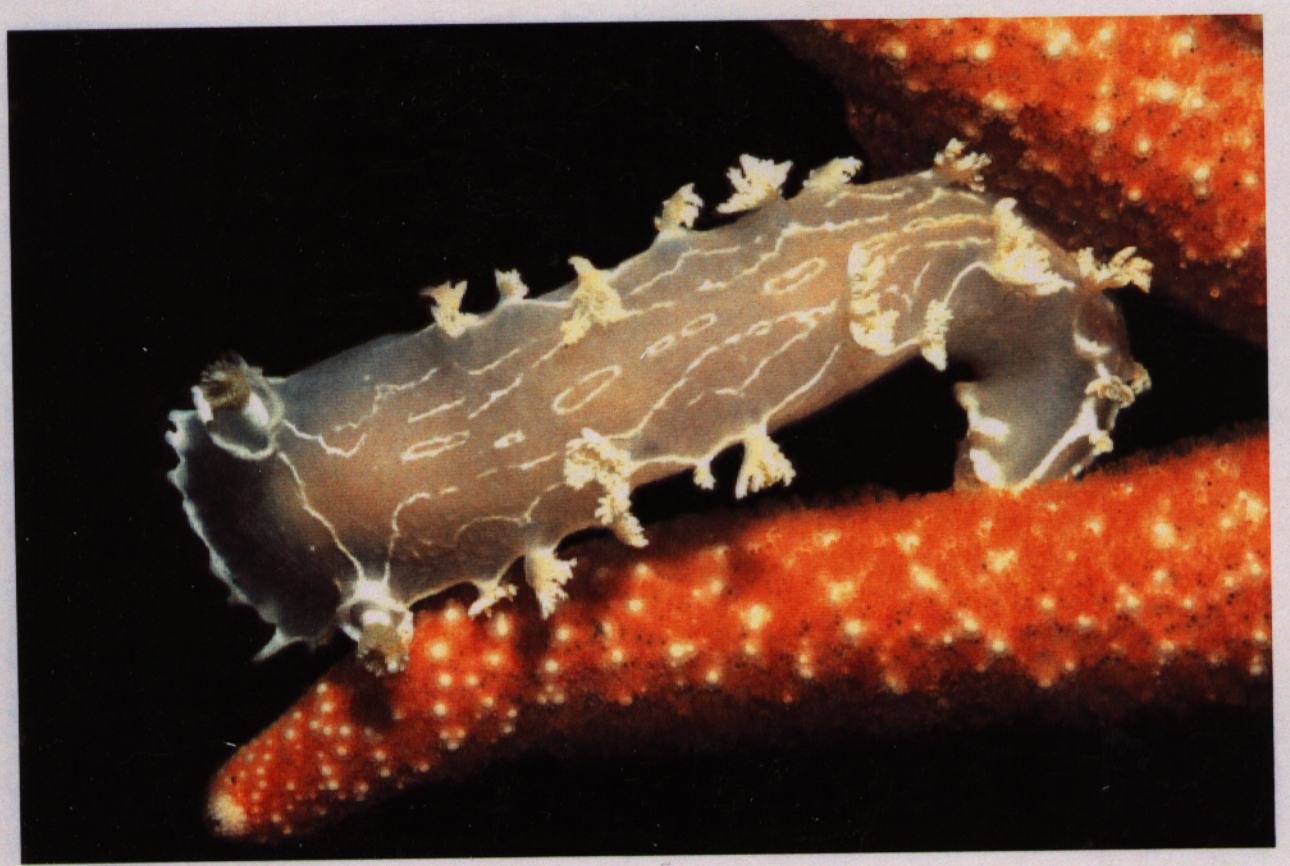
OCS Study
MMS 96-0002

Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and Western Santa Barbara Channel

FINAL REPORT
Volume 9 of 14

The Mollusca Part 2 — Gastropoda



U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

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Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and Western Santa Barbara Channel

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Volume 9 of 14

The Mollusca Part 2 — Gastropoda

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For:

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Minerals Management Service
Pacific OCS Region
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Minerals Management Service
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TAXONOMIC DISCLAIMER

This report is not deemed nor intended to be a valid publication for the naming of new taxa as stipulated in the International Code of Zoological Nomenclature, Article 8b.

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KEY WORDS: Marine invertebrates, Mollusca, Gastropoda, Prosobranchia, Opishtobranchia, taxonomy, California, Santa Maria Basin, Santa Barbara Channel, continental shelf.

BACKGROUND: The Taxonomic Atlas of the Santa Maria Basin and western Santa Barbara Channel is an extension of the benthic reconnaissance (Phase I) and monitoring programs (Phase II) that were conducted by the MMS since 1983. The organisms that were collected as part of those programs provide the material on which the Atlas is developed. In order to fully document the fauna collected by those programs, a series of 14 volumes will be prepared that provide keys, descriptions, and illustrations of the benthic fauna of the hard and soft substrate environments. A team of 40 experts on the fauna has been assembled to carry out this work and their contributions are distributed among the 14 volumes.

OBJECTIVES: The objectives of Volume 9 are to provide keys, descriptions, and illustrations to the gastropod mollusks of the Santa Maria Basin and western Santa Barbara Channel.

DESCRIPTION: This compilation of the marine gastropod fauna of southern California is the first major treatment of the prosobranch gastropods since McLean (1978) and for the opisthobranch fauna since McDonald and Nybakken (1980). The present work consists of an introduction, laboratory and field methodology, a glossary, and identification keys for both gastropod groups. Forty six families and 81 genera are diagnosed. One of the genera is identified as new and here described for the first time. A total of 154 species are illustrated in photographs or line drawings. Of these seven species are identified as new to science and are here described for the first time.

SIGNIFICANT CONCLUSIONS: The keys, detailed descriptions, and illustrations to the 154 species treated in this volume represent a major contribution to gastropod mollusk systematics for the eastern Pacific. Many poorly known species are newly defined with new illustrations and photographs. The prosobranch gastropods

are placed in a modern classification for the first time. One new gastropod genus and seven new species are described.

STUDY RESULTS: The fauna of the Santa Maria Basin and western Santa Barbara Channel is evaluated from samples that were taken from depths of about 50 to 1,000 m. Organisms were collected from soft sediments using box cores and from rocks using manipulator arms of submersibles and remotely operated vehicles. The collections are organized into sets of vouchers from Phase I and II that have been made available to the team of investigators. Additional material from the bulk collections now archived with the Natural History Museum of Los Angeles County is also being examined. The total number of species treated in the entire Taxonomic Atlas (14 volumes) may exceed 1,000 species.

A total of 154 species in 81 genera and 46 families are treated as part of volume 9. The scope of this volume includes materials from the MMS surveys as well as additional materials from the eastern Pacific accumulated by the authors. The authors have also examined numerous type specimens of most species and along with the collections treated have produced a monograph that will be applicable to the entire marine environment of western North America. In this regard, the volume becomes the most important compilation of data on northeastern Pacific gastropods in the last two decades. In addition to being an important taxonomic contribution, this study is a valuable contribution to understanding the distribution and zoogeography of gastropods in the eastern Pacific. The ranges of many species are extended; others restricted. One new genus and seven new species of prosobranch gastropods are here described for the first time.

STUDY PRODUCT: Scott, P. H., J. A. Blake, and A. L. Lissner (Editors). 1996. Taxonomic Atlas of the Santa Maria Basin and Western Santa Barbara Channel. Volume 9: The Mollusca Part 2 — Gastropoda. A final report prepared by Science Applications International Corporation, for the U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. OCS Study MMS 96-0002. Contract No. 14-35-0001-30484.

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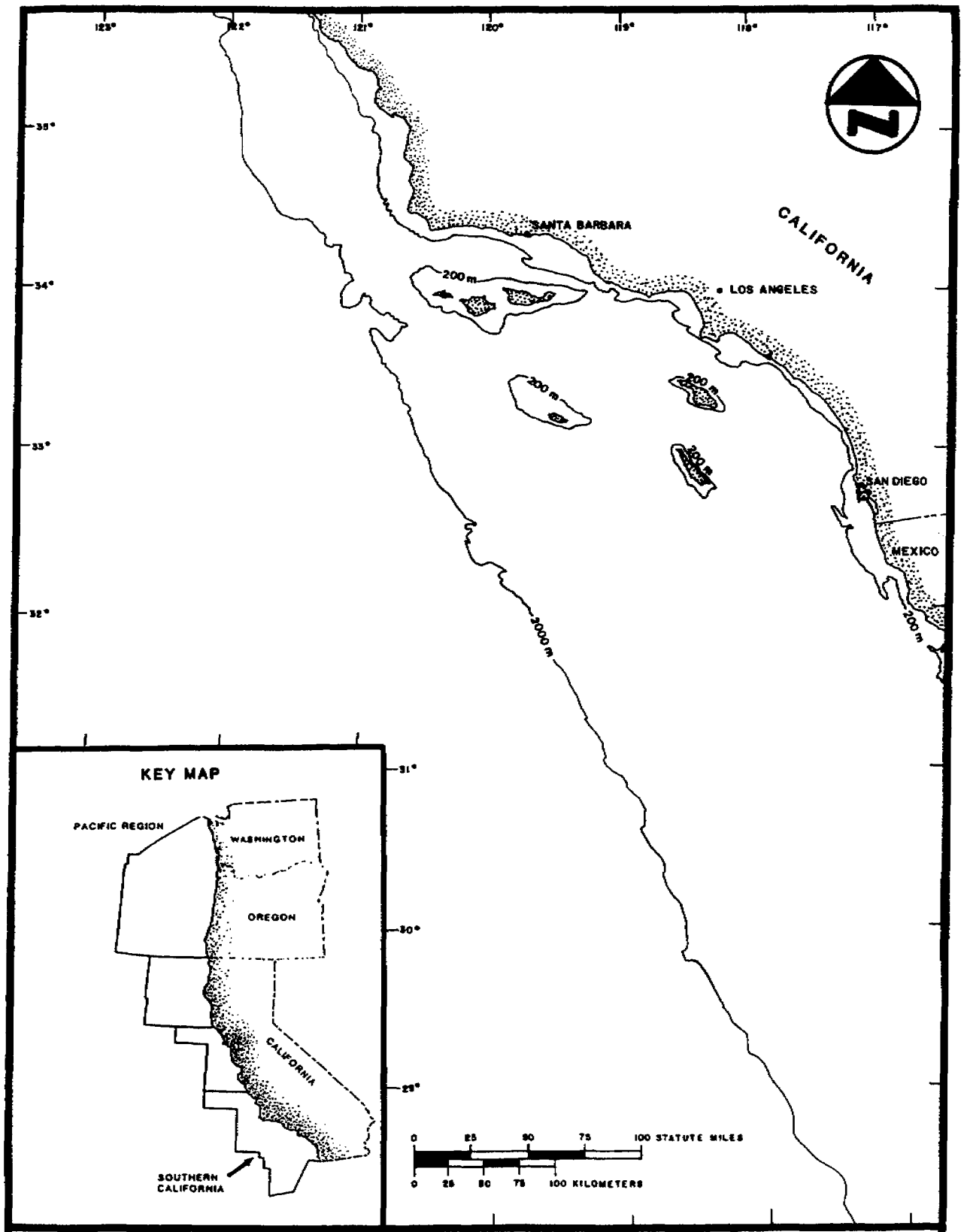

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16. Abstract (Limit: 200 words)

This compilation of the marine gastropod fauna of southern California is the first major treatment of the prosobranch gastropods since McLean (1978) and for the opisthobranch fauna since McDonald and Nybakken (1980). The present work consists of an introduction, laboratory and field methodology, a glossary, and identification keys for both gastropod groups. The scope of this volume includes materials from the MMS surveys as well as additional materials from the eastern Pacific accumulated by the authors. The authors have also examined numerous type specimens of most species and along with the collections treated have produced a monograph that will be applicable to the entire marine environment of western North America. In this regard, the volume becomes the most important compilation of data on northeastern Pacific gastropods in the last two decades. In addition to being an important taxonomic contribution, this study is a valuable contribution to understanding the distribution and zoogeography of gastropods in the eastern Pacific. The ranges of many species are extended; others restricted. Forty six families and 81 genera are diagnosed. One of the genera is identified as new and here described for the first time. A total of 154 species are illustrated in photographs or line drawings. Of these seven species are identified as new to science and are here described for the first time.

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List of Acronyms

ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania.
BLM	Bureau of Land Management.
BRA	Refers to a station designation from the MMS Phase I Reconnaissance: Benthic Rocky, transect A/B.
BRC	Refers to a station designation from the MMS Phase I Reconnaissance: Benthic Rocky, transect C/D.
CAS	California Academy of Sciences, Department of Invertebrate Zoology, San Francisco, California, USA.
LACM	Natural History Museum of Los Angeles County, Los Angeles, California, USA.
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA.
MMS	United States Minerals Management Service.
NHML	The Natural History Museum, London, United Kingdom.
SCAMIT	Southern California Association of Invertebrate Taxonomists.
SBMNH	Santa Barbara Museum of Natural History, Santa Barbara, California, USA.
SDNHM	San Diego Natural History Museum, San Diego, California, USA.
USNM	United States National Museum. A historical designation for the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, D.C., USA.
UCMP	Univesity of California Museum of Paleontology, Berkeley, California, USA.

1. The Prosobranchia

by

James H. McLean[1]

Introduction

The Subclass Prosobranchia, also known as Streptoneura, is used here in its traditional sense, although it is now understood to be a paraphyletic group, rather than one that is monophyletic and includes all of its descendants. As used here it includes the recently recognized suborder Patellogastropoda and the recently recognized suborder Vetigastropoda (Patellogastropoda and Vetigastropoda are part of the old suborder Archaeogastropoda), and the suborders Mesogastropoda and Neogastropoda (which together are also known as Caenogastropoda). These are the gastropods in which the effect of torsion is retained in the adult members—the mantle cavity retains its anterior position. The gill is a typical ctenidium, for the most part bipectinate in Patellogastropoda and Vetigastropoda, and monopectinate in Caenogastropoda. Most members, including all that are treated here, have external shells.

Some families that have previously been treated as prosobranchs, including the families Pyramidellidae, Architectonicidae, and Rissoellidae, are now considered primitive members of the Heterobranchia along with the more derived groups Opisthobranchia and Pulmonata; the latter two groups are united as Euthyneura (see Gosliner, Chapter 2).

Gastropod classification is currently in a state of flux and is likely to remain unsettled for some time. A traditional classification was outlined by Vaught (1989), but changes based on cladistic analysis of anatomical characters have been proposed by recent authors, including Haszprunar (1988, 1993) and Ponder and Waren (1988). Further modifications are anticipated. A detailed treatment of phylogeny and classification is omitted here because this work is intended primarily as an identification manual.

Prosobranch gastropods represent the largest group of marine mollusks; in numbers of species they surpass those of all other groups combined. Species can usually be identified on shell characters alone. The morphology of the radula differs among species in some families, providing additional characters for species differentiation; in other families it may be useful only at the family level.

Laboratory Methods

Identification of shelled gastropods is possible without using specialized techniques for relaxation or preservation, although the methods described by Gosliner in Chapter 2 of this volume are equally applicable and should be used for purposes other than identification of species. Small-shelled specimens can be fixed intact in 75% ethyl alcohol or 10% buffered formalin for 24 hours, followed by washing and transfer to 75% ethyl alcohol. The entire bodies of larger specimens cannot be fixed unless the shell is cracked in a vice, in order enable the fixative to penetrate through the early coils of the shell. Shells are best preserved in a dry state; even those kept in buffered alcohol will suffer corrosion after a number of years. Specimens previously fixed in formalin or alcohol can be washed and dried; the initial fixation allows the tissues to dry without decomposition. The radula (and to some extent, other organs) can still be studied at a later date by rehydrating the specimen, followed by preparation using conventional methods.

[1] Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007

Scope

The objective of this work is to provide an illustrated identification manual for the prosobranch gastropods occurring offshore at depths of 50 to 500 m in the vicinity of the Santa Maria Basin and the western Santa Barbara Channel. For the most part, it also applies to those of the southern California Bight, the entire area from Point Conception to the Mexican border. It is intended to provide coverage for species not included in my earlier field guide *Marine Shells of Southern California* (McLean, 1969; revised, 1978), in which I treated the species likely to be found in the intertidal zone and in the rocky sublittoral zone accessible by diving. A total of 126 species are treated herein, including 7 new species. Major revisions of the genera *Lirobittium*, *Boreotrophon*, *Scabrotrophon* (new genus), *Borsonella*, *Ophiodermella* and *Crockerella* are accomplished here.

Although my original intention had been to treat the heterobranch Pyramidellidae, which are well represented in the offshore habitats of southern California, they are not treated here because I have not as yet studied them to the same extent as the groups that are treated in this work.

There is little material in museum collections and few published records for the offshore gastropod fauna from the Santa Maria Basin and the entire area north of Point Conception. The collection produced by the Santa Maria Basin project thus fills a major gap. However, the voucher collection does not include many species of moderate to even large size that are expected to occur there, considering that their known distributions include the Monterey Bay area and the southern California Bight. I have therefore included species not in the voucher collection and have attempted to treat most of the offshore species not covered in *Marine Shells of Southern California* that are well represented in collections and known to occur between Monterey Bay and southern California. In order to increase the general utility of this work, there are some included species that are yet known only from the southern California Bight. Such species can be expected to occur north of Point Conception because the offshore fauna is less subject to the thermal barriers that may delimit the northern and southern faunas at Point Conception. However, budget limitations have made it necessary to omit some of the offshore species known only from the southern California Bight. Other species omitted are those of the lower continental slope below 500 m and the few broad ranging, true abyssal species, which have been poorly sampled off southern California.

This work coincides with work of mine on the entire prosobranch and shell-bearing heterobranch gastropod fauna ranging from Alaska to the outer coast of Baja California. Detailed accounts for approximately 1,100 species are in preparation, both for an annotated checklist and for an illustrated manual to follow. The checklist, which is nearing completion, will provide a current summary of my understanding of the systematic arrangement and synonymy of all names for shelled, benthic gastropods that have been proposed for the faunal provinces between Alaska and Baja California, giving geographic distributions and depth ranges for each species. Additional genera necessary for the species included here and in the larger context have been published (McLean, 1995), although one further new genus is introduced herein. Taxonomic innovations made here have also been done in the larger context of consideration of the entire fauna. Species that had to be omitted from the present work will therefore soon be fully treated, both in the checklist and the illustrated manual.

Conventions

Superfamilies

Traditional superfamilies are given in centered heading but are not diagnosed.

Families and Subfamilies

Families and subfamilies are diagnosed and notes on biology and general remarks with references to major revisions are included. These treatments are not exhaustive and may not be consistent from one family to the next. The objective here, however, is to lead the reader to the most recent accounts of the taxonomy and phylogeny of the group.

Genera

An understanding of generic concepts depends upon a comparison to the type species, which is a matter of importance to taxonomists. Type species and the manner of their designation are therefore cited here. The type species is the one species in the genus that is representative of the genus. If the type species was explicitly indicated in the original description the designation is called *original designation* (OD). If only one species was included in the original account and there is no statement to designate a type species, it becomes the type species by *monotypy* (M). If, however, more than one species was included and the author of the genus did not select a type species, then the first subsequent author who does so is cited as designator by *subsequent designation* (SD). Type species are cited by their *original combination*, the genus and species in which they were first proposed, although this may have little bearing on the genus to which they are now assigned. In addition, the faunal affinity of the type species is indicated.

Diagnosis. Brief description of the genus, intended to be applicable to all members.

Biology. Information about feeding and reproduction. If this section is omitted, see the heading under the family.

Remarks. Notes that apply to all species of the genus, including references to papers that are restricted in scope to the genus.

Species

Synonymies. All synonymies include the citation of the original description for the nominate species and its synonyms. Additional references in the synonymies are not complete but are intended to give major illustrated works, including the first illustration for a species originally described without figures.

References to the three volume work of Oldroyd (1927) are given because she provided a useful reprint of the original description and copies of original figures. Note that pagination for Oldroyd is that from the bottom of the page, continuous for the three volumes. References to Abbott's *American Seashells* (1974) serve to indicate some recent name changes.

To make it easier to follow, each name in a synonymy is treated in its various permutations before going on to the next synonym.

Material Examined. Gives station numbers and number of specimens for examined lots in the voucher collections for the Santa Maria Basin project. For maps showing positions of the stations see the appendix at the end of this volume. According to the contract for the preparation of this series, the Phase I and Phase II voucher specimens are being divided between the collections of the Santa Barbara Museum of Natural History and the United States National Museum of Natural History.

The number of examined lots in the LACM collection are also given to provide a quantitative measure of abundance for each species. Lots are the curated units in reference collections of mollusks; each lot can contain one or more specimens from the same collecting station.

Description. Brief descriptions are based on examination of specimens and study of previous literature. Size is indicated in mm for specimens considered to be mature, with a lower and upper limit.

Type Locality and Type Specimens. The type locality is the locality cited in the original publication, in some cases slightly abbreviated here for consistency. For some species, in which only museum catalog numbers for type material was originally included, I give further information from the original label.

Type specimens cited here are of three kinds. *Holotype*: The single specimen used in the original description. *Syntypes*: The original specimens used in an original description—indicating that a single specimen was not designated as the holotype by the original author. *Lectotype*: A single specimen from a syntype lot that has been designated by a later author to be the primary specimen of comparable standing to a holotype. References to lectotypes require citation of the author and date of the publication in which the designation was made. A number of lectotype designations for species and synonyms described by Dall are made herein. Paratypes and paralectotypes are not cited in the present work, except for the new species.

Depth records for the primary types are given in the original form, usually in fathoms. If this information is missing, none was provided in the original description.

Institutional abbreviations are found on after the List of Figures in the preface (page xx).

Catalog numbers for types at the CAS have been updated to the new 6-digit numbering system.

Distribution. Distributions are given north to south. States are cited, but not countries (e.g., Canada and Mexico). To assist in locating the end points, the latitude is given to the nearest half degree (e.g., 33°N, 35.5°N).

Northern and southern records are based on specimens in the LACM collection, unless the record is held in another museum, in which case the museum and catalog number is cited. For some species, the distributional record may be based on a published record, which is then cited by author, date, and page. In some cases the LACM catalog number of a distributional record is given in brackets.

Many of the end points represent new distributional records, but no effort is made to distinguish new limits because the baseline records in the literature for eastern Pacific gastropods are so out of date that there is no recognized source of information.

Habitat. Species are noted as being characteristic of either hard or soft bottoms and an estimation of the upper and lower limits of bathymetric occurrence is indicated in meters. These estimates are obtained from museum labels and take into account the original depths for type material. Extreme records from collections are ignored, as the objective is to increase the predictive value of the information.

Remarks. Comparisons to related species and notes relevant to the taxonomic history are given in this section. Changes to previously understood synonymies and classification are mentioned here.

If a species is often assigned to an established subgenus, this is mentioned here. Subgenera are usually omitted in the preparation of faunal lists and they are therefore not used in the formal headings in this work.

Illustrations. Locality information in the captions is abbreviated and does not include geographic coordinates from the LACM labels. The size for each figure was calculated from a plot of shell height against figure height, in order to show larger shells at a larger size than those of small-shelled species.

Literature Cited

The Literature Cited is intended to be complete for all references to publications in the text and the entries in the synonymies for which the pagination is given. It does not include references to the authors of families, genera and the type designations. It does not include references to species cited in the text for purposes of comparison; in such cases, the date is part of the name of the species, rather than a referral to the Literature Cited.

Multiple publications by the same author in a single year in the Literature Cited are not distinguished by subscripts (e.g., *a,b*). It is a simple matter to determine the correct reference by checking the pagination and figures for synonymy entries to see if they coincide with the inclusive pagination for each reference.

Glossary

Anal notch. Notch on outer lip near suture, corresponding to position of anus.

Anal sinus. Same as anal notch.

Angulation. Carina at midwhorl position.

Anterior notch. Notch at base of shell for the siphon of the living animal.

Aperture. Opening of the last whorl, through which the head and foot of the living animal emerge.

Aphallic. Lacking a penis or copulatory organ.

Apex. Early whorls or tip of the spire; this is the posterior end.

Apical. Pertaining to the apex.

Aspinose. Lacking spines.

Axial lamellae. Axial ribs of thin, bladelike form.

Axial ribs. Sculpture parallel to the axis of coiling.

Axis of coiling. Imaginary line around which the shell coils.

Base. Anterior end of the shell, the lower part to the left of the aperture if a dextral shell is held apex up.

Beading. Sculpture produced where axial ribs are crossed by spiral cords.

Bicarinate. Having two carina per whorl.

Body whorl. The largest and terminal spiral whorl of the shell.

Calcification. Formation of shell from calcium carbonate.

Callus. Thick deposit of shell material.

Canal. Extensions of the aperture; anterior or siphonal canal protects the siphon; posterior canal may be called the anal notch.

Cancellate sculpture. Formed by axial ribs and spiral cords intersecting at right angles.

Carina. Prominent spiral keel or ridge.

Chitin. Uncalcified protein forming periostracum and operculum.

Clathrate. Same as cancellate.

Columella. Shell pillar surrounding the axis of coiling.

Concentric. Sculpture of a limpet that corresponds to growth rings.

Cord. Ridgelike spiral sculpture.

Costae. Thin, strongly projecting axial ribs.

Crenulate. Having a regularly notched edge, usually from terminations of spiral sculpture.

Deck. Shelf of shell material in aperture of calyptraeids.

Denticle. Tooth shaped projections on inner and/or outer lip.

Dextral. Shell coiling in which the aperture is on the right when the shell is viewed with apex at the top.

Direct development. Larval stage passed within egg capsule.

Dorsum. Back side of gastropod shell, opposite aperture.

Fold. A ridge or plication on the columella.

Foramen. Hole in shell of Fissurellidae marking position of anal siphon.

Fossa. Broad trenchlike depression.

Fusiform. Elongate shell profile with spire and canal of similar length.

Growth lines. Simple axial sculpture resulting from successive growth increments on the outer lip.

Incised sculpture. Sharply cut grooves.

Inner lip. Inner margin of the aperture.

Intercalary cords. Cords of lesser strength between primary cords.

Involute. Shell growth in which the length of the aperture increases, concealing the spire

Lamellae. Sculpture of thin scales.

Lateral teeth. Teeth on either side of the rachidian tooth.

Lip. The growing edge of the shell.

Lip lirae. Spiral ridges within aperture at outer lip.

Marginal teeth. The outermost radular teeth in the row.

Multispiral operculum. Operculum having many whorls or turns.

Multispiral protoconch. Protoconch having many whorls or turns.

Nacre. Pearly interior layer of the shell (if present).

Nodose. Bearing tubercles or knobs.

Notch. Indented margin of shell.

Odontophore. Cartilage associated with radula.

Operculum. A horny, sometimes calcified, structure attached to the foot that may seal the aperture of the shell when the animal retracts.

Outer lip. Outermost margin of the aperture, the growing edge of the shell.

Parietal wall. Broad inner lip area of the body whorl.

Paucispiral operculum. Operculum having few whorls.

Paucispiral protoconch. Protoconch having only a few whorls or turns.

Penultimate whorl. The next to last whorl.

Periostracum. Horny or fibrous outermost layer of the shell, composed of conchiolin.

Peristome. Outline of the aperture.

Periphery. Outermost part of the whorl that projects farthest from the axis.

Peritreme. Combined growing edge of aperture, including inner and outer lips.

Planktotrophic. Larval stage that is free-swimming and feeding in the plankton.

Pustule. Small unit of knobby sculpture.

Plait. A fold or plication on the columella.

Plicae. Folds. Columellar plicae are folds on the columella.

Plicate: Folded or twisted.

Ptenoglossate. Type of radula with similar teeth in the row.

Protandric hermaphrodite. Sex change from male to female.

Protoconch. The larval shell.

Protractive. Axial sculpture in which the ribs project forward.

Rachidian tooth. The central radular tooth in the row.

Radial. Sculpture of a limpet that radiates from the apex.

Radula. Ribbon bearing teeth used for rasping food.

Retractive. Axial sculpture in which the ribs (and growing edge) curve backward.

Selenizone. Lamellar deposition marking previous positions of the anal notch.

Semilunate. Half moon outline of aperture produced by straight columella and rounded outer lip.

Sinistral. Shell coiling in which the aperture is on the left when the shell is viewed with apex at the top.

Siphon. Anterior extension of mantle used for water intake.

Siphonal canal. Anterior extension of shell surrounding the siphon.

Siphonal fasciole. Lamellar deposition marking previous positions of the siphonal canal.

Siphonal notch. Indented margin of shell for protrusion of siphon.

Shoulder. Uppermost projecting area on the whorl.

Slit. Indented margin of shell for water intake in Scissurellidae.

Spiral cords. Raised ridges that encircle the shell at right angle to coiling axis.

Spire. Whorls at apical end of the gastropod, posterior to the aperture.

Striae. Sculpture of minute grooves or ridges.

Subsutural. Referring to area just below suture when apex is held up.

Suture. Line marking the junction of the whorls.

Tabulate. With shelflike area below suture.

Teleoconch. The shell except for the protoconch.

Umbilicus. Open cavity at the base of the shell, within the axis of coiling.

Umbilical chink. Narrow depression, rather than open cavity.

Varices. Pleural of varix.

Varix. A larger than ordinary axial rib, representing the outer lip during a resting growth stage.

Veliger. Larval stage of gastropods with velar lobes.

Volution. A whorl of a shell or turn in an operculum.

Whorl. A turn or coil in a spirally coiled shell. The body whorl is the last and most inflated; the penultimate is the next to the last whorl.

List of Prosobranch Species

(new species in bold)

Family Lepetidae
Iothia lindbergi McLean, 1985

Family Lottiidae
Niveotectura funiculata (Carpenter, 1864)

Family Scissurellidae
Anatoma crispata (Fleming, 1832)

Family Fissurellidae
Scelidotoma bella (Gabb, 1865)
Cranopsis cucullata (Gould, 1846)
Puncturella cooperi Carpenter, 1864
Puncturella punctocostata Berry, 1947

Family Turbinidae
Macrarene farallonensis (A. G. Smith, 1952)
Homalopoma draperi McLean, 1984
Homalopoma paucicostatum (Dall, 1871)
Homalopoma berryi McLean, 1964
***Homalopoma cordellensis* McLean, new species**

Family Trochidae
Bathybembix bairdii (Dall, 1889)
Cidarina cidaris (Carpenter, 1864)
Calliostoma turbinum Dall, 1896
Calliostoma variegatum Carpenter, 1864
Calliostoma platinum Dall, 1890
Solariella peramabilis Carpenter, 1864
Solariella nuda Dall, 1896
Halistylus pupoideus (Carpenter, 1864)

Family Cerithiidae
Lirobittium rugatum (Carpenter, 1864)
Lirobittium lomaense (Bartsch, 1911)
Lirobittium fetellum (Bartsch, 1911)
Lirobittium larum (Bartsch, 1911)
Lirobittium paganicum (Dall, 1919)

Family Turritellidae
Turritella cooperi Carpenter, 1864

Family Rissoidae
Alvania rosana Bartsch, 1911
Alvania tumida Carpenter, 1857

Family Vitrinellidae
Vitrinella eschnaurae Bartsch, 1907

Family Caecidae
Caecum crebricinctum Carpenter, 1864

Family Vanikoridae
Megalomphalus californicus (Dall, 1903)
***Megalomphalus schmiederi* McLean, new species**

Family Calyptraeidae
Crepidula glottidiarum Dall, 1905
Crepipatella dorsata (Broperip, 1834)
Crepipatella orbiculata (Dall, 1919)

Family Ovulidae
Neosimnia loebeckiana (Weinkauff, 1881)
Neosimnia barbarensis (Dall, 1892)

Family Triviidae
Trivia ritteri Raymond, 1903

Family Naticidae
Euspira pallida (Broderip and Sowerby, 1829)
Calinaticina oldroydi (Dall, 1897)
Cryptonatica affinis (Gmelin, 1791)

Family Epitoniidae
Epitonium berryi (Dall, 1907)
Epitonium hindsii (Carpenter, 1856)
Epitonium indianorum (Carpenter, 1864)
Epitonium sawinae (Dall, 1903)
Epitonium lowei (Dall, 1906)
Nodiscala spongiosa (Carpenter, 1864)

Family Eulimidae
Eulima raymondi Rivers, 1904
Pseudosabinella bakeri (Bartsch, 1907)
Balcis micans (Carpenter, 1864)
Balcis oldroydae (Bartsch, 1917)
Polygireulima rutila (Carpenter, 1864)
Vitreolina columbiana (Bartsch, 1917)
Vitreolina macra (Bartsch, 1917)
Vitreolina yod (Carpenter, 1857)
Haliella abyssicola Bartsch, 1917

Family Muricidae
Ocinebrina lurida (Middendorff, 1848)
Ocinebrina barbarensis (Gabb, 1865)
Austrotrophon catalinensis (Oldroyd, 1927)
Boreotrophon triangulatus (Carpenter, 1864)

Boreotrophon multicostatus (Eschscholtz, 1829)
Boreotrophon bentleyi Dall, 1908
Boreotrophon avalonensis Dall, 1902
Boreotrophon eucymatus Dall, 1902
Boreotrophon apolyonis (Dall, 1902)
Boreotrophon raymondi (Moody, 1916)
Boreotrophon keepi (Strong and Hertlein, 1937)
***Boreotrophon kabati* McLean, new species**
Boreotrophon tolomius (Dall, 1919)
***Boreotrophon hazardi* McLean, new species**
Boreotrophon pedroanus (Arnold, 1903)
Boreotrophon stuarti (E. A. Smith, 1880)
Scabrotrophon maltzani (Kobelt and Küster, 1878)
Scabrotrophon cerritensis (Arnold,1903)
Scabrotrophon lasius (Dall, 1919)
***Scabrotrophon grovesi* McLean, new species**
***Scabrotrophon clarki* McLean, new species**
Ocenotrophon painei (Dall, 1903)

Family Turbinellidae
Exilioidea rectirostris (Carpenter, 1864)
Exilioidea kelseyi (Dall, 1908)

Family Buccinidae
Neptunea amianta (Dall, 1890)
Neptunea tabulata (Baird, 1863)

Family Nassariidae
Nassarius perpinguis (Hinds, 1844)
Nassarius rhinetes Berry, 1953
Nassarius insculptus (Carpenter, 1864)

Family Fasciolariidae
Fusinus barbarensis (Trask, 1855)

Family Columbellidae
Astyris gausapata (Gould, 1850)
Astyris permodesta (Dall, 1890)
Amphissa reticulata Dall, 1916
Amphissa bicolor Dall, 1892
Amphissa undata (Carpenter, 1864)

Family Cystiscidae
Plesiocystiscus myrmecoon (Dall, 1919)

Family Cancellariidae
Cancellaria cooperii Gabb, 1865
Cancellaria crawfordiana Dall, 1891
Admete californica (Dall, 1908)
Admete gracilior (Carpenter, 1869)

Family Turridae
Antiplanes catalinae (Raymond, 1904)
Antiplanes thalea (Dall, 1902)
Antiplanes briseis Dall, 1919
Carinoturris fortis Bartsch, 1944
Rhodopetoma diaulax (Dall, 1908)
Rhodopetoma renaudi (Arnold, 1903)
Pseudotaranis strongi (Arnold, 1903)
Pseudotaranis hyperia (Dall, 1919)

Family Conidae
Borsonella bartschi (Arnold, 1903)
Borsonella coronadoi (Dall, 1908)
Borsonella omphale Dall, 1919
Borsonella merriami (Arnold, 1903)
Borsonella hooveri (Arnold, 1903)
Borsonella pinosensis Bartsch, 1944
Ophiodermella inermis (Reeve, 1843)
Ophiodermella cancellata (Carpenter, 1864)
Ophiodermella fancherae (Dall, 1903)
Kurtzina beta (Dall, 1919)
Kurtzia arteaga (Dall and Bartsch, 1910)
Crockerella lowei (Dall, 1903)
Crockerella crystallina (Gabb, 1865)
Crockerella eriphyle (Dall, 1919)
Crockerella tridesmia (Berry, 1941)
Crockerella evadne (Dall, 1919)
Crockerella conradiana (Gabb, 1869)
***Crockerella scotti* McLean, new species**
Crockerella philodoce (Dall, 1919)
Crockerella cymodoce (Dall, 1919)
Crockerella castianira (Dall, 1919)
Daphnella clathrata Gabb, 1865

Key to Families

(based on shell characters of species treated herein)

Because shell characters are often convergent among prosobranch families, few can be defined on shell characters alone. The key that follows is not based on relationships and applies only to the species treated herein; other species in some families may not conform to the distinctions used here. A key based on phylogenetic distinctions would also be based on characters of radula and anatomy, but would be more difficult to use for identification purposes.

1A. Shell of limpet form 2
1B. Shell spirally coiled or tubular 5

2A. Shell simple cap-shaped 3
2B. Shell with foramen, notch at margin, or interior deck 4

3A. Apex one-forth shell length from anterior margin ..... Lepetidae
3B. Apex nearly central ..... Lottiidae

4A. Shell with notch or hole ..... Fissurellidae
4B. Shell with interior deck ..... Calyptraeidae

5A. Shell elongate, tubular ..... Caecidae
5B. Shell spirally coiled 6

6A. Shell with deep slit at periphery ..... Scissurellidae
6B. Shell not with deep slit at periphery 7

7A. Aperture circular or nearly so, rounded anteriorly, lacking siphonal canal or notch 8
7B. Aperture elongate, with siphonal canal or notch 16

8A. Shell interior nacreous 9
8B. Shell interior not nacreous 10

9A. Operculum calcified on outer surface ..... Turbinidae
9B. Operculum not calcified on outer surface ..... Trochidae

10A. High-spired, shell height more than 3 times aperture length 11
10B. Low-spired, shell height less than 3 times aperture length 13

11A. Axial ribs present ..... Epitoniidae
11B. Axial ribs lacking 12

12A. Spiral sculpture present ..... Turritellidae
12B. Spiral sculpture absent ..... Eulimidae

13A. Shell medium to large, over 8 mm diameter ..... Naticidae
13B. Shell minute, under 5 mm diameter 14

14A. Shell not umbilicate ..... Rissoidae
14B. Shell umbilicate 15

15A. Axial sculpture present ..... Vanikoridae
15B. Axial sculpture lacking ..... Vitrinellidae

16A. Aperture as long as shell 17
16B. Aperture less than length of shell 18

17A. Spiral sculpture lacking ..... Ovulidae
17B. Spiral sculpture present ..... Triviidae

18A. Columella with plications 19
18B. Columella smooth 20

19A. Sculpture lacking ..... Cysticidae
19B. Axial and spiral sculpture present ..... Cancellariidae

20A. Canal short or lacking 21
20B. Canal extending past length of aperture 23

21A. Aperture not deeply notched ..... Cerithiidae
21B. Aperture with deep siphonal notch 22

22A. Fasciole with deep fossa ..... Nassariidae
22B. Fasciole lacking deep fossa ..... Columbellidae

23A. Outer lip with deep anal sinus ..... Turridae, Conidae
23B. Outer lip not with deep anal sinus 24

24A. Sculpture spinous or lamellar ..... Muricidae
24B. Sculpture not spinous or lamellar 25

25A. Sculpture spiral only ..... Buccinidae
25B. Sculpture axial and spiral 26

26A. Periostracum smooth, glossy ..... Turbinellidae
26B. Periostracum rough, fibrous ..... Fasciolariidae

Descriptions of Species

Superfamily Acmaeoidea

According to the recent classification of Lindberg (1988:55), there are three families in the superfamily: Lepetidae, Acmaeidae, and Lottiidae. The distinction between the Lottiidae and the Acmaeidae was detailed by Lindberg (1986:142), along with other generic changes among the patellogastropod limpets of the northeastern Pacific.

Family Lepetidae Gray, 1850

Diagnosis. Shell of limpet form, with horseshoe-shaped muscle scar opening anteriorly; apex anterior, anterior slope concave, posterior slope convex, color usually white. Intermediate shell layers foliated and concentric crossed lamellar. Eyes and nuchal cavity gill lacking. Radula with 2 or 3 pairs of lateral teeth, first pair medially fused, forming a central tooth; marginal teeth 2 pairs, well developed.

Biology. Lepetid species live in cold water faunal provinces, some occurring in shallow water at high latitudes, others are deeply submergent at low latitudes. The only paper on the biology of a lepetid species is that of Yonge (1960).

Remarks. The Lepetidae are commonly known as the blind limpets, as the eyes of other patellogastropods are lacking.

Genera and species of Lepetidae are few. The family was reviewed worldwide by Moskalev (1977). Because differences in shell sculpture and external anatomy provide few generic characters, the classification is primarily based on radular characters. There are two main expressions of the fused inner lateral tooth: one having a long and tapered point, and one having cutting edge extending straight across. There is also a basic difference in marginal teeth, one kind has the cusp of the marginal teeth smooth and the other has a comblike fringe. Combinations of these two traits enables the definition of four genera on the basis of these characters.

Genus *Iothia* Gray, 1850

Iothia Gray, 1850. **Type species** (M): *Patella fulva* Müller, 1776. Northeastern Atlantic.

Diagnosis. Shell small, white, red-orange, or white with gray markings; sculpture of broadly spaced, imbricate radial ribs. Apex inclined anteriorly; protoconch erect, rounded, subspiral; apex of adult shell worn away. Interior termination of muscle scar posterior to apex. Animal with paired labial appendages. Fused inner lateral tooth of radula elongate and sharp pointed, outer pair of laterals greatly reduced and closely adjacent to fused inner laterals; marginal teeth narrow, inner surface with comblike fringe.

Remarks. *Iothia* differs from *Lepeta* Gray, 1847, in having an erect, non-spiral protoconch, the termination of the muscle scar behind the apex rather than in front of it, the marginal teeth narrower and fringed rather than smooth.

The massive, sharp-pointed central tooth (a fusion of the inner lateral teeth) may function to pierce the tests of encrusting bryozoa, which often occurs on rocks bearing *Iothia*.

Iothia species occur offshore, usually at depths greater than those accessible to divers.

Iothia lindbergi McLean, 1985

Figure 1.1A

Iothia lindbergi McLean, 1985:336, fig. 1.

Material Examined. California, Santa Maria Basin, Phase I: sta. 2, 200 m (4); sta. 6, 109 m (7). Other material: 22 lots in the LACM collection.

Description. Shell thin, translucent. Anterior slope concave to straight, posterior slope convex. Sculpture of concentric growth lines and widely spaced, irregular, imbricate ribs. Exterior and interior of shell white. Radula as for genus Length 5-10 mm.

Type Locality and Type Specimens. Off Point Piños, Monterey County, California, 180 m. Holotype: LACM 2063.

Distribution. Queen Charlotte Islands, British Columbia (54°N), to Islas San Benitos, Baja California (28°N).

Habitat. Rocky bottoms, 40-900 m.

Remarks. This species differs from *Iothia fulva* (Müller, 1776) in the northeast Atlantic primarily in lacking the reddish orange coloration of that species. No members of the genus are known to occur in the Arctic Ocean.

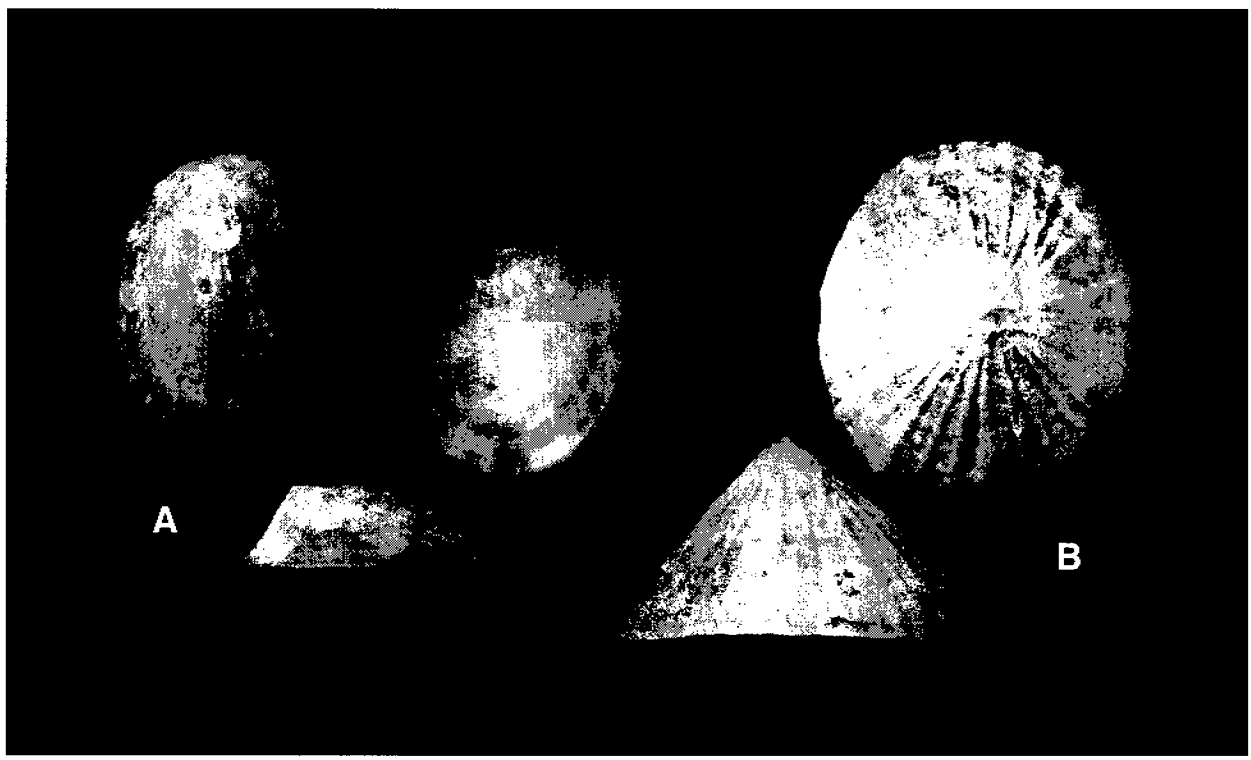


Figure 1.1. Lepetidae, Lottiidae. **A.** *Iothia lindbergi* McLean, 1985: 183 m, off Point Piños, Monterey County, California (LACM 2063, holotype); length 6.2 mm, 3 views. **B.** *Niveotectura funiculta* (Carpenter, 1864): 29 m, off Point Fermin, Los Angeles County, California (LACM 65-2.14); length 19.3 mm, 2 views.

Family Lottiidae Gray, 1840

Diagnosis. Shell of limpet form, with horseshoe-shaped muscle scar opening anteriorly; apex anterior, shell variously colored. Shell comprised of prismatic outer layers and crossed-lamellar inner layers. Eyes present, nuchal cavity gill usually present on left side. Radula with 3 pairs of mineralized lateral teeth; marginal teeth either 2 pairs, 1 pair, or lacking.

Biology. Lottiid limpets graze on surficial algae and diatoms. They are broadcast spawners.

Remarks. Lottiid limpets are abundant in numbers of species and individuals in the intertidal zone of the eastern Pacific.

Generic characters include details of shell structure and the number of marginal teeth and their morphology.

Genus *Niveotectura* Habe, 1944

Niveotectura Habe, 1944. **Type species** (OD): *Patella pallida* Gould, 1859. Northwestern Pacific.

Diagnosis. Shell medium to large, white; sculpture of strong radial ribs; lateral teeth 3 pairs; marginal teeth lacking.

Biology. The species of *Niveotectura* have the lateral teeth with blunt tips suited for grazing on coralline algae.

Remarks. There are two living species, the type species, which is a relatively large species common in shallow water of the northwest Pacific, and the smaller *Niveotectura funiculata*, occurring offshore in the northeastern Pacific. The genus was treated in detail by Lindberg and Marincovich (1988), who described a fossil species from Alaska.

Niveotectura funiculata (Carpenter, 1864)

Figure 1.1B

Scurria mitra var. *funiculata* Carpenter, 1864:650.—Palmer, 1958:123, pl. 17, figs. 24, 25 [holotype:].

Acmaea mitra var. *funiculata*: Oldroyd, 1927:747.

Acmaea funiculata: Hanna and Smith, 1931:21, pl. 2, figs. 1,3,4.—Lindberg, 1981:96, fig. 96A.

Niveotectura funiculata: Lindberg, 1988:143.

Scurria mitra var. *tenuisculpta* Carpenter, 1866:346 [nomen nudum].

Scurria mitra var. *tenuisculpta* "Carpenter," Dall, 1871:242.—Palmer, 1958:124, pl. 18, figs. 11-13 [syntype].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 47 lots in the LACM collection.

Description. Shell of medium to high profile, apex subcentral. All slopes straight. Sculpture of broad, flat radial ribs. Exterior and interior color white, sometimes tinted with pink. Radular teeth approximately equal in size and shape; cusps blunt; basal plates simple. Length 15-25 mm.

Type Locality and Type Specimens. Monterey, California. Holotype: USNM 14799. *Scurria mitra* var. *tenuisculpta*: Neah Bay, Clallam County, Washington; syntypes: USNM 15490.

