figured specimen.—UCR 4752/61.

Locality.—UCR 4752. Ventura County, Calif. Juncal Formation, *Turritella uvasana applinae* fauna, Eocene.

Comparison.—" *'Perna' goniglensis* Hanna***and *'Pedalion' joaquinensis* Vokes***from the middle Eocene ('Domengine Stage') of California are distinguished from *Isognomon* n.sp.? by their much smaller size and by the presence of only 3-5 ligament grooves on the hinge area. These species appear to be referable to *Pachyperna* Oppenheim***of the European middle Eocene." (Givens, 1974, p. 44)

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Juncal Formation (*Turritella uvasana applinae* fauna, Givens, 1974).

Genus PACHYPERNA Oppenheim, 1900

Moderately small, ovate, higher than long, not oblique, subequivalve, strongly convex; shell wall very thick; with small anterior auricle but with no differentiated posterior wing; umbones ill-defined, not protruding; anterior face with broad, shallow lunule but without byssal gape; ligamental area broad with not more than five relatively wide pits.

Geographic range.—France, northern Italy, California?

Geologic range.—Eocene (table 8).

Genus PACHYPERNA?

Pachyperna? goniglensis (M. A. Hanna)

Plate 26, figure 4

Perna goniglensis M. A. Hanna, 1927, p. 275, pl. 27, figs. 12-14.

"Perna" goniglensis Hanna. Givens, 1974, p. 44.

Original description.—"Shell of medium size, moderately inflated; dorsal edge straight to gently rounded; posterior side straight to slightly rounded; ventral margin regularly rounded to the deep indentation on the anterior side; beak sharply rounded; outer surface evidently smooth; shell chalky, fairly heavy; ligamental grooves elongate normal to the ligamental surface, three to four grooves separated by flat-topped ridges of various widths, but wider than the grooves; character of the interior not evident. *Dimensions:* Altitude 30 mm, length 25 mm."

Holotype.—UCMP 30912.

Type locality.—UC 4233. San Diego County, Calif. Ardath Shale, Eocene.

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Ardath Shale.

Pachyperna? joaquinensis (Vokes)

Plate 26, figure 5

Pedalion joaquinensis Vokes, 1939, p. 52-53, pl. 2, figs. 3, 6, 10, 12, 15.

"Pedalion" joaquinensis Vokes. Givens, 1974, p. 44.

Original description.—"Shell of medium size, compressed; dorsal margin straight, the posterior and ventral rounded, the anterior slightly concave; a small anterior ear angulate to the dorsal margin; umbos anterior, sharply prosogyrate; shell laminated, iridiscent; surface smooth except for growth-lines; ligamental grooves four or five, narrow-elongate, separated by interspaces equal in width to the grooves at the beak and becoming progressively wider posteriorly."

Holotype.—UCMP 15577.

Type locality.—UC 7177. Fresno County, Calif. Domengine Formation, Eocene.

Comparison.—"This species differs from *P. goniglensis* M. A. Hanna***in lacking the deep anterior indentation characteristic of the San Diego species; the anterior margin, ventral to the byssal notch, does not project as far forward in the Coalinga species. The dorsal margin is never rounded, and the ear, characteristic of *P. joaquinensis*, is not well developed on *P. goniglensis*." (Vokes, 1939, p. 53)

Geographic range.—Middle California.

Geologic range.—Eocene.

Occurrence in California.—Domengine Formation.

Family PULVINITIDAE

Genus PULVINITES Defrance, 1824

Orbicular or broadly trigonal; right valve flat or slightly concave, with byssal foramen below middle of ligamental area.

Geographic range.—France, Lebanon, North America.

Geologic range.—Jurassic to Paleocene; Holocene of Australia.

Habitat.—Attached by byssus through foramenal opening.

Pulvinites californica Zinsmeister

Plate 26, figure 6

Pulvinites californica Zinsmeister, 1978, p. 568, pl. 1, figs. 7-10 [erroneously cited in text as figs. 5, 6].

Original description.—"Shell small orbicular, compressed. Right valve flat to slightly concave with small slightly elliptical foramen located immediately below hinge, a short suture extends from foramen to anterior edge of shell below hinge; left valve weakly convex with faint, irregular undulations. Small, subcentrally located adductor muscle scar in each valve. Hinge edentulous with narrow ligamental area, 4 to 5 ligamental grooves."

Holotype.—UCR 6821/19.

Type locality.—UCR 6821. Ventura County, Calif., Paleocene.

Comparison.—"This small species is distinguished from *Pulvinites pacifica* by the convex left valve and small size. The two species have never been found together." (Zinsmeister, 1978, p. 568)

Geographic range.—Southern California.

Geologic range.—Paleocene.

Occurrence in California.—Lower part of Santa Susana Formation.

Pulvinites pacifica Zinsmeister

Plate 26, figures 2, 7

Pedalion sp. Nelson, 1925, p. 405, pl. 49, figs. 8. 9.

Pulvinites pacifica Zinsmeister, 1978, p. 569, pl. 1, figs. 5, 6 [erroneously cited in text as figs. 7-10].

Original description.—"Shell orbicular, compressed, lamellose. Right valve flat to slightly concave with moderately large slightly elliptical foramen, located 4 mm ventrally from the dorsal edge of valve, anterior to foramen, the laminar shell layers are closely packed. Moderately large adductor muscle medially located in each valve, left valve slightly convex, with centrally located adductor muscle scar with a faint radiating retractor scar. Hinge edentulous, with approximately 5 ligamental grooves."

Holotype.—UCR 7342/1 (*not* 6900/101; J. D. Mount, written commun., 1978).

Type locality.—UCR 7342. (Not UCR 6900; J. D. Mount, written commun., 1978). Ventura County, Calif. Paleocene.

Supplementary description.—"Specimens of *Pulvinites* are generally poorly preserved because of the hard matrix and laminar nature of the shell structure. No suture is immediately obvious, but the close bunching of the laminar shell constrictions anterior to the foramen probably represents the location of the suture.

"The occurrence of *Pulvinites* in the Paleocene of California is the first recognized occurrence of the genus in the Tertiary. Nelson (1925) found poorly preserved fragments of *Pulvinites*, but because the foramen was not preserved in his material, he did not recognize that it was a pulvinitid and referred it to the genus *Pedalion*." (Zinsmeister, 1978, p. 569)

Comparison.—"The large foramenal opening (4 to 5 mm.), narrow hinge, and ventrally located suture separates *Pulvinites pacifica* from other known Paleocene species of *Pulvinites*. *Pulvinites californica* which also occurs in the Simi Hills is considerably smaller with a more convex left valve." (Zinsmeister, 1978, p. 569)

Geographic range.—Southern California.

Geologic range.—Paleocene.

Occurrence in California.—Lower part of Santa Susana Formation.

Family MALLEIDAE

Genus NAYADINA Munier-Chalmas, 1864

Subequivalve of various shapes, commonly elongate and equilateral; valves with or without narrow, simple gape; ligamental area well exposed to exterior, with broad, deeply concave ligamental pit occupying most of its width.

Geographic range.—Europe, North America, North Africa, southwest Asia.

Geologic range.—Cretaceous to Eocene.

Subgenus EXPUTENS Clark, 1934

Elongate, oblong, inequilateral, with posterior end extended; subauriculate anteriorly; valve margins not gaping; umbones commonly pointed and prominent; ligamental area broad, overhanging platform extending posterior from umbones; surface smooth except for well-marked growth lines.

Geographic range.—California and Jamaica.

Geologic range.—Eocene.

Nayadina (Exputens) alexi (Clark)

Plate 26, figures 8, 9

Exputens alexi Clark, 1934, p. 271-272, pl. 37, figs. 19-24. Vokes, 1939, p. 51, pl. 2, figs. 2, 5, 9.

Original description.—"Shell moderately thick for the size, elongate subquadrate to subtrapezoidal in outline; beaks inconspicuous, in the anterior third of the shell; anterior end broad and bluntly rounded; posterior end narrower than anterior and regularly rounded; the anterior ear stands up prominently above the beaks as though this portion of the shell had been twisted upward and backward. A large triangular ligamental area, only moderately depressed. The line of greatest convexity of the surface of the shell extends from the beak to the posterior end. The general surface of an unweathered specimen is sculptured by somewhat irregular concentric undulations. The large posterior adductor scars are close to the ventral edge and only slightly posterior to the beaks. The small anterior scars are just below the beaks and somewhat obscure on some of the specimens."

Holotype.—UCMP 32386.

Type locality.—UC A-1007. Fresno County, Calif. Domengine Formation, Eocene.

Comparison.—"*Exputens alexi* may be distinguished from *E. llajasensis* by the position of the ears, which on the former stand out above the beaks whereas on the latter they are in the normal position in front of the beaks. Another character, in which the two species differ, is the ligamental pit; on the former it is much less depressed than on the latter. Apparently *E. llajasensis* is a more variable form than *E. alexi*. None of the specimens of the latter species is as large as the average size of the former." (Clark, 1934, p. 272)

Geographic range.—Middle and southern California.

Geologic range.—Eocene.

Occurrence in California.—Avenal Sandstone (Stewart, 1946) and Domengine Formation.

Nayadina (Exputens) llajasensis (Clark)

Plate 26, figures 10, 13

Exputens llajasensis Clark, 1934, p. 270-271, pl. 37, figs. 11-18. Vokes, 1939, p. 51 [Designated as genotype].

Nayadina (Exputens) llajasensis (Clark). Givens, 1974, p. 44, pl. 1, fig. 9.

Original description.—"Shell thin, variable in outline, roughly elongate, subquadrate in outline; surface smooth except for fairly heavy, irregular lines of growth; beaks in the anterior third of the shell, variable in prominence, inconspicuous on the type. Anterior ears defined and in front of the beak; ligamental area broad triangular in outline and situated on a chrondrophore-like platform which stands out almost at right angles to the main surface of the shell; posterior muscle scar large near the ventral edge and a little posterior to the beak; anterior scar small and situated below the beak and the anterior edge of the ligamental platform, obscure on some specimens."

Holotype.—UCMP 32391.

Type locality.—UC 7004. Ventura County, Calif. Llajas Formation, Eocene.

Supplementary description.—"There are several distinct variants of this species as found at the type locality***variety A***is a perfect specimen showing both valves; it is long and narrow and has well-developed anterior ears; the beaks are only moderately conspicuous***.

"variety B. On this specimen the beaks are so inconspicuous as to be hardly discernible. The ear is larger than on variety A and the anterior end is broadly rounded, sloping down from the outer angle of the ear almost at right angles to the posterior dorsal margin and giving a subquadrate appearance to the shell.

"variety C, a form in which the beaks are conspicuous and opisthogyrous. The ear is almost obsolete; this is brought about by the fact that the upper margin of the ear slopes abruptly downward and joins the anterior edge of the shell without any break such as is seen in varieties A and B***.

"Most of the specimens of this species show irregularities in the surface of the shell. This, together with the variability in outline, the general elongate shape, and the lack of any well-defined byssal notch, suggests that the species was a nestler." (Clark, 1934, p. 271)

Comparison.—[See *N.* (*E.*) *alexi.*]

Geographic range.—Southern California.

Geologic range.—Eocene.

Occurrence in California.—Juncal (*Turritella uvasana infera* fauna, Givens, 1974) and Llajas (Keen and Bentson, 1944) Formation.

Genus VULSELLA Röding, 1798

Shell elongated dorsoventrally, linguiform, subequivalve, compressed, gaping anteriorly and posteriorly; ears absent or small; surface concentrically lamellose, radial ribbing present in some forms; not byssiferous.

Geologic range.—Cretaceous through Holocene.

Habitat.—Living forms commonly commensal in sponges; no byssus.

Genus VULSELLA?

Vulsella? clarki Vokes

Plate 26, figures 11, 12

Vulsella(?) *clarki* Vokes, 1939, p. 53-54, pl. 3, fig. i.

Original description.—"Shell ostreiform, moderately large, elongate posteriorly, inflated, attached; surface, other than area of attachment, marked by coarse lines of growth; ligamental groove external, elongate, triangular; shell thin at area of attachment, thick elsewhere; muscle-scar subcentral, moderately large."

Holotype.—UCMP 15743.

Type locality.—UC 1817. Fresno County,Calif. Lodo Formation, Paleocene and Eocene.

Supplementary description.—"According to Reeves the genus occurs principally in association with sponges, and none of the figured species shows any indication of an area of attachment. The generic determination of the new species is therefore questioned, as a prominent area of attachment is visible on all the specimens in the collection.

"One large specimen appears to have been attached to a large flat surface (possibly an *Aturia*) and, as a result, tends to be elongated ventrally rather than posteriorly." (Vokes, p. 53-54)

Comparison.—"*Vulsella*(?) *clarki* may be distinguished from all described West American species by its ostreiform shape and the external ligamental pit." (Vokes, 1939, p. 53)

Geographic range.—Middle California.

Geologic range.—Paleocene to California.

Occurrence in California.—Paleocene and Eocene: Cerros Shale Member of the Lodo Formation (Keen and Bentson, 1944).

FOSSIL LOCALITIES

[Corrections and information not in the original description are in brackets; miles and feet are converted to metric units; formations are cited as emended by later work where pertinent]

California Academy of Sciences:

- CAS 68. North bank of Kern River, about 1 km west of the power plant and 5 km east of the Rio Bravo Ranch House [Caliente quadrangle], Kern County, Calif. Temblor Formation.
- CAS 119. East bank of Eel River, 2 km north of Scotia, Humboldt County, Calif. Upper part of Rio Dell Formation or lower part of Scotia Bluffs Sandstone.
- CAS 244. In east bank of Live Oak Creek. 1.2 km from mouth, 4.8 km due east of mouth of Grapevine Canyon, Tejon quadrangle, Kern County, Calif. Tejon Formation.
- CAS 245. Along east bank of a small gulch 0.4 km east of pumping plant at mouth of Grapevine Canyon, 56 km south of Bakersfield, Tejon quadrangle, Kern County, Calif. Tejon Formation.
- CAS 711. East side of Grapevine Creek near point where it enters valley floor, Tejon quadrangle, Kern County, Calif. Tejon Formation.
- CAS 788. Along east bank of gulch 400 m east of pumping plant at mouth of Grapevine Canyon, 56 km south of Bakersfield, Tejon quadrangle, Kern County, Calif. Tejon Formation.
- CAS 1156. About 0.4 km southeast of spring on ridge south of San Augustine Canyon, east of dike near top of hill, Santa Rosa Island, Santa Barbara County, Calif. Rincon Shale.
- CAS 12099. Well in Balboa Park, San Diego, San Diego County, Calif. San Diego Formation.
- CAS 53043. Rio Dell side of Eel River, 730-825 m downstream from Scotia-Rio Dell bridge, Humboldt County, Calif. Rio Dell Formation.

California Institute of Technology:

- CIT 738. South slope of Carrizo Mountain, crest of ridge 1,120 m northeast of mouth of Alverson Canyon, Imperial County, Calif. Imperial Formation.

Los Angeles Natural History Museum:

- LAM 107. Thirty-meter bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego, Calif. San Diego Formation.

San Diego Natural History Museum:

- SDNM 207. Near Elsmere Canyon, in ridge, sec. 8, T. 3 N., R. 15 W., SB [San Fernando quadrangle], Los Angeles County, Calif. Fernando Formation.
- SDNM 407. South wall of Little Sespe River, just above its junction with Big Sespe River, Ventura County, Calif. Vaqueros Formation.
- SDNM 432. [See SU 432.]
- SDNM 442. On a spur in a small canyon about 2 km west of San Martinez Grande Canyon, north side of Santa Clara Valley, approximately on the boundary line between Los Angeles and Ventura Counties, Calif. Pico(?) Formation.
- SDNM 443. Near center of south line of SE½ sec. 36, T. 9 S., R. 2 W., Santa Cruz quadrangle, California. On old road, about ½ km southwest of Zayante R. R. station. Elevation about 300 m. Monterey Shale.

Stanford University [These collections are now housed in the California Academy of Sciences]:

SU 111. Two Bar Creek, 0.4 km above junction with San Lorenzo River, Santa Cruz County, Calif., about 185 m above base. Vaqueros Formation.

SU 200. East side of Vaqueros Creek, SE¼ sec. 9, T. 20 S., R. 6 E., Junipero Serra quadrangle, Monterey County, Calif. Vaqueros Formation.

SU 425. Head of small canyon trending westward from head of Dry Canyon at base of east-west ridge forming divide, 3 km south of Calabasas, Santa Monica Mountains [sec. 34, T. 1 N., R. 17 W., Calabasas quadrangle], Los Angeles County, Calif. Topanga Formation.

SU 432. East slope of first ridge west of Syncline Hill, 3 km west of Simmler [SW¼ sec. 35, T. 29 S., R. 17 E., La Panza quadrangle], San Luis Obispo County, Calif. Temblor Formation.

SU 834. 19 mm west and 82 mm south of the intersection of lines indicating lat 34°40′ N. and long 129°10′ W. on Lompoc quadrangle (1905 ed.), east side of Nojoqui Creek, due east of the letter "R" of the word "Creek," just 5 km north of Gaviota Pass, Santa Barbara County, Calif. Gaviota Formation of some authors.

SU 2121. Near center of SW¼ sec. 6, T. 29 S., R. 30 E., Caliente quadrangle, Kern County, Calif. Lowermost part of Round Mountain Silt.

SU 2696. McCray Wells [Oil Canyon, 5 km N. 20° E. of B.M. 961 at Santa Susana, Santa Susana quadrangle], Ventura County, Calif. Llajas Formation.

University of California at Berkeley:

UC 15. N½ sec. 23, T. 1 N., R. 3 W., Concord quadrangle, Contra Costa County, Calif. Briones Sandstone.

UC 52. South of town of Walnut Creek 2 km, near top of first ridge west of creek, long 122°3′30″ W., lat 37°52′44″ N. [Concord quadrangle], Contra Costa County, Calif. San Ramon Sandstone.

UC 78. About 5 km south of Pittsburg, close to west edge of SW¼ sec. 30, T. 2 N., R. 1 E., Contra Costa County, Calif. Kirker Tuff.

UC 118. Southeast side of prominent hill at elevation of about 305 m, near center of NW¼NW¼ sec. 9, T. 1 S., R. 1 W. [Contra Costa County], Calif. Neroly Sandstone.

UC 331. On first ridge north of Sobrante Ridge, southeast of west fork of Bear Creek, long 122°12′22″ W., lat 37°55′58″ N., Contra Costa County, Calif. San Ramon Sandstone.

UC 333. 16.5 cm east, 7 cm south of northwest corner of map sheet, Concord quadrangle, Contra Costa County, Calif. Martinez Formation.

UC 402. [To south of Pittsburg] a little east of saddle southwest of 198 m hill near west side of NW¼ sec. 30, T. 2 N., R. 1 E. [Contra Costa County], Calif. Cierbo Sandstone.

UC 458. West side of Grapevine Creek, 7.2 km S., 6° W. of B.M. 1058, Tejon quadrangle, Kern County, Calif. Tejon Formation.

UC 672. South part of crest of Parson's Peak, SW¼NW¼ T. 18 S., R. 14 E., Coalinga quadrangle [Fresno County], Calif. Domengine Formation.

UC 784. Near Lower Lake, at old brick yard, 0.4 km east of village NW¼NE¼ sec. 11, T. 12 N., R. 7 W., Lake County, Calif. Martinez Formation.

UC 790. East of Lower Lake village 1 km 365 m south of Herndon Creek Bridge, SE¼NE¼ sec. 11, T. 12 N., R. 7 W., Lake County, Calif. Martinez Formation.

UC 798. Lat 37.2° N., long 122.1° W., Santa Cruz County, Calif. San Ramon Sandstone.

UC 1547. Just south of Arroyo del Hambre Creek, 12 km south of north edge of Concord quadrangle, Contra Costa County, Calif. Martinez Formation.

UC 1556. A little more than 1.5 km south of Stewartville, NE¼NW¼ sec. 15, T. 1 N., R. 1 E., Mount Diablo quadrangle, Contra Costa County, Calif. Martinez Formation.

UC 1617. About 0.5 km east of Rodeo[NE¼ sec. 13, T. 2 N., R. 4 W.], Napa quadrangle, Contra Costa County, Calif. Neroly Sandstone.

UC 1817. Opposite the place where Urruttia Canyon enters Salt Creek, 30 m up fourth small draw from west end of ridge, SW¼NW¼ sec. 15, T. 18 S., R. 14 E., Coalinga quadrangle [Fresno County], Calif. Cerros Shale Member of the Lodo Formation.

UC 1853. Marysville [Sutter] Buttes, N½ sec. 28, T. 16 N., R. 1 E., Marysville [Sutter] Buttes quadrangle, Sutter County, Calif. Capay Formation.

UC 1859 and 1860. In seacliff at mouth of small gulch 0.5 km north of Guthrie Creek, 13 km southwest of Ferndale [SW¼ sec. 13, T. 2 N., R. 3 W., H.], Humboldt County, Calif. Wildcat Group.

UC 1895. About 4.5 km south of Pittsburg, north of Mount Diablo, near center of SE¼ sec. 29, T. 2 N., R. 1 E., Contra Costa County, Calif. Kirker Tuff.

UC 2033. South of Hill 651 about 0.4 km, 0.8 km west of Kirker's Creek, near west edge of sec. 30, T. 2 N., R. 1 E., Mount Diablo quadrangle, Contra Costa County, Calif. Kirker Tuff.

UC 2040. On southeast side of 285 m hill at elevation of about 100 m, near south edge of NE¼ sec. 33, T. 2 N., R. 1 E., [Mount Diablo quadrangle, Contra Costa County], Calif. San Pablo Group.

UC 2276. Northeast of Coalinga about 16 km, on hill near SW cor. SE¼NE¼ sec. 10, T. 19 S., R. 15 E. [Coalinga quadrangle], Fresno County, Calif. Santa Margarita Formation.

UC 2284. Sixteen kilometers northeast of Coalinga, middle of south line of NE¼ sec. 10, T. 19 S., R. 15 E., Fresno County, Calif. Santa Margarita Formation.

UC 2287. West side of Domengine Canyon, SW cor. SW¼SE¼ sec. 29, T. 18 S., R. 15 E., Fresno County, Calif. Domengine Formation.

UC 2680. Near top of ridge at center of NW¼ sec. 8, T. 22 S., R. 15 E., M.D.B.M., Fresno County, Calif. Etchegoin Formation.

UC 2754. On Sobrante Ridge on branch of San Pablo Creek, northeast of California and Nevada Railroad, long 122°14.1″ W., lat 37°56′54″ N. [Concord quadrangle], Contra Costa County, Calif. San Ramon Sandstone.

UC 2755. Valley north of Sobrante Ridge; on west fork of Bear Creek, long 122°12′35″ W., lat 37°55′58″ N., Contra Costa County, Calif. Kirker Tuff.

UC 3080. East side of Markley Canyon opposite L. Loughrie's house; elevation 215 m, SW¼ sec. 34, T. 2 N., R. 1 E., Contra Costa County, Calif. Kirker Tuff.

UC 3081. Near mouth of Markley Canyon on west side, opposite tunnel of Pittsburg Railroad, near SE cor. NE¼ sec. 33, T. 2 N., R. 1 E., Mount Diablo quadrangle, Contra Costa County, Calif. San Ramon Sandstone.

UC 3152. [Deer Valley, NW¼ sec. 20, T. 1 N., R. 2 E., Mount Diablo quadrangle], Contra Costa County, Calif. Meganos Formation.

UC 3155. [NE¼SE¼ sec. 7, T. 1 N., R. 1 E., Mount Diablo quadrangle], Contra Costa County, Calif. Meganos Formation.

UC 3529. W½ sec. 4, T., 4 S., R. 1 E., Pleasanton quadrangle, Alameda County, Calif. Briones Sandstone.

UC 3573. Near Vacaville, banks of Ualtis Creek, just south of Dunn's Peak, Vaca Valley [sec. 19, T. 6 N., R. 1 W., Napa quadrangle], Solano County, Calif. Capay (?) Formation.

