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AN UPPER PLEISTOCENE FAUNA FROM THE BALDWIN HILLS, LOS ANGELES COUNTY, CALIFORNIA

BY

GEORGE WILLETT

Los Angeles Museum

SAN DIEGO, CALIFORNIA

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In 1926 Professor A. J. Tieje (Bull. Am. Assoc. Petr. Geol., Vol. 10, p. 510), in a discussion of the Pliocene and Pleistocene history of the Baldwin Hills, referred to a warm water fauna uncovered in Trench 6 of the Los Angeles Outfall Sewer, giving it the name of the Centinela Gravels. A much more extensive exposure of what is apparently the same fauna occurred a few years later during the widening of Lincoln Avenue, which crosses the outfall sewer about two miles northeast of Playa del Rey. At a point just south of the sewer, at an altitude of about fifty feet above sea level, excavations by steam shovels cut into the upper part of the fossiliferous strata, exposing large numbers of marine invertebrates.

During the summer of 1935 a number of lots of fossil shells from this section were brought to me for identification, and, after studying them, I became sufficiently interested in certain features of the collections to undertake a rather careful examination of the locality from whence they came.

The fossiliferous stratum, from eight to twelve inches thick in most places, was found to be mainly from two to four feet below the present surface. It was bordered, both above and below, by sand which sometimes contained sparsely scattered, small, water-worn stones. In some sections there was a thin stratum of echinoderms a few inches above the mollusk-bearing vein, but this was by no means constant.

During 1935 and 1936 I made many trips to this fossil locality, and excavated, screened and carefully examined several tons of material. This resulted in an accumulation in the Los Angeles Museum of more than 30,000 specimens. While the majority of these are mollusks, several other groups were well represented. No attempt was made to preserve all the specimens uncovered, in the case of the more common species only a good representation being kept, and all badly worn or broken specimens being discarded except in case of the rarer species. A million would probably be

a conservative estimate of the total number of specimens examined.

In addition to the above, I have had access to the collections of John Q. and Tom Burch, Alex Clark, Mr. and Mrs. Philip M. Connelly, Miss Edna T. Cook, Mrs. Bertha M. Fuller, Steve A. Glassell, J. C. Marsh, Miss Alice Waterbury, and H. C. and Homer L. White, all of whom possess considerable material from the Del Rey deposits. To these friends, who have not only allowed free use of their collections, but have donated numerous specimens to the Los Angeles Museum, my sincere thanks are due. I am also indebted to the following students for classifying material in their respective fields: Steve A. Glassell, decapod crustaceans; Dr. U. S. Grant, echinoderms; Dr. Howard R. Hill, barnacles and bryozoans; and Dr. Hildegarde Howard, birds. Finally my gratitude is expressed to Dr. U. S. Grant and A. M. Strong for helpful information regarding literature and taxonomic questions.

Among the more striking features of this deposit are the abundance of crustacean remains, the great number of specimens of small mollusks, such as Pyramidellids, Melanellids and Turrids, and the periodic purity of the entire assemblage; that is, it may be almost entirely attributed to one distinct and rather exact period. There has apparently been very little mixing of materials from different geological ages, as is so common in many of our coastal fossil deposits. That this horizon is the same as Professor Tieje's "Centinela Gravels" is indicated, not only by locality, but by comparison with a list of fifty-five species of mollusks in an unpublished manuscript of Professor Tieje.

From a study of the nature of the marine fauna of this section, it would appear that its habitat was sandy ocean bottom, at a depth of from ten to twelve fathoms, near the mouth of a bay or slough, the latter feature being indicated by the presence of a few examples of marsh species such as *Melampus, Helisoma* and *Gyraulus,* which must have drifted down from coastal marshes.

A summary of the material preserved is as follows. Of mammals there are the remains of two species, a seal, and a dolphin or porpoise, that we have not identified more closely up to the present. According to Dr. Hildegarde Howard, ten species of birds are represented, two being extinct and the other eight apparently Recent. One of the fossil species is *Chendytes lawi,* a very large diving duck, first described by Dr. Loye Miller from the Upper San Pedro formation of Santa Monica Canyon. The other fossil bird is a hitherto undescribed gannet, of the genus *Moris,*

this genus being previously known on the Pacific coast by only one species, from the Miocene of Kern County. In the 'Condor' (vol. 38, 1936, p. 213) Dr. Howard has named this gannet *Moris reyana* and has given a detailed account of the avian remains found in this deposit.

There is a goodly representation of fish material, more than 700 specimens being preserved, but we have, as yet, not found any ichthyologist who can give the time necessary to identify all of the elements. Teeth of at least two species of sharks are rather common, and teeth and stingers of rays are even more so. There are also teeth of a sheephead, and many ear bones, vertebrae and other elements unidentified as yet.

Echinoderms were abundant, but very fragile, and perfect specimens difficult to obtain. According to Dr. U. S. Grant, the following are represented: *Strongylocentrotus* sp. ?., *Lovenia cardiformis* A. Agassiz, and *Dendraster* sp. nov. The latter species is known only from late Pleistocene, the others being found living in this same latitude today. The Round Bryozoa, *Lichenopora radiata* (Audouin), the only member of the group found, was abundant and usually well preserved. The barnacles, identified by Dr. Howard R. Hill, are of three species. The Pink Barnacle, *Balanus tintinnabulum californicus* Pilsbry, was abundant; two specimens of *Tetraclita squamosa rubescens* Darwin were found, also a number of segments of the Whale Barnacle, *Coronula regina* Darwin.

The decapod crustaceans were studied by Steve A. Glassell, who reports the following species: *Callianassa longimana* Stimpson, *Dardanus arnoldi* Rathbun, *Dromidia larraburei* Rathbun, *Randallia ornata* (Randall) (by far, the most abundant species), *Hepatus lineatus* Rathbun, *Heterocrypta occidentalis* (Dana) (second in numbers), *Mesorhoea idae* Rathbun, *Pyromaia tuberculata* (Lockington), *Pugettia producta* (Randall), *Pugettia richii* Dana, *Taliepus nuttallii* (Randall), *Loxorhynchus grandis* Stimpson, *Callinectes bellicosus* Stimpson, *Portunus xantusii* (Stimpson), *Cancer branneri* Rathbun, *Cancer antennarius* Stimpson, *Cancer gracilis* Dana, *Cancer anthonyi* Rathbun, *Cancer productus* Randall, *Lophopanopeus frontalis* (Rathbun), *Lophopanopeus diegensis* Rathbun, and *Cycloxanthops novemdentatus* (Lockington); also three species not yet determined, probably undescribed.

Mr. Glassell comments on this assemblage as follows: "Of the identified species, the greater per cent are living here today. Three (*Mesorhoea idae* and two species as yet unnamed) are only known as fossils, but may, like two other species (*Hepatus lineatus* and *Callinectes bellicosus*) found

in this horizon, be represented at the present time in lower latitudes. In this lot also have been found three species of our present day fauna which have not previously been reported as fossil. These are *Dromidia larraburei, Taliepus nuttallii,* and *Cancer antennarius.* A striking feature of the collection is the absence of the remains of strictly inter-tidal forms. So far, not a single specimen of these numerous species has been observed, although an occasional one might well be expected. While all of the species are not intrinsically shallow water forms (some having a bathymetric range of over fifty fathoms), still the living ones may all be taken today from the extreme minus tide line to at least the fifteen fathom contour. Due to the preponderance of fragments of one or two species (nothing but pieces remaining), it might be inferred that the balance of species in this Pleistocene deposit was not the same as the present day fauna. This, however, is probably not the case, for it is safe to assume that only those crustacean processes have survived which were structurally able to do so."

A study of the mollusks has resulted in recognition of 296 species, which divide as follows: Pelecypods, 90; Scaphopods, 5; Gastropods, 201. Five genera and forty-eight species are added to the Californian fossil list. These genera are *Ensis, Siphonodentalium, Atys, Engina* and *Simnia.* The species are *Mytilus adamsianus* Dkr., *Rochefortia reyana* sp. nov., *Bornia cooki* sp. nov., *Petricola tellimyalis* (Cpr.), *Ensis californicus* Dall, *Dentalium numerosum* Dall, *Siphonodentalium quadrifissatum* Dall, *Cavolina trispinosa* Lesueur, *Atys casta* Cpr., *Cancellaria bullata* Sby., *Engina strongi* Pils. and Lowe, *Purpura carpenteri* (Dall), *Purpura petri* (Dall), *Purpura gemma* (Dall), *Purpura santarosana* (Dall), *Thais biserialis* (Blain.), *Simnia catalinensis* (Berry), *Erato vitellina* Hinds, *Alabina tenuisculpta diegensis* Bartsch, *Cerithiopsis cosmia* Bartsch, *Cerithiopsis halia* Bartsch, *Cerithiopsis oxys* Bartsch, *Cerithiopsis antemunda* Bartsch, *Rissoella* sp. ?, *Fartulum orcutti* Dall, *Fartulum occidentale* Bartsch, *Calyptraea contorta* Cpr., *Acmaea cassis nacelloides* Dall, *Tricolia substriata* (Cpr.), *Tegula pulligo* (Mart.), *Calliostoma gloriosum* Dall, *Epitonium sawinae* Dall, *Turbonilla sanctorum* Dall and Bartsch, *Turbonilla superba* Dall and Bartsch, *Turbonilla vexativa* Dall and Bartsch, *Turbonilla antestriata* Dall and Bartsch, *Turbonilla almo* Dall and Bartsch, *Turbonilla adusta* Dall and Bartsch, *Turbonilla weldi* Dall and Bartsch, *Turbonilla ista* Bartsch, *Turbonilla canfieldi* Dall and Bartsch, *Turbonilla regina* Dall and Bartsch, *Odostomia eugena* Dall and Bartsch, *Odostomia nemo* Dall and Bartsch, *Odostomia donilla* Dall and Bartsch, *Odostomia helena* Bartsch, and *Lepidopleurus nexus* (Cpr.).

That there has been a mixing of faunas, though an exceedingly limited one, is indicated by the presence of examples of the following ten species of a colder water fauna: *Pecten hericeus* Gld., *Lora fidicula* (Gld.), *Spirotropis barbarensis* (Dall), *Spirotropis perversa* (Gabb), *Neptunea tabulata* (Baird), *Exilioidea rectirostris* (Cpr.), *Trophon orpheus* (Gld.), *Ranella oregonensis* (Redf.), *Epitonium wroblewskyi* (Mörch), and *Tegula pulligo* (Mart.). These are all Recent species, occurring at the present time either further to the northward or in deeper water in our latitude. The total number of individuals of these ten species in our collections is only seventeen, so that the true ratio of their abundance would be, not ten to 289, but seventeen to several hundred thousand, as all representatives of the cold water fauna were preserved, while the majority of warmer water forms were discarded. Most of these seventeen specimens are more or less fragmentary and all are much eroded, their appearance thus indicating greater age than that of the remainder of the fauna. There is no doubt in my mind that the few representatives of this older fauna were already fossils at the time the others were living.

These deposits have been referred to as being, for the greater part, representatives of a warm water fauna, and that the water was even less cold than it is today is indicated by the following facts. Of the 286 species (after deleting the ten older ones), 261 occur living in this latitude today, and nineteen are found, so far as we know, only further to the southward, many of them being confined to Mexican waters. These are: *Pecten vogdesi* Arnold, *Crassinella branneri* (Arnold), *Crassinella varians* (Cpr.), *Aligena cerritensis* Arnold, *Cardium procerum* Sby., *Mactra pallida* Brd. and Sby., *Dentalium numerosum* Dall, *Retusa carinata* (Cpr.), *Bulla punctulata* A. Adams, *Pseudomelatoma penicillata semiinflata* Grant and Gale, *Mangelia cetolaca* Dall, *Cancellaria bullata* Sby., *Mitra fultoni* E. A. Smith, *Cantharus fortis* (Cpr.), *Nassarius cerritensis* Arnold, *Purpura leeana* (Dall), *Thais biserialis* (Blain.), *Turbonilla sanctorum* Dall and Bartsch, and *Turbonilla superba* Dall and Bartsch. Six remaining species, *Rochefortia reyana* sp. nov., *Bornia cooki* sp. nov., *Rissoina pleistocena* Bartsch, *Delphinoidea coronadoensis* Arnold, *Epitonium clarki* T. S. Oldroyd, and *Ischnochiton sanctaemonicae* Berry are listed as extinct. However, a Recent specimen of *Epitonium clarki,* from Lower Californian waters, has been examined, and it is entirely possible, if not probable, that the other five may eventually be found living in moderate depths off Lower California, this being a region where very little shallow dredging has been done to date.

Among the interesting facts brought out by a study of the genetic relationship of the mollusks in this deposit, two features were emphasized particularly. First, in no single instance, where a sufficient amount of comparative Recent material was available, was there any perceptible difference in either form or sculpture between fossil and Recent examples of a species. Second, the accumulation of an abundant representation of some supposed species, previously known by very few specimens, indicates that many characters generally used in differentiating species are extremely inconstant, and can be considered to represent only individual variation within the species.

The literature most used in this study includes: Paleontology and Stratigraphy of San Pedro, California, by Ralph Arnold (1903); A Monograph of West American Pyramidellid Mollusks, by Dall and Bartsch (1909); Marine Shellbearing Mollusks of the Northwest Coast of America, by W. H. Dall (1921); Marine Shells of the West Coast of North America, by Mrs. Ida S. Oldroyd (1924-27), and Pliocene and Pleistocene Mollusca of California, by Grant and Gale (1931). No attempt has been made to include a complete synonymy of the species, but where the names in the above works differ from those used in this paper, they are listed as synonyms.

The following is a list of the mollusks, with remarks on some of the species. A number after the name of a species refers to the number of specimens preserved in the Los Angeles Museum, unless otherwise stated.

Nucula (Nucula) exigua Sowerby.— Syn., *Nucula suprastriata* Cpr. (Arnold, 1903).— Abundant; many still in pairs. (550 pairs, 1150 valves).

Leda taphria Dall.— Syn., *Nuculana taphria* (Dall) (Grant and Gale, 1931).— Common. (30 pairs, 120 valves).

Yoldia cooperi Gabb.— 1 fragment, including hinge, found by Miss Edna T. Cook.

Glycymeris septentrionalis (Middendorff).— Syn., *G. subobsoleta* (Cpr.): *G. barbarensis* Conr.: *G. corteziana* Dall ?.— (110 valves). I am not sure of the above synonymy, but believe it correct, with the possible exception of the last name. Shells in my collection, identified by Dr. Dall as *corteziana,* are certainly the same as the fossils, but I have not seen the type of *corteziana.* These shells differ greatly individually as regards shape, thickness and amount of sculpture.

Ostrea lurida Carpenter.— 13 valves.

Ostrea palmula Carpenter.— 1 valve.

Pecten (Hinnites) multirugosus Gale.— Syn., *Pecten giganteus* Gray (Arnold, 1903): *Hinnites giganteus* Gray (Dall, 1921; Oldroyd, 1924).— Not

very common, probably because of sandy character of locality. (7 valves).

Pecten (Chlamys) hericeus Gould.— Syn., *"Pecten hastatus* Sby." (Grant and Gale, 1931).— 2 valves in White collection.

Pecten (Aequipecten) latiauritus Conrad.— Abundant. (170 valves).

Pecten (Aequipecten) circularis Sowerby.— Syn., *P. c. aequisulcatus* Cpr. (Dall, 1921; Oldroyd, 1924).— Much less common than the last. (8 valves).

Pecten (Pecten) stearnsii diegensis Dall.— 2 right valves, 1 left valve, 25 fragments.

Pecten (Pecten) vogdesi Arnold.— Syn., *P. dentatus*, of some authors; not of J. Sowerby; *P. excavatus*, of some authors; not of Anton: *P. cataractes* Dall (Nautilus, 27, 1914, p. 121): *P. heimi* Hertlein (Proc. Calif. Acad. Sci., Ser. 4, 14, 1925, p. 9).— 1 right valve and 9 fragments; 2 valves in White collection.

Lima dehiscens Conrad.— 5 valves.

Anomia peruviana d'Orbigny.— Syn., *A. lampe* Gray (Arnold, 1903). — Upper valves common, probably having drifted in from rocky localities.

Pododesmus macroschisma (Deshayes).— Much less plentiful than *Anomia*. 2 valves taken by the writer and 1 by Mrs. Fuller.

Mytilus (Mytilus) californianus Conrad.— 1 half valve (with hinge) found by Mrs. Fuller; 1 pair in White collection.

Mytilus (Mytilus) adamsianus Dunker.— 1 valve.

Volsella modiolus (Linnaeus).— Syn., *Modiolus modiolus* Linn. (Dall, 1921; Oldroyd, 1924).— 8 valves, 12 fragments.

Volsella capax (Conrad).— Syn., *Modiolus capax* Conr. (Dall, 1921; Oldroyd, 1924).— 3 valves.

Volsella flabellata (Gould).— Syn., *Modiolus flabellatus* Gld. (Dall, 1921; Oldroyd, 1924).— 9 fragments.

Lithophaga plumula (Hanley).— 1 pair collected by Tom Burch.

Periploma planiuscula Sowerby.— Syn., *P. argentaria* Conr. (Arnold, 1903).— Hinge teeth rather common; occasional fragments of other sections of shell.

Thracia (Cyathodonta) undulata (Conrad).— Syn., *Cyathodonta dubiosa* Dall, *C. pedroana* Dall (Dall, 1921; Oldroyd, 1924).— 10 fragments.

Pandora punctata Conrad.— Syn., *Clidiophora punctata* Conr. (Arnold, 1903).— 2 pairs, 6 fragments.

Crassinella branneri (Arnold).—Syn., *Astarte branneri* (Arnold, 1903).— 180 valves.

Crassinella varians (Carpenter).— (6 pairs, 45 valves). Not listed by Grant and Gale, but recorded by Woodring (Am. Journ. Sci., 29, 1935, p. 303) from San Pedro Hills.

Glans carpenteri (Lamy).— Syn., *Lazaria subquadrata* Cpr. (Arnold,

1903): *Cardita subquadrata* Cpr. (Dall, 1921; Oldroyd, 1924): *Glans minuscula* (Grant and Gale, 1931).— 2 valves.

Chama pellucida Broderip.— 34 valves.

Lucina (Myrtea) californica Conrad.— Syn., *Phacoides californicus* Conr. (Dall, 1921; Oldroyd, 1924).— 1 valve.

Lucina (Myrtea) nuttallii Conrad.— Syn., *Phacoides nuttallii* Conr. (Dall, 1921; Oldroyd, 1924).— Abundant. (3 pairs, 85 valves).

Lucina (Myrtea) tenuisculpta approximata (Dall).— Syn., *L. tenuisculpta* Cpr. (Arnold, 1903, at least part): *Phacoides approximatus* Dall (Dall, 1921; Oldroyd, 1924).— Abundant. (375 valves). This appears to be a southern race of *L. tenuisculpta* and it is probable that Arnold's "Upper San Pedro" specimens are referable to it. Southern shells are smaller, with accentuated radial sculpture. That the two forms exist in the same latitude, as has been inferred by many authors, is perhaps doubtful.

Lucina (Here) excavata Carpenter.— Syn., *Phacoides richthofeni* Gabb (Dall, 1921; Oldroyd, 1924).— (67 valves). Gabb's *richthofeni* is undoubtedly the adult of Carpenter's *excavata*.

Taras orbellus (Gould).— Syn., *Diplodonta orbella* Gld. (Arnold, 1903; Dall, 1921; Oldroyd, 1924).— 6 valves.

Kellia suborbicularis laperousii (Deshayes).— Syn., *Chironia suborbicularis laperousii* Desh. (Grant and Gale, 1931).— This species is so fragile that it occurs mostly in fragments. However, 16 valves in fair condition are preserved. The name *laperousii* is used here solely because of the statement by Grant and Gale that Pacific coast specimens average larger than shells of the British Isles. These authors used the generic name *Chironia* with this species on the grounds that Heermannson (1847) named *Cardium* (*Lasaea*) *rubrum* Mont. as type of the genus *Kellia*. However, Winckworth (Journ. Conch., 20, 1934, p. 52) calls attention to the fact that Recluz (Revue Zool. Cuv., 7, 1844, p. 295) had previously designated *Mya suborbicularis* Mont. as the type of *Kellia*.

Aligena cerritensis Arnold.— 7 valves.

Rochefortia aleutica (Dall).— Common. (40 pairs, 220 valves).

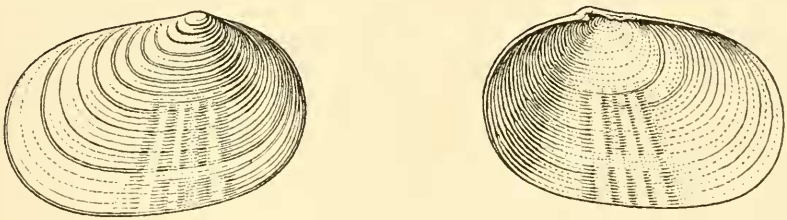
Rochefortia reyana, sp. nov.
Plate 25, figs. 1, 2

Similar to *R. pedroana* Dall, but more equilateral, and with heavier and more elongated hinge teeth, the hinge line in the right valve occupying almost one-half of the margin of the valve. Left valve with one very small lamella immediately below the umbone, and deflected umbonal margin.

Types, right and left valves, No. 1046 L. A. Mus., taken by the writer, with thirty-six additional valves and one connected pair, in the Del Rey Pleistocene deposit. Type right valve measures, in millimeters: diam., 6.7; alt., 5.2; ant. lateral, 4; post. lateral, 3: left valve, diam., 7.6; alt., 5.9.

Bornia retifera Dall.— Like *Kellia*, this shell is very fragile and seldom found entire. It was probably more plentiful than the specimens preserved (1 pair and 21 valves) would indicate.

1



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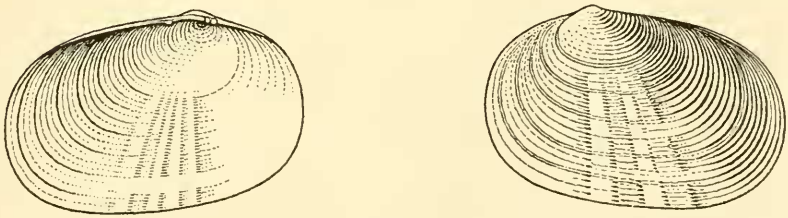

3

David P. Willoughby

Fig. 1. *Rochefortia reyana* Willett, type, right and left valves; x 4.
Fig. 2. *Bornia cooki* Willett, type, left valve; x 4.
Fig. 3. *Bornia cooki* Willett, type, right valve; x 4.

Bornia cooki, sp. nov.
Plate 25, figs. 3-6

Shell thin, white, moderately convex, oblong, inequilateral; beaks small, distinct, situated at posterior third of shell. Surface marked by numerous concentric striations and growth lines of varying strength; also by several faint, rounded, radial ridges which start near the center of the valve and run to the ventral margin. In the type there are four of these ridges and trace of a fifth, and in the paratype, in Miss Cook's collection, the ridges are fainter but more numerous (6-7). The shagreened pattern, usual to members of the genus, is only perceptible near the margins, but it is possible that this may have been worn away on the earlier portions of the shell. Dentition similar to that of *B. retifera* Dall, but with shorter laterals and wider notch.

Type pair, No. 1047 L. A. Mus., collected, together with another right valve, by Miss Edna T. Cook, for whom it is named. The type measures, in millimeters: diam., 9.9; alt., 6.4. The paratype, in Miss Cook's collection, measures: diam., 11.4; alt., 6.8.

Except in dentition, this species is quite different from *B. retifera* Dall, the only other member of the genus found in this deposit. In its oblong, inequilateral form it is more similar to some species of the genera *Erycina*, *Montacuta* and *Sportella*, but its dentition would seem to place it with *Bornia*.

Cardium (Laevicardium) elatum Sowerby.— 8 valves; many fragments noted.

The writer prefers not to follow some recent authors who have divided this old familiar genus. He believes that the various divisions in the group may be satisfactorily indicated by using subgeneric names, as was done by Dr. Dall (1921).

Cardium (Laevicardium) substriatum Conrad.— 1 valve found.

Cardium (Laevicardium) procerum Sowerby.— Common. (60 valves).

Cardium (Laevicardium) quadragenarium Conrad.— The most plentiful species of the genus.

Cardium (Fragum) biangulatum Broderip and Sowerby.— Fairly common. (30 valves).

Venus (Antigona) fordii Yates.— 1 immature valve.

Venus (Chione) succincta Valenciennes.— Syn., *Chione undatella* Sby. (Dall, 1921; Oldroyd, 1924): *Venus neglecta* Sby., *V. simillima* Sby. (Arnold, 1903).— 21 valves.

Venus (Chione) fluctifraga Sowerby.— 3 valves.

Venerupis (Callithaca) tenerrima (Carpenter).— Syn., *Tapes tenerrima* Cpr. (Arnold, 1903): *Paphia tenerrima* Cpr. (Dall, 1921; Oldroyd, 1924).— Fairly common, but usually broken. (2 pairs, 4 hinges).

Venerupis (Protothaca) staminea (Conrad).— Syn., *Tapes staminea* Conr. (Arnold, 1903): *Paphia staminea* Conr. (Dall, 1921; Oldroyd, 1924).— Less plentiful than the last. (3 valves, 2 fragments).

Compsomyax subdiaphana (Carpenter).— Syn., *Callista subdiaphana* Cpr. (Arnold, 1903): *Marcia subdiaphana* Cpr. (Dall 1921; Oldroyd, 1924): *Clementia subdiaphana* Cpr. (Grant and Gale, 1931).— (2 valves). Dr. U. S. Grant informs me that he now considers this species generically different from *Clementia*.

Transenella tantilla (Gould).— Syn., *Psephis tantilla* Gld. (Arnold, 1903).— 5 valves.

Tivela (Pachydesma) stultorum (Mawe).— Syn., *T. crassatelloides* Conr. (Arnold, 1903).— (2 valves). There appears to be some doubt whether Mawe's *Donax stultorum*, stated to be from "Indian Seas," is really the same as this species, though his figure shows a similar shell. Possibly Conrad's name *crassatelloides* should be revived.

Saxidomus nuttalli Conrad.— Syn., *S. aratus* Gld. (Arnold, 1903).— 1 valve.

Pitar newcombianus (Gabb).— Syn., *Callista newcombiana* Gabb (Arnold, 1903): *Pitaria newcombiana* Gabb (Dall, 1921; Oldroyd, 1924).— 1 valve.

Amiantis callosa (Conrad).— Syn., *Callista callosa* Conr. (Arnold, 1903).— Abundant.

Petricola tellimyalis (Carpenter).— 70 valves.

Petricola californiensis Pilsbry and Lowe.— Syn., *P. denticulata* Sby. (Arnold, 1903; Dall, 1921; Oldroyd, 1924; Grant and Gale, 1931).— 2 valves.

Petricola carditoides (Conrad).— 1 valve collected by Miss Edna Cook.

Cooperella subdiaphana Carpenter.— 4 valves (three in Miss Cook's collection).

Tellina idae Dall.— Common. (10 pairs, 26 valves).

Tellina buttoni Dall.— 3 valves.

Tellina bodegensis Hinds.— 8 valves.

Tellina santarosae Dall.— 3 valves.

Apolymetis biangulata (Carpenter).— Syn., *Metis alta* Conr. (Arnold, 1903; Dall, 1921; Oldroyd, 1924).— Common. (5 pairs, 2 valves).

Macoma nasuta (Conrad).— 5 valves.

Macoma yoldiformis Carpenter.— 6 pairs, 22 valves.

Macoma secta (Conrad).— Common. (15 valves).

Macoma indentata Carpenter.— Syn., *M. i. tenuirostris* Dall (Dall, 1921; Oldroyd, 1924).— Abundant. (5 pairs, 40 valves).

Semele decisa (Conrad.)— 1 fragment found by the writer, another by Miss Cook.

Semele pulchra (Sowerby).— 7 valves.

Donax californicus Conrad.— 1 valve; 2 valves in Miss Cook's collection.

Donax gouldii Dall.— Syn., *D. laevigata* Desh. (Arnold, 1903).—

Abundant. (30 valves).

Gari edentula (Gabb).— Syn., *Psammobia edentula* Gabb (Arnold, 1903; Dall, 1921; Oldroyd, 1924).— 3 fragments, with hinges.

Tagelus californianus (Conrad).— 1 fragment, with hinge.

Tagelus subteres (Conrad).— 1 valve.

Solen sicarius Gould.— 20 fragments, with hinges.

Ensis californicus Dall.— 24 valves.

Siliqua lucida (Conrad).— 1 valve, 7 hinges.

Mactra (Mactra) californica Conrad.— Common. (23 valves).

Mactra (Spisula) planulata Conrad.— Syn., "*Mactra falcata* Gld." (Arnold, 1903): *Spisula planulata* Conr. (Dall, 1921; Oldroyd, 1924).— Abundant. (1 pair, 50 valves).

Mactra (Spisula) hemphilli Dall.— Common. (3 pairs, 21 valves).

Mactra (Spisula) catilliformis (Conrad).— 1 valve.

Mactra (Mulinia) pallida modesta (Dall).— Syn., "*Mactra exoleta* Gray" (Arnold, 1903).— Rather common. (3 pairs, 45 valves).

Schizothaerus nuttallii (Conrad).— Syn., *Tresus nuttalli* Conr. (Arnold, 1903).— Not rare, but mostly fragmentary. (2 pairs).

Cryptomya californica (Conrad).— Abundant. (8 pairs, 60 valves).

Corbula (Lentidium) luteola Carpenter.— Abundant; pairs of connected valves common. (250 pairs, 100 valves).

Panope (Panope) generosa Gould.— Syn., *Panopea generosa* Gld. (Arnold, 1903; Oldroyd, 1924).— Fairly common. (1 pair, 6 valves, 5 hinges).

Saxicava arctica (Linnaeus).— 1 valve.

Pholas pilsbryi Lowe.— Syn., *Zirphaea gabbi* Tryon (Arnold, 1903; Dall, 1921; Oldroyd, 1924): *Pholas gabbi* Tryon (Grant and Gale, 1931).— 1 valve, 1 fragment.

Pholadidea (Pholadidea) penita (Conrad).— 1 pair.

Dentalium neohexagonum Sharp and Pilsbry.— Syn., *Dentalium pseudohexagonum* Dall (Arnold, 1903).— Abundant. (700).

Dentalium numerosum Dall.— Six specimens seem referable to this species. In addition to these are numerous examples, referred to *neohexagonum*, that have more ribs than the typical of that form and, although complete intergradation between *neohexagonum* and *numerosum* is not shown in our series, rather close relationship between the two appears to be indicated.

Dentalium semipolitum Broderip and Sowerby.— 58 specimens, mostly more or less fragmentary.

Siphonodentalium quadrifissatum Dall.— 17 specimens.

Cadulus fusiformis Pilsbry and Sharp.— Abundant. (1300). Considering the abundance of this species in a deposit so near those worked by Arnold, it is difficult to understand why he did not find it. Pilsbry (Nautilus, 17, 1904, p. 108) believed Arnold's figure of "*Cadulus nitentior* Cpr." to be "probably of a

serpuloid annelid," but, if possible, this should be checked by a study of Arnold's material. There is some variation in this species in both shape and diameter, and Arnold's figure may represent a worn *Cadulus*.

Cavolina telemus tricuspida (Rivers).— Syn. *Cavolina occidentalis* Dall (Dall, 1921; Oldroyd, 1927).— 1 specimen collected by Miss Edna T. Cook.

Cavolina trispinosa Lesueur.— 1 in Museum collection and 3 in collection of Miss Cook.

Acteon (Acteon) traski Stearns.— Rather common, though usually broken. (225).

Acteon (Rictaxis) punctocaelatus (Carpenter).— 38.

Retusa (Acteocina) culcitella (Gould).— Syn., *Tornatina culcitella* Gld., *T. cerealis* Gld. (Arnold, 1903): *Acteocina culcitella* Gld. (Dall, 1921; Oldroyd, 1927): *Acteocina pedroensis* T. S. Oldroyd (Proc. U. S. Nat. Mus., 65, 1925, art. 22, pp. 23, 24).— Common. (600).

Retusa (Acteocina) carinata (Carpenter).

Retusa (Acteocina) inculta (Gould).— More than 600 specimens of the short, blunt-spired Retusas were preserved. While the majority of these appear referable to *carinata*, a few are indistinguishable from *inculta* and others are variously intermediate between the two. A sufficient number of Recent specimens will probably show that *carinata* and *inculta* are not more than subspecifically distinct, the former being a southern form and the latter a more northern one of the same species.

Volvulella cylindrica (Carpenter).— Syn., *Volvula cylindrica* Cpr. (Arnold, 1903).— (700). A careful examination of this splendid series shows much variation in size, length of spire, and amount of spiral sculpture. It is probable that some other named species are only variants of *cylindrica*.

Atys casta Carpenter.— 1 juvenile specimen.

Cylichna attonsa Carpenter.— Syn., *Cylichna alba* Brown (Arnold, 1903, at least part): *Cylichnella attonsa* Cpr. (Dall, 1921; Oldroyd, 1927).— (1000). Although there is considerable variation in this series, it seems advisable to refer them all to the above species, of which many are typical. Some specimens approach *C. diegensis* Dall, which may be the same as *C. propinqua* Smith. None appears referable to *C. alba* Brown, which name, in the past, has been used for most southern Californian fossils. This latter species is probably confined to northern waters and, if it has appeared at all as a fossil in southern California, it should be only in a cold water fauna.

Bulla punctulata A. Adams.— Syn., *Bullus punctulatus* (A. Ad.) (Grant and Gale, 1931).— (62). Our specimens assigned to this species differ from available Lower Californian examples in larger size (largest, 48x33 mm.), slightly more globular form, and fewer (3-6) spirals in the umbilicus. This is probably the shell that Pilsbry (Man. Conch., 15, 1893, p. 341) refers doubtfully to *B. aspersa* A. Adams. The difference in number of spirals in the umbilicus does not appear to coincide with different localities, as both types are present in specimens from the west coast of South America in the H. N. Lowe

collection. For use of *Bulla* instead of *Bullus*, see Pilsbry, Nautilus, 44, 1931, p. 98.

Haminoea vesicula (Gould).— 1 juvenile.

Melampus olivaceous Carpenter.— (14). These undoubtedly washed down from coastal marshes.

Williamia peltoides (Carpenter).— (26). The species represented is the one with elevated apex. Whether the above name is correctly applied here may be open to question (see Grant and Gale, 1931, p. 464).

Terebra (Strioterebrum) pedroana Dall.— Syn., *T. simplex* Cpr. (Arnold, 1903): *T. pedroana philippiana* Dall (Dall, 1921; Oldroyd, 1927).— (260). Abundant. The typical and the variant named *philippiana* both present.

Conus californicus Hinds.— Rather common. (16).

Megasurcula remondii (Gabb).— Syn., *Cryptoconus stearnsianus* Raymond (Dall, 1921; Oldroyd, 1927): *Surculites remondii* (Gabb) (Grant and Gale, 1931).— 41.

Megasurcula carpenteriana (Gabb).— Syn., *Pleurotoma carpenteriana* Gabb, *P. tryoniana* Gabb (Arnold, 1903): *Cryptoconus carpenterianus* Gabb, *C. tryonianus* Gabb, *C. tremperianus* Dall (Dall, 1921; Oldroyd, 1927): *Surculites carpenterianus* (Gabb) (Grant and Gale, 1931).— (130). A common and very variable species.

Lora fidicula (Gould).— Syn., *Bela fidicula* Gld. (Arnold, 1903, part): "*Lora viridula* Fabr." (Grant and Gale, 1931).— 1 specimen collected by Miss Edna T. Cook.

Spirotropis (Borsonella) barbarensis (Dall).— Syn., *Borsonella barbarensis* Dall (Dall, 1921; Oldroyd, 1927): "*Borsonella dalli* Arnold" (Dall, 1921, part; Oldroyd, 1927, part).— 1 specimen in Museum collection and another in collection of Mrs. E. M. Clark.

Spirotropis (Antiplanes) perversa (Gabb).— Syn., *Pleurotoma perversa* Gabb (Arnold, 1903): *Antiplanes perversa* Gabb (Dall, 1921; Oldroyd, 1927).— 8 specimens, all much worn and few entire. Evidently of an older fauna than the bulk of the deposit.

The writer cannot follow Grant and Gale in relegating such species as *rotula, santarosana* and *catalinae* to the synonymy of *perversa*. They appear to have not only different forms, but different ranges.

Moniliopsis incisa fancherae (Dall).— Syn., "*Drillia inermis* Hds." (Arnold, 1903): *Clathrodrillia halcyonis* Dall (Dall, 1921; Oldroyd, 1927).— Abundant. (150).

Moniliopsis incisa ophioderma (Dall).— Syn., "*Drillia inermis penicillata* Cpr." (Arnold, 1903): "*Moniliopsis incisa* Cpr." (Dall, Proc. U. S. Nat. Mus., 56, 1919, pl. 12, fig. 7; Oldroyd, 1927, pl. 18, fig. 3).— (10). Much less common than the last.

There has been much confusion among authors regarding the names to be applied to the varieties of this well known species. It would seem that the correct application of names depends entirely upon the identity of Carpenter's type of *incisa*, which does not appear to be definitely established. The arrangement here

used is based on the assumption that typical *incisa* is the northern form with "grooved" spirals and axial sculpture confined to faint growth lines. This is the shell figured by Grant and Gale (1931, pl. 26, fig. 21) as the "typical variety," but is not the same as some of the forms included in their synonymy.

The fact is that we have in southern California, both fossil and Recent, two common varieties of *M. incisa*, each of which has been referred to by several names. One type (*fancherae*, as used here) is more slender, with rounder body whorl, and sharper spiral sculpture, and is a dredged shell. The other (*ophioderma*), frequently collected at low tide, is characterized by greater diameter, more or less flattened body whorl, less sharp spiral sculpture, and (in life) vertical reddish lines. Dall's figures of both *incisa* and *ophioderma* (Proc. U. S. Nat. Mus., 56, 1919, pl. 12, figs. 5 and 7) appear to be of this latter form. *M. rhines* Dall (*cancellata* Cpr.) is probably a color form of *fancherae*, Carpenter's description calling for a white shell. Such specimens are in the writer's collection from Catalina Island.

Clavus (Cymatosyrinx) empyrosia (Dall).— Syn., "*C. pallidus* Sby." (Grant and Gale, 1931, part).— 1.

Clavus (Cymatosyrinx) halocydne (Dall).—Syn., "*C. pallidus* Sby." (Grant and Gale, 1931, part).— (3). Although Grant and Gale place this and the last species in the synonymy of *C. pallidus* (Sby.), the writer does not consider such action justified. A comparison of *halocydne* and *pallidus* shows that the latter is larger and relatively wider, and has a much heavier callus on the inner lip and a narrower constricted area at the suture. In *halocydne* this constriction, on all whorls but the last, is almost as wide as the remainder of the whorl. Furthermore, the color of *halocydne* is not white like *pallidus*, but light brown, darker in the aperture. *C. empyrosia* differs from *halocydne* and *pallidus* in both size and sculpture.

Clavus (Cymatosyrinx) hemphilli (Stearns).— Syn., *Drillia hemphilli* Sts. (Arnold, 1903): *Cymatosyrinx hemphilli* Sts. (Dall, 1921; Oldroyd, 1927): *C. aeolia* Dall (Proc. U. S. Nat. Mus., 56, 1919, p. 11).— (16). All are of the ribbed form called *aeolia* by Dr. Dall. A fine series of topotypes of *hemphilli* collected by Mr. and Mrs. P. M. Connelly at Todos Santos Bay, Lower California, are mostly quite different, both in sculpture and color, from Los Angeles County specimens of "*aeolia*," but enough intergrades have been examined to show that the two are conspecific. It is possible that *aeolia* may be a geographical race of *hemphilli*, but this remains to be demonstrated.

Clavus (Crassispira) montereyensis (Stearns).— Syn., *Crassispira arsinoë* Dall (Proc. U. S. Nat. Mus., 56, 1919, p. 26).— 1 specimen found by Miss Alice Waterbury and donated to the Museum.

Mangelia (Mangelia) hexagona Gabb.— Syn., *Mangilia branneri* Arnold (Arnold, 1903; Dall, 1921).— 7.

Mangelia (Mangelia) merita (Hinds).— 1.

Mangelia (Bela) variegata Carpenter.— Syn., *M. angulata* Cpr., not Reeve (Arnold, 1903; Dall, 1921): *M. oenoa* Dall, *M. pulchrior* Dall, *M. beta* Dall (Dall, 1921; Oldroyd, 1927): *M. barbarensis* Oldroyd (1927): "*M. hecetae* Dall and Bartsch" (Grant and Gale, 1931).— (1800). Our specimens of

this species exhibit every variation between typical *variegata* and the other forms listed in the above synonymy. Plate 26, fig. 1, shows intergradation between the two extremes, typical *variegata* on the one hand, and the angulated variety on the other. That this intergradation also occurs at the present time is indicated by specimens in the writer's collection. While, as Grant and Gale point out (1931, p. 593), the shell of *M. hecetae* Dall is indistinguishable from some specimens of the angulated form of *variegata*, an example of *hecetae* in the writer's collection, taken in southeastern Alaska, possesses an operculum, which, according to our present understanding, would place it in the genus *Lora*.

Mangelia (Bela) cetolaca Dall.— Syn., *Columbella* (*Aesopus*) *oldroydi* (Arnold, 1903, p. 238), not *Mangilia oldroydi* (Arnold, 1903, p. 213): "*Mangelia perattenuata* Dall" (Grant and Gale, 1931).— (720). Grant and Gale considered *M. perattenuata* Dall, *Philbertia phylira* Dall, and *P. amyela* Dall identical with this species. However, an examination of our large series does not appear to substantiate their views. *Perattenuata* seems more tapering than *cetolaca*, with sutures far too narrow, and with the last whorl longer than the rest of the shell, which is not the case in specimens of *cetolaca* the same size as the type of *perattenuata*. *Philbertia phylira* has fewer and more regularly spaced spiral cords than *M. cetolaca*, and *Philbertia amyela* has too few axials.

Mangelia (Bela) arteaga roperi Dall.— Syn., "*Mangilia sculpturata* Dall" (Arnold, 1903).— (360). Our specimens are uniformly more slender than examples of the typical form. It is probable that *roperi* is a southern race and that typical *arteaga* does not range as far southward as has been generally believed.

Cancellaria bullata Sowerby.— Rather rare. 1 specimen in the Museum collection, and 3 in the White collection.

Cancellaria crawfordiana Dall.— 2 specimens found, one by the writer and the other by Mrs. E. M. Clark.

Cancellaria cooperi Gabb.— 1 broken specimen.

Olivella biplicata (Sowerby).— Common. (76).

Olivella baetica Carpenter.— Abundant. (170).

Hyalina (Cypraeolina) pyriformis (Carpenter).— Syn., *Merovia pyriformis* Cpr. (Dall, 1921): *Cypraeolina pyriformis* Cpr. (Oldroyd, 1927).— 1 specimen collected by Mrs. Clark.

Mitra idae Melvill.— Syn., "*Mitra maura* Swain." (Arnold, 1903): *Strigatella idae* Mel. (Dall, 1921).— 1 specimen in White collection.

Mitra fultoni E. A. Smith.— 11.

Mitra catalinae (Dall).— 10.

Fusinus barbarensis (Trask).— Syn., *Fusus barbarensis* Trask (Arnold, 1903).— 1.

Fusinus arnoldi (Cossman).— Syn., *Fusus rugosus* Trask (Arnold, 1903): *Fusinus traski* Dall (Dall, 1921; Oldroyd, 1927).— 22.

Fusinus kobelti (Dall).— 6.

Fusinus monksae (Dall).— Syn., "*Fusus robustus* Trask" (Arnold,

1903).— 1.

Fusinus luteopictus (Dall).— (130). By far, the most common species of the genus.

Kelletia (Kelletia) kelletii (Forbes).—Syn., *Siphonalia kellettii* Fbs. (Arnold, 1903). Rather common. (9).

Cantharus fortis (Carpenter).— Syn., *Pisania fortis* Cpr. (Arnold, 1903).— 1 specimen; 2 additional in White collection.

Neptunea (Sulcosipho) tabulata (Baird).—Syn., *Chrysodomus tabulatus* Baird (Arnold, 1903; Dall, 1921; Oldroyd, 1927).— 3 fragments.

Exilioidea rectirostris (Carpenter).— Syn., *Chrysodomus rectirostris* Cpr. (Arnold, 1903): *Exilia rectirostris* Cpr. (Dall, 1921; Oldroyd, 1927).— 1 specimen.

Engina strongi Pilsbry and Lowe.— Syn., "*Engina carbonaria* Rve." (Dall, 1921; Oldroyd, 1927).— 2 specimens; an additional one in Miss Cook's collection.

Nassarius (Zeuxis) tegula (Reeve).— Syn., *Nassa tegula* Rve. (Arnold, 1903): *Alectrion tegula* Rve. (Dall, 1921; Oldroyd, 1927).— 55.

Nassarius (Schizopyga) californianus (Conrad).— Syn., *Nassa californiana* (Conr.) (Arnold, 1903): *Alectrion californiana* Conr. (Dall, 1921; Oldroyd, 1927).— 290.

Nassarius (Schizopyga) cerritensis (Arnold).— Syn., *Nassa cerritensis* Arn. (Arnold, 1903): *Alectrion cerritensis* Arn. (Dall, 1921; Oldroyd, 1927).— (160). Our series appears to show that this species grades into *N. californianus* at one end, and approaches very near to *N. mendicus cooperi* at the other, though none have as few axial ribs as *cooperi*.

Nassarius (Schizopyga) mendicus cooperi (Forbes).—Syn., *Nassa mendica cooperi* Fbs. (Arnold, 1903): *Alectrion cooperi* Fbs. (Dall, 1921; Oldroyd, 1927).— 135.

Nassarius (Schizopyga) perpinguis (Hinds).— Syn., *Nassa perpinguis* Hds. (Arnold, 1903): *Alectrion perpinguis* Hds. (Dall, 1921; Oldroyd, 1927).— 260.

Nassarius (Schizopyga) fossatus (Gould).— Syn., *Nassa fossata* (Gld.) (Arnold, 1903): *Alectrion fossata* Gld. (Dall, 1921; Oldroyd, 1927).— 50.

Nassarius (Schizopyga) insculptus (Carpenter).— Syn., *Nassa insculpta* Cpr. (Arnold, 1903): *Alectrion insculptus* Cpr. (Dall, 1921; Oldroyd, 1927).— 2.

Mitrella carinata (Hinds).—Syn., *Columbella carinata* Hds. (Arnold, 1903; Dall, 1921; Oldroyd, 1927): *C. carinata hindsi* (Gask.) Rve. (Dall, 1921; Oldroyd, 1927).

Mitrella carinata gausapata (Gould).— Syn., *Columbella gausapata* Gld. (Arnold, 1903; Dall, 1921; Oldroyd, 1927): *C. californiana* Gask. (Arnold, 1903): *C. carinata californiana* Gask. (Dall, 1921; Oldroyd, 1927).— (400). In this series are examples typical of each of the two above forms and

many intergrades between them. If only southern Californian specimens were considered, there would seem to be no justification in recognition of more than one race, as our shells, both fossil and Recent, show no point of division. From what is known at the present time, however, it appears that the range of the form *gausapata* extends considerably farther north than typical *carinata*. In a sense, therefore, they may be considered geographical races.

Mitrella tuberosa (Carpenter).—Syn., *Columbella tuberosa* Cpr. (Arnold, 1903; Dall, 1921; Oldroyd, 1927).— 130.

Amphissa reticulata Dall.— 3.

Amphissa versicolor Dall.— (40). Because of the great amount of variation in these species, I find it difficult to separate *reticulata* from *versicolor*, especially in the case of immature specimens. Three are referred to *reticulata* largely on account of their greater size.

Amphissa undata Carpenter.— 7.

Purpura (Pteropurpura) carpenteri (Dall).— Syn., *Murex carpenteri* Dall (Dall, 1921; Oldroyd, 1927).— 8.

Purpura (Pteropurpura) petri (Dall).— Syn., *Murex petri* Dall (Dall, 1921; Oldroyd, 1927).— 46.

Purpura (Centrifuga) leeana (Dall).— Syn., *Murex leeanus* Dall (Arnold, 1903).— (70). A rather common species, a fine growth series being preserved. An interesting feature is the similarity of the young of this species to half-grown *Tritonalia barbarensis* (Gabb) (see Plate 26, figs. 2, 3).

Purpura (Jaton) festiva (Hinds).—Syn., *Murex festivus* Hds. (Arnold, 1903; Dall, 1921; Oldroyd, 1927).— Abundant. (100).

Purpura (Jaton) gemma (Sowerby).— Syn., *Murex gemma* Sby. (Dall, 1921; Oldroyd, 1927).— 6.

Purpura (Jaton) santarosana (Dall).— Syn., *Murex santarosana* Dall (Dall, 1921; Oldroyd, 1927).— 1.

Tritonalia foveolata (Hinds).— Syn., *Ocinebra foveolata* Hds. (Arnold, 1903).— (40). Arnold's record of "*Ocinebra perita* Hds." may refer to this species.

Tritonalia interfossa (Carpenter).— Syn., *Ocinebra interfossa* Cpr. (Arnold, 1903).— 2, one typical and the other near to the form *beta* Dall.

Tritonalia poulsoni (Nuttall in Carpenter).— Syn., *Ocinebra poulsoni* Nutt. (Arnold, 1903).— (85). The most common member of the genus.

Thais biserialis (Blainville).— 38.

Thais emarginata (Deshayes).—Syn., *Purpura saxicola* Val. (Arnold, 1903).— 2 in White collection

Acanthina spirata (Blainville).— Syn., *Monoceros engonatum* Conr. (Arnold, 1903).— (85). This series varies from the high spired form, with rounded whorls, to the short, carinated one.

Trophon (Boreotrophon) orpheus (Gould).— 1.

Forreria belcheri (Hinds).— Syn., *Chorus belcheri* Hds. (Arnold,

1903).— Common.

Bursa californica (Hinds).— Syn., *Ranella californica* Hds. (Arnold, 1903).— Abundant.

Ranella (Priene) oregonensis (Redfield).— Syn., *Tritonium oregonensis* Redf. (Arnold, 1903): *Argobuccinum oregonensis* Redf. (Dall, 1921; Oldroyd, 1927).— 1 collected by Miss Edna Cook and another by J. C. Marsh.

Simnia (Neosimnia) catalinensis (Berry).— Syn., *Neosimnia catalinensis* (Berry, Nautilus, 30, 1916, p. 21).— 2 specimens in Museum collection and 2 more in White collection. Our largest measures 24x9 millimeters, and a Recent specimen in the writer's collection measures 32.5x12 millimeters. When these measurements are considered, the statement of F. A. Schilder (Proc. Mal. Soc. London, 20, 1932, p. 54) that *catalinensis* is "evidently the young of *loebbeckeana* Weinkauff" would seem palpably erroneous.

Cypraea spadicea Swainson.— 4.

Trivia californiana (Gray).— Syn., *T. californica* Gray (Arnold, 1903).— 3.

Trivia solandri (Gray in Sowerby).— 1.

Erato vitellina Hinds.— 1.

Erato columbella Menke.— 4.

Alabina tenuisculpta diegensis Bartsch.— 5.

Bittium (Lirobittium) ornatissimum Bartsch.— 1 collected by Tom Burch.

Bittium (Semibittium) rugatum Carpenter.— 2 collected by the writer and another by Miss Edna Cook. One of the features of this deposit was the scarcity of Bittiums which are usually so abundant in our Pleistocene localities.

Cerithidea californica (Haldeman).— (29). Undoubtedly washed down from salt marshes.

Seila montereyensis Bartsch.— Syn., "*Seila assimilata* C. B. Ad." (Arnold, 1903).— (100). The commonest species of the family.

Cerithiopsis antefilosa Bartsch.— 2.

Cerithiopsis cosmia Bartsch.— 29.

Cerithiopsis oxys Bartsch.— 16.

Cerithiopsis antemunda Bartsch.— 8.

Cerithiopsis halia Bartsch.— 3.

Triphora pedroana (Bartsch).— Syn., *Trifora pedroana* Bart. (Dall, 1921).— 1 in White collection.

Rissoella sp. ?— 18 specimens tentatively referred to this genus, but absence of opercula and soft parts makes the assignment uncertain. These resemble somewhat elongated specimens of *Syncera translucens* (Cpr.), but they are narrowly umbilicated and spirally striated. This may be the species described by Bartsch (Proc. U. S. Nat. Mus., 70, 1927, p. 31) as *Rissoella ? californica*, but it appears to differ from the figure of that species in much rounder body whorl and less open umbilicus.

Rissoina kelseyi (Dall and Bartsch).— Syn., *Alaba oldroydi* Dall (Nautilus, 19, 1905, p. 15).— 3.

Rissoina pleistocena Bartsch.— 1 specimen collected by Mrs. E. M. Clark.

Turritella jewettii Carpenter.— 1 very worn specimen found by J. C. Marsh.

Turritella cooperi Carpenter.— 38.

Vermicularia eburnea (Reeve).— 4.

Aletes squamigerus Carpenter.— Syn., *Serpulorbis squamigerus* Cpr. (Arnold, 1903).— 19 specimens, one of which is probably referable to *A. s. pennatus* (Mörch). Whether this latter form is of any ecological significance is questionable.

Spiroglyphus lituellus (Mörch).— 1.

Micranellum crebricinctum (Carpenter).— Syn., *Caecum crebricinctum* Cpr., "*Caecum magnum* Stearns" (Arnold, 1903): *Micranellum pedroense* Bartsch (Dall, 1921; Oldroyd, 1927; Grant and Gale, 1931).— Common. (197).

It appears to the writer that *M. pedroense* Bartsch, and "*Caecum magnum* Sts." as figured by Arnold, are the young of *M. crebricinctum* Cpr. This species, during juvenility, is slender, rather strongly curved, and the plug is longer and narrower; as it becomes older, the slender part of the shell is discarded; some of the curve being lost, and the plug becomes thicker and more blunt.

Fartulum orcutti (Dall).— 3.

Fartulum occidentale Bartsch.— Common. (920).

Littorina scutulata Gould.— 2 immature specimens.

Lacuna unifasciata Carpenter.— 65.

Iselica fenestrata (Carpenter).— Syn., *Fossarus fenestrata* Cpr. (Arnold, 1903).— 1 collected by Miss Edna T. Cook.

Hipponix antiquatus cranioides Carpenter.— 2.

Hipponix tumens Carpenter.— 2.

Crepidula onyx Sowerby.— Common.

Crepidula excavata (Broderip).— Abundant.

Crepidula lingulata Gould.— Syn., *Crepidula dorsata* Brod. (Arnold, 1903).— Common.

Crepidula nummaria Gould.— Syn., *C. navicelloides* Nutt. (Arnold, 1903): "*C. nivea* C. B. Ad." (Oldroyd, 1927).— Common.

Crepidula nummaria glottidiarum Dall.— (30). An interesting feature in the presence of this race is that no trace was found of the Brachiopod, *Glottidia*, upon which it undoubtedly lived.

Crucibulum spinosum (Sowerby).— 7.

Calyptraea contorta Carpenter.— Syn., *Galerus mammillaris* Brod. (Arnold, 1903, at least part): *Calyptraea mammillaris* Brod. (Grant and Gale, 1931, part).— (380). This is probably the only species of the genus to be found

in the Upper San Pedro formation, but it is possible that the more northern *C. fastigiata* Gld. occurred in earlier periods. *Contorta* may be a stunted, southern form of *fastigiata*, but both differ from *mammillaris*, of southern waters, in their thinner shell.

Polinices (Neverita) reclusianus (Deshayes).— Common. (45).

Polinices (Neverita) altus Dall.— Abundant. (60).

Polinices (Euspira) lewisii (Gould).— Only 1 specimen is referred to this species, although a number of individuals in our series of *Polinices* have an open umbilicus. Neither this feature nor the presence or absence of a funicle seem to be good characters in differentiating between *lewisii* and *reclusianus*. A series of specimens before me at this writing proceeds without a perceptible break from a completely closed umbilicus to a wide open one. The funicle is often present in the juvenile shell and absent in the adult. The shoulder of the whorls is not a constant feature in *lewisii*, but is usually present; it is, also, sometimes indicated in *reclusianus*. *Lewisii* grows to a much greater size than *reclusianus* and ranges considerably farther north, specimens having been taken by the writer in southeastern Alaska.

Sinum scopulosum (Conrad).— Syn., *S. debile*, of some authors; not of Gould, 1853: *S. californicum* Oldroyd (Dall, 1921; Oldroyd, 1927).— Common. (130).

Acmaea cassis Eschscholtz subsp. ?— 2 juveniles.

Acmaea cassis nacelloides Dall.— 1.

Acmaea insessa (Hinds).— (30). The fact that this species, which lives on kelp, is the only member of the genus that is at all common in the deposit, is added evidence of scarcity of rocks.

Tricolia pulloides (Carpenter).— Syn., *Phasianella pulloidea* Cpr. (Dall, 1921): *P. pulloides* Cpr. (Oldroyd, 1927).— (300). Arnold's specimens of "*Phasianella compta* Gld." should be checked with this species.

Tricolia substriata (Carpenter).— Syn., *Phasianella substriata* Cpr. (Dall, 1921; Oldroyd, 1927).— 135.

Astraea (Pomaulax) undosa (Wood).— Syn., *Pomaulax undosus* Wood (Arnold, 1903).— 12.

Leptothyra carpenteri Pilsbry.— Syn., *Homalopoma carpenteri* Pils. (Grant and Gale, 1931).— 1.

Norrisia norrisi (Sowerby).— 10.

Halistylus pupoideus (Carpenter).— Syn., *H. subpupoideus* Tryon (Dall, 1921; Oldroyd, 1927).— 8.

Tegula (Chlorostoma) gallina (Forbes).— Syn., *Chlorostoma gallina* Fbs. (Arnold, 1903).— 17.

Tegula (Chlorostoma) gallina multifilosa (Stearns).— 1.

Tegula (Chlorostoma) aureotincta (Forbes).— Syn., *Chlorostoma aureotinctum* Fbs. (Arnold, 1903).— 26.

Tegula (? Chlorostoma) ligulata (Menke).— Syn., *Chlorostoma viridulum ligulatum* Mke. (Arnold, 1903).— 19.

Tegula (Promartynia) pulligo (Martyn).— 1 specimen in White collection.

Calliostoma canaliculatum (Martyn).— Common. (70).

Calliostoma gemmulatum Carpenter.— 18.

Calliostoma tricolor (Gabb).— Abundant. (190).

Calliostoma gloriosum Dall.— 1 collected by the writer, 2 by Miss Edna T. Cook.

Calliostoma supragranosum Carpenter.— 2.

Calliostoma splendens Carpenter.— 6.

Turcica caffea Gabb.— Syn., *Thalotia caffea* Gabb (Arnold, 1903).—2.

Margarites (Lirularia) optabilis (Carpenter).— Syn., *M. o. knechti* Arn., *M. o. nodosa* Arn. (Arnold, 1903; Grant and Gale, 1931).— (30). This series includes both the typical form and the variety *acuticostatus* Carpenter.

Vitrinella williamsoni Dall.— 29.

Vitrinella eshnauri Bartsch.— 13.

Vitrinella stearnsi Bartsch.— 17.

Delphinoidea coronadoensis Arnold.— 1.

Haliotis cracherodii Leach.— 1 fragment.

Fissurella volcano Reeve.— Syn., *F. v. crucifera* Dall (Dall, 1921; Oldroyd, 1927).— 3 specimens (Museum, 2; Miss Cook, 1).

Epitonium (Opalia) wroblewskyi (Mörch).— Syn., *Opalia borealis* Gld. (Arnold, 1903).— 1.

Epitonium (Opalia) retiporosum (Carpenter).— 2.

Epitonium (Asperiscala) bellastriatum (Carpenter).— Syn., *Scala bellastriata* Cpr. (Arnold, 1903).— Common. (240).

Epitonium (Asperiscala) clarki T. S. Oldroyd.— Abundant. (490).

Epitonium (Nitidiscala) acrostephanum Dall.— 25.

Epitonium (Nitidiscala) indianorum (Carpenter).— Syn., *Scala indianorum* Cpr. (Arnold, 1903).— (32). This is a puzzling series, varying greatly in number and form of varices. It may not be true *indianorum*, though I am not able to distinguish it from young of that species. None approaches the size of adults of *indianorum* from the north.

Epitonium (Nitidiscala) tinctum (Carpenter).— (35). Lacking the color band, this species is difficult to identify in the fossil, and it is probable that mistakes have been made. 150 juveniles of this group remain undetermined.

Epitonium (Nitidiscala) cooperi Strong.— Syn., "*Scala tincta* Cpr." (Arnold, 1903): *Epitonium hindsii* Cpr. (Packard, Univ. Calif. Publ. Zool., 14, 1918, p. 319): *E. fallaciosum* Dall (Dall, 1921; Oldroyd, 1927).— 48.

Epitonium (Nitidiscala) sawinae Dall.— Syn., *E. catalinensis* Dall (Dall, 1921; Oldroyd, 1927).— 64.

Melanella micans (Carpenter).— Syn., *Eulima micans* Cpr. (Arnold, 1903).— Abundant. (1850).

Melanella oldroydi Bartsch.— Rather uncommon. (24).

Melanella rutila (Carpenter).— Abundant. (1100).

Melanella sp. ? —3 specimens, the size of *rutila*, but less slender and with higher body whorl.

Strombiformis raymondi (Rivers).— Syn., *S. riversi* Bartsch (Proc. U. S. Nat. Mus., 53, 1917, p. 339).— (17). *S. californica* Bartsch is very similar to this species and may be the same, but none of our specimens of the Recent form is as large as adults of the fossil.

Turbonilla (Turbonilla) hypolispa Dall and Bartsch.— 21.

It is with much hesitation that the writer employs here a division of subgenera different from that in general use. The easier method would be to follow, without comment, the arrangement used by Dall and Bartsch in their great "Monograph of West American Pyramidellid Mollusks," which appeared in 1909. However, after intensive study of west American Turbonillas, the writer is not convinced that the generally accepted division of the group as regards subgenera is not more arbitrary than natural. In fact, a number of excellent conchologists, known as keen students of Californian shells, have expressed their inability to separate the various subgenera of *Turbonilla* by their supposed characters. The natural inference drawn by an average student from such a condition might well be that there is no difference in value between a subgenus and a section.

It appears to the writer that Californian members of the genus *Turbonilla* fall into five natural groups, as follows: *Turbonilla* (including *Chemnitzia* and *Strioturbonilla*), *Pyrgolampros, Pyrgiscus* (including *Pyrgisculus*), *Bartschella* (*Dunkeria*), and *Mormula.*

Chemnitzia and *Strioturbonilla* have been differentiated from the subgenus *Turbonilla* because their axial sculpture does not extend onto the base and, in case of *Strioturbonilla*, because of spiral striations. In the species usually assigned to the subgenus *Turbonilla* the strength of the basal sculpture varies greatly; in some species, such as *centrota* and *gilli*, it is very weak, while in others like *acra* and *diegensis*, it is strong. At least one species, *cayucosensis* Willett (Nautilus, 43, 1929, p. 26), lacks basal sculpture in the young and shows it in the adult. As to *Strioturbonilla*: Although Dall and Bartsch state that the "spiral sculpture is always stronger than microscopic striations," in the majority of specimens examined by the writer this sculpture was not perceptible under a magnification of thirty diameters. The characters cited as a basis of separation of *Pyrgisculus* from *Pyrgiscus* appear to the writer to be only of sectional value, rather than subgeneric. Of the known Californian species, only *laminata* is here assigned to the subgenus *Bartschella. Arata*, which was included in this subgenus by Dall and Bartsch, when further material is available, may prove to be conspecific with *weldi*, generally included in *Pyrgiscus.*

Turbonilla (Turbonilla) asser Dall and Bartsch.— 500.

Turbonilla (Turbonilla) torquata (Gould).— 145.

Turbonilla (Turbonilla) stylina (Carpenter).— 111.

Turbonilla (Turbonilla) buttoni Dall and Bartsch.— 4.

Turbonilla (Turbonilla) ralphi Dall and Bartsch.— Syn., "*T. torquata*

Gld." (Arnold, 1903).— 160.

Turbonilla (Turbonilla) simpsoni Dall and Bartsch.— 22.

Turbonilla (Pyrgolampros) lowei Dall and Bartsch.— 200.

Turbonilla (Pyrgolampros) pedroana Dall and Bartsch.— 175.

The last two species have been divided solely on the difference in number of ribs on the early whorls, no other stable differences being perceptible to me. There are also some specimens that appear to bridge the gap between *pedroana* and the following species.

Turbonilla (Pyrgolampros) arnoldi Dall and Bartsch.

Turbonilla (Pyrgolampros) halia Dall and Bartsch..

Turbonilla (Pyrgolampros) keepi Dall and Bartsch.— 1500. This splendid series appears to demonstrate conclusively that the three above named were conspecific in late Pleistocene. They exhibit a surprising amount of variation and, in addition to ranging through the three already described species, there are numerous variants that, if found under some conditions, would undoubtedly be considered worthy of naming. Whether these three species are still connected, or whether the connecting links have disappeared since late Pleistocene, will remain uncertain until a larger number of Recent specimens are available for study.

Turbonilla (Pyrgiscus) sanctorum Dall and Bartsch.— 3 specimens are referred to this species, although they have a few more incised spirals than the type has. The largest of our specimens has fifteen whorls and measures: alt., 10 mm.; diam., 2.2 mm.

Turbonilla (Pyrgiscus) cf. **superba** Dall and Bartsch.— 1 specimen, taken by Mrs. E. M. Clark and donated to the Museum, appears nearest to this species, but differs from the type in position of median series of pits, which is a little anterior to the middle of the whorl instead of posterior to it; furthermore, the ribs do not terminate as abruptly at the suture as is shown in the figure of *superba*. Our series of about 1000 specimens of the subgenus *Pyrgiscus* clearly demonstrates that many of the features generally used in differentiation of the species in the group are of little value. Variation in number and strength of both spirals and axials are endless. In many groups, undoubtedly of the same species, it is difficult to find two specimens exactly alike. These facts have caused the writer to adopt an entirely different view of the definition of species in the genus *Turbonilla*, with the direct result that no new ones are named in this paper, although there are numerous specimens that are different in appearance from anything hitherto described.

Turbonilla (Pyrgiscus) vexativa Dall and Bartsch.— 2.

Turbonilla (Pyrgiscus) antestriata Dall and Bartsch.— 290.

Turbonilla (Pyrgiscus) almo Dall and Bartsch.— (460). A study of our series leads to the conclusion that the type of *almo* was not adult. For variation in the species, see Plate 26, fig. 4.

Turbonilla (Pyrgiscus) adusta Dall and Bartsch.— 1.

Turbonilla (Pyrgiscus) weldi Dall and Bartsch.— Our 80 specimens exhibit great variation and appear to show intergradation between *weldi*, *wickhami* and *arata*.

Turbonilla (Pyrgiscus) cf. **ista** Bartsch.— 2.

Turbonilla (Pyrgiscus) canfieldi Dall and Bartsch.— (193). A variable series, extending from typical *canfieldi* to *histias;* some individuals indicating close relationship to *macbridei* and *almejasensis.*

Turbonilla (Bartschella) laminata (Carpenter).— 43.

Turbonilla (Mormula) tridentata (Carpenter).— Syn., *T. ambusta* Dall and Bartsch.— 565.

Turbonilla (Mormula) regina Dall and Bartsch.— Syn., *T. catalinensis* Dall and Bartsch.— (18). Throughout the subgenus *Mormula* the number of incised lines and axial ribs, and basal sculpture vary greatly within the species, in both fossil and Recent specimens. The writer is unable to find any constant characters separating *regina* from *catalinensis,* or *ambusta* from *tridentata.*

Turbonilla (Mormula) pentalopha Dall and Bartsch.—(23). The adult of this species is quite different in appearance from the figure of the type given by Dall and Bartsch; in fact, it is much more like their figure of the type of *castanea.* The last whorl is long and rounded and, in some examples, possesses more than forty axials, and the internal lirations are so far back as to be hardly perceptible without breaking away the outer lip.

Odostomia (Chrysallida) eugena Dall and Bartsch.— 2 specimens; an additional one in Miss Cook's collection.

Odostomia (Evalea) nemo Dall and Bartsch.— (2100). By far the most abundant *Odostomia.*

Odostomia (Evalea) donilla Dall and Bartsch.— 9.

Odostomia (Evalea) cf. **phanea** Dall and Bartsch.— 1.

Odostomia (Amaura) helena Bartsch.— (188). This species varies considerably in diameter and in amount of tabulation of whorls. Some specimens show spiral sculpture.

Lepidopleurus nexus (Carpenter).— Syn., *L. heathi* Berry, *L. ambustus* Dall (Dall, 1921; Oldroyd, 1927).— 2 head and 2 median valves.

Mopalia acuta (Carpenter).— 1 head, 2 tail and 7 median valves.

Ischnochiton sanctaemonicae Berry.— 1 median valve found by Miss Cook and donated to the Museum.

Helisoma cf. **trivolvis** (Say).— 2 juveniles.

Gyraulus vermicularis (Gould).— 2.

Zonitoides arboreus Say.— 1.