Distribution. Shumagin Islands, Alaska (55°N, 160°W), to Bahía Magdalena, Baja California Sur, Mexico (25°N).

Habitat. 20-70 m, rock bottoms with coralline algae, below the thermocline in California.

Remarks. This species was first assigned to *Niveotectura* by Lindberg (1986:143). Superficially it resembles *Acmaea mitra* Rathke, 1833, in the family Acmaeidae, the shell of which differs in structure of its shell layers and in lacking the radial sculpture. Although the distribution of *Acmaea mitra* extends into the sublittoral, *Niveotectura funiculata* replaces it at greater depths, where it is the only species of Lottiidae known to occur. There is variation in shell height and strength of the radial ribbing. A detailed account of this species was first given by Hanna and Smith (1931). Palmer (1958:124) discussed the nude name *Scurria mitra* var. *tenuisculpta*, the validation of which she credited to Dall (1871).

Superfamily Scissurelloidea

Family Scissurellidae Gray, 1847

Diagnosis. Shell small, turbinate, umbilicate; lip with either slit or foramen; operculum multispiral. Shell structure of lamellar aragonite, interior lacking nacre. Ctenidia paired, the left larger than the right, ctenidial filaments finger-shaped. Left kidney a papillary sac; columellar muscles paired. Cephalic lappets and neck lobes lacking, cephalic tentacles setose, epipodial tentacles setose (except first 2 pairs); mantle margin with small papillae and setose pallial tentacles projecting through slit. Rachidian tooth of radula broad at base, tip narrow, with finely denticulate, overhanging cutting edge; first 4 lateral teeth cusped like rachidian and with broad basal areas overlaping adjacent laterals; fifth lateral larger and having long, finely denticulate tip; marginal teeth numerous, with long, serrate tips.

Biology. Scissurellids occur on soft bottoms offshore and on rock and gravel bottoms in shallow water. What little is known of the biology of scissurellids is based on knowledge of *Anatoma crispata*, as detailed by Fretter and Graham (1962, 1976). That species feeds on detrital material; its reproductive biology is unknown.

The most recent account of scissurellid anatomy is that of Haszprunar (1989).

Remarks. The Scissurellidae have small white shells with an open slit or foramen, which serves as an excurrent opening for water currents passing through the mantle cavity. Scissurellids resemble the much larger pleurotomariid slit-shells. Most scissurellid species occur offshore, where they are often overlooked because of their small size.

The Scissurellidae have long been recognized as a family. Based on anatomical differences from the Pleurotomariidae, the group has recently been elevated to the superfamily level (Haszprunar, 1989; McLean, 1989), an action more recently supported by studies of pleurotomariid sperm morphology by Healy and Harasewych (1992).

McLean (1989) offered a subfamilial classification of Scissurellidae based on gill and protoconch characters, recognizing four subfamilies. In addition to the typical subfamily, three were proposed as new: Anatominae, Temnocinclinae, and Sutilizoninae, the last two restricted to the hydrothermal-vent habitat.

Subfamily Anatominae McLean, 1989

Diagnosis. Genera of Anatominae have the protoconch sculpture finely reticulate, the ctenidia bipectinate and the radula with an enlarged pluricuspid (fourth lateral tooth).

Remarks. Anatominae differ from Scissurellinae in protoconch sculpture. Protoconchs of the scissurelline genera *Scissurella* d'Orbigny, 1824, and *Sinezona* Finlay, 1927, differ in having sculpture of strong axial ribs.

Genus *Anatoma* Woodward, 1839

Anatoma Woodward, 1839. **Type species** (M): *Scissurella crispata* Fleming, 1832. Circumboreal.

Description. Shell turbinate, umbilicate; spire elevated. Selenizone at the periphery, slit open one-fifth circumference of last whorl. Sculpture cancellate; protoconch smooth.

Remarks. Species occur in all oceans, primarily offshore on soft bottoms. The type species has the largest sized shell in the family. The genus *Scissurella* d'Orbigny, 1824, which is unknown in the eastern Pacific, differs in having the selenizone positioned on the shoulder, a lower spire, and a protoconch with axial sculpture.

Anatoma crispata (Fleming, 1832)

Figure 1.2A

Scissurella crispata Fleming, 1832:385.—Fretter and Graham, 1976:2, figs. 1, 2.

Scissurella (*Anatoma*) *crispata*: McLean, 1967:405, pl. 56, figs. 1-4.

Scissurella (*Schizotrochus*) kelseyi Dall, 1905:124.

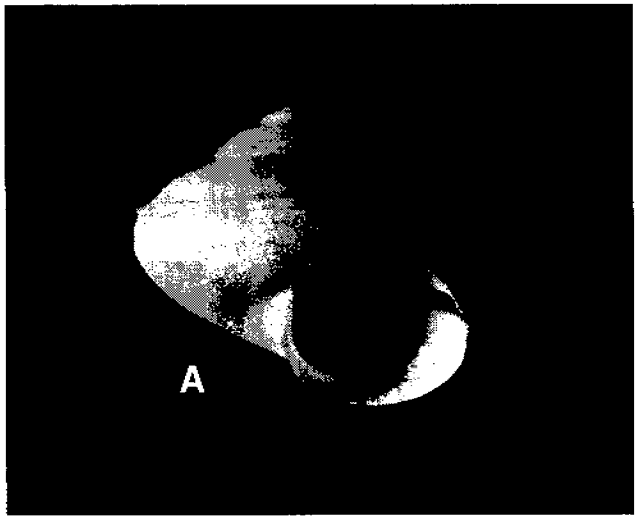
Scissurella chiricova Dall, 1919: 370.

Material Examined. California, Santa Maria Basin, Phase I: sta. 36, 492 m (1); sta. 108, 492 m (2). Other material: 30 lots in the LACM collection.

Description. Globose, delicate, translucent white, whorls 4, edges of selenizone sharp, raised. Axial sculpture of fine raised ridges, crossed by fine spiral ridges of equal strength. Outer lip thin, inner lip slightly reflected; umbilicus deep. Height 3-6 mm.

Type Locality and Type Specimens. Noss Island, Shetland Islands, Scotland; type material not located. *Scissurella kelseyi*: off Point Loma, San Diego County, California, 640 fathoms; holotype: USNM 181820, specimen missing. *Scissurella chiricova*, SE of Chirikov Island, Alaska, 695 fathoms; holotype: USNM 206509.

Distribution. Circumboreal, Arctic Ocean to Isla Cedros, Baja California (28°N); also south to the Mediterranean, the Azores, New England, and Japan.



Habitat. Soft bottoms from sublittoral to abyssal depths, becoming deeply submergent at lower latitudes. In the eastern Pacific it occurs as shallow as 55 m off the Queen Charlotte Islands, British Columbia, and at 400-1800 m off California.

Remarks. This species, described originally from the North Atlantic, has a number of additional synonyms from localities other than the eastern Pacific, as indicated by McLean (1967). The synonym *S. kelseyi* Dall was based on an exceptionally large specimen, 6 mm in height. One other species of the genus, *Anatoma lyra* (Berry, 1947), occurs in rocky sublittoral habitats in southern California (McLean, 1967).

Figure 1.2. Scissurellidae. **A.** *Anatoma crispata* (Fleming, 1832): 511-530 m, NW of Tanner Bank, California (LACM 77-250.23); height 4.0 mm.

Superfamily Fissurelloidea

Family Fissurellidae Fleming, 1822

Diagnosis. Shell conical, of limpet form, with anterior slit, notch, or dorsal foramen marking position of exhalent siphon; operculum lacking in adult. Shell composed of lamellar aragonite (some with exterior calcitic layer); shell interior not nacreous. Sculpture of radial ribs and concentric ribs of lesser strength; muscle scar horseshoe-shaped. Heart diotocardian, ctenidia paired, of equal size, with afferent and efferent membranes. Left kidney reduced, nearly vestigial. Epipodial tentacles stubby, in single row along sides of foot. Mantle folds capable of expansion to envelop shell, head, and foot. Radula rhipidoglossate, strongly asymmetric, the rachidian and 4 laterals weakly cusped, pluricuspid (outermost fifth lateral) large and strongly cusped; marginals numerous.

Biology. Members of the geologically oldest genera live from shallow to moderate depths and are known to graze upon encrusting invertebrates, particularly sponges and compound ascidians. The youngest genus, *Fissurella* Bruguière, 1789, feeds upon intertidal algae. Fissurellids are broadcast spawners; the planktonic veliger stage is short (Fretter and Graham, 1976).

Remarks. The fissurellid limpets are known as the slit limpets or the keyhole limpets, owing to the slit or fissure in the shell that serves as the excurrent opening from the mantle cavity. This is the only limpet group with paired gills.

The subfamily classification followed here is modified from that of Thiele (1929). Two subfamilies, the Emarginulinae and the Fissurellinae, are recognized, based primarily on radular differences (McLean, 1984, both references). Characters of the radula and the ontogeny of the slit or foramen provide the basis for the principal dichotomy. In the older Emarginulinae, the radula has a rhomboidal rachidian tooth, the outer lateral tooth is usually bicuspid, there are varying expressions of the slit or foramen, and a selenizone is represented, if only in early shell ontogeny. In the Fissurellinae, the rachidian tooth has a narrow neck and is similar in shape to the adjacent laterals; the outer lateral tooth is usually quadricuspid. The excurrent opening in the shell is always an apical foramen and there is no indication of a selenizone in early ontogeny.

Key to Species of Fissurellidae

1A. Shell with anterior notch at margin ..... *Scelidotoma bella*

1B. Shell with interior septum; foramen on anterior slope 2

2A. Mature shell length < 4 mm ..... *Puncturella punctocostata*

2B. Mature shell length > 6 mm 3

3A. Radial ribs strong, projecting at margin ..... *Cranopsis cucullata*

3B. Radial ribs low, not projecting at margin ..... *Puncturella cooperi*

Subfamily Emarginulinae Gray, 1834

Diagnosis. Rachidian tooth rhomboidal, outer lateral tooth bicuspid; slit or foramen preceded by selenizone, at least in early growth stages.

Remarks. All eastern Pacific fissurellids other than *Fissurella* are assigned to the Emarginulinae.

Genus *Scelidotoma* McLean, 1966

Scelidotoma McLean, 1966. **Type species** (OD): *Emarginula bella* Gabb, 1865. Northeastern Pacific.

Diagnosis. Shell large, white, with coarse radial ribs. Apex nearly central; selenizone marked by interior channel and arched exteriorly. Juvenile shells finely punctate and deeply notched, apex close to posterior edge of shell.

Remarks. *Scelidotoma* differs from other emarginuline genera in undergoing an ontogenetic change—the juvenile shells are deeply notched as in *Emarginula*, the notch becoming sinuous and marginal in mature shells.

I had previouly thought that the genus *Arginula* Palmer, 1937, type species *Emarginula arata* Conrad, 1833, from the Eocene of Alabama, was appropriate for the species *bella*, as used by Kozloff (1987:200), but no longer hold that view.

There are two species in the northwestern Pacific: *Scelidotoma gigas* (Von Martens, 1881), and *S. vadosinuata* (Yokoyama, 1922).

Scelidotoma bella (Gabb, 1865)

Figure 1.3A

Emarginula bella Gabb, 1865:188.

Hemitoma bella: Oldroyd, 1927:840.—Abbott, 1974:21 (listed only).

Scelidotoma bella: McLean, 1966:1, figs 1-2.

Subemarginula yatesii Dall, 1901:125.—Dall, 1902:555, pl. 38, figs. 1, 3.

Material Examined. Not represented in the Santa Maria Basin voucher collection, but occurring on hard bottoms to the north and south. Other material: 21 lots in the LACM collection.

Description. Shell relatively large, yellow-white; sculpture of about 24 strong primary ribs alternating with 1-3 secondary ribs. Margin crenulate; interior glossy white. Mantle yellow-white, foot slightly larger than shell. Length 40-75 mm.

Type Locality and Type Specimens. Monterey, California; "dredged." Holotype: UCMP 12552. *Subemarginula yatesii*: Monterey, California; holotype: USNM 162062.

Distribution. Forrester Island, southeastern Alaska (55°N), to Cabo San Martin, Baja California (30°N).

Habitat. Uncommon throughout its range, it has been found intertidally only in Alaska; in California it occurs on rocky bottoms below the thermocline at 20-110 m.

Remarks. The lack of an illustration and the smaller size (13.8 mm) of the original specimen of *Scelidotoma bella* accounted for the description of Dall's synonym *Subemarginula yatesii*.

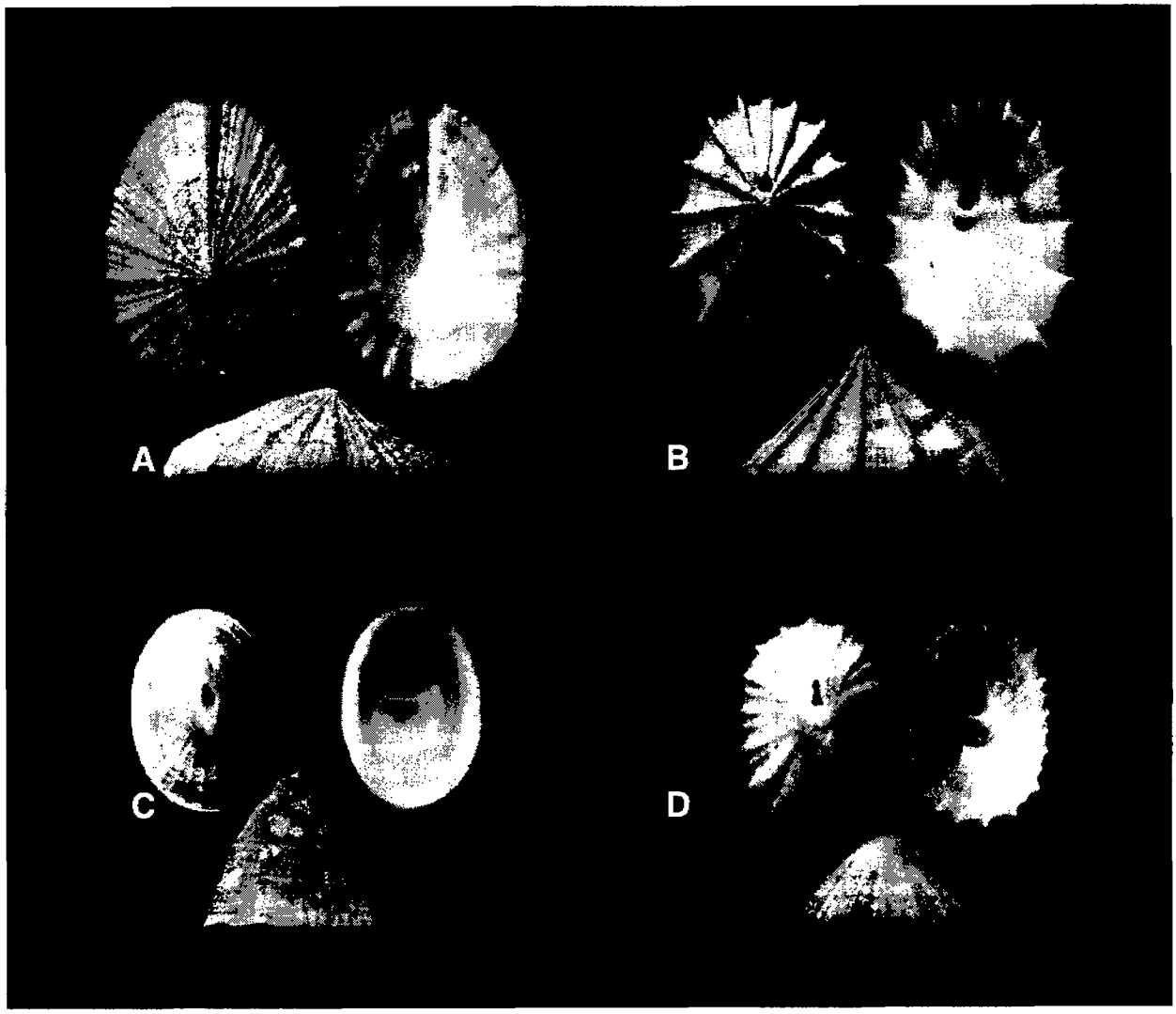


Figure 1.3. Fissurellidae. **A.** *Scelidotoma bella* (Gabb, 1865): 30 m, Monterey Bay, California (USNM 162062, holotype of *Subemarginula yatesii*); length 51 mm, 3 views. **B.** *Cranopsis cucullata* (Gould, 1846): 12-38 m, Carmel, Monterey County, California (LACM 60-24.71); length 31.8 mm, 3 views. **C.** *Puncturella cooperi* Carpenter, 1864: 86-117 m, Santa Catalina Island, California (LACM 40-155.17); length 7.2 mm, 3 views. **D.** *Puncturella punctocostata* Berry, 1947: 39 m, Carmel, Monterey County, California (LACM 60-24.72); length 3.1 mm, 3 views.

Genus *Cranopsis* A. Adams, 1860

Cranopsis A. Adams, 1860. **Type species** (M): *Cranopsis pelex* A. Adams, 1860. Japan.

Diagnosis. Anterior slope with interior and exterior groove or seam that extends from constricted lower end of foramen to shell margin. Groove located exteriorly between 2 closely adjacent ribs that form doubled, anteriormost primary rib; doubled rib deflected slightly toward right. Mantle skirt correspondingly split. Septum arched convexly, not supported by props.

Remarks. Earlier authors placed the *Cranopis* species in *Puncturella* Lowe, 1827, but the split mantle skirt of *Cranopsis* (described by Cowan and McLean, 1968) is unlike that of *Puncturella* Lowe, 1827, in which there is neither a split mantle nor a seam on the anterior slope of the shell, a distinction sufficient for the separate generic ranking of the two taxa.

Species of *Cranopsis* occur in both the northern and southern hemispheres, in shallow water at high latitudes and at greater depths at low latitudes.

Cranopsis cucullata (Gould, 1846)

Figure 1.3B

Rimula cucullata Gould, 1846: 159.

Puncturella cucullata: Oldroyd, 1927:843, pl. 93, fig. 4.

Puncturella (*Cranopsis*) *cucullata*: Abbott, 1974:22, fig. 59.

Material Examined. Santa Maria Basin, Phase I: sta. 6, 109 m (1); sta. 20, 396 m (1). Other material: 85 lots in LACM collection.

Description. Shell relatively large, outline high conical, primary ribs narrow, raised, usually 16, anteriormost lower than others and doubled; interspaces broad, secondary ribbing faint; apex anterior to center; foramen just anterior to apex, short, diamond-shaped; septum simple, convex. Length 30-42 mm.

Type Locality and Type Specimens. Puget Sound, Washington. Lectotype (selected by Johnson, 1964: 63): USNM 4325.

Distribution. Kodiak Island, Alaska (57°N), to Cabo San Quintin, Baja California (30°N).

Habitat. Occurring on vertical rock surfaces where it feeds on sponges. It occurs in progressively deeper water toward the southern part of its range: intertidal in the Gulf of Alaska, at 5 m in Southeastern Alaska, below 20 m in central California, and below 100 m in southern California.

Remarks. Other northeastern Pacific species of *Cranopsis* are *C. major* (Dall, 1891), *C. multistriata* (Dall, 1914), and *C. decorata* Cowan and McLean, 1968. The latter two species are also known from deep water in southern California. *Cranopsis cucullata* differs from each in having fewer radial ribs.

Genus *Puncturella* Lowe, 1827

Puncturella Lowe, 1827. **Type species** (monotypy): *Patella noachina* Linnaeus, 1771. Circumboreal.

Diagnosis. Shell conical, white; young shells with fine white punctations. Foramen on anterior slope, apex inclined toward right. Interior with forward-sloping septum separateing mantle cavity from visceral region; septum often flattened, supported by props; septum continuous with depressed selenizone originating just anterior to apex.

Remarks. *Puncturella* lacks the anterior seam on the shell and the split mantle roof that characterizes *Cranopsis*. The shells are also somewhat smaller than those of *Cranopsis*. Like *Cranopsis*, *Puncturella* species occur at high latitudes or in deeper waters at low latitudes in both the northern and southern hemispheres.

Puncturella cooperi Carpenter, 1864

Figure 1.3C

Puncturella cooperi Carpenter, 1864:651.—Oldroyd, 1927:842.—Palmer, 1958:120, pl. 18, figs. 16, 17.
Puncturella eyerdami Dall, 1924:133.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin, but occurring to the north and south. Other material: 64 lots in LACM collection.

Description. Relatively small, high-conical; outline oval. Septum simple, extending straight across, lacking props. Sculpture of numerous low, unequal ribs of varying strength, interspaces usually with fine granular punctations. Length 6-9 mm, height 6-10 mm.

Type Locality and Type Specimens. Off Santa Catalina Island, California, 20-40 fathoms. Holotype: USNM 11848. *Puncturella eyerdami*: Knight Island, Prince William Sound, Alaska; lectotype (**here designated**): USNM 360136.

Distribution. Kenai Peninsula, Alaska (59°N), to Punta Rompiente, Baja California (28°N). There is also a record (LACM 69-59.2) from the Cerralvo Channel, Gulf of California.

Habitat. On rock bottoms at 20-130 m throughout its distribution, not uncommon.

Remarks. Most specimens have the sculpture eroded. The lectotype of *P. eyerdami* is an uneroded specimen that shows fine punctations, which led Dall to believe that what he described as that species was different.

Puncturella punctocostata Berry, 1947

Figure 1.3D

Puncturella punctocostata Berry, 1947:11, pl. 1, figs. 7-9.
Puncturella ralphi Berry, 1947:13, pl. 1, figs. 4-6.
Puncturella (*Puncturella*) *punctocostata*: McLean *in* Keen, 1971:313, fig. 11.

Material Examined. There are no specimens represented in the voucher collection from the Santa Maria Basin, but the species is common offshore to the north and south. Other material: 37 lots in the LACM collection.

Description. Small, apex relatively large, posterior to center. Septum thin, extending straight across and lacking props. Ribs beaded and varying in number, strength, and prominence of the beading; rib interspaces finely punctate. Outline variable, nearly circular to elongate-oval. Length 2.0-3.5 mm.

Type Locality and Type Specimens. Middle Pleistocene, Lomita Marl, San Pedro, California. Holotype: S. S. Berry Collection no. 11998. *Puncturella ralphi*: Same locality; holotype: Berry no. 11999; paratypes: SBMNH 34530. Holotypes for both taxa are missing; they have not been located in Berry material at SBMNH or CAS.

Distribution. Cordell Bank, off Point Reyes, Marin County, California (38°N), to Cortes Bank, California (32°N) and Isla Guadalupe, Baja California (29°N). There is a single record from the Gulf of California: 55 m at Isla Carmen (26°N) (SDNHM).

Habitat. On rocky bottoms in 20-100 m, particularly at the offshore banks and islands where it may be collected by divers.

Remarks. This species and its synonym were described originally from the Pleistocene of southern California, but has subsequently been found living. *Puncturella ralphi* was based on specimens with more numerous ribs, but such specimens are well within the range of variation observed in Recent specimens.

Superfamily Trochoidea

Family Turbinidae Rafinesque, 1815

Diagnosis. Shell small to large, interior usually nacreous, umbilicate or non-umbilicate; aperture oblique, sculpture varied. Operculum with paucispiral pattern on corneous inner surface; outer surface with thick calcareous deposit, with pattern of sculpture produced by envelopment by foot. Protoconch with pointed tip. Ctenidium bipectinate, having free tip and either long or very short dorsal afferent membrane. Radula rhipidoglossate; rachidian tooth larger than laterals; marginals numerous.

Biology. Turbinids generally live on hard bottoms, grazing on algal films. They are broadcast spawners, with short veliger stages.

Remarks. Turbinids are characterized by a calcareous operculum, which is secreted by, and enveloped by, the foot, except when the animal is disturbed and the foot withdrawn into the shell. Hickman and McLean (1990) divided the family into several subfamilies, including Liotiinae, Colloniinae, Turbininae, and Tricoliinae. The rhipidoglossate radula has a similar pattern throughout the family, unlike the Trochidae in which there is much greater radular diversity. The relatively unspecialized radula led Hickman and McLean (1990) to regard the Turbinidae as more primitive than the Trochidae.

Key to Species of Turbinidae

1A. Operculum with calcareous beads on external surface ..... *Macrarene farallonensis*

1B. Operculum with fully calcified external surface 2

2A. Axial sculpture present ..... *Homalopoma draperi*

2B. Axial sculpture lacking 3

3A. Three spiral cords per whorl ..... *Homalopoma paucicostatum*

3B. More than 3 spiral cords per whorl 4

4A. Four to 5 spiral cords per whorl ..... *Homalopoma cordellensis*

4B. More than 6 spiral cords per whorl ..... *Homalopoma berryi*

Subfamily Liotiinae H. and A. Adams, 1854

Diagnosis. Shell small to medium-sized, deeply umbilicate, interior nacreous. Aperture circular, peritreme complete, suture descending on final whorl; final lip usually thickened. Axial sculpture of sharp lamellar increments and more broadly spaced axial ribs, both kinds of axial sculpture especially prominent deep within umbilicus; spiral sculpture of prominent cords. Operculum multispiral, corneous on inner surface, outer surface with calcareous granules or beads deposited on each volution and aligned in radiating pattern; chitinous fringe produced at outer edge of each volution. Left ctenidium lacking dorsal afferent membrane along most of length. Cephalic lappets lacking, neck lobes simple. Rachidian tooth broad, cutting edge poorly developed; lateral teeth 5, with overhanging tips, bulging laterally and overlapping adjacent lateral teeth; marginals numerous, inner marginals like those that follow.

Remarks. The scaly sculpture, thickened final lip, and beaded operculum are characteristic features of this subfamily.

Genus *Macrarene* Hertlein and Strong, 1951

Macrarene Hertlein and Strong, 1951. **Type species** (OD): *Liotia californica* Dall, 1908. Southern California.

Diagnosis. Relatively large for family, white, depressed turbiniform; umbilicus broad; aperture circular, inflated, suture descending on final whorl. Sculpture of fine axial fimbriations and coarse spiral cords; periphery strongly keeled, made stellate by axial ribs on upper half of whorl. Final lip lacking varix; axial sculpture more closely spaced preceding final lip. Operculum markedly concave, each whorl with thin calcareous ridge and dense tufts of chitinous material projecting at margin.

Remarks. Macrarenes are the largest liotiids. Small specimens have the appearance of the genus *Liotia*.

One other species occurs in California, the larger *M. cookeana* (Dall, 1918), which lives at depths accessible to divers as far north as Anacapa Island (see McLean, 1978:23, fig. 9.8).

Macrarene farallonensis (A. G. Smith, 1952)

Figure 1.4A

Liotia farallonensis A. G. Smith, 1952:385, pl. 20, figs. 2-4.

Macrarene farallonensis: McLean *in* Keen, 1971:348, fig. 137.

Arene (*Macrarene*) *farallonensis*: Abbott, 1974:55.

Material Examined. Not represented in the voucher material from the Santa Maria Basin, but occurring to the north and south. Other material: 4 LACM lots.

Description. Shell white, periphery stellate to spinose. Spiral sculpture of 3 major cords: peripheral cord, another at level of suture, and strong basal cord. Axial sculpture strongest across base. Height 9 mm, diameter 12 mm.

Type Locality and Type Specimens. Southeast Farallon Island, California. Holotype: CAS 064382.

Distribution. Cordell Bank, California (38°N), to San Jaime Bank, off Cabo San Lucas, Baja California Sur (23°N).

Habitat. Rocky bottoms, 60-140 m, below depths accessible to divers.

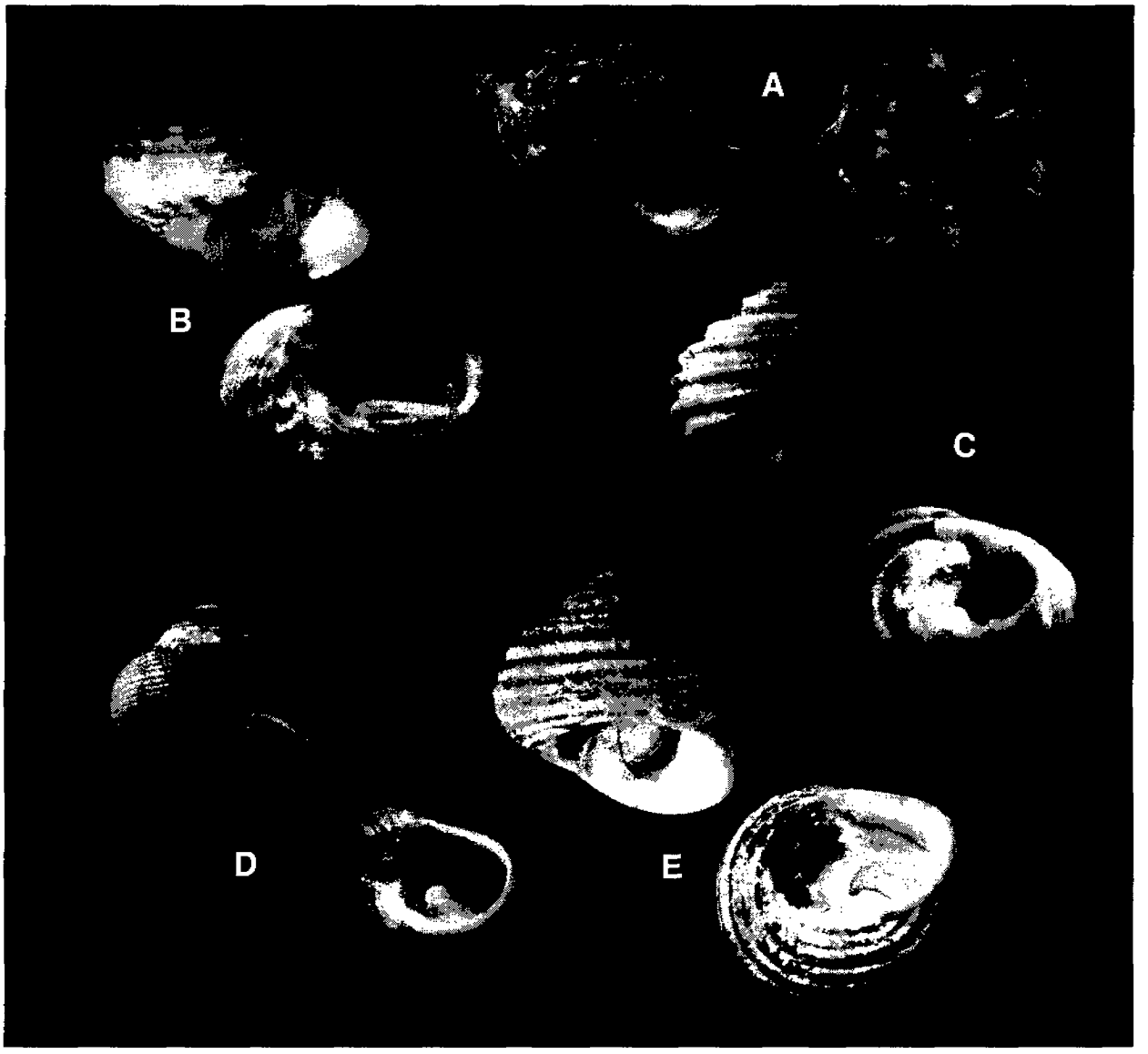


Figure 1.4. Turbinidae. **A.** *Macrarene farallonensis* (A. G. Smith, 1952): 64-66 m, Santa Rosa Island, California (LACM 41-197.2); height 8.6 mm, 2 views. **B.** *Homalopoma draperi* McLean, 1984: 20-30 m, Isthmus Cove, Santa Catalina Island, California (LACM 2001, holotype); height 4 mm, 2 views. **C.** *Homalopoma paucicostatum* (Dall, 1871): 9-15 m, N side Santa Cruz Island, California (LACM 63-5.30); height 4.4 mm, 2 views. **D.** *Homalopoma berryi* McLean, 1964: 21 m, N side San Nicolas Island, California (LACM 72-101.33); height 3.7 mm, 2 views. **E. *Homalopoma cordellensis* McLean, new species**: 37-55 m, off Point Sur, Monterey County, California (LACM 2779, holotype); height 7.2 mm, 2 views.

Remarks. Two forms of this species usually occur together: one has well developed axial sculpture (as in the holotype figured by A. G. Smith) and the other has a more stellate peripheral cord and weaker axial sculpture (figure 1.4A). Such variation would suggest the presence of two separate species if intermediate forms were not known from most localities at which the species has been collected.

The species was first discovered in bird guano at Southeast Farallon Island, the original specimen having evidently first been swallowed by a bottom-feeding fish.

Subfamily Colloniinae Cossmann, 1916

Diagnosis. Shell small to medium in size, sculpture chiefly spiral, columella usually with 1 or 2 low denticles, mature lip often thickened. Operculum calcareous on outer surface.

Biology. Little is known of the biology of colloniine species. They occur on rock or gravel bottoms.

Remarks. Prior to the revision of Hickman and McLean (1990), this group was known as the Homalopomatinae Keen, 1960. Hickman and McLean used the older name Colloniinae Cossmann, 1916, a name that had originally been intended for non-nacreous genera. However, the presence or absence of interior nacre is not significant in the subfamily, even at the generic level. The radula is similar to that of the Liotiinae, unlike the more modified radula of the Turbininae.

Genus *Homalopoma* Carpenter, 1864

Homalopoma Carpenter, 1864. **Type species** (M): *Turbo sanguineus* Linnaeus, 1758. Mediterranean.

Diagnosis. Shell relatively small, solid, spire depressed; juvenile shell umbilicate, adult shell usually imperforate. Suture shallow, descending on final whorl; lip thickened in mature shells. Sculpture chiefly spiral, some species with axial ribs, columella with a moderately strong denticle at base, and another, smaller denticle a little lower on basal lip. Aperture nacreous white, thin glaze of callus extending on base in advance of aperture. Inner side of operculum corneous, with a multispiral pattern; external surface concave, showing multispiral pattern at first, final whorl more rapidly expanding and thickened close to columella.

Cephalic lappets lacking, left and right neck lobes simple, mouth a vertical slit, lip not slit mid-ventrally. Rachidian tooth of radula uncusped or weakly cusped, lateral teeth 5 pairs, their bases overlapping those of adjacent laterals; intermediate uncusped tooth (lateromarginal plate) present between laterals and marginals; marginals numerous .

Remarks. *Homalopoma* species are abundantly represented in the northeastern Pacific, particularly in shallow water (McLean, 1978). Another offshore species in southern California is *Homalopoma grippi* (Dall, 1911), treated by McLean *in* Keen (1971:350).

***Homalopoma draperi* McLean, 1984**

Figure 1.4B

Homalopoma draperi McLean, 1984:238, fig. 8.

Material Examined. California, Santa Maria Basin, Phase I: sta. 6, 109 m (1); sta. 20, 396 m (1). Other material: 45 lots in LACM collection.

Description. Medium sized, color usually pink with white flecks on cords; suture deeply impressed. Early cords fine and numerous, mature cords irregular in strength and spacing; basal sculpture variable, some specimens with 2-3 strong, well spaced cords, others with fine regular basal cords. Parietal callus covering umbilical chink and forming projecting inner lip; callus extending in advance of aperture on base, forming distinct glazed area. Height 3-5 mm.

Type Locality and Type Specimens. Isthmus Cove, Santa Catalina Island, California, 20-30 m. Holotype: LACM 2001.

Distribution. Pacific Grove, Monterey County (37°N), to Cortez Bank, California (33°N).

Habitat. Living on gravel bottoms at 20-100 m, particularly at the Channel Islands off southern California.

Remarks. This species is characterized by the fine early cords and the irregular strength of the cords on mature whorls. It is highly variable, prior to its description having been confused with the common shallow-water species *Homalopoma luridum* (Dall, 1885), which differs in having cords of regular strength and spacing. This species occurs away from rocky bottoms; it replaces *H. luridum* on gravel slopes below the kelp zone.

Homalopoma paucicostatum (Dall, 1871)

Figure 1.4C

Leptothyra paucicostatum Dall, 1871: 131, pl. 15, fig. 10.—Oldroyd, 1927:770.

Homalopoma paucicostatum: McLean, 1978:24, fig. 10.1.

Material Examined. California, Santa Maria Basin, Phase I: sta. 6, 109 m (1). Other material: 47 lots in LACM collection.

Description. Medium sized, sculpture of 4 strongly elevated spiral cords per whorl, base with 3 additional spiral cords; interspaces broader than cords; axial sculpture wanting; mature lip greatly thickened, columellar denticle prominent; color usually tan with pink cords; red and white color forms also known. Height 4.5 mm.

Type Locality and Type Specimens. Monterey, California. Lectotype (here selected): USNM 193796.

Distribution. Salt Point, Sonoma County, California (38°N), to Cabo San Quintin, Baja California (30°N).

Habitat. Not uncommon on gravel bottoms under kelp; unknown from the intertidal zone.

Remarks. This species lacks all traces of axial sculpture. It is one of the few species from hard bottoms in the Santa Maria Basin that can also be collected at sublittoral depths accessible to divers.

Homalopoma berryi McLean, 1964

Figure 1.4D

Homalopoma berryi McLean, 1964: 132, pl. 24, figs. 7, 8.

Material Examined. Not recorded from Santa Maria Basin. Other material: 24 lots in the LACM collection.

Description. Shell relatively small, suture moderately impressed. Sculpture of fine evenly spaced spiral cords on whorls and base, suture descending on final whorl, lip not greatly thickened in mature specimens. Color usually dark pink, white in area adjacent to columella; gray, brown, or white forms also known. Height 3.5 mm.

Type Locality and Type Specimens. Middle Pleistocene, Timms Point Silt, San Pedro, California. Holotype: LACM 1138.

Distribution. Cordell Bank, Marin County, California (38°N), to Isla Todos Santos, Baja California (32°N).

Habitat. Rocky bottoms, usually below depths accessible to divers, 20-110 m.

Remarks. The shell is smaller and has much finer and more regular spiral cords than the common shallow-water species *Homalopoma luridum* (Dall, 1885). *Homalopoma berryi* was described from Lower Pleistocene formations at San Pedro and Santa Barbara, California; however, living specimens are now known from moderately deep water at Cordell Bank and near most of the Channel Islands in southern California.

Homalopoma cordellensis McLean, new species

Figure 1.4E

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined in addition to type lot: LACM 81-50.35, Cordell Bank, off Point Reyes, Marin County, California, 37-52 m, on granite pinnacles; leg. R. W. Schmieder, 1981-1984 (604 shells). LACM 69-35.30, Tanner Bank, California, 30-37 m; J. H. McLean, 5 October 1969 (11, bryozoan encrusted). LACM 49-141.5; Osborn Bank, California, 64 m (1 shell).

Description. Shell of medium size for genus, spire moderately high; whorls 3.5; periphery rounded; suture not deeply impressed, descending on final whorl. Color brick red, strongest on crests of spiral cords, interspaces lighter in color. Protoconch diameter 0.3 mm; early whorls rounded, at first with 4 cords, then 5 cords on final whorl opposite aperture. Mature cords on final whorl 11, including cord bordering columella, cords of even strength and spacing throughout; interspaces slightly broader than cords. Immature specimens narrowly umbilicate. Mature aperture oblique; parietal area in advance of aperture glazed, red. Columella with 1 prominent tubercle and 1 lesser tubercle below; outer lip weakly lirate within. Nacre of aperture thin, overall appearing white. Operculum typical for genus, opaque white, thicker where adjacent to columella. Height 7.2 mm (holotype with operculum in place); height 6.2 mm (live-collected paratype with operculum in place).

Type Locality and Type Specimens. Unnamed rocky bank, 3 miles WSW of Point Sur, Monterey County, California (36°17'N, 121°58'W), 37-55 m, collected by R. W. Schmieder and other divers of Cordell Expeditions, September 1988 and October 1989; 386 mature specimens and numerous juveniles, of which two mature specimens have the operculum in place. Holotype LACM 2779; 370 paratypes LACM 2780; 5 paratypes USNM 887573; 5 paratypes SBMNH 142894; 5 paratypes CAS 102982.

Distribution. Cordell Bank (38°N) to Tanner Bank, California (32.5°N).

Habitat. Rocky bottoms of offshore banks, 30-55 m.

Remarks. This species differs from the common shallow-water species *Homalopoma luridum* (Dall, 1885) in having a consistent red color and fewer and more broadly spaced spiral cords (11 cords rather than 13-14 cords). Populations of *H. luridum* that occur in southern California have smaller shells and color variations that include white and red to gray-brown forms, although more northern populations tend to be larger and more consistently reddish.

I had initially considered that the new species could represent a form of *Homalopoma luridum* with fewer cords that occurs at greater depths. The two species seldom occur at the same station. However, one lot from Cordell Bank, collected by Schmieder (LACM 82-50.34, 17 specimens), is identified as *H. luridum* and suggests that where the two occur together, *H. luridum* is mature at a much smaller size and has more numerous spiral cords. This is consistent with the observation that other lots identified as *H. luridum* from offshore stations throughout the distribution of the species are generally of smaller size than those occurring in shallow water.

Homalopoma draperi McLean, 1984, differs in its lower profile and more numerous early cords; it also replaces *H. luridum* at depths below the thermocline in southern California. *Homalopoma draperi* is more commonly represented offshore in southern California than is *H. cordellensis,* which is better represented from material from central and northern California.

The name derives from the Cordell Expeditions (organized by Robert Schmieder) to that bank and other offshore banks. Numerous empty shells were collected at Cordell Bank during four years diving expeditions during the fall months of 1981-84, but it was not until the 1988-89 expeditions to the unnamed bank off Point Sur that two live-collected specimens were obtained.

Family Trochidae Rafinesque, 1815

Diagnosis. Shell size medium to large, interior usually nacreous; umbilicate or non-umbilicate, aperture oblique, peritreme complete or incomplete, final lip rarely thickened; sculpture varied. Operculum corneous, pattern multispiral on both surfaces, never enveloped by foot. Protoconch with pointed tip. Ctenidium bipectinate, with free tip and either long or very short dorsal afferent membrane, or monopectinate and lacking afferent membrane. Epipodium variously developed; cephalic lappets present or lacking; neck lobes simple, digitiform, or rolled to form siphons. Radula rhipidoglossate, lateral teeth typically 5 pairs, usually similar to rachidian tooth, lateromarginal plate well developed, marginals numerous.

Biology. Life modes and feeding habits in the Trochidae are diverse and differ among the numerous subfamilies. Some groups live on hard bottoms and feed by grazing on algal films, others live on soft bottoms and ingest mud, while others have become infaunal and derive part of their nutrition from deposit or suspension feeding, having highly modified gills for the purpose. Some groups have become carnivorous, feeding on cnidarians. Differing feeding specializations are reflected in the diverse radular patterns known in the family.

Remarks. The Trochidae, commonly known as the top shells, are extremely diverse. Numerous genera and species inhabit all oceans, living at all depths, on both hard and soft bottoms. Like the turbinids, the innermost shell layer is nacreous. They differ from the turbinids in lacking the exterior calcified layer on the operculum.

Hickman and McLean (1990) divided this large family into 10 subfamilies, based on characters of the radula, gill, and external morphology of the epipodium. Unlike the turbinids in which the radular plan is conservative, the trochid radula has specialized features in each of the subfamilies. Modifications of the epipodium and snout are diverse in the trochids; these features are useful as characters for subfamily classification. Shell characters are often convergent between subfamilies and there are many examples of similar shell morphology in unrelated groups having widely differing radular and epipodial characters.

Key to Species of Trochidae

1A. Interior not nacreous ..... *Halistylus pupoideus*
1B. Interior nacreous 2

2A. Umbilicus lacking in mature shell 3
2B. Umbilicus present in mature shell 7

3A. Sculpture coarsely clathrate 4
3B. Sculpture of finely beaded spiral cords 5

4A. Mature shell height > 40 mm ..... *Bathybembix bairdii*
4B. Mature shell height < 30 mm ..... *Cidarina cidaris*

5A. Surface gray, spiral cords weak to absent ..... *Calliostoma platinum*

5B. Surface not gray, spiral cords strong 6

6A. Whorls rounded ..... *Calliostoma turbinum*

6B. Whorls nearly flat-sided ..... *Calliostoma variegatum*

7A. Body whorl with strong spiral sculpture ..... *Solariella peramabilis*

7B. Body whorl smooth ..... *Solariella nuda*

Subfamily Calliotropinae Hickman and McLean, 1990

Diagnosis. Umbilicus open or closed, shell sculpture coarsely cancellate, often with prominent nodes. Outer lip simple, columella lacking denticles. Gill with short afferent membrane; snout tip expanded. Base of rachidian tooth broad, excavated at sides to interlock with adjacent marginals, lateral teeth often reduced to 3 pairs.

Remarks. Hickman and McLean (1990) recognized this group at the level of a tribe in the subfamily Eucyclinae Koken, 1897. I have elected to follow Waren and Bouchet (1993:11) in treating it at the subfamily level in order to avoid the ambiguity of including an extinct fossil group for which the affinity remains speculative.

Genera of Calliotropinae occur offshore on soft bottoms. The expanded snout tip assists in feeding by mud-ingestion.

Genus *Bathybembix* Crosse, 1893

Bathybembix Crosse, 1893. New name for *Bembix* Watson, 1879, not DeKoninck, 1844. **Type species** (OD): *Bembix aeola* Watson, 1879. Japan.

Diagnosis. Shell moderately large, thin, suture deeply impressed; umbilicus closed in mature shell. Sculpture of well-spaced axial and spiral cords, nodose at intersections. Color white under a gray to greenish, waxy-brown periostracum. Rachidian tooth broadly flanged, bearing numerous fine serrations along sides; lateral teeth 3 pairs; marginal teeth numerous.

Remarks. All species occur offshore on soft bottoms, some at abyssal depths. In addition to the following species, the genus is represented in the eastern Pacific by *Bathybembix macdonaldi* (Dall, 1890) and *B. humboldti* Rehder, 1971, both of which occur off the western coast of South America. Several species occur off Japan.

***Bathybembix bairdii* (Dall, 1889)**

Figure 1.5A

Turcicula bairdii Dall, 1889: 378.—Dall, 1890:346, pl. 7, fig. 3—Oldroyd, 1927:793.

Lischkeia bairdii: Abbott, 1974:39, fig. 263.

Bathybembix bairdii: McLean *in* Keen, 1971:331, fig. 62.—Hickman and McLean, 1990:82, fig. 44B.

Solariella oxybasis Dall, 1890:352.

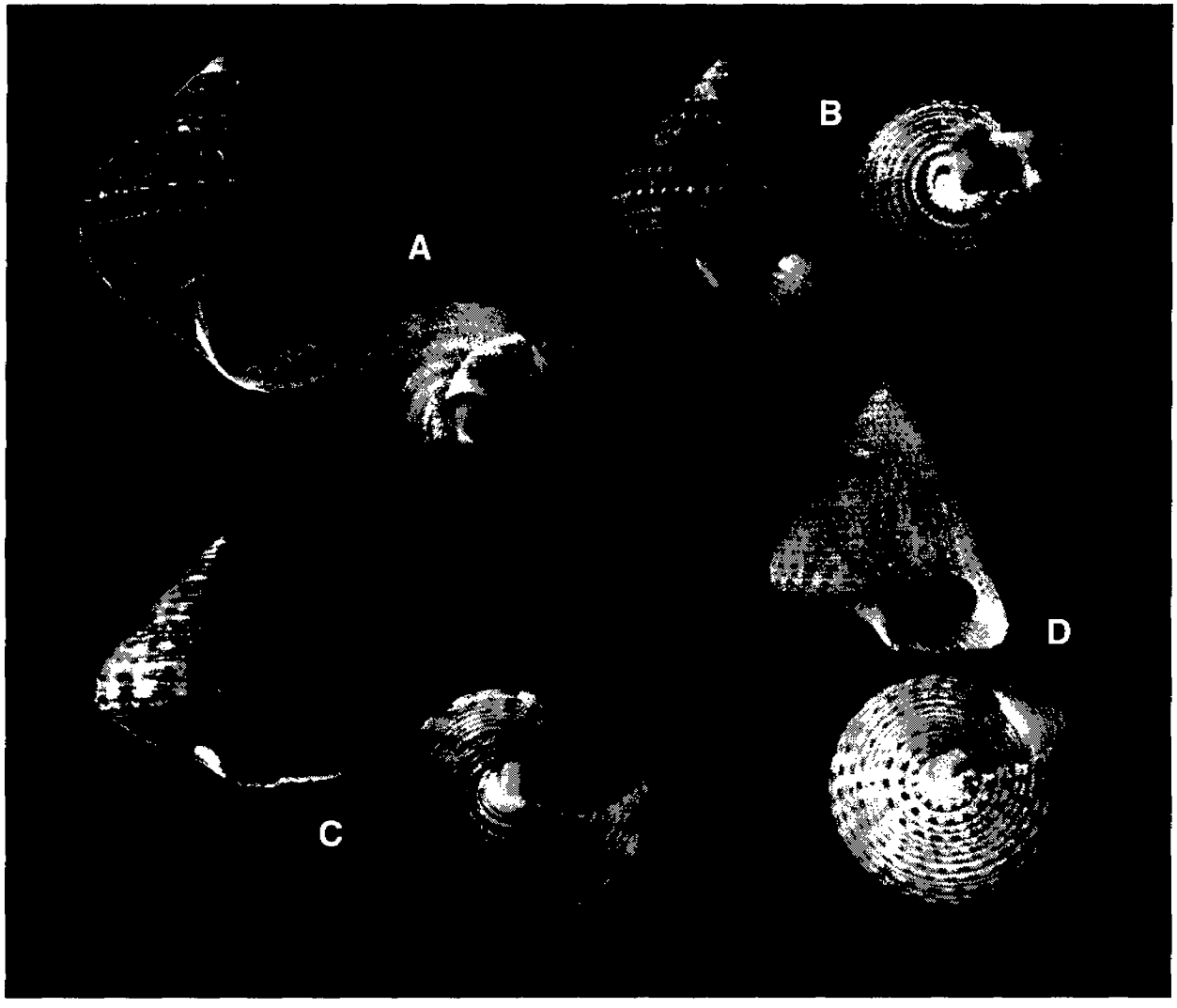


Figure 1.5. Trochidae. **A.** *Bathybembix bairdii* (Dall, 1889): 757 m, off San Clemente Island, California (USNM 94865, lectotype); height 50 mm, 2 views. **B.** *Cidarina cidaris* (Carpenter, 1864): 265-274 m, SE of Santa Catalina Island, California (LACM 40-146.1); height 23.3 mm, 2 views. **C.** *Calliostoma turbinum* Dall, 1896: 183 m, off Point Conception, Santa Barbara County, California (USNM 122578, holotype); height 12 mm, 2 views. **D.** *Calliostoma variegatum* Carpenter, 1864: 73 m, off Long Point, Santa Catalina Island, California (LACM 53-69.1); height 22.9 mm, 2 views.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material: 51 lots in the LACM collection.