UC 3577. [Los Meganos Grant, north of Briones Valley, east of crest of Hill 392, Brentwood quadrangle], Contra Costa County, Calif. Meganos Formation.

UC 3579. [Southwest of ridge east of Marsh Creek, 0.4 km east of Hill 386, Bryon quadrangle], Contra Costa County, Calif. Meganos Formation.

UC 3609. [Sec. 23, T. 1 N., R. 2 W., Bryon quadrangle], Contra Costa County, Calif. Meganos Formation.

UC 3675. North of road and east of summit of Reliz-Vaqueros Creek Road, Junipero Serra quadrangle, Monterey County, Calif. Between 300 and 460 m below the top of the Vaqueros Formation.

UC 3752. Simi Valley, Santa Susana quadrangle, SE¼SE¼ sec. 7, T. 2 N., R. 17 W., SB, Ventura County, Calif. Martinez Formation.

UC 3771. Northeast cor. sec. 23, T. 2 N., R. 18 W., SB, Ventura County, Calif. Martinez Formation.

UC 3776. West side of bottom of canyon, 1,615 m N. 3° W. of Hill 2150, Simi Hills, Calabasas quadrangle, Ventura County, Calif. Martinez Formation.

UC 3809. SE cor. sec. 28, T. 2 N., R. 18 W., Camulos quadrangle, Simi Hills, Ventura County, Calif. Martinez Formation.

UC 3981. At 15 m above high-tide level in small gully 0.4 km south of mouth of Soledad Valley, La Jolla quadrangle, San Diego County, Calif. Delmar Formation.

UC 3990. On the east side of canyon in bottom of Rose Creek 0.5 km east of "t" of "Soledad Mountain," La Jolla quadrangle, San Deigo County, Calif. Ardath Shale.

UC 3993. In bottom of Rose Creek where creek makes a strong bend to west, 0.8 km south of B.M. 176, 3 km east of La Jolla, La Jolla quadrangle, San Diego County, Calif. Ardath Shale.

UC 4004. In saddle 2,745 m N. 88° W. of Hill 1926, Simi Hills, Camulos quadrangle, Ventura County, Calif. Martinez Formation.

UC 4180. 105 m north, 365 m west from the northwest corner sec. 1, T. 32 S., R. 14 E., Nipoma quadrangle 91952 ed.), San Luis Obispo County, Calif. Phoenix Member, Santa Margarita Formation.

UC 4182. At the new city reservoir, Eugene, Lane County, Oreg. Eugene Formation.

UC 4233. In a creek, in the NE¼ sec. 12, T. 14 S., R. 3 W., La Jolla quadrangle, San Diego County, Calif. Ardath Shale.

UC 5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between "P" and "u" of "Pueblo," La Jolla quadrangle, San Diego County, Calif. Ardath Shale.

UC 5091. Tecolote Creek about 0.5 km north of its junction with its largest tributary, La Jolla quadrangle, San Diego County, Calif. Ardath Shale.

UC 6128. At base of bluff, west of south end of remnant hill on lower plain, west side of Plano Trabuco, Santa Ana Mountains, Corona quadrangle, Orange County, Calif. Vaqueros Formation.

UC 7004. Branch of Las Llajas Canyon just north of northernmost extent of 1,500-foot contour, Simi Valley [Santa Susana quadrangle], Ventura County, Calif. Llajas Formation.

UC 7100. Northwest cor. sec. 3, T. 3 N., R. 21 W., Ventura County, Calif. San Pedro(?) Formation.

UC 7177. Upper fossiliferous ledge at San Joaquin coal mine, sec. 26, T. 20 S., R. 14 E., Coalinga quadrangle [Fresno County], Calif. Domengine Formation.

UC 9069. In a cut on the Wynoochee River road about 135 m south of the railroad that goes up Black Creek, sec. 26, T. 18 N., R. 8 W., Grays Harbor County, Wash. Montesano Formation.

UC A-252. Along northeast-southwest ridge west of mouth of Wiley Canyon, south center of SE¼ sec. 35, T. 4 N., R. 19 W., [Piru quadrangle], Ventura County, Calif. Vaqueros Formation.

UC A-527. On spur in large turn in Laguna Canyon (west side of canyon), San Joaquin Hills, Orange County, Calif. Uppermost Vaqueros Formation.

UC A-543. At south end of long ridge, 4.2 km N. 21° E. of Abalone Point between forks of canyon, San Joaquin Hills [Corona quadrangle], Orange County, Calif. Vaqueros Formation.

UC A-838. Bed of Middle Fork of Coquille River opposite Roseburg-Coos Bay Highway survey station 834 + 34, Coos County, Oreg. Lower part of Umpqua Formation.

UC A-976. Big Tar Canyon, Reef Ridge, T. 23 S., R. 17 E., Cholame quadrangle [Kings County], Calif. Avenal Sandstone.

UC A-1007. North bank of Los Gatos Creek, 90 m from mouth, NE¼ sec. 10, T. 20 S., R. 14 E., Coalinga quadrangle [Fresno County], Calif. Domengine Formation.

UC A-1165. East side of Big Tar Canyon at end of Eocene ridge, T. 23 S., R. 17 E., Cholame quadrangle [Kings County], Calif. Avenal Sandstone.

UC A-1297. Sandstone cliff on northeast bank of Pleasants Creek opposite Brink Ranch House about 1 km east of B.M. 257, 3 km south of Putah Creek, W½ sec. 12, T. 7 N., R. 2 W., Napa quadrangle, Solano County, Calif. Markley Formation.

UC A-1319. About 215 m south and 30 m west of the east quarter corner of sec. 26, T. 10 N., R. 3 E., Capay Valley quadrangle, Yolo County, Calif. About 185 m east of the contact between Cretaceous and Eocene rocks and about 60 to 105 m above base of Capay Formation, which here totals about 455 to 550 m.

UC A-3519. Sea cliff near south end of bay. Coral reef exposed in cliff on north side of large southern arroyo at its junction with sea cliff. Rests on bed of calcareous algae and sandy marl with an irregular contact marked by boulders of volcanic material. Marquer Bay, Carmen Island, Gulf of California. Marquer Formation.

UC A-3595. North of San Telmo Point, Baja California (approx. 25° N. lat). From sea cliff to north of large arroyo. In a massive calcareous pebbly sandstone carrying abundant arcas, at top of thin-bedded cherty sands and shales. Approximately 45 m stratigraphically higher than *Cornwallius* teeth, but fragments of bone were noted scattered through section to about this level. San Gregorio Formation.

University of California at Davis:

UC D1063. Sec. 3, T. 33 S., R. 16 E., 345 m north, 220 m west, Reef Ridge quadrangle, Fresno County, Calif. Temblor Formation.

UC D1065. Sec. 33, T. 22 S., R. 16 E. 185 m north, 1,080 m west, Reef Ridge quadrangle, Fresno County, Calif. Temblor Formation.

University of California at Los Angeles:

UCLA 391. On Mulholland Drive, 3 km west, by road, from intersection of Laurel Canyon Road and Mulholland Drive. 335 m north, 215 m west of SE cor. sec. 36, T. 1 N., R. 15 W. Road cut about 45 m north of a small basalt sill. Santa Monica Mountains, Los Angeles County, Calif. Topanga Formation.

UCLA 4180. 105 m north, 365 m west of NW cor. sec. 1, T. 32 S., R. 14 E., Nipoma quadrangle (1952 ed.), San Luis Obispo

County, Calif. Phoenix Member, Santa Margarita Formation.

University of California at Riverside:

UCR 4752. 185 m S. 45° W. of UCR 4751, 535 m south, 745 m east of NW cor. sec. 32, T. 7 N., R. 21 W., Ventura County, Calif. Juncal Formation.

UCR 6821. West side of Meier Canyon, 490 m north, 8 m east of hill 1658, 269 m due south of hill 1490, elevation 300 m, Simi Hills, Ventura County, Calif. Upper part of Santa Susana Formation.

UCR 7342. On low hill 390 m NE 17° from hill 3151 and 410 m NW 7° from hill 2160, Calabasas 7.5′ quadrangle, Ventura County, Calif. Lower Santa Susana Formation.

U.S. Geological Survey, Washington, D. C., register:

USGS 2714. [Sec. 23, T. 5 N., R. 4 W., Vernonia quadrangle], Pittsburg, Columbia County, Oreg. Pittsburg Bluff Formation.

USGS 3922. At head of Garnet Canyon on north side of Coyote Mountain [W½ sec. 3, T. 16 S., R. 10 E.], Imperial County, Calif. Imperial Formation.

USGS 4473. Waldorf asphalt mine, 6 km south of Guadelupe [Guadelupe quadrangle], Santa Barbara County, Calif. Careaga Sandstone.

USGS 4504. San Julian Ranch, 16 km southeast of Lompoc, N½ sec. 35, T. 6 N., R. 33 W., Santa Barbara County, Calif. Vaqueros Formation.

USGS 4634. Hill south of oil well, 4.5 km southwest of Coalinga, in NE¼ sec. 12, T. 21 S., R. 14 E., Fresno County, Calif. Etchegoin Formation.

USGS 4656. At northwest end of Anticline Ridge, 10 km north-northeast of Coalinga, SW¼ sec. 34, T. 19 S., R. 15 E. [Coalinga quadrangle, Fresno County, Calif.], Etchegoin Formation.

USGS 15020. Solomon Hills, 5.4 km northeast of Los Alamos, 275 m southeast of Pinal Dome Pezzoni 2 well, Santa Barbara County, Calif. Todos Santos Claystone member of the Sisquoc Formation.

U.S. Geological Survey, Menlo Park, Calif. register:

USGS M5219. Near base of cliff on north side of State Route 105, 1,020 m S., 900 m W. of NE cor. sec. 5, T. 14 S., R. 10 W., Bay Center 7½′ quadrangle, Pacific County, Wash., *Mytilus*-bearing beds about 3.6 m thick overlying a 60-cm-thick *Macoma* bed. Unnamed formation of late Pliocene age.

University of Washington [Seattle]:

UW 63. East branch of Clemons logging road, south of Montesano, Grays Harbor County, Wash. NW¼ sec. 28, T. 17 N., R. 7 W. Astoria(?) Formation.

UW 239. East side of Cowlitz River 1.2 km above ferry near Gries Ranch, NE¼ sec. 25, T. 11 N., R. 2 W., Cowlitz County, Wash. Gries Ranch Formation.

UW 256. In Union Pacific railway cut 400 m northwest of Galvin Station, sec. 27, T. 15 N., R. 3 W., Lewis County, Wash. Lincoln Creek Formation.

UW 329. On north bank of the Cowlitz River at bend 1.5 to 2.5 km east of Vader, sec. 28, T. 11 N., R. 2 W., Lewis County, Wash. Cowlitz Formation.

UW 345. On Coal Creek, at large falls about 1 km below the schoolhouse, sec. 35, T. 9 N., R. 3 W., Cowlitz County, Wash. Cowlitz Formation.

GEOLOGIC FORMATIONS CITED FOR OCCURRENCE OF PELECYPODS

FAMILY NUCULIDAE TO FAMILY MALLEIDAE

Name	*Age*
California:	
Alegria Formation[1]	Oligocene.
Ardath Shale	Eocene.
Arroyo Hondo Shale Member, Lodo Formation	Eocene.
Avenal Sandstone	Eocene.
Branch Canyon Sandstone	Miocene.
Briones Sandstone, San Pablo Group	Miocene.
Butano Sandstone	Eocene.
Buttonbed Sandstone Member, Temblor Formation	Miocene.
Capay Formation	Eocene.
Capistrano Formation	Miocene and Pliocene.
Careaga Sandstone	Pliocene.
Carlotta Formation	Pleistocene.
Castaic Formation[1]	Miocene.
Cebada Member, Careaga Sand or Sandstone	Pliocene.
Cerros Shale Member, Lodo Formation	Paleocene.
Chamisal Formation[1]	Miocene.
Cierbo Sandstone, San Pablo Group	Miocene.
Coldwater Sandstone and Coldwater Sandstone Member,[1] Tejon Formation	Eocene.
Concord Formation[1]	Oligocene.
Cozy Dell Shale and Cozy Dell Shale Member,[1] Tejon Formation	Eocene.
Delmar Formation, La Jolla Group	Eocene.
Dip Creek Formation[1]	Paleocene.
Domengine Formation or Sandstone	Eocene.
Etchegoin Formation	Miocene and Pliocene.
Falor Formation	Pliocene.
Fernando Formation	Pliocene and Pleistocene.
Foxen Mudstone	Pliocene.
Freeman Silt	Miocene.
Gaviota Formation[1]	Eocene and Oligocene.
Gould Shale Member, Monterey Formation	Miocene.
Hambre Sandstone, Monterey Group	Miocene.
Imperial Formation	Miocene or Pliocene.
Ione Formation	Eocene.
Juncal Formation	Eocene.
Kirker Tuff	Oligocene.
Kreyenhagen Shale or Formation	Eocene and Oligocene.
La Jolla Group	Eocene.
Las Virgenes Sandstone	Paleocene.
Lindavista Formation	Pleistocene.
Llajas Formation	Eocene.
Locatelli Formation	Paleocene.
Lodo Formation	Paleocene and Eocene.
Lomita Marl Member, San Pedro Formation	Pliocene.
Los Tularcitos Member,[1] Chamisal Formation	Miocene.
Markley Sandstone Member, Kreyenhagen Formation	Eocene.
Martinez Formation	Paleocene.
Marysville Claystone Member, Meganos Formation	Paleocene.
Matilija Sandstone	Eocene.

[1]Stratigraphic nomenclature used is that of the reference cited in the text and does not necessarily accord with that of the U.S. Geological Survey.

McLure Shale Member, Monterey Formation	Miocene.
Meganos Formation	Paleocene.
Merced Formation	Pliocene and Pleistocene.
Monterey Formation, Shale, or Group	Miocene.
Muir Sandstone[1]	Eocene.
Neroly Sandstone, San Pablo Group	Miocene.
Niguel Formation	Pliocene.
Ohlson Ranch Formation[1]	Pliocene.
Olcese Sand	Miocene.
Orinda Formation, Contra Costa Group	Miocene.
Oso Member, Capistrano Formation	Miocene.
Oursan Sandstone, Monterey Group	Miocene.
Palos Verdes Sand	Pleistocene.
Pancho Rico Formation	Miocene.
Paso Robles Formation	Miocene, Pliocene, and Pleistocene.
Phoenix Member,[1] Santa Margarita Formation	Miocene.
Pico Formation	Pliocene and Pleistocene.
Pleito Formation	Oligocene.
Pomponio Mudstone Member, Purisima Formation	Pliocene.
Poway Group	Eocene.
Pullen Formation	Pliocene.
Purisima Formation	Miocene and Pliocene.
Rices Mudstone Member, San Lorenzo Formation	Eocene and Oligocene.
Rincon Shale	Oligocene and Miocene.
Rio Dell Formation, Wildcat Group	Pliocene and Pleistocene.
Round Mountain Silt	Miocene.
Sacate Formation[1]	Eocene.
Saltos Shale Member, Monterey Shale	Miocene.
San Diego Formation	Pliocene.
San Emigdio Formation	Eocene and Oligocene.
San Joaquin Formation	Pliocene.
San Juan Bautista Formation[1]	Eocene and Oligocene.
San Lorenzo Formation	Eocene and Oligocene.
San Pablo Formation or Group	Miocene.
San Pedro Formation	Pliocene and Pleistocene.
San Ramon Sandstone	Miocene(?).
Santa Barbara Formation	Pliocene and Pleistocene.
Santa Cruz Mudstone	Miocene.
Santa Margarita Formation	Miocene.
Santa Susana Formation[1]	Paleocene and Eocene.
Santos Shale Member, Temblor Formation	Oligocene and Miocene.
Saugus Formation	Pliocene and Pleistocene.
Scotia Bluffs Sandstone	Pleistocene.
Sespe Formation	Eocene to Miocene.
Silverado Formation	Paleocene.
Sisquoc Formation	Miocene and Pliocene.
Sobrante Sandstone	Miocene.
Tahana Member, Purisima Formation	Miocene and Pliocene.
Tejon Formation	Eocene.
Temblor Formation	Oligocene and Miocene.
Tice Shale, Monterey Group	Miocene.
Tierra Redonda Formation	Miocene.
Timms Point Silt Member, San Pedro Formation	Pleistocene.
Tinaquaic Sandstone Member, Sisquoc Formation	Pliocene.
Todos Santos Claystone Member, Sisquoc Formation	Miocene and Pleistocene.
Topanga Formation	Miocene.
Towsley Formation	Miocene and Pliocene.
Tumey Formation [1]	Oligocene.
Twobar Shale Member, San Lorenzo Formation	Eocene.
Vacaville Shale[1]	Eocene.
Vaqueros Formation	Oligocene and Miocene.
Wheatland Formation[1]	Eocene and Oligocene.
Wildcat Group	Pliocene and Pleistocene.
Wygal Sandstone Member, Temblor Formation	Oligocene.
Baja California Peninsula:	
Almejas Formation	Pliocene.
Carmen Formation	Pliocene.
Gloria Formation	Pliocene.
Infierno Formation	Pliocene.
Isidro Formation	Miocene.
Marquer Formation	Pliocene.
Rosarito Beach Formation	Miocene.
Salada Formation	Oligocene.
San Gregorio Formation	Pliocene.
San Marcos Formation	Pliocene.
Tepetate Formation	Paleocene and Eocene.
Tortugas Formation	Miocene.
Oregon:	
Empire Formation	Miocene.
Pittsburg Bluff Formation	Oligocene.
Washington:	
Gries Ranch Formation	Oligocene.
Lincoln Creek Formation	Eocene to Miocene.

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PLATES 1–27

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

PLATE 1

FIGURES 1, 2. *Nucula* (*Nucula*) *capayensis* Schenck (p. A6).
Holotype UCMP 30196. Length 32 mm, height 24 mm, thickness 8 mm (one valve). Capay Formation, California, Eocene.

3, 4. *Nucula* (*Nucula*) *cooperi* Dickerson (p. A6).
Holotype UCMP 11754a (× 4.0). Length 9 mm, height 7 mm. Capay Formation, California, Eocene.

5. *Nucula* (*Nucula*) *vitis* Anderson and Hanna (p. A7).
Holotype CAS 788 (× 4.0). Length 8 mm, height 7 mm. Tejon Formation, California, Eocene.

6, 7. *Nucula*? *bifida* Clark (p. A7).
Holotype UCMP 11184 (× 6.0). Length 6 mm, height 5 mm, thickness 3 mm (both valves). San Ramon Sandstone, California, Miocene(?).

8, 9. *Nucula* (*Leionucula*) *birchi* Keen (p. A7).
Holotype CAS/SU 7527 (× 3.0). Length 7 mm, height 5 mm, thickness 2 mm (one valve). Round Mountain Silt, California, Miocene.

10. *Nucula* (*Leionucula*) *balboana* Hertlein and Grant (p. A8).
Holotype CAS 59684 (× 1.5). Length 13 mm, height 11 mm, thickness 7 mm (both valves). San Diego Formation, California, Pliocene.

11. *Acila* (*Acila*) *gettysburgensis* (Reagan) (p. A9).
Holotype USNM 328302 (× 1.5). Length 26 mm, height 19 mm, thickness 8 mm (one valve). Twin River Formation, Washington, Eocene to Miocene.

12. *Nucula* (*Leionucula*) *postangulata* Clark (p. A8).
Holotype UCMP 11260 (× 3.0). Length 7 mm, height 5 mm, thickness 3 mm (both valves). San Ramon Sandstone, California, Miocene(?).

13. *Nucula* (*Lamellinucula*) *exigua* Sowerby (p. A8).
Hypotype UCLA 48610 (× 4.0; Hertlein and Grant, 1972, pl. 27, figs. 5, 6). Length 5 mm, height 5 mm. San Diego Formation, California, Pliocene. (Photography courtesy of the California Academy of Sciences).

14. *Acila* (*Truncacila*) *decisa* (Conrad) (p. A10).
Neotype UCMP 31132 (× 2.0). Length 12 mm, height 9 mm, thickness 3 mm (one valve). Ardath Shale, California, Eocene.

15, 16. *Acila* (*Truncacila*) *shumardi* (Dall) (p. A10).
Holotype USNM 406405 (× 1.5). Length 24 mm, height 18 mm. Pittsburg Bluff Formation, Oregon, Oligocene.

17. *Acila* (*Truncacila*) *decisa* (Conrad), unnamed form, Vokes (p. A10).
Hypotype UCMP 15477 (× 4.0). Length 8 mm, height 7 mm, thickness 5 mm (both valves). Avenal Sandstone, California, Eocene.

18. *Acila* (*Truncacila*) *dalli* (Arnold) (p. A11).
Holotype USNM 165452. Length 35 mm, height 27 mm. San Lorenzo Formation, California, Eocene and Oligocene.

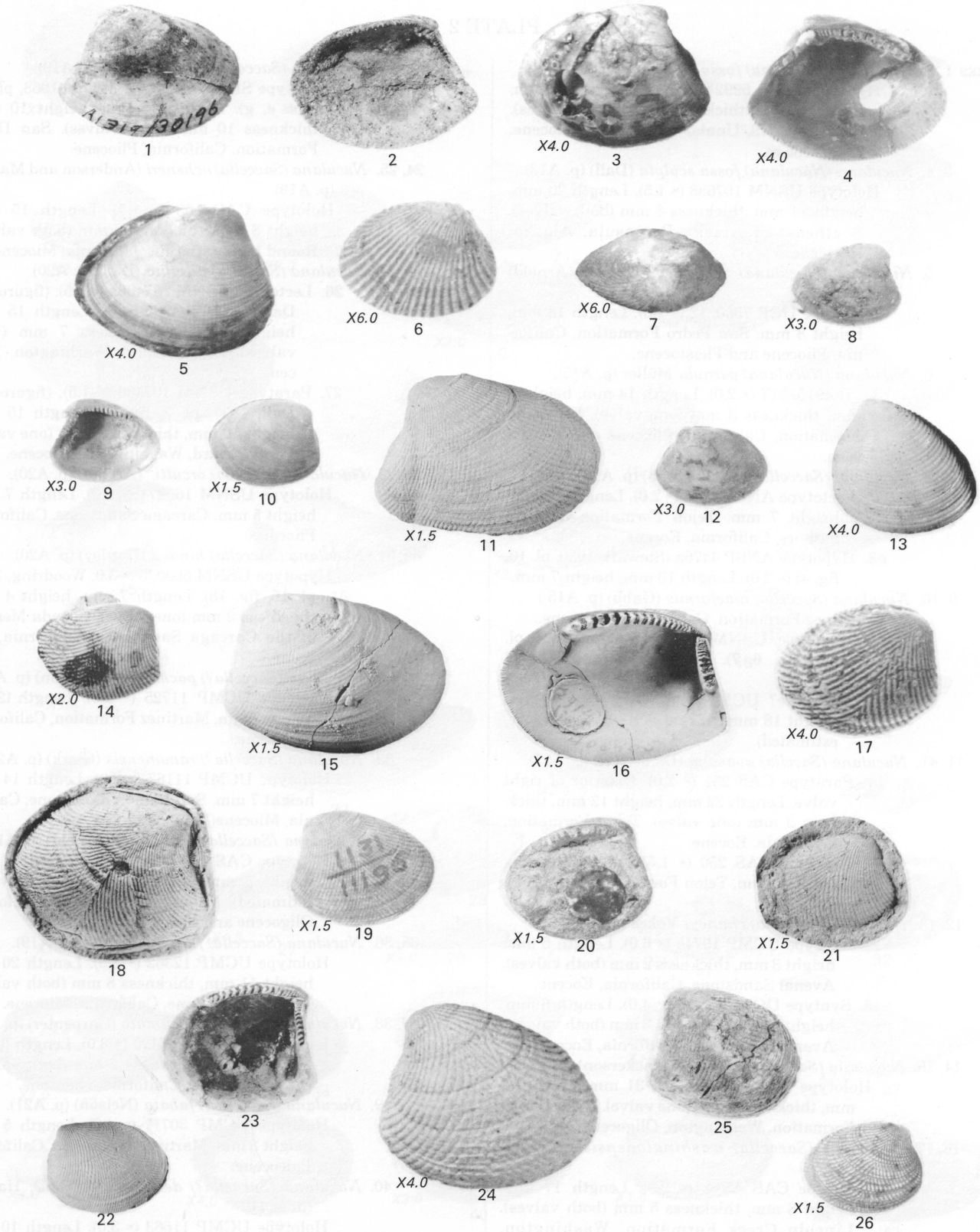
19, 20. *Acila* (*Truncacila*) *muta* Clark (p. A11).
Holotype UCMP 11196 (× 1.5). Length 18 mm, height 15 mm, thickness 6 mm (one valve). San Ramon Sandstone, California, Miocene.

21, 22. *Acila* (*Truncacila*) *conradi* (Meek) (p. A12).
21. Neotype USNM 3526 (× 1.5; latex impression). Length 8 mm, height 10 mm. Astoria Formation, Oregon, Miocene.
22. Hypotype USNM 563204 (Moore, 1963, pl. 12, fig. 2). Length 21 mm, height 17 mm, thickness 10 mm (both valves). Astoria Formation, Oregon, Miocene.

23, 25. *Acila* (*Acila*) *semirostrata* (Grant and Gale) (p. A9).
Holotype SDNM 370. Length 27 mm, height 23 mm, thickness 9 mm (one valve). Pico(?) Formation, California, Pliocene.

24. *Acila* (*Truncacila*) *castrensis* (Hinds) (p. A12).
Hypotype LAM 4448 (× 4.0); Hertlein and Grant, 1972, pl. 27, fig. 8). Length 10 mm, height 8 mm. San Diego Formation, California, Pliocene. (Photography courtesy of the California Academy of Sciences.)

26. *Acila* (*Truncacila*) *empirensis* Howe (p. A12).
Holotype UCMP 30032 (× 1.5). Length 14 mm, height 11 mm, thickness 8 mm (both valves). Empire Formation, Oregon, Miocene.



NUCULANIDAE

PLATE 2

FIGURES 1, 2. *Nuculana (Nuculana) fossa* (Baird) (p. A13).
Hypotype CAS 59924 (× 1.5). Length 25 mm, height 14 mm, thickness 9 mm (both valves). CAS/SU 1079, Unalaska, Alaska, Holocene. Depth 135 m.

3, 4. *Nuculana (Nuculana) fossa sculpta* (Dall) (p. A13).
Holotype USNM 107688 (× 1.5). Length 20 mm, height 11 mm, thickness 8 mm (both valves). Southeast of Alaska Peninsula, Alaska, Holocene.

5. *Nuculana (Nuculana) minuta praecursor* (Arnold) (p. A14).
Hypotype UCR 7560/12 (× 2.0). Length 18 mm, height 8 mm. San Pedro Formation, California, Pliocene and Pleistocene.

6. *Nuculana (Nuculana) pernula* Müller (p. A15).
UCR 4915/317 (× 2.0). Length 14 mm, height 7 mm, thickness 3 mm (one valve). Fernando Formation, California, Pliocene and Pleistocene.

7, 8. *Nuculana (Saccella) gabbii* (Gabb) (p. A16).
7. Lectotype ANSP 4476 (× 2.0). Length 12 mm, height 7 mm. Tejon Formation of some authors, California, Eocene.
8. Hypotype ANSP 4476a (Stewart, 1930, pl. 10, fig. 4) (× 2.0). Length 13 mm, height 7 mm.

9, 10. *Nuculana (Saccella) alaeformis* (Gabb) (p. A15)
Martinez Formation, California, Paleocene..
9. Hypotype, USNM 157829 (Stanton, 1896, pl. 64, figs. 6, 7). Length 34 mm, height 18 mm.
10. Paratype? UCMP 32515. Length 29 mm, height 18 mm, thickness 5 mm (one valve, estimated).

11, 41. *Nuculana (Sacella) uvasana* (Dickerson) (p. A17).
11. Paratype CAS 251 (× 2.0). Exterior of right valve. Length 22 mm, height 12 mm, thickness 3 mm (one valve). Tejon Formation, California, Eocene.
41. Holotype CAS 250 (× 1.5). Length 18 mm, height 9 mm. Tejon Formation, California, Eocene.

12, 13. *Nuculana (Saccella) chaneyi* Vokes (p. A16).
12. Syntype UCMP 15745 (× 6.0). Length 5 mm, height 3 mm, thickness 2 mm (both valves). Avenal Sandstone, California, Eocene.
13. Syntype UCMP 15746 (× 4.0). Length 6 mm, height 3 mm, thickness 3 mm (both valves). Avenal Sandstone, California, Eocene.

14, 15. *Nuculana (Saccella) merriami* (Dickerson) (p. A17).
Holotype CAS 381. Length 31 mm, height 18 mm, thickness 6 mm (one valve). Gries Ranch Formation, Washington, Oligocene.

16, 17. *Nuculana (Saccella) washingtonensis* (Weaver) (p. A17).
Paratype CAS 450A (× 2.0). Length 17 mm, height 8 mm, thickness 5 mm (both valves). Lincoln Creek Formation, Washington, Eocene to Miocene.

18, 19. *Nuculana (Saccella) pulchrisinuosa* (Clark) (p. A18).
Holotype UCMP 11109 (× 3.0). Length 9 mm (incomplete), height 5 mm (incomplete), thickness 4 mm (both valves). San Ramon Sandstone, California, Miocene.

20, 21. *Nuculana (Saccella) chehalisensis* (Weaver) (p. A18).
Holotype CAS 539 (× 1.5). Length 14 mm, height 9 mm, thickness 7 mm. Astoria Formation, Washington, Miocene.

22, 23. *Nuculana (Saccella) taphria* (Dall) (p. A19).
Hypotype SDNM 77 (× 2.5; Moore, 1968, pl. 23, figs. e, g). Length 16 mm, height 10 mm, thickness 10 mm (both valves). San Diego Formation, California, Pliocene.

24, 25. *Nuculana (Saccella) ochsneri* (Anderson and Martin) (p. A19).
Holotype CAS 103 (× 1.5). Length 15 mm, height 8 mm, thickness 6 mm (both valves). Round Mountain Silt, California, Miocene.

26, 27. *Nuculana (Saccella) cellulita* (Dall) (p. A20)
26. Lectotype USNM 107436a (× 1.5); (figured by Dall, 1897, pl. 2, fig. 5). Length 15 mm, height 10 mm, thickness 7 mm (both valves). Port Orchard, Washington, Holocene.
27. Paratype USNM 107436 (× 1.5); (figured by Dall, 1897, pl. 2, fig. 7). Length 15 mm, height 10 mm, thickness 4 mm (one valve). Port Orchard, Washington, Holocene.

28, 29. *Nuculana (Saccella) orcutti* (Arnold) (p. A20).
Holotype USNM 165271 (× 3.0). Length 7 mm, height 5 mm. Careaga Sandstone, California, Pliocene.

30, 31. *Nuculana (Saccella) hindsii* (Hanley) (p. A20).
Hypotype USNM 560096 (× 3.0; Woodring, 1950, pl. 16, fig. 18). Length 7 mm, height 4 mm, thickness 2 mm (one valve). Cebada Member of the Careaga Sandstone, California, Pliocene.

32. *Nuculana (Saccella?) packardi* (Dickerson) (p A21).
Holotype UCMP 11725 (× 2.0). Length 12 mm, height 7 mm. Martinez Formation, California, Paleocene.

33. *Nuculana (Saccella?) ramonensis* (Clark) (p. A21).
Holotype UCMP 11167 (× 2.0). Length 14 mm, height 7 mm. San Ramon Sandstone, California, Miocene(?).

34. *Nuculana (Saccella) cahillensis* (Arnold) (p. A17).
Holotype CAS/SU 5368 (× 3.0). Length 7 mm, height 5 mm, thickness 2 mm (one valve, estimated). Vaqueros Formation, California, Oligocene and Miocene.

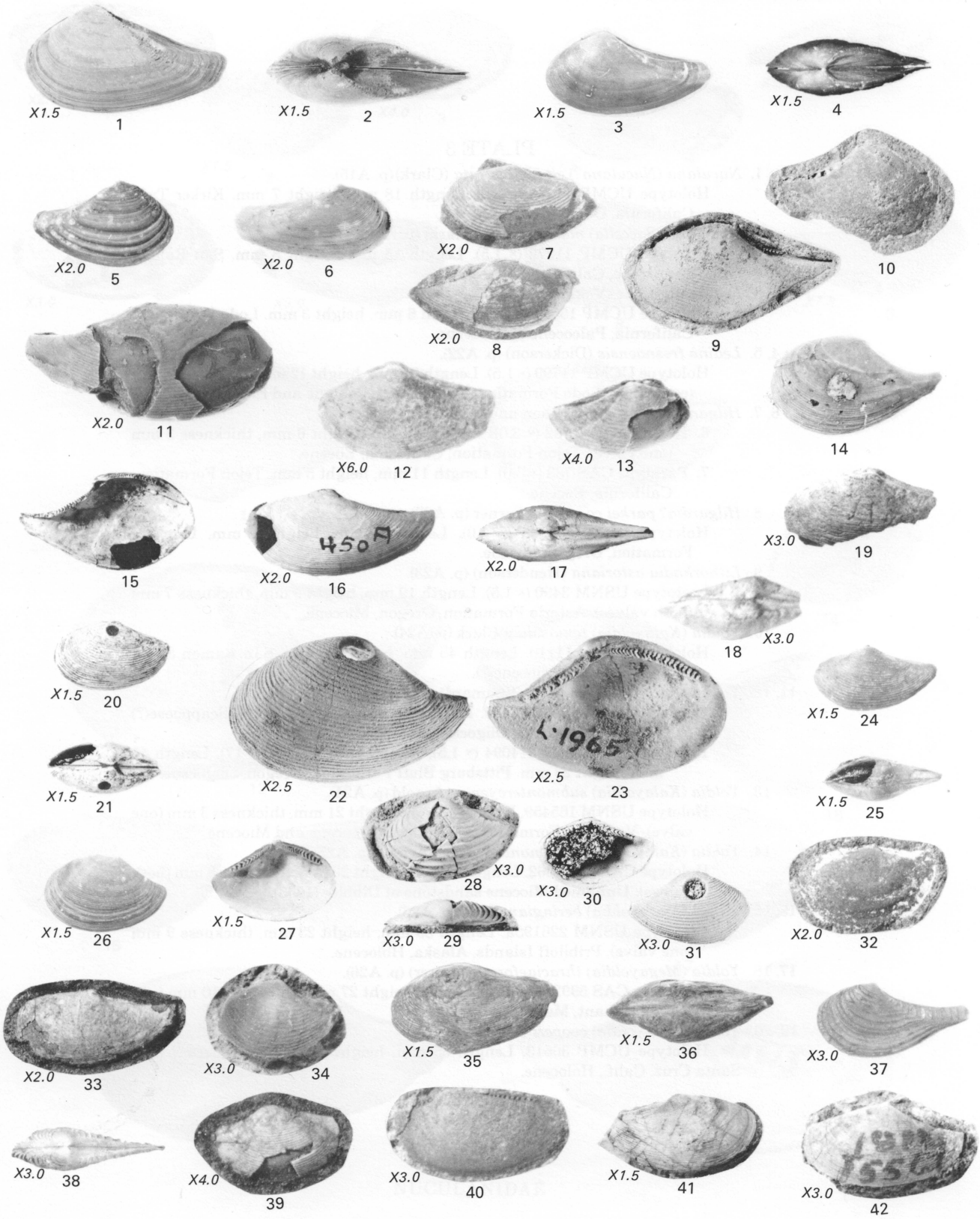
35, 36. *Nuculana (Saccella) furlongi* (Trask) (p. A19).
Holotype UCMP 12362 (× 1.5). Length 20 mm, height 11 mm, thickness 8 mm (both valves). Briones Sandstone, California, Miocene.

37, 38. *Nuculana (Thestyleda) hamata* (Carpenter) (p. A22).
Lectotype USNM 107420 (× 3.0). Length 9 mm, height 5 mm, thickness 2 mm (both valves). Catalina Island, California, Holocene.

39. *Nuculana (Saccella?) fabata* (Nelson) (p. A21).
Holotype UCMP 30717 (× 4.0). Length 5 mm, height 3 mm. Martinez Formation, California, Paleocene.

40. *Nuculana (Saccella?) denominata* (G D. Hanna) (p. A21).
Holotype UCMP 11663 (× 3.0). Length 10 mm, height 5 mm. Martinez Formation, California, Paleocene.

42. *Nuculana (Saccella) hondana* Vokes (p. A16).
Holotype UCMP 15561 (× 3.0). Length 9 mm, height 5 mm, thickness 3 mm (one valve). Lodo Formation, California, Paleocene and Eocene.



NUCULANIDAE

PLATE 3

FIGURES 1. *Nuculana* (*Nuculana*?) *elongorostrata* (Clark) (p. A15).
Holotype UCMP 11206 (× 2.0). Length 18 mm, height 7 mm. Kirker Tuff, California, Oligocene.

2. *Nuculana* (*Saccella*) *markleyensis* (Clark) (p. A18).
Holotype UCMP 11272 (× 1.5). Length 15 mm, height 8 mm. San Ramon Sandstone, California, Miocene(?).

3. *Ledina duttonae* (Vokes) (p. A22).
Holotype UCMP 15564 (× 4.0). Length 6 mm, height 3 mm. Lodo Formation, California, Paleocene and Eocene.

4, 5. *Ledina fresnoensis* (Dickerson) (p. A22).
Holotype UCMP 11790 (× 1.5). Length 21 mm, height 12 mm, thickness 6 mm (one valve). Lodo Formation, California, Paleocene and Eocene.

6, 7. *Hilgardia*? *parkei* (Anderson and G D. Hanna) (p. A22).
6. Holotype CAS 782 (× 3.0). Length 11 mm, height 6 mm, thickness 3 mm (one valve). Tejon Formation, California, Eocene.
7. Paratype CAS 783 (× 3.0). Length 11 mm, height 5 mm. Tejon Formation, California, Eocene.

8. *Hilgardia*? *parkei coosensis* Turner (p. A23)
Holotype UCMP 33205 (× 3.0). Length 9 mm, height 5 mm. Umpqua Formation, Oregon, Eocene.

9. *Lithorhadia astoriana* (Henderson) (p. A23).
Lectotype USNM 3490 (× 1.5). Length 19 mm, height 9 mm, thickness 7 mm (both valves). Astoria Formation, Oregon, Miocene.

10. *Yoldia* (*Kalayoldia*) *tenuissima* Clark (p. A24).
Holotype UCMP 11110. Length 45 mm, height 24 mm. San Ramon Sandstone, California, Miocene(?).

11, 12. *Yoldia* (*Kalayoldia*) *oregona* (Shumard) (p. A24).
11. Lectotype USNM 562470. Length 41 mm, height 22 mm. Scappoose(?) Formation, Oregon, Oligocene and Miocene.
12. Hypotype USNM 214094 (× 1.5); Moore, 1976, pl. 9, fig. 17). Length 41 mm, height 23 mm. Pittsburg Bluff Formation, Oregon, Oligocene.

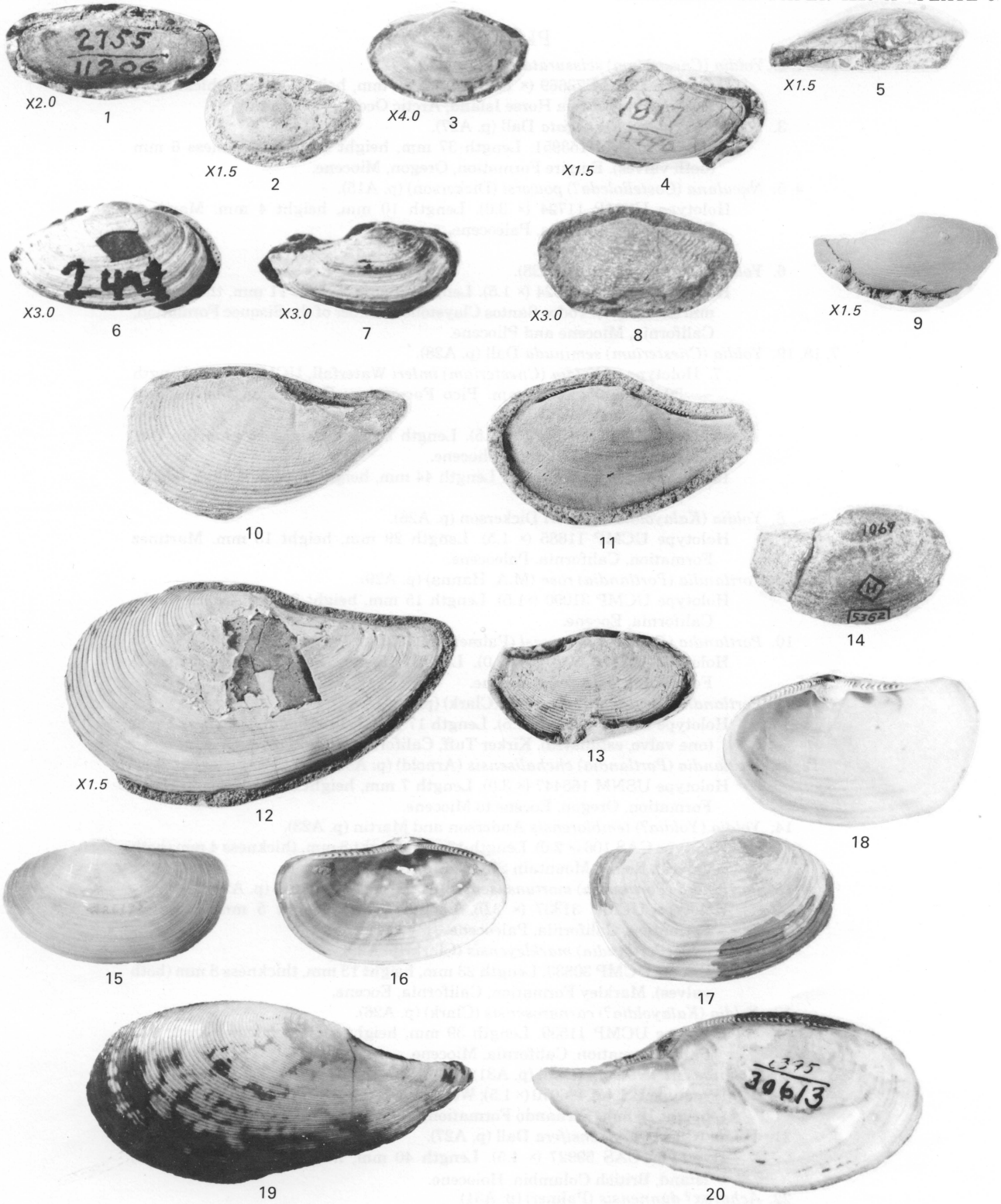
13. *Yoldia* (*Kalayoldia*) *submontereyensis* Arnold (p. A24).
Holotype USNM 165459. Length 32 mm, height 21 mm, thickness 3 mm (one valve). Vaqueros Formation, California, Oligocene and Miocene.

14. *Yoldia* (*Kalayoldia*) *supramontereyensis* Arnold (p. A25).
Holotype CAS/SU 5362. Length 35 mm, height 20 mm, thickness 8 mm (both valves). Unnamed Miocene sandstone of Dibblee (1966).

15, 16. *Yoldia* (*Megayoldia*) *beringiana* Dall (p. A26).
Lectotype USNM 226195a. Length 39 mm, height 23 mm, thickness 9 mm (one valve). Pribiloff Islands, Alaska, Holocene.

17, 18. *Yoldia* (*Megayoldia*) *thraciaeformis* (Storer) (p. A26).
Hypotype CAS 59925. Length 43 mm, height 27 mm, thickness 10 mm (one valve). Nahant, Mass., Holocene.

19, 20. *Yoldia* (*Kalayoldia*) *cooperi* Gabb (p. A25).
Holotype UCMP 30613. Length 65 mm, height 32 mm, thickness 7 mm. Santa Cruz, Calif., Holocene.



NUCULANIDAE

PLATE 4

FIGURES 1, 2. *Yoldia* (*Cnesterium*) *scissurata* Dall (p. A27).
Hypotype USNM 73669 (× 1.5). Length 29 mm, height 16 mm, thickness 4 mm (one valve). Sea Horse Island, Arctic Ocean, Holocene.

3. *Yoldia* (*Cnesterium*) *strigata* Dall (p. A27).
Holotype USNM 153951. Length 37 mm, height 20 mm, thickness 6 mm (both valves). Empire Formation, Oregon, Miocene.

4, 5. *Nuculana* (*Costelloleda*?) *powersi* (Dickerson) (p. A15).
Holotype UCMP 11724 (× 3.0). Length 10 mm, height 4 mm. Martinez Formation, California, Paleocene.
5. Tipped to show teeth.

6. *Yoldia*? *gala* Woodring (p. A28).
Holotype USNM 560024 (× 1.5). Length 26 mm, height 11 mm, thickness 3 mm (one valve). Todos Santos Claystone Member of the Sisquoc Formation, California, Miocene and Pliocene.

7, 18, 19. *Yoldia* (*Cnesterium*) *seminuda* Dall (p. A28).
7. Holotype of *Yoldia* (*Cnesterium*) *imleri* Waterfall, UCMP 31420. Length 39 mm, height 21 mm. Pico Formation, California, Pliocene and Pleistocene.
18. Hypotype CAS 59920 (× 1.5). Length 36 mm, height 16 mm. Rio Dell Formation, California, Pliocene.
19. Holotype USNM 197678. Length 44 mm, height 22 mm. Kodiak Island, Alaska, Holocene.

8. *Yoldia* (*Kalayoldia*?) *gesteri* Dickerson (p. A26).
Holotype UCMP 11685 (× 1.5). Length 29 mm, height 13 mm. Martinez Formation, California, Paleocene.

9. *Portlandia* (*Portlandia*) *rosa* (M.A. Hanna) (p. A29).
Holotype UCMP 31090 (×1.5). Length 15 mm, height 8 mm. Ardath Shale, California, Eocene.

10. *Portlandia* (*Portlandia*) *mosesi* (Palmer) (p. A30).
Holotype UCMP 30704 (× 2.0). Length 15 mm, height 9 mm. Capay(?) Formation, California, Eocene.

11. *Portlandia* (*Portlandia*) *packardi* (Clark) (p. A30).
Holotype UCMP 11154 (× 1.5). Length 17 mm, height 9 mm, thickness 5 mm (one valve, estimated). Kirker Tuff, California, Oligocene.

12, 13. *Portlandia* (*Portlandia*) *chehalisensis* (Arnold) (p. A30).
Holotype USNM 165447 (× 3.0). Length 7 mm, height 5 mm. Lincoln Creek Formation, Oregon, Eocene to Miocene.

14. *Yoldia* (*Yoldia*?) *temblorensis* Anderson and Martin (p. A23).
Holotype CAS 106 (× 2.0). Length 18 mm, height 8 mm, thickness 4 mm (both valves). Round Mountain Silt, California, Miocene.

15. *Portlandia* (*Portlandia*) *mortuasusensis* (Clark and Woodford) (p. A29).
Holotype UCMP 31337 (× 3.0). Length 9 mm, height 5 mm. Meganos Formation, California, Paleocene.

16. *Portlandia* (*Portlandia*) *markleyensis* (Clark) (p. A29).
Holotype UCMP 30833. Length 23 mm, height 13 mm, thickness 8 mm (both valves). Markley Formation, California, Eocene.

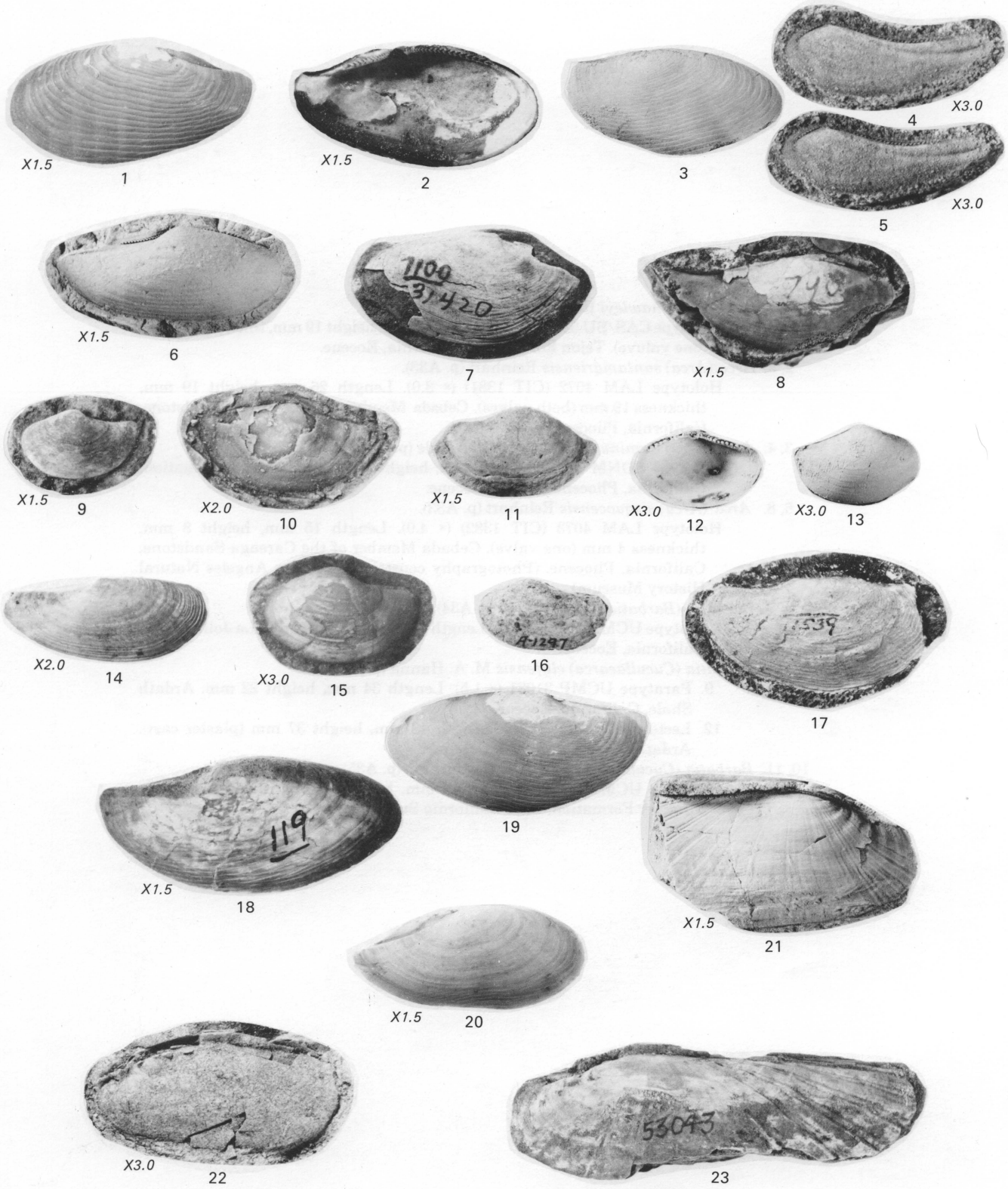
17. *Yoldia* (*Kalayoldia*?) *carnarosensis* (Clark) (p. A26).
Holotype UCMP 11539. Length 39 mm, height 21 mm (plaster cast). San Pablo Formation, California, Miocene.

20. *Acharax* aff. *johnsoni* (Dall) (p. A31).
Hypotype USNM 496070 (× 1.5); Woodring, 1938, pl. 5, fig. 14). Length 31 mm, height 16 mm. Fernando Formation, California, Pliocene and Pleistocene.

21. *Yoldia* (*Cnesterium*) *ensifera* Dall (p. A27).
Hypotype CAS 59927 (× 1.5). Length 40 mm, height 19 mm. Vancouver Island, British Columbia. Holocene.

22. *Acharax? dunnensis* (Palmer) (p. A31)
Holotype UCMP 30690 (× 3.0). Length 14 mm, height 7 mm. Capay(?) Formation, California, Eocene.

23. *Acharax johnsoni* (Dall) (p. A31).
Hypotype CAS 53043. Length 70 mm, height 23 mm. Rio Dell Formation, California, Pliocene.



NUCULANIDAE, SOLEMYIDAE

PLATE 5

FIGURES 1. *Arca* (*Arca*) *hawleyi* Reinhart (p. A31).
Holotype CAS/SU 5343 (× 1.5). Length 42 mm, height 19 mm, thickness 14 mm (one valuve). Tejon Formation, California, Eocene.

2, 5. *Arca* (*Arca*) *santamariensis* Reinhart (p. A33).
Holotype LAM 4072 (CIT 1381) (× 3.0). Length 26 mm, height 19 mm, thickness 19 mm (both valves). Cebada Member of the Careaga Sandstone, California, Pliocene.

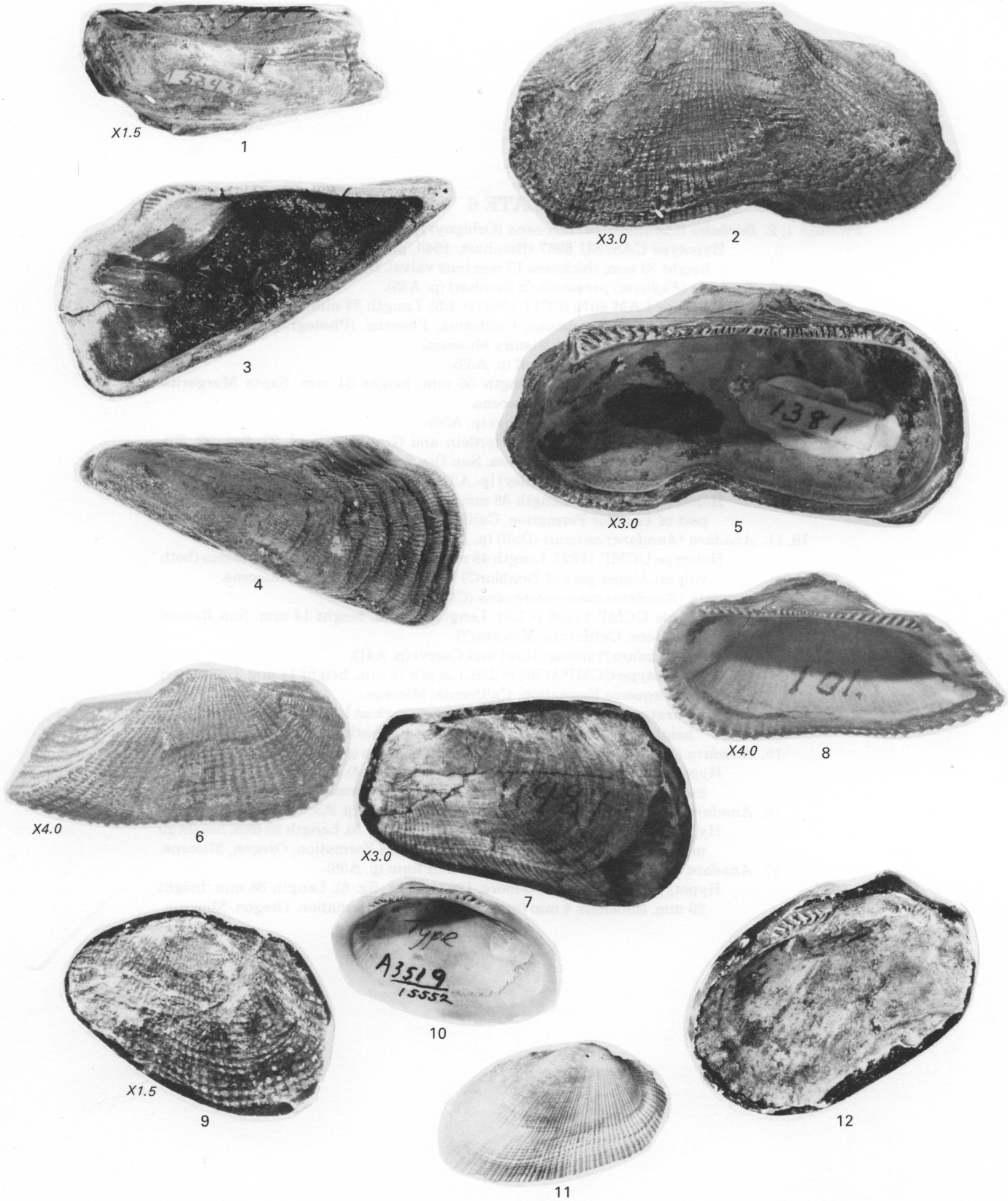
3, 4. *Arca* (*Arca*) *terminumbonis* Grant and Gale (p. A33).
Holotype SDNM 79. Length 70 mm, height 37 mm. Fernando Formation, California, Pliocene and Pleistocene.

6, 8. *Arca* (*Arca*) *sisquocensis* Reinhart (p. A33).
Holotype LAM 4073 (CIT 1382) (× 4.0). Length 15 mm, height 8 mm, thickness 4 mm (one valve). Cebada Member of the Careaga Sandstone, California, Pliocene. (Photography courtesy of the Los Angeles Natural History Museum)

7. *Barbatia* (*Barbatia*) *morsei* Gabb (p. A34).
Lectotype UCMP 11984 (× 3.0). Length 19 mm, height 16 mm. La Jolla Group, California, Eocene.

9, 12. *Barbatia* (*Cucullaearca*) *cliffensis* M. A. Hanna (p. A34).
9. Paratype UCMP 31081 (× 1.5). Length 34 mm, height 22 mm. Ardath Shale, California, Eocene.
12. Lectotype UMCP 31077. Length 48 mm, height 37 mm (plaster cast). Ardath Shale, California, Eocene.

10, 11. *Barbatia* (*Cucullaearca*) *bramkampi* Durham (p. A35).
Holotype UCMP 15552. Length 40 mm, height 24 mm, thickness 8 mm. Marquer Formation, Baja California Sur, Pliocene.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A3519
15552
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X1.5
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ARCIDAE

PLATE 6

FIGURES 1, 2. *Barbatia* (*Cucullaearca*) *reeveana* (Orbigny) (p. A35).
Hypotype CAS/SU 6967 (Reinhart, 1943, pl. 15, figs. 1-3). Length 66 mm, height 38 mm, thickness 13 mm (one valve). Baja California, Holocene.

3, 5. *Barbatia* (*Fugleria*) *pseudoillota* Reinhart (p. A35).
Holotype LAM 4075 (CCIT 1381) (× 1.5). Length 34 mm. Cebada Member of the Careaga Sandstone, California, Pliocene. (Photography courtesy of Los Angeles Natural History Museum)

4. *Arca* (*Arca*) *leptogrammica* Hall (p. A32).
Holotype UCLA 34977. Length 56 mm, height 34 mm. Santa Margarita Formation, California, Miocene.

6, 7. *Barbatia* (*Fugleria*) *illota* (Sowerby) (p. A36).
Hypotype LAM 4464 (× 2.0; Hertlein and Grant, 1972, pl. 27, figs. 38, 39). Length 20 mm, height 14 mm. San Diego Formation, California, Pliocene.

8, 9. *Anadara* (*Anadara*) *lakei* (Wiedey) (p. A37).
Holotype SDNM 19. Length 38 mm, height 34 mm, thickness 28 mm. Upper part of Temblor Formation, California, Miocene.

10, 11. *Anadara* (*Anadara*) *osmonti* (Dall) (p. A36).
Holotype UCMP 11927. Length 48 mm, height 42 mm, thickness 36 mm (both valves). Upper part of Temblor(?) Formation, California, Miocene.

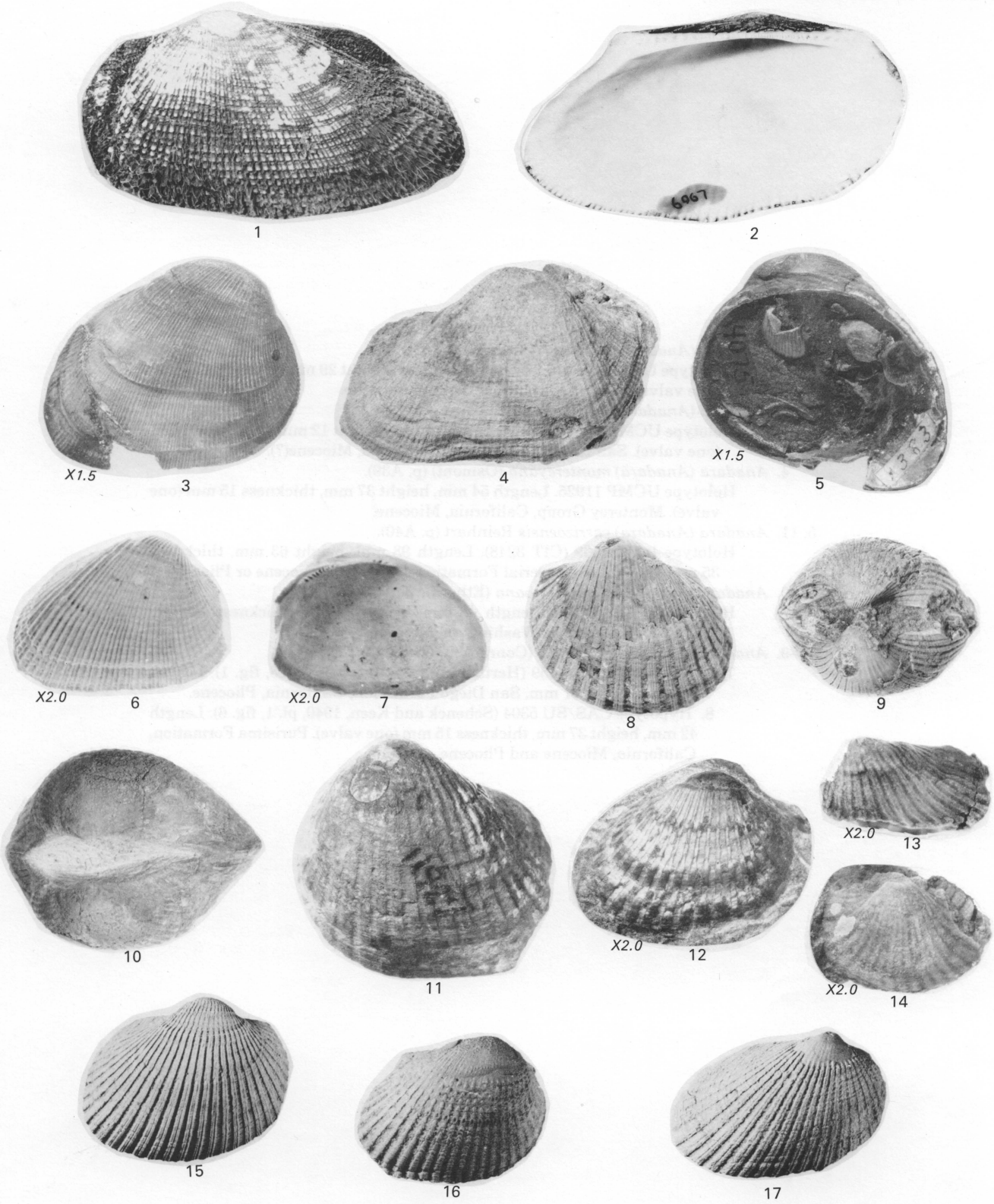
12. *Anadara* (*Anadara*) *submontereyana* (Clark) (p. A37).
Holotype UCMP 11186 (× 2.0). Length 18 mm, height 14 mm. San Ramon Sandstone, California, Miocene(?).

13, 14. *Anadara* (*Anadara*?) *strongi* (Loel and Corey) (p. A41).
13. Lectotype UCMP 31762 (× 2.0). Length 16 mm, height 11 mm. Upper part of Vaqueros Formation, California, Miocene.
14. Paratype UCMP 31762 (× 2.0; on same rock as lectotype). Length 15 mm, height 9 mm. Upper part of Vaqueros Formation, California, Miocene.

15. *Anadara* (*Anadara*) *devincta* (Conrad), split-rib form (p. A38).
Hypotype USNM 563220 (Moore, 1963, pl. 14, fig. 4). Length 35 mm, height 28 mm, thickness 23 mm (both valves). Astoria Formation, Oregon, Miocene.

16. *Anadara* (*Anadara*) *devincta* (Conrad), inflated form (p. A38).
Hypotype USNM 563221 (Moore, 1963, pl. 14, fig. 5). Length 23 mm, height 25 mm, thickness 27 mm (both valves). Astoria Formation, Oregon, Miocene.

17. *Anadara* (*Anadara*) *devincta* (Conrad), thin form (p. A38).
Hypotype USNM 56322 (Moore, 1963, pl. 14, fig. 6). Length 36 mm, height 26 mm, thickness 4 mm (one valve). Astoria Formation, Oregon, Miocene.



ARCIDAE

PLATE 7

FIGURES 1. *Anadara* (*Anadara*) *devincta* (Conrad) (p. A38).
Lectotype USNM 3499 (× 1.5). Length 37 mm, height 29 mm, thickness 15 mm (one valve). Astoria Formation, Oregon, Miocene.

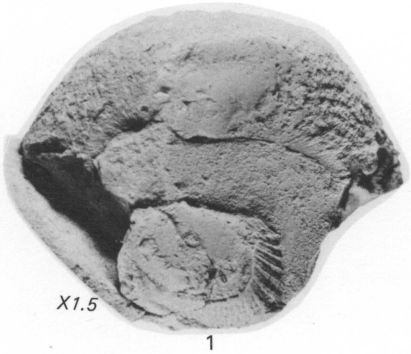
2, 3. *Anadara* (*Anadara*) *mediaimpressa* (Clark) (p. A38).
Holotype UCMP 11174 (× 2.0). Length 15 mm, height 12 mm, thickness 6 mm (one valve). San Ramon Sandstone, California, Miocene(?).

4. *Anadara* (*Anadara*) *montereyana* (Osmont) (p. A39).
Holotype UCMP 11925. Length 54 mm, height 37 mm, thickness 15 mm (one valve). Monterey Group, California, Miocene.

5, 11. *Anadara* (*Anadara*) *carrizoensis* Reinhart (p. A40).
Holotype LAM 4069 (CIT 3248). Length 98 mm, height 63 mm, thickness 35 mm (one valve). Imperial Formation, California, Miocene or Pliocene.

6, 10. *Anadara* (*Anadara*) *montesanoana* (Etherington) (p. A39).
Holotype UCMP 31922. Length 48 mm, height 40 mm, thickness 18 mm. Montesano Formation, Washington, Miocene.

7-9. *Anadara* (*Anadara*) *trilineata* (Conrad) (p. A40).
7, 9. Hypotype LAM 4459 (Hertlein and Grant, 1972, pl. 28, fig. 1). Length 67 mm, height 51 mm. San Diego Formation, California, Pliocene.
8. Hypotype CAS/SU 5304 (Schenck and Keen, 1940, pl. 1, fig. 6). Length 42 mm, height 37 mm, thickness 15 mm (one valve). Purisima Formation, California, Miocene and Pliocene.



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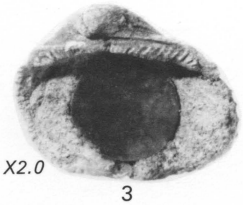

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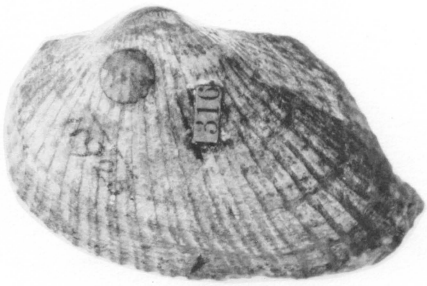
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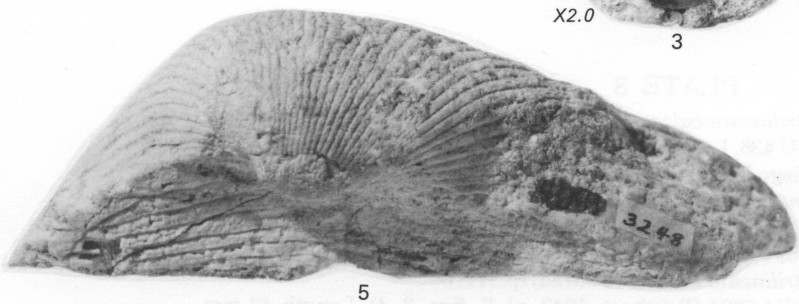
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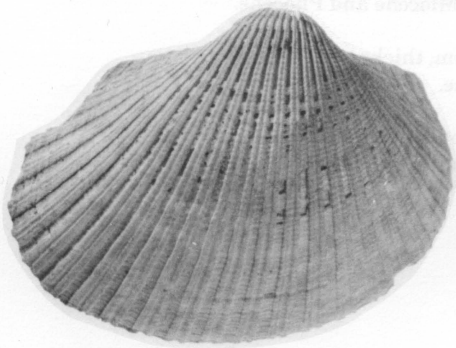
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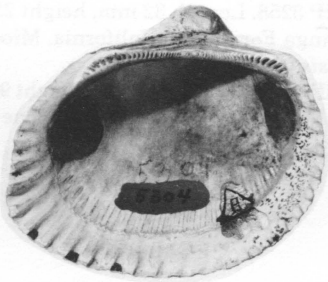
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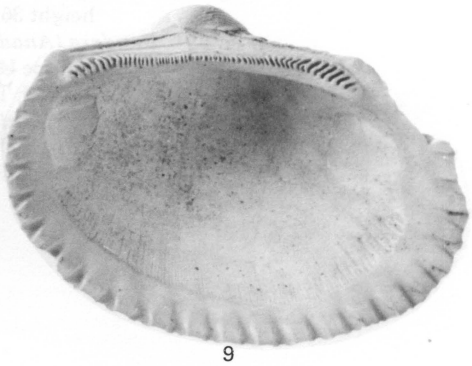
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ARCIDAE

PLATE 8

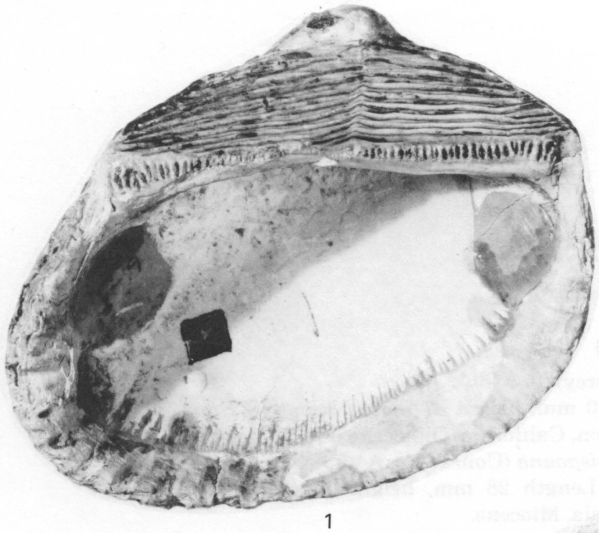
FIGURES 1, 2. *Anadara* (*Anadara*) *trilineata calcarea* (Grant and Gale) (p. A41).
Holotype CAS/SU 436. Length 78 mm, height 70 mm, thickness 70 mm (both valves). San Diego Formation, California, Pliocene.

3, 7. *Larkinia santana santana* (Loel and Corey) (p. A42).
Holotype UCMP 31768. Length 39 mm, height 40 mm, thickness 21 mm (one valve). Vaqueros Formation, California, Oligocene and Miocene.

4. *Anadara* (*Anadara*) *trilineata canalis* (Conrad) (p. A41).
Hypotype CAS/SU 5304 (Reinhart, 1943, pl. 7, figs. 3, 4). Length 42 mm, height 36 mm. Purisima Formation, California, Miocene and Pliocene.

5, 6. *Anadara* (*Anadara*) *topangaensis* Reinhart (p. A40).
Holotype ~~UCMP~~ 3258. Length 32 mm, height 25 mm, thickness 23 mm (both valves). Topanga Formation, California, Miocene.

8, 9. *Larkinia camuloensis* (Osmont) (p. A43).
Holotype UCMP 12006. Length 95 mm, height 90 mm, thickness 78 mm (both valves). Pico Formation, California, Pliocene and Pleistocene.



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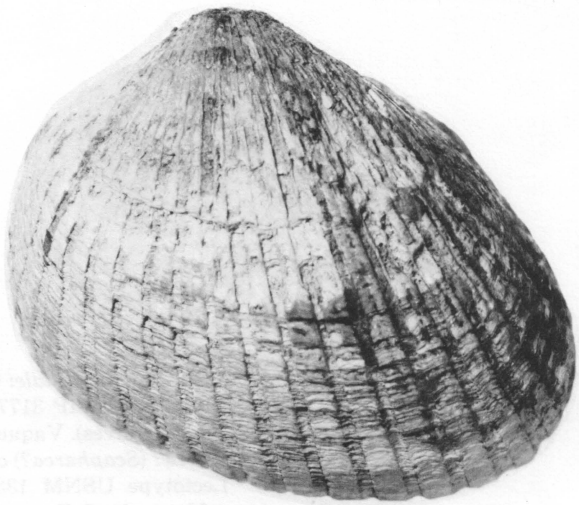

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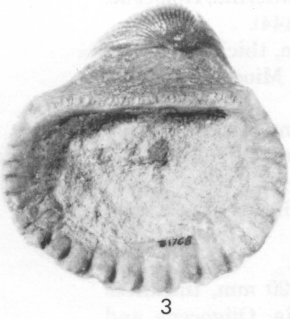

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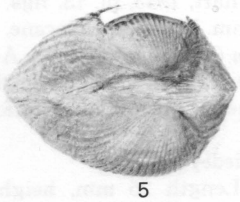

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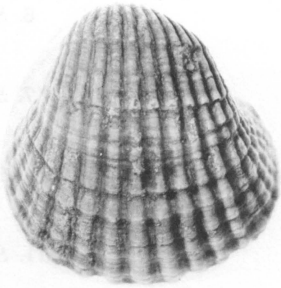

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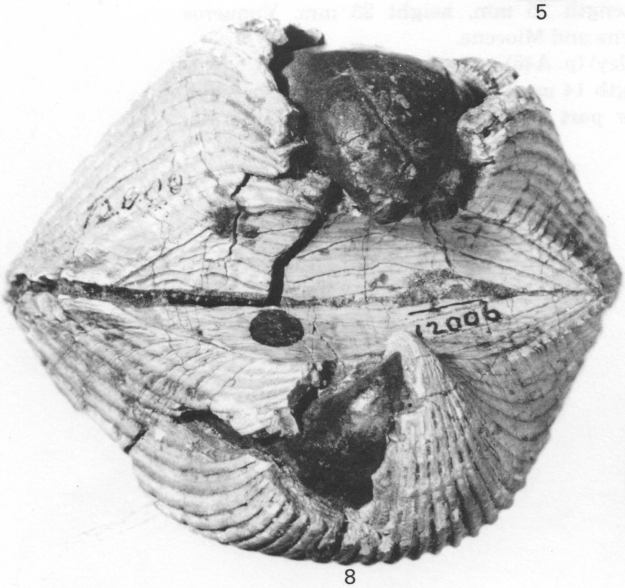

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ARCIDAE

PLATE 9

FIGURES 1, 2. *Larkinia santana weddlei* (Loel and Corey) (p. A43).
Holotype UCMP 31771. Length 40 mm, height 37 mm, thickness 37 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.

3. *Scapharca*? (*Scapharca*?) *obispoana obispoana* (Conrad) (p. A44).
Lectotype USNM 13330 (× 1.5). Length 28 mm, height 17 mm. Santa Margarita(?) Formation, California, Miocene.

4, 5. *Larkinia multicostata* (Sowerby) (p. A43).
Hypotype CAS/SU 5294 (Reinhart, 1943, pl. 3, figs. 9-11). Length 59 mm, height 53 mm, thickness 44 mm (both valves). Gulf of California, Holocene.

6. *Scapharca*? (*Scapharca*?) *obispoana perdisparis* (Wiedey) (p. A44).
Holotype SDNM 23 (× 1.5). Length 33 mm, height 24 mm, thickness 4 mm (one valve; estimated). Monterey Formation, California, Miocene.

7. *Scapharca* (*Cunearca*) *vanderhoofi* Durham (p. A44).
Holotype UCMP 30548 (× 1.5). Length 18 mm, height 15 mm, thickness 7 mm (one valve). San Gregorio Formation, Baja California Sur, Oligocene.

8, 9. *Grandiarca grandis* (Broderip and Sowerby) (p. A42).
Hypotype CAS/SU 6964 (Reinhart, 1943, pl. 13, figs. 4-6). Length 96 mm, height 77 mm, thickness 42 mm. Ecuador, Holocene.

10, 11. *Scapharca* (*Cunearca*) *santaclarana* (Loel and Corey) (p. A44).
Holotype UCMP 31765 (× 1.5). Length 22 mm, height 20 mm, thickness 21 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.

12. *Scapharca* (*Cunearca*) *hamelini* (Wiedey) (p. A45).
Holotype SDNM 18 (× 2.0). Length 25 mm, height 23 mm. Vaqueros Formation, California, Oligocene and Miocene.

13. *Scapharca* (*Cunearca*) *rivulata* (Wiedey) (p. A45).
Holotype SDNM 20 (× 3.0). Length 14 mm, height 15 mm, thickness 7 mm (one valve; estimated). Upper part of Temblor Formation, California, Miocene.

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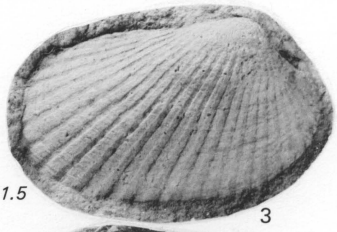
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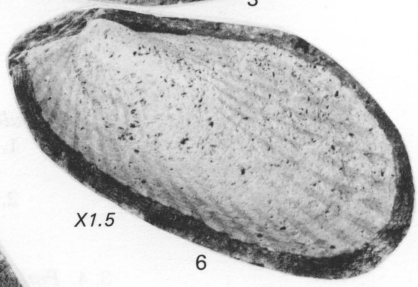
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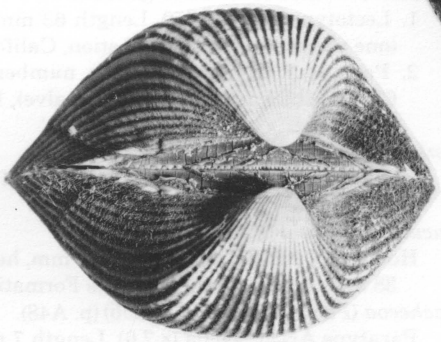
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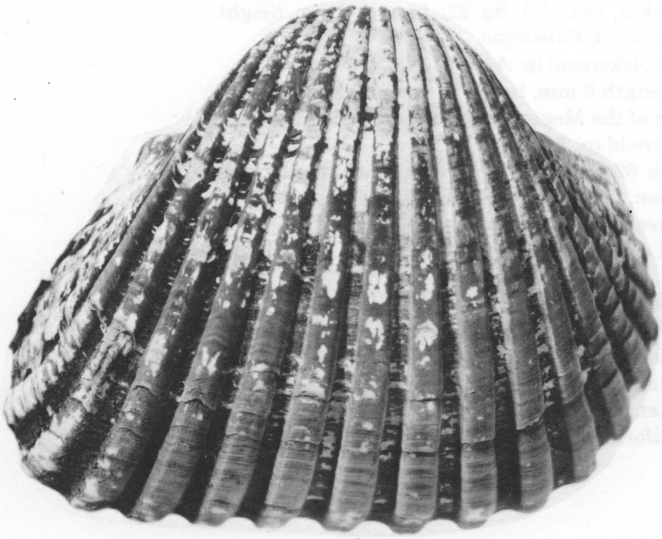
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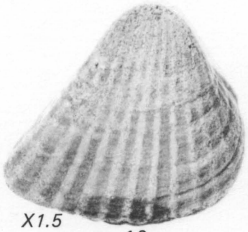
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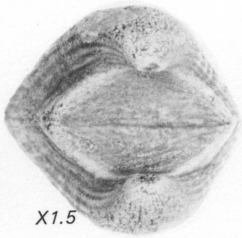
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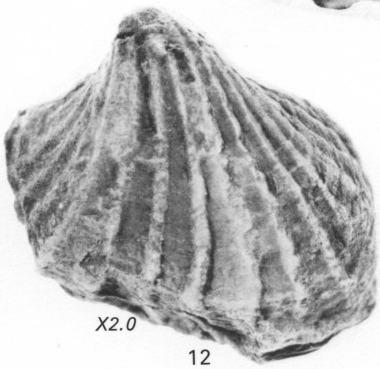
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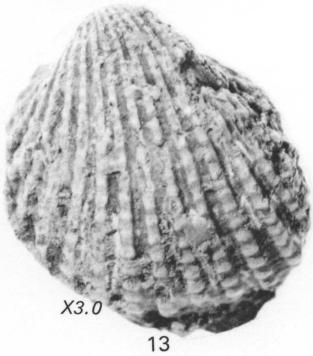

X3.0 13

ARCIDAE

PLATE 10

FIGURES 1, 2. *Cucullaea mathewsonii* Gabb (p. A47).

1. Lectotype ANSP 4559. Length 63 mm, height 58 mm, thickness 28 mm (one valve). Martinez Formation, California, Paleocene.
2. Paratype? ANSP 4559 (also numbered 6125). Length 75 mm, height 67 mm, thickness 37 mm (one valve). Martinez(?) Formation, California, Paleocene.

3, 4. *Porterius woodfordi* (M. A. Hanna) (p. A46).
Holotype UCMP 31062 (× 5.0). Length 4 mm, height 3 mm. Ardath Shale, California, Eocene.

5, 6. *Cucullaea morani* Waring (p. A47).
Holotype CAS/SU 166. Length 50 mm, height 30 mm (incomplete), thickness 38 mm (both valves). Meganos Formation, California, Paleocene.

7. *Pachecoa* (*Pachecoa*) *hornii* (Gabb) (p. A48).
Paratype ANSP 4460a (× 7.0). Length 7 mm, height 6 mm, thickness 4 mm. Tejon Formation, California, Eocene.

8. *Pachecoa* (*Pachecoa*) *hornii elusa* (Clark and Woodford) (p. A48).
Hypotype UCMP 15594 (× 5.0; Vokes, 193, pl. 1, fig. 22). Length 4 mm, height 3 mm. Meganos Formation, California, Paleocene.

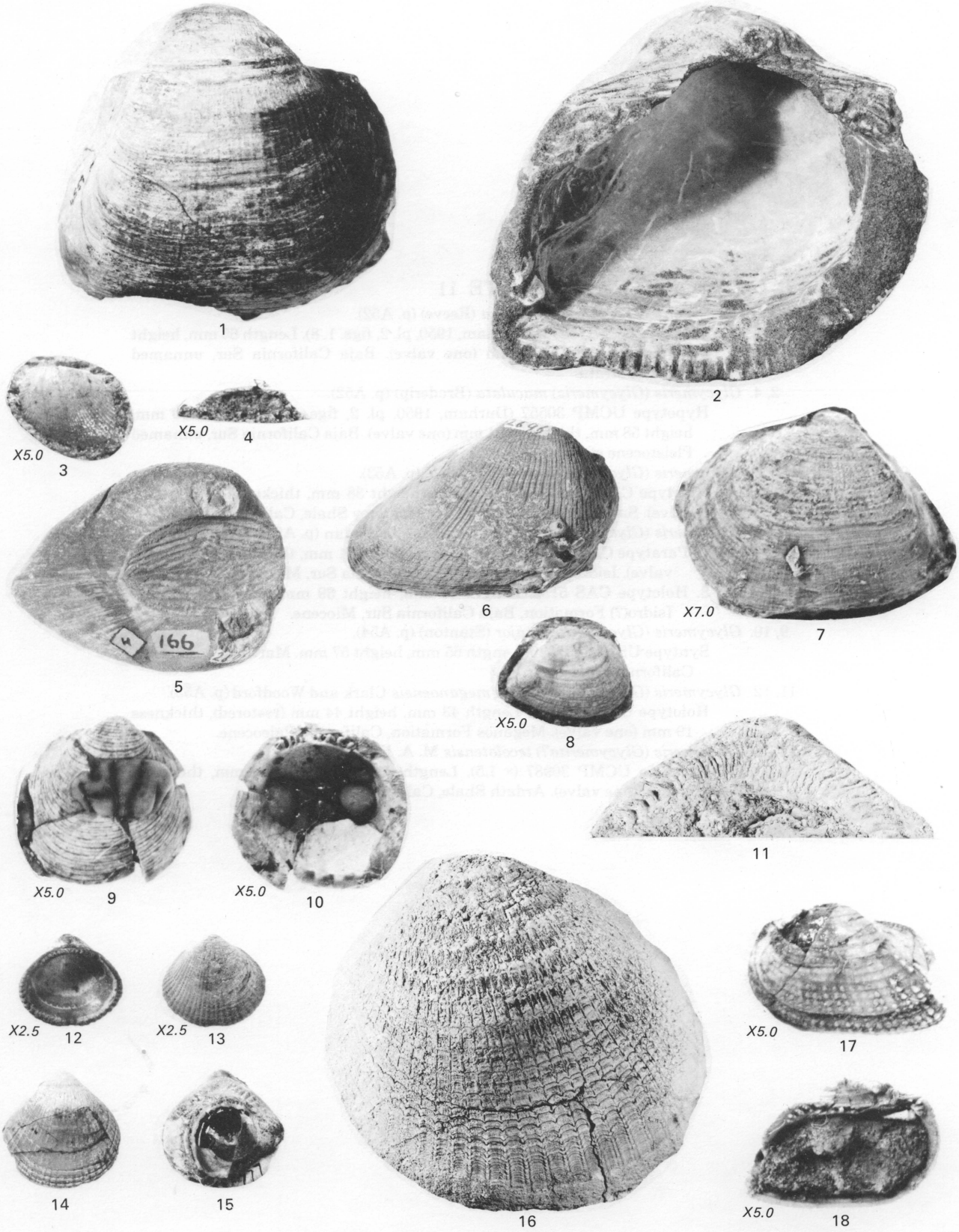
9, 10. *Limopsis* (*Limposis*) *marysvillensis* (Dickerson) (p. A49).
Holotype UCMP 11766 (× 5.0). Length 6 mm, height 6 mm, thickness 3 mm. Marysville Claystone Member of the Meganos Formation, Paleocene.

11, 16. *Glycymeris* (*Glycymeris*) *branneri* Arnold (p. A51).
Holotype USNM 165455. Length 62 mm, height 62 mm, thickness 23 mm (one valve). Vaqueros Formation, California, Oligocene and Miocene.

12, 13. *Glycymeris* (*Glycymeris*) *rosecanyonensis* M. A. Hanna (p. A49).
Holotype UCMP 30989 (× 2.5). Length 7 mm, height 6 mm. Ardath Shale, California, Eocene.

14, 15. *Glycymeris* (*Glycymeris*) *viticola* Anderson and Hanna (p. A50).
Holotype CAS 777. Length 22 mm, height 21 mm, thickness 8 mm (one valve). Tejon Formation, California, Eocene.

17, 18. *Arcopsis* (*Arcopsis*) *eba* (M. A. Hanna) (p. A47).
Holotype UCMP 31047 (× 5.0). Length 7 mm, height 5 mm, thickness 3 mm (one valve). Ardath Shale, California, Eocene.



CUCULLAEIDAE, NOETIIDAE, LIMOPSIDAE, GLYCYMERIDIDAE

PLATE 11

FIGURES 1, 3. *Glycymeris* (*Glycymeris*) *gigantea* (Reeve) (p. A52).
Holotype UCMP 30554 (Durham, 1950, pl. 2, figs. 1, 8). Length 65 mm, height 64 mm, thickness 24 mm (one valve). Baja California Sur, unnamed Pliocene strata.

2, 4. *Glycymeris* (*Glycymeris*) *maculata* (Broderip) (p. A52).
Hypotype UCMP 30557 (Durham, 1950, pl. 2, figs. 3, 5). Length 60 mm, height 58 mm, thickness 21 mm (one valve). Baja California Sur, unnamed Pleistocene strata.

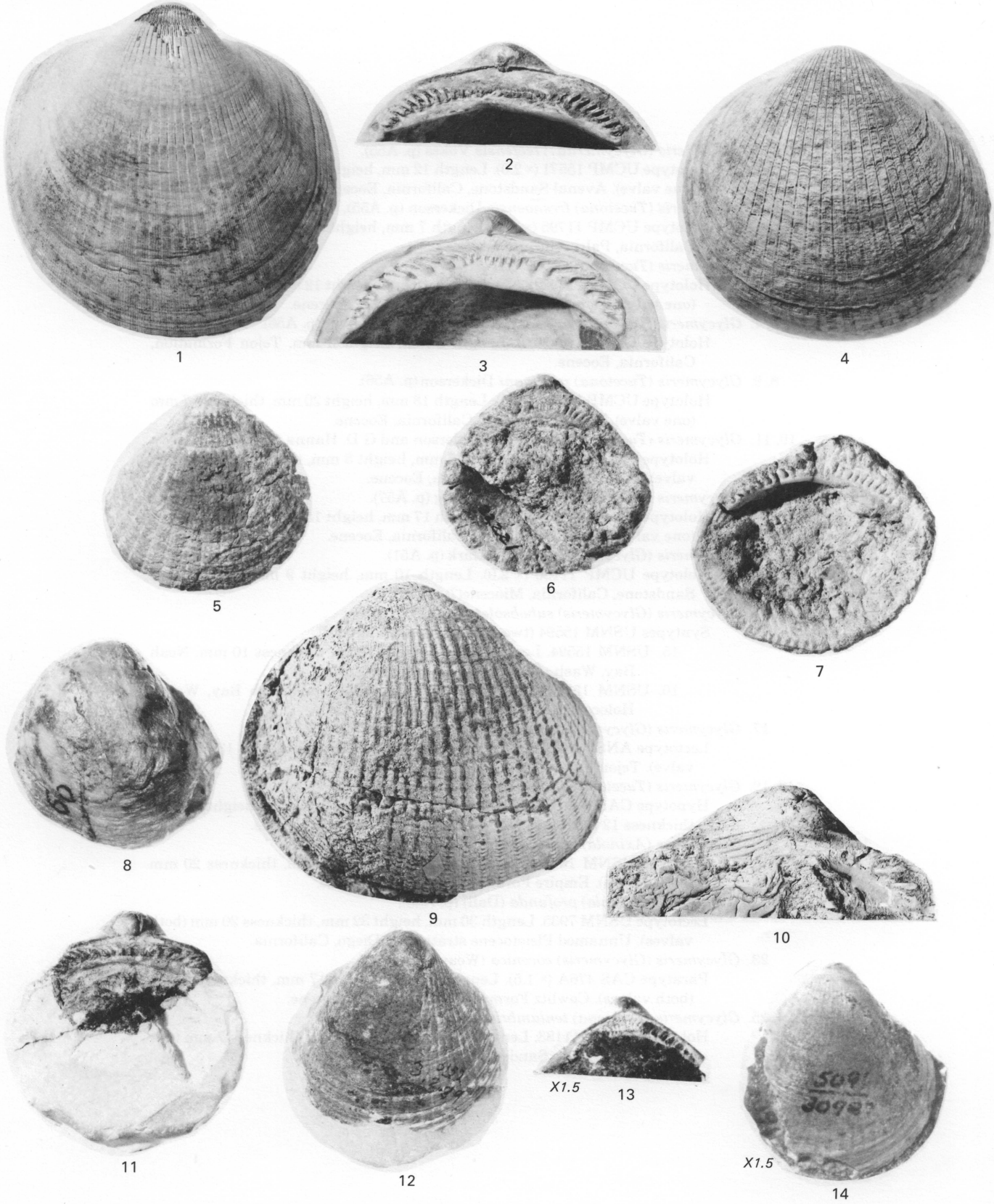
5, 6. *Glycymeris* (*Glycymeris*?) *whayleyi* Nicol (p. A53).
Holotype CAS 8584. Length 39 mm, height 38 mm, thickness 13 mm (one valve). Saltos Shale Member of the Monterey Shale, California, Miocene.

7, 8. *Glycymeris* (*Glycymeris*?) *swartsi* Hertlein and Jordan (p. A53).
7. Paratype CAS 2659. Length 42 mm, height 41 mm, thickness 15 mm (one valve). Isidro(?) Formation, Baja California Sur, Miocene.
8. Holotype CAS 5132. Length 40 mm, height 39 mm, thickness 30 mm. Isidro(?) Formation, Baja California Sur, Miocene.

9, 10. *Glycymeris* (*Glycymerita*) *major* (Stanton) (p. A54).
Syntype USNM 157830. Length 65 mm, height 57 mm. Martinez Formation, California, Paleocene.

11, 12. *Glycymeris* (*Glycymerita*) *major meganoensis* Clark and Woodford (p. A53).
Holotype UCMP 31289. Length 43 mm, height 44 mm (restored), thickness 19 mm (one valve). Meganos Formation, California, Paleocene.

13, 14. *Glycymeris* (*Glycymerita*?) *tecolotensis* M. A. Hanna (p. A55).
Holotype UCMP 30987 (× 1.5). Length 24 mm, height 27 mm, thickness 10 mm (one valve). Ardath Shale, California, Eocene.



GLYCYMERIDIDAE

PLATE 12

FIGURES 1. *Glycymeris* (*Glycymerita*?) *reefensis* Vokes (p. A55).
Holotype UCMP 15571 (× 2.0). Length 12 mm, height 12 mm, thickness 5 mm (one valve). Avenal Sandstone, California, Eocene.

2, 3. *Glycymeris* (*Tucetona*) *fresnoensis* Dickerson (p. A55).
Holotype UCMP 11795 (× 3.0). Length 7 mm, height 8 mm. Lodo Formation, California, Paleocene and Eocene.

4, 5. *Glycymeris* (*Tucetona*) *perrini* Dickerson (p. A55).
Holotype UCMP 11792 (× 1.5). Length 12 mm, height 12 mm, thickness 4 mm (one valve). Domengine Formation, California, Eocene.

6, 7. *Glycymeris* (*Tucetona*) *evermanni* Anderson and Hanna (p. A56).
Holotype CAS 964 (× 8.0). Length 3 mm, height 3 mm. Tejon Formation, California, Eocene.

8, 9. *Glycymeris* (*Tucetona*) *ruckmani* Dickerson (p. A56).
Holotype UCMP 11051 (× 1.5). Length 18 mm, height 20 mm, thickness 7 mm (one valve). Tejon Formation, California, Eocene.

10, 11. *Glycymeris* (*Tucetona*) *verticordia* Anderson and G D. Hanna (p. A56).
Holotype CAS 776 (× 3.0). Length 8 mm, height 8 mm, thickness 3 mm (one valve). Tejon Formation, California, Eocene.

12. *Glycymeris* (*Tucetona*?) *maccrayi* Waring (p. A57).
Holotype CAS/SU 167 (× 1.5). Length 17 mm, height 15 mm, thickness 5 mm (one valve). Llajas Formation, California, Eocene.

13, 14. *Glycymeris* (*Glycymeris*) *buwaldi* Clark (p. A51).
Holotype UCMP 11150 (× 2.0). Length 10 mm, height 9 mm. San Ramon Sandstone, California, Miocene(?).

15, 16. *Glycymeris* (*Glycymeris*) *subobsoleta* Cooper (p. A52).
Syntypes USNM 15594 (two specimens; both figured).
15. USNM 15594. Length 33 m, height 31 mm, thickness 10 mm. Neah Bay, Wash., Holocene.
16. USNM 15594. Length 28 mm, height 28 mm, Neah Bay, Wash., Holocene.

17. *Glycymeris* (*Glycymerita*) *sagittata* (Gabb) (p. A54).
Lectotype ANSP 4422. Length 34 mm, height 31 mm, thickness 13 mm (one valve). Tejon Formation, California, Eocene.

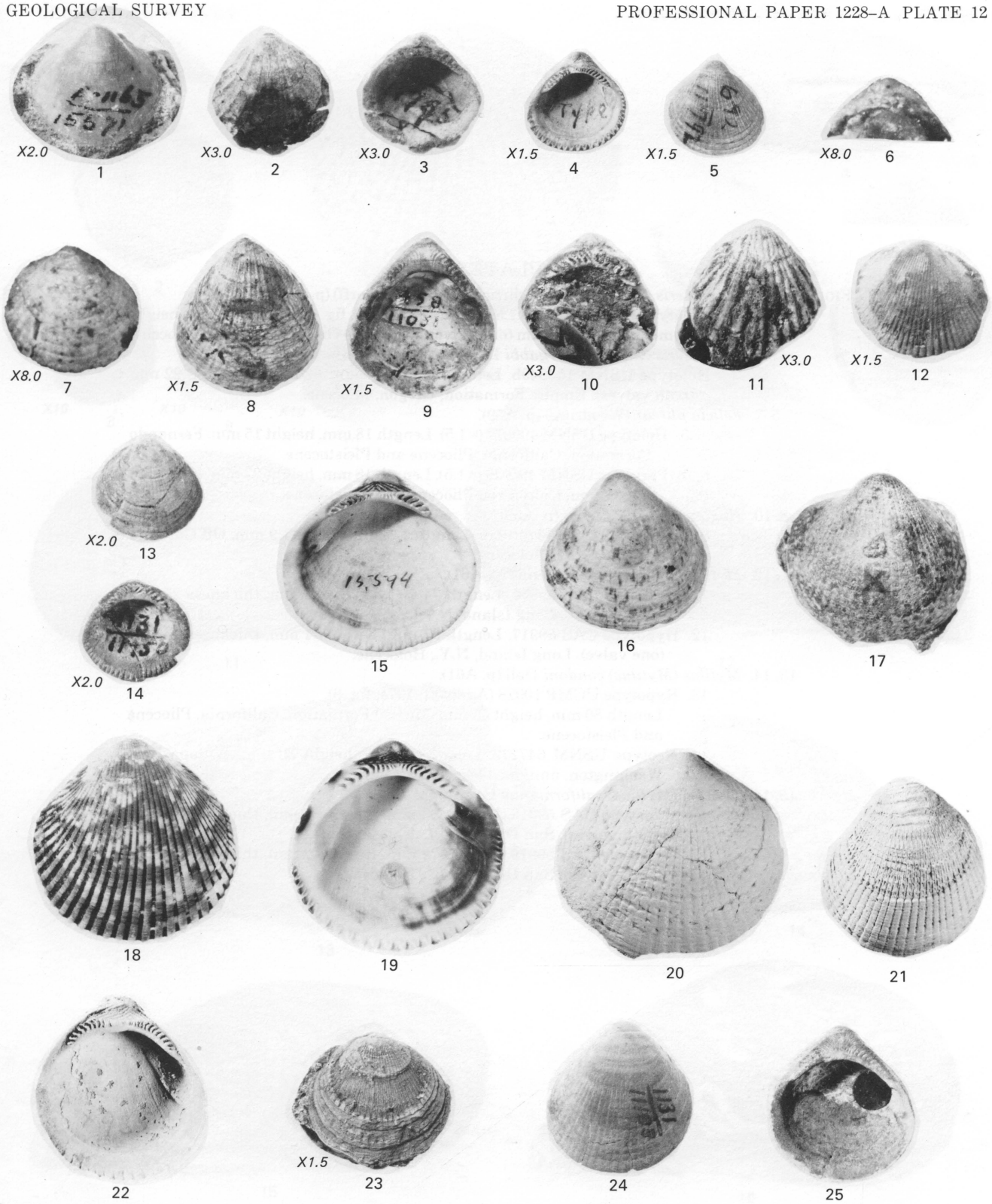
18, 19. *Glycymeris* (*Tucetona*) *multicostata* (Sowerby) (p. A57).
Hypotype CAS/SU 385 (Keen, 1971, fig. 116). Length 37 mm, height 38 mm, thickness 12 mm (both valves). Gulf of California, Holocene.

20. *Glycymeris* (*Axinola*) *grewingki* Dall (p. A58).
Holotype USNM 107784. Length 38 mm, height 38 mm, thickness 20 mm (both valves). Empire Formation, Oregon, Miocene.

21, 22. *Glycymeris* (*Axinola*) *profunda* (Dall) (p. A58).
Lectotype USNM 7935. Length 30 mm, height 32 mm, thickness 20 mm (both valves). Unnamed Pleistocene strata, San Diego, California.

23. *Glycymeris* (*Glycymeris*) *eocenica* (Weaver) (p. A50).
Paratype CAS 476A (× 1.5). Length 17 mm, height 17 mm, thickness 9 mm (both valves). Cowlitz Formation, Washington, Eocene.

24, 25. *Glycymeris* (*Tucetona*) *teniumbricata* Clark (p. A56).
Holotype UCMP 11183. Length 26 mm, height 28 mm, thickness 7 mm (one valve). San Ramon Sandstone, California, Miocene(?).



GLYCYMERIDIDAE

PLATE 13

FIGURES 1, 2. *Glycymeris* (*Tucetona*?) *septentrionalis* (Middendorff) (p. A57).
Holotype UCMP 11520 (× 1.5; Clark, 1915, pl. 48, fig. 4). Length 19 mm, height 19 mm, thickness 5 mm (one valve). San Pablo Group, California, Miocene.

3, 4. *Glycymeris* (*Glycymeris*) *gabbi* Dall (p. A52).
Holotype USNM 153949b. Length 53 mm, height 52 mm, thickness 22 mm (both valves). Empire Formation, Oregon, Miocene.

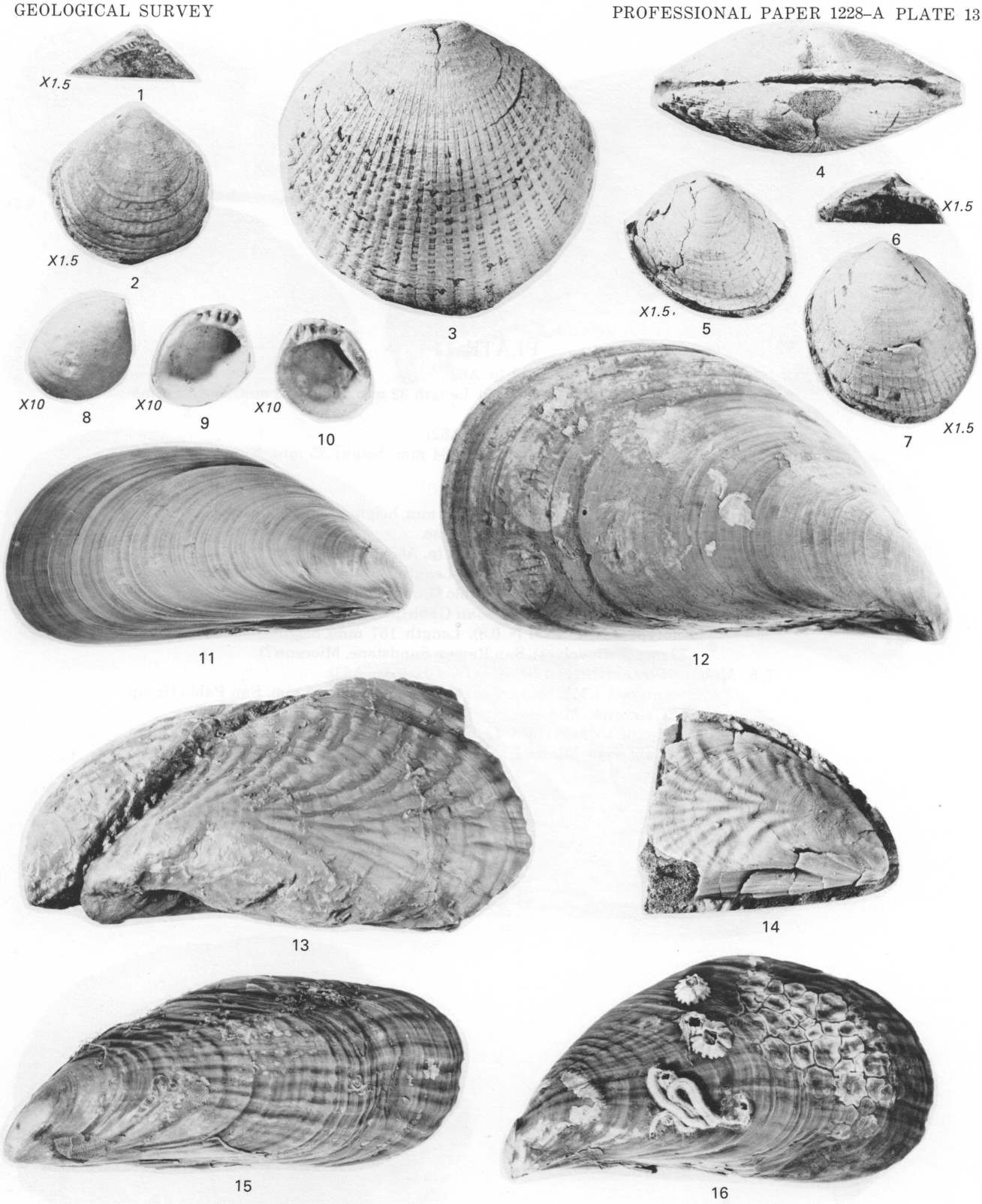
5–7. *Felicia phrear* (Woodring) (p. A59).
5. Holotype USNM 496077 (× 1.5). Length 18 mm, height 15 mm. Fernando Formation, California, Pliocene and Pleistocene.
6, 7. Paratype USNM 496079 (× 1.5). Length 18 mm, height 22 mm. Fernando Formation, California, Pliocene and Pleistocene.

8–10. *Huxleyia munita* (Dall) (p. A59).
Syntype USNM 23243 (× 10.0). Length 1.6 mm, height 1.9 mm. Off Catalina Island, California, Holocene.

11, 12. *Mytilus* (*Mytilus*) *edulis* Linné (p. A61).
11. Hypotype CAS 59916. Length 74 mm, height 40 mm, thickness 25 mm (both valves). Long Island, N.Y., Holocene.
12. Hypotype CAS 59917. Length 97 mm, height 54 mm, thickness 23 mm (one valve). Long Island, N.Y., Holocene.

13, 14. *Mytilus* (*Mytilus*) *condoni* Dall (p. A61).
13. Hypotype UCMP 10928 (Addicott, 1974, fig. 9).
Length 80 mm, height 45 mm. Merced Formation, California, Pliocene and Pleistocene.
14. Neotype USNM 647272. Length 42 mm, height 33 mm. Willapa Bay, Washington, unnamed Pliocene strata.

15, 16. *Mytilus* (*Mytilus*) *californianus* Conrad (p. A61).
15. Hypotype CAS 59918. Length 85 mm, height 35 mm, thickness 33 mm (both valves). San Diego, Calif., Holocene.
16. Hypotype CAS 59919. Length 78 mm, height 42 mm, thickness 31 mm (both valves). San Diego, Calif., Holocene.



GLYCYMERIDIDAE, MYTILIDAE

PLATE 14

FIGURES 1. *Mytilus* (*Mytilus*?) *ascia* Gabb (p. A62).
Holotype UCMP 11989 (× 2.0). Length 32 mm, height 18 mm. Tejon Formation, California, Eocene.

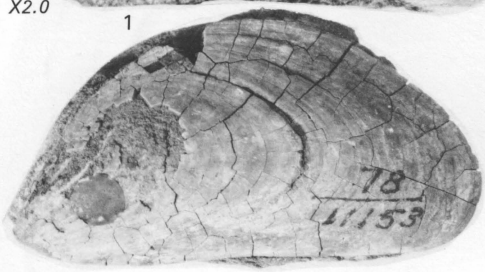
2. *Mytilus* (*Mytilus*?) *arnoldi* Clark (p. A62).
Holotype UCMP 11153. Length 64 mm, height 35 mm. Kirker Tuff, California, Oligocene.

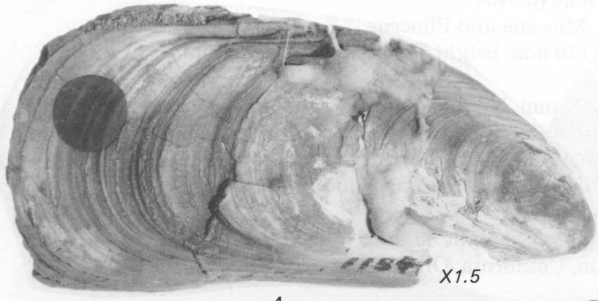
3. *Mytilus* (*Mytilus*?) loeli Grant (p. A62).
Holotype CAS/SU 515. Length 101 mm, height 60 mm. Vaqueros Formation, California, Oligocene and Miocene.

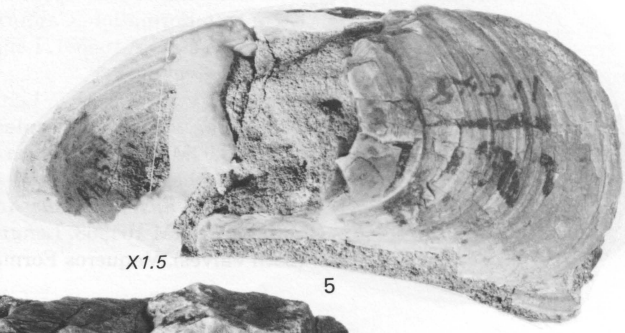
4, 5. *Mytilus (Crenomytilus?) perrini* Clark (p. A65)
Holotype UCMP 11548 (× 1.5). Length 55 mm, height 28 mm, thickness 16 mm (both valves). San Pablo Group, California, Miocene.

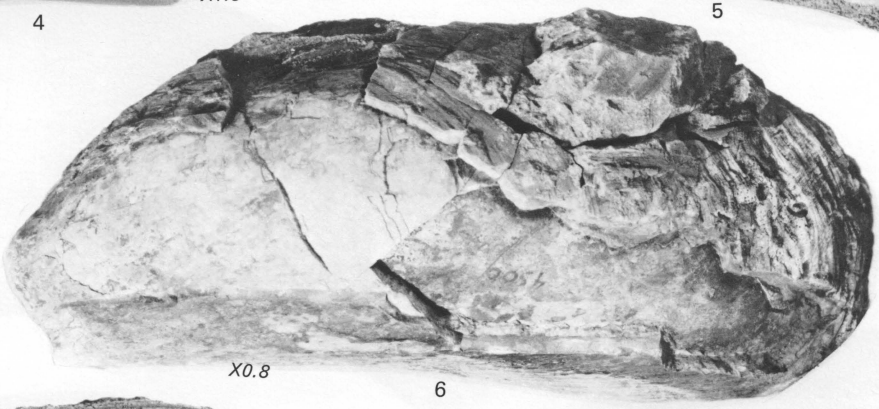
6. *Mytilus* (*Crenomytilus*) *mathewsonii* Gabb (p. A63).
Lectotype ANSP 4500 (× 0.8). Length 157 mm, height 70 mm, thickness 72 mm (both valves). San Ramon Sandstone, Miocene(?).

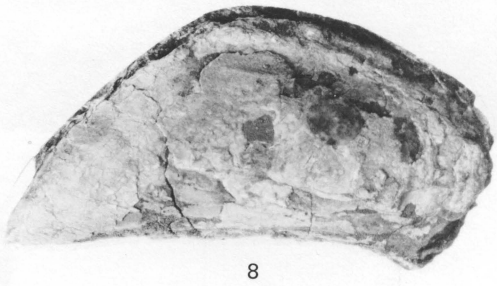
7, 8. *Mytilus* (*Crenomytilus*) *trampasensis* (Clark) (p. A63).
7. Syntype UCMP 11545. Length 80 mm, height 48 mm. San Pablo Group, California, Miocene.
8. Syntype UCMP 11546. Length 64 mm, height 39 mm. San Pablo Group, California, Miocene.











MYTILIDAE

PLATE 15

FIGURES 1-3. *Mytilus* (*Crenomytilus*) *coalingensis* Arnold (p. A64).
Etchegoin Formation, California, Miocene and Pliocene.
1, 3. Holotype USNM 165551. Length 110 mm, height 52 mm, thickness 35 mm (one valve).
2. Paratype USNM 165557. Length 99 mm, height 54 mm.

4. *Mytilus* (*Crenomytilus*) *kewi* Nomland (p. A63).
Holotype UCMP 12061. Length 84 mm, height 42 mm, thickness 33 mm (one valve). Etchegoin Formation, California, Miocene and Pliocene.

5. *Mytilus* (*Crenomytilus*) *expansus* Arnold (p. A63).
Holotype USNM 164968. Length 105 mm, height 50 mm, thickness 60 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.

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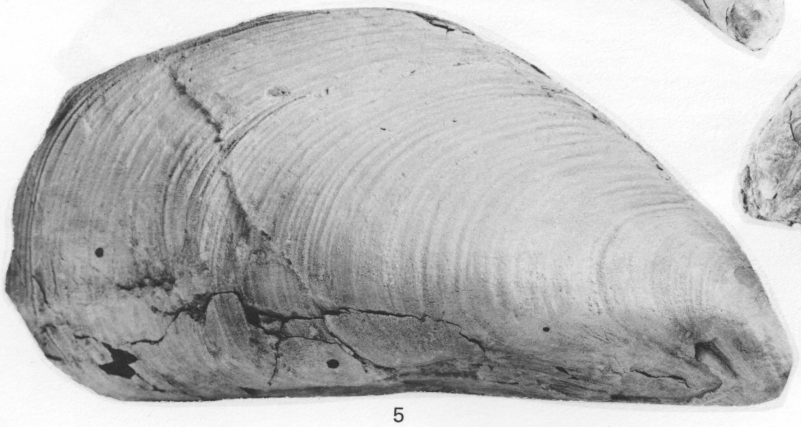


5

MYTILIDAE

PLATE 16

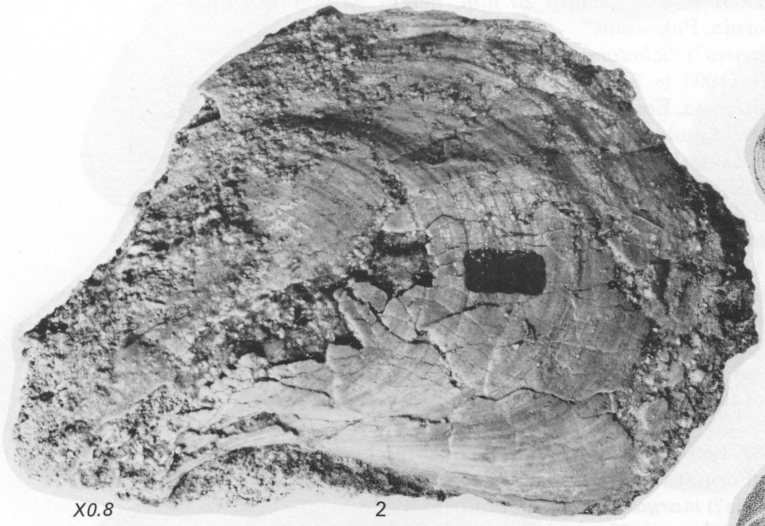
FIGURES 1. *Mytilus* (*Crenomytilus*) *sternbergi* Hertlein and Grant (p. A64).
Holotype LAM 4470. Length 238 mm, height 134 mm. San Diego Formation, California, Pliocene.

2. *Mytilus* (*Crenomytilus*?) *schencki* G D. Hanna and Hertlein (p. A64).
Holotype CAS 4686 (× 0.8). Length 130 mm, height 108 mm. Santa Margarita(?) Formation, California, Miocene.

3–6. *Mytilus* (*Plicatomytilus*) *middendorffi* Grewingk (p. A65).

3. Copy of original drawing (Grewingk, 1850, pl. 7, fig. 3a).
4. Copy of original drawing (Grewingk, 1950, pl. 7, fig. 3b).
5. Hypotype USNM 647060 (Allison and Addicott, 1976, pl. 1, fig. 6). Length 102 mm. Lower part of Empire Formation, Oregon, Miocene.
6. Hypotype USNM 647062 (Allison and Addicott, 1976, pl. 1, fig. 7). Length 86 mm (a rubber cast). Lower part of Empire Formation, Oregon, Miocene.

1



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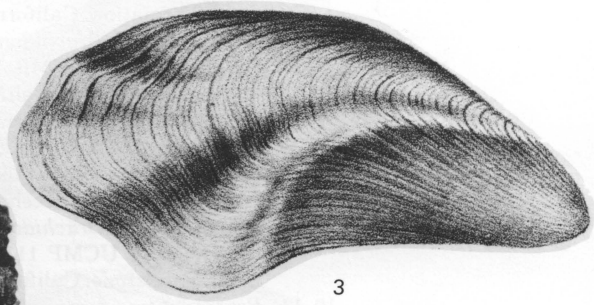

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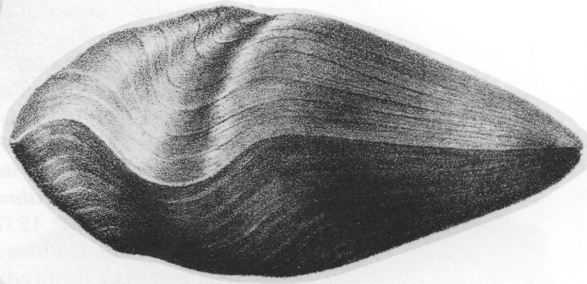

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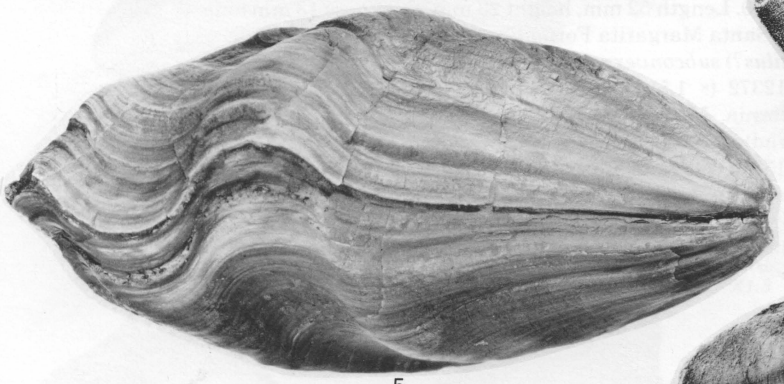

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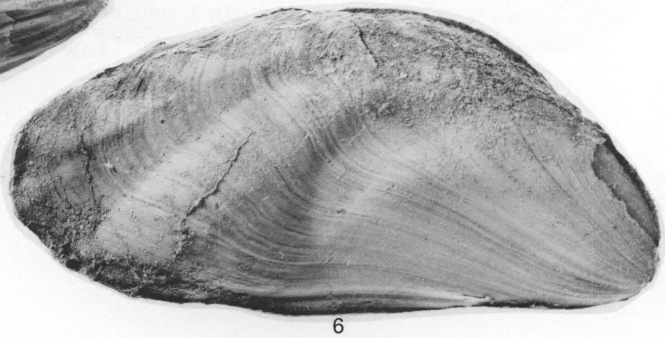


6

MYTILIDAE

PLATE 17

FIGURES 1. *Brachidontes* (*Brachidontes*) *cowlitzensis* (Weaver and Palmer) (p. A66).
Holotype CAS 7406 (× 2.0). Length 18 mm, height 14 mm. Cowlitz Formation, Washington, Eocene.

2. *Brachidontes*? (*Brachidontes*?) *susanaensis* (Nelson) (p. A67).
Holotype UCMP 30501 (× 5.0). Length 8 mm, height 5 mm. Martinez Formation, California, Paleocene.

3, 4. *Brachidontes*? (*Brachidontes*?) *altiobliquus* (Nelson) (p. A67).
Holotype UCMP 30587 (× 3.0). Length 14 mm, height 10 mm. Martinez Formation, California, Paleocene.

5. *Brachidontes*? (*Brachidontes*?) *lawsoni* (Nelson) (p. A68).
Holotype UCMP 30651 (× 2.0). Length 25 mm, height 13 mm. Martinez Formation, California, Paleocene.

6, 7. *Brachidontes*? (*Brachidontes*?) *dichotomus* (Gabb) (p. A68).
6. Holotype UCMP 11993 (× 3.0). Length 16 mm, height 11 mm. Tejon Formation, California, Eocene.
7. Rubber impression of mold from which holotype was removed.

8. *Brachidontes* (*Aeidimytilus*) *gabbi* (Clark) (p. A69).
Holotype UCMP 11550. Length 68 mm, height 28 mm. San Pablo Group, California, Miocene.

9. *Brachidontes*? (*Brachidontes*?) *kirkerensis* (Clark) (p. A68).
Holotype UCMP 11121 (× 1.5). Length 38 mm, height 18 mm. San Ramon Sandstone, California, Miocene(?).

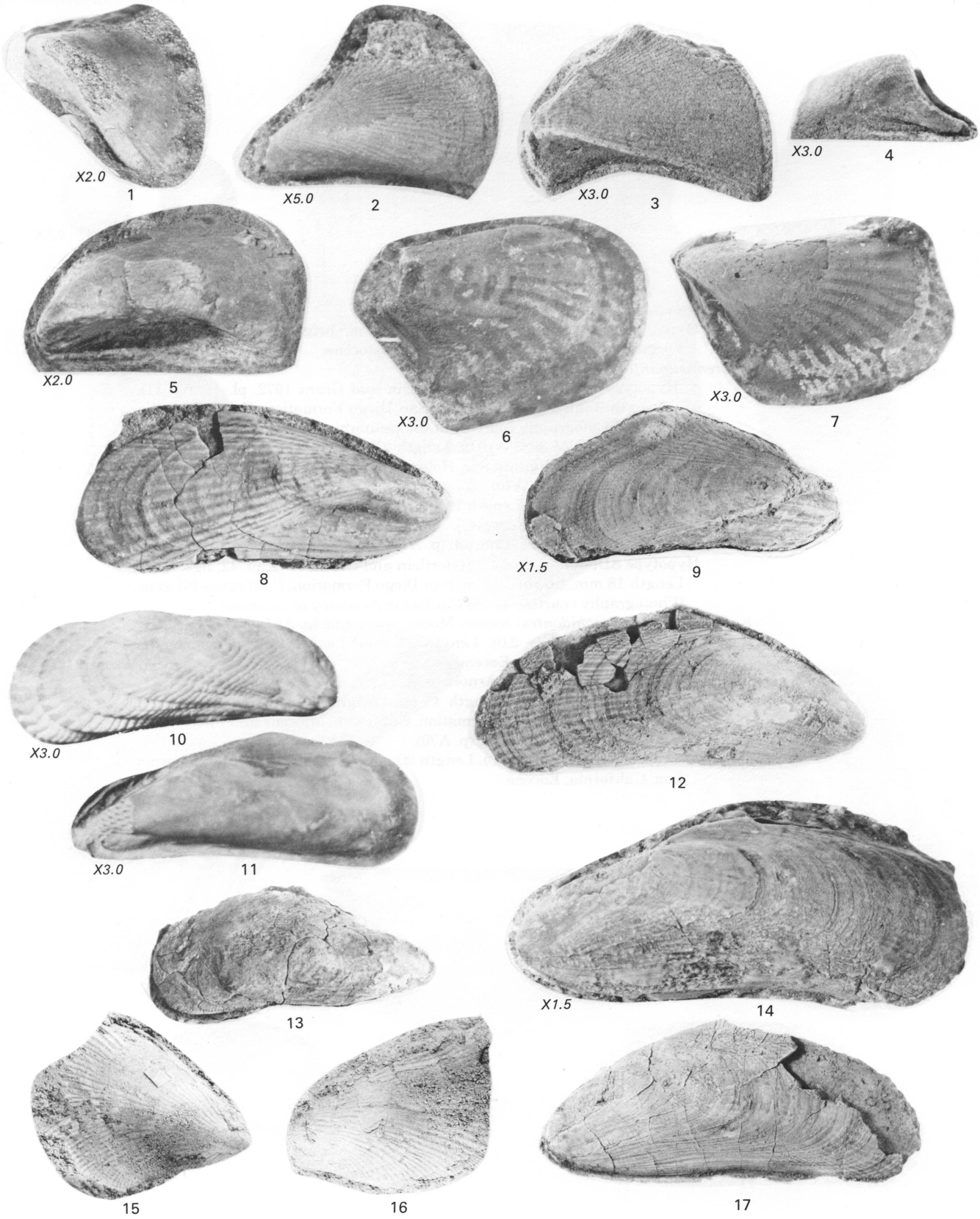
10, 11. *Brachidontes* (*Aeidimytilus*) *adamsianus* (Dunker) (p. A70).
Hypotype LAM 4473 (× 3.0; Hertlein and Grant, 1972, pl. 42, figs. 4, 5). Length 19 mm, height 7 mm. San Diego Formation, California, Pliocene. (Photography courtesy of the California Academy of Sciences)

12, 17. *Brachidontes* (*Scolimytilus*?) *multiradiatus* (Gabb) (p. A69).
Holotype ANSP 4482. Length 71 mm, height 30 mm, thickness 22 mm (both valves). Martinez Formation, California, Paleocene.

13. *Brachidontes* (*Scolimytilus*?) *margaritana* (Nomland) (p. A69).
Holotype UCMP 11310. Length 52 mm, height 23 mm, thickness 13 mm (one valve; estimated). Santa Margarita Formation, California, Miocene.

14. *Brachidontes* (*Scolimytilus*?) *subconvexus* (Trask) (p. A69).
Holotype UCMP 12372 (× 1.5). Length 56 mm, height 25 mm. Briones Sandstone, California, Miocene.

15, 16. *Mytella inezensis* (Conrad) (p. A70).
Syntypes USNM 13319. Gaviota Formation of some authors, California, Eocene and Oligocene.
15. Length 40 mm, height 32 mm.
16. Length 35 mm, height 30 mm.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MYTILIDAE

PLATE 18

FIGURES 1, 2. *Crenella decussata* (Montagu) (p. A71).

Hypotype LAM 5747 (× 7.0). Length 2 mm, height 2.5 mm. Fernando Formation, California, Pliocene and Pleistocene.

3, 5, 6. *Crennella inflata* Carpenter (p. A72).

3. Hypotype LAM 4479 (× 9.0); (Hertlein and Grant 1972, pl. 41, fig. 11). Length 3 mm, height 2.3 mm. San Diego Formation, California, Pliocene. (Photography courtesy of the California Academy of Sciences)

5, 6. Holotype USNM 3988 (×10.0). Length 2.4 mm, height 3.0 mm. Cabo San Lucas, Baja California Sur, Holocene.

4. *Perna montana* Conrad (p. A70).

Holotype USNM 13329. Length 70 mm, height 110 mm. Formation unknown; southern California, Eocene(?).

7, 9. *Septifer* (*Septifer*) *bifurcatus* (Conrad) (p. A71).

Hypotype SDNM 04319 (× 4.0); (Hertlein and Grant, 1972, pl. 42, figs. 6, 12). Length 18 mm, height 10 mm. San Diego Formation, California, Pliocene. (Photography courtesy of the California Academy of Sciences)

8. *Brachidontes* (*Brachidontes*) *cooperi* Moore, new name (p. A67).

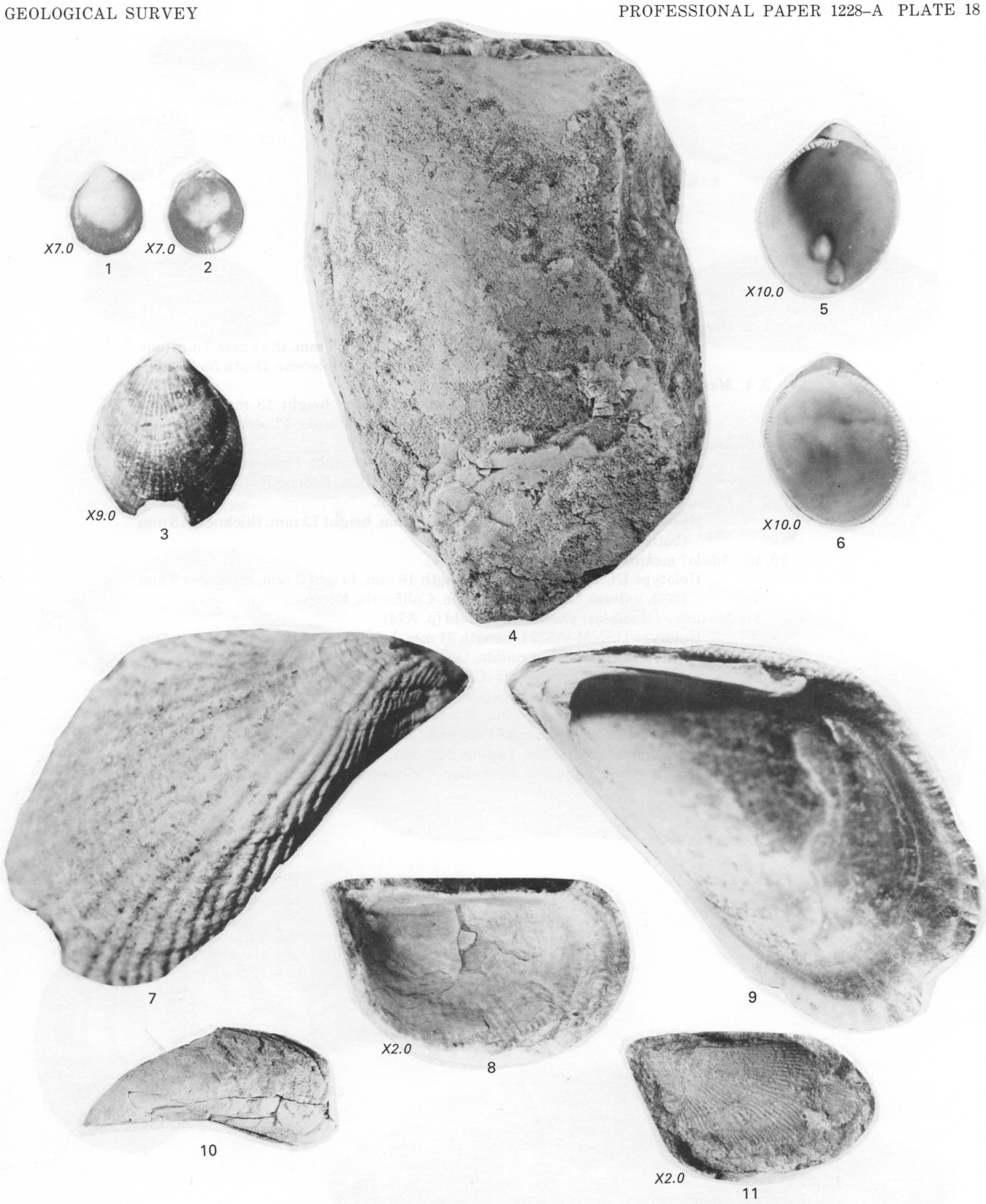
Holotype CAS 613 (× 2.0). Length 26 mm, height 14 mm. Domengine Formation, California, Eocene.

10. *Septifer (Septifer) coalingensis* Arnold (p. A71).

Holotype USNM 165580. Length 45 mm, height 19 mm, thickness 18 mm (both valves). Etchegoin Formation, California, Miocene and Pliocene.

11. *Septifer* (*Septifer*) *elegans* Waring (p. A70).

Neotype CAS/SU 322 (× 2.0). Length 20 mm, height 13 mm. Llajas Formation, California, Eocene.



MYTILIDAE

PLATE 19

FIGURES 1, 2. *Gregariella chenui* (Récluz) (p. A72).
Hypotype CAS 59920 (× 3.0). Length 9 mm, height 7 mm, thickness 3 mm (one valve). Isthmus Cove, Catalina Island, Calif., Holocene. Depth 55-90 m.

3, 4. *Musculus* (*Musculus*) *stalderi* (Martin) (p. A73).
Holotype UCMP 12354 (× 1.5). Length 34 mm, height 18 mm, thickness 13 mm (both valves). Rio Dell Formation, California, Pliocene.

5, 6. *Lithophaga* (*Lithophaga*) *clarki* M. A. Hanna (p. A73).
Holotype UCMP 31031 (× 3.0). Length 13 mm, height 7 mm, thickness 5 mm (both valves). Delmar(?) Formation, California, Eocene(?).

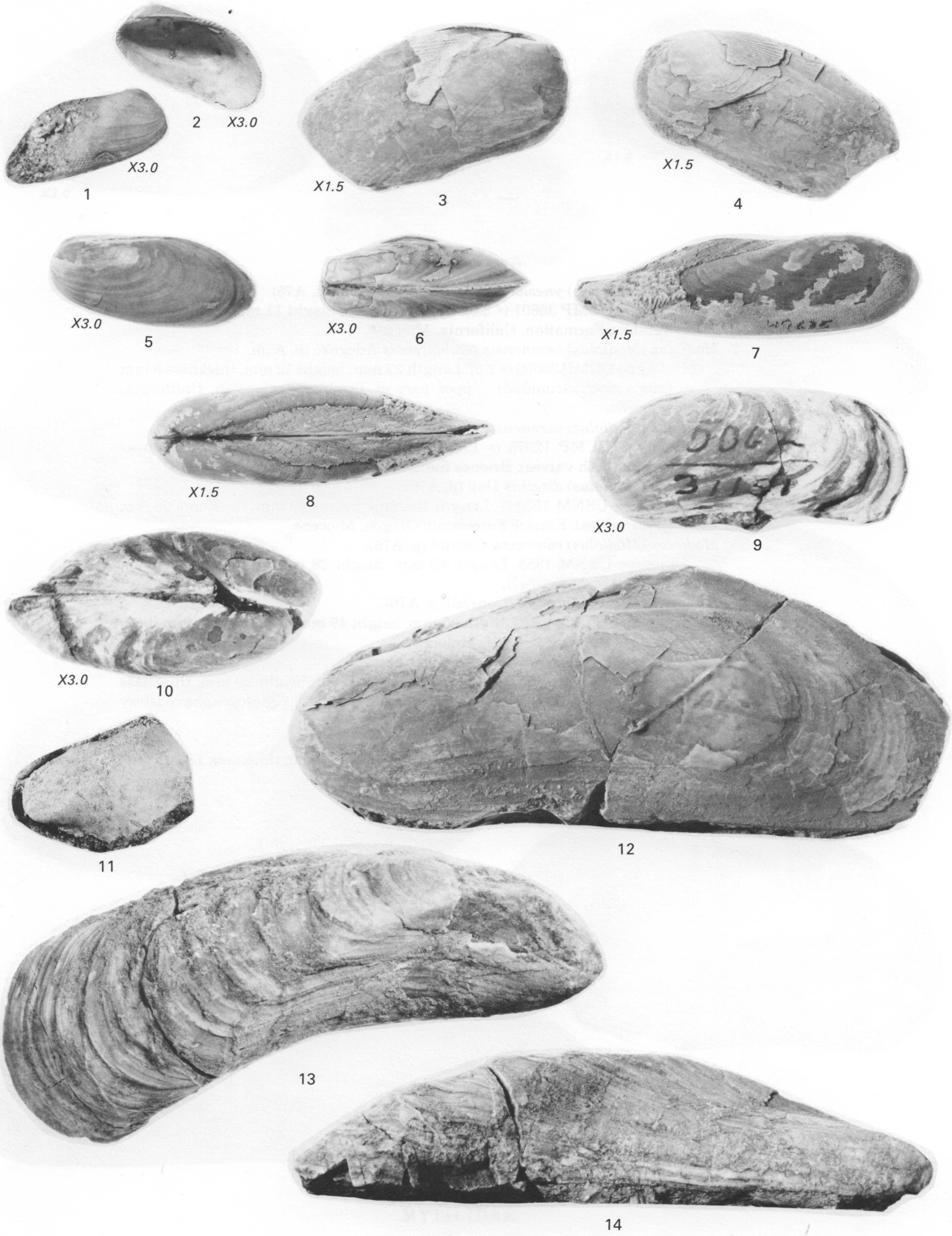
7, 8. *Lithophaga* (*Diberus*) *plumula* (Hanley) (p. A73).
Hypotype CAS 59921 (× 1.5). Length 42 mm, height 13 mm, thickness 13 mm (both valves). Panama, Holocene.

9, 10. *Adula*? *mcknighti* (M. A. Hanna) (p. A74).
Holotype UCMP 31151 (× 3.0). Length 19 mm, height 9 mm, thickness 9 mm (both valves). Delmar Formation, California, Eocene.

11. *Modiolus* (*Modiolus*) *ynezianus* Arnold (p. A74).
Holotype USNM 165324. Length 31 mm, height 8 mm, thickness 11 mm (one valve). Vaqueros Formation, Oligocene and Miocene.

12. *Modiolus* (*Modiolus*) *eugenensis* (Clark) (p. A74).
Holotype UCMP 30319. Length 120 mm, height 50 mm. Eugene Formation, Oligocene, Oregon.

13, 14. *Modiolus* (*Modiolus*) *lagunanus* Loel and Corey (p. A75).
Holotype UCMP 31788. Length 113 mm, height 44 mm, thickness 33 mm (one valve). Vaqueros Formation, California, Oligocene and Miocene.



MYTILIDAE

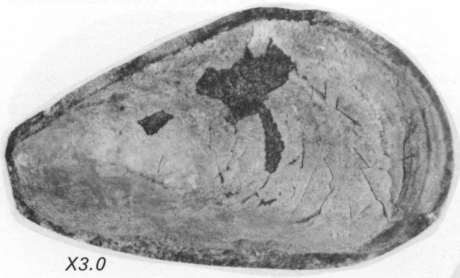
PLATE 20

FIGURES

1. *Modiolus* (*Modiolus*) *ynezianus garzaensis* Adegoke (p. A75).
   Holotype UCMP 36601 (× 3.0). Length 19 mm, height 11 mm. Upper part of Temblor Formation, California, Miocene.
2. *Modiolus* (*Modiolus*) *veronensis temblorensis* Adegoke (p. A75).
   Holotype UCMP 36606 (× 2.0). Length 23 mm, height 12 mm, thickness 6 mm (one valve; estimated). Upper part of Temblor Formation, California, Miocene.
3. *Modiolus* (*Modiolus*) *veronensis veronensis* Trask (p. A75).
   Holotype UCMP 12373 (× 1.5). Length 40 mm, height 19 mm, thickness 14 mm (both valves). Briones Sandstone, California, Miocene.
4. *Modiolus* (*Modiolus*) *directus* Dall (p. A76).
   Lectotype USNM 153947. Length 105 mm, height 40 mm, thickness 26 mm (both valves). Empire Formation, Oregon, Miocene.
5. *Modiolus* (*Modiolus*) *contracta* Conrad (p. A76).
   Holotype USNM 1853. Length 63 mm, height 28 mm. Monterey(?) Group, California, Miocene(?).
6. *Modiolus* (*Modiolus*) *capax* (Conrad) (p. A76).
   Hypotype CAS 59922. Length 95 mm, height 49 mm, thickness 44 mm (both valves). San Diego, Calif., Holocene.

7, 8. *Modiolus* (*Modiolus*) *carpenteri* Soot-Ryen (p. A77).
   Holotype Redpath Museum 3133. Length 36 mm, height 20 mm, thickness 12 mm (one valve). Santa Barbara, Calif., Holocene. (Photographs courtesy of Katherine V. W. Palmer).

9. *Modiolus* (*Modiolus*) *rectus* Conrad (p. A76).
   Hypotype CAS 59923. Length 125 mm, height 43 mm, thickness 18 mm (one valve). San Diego, Calif., Holocene.



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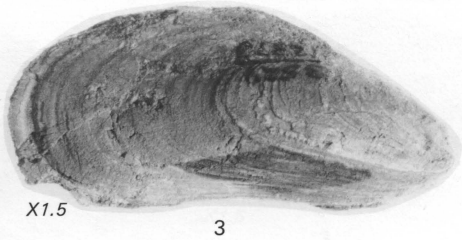

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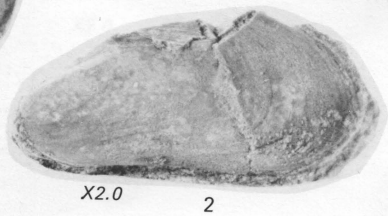

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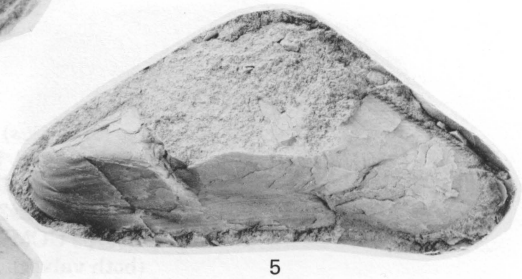

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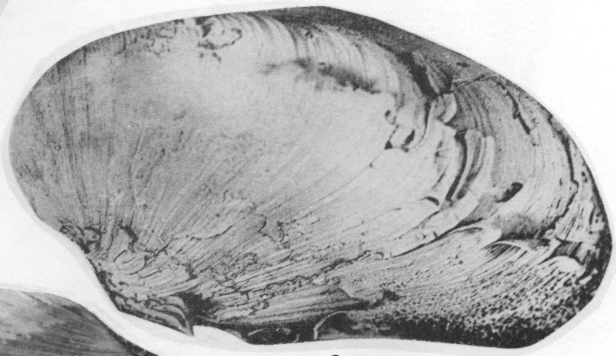

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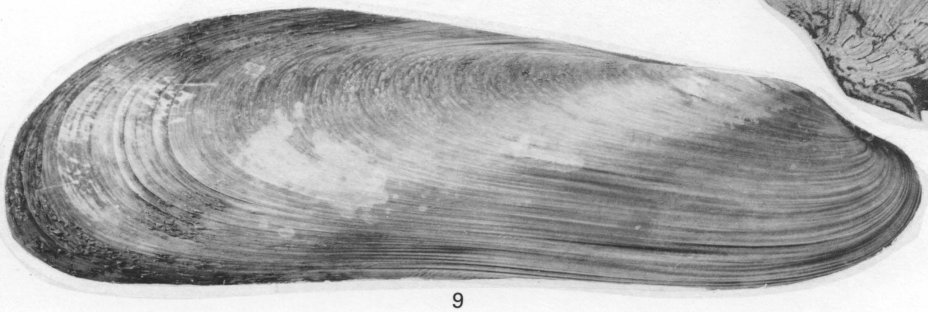


9

MYTILIDAE

PLATE 21

FIGURES 1. *Modiolus* (*Modiolus*) *sacculifer* (Berry) (p. A77).
Holotype CAS/SU 7853 (× 1.5). Length 37 mm, height 20 mm, thickness 9 mm (one valve). San Pedro, Calif., Holocene.

2. *Modiolus* (*Modiolus*?) *merriami* (Weaver) (p. A77).
Holotype UCMP 11892 (× 2.0). Length 28 mm, height 13 mm, thickness 8 mm (both valves). Martinez Formation, California, Paleocene.

3, 4. *Modiolus* (*Modiolus*?) *pittsburgensis* Clark (p. A77).
Holotype UCMP 11122 (× 1.5; specimen illustrated is a plaster cast. Length 33 mm, height 20 mm, thickness 13 mm, both valves). Kirker Tuff, California, Oligocene.

5. *Modiolus*? (*Modiolus*?) *meganosensis* Clark and Woodford (p. A78).
Holotype UCMP 31363 (× 3.0). Length 16 mm, height 10 mm. Meganos Formation, California, Paleocene.

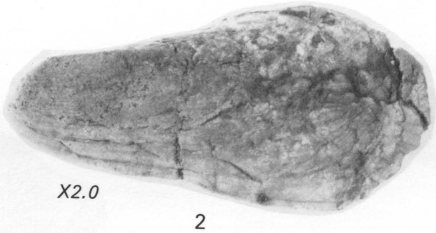
6, 7. *Idasola*? *bakeri* (Dickerson) (p. A78).
Holotype UCMP 11686 (× 2.0). Length 26 mm, height 17 mm, thickness 10 mm (one valve; estimated). Martinez Formation, California, Paleocene.

8, 9. *Modiolus*? (*Modiolus*?) *clarki* Moore, new name (p. A78).
Holotype UCMP 11544. Length 102 mm, height 53 mm, thickness 49 mm (one valve). Neroly Sandstone, Miocene.

10. *Pinna* (*Pinna*) *lewisi* Waring (p. A79).
Holotype CAS/SU 5194. Length 63 mm, height 50 mm, thickness 27 mm (both valves). Llajas Formation, California, Eocene.

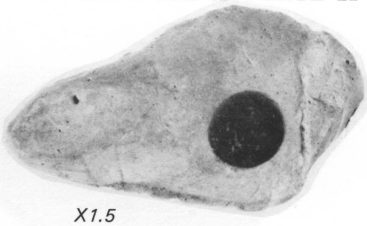
X1.5

1



X2.0

2



X1.5

3

X1.5

4

X3.0

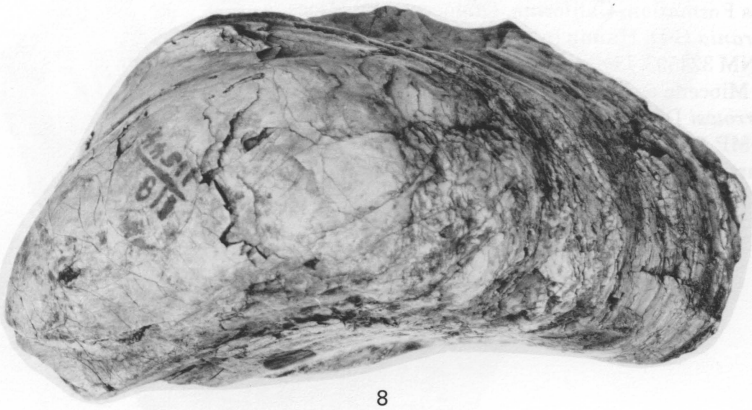
5

X2.0

6

X2.0

7



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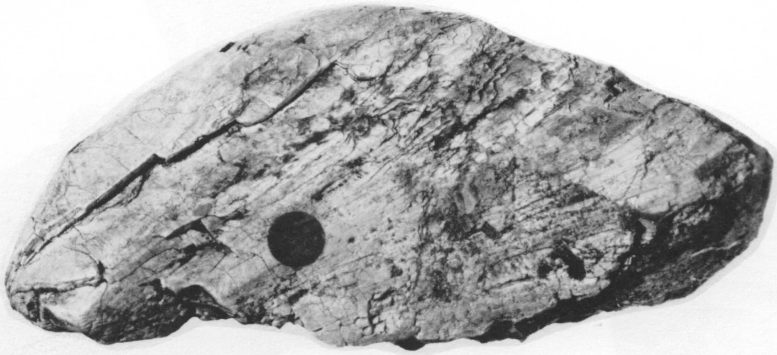


9

10

MYTILIDAE, PINNIDAE

PLATE 22

FIGURES 1. *Pinna (Pinna)* n. sp. Vokes (p. A79).

Hypotype UCMP 32595 (Vokes, 1939, pl. 2, fig. 14). Length 60 mm, height 54 mm. Domengine Formation, California, Eocene.

2, 3. *Pinna* (*Pinna*) *stocktoni* Loel and Corey (p. A79).

2. Syntype UCMP 31779. Length 62 mm, height 37 mm, thickness 18 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.

3. Syntype UCMP 31778. Length 80 mm, height 100 mm, thickness 50 mm. Vaqueros Formation, California, Oligocene and Miocene.

4. *Pinna* (*Pinna*) *latrania* G D. Hanna (p. A79).

Holotype USNM 324593. Length 135 mm, height 63 mm. Imperial Formation, California, Miocene or Pliocene.

5, 6. *Pinna* (*Pinna*) *barrowsi* Dickerson (p. A79).

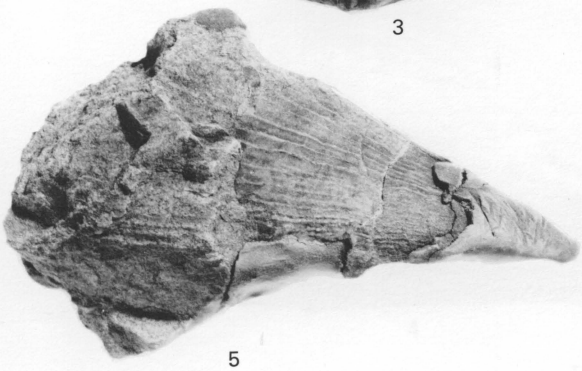
Holotype UCMP 11728. Length 75 mm, height 40 mm, thickness 17 m (both valves). Martinez Formation, California, Paleocene.

1

2

3

4



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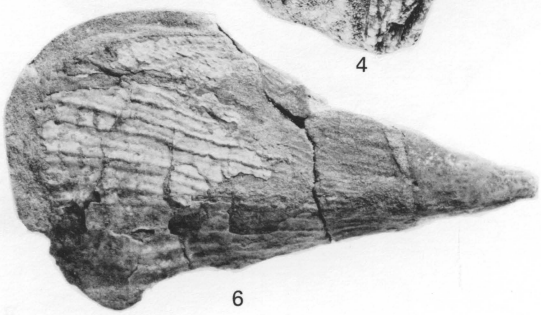


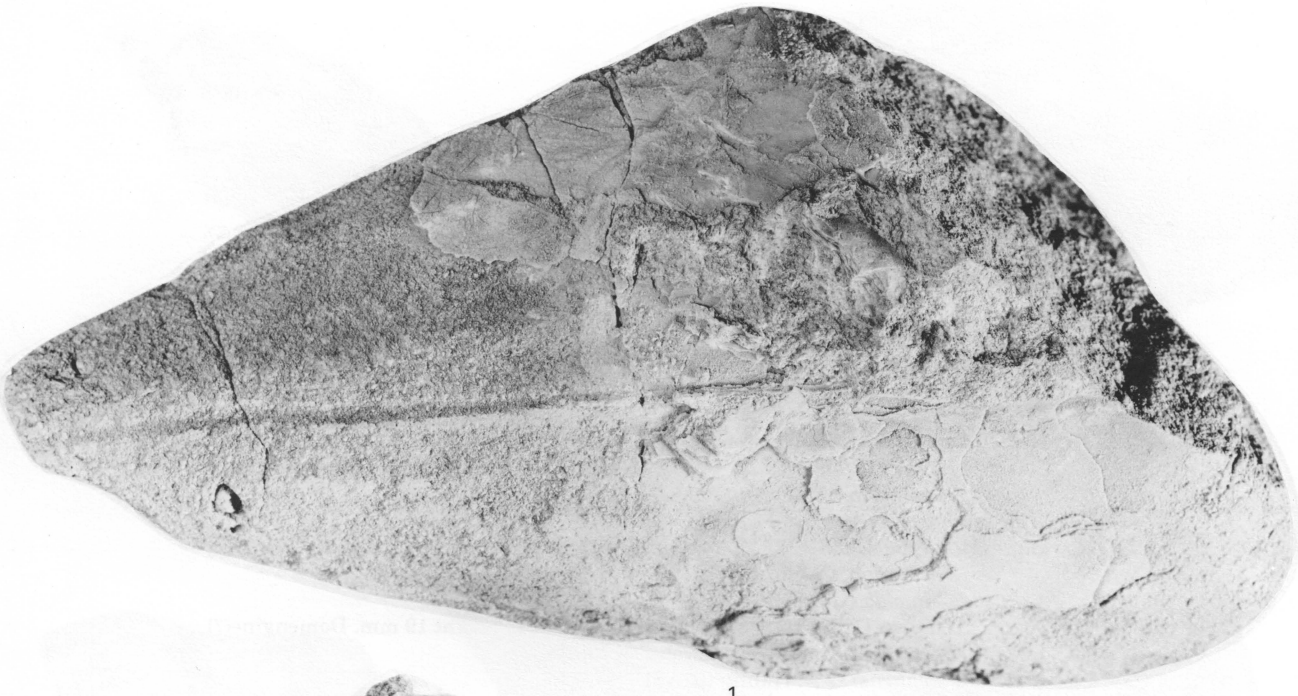
6

PINNIDAE

PLATE 23

FIGURES

1. *Pinna* (*Pinna*) *mendenhalli* G D. Hanna (p. A80).
   Holotype USNM 324593a. Length 167mm, height 98 mm, thickness 58 mm (both valves). Imperial Formation, California, Miocene or Pliocene.
2. *Atrina venturensis* (Yates) (p. A80).
   Hypotype CAS 622 (Cooper, 1894, pl. 4, fig. 54). Length 96 mm, height 60 mm, thickness 33 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.
3. *Atrina alamedensis* (Yates) (p. A80).
   Hypotype CAS 5 (× 0.8; Cooper, 1894, pl. 4, fig. 53). Length 128 mm, height 104 mm, thickness 59 mm (both valves). San Pablo(?) Group, California, Miocene.
4. *Atrina bicuneata* (Nomland) (p. A81).
   Holotype UCMP 11307. Length 95 mm, height 42 mm, thickness 18 mm (both valves). Santa Margarita Formation, California, Miocene.



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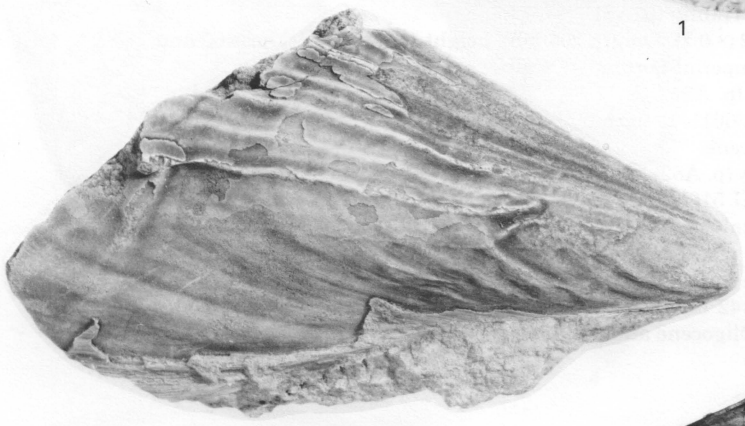

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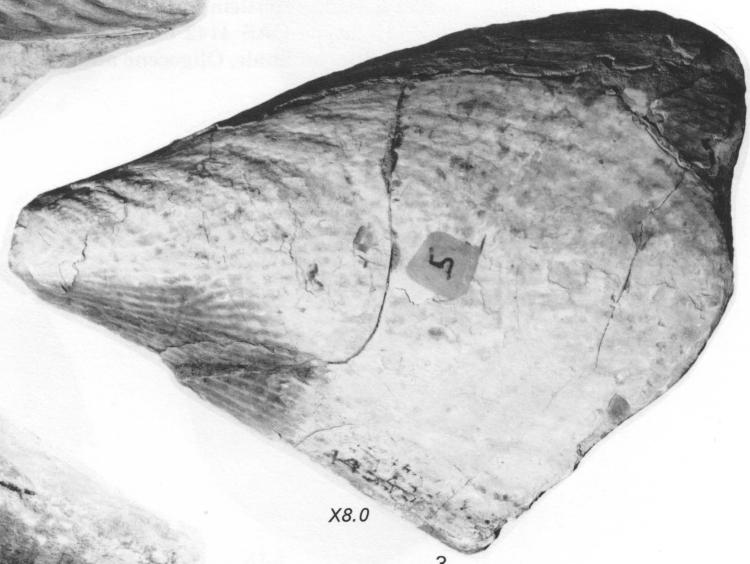


X8.0

3

4

PINNIDAE

PLATE 24

FIGURES

1. *Pteria* sp. Clark and Woodford (p. A82).
   Hypotype UCMP 31321 (× 2.0). Length 23 mm, height 17 mm. Meganos Formation, California, Paleocene.
2. *Pteria howei* Nelson (p. A81).
   Holotype UCMP 30515 (× 2.0). Length 33 mm, height 14 mm. Martinez Formation, California, Paleocene.
3. *Pteria pellucida* (Gabb) (p. A82).
   Lectotype UCMP 11983 (× 1.5). Length 33 mm, height 19 mm. Domengine(?) Formation, California, Eocene.
4. *Atrina stephensi* G D. Hanna (p. A81).
   Holotype SDNM 2 (× 0.5). Length 205 mm, height 111 mm, thickness 60 mm (both valves). Imperial Formation, California, Miocene or Plicoene.
5. *Pteria berryi* Adegoke (p. A82).
   Holotype UCMP 36611. Length 60 mm. Upper part of Temblor Formation, California, Miocene.
6. *Pteria hertleini* Wiedey (p. A82).
   Holotype CAS/SU 5160 (× 0.7). Length 95 mm, height 100 mm, thickness 70 mm (both valves). Vaqueros Formation, California, Oligocene and Miocene.
7. *Pteria rositae* Hertlein (p. A83).
   Holotype CAS 4142 (× 1.5). Length of hinge line 43 mm, height 27 mm. Rincon Shale, Oligocene and Miocene.

PTERIIDAE

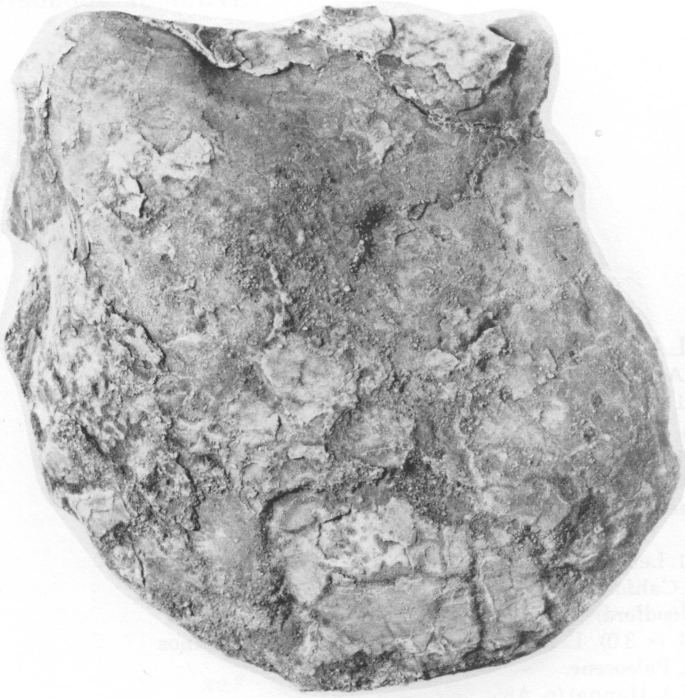
PLATE 25

FIGURES 1. *Pteria jordani* Wiedey (p. A83).
Holotype SDNM 25. Length 95 mm, height 95 mm, thickness 41 mm (both valves). Topanga Formation, California, Miocene.

2. *Pinctada mazatlanica* (Hanley) (p. A83).
Hypotype UCMP 15965 (Durham, 1950, pl. 2, fig. 6). Length 73 mm, height 79 mm, thickness 17 mm (one valve). Unnamed Pleistocene strata, Baja California Sur.

3, 6. *Isognomon (Isognomon) panzana* Loel and Corey (p. A84).
Holotype UCMP 31780. Length 52 mm, height 94 mm, thickness 23 mm (one valve). Vaqueros Formation, California, Oligocene and Miocene.

4, 5. *Isognomon (Isognomon) janus* Carpenter (p. A84).
Hypotype UCMP 30563 (× 2.0). Durham, 1950, pl. 3, fig. 4). Length 22 m. Marquer Formation, Baja California Sur, Pliocene.



1

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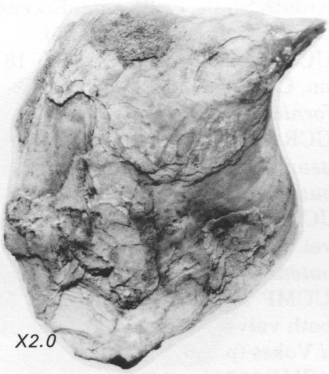


X2.0

4

X2.0

5

6

PTERIIDAE, ISOGNOMONIDAE

PLATE 26

FIGURES 1. *Isognomon* n. sp. Givens (p. A85).
Hypotype UCR 4752/61 (× 0.7). Length 130 mm, height 118 mm. Juncal Formation, California, Eocene.

2, 7. *Pulvinites pacifica* Zinsmeister (p. A86).
2. Hypotype UCMP 30513 (*Pedalion* sp. Nelson, 1925, pl. 49, figs. 8, 9). Length 35 mm, height 35 mm. Martinez Formation, California, Paleocene.
7. Holotype UCR 7342/1. Length 35 mm, height 40 mm. Lower part of Santa Susana Formation, California, Paleocene.

3. *Isognomon* sp. (Clark and Woodford) (p. A84).
Hypotype UCMP 31301 (× 3.0). Length 9 mm, height 12 mm. Meganos Formation, California, Paleocene.

4. *Pachyperna? goniglensis* (M.A. Hanna) (p. A85).
Holotype UCMP 30912 (× 1.5; plaster cast illustrated). Length 25 mm, height 30 mm. Ardath Shale, California, Eocene.

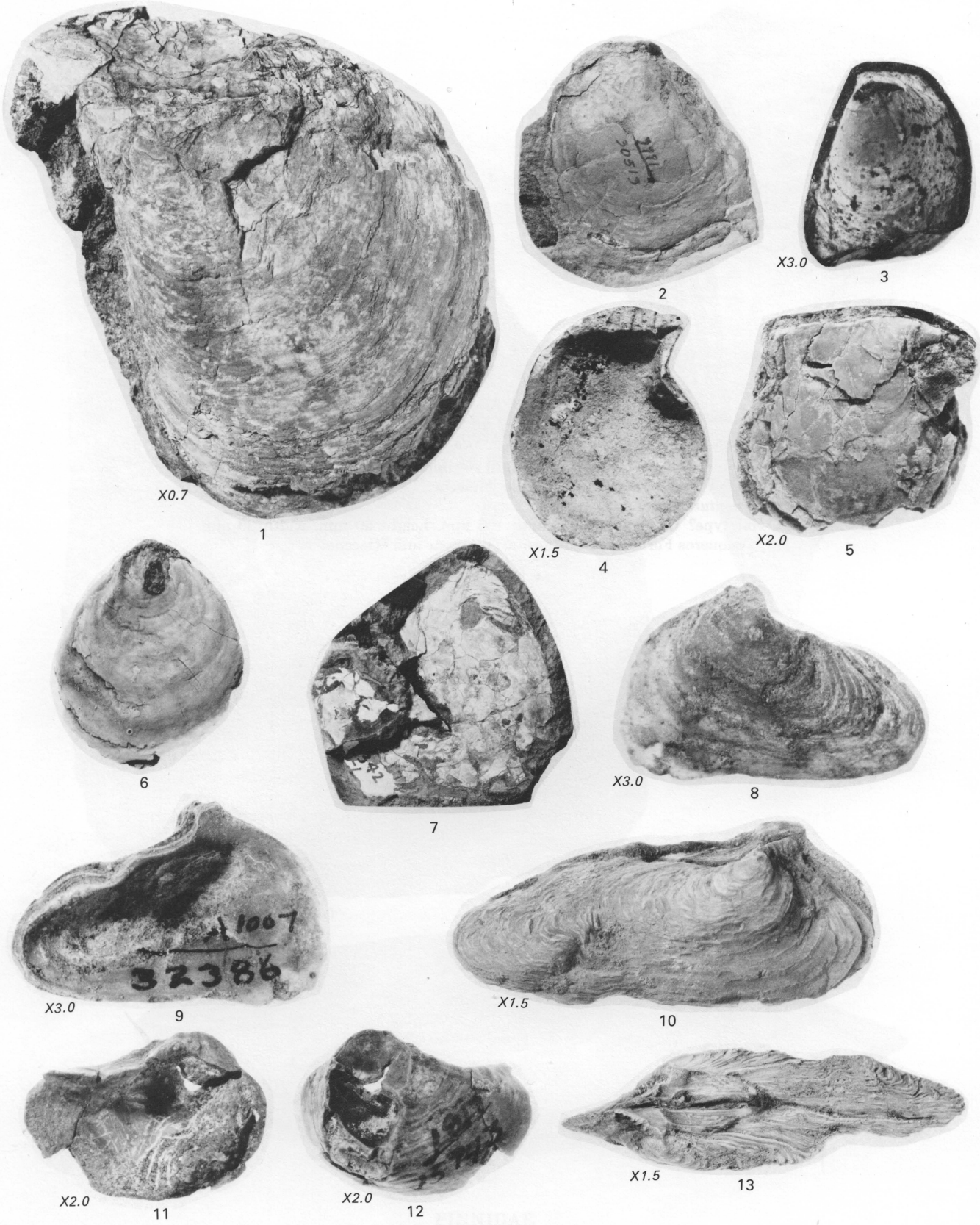
5. *Pachyperna? joaquinensis* (Vokes) (p. A85).
Holotype UCMP 15577 (× 2.0). Length 18 mm, height 20 mm. Domengine Formation, California, Eocene.

6. *Pulvinites californica* Zinsmeister (p. A85).
Holotype UCR 6821/19 (× 2.0). Length 18 mm, height 20 m. Lower part of Santa Susana Formation, California, Paleocene.

8, 9. *Nayadina* (*Exputens*) *alexi* (Clark) (p. A86).
Holotype UCMP 32386 (× 3.0). Length 18 mm, height 13 mm, thickness 5 mm (one valve). Domengine Formation, California, Eocene.

10, 13. *Nayadina* (*Exputens*) *llajasensis* (Clark) (p. A86).
Holotype UCMP 32391 (× 1.5). Length 52 mm, height 26 mm, thickness 15 mm (both valves). Llajas Formation, California, Eocene.

11, 12. *Vulsella? clarki* Vokes (p. A87).
Holotype UCMP 15743 (× 2.0). Length 21 mm, height 17 mm, thickness 7 mm (one valve). Lodo Formation, California, Paleocene and Eocene.



ISOGNOMONIDAE, PULVINITIDAE, MALLEIDAE

PLATE 27

FIGURES 1, 3. *Atrina alamedensis* (Yates) (p. A80).

Holotype? UCSB Y474 (× 0.7). Length 200 mm, height 130 mm, width 56 mm. San Pablo Formation, California, Miocene.

2. *Atrina venturensis* (Yates) (p. A80).

Holotype? UCSB Y3096. Length 106 mm, height 60 mm, width 30 mm. Vaqueros Formation, California, Oligocene and Miocene.

PINNIDAE