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PECTINIDS AND OYSTERS FROM THE PLIOCENE LORETO BASIN (BAJA CALIFORNIA SUR, MEXICO)*

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Key-words: Pectinids, Oysters, Pliocene, Paleontology, Paleoecology, Baja California Sur.

Riassunto. Quattordici specie di Pettinidi ed Ostriche provenienti dal bacino pliocenico di Loreto (Bassa California meridionale, Messico) vengono esaminate in funzione dei loro rapporti con specie affini, della distribuzione stratigrafica e geografica e, infine, del loro significato paleoecologico. Nel complesso l'associazione fossile esaminata sembra indicare una generica età pliocenica. In particolare, due delle specie rinvenute, *Aequipecten dallasi* e *Argopecten abietis abietis*, assumono particolare significato biostratigrafico in quanto sembrano limitare la loro distribuzione al solo Pliocene. La maggior parte delle specie era confinata nelle regioni meridionali durante il Pliocene; *Crassostrea californica osunai* sembra essere stata endemica della Baja California Sur. Pettinidi e Ostriche popolavano fondi di sabbia da fine a grossolana soggetti a correnti o all'ondazione e ubicati nella parte superiore del piano infralitorale; l'energia dell'ambiente era probabilmente il principale fattore limitante. Infine viene dato risalto alla descrizione di una inconsueta associazione a Vermetidi e *Nodipecten*, della quale viene fornita l'interpretazione in chiave paleoecologica.

Abstract. Fourteen pectinid and oyster species from the Pliocene Loreto Basin (Baja California Sur, Mexico) are recorded and discussed with regard to their relationships with closely related taxa. The whole assemblage points toward a Pliocene age. *Aequipecten dallasi* and *Argopecten abietis abietis* resulted to be the most useful biostratigraphic taxa, being restricted to Pliocene. The bulk of the considered species were confined within southern regions during the Pliocene. *Crassostrea californica osunai* is likely to have been endemic of Baja California Sur. Pectinids and oysters appear to have inhabited fine to coarse shallow infralittoral bottoms wave- or current-influenced. The environmental energy was the main factor controlling presence/absence of species. Finally, a unusual vermetid-*Nodipecten* association is described and interpreted in terms of paleoenvironmental meaning.

Introduction.

The present paper examines pectinid and oyster species recovered from the Pliocene succession of the Loreto Basin, Baja California Sur, Mexico. Field work was carried out in 1988 and the fossil material was obtained from stratigraphic sections and

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spot localities (Fig. 1). The study intends to record and discuss species in terms of taxonomic allocation, relationships with other taxa, biostratigraphic and paleoecological meaning.

The extremely rich fossil faunas of the considered basin have so far received little attention. In fact, very few authors have dealt only occasionally with these faunas. Reference is made to Hanna & Hertlein (1927), Durham (1950) and Smith (1991a, b). Relevant information on Pliocene molluscs (including pectinids and oysters) of other areas of Baja California Sur was provided by Arnold (1906), Jordan & Hertlein (1926a, b), Durham (1950), Hertlein & Emerson (1959), Hertlein (1966), Moore (1984, 1987), Smith (1984, 1991a, b), and Quiroz-Barroso & Perrilliat (1989).

The Pliocene lithostratigraphy of Baja California Sur reported on by the authors appears to be rather puzzling. In fact, (1) the "Salada Formation" has worked as a repository for all clastic shallow-water deposits regardless of their age and geographic location, and (2) various units whose reciprocal relations are unclear were established later on in different areas, thus enhancing the confusion. In the following pages we shortly discuss previous lithostratigraphic units and describe those proposed by Zanchi et al. (submitted) for the Loreto Basin and used herein.

The Loreto Basin.

The Loreto Basin is located in the southern part of Baja California Peninsula, just north of the town of Loreto, and stretches along the western escarpment of the Gulf formed by the Sierra de La Giganta. The Cretaceous granitic basement, exposed northwest of Loreto, is overlain by the late Oligocene to middle Miocene volcaniclastic deposits and lava flows currently referred to the Comondù Group (Gastil et al., 1979; McLean, 1988). According to Hausback (1984), the Comondù Formation is restrictively intended herein to include only the products of the Miocene calcalkaline arc. During the transtensional event started at about 4.5 Ma (Zanchi, 1989b, 1993), a marine basin developed north of Loreto between the Sierra de La Giganta and strongly tilted blocks of the Comondù Formation (McLean, 1988; Zanchi, 1989b).

The basin was filled with more than 1000 m of mainly marine sediments. These unconformably overlie the tilted blocks of the Comondù Formation and form two distinct sequences separated by an unconformity (Zanchi, 1989a, 1989b, 1993; Zanchi et al., 1988; Zanchi et al., submitted). Sedimentation in the basin was coeval with the intensive volcanic activity of the Mencenares Volcanic Complex (Bigioggero, 1993, written communication) as indicated by reworked pyroclastics in both sequences and manifest interfingering between volcanics and marine deposits of the upper sequence (Zanchi, 1989b, 1993).

The lithostratigraphic units.

A great part of the Pliocene deposits exposed in the eastern Baja California Peninsula were assigned to the Salada Formation (Touwaide, 1930; Boehm, 1984;

McCloy, 1984). The same unit was regarded by Anderson (1950) as a group to include the San Marcos, Carmen and Marquer Formations. The Salada Formation, originally proposed by Heim (1922) for marine sediments in the western Magdalena Plain, has been recently reconsidered and revised by Smith (1992). The latter author, on the basis of the fossil contents of the type-section and of the radiometric date of a pectinid from

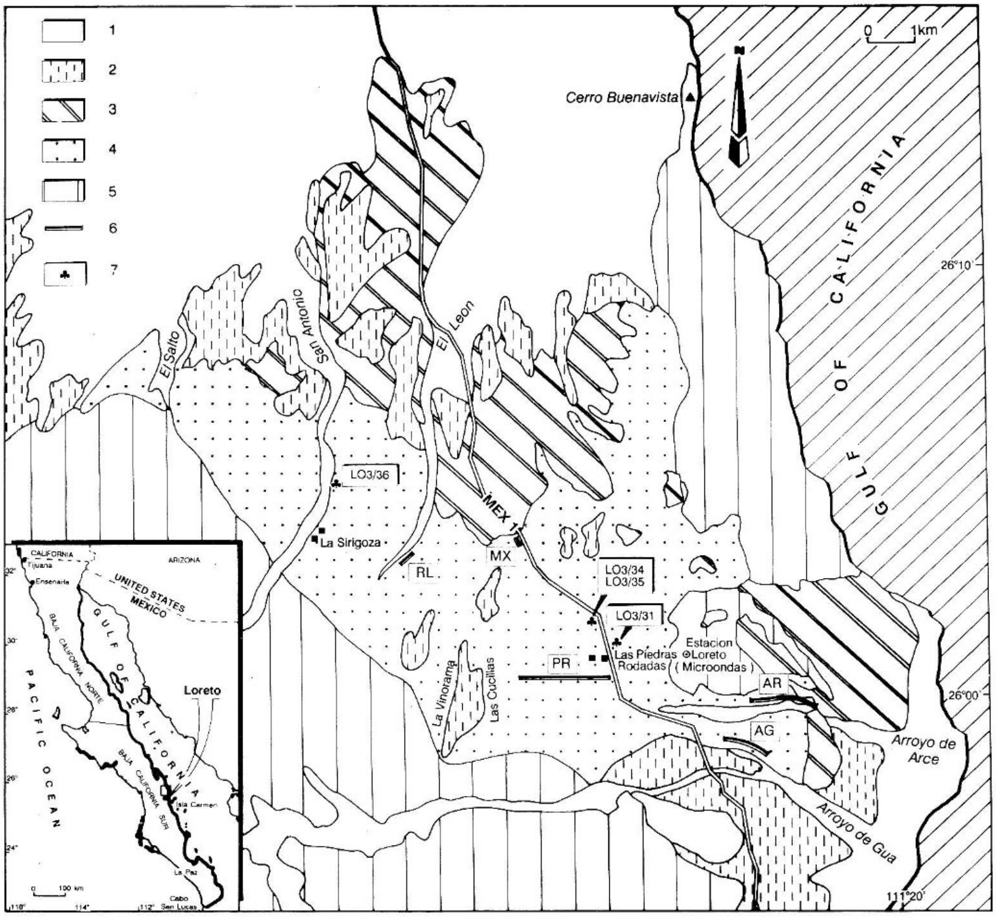


Fig. 1 - Simplified geological map of the study area (based on Zanchi et al., submitted) showing location of stratigraphic sections and spot samples. 1) Recent alluvial deposits; 2) terrace alluvial deposits; 3) Upper Sequence (Arroyo de Arce Sur Limestone, San Antonio Formation, El Troquero Volcanoclastics, San Juan Limestone); 4) Lower Sequence (Cerro Microondas Conglomerate, La Vinorama Conglomerate, Piedras Rodadas Sandstone, Uña de Gato Sandstone, Arroyo de Arce Norte Sandstone); 5) pre-Pliocene rocks (granodiorites, Comondù Group); 6) trace of stratigraphic sections; 7) spot samples (LO3/10 was obtained from Cañada El Atacado, on the southern slope of Mencenares Volcanic Complex, just north of the area depicted in the map). RL) Rancho El Leon Section; MX) Highway (Mexico 1) Section; PR) Rancho Piedras Rodadas Section; AG) Arroyo de Gua Section; AR) Arroyo de Arce Section.

the topmost part, deduced a middle-late Miocene age for the formation. We concur with Smith in considering the name Salada Formation untenable for the Pliocene rocks of the eastern basins and islands in the Gulf of California because of its different age and paleogeographic setting.

The other names used for the Pliocene deposits of the Loreto Basin result to be San Marcos, Carmen and Marquer Formations (Salada Group) which were proposed by Anderson (1950) on the basis of exposures in the Carmen and San Marcos islands, and referred to early, middle and late Pliocene respectively. Anderson stressed the stricking similarity, as regards both lithologies and megafaunas, between these formations and respectively the Boleo, Gloria and Infierno Formations designated by Wilson (1948) some 200 km northward, in the Santa Rosalia Basin. Moreover, he pointed out (p. 12) that "future work in the Gulf islands and Lower California may determine that the formational names of the Salada group used in this paper are unnecessary". Later, Carreño (1982) noted that the name Gloria Formation had been already used for Mesozoic rocks and correctly suggested to substitute it with the name Tirabuzón Formation. Actually, the stratigraphic relations between the units in the Santa Rosalia Basin and those in the Carmen and San Marcos islands are unclear. Moreover, there are problems associated with Anderson's formations which were supposed to overlap one another on the basis of respective age assignment largely relying upon known ranges of pectinid and oyster species (Durham, 1950). As will be shown in the following section, some Durham's statements have proved to be uncorrect. In fact, pectinids and oysters simply suggest a general Pliocene age and do not allow any further detail. In conclusion, previous formational names hardly serve to allocate the lithostratigraphic units noted in the Loreto Basin.

Recent work in the Loreto Basin has led Zanchi et al. (submitted) to set up a quite different, much more detailed lithostratigraphic framework (Fig. 2) which is followed herein. Two sequences separated by a regional unconformity have been distinguished within the basin. The lower sedimentary sequence rests directly on the Comondù Formation with a strong angular unconformity. It consists of debris flow dominated fan-delta deposits evolving laterally and upward into thick fossiliferous sediments of shallow sea environment. The upper sequence contains bioclastic and terrigenous units, and is clearly transgressive along the margin of the basin. A total of 9 lithostratigraphic units have been proposed which are shortly reported on below; for further details reference can be made to the cited authors.

Cerro Microondas Conglomerate. Alluvial fan reddish conglomerate with well rounded pebbles, generally matrix-supported, and with low angle oblique lamination. Discontinuous sandy layers and clast-supported conglomerates (channel lag) are interbedded. The maximum thickness does not exceed 150 m.

La Vinorama Conglomerate. Debris flow grey massive conglomerate, matrix-supported, poorly sorted; metric angular boulders can be observed in the marginal areas of the basin. Coarse bedding, reverse grading and matrix content increase toward the center of the basin. A 2 m-thick bed of withish cineritic tuffite with thin parallel and

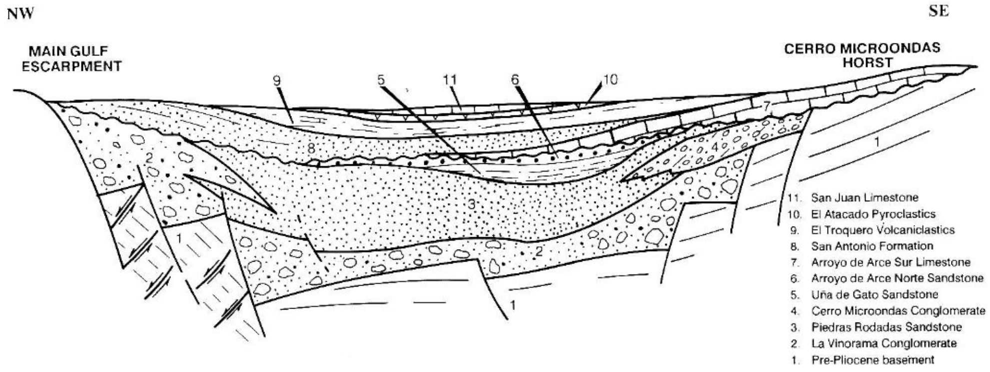


Fig. 2 - Generalized cross-section of the Loreto Basin showing the relationships among lithostratigraphic units (based on Zanchi et al., submitted).

cross lamination occurs at the top of the unit in the Piedras Rodadas area. Maximum exposed thickness is of 300 m.

Piedras Rodadas Sandstone. Inner shelf grey to yellowish-grey massive sand and sandstone, medium to coarse, bioturbated and richly fossiliferous. Lenticular beds of poorly sorted or coarse graded loose conglomerate with erosional base and large scale cross stratification are also observed, linked to a prograding delta. The total thickness is about 400 m.

Uña de Gato Sandstone. Yellowish sandstone and mudstone regularly interbedded. Thin bedded, normally graded and laminated sandstones also occur, generally in lenticular beds. Total thickness averages 60 m.

Arroyo de Arce Norte Sandstone. Inner shelf grey to yellowish-grey well sorted fossiliferous sandstone and subordinate conglomeratic sandstone in lenticular beds with cross bedded metric lamination. Thickness measured along the Mexican Highway 1 is about 60 m.

- Unconformity

Arroyo de Arce Sur Limestone. Yellowish-grey massive bioclastic limestone made of loose, horizontally packed pectinid valves and with largely subordinate bioclastic matrix; topset and foreset conglomerates are interbedded. Maximum thickness exceeds 100 m.

San Antonio Formation. Deltaic massive sandstone beds and alternating conglomerates generally clinostratified and coarse-graded. The exposed thickness is 20 m.

El Troquero Volcaniclastics. Yellow, thin-bedded volcaniclastic siltstone and sandstone with intercalations of bioclastic limestone. The unit also includes yellow siltstone and mudstone with frequent steinkerns of small bivalves, exposed along the southern slope of the Mencenares Volcanic Complex. Maximum thickness 100 m.

San Juan Limestone. Withish coarse-bedded and clinostratified bioclastic limestone; thick lava flows are interbedded in the upper part. The unit interfingers with the El Atacado Pyroclastics.

The sedimentary succession of the Loreto Basin is topped by pyroclastic deposits (El Atacado Pyroclastics) linked to the activity of the Mencenares Volcanic Complex. Fig. 3 depicts the stratigraphic sections measured in the lower sequence and described in detail by Zanchi et al. (submitted).

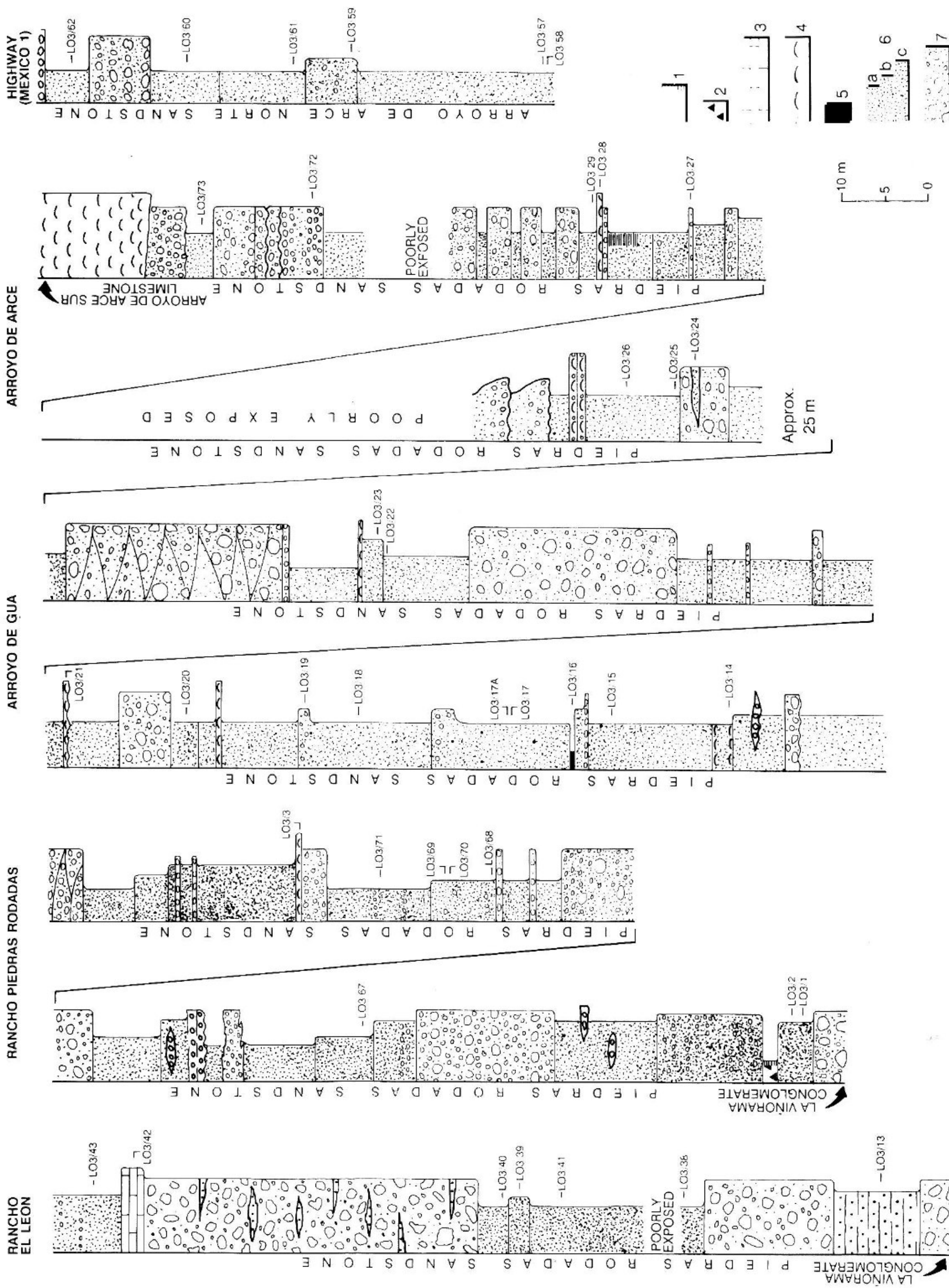
McLean (1988) obtained a K/Ar date of 3.3 Ma for the tuff occurring at the top of La Vinorama Conglomerate in the Piedras Rodadas area. Age-diagnostic microfaunas were recovered only from marly and clayey layers in the upper sequence (El Troquero Volcaniclastics) and from the lower part of El Atacado Pyroclastics. Foraminiferal assemblages including *Pulleniatina obliquiloculata*, *P. primalis*, *P. finalis*, *Globigerinoides obliquus*, *G. extremus*, *G. bollii* point toward a N 21 Zone assignment, i.e. a late Pliocene age not older than 2.5 Ma (Gelati & Valdisturlo, written communication, 1992). The inception of the transtensional event (4.5 Ma) and the date provided by McLean (1988) are obvious constraints as regards the start of deposition in the Loreto Basin. On the basis of these evidences, the whole stratigraphic succession of the Loreto Basin is likely to have deposited during the time span from middle early Pliocene to late Pliocene (mid Zanclean to late Piacenzian). Recurrent lithologies and scarcely reliable age assignments of the formations designed in the Santa Rosalia Basin (Wilson, 1948; Wilson & Rocha, 1955; Carreño, 1981), Carmen and San Marcos islands (Durham, 1950) make conjectural any correlation with the units distinguished in the Loreto Basin.

Biostratigraphic and paleogeographic bearing of species.

Pectinids and oysters occur throughout the sedimentary succession of the Loreto Basin, being particularly abundant in the Piedras Rodadas Sandstone and Arroyo de Arce Sur Limestone. Available information on age ranges of species (Fig. 4) is recorded and discussed below.

Some taxa, i.e. *Argopecten circularis circularis*, *Argopecten circularis aequisulcatus*, *Myrakeena angelica* and *Undulostrea megodon*, are long ranging, being distributed from mid-late Miocene up to Recent, and are of no age-diagnostic value. Durham (1950) reported that *Argopecten circularis*, absent in the San Marcos and Carmen Formation, replaces *Argopecten abietis* in the upper part of the Marquer Formation, thus emphasizing the biostratigraphic value of this event. The author also noted that *Myrakeena angelica* (quoted as *Ostrea vespertina*) is replaced by *Ostrea cumingiana* basically at the same stratigraphic level. According to our records, *Argopecten abietis*, *Argopecten circularis* and *Myrakeena angelica* are present in all the fossil-bearing units, occurring together from the lower Piedras Rodadas Sandstone up to the El Atacado Pyroclastics.

Fig. 3 - Columnar sections in the Piedras Rodadas Sandstone and Arroyo de Arce Norte Sandstone, showing sampled horizons (based on Zanchi et al., submitted). 1) Lamination; 2) cineritic tuffite; 3) limestone; 4) shell layer; 5) mudstone; 6) sand (a: fine, b: medium, c: coarse); 7) conglomerate.


HIGHWAY (MEXICO 1)
ARROYO DE ARCE NORTE SANDSTONE
ARROYO DE ARCE
ARROYO DE ARCE SUR LIMESTONE
PIEDRAS RODADAS SANDSTONE
POORLY EXPOSED
Approx. 25 m
ARROYO DE GUA
RANCHO PIEDRAS RODADAS
LA VIÑORAMA CONGLOMERATE
RANCHO EL LEON
10 m
5
0

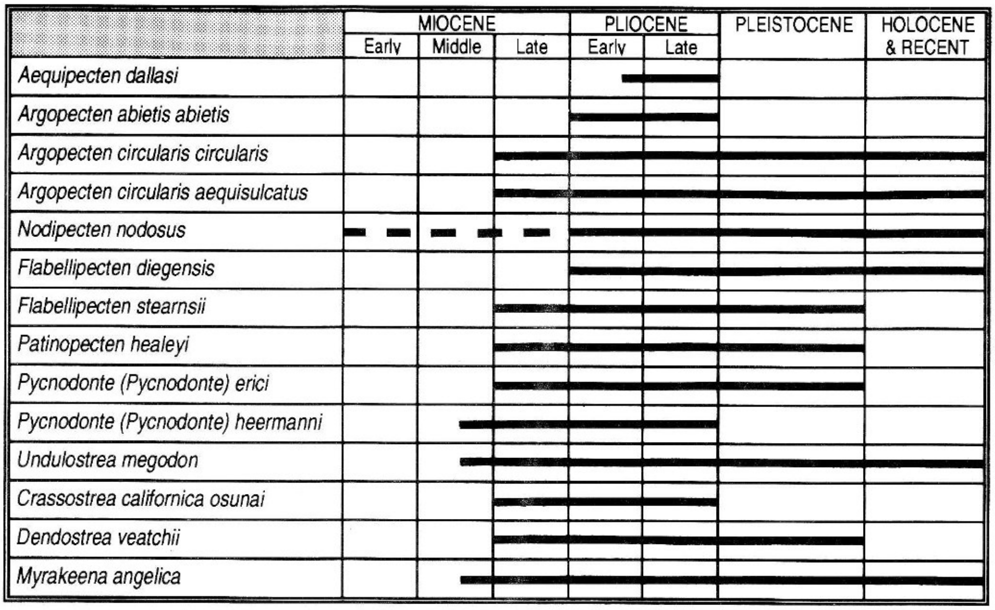


Fig. 4 - Range of species based on reviewed literature data.

Pycnodonte (*Pycnodonte*) *heermanni* and *Crassostrea californica osunai*, already present during the mid-late Miocene, became extinct at the end of the Pliocene. The extant species *Flabellipecten diegensis* results to have appeared in the earliest Pliocene. These taxa together provide evidence for a generic Pliocene assignment.

Argopecten abietis abietis and *Aequipecten dallasi*, which are restricted respectively to Pliocene and mid-late Pliocene, are the most significant forms. The latter species first occurs in the Piedras Rodadas Sandstone, somewhat above the 3.3 Ma tuff. This date (McLean, 1988) may be a constraint as regards the first appearance of *Aequipecten dallasi*. Subsequent records are from the lower sequence only. A similar range was indicated by Durham (1950) and, if proved to be correct, would qualify *Aequipecten dallasi* as a significant biostratigraphic taxon. The apparent absence of *Aequipecten dallasi* in the upper sequence may be due either to the fact that it has reached extinction prior to the end of the Pliocene, or to ecological factors, or simply the matter of less detailed sampling. This is a point to be considered accurately in further investigations.

In summary, the age ranges of species are consistent with the assignment of the whole succession of the Loreto Basin to a time interval spanning from mid Zanclean to the end of Piacenzian.

The following short comments on species zoogeography are based on reliable information from the literature and personal evidence. A note of caution is made here since distributional data may be still scanty, at least in some instances. The distribution patterns of *Nodipecten nodosus* have been thoroughly treated recently by Smith (1991a) and do not need further remarks.

The bulk of the considered pectinids and oysters have a Pliocene distribution restricted to southern regions; only a few were present more northward up to Northern California. *Patinopecten healeyi* is the most widely ranging taxon, its occurrences being from Northern California to Baja California Sur. It was reported to be a cool-temperate element anomalously co-occurring with the warm-water *Nodipecten* in Baja California Sur (Addicott, 1974). *Flabellipecten stearnsii* and *Pycnodonte* (*Pycnodonte*) *erici* were distributed from Middle California southward. A third large group includes tropical and subtropical species never recorded north of Southern California, i.e. *Argopecten circularis circularis*, *Argopecten circularis aequisulcatus*, *Flabellipecten diegensis*, *Pycnodonte* (*Pycnodonte*) *heermanni*, *Undulostrea megodon*, *Dendostrea veatchii* and *Myrakeena angelica*. Finally, *Aequipecten dallasi*, *Argopecten abietis abietis*, *Nodipecten nodosus* and *Crassostrea californica osunai* were restricted to Baja California Sur or also present south of peninsular California. On the basis of data obtained so far, *Crassostrea californica osunai* appears to have been endemic of Baja California Sur.

Argopecten circularis circularis, *Pycnodonte* (*Pycnodonte*) *heermanni*, *Undulostrea megodon* and *Myrakeena angelica* appeared during the middle or late Miocene in Southern and Baja California and did not enlarge significantly their geographic range later on. Instead, *Argopecten circularis aequisulcatus*, *Flabellipecten stearnsii* and *Dendostrea veatchii* apparently originated in Baja California and migrated northward to Southern and/or Middle California, where they are not known prior to the early Pliocene. Likewise, *Patinopecten healeyi* and *Pycnodonte* (*Pycnodonte*) *erici*, already present in the Miocene of both Baja and Southern California, reached Middle and Northern California not earlier than the Pliocene. Northward migration of species was already considered by some workers (cf. Addicott, 1970, 1974). Explanations proposed basically involve the larval transport by inshore current systems.

The tropical and subtropical elements *Argopecten circularis circularis*, *Nodipecten nodosus*, *Undulostrea megodon* and *Myrakeena angelica* shifted their range southward in the Quaternary, in concomitance with the progressive climatic cooling. The contemporary northward expansion of *Flabellipecten diegensis*, from Southern to Northern California, is difficult to explain: local biotic factors may have been responsible for it.

Paleoecological meaning of species.

Species are discussed in terms of their known or inferred ecological requirements, focusing on substrate preference, bathymetric meaning, salinity, and environmental energy. Information on extinct taxa was deduced mainly on the basis of recurrent association with other species and sedimentological evidences.

Aequipecten dallasi. No information does exist on the ecology of this strictly Pliocene species. It was observed to co-occur with *Argopecten abietis abietis* in the Piedras Rodadas Sandstone (Arroyo de Arce Section), in layers bearing well preserved whole shells of both species, and may have the same paleobathymetric meaning of the latter. Moreover, *Aequipecten dallasi* was noted to constitute autochthonous monospecific assemblages occurring at several locations, in fine sandy beds whose sedimentological features point toward a moderate environmental energy.

Argopecten abietis abietis. This byssally-attached form is by far the most common pectinid in the Piedras Rodadas Sandstone, often forming beds entirely made of horizontally-packed loose valves. In several instances, whole shells in living position were noted to form scattered clusters linked to the presence of matrix-supported pebble layers; complete specimens of *Myrakeena angelica* often appear to have settled following the pectinid population. Other autochthonous occurrences are within molluscan associations dominated by infaunal suspension-feeders, and inferred to have inhabited sublittoral bottoms 5-15 m deep (personal data). On the basis of our evidences, *Argopecten abietis abietis* can be regarded as a shallow infralittoral element, related to sandy or coarse substrates swept by bottom currents.

Argopecten circularis circularis. This is an extant subspecies reported to dwell rocky, gravelly, sandy, muddy or mixed substrates, in association with kelp, corallines or gorgonians, at depths of 1-135 m (Waller, 1969). Its nearly constant co-occurrence with *Argopecten abietis abietis* suggests that only the uppermost part of that depth range was available in the Loreto Basin.

Argopecten circularis aequisulcatus. According to Waller (1969), this pectinid occurs "from several inches below the surface at low tide to about 25 fathoms (45 m), possibly deeper, on sand or mud bottoms, often in eel grass beds. It is usually found in bays or lagoons and less commonly in quiet water just offshore". The single valve in hand is abraded and clearly transported in. It was recovered from a sandy layer (Piedras Rodadas Sandstone, Arroyo de Gua Section) where *Argopecten abietis abietis* and *Argopecten circularis circularis* also occur.

Nodipecten nodosus. Smith (1991a) has summarized the behaviour of individual nodipectens; the depth range of *Nodipecten nodosus*, based on specimens collected alive, was reported to be 10-15 m. According to Humfrey (1975), live shells are occasionally trawled at depths of about 45 m in the southern Caribbean. The most confident autochthonous occurrences of the species are from the Piedras Rodadas Sandstone where a vermetid-*Nodipecten* association was sporadically observed to form beds a few decimeters thick. Large shells of *Nodipecten nodosus* lie parallel to bedding planes with the right valve down; the left exposed valve is more or less strongly overgrown by encrusters such as barnacles and worms. *Nodipecten* specimens are embedded in a dense network of vermetid tubes attaining 15 mm in diameter. *Chama* sp. and the shallow inner sublittoral *Dosinia* (*Dosinia*) *ponderosa* are also present in living position. Modern vermetid aggregations and reefs are known to occur at several locations in warm seas. They develop intertidally and/or slightly below low water mark, and the species involved are small-sized forms of the genera *Dendropoma* and *Petaloconchus* (Kay, 1979; Al Barash & Zenziper, 1985; Laborel, 1987). We interpret the vermetid mats as formed somewhat above the upper bathymetric limit of *Nodipecten nodosus*, i.e. at a depth of 2-5 m. In conclusion, Pliocene specimens of *Nodipecten nodosus* were also associated with mat constructing vermetids, in definitely shallow water.

Flabellipecten diegensis. The species is reported to dwell a variety of substrates within a bathymetric range of 10-150 m (Abbott, 1954; Grau, 1959). *Flabellipecten stearnsii* has been regarded as a precursor of the former species and supposed to have the same ecological meaning. The specimens in hand were recovered from layers whose megafauna, on the whole, appeared to have suffered a more or less intensive transport.

Patinopecten healeyi. The ecology has been discussed by Moore (1979) who inferred a depth range of 0-50 m for the Pliocene representatives of this species. Our specimens are from sandy layers that yielded shallow infralittoral molluscan assemblages. *Argopecten abietis abietis* is a common associate. Both sedimentological evidences (cross bedding, ripples) and biofacies point toward a sandy bottom above wave base.

Pycnodonte (*Pycnodonte*) *erici* and *Pycnodonte* (*Pycnodonte*) *heermanni*. These species co-occur in sample LO3/10 (El Atacado Pyroclastics, Cañada El Atacado Section), each being represented by a single specimen. Other associates are *Argopecten abietis abietis*, *Argopecten circularis circularis*, *Flabellipecten stearnsii*, *Myrakeena angelica*, *Dendostrea veatchii*, *Spondylus* sp. Undetermined bivalve and gastropod steinkerns, coral and barnacle remains were also observed. Little can be stated on the basis of the considered Pycnodonteinae except for a generic inference of euhaline waters.

Undulostrea megodon. According to Harry (1985), the species lives in water of normal salinity, from low tide mark to several meters depth. In the Loreto Basin it is apparently uncommon. The two left valves recovered from sample LO3/3 (Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section) are damaged and likely to have been transported into a shallow infralittoral assemblage.

Crassostrea californica osunai. The species was recovered only from sample LO3/24 (Piedras Rodadas Sandstone, Arroyo de Arce Section). Large-sized *Crassostrea* shells occur in living position to form the top of a sandy layer in between two conglomeratic bodies. The oyster build up, some 20 cm-thick, is truncated by the upper conglomerate. We interpret the *Crassostrea* bed as an incipient fringe reef killed by sudden pebble deposition. Fringe reefs commonly develop on shoulders alongside channels in delta and estuary environments (Stenzel, 1971), at depths hardly exceeding 6-7 m. Pertinent examples from western Atlantic and West Pacific oceans are provided respectively by the extant species *Crassostrea virginica* and *Crassostrea gigas*. The *Crassostrea californica osunai* bed would have formed under comparable conditions, and this inference is consistent with the general depositional scenario deduced for the Piedras Rodadas Sandstone, i.e. an inner shelf delta environment. It is of note that the euryhaline genus *Crassostrea* is reported to require high summer temperatures for successful propagation.

Dendostrea veatchii. The species quite possibly has a paleobathymetric meaning similar to that of *Myrakeena angelica* with which, however, it was never observed to co-occur in autochthonous settings.

Myrakeena angelica. This is the most common oyster: occurrences refer to autochthonous shells or transported valves. In the Piedras Rodadas Sandstone, the shells of *Myrakeena angelica* in living position, adhering to pebbles or to one another, were observed to form layers or clusters at the top of sandy beds (samples LO3/14, LO3/68). These beds have yielded a molluscan community dominated by sand-related infaunal suspension-feeders, allowing to infer a quite shallow infralittoral environment (personal data). The species lives in water of marine oceanic salinity, in locations sheltered from strong wave action, at very low tide level and slightly deeper (Harry, 1985). According to Moore (1987), *Myrakeena angelica* ranges from 1 to 5 m in depth, on current influenced bottoms. The two sets of information combined suggest that oysters settled at a depth not exceeding 5 m, in concomitance with marked decreases of the sedimentation rate.

Pectinids and oysters appear to have inhabited fine to coarse shallow infralittoral bottoms, wave- or current-influenced. The energy involved seems to have been the main controlling factor having had a strong impact on the presence/absence of a given species. *Aequipecten dallasi*, *Argopecten abietis abietis*, *Nodipecten nodosus*, *Myrakeena angelica* and *Dendostrea veatchii* result to be the most significant species, useful in reconstructing local paleoenvironments, and deserve further comment. *Aequipecten dallasi* and *Argopecten abietis abietis* may be found together within shallow inner sublittoral molluscan communities. However, large autochthonous populations of these species were never observed to overlap. The sand-related *Aequipecten dallasi* would have preferred relatively sheltered, low energy conditions, being replaced by *Argopecten abietis abietis* in coarser, current-influenced bottoms. Currents were swift enough to remove fine sand and erode the bed, as suggested by scour marks. More or less dense clusters of *Argopecten abietis abietis* commonly succeed to diverse autochthonous communities contained in bioturbated sandy beds, and appear to have settled in concomitance with an increased speed of the current.

As previously said, *Myrakeena angelica* and *Dendostrea veatchii* do not co-occur. Distinct niches are to be considered, connected with different wave exposure. In modern settings, the former species was reported to dwell current-influenced bottoms, relatively sheltered from wave action. Both faunal and sedimentological evidences from the Loreto sedimentary sequence support this habitat preference also as regards the Pliocene specimens. It is of note that *Myrakeena angelica* settlements were often found to immediately overlay layers topped by clusters of the current-related *Argopecten abietis abietis*. *Dendostrea veatchii* seems to have been restricted to more exposed settings, subjected to strong surf. This inference is consistent with the rapid substitution of crowded populations of this species with the vermetid-*Nodipecten* association, observed in some instances. In summary, *Dendostrea veatchii* can be regarded as the exposed counterpart of *Myrakeena angelica*.

Systematic paleontology

The classification scheme adopted is that followed in the Treatise on Invertebrate Paleontology, Part N, v. 1 (1969), v. 3 (1971) modified according to recently proposed changes (cf. Waller, 1978; Harry, 1985).

Abbreviations of repository institutions. ANSP, Academy of Natural Sciences of Philadelphia, PA; BM(NH), British Museum of Natural History, London, U.K.; CAS, California Academy of Sciences, San Francisco, CA; MLU, Museum Ludovicae Ulricae, Uppsala, Sweden; MNHN, Muséum National d'Histoire Naturelle, Paris, France; MPUM, Museo di Paleontologia dell'Università, Milano, Italy; USNM, National Museum of Natural History, Washington, DC.

Phylum **Mollusca**

Class **Bivalvia** Linnaeus, 1758

Subclass **Pteriomorphia** Beurlen, 1944

Order **Pterioida** Newell, 1965

Family *Pectinidae* Rafinesque, 1815

Genus *Aequipecten* Fischer, 1886

Aequipecten dallasi (Jordan & Hertlein, 1926)

Pl. 1, fig. 1-4

1926a *Pecten (Chlamys) dallasi* Jordan & Hertlein, p. 213, pl. 23, fig. 2, 5, 6, 8.
1931 *Pecten (Pecten) dallasi* - Grant & Gale, p. 169.
1950 *Chlamys dallasi* - Durham, p. 65, pl. 6, fig. 2.
1984 *Aequipecten dallasi* - Moore, p. 31, pl. 9, fig. 10, 12.
1989 *Chlamys dallasi* - Quiroz-Barroso & Perrilliat, p. 12, pl. 1, fig. 4; pl. 2, fig. 1.

Holotype. CAS 1862.

Type locality. Cañon 1 or 2 miles from Punta San Antonino, east coast of Baja California Sur (Jordan & Hertlein, 1926a). Presumably Infierno Formation, late Pliocene.

Occurrence. Piedras Rodadas Sandstone: LO3/28, LO3/29, LO3/72; Arroyo de Arce Norte Sandstone: LO3/61. Fifteen mostly well preserved double-valved shells, 31 loose valves, and fragments. MPUM 6934-6937.

Remarks. *Aequipecten dallasi* (Jordan & Hertlein, 1926a) has been thoroughly described by the authors cited in the above references, and does not need any supplementary description. *Chlamys sanctiludovici* (Anderson & Martin, 1914), with which the present species has been compared, differs in having higher shell, wider byssal notch, and distinctly rough riblets. The first two characters support its allocation in the genus *Chlamys* Röding, 1798 even if the sculptural features are reminiscent of *Aequipecten* Fischer, 1886.

Distribution. Mid-late Pliocene, Baja California Sur: Tirabuzón and Infierno Formations; Mexico (Maria Madre Island): Infierno Formation.

Genus *Argopecten* Monterosato, 1889

Argopecten abietis abietis (Jordan & Hertlein, 1926)

Pl. 2, fig. 1-3; Pl. 3, fig. 6

1926a *Pecten (Plagioctenium) abietis* Jordan & Hertlein, p. 214, pl. 23, fig. 1, 3, 7.
1950 *Aequipecten abietis* - Durham, p. 62, pl. 10, fig. 4, 7; pl. 11, fig. 4.
1964 *Chlamys (Argopecten) abietis* - Emerson & Hertlein, p. 349, fig. 4a-e.
1966 *Chlamys (Argopecten) abietis* - Hertlein, p. 278, fig. 15.
1984 *Argopecten abietis abietis* - Moore, p. 41, pl. 11, fig. 2; pl. 12, fig. 3.
1989 *Argopecten abietis* - Quiroz-Barroso & Perrilliat, p. 16, pl. 5, fig. 1, 2; pl. 6, fig. 2, 3.

Holotype. CAS 2079.

Type locality. Loc. CAS 937, Isla Maria Madre, Mexico (Jordan & Hertlein, 1926a), presumably Infierno Formation, late Pliocene.

Occurrence. Piedras Rodadas Sandstone: LO3/2, LO3/3, LO3/13, LO3/14, LO3/17, LO3/17A, LO3/18, LO3/20, LO3/21, LO3/22, LO3/28, LO3/29, LO3/35, LO3/36, LO3/38, LO3/39, LO3/40, LO3/41, LO3/43, LO3/70, LO3/71, LO3/72, LO3/73; Arroyo de Arce Norte Sandstone: LO3/57, LO3/58, LO3/59, LO3/61; El Atacado Pyroclastics: LO3/10, LO3/12. Sixteen double-valved shells, 131 variously preserved loose valves, and fragments. MPUM 6938-6966.

Remarks. The material in hand fits in with the characters of the nominotypical subspecies; a few right valves exhibit a slightly deeper byssal notch somewhat reminiscent of *Argopecten abietis abbotti* (Hertlein & Grant, 1972). This latter subspecies appears to be restricted to southern California, thus occupying the northern part of the geographic range of the species. It is distinguished on the basis of very subtle differences, i.e. deeper byssal notch, more widely spaced ribs, and marked flattening of the ribs toward the ventral margin of the left valve (Moore, 1984).

Argopecten mendenhalli (Arnold, 1906) appears to be a closely related species. Basically, it differs in having distinctly subrounded ribs whereas the present species is sculptured with subtriangular ribs. It is of note that Durham (1950) set out the hypothesis that *Argopecten mendenhalli* and *Argopecten abietis* may be synonym. Actually, the observed difference of the ribbing seems to be a fixed character, enough for keeping the two taxa as distinct.

The Miocene to Recent *Argopecten circularis* (Sowerby) is another relative taxon. As already pointed out by several workers, the flat-topped, steep-sided ribs, separated by comparatively wider interspaces, stand as the most distinctive character. On the basis of our material, we can remark that the dorsal one third of fully grown specimens is less swollen in *Argopecten circularis* than in *Argopecten abietis.*

Waller (1969) described *Argopecten* species *a* from late Miocene of Florida. He stated that".. to what degree *Argopecten* species *a* differs from forms that appear morphologically similar in the Pliocene of the West Coast is unclear..", and cited *Argopecten abietis* as a possible western counterpart. Waller's form differs markedly from *Argopecten abietis* in that has the right valve sculptured with ribs sharply trapezoidal to low and rounded in cross section, and the more convex left one bearing relatively narrow ribs. In case, a comparison could be made with subspecies of *Argopecten circularis.*

Distribution. Pliocene, Baja California Sur: Boleo, Tirabuzón and Infierno Formations; Mexico: Infierno Formation of Islas Tres Marias.

Argopecten circularis circularis (Sowerby, 1835)

Pl. 1, fig. 5-9

1835 *Pecten circularis* Sowerby, p. 110.
1887 *Pecten (Dentipecten) circularis* - Kobelt, p. 188, pl. 51, fig. 5, 8.
1895 *Pecten (Plagioctenium) ventricosus* - Dall, p. 710.
1898 *Pecten compactus* Dall, p. 707, pl. 34, fig. 5.
1903 *Pecten (Plagioctenium) ventricosus* - Arnold, p. 114, pl. 11, fig. 3, 3a, 6, 6a.
1906 *Pecten (Plagioctenium) circularis* - Arnold, p. 125, pl. 42, fig. 3, 6; pl. 44, fig. 6, 7.
1907 *Pecten (Plagioctenium) circularis* - Eldridge & Arnold, pl. 35, fig. 4.
1909 *Chlamys (Aequipecten) ventricosa* - Lamy, p. 213.
1935 *Pecten (Plagioctenium) circularis* - Hertlein, p. 311.
1946 *Pecten (Plagioctenium) circularis* - Hertlein & Strong, p. 57.
1950 *Aequipecten circularis* - Durham, p. 63, pl. 10, fig. 1, 5.
1958 *Aequipecten (Plagioctenium) circularis* - Keen, p. 72, fig. 132.
1959 *Chlamys (Argopecten) circularis* - Grau, p. 97, pl. 32 (see for further synonymy).
1961 *Aequipecten (Plagioctenium) circularis* - Olsson, p. 163, pl. 19, fig. 2-2b.
1969 *Argopecten circularis* - Waller, p. 46, pl. 5, fig. 12.
1971 *Argopecten circularis* - Keen, p. 87, fig. 182.
1972 *Chlamys (Argopecten) circularis* - Hertlein & Grant, p. 197, pl. 32, fig. 4, 15, 16.
1981 *Argopecten circularis* - Eisenberg, p. 159, pl. 141, fig. 1-1c.
1982 *Argopecten circularis* - Abbott & Dance, p. 310, fig. in lower mid row, left.
1984 *Argopecten circularis circularis* - Moore, p. 34, pl. 9, fig. 7, 8 (see for further synonymy).
1989 *Argopecten circularis* - Quiroz-Barroso & Perrilliat, p. 14, pl. 3, fig. 1-4; pl. 8, fig. 3 (see for further synonymy).

Holotype. BM(NH) 1950-11-14.18.19.

Type locality. Guaymas, Mexico, Holocene (Moore, 1984).

Occurrence. Piedras Rodadas Sandstone: LO3/2, LO3/3, LO3/13, LO3/14, LO3/15, LO3/17, LO3/18, LO3/20, LO3/21, LO3/27, LO3/28, LO3/34, LO3/35, LO3/40, LO3/43, LO3/67, LO3/70, LO3/71, LO3/72; Arroyo de Arce Norte Sandstone: LO3/57, LO3/58, LO3/59, LO3/61; El Atacado Pyroclastics: LO3/10. A total of 159 variously preserved loose valves and a few fragments. MPUM 6967-6990.

Remarks. The whole material in hand fits in with the characters of the nominotypical subspecies of *Argopecten circularis* (Sowerby). This taxon has been extensively treated by several workers and does not need any complementary description.

The subspecies *calli* (Hertlein, 1925), *bramkampi* (Durham, 1950), *eldridgei* (Arnold, 1906), and *impostor* (Hanna, 1924) of *Argopecten circularis* have been thoroughly discussed by Moore (1984). Reciprocal relationships and those with the typical form have been reliably pointed out by this author and are agreed upon herein. *Pecten aequisulcatus* Carpenter, 1864 has been currently regarded as a subspecies of *Argopecten circularis*, but some workers dealing with Recent faunas have treated it as a distinct species (Olsson, 1961; Keen, 1971). On the basis of the descriptions and the illustrations given in the literature, it appears that Carpenter's taxon differs from the typical form of *Argopecten circularis* in having comparatively larger and thinner shell, flatter left valve, narrower ribs, and more prominent concentric lamellae. These differences, reported as being constant (Grau, 1959), do not allow any separation but at the subspecies level.

F. & H. Hodson (in Hodson et al., 1927) proposed the new subspecies *Pecten circularis venezuelanus*, based on material from the State of Falcon, Venezuela, and recovered from deposits reported to be of Miocene and Pliocene age (presumably, the late Miocene Cuajarao and Urumaco Formations). The authors noted that the new form is distinguished from Sowerby's taxon by slight differences, i.e. smaller size, narrower umbonal area, and stronger riblets on the anterior auricle. *Pecten circularis venezuelanus* was reconsidered later on only by Woodring (1982) who regarded it as a distinct species, but did not provide any argument to support his decision. He suggested that the Venezuelan form is a "predecessor" of the eastern Pacific *Argopecten circularis*. According to the figures given by the original authors, *Pecten circularis venezuelanus* appears to be exceedingly similar to *Argopecten circularis circularis* and may be a junior synonym of it. However, a final statement in this respect must await the direct examination of the Venezuelan specimens. It is of note that, the synonymy having been proved, *Argopecten circularis circularis* would result to have ranged during late Miocene in both the Atlantic and the eastern Pacific oceans.

We do not concur with Woodring (1982) in considering the Miocene Venezuelan *Pecten circularis cornellanus* F. & H. Hodson (in Hodson et al., 1927) as a younger synonym of *Argopecten levicostatus* (Toula, 1909). According to the figures published by Woodring, Toula's species appears to have the concentric lamellae that parallel those of *Argopecten circularis* (i.e. they are crowded, raised and markedly convex toward the ventral margin across interspaces), thus being much more similar to this latter taxon than to *Pecten circularis cornellanus*. *Pecten circularis cornellanus* exhibits a quite different course of the lamellae which are only gently wavy (cf. Hodson et al., 1927, pl. 16, fig. 3), and can be regarded as a distinct species, possibly related to *Argopecten nucleus* (Born, 1780).

The late Miocene *Pecten circularis caucanus* F. & H. Hodson (in Hodson et al., 1927) appears to be unrelated to *Argopecten circularis*. In fact, the accurate illustration of the holotype shows that secondary riblets are present in the interspaces and on ribs, a character which is never observed in Sowerby's species. In case, a superficial resemblance is to be noted with the North American *Argopecten nicholsi* (Gardner, 1926).

Waller (1969) regarded *Argopecten circularis* as a Pacific member of the *Argopecten gibbus* stock, which diverged from *Argopecten comparilis* (Tuomey & Holmes, 1857) during late Miocene. The author discussed the relationships of Sowerby's species with *Argopecten nucleus* (Born, 1780), *Argopecten gibbus* (Linnaeus, 1758) and *Argopecten eboreus* (Conrad, 1833), and set out the basis to distinguish these taxa from each other. His conclusions are fully agreed upon by the present authors.

Distribution. Late Miocene and earliest Pliocene, Southern California: Towsley Formation; Baja California Sur: Almejas Formation. Pliocene, Southern California: Niguel, Pico and San Diego Formations; Baja California Sur: Tirabuzón and Infierno Formations. Pliocene and Pleistocene, Southern California: Fernando and Saugus Formations. Pleistocene, Southern California: Palos Verdes Sand and Bay Point Formations; Baja California Sur: Santa Rosalia Formation, terrace deposits of Turtle Bay, San Marcos and Coronado Islands, Santa Inès Bay, Sañ Telmo Point. Quotations from Pliocene and Pleistocene deposits of Panama, Ecuador and Peru need to be confirmed; it is not unlikely that they refer to other related species. The modern geographic range of *Argopecten circularis circularis* is from Cedros Island, Baja California Norte to Paita, Peru and the Galapagos Islands (Keen, 1971; Moore, 1984).

Argopecten circularis aequisulcatus (Carpenter, 1864)

Pl. 1, fig. 10

1864 *Pecten ventricosus* var. *aequisulcatus* Carpenter, pp. 536, 540 (*nomen nudum*).
1864 *Pecten aequisulcatus* ? n.s. Carpenter, p. 645.
1906 *Pecten* (*Plagioctenium*) *circularis* var. *aequisulcatus* - Arnold, p. 132, pl. 50, fig. 1-1b; text-fig. 1, 2.
1958 *Pecten* (*Plagioctenium*) *circularis aequisulcatus* - Palmer, p. 71, pl. 3, fig. 1-3.
1959 *Chlamys* (*Argopecten*) *circularis aequisulcata* - Grau, p. 100, pl. 33 (see for further synonymy).
1971 *Argopecten aequisulcatus* - Keen, p. 87, fig. 182a.
1981 *Argopecten circularis aequisulcatus* - Eisenberg, p. 159, pl. 141, fig. 2, 2A.

Syntypes. USNM 15645.
Type locality. San Diego, California, Recent.
Occurrence. Piedras Rodadas Sandstone: LO3/18.. One abraded left valve filled with sediment. MPUM 6991.

Description. Valve thin, evenly convex, obliquely oval in outline, and with the posterior part distinctly more produced than the anterior one. Hinge margin slightly exceeding half shell length. Beak small, pointed, slightly projecting beyond hinge line. Auricles unequal, of comparable length, bearing a few riblets on the lower half and overriding, dense growth lamellae. Anterior margin of the anterior auricle broadly rounded; byssal notch circular, relatively shallow. Posterior margin of the posterior auricle nearly straight, forming an acute angle with the hinge line. Anterodorsal margin very gently concave, shorter than the rectilinear posterodorsal margin. Ventral margin arched, with the maximum curvature placed posteriorly. Disc sculptured with 20 broad, low ribs, subrounded in cross section; intervening furrows are narrow and shallow. Dense and raised concentric lamellae are observable on rib sides and in interspaces; they are strongly convex toward the ventral margin across interspaces. Disc flanks devoid of ribs or with some incipient ones.

Dimensions:

length	height	thickness	height/length	hinge length	apical angle
48 mm	41 mm	12 mm	0.85	22 mm	109°

Remarks. The 20-ribbed left valve in hand conforms to the characters of the subspecies group of *Argopecten circularis* (Sowerby). In fact, the ribs are equally shaped and the crowded concentric lamellae (preserved in a few interspaces) appear to be raised and markedly convex toward the ventral margin. It exhibits the greatest similarity with *Argopecten circularis aequisulcatus* (Carpenter) in being relatively thin, oblique, distinctly longer than high, and in having the ribs less steep-sided than in the typical form. Compared with the shell material figured by the authors in the above references, the present specimen shows a slightly smaller H/L ratio, i.e. 0.85 instead of 0.89-0.96.

Distribution. Late Miocene to earliest Pliocene, Baja California Norte (Cedros Island): Almejas Formation. Pliocene, Southern California: Pico Formation. Pliocene and Pleistocene, Southern California: Fernando Formation. Pleistocene, Southern California: Bay Point Formation, unnamed deposits at Newport Bay. The modern distribution is from Middle California to Cape San Lucas (Baja California Sur); according to Keen (1971), the species ranges in southern Gulf of California as far as La Paz.

Genus *Nodipecten* Dall, 1898

Nodipecten nodosus (Linnaeus, 1758)

Pl. 3, fig. 1; Pl. 5, fig. 1, 2

1758 *Ostrea nodosa* Linnaeus, p. 697, n. 164.
1898 *Pecten (Nodipecten) nodosus* - Dall, p. 728.
1940 *Pecten (Lyropecten) nodosus* - Perry, p. 42, pl. 6, fig. 30.
1954 *Lyropecten (Nodipecten) nodosus* - Abbott, p. 366, pl. 33b.
1961 *Lyropecten (Nodipecten) nodosus* - Warmke & Abbott, p. 169, pl. 4b, 33g.
1964 *Lyropecten (Nodipecten) nodosus* ? - Weisbord, p. 156, pl. 17, fig. 1 (see for further synonymy).
1969 *Chlamys (Nodipecten) nodosa* - Cox, p. N41, fig. 41.
1975 *Lyropecten nodosus* - Humfrey, p. 228, pl. 1, fig. 2; pl. 27, fig. 1.
1978 non *Lyropecten nodosus* - Morris, p. 29, pl. 2, fig. 4.
1981 *Lyropecten nodosus* - Eisenberg, pl. 160, fig. 13.
1982 *Lyropecten nodosus* - Abbott & Dance, p. 309, fig. in lower row, left.
1989 *Nodipecten nodosus* - Quiroz-Barroso & Perrilliat, p. 20, pl. 6, fig. 1; pl. 9, fig. 1 (see for further synonymy).
1991a *Nodipecten nodosus* - Smith, p. 93, pl. 3, fig. 3, 4, 6; pl. 4, fig. 3, 4; pl. 7, fig. 6, 7; pl. 8, fig. 1, 3, 4; pl. 9, fig. 1, 2 (see for further synonymy).

Lectotype. MLU 106 (designated by Smith, 1991a).
Type locality. Southern Caribbean (see Smith, 1991a).
Occurrence. Piedras Rodadas Sandstone: LO3/27, LO3/28, LO3/69, LO3/70. Two double-valved shells, 1 damaged shell, and 10 variously preserved loose valves. MPUM 6992-6995.

Remarks. The present species has been thorougly discussed by Smith (1991a), in terms of variability, phylogenetic affinities and relationships with relative taxa. *Nodipecten subnodosus* (Sowerby, 1835) is the most closely related species, mainly distinguished in having a somewhat longer shell and more bulbous nodes. On the basis of our material and of specimens confidently assigned to these two species, figured in the literature, it seems that fully grown shells of *Nodipecten nodosus* (Linnaeus) constantly have the left valve with one rib less in respect to the right valve (incipient riblets were not considered). The same was not observed to occur in *Nodipecten subnodosus*.

Distribution. Pliocene, Baja California Sur: Boleo, Tirabuzón and Infierno Formations, algal sandstone and *Pecten* beds equivalent of Tirabuzón Formation in Monserrate Island. Pleistocene, Venezuela: Catia Member of the Playa Grande Formation, and from Paraguanà Peninsula, Tortuga and Cubagua Islands; Eastern Antilles, St. Kitts, St. Eustasias; Bowden, Jamaica. Holocene: Baja California Sur, Guadeloupe and northern Venezuela. Quotations from Miocene deposits of Puerto Rico and the Dominican Republic quite possibly refer to other species. The species has a modern distribution in shallow tropical water, being widespread in the Caribbean south of the Greater Antilles, the Virgin Islands, Eastern Antilles, eastern Central America south of the Yucatan Peninsula, eastern Panama to Colombia and Venezuela, and discontinuously as far south as Rio de Janeiro, Brazil (Smith, 1991a). According to Abbott (1954) and Abbott & Dance (1982), it occurs also from North Carolina to Florida and in coastal waters of Ascension Island.

Genus *Flabellipecten* Sacco, 1897

Flabellipecten diegensis (Dall, 1898)

Pl. 3, fig. 2, 3

1898 *Pecten (Pecten) diegensis* Dall, p. 710.
1903 *Pecten (Pecten) diegensis* - Arnold, p. 10, pl. 12, fig. 5.
1906 *Pecten (Pecten) diegensis* - Arnold, p. 127, pl. 51, fig. 1-1b.
1931 *Pecten (Janira) stearnsii* var. *diegensis* - Grant & Gale, p. 302, pl. 19, fig. 5, 6.
1935 *Pecten (Pecten) diegensis* - Hertlein, p. 302, pl. 19, fig. 5, 6.
1946 *Pecten (Pecten) diegensis* - Hertlein & Strong, p. 56.
1954 *Pecten diegensis* - Abbott, p. 361, pl. 33e.
1959 *Pecten diegensis* - Grau, p. 143, pl. 52-53 (see for further synonymy).
1982 *Pecten diegensis* - Abbott & Dance, p. 305, fig. in lower middle row, right.
1984 *Flabellipecten diegensis* - Moore, p. 73, pl. 31, fig. 2; pl. 32, fig. 4 (see for further synonymy).

Holotype. BM (NH) 79.2.26.241 (fide Moore, 1984).
Type locality. San Diego, San Diego County, California, Holocene (Moore, 1984).
Occurrence. Piedras Rodadas Sandstone: LO3/3, LO3/67, LO3/72; Arroyo de Arce Norte Sandstone: LO3/59. Two well preserved valves, 1 damaged valve, and fragments. MPUM 6996-6999.

Remarks. The relationships with the related species *Flabellipecten stearnsii* (Dall, 1878) have been already dealt with by Moore (1984) with which we concur.

Distribution. Pliocene, Southern California: Santa Barbara Formation. Pleistocene, Southern California: unnamed deposits at Newport Bay; Baja California Norte: unnamed deposits. The species ranges today from northern California to Guadalupe Island and as far south as Cape San Lucas, Baja California.

Flabellipecten stearnsii (Dall, 1878)

Pl. 3, fig. 4, 5

1878 *Pecten stearnsii* Dall, p. 11, 14.
1898 *Pecten (Pecten) stearnsii* - Dall, p. 706, pl. 26, fig. 5.
1903 *Pecten (Pecten) stearnsii* - Arnold, p. 106, pl. 12, fig. 3.
1906 *Pecten (Pecten) stearnsii* - Arnold, p. 100, pl. 32, fig. 1, 1a.
1907 *Pecten (Pecten) stearnsii* - Eldridge & Arnold, p. 152, pl. 35, fig. 2; pl. 36, fig. 4.
1931 *Pecten (Janira) stearnsii* var. *stearnsii* - Grant & Gale, p. 223, pl. 3, fig. 2a, b.
1946 *Pecten stearnsii* - Woodring et al., p. 80, pl. 30, fig. 9, 11; pl. 32, fig. 14, 15.
1972 *Pecten (Flabellipecten) stearnsii* - Hertlein & Grant, p. 178, pl. 29, fig. 2, 4; pl. 35, fig. 10; text fig. 8.
1984 *Flabellipecten stearnsii* - Moore, p. 72, pl. 31, fig. 7, 8 (see for further synonymy).
non 1989 *Flabellipecten stearnsii* - Quiroz-Barroso & Perrilliat, p. 23, pl. 10, fig. 5, 6; pl. 11, fig. 1.

Holotype. USNM 7942.

Type locality. Well at San Diego, San Diego County, California, San Diego Formation, Pliocene (Moore, 1984).

Occurrence. Piedras Rodadas Sandstone: LO3/3, LO3/26, LO3/71; Arroyo de Arce Norte Sandstone: LO3/57, LO3/58, LO3/59, LO3/61, LO3/62; El Atacado Pyroclastics: LO3/10. Eight whole valves, 18 more or less damaged valves. MPUM 7000-7008.

Remarks. The Pliocene specimens recovered from Tirabuzón and Infierno Formations of Baja California Sur, figured by Quiroz-Barroso & Perrilliat (1989) and referred to as *Flabellipecten stearnsii* (Dall), do not agree satisfactorily with the characters of Dall's species. In fact, the right valve bears 22 ribs instead of 23-26. Moreover, the ribs appear to be differently shaped, particularly if compared with those of the holotype of *Flabellipecten stearnsii.* These specimens exhibit stronger affinities with *Flabellipecten diegensis* (Dall) and may well represent an intermediate form between *Flabellipecten stearnsii* and *Flabellipecten diegensis.*

Distribution. Late Miocene and earliest Pliocene, Baja California: Almejas Formation. Pliocene, Middle California: Purisima Formation; Southern California: Niguel and San Diego Formations; Mexico (Maria Madre Island): Infierno Formation. Pliocene and Pleistocene, Middle California: Merced Formation; Southern California: Fernando Formation. Pleistocene, Southern California: Lomita Marl and Timms Point Silt Members of the San Pedro Formation.

Genus *Patinopecten* Dall, 1898

Patinopecten healeyi (Arnold, 1906)

Pl. 4, fig. 1, 2

1878 *Pecten expansus* Dall, p. 14.
1898 *Pecten (Patinopecten) expansus* - Dall, p. 706, pl. 26, fig. 1.
1903 *Pecten (Patinopecten) expansus* - Arnold, p. 108.
1906 *Pecten (Patinopecten) healeyi* Arnold, p. 103, pl. 36, fig. 1, 1A; pl. 37, fig. 1, 2.
1931 *Pecten (Patinopecten) healeyi* - Grant & Gale, p. 196, pl. 6, fig. 2a,b.
1972 *Pecten (Patinopecten) healeyi* - Hertlein & Grant, p. 183, pl. 31, fig. 1, 4, 6, 7; pl. 33, fig. 9; pl. 36, fig. 8, 9; text fig. 9.
1979 *Patinopecten healeyi* - Moore, p. 2, pl. 1-15.
1984 *Patinopecten healeyi* - Moore, p. 81, pl. 34, fig. 3; pl. 35, fig. 3; pl. 36, fig. 4; pl. 37, fig. 3; pl. 38, fig. 2-5; pl. 39, fig. 1; pl. 40, fig. 5; pl. 41, fig. 2; pl. 42, fig. 1-3 (see for further synonymy).

Holotype. USNM 148012.

Type locality. San Diego, San Diego County, California, San Diego Formation, Pliocene (Moore, 1984).

Occurrence. Piedras Rodadas Sandstone: LO3/27, LO3/71, LO3/72; Arroyo de Arce Norte Sandstone: LO3/57, LO3/58. Five whole valves, 5 more or less damaged valves, and fragments. MPUM 7009-7013.

Remarks. The species has been treated in detail by Moore (1979, 1984) and does not need further comments.

Distribution. Late Miocene and earliest Pliocene, Southern California: Capistrano Formation; Baja California Sur: Almejas Formation. Pliocene, Northern California: Eureka and Cape Mendocino areas, Falor Formation; Middle California: Purisima Formation; Southern California: Pico, Etchegoin, Foxen, Careaga, Niguel, San Diego and San Joaquin Formations, and unnamed strata of San Clemente Island. Pliocene and Pleistocene, Middle California: Merced Formation; Southern California: Fernando and Saugus Formations. Pleistocene, Southern California: basal las Posas Formation.

Family *Gryphaeidae* Vyalov, 1936

Subfamily *Pycnodonteinae* Stenzel, 1959

Genus *Pycnodonte* Fischer de Waldheim, 1835

Subgenus *Pycnodonte* Fischer de Waldheim, 1835

Pycnodonte (Pycnodonte) erici (Hertlein, 1929)

Pl. 4, fig. 3

1929 *Ostrea erici* Hertlein, p. 295.
1950 *Ostrea erici* - Durham, p. 59, pl. 4, fig. 2.
1972 *Ostrea erici* - Hertlein & Grant, p. 217, pl. 38, fig. 4, 6, 8, 9.
1987 *Pycnodonte (Pycnodonte) erici* - Moore, p. 19, pl. 12, fig. 1, 4, 7, 8 (see for further synonymy).

Holotype. CAS 2094.

Type locality. Laguna Scammon, Baja California Sur, Almejas Formation, late Miocene and earliest Pliocene (Moore, 1987).

Occurrence. El Atacado Pyroclastics: LO3/10. One damaged left valve. MPUM 7014.

Distribution. Late Miocene and earliest Pliocene, Baja California Sur: Almejas Formation. Miocene and Pliocene, Southern California: Sisquoc Formation. Pliocene, Middle California: Purisima Formation; Southern California: Niguel, Careaga Formations and Foxen Mudstone; Baja California Sur: Boleo and Tirabuzón Formations. Pliocene and Pleistocene, Southern California: Fernando Formation.

Pycnodonte (Pycnodonte) heermanni (Conrad, 1855)

Pl. 5, fig. 3

1855 *Ostrea heermanni* Conrad, p. 267.
1987 *Pycnodonte? (Pycnodonte?) heermanni* - Moore, p. 21, pl. 13, fig. 1, 4, 6, 7; pl. 14, fig. 4; pl. 16, fig. 4; pl. 17, fig. 6, 7.

Holotype. ANSP 13367 (Woodring, 1938).
Type locality. Colorado Desert, Imperial County, Southern California, Imperial Formation (Moore, 1987), late Miocene.
Occurrence. El Atacado Pyroclastics: LO3/10. One heavily abraded left valve. MPUM 7015.

Remarks. The poorly preserved left valve in hand fits in with the characters of *Ostrea heermanni* Conrad. In fact, it is subcircular in outline, thick, has a short hinge line and a definitely shallow body cavity. The quite evident vesicular shell structure points toward the pycnodonteine, and the bulk of the features suggests the allocation within the nominotypical subgenus of the genus *Pycnodonte* Fischer de Waldheim, 1835. The Oligo-Miocene *Ostrea loeli* Hertlein, 1928 is a strictly related species, differing mainly in that has a quadrate shell with a longer hinge line.

Distribution. Late middle Miocene to Pliocene, Southern California: Imperial Formation. Late Miocene and earliest Pliocene, Baja California Sur: Almejas Formation. Pliocene, Baja California Norte: unnamed strata at San Felipe; Baja California Sur: presumably Infierno Formation.

Family *Ostreidae* Rafinesque, 1815
Subfamily *Ostreinae* Rafinesque, 1815
Genus *Undulostrea* Harry, 1985

Undulostrea megodon (Hanley, 1845)

Pl. 4, fig. 4

1845 *Ostrea megodon* Hanley, p. 106.
1866 *Ostrea cerrosensis* Gabb, p. 35, pl. 11, fig. 61.
1895 *Ostrea megodon* - Dall, p. 685.
1926b *Ostrea megodon* - Jordan & Hertlein, p. 427, pl. 28, fig. 1.
1929 *Ostrea megodon* - Anderson, p. 154.
1946 *Ostrea megodon* - Hertlein & Strong, p. 55.
1950 *Ostrea megodon* - Durham, p. 59, pl. 5, fig. 3.
1958 *Ostrea (Lopha) megodon* - Keen, p. 66, fig. 123.
1961 *Ostrea (Alectryonia) megodon* - Olsson, p. 172, pl. 23, fig. 3, 3a (see for further synonymy).
1964 *Ostrea (Alectryonia) megodon* - Olsson, p. 39, pl. 1, fig. 1-1b.
1971 *Ostrea (Lopha) megodon* - Keen, p. 84, fig. 173.
1972 *Ostrea (Agerostrea) megodon* - Hertlein & Grant, p. 221, pl. 38, fig. 1, 5, 7.
1984 *Ostrea (Agerostrea) megodon* - Smith, p. 206, pl. 4, fig. 1, 2.
1985 *Undulostrea megodon* - Harry, p. 147, fig. 26.
1987 *Ostreola? megodon* - Moore, p. 29, pl. 32, fig. 2, 5; pl. 34, fig. 1, 3, 6, 8 (see for further synonymy).

Holotype. BM(NH).
Type locality. Peru (Hanley, 1845).
Occurrence. Piedras Rodadas Sandstone: LO3/3. Two left valves. MPUM 7016.

Remarks. *Ostrea megodon* Hanley is the type of the genus *Undulostrea* Harry, 1985 by original designation. This monotypical genus was erected to allocate falcate oyster shells having ostreine chomata and large undulations developed along the anteroventral margin.

The Ecuadorian Neogene specimens figured by Olsson (1964) and referred to as *Ostrea (Alectryonia) megodon* Hanley, appear to be exceedingly similar to the Pliocene to Recent individuals of that species, recovered from California. In the opinion of the present authors, there is no way to distinguish them.

The Caribbean Neogene *Ostrea messor* Maury, 1925 is a strictly related species which exhibits only very subtle differences. We concur with Olsson (1964) who stated that a sharp separation between these forms is questionable. *Ostrea (Agerostrea?) antecursor* Weisbord, 1964 described from Pleistocene deposits of Venezuela, is related too. It differs in having the radial folds arising near the umbo, whereas in *Undulostrea megodon* they develop close to the valve margin.

Distribution. Late middle Miocene to Pliocene, Southern California: Imperial Formation. Late Miocene and earliest Pliocene, Baja California Sur: Almejas Formation; Ecuador: Esmeraldas Formation. Pliocene, Southern California: San Diego Formation; Baja California Sur: Boleo and Tirabuzón Formations; Mexico (Maria Madre Island): Infierno Formation; Panama: Burica Peninsula. Pleistocene, Southern California: Lomita Marl Member of San Pedro Formation, unnamed strata at Newport Bay; Baja California Norte: unnamed deposits. The species has a modern distribution from Baja California Sur to Peru (Olsson, 1961; Keen, 1971).

Genus *Crassostrea* Sacco, 1897

Crassostrea californica osunai (Hertlein, 1966)

Pl. 4, fig. 5

1966 *Ostrea californica osunai* Hertlein, p. 272, fig. 2-6, 8, 9.
1987 *Crassostrea? californica osunai* - Moore, p. 40, pl. 27, fig. 2.

Holotype. CAS 12823.

Type locality. Loc. CAS 38855, southwest end of Punta Concepcion, Baja California Sur, layers formerly included in the Salada Formation, Pliocene (Moore, 1987).

Occurrence. Piedras Rodadas Sandstone: LO3/24. One demaged double-valved shell, and fragments. MPUM 7017.

Remarks. The present taxon has an exceedingly high ligamental area reminiscent of *Striostrea* Vyalov, 1936. However, all the other features fully match the diagnostic characters of *Crassostrea* Sacco, 1897. *Crassostrea californica osunai* (Hertlein) seems to be the largest *Crassostrea* hitherto recovered from Miocene to Recent deposits of the Californias.

Distribution. Late Miocene and early Pliocene, Baja California Sur: Trinidad Formation. Pliocene, Baja California Sur: Punta Concepcion.

Subfamily *Lophinae* Vyalov, 1936

Genus *Dendostrea* Swainson, 1835

Dendostrea veatchii (Gabb, 1866)

Pl. 4, fig. 6

1866 *Ostrea veatchii* Gabb, p. 34, pl. 11, fig. 59.
1972 *Ostrea veatchii* - Hertlein & Grant, p. 219, pl. 39, fig. 4; pl. 40, fig. 1, 4-6.
1984 "*Ostrea*" *veatchii* - Smith, p. 206, pl. 4, fig. 6.
1987 *Lopha? ("Lopha") veatchii* - Moore, p. 24, pl. 17, fig. 1-5 (see for further synonymy).

Holotype. ANSP 4502.

Type locality. Cedros Island, Baja California Norte, Almejas Formation, late Miocene and earliest Pliocene (Moore, 1987).

Occurrence. Piedras Rodadas Sandstone: LO3/14, LO3/20 LO3/69; El Atacado Pyroclastics: LO3/10. One double-valved shell and 3 right valves in a fair state of preservation. MPUM 7018-7021.

Remarks. *Ostrea veatchii* Gabb has sculptural features of both the pycnodonteine genus *Hyotissa* Stenzel, 1971 and the Lophinae. However, the absence of vesicular shell structure and of vermiculate chomata is against a pycnodonteine allocation. The relatively numerous radial plicae (9 or 10) devoid of pustules and the ostreine chomata strongly favor the assignment to the lophine genus *Dendostrea* Swainson, 1835 as recently revised by Harry (1985).

Distribution. Late Miocene and earliest Pliocene, Baja California Sur: Almejas Formation. Pliocene, Southern California: Pico, Niguel and San Diego Formations; Baja California Norte: Cantil Costero Formation; Baja California Sur: Boleo, Tirabuzón and Infierno Formations; Mexico (Isla Tres Marias): Infierno Formation. Pliocene and Pleistocene, Southern California: Fernando and Saugus Formations.

Genus *Myrakeena* Harry, 1985

Myrakeena angelica (Rochebrune, 1895)

Pl. 5, fig. 4, 5

1895 *Ostrea angelica* Rochebrune, p. 241.
1950 *Ostrea vespertina* - Durham, p. 59, pl. 5, fig. 1, 2, 5, 7.
1958 *Ostrea angelica* - Keen, p. 65, fig. 117.
1964 *Ostrea angelica* - Emerson & Hertlein, p. 353, fig. 3a-c.
1971 *Ostrea angelica* - Keen, p. 82, fig. 167.
1972 *Ostrea angelica* - Hertlein & Grant, p. 216, pl. 38, fig. 2, 3.
1985 *Myrakeena angelica* - Harry, p. 138, fig. 19.
1987 *Dendostrea? angelica* - Moore, p. 26, pl. 32, fig. 1, 8, 9; pl. 34, fig. 7, 9, 10 (non fig. 2: *Ostrea cumingiana* Dunker of Durham, 1950).

Holotype. MNHN (according to Moore, 1987).

Type locality. Bahia de Los Angeles, Baja California Sur, Holocene (Moore, 1987).

Occurrence. Piedras Rodadas Sandstone: LO3/14, LO3/13, LO3/25, LO3/31, LO3/39, LO3/42, LO3/68; Arroyo de Arce Norte Sandstone: LO3/59, LO3/61; El Atacado Pyroclastics: LO3/10. The material consists of 3 double-valved shells and 36 loose valves. MPUM 7022-7031. All features are observable except for minute details hindered by bioerosion and/or abrasion.

Remarks. Harry (1985) based the new genus *Myrakeena* on *Ostrea angelica* Rochebrune which is the type by monotypy. Moore (1987) listed in the synonymy of the present species the Plio-Pleistocene specimens from Baja California figured by Durham (1950) and referred to as *Ostrea cumingiana* Dunker, 1846. On the basis of the figure given by Durham (pl. 5, fig. 6), those shells appear to have vermiculate chomata, a well developed commissural shelf, and nearly straight margins. These characters seem to be consistent with a pycnodonteine more than with a lophine assignment.

Myrakeena angelica differs from *Dendostrea veatchii* (Gabb) basically in having a thicker shell, less numerous and more raised radial folds which are completely devoid of hyotal spines.

Distribution. Late middle Miocene to Pliocene, Southern California: Imperial Formation. Late Miocene and earliest Pliocene, Baja California Sur: Almejas Formation. Pliocene, Southern California: San Diego Formation; Baja California Sur: Boleo, Tirabuzón and Infierno Formations. Pleistocene, Southern California: Bay Point Formation; Baja California Sur: unnamed deposits at Turtle Bay; Mexico: unnamed strata. The species has a modern distribution that seems to be restricted to the Gulf of California (Harry, 1985).

Locality data.

(Loreto quadrangle, 1:50,000, G12A88)

LO3/10. West side of Cañada El Atacado 1.8 km southeast of Cerro San Juan, elevation 180 m. Grey sandstone, upper El Atacado Pyroclastics.

LO3/12. Same location as LO3/10, elevation 200 m. Grey sandstone, uppermost El Atacado Pyroclastics.

LO3/31. Mouth of unnamed cañada opposite of Rancho Las Piedras Rodadas, 250 m east of Mexico Highway 1. Grey sandy marl overlying matrix-supported conglomerate, lowermost Piedras Rodadas Sandstone.

LO3/34. Road cut on west side of big bend in Mexican Highway 1, 1.1 km north of Rancho Las Piedras Rodadas. Grey sandy marl forming a 3 m thick bed with abundant bivalves in living position, basal Piedras Rodadas Sandstone.

LO3/35. Same location as LO3/34. Conglomeratic bed 0.30 m thick that overlies the sandy marl, basal Piedras Rodadas Sandstone.

LO3/36. East side of Arroyo San Antonio approximately halfway between San Antonio and La Sirigoza, 1.5 km north of the latter locality. Grey sand bearing abundant bivalves in living position, basal Piedras Rodadas Sandstone.

Rancho El Leon Section (RL). East side of Arroyo El Leon, at Rancho El Leon. Basal Piedras Rodadas Sandstone.

Highway Section (MX). Road cut on Mexican Highway 1, 3.8 km north of Rancho Piedras Rodadas and 1 km southwest of Rancho Uña de Gato (abandoned), between 160 m and 180 m contour. Arroyo de Arce Norte Sandstone.

Piedras Rodadas Section (PR). Eastern slope of Las Cuchillas between south side of Rancho Piedras Rodadas and elevation 230 m. Piedras Rodadas Sandstone.

Arroyo de Gua Section (AG). North side of Arroyo de Gua between point 200 m east of Vado on Mexican Highway 1 and cliff at 100 m contour about 1250 m downstream. Lower Piedras Rodadas Sandstone.

Arroyo de Arce Section (AR). North side of arroyo de Arce between point (elevation 70 m) 1.5 km east of junction of the arroyo with road to Estacion Loreto Microondas and the cliffs constricting the arroyo before the coastal plain. Upper Piedras Rodadas Sandstone.

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PLATE 1

Fig. 1 - *Aequipecten dallasi* (Jordan & Hertlein, 1926). Left valve, length 45 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/72. MPUM 6936/1.

Fig. 2 - *Aequipecten dallasi* (Jordan & Hertlein, 1926). Right valve, length 46 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/72. MPUM 6936/2.

Fig. 3 - *Aequipecten dallasi* (Jordan & Hertlein, 1926). Left valve, length 37 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/29. MPUM 6935/1.

Fig. 4 - *Aequipecten dallasi* (Jordan & Hertlein, 1926). Right valve, length 36 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/29. MPUM 6935/2.

Fig. 5 - *Argopecten circularis circularis* (Sowerby, 1835). Right valve, length 25 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/70. MPUM 6983/1.

Fig. 6 - *Argopecten circularis circularis* (Sowerby, 1835). Right valve, length 30 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/59. MPUM 6988/1.

Fig. 7 - *Argopecten circularis circularis* (Sowerby, 1835). Right valve, length 30 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/59. MPUM 6988/2.

Fig. 8 - *Argopecten circularis circularis* (Sowerby, 1835). Right valve, length 34 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/59. MPUM 6988/3.

Fig. 9 - *Argopecten circularis circularis* (Sowerby, 1835). Left valve, length 29 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/59. MPUM 6988/4.

Fig. 10 - *Argopecten circularis aequisulcatus* (Carpenter, 1864). Left valve, length 48 mm. Piedras Rodadas Sandstone, Arroyo de Gua Section, LO3/18. MPUM 6991.

PLATE 2

Fig. 1 - *Argopecten abietis abietis* (Jordan & Hertlein, 1926). a) Right valve, b) left valve of the same specimen; length 83 mm. Piedras Rodadas Sandstone, Arroyo de Gua Section, LO3/18. MPUM 6944/1.

Fig. 2 - *Argopecten abietis abietis* (Jordan & Hertlein, 1926). Left valve, length 66 mm. Piedras Rodadas Sandstone, Arroyo de Gua Section, LO3/22. MPUM 6947/1. Scale bar = 10 mm.

Fig. 3 - *Argopecten abietis abietis* (Jordan & Hertlein, 1926). Right valve, length 119 mm. Piedras Rodadas Sandstone, Rancho El Leon Section, LO3/41. MPUM 6955/1. Scale bar = 10 mm.

PLATE 3

Fig. 1 - *Nodipecten nodosus* (Linnaeus, 1758). a) Right valve, b) left valve of the same specimen; length 115 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/28. MPUM 6993/1.

Fig. 2 - *Flabellipecten diegensis* (Dall, 1898). Right valve, length 119 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/67. MPUM 6997/1.

Fig. 3 - *Flabellipecten diegensis* (Dall, 1898). Left valve, length 37 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/72. MPUM 6998/1.

Fig. 4 - *Flabellipecten stearnsii* (Dall, 1878). Right valve, length 82 mm. El Atacado Pyroclastics, LO3/10. MPUM 7008/1.

Fig. 5 - *Flabellipecten stearnsii* (Dall, 1878). Left valve, length 50 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/62. MPUM 7007/1.

Fig. 6 - *Argopecten abietis abietis* (Jordan & Hertlein, 1926). Right valve, length 47 mm. El Atacado Pyroclastics, LO3/12. MPUM 6966/1.

PLATE 4

Fig. 1 - *Patinopecten healeyi* (Arnold, 1906). Left valve, length 47 mm. Arroyo de Arce Norte Sandstone, Highway Section, LO3/58. MPUM 7013/1.

Fig. 2 - *Patinopecten healeyi* (Arnold, 1906). Right valve, length 30 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/71. MPUM 7010/1.

Fig. 3 - *Pycnodonte (Pycnodonte) erici* (Hertlein, 1929). Left valve, length 71 mm. El Atacado Pyroclastics, LO3/10. MPUM 7014.

Fig. 4 - *Undulostrea megodon* (Hanley, 1845). Left valve, length 24 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/3. MPUM 7016/1.

Fig. 5 - *Crassostrea californica osunai* (Hertlein, 1966). Left valve, height 300 mm (preserved part). Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/24. MPUM 7017.

Fig. 6 - *Dendostrea veatchii* (Gabb, 1866). Left valve, length 56 mm. El Atacado Pyroclastics, LO3/10. MPUM 7021/1.

PLATE 5

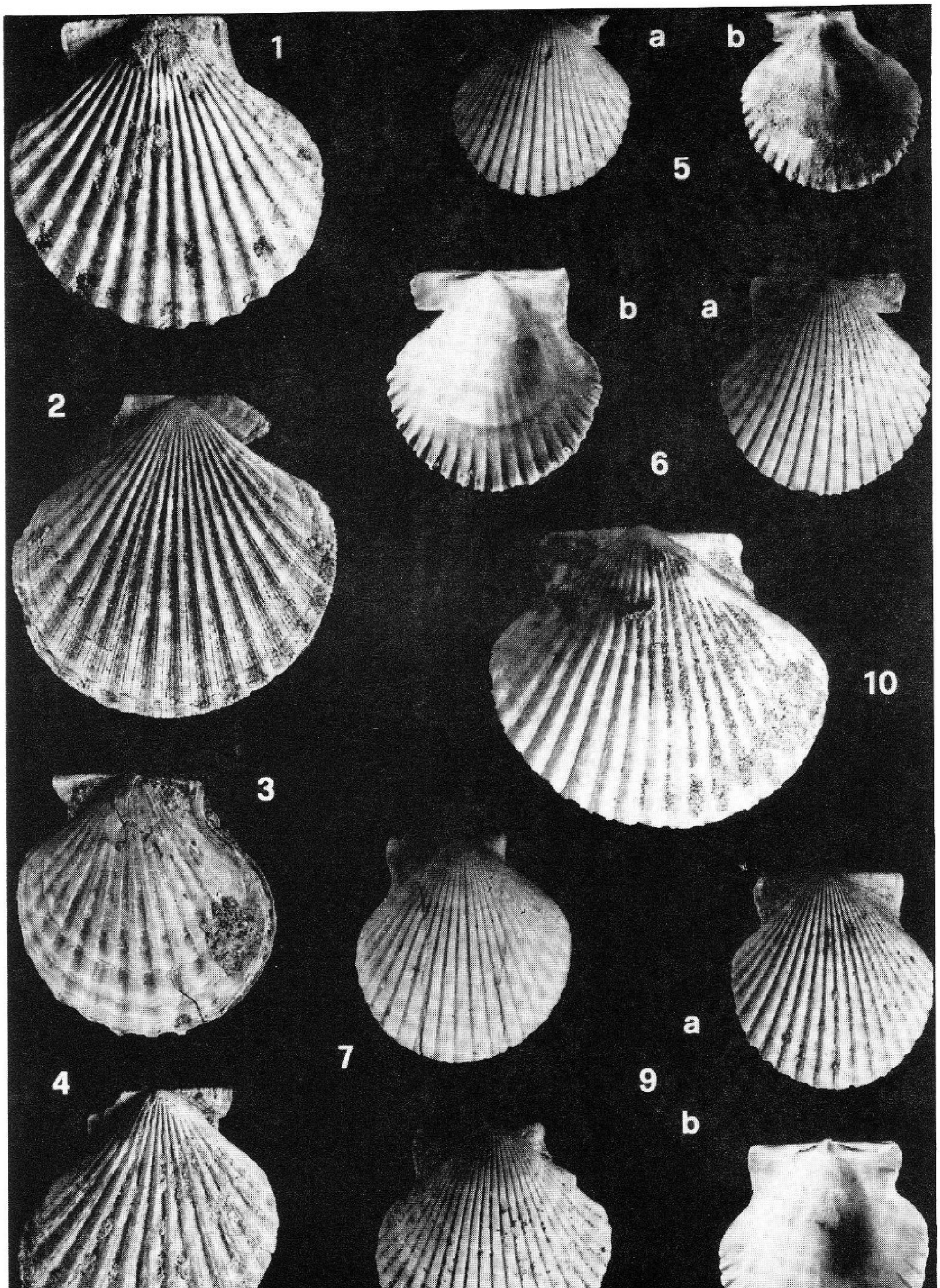
Fig. 1 - *Nodipecten nodosus* (Linnaeus, 1758). Right valve, length 45 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/28. MPUM 6993/2.

Fig. 2 - *Nodipecten nodosus* (Linnaeus, 1758). Right valve, length 122 mm. Piedras Rodadas Sandstone, Arroyo de Arce Section, LO3/28. MPUM 6993/3.

Fig. 3 - *Pycnodonte (Pycnodonte) heermanni* (Conrad, 1855). Left valve, length 129 mm. El Atacado Pyroclastics, LO3/10. MPUM 7015.

Fig. 4 - *Myrakeena angelica* (Rochebrune, 1895). a) Right valve, b) left valve, and c) ventral view of the same specimen; length 51 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/13. MPUM 7023/1.

Fig. 5 - *Myrakeena angelica* (Rochebrune, 1895). Left valve, length 68 mm. Piedras Rodadas Sandstone, Rancho Piedras Rodadas Section, LO3/13. MPUM 7023/2.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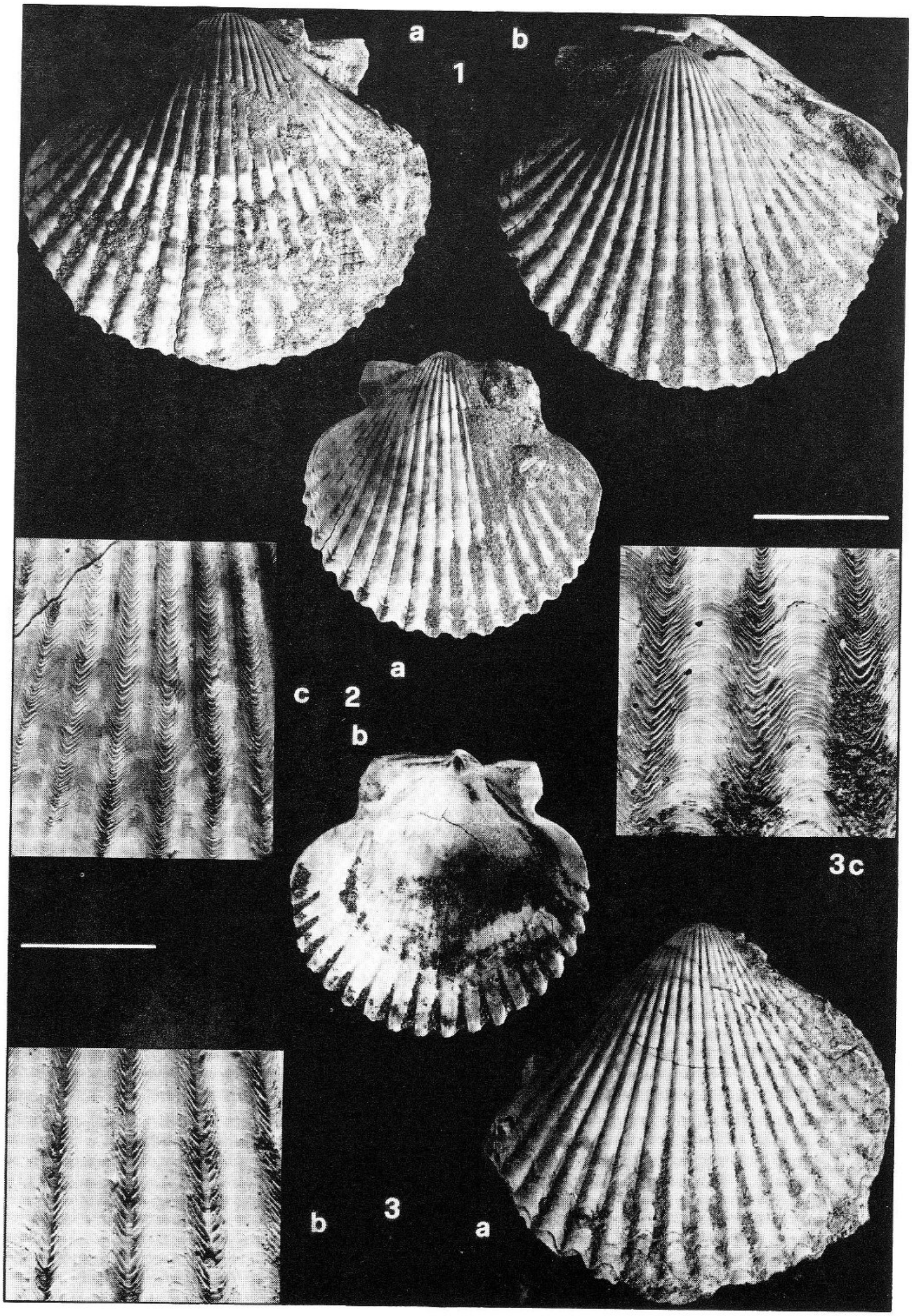
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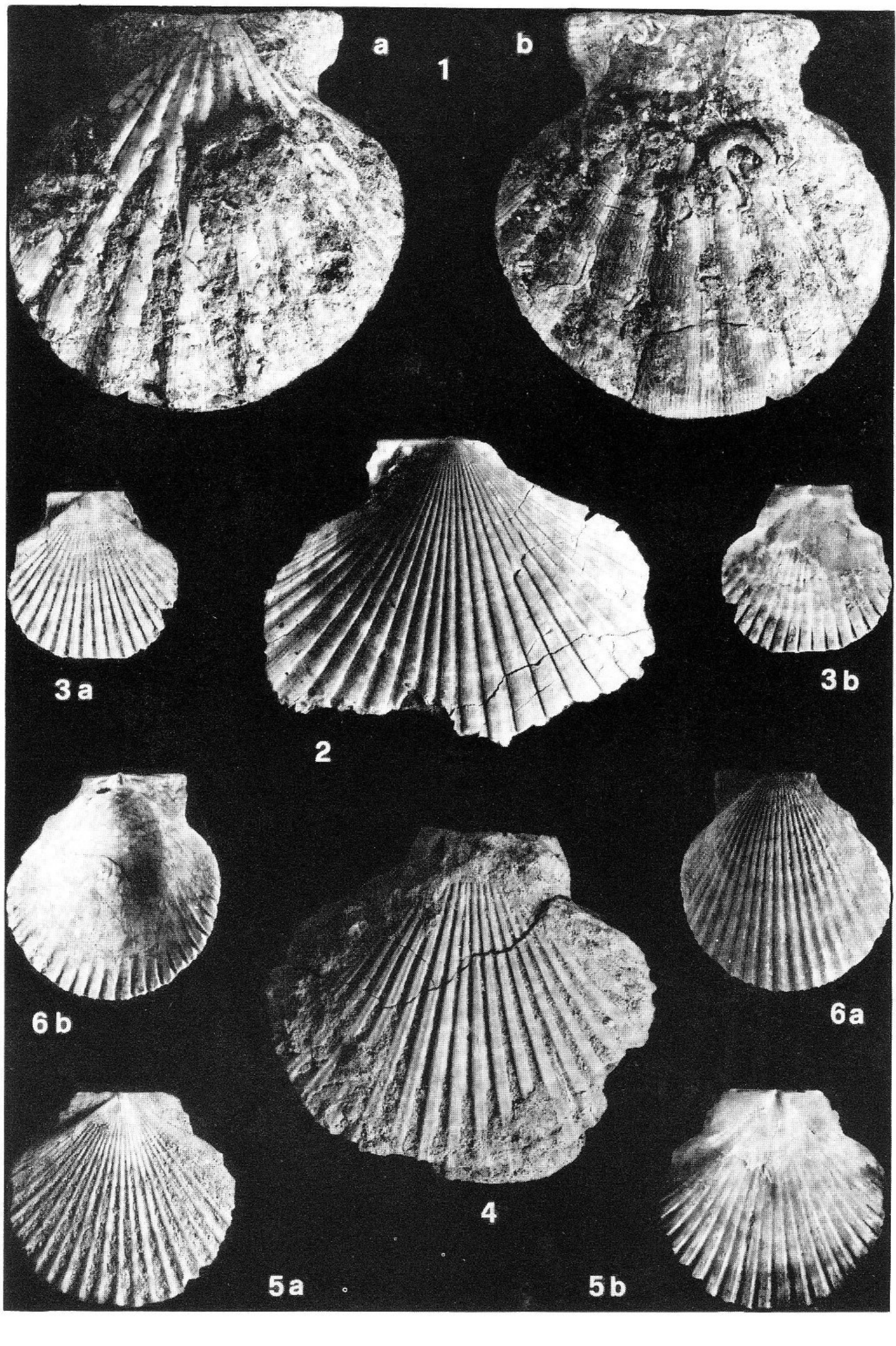
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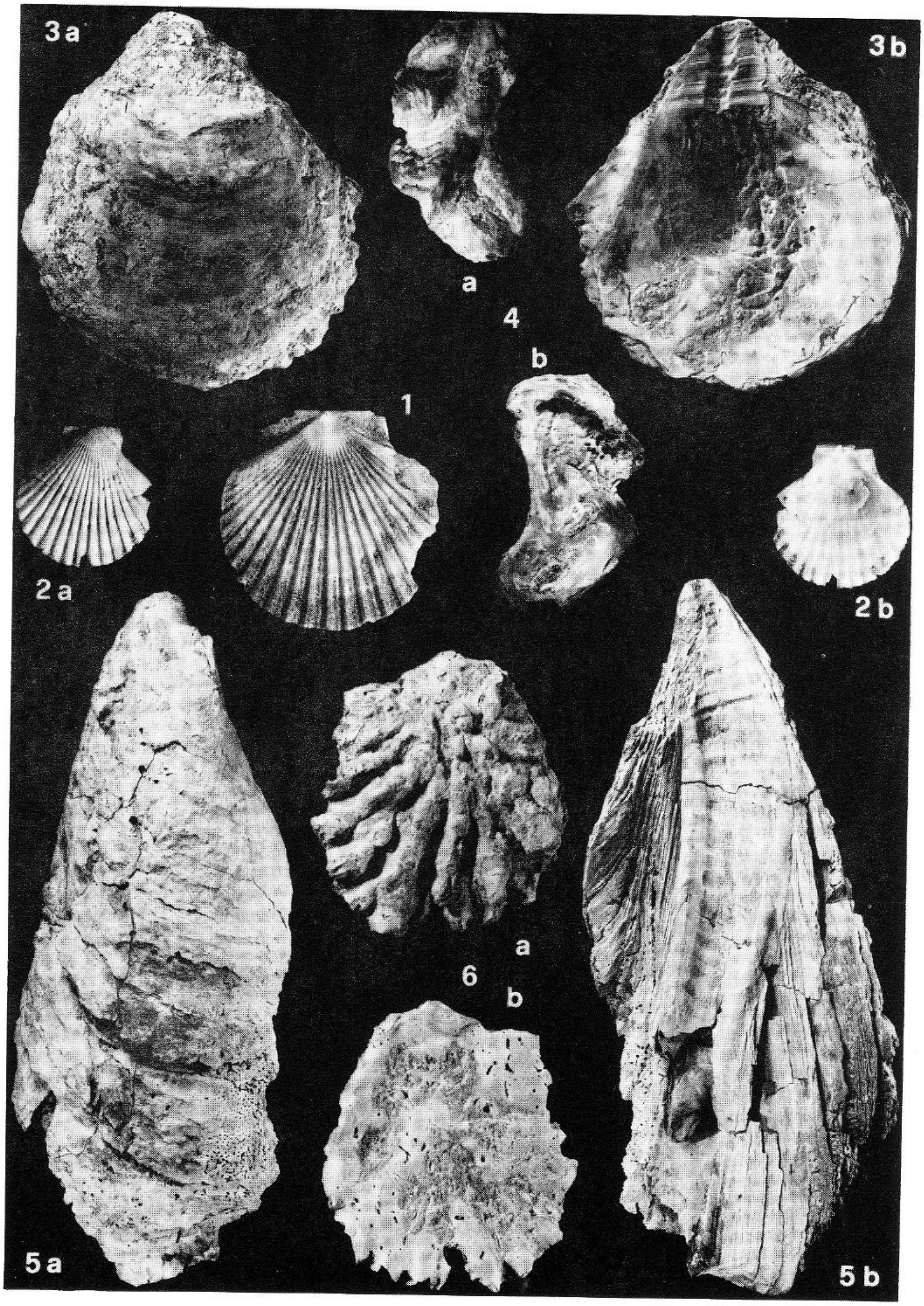
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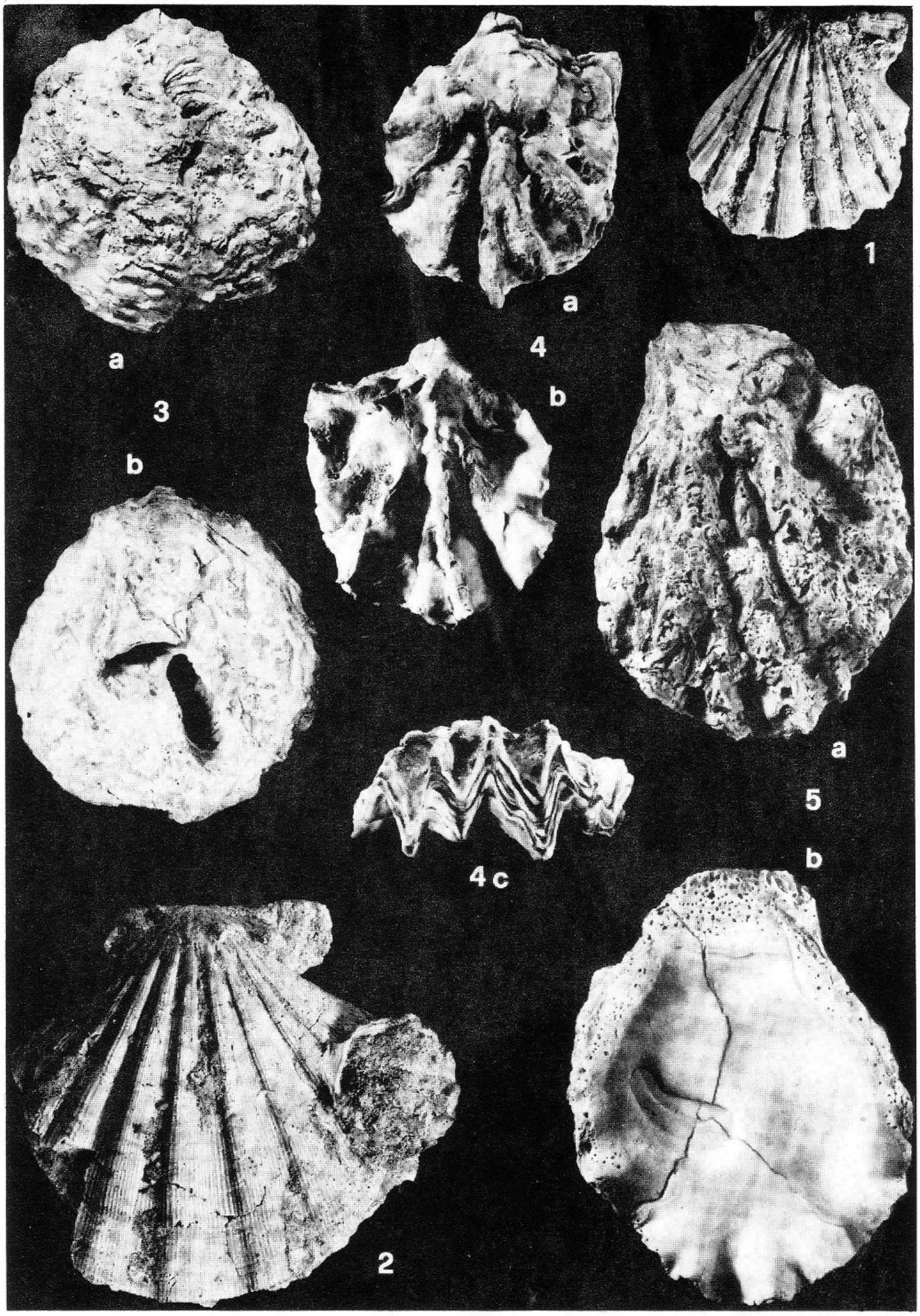
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