Description. Suture strongly channeled, early whorls with 3 nodular carinations connected by fine axial ridges, middle carination sometimes obsolete; final whorl with prominent peripheral nodes; base with finely beaded lirations; interior nacreous white. Height 40-50 mm.

Type Locality and Type Specimens. Off San Clemente Island, California, 414 fathoms. Lectotype (designated by McLean *in* Keen, 1971:944): USNM 94865. *Solariella oxybasis*: 414 fathoms off the Santa Barbara Islands; holotype: USNM 87587.

Distribution. Queen Charlotte Islands, British Columbia (54°N), to the Gulf of Tehuantepec, Mexico (15°N).

Habitat. Mud bottoms, 350-1400 m. Merriman (1967) reported the gut of *Bathybembix* to be filled with mud, as expected in a deposit feeder, although Hickman (1981) described selection for small particles.

Remarks. The synonym *Solariella oxybasis* was based on a juvenile specimen.

Genus *Cidarina* Dall, 1908

Cidarina Dall, 1908. **Type species** (OD): *Margarita cidaris* Carpenter, 1864. Northeastern Pacific.

Remarks. The genus is monotypic; generic and specific accounts are combined.

Cidarina cidaris (Carpenter, 1864)

Figure 1.5B

Margarita cidaris Carpenter, 1864:653 [cited as "A. Adams, n. s."].

Cidarina cidaris: Oldroyd, 1927:795, pl. 91, fig. 7—Palmer, 1958:137, pl. 17, fig. 13 (holotype).—Hickman and McLean, 1990:82, fig. 44G.

Lischkeia (*Cidarina*) *cidaris*: Abbott, 1974:39, fig. 264.

Material Examined. California, Santa Maria Basin, Phase I: sta. 14, 299 m (1 juvenile). Other material examined: 127 lots in LACM collection.

Description. Suture deeply channeled, early whorls with 3 strongly noded cords, intercalary cords appearing on later whorls; whorls flat-sided at first, mature whorls evenly rounded; base with evenly spaced spiral cords, strongly beaded near umbilical chink. Color white under a closely adherent, gray, dull-surfaced periostracum. Lateral teeth of radula 3 pairs. Height 25-35 mm.

Type Locality and Type Specimens. Neah Bay, Clallum County, Washington. Holotype: USNM 15600.

Distribution. Prince William Sound, Alaska (60°N), through the Gulf of Alaska, south to Isla Cedros, Baja California (28°N).

Habitat. This species occurs as shallow as 35 m in the northern part of its range, but is usually found deeper than 100 m in California, extending to depths of 300 m. The feeding biology of this species has not been investigated, but may prove to be similar to that of the closely related *Bathybembix bairdii*.

Remarks. Shells are smaller, thicker, and more sharply sculptured than those of *Bathybembix*. *Cidarina* occurs at shallower depths than *Bathybembix*. Specimens from California tend to have more closely spaced nodes than those from British Columbia.

Subfamily Calliostomatinae Thiele, 1924

Diagnosis. Shell morphology and sculpture varied. Afferent ctenidial membrane present; cephalic lappets present. Left and right neck lobes with simple margins or rolled into siphons. Snout with pseudoproboscis, a gutter-shaped, tubular extension of mid-ventral lip directed to right. Foot expanding over base of shell. Rachidian and lateral teeth thin, with long tapered overhanging tips, finely serrate on each side; marginal teeth numerous; first marginal strong, with a number of inwardly directed cusps; second marginal of similar shape but thinner and longer; outer marginals long.

Biology. The diet of *Calliostoma*, unlike other trochids, has been reported to include hydroids, gorgonians, and anemones (Perron and Turner, 1978). The large first marginals of the calliostomatine radula are probably the most important in cutting; the rachidian, the lateral, and the marginal teeth have such a delicate appearance that they probably are used solely in sweeping.

Remarks. The subfamily Calliostomatinae has two features that readily distinguish it from all other trochid subfamilies: the enlarged first marginal of the radula and the pseudoproboscis. The familiar genus *Calliostoma* is readily recognized by its beaded sculpture, but there are other members of the subfamily with smooth shells—the south boreal group that includes *Photinula* and related genera. These genera are included in the subfamily because they have both the characteristic radula with the enlarged first marginal and the pseudoproboscis.

The function of the pseudoproboscis is not well understood, although Fretter and Graham (1962) have suggested that it may assist in grasping the food.

Genus *Calliostoma* Swainson, 1840

Calliostoma Swainson, 1840. **Type species** (SD, Hermannsen, 1846): *Trochus conulus* Linnaeus, 1758. Northeastern Atlantic.

Diagnosis. Moderately high-spired, whorls flat-sided or rounded; final lip not thickened. Peristome incomplete, columella lacking folds or denticles, although somewhat thickened and truncate toward base; base usually with umbilical depression or open umbilicus. Early sculpture of beaded spiral cords, cords and beading either persisting or lost in later growth stages. Protoconch with reticulate sculpture and rounded pits. Color patterns often variegated; interior iridescent, exterior surface often showing metallic luster.

Remarks. All *Calliostoma* have a reticulate protoconch and early sculpture of three spiral cords. Although there are many generic-level taxa available as subgenera, efforts to arrange the worldwide members of the group into a meaningful scheme have not been successful.

Calliostoma turbinum Dall, 1896

Figure 1.5C

Calliostoma turbinum Dall, 1896: 8.—Oldroyd, 1927:792, pl. 100, fig. 1.

Material Examined. California, Santa Maria Basin: Phase I, sta. 79, 98 m (1). Phase II, sta. R-8, 90 m, 1 juvenile specimen. Other material examined: 14 LACM lots.

Description. Medium-sized, mature whorls rounded, suture channeled. Spiral sculpture of 4 principal cords per whorl; cords narrow, with broad interspaces, uppermost cords beaded; interspaces with coppery iridescence, major cords darker brown in radial pattern; basal cords numerous, finely beaded. Height 15-21 mm.

Type Locality and Type Specimens. Off Point Conception, Santa Barbara County, California, 100 fathoms. Holotype: USNM 122578.

Distribution. Point Conception, Santa Barbara County, California (34°N), to Islas San Benito, Baja California (28°N).

Habitat. Rocky bottoms, 70-140 m.

Remarks. The coppery iridescence of the shell surface is the most striking feature of this species.

Calliostoma variegatum Carpenter, 1864

Figure 1.5D

Calliostoma variegatum Carpenter, 1864: 652—Oldroyd, 1927: 787, pl. 100, fig. 10—Palmer, 1958:141, pl. 17, figs. 9, 10—Abbott, 1974:47, fig. 357.

Material Examined. California, Santa Maria Basin, Phase I, sta. 6, 109 mm (1 juvenile). Other material examined: 37 LACM lots.

Description. Flat-sided and relatively high-spired, base of juvenile shell defined by double carination, periphery of mature shells tending to become rounded. Sculpture of evenly beaded spiral cords. Color yellowish with brown flecks on cords, interspaces on early whorls with greenish or bronze iridescence. Height 18-27 mm.

Type Locality and Type Specimens. Puget Sound, Washington. Holotype: USNM 4201.

Distribution. Forrester Island, southeast Alaska (55°N), to Isla Cedros, Baja California (28°N).

Habitat. Rocky bottoms 10-60 m; occurring below 60 m in southern California.

Remarks. *Calliostoma variegatum* has sculpture rather similar to that of *C. annulatum* Lightfoot, 1786, a species occurring in shallower water, but does not have the striking color pattern of purple and gold bands of that species.

Calliostoma platinum Dall, 1890

Figure 1.6A

Calliostoma platinum Dall, 1890:343, pl. 7, fig. 2.—Oldroyd, 1927:788.—Abbott, 1974:48, fig. 362.

Material Examined. Although not recorded from the Santa Maria Basin, the area is within the distribution of this offshore species. There are 18 lots in the LACM collection from throughout the distribution.

Description. Relatively large, thin shelled; early whorls with 2 carinations that become obsolete on later whorls; periphery defined by single projecting thread upon which succeeding suture is laid. Spiral sculpture consisting of fine striae, most strongly developed on base. Height 25-32 mm.

Type Locality and Type Specimens. "Near Santa Barbara Islands, California," 414 fathoms. Holotype: USNM 96558.

Distribution. Moresby Island, Queen Charlotte Islands, British Columbia (53°N), to San Diego, California (33°N).

Habitat. Soft bottoms, 180-700 m. Feeding biology is unknown, but would be of unusual interest, as this species is unlike most members of the genus in its soft rather than hard bottom habitat.

Remarks. A related species is *Calliostoma titanium* McLean, 1984, which has a sturdier shell and finely beaded spiral cords; it is known only from the original material from the vicinity of Santa Catalina Island and Cortez Bank. *Calliostoma chilena* Rehder, 1971, from Chile, is very similar to *C. platinum*.

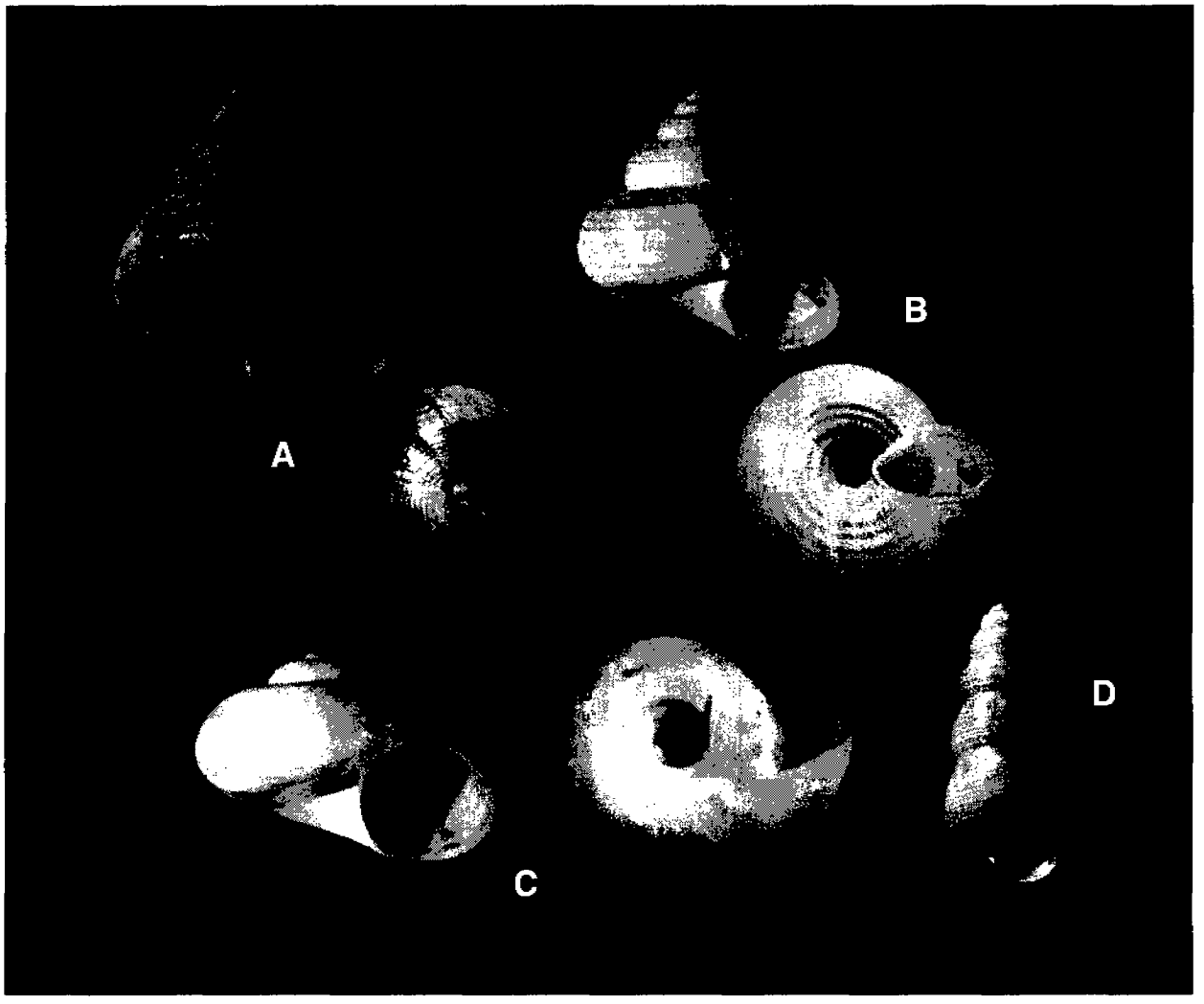


Figure 1.6. Trochidae. **A.** *Calliostoma platinum* Dall, 1890: 752 m, off Santa Barbara Island, California (USNM 96558, holotype); height 32 mm, 2 views. **B.** *Solariella peramabilis* Carpenter, 1864: 88-93 m, Cortes Bank, California (LACM 41-112.2); height 16.3 mm, 2 views. **C.** *Solariella nuda* Dall, 1896: 421-695 m, E of Long Point, Santa Catalina Island, California (LACM 40-130.5); height 11.3 mm, 2 views. **D.** *Halistylus pupoideus* (Carpenter, 1864): 22 m, off Point Vicente, Los Angeles County, California (LACM 19731); height 5.7 mm.

Subfamily Solariellinae Powell, 1951

Diagnosis. Shell umbilicate, whorls rounded, peristome complete; aperture not strongly oblique. Afferent ctenidial membrane present. Cephalic lappets lacking, left and right neck lobes much reduced. Snout with long papillae around mouth; mouth broad, opening a longitudinal slit; cephalic tentacles expanded at base. Foot with drawn-out anterior-lateral corners and elongate, tapered posterior end, capable of expanding over base of shell. Rachidian, lateral, and marginal teeth of radula with overhanging and pointed tips; rachidian with broad base but not flanged; lateral teeth 2-3 pairs, with denticles only on outer sides; marginal teeth numerous.

Biology. The Solariellinae live offshore on soft bottoms. The external features of the animal, particularly the morphology of the snout and the minimal development of neck lobes, are unlike those of other trochids, modified for a particular kind of food collecting on soft bottoms, as first noted by Fretter and Graham (1977) and treated further by Herbert (1987) and Hickman and McLean (1990). The gill condition, in which the afferent membrane is present, is that of advanced trochids; the reduced neck lobes and absence of the cephalic lappets may therefore be a secondary loss in this group.

Remarks. All genera have an open umbilicus, an impressed suture and a complete peritreme with little slant to the apertural margin. The radula is unique to the subfamily.

The subfamily is widely distributed in all seas and has an extensive fossil record since the Upper Cretaceous. Herbert (1987) reviewed the numerous southern African members of Solariellinae.

Genus *Solariella* Wood, 1842

Solariella Wood, 1842. **Type species** (M): *Solariella maculata* Wood, 1842. Pliocene, England.

Diagnosis. Shell relatively small, thin, broadly umbilicate; aperture not oblique, nearly circular, peritreme nearly complete; umbilicus bordered by beaded cord. Opercular volutions with fine projecting fringe. Epipodium and radula as described for subfamily.

Remarks. The genus is broadly distributed in world oceans.

Solariella peramabilis Carpenter, 1864

Figure 1.6B

Solariella peramabilis Carpenter, 1864:653.—Dall, 1921:177, pl. 17, fig. 8.—Oldroyd, 1927:797, pl. 91, fig. 8, pl. 101, fig. 7.—Palmer, 1958:138, pl. 17, figs. 3, 4 (lectotype).—Abbott, 1974:41, fig. 296.
Solariella rhyssa Dall, 1919:360.

Material Examined. California, Santa Maria Basin: included on soft-bottom faunal check list, but no voucher examined. Other material: 271 lots in the LACM collection.

Description. Shell moderately large for genus; suture impressed, whorls shouldered below suture. Sculpture of rounded cords on body whorl, base, and within umbilicus; intercalary cords of lesser strength arising on final whorl; cords bordering umbilicus strongly beaded; incremental axial sculpture predominating on early whorls. Lateral teeth 3 pairs, marginal teeth relatively few. Color tan with axial flecks of brown. Shell height 10-20 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 30-120 fathoms. Lectotype (Palmer, 1958:138): USNM 16281. *Solariella rhyssa*: Catalina Channel, California; holotype: USNM 173803.

Distribution. Forrester Island, southeastern Alaska (55°N), to Baja California, the central and southern Gulf of California, to Isla Clarión, Islas Revillagigedos Islands, Mexico (18°N)

Habitat. Common on soft bottoms, 50-350 m. Hickman and McLean (1990) illustrated the external anatomy of this species. Long tentacular processes near the mouth sweep the substrate for detrital feeding on soft bottoms.

Remarks. This species is placed in the subgenus *Minolia* A. Adams, 1860 (type species *Minolia punctata* A. Adams, 1860, offshore waters of Japan), because of its very prominent spiral cords. The synonym *Solariella rhyssa* was based on a juvenile specimen of 1.7 mm in height on which the axial sculpture is prominent, a characteristic feature of juvenile shells.

Solariella nuda Dall, 1896

Figure 1.6C

Solariella nuda Dall, 1896: 9.—Oldroyd, 1927:799, pl. 91, figs. 2, 5.—McLean *in* Keen, 1971:331, fig. 70.

Material Examined. California, Santa Maria Basin, Phase I, sta. 46, 597 m (1). Other material: 12 lots in LACM collection.

Description. Moderately large for genus, uniformly gray-white. Low-spired, with broadly inflated and rounded whorls; suture distinct, umbilicus bordered by sharp angulation. Shell smooth, polished except for fine reticulate sculpture on first 2 whorls. Lateral teeth 3 pairs. Height 9-15 m.

Type Locality and Type Specimens. Off Isla Clarión, Islas Revillagigedos, Mexico, 460 fathoms. Lectotype (designated by McLean *in* Keen, 1971:944): USNM 122580.

Distribution. Tofino, British Columbia (49°N), to Isla Clarion, Islas Revillagigedos, Mexico (18°N).

Habitat. Soft bottoms, at continental slope to abyssal depths, 360-2800 m.

Remarks. The smooth sculpture of mature specimens is unlike that of most members of the genus, but the strongly sculptured juvenile shell is quite typical of the genus.

Subfamily Halistylinae Keen, 1958

Diagnosis. Shell small, thick, lacking interior nacre, sculpture smooth to spiral. Ctenidium lacking free tip, monopectinate, with enlarged bursicles; eyes on dorsal surface of eyestalk. Radula lacking cusps on rachidian and lateral teeth.

Remarks. Hickman and McLean (1990:122) discussed the affinity of the group, which has links to the subfamilies Lirulariinae and Umboniinae, particularly in its radular characters, but does not have the extreme modification of gill that characterizes the Lirulariinae and Umboniinae.

Genus *Halistylus* Dall, 1890

Halistylus Dall, 1890. **Type species** (OD): *Halistylus columna* Dall, 1890. Brazil.

Diagnosis. Shell small, high-spired, whorls rounded, sculpture spiral.

Remarks. An additional species, *Halistylus genecoani* McLean, 1984, has been described from central and southern Baja California.

Halistylus pupoideus (Carpenter, 1864)

Figure 1.6D

Fenella pupoidea Carpenter, 1864: 656;

Halistylus pupoideus: Palmer, 1958:142, pl. 19, fig. 4 [syntype].—Abbott, 1974:52, fig. 399 [as *pupoides*].—Hickman and McLean, 1990:120, figs. 76A, D, E, 77, 78A.

Fenella subpupoidea Tryon, 1887: 394 [unnecessary new name for *Fenella pupoidea* Carpenter].

Halistylus subpupoideus: Dall, 1921:174.—Oldroyd, 1927:775.

Material Examined. Not represented in the Santa Maria Basin voucher collection, but common offshore to the north and south. There are 92 lots in the LACM collection.

Description. Shell small, high-spired, whorls rounded, but more flattened near suture and bulging toward base. Spiral sculpture of raised threads of irregular width, interspaces narrow. Aperture round, lip thickened posteriorly by callus deposition. Color yellowish tan, gray, or pink, some specimens with irregular gray markings; early whorls colorless. Juvenile shell with open umbilical area. Height 5.0-6.6 mm.

Type Locality and Type Specimens. Monterey, California, 20 fathoms. Holotype: USNM 14824.

Distribution. Forrester Island, southeastern Alaska (55°N), to Bahía San Bartolomé (Bahía Tortuga), Baja California (28°N).

Habitat. 20-90 m, common on sand and gravel bottoms.

Remarks. Tryon's replacement name was unnecessary; Carpenter's name is not a homonym of *Fenella pupoides* A. Adams, 1860.

Superfamily Cerithioidea

Family Cerithiidae Fleming, 1822

Diagnosis. Shell tall-spired, usually with flared outer lip and reflexed siphonal canal. Operculum paucispiral. Males aphallate; females with open pallial gonoducts.

Biology. Cerithiids are generally understood to be detritus browsers and grazers. As in other groups that feed at low trophic levels, the species are often abundant in their habitat.

Remarks. Anatomy for the family was summarized by Houbrick (1988:116), who indicated about 25 genera and hundreds of species, most of which occur in tropical and subtropical waters.

Key to Species of Cerithiidae

1A. Axial sculpture lacking on body whorl ..... *Lirobittium paganicum*
1B. Axial sculpture present on body whorl 2

2A. Three primary spiral cords per whorl 3
2B. Four primary spiral cords per whorl 4

3A. Terminal whorl with intercalary spiral cords ..... *Lirobittium rugatum*
3B. Terminal whorl lacking intercalary spiral cords ..... *Lirobittium fetellum*

4A. Whorl profile rounded ..... *Lirobittium lomaense*
4B. Whorl profile flat-sided, projecting over suture below ..... *Lirobittium larum*

Subfamily Bittiinae Cossmann, 1906

Diagnosis. Shell small, with short anterior canal.

Remarks. Houbrick (1993) reviewed the subfamily and provided anatomical definitions for the group and for six genera that he recognized worldwide. The subfamily is represented in the shallow-water and offshore fauna of southern California by the genus *Lirobittium*. Houbrick also used *Stylidium* Dall, 1907, for the shallow-water species *Stylidium eschrichtii* (Middendorff, 1849)

Genus *Lirobittium* Bartsch, 1911

Lirobittium Bartsch, 1911. **Type species** (OD): *Bittium* (*Lirobittium*) *catalinensis* Bartsch, 1911; = *Bittium purpureum* Carpenter, 1864. Northeastern Pacific.

Diagnosis. Shell small, tall, whorls moderately inflated; sculpture axial and spiral, usually reticulate; sculpture of base spiral; anterior canal very shallow, anal sinus weak, lip thin, smooth. Protoconch of two and one-half whorls, becoming bicarinate early to late on second protoconch whorl.

Biology. Direct development has been noted for the intertidal species *Stylidium eschrichtii* (Middendorff, 1849) by Strathmann (1987:241). Reproduction in other northeastern Pacific species has not been studied, and there are no papers that treat the biology of any species in the group.

Remarks. Northeastern Pacific species are unlike those of typical *Bittium* of the northeastern Atlantic and Mediterranean in having sculpture of spiral carinations on the second and third whorls of the protoconch. Anatomical differences were found by Houbrick (1993), who assigned the species other than *Stylidium eschrichtii* to the genus *Lirobittium* Bartsch, 1911.

Eastern Pacific species were last reviewed by Bartsch (1911), who proposed an excessive number of names, of which many are now relegated to synonymy. The numerous synonyms are an indication of the high variability among the species. Shallow-water species were reviewed by McLean (1978). The synonymies given here are based on my study of type material of all eastern Pacific members of the group.

Lirobittium rugatum (Carpenter, 1864)

Figure 1.7A

Bittium rugatum Carpenter, 1864:539.

Bittium (*Semibittium*) *rugatum*: Bartsch, 1911:397, pl. 56, figs, 4, 5.—Oldroyd, 1927:625.—Palmer, 1958:179.—Abbott, 1974:106, fig. 1016.

Bittium subplanatum Bartsch, 1911:395, pl. 57, fig. 5.—Oldroyd, 1927:625, pl. 77, fig. 5.

Alabina calena Dall, 1919:345.—Oldroyd, 1927:614.

Material Examined. California: Santa Maria Basin, Phase I, sta. 40, 392 m (1); Phase II, sta. R-2, 161 m (1); sta. R-6, 410 m (1). Other material: 247 lots in LACM collection.

Description. Axial ribs strong to weak, retractive, extending suture to suture; 3 major spiral cords per whorl, incremental cords added in final whorl. Intersections of cords producing large beads that may project with high relief; whorl sides rounded. Height 7-11 mm.

Type Locality and Type Specimens. Middle Pleistocene, Santa Barbara Formation, Santa Barbara, California. Holotype: USNM 7154. *Bittium subplanatum*: Santa Catalina Island, California; holotype: USNM 160076. *Alabina calena*: San Luis Obispo Bay, 252 fathoms; holotype: USNM 271070.

Distribution. Off Point Piños, Monterey County, California (37°N), to Islas San Benito, Baja California (28°N).

Habitat. Common on soft bottoms, 30-500 m.

Remarks. Shells vary in the number of axial ribs per whorl and relative strength of the axial ribs. Carpenter's name was based on Pleistocene material from Santa Barbara. Hertz (1981) illustrated additional fossil specimens. The synonym "*Alabina*" *calena* represents a form occurring at depths of 200-300 m, in which axial sculpture is not developed on the mature whorls.

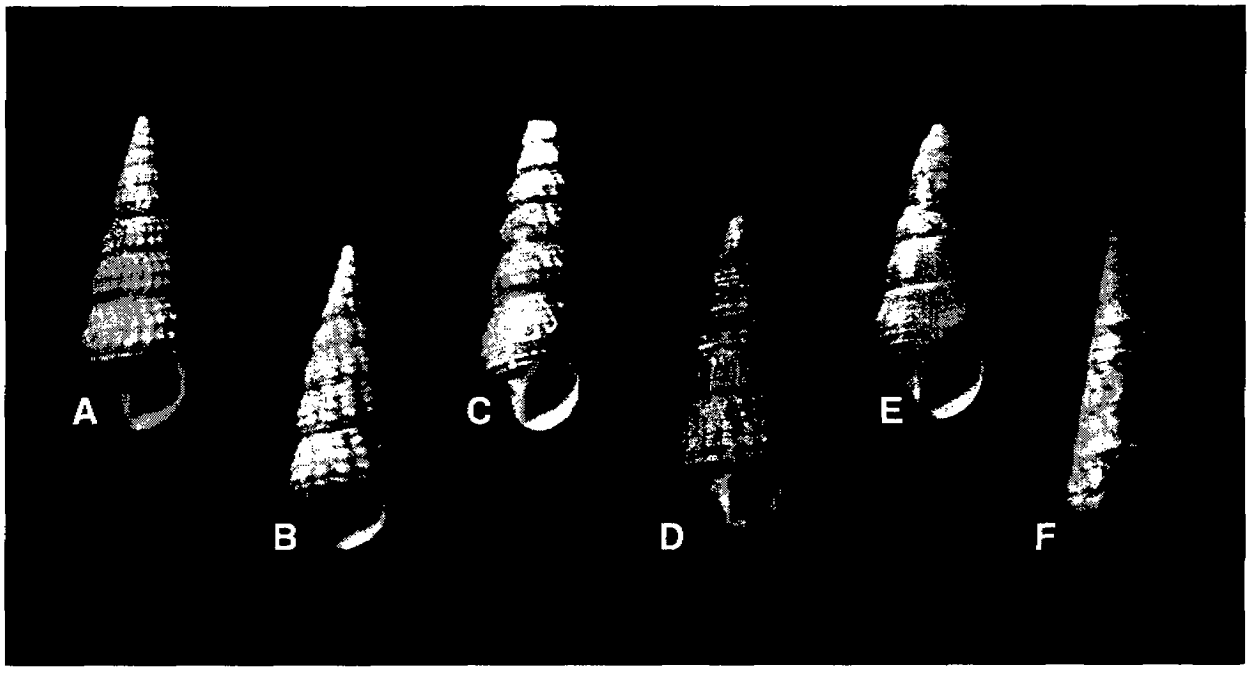


Figure 1.7. Cerithiidae, Turritellidae. **A.** *Lirobittium rugatum* (Carpenter, 1864): 95-101 m, off East Point, Santa Rosa Island, California (LACM 41-168.8); height 10.9 mm. **B.** *Lirobittium lomaense* (Bartsch, 1911): 165-185 m, off Long Point, Santa Catalina Island, California (LACM 39-104.13); height 10.3 mm. **C.** *Lirobittium fetellum* (Bartsch, 1911): 64 m, off Santa Barbara Point, Santa Barbara County, California (LACM 5-20.8); height 8.9 mm. **D.** *Lirobittium larum* (Bartsch, 1911): 59 m, off Whites Point, Los Angeles County, California (LACM 48-14.2); height 10.5 mm. **E.** *Lirobittium paganicum* (Dall, 1919): 410 m, off Purisima Point, Santa Barbara County, California (SBMNH 142800, Santa Maria Basin, sta. R-6); height 7.8 mm. **F.** *Turritella cooperi* Carpenter, 1864: 46-51 m, S of Fraser Point, Santa Cruz Island, California (LACM 41-06.3); height 35.8 mm.

Lirobittium lomaense (Bartsch, 1911)

Figure 1.7B

Bittium (*Lirobittium*) *asperum lomaense* Bartsch, 1911:505, pl. 56, f. 1.—Oldroyd, 1927:636.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 11 LACM lots.

Description. Whorl profile rounded, but slightly indented below suture. Axial ribs strong except below suture, ribs broadly spaced; 4 spiral cords per whorl, subsutural cord weakest. Initial whorl of protoconch round. Shell flesh colored under thin periostracum.

Type Locality and Type Specimens. Off Point Loma, San Diego County, California, 71-75 fathoms. Lectotype **(here designated)**: USNM 195130.

Distribution. Santa Cruz Island (34°N), to San Diego, California (33°N).

Habitat. Soft bottoms, 30-100 m, much less abundant that *Lirobittium rugatum*.

Remarks. This differs from *Lirobittium rugatum* in its pink coloration, more broadly spaced axial ribs and lack of incremental spiral cords. This was described initially as a living form of the extinct Neogene species *Lirobittium asperum* (Gabb, 1861), but does not have the even, more broadly spaced axial ribs and lacks the strongly carinate protoconch of that species. It is here first recognized as a full species.

Lirobittium fetellum (Bartsch, 1911)

Figure 1.7C

Bittium fetellum Bartsch, 1911:409, pl. 51, fig. 4.—Oldroyd, 1927:638, pl. 75, fig. 4.—Abbott, 1974:107.

Material Examined. California: Santa Maria Basin, Phase I, sta. 85, 113 m (13); Phase II, sta. PJ-1, 146 m (2); sta. PJ-10, 147 m (2); sta. PJ-18 (3). Other material examined: 58 LACM lots.

Description. Slender, with rounded whorls; three strong spiral cords intersect with sharply defined axial ribs to produce square cancellations. Height 7-9 mm.

Type Locality and Type Specimens. Off Santa Catalina Island, California, 16 fathoms. Lectotype **(here designated)**: USNM 198617.

Distribution. Point Conception, Santa Barbara County (35°N), to Huntington Beach, Orange County, California (34°N).

Habitat. Common on mud bottoms along the mainland coast, 50-180 m, often occurring with *Lirobittium rugatum* and with *L. larum.*

Remarks. Differs from *Lirobittium rugatum* in having more rounded whorls and a more slender profile and completely lacking the spiral threading of the latter species.

Lirobittium larum (Bartsch, 1911)

Figure 1.7D

Bittium (*Semibittium*) *larum* Bartsch, 1911:407, pl. 57, fig. 4.

Bittium (*Lirobittium*) *larum*: Oldroyd, 1927:636.—Abbott, 1974:107, fig. 1024.

Material Examined. Not represented in Santa Maria Basin voucher collection, although this species is common to the south of Point Conception. Material examined: 136 LACM lots.

Description. Relatively large, color medium brown, especially showing at aperture; whorls flat-sided and bulging toward base; 4 major spiral cords per whorl, with minor cords between; axial ribs broadly spaced, producing beads and elongate, rectangular cancellations where intersecting with spiral cords. Height 10-14 mm.

Type Locality and Type Specimens. Off San Pedro, Los Angeles County, California, 4 fathoms. Lectotype **(here designated)**: USNM 195156.

Distribution. Gaviota, Santa Barbara County, California (34°N), to south of Bahía Magdalena, Baja California Sur (24°N). Usually not occurring near offshore islands.

Habitat. Common on mud bottoms, 30-100 m.

Remarks. The elongate cancellations produced by this species in the early whorls are distinctive.

Lirobittium paganicum (Dall, 1919)

Figure 1.7E

Stylidium paganicum Dall, 1919:345.

Bittium (*Stylidium*) *paganicum*: Oldroyd, 1927:622.

Material Examined. California: Santa Maria Basin, Phase II, sta. R-3, 409 m (1); sta. R-6, 410 m (6). Other material examined: type material and LACM 65-38.1, off San Pedro, Los Angeles County, 640 m; LACM 54-53.1, off Dana Point, Orange County, 366 m.

Description. White, ribs obsolete on final whorl; sculpture of incised spiral lirae. Protoconch worn on all specimens. Height 8.0 mm.

Type Locality and Type Specimens. Off Point Piños, Monterey County, California, 292-356 fathoms. Lectotype **(here designated)**: USNM 271078.

Distribution. Off Point Piños, Monterey County (37°N), to Dana Point, Orange County, California (33°N).

Habitat. 360-650 m on mud bottoms.

Remarks. Dall's type material has not been figured and the identity of this species was uncertain until the recognition of more recently collected LACM material from southern California. It remains a rare species known from relatively few specimens. Specimens may be coated with rusty appearing mineral deposits (as in the lectotype), or, the deposits may be lacking or minimal, but partially filling the spiral striations, giving the appearance of narrow, reddish brown colored bands.

Family Turritellidae Lóven, 1847

Diagnosis. Tall shells with numerous whorls; aperture round, lacking anterior or posterior canals; operculum multispiral. Radula taenioglossate.

Biology. Anatomy is typically cerithioidean with aphallate males and open pallial gonoducts. There are further modifications for suspension feeding (Houbrick, 1988:118).

Remarks. Genera of Turritellidae were reviewed by Marwick (1957).

Genus *Turritella* Lamarck, 1799

Turritella Lamarck, 1799. **Type species** (M): *Turbo terebra* Linnaeus, 1758. East Indies.

Diagnosis. Outer lip and basal lip forming broad sinus.

Biology. Graham (1938) and Yonge (1946) gave details of the functional morphology of the European species *Turritella communis* Risso, 1826, and it has been assumed that other species fit this pattern. They showed that *T. communis* lies partially buried on soft bottoms and has a ciliary feeding mechanism, using a modified ctenidium to collect food particles. Modifications of the mantle form a tentacular screen that serves to keep large particles out of the mantle cavity.

Current knowledge of biology and distribution of *Turritella* species has been reviewed by Allmon (1988).

Remarks. *Turritella* species have not been reviewed worldwide and a modern subgeneric classification remains to be done, although many names are available. Subgeneric characters are provided by morphology of the protoconch and sculpture of the early whorls.

There are about 15 species in the Panamic Province and a single species living offshore in southern California. The Cretaceous and Tertiary formations of the West Coast are rich in species and are useful for stratigraphic correlation. The fossil species have been given monographic treatment by Merriam (1941) and Saul (1983).

The type species of *Turritella* is relatively large for the family. Nothing is known of its biology.

Turritella cooperi Carpenter, 1864

Figure 1.7F

Turritella cooperi Carpenter, 1864:655.—Oldroyd, 1927:657.—Palmer, 1958:168, pl. 20, fig. 7.

Turritella jewetti Carpenter, 1864:539.—Oldroyd, 1927:656.—Palmer, 1958:169.—Valentine, 1962:3.

Turritella orthosymmetra Berry, 1953:412, pl. 28, fig. 5.

Material Examined. Although this species is not represented in the voucher collection from the Santa Maria Basin, it is a common species on sand bottoms in southern California. The LACM collections contains 117 lots from California as well as additional lots from Baja California.

Description. Shell small for genus, thin; spiral sculpture of 2 prominent carinations per whorl and fine spiral striae; basal carination projecting and similar in strength to principal carinations; suture laid below basal angulation, base smooth except for fine spiral striae. Early whorls with lowermost carination developing first. Tan with brown axial markings. Height 35-55 mm.

Type Locality and Type Specimens. Santa Barbara, California, middle Pleistocene. According to Palmer (1958), the type material of *Turritella cooperi* has not been located. *Turritella jewetti*: middle Pleistocene, Santa Barbara; type material not located by Palmer (1958:169). *Turritella orthosymmetra*: Catalina Island, 50 fathoms; holotype: SBMNH 34534.

Distribution. Point Piños, Monterey County, California (37°N), to southern Baja California south of Bahía Magdalena (24°N), and the western side of the Gulf of California north to San Felipe. Its presence in the Gulf of California has not previously been reported.

Habitat. Living populations have not been studied. Common (except in Gulf of California) on sand bottoms at 25-100 m.

Remarks. The two strong carinae may project or be nearly flush with the profile of the shell (as in the synonym *T. orthosymmetra*). Merriam (1941) recognized three "varieties" of Pliocene age. *Turritella jewetti* is a probable synonym; it was discussed by Woodring (1946:69) and Valentine (1962).

Turritella cooperi is similar in size and occurrence to the North Atlantic species *T. communis* Risso, 1826, which has been extensively studied.

Superfamily Rissoidea

Family Rissoidae Gray, 1847

Subfamily Rissoinae Gray, 1847

Diagnosis. Small to minute mesogastropods with moderately elevated spires; sculpture smooth or with various kinds of axial and spiral cords. Radula taenioglossate.

Biology. Species of most genera feed on diatoms or microalgal films. Most species have a planktonic larval stage, but direct development is also known in some genera.

Remarks. This is a large family, with numerous genera and species, often occurring in large numbers, particularly in shallow water. Ponder (1985) has reviewed genera worldwide and has revised the classification based on anatomical characters.

Two subfamilies were recognized by Ponder (1985): Rissoinae Gray, 1847 and Rissoininae Stimpson, 1865.

Key to Species of Rissoidae

1A. Shell height about 2.0 mm ..... *Alvania rosana*

1B. Shell height about 1.2 mm ..... *Alvania tumida*

Genus *Alvania* Risso, 1826

Alvania Risso, 1826. **Type species** (SD, Nevill, 1885): *Alvania europea* Risso, 1826 [= *Turbo cimex* Linnaeus, 1758]. Mediterranean.

Diagnosis. Shell minute, moderately elevated, whorls rounded, suture deep; sculpture clathrate, with axial and spiral elements; aperture simple, rounded.

Biology. Like other rissoids, species of *Alvania* feed on diatoms and microalgae. Eastern Pacific species have a planktonic larval stage.

Remarks. The genus is worldwide with numerous species. Ponder (1985:36) treated anatomical characters and recognized five subgenera worldwide. Eastern Pacific species were placed in the typical subgenus. The two species treated here are the only species occurring offshore in southern California.

Alvania rosana Bartsch, 1911

Figure 1.8A

Alvania rosana Bartsch, 1911:349, pl. 31, fig. 6.—Oldroyd, 1927:609, pl. 82, fig. 6.—Abbott, 1974:72, fig. 609.

Alvania burrardensis Bartsch, 1921:38.—Bartsch, 1927:30, pl. 3, fig. 5.—Oldroyd, 1927:740.—Abbott, 1974:74 (listed only).

Material Examined. California, Santa Maria Basin, Phase I sta. 17, 654 m (2); Phase I, sta. 73, 98 m (6). Phase II, sta. PJ-12, 145 m, 34 specimens. Other material: 98 lots in LACM collection.

Description. Shell small (maximum length 2.6 mm), whorls rounded, suture deeply impressed, aperture slightly less than half length of shell; protoconch whorls 2.5, smooth. Aperture oval, columella with umbilical chink. Axial sculpture of narrow, sharply raised ribs and regular spiral cords of lesser strength, producing rectangular clathrations; base with spiral sculpture only.

Type Locality and Type Specimens. Off Santa Rosa Island, California, 48 fathoms. Lectotype **(here designated)**: USNM 213688. *Alvania burrardensis*: Burrard Inlet, British Columbia (no depth mentioned); holotype: USNM 340938.

Distribution. Kachemak Bay, Alaska (59°N), to Punta San Pablo, Baja California Sur (27°N).

Habitat. Soft bottoms offshore, 20-300 m.

Remarks. This species is common throughout its distribution. It resembles *Alvania compacta* (Carpenter, 1864), which occurs in shallow water (see McLean, 1978:27, fig. 14.4), but has a deeper suture and more rounded whorls.

Alvania tumida Carpenter, 1857

Figure 1.8B

Alvania tumida Carpenter, 1857:360.—Bartsch, 1911:361, pl. 32, fig. 2.—Keen, 1971:370.

Material Examined. California, Santa Maria Basin, Phase I, sta. 73, 98 m (7). Phase II, sta. R-4, 92 m (1); sta. R-8, 90 m (2). Other material: 98 lots in the LACM collection.

Description. Shell small for genus (maximum length 1.2 mm), whorls rounded, suture deeply impressed, aperture length one-third shell length. Protoconch whorls 2, rounded, faintly sculptured. Axial and spiral sculpture of fine cords of equal strength and spacing, producing square cancellations. Aperture oval, inner lip strongly set off from umbilicus.

Type Locality and Type Specimens. Cabo San Lucas, Baja California Sur. Holotype: USNM 16206.

Distribution. Santa Maria Basin, California (34.5°N), to Panama. In the LACM collection this species is common near Isla Cedros, Baja California, and to the south. There is one specimen in the LACM collection from near Santa Catalina Island. The material from the Santa Maria Basin is a major extension to the north for this typically tropical species. Keen (1971) gave the distribution as Mazatlán, Mexico, to Panama.

Habitat. Soft bottoms offshore throughout the range, 20-90 m.

Remarks. This is the smallest eastern Pacific species of *Alvania*, easily recognized by its small size and fine clathrate sculpture.

Family Vitrinellidae Bush, 1897

Diagnosis. Shell small to minute, spire depressed, variously ornamented with axial and spiral sculpture.

Remarks. This is a large family, with numerous genera, particularly in tropical regions, but very little is known of the anatomy and biology. Few species are common and most are known only from empty shells. Pilsbry and Olsson (1945, 1952) reviewed the genera and species of the tropical eastern Pacific, but work on the radula and anatomy remains to be done.

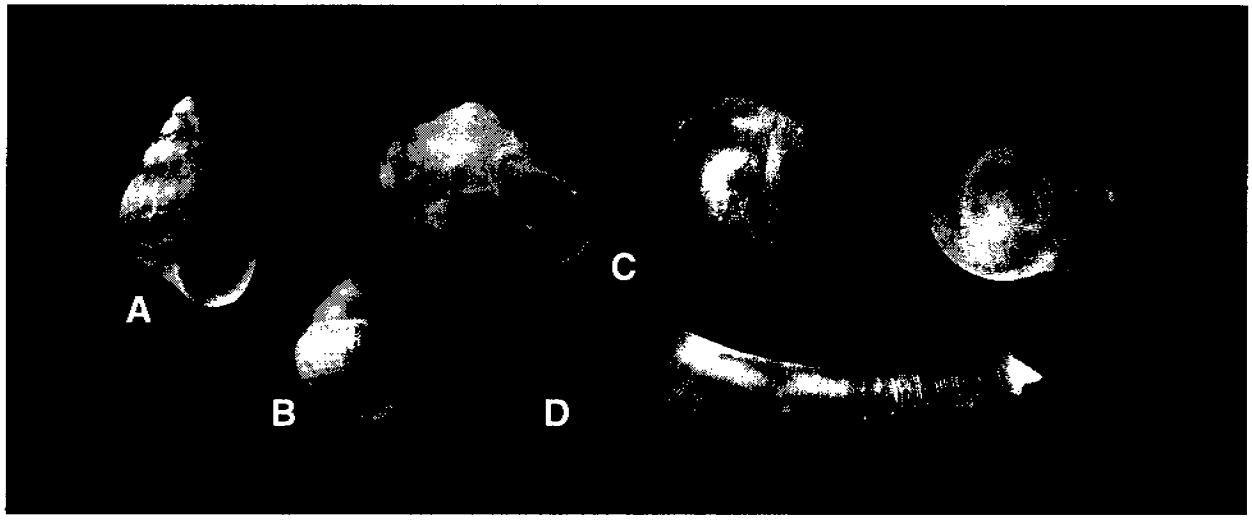


Figure 1.8. Rissoidae, Vitrinellidae, Caecidae. **A.** *Alvania rosana* Bartsch, 1911: 64-183 m, off Newport Beach, Orange County, California (LACM 65-63.4); height 2.1 mm. **B.** *Alvania tumida* Carpenter, 1857: 27-34 m, NE end Isla Cedros, Baja California (LACM 71-156.21); height 1.2 mm. **C.** *Vitrinella eschnaurae* Bartsch, 1907: San Pedro, Los Angeles County, California (USNM 127559, holotype); diameter 2.3 mm, 3 views. **D.** *Caecum crebricinctum* Carpenter, 1864: San Diego, California (USNM 14930, lectotype); length 6.2 mm.

Genus *Vitrinella* C. B. Adams, 1852

Vitrinella C. B. Adams, 1852. **Type species** (SD, Bush, 1897): *Vitrinella helicoidea* C. B. Adams, 1852. Pacific Panama.

Diagnosis. Shell with low, nearly flat spire; umbilicus broadly open, exposing whorl below; surface smooth; axial and spiral sculpture lacking.

Remarks. Eastern Pacific species are in need of review; SEM work has not been done on shells or radulae. They are sufficiently uncommon to suggest that they may have specific habitat requirements that are yet unknown.

Vitrinella eschnaurae Bartsch, 1907

Figure 1.8C

Vitrinella eschnauri Bartsch, 1907:168, fig. 2.—Oldroyd, 1927:819, pl. 106, figs. 5,7,9.

Vitrinella eschnaurae: Abbott, 1974:83 (listed only).

Teinostoma (*Pseudorotella*) *salvania* Dall, 1919:369.—Oldroyd, 1927:828.—Abbott, 1974:89 (listed only).

Material Examined. California, Santa Maria Basin, Phase I, sta. 21, 49 m (1). Phase II, sta. R-8, 90 m (2). Other material: 20 lots in the LACM collection. The voucher material is not mature and can only tentatively be identified as this species.

Description. Shell small, spire low, whorls 3, rounded, smooth; aperture circular; protoconch whorls 1.5, smooth; sculpture lacking, except for growth lines. Maximum diameter 2.3 mm.

Type Locality and Type Specimens. San Pedro, California. Holotype: USNM 127559. Dall's species *Teinostoma salvania* seems to be based on a smaller specimen of *Vitrinella eschnaurae*; it came from Isla Coronado, Baja California (Holotype: USNM 225190).

Distribution. Monterey, California (37°N), to Isla Asunción, Baja California Sur (27°N).

Habitat. Specimens in the LACM collection were taken by divers on rock bottoms at depths of 10-20 m, although not in abundance. The Phase II specimens were taken on hard bottoms at 90 m.

Remarks. This species differs from other species of *Vitrinella* in having a higher shell profile. Other species in southern California have more nearly flat spires. The name was emended by Abbott (1974) to the feminine ending because Bartsch mentioned that the original specimens came from Mrs. Eschnaur's collection.

Family Caecidae Gray, 1850

Diagnosis. Adult shell small to minute, tubular, slender, curved. Protoconch spiral, deciduous. Apical area sealed with a septum or plug, often with a mucro, or pointed tip. With growth, new septa are formed within and earlier shell portions of lesser diameter are shed. Operculum multispiral. Eyes at bases of tentacles, foot short. Radula taenioglossate.

Biology. Caecids are often extremely abundant in shallow water. The food consists of detrital particles and diatoms. Caecids have a planktonic larval stage. Fretter and Graham (1978) described the life habits of British caecids.

Remarks. Although there are systematic papers that treat regional faunas, the Caecidae are in major need of a worldwide revision. A dozen genera are available but these have not been reviewed and there is little agreement as to their application. Moore (1962) showed that the family has rissoidean affinities. The shallow-water caecid species of southern California were illustrated by McLean (1978).

Genus *Caecum* Fleming, 1833

Caecum Fleming, 1833. **Type species** (SD, Gray, 1847): *Dentalium trachea* Montague, 1803. Northeastern Atlantic.

Micranellum Bartsch, 1920. **Type species** (OD): *Caecum crebricinctum* Carpenter, 1864. Northeastern Pacific.

Diagnosis. Shell sculpture of rings or annulations that correspond to the round aperture; longitudinal sculpture lacking. Mucro of septum projecting, pointed.

Remarks. The genus *Micranellum* was proposed for the relatively large species treated here. Although the type species has more numerous annulations, this seems to be a specific level character only.

Caecum crebricinctum Carpenter, 1864

Figure 1.8D

Caecum crebricinctum Carpenter, 1864:655.—Abbott, 1974:91, fig. 873.—McLean, 1978:30, fig. 14.1.

Micranellum crebricinctum; Bartsch, 1920:568.—Oldroyd, 1927:647.—Palmer, 1958:174, pl. 20, figs. 10-11.

Caecum magnum "Stearns", Tryon, 1886, vol. 8:219, pl. 67, f. 83.

Micranellum pedroense Bartsch, 1920:569.

Micranellum catalinense Bartsch, 1920:569.

Micranellum profundicolum Bartsch, 1920:569.

Micranellum barkleyense Bartsch, 1920:569.

Micranellum oregonense Bartsch, 1920:569.

Micranellum rosanum Bartsch, 1920:569.

Material Examined. Santa Maria Basin, Phase I, sta. 50, 591 m (1). Phase II, sta. R-1, 91 m (1). Other material examined: 298 lots in the LACM collection.

Description. Relatively large for genus, with numerous annulations; mucro sharply projecting. Shell cream colored, often with light brown mottling. Length 5-6 mm.

Type Locality and Type Specimens. San Diego, California. Lectotype **(here designated)**: USNM 14930. Bartsch described six other taxa from northeastern Pacific localities, as listed in the synonymy above. These have not been figured, but I have examined and photographed the type material and all fall within the range of variation for *Caecum crebricinctum*. All types are in the USNM.

Distribution. Kachemak Bay, Alaska (59°N), to Punta Abreojos, Baja California Sur, Mexico (26°N).

Habitat. 10-200 m, on many different kinds of substrates, including gravel near rocks and fine particles in deeper water.

Remarks. This species is the largest species known in the family. It is the only member of the family occurring in relatively deep water in the northeastern Pacific. Draper (1982) described the living animal of *Caecum crebricinctum*.

Superfamily Vanikoroidea

Family Vanikoridae Gray, 1840

Diagnosis. Shell small to medium in size, white, turbiniform, umbilicate, with large final whorl; sculpture axial and spiral. Protoconch conical, whorls 2-4. Foot with large fleshy epipodial folds. Operculum paucispiral. Radula taenioglossate.

Biology. Little is known about the biology of vanikorids. The multispiral protoconch is indicative of planktotrophic development.

Remarks. This is a poorly known family with few genera. Warén and Bouchet (1988:94) expanded the concept of the family, adding small-shelled genera previously placed in the Fossaridae. They gave a more complete diagnosis of the family, with a detailed description of radular characters.

Key to Species of Vanikoridae

1A. Base lacking broad channel ..... *Megalomphalus californicus*

1B. Base with broad channel ..... *Megalomphalus schmiederi*

Genus *Megalomphalus* Brusina, 1871

Megalomphalus Brusina, 1871. **Type species** (M): *Stomatia azonea* Brusina, 1864. Adriatic Sea.

Macromphalina Cossmann, 1888. **Type species** (OD): *Sigaretus problematicus* Deshayes, 1864. Eocene, Paris Basin.

Chonebasis Pilsbry and Olsson, 1945. **Type species** (OD): *Chonebasis peruviana* Pilsbry and Olsson, 1945. Peru.

Diagnosis. Shell small to minute, turbiniform, with small spire and large final whorl; umbilicus broad, funnel-shaped. Protoconch small, elevated, with two and one-half whorls. Foot with projecting epipodial folds (Warén and Bouchet, 1988, fig. 7).

Remarks. Although Dall (1921) had correctly treated the species that follows as *Megalomphalus* in the Vanikoridae, Keen (1971:453) used the genus *Macromphalina* in the Fossaridae. Gougerot and Le Renard (1981) returned *Macromphalina* to the synonymy of *Megalomphalus*, retaining it in the Vanikoridae. The type species of *Megalomphalus*, as figured by Warén and Bouchet (1988, figs. 30-32) is very similar to *Megalomphalus californicus*.

Megalomphalus californicus (Dall, 1903)

Figure 1.9A

Macromphalina californica Dall, 1903:175.—Abbott, 1974:90, fig. 858.—McLean, 1978:34, fig. 17.5.

Megalomphalus californicus: Dall, 1921:166, pl. 14, fig. 7.—Oldroyd, 1927:737, pl. 97, fig. 7.

Material Examined. Not represented in voucher material from Santa Maria Basin. Other material: 20 lots in LACM collection.

Description. Shell small, cream colored, with large final whorl; umbilicus broad, exposing broad umbilical wall; sculpture of numerous, narrow, raised axial ribs, cresting on base and umbilical rim, and finer spiral cords; spiral sculpture anastomosing at later growth stages; protoconch whorls brown. Height 5.5 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, California. Holotype: USNM 109307.

Distribution. Santa Cruz Island, California (34°N), to Isla Asunción, Baja California Sur (27°N).

Habitat. Rocky bottoms, 10-70 m, not common.

Remarks. This species is here returned to *Megalomphalus*, in which it had been placed by Dall (1921).

Megalomphalus schmiederi McLean, new species

Figure 1.9B

Material Examined. California: Santa Maria Basin Phase I, sta. 6, 109 m (1); sta. 16, 591 m (1). LACM material in addition to the type lot: LACM 40-223.3, W of Santa Barbara Island, California, 274 m (1); LACM 41-288.6, Cortes Bank, California, 91 m (1).

Description. Shell small, teleoconch dull white, whorls rounded, slightly tabulate below suture, suture deeply impressed. Protoconch projecting, brown, second stage (protoconch II) of 1.3 whorls, with spiral ribs apparent on last quarter turn. Aperture oblique; axial ribs raised, strong, wavy, colabral, with slightly broader interspaces except below suture and toward basal terminus, interspaces compressed at suture and basal termination. Spiral sculpture weak, producing fine crenulations on back side of axial ribs. Peristome complete, columellar lip slightly thickened, straight. Umbilicus narrow, open; umbilical wall nearly smooth, umbilicus bordered by broad cord separated from base of shell by channel of same width as cord bordering umbilicus; axial ribs extending across both channel and cord bordering umbilicus. Height 2.3 mm, diameter 2.0 mm (holotype).

Type Locality and Type Specimens. Unnamed rocky bank, 3 miles WSW of Point Sur, Monterey County, California (36°17'N, 121°58'W), 37-55 m, collected by R. W. Schmieder and other divers of Cordell Expeditions, September 1988 and October 1989. 91 specimens recovered from sediment samples. Only one specimen was live-collected and retains the operculum; it is a LACM paratype rather than the holotype because the lip is broken. Holotype LACM 2777; 84 paratypes LACM 2778; 2 paratypes USNM 887574; 2 paratypes SBMNH 142895; 2 paratypes CAS 102983.

Distribution. Point Sur, Monterey County (36°N), to Cortez Bank California (32.5°N).

Habitat. 40-270 m, soft bottoms. The record cited above for the voucher specimen from 591 m may be in error.

Remarks. This species differs from *Megalomphalus californicus*, the only other member of the genus known from California, in its smaller size (half the height), less broad profile, more numerous and more closely spaced axial ribs, and in having the deep channel on the base of the shell.

The name honors Robert Schmieder, leader of Cordell Expeditions, whose team conducted the diving at the type locality.

Superfamily Calyptraeoidea

Family Calyptraeidae Lamarck, 1809

Diagnosis. Shell of limpet form; outline irregular; with septum or deck formed by columellar border of aperture. Early teleoconch with traces of spiral sculpture strongly or weakly represented or lacking. Operculum lacking. Head and neck long, flattened, bearing cephalic lappets; tentacles short, eyes at bases. Mantle cavity deep, filaments of ctenidium modified for filter feeding, tips of filaments overlying food groove leading to mouth.

Biology. Calyptraeids are sedentary limpets with unique modifications of the ctenidium and mantle cavity for filter feeding. The shell conforms to the area of attachment. All are protandrous hermaphrodites, starting as male and changing to female as larger sizes are attained.

Remarks. Genera are distinguished by placement of the septum and amount of coiling retained. Genera that retain the most coiling in the teleoconch are considered the most primitive in the family.

Key to Species of Calyptraeidae

1A. Deck attached on both sides ..... *Crepidula glottidiarum*

1B. Deck not attached on left side 2

2A. Exterior lacking coarse ribs ..... *Crepipatella dorsata*

2B. Exterior with coarse ribs ..... *Crepipatella orbiculata*

Genus *Crepidula* Lamarck, 1799

Crepidula Lamarck, 1799. **Type species** (M): *Patella fornicata* Linnaeus, 1758. Northeastern Atlantic.

Diagnosis. Shell oval, apex at or near posterior margin, coiled stage limited to protoconch; deck extending across full width of aperture, attached on both sides.

Remarks. Species are distinguished by position of the apex, whether at the margin or raised above it, and by the curvature of the edge of the deck and whether it projects forward at either edge. Subgenera are based on the form and position of the deck or septum, and are useful for the placement of fossil forms, although they were not utilized by Hoagland (1977). Applicable subgenera for this and the following genus are mentioned under the remarks for each species.

Crepidula glottidiarum Dall, 1905

Figure 1.9C

Crepidula nivea var. *glottidiarum* Dall, 1905:26.—Oldroyd, 1927:723.—Hoagland, 1977:377 [under *Crepidula nummaria* Gould, 1846].

Material Examined. Santa Maria Basin, Phase I, sta. 64, 59 m (2). Other material examined: 12 lots in LACM collection.

Description. Shell elongate, about twice as long as broad, moderately inflated, white; apex at posterior margin, slightly deflected to right; septum extending half length of shell, undulating on left side; periostracum light brown, thin, closely adherent. Length 15-23 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California. Lectotype **(here designated)**: USNM 183455.

Distribution. Point Conception (34°N), to Laguna Beach, Orange County, California (33°N).

Habitat. Living on the sides of the burrowing brachiopod *Glottidia alba* Hinds, 20-70 m. It assumes a convex form to match that of the outer surface of the *Glottidia*, but does not grow larger than its host.

Remarks. This species has usually been dismissed as a form or variety of some other species since it was first described by Dall. Hoagland (1977:393) placed it under *Crepidula nummaria* Gould, 1846 [for which see Abbott, 1974:142, fig. 1571]. I tentatively recognize it here to call attention to the fact that this question needs to be investigated by means of life history studies and biochemical genetics. As Hoagland notes (1977:393), all of the white-shelled, planar species of *Crepidula* from the eastern Pacific are in need of attention. Typical specimens of *Crepidula nummaria* have a thick periostracum and are more oval at all growth stages. The fact that very small specimens of *C. glottidiarum* are relatively elongate suggests that the species may be more than a situs form of *C. nummaria*.

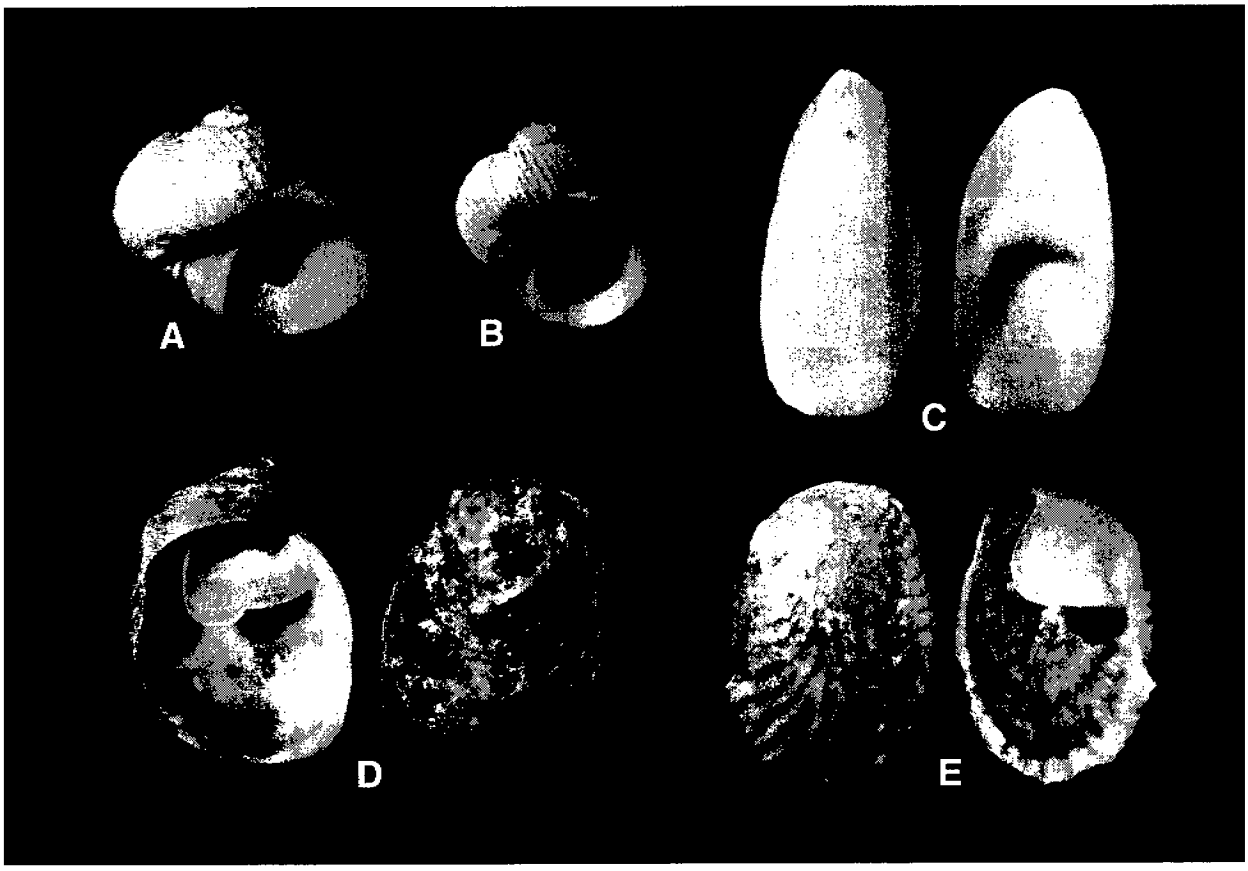


Figure 1.9. Vanikoridae, Calyptraeidae. **A.** *Megalomphalus californicus* (Dall, 1903): 8-21 m, Isla Asuncíon, Baja California Sur (LACM 67-66.49); height 4.6 mm. **B.** ***Megalomphalus schmiederi*** **McLean, new species**: 37-55 m, off Point Sur, Monterey County, California (LACM 2777, holotype); height 2.3 mm. **C.** *Crepidula glottidiarum* Dall, 1905: San Pedro, California (USNM 183455, syntype); length 20.8 mm, 2 views. **D.** *Crepipatella dorsata* (Broperip, 1834): 109 m, off Point Buchon, San Luis Obispo County, California (SBMNH 142801, Santa Maria Basin, sta. 6); length 14.9 mm, 2 views. **E.** *Crepipatella orbiculata* (Dall, 1919): 591 m, off Point Buchon (SBMNH 142802, Santa Maria Basin, sta. 16); length 13.2 mm, 2 views.

The planar species of *Crepidula,* including the more typically shallow water species *C. nummaria* and *C. perforans* (Valenciennes, 1846), are allocated to the subgenus *Ianacus* Mörch, 1852, for which the type species is the Mediterranean *C. unguiformis* Lamarck, 1767.

Genus *Crepipatella* Lesson, 1830

Crepipatella Lesson, 1830. **Type species** (OD): *Calyptraea* (*Crepipatella*) *adolphi* Lesson, 1830 [=*Crepidula dilatata* Lamarck, 1822]. Chile.

Diagnosis. Shell broadly oval, apex at posterior margin; coiled stage limited to early juvenile, deck attached to shell at left side and posteriorly; right side of shell interior marked by deep sinus separating deck.

Remarks. The genus differs from *Crepidula* in having the deck attached only on the left side. Hoagland (1977) placed it in the synonymy of *Crepidula*. However, following the tradition of previous authors, *Crepipatella* is here used as a genus because the deck condition is a clear character that can be recognized in fossil forms.

Crepipatella dorsata (Broderip, 1834)

Figure 1.9D

Calyptraea dorsata Broderip, 1834:38.

Crepipatella dorsata: Keen, 1971:461, fig. 819.

Crepidula dorsata: Hoagland, 1977:373 [discussed but not illustrated].

Crepidula lingulata Gould, 1846:160.

Crepipatella lingulata: Keen, 1971:461, fig. 820—Abbott, 1974:141, fig. 1554.—McLean, 1978:37, fig. 18.7.

Crepidula bilobata "Gray", Reeve, 1859, pl. 5, fig. 29.

Crepidula fissurata Sowerby, 1883:67, pl. 9, fig. 151.

Material Examined. Santa Maria Basin, Phase I, sta. 6, 109 m (1); sta. 25, 390 m (1). Other material examined: 830 lots in LACM collection.

Description. Shell broadly oval, but irregular in outline, moderately inflated; surface smooth or with undulating radial ribs; apex at posterior margin; coiled stage limited to early juvenile, deck with raised medial fold, attached at left side and posteriorly; color mottled brown and white. Length 12-25 mm.

Type Locality and Type Specimens. Santa Elena, Ecuador. Type material unknown. The species is better known by its junior synonym *Crepidula lingulata* Gould, described from Puget Sound, for which the holotype is USNM 5871.

Distribution. Bering Sea, Alaska, to Bahía Independencia, Peru (14°S).

Habitat. Abundant on rocky substrates from the intertidal zone to 20 m, less common in deeper water to 100 m. This is one of the most abundant of eastern Pacific gastropods.

Remarks. The name *Crepipatella dorsata* has previously been applied to forms occurring in the tropical eastern Pacific, whereas *Crepipatella lingulata* has been used for the northern forms, but there is no evidence that there is a distinction between a tropical and a more northern species. Hoagland (1977:373) placed the taxa *C. dorsata* and *C. lingulata* in synonymy, a course of action followed here.

Crepipatella orbiculata (Dall, 1919)

Figure 1.9E

Crepidula orbiculata Dall, 1919:351.

Verticumbo charybdis Berry, 1940:8, pl. 1, fig. 6-10.

Crepipatella (*Verticumbo*) *charybdis*: Abbott, 1974:141 (listed only).

Material Examined. Santa Maria Basin, Phase I, sta. 13, 197 m (5); sta. 16, 591 m (1). Other material examined: 3 lots in LACM collection.

Description. Shell of moderate size, smooth or with sculpture of weak to strong divaricating ribs. Apex close to posterior margin, protoconch with tip immersed, early teleoconch with fine spiral sculpture through shell diameter of 1.3 mm, at this diameter there is a resting stage; subsequent growth smooth. Coarse rugose sculpture of some specimens emerging at later growth stage. Deck attached half length on right side. Length 10-26 mm.

Type Locality and Type Specimens. Victoria, Vancouver Island, British Columbia, 60 fathoms. Holotype: USNM 31100. *Verticumbo charybdis* was described from the middle Pleistocene Timms Point Silt, San Pedro, California. Paratypes are at the SBMNH, but the location of the holotype is unknown.

Distribution. Bering Sea, Alaska (Dall, 1921), to San Diego, California (33°N).

Habitat. 100-2100 m, attached to shells or other hard substrata. This is the only calyptraeid in the northeastern Pacific known from abyssal depths [LACM 64-109, from the Cascadia Abyssal Plain, Oregon, 2086 m]. It is an uncommon species in collections, owing to its deep-water habitat.

Remarks. This differs from *Crepipatella dorsata* in the presence of rugose sculpture (although not in all specimens) and in having a larger spiral phase of the early teleoconch and a less deeply detached deck on the right side.

Dall's holotype of *C. orbiculata* was smooth-shelled and the apical area is worn. Berry (1940) noted sculptured and smooth forms in the Pleistocene species he described as *Verticumbo charybdis*. Woodring (1946) reported Berry's species to be living off southern California and compared the morphology of the deck to that of Dall's species. Here I synonymize the two taxa and note that the Recent material also varies from smooth to strongly sculptured.

This species is the type species and only known member of the subgenus *Verticumbo* Berry, 1940, which is distinguished by its relatively large early teleoconch with fine, sharp spiral cords through a shell diameter of 1.3 mm. Hoagland (1977:374) did not have sufficient material to determine the status of *Verticumbo*.

Superfamily Cypraeoidea

Family Ovulidae Fleming, 1822

Diagnosis. Shell usually slender, attenuate anteriorly and posteriorly, lip broadly expanded, covering the entire spire. Protoconch cancellate, concealed in mature shell. Radula taenioglossate.

Biology. All species are parasitic on cnidarians, including gorgonians, corals, hydrocorals, and sea pens. In living animals, the mantle expands over the surface of the shell and often has a color pattern and pattern of tubercles and papillae resembling that of the host gorgonian. Individuals may leave the host in search of uncolonized hosts, but eggs are laid directly on the host. Liltved (1989) provided a useful overview of anatomy and biology in the family.

Remarks. Ovulids are similar to cowries in having the involute spire, but are more elongate and lack the denticles on the outer and inner lips.

Cate (1973) reviewed the family worldwide, proposing a number of genera for eastern Pacific species previously placed in *Neosimnia*. However, he did not distinguish his genera from others nor did he provide any remarks to justify his new taxa. Most of the genera proposed by Cate seem to be based on differences in shell characters that are significant only at the species level. Until the Cate genera can be re-evaluated, the species are retained in *Neosimnia*.

Key to Species of Ovulidae

1A. Final whorl inflated; lip edge slightly thickened ..... *Neosimnia loebbeckeana*

1B. Final whorl not greatly inflated; lip edge thick ..... *Neosimnia barbarensis*

Genus *Neosimnia* Fischer, 1884

Neosimia Fischer, 1884. **Type species** (M): *Bulla spelta* Linnaeus, 1758. Mediterranean.

Diagnosis. Shell small to moderate in size for family, attenuate anteriorly and posteriorly; inner lip defined by projecting ridge, outer lip with simple thickening.

Remarks. Species in California in addition to the two species treated here are *Neosimnia aequalis* (Sowerby, 1832), which occurs in relatively shallow water [see McLean 1978:40, as *Simnia vidleri* (Sowerby, 1881)], and *Neosimnia bellamaris* Berry, 1946 [see Cate, 1973:72, as *Subsimnia bellamaris*], which has been reported only from San Diego County, California.

Neosimnia loebbeckeana (Weinkauff, 1881)

Figure 1.10A

Ovula loebbeckeana Weinkauaff, 1881:197, pl. 50, figs. 6, 7.

Spiculata loebbeckeana: Cate, 1973:82, figs. 182,182a

Simnia loebbeckeana: Abbott, 1974:152 [described, no figure].

Material Examined. California: Santa Maria Basin, Phase II, sta. R-5, 154 m (1). Other material: 25 lots in the LACM collection.

Description. Shell size small to moderate; ivory white, smooth except for fine growth lines and fine spiral sculpture near tips. Mature lip thickened, convex; body whorl bulging at midpoint, slightly concave at either end opposite mature lip; columella weakly plicate and concave anteriorly; spire tip with weak funicle. Length 15-22 mm.

Type Locality and Type Specimens. "Vancouver Island," evidently in error (Cate, 1973:82). Type material is said by Cate to be in the Museum Loebbeckeana, Dusseldorf.

Distribution. Monterey, California (37°N) to Bahía Magdalena, Baja California Sur, (25°N).

Habitat. On gorgonians, 40-140 m.

Remarks. This is the type species of *Spiculata* Cate, 1973. It differs from *Neosimnia barbarensis* in its smaller size and concave profile at either end.

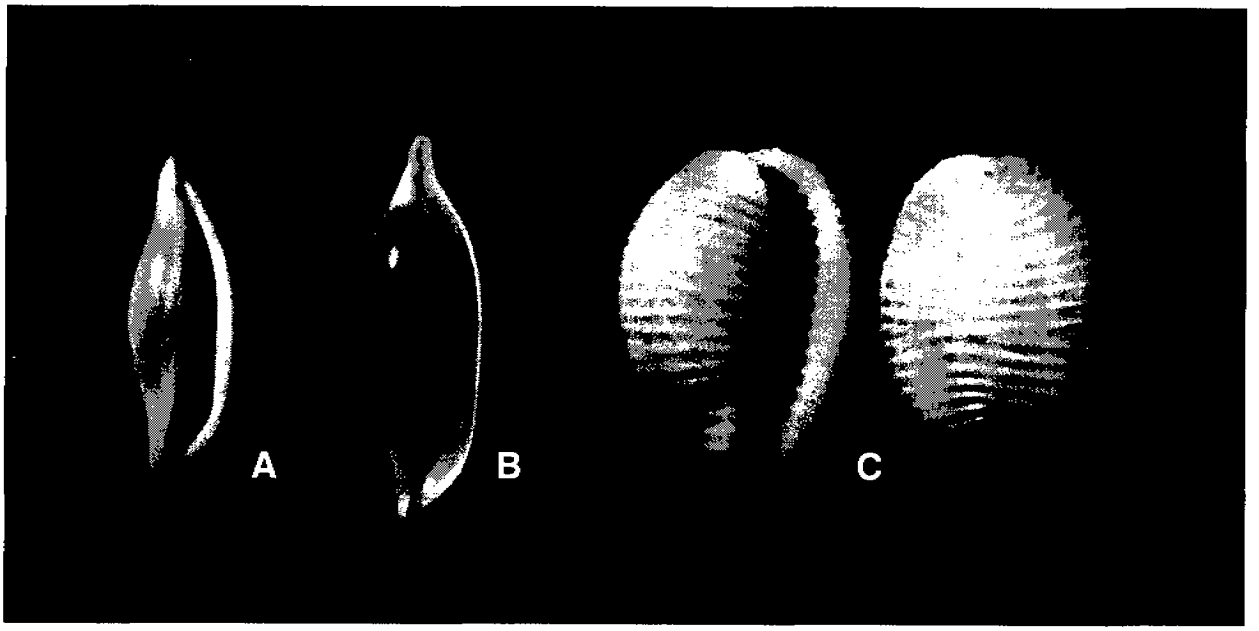


Figure 1.10. Ovulidae, Triviidae. **A.** *Neosimnia loebbeckeana* (Weinkauff, 1881): 41 m, off Huntington Beach, Orange County, California (LACM 49-135.7); height 14.4 mm. **B.** *Neosimnia barbarensis* (Dall, 1892): 91 m, off Avalon, Santa Catalina Island, California (SBMNH 34497, holotype of *Neosimnia catalinensis*); height 23 mm. **C.** *Trivia ritteri* Raymond, 1903: 74 m, off W end, Anacapa Island, California (LACM 50-17.4); height 11.2 mm.

Neosimnia barbarensis (Dall, 1892)

Figure 1.10B

Ovula (*Simnia*) *deflexa* var. *barbarense* Dall, *in* Williamson, 1892:206, pl. 21, fig. 1.

Simnia (*Neosimnia*) *barbarensis*: Oldroyd, 1927:534, pl. 98, fig. 4.

Spiculata barbarensis: Cate, 1973:83, figs. 183 [copy Dall figure], 183a [neotype].

Neosiminia catalinensis Berry, 1916:21, pl. 5, fig. 2.

Simnia (*Neosimnia*) *catalinensis*: Oldroyd, 1927:533.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Material examined: 18 lots in the LACM collection.

Description. Shell relatively large, thin, translucent white, broadly inflated, upper portion of whorl convex; smooth except for fine growth lines and fine spiral sculpture at the tips; columella concave anteriorly; spire tip with weak funicle. Length 25-30 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles, California. Neotype designated by Cate (1973:83): CAS 32437. *Neosimnia catalinensis*: Santa Catalina Island, California, 50 fathoms; holotype: Berry Collection 1224 [not now at SBMNH or CAS].

Distribution. Fort Bragg, Mendocino County, California [LACM 71-131] (40°N), to Isla Cedros, Baja California [LACM 71-157] (28°N).

Habitat. 40-90 m, on gorgonians and the sea plume *Ptilosarcus*.

Remarks. This differs from *Neosimnia loebbeckeana* in its larger size and broader body whorl. The synonymy was established by Cate (1973).

Superfamily Lamellarioidea

Family Triviidae Troschel, 1863

Diagnosis. Spire low, aperture elongate, inner and outer lips bearing denticles.

Biology. Feeding is upon tunicates. Liltved (1989) provided a detailed treatment of anatomy and biology of the family.

Remarks. There are two subfamilies, Triviinae and Eratoinae. Worldwide species of Eratoinae were reviewed by Cate (1977) and those of Triviinae by Cate (1979).

Subfamily Triviinae Troschel, 1863

Genus *Trivia* Broderip, 1837

Trivia Broderip, 1837. **Type species** (SD Gray, 1847): *Cypraea europaea* Montagu, 1808; northeastern Atlantic.

Diagnosis. Spire concealed, outer lip folded in; sculpture of transverse ridges extending within inner and outer lips.

Biology. As described for family.

Remarks. Cate (1979) proposed a number of genera in addition to those already available. However, Gosliner and Liltved (1987) and Liltved (1989) argued that genera have been based on superficial shell characters and recommended that the single genus *Trivia* be used until anatomical characters have been evaluated.

Trivia ritteri Raymond, 1903

Figure 1.10C

Trivia ritteri Raymond, 1903:85.—Oldroyd, 1927:536.—Grant and Gale, 1931:754.—Bertsch and Myers, 1982:96, figs. 2-8.

Trivia (*Dolichupis*) *ritteri*: Abbott, 1974:149, fig. 1637.

Decoriatrivia ritteri: Cate, 1979:98, fig. 94.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 39 lots in the LACM collection.

Description. Shell of medium size for genus, white, sculpture of about 20 sharp ridges extending across dorsum to curved outer lip and into aperture on columella, several ribs terminating before reaching columella; ribs not interrupted by dorsal furrow on dorsum. Length 10-12 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 60 fathoms. Lectotype (selected by Cate, 1979:98): CAS 066533.

Distribution. Cordell Bank, California [LACM 81-50.2] (38°N), to Punta San Pablo, Baja California Sur [LACM 71-176.14] (27°N).

Habitat. 50-150 m, rocky bottoms. This is a characteristic species of rocky banks offshore, usually in depths below those accessible to divers.

Remarks. This species has usually been allocated to the subgenus *Dolichupis* Iredale, 1930, characterized by its weak dorsal furrow, in contrast to the subgenus *Pusula* Jousseaume, 1884, used for most of the shallow water eastern Pacific species, in which there is a strong dorsal furrow. However, Cate (1979) placed it in *Decoriatrivia* Cate, 1979. Bertsch and Myers (1982) illustrated the radula and treated variation in size and number of ridges.

Superfamily Naticoidea

Family Naticidae Forbes, 1838

Diagnosis. Spire short, body whorl large; suture not deeply impressed; aperture oval to semicircular, umbilicus broad, often filled with callus, operculum paucispiral. Body expanding to envelop shell; radula taenioglossate.

Biology. Naticids are well adapted for burrowing in soft sediments and feeding on bivalves, which they drill with the radula, forming round holes. Eggs are deposited in "sand collars," formed by cementing sand grains with mucus.

Remarks. Marincovich (1977) monographed the fossil and Recent species of naticids from the northeastern Pacific. Authors have traditionally been conservative in the usage of such broadly defined genera as *Polinices* Montfort, 1810. However, I follow the more recent generic revision of Majima (1989), in which more taxa are recognized at the generic level. Kabat (1991) reviewed all generic level names in the family; in many cases he corrected erroneous citations of type designations.

Four subfamilies are recognized by recent authors: Ampullospirinae, Polinicinae, Sininae, and Naticinae.

Key to Species of Naticidae

1A. Umbilicus sealed with callus pad ..... *Cryptonatica affinis*

1B. Umbilicus narrow to broad 2

2A. Umbilicus narrow ..... *Euspira pallida*

2B. Umbilicus broad ..... *Calinaticina oldroydii*

Subfamily Polinicinae Finlay and Marwick, 1937

Diagnosis. Shell globose; operculum chitinous, filling aperture.

Remarks. This is a large diverse subfamily of naticids. For a more detailed diagnosis, see Marincovich (1977:244).

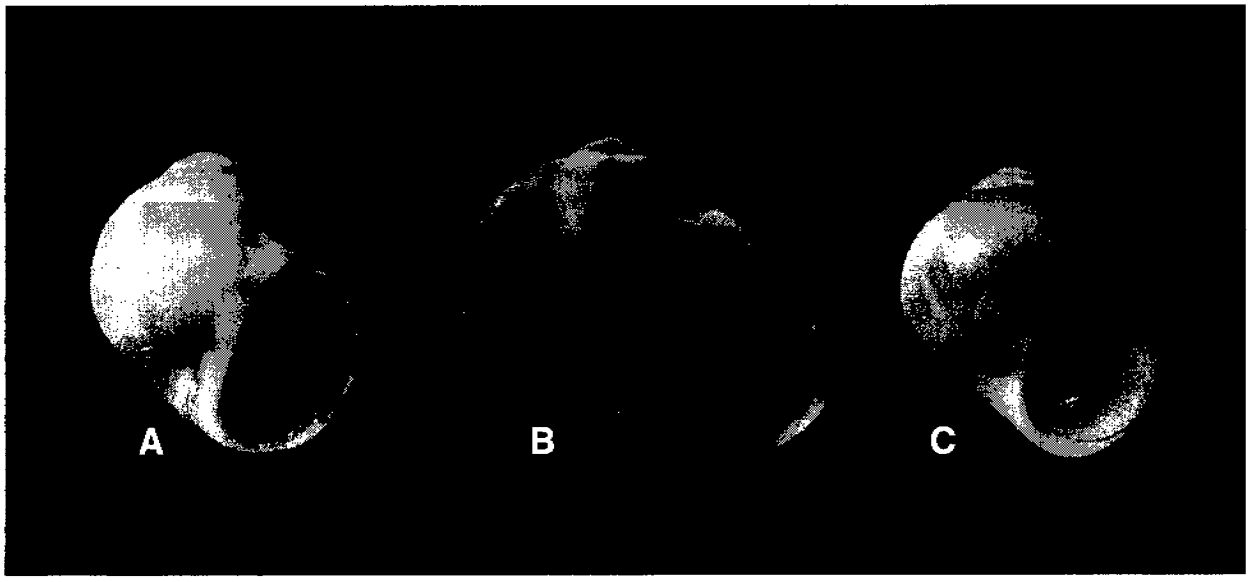


Figure 1.11. Naticidae. **A.** *Euspira pallida* (Broderip and Sowerby, 1829): 256 m, SE of Santa Catalina Island, California (LACM 39-131.6); height 10.8 mm. **B.** *Calinaticina oldroydi* (Dall, 1897): Off Santa Catalina Island, California (CAS 064315 holotype); height 35 mm. **C.** *Cryptonatica affinis* (Gmelin, 1791): 256 m, SE of Santa Catalina Island, California (LACM 39-131.5); height 9.5 mm.

Genus *Euspira* Agassiz, 1837

Euspira Agassiz, *in* J. Sowerby, 1837. **Type species** (SD, Bucquoy, Dautzenberg and Dollfus, 1883): *Natica glaucinoides* J. Sowerby, 1812 [*non* Deshayes, 1832], = *Natica labellata* Lamarck, 1804.

Lunatia Gray, 1847. **Type species** (OD): *Natica ampullaria* Lamarck, 1822. Tertiary, Europe.

Diagnosis. Shell globose, spire moderately elevated; umbilicus open, umbilical callus weakly developed, only partially blocking umbilicus.

Remarks. Majima (1989:33) and Bouchet and Warén (1993:767) have treated *Euspira* as a full genus, placing *Lunatia* in synonymy. Species were previously placed in *Polinices*, but that genus is best left for tropical species with glossy shells. Kabat (1991:429) corrected errors in type designation citations of previous authors.

Euspira pallida (Broderip and Sowerby, 1829)

Figure 1.11A

Natica pallida Broderip and Sowerby, 1829:372.

Polinices (*Euspira*) *pallidus*: Oldroyd, 1927:728, pl. 97, fig. 9.—Marincovich, 1977:278, pl. 25, figs. 1-6, 8.

Lunatia pallida: Abbott, 1974:156, fig. 1693.

Euspira pallida: Majima, 1989:37, pl. 3, figs. 7-13.

Material Examined. Not represented in the voucher collection, but common on soft bottoms at moderate depths. Material examined: 220 lots in the LACM collection.

Description. Shell of medium size, moderately elevated, umbilicus narrow; whorls flattened below suture; spiral sculpture of fine striae, axial sculpture of fine growth lines; parietal callus white, only partially filling umbilicus; operculum corneous, paucispiral, filling aperture. Length 30-40 mm.

Type Locality and Type Specimens. Icy Cape, Alaska, Arctic Ocean. Type material unknown (Majima, 1989:37).

Distribution. Arctic Ocean, south to Mexican border; also Japan (Marincovich, 1977:277).

Habitat. Common on soft bottoms; at depths of 100-500 m in southern California. Occurring in shallower water in the northern part of its distribution; it may occur in the intertidal zone in Alaska.

Remarks. This is the most commonly occurring member of the family at continental shelf and slope depths in the northeastern Pacific. Additional synonyms were cited by Marincovich (1977:277).

Genus *Calinaticina* Burch and Campbell, 1963

Calinaticina Burch and Campbell, 1963. **Type species** (OD): *Sigaretus oldroydii* Dall, 1897. Northeastern Pacific.

Diagnosis. Shell large, thin, umbilicus open, partially obstructed by thin parietal wall.

Remarks. The genus is monotypic. The shell form is intermediate between that of *Euspira* and *Sinum*. A more detailed diagnosis was provided by Marincovich (1977:333).

***Calinaticina oldroydii* (Dall, 1897)**

Figure 1.11B

Sigaretus oldroydii Dall, 1897: 85.—Dall, 1899:85.

Eunaticina oldroydii: Dall, 1921:165, pl. 14, figs. 1, 3.—Oldroyd, 1927:734, pl. 92, fig. 11.

Calinaticina oldroydii: Burch and Campbell, 1963:221, fig. 2 [radula].—Abbott, 1974:155, fig. 1686.—Marincovich, 1977:334, pl. 31, fig. 3.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material: 32 lots in the LACM collection.

Description. Shell relatively large, thin; whorls 4; spire elevated; umbilicus narrow; parietal wall thin, edge straight, reflected to partially obstruct umbilicus; spiral sculpture of fine striae; axial sculpture of growth increments; light brown under thin brown periostracum; periostracum shaggy within umbilicus; operculum corneous, paucispiral, filling aperture. Length 40-70 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, "in deep water." Holotype: CAS 064315.

Distribution. Yachats, Lincoln County, Oregon [LACM 61-47.2] (44.5°N), to Islas San Benito, Baja California [LACM 39-114.9] (28°N).

Habitat. Soft bottoms, 30-400 m.

Remarks. Specimens in the LACM collection are well represented throughout the range of the species. The inner and outer lips are sharp and thin in growing specimens, becoming thicker and stronger in mature specimens.

Subfamily Naticinae Forbes, 1838

Diagnosis. Shell globose, mostly smooth, spire low to moderately elevated, umbilicate, parietal callus well developed; operculum with external calcareous layer.

Remarks. This is primarily a tropical group; the genus *Cryptonatica* is an exception.

Genus *Cryptonatica* Dall, 1892

Cryptonatica Dall, 1892. **Type species** (SD, Cossmann, 1896): *Natica* (*Cryptonatica*) *floridana* Dall, 1892. Tertiary, southeastern United States.

Sulconatica Golikov and Kussakin, 1974. **Type species** (OD): *Natica janthostoma* Deshayes, 1839. Northwestern Pacific.

Boreonatica Golikov and Kussakin, 1974. **Type species** (OD): *Natica clausa* Broderip and Sowerby. Northern Pacific.

Diagnosis. Shell globose, smooth, umbilicus filled by thick smooth, semicircular callus; operculum smooth, concave, outer edge marked by narrow furrow.

Remarks. Dall's original proposal of the genus was not accompanied by a valid type designation. Although Dall's (1909) type designation of *Natica clausa* has been cited by recent authors, Kabat (1991:428) noted that an earlier designation by Cossmann (1896) takes precedence. The concept of the genus does not change, however. Bouchet and Warén (1993:758) provided the most recent and complete account of the genus and treated three species. A single species is represented in the northeastern Pacific.

Cryptonatica affinis (Gmelin, 1791)

Figure 1.11C

Natica affinis Gmelin, 1791: 3675.

Cryptonatica affinis: Bouchet and Warén, 1993:763, figs 1789-1792, 1810-1812, 1817-1821, 1840, 1846, 1877, 1891, 1905.

Natica clausa Broderip and Sowerby, 1829: 372.

Natica (*Cryptonatica*) *clausa*: Dall, 1921:163, pl. 14, fig. 1.—Oldroyd, 1927:724, pl. 97, fig. 2.—Marincovich, 1977:410, pl. 41, figs. 7-10; pl. 42, figs. 1-6.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material: 232 lots in the LACM collection.

Description. Shell small to medium-sized, white under tan periostracum; spire moderately elevated, umbilicus filled by white callus pad, operculum with thin white calcareous layer, marked by groove along outer edge. Length 10-60 mm.

Type Locality and Type Specimens. Iceland, type material unknown (Bouchet and Warén, 1993:763). *Natica clausa*: type locality and type material unknown.

Distribution. Arctic Ocean, circumpolar; south in the eastern Pacific to San Diego (33°N); south in the North Atlantic to the Bay of Biscay, France, and North Carolina (Bouchet and Warén, 1993).

Habitat. Soft bottoms, from 0-200 m in the Arctic; at greater depths near southern range limits. There are 68 lots from southern California in the LACM collection, occurring at depths of 80-400 m.

Remarks. *Natica affinis* is a common member of the offshore assemblage in southern California. Specimens are small at maturity (length to 15 mm), compared to those from northern localities, which may approach a length of 60 mm.

This species is better known to authors treating the eastern Pacific under the name *Natica clausa* Broderip and Sowerby, 1829, from an unknown type locality, but Bouchet and Warén (1993:763) showed that usage of the older name is unavoidable. It has been treated in more detail by Bouchet and Warén and by Marincovich (1977:410), who cited numerous synonyms from type localities in the Arctic, North Atlantic and North Pacific.

Superfamily Janthinoidea

Family Epitoniidae Berry, 1910

Diagnosis. Shell usually white, with high spire, deep suture and rounded aperture. Sculpture predominantly axial; spiral elements if present of lesser strength. Radula ptenoglossate, consisting of numerous similar teeth in the row.

Biology. All members of the family are parasitic on cnidarians, chiefly anemones, although some tropical species occur on corals. Living specimens may occasionally be collected away from the host anemones when they are searching for new hosts. The proboscis is acrembolic and they are hermaphroditic and aphallic, producing spermatozeugmata or sperm packets. The numerous fanglike teeth of the radula are designed for the rasping and cutting of the cnidarian prey.

Remarks. Epitoniids are commonly known as wentletrap shells. Northeastern Pacific species were reviewed by DuShane (1979). Bouchet and Warén (1986) discussed classification at the generic level in their review of the North Atlantic species.

Key to Species of Epitoniidae

1A. Axial costae thick ..... *Nodiscala spongiosa*
1B. Axial costae thin 2

2A. Axial costae rounded in profile 3
2B. Axial costae projecting at shoulder 4

3A. Axial costae > 25 per whorl ..... *Epitonium berryi*
3B. Axial costae < 20 per whorl ..... *Epitonium indianorum*

4A. Axial costae back-folded ..... *Epitonium lowei*
4B. Axial costae projecting, not back-folded 5

5A. Axial costae 8-14 per whorl ..... *Epitonium hindsii*
5B. Axial costae 14-21 per whorl ..... *Epitonium sawinae*

Genus *Epitonium* Röding, 1798

Epitonium Röding, 1798. **Type species** (SD, Suter, 1913): *Turbo scalaris* Linnaeus, 1758. Indo-Pacific.

Diagnosis. Shell with high spire and deep suture, lacking a basal disk. Axial sculpture of thin, projecting costae, spiral sculpture lacking or of fine striae.

Remarks. DuShane (1979) placed species with rounded whorls and no spiral sculpture in *Nitidscala* DeBoury, 1909 (type species *Scalaria unifasciata* G. B. Sowerby II, West Indies), which differs from the type species of *Epitonium* only in its more slender profile. Those with fine spiral sculpture were placed in *Asperiscala* DeBoury, 1909 (type species *Scalaria bellastriata* Carpenter, 1864, California). Authors prior to DuShane (1979) had used these taxa at the subgeneric level. In treating the North Atlantic species, Bouchet and Warén (1986) ignored all subgenera and placed all species with rounded whorls, varying expression of spiral sculpture and lacking a basal disk in *Epitonium*. Here I return the northeastern Pacific species to *Epitonium*, mentioning the appropriate subgenus in the remarks under each species.

This treatment of the offshore species of *Epitonium* includes all that are known from southern California. DuShane (1979) did a monumental job of reducing the excessive number of unillustrated taxa described by Dall in his declining years. Revisions to the synonymy of two of the species treated by DuShane (*E. berryi* and *E. sawinae*) are made here.

Epitonium berryi (Dall, 1907)

Figure 1.12A

Scala berryi Dall, 1907:127.

Epitonium (*Nitidiscala*) *berryi*: Oldroyd, 1927:361.

Epitonium (*Epitonium*) *berryi*: Abbott, 1974:123 [listed only].

Scala rectilaminata Dall, 1907:127.

"*Epitonium* (*Nitidiscala*) *inconspicua* G. B. Sowerby II, 1847".—*of* Dall, 1921:116.

Epitonium ["group" *Nitidoscala* sic] *sawinae* var.? *catalinense* Dall, 1917:481.

Nitidiscala catalinense: DuShane, 1979:110, fig. 28 [holotype].

Material Examined. Santa Maria Basin, Phase I, sta. 20, 396 m (1). Other material: 38 lots in the LACM collection.

Description. Shell white, up to 10 whorls; costae thin, low, numerous, not spinose, up to 30 per whorl; suture deep, base rounded. Length 10-22 mm.

Type Locality and Type Specimens. San Pedro Bay, Los Angeles County, California, 200 fathoms. Holotype: USNM 107724. *Scala rectilaminata*: Monterey Bay, California, 12 fathoms; lectotype **(here designated)**: USNM 11048. *Epitonium catalinense*: Santa Catalina Island, California; lectotype **(here designated)**: USNM 109502.

Distribution. Vancouver Island, British Columbia (49°N), to Isla Todos Santos, Baja California (32°N) (DuShane, 1979:111).

Habitat. Soft bottoms, 20-360 m (DuShane, 1979:111).

Remarks. This species is characterized by its numerous low, closely spaced costae.

The name of the species has been confused in the literature owing to the fact that the holotype of *Scala berryi* is a juvenile specimen, as is the holotype of *S. rectilaminata*. Mature specimens were not seen by Dall until the description of *Epitonium catalinense* by Dall (1917). DuShane (1979:110) incorrectly used the junior synonym "*Nitidiscala*" *catalinense* Dall, 1917, for this species.

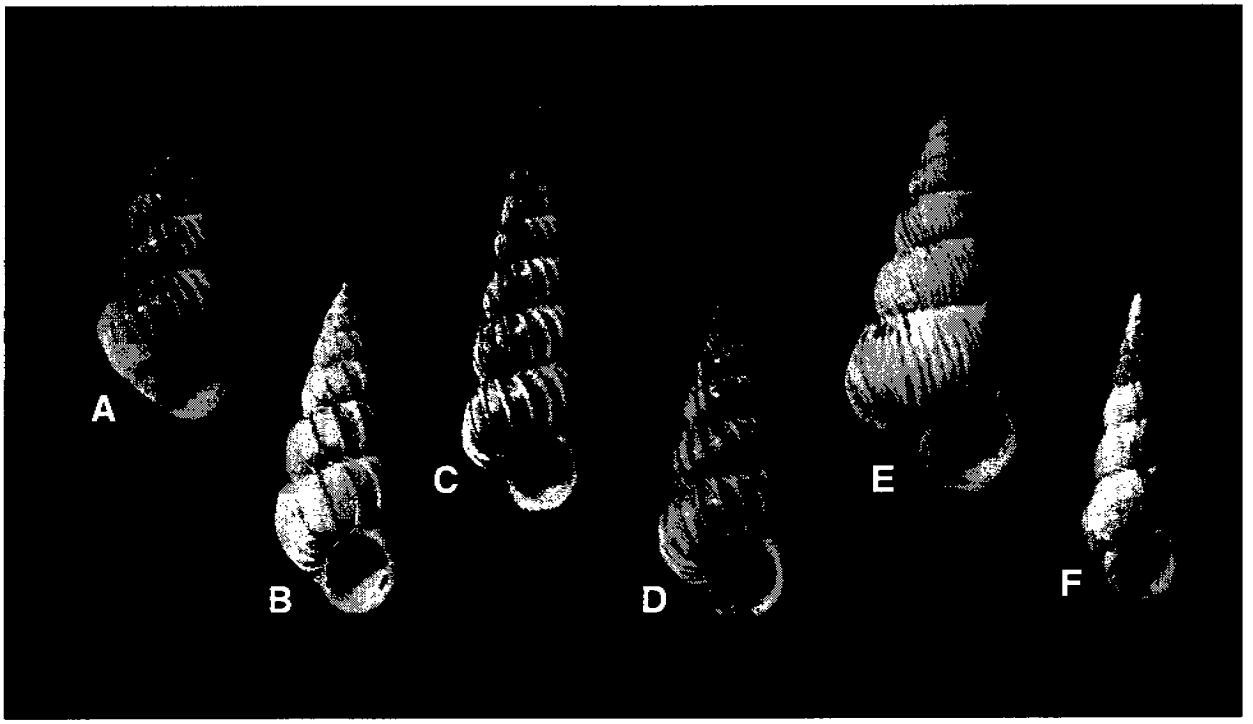


Figure 1.12. Epitoniidae. **A.** *Epitonium berryi* (Dall, 1907): Off Santa Catalina Island, California (USNM 109502, holotype of *Epitonium sawinae* var. *catalinense*); height 13.5 mm. **B.** *Epitonium hindsii* (Carpenter, 1856): San Pedro, Los Angeles County, California (USNM 46222; height 18.2 mm. **C.** *Epitonium indianorum* (Carpenter, 1864): 12-38 m, Carmel, Monterey County, California (LACM 60-24.73); height 37.8 mm. **D.** *Epitonium sawinae* (Dall, 1903): Off Newport, Orange County, California (USNM 110638, holotype of *Epitonium acrostephanus*); height 20 mm. **E.** *Epitonium lowei* (Dall, 1906): 210 m, off El Capitan, Santa Barbara County, California (LACM 118106); height 30.5 mm. **F.** *Nodiscala spongiosa* (Carpenter, 1864): 46-49 m, E of Santa Barbara Island, California (LACM 39-79.9); height 9.8 mm.

Epitonium hindsii (Carpenter, 1856)

Figure 1.12B

Scalaria hindsii Carpenter, 1856:165.

Nitidiscala hindsii: DuShane, 1979:111, figs. 32-35.

Epitonium ["group" *Nitodoscala* sic] *persuturum* Dall, 1917:478.

Epitonium contrerasi Jordan and Hertlein, 1926:446, pl. 30, fig. 4.

Epitonium cooperi Strong, 1930:194, pl. 20, fig. 6-8.

Material Examined. Not represented in the voucher collection, but occurring offshore in southern California. Material examined: 73 lots in the LACM collection.

Description. Shell white, maximum size about 22 mm, up to 11 whorls; costae thin, low, 8-14 per whorl, not spinose; suture deep, base rounded.

Type Locality and Type Specimens. Panama. Lectotype (designated by DuShane, 1979:112): NHML 1963.21. *Epitonium persuturum*: San Diego; holotype: USNM 211021. *Epitonium contrerasi*: Bahía Tortuga, Baja California; holotype: CAS 2121. *Epitonium cooperi*: San Pedro, Los Angeles County, California; holotype: SDNHM 345.

Distribution. Forrester Island, Alaska (55°N), to Peru (14° S) (DuShane, 1979:112).

Habitat. Intertidal to 195 m, on soft bottoms (DuShane, 1979: 112).

Remarks. This species is characterized by the low number of slightly spinose costae per whorl. The synonymy cited above follows that of DuShane (1979:111).

Epitonium indianorum (Carpenter, 1864)

Figure 1.12C

Scalaria indianorum Carpenter, 1864:660.

Epitonium (*Nitidscala*) *indianorum*: Oldroyd, 1927:355.—Palmer, 1958:186, pl. 20, figs. 23, 24.

Epitonium (*Epitonium*) *indianorum*: Abbott, 1974:119, fig. 1233.

Nitidiscala indianorum: DuShane, 1979:113, figs. 36-38.

Epitonium ["group" *Nitidoscala* sic] *columbianum* Dall, 1917:481.

Epitonium ["group" *Nitidoscala* sic] *montereyensis* Dall, 1917:481; not *Scala* (*Cirsotrema*) *montereyensis* Dall, 1907.

Scalaria regiomontana Dall, *in* DeBoury, 1919:39 [new name for *E. montereyensis* Dall, 1917].

Material Examined. Not represented in the voucher collection, but occurring offshore in California. Other material: 84 lots in the LACM collection.

Description. Shell white, relatively large, up to 10 whorls; costae 10-17 per whorl, low, strong, continuous whorl to whorl, usually lacking small spine at shoulder; suture deep, base rounded. Length 15-38 mm.

Type Locality and Type Specimens. Neah Bay, Clallam County, Washington. Lectotype (designated by Palmer, 1958:187): USNM 15521. *Epitonium columbianum*: Off Columbia River, Oregon, 27 fathoms; holotype: USNM 111211. *Epitonium montereyense*: Monterey Bay, California, 30 fathoms; holotype: USNM 111217.

Distribution. Forrester Island, Alaska (55°N), to Bahía Todos Santos, Baja California (32° S) (DuShane, 1979:113).

Habitat. Intertidal to 120 m, soft and rocky bottoms. Occurring below 30 m in southern California.

Remarks. This species is characterized by its large size and moderate number of rounded costae without spines. It is the largest species of *Epitonium* occurring offshore in southern California. The synonymy indicated here follows that of DuShane (1979:113).

Epitonium sawinae (Dall, 1903)

Figure 1.12D

Scala sawinae Dall, 1903:175.

Epitonium (*Nitidiscala*) *sawinae*: Dall, 1921:115, pl. 6, fig. 12.—Oldroyd, 1927:358, pl. 31, fig. 2.

Epitonium (*Epitonium*) *sawinae*: Abbott, 1974:119, fig. 1237.

Nitidiscala sawinae: DuShane, 1979:115, figs. 42-44 [not figs. 39, 40].

Epitonium (*Crisposcala*) *acrostephanus* Dall, 1908:251.

Epitonium (*Crisposcala*) *catalinae* Dall, 1908:252.

Epitonium ["group" *Nitodoscala,* sic] *tabulatum* Dall, 1917:482.

Epitonium ["group" *Nitodoscala,* sic] *regime* Dall, 1917:484.

Material Examined. California: Santa Maria Basin, Phase I, sta. 42, 100 m (1); Phase II, sta. R-1, 91 m (3); sta. R-4, 92 m (1); sta. R-8, 90 m (1). Other material: 340 lots in the LACM collection.

Description. Shell white, medium to large, up to 10 whorls; costae 14-21 per whorl, strong, with pronounced shoulder spine, producing tabulate profile, costae often broad and fused with those behind. Length 15-24 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 16 fathoms. Lectotype **(here designated)**: USNM 109309. *Epitonium acrostephanus*: Newport, Orange County, California; lectotype **(here designated)**: USNM 110638. *Epitonium catalinae*: Santa Catalina Island, California, 16 fathoms; holotype USNM 198628. *Epitonium tabulatum*: Islas Coronados, Baja California, 16 fathoms; holotype: USNM 109569. *Epitonium regum*: Point Reyes, Marin County, California, 61 fathoms; holotype: USNM 206576.

Distribution. British Columbia (54°N), to Bahía Magdalena, Baja California Sur (24°N) (DuShane, 1979:116).

Habitat. 18-360 m on soft bottoms (DuShane, 1979:116).

Remarks. This species is characterized by its deep suture and tabulate aspect produced by the spinose costae that are often folded back. The suture is deeper than that of *E. berryi.*

Changes are made here to the synonymy of this species given by DuShane (1979:115): *Epitonium catalinae* Dall, 1908, is added to the synonymy, and *E. berryi* and *E. rectilaminatum*, both Dall, 1907, are removed.

Epitonium lowei (Dall, 1906)

Figure 1.12E

Scala lowei Dall, 1906:44.

Epitonium (*Asperiscala*) *lowei*: Oldroyd, 1927:354, pl. 31, fig. 11.

Aperiscala lowei: Abbott, 1974:123. fig. 1290.

Asperiscala lowei: DuShane, 1979:101, fig. 9.

Material Examined. California: Santa Maria Basin, Phase II, sta. R-2, 161 m (1); sta. R-4, 92 m (1); sta. R-8, 90 m (1). Other material: 18 lots in the LACM collection.

Description. Shell white, medium in size, up to 9 rapidly expanding whorls, umbilicus deep; costae 25-32, slightly spinose at the shoulder, with some costae larger than the others; spiral sculpture of raised spiral ridges; sulci between ridges twice width of ridges. Length 15-25 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, California, 40-60 fathoms. Holotype: lost (DuShane, 1979); paratype USNM 191548.

Distribution. Santa Maria Basin, California (35°N) to Bahía Magdalena, Baja California Sur (24°N), and the Gulf of California. DuShane (1979) placed the northern limit at Anacapa Island, California, so the present material constitutes a significant range extension. DuShane's (1979) record of the species from Panama was based on a specimen of 5 mm in length and needs to be confirmed by specimens of larger size.

Habitat. Soft bottoms, 25-170 m (DuShane, 1979:103).

Remarks. This species resembles the *Epitonium bellastriatum* (Carpenter, 1864), which occurs in shallower water, but is larger and more slender. These two species are assigned to the subgenus *Asperiscala*, characterized by the spiral sculpture.

Genus *Nodiscala* DeBoury, 1889

Nodiscala DeBoury, 1889. **Type species** (OD): *Scalaria bicarinata* Sowerby, 1844. Philippines.

Diagnosis. Small, slender, with serrate suture defined by terminus of axial ribs; spiral sculpture finely punctate, aperture semilunate, basal disk poorly developed.

Remarks. Although usually treated as a subgenus of *Opalia* H. and A. Adams, 1853, in which there is a well-marked basal disk, *Nodiscala* is sufficiently different in size and sculpture to qualify as a full genus. DuShane (1974) recognized *Nodiscala* as a subgenus, but she used only *Opalia* for the *Nodiscala* species in her subsequent paper (DuShane, 1979).

***Nodiscala spongiosa* (Carpenter, 1864)**

Figure 1.12F

Opalia spongiosa Carpenter, 1864:660.—DuShane, 1979:126, figs. 62, 63.

Epitonium (*Nodiscala*) *spongiosum*: Oldroyd, 1927:351.

Opalia (*Nodiscala*) *spongiosa*: Palmer, 1958:193, pl. 22, figs. 1-3, 6-8.—DuShane, 1974:69, figs. 138, 139.

Opalia (*Dentiscala*) *spongiosa*: Abbott, 1974:116, fig. 1207.

Opalia retiporosa Carpenter, 1864:660.

Opalia (*Nodiscala*) *retiporosa*. Oldroyd, 1927:352.

Material Examined. California: Santa Maria Basin, Phase I, sta. 16, 591 m (1). Other material: 58 lots in the LACM collection.

Description. Shell light brown, small; whorls 8-9; axial ribs 10-15, strong, crenulating suture, ribs undulating, occasional ribs larger, forming varices; spiral sculpture of rows of fine punctations; final lip thickened. Length 7-13 mm.

Type Locality and Type Specimens. Monterey, California. Holotype: USNM 14830. *Opalia retiporosa*: Santa Catalina Island, California, 40 fathoms; holotype: USNM 11843.

Distribution. Monterey, California (37 °N), to the Gulf of California, southern Mexico, and the Galapagos Islands (DuShane, 1979:126).

Habitat. Rocky and gravel bottoms, 18-72 m (DuShane, 1979:126).

Remarks. The depth record of 591 m for the voucher specimen may be erroneous.

Superfamily Eulimoidea

Family Eulimidae Troschel, 1853

Diagnosis. Shell white to brown, usually glossy and smooth; often showing scars from earlier positions of outer lip; aperture lacking siphonal canal; protoconch smooth, of 2.5-4 whorls; operculum usually present. Radula lacking in most genera.

Biology. Parasitic on echinoderms, attached by the snout or proboscis, by which they extract body fluids. Individuals found away from their hosts are thought to be resting between feeding or searching for new hosts. Development in most eulimids is planktotrophic. Genera are usually restricted to one class of echinoderms; some species are known only from single host species.

Remarks. Most species of eastern Pacific Eulimidae were treated by Bartsch (1917). Few changes were made in the classification of the group until Warén (1984) published his generic review, which has enabled a complete reassessment of the genera in use for the eastern Pacific species.

Key to Species of Eulimidae

1A. Whorls markedly inflated 2
1B. Whorls flat-sided or nearly so 3

2A. Outer lip projecting ..... *Pseudosabinella bakeri*
2B. Outer lip not projecting ..... *Haliella abyssicola*

3A. Shell axis nearly straight 4
3B. Shell axis flexed 7

4A. Shell with brown spiral lines ..... *Eulima raymondi*
4B. Shell white 5

5A. Whorl sides straight ..... *Polygireulima rutila*
5B. Whorls faintly inflated 6

6A. Breadth of shell about 4 mm ..... *Balcis micans*
6B. Breadth of shell under 3 mm ..... *Balcis oldroydae*

7A. Mature shell < 3.5 mm in length ..... *Vitreolina yod*
7B. Mature shell > 4.5 mm in length 8

8A. Body whorl more strongly inflated than other whorls ..... *Vitreolina columbiana*
8B. All whorls very faintly inflated ..... *Vitreolina macra*

Genus *Eulima* Risso, 1826

Strombiformis Da Costa, 1779 [rejected, ICZN Opinion 1718].

Eulima Risso, 1826. **Type species** (ICZN Opinion 1718): *Turbo subulatus* Donovan, 1803. Southwestern Europe.

Diagnosis. Shell tall, slender, with color pattern of brown spiral bands; whorls flat-sided, aperture elongate; radula ptenoglossate.

Biology: Waren (1984:45) noted that the European *Eulima bilineata* is parasitic on ophiuroids. However, there are no records of hosts for eastern Pacific species.

Remarks. The tall shell with flat-sided whorls, elongate aperture and color pattern of brown lines characterize this genus. The genus was also discussed by Bouchet and Warén (1986:318) and Warén (1992:179).

Eulima raymondi Rivers, 1904

Figure 1.13A

Eulima raymondi Rivers, 1904:70, fig. 2 (Pleistocene).

Strombiformis raymondi: Grant and Gale, 1931:864.

Strombiformis riversi Bartsch, 1917:339, pl. 45, fig. 3 (Pleistocene).

Strombiformis californica Bartsch, 1917:340, pl. 45, fig. 5.—Oldroyd, 1927:380, pl. 40, fig. 5.—Abbott, 1974:127, fig. 1395.

Strombiformis lapazana Bartsch, 1917:341, pl. 46, fig. 3.

Strombiformis townsendi Bartsch, 1917:340, pl. 46, fig. 4.

Material Examined. California: Santa Maria Basin, Phase I, sta. 21, 49 m (1); sta. 64, 59 m (1); Phase II, sta. R-5, 154 m (1); sta. PJ-6, 148 m (1); sta. PJ-7, 123 m (1). Other material: 115 lots in the LACM collection.

Description. Shell tall and narrow, length to 12 mm; whorls flat-sided, aperture extremely elongate; light brown with 2 narrow dark brown bands on final whorl, lowermost covered by growing lip so that only single band shows on spire whorls.

Type Locality and Type Specimens. Santa Monica Canyon, Pleistocene. Holotype not located. *Strombiformis riversi*: Santa Monica Canyon, Pleistocene; holotype: USNM 251390. *Strombiformis californica*: San Diego Bay; holotype: USNM 249619. *Strombiformis lapazana*: La Paz, Baja California Sur; holotype: USNM 211388. *Strombiformis townsendi*: La Paz, Baja California Sur; holotype: USNM 252391.

Distribution. Monterey Bay, California [LACM 60-23] (37°N), to Bahía Guatulco, Oaxaca, Mexico [LACM 38-9] (16°N).

Habitat. Soft bottoms, 40-100 m.

Remarks. This species is characterized by the two narrow dark brown bands on the final whorl, although color fades rapidly in dead specimens and is not apparent on fossil specimens. Bartsch (1917) overlooked the earliest name, which was based on fossil specimens, and proposed four additional names for this species. The species is best known under the name *Eulima californica*. The synonymy above is introduced here.

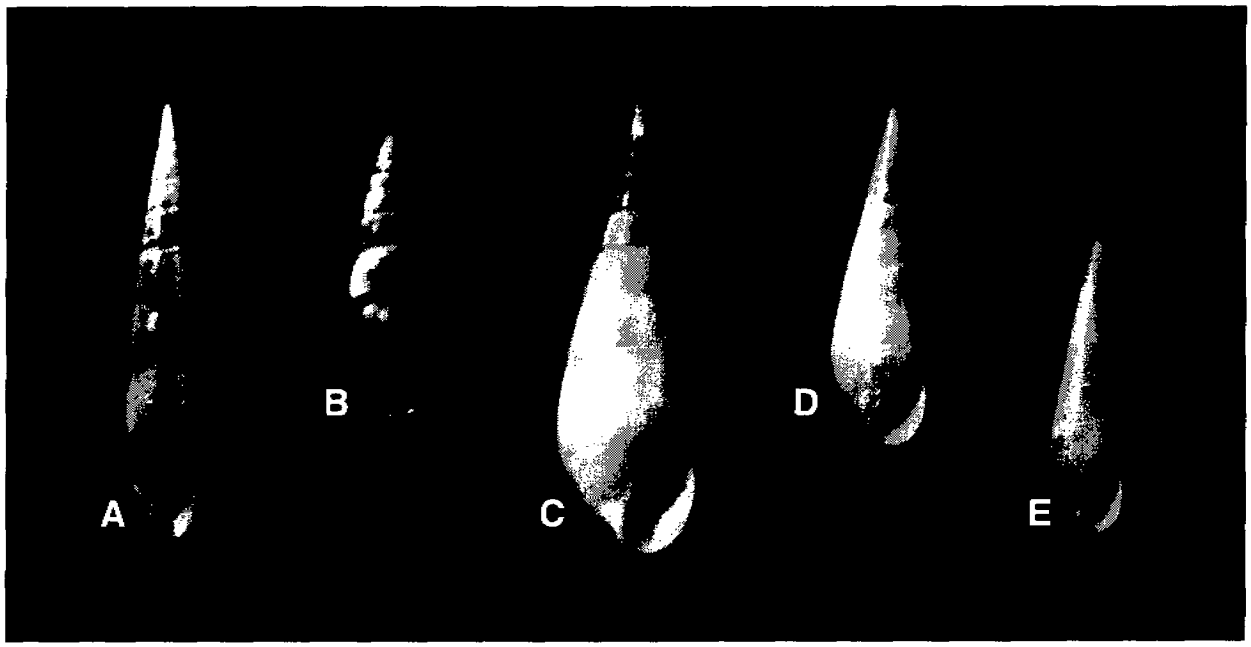


Figure 1.13. Eulimidae. **A.** *Eulima raymondi* Rivers, 1904: 46-53 m, off Abalone Point, Orange County, California (LACM 40-104.53); height 12.2 mm. **B.** *Pseudosabinella bakeri* (Bartsch, 1907): 82-91 m, Isthmus Cove, Santa Catalina Island, California (LACM 70-15.7); height 5.6 mm. **C.** *Balcis micans* (Carpenter, 1864): 66-86 N, Off Platt Point, Santa Cruz Island, California (LACM 41-83.22): height 12.8 mm. **D.** *Balcis oldroydae* (Bartsch, 1917): on sea cucumbers, off San Pedro, Los Angeles County, California (LACM 151631): height 8.6 mm. **E.** *Polygireulima rutila* (Carpenter, 1864): 131 m, off Santa Catalina Island, California (LACM 54-76.9); height 7.0 mm.

Genus *Pseudosabinella* McLean, 1995

Pseudosabinella McLean, 1995. **Type species** (OD): *Sabinella bakeri* Bartsch, 1917. California.

Diagnosis. See species description below.

Biology. Echinoderm host unknown (Waren, 1992:189).

Remarks. McLean (1995:39) proposed a genus for this monotypic species because the shell characters are well marked and unique in the family. Earlier, Warén (1992:189) noted for *Sabinella bakeri*: "This species probably is an eulimid despite having a rather fragile and irregular shell. I have examined a specimen with dried soft parts, and it has a ptenoglossate radula, similar to species of *Eulima*."

***Pseudosabinella bakeri* (Bartsch, 1917)**

Figure 1.13B

Sabinella bakeri Bartsch, 1917:334, pl. 43, fig. 5.—Waren, 1992:189.

Melanella (*Sabinella*) *bakeri*: Oldroyd, 1927:376.—Abbott, 1974:126. fig. 1382.

Pseudosabinella bakeri: McLean, 1995:39.

Alaba catalinensis Bartsch, 1920:572.

Alaba serrana Smith and Gordon, 1948:225, pl. 4, fig. 1,2.

Material Examined. California: Santa Maria Basin, Phase I, sta. 2, 200 m (1); sta. 20, 396 m (1); Phase II, sta. R-4, 92 m (1); sta. PJ-1, 145 m (1); sta. PJ-10, 147 m (1); sta. PJ-22, 143 m (2). Other material: 19 lots in the LACM collection.

Description. Shell thin, light brown; whorls rounded, suture deep, final lip inflated and produced anteriorly, umbilical chink present, lip scars slightly raised, variable in position. Ptenoglossate radula present. Length 3-6 mm.

Type Locality and Type Specimens. San Diego, California. Holotype: USNM 215786. *Alaba catalinensis*: Santa Catalina Island, California, 40 fathoms; holotype: USNM 213369. *Alaba serrana*: Carmel Bay, Monterey County, California, 25 fathoms; holotype: CAS 065531.

Distribution. Carmel, Monterey County, California (36°N), to Isla Cedros, Baja California (28°N).

Habitat. Rocky bottoms, 10-150 m. Specimens have been recovered from gravel taken by divers in the shallow sublittoral in southern California.

Remarks. This species is characterized by its light brown shell with inflated whorls and greatly expanded outer lip. There are significant size differences, which may be an indication of sexual dimorphism. It has been confused with the genus *Alaba* (family Litiopidae), from which it differs in shell characters by its glossy shell, growth scars, and expanded lip. The synonymy was first indicated by McLean (1995).

Genus *Balcis* Leach, 1847

Balcis Leach *in* Gray, 1847. **Type species**: *Balcis montagui* Leach *in* Gray, 1847 [= *Strombiformis albus* Da Costa, 1779]. Western and southern Europe.

Diagnosis. Shell tall, white, straight-sided, aperture of moderate length.

Biology. The type species is parasitic on holothurians (Warén, 1984:32).

Remarks. On shell characters, the genus differs from *Melanella* in its straight-sided, rather than inflated whorls.

***Balcis micans* (Carpenter, 1864)**

Figure 1.13C

Eulima micans Carpenter, 1864:659.

Melanella micans: Oldroyd, 1927:372.

Balcis micans: Palmer, 1958:195.

Melanella (*Balcis*) *micans*: Abbott, 1974:125, fig. 1338.

Material Examined. Not represented in the voucher collection. Other material: 32 lots in LACM collection.

Description. Shell moderately large for family; diameter exceeding 3 mm; glossy white, up to 15 whorls; whorls nearly straight-sided; growth scars few, irregular in position. Length 10-13 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California. Holotype: USNM 14850.

Distribution. Kodiak Island, Alaska (Bartsch, 1917:308) (57°N), to Punta Abreojos, Baja California Sur (Dall, 1921:118) (27°N). The LACM collection contains material ranging from Vancouver Island to southern California.

Habitat. The echinoderm host is unknown, although the species is presumed to be parasitic on holothurians. Depth records are 30-100 m.

Remarks. This is one of the largest of northeastern Pacific eulimids, differing from the following species in size. Shell diameter exceeds 3 mm and may reach 4.5 mm.

Balcis oldroydae (Bartsch, 1917)

Figure 1.13D

Melanella (Melanella) oldroydi Bartsch, 1917:309, pl. 36, figs. 5-7.—Oldroyd, 1927:374, pl. 41, figs. 5-7.—Abbott, 1974:126, fig. 1378.

Melanella (Melanella) micans borealis Bartsch, 1917:305, pl. 35, fig. 7.

Material Examined. California: Santa Maria Basin, Phase I, sta. 21, 49 m (1). Other material: 63 lots in the LACM collection.

Description. Shell of moderate size for family, length to 10 mm, diameter not exceeding 2.6 mm; glossy white, up to 14 whorls; whorls nearly straight-sided; growth scars few, irregular in position. Length 8-10 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California. Holotype: USNM 109641. *Melanella micans borealis*: Comax, Vancouver Island, British Columbia; holotype: USNM 150954.

Distribution. Kachemak Bay, Alaska [LACM 80-74.8] (59°N) to Isla Cedros, Baja California [LACM 71-158] (28°N).

Habitat. Soft bottoms, 20-90 m. A single LACM lot from San Pedro, Los Angeles County, California, is annotated: "off sea cucumbers" (figure 1.13D).

Remarks. This is a smaller species than *Balcis micans*, but is much larger than the following species. Bartsch's *Melanella micans borealis* is here added to the synonymy of *Balcis oldroydae*. The name is emended to *oldroydae* because Bartsch indicated that it was named after Mrs. Oldroyd.

Genus *Polygireulima* Sacco, 1892

Polygireulima Sacco, 1892. **Type species** (OD): *Eulima spina* Grateloup, 1838. Miocene, France.

Diagnosis. Shell tall, straight-sided, smooth, except for growth scars.

Biology. The host echinoderm of the European species is unknown (Warén, 1984:66), but the eastern Pacific species assigned to this genus is known to be parasitic on sea stars of many genera.

Remarks. The following species has traditionally been placed in *Balcis*, the species of which are parasitic on holothurians. Warén (1984) precludes the placement of species from different classes of echinoderms in the same genus. Because the following species is known to be associated with sea stars rather than holothurians, it is here assigned to the genus *Polygireulima*, the type species of which is a close match for shell characters.

Polygireulima rutila (Carpenter, 1864)

Figure 1.13E

Eulima rutila Carpenter, 1864:659.

Melanella (*Melanella*) *rutila*: Bartsch, 1917:306, pl. 35, fig. 2, 3, 6.

Melanella rutila: Oldroyd, 1927:373, pl. 46, figs. 2,3,6.

Balcis rutila: Palmer, 1958:195.

Melanella (*Balcis*) *rutila*: Abbott, 1974:125, fig. 1340.

Material Examined. California: Santa Maria Basin, Phase I, sta. 23, 195 m (2); sta. 84, 394 m (1); sta. 101, 357 m (1); Phase II, sta. PJ-12, 145 m (1); sta. PJ-14, 134 m (1); sta. PJ-15, 155 m (1); sta. PJ-17, 126 m (2). Other material: 140 lots in the LACM collection.

Description. Small, slender, straight; up to 13 whorls, flat-sided, smooth; growth scars few; aperture moderately elongate. Length 6-8 mm.

Type Locality and Type Specimens. Monterey, California. Holotype: USNM 14928.

Distribution. Monterey Peninsula, California (37°N) to Bahía Magdalena, Baja California Sur (Dall, 1921:118) (25°N). Occurring on hard and soft bottoms, 10-400 m.

Habitat. I have observed this species on asteroids of various species in the vicinity of Monterey Bay, California. It occurs in depths accessible to divers and offshore to 200 m or more.

Remarks. Although the shell characters of this species resemble those of *Balcis oldroydae*, it differs in its smaller size and its more slender profile. The species is here first assigned to *Polygireulima*.

Genus *Vitreolina* Monterosato, 1884

Vitreolina Monterosato, 1884. **Type species** (SD, Bucquoy, Dautzenberg and Dollfus, 1883): *Eulima incurva* Bucquoy, Dautzenberg and Dollfus, 1883. Europe.

Diagnosis. Shell slightly to strongly curved, oval in cross section, transparent; suture making marked dip at position of growth scar on shell.

Biology. The echinoderm host of the type species in unknown. European species for which hosts are known occur on ophiuroids, echinoids, and holothurians.

Remarks. *Vitreolina* is an exception among eulimid genera in having host echioderms of different classes. The other possibility admitted by Warén (1984) is that the genus is being used too broadly. However, the genus is well defined by its curved profile.

Vitreolina columbiana (Bartsch, 1917)

Figure 1.14A

Melanella (*Balcis*) *columbiana* Bartsch, 1917:324, pl. 41, fig. 5.—Abbott, 1974:126 [listed only].

Melanella columbiana: Oldroyd, 1927:369, pl. 47, fig. 5.

Melanella (*Balcis*) *grippi* Bartsch, 1917:326, pl. 42, fig. 5.

Balcis (*Vitreolina*) *titubans* Berry, 1956:154, fig. 7, 8.

Material Examined. Santa Maria Basin, Phase I, sta. 4, 393 m (1). Other material: 53 lots in the LACM collection.

Description. Relatively large, transparent, extremely flexed; whorls 15, body whorl slightly inflated; aperture long. Length 6-9.5 mm.

Type Locality and Type Specimens. Departure Bay, British Columbia. Holotype: USNM 207771. *Melanalla grippi*: Newport, Orange County, California; holotype: USNM 203665. *Balcis titubans*: Anacapa Island, California; holotype: SBMNH 34554.

Distribution. Attu, Aleutian Islands, Alaska [LACM 86-312] (53°N), to Isla Cedros, Baja California [LACM 71-156] (28°N).

Habitat. One LACM record (LACM 151103) indicates association with a large holothurian *Cucumaria* sp. Most records in the LACM collection indicate a depth of 50 m or less. Common in the northern part of the distribution, where it may occur in the intertidal zone.

Remarks. This species has the most extreme curvature of the northeastern Pacific species, differing also from other species in its relatively broad final whorl. The synonymy given above is a based on my examination of type material.

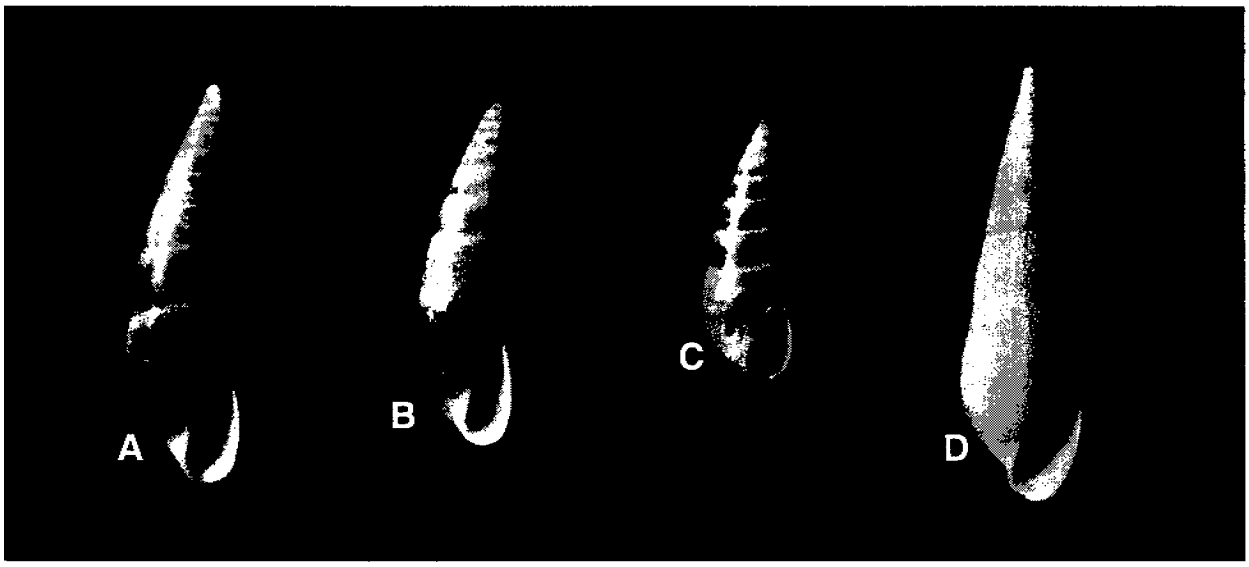


Figure 1.14. Eulimidae. **A.** *Vitreolina columbiana* (Bartsch, 1917): 27 m, off San Pedro, Los Angeles County, California (LACM 65-35.22); height 6.8 mm. **B.** *Vitreolina macra*: (Bartsch, 1917): 82 m, off Ship Rock, Santa Catalina Island, California (LACM 65-6.22); height 4.9 mm. **C.** *Vitreolina yod* (Carpenter, 1857): 366-375 m, off SE side San Nicolas Island, California (LACM 77-132.8); height 3.2 mm. **D.** *Haliella abyssicola* Bartsch, 1917: 392 m, off Point Sal, Santa Barbara County, California (SBMNH 142803, Santa Maria Basin, sta. 40); height 10.2 mm.

Vitreolina macra (Bartsch, 1917)

Figure 1.14B

Melanella (*Balcis*) *macra* Bartsch, 1917:326, pl. 41, fig. 6.—Abbott, 1974:126 [listed only].

Melanella macra: Oldroyd, 1927:370, pl. 47, fig. 6.

Melanella (*Balcis*) *catalinensis* Bartsch, 1917:329, pl. 40, fig. 7.

Melanella (*Balcis*) *prefalcata* Bartsch, 1917:327, pl. 42, fig. 4 (Pleistocene).

Balcis (*Vitreolina*) *obstipa* Berry, 1954:8, pl. 1, fig. 5,6 (Pleistocene).

Material Examined. Santa Maria Basin, Phase I, sta. 1, 98 m (2). Other material: 44 lots in the LACM collection.

Description. Shell of medium size, transparent, moderately flexed; whorls 13, nearly flat-sided, aperture relatively long. Length 6-7.5 mm.

Type Localities and Type Specimens. Departure Bay, British Columbia. Holotype: USNM 207772. *Melanella catalinensis*: Catalina Channel, California; holotype: USNM 173802. *Melanella prefalcata*: San Pedro, Los Angeles County, California, Pleistocene; holotype: USNM 215774. *Balcis obstipa*: San Pedro, Los Angeles County, California, Pleistocene; holotype: SBMNH 34546.

Distribution. Kachemak Bay, Alaska [LACM 80-76.36] (59°), to Islas Coronados, Baja California [LACM 79-106] (32°N).

Habitat. Hard and soft bottoms, 20-100 m; host unknown.

Remarks. This species is readily recognized by its longer aperture, more slender and less flexed profile than that of *Vitreolina columbiana*. The above synonymy is based on my examination of type material.

Vitreolina yod (Carpenter, 1857)

Figure 1.14C

Leiostraca yod Carpenter, 1857:441.—Brann, 1966, pl. 48, fig. 55b.—Keen, 1968:407, fig. 35.

Melanella (*Balcis*) *yod*: Bartsch, 1917:330, pl. 40, fig. 9.

Melanella (*Balcis*) *taravali* Bartsch, 1917:328, pl. 42, fig. 2.

Material Examined. Santa Maria Basin, Phase I, sta. 4, 393 m (1); sta. 2, 200 m (1). Other material: 27 lots in the LACM collection.

Description. Small, transparent, substantially flexed; whorls 8, slightly inflated; aperture moderately long. Length 2-3 mm.

Type Locality and Type Specimens. Mazatlán, Sinaloa. Syntype: NHML Carpenter tablet 2027. *Melanella taravalli*: Punta Abreojos, Baja California Sur; holotype: USNM 215779.

Distribution. Santa Maria Basin [voucher specimen] (35°N)] to Mazatlán, Sinaloa [type locality] (23°N). Although this species has a Panamic type locality and is common in the Gulf of California, there are 13 lots in the LACM collection from southern California.

Habitat. Soft bottoms, 20-400 m, host unknown.

Remarks. The distribution is here extended north from the Gulf of California; Keen (1971:446) indicated a distribution from Guaymas, Sonora, to Mazatlán, Sinaloa. This species is readily distinguished from other *Vitriolina* by its small size. The synonym *Melanella taravali* Bartsch is based on an immature specimen.

Genus *Haliella* Monterosato, 1878

Haliella Monterosato, 1878. **Type species** (M): *Eulima stenostoma* Jeffreys, 1858. North Atlantic.

Diagnosis. Shell tall and slender, with rounded whorls, aperture elongate, columella indented.

Biology. Species occur in relatively deep water at depths below 400 m. Echinoderm host unknown, although Warén (1984:47) suggests that it may prove to be an ophiuroid. Warén has studied the anatomy of the type species and notes that it is a protandric hermaphrodite.

Remarks. Warén (1984:47) indicated that there may be about six species worldwide.

Haliella abyssicola Bartsch, 1917

Figure 1.14D

Haliella abyssicola Bartsch, 1917:336, pl. 43, fig. 8.—Abbott, 1974:128, fig. 1406.

Material Examined. California: Santa Maria Basin, Phase I, sta. 40, 392 m (1). Other material: two specimens at CAS [ex Stanford 51315].

Description. Shell tall, moderately large, opaque white; whorls 10, slightly rounded; growth scars irregular in position; columella with indentation; aperture long. Length 11 mm.

Type Locality and Type Specimens. Off San Diego, 822 fathoms. Holotype: USNM 251266.

Distribution. Off Columbia River, Oregon [CAS 102991] (46°N), to Punta San Pablo, Baja California Sur [USNM 266887] (27°N).

Habitat. Soft bottoms, 400-1500 m; echinoderm host unknown.

Remarks. This species can be confused with no other. Its opaque shell with inflated whorls is characteristic.

Superfamily Muricoidea

Family Muricidae Rafinesque, 1815

Diagnosis. Shell with moderately high spire and short to long anterior canal. Sculpture both axial and spiral, often producing elaborate spines on regularly spaced varices. Operculum oval, with apical or lateral nucleus. Radula rachiglossate; rachidian multicuspid; lateral unicuspid.

Biology. Species are carnivorous, capable of boring into barnacle and bivalve shells. Egg capsules are attached to rocks or other shells.

Remarks. The most recent comprehensive treatment of worldwide muricid shells was that Radwin and D'Attilio (1976), although many groups were omitted. Muricid classification is in a state of flux, as recently discussed in two papers by Kool (1993).

Two subfamilies are utilized for the offshore species included here: Ocenebrinae and Trophoninae.

Key to Species of Muricidae

1A. Canal of mature shell sealed 2
1B. Canal of mature shell open 4

2A. Whorls rounded ..... *Ocinebrina lurida*
2B. Whorls shouldered 3

3A. Shoulder spinose ..... *Ocinebrina barbarensis*
3B. Shoulder aspinose ..... *Ocenotrophon painei*

4A. Sculpture axial, or axial with faint spiral striae 5
4B. Sculpture axial, with well-developed spiral cords 15

5A. Shell length > 40 mm ..... *Austrotrophon catalinensis*
5B. Shell length < 30 mm 6

6A. Shoulder aspinose 7
6B. Shoulder spinose 10

7A. Axial lamellae under 20 on final whorl 8
7B. Axial lamellae over 20 on final whorl 9

8A. Canal as long as aperture length ..... *Boreotrophon eucymatus*
8B. Canal shorter than aperture length ..... *Boreotrophon apolyonis*

9A. Canal as long as aperture length ..... *Boreotrophon kabati*
9B. Canal shorter than aperture length ..... *Boreotrophon tolomius*

10A. Spines laterally projecting 11
10B. Spines upturned 13

11A. Profile tabulate, shoulder area narrow ..... *Boreotrophon raymondi*
11B. Profile not tabulate, shoulder area broad 12

12A. Profile broad, length about 1.5 times breadth ..... *Boreotrophon triangulatus*
12B. Profiles narrow, length about 1.9 times breadth ..... *Boreotrophon avalonensis*

13A. Profile broad, length about twice breadth ..... *Boreotrophon multicostatus*
13B. Profile narrow, length about 3 times breadth 14

14A. Spines long, lamellae fading across base ..... *Boreotrophon bentleyi*
14B. Spines short, lamellae strong across base ..... *Boreotrophon keepi*

15A. Axial sculpture dominant in early teleoconch 16
15B. Spiral sculpture of two lamellar cords in early teleoconch 18

16A. Shoulder with upturned varices ..... *Boreotrophon stuarti*
16B. Shoulder lacking upturned varices 17

17A. Whorl profile angulate ..... *Boreotrophon pedroanus*
17B. Whorl profile rounded ..... *Boreotrophon hazardi*

18A. Whorls rounded ..... *Scabrotrophon lasius*
18B. Whorls shouldered 19

19A. Shoulder lacking strong spines 20
19B. Shoulder with strong spines 21

20A. Shoulder area with axial and spiral sculpture ..... *Scabrotrophon maltzani*
20B. Shoulder area with axial sculpture only ..... *Scabrotrophon cerritensis*

21A. Spines laterally projecting ..... *Scabrotrophon grovesi*
21B. Spines bent toward shell axis ..... *Scabrotrophon clarki*

Subfamily Ocenebrinae Cossmann, 1903

Diagnosis. Shell small to medium-sized, sculpture usually of scaly spiral cords, outer lip usually with denticles; operculum with lateral nucleus.

Remarks. Subfamilial classification of the Ocenebrinae was discussed in both papers by Kool (1993).

Genus *Ocinebrina* Jousseaume, 1880

Ocinebrina Jousseaume, 1880. **Type species** (OD): *Murex corallinus* Scacchi, 1836; = *Murex aciculatus* Lamarck, 1822. North Atlantic and Mediterranean.

Diagnosis. Shell small to medium in size; canal relatively short, sealed at maturity; mature lip thickened and projecting, with labial denticles; sculpture of finely imbricate spiral cords overriding axial ribs; protoconch paucispiral; operculum with lateral nucleus.

Biology. The paucispiral protoconch is indicative of direct development. Life histories of several species from Puget Sound were studied by Spight *et al.* (1974).

Remarks. The northeastern Pacific species formerly treated in *Ocenebra* Gray, 1847 [**type species** *Murex erinaceus* Linnaeus, 1758], are here placed in *Ocinebrina* on the recommendation of E. Vokes (personal communication). In the type species of *Ocenebra*, a thick lip with labial denticles and a sealed canal is formed repeatedly during resting stages of shell growth, whereas in *Ocinebrina* the siphonal canal remains open until final maturity is reached and the lip expands and produces labial denticles. Radwin and D'Attilio (1976:125, pl. 21, fig. 8) treated the European type species of *Ocinebrina,* which better resembles the eastern Pacific species than does the European type species of *Ocenebra* (Radwin and D'Attilio, 1976:119, pl. 18, figs. 4, 5).

Ocinebrina lurida (Middendorff, 1848)

Figure 1.15A

Tritonium luridum Middendorff, 1848:244.—Middendorff, 1848:479, pl. 4, figs. 4,5.

Tritonalia lurida: Oldroyd, 1927:314.

Urosalpinx lurida: Abbott, 1974:179, fig. 1886.

Ocenebra lurida: Radwin and D'Attilio, 1976:123, pl. 20, figs. 4,5.—McLean, 1978:43, fig. 22.7.

Vitularia aspera Baird, 1863:66 [unfigured].

Ocinebra lurida var. *munda* Carpenter, 1864:663.

Ocenebra lurida var. *munda*: Dall, *in* Williamson, 1892:215, pl. 20, fig. 3.—Palmer, 1958:204.

Material Examined. California: Santa Maria Basin, Phase I, sta. 13, 197 m (1 juvenile); sta. 27, 611 m (1). Other material: 215 lots in the LACM collection.

Description. Shell small, whorls rounded, suture moderately impressed, profile varying from slender to robust. Sculpture of low axial ribs that are overriden by spiral cords; axial ribs reduced anteriorly. Periostracum thick; shell color dark yellow to brownish orange, some specimens with darker brown bands or uniformly dark brown. Length 13-28 mm.

Type Locality and Type Specimens. Sitka, Alaska. Type material apparently lost; not in Zoological Institute, St. Petersburg. *Vitularia aspera*: Esquimalt Harbor, Vancouver Island, British Columbia; type material in the Natural History Museum, London. *Ocenebra lurida* var. *munda*: type material lost (Palmer, 1958:205); Palmer considered the name to have been validated by Dall *in* Williamson, and designated a lectotype from

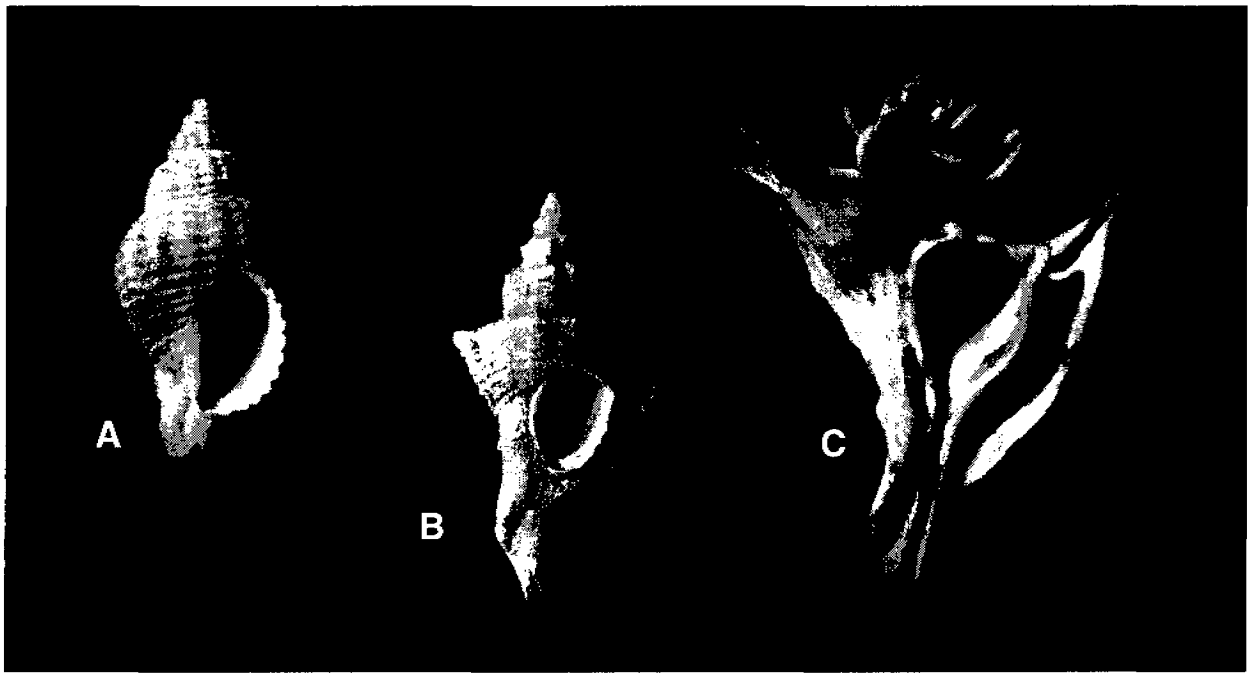


Figure 1.15. Muricidae. **A.** *Ocinebrina lurida* (Middendorff, 1848): 12-38 m, Carmel, Monterey County, California (LACM 60-24.66); height 14.1 mm. **B.** *Ocinebrina barbarensis* (Gabb, 1865): 86 m, S of Long Point, Santa Catalina Island, California (LACM 41-179.8); height 20.1 mm. **C.** *Austrotrophon catalinensis* (Oldroyd, 1927): 46 m, off San Pedro, Los Angeles County, California (CAS 063306, holotype); height 100 mm.

Monterey, California (USNM 46708), the locality taken from the specimen label. However, Carpenter's description is hardly less detailed than that of others of Carpenter and the name is here considered validated by Carpenter.

Distribution. Kenai Peninsula, Alaska (59°N, 151°W), to Puerto Santo Tomás, Baja California (31.5°N).

Habitat. Rocky bottoms, intertidal zone to 200 m.

Remarks. *Ocinebrina lurida* varies in overall length and in breadth of the shell. Shells from deeper water, as in the offshore form illustrated here, are generally more slender. *Ocinebrina sclera* (Dall, 1919), which was figured by Radwin and D'Attilio (1976, pl. 20, fig. 5), is a separate species of more northern occurrence; it is not a synonym of *O. lurida*, under which it was placed by Radwin and D'Attilio.

Ocinebrina barbarensis (Gabb, 1865)

Figure 1.15B

Murex (*Muricidea*) *barbarensis* Gabb, 1865:183.

Tritonalia barbarensis: Dall, 1921:108, pl. 6, fig. 5, pl. 15, fig. 11.

Ocenebra barbarensis: Abbott, 1974:183, fig. 1915.—McLean, 1978:42, fig. 22.2.

Ocenebra crispatissima Berry, 1953:414, pl. 28, fig. 6.

Material Examined. Santa Maria Basin, Phase I, sta. 1, 98 m (1 immature). Other material: 52 lots in the LACM collection.

Description. Shell slender, with canal longer than aperture. Shoulder strongly angulate, usually with upturned spines, but aspinose specimens known. Single upturned spine of terminal lip larger and more outwardly projecting than earlier formed spines. Length 15-20 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 40 fathoms. Lectotype **(here designated)** UCBP 10611 [syntypes were reported by Coan and Bogan, 1988:277].

Distribution. Monterey Bay, California (37°N), to Isla Cedros, Baja California (28°N). *Ocenebra crispatissima*: Isthmus Cove, Santa Catalina Island, California, 33 fathoms; holotype: CAS 064468.

Habitat. Rocky bottoms, 10-100 m.

Remarks. The species concept is based on figures of Dall (1921), not of type material, which has not been illustrated. *Ocenebra crispatissima* Berry was based on an aspinose specimen. Although both *Ocinebrina barbarensis* and *O. crispatissima* were treated by Radwin and D'Attillio (1976:120) as synonyms of *Ocinebrina foveolata* (Hinds, 1844), *Ocinebrina barbarensis* is a well-differentiated species, having the longest canal of the northeastern Pacific species.

Genus *Austrotrophon* Dall, 1902

Austrotrophon Dall, 1902. **Type species** (SD, Grant and Gale, 1931): *Trophon cerrosensis* Dall, 1891. Tropical eastern Pacific.

Diagnosis. Shell moderately large; axial sculpture of broad winglike varices producing long spines at shoulder; color light brown, surface not chalky. Operculum with lateral nucleus.

Remarks. This genus is known from southern California and the Panamic Province. The type species, figured by Keen (1971:537, fig. 1044), has prominent spiral cords on the body whorl.

Although the shell sculpture of broad varices resembles that expected in the subfamily Trophoninae, the nucleus of the operculum is lateral rather than terminal. *Austrotropon* has been placed in different subfamilies by previous authors. Radwin and D'Attillio (1976:176) did not treat it in their book on Muricidae because they considered that the radula placed it in the family Thaididae (now the muricid subfamily Rapaninae). The operculum is similar to that of *Forreria belcheri* (Hinds. 1844), which was placed by Kool (1993: 227) in the Ocenebrinae on the basis of anatomical characters. I therefore group *Austrotrophon* in the Ocenebrinae.

Austrotrophon catalinensis (Oldroyd, 1927)

Figure 1.15C

Trophon (Austrotrophon) catalinensis Oldroyd, 1927:327, pl. 34, f. 1-5.

Forreria (Austrotrophon) catalinensis: Grant and Gale, 1931:726.

Trophon (Austrotrophon) cerrosensis catalinensis: Abbott, 1974:191, pl. 9, fig. 2008.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 43 LACM lots.

Description. Shell light brown, often with darker brown axial markings and faint spiral bands; sculpture of 7 sharp varices per whorl, upturned and projecting diagonally, forming spines open in front; aperture white, glossy; parietal wall broad, inner lip raised; siphonal canal long, open, forming a fasciole, nearly straight or twisted to left. Length 80-100 mm.

Type Locality and Type Specimens. Off San Pedro, Los Angeles County, California, 25 fathoms. Holotype: CAS 063306.

Distribution. Off Point Conception, Santa Barbara County, California (34.5°N) to Punta Abreojos, Baja California Sur (26°N).

Habitat. 40-160 m on soft bottoms.

Remarks. In her description of this species, Oldroyd (1927:327) noted that this species "has been called *Trophon triangulatus* Carpenter," evidently referring to illustrations of Dall (1891, pl. 5, figs. 1, 6). However, in my opinion, Dall's illustrations represents a variant of the type species *Trophon cerrosensis*, which Dall described in the same paper. Abbott (1974:191) placed *Austrotrophon catalinensis* as a subspecies of under *A. cerrosensis*, but that species, the type species of *Austrotrophon*, differs in having spiral sculpture and more laterally directed shoulder spines. *Austrotrophon pinnatus* (Dall, 1902), which has a more southern distribution in Baja California, is a similar species. It differs in its higher spire, more twisted fasciole and more extensive development of a broad flaring varix below the aperture.

Subfamily Trophoninae Cossmann, 1903

Diagnosis. Shell fusiform, usually white; sculpture of axial lamellae not forming varices of alternating strength, with spiral sculpture usually weak or lacking. Operculum with apical nucleus.

Remarks. Genera occur in cool water, usually at high latitudes, or deeply submergent at tropical latitudes. The genera are poorly known and in need of review. Generic characters emphasized here are provided by the early teleoconch sculpture.

Kool (1993:55) noted that *Trophon geversianaus* (Pallas, 1774), the type species of the nominate genus *Trophon* Montfort, 1910, is atypical of species usually included in Trophoninae, and suggested that the group may not be monophyletic.

Genus *Boreotrophon* Fischer, 1884

Boreotrophon Fischer, 1884. **Type species** (M): *Murex clathratus* Linnaeus, 1767. Arctic Ocean.

Diagnosis. Shell fusiform, with long anterior canal; protoconch paucispiral, of 1.5 rounded, well-separated whorls; axial sculpture of strong lamellae, early teleoconch sculpture axial; spiral sculpture if present not crossing or raised above axial lamellae.

Remarks. Many species of *Boreotrophon* lack spiral sculpture altogether. Spiral sculpture in the species that have it is of lesser strength than the axial sculpture and does not override the axial lamellae. The earliest teleoconch sculpture is always dominated by axial elements.

This is a genus of the Northern Hemisphere, with numerous species in the Arctic Ocean, the North Atlantic and the North Pacific.

Egorov (1992, 1993) reviewed the species of the northwestern Pacific. Radwin and D'Attilio (1976:179) treated the type species, but did not treat other species of the genus. All species known from southern California are treated here.

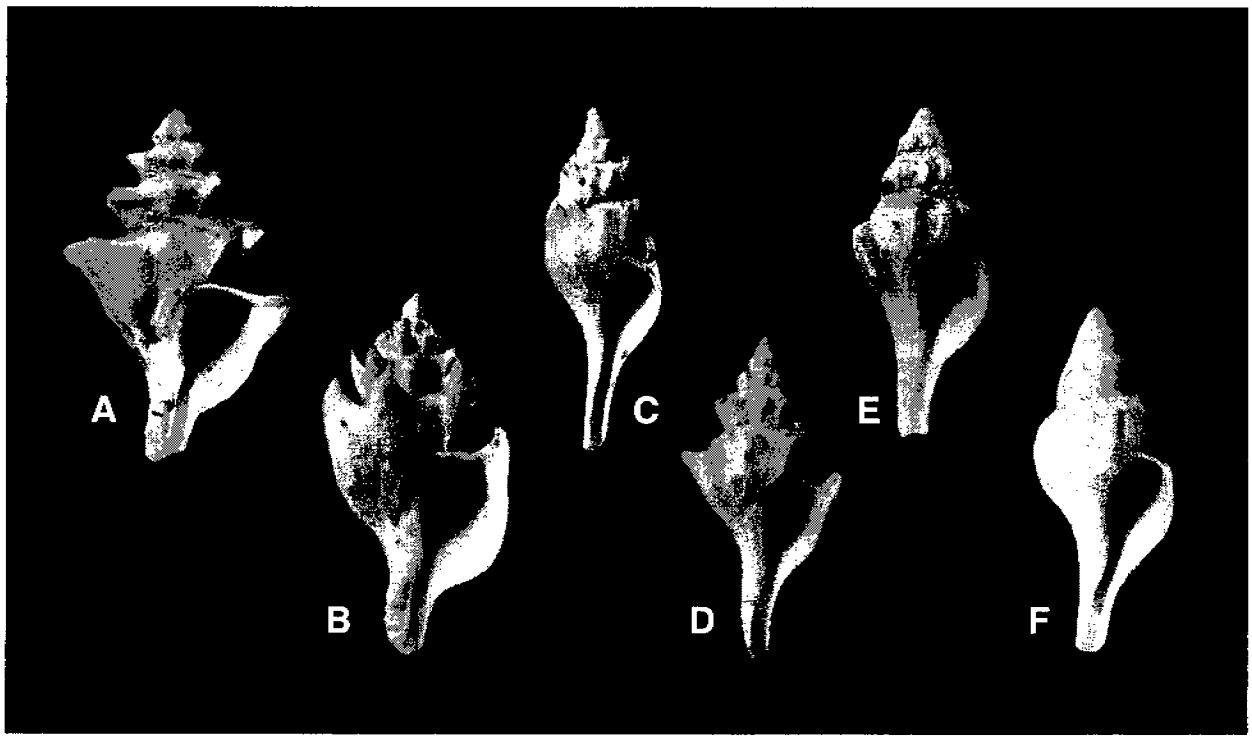


Figure 1.16. Muricidae. **A.** *Boreotrophon triangulatus* (Carpenter, 1864): 55 m, off White's Landing, Santa Catalina Island, California (LACM 1028, holotype of *Trophon albospinosus*), height 21 mm. **B.** *Boreotrophon multicostatus* (Eschscholtz, 1829): 29 m, off Santa Catalina Island, California (USNM 109165, holotype of *Boreotrophon peregrinus*); height 23 mm. **C.** *Boreotrophon bentleyi* Dall, 1908: 37 m, off San Diego Harbor, California (USNM 110648, holotype); height 19.5 mm. **D.** *Boreotrophon avalonensis* Dall, 1902: 146 m, off Avalon, Santa Catalina Island, California (USNM 109109); height 16.5 mm. **E.** *Boreotrophon avalonensis* Dall, 1902: 40 m, Cortez Bank, California (CAS 102992); height 19 mm. **F.** *Boreotrophon eucymatus* Dall, 1902: 227 m, off San Diego, California (USNM 109089, holotype); height 21 mm [not 27 mm].

Boreotrophon triangulatus (Carpenter, 1864)

Figure 1.16A

Trophon triangulatus Carpenter, 1864:653.—Dall, 1891:181, pl. 5, fig. 3.

Trophon (*Austrotrophon*) *triangulatus*: Oldroyd, 1927:326, pl. 34, figs. 6, 7.

Trophonopsis triangulatus: Palmer, 1958:207.

Trophon (*Boreotrophon*) *albospinosus* Willett, 1931:66, pl. 4, fig. 3.

Material Examined. No material is present in the voucher collection. Other material: 26 LACM lots.

Description. Shell white, relatively small, profile broad; whorls markedly angulate, anterior canal short; axial lamellae about 6-8 per whorl, lamellae spinose, laterally projecting at periphery; spiral sculpture lacking. Length 15-21 mm.

Type Locality and Type Specimens. Santa Catalina Island, California. Lectotype (selected by Palmer, 1958:208): UCMP 12572. *Trophon albospinosus*: White's Landing, Santa Catalina Island, 30 fathoms; holotype: LACM 1028.

Distribution. Point Conception, Santa Barbara County (34.5°N), to Santa Catalina Island, California (33°N).

Habitat. Rocky bottoms, 20-90 m.

Remarks. This species is broad, with the body whorl and base having a triangular profile. It resembles *Boreotrophon avalonensis*, but is broader, with a shorter canal. It also resembles the more northern species *B. multicostatus* (Eschscholtz, 1829), which reaches larger sizes, has a more cylindrical profile, and has spines that are upturned.

Boreotrophon multicostatus (Eschscholtz, 1829)

Figure 1.16B

Murex multicostatus Eschscholtz, 1829 [1829-31], part 2:11, pl. 4, fig. 4.

Trophon (*Neptunea*) *multicostatus*: Oldroyd, 1927:331, pl. 33, fig. 11.

Trophon (*Boreotrophon*) *multicostatus*: Grant and Gale, 1931:722.

Boreotrophon peregrinus Dall, 1902:543.—Dall, 1921:110, pl. 8, fig. 5.

Material Examined. Not represented in the Santa Maria voucher collection. Other material examined: 78 LACM lots, including 13 lots from south of Point Conception.

Description. Shell white, aperture usually brown within; small to medium size, profile broad; anterior canal moderately long, less than length of aperture; axial lamellae 6-10 per whorl, spinose at shoulder, spiral sculpture of fine striae. Length 20-30 mm.

Type Locality and Type Specimens. Sitka, Alaska; type material not located. *Boreotrophon peregrinus*: Catalina Harbor, Santa Catalina Island, California, 16 fathoms; holotype: USNM 109165.

Distribution. Kenai Peninsula, Alaska (59°N, 152°W), to Laguna Beach, Orange County, California (33.5°N).

Habitat. Rocky and gravel bottoms, intertidal to 100 m. Specimens from southern California are submergent, at depths greater than 40 m.

Remarks. Dall's taxon *Boreotrophon peregrinus* is here first placed in the synonymy of this species. *Boreotrophon multicostatus* has been considered to be a more northern species, but there are specimens in the LACM collection from throughout the distribution. Northern specimens tend to reach larger sizes and may have more numerous axial lamellae than those occurring in southern California.

The profile is broader and more cylindrical than that of *Boreotrophon triangulatus* and the shoulder spines are more upturned.

Boreotrophon bentleyi Dall, 1908

Figure 1.16C

Boreotrophon bentleyi Dall, 1908:249.—Abbott, 1974:190 [listed only].

Trophon (*Neptunea*) *bentleyi*: Oldroyd, 1927:333.

Material Examined. California: Santa Maria Basin, Phase I, sta. 17, 654 m (1 immature); Phase II, sta. R-2, 161 m (1). Other material: 40 lots in the LACM collection.

Description. Shell white, relatively small, slender; anterior canal long; axial lamellae 9-12 per whorl; lamellae spinose, upturned and strongly projecting at shoulder, fading across base; spiral sculpture lacking or faintly indicated. Length 20-27 mm.

Type Locality and Type Specimens. San Diego, California, 20 fathoms. Holotype: USNM 110648.

Distribution. Off Gaviota, Santa Barbara County (34°N), to La Jolla, San Diego County, California (33°N).

Habitat. Rocky bottoms, 100-350 m.

Remarks. This species is characterized by its slender profile and prominent upturned spines; the spines are parallel to the body whorl and not laterally projecting.

Boreotrophon avalonensis Dall, 1902

Figure 1.16D,E

Boreotrophon avalonensis Dall, 1902:546.—Dall, 1921:110, pl. 8, fig. 8.—Abbott, 1974:190, fig. 1980 [copy Dall figure].

Neptunea callicerata Dall, 1919:338 [holotype unfigured].

Neptunea staphylina Dall, 1919:338 [holotype unfandigured].

Material Examined. No material is present in the voucher collection. Other material: 29 lots in the LACM collection.

Description. Shell white, relatively small; profile moderate, anterior canal relatively long; axial lamellae about 7-9, usually spinose and laterally projecting at shoulder, spiral sculpture lacking. Length 15-21 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, California, 80 fathoms. Holotype: USNM 109109. *Neptunea callicerata*: Off Point Loma, San Diego County, California; 120-131 fathoms; holotype: USNM 209914. *Neptunea staphylina*: Off Santa Barbara Island, California, 302-638 fathoms; holotype: USNM 209947.

Distribution. Santa Rosa Island, California (34°N), to Islas San Benito, Baja California (28 °N).

Habitat. Rocky bottoms, 80-270 m.

Remarks. This resembles *Boreotrophon triangulatus* in its laterally projecting spines, but has a longer canal, more lamellae, and is smaller. It is broader than *B. bentleyi*, with the spines lower on the shoulder, and more laterally projecting.

The synonymy above is introduced here. The holotype of the junior synonym *Neptunea callicerata* is similar to that of *Boreotrophon avalonensis*. The holotype of the junior synonym *Neptunea staphylina* has weak spines. Figure 16E shows a specimen lacking development of the spines; this specimen is referred to *B. avalonensis* because the angulate periphery is low on the whorl.

Boreotrophon eucymatus Dall, 1902

Figure 1.16F

Boreotrophon (*avalonensis* var.?) *eucymatus* Dall, 1902:547.—Dall, 1921:110, pl. 15, fig. 7.

Trophon (*Neptunea*) *eucymatus*: Oldroyd, 1927:333, pl. 30, fig. 9.

Boreotrophon eucymatus: Abbott, 1976, fig. 1984 [not fig. 1989].

Material Examined. No material is present in the voucher collection, although the species occurs in southern California. Other material: 19 lots in the LACM collection.

Description. Shell white, relatively small, profile of moderate breadth, anterior canal long; axial lamellae about 13-19; lamellae aspinose, backfilled; shoulder angulate; spiral sculpture lacking. Length 15-26 mm.

Type Locality and Type Specimens. Off San Diego, California, 124 fathoms. Lectotype **(here designated)**: USNM 109087.

Distribution. Off Santa Barbara Island (33.5°N) to N of San Clemente Island, California (33°N).

Habitat. Rocky bottoms, 100-500 m.

Remarks. This species differs from other species in southern California in lacking spines at the shoulder and in having the lamellae low and backfilled. The shoulder is higher on the whorl than that of *Boreotrophon avalonensis*.

Boreotrophon apolyonis (Dall, 1919)

Figures 1.17A,B

Neptunea apolyonis Dall, 1919:337.

Trophon (*Neptunea*) *apolyonis*: Oldroyd, 1927:338.

Trophonopsis apolyonis: Abbott, 1974: 191 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: LACM 76-313.1, Tanner Bank, California, 390 m (1); LACM 77-250.16, Tanner Bank California, 511-530 m (1).

Description. Shell white, size medium, of moderate width, canal deflected to left, length less than aperture length; axial lamellae retractively flexed at shoulder, 13-15 on final whorl, cresting and faintly spinose at shoulder; spiral sculpture of fine, regularly spaced, incised striae. Length 14-21 mm.

Type Locality and Type Specimens. "Vicinity of Santa Barbara Islands" [off San Nicolas Island, California], 216-339 fathoms. Lectotype **(here designated)**: USNM 209303.

Distribution. San Nicolas Island (33°N) to Tanner Bank, California (33.5°N).

Habitat. Soft bottoms, 390-620 m.

Remarks. Type material is illustrated here for the first time (Figure 17A) and the first subsequent records of the species are also reported here (Figure 17B). The three known records for this species are from greater depths than those of the preceding species.

Boreotrophon apolyonis has a shell profile suggestive of the boreal type species, *Boreotrophon clathratus* (Linnaeus, 1767), but differs in its smaller size and presence of spiral sculpture.

Boreotrophon raymondi (Moody, 1916)

Figure 1.17C,D

Trophon raymondi Moody, 1916:53, pl. 1, figs. 1a, 1b.

Trophon (*Boreotrophon*) *raymondi*: Grant and Gale, 1931:724.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material: 17 LACM lots.

Description. Shell white, relatively small, of moderate width; body whorl constricted at base, canal long and straight, length of canal greater than length of aperture; shoulder area concave. Axial lamellae retractively flexed at shoulder, poorly developed on shoulder, 11-14 on final whorl, sharply spinose at shoulder, spines laterally directed; spiral sculpture of fine striae. Length 14-20 mm.

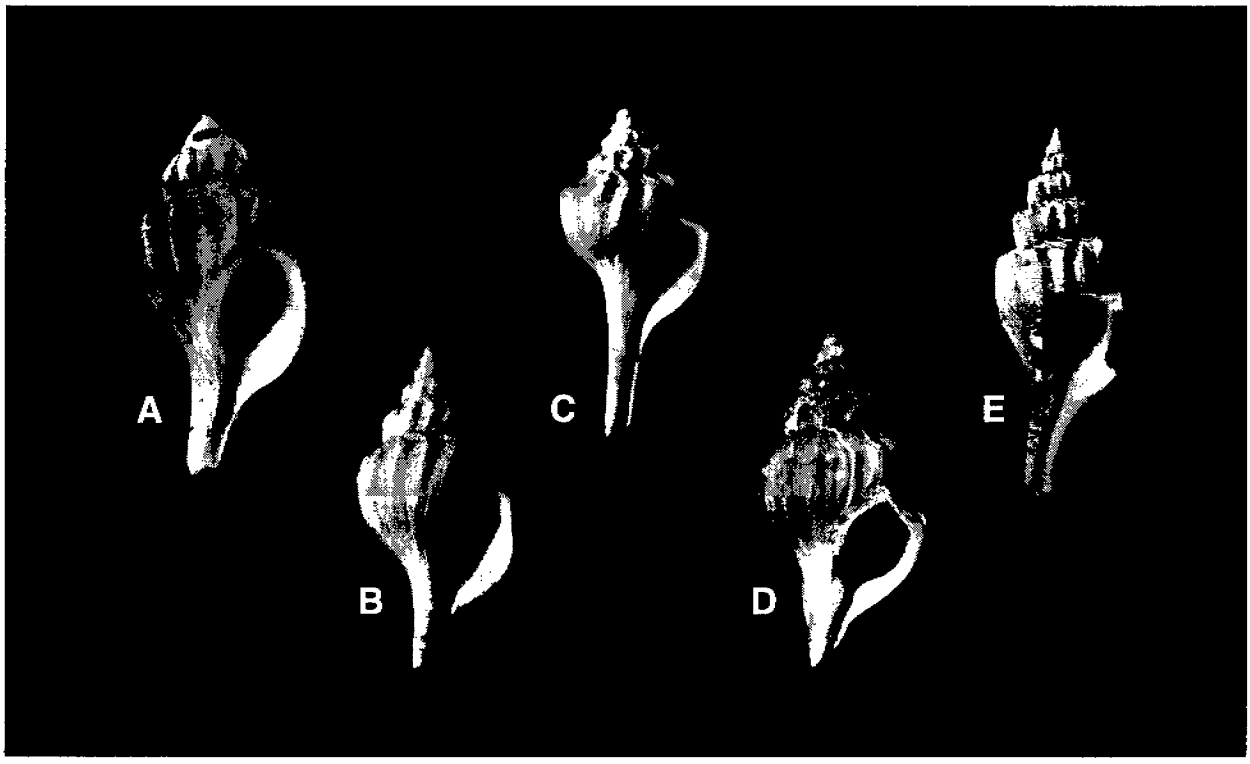


Figure 1.17. Muricidae. **A.** *Boreotrophon apolyonis* (Dall, 1919): 395-620 m, Santa Barbara Islands, California (USNM 209303, lectotype); height 21 mm. **B.** *Boreotrophon apolyonis* (Dall, 1919): 390 m, Tanner Bank, California (LACM 76-313.1); height 14.0 mm. **C.** *Boreotrophon raymondi* (Moody, 1916): 390 m, Tanner Bank, California (LACM 76-313.3); height 14.9 mm. **D.** *Boreotrophon raymondi* (Moody, 1916): Off China Harbor, Santa Cruz Island, California, 234 m (Thelma Crow collection); height 18.8 mm. **E.** *Boreotrophon keepi* (Strong and Hertlein, 1937): 55-91 m, off W end San Nicolas Island, California (CAS 065961, holotype); height 26.9 mm.

Type Locality and Type Specimens. Upper Pliocene, Fourth and Broadway, Los Angeles, California. Holotype: UCMP 11088.

Distribution. Queen Charlotte Sound, British Columbia [LACM 69-71.11] (52°N), to San Clemente Island, California [LACM 76-387.8] (32.5°N).

Habitat. Soft bottoms, 80-440 m. Occurring at minimal depths in the northern part of the distribution; at depths greater than 300 m in southern California.

Remarks. This species, which was originally described from the Upper Pliocene of Los Angeles, is here first reported in the living fauna. There is variation in size in the living material, as also reported by Moody for fossil specimens, as well as variation in spire height and the number of axial lamellae. Figure 17D shows a higher-spired specimen in which the canal tip is missing due to breakage.

The long canal and overall profile of *Boreotrophon raymondi* resembles that of *B. coronatus* (H. and A. Adams, 1864) [=*Trophon muriciformis* Dall, 1877], a much larger, northern species from the Chukchi and Bering Seas. Immature shells of that species comparable in size to specimens of *B. raymondi* differ in being more slender and in having one less teleoconch whorl, and also differ in lacking the fine spiral sculpture of *B. raymondi*.

Boreotrophon keepi (Strong and Hertlein, 1937)

Figure 1.17E

Trophon keepi Strong and Hertlein, 1937:170, pl. 35, fig. 8.

Trophonopsis keepi: Abbott, 1974:191 [listed]

Material Examined. Not represented in the Santa Maria Basin collection. Material examined: holotype and LACM 75-319.2, off South Point, Santa Rosa Island, California, 115 m (5).

Description. Shell white, size medium, of slender profile; canal length equal to aperture length; axial lamellae 10-12, of moderate strength, slightly spinous at shoulder, extending from shoulder to canal, but lower and more crowded on canal; spiral sculpture of microscopic striae. Height 26.9 mm.

Type Locality and Type Specimens. Off W end San Nicolas Island, California, 30-50 fathoms. Holotype: CAS 065961.

Distribution. Off Santa Rosa Island (34°N) to San Nicolas Island, California (33°N).

Habitat. Soft bottoms, 55-90 m.

Remarks. This species has a moderate number of axial lamellae that extend across the body whorl and crest at the shoulder. It is more slender, with more numerous, but less raised lamellae than those of *Boreotrophon multicostatus*. It is larger than *B. bentleyi*, from which it differs in having less projecting spines at the shoulder and lamellae that extend across the body whorl. It differs from *B. apolyonis* in its more slender profile and lack of broadly marked spiral sculpture. It most resembles the more northern *B. clathratus* (Linnaeus, 1767), from which it differs in its much more slender profile.

The five specimens reported here from Santa Rosa Island are the only additional specimens known. They are immature (the largest measures 13.2 mm in height), but the identity is certain because of their extremely slender profile.

Boreotrophon kabati McLean, new species

Figure 1.18A

Material Examined. Not represented in the Santa Maria voucher collection. Other material in addition to holotype: LACM 41-204.6, off Long Point, Santa Catalina Island, California, 488-635 m (1); LACM 53-6.2, off Long Point, Santa Catalina Island, California, 419 m (1); LACM 75-320.5, off South Point, Santa Rosa Island, California, 103 m (1); LACM 40-170.6, off Gull Island, S side Santa Cruz Island, California, 201-256 m (1).

Description. Shell white, relatively small, slender; shoulder rounded, high on whorl. Canal long, of length equal to that of aperture length. Apex eroded on all specimens. Axial lamellae numerous, low, partially backfilled, 28-37 on final whorl (28 on holotype), retractively flexed at shoulder, but not spinous, well developed on shoulder and body whorl, well marked but less elevated on canal. Spiral sculpture lacking. Length of holotype 17.0 mm.

Type Locality and Type Specimens. Off Long Point, Santa Catalina Island, California (33°24.7'N, 118°14.1'W), *Velero* IV, sta. 1402-41, 440-488 m, 1 specimen. Holotype: LACM 2782.

Distribution. Santa Rosa Island (34°N), to Santa Catalina Island, California (33.5°N).

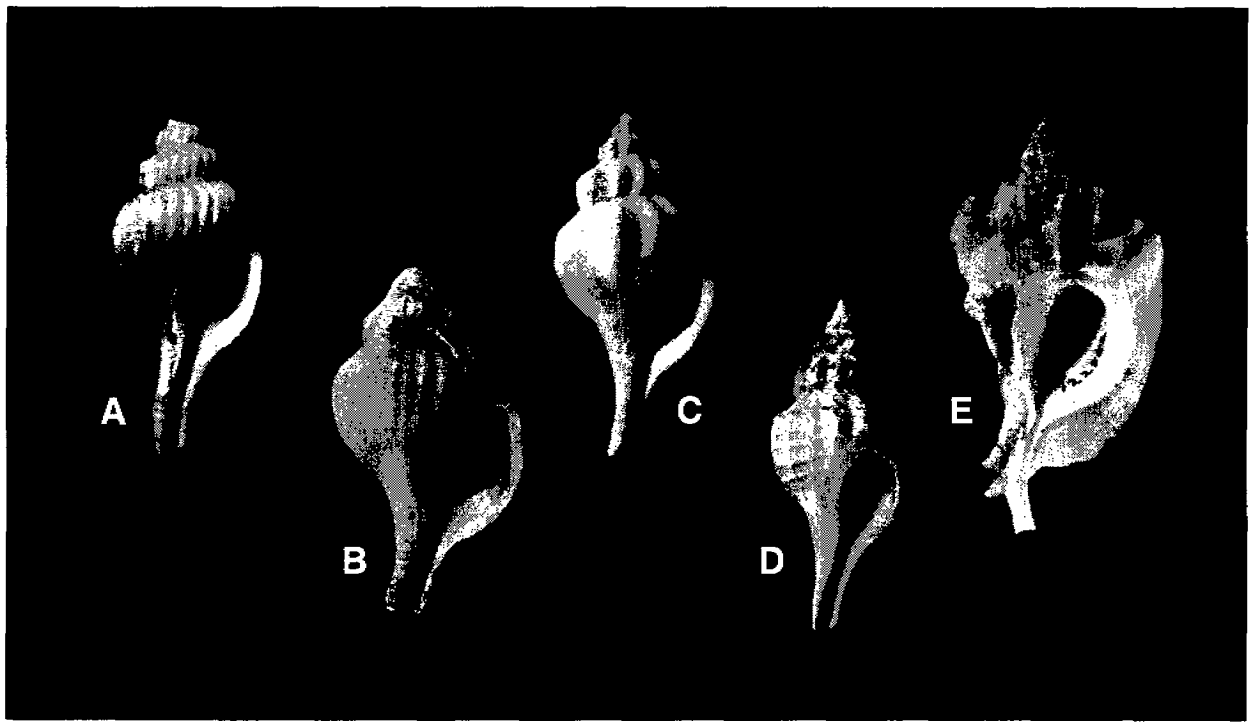


Figure 1.18. **A. *Boretrophon kabati* McLean, new species**: 439-488 m, off Long Point, Santa Catalina Island, California (LACM 2782, holotype); height 17.0 mm. **B.** *Boreotrophon tolomius* (Dall, 1919): off San Miguel Island, California (USNM 222441, holotype); height 19 mm. **C. *Boreotrophon hazardi* McLean, new species**: 219 m, off Isla Vista, Santa Barbara County, California (LACM 2783, holotype); height 20.0 mm. **D.** *Boreotrophon pedroanus* (Arnold, 1903): 270 m, off Gaviota, Santa Barbara County, California (LACM 65582); height 14.5 mm. **E.** *Boreotrophon stuarti* (E. A. Smith, 1880): 112 m, off Santa Barbara, California (USNM 122582, holotype of *Boreotrophon smithi*); height 41 mm.

Habitat. Soft bottoms, 100-490 m.

Remarks. This species differs from other eastern Pacific species in its slender profile and numerous axial lamellae. In its numerous ribs it most closely resembles *Boreotrophon tolomius*, but that species differs in its broader profile, shorter canal and faint spiral sculpture. It also resembles the more northern species *B. tripherus* Dall, 1902, which has traces of spiral sculpture, and axial ribs that are more strongly retractive and fewer (approximately 14) that fade on the body whorl below the shoulder.

The name honors Dr. Alan R. Kabat, formerly of the U.S. National Museum of Natural History.

Boreotrophon tolomius (Dall, 1919)

Figure 1.18B

Neptunea tolomia Dall, 1919: 337.

Trophon (*Neptunea*) *tolomia*: Oldroyd, 1927:339.

Trophonopsis tolomius: Abbott, 1974:191 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Material examined: holotype.

Description. Shell white, size medium, profile broad, canal relatively short, less than half length of aperture. Axial lamellae numerous, 35 on final whorl, low, backfilled, extending across shoulder and body whorl, but diminished on canal. Shoulder weakly angulate; spiral cords weak, about 6 on shoulder and body whorl, forming faint nodes where crossing axial ribs. Length of holotype 19.3 mm.

Type Locality and Type Specimens. Off San Miguel Island, California, 376 fathoms. Holotype: USNM 222441.

Distribution. Off San Miguel Island, California (known only from holotype).

Habitat. Soft bottoms, 690 m.

Remarks. This species is unlike others from the northeastern Pacific in its broad profile and large number of axial lamellae. In its numerous axial lamellae, it is similar to *Boreotrophon kabati*, but differs in its broader profile, shorter canal, and faint spiral sculpture. Dall's original description made no mention of the spiral sculpture, but it is apparent in the illustration here.

Although the depth reported for this species is greater than that of other species included in this work, an exception is made in order to figure the holotype for the first time and provide a basis for comparison to the new species *B. kabati*.

Boreotrophon hazardi McLean, new species

Figure 1.18C

Material Examined. Not represented in the Santa Maria Basin voucher collection. Known only from holotype and paratype.

Description. Shell white, size medium, profile moderately broad, suture constricted. Whorls 4, rounded on final whorl, weakly angulate on early whorls; canal length equal to aperture length. Axial ribs few, 10 on final whorl, number of axial ribs constant from whorl to whorl, ribs projecting, backfilled, extending across shoulder and body whorl but obsolete on canal. Spiral cords faint, 4, interspaces of similar width, detected only on final whorl and penultimate whorl. Columellar wall not projecting to form raised inner lip. Height of holotype 20.0 mm.

Type Locality and Type Specimens. Off Naples Point, Isla Vista, Santa Barbara County, California (approximately 34°23'N, 120°00'W), 220 m. Collected by Ralph Hazard on dragboat *Kildee*, January 1974. Holotype: LACM 2783. There was an additional paratype specimen (length 18.8 mm) from the same sample retained by the late Thelma Crow, but the whereabouts of that specimen is now unknown. Although the tip of the canal in the holotype is broken, the canal apparently retains its original length.

Distribution. Off Isla Vista, Santa Barbara County (34.5°N); known only from type locality.

Habitat. Soft bottoms, 220 m.

Remarks. This species is unlike other northeastern Pacific species in its relatively few, massive, backfilled axial ribs, faint spiral sculpture, and deeply impressed suture.

This species is named after Ralph Hazard, skipper of the dragboat *Kildee*, who saved numerous shells for the late Thelma Crow, who in turn donated them to the LACM collection.

Boreotrophon pedroanus (Arnold, 1903)

Figure 1.18D

Trophon (*Boreotrophon pedroana* Arnold, 1903:251, pl. 6, fig. 12.

Trophon (*Boreotrophon*) *orpheus* var. *pedroana*: Grant and Gale, 1931:723.

Boreotrophon pedroanus: Woodring, 1946:76.

Trophon (*Boreotrophon*) *stuarti* var. *praecursor* Arnold, 1903:253, pl. 6, fig. 5.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 21 LACM lots.

Description. Shell light tan with darker aperture, relatively small; spire high, suture deeply impressed; whorls shouldered, canal moderately long. Axial lamellae low, 16-18 on final whorl, crossed by 4 spiral cords of equal strength, one defining the shoulder, one at periphery and 2 below. Early whorls showing the shoulder cord and the peripheral cord. Height 14-20 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype not located. *Trophon stuarti* var. *praecursor*: San Pedro, California, Pleistocene; holotype: USNM 162546.

Distribution. Santa Rosa Island, California (34°N), to Isla Todos Santos, Baja California (32°N) [LACM 41-25.16].

Habitat. 40-270 m, soft bottoms.

Remarks. This species is here reported living for the first time, having been first described as a Pleistocene fossil. Grant and Gale (1931) and Woodring (1946) associated the two names. Although most specimens in the LACM collection were not live-collected, one lot (LACM 150844) has immature specimens that were live-collected.

Boreotrophon pedroanus resembles the more northern species *B. orpheus* (Gould, 1849), which differs in having more numerous spiral cords of lesser strength than that of the axial varices.

Boreotrophon stuarti (E. A. Smith, 1880)

Figure 1.18E

Trophon stuarti E. A. Smith, 1880:481, pl. 48, fig. 6.

Trophon (*Neptunea*) *stuarti*: Oldroyd, 1927:333, pl. 33, fig. 13.

Trophon (*Boreotrophon*) *stuarti*: Arnold, 1903:252, pl. 6, fig. 4.

Boreotrophon stuarti: Abbott, 1974:189 [not fig. 1973, *smithi*].

Boreotrophon (*stuarti* var.?) *smithi* Dall, 1902:542.

Trophon (*Neptunea*) *smithi*: Dall, 1921:111, pl. 13, fig. 8.—Oldroyd, 1927:336, pl. 33, fig. 14 [copy Dall fig.].

Boreotrophon smithi: Abbott, 1974:189, fig. 1973 [as synonym of *B. stuarti*].

Material Examined. Not represented in the Santa Maria Basin voucher collection, but occurring offshore in California. Material examined: 53 LACM lots.

Description. Shell white, relatively large; spire high, whorls shouldered, canal moderately long. Axial lamellae 7-11 per whorl, thin, strongly projecting, crossed by narrow, raised spiral cords, 2 on early whorls, about 5 on body whorl (but sometimes obsolete on body whorl), producing coarse cancellations; inner lip thin, raised, outer lip with thin projecting edge. Length 35-60 mm.

Type Locality and Type Specimens. Vancouver Island, British Columbia; holotype: Natural History Museum, London. *Boreotrophon stuarti* var. *smithi*: off Santa Barbara Island, California, 61 fathoms; holotype USNM 122582.

Distribution. Pribilof Islands, Bering Sea (58°N); Kenai Peninsula, Alaska, to Newport Beach, Orange County, California (33°N).

Habitat. Rocky bottoms, 0-100 m, occurring in the intertidal and offshore in Alaska, but deeply submergent in California.

Remarks. Specimens in collections from California are smaller than those from more northern localities. The variety *Boreotrophon smithi* differs in lacking spiral sculpture in later whorls and in its broader profile and wider lamellae. It occurs throughout the range of *B. stuarti*

Genus *Scabrotrophon* McLean, new genus

Type species (here designated): *Trophon maltzani* Kobelt and Küster, 1878. Northeastern Pacific.

Diagnosis. Shell small to medium in size, canal moderately long, open; protoconch paucispiral, of 1.5 rounded, well-separated whorls. Sculpture axial and spiral; early sculpture dominated by 2 strong spiral cords; spiral cords scabrous, overriding axial ribs of mature sculpture.

Remarks. *Scabrotrophon* is characterized by the two dominant spiral cords of the early sculpture and strongly scabrous spiral cords of mature whorls. It differs from *Boreotrophon*, in which the dominant early sculpture is axial, in having spiral sculpture that overrides the axial ribs at all growth stages. In *Boreotrophon*, spiral sculpture (if present) does not override the axial ribs.

Eastern Pacific species of this genus have previously been allocated to *Trophonopsis* Bucquoy, Dautzenberg, and Dollfus, 1882 [**type species** (OD): *Murex muricatus* Montagu, 1803; Europe], and, more recently to *Nipponotrophon* Kuroda and Habe, 1971 [**type species** *Boreotrophon echinus* Dall, 1918; Japan].

The genus *Trophonopsis* is inappropriate because the north European and Mediterranean type species (see Egorov, 1993, figs. 34E, F) has dominant axial rather than spiral sculpture in the early whorls. The very prominent axial ribs are overriden by spiral sculpture that forms beads at intersections with the axial sculpture. Moreover, there are prominent labial denticles, which are not seen in the northeastern Pacific species.

Radwin and D'Attilio (1976:82) used the genus *Nipponotrophon*, but that genus is characterized by a strong mid-whorl angulation at all growth stages. Although the assignment of eastern Pacific species to *Nipponotrophon* has been followed without discussion by subsequent authors, the northeastern Pacific species differ in having the two spiral cords in the early teleoconch and more extensive spiral sculpture at maturity. I do not consider *Nipponotrophon* to be applicable to any northeastern Pacific species. Like the genus *Boreotrophon*, I consider *Scabrotrophon* to be restricted to the Northern Hemisphere.

Five species are treated here, including 2 new species. Four of these species were considered variants of the following species by such authors as Willett (1938) and Myers and D'Attilio (1980).

Scabrotrophon maltzani (Kobelt and Küster, 1878)

Figure 1.19A

"*Trophon tenuisculpta* Carpenter, 1866."—*of authors.*

Trophon maltzani Kobelt and Küster, 1878:301, pl. 75, fig. 17,18.

Nipponotrophon maltzani: Houart, 1985:61, figs. 2-5.

Trophon subserratus Sowerby, 1880 [1842-87], vol. 4, *Trophon*, p. 65, pl. 2, fig. 32-33.

Nipponotrophon subserratus.—Roth, 1981:58, figs. 1, 2.

"*Trophon* (*Trophonopsis*) *lasius* (Dall, 1919)".—*in part of* Willett, 1938:10, pl. 1, figs. 2-5 [not 1, 6].

"*Trophonopsis lasius* (Dall, 1919)".—*in part of* Abbott, 1974:191, fig. 2000 [left only].

"*Nipponotrophon lasius* (Dall, 1919)".—*of* Radwin and D'Attilio, 1976:84, pl. 13, fig. 6-8.

Material Examined. Not represented in the voucher collection, but occurring offshore in southern California. Material examined: 138 LACM lots.

Description. Shell white, thick and heavy, medium-sized; spire high, whorls weakly shouldered, canal moderately long. Axial ribs 10-12, rounded to sharp, strongly developed on early whorls, sometimes faint on final whorl. Spiral cords numerous, even, separated by narrower interspaces; cords finely imbricate. Length 30-45 mm.

Type Locality and Type Specimens. Kodiak, Alaska; type material in Berlin Museum (Houart, 1985). *Trophon subserratus*: Vancouver Island, British Columbia; syntype material in NHML (Roth, 1981).

Distribution. Aleutian Islands, Alaska, to Cortes Bank, California [LACM 41-121.6] (32.5°N).

Habitat. Rocky bottoms, 0-300 m. Occurring in the intertidal zone in Alaska, but deeply submergent at depths below 80 m in California.

Remarks. Early authors used the name *Trophon tenuisculpta* Carpenter, for this species, but syntype material figured by Palmer (1958, pl. 23, figs. 9-12) has a short canal; the syntypes are here identified as an immature stage of *Ocenebrina interfossa* (Carpenter, 1864), in which the canal had not achieved its sealed mature form.

Dall missed two early names for this species. Roth (1981) recognized *Trophon subserratus* Sowerby, 1880, from British Columbia, and Houart (1985) showed that the earliest name for this species is *Trophon maltzani* Kobelt and Küster, 1878, which has an Alaskan type locality. However, I do not follow Houart (1985) in placing *Trophon* (*Boreotrophon*) *scitulus* Dall, 1891, and *Neptunea* (*Trophonopsis*) *lasia* Dall, 1919, in the synonymy of *Scabrotrophon maltzani*.

The LACM collection has 20 lots of this species from offshore localities in southern California. These specimens show the same range of variation as those from more northern localities.

Scabrotrophon cerritensis (Arnold, 1903)

Figure 1.19B

Trophon (*Boreotrophon*) *cerritensis* Arnold, 1903:249, pl. 6, fig. 6 [Pleistocene].

"*Nipponotrophon scitulus* (Dall, 1891)."—*in part of* Myers and D'Attilio, 1980:84, figs. 6, 7 [not figs. 1-5, 8-14].

Material Examined. No specimens are represented in the voucher collection from the Santa Maria Basin. Other material: 9 lots in the LACM collection.

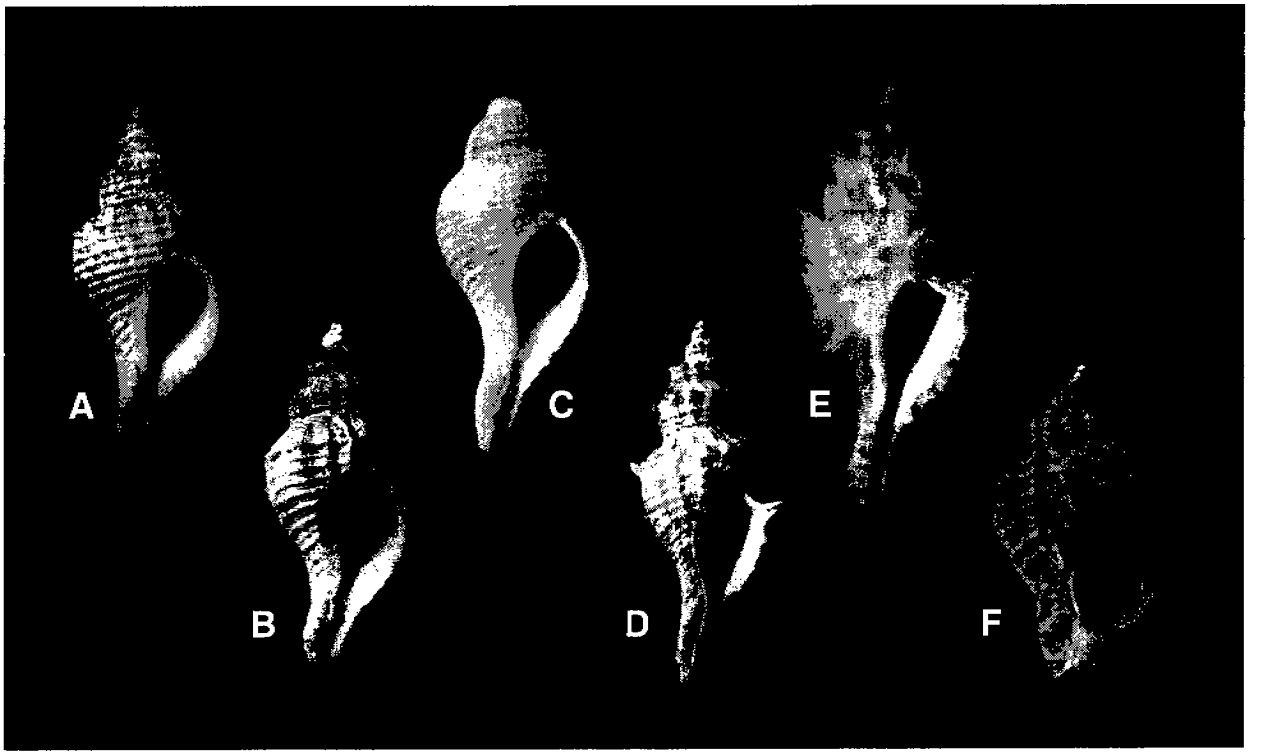


Figure 1.19. Muricidae. **A.** *Scabrotrophon maltzani* (Kobelt and Küster, 1878): 265-274 m, SE of Santa Catalina Island, California (LACM 40-146.6); height 21.5 mm. **B.** *Scabrotrophon cerritensis* (Arnold, 1903): 270 m, off San Clemente Island, California (LACM 150961); height 21.5 mm **C.** *Scabrotrophon lasius* (Dall, 1919): 366-375 m, off SE end of San Nicolas Island, California (LACM 77-132.4); height 22.9 mm. **D.** ***Scabrotrophon grovesi*** **McLean, new species**: 79-140 m, off NE side of Santa Catalina Island, California (CAS 074962); height 28.1 mm. **E.** ***Scabrotrophon clarki*** **McLean, new species**: 213 m, off Monterey, Monterey County, California (LACM 2774, holotype); height 43.4 mm. **F.** *Ocenotrophon painei* (Dall, 1903): 91 m, off Avalon, Santa Catalina Island, California (USNM 109306, holotype); height 14.2 mm.

Description. Shell white, medium-sized; spire high but suture not deeply impressed, whorls shouldered, canal moderately long. Axial ribs 13-15; spiral cords two on early whorls, with relatively few on body whorl, interspaces of same width; cords finely imbricate, producing cancellations on crossing axial sculpture. Length 20-33 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 162545.

Distribution. Santa Rosa Island (34°N) to San Diego, California (33°N).

Habitat. Rocky bottoms, 110-270 m.

Remarks. *Scabrotrophon cerritensis* was based on Pleistocene material and the name has been ignored in the literature. Here it is introduced for a species living offshore in southern California. As noted in the synonymy above, Myers and D'Attilio (1980) figured a specimen of this species identified as *Nipponotrophon scitulus* [see comparisons under *Scabrotrophon grovesi* below].

This species resembles *Scabrotrophon maltzani* in profile, but differs in its coarser and more cancellate sculpture and broader interspaces between the cords. The shoulder area has axial sculpture only, rather than the three spiral cords of *S. maltzani*, and the body whorl has fewer and larger cords.

Scabrotrophon lasius (Dall, 1919)

Figure 1.19C

Neptunea (*Trophonopsis*) *lasia* Dall, 1919:338.—Willett, 1938:11, pl. 1, fig. 6 [holotype].

Trophon (*Neptunea*) *lasius*: Oldroyd, 1927:337.

Material Examined. Not represented in the Santa Maria Basin voucher collection, but occurring offshore in California. Material examined: 20 LACM lots.

Description. Shell white, small to medium-sized; spire high, whorls rounded, canal moderately long. Axial ribs irregular, low, sometimes sharply raised, sometimes lacking on final whorl. Spiral cords finely imbricate, numerous, even, separated by equal interspaces. Length 20-30 mm.

Type Locality and Type Specimens. Off Point Piños, Monterey County, California, 198-495 fathoms. Holotype: USNM 210087.

Distribution. Off Graham Island, Queen Charlotte Islands, British Columbia (54°N), to N of San Clemente Island, California (33°N).

Habitat. 90-550 m, bottom conditions unknown.

Remarks. Although this has been considered a synonym of *Scabrotrophon maltzani,* it differs in having a thinner shell, finer spiral sculpture, and rounded rather than shouldered whorls. It usually occurs in deeper water than does *S. maltzani*, but depth ranges of the two species overlap. Willett (1938:11, pl. 1, fig. 6) figured the holotype. Other shells illustrated by Willett are here identified as *S. maltzani* (pl. 1, figs. 2-5) and *S. grovesi*, new species (pl. 1, fig. 1).

Scabrotrophon grovesi McLean, new species

Figure 1.19D

"*Trophon lasius* (Dall, 1919)."—*in part of* Willett, 1938:10, pl. 1, fig. 1 [not figs. 2-5].

"*Nipponotrophon scitulus* (Dall, 1891)."—*in part of* Myers and D'Attilio, 1980:84, figs. 1-5, 8 [not figs. 7, 9-13].

Material Examined. Santa Maria Basin, Phase I, sta. 16, 591 m (1). Other material examined: LACM 39-4.9, off White Cove, Santa Catalina Island, California, 73-146 m (1); LACM 41-9, off San Pedro, Los Angeles County, California, 148-152 m (1); LACM 41-19, off Wilson Cove, San Clemente Island, California, 95-112 m (1); LACM 41-20, off San Diego, California, 143-148 m (1); LACM 41-56, off Point Dume, Ventura County, California, 86-88 m (1); SDNHM 73594, off La Jolla, San Diego County, California, 91-123 m (1); SDNHM 22951, off Santa Catalina Island, California (1).

Description. Shell white, medium-sized; spire high, whorls 5; canal long, open, length of canal equal to length of aperture. Spiral sculpture of 2 strong cords on early whorls, uppermost strongest. Uppermost cord with open, laterally projecting spines developing by third whorl. Penultimate whorl with shoulder cord and 1-3 lesser cords (3 in holotype). Body whorl with strong shoulder cord and 5-7 additional primary cords; canal with about 5 weak cords; cords becoming spinose on crossing axial sculpture; spines of much lesser strength than those of shoulder cord; interspaces between cords of nearly same breadth as spiral cords, uppermost

interspaces broader. Axial ribs 11-12 on mature shell, forming square cancellations with spiral cords of early whorls; axial sculpture strongly developed only where crossing spiral cords. Canal with imbricate fasciole produced by successive growth stages corresponding to production of axial sculpture. Inner lip thin, raised. Length 28.1 mm (holotype).

Type Locality and Type Specimens. Off NE side Santa Catalina Island, California (33°N, 118°W); 79-140 m on pebbles and stones. 7 specimens. Holotype CAS 074962; 3 paratypes CAS 075613; 1 paratype LACM 2781; 1 paratype, SBMNH 142897; 1 paratype USNM 887572.

Distribution. Point Buchon, San Luis Obispo County (35°N), to La Jolla, San Diego County, California (33°N).

Habitat. 70-590 m, hard bottoms.

Remarks. This species has previously been figured, as noted in the above synonymy. Willett (1938) considered it an "ornately frilled" form of *"Trophonopsis" lasius* (Dall, 1919) and Myers and D'Attilio (1980), treated it as *"Nipponotrophon" scitulus* (Dall, 1891).

Scabrotrophon grovesi differs from the Alaskan species *S. scitulus*, which has best been illustrated by Radwin and D'Attillio (1974, pl. 14, figs. 10, 11), in its smaller size, more slender profile, shorter and less sloping shoulder, and presence of lamellar spiral cords on the canal, which are not present in *S. scitulus*. Spiral cords are fewer and interspaces broader than those of *S. maltzani*, in which the interspaces between cords are narrower than the cords.

There are forms of *Scabrotrophon maltzani* in which there is a prominent shoulder angulation (see Radwin and D'Attilio, 1974, pl. 13, fig. 7), but *S. grovesi* differs from such specimens in having spines that are longer and has fewer spiral cords on the body whorl.

The holotype specimen has relatively short spines compared to others in the same lot. Other specimens have even shorter spines (LACM 41-9; LACM 41-19; LACM 41-20; LACM 41-56, as cited above). Such specimens may be distinguished from other species of *Scabrotrophon* in having higher, more elongate spires, with the suture more tightly constricted.

This species is named after Lindsey Groves of the Malacology Section, Los Angeles County Museum of Natural History.

Scabrotrophon clarki McLean, new species

Figure 1.19E

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material in addition to holotype: LACM 41-172.13, 6.5 miles ESE of South Point, Santa Rosa Island, California, *Velero* III, sta. 1392-41, 104 m (1 juvenile, length 9.4 mm).

Description. Shell white, large for genus, spire moderately high; whorls five, tabulate; canal long, open, length of canal equal to length of aperture. Protoconch paucispiral, whorls 1.2, sharply defined, maximum diameter 1.3 mm. Early sculpture of 2 strong spiral cords, crossed by axial ribs of lesser strength that produce square cancellations. Second teleoconch whorl with upturned spines, which become long and recurved toward coiling axis on third whorl. Body whorl with strong shoulder cord and four additional cords; base and canal with 5 cords of lesser strength. Cords forming open spines on crossing fluted axial ribs; recurved spines of shoulder about 3 times longer than other spines. Spaces between cords with fine spiral striae, except those of base and canal. Axial lamellae 14 on final whorl and on penultimate whorl. Canal with imbricate fasciole produced by growth stages corresponding to production of axial sculpture. Columella white, concave, inner lip thin, raised, reflected over projecting lamellae of base and canal. Length 43.4 mm (holotype).

Type Locality and Type Specimens. Off Monterey, California, 213 m (700 feet), in shrimp pot of Tom Ghio (Watsonville, California), received from Roger Clark, 1994. Exact position unknown. The holotype was evidently live-collected, but the operculum was not saved. Holotype LACM 2774.

Distribution. Monterey (37°N) to Santa Rosa Island, California (34°N).

Habitat. 100-210 m, bottom conditions unknown. The shallow limit is based on the juvenile specimen cited above and the lower limit is based on the collection depth of the holotype.

Remarks. This species has not been previously illustrated. It is known from two specimens, the holotype from Monterey and a juvenile shell of 2.4 whorls from S of Santa Rosa Island.

Although *Scabrotrophon clarki* resembles *S. grovesi* in its tabulate shoulder with upturned spines, it differs in overall size, size of protoconch, whorl profile, and details of sculpture. The holotype of *S. clarki* is approximately twice as long as the known specimens of *S. grovesi*, but it is not a larger than usual specimen of that species because it has the same number of whorls (5) and a larger protoconch. Compared to that species, the early whorls of *S. clarki* are more vertically compressed and spines develop on the second rather than third whorl. The recurved spines, which are bent toward the coiling axis, are characteristic and do not occur in *S. grovesi*. The usual number of axial lamellae of *S. clarki* is 14, compared to 12 in *S. grovesi*.

Scabrotrophon clarki also resembles the Alaskan species *S. scitulus* (Dall, 1891), from which it differs in its larger size, having a more slender profile, having recurved spines, and having strong cords on the canal, which are lacking in *S. scitulus*.

The species is named after Roger Clark, who provided the holotype.

Genus *Ocenotrophon* McLean, 1995

Ocenotrophon McLean, 1995. **Type species** (OD): *Murex* (*Ocinebra*?) *painei* Dall, 1903. California.

Diagnosis. Shell small, sculpture of numerous lamellar cords of unequal prominence, crossed by sharply raised ribs, forming nodes at intersections; early teleoconch sculpture of two spiral cords, canal short, sealed.

Remarks. This genus differs from both *Boreotrophon* and *Scabrotrophon* in having the canal closed at maturity. D'Attilio (1980:6) discussed the anomalous shell characters of the type species, placing it in *Trophon* Montfort, 1810, on the basis of radular characters, although the closed canal is more like that of *Ocinebrina*. The genus is monotypic.

Ocenotrophon painei (Dall, 1903)

Figure 1.19F

Murex (*Ocinebra*?) *painei* Dall, 1903:174.—Dall, 1921:107, pl. 6, fig. 1.

Tritonalia painei: Dall, 1921:107, pl. 6, fig. 1.—Oldroyd, 1927:318, pl. 32, fig. 7.

? *Ocenebra painei*: Radwin and D'Attilio, 1976:123, pl. 20. fig. 8.

Trophon painei: D'Attilio, 1980:6, figs. 1-4.

Ocenotrophon painei: McLean, 1995:40.

Material Examined. Not represented in the Santa Maria Basin voucher collection, but occurring offshore in southern California. Material examined: 31 LACM lots.

Description. Shell white, small; spire of moderate height, whorls strongly shouldered, suture deep, canal short, sealed, fasciole broad. Axial ribs about 15, narrow and projecting, crossed by spiral cords of slightly lesser strength, forming weak nodes at intersections. Inner lip sharply raised, outer lip smooth within. Length 12-15 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, California (from specimen label). Lectotype **(here designated)**: USNM 109306.

Distribution. Queen Charlotte Sound, British Columbia [LACM 70-87] (51°N) to Punta Rompiente, Baja California [LACM 71-168] (28°N).

Habitat. Rocky bottoms, 110-270 m.

Remarks. This species can not be confused with any other. It recalls species of *Ocenebrina*, but differs in lacking color and denticles within the outer lip.

Family Turbinellidae Swainson, 1835

Diagnosis. Shell fusiform, usually with long anterior canal; with or without up to 4 columellar plications; protoconch paucispiral, bulbous. Radular ribbon small, rachidian tricuspid, laterals unicuspid or bicuspid.

Biology. The animals feed on polychaete or sipunculid worms. The paucispiral protoconchs indicate direct development.

Remarks. Harasewych (1987) reviewed anatomical characters and outlined a classification for the family. Recognized subfamilies are Vasinae, Columbariinae, Ptychatractinae and Turbinellinae. Only the subfamily Ptychatractinae is represented in the northeastern Pacific.

Key to Species of Turbinellidae

1A. Penultimate whorl bulging, axial ribs strong ..... *Exilioidea rectirostris*

1B. Penultimate whorl faintly rounded, axial ribs weak ..... *Exilioidea kelseyi*

Subfamily Ptychatractinae Stimpson, 1865

Diagnosis. Shell small, fusiform, high-spired; aperture narrow; columellar teeth 0-4.

Biology. Genera inhabit cold waters, at bathyal to abyssal depths, except for the more shallow occurrence of boreal groups.

Remarks. Harasewych (1987) provides further notes on the subfamily.

Genus *Exilioidea* Grant and Gale, 1931

Exilioidea Grant and Gale, 1931. **Type species (OD)**: *Chrysodomus rectirostris* Carpenter, 1864. Northeastern Pacific.

Diagnosis. Shell fusiform, tall-spired, with long anterior canal. Sculpture of retractively curved axial ribs and fine spiral cords. Operculum elongate, filling aperture, nucleus anterior. Radular ribbon extremely minute, total length not exceeding 0.14 mm.

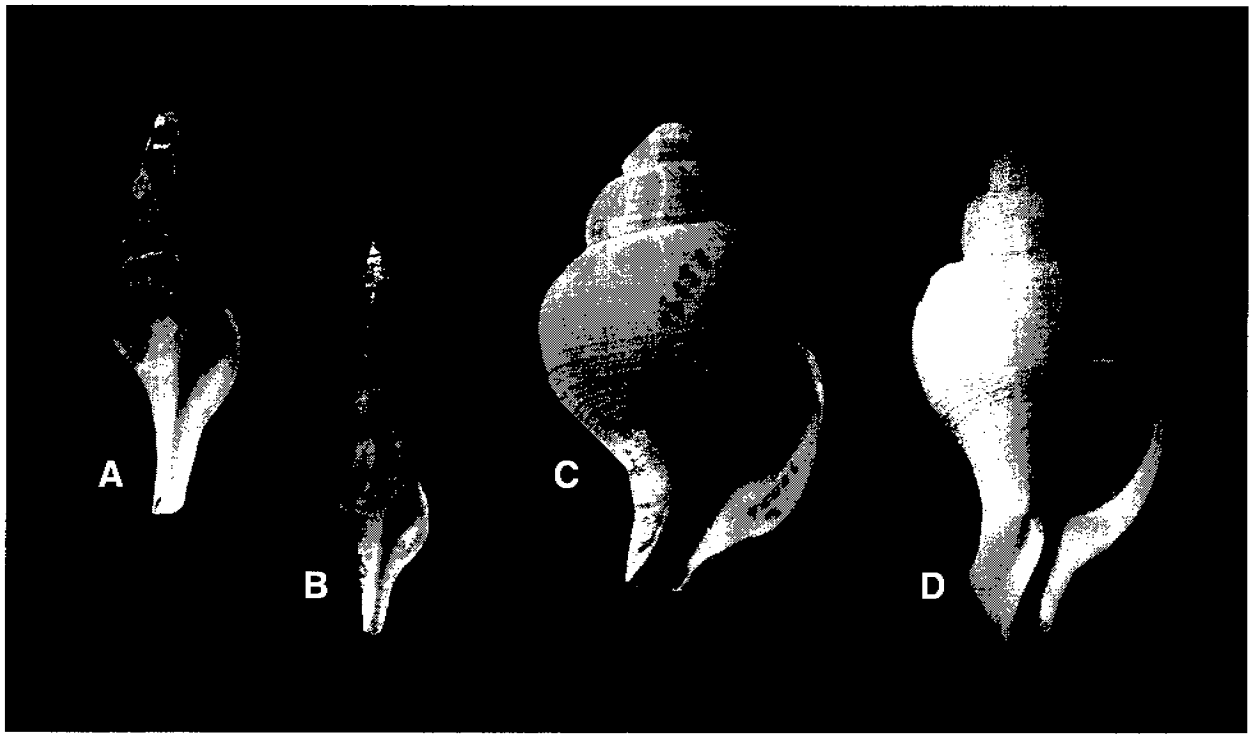


Figure 1.20. Turbinellidae, Buccinidae. **A.** *Exilioidea rectirostris* (Carpenter, 1864): 426 m, Santa Barbara Channel, California (USNM 213359); height 33.7 mm. **B.** *Exilioidea kelseyi* (Dall, 1908): 91 m, off San Diego, California (USNM 110631, holotype); height 33.5 mm. **C.** *Neptunea amianta* (Dall, 1890): 757 m, off Santa Barbara Islands, California (USNM 96556, holotype); height 72 mm. **D.** *Neptunea tabulata* (Baird, 1863): 137 m, off Anacapa Island, California (LACM 150502); height 91.2 mm.

Remarks. Bouchet and Warén (1988:173) first allocated *Exilioidea* to the Turbinellidae, having found the extremely minute radula that had eluded Bartsch (1945:61), who had tentatively placed the genus in the Fusinidae (now Fasciolariidae). Bouchet and Warén concluded that there is a single highly variable northeastern Pacific species, *E. rectirostris*, but I do not agree and here reinstate *E. kelseyi* as a separate species, as discussed below.

Exilioidea rectirostris (Carpenter, 1864)

Figure 1.20A

Chrysodomus rectirostris Carpenter, 1864: 664.—Arnold, 1903:228, pl. 7, fig. 7.

Tritonofusus (*Plicifusus*) *rectirostris*: Dall, 1902: 525, pl. 34, fig. 2.

Exilia rectirostris: Oldroyd, 1927:206, pl. 6, fig. 7 [copy Dall fig.].

Exilioidea rectirostris: Grant and Gale, 1931:665, pl. 28, fig. 5.—Bentson, 1940:224, pl. 2, figs. 23 [holotype], 24.—Bartsch, 1945:61, pl. 7, figs. 2, 3, 6.—Palmer, 1958:215.—Abbott, 1974:216.—Bouchet and Warén, 1988:174, figs. 16, 18, 22 [not figs. 17, 19-21].

Plicifusus (*Microfusus*) *obsoletus* Talmadge, 1971: 42, figs. 3,4.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material examined: 27 lots in the LACM collection.

Description. Fusiform, whorls 6, apical area eroded in mature specimens; siphonal canal long, aperture less than half shell length, axial sculpture of numerous retractively curved ribs, obsolete on lower half of shell; spiral sculpture of fine raised striae. Shell white with mid-whorl band of light brown. Periostracum dark yellow-brown, lighter in color across base, columella white. Length 25-30 mm.

Type Locality and Type Specimens. Puget Sound, Washington. Holotype: USNM 4515. *Plicifusus obsoletus*: Off Eureka, Humboldt County, California, 450 fathoms; holotype: CAS 063623 (ex CAS 13319).

Distribution. Behm Canal, Alaska (Dall, 1921:92) (55°N), to San Diego, California [USNM 122621] (33°N).

Habitat. Soft bottoms, 60-800 m. Below 220 m in southern California.

Remarks. Specimens from depths below 200 m are relatively broad with inflated whorls and strongly projecting axial ribs, as typified by the population described by Talmadge (1971) under the name *Plicifusus obsoletus*.

Exilioidea kelseyi (Dall, 1908)

Figure 1.20B

Tritonofusus (*Plicifusus*) *kelseyi* Dall, 1908:249.

Exilia kelseyi: Dall, 1921:92.—Dall, 1925:17, pl. 1, fig. 6.

Exilioidea kelseyi: Bartsch, 1945:62, pl. 7, figs. 1, 4, 5.—Abbott, 1974:216, fig. 2388.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material examined: 15 lots in the LACM collection.

Description. Slender, whorls 7, apical area eroded in mature specimens; siphonal canal long, aperture less than half shell length; axial sculpture of numerous slightly curved ribs, becoming obsolete on later whorls and dorsal side of mature shell, not extending to lower half of shell, spiral sculpture of faint striae. Shell cream-colored with mid-whorl band of light brown, columella white. Periostracum dark grayish brown. Length 25-30 mm.

Type Locality and Type Specimens. Off San Diego, California, 50 fathoms. Holotype: USNM 110631.

Distribution. Strait of Georgia, British Columbia [LACM 63-17] (50°N), to Redondo Beach, Los Angeles County, California [LACM 10935] (34°N).

Habitat. Soft bottoms, 90-200 m.

Remarks. This is more slender and has less convex whorls than *Exilioidea rectirostris*. The periostracum is darker than that of *E. rectirostris*. The species is here reinstated and removed from the synonymy of *E. rectirostris*, under which it was placed by Bouchet and Warén (1988:173). Specimens figured by Bouchet and Warén that I identify as *E. kelseyi* are shown in their figures 17, 19-20. Although slender specimens with strong axial ribs are known, the ribs become nearly obsolete on the dorsal side of the final whorl. Both species occur together at some stations and are morphologically very close, but separation to two species is possible.

Family Buccinidae Rafinesque, 1815

Diagnosis. Shell small to large, with high spire; canal long to short. Operculum ovate, nucleus usually terminal. Radula rachiglossate; rachidian with 1-5 cusps; laterals with 2-6 cusps.

Biology. Buccinids are carnivores that either feed on living prey or are scavengers.

Remarks. Ponder and Warén (1988) placed three additional groups usually treated as full families (Nassariidae, Melongenidae, Fasciolariidae) as subfamilies of Buccinidae, but I retain the traditional separation of the families of the recommendation of M. G. Harasewych. Subfamily classification of Buccinidae proper is unsettled and no division into subfamilies is utilized here.

Key to Species of Buccinidae

1A. Whorls rounded ..... *Neptunea amianta*

1B. Whorls shouldered ..... *Neptunea tabulata*

Genus *Neptunea* Röding, 1798

Neptunea Röding, 1798. **Type species** (SD, Sandberger, 1861); *Fusus antiquus* Linnaeus, 1758. Northeastern Atlantic.

Golikovia Habe and Sato, 1973. **Type species** (OD): *Neptunea fukuae* Kira, 1959. Japan.

Diagnosis. Shell large, sturdy, profile broad, with twisted siphonal canal; sculpture chiefly spiral, protoconch paucispiral, smooth; operculum large, filling aperture, nucleus terminal.

Biology. Neptunes in Alaska are chiefly predators on living bivalves and large tubiculous polychaetes (Shimek, 1984). In feeding they make use of a highly extendible proboscis. Upright egg capsules are laid in clusters.

Remarks. The neptunes are large and important gastropods of the Arctic and northern oceans. They have been monographed in an unpublished thesis by C. Nelson (1974) and by Golikov (1963). Nelson (1976:139) corrected earlier errors in the type designation for *Neptunea*. The origin of the genus was discussed by Nelson (1978). Northern species are highly variable and the taxonomy remains unsettled.

Neptunea amianta (Dall, 1890)

Figure 1.20C

Chrysodomus amiantus Dall, 1890:321, pl. 5, f. 10.—Oldroyd, 1927:96.

Neptunea amianta: Abbott, 1974:213, fig. 2358.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material examined: 102 lots in the LACM collection.

Description. Shell of moderate size for genus; whorls 4, thin, chalky white under thin brown periostracum. Early whorls with strong peripheral carination, mature whorls rounded. Spiral sculpture of numerous narrow, low cords of unequal strength and spacing; axial sculpture of growth increments only. Canal short, lip usually thin and easily broken, seldom flaring when mature. Length 60-90 mm.

Type Locality and Type Specimens. "Santa Barbara Islands," California, 414 fathoms. Lectotype (here selected): USNM 96556.

Distribution. Pribilof Islands, Bering Sea, Alaska [USNM, LACM] (57°N), to Punta San José, Baja California [LACM 93-76.3] (31°N). Alaskan specimens are few in collections. The species becomes common south of the Queen Charlotte Islands, British Columbia.

Habitat. Soft bottoms, 300-1500 m.

Remarks. *Neptunea amianta* resembles *N. pribiloffensis* (Dall, 1919), a much larger species of broader profile that ranges from the Bering Sea to British Columbia.

Neptunea tabulata (Baird, 1863)

Figure 1.20D

Chrysodomus tabulatus Baird, 1863:66, pl. 1, f. 1.—Dall, 1902:524, pl. 36, fig. 5.—Arnold, 1903:228, pl. 7, fig. 6.—Oldroyd, 1927:227, pl. 4, fig. 5, pl. 18, fig. 4.

Neptunea (*Sulcosipho*) *tabulata*: Grant and Gale, 1931:658.—Abbott, 1974:215, fig. 2374.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material examined: 53 lots in the LACM collection.

Description. Shell moderately large for genus; whorls 7, sturdy, cream-colored under thin, brown periostracum. Suture deeply impressed, shoulder strongly tabulate, smooth, marked by sharp projecting carination; sculpture below shoulder of numerous, narrow, closely spaced, imbricate spiral cords; canal long, twisted; fasciole producing umbilical chink; lip thick and slightly flaring at maturity. Length 80-110 mm.

Type Locality and Type Specimens. Vancouver Island, British Columbia. Holotype: Natural History Museum, London.

Distribution. Petersburg, Alaska [LACM 147302] (57°N), to Newport Bay, Orange County, California [LACM 70-69.13] (33.5°N).

Habitat. Soft bottoms, 50-200 m.

Remarks. This is the type and only living species of the subgenus *Sulcosipho*, Dall, 1918, which denotes the deep suture and tabulate shoulder. There is a Miocene predecessor, *Chrysodomus bairdii* Dall, 1909, which Grant and Gale (1931:658) placed in synonymy.

Family Nassariidae Iredale, 1916

Diagnosis. Shell small to medium in size, with high spire, ovate aperture, and short anterior canal; posterior anal canal lacking, columella short and twisted, usually with well-formed columellar callus. Operculum ovate, edge often serrate. Radula stenoglossate, with multicuspid central and two-pronged lateral teeth.

Biology. The animals are carnivorous and are chiefly scavengers on sand and mud bottoms. Eggs are laid in capsules and in most species there are free swimming veliger larvae.

Remarks. The most comprehensive source of information is the major monograph of Cernohorsky (1984) in which three subfamilies were defined: Nassariinae, Dorsaniinae, and Cylleninae. Cernohorsky treated in full the Indo-Pacific species of Nassariinae and Cylleninae and all others were treated in at least checklist form.

Key to Species of Nassariidae

1A. Columellar wall with prominent pustules ..... *Nassarius insculptus*

1B. Columellar wall smooth 2

2A. Shell length 18-22 mm ..... *Nassarius perpinguis*

2B. Shell length 22-35 mm ..... *Nassarius rhinetes*

Genus *Nassarius* Dúmeril, 1806

Nassarius Dúmeril, 1806. **Type species** (SM, Froriep, 1806): *Buccinum arcularia* Linnaeus, 1758. Indo-Pacific.

Diagnosis. Base of shell with deep groove or fossa; columella concave; siphonal notch deep, siphonal canal short; sculpture spiral and axial, often cancellate. Operculum with serrate edge on side adjacent to outer lip.

Remarks. Demond (1952) and Cernohorsky (1975) reviewed the northeastern Pacific species of *Nassarius*. Addicott (1965) treated fossil and living species of the northeastern Pacific. A large number of taxa were recognized as subgenera of *Nassarius* by Cernohorsky; those in use for the northeastern Pacific species are mentioned under the remarks section of each species.

An additional species that may be present at depths to 200 meters is the well-known shallow-water species *Nassarius mendicus* (Gould, 1850) and its forms *N. cooperi* (Forbes, 1852), and *N. indisputabilis* (Oldroyd, 1927). This species has been treated in detail by Demond (1952:308), Addicott (1965:3), Abbott (1974:225) and Cernohorsky (1975:124).

Nassarius perpinguis (Hinds, 1844)

Figure 1.21A

Nassa perpinguis Hinds, 1844 [1844-45]:36, pl. 9, figs. 12, 13.

Nassarius (Schizopyga) perpinguis: Grant and Gale, 1931:673, pl. 26, figs. 51, 52.

Nassarius perpinguis: Demond, 1952:305, pl. 2, figs. 4, 5.—Cernohorsky, 1975: 123, figs. 1, 2 [holotype].—McLean, 1978:48, fig. 26.3.

Nassarius (Hinea) perpinguis: Abbott, 1974:224, fig. 2460.—Cernohorsky, 1984:35.

Nassa perpinguis var. *bifasciata* Berry, 1908:39.

Material Examined. California: Santa Maria Basin, Phase I, sta. 21, 49 m (1 immature). Other material: 231 lots in the LACM collection.

Description. Shell of moderate size, white to light brown under closely adherent periostracum, with darker bands of brown; whorls evenly rounded, fossa deep; axial and spiral sculpture of nearly equal strength, producing fine, even cancellations; mature lip only slightly thickened, deeply lirate within; columella with fine raised lines on lower portion; parietal shield with single raised fold. Length 18-22 mm.

Type Locality and Type Specimens. Bahía Magdalena, Baja California Sur (probable error). Holotype, NHML 44.9.23.5. *Nassa perpinguis* var. *bifasciata*: San Pedro, Los Angeles County, California; lectotype **(here designated)**: CAS 064634 (Figure 1.18A).

Distribution. Point Reyes, Marin County, California (38°N) to Isla Cedros, Baja California (28°N)

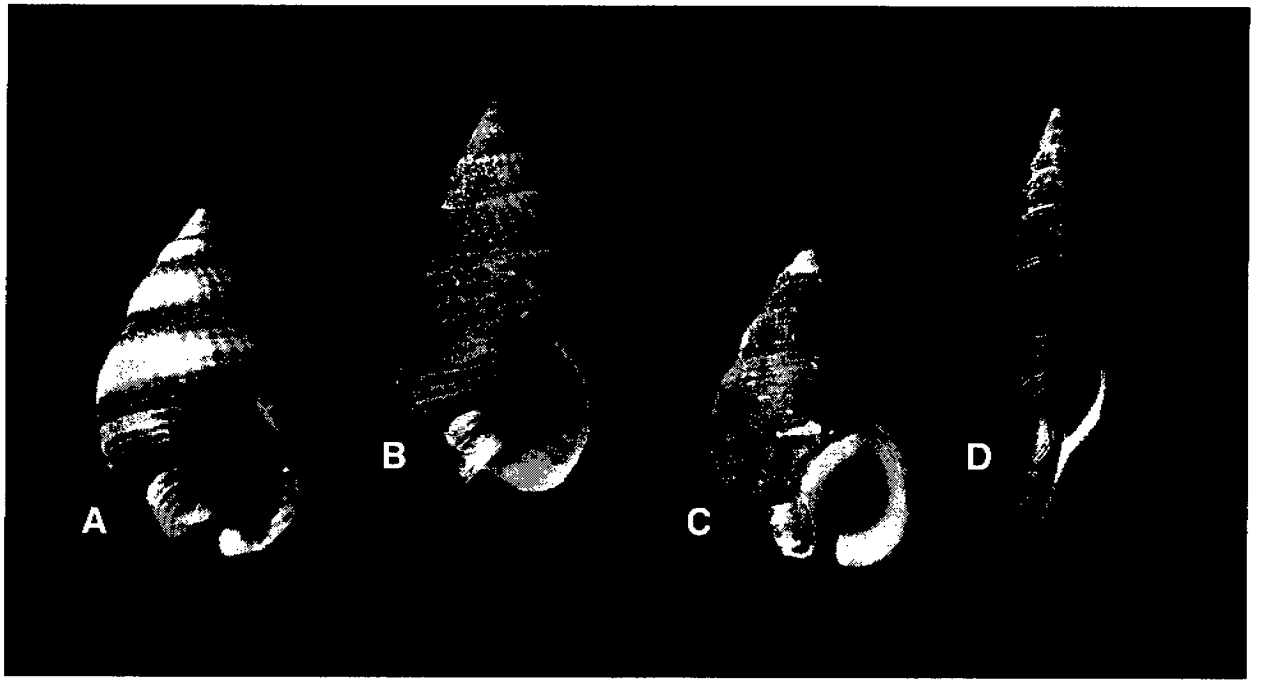


Figure 1.21. Nassariidae, Fasciolariidae. **A.** *Nassarius perpinguis* (Hinds, 1844): San Pedro, Los Angeles County, California (CAS 064364, lectotype of *Nassa perpinguis* var. *bifasciatus*); height 21.2 mm. **B.** *Nassarius rhinetes* Berry, 1953: 68 m, Monterey Bay, California (USNM 212133); height 33 mm. **C.** *Nassarius insculptus* (Carpenter, 1864): 174-247 m, off Point Loma, San Diego County, California (USNM 209046, *Alectrion insulptus* var. *eupleura*, holotype); height 15 mm. **D.** *Fusinus barbarensis* (Trask, 1855): 91 m, S of Santa Catalina Island, California (SBMNH 118915); height 98 mm.

Habitat. Soft bottoms, intertidal to 60 m.

Remarks. This is the type species of the subgenus *Caesia* H. and A. Adams, 1853, which has been used for most of the northeastern Pacific species of *Nassarius* (see Cernohorsky, 1984:32). Type material of two additional synonyms from erroneous localities was illustrated by Cernohorsky (1975).

Nassarius rhinetes Berry, 1953

Figure 1.21B

"*Nassa californiana* (Conrad, 1856)."—*of* Dall, 1891: 177.—Dall, 1921:102, pl. 11, fig. 4.

"*Nassarius* (*Schizopyga*) *californianus*."—*of* Grant and Gale, 1931:672, pl. 26, fig. 49.—Oldroyd, 1927:264, pl. 26, fig. 13.

"*Nassarius californianus*."—*of* Demond, 1952:206, pl. 2, fig. 6.

Nassarius (*Schizopyga*) *rhinetes* Berry, 1953: 415, pl. 28, f. 7.

Nassarius (*Caesia*) *rhinetes*: Addicott, 1965:10, pl. 2, fig. 28.

Nassarius rhinetes: Cernohorsky, 1984:35.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material: 13 lots in the LACM collection.

Description. Shell large for family, light brown with lighter bands under closely adherent periostracum; whorls evenly rounded, fossa deep; axial ribs numerous, slanted; spiral cords 6 on penultimate whorl; axial and spiral sculpture of nearly equal strength, producing beaded intersections; columella concave, projecting and twisted at base; mature lip only slightly thickened, lirate within. Length 22-33 mm.

Type Locality and Type Specimens. Off Moss Landing, Monterey County, California, 40 fathoms. Holotype: SBMNH 34536.

Distribution. Off Punta Delgada, Humboldt County, California [LACM 71-127.2] (40°N), to Bahía Blanca, Baja California [LACM 51-13.9] (29°N).

Habitat. Soft bottoms, 10-91 m.

Remarks. Early authors misidentifed this species as *Nassa californiana* Conrad, 1856, a species shown by Berry (1953) and Addicott (1965:3) to be extinct. It is closest to *Nassarius perpinguis,* but is larger and has coarser clathrate sculpture. Interspersed spiral striae as in *N. perpinguis* are not present. This species is much less common than *N. perpinguis*. It is a more characteristic species of northern and central California than of southern California.

Nassarius insculptus (Carpenter, 1864)

Figure 1.21C

Nassa insculpta Carpenter, 1864: 662 [unfigured].

Nassarius insculptus: Demond, 1952:317, pl. 2, figs. 1, 3.—Palmer, 1958:214.—Cernohorsky 1984:34.

Nassarius (Uzita) insculptus: Addicott, 1965:11.

Nassarius (Nassarius) insculptus: Abbott, 1974: 224, fig. 2455.

Alectrion insculptus var. *eupleura* Dall, 1917: 576.

Nassarius insculptus gordanus Hertlein and Strong, 1951: 81, pl. 8, fig. 6.

Material Examined. Not represented in the voucher collection, but occurring abundantly offshore in southern California. Material examined 376 LACM lots.

Description. Shell of moderate size, white under closely adherent greenish-brown periostracum; whorls 7, whorls slightly inflated; axial sculpture of strong ridges on early whorls, usually fading on later whorls; spiral sculpture of shallow grooves, about 10 per whorl; fossa shallow; outer lip inflated and thickened, inner lip with broad shield of callus, one strong basal fold and smaller raised folds becoming pustular near termination of inner lip callus. Length 18-25 mm.

Type Locality and Type Specimens. Santa Catalina Island, California. Type material not found by Palmer (1958:214). *Alectrion insculptus* var. *eupleura*: Off Point Loma, San Diego County, California, 95-135 fathoms (type locality from holotype label); holotype: USNM 209046. *Nassarius insculptus gordanus*: Gorda Bank, off S tip Baja California Sur, 60 fathoms; holotype: CAS 065081.

Distribution. Point Arena, Mendocino County, California (39°N), to Gorda Bank, Baja California (23°N). Also in the Gulf of California and at Isla Clarion, Islas Revillagigedos, Mexico.

Habitat. Soft bottoms, 50-530 m. This is perhaps the most abundant gastropod of its size occurring offshore in southern California.

Remarks. This species is the only *Nassarius* in the northeastern Pacific with the shell nearly smooth except for the incised sculpture. It was placed by Addicott (1965:11) in the subgenus *Uzita* H. and A. Adams, 1853, characterized by the fine plaits on the inner lip. Related species occur off west Africa.

Family **Fasciolariidae** Gray, 1853

Diagnosis. Shell of medium to large size, anterior canal usually long. Animal red colored.

Biology. Carnivores, mostly preying on mollusks.

Remarks. Subfamilies are: Fusininae, Fasciolariinae, and Peristerniinae. The genus *Fusinus* is assigned to the Subfamily Fusininae Wrigley, 1927.

Genus *Fusinus* Rafinesque, 1815

Fusinus Rafinesque, 1815. **Type species** (SM, Lamarck, 1799; ICZN Opinion 1765): *Murex colus* Linnaeus, 1758. Indo-Pacific.

Gracilipurpura Jousseaume, 1880. **Type species** (OD): *Fusus strigosus* Lamarck, 1822; = *Murex rostratus* Olivi, 1792, not Solander *in* Brander, 1766.

Barbarofusus Grabau and Shimer, 1909. **Type species** (OD): *Fusus barbarensis* Trask, 1855. Eastern Pacific.

Harfordia Dall, 1921. **Type species** (M): *Fusus harfordi* Stearns, 1871. Eastern Pacific.

Diagnosis. Shell elongate, fusiform, with tall spire and long siphonal canal; sculpture of axial ribs and spiral cords; columella without folds. Protoconch paucispiral, early teleoconch whorl with strong axial ribs. Rachidian with three short cusps; laterals multicuspid.

Remarks. The genus has not been reviewed worldwide. The generic synonymy above is from Bouchet and Warén (1985:160), who did not distinguish subgenera except for the shallow-water *Aptyxis* Troschel, 1868.

Fusinus barbarensis (Trask, 1855)

Figure 1.21D

Fusus barbarensis Trask, 1855: 55.—Arnold, 1903:224, pl. 4, fig. 10.

Fusinus barbarensis: Dall, 1915:55.—Oldroyd, 1927:177.—Grant and Gale, 1931:639, pl. 27, fig. 11.—Woodring, 1946:73, pl. 34, fig. 9.—Abbott, 1974:2519, fig. 230.

Material Examined. Not represented in the voucher collection from the Santa Maria Basin. Other material examined: 129 lots in the LACM collection.

Description. Shell large; whorls 7, rounded; canal long, of same length as aperture; lip lirate within; axial ribs 8-12, strong on early whorls, usually lacking on later whorls; spiral cords 4 on early whorls, secondary cords arising in interspaces so that final whorl is covered by numerous cords of irregular strength and spacing; color white to tan under brown periostracum, cords often darker brown. Length 50-110 mm.

Type Locality and Type Specimens. Santa Barbara, Pleistocene; type material lost (Woodring, 1946:73). The type specimen was not figured and was lost in the fire at the California Academy that followed the 1906 earthquake.

Distribution. Monterey Bay, California [LACM 60-21] (36.5°N), to Gorda Bank, off Cabo San Lucas, Baja California Sur [LACM 40-7] (23°N).

Habitat. Soft bottoms, 50-350 m.

Remarks. *Fusinus barbarensis* is highly variable in number of axial ribs and strength and spacing of the spiral cords. Large specimens are not common in collections although there are many immature specimens. Specimens from Baja California are somewhat smaller, although there are specimens that reach 90 mm from the vicinity of Isla Cedros.

Family Columbellidae Swainson, 1840

Diagnosis. Shell minute to small; sturdy, outer lip thickened and usually denticulate within; columella smooth or plaited, siphonal canal short. Radula rachiglossate, rachidian rectangular, lacking cusps, lateral teeth elongate, bearing 2-3 cusps near tip.

Biology. Little is known of the biology of columbellids. There are both carnivorous and herbivorous groups. Egg capsules are attached to differing substrata, including shells of the same species. Veliger larvae are produced; the veliger stage occurs before hatching in most species. Boss (1982:1015) summarized the recent literature on the anatomy and biology of the family.

Remarks. Two subfamilies were recognized by Radwin (1977, 1978) in his review of western Atlantic genera and species: Columbellinae, with the lateral teeth of the radula broad and flat and with strongly flexed basal flanges, and Pyreninae, with the lateral teeth sigmoid and unflanged.

Species formerly assigned to *Mitrella* Risso, 1826, are now distributed among three genera in two subfamilies: *Alia* H. and A. Adams, 1853, which occurs in shallow water (Columbellinae); and, in the Pyreninae, *Astyris* H. and A. Adams, 1853, and *Mitrella*. *Mitrella* occurs in tropical waters and is characterized by its columellar denticles (Radwin, 1978:337).

Key to Species of Columbellidae

1A. Sculpture lacking except for spiral grooves on canal 2
1B. Sculpture of axial ribs and spiral cords 3

2A. Outer lip lirate ..... *Astyris gausapata*
2B. Outer lip not lirate ..... *Astyris permodesta*

3A. Whorl profile slightly concave below suture ..... *Amphissa undata*
3B. Whorls rounded 4

4A. Axial ribs > 15 per whorl ..... *Amphissa reticulata*
4B. Axial ribs < 14 per whorl ..... *Amphissa bicolor*

Subfamily Pyreninae Suter, 1919

Diagnosis. Shells usually narrow, fusiform. Lateral teeth of radula sigmoid.

Remarks. Western Atlantic genera and species of Pyreninae were reviewed by Radwin (1978).

Genus *Astyris* H. and A. Adams, 1853

Astyris H. and A. Adams, 1853. **Type species** (OD): *Buccinum rosaceum* Gould, 1840. Arctic Ocean.

Diagnosis. Shell small, high-spired, whorls smooth, lacking axial and spiral sculpture, except for spiral incisions on base; aperture narrow, canal short but deeply notched; anal notch lacking; protoconch paucispiral.

Biology. As for family. Species occur at shallow to offshore depths.

Remarks. The diagnosis given here is tentative, as Radwin (1978:331) neglected to diagnose this genus. He provided only a list of western Atlantic species that he allocated to it.

Species that I group in *Astyris* lack or have weak labial denticles and have a paucispiral protoconch indicative of direct development. *Astyris aurantiaca* (Dall, 1871) is a shallow-water member of the genus having a paucispiral protoconch. In contrast, shallow-water species of the columbelline genus *Alia* H. and A. Adams, 1853, including *Alia carinata* (Hinds, 1844) and *A. tuberosa* (Carpenter, 1864), have strong labial denticles and a multispiral protoconch indicative of planktotrophic development.

Astyris gausapata (Gould, 1850)

Figure 1.22A

Columbella gausapata Gould, 1850:170.—Gould, 1852:267, pl. 19, fig. 337.—Johnson, 1964:82 [citation of type material].

Nitidella gouldii Carpenter *in* Gould and Carpenter, 1857:208.—Oldroyd, 1927:277.—Abbott, 1974:198, fig. 2103.

Mitrella gouldii: Grant and Gale, 1931:695.

Columbella (*Nitidella* ?) *dalli* E. A. Smith, 1880:287 [unfigured].

Nitidella ? *lutulenta* Dall, 1919:331 [unfigured].

Alia casciana Dall, 1919:330 [unfigured].

Material Examined. California: Santa Maria Basin, Phase I, sta. 85, 113 m (1); sta. 102, 99 m (1); Phase II, sta. R-2, 161 m (1 immature); sta. PJ-7, 123 m (2 immature); sta. PJ-14 (1). Other material: 271 lots in the LACM collection.

Description. Shell small, thick, whorls 5, smooth except for microscopic striations; base with spiral sculpture; protoconch paucispiral, usually deeply eroded in mature specimens; lip with weak lirae away from edge; periostracum adherent, brown; shell color light yellowish brown, with darker chevron or mottled markings. Length 8-13 mm.

Type Locality and Type Specimens. Puget Sound, Washington. Lectotype selected by Johnson (1964:82): USNM 5732. *Nitidella gouldii*: Santa Barbara, California; type material not located by Palmer (1958:210). *Columbella dalli*: Vancouver Island, British Columbia; type material in NHML. *Nitidella lutulenta*: Gulf of the Farallones, off San Francisco, California, 24 fathoms; lectotype (here selected): USNM 211068. *Alia casciana*: Off La Jolla, San Diego County, California, 110-199 fathoms; lectotype (here selected): USNM 209456.

Distribution. Bechevin Bay, NW side Alaska Peninsula, Alaska [LACM 90-197.1] (55°N, 163°W), to Punta San Pablo, Baja California Sur [LACM 71-176] (27°N).

Habitat. Soft bottoms, 30-200 m.

Remarks. Gould's name *Columbella gausapata* is the older name for this species, based on a redetermination of the holotype, although authors including Grant and Gale (1931:695) had incorrectly considered it a synonym of the shallow-water species *Alia carinata* (Hinds, 1844). This species is better known under the name *Mitrella gouldii* (Carpenter), as used by Grant and Gale (1931:695) and Abbott (1974:198). It is placed in *Astyris* because the paucispiral protoconch is indicative of direct development. Dall's taxa *Nitidella lutulenta* and *Alia casciana* have been ignored in the literature but are here placed in the synonymy of this species.

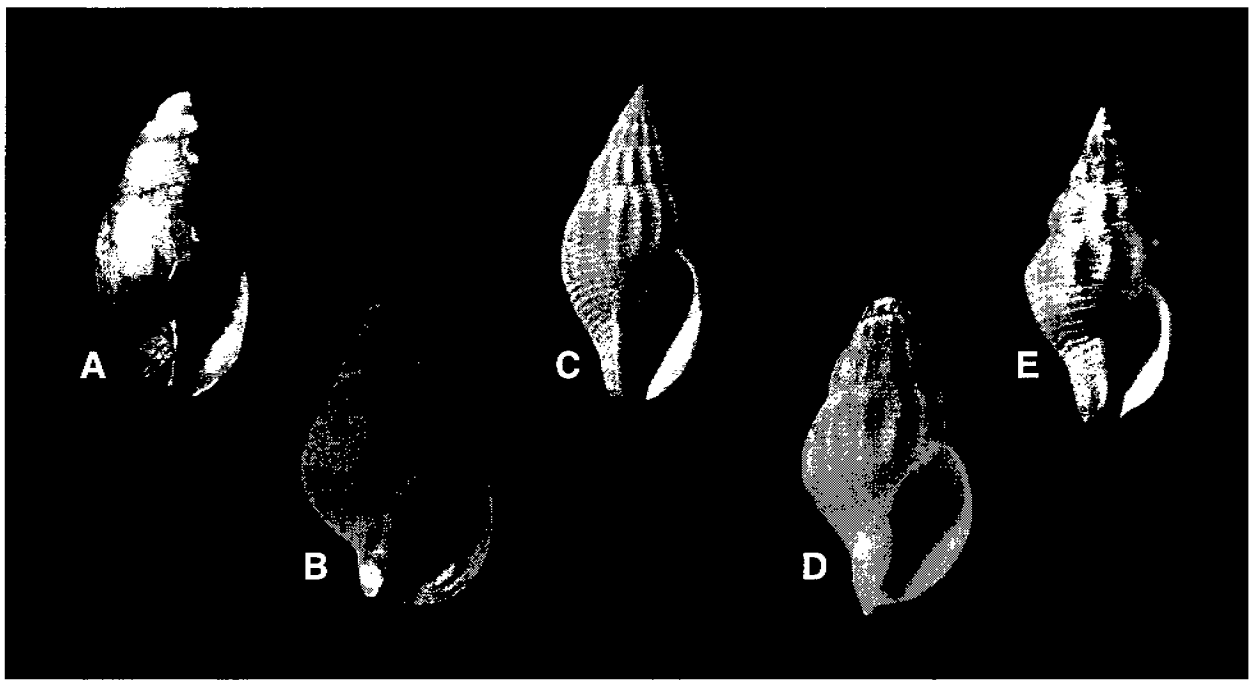


Figure 1.22. Columbellidae. **A.** *Astyris gausapata* (Gould, 1850): 82-91 m, off Long Point, Santa Catalina Island, California (LACM 41-185.4); height 10.5 mm. **B.** *Astyris permodesta* (Dall, 1890): 505 m, off Santa Barbara Islands, California (USNM 96526, lectotype); height 12.5 mm. **C.** *Amphissa reticulata* Dall, 1916: 113-335 m, off Point Loma, San Diego County, California (USNM 210004, lectotype); height 16 mm. **D.** *Amphissa bicolor* Dall, 1892: 563 m, off Point Sur, Monterey County, California (USNM 106877, syntype); height 13.8 mm. **E.** *Amphissa undata* (Carpenter, 1864): 68-73 m, S side Santa Cruz Island, California (LACM 40-165.31); height 12.0 mm.

Astyris permodesta (Dall, 1890)

Figure 1.22B

Columbella permodesta Dall, 1890: 327, pl. 5, fig. 4.

Columbella (*Astyris*) *permodesta*: Oldroyd, 1927:275.

Mitrella permodesta: Abbott, 1974:200, fig. 2141.

Material Examined. California: Santa Maria Basin, Phase I, sta. 89, 471 m (18); sta. 99, 540 m (5); Phase II, sta. R-7, 565 m (6). Other material: 35 lots in the LACM collection.

Description. Shell of moderate size for genus, broadly inflated, thin, white under greenish brown periostracum, but often coated with dark brown mineral deposits; apex usually eroded; sculpture lacking except for weak spiral cords on base of shell. Lip thin, lacking lirae; columella simple, translucent. Length 10-14 mm.

Type Locality and Type Specimens. Santa Barbara Islands, California, 276 fathoms. Lectotype **(here designated)**: USNM 96526 (Figure 1.19B).

Distribution. Monterey Bay, California, to Bahía Magdalena, Baja California Sur [USNM 265899] (24.5°N).

Habitat. Soft bottoms, 300-1000 m. The species is characteristic of anoxic bottoms of offshore basins. It has also been recorded along with species of *Calyptogena* Dall, 1891, large vesicomyid bivalves that are characteristic of reducing environments.

Remarks. The generic assignment is based on the paucispiral protoconch and the thin lip without lirae. It differs from *Astyris gausapata* in lacking the lirae and in having the shell thinner and broader.

Genus *Amphissa* H. and A. Adams, 1853

Amphissa H. and A. Adams, 1853. **Type species** (SD, Dall, 1913): *Buccinum corrugatum* Reeve, 1846, not Brocchi, 1814 [= *Amphissa columbiana* Dall, 1916]. Northeastern Pacific.

Diagnosis. Shell large for family, high-spired with inflated whorls and deep suture; columella smooth, siphonal canal short, sculpture of axial ribs and incised spiral lines; lip lirate within; protoconch multispiral.

Biology. The multispiral protoconch is indicative of a planktonic veliger stage. Eggs are laid in capsules that release veliger larvae.

Remarks. *Amphissa* is a characteristic genus of cool waters of the northeastern Pacific. Two species occur in shallow water: *A. versicolor* Dall, 1871, and *A. columbiana* (Dall, 1916). There is also a single species that occurs in the North Atlantic (Radwin, 1978:329).

Amphissa reticulata Dall, 1916

Figure 1.22C

Amphissa versicolor var. *reticulata* Dall, 1916: 27.

Amphissa reticulata: Oldroyd, 1927:283.—Abbott, 1974:203.

Material Examined. California: Santa Maria Basin, Phase I, sta. 2, 200 m (1). Other material: 133 lots in the LACM collection.

Description. Shell light tan under greenish brown periostracum, some with 2 light brown bands; whorls moderately inflated; axial ribs about 16 per whorl, nearly straight, fading across base; spiral cords strong, overriding axial ribs, producing beads at intersections; lip lirae relatively poorly developed. Length 12-16 mm.

Type Locality and Type Specimens. Off Point Loma, San Diego County, California, 62-183 m. Lectotype **(here designated)**: USNM 210004 (Figure 1.22C). The original description cited only the catalog number; the type locality is taken from the specimen label.

Distribution. Kenai Peninsula, Alaska (59.5°N, 151.5°W), to Islas San Benito, Baja California (28°N).

Habitat. Soft bottoms, 30-300 m.

Remarks. Surprisingly, this species has not previously been figured. It differs from the shallow-water species *Amphissa versicolor* in its more slender profile, lack of color markings on the shell, and weak development of the labial lirae. Unlike *A. versicolor*, it occurs offshore, frequently with *Astyris gausapata*.

Amphissa bicolor Dall, 1892

Figure 1.22D

Amphissa bicolor Dall *in* Williamson, 1892:213, pl. 20, fig. 4.—Oldroyd, 1927:282.—Abbott, 1974:203.

Material Examined. California: Santa Maria Basin, Phase I, sta. 68, 390 m (11); sta. 72, 401 m (21); Phase II, sta. R-6, 410 m (5). Other material: 65 lots in the LACM collection.

Description. Shell light tan under tan periostracum, marked with 2 broad brown bands, 1 at midwhorl and 1 on base; whorls strongly inflated; axial ribs 11-13 per whorl, fading across base, slanted to left; spiral sculpture weak, consisting of incised striae overriding axial ribs; lip lirae not developed. Length 12-14 mm.

Type Locality and Type Specimens. Off Point Sur, Monterey County, California, 298 fathoms (from label). Lectotype **(here designated)**: USNM 106877, based on the catalog number cited in the original caption.

Distribution. Farallon Islands (37.5°N) to San Diego, California (33°N). Distribution limits from Dall (1921:105). The LACM collection has specimens from Monterey to Newport Bay, Orange County, California.

Habitat. Soft bottoms, 90-600 m.

Remarks. *Amphissa bicolor* is easily recognized by its banded color pattern, broadly spaced axial ribs, subdued spiral sculpture, and lack of lip lirae.

This species is more characteristic of greater depths than those known for *Amphissa reticulata* and *A. undata*. Like *Astyris permodesta*, it has been found in association with *Calyptogena* in anoxic, reducing environments. However, unlike *A. permodesta*, there are numerous lots known from normal habitats.

Amphissa undata (Carpenter, 1864)

Figure 1.22E

Amycla undata Carpenter, 1864: 224.

Amphissa undata: Dall *in* Williamson, 1892:214, pl. 20, fig. 8.—Oldroyd, 1927:282.—Abbott, 1974:203, fig. 2183.—Palmer, 1958:211, figs. 21, 22 [holotype].

Amphissa ventricosa Arnold, 1903: 242, pl. 5, fig. 11 [Pleistocene].

Material Examined. California: Santa Maria Basin, Phase I, sta. 4, 393 m; Sta. R-4, 90 m (1). Other material: 272 lots in the LACM collection.

Description. Shell tan with variegated pattern of lighter and darker brown markings under light tan periostracum; whorls strongly inflated, suture deep; axial ribs 12-14, projecting strongly at periphery, fading across base; spiral cords strong but narrow, overriding axial ribs, interspaces wider than cords; lip lirae moderately developed. Length 12-16 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 40 fathoms. Holotype: USNM 23284. *Amphissa ventricosa*: San Pedro, Los Angeles County, California; Pleistocene; holotype USNM 162550.

Distribution. Monterey Bay, California (36.5°N), to Isla Asunción Island, Baja California (27°N). There are two lots in the LACM collection from the Gulf of California (off Isla Espiritu Santo and Puerto Escondido).

Habitat. Soft bottoms, 30-90 m.

Remarks. This species is characterized by its color pattern, deep suture and narrow spiral cords. There is a slightly concave shoulder, which imparts a profile that differs from that of the other two species treated here.

Woodring (1946:77) first placed Arnold's *Amphissa ventricosa* in the synonymy of *A. undata*.

Family Cystiscidae Stimpson, 1865

Diagnosis. Shell small to minute, glossy, with low spire, thickened outer lip and columellar plications; internal whorls partially resorbed; protoconch paucispiral. The mantle of living animals envelops the shell, keeping its surface glossy. The radula is rachiglossate with a multicuspid rachidian tooth; lateral teeth lacking in most genera.

Biology. Cystiscids are carnivorous. The paucispiral protoconch is indicative of direct development. Coovert and Coovert (1995) treated the anatomy and biology of the marginelliform families Cystiscidae and Marginellidae.

Remarks. Until the work of Coovert and Coovert (1995), the families Cystiscidae and Marginellidae were separated at the subfamily level in the Marginellidae. These authors described significant anatomical and radular differences in addition to the shell character distinction that cystiscids partially resorb the internal whorls, whereas marginellids do not.

Coovert and Coovert (1995) recognized four subfamilies in the Cystiscidae. The genus that follows was placed in the subfamily Plesiocystiscinae Coovert and Coovert, 1995.

Genus *Plesiocystiscus* Coovert and Coovert, 1995

Plesiocystiscus Coovert and Coovert, 1995. Type species (OD): *Marginella jewettii* Carpenter, 1857. California.

Diagnosis. Shell minute, spire low, not concealed, anterior margin rounded, without a siphonal notch; lip thickened, smooth within; lateral teeth of radula present.

Remarks. Eastern Pacific species were formerly placed in *Cystiscus* Stimpson, 1865, a genus now limited to South Africa. Eastern Pacific species of *Plesiocystiscus* were treated by Coan and Roth (1966) and Roth and Coan (1968).

***Plesiocystiscus myrmecoon* (Dall, 1919)**

Figure 1.23A

Hyalina myrmecoon Dall, 1919: 308.

Marginella (*Hyalina*) *myrmecoon*: Oldroyd, 1927:165.

Cystiscus myrmecoon: Coan and Roth, 1966:291, pl. 51, fig. 65.

Material Examined. California: Santa Maria Basin, Phase I, sta. 16, 591 m (2). Other material: 37 lots in the LACM collection.

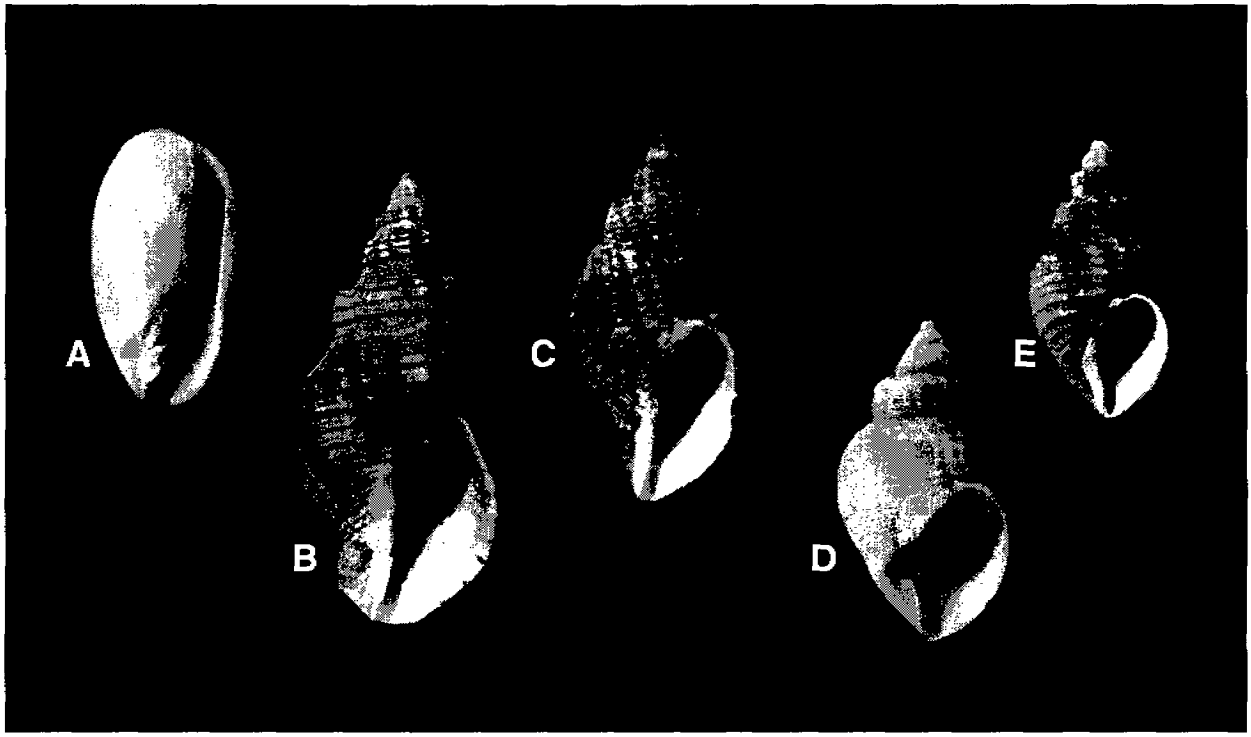


Figure 1.23. Cystiscidae, Cancellariidae. **A.** *Pleisocystiscus myrmecoon* (Dall, 1919): 591 m, off Point Buchon, San Luis Obispo County, California (SBMNH 142804, Santa Maria Basin, sta. 16); height 3.9 mm. **B.** *Cancellaria cooperi* Gabb, 1865: 124 m, off Santa Barbara, California (USNM 106860); height 56 mm. **C.** *Cancellaria crawfordiana* Dall, 1891: Off Redondo Beach, Los Angeles County, California (LACM 72505); height 49.8 mm. **D.** *Admete californica* (Dall, 1908): 1103 m, off San Diego, California (USNM 110626, lectotype); height 15.8 mm. **E.** *Admete gracilior* (Carpenter, 1869): 69 m, off Point Fermin, Los Angeles County, California (LACM 57-90.1); height 11.4 mm.

Description. Shell small, white, smooth; whorls 3, columella with 3 prominent plaits and 3 smaller, more posterior plaits. Profile of lip straight to slightly concave. Length 3.3-4.8 mm.

Type Locality and Type Specimens. San Diego, California. Holotype USNM 9440.

Distribution. Pacific Grove, Monterey County, California (36° N), to Punta Rompiente, Baja California Sur (27.5° N).

Habitat. Intertidal to 40 m. The voucher specimens from 591 m were live-collected, which suggests that there was a station error, as there are no specimens in the LACM collection from comparable depths.

Remarks. This species is here reinstated and removed from the synonymy of *Plesiocystiscus politulus* (Dall, 1919), in which it had been placed by Roth and Coan (1968:64). Earlier, Coan and Roth (1966:291) had illustrated the holotype, but had been uncertain as to its validity.

Plesiocystiscus myrmecoon is characterized by its relatively slender profile and by its size, which ranges from 3.3-4.8 mm, intermediate between that of the larger *P. jewetti* (Carpenter, 1857) and the smaller *P. politulus* (Dall, 1919). Specimens of *P. myrmecoon* in collections had previously been thought to be smaller-sized specimens of *P. jewetti*. Distributions of the three species overlap in southern California.

Superfamily Cancellarioidea

Family Cancellariidae Forbes and Hanley, 1851

Diagnosis. Shell small to large, spire elevated; sculpture both axial and spiral; columella with 2-4 weak to strong plaits; canal short, operculum lacking; protoconch paucispiral. Radula nematoglossan, of long central teeth only.

Biology. The biology of cancellariids is poorly known. Recent papers are those of Harasewych and Petit (1982, 1986) and Petit and Harasewych (1986). The elongate teeth of the nematoglossan radula are unlike that of other neogastropods, accounting for the placement of this family in its own superfamily. All cancellariids are believed to feed suctorially on internal fluids of prey animals, using the long teeth to penetrate the bodies of the prey.

Cancellariids live on soft substrates from shallow to deep water. Egg capsules are attached by long stalks. Planktotrophic veligers may be released or development may be direct (Pawlik *et al.*, 1988).

Remarks: Petit and Harasewych (1990) published a catalog of all generic and specific level taxa that have been proposed in the family. It is still premature to offer a complete classification because so few genera are known anatomically. Two subfamilies are known, Cancellariinae and Admetinae.

Key to Species of Cancellariidae

1A. Columellar plaits strong 2

1B. Columellar plaits weak 3

2A. Color pattern of narrow dark bands on lighter ground ..... *Cancellaria cooperii*

2B. Color pattern lacking ..... *Cancellaria crawfordiana*

3A. Whorl profile angulate ..... *Admete californica*

3B Whorl profile rounded ..... *Admete gracilior*

Subfamily Cancellariinae Forbes and Hanley, 1851

Diagnosis. Shell of medium to large size, columellar plicae well developed.

Remarks. Cancellariinae are typically a more tropical group than the Admetinae.

Genus *Cancellaria* Lamarck, 1799

Cancellaria Lamarck, 1799. **Type species** (M): *Voluta reticulata* Linnaeus, 1767. Caribbean.

Diagnosis. Shell of moderate to large size, spire of moderate height, sculpture both axial and spiral; columella with well-developed callus and three plaits, the uppermost the strongest; canal usually short; operculum lacking. Radula nematoglossan, of long central teeth only.

Biology. As described for family.

Remarks. Shell characters provide useful distinctions at the subgeneric level. Most authors have not elevated them to full genera, however. The applicable subgenera for the two species treated here are mentioned in the remarks section for each.

Cancellaria cooperii Gabb, 1865

Figure 1.23B

Cancellaria (*Narona*) *cooperii* Gabb, 1865:186 [unfigured].

Cancellaria (*Progabbia*) *cooperi*: Dall, 1921:83, pl. 5, figs. 3, 4.—Oldroyd, 1927:152, pl. 11, fig. 14.—Abbott, 1974:247, fig. 2694.

Cancellaria cooperi: Grant and Gale, 1931:619.—McLean, 1978:51, fig. 28.1.

Material Examined. Santa Maria Basin, Phase I, sta. 31, 100 m (1). Other material: 51 lots in the LACM collection.

Description. Shell large, high-spired; shoulder slightly concave; columella with 2 strong plicae and a basal fold; lip strongly lirate within. Ground color yellow brown, with low thin spiral cords of darker brown. Axial sculpture of broad ribs, forming projecting nodes but not extending across the shoulder. Length 40-90 mm.

Type Locality and Type Specimens. San Diego and Monterey, California. Type material not located (Coan and Bogan, 1988:278).

Distribution. Monterey Bay, California (36.5°N), to Punta San Pablo, Baja California Sur (27°N).

Habitat. Soft bottoms, 30-280 m.

Remarks. The color markings of this species are characteristic and it can be confused with no other.

O'Sullivan *et al.* (1987) reported that *Cancellaria cooperi* parasitizes the California electric ray, as it rests on the sea bottom, but not other bottom fishes. In the absence of electric rays the snails remain buried in the sand. This is the only member of the Cancellariidae for which the feeding relationship is known. Reproduction in this species was described in detail by Pawlik *et al.* (1988).

Gabb's original spelling of the name *cooperii* is used, because the current rules of zoological nomenclature do not allow for emendation to the preferable spelling *cooperi*.

This species is the type species of *Progabbia* Dall, 1918 (Petit and Harasewych, 1990:7).

Cancellaria crawfordiana Dall, 1891

Figure 1.23C

Cancellaria crawfordiana Dall, 1891:182, pl. 6, fig. 1.

Cancellaria (*Progabbia*) *crawfordiana*: Grant and Gale, 1931:614.—Oldroyd, 1927:153.

Cancellaria (*Crawfordina*) *crawfordiana*: Abbott, 1974:247, fig. 2692.

Cancellaria ghiorum Costa, 1993:9, figs. 1-4.

Material Examined. California: Santa Maria Basin, Phase II, sta. R-6, 410 m (1); sta. PJ-16, 130 m (1 immature). Other material: 28 lots in the LACM collection.

Description. Shell moderately large, high-spired; whorls rounded, suture impressed, upper part of whorl slightly tabulate; columella with 3 plications. Axial sculpture of strong ribs, extending to canal; spiral sculpture of narrow cords, overriding axial ribs and forming nodes at intersections. Lip strongly lirate within. Shell cream colored under a thick, dark brown periostracum. Length 30-48 mm.

Type Locality and Type Specimens. Drake's Bay, Marin California, 24 fathoms. Holotype: USNM 122400. *Cancellaria ghiorum*: Carmel, Monterey County, California, 300 m; holotype: CAS 086776.

Distribution. Coos Bay, Oregon (43.5°N), to Punta Rompiente, Baja California Sur (27.5°N)

Habitat. Soft bottoms, 40-290 m. Feeding habits are unknown. The bathymetric range exceeds that of *Cancellaria cooperi*.

Remarks. The illustrated specimens of the recently proposed *Cancellaria ghiorum* are well within the variation of *C. crawfordiana*, and the name is here added to the synonymy.

This is the type species of the subgenus *Crawfordina* Dall, 1891 (Petit and Harasewych, 1990:5).

Subfamily Admetinae Troschel, 1866

Diagnosis. Shell small to medium in size; columellar plaits reduced; radula lacking.

Remarks. Members of this group occur in cooler or deeper water than the more tropical Cancellariinae.

Genus *Admete* Möller, 1842

Admete Möller, 1842. **Type species** (M): *Admete crispa* Möller, 1842; = *Tritonium viridulum* Fabricius, 1780. North Atlantic.

Diagnosis. Shell relatively small, thin, spire high; sculpture axial and spiral; columella concave, with weak development of plaits; operculum lacking; radula lacking.

Biology. Anatomy of the type species was studied by Haresewych and Petit (1986). Despite the loss of the radula, other anatomical characters of the digestive system were comparable to those of *Cancellaria* and Haresewych and Petit considered the admetines to feed suctorially, although the prey organisms are unknown.

Remarks. The type species *Admete viridula* is broadly distributed throughout the Arctic Ocean and the North Atlantic, as well as the northeastern Pacific south to Oregon (in the LACM collection). It is characterized by broad spiral cords with narrower interspaces. It is highly variable in profile and numerous synonyms have been proposed.

There has been debate in the literature about the use of the name *viridula* for the type species. To settle the matter, Bouchet and Warén (1985:258) designated a neotype, figured specimens representing a range of variation, and listed a number of additional synonyms. Further arguments in support of the type species as *Admete viridula* were provided by Harasewych and Petit (1987:48). The type species is often cited as *A. couthouyi* Jay, 1839, which is another synonym.

Admete californica (Dall, 1908)

Figure 1.23D

Cancellaria (*Admete* ?) *californica* Dall, 1908:296, pl. 4, fig. 4.

Admete californica: Oldroyd, 1927:159, pl. 11, fig. 6.—Abbott, 1974:248.

Material Examined. California: Santa Maria Basin, Phase I, sta. 46, 597 m (1). Other material: 42 lots in the LACM collection.

Description. Shell of medium size, whorls 4, spire high, suture deeply impressed, whorls with tabulate profile defined by peripheral angulation; shoulder area slightly convex; columella with concave profile and pronounced umbilical chink; columella plaits weak; axial and spiral sculpture producing square cancellations with beads at intersections; 4 spiral cords on early whorls and 10 more across base. Shell white under olive brown periostracum. Length 12-16 mm.

Type Locality and Type Specimens. Off San Diego, California, 603 fathoms. Lectotype **(here designated)**: USNM 110626.

Distribution. Off S end Kruzof Island, Alaska (57.5°N), to Islas Coronados, Baja California (32.5°N). Dall (1921:84) reported the southern distribution to extend to the Gulf of California, but the locality information for the single lot [USNM 211379] is suspect and the record is discounted.

Habitat. Soft bottoms, 170-2,000 m.

Remarks. *Admete californica* differs from the type species *A. viridula* in having a pronounced umbilical chink, a strongly tabulate shoulder at least in early whorls, and in having evenly cancellate sculpture rather than sculpture dominated by axial ribs. The umbilical chink is apparent on large specimens, but is not evident on specimens under 10 mm in length. The species is variable in the strength of the axial and spiral elements.

Admete gracilior (Carpenter, 1869)

Figure 1.23E

Cancellaria gracilior Carpenter *in* Gabb, 1869 [1866-69]:50—Palmer, 1958:223, pl. 26, fig. 6, 7 [holotype].

Admete couthouyi gracilior: Oldroyd, 1927:158.

Admete woodworthi Dall, 1905:123.—Oldroyd, 1927:160 [unfigured].

Admete rhyssa Dall, 1919:306.—Oldroyd, 1927:156 [unfigured].

Admete seftoni Berry, 1956:155, figs. 2, 9.

Material Examined. California: Santa Maria Basin, Phase II, sta. R-9, 410 m (1 juvenile); sta. PJ-8, 150 m (1 immature). Other material: 74 lots in the LACM collection.

Description. Shell small, high-spired; whorls 4, suture deeply impressed, whorls evenly rounded; columella with concave profile, plaits weak; umbilical chink usually closed by columellar lip; axial sculpture of 9-14 strongly projecting ribs, crossed by narrow, raised spiral cords. Shell white under olive brown periostracum. Height 10-12 mm.

Type Locality and Type Specimens. Santa Barbara, middle Pleistocene. Holotype: UCMBP 15560. *Admete woodworthi*: Monterey Bay, 10-45 fathoms; holotype: USNM 181822. *Admete rhyssa*: off South Coronado Island, Baja California, 155 fathoms; holotype: USNM 211241. *Admete seftoni*: N of Anacapa Island, California, 46-58 fathoms; holotype: SBMNH 34555.

Distribution. Monterey Bay (36.5°N), to Punta San Pablo, Baja California Sur (27°N).

Habitat. Soft bottoms, 60-250 m.

Remarks. Four taxa are here grouped as a species variable in breadth and in number of axial ribs. The species is characterized by rounded, projecting axial ribs, narrow spiral cords and a deep suture. Carpenter's taxon, based on a specimen from the middle Pleistocene, was thought to be extinct, but is represented by living specimens of slender profile. *Admete woodworthi* was based on a slender form with a minimal number of axial ribs, whereas *A. rhyssa* and *A. seftoni* were based on type material of broader profile.

Superfamily Conoidea

Until recently, the superfamily Conoidea included three main families: Turridae, Terebridae, and Conidae. The family Turridae (which had been defined on the shell character of a subsutural sinus) as used by previous authors, has recently been subdivided as a result of phylogenetic analysis by Taylor, *et al.* (1993). Based on a comparative study of foregut anatomy and corresponding radular characters, the old family Turridae has been subdivided into five families (here called turriform families) that were previously regarded as subfamilies: Drilliidae, Pseudomelotomidae, Strictispiridae, Turridae, and Conidae (Conidae now includes some turriform subfamilies). Sysoev (*in* Taylor *et al.*, 1993, Appendix 2) assigned all turriform genera to the revised classification of Taylor *et al.*

Two turriform families, the Turridae, and the redefined Conidae, are represented in the benthic fauna of southern California. There is a major difference in radular structure and function; but, on shell characters, they can not readily be distinguished. Genera of both families are therefore placed in the same key based on shell characters.

Key to Species of Turridae and Conidae

1A. Anal sinus not bordered by thick callus 2
1B. Anal sinus bordered by thick callus on both sides 21

2A. Shell nearly smooth, lacking axial and spiral sculpture 3
2B. Shell with spiral or axial sculpture or both 4

3A. Shell sinistral ..... *Antiplanes catalinae*
3B. Shell dextral ..... *Antiplanes thalea*

4A. Sculpture spiral only 5
4B. Sculpture both axial and spiral 8

5A. Canal nearly as long as aperture 6
5B. Canal short, less than length of aperture 7

6A. Three spiral cords at periphery ..... *Antiplanes briseis*
6B. Single spiral cord at periphery ..... *Carinoturris fortis*

7A. Whorls strongly inflated ..... *Pseudotaranis strongi*
7B. Whorls only slightly inflated ..... *Pseudotaranis hyperia*

8A. Early whorls with axial nodes on peripheral carination 9
8B. Early whorls not having axial nodes on peripheral carination 16

9A. Columella lacking single carination 10
9B. Columella with single carination 11

10A. Shell length over 17 mm ..... *Rhodopetoma diaulax*
10B. Shell length under 16 mm ..... *Rhodopetoma renaudi*

11A. Axial nodes persisting on final whorl 12
12B. Axial nodes not persisting on final whorl 13

12A. Shell relatively slender, profile from whorl to whorl convex ..... *Borsonella bartschi*
12B. Shell relatively broad, profile from whorl to whorl straight ..... *Borsonella merriami*

13A. Periphery angulate 14
13B. Periphery not angulate 15

14A. Shoulder concave ..... *Borsonella coronadoi*
14B. Shoulder flat-sided ..... *Borsonella hooveri*

15A. Whorl profile rounded ..... *Borsonella omphale*
15B. Whorl profile constricted below suture ..... *Borsonella pinosensis*

16A. Whorl profile rounded 17
16B. Whorl profile angulate 20

17A. Axial sculpture on early whorls, lacking on final whorl ..... *Daphnella clathrata*
17B. Axial and spiral sculpture retained at all growth stages 18

18A. Mature shell > 20 mm ..... *Ophiodermella inermis*
18B. Mature shell < 15 mm 19

19A. Profile broad, aperture length nearly half the length of shell ..... *Ophiodermella cancellata*
19B. Profile slender, aperture length about one-third the length of shell ..... *Ophiodermella fancherae*

20A. Outer lip thin at edge ..... *Kurtzina beta*
20B. Outer lip thickened at edge ..... *Kurtzia arteaga*

21A. Final whorl lacking axial ribs 22
21B. Final whorl with axial ribs 23

22A. With strong peripheral carination ..... *Crockerella evadne*
22B. Lacking strong peripheral carination ..... *Crockerella philodoce*

23A. Spiral cords of penultimate whorl broader than interspaces 24
23B. Spiral cords of penultimate whorl narrower than interspaces 25

24A. Interspaces deeply incised ..... *Crockerella tridesmia*
24A. Interspaces not deeply incised ..... *Crockerella castianira*

25A. Axial and spiral sculpture equal in strength ..... *Crockerella crystallina*
25B. Axial ribs stronger than spiral cords 26

26A. Shoulder tabulate 27
26B. Shoulder not tabulate 28

27A. Profile slender, axial ribs about 10 per whorl ..... *Crockerella conradiana*
27B. Profile broad, axial ribs about 12 per whorl ..... *Crockerella scotti*

28A. Spiral cords alternating in size ..... *Crockerella cymodoce*
28B. Spiral cords not alternating in size 29

29A. Whorls rounded, not shouldered ..... *Crockerella eriphyle*
29B. Whorls with concave shoulder ..... *Crockerella lowei*

Family Turridae Swainson, 1840

Diagnosis. Shell tall-spired, aperture elongate, with anterior canal or notch; and sinuous posterior notch; sculpture varied. Odontophore present, radular teeth attached to membrane, usually of wishbone type of marginals only; venom gland present.

Biology. This group of turriform gastropods uses the venom gland to paralyze prey organisms. Although the rachididan and lateral teeth (if present) are vestigial, and the functional teeth consist of the marginal teeth; the odontophore and radular ribbon are still functional. Reproduction can be either direct or with a planktotrophic veliger stage.

Remarks. In the classification of Taylor *et al.* (1993), the newly redefined Turridae retains five subfamilies (Clavatulinae, Crassispirinae, Zonulispirinae, Cochespirinae, Turrinae) and a large number of genera.

Subfamily Cochlespirinae Powell, 1942

Diagnosis. Shell medium to large, fusiform, anterior canal moderately long, anal sinus on shoulder.

Remarks. This group was previously known as Turriculinae, but the type genus *Turricula* Schumacher, 1817, was transferred to the Clavatulinae by Sysoev *in* Taylor *et al.* (1993:160).

Genus *Antiplanes* Dall, 1902

Antiplanes Dall, 1902. **Type species** (OD): *Pleurotoma* (*Surcula*) *perversa* Gabb, 1865, not Philippi, 1847 [= *Pleurotoma* (*Antiplanes*) *catalinae* Raymond, 1904]. Northeast Pacific.

Rectiplanes Bartsch, 1944. **Type species** (OD): *Pleurotoma* (*Antiplanes*) *santarosana* Dall, 1902. Northeast Pacific.

Diagnosis. Shell large, fusiform, dextral or sinistral; axial sculpture absent; spiral sculpture of cords or lacking; anal sinus deep, U-shaped, on shoulder; siphonal canal long. Protoconch paucispiral. Operculum filling aperture, nucleus terminal. Radula teeth of bifurcated marginals and vestigial rachidian.

Biology. The paucispiral protoconch is indicative of direct development. The circular egg capsule was figured by Kantor and Sysoev (1991, fig. 101).

Remarks. Kantor and Sysoev (1991) reviewed the northwestern Pacific members of this genus. Dextral and sinistral species are known and subgenera have been based on this distinction. However, Kantor and Sysoev did not consider the distinction worthy of recognition. The significance of this difference is not understood. *Antiplanes* has been used as a subgenus for the sinistral species and *Rectiplanes* Bartsch, 1944, for the dextral species.

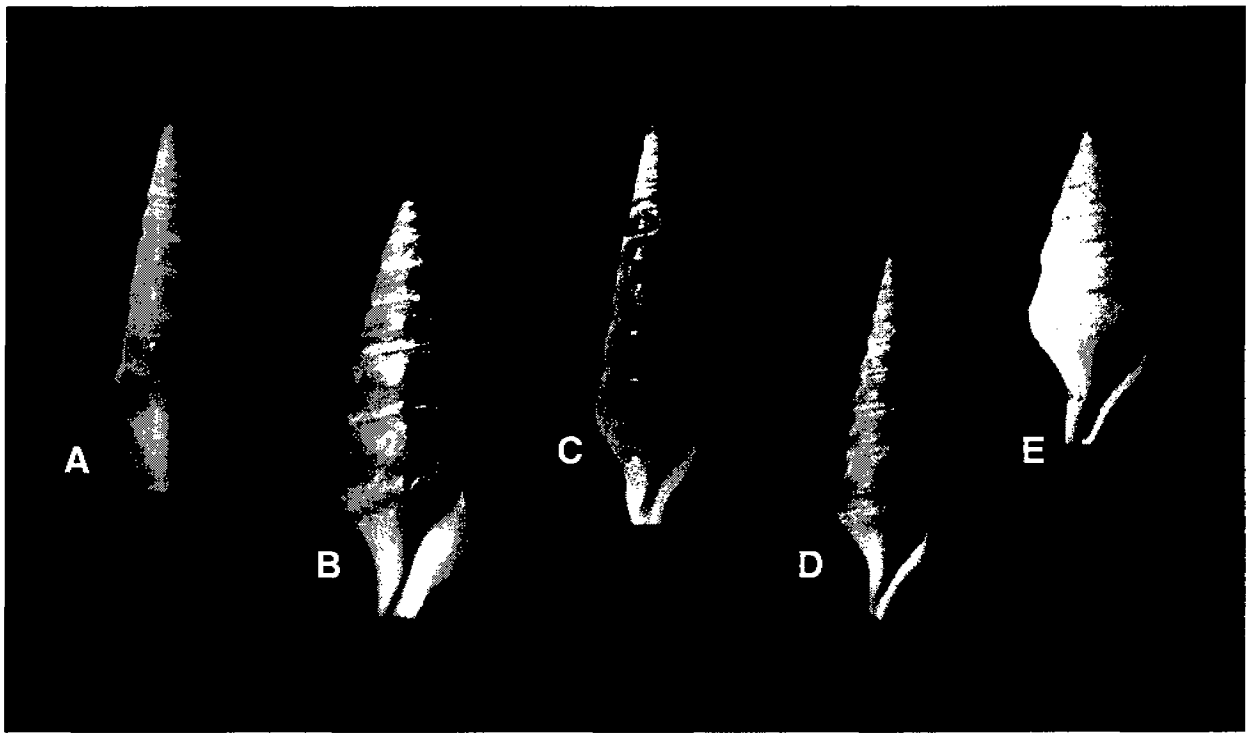


Figure 1.24. Turridae. **A.** *Antiplanes catalinae* (Raymond, 1904): 229 m, off Santa Catalina Island, California (USNM 192087, lectotype); height 25.1 mm. **B.** *Antiplanes thalea* (Dall, 1902): 461 m, off San Luis Obispo, California (USNM 122568, holotype); height 40 mm. **C.** *Antiplanes thalea* (Dall, 1902): 97 m, off Santa Rosa Island, California (USNM 109198, holotype of *A. santarosana*); height 36 mm. **D.** *Antiplanes briseis* Dall, 1919: 150-161 m, Avalon Bay, Santa Catalina Island, California (LACM 40-123.7); height 25.0 mm. **E.** *Carinoturris fortis* Bartsch, 1944: 227-229 m, N of Anacapa Island, California (LACM 41-52.3); height 14.3 mm.

Antiplanes catalinae (Raymond, 1904)

Figure 1.24A

Pleurotoma (*Surcula*) *perversa* Gabb, 1865:183 [not Philippi, 1847].

Antiplanes perversa: Oldroyd, 1927:82, pl. 11, fig. 9, pl. 28, fig. 8.

Pleurotoma (*Antiplanes*) *catalinae* Raymond, 1904: 2 [unfigured].

Antiplanes major Bartsch, 1944: 29 [unfigured].

"Antiplanes voyi (Gabb, 1866)."— *of* Abbott, 1974:267.

Antiplanes gabbi Kantor and Sysoev, 1991:122 [unnecessary new name for *Pleurotoma perversa* Gabb]

Material Examined. Not represented in the voucher collection, but occurring offshore in southern California. Other material examined: 232 lots in the LACM collection.

Description. Shell moderately large, sinistral; spire high, whorls 8-10, evenly rounded, suture moderately impressed; spiral sculpture of fine striae, axial sculpture of fine growth lines; sinus deep, U-shaped, lip greatly protracted below sinus; protoconch paucispiral, of 1.5 rounded whorls. Periostracum tan; shell light brown, with lighter band at periphery; interior glossy brown, showing light peripheral band. Length 40-55 mm.

Type Locality and Type Specimens. *Pleurotoma perversa*: Santa Catalina Island, California, 60 fathoms. Syntypes: UCMP 15929. *Pleurotoma catalinae*: Santa Catalina Island, California, 125 fathoms; lectotype **(here designated)** USNM 192087 (Figure 1.22A). *Antiplanes major*: off Bodega Head, Sonoma County, California, 62 fathoms; holotype: USNM 224347.

Distribution. Queen Charlotte Sound, British Columbia (51.5°N), to San Diego, California (33°N).

Habitat. Soft bottoms, 90-270 m.

Remarks. The earliest name for this species is preoccupied. The species therefore takes the name of the next available synonym. Although Raymond claimed that his species *Antiplanes catalinae* was more slender than *Antiplanes perversa*, separation into two species of the large number of specimens in collections is not possible.

Grant and Gale (1931:553) placed all sinistral and dextral taxa named from the eastern Pacific under the name *Antiplanes perversa* (Gabb), believing that dextral and sinistral forms could occur in the same species, but that view is ruled out by the size discrepancies between the dextral and sinistral forms.

Abbott (1974:267) incorrectly used the taxon *Antiplanes voyi* (Gabb, 1866), for this species, but that name is not applicable, as it was based on a dextral species of stout profile that is now considered to be extinct.

Antiplanes vinosa (Dall, 1902) is a similar sinistral species described from the Aleutian Islands and occurring in the Northwest Pacific to the Okhotsk Sea, Russia (Kantor and Sysoev, 1991:137). As there is no sinistral species known from the Gulf of Alaska or southeast Alaska, the two species *A. catalinae* and *A. vinosa* are allopatric and can be considered distinct, although they are certainly closely related.

Antiplanes thalea (Dall, 1902)

Figures 1.24B,C

Pleurotoma (*Antiplanes*) *thalea* Dall, 1902:514.—Dall, 1919:37, pl. 11, fig. 6.—Dall, 1921:72, pl. 1, fig. 8 [not fig. 9].—Dall, 1925:4, pl. 22, fig. 1.

Antiplanes santarosana Dall, 1902:515.—Dall, 1919: 36, pl. 11, fig. 3.—Dall, 1921:71, pl. 1, fig. 9 [not fig. 8].

Antiplanes (*Rectiplanes*) *santarosana*: McLean, 1971:120, fig. 39 [radula].

Pleurotoma (*Spirotropis*) *smithi* Arnold, 1903:216, pl. 6, fig. 13 [not *Pleurotoma smithii* Forbes, 1840].

Antiplanes rotula Dall, 1921:71 [new name for *Pleurotoma smithi* Arnold, not Forbes; incorrectly cited as "Dall, 1919"].

Antiplanes (*Rectiplanes*) *willetti* Berry, 1953: 419, pl. 29, fig. 2.

Material Examined. California: Santa Maria Basin, Phase II, sta. R-2, 161 m (1 immature). Other material: 94 lots in the LACM collection

Description. Shell of moderate size, dextral, spire high, whorls 8-11, evenly rounded, suture moderately impressed; spiral sculpture of fine striae, axial sculpture of fine growth lines; sinus deep, U-shaped, lip greatly protracted below sinus; protoconch paucispiral, of about 1.5 rounded whorls. Periostracum light olive-green, frequently with a thin darker line at midwhorl; shell white to light tan under periostracum. Length 30-40 mm.

Type Locality and Type Specimens. Off San Luis Obispo, California, 252 fathoms. Lectotype **(here designated)**: USNM 122568. *Pleurotoma santarosana*: Off Santa Rosa Island, California, 53 fathoms; lectotype **(here designated)**: USNM 109198. *Pleurotoma smithi*: San Pedro, Los Angeles, California, Pleistocene; holotype: USNM 162566. *Antiplanes willetti*; Forrester Island, Alaska, 50 fathoms; holotype: CAS 064665.

Distribution. Petrel Bank, N of Semisopochnoi Island, Aleutian Islands, Alaska [LACM 86-326.3] (52°N, 180°W), to Islas San Benito, Baja, California (28°N).

Habitat. Soft bottoms, 130-400 m.

Remarks. One species of smooth-shelled, dextral *Antiplanes* seems to occur in the northeastern Pacific. The lectotypes of *Antiplanes thalea* and *A. santorosana* represent extremes of variation: that of *A. thalea* (Figure 1.24B) is relatively broad, with fewer whorls than that of *santarosana* (Figure 1.24C), which is slender with more whorls. Attempts to divide the LACM material between two species have not succeeded.

This species is the type species of the subgenus *Rectiplanes*, based on its dextral shell, although the significance of such a distinction is not clear.

Antiplanes briseis Dall, 1919

Figure 1.24D

Antiplanes briseis Dall, 1919:35, pl. 22, fig. 1.—Oldroyd, 1927:85.—Abbott, 1974:267 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 16 LACM lots.

Description. Shell tall-spired, slender; aperture length less than one-third shell length; shoulder slightly concave; periphery marked by single prominent spiral cord; base with numerous spiral cords; axial sculpture lacking except for growth increments. Sinus deep, filling area above peripheral cord. Length 18-25 mm.

Type Locality and Type Specimens. Off Drakes Bay, Marin County, California, 30 fathoms. Holotype: USNM 212329.

Distribution. Drakes Bay, Marin County (38°N), to San Diego, California [LACM 41-20] (33°N).

Habitat. 100-230 m, soft bottoms.

Remarks. This resembles *Rhodopetoma diaulax* but lacks the axial nodes of that species and has more prominent spiral cords on the base.

The type locality is in northern California, but all specimens in the LACM collection are from southern California, San Miguel Island to San Diego.

Genus *Carinoturris* Bartsch, 1944

Carinoturris Bartsch, 1944. **Type species** (OD): *Cryptogemma adrastia* Dall, 1919. California.

Diagnosis. Shell small (length 14-20 mm); canal long, sinus on shoulder just above periphery; spiral sculpture of single peripheral carination; axial sculpture lacking. Radula of wishbone type.

Remarks. The shell and radula of the type species were figured by Powell (1966:49, pl. 6, fig. 10, text fig. B36). The type species occurs in much deeper water than does the following species and is therefore not treated here.

Carinoturris fortis Bartsch, 1944

Figure 1.24E

Carinoturris fortis Bartsch, 1944:60.—Abbott, 1974:266 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 4 LACM lots.

Description. Shell white under light brown periostracum; shoulder convex to nearly flat; canal of moderate length; spiral sculpture of single peripheral carination; axial sculpture lacking. Protoconch eroded on available specimens. Length 14-16 mm.

Type Locality and Type Specimens. Off Point Sur, Monterey County, California, 298 fathoms. Holotype: USNM 212323.

Distribution. Off Eel River, Humboldt County [LACM 147411] (41°N), to Anacapa Island, California [LACM 41-52] (34°N).

Habitat. 180-550 m, soft bottoms.

Remarks. This species is illustrated here for the first time. It differs from the type species of *Carinoturris* in having a longer aperture, less concave shoulder, less vertically compressed whorls, a weaker projecting carination and a less deeply impressed suture. It occurs in shallower water than the type species.

Genus *Rhodopetoma* Bartsch, 1944

Rhodopetoma Bartsch, 1944. **Type species** (OD): *Borsonella rhodope* Dall, 1919 [= *Turris* (*Antiplanes*) *diaulax* Dall, 1908]. Northeastern Pacific.

Diagnosis. Shell tall-spired, canal twisted to left; sinus on excavated shoulder; spiral sculpture of peripheral cord low on whorl; axial sculpture of weak swellings on peripheral cord; protoconch paucispiral. Radula of wishbone type marginals.

Remarks. *Rhodopetoma* differs from *Antiplanes* chiefly in having axial swellings; the radula, as illustrated by Powell (1966) and McLean (1971) is like that of *Antiplanes*. The tall profile and axial swellings resemble those of *Borsonella*, but there is no plication on the columella, the periostracum is thin and the microscopic vermiculate sculpture of *Borsonella* is lacking.

One additional species, *Rhodopetoma renaudi* (Arnold, 1903) is here transferred to *Rhodopetoma*.

Rhodopetoma diaulax (Dall, 1908)

Figure 1.25A,B

Turris (*Antiplanes*) *diaulax* Dall, 1908:247 [unfigured].

Antiplanes diaulax: Oldroyd, 1927:84.—Abbott, 1974:267 [listed].

Borsonella rhodope Dall, 1919: 39, pl. 12, f. 3.

Rhodopetoma rhodope: Bartsch, 1944:59.—Powell, 1966:32, pl. 2, fig. 16; text fig. B13 [radula].—McLean, 1971:119, fig. 42 [radula].—Abbott, 1974:265 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 7 LACM lots.

Description. Shell with thick, dull-surfaced, olive-colored periostracum; canal short, twisted to left; sinus on excavated shoulder; axial sculpture of weak peripheral swellings, becoming obsolete in final whorl; spiral sculpture of broad peripheral cord and numerous spiral cords below periphery. Length 18-23 mm.

Type Locality and Type Specimens. San Diego, California, 34 fathoms. Holotype: USNM 110609. *Borsonella rhodope*: off Santa Rosa Island, 82 fathoms; holotype: USNM 212361.

Distribution. Santa Rosa Island (34°N), to Cortes, Bank, California (32.5°N).

Habitat. 200-570 m, soft bottoms.

Remarks. The oldest name for this species (for which the holotype is here first figured) is used. Dall did not mention the axial nodes of the holotype of *Rhodopetoma diaulax*, but these show clearly in Figure 25A; the dimensions and other details of this specimen match the description, so it is clear that the specimen, which is labeled "type," is correctly identified.

This is the first report of new records for the species subsequent to the original material described by Dall, under either the names *Rhodopetoma diaulax* or *R. rhodope*.

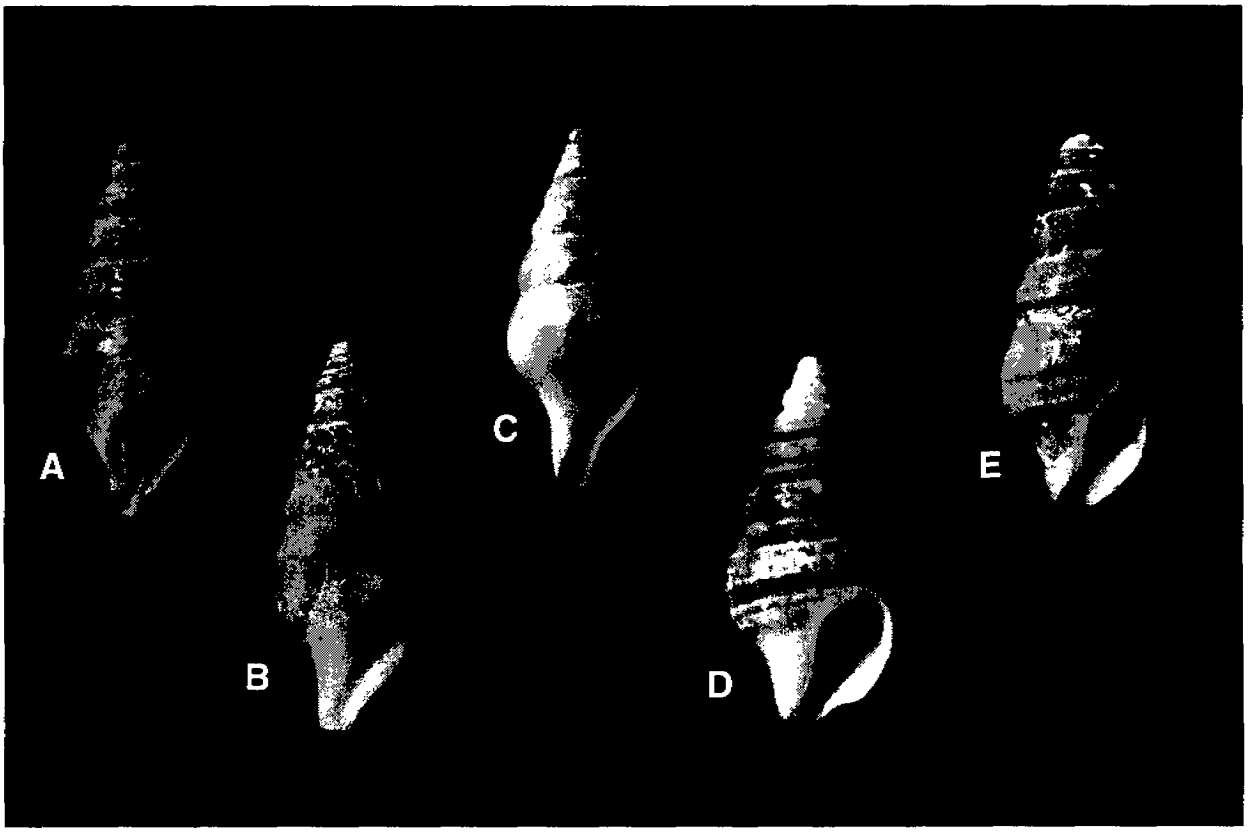


Figure 1.25. Turridae. **A.** *Rhodopetoma diaulax* (Dall, 1908): 62 m, off Islas Los Coronodos, Baja California (holotype, USNM 110609); height 19.0 mm. **B.** *Rhodopetoma diaulax* (Dall, 1908): 150 m, off Santa Rosa Island, California (holotype of *B. rhodope*, USNM 212361); height 19 mm. **C.** *Rhodopetoma renaudi* (Arnold, 1903): 159-174 m, SE of Santa Catalina Island, California (LACM 41-209.12); height 12.3 mm. **D.** *Pseudotaranis strongi* (Arnold, 1903): 511-530 m, Tanner Bank, California (LACM 77-250.22); height 13.1 mm. **E.** *Pseudotaranis hyperia* (Dall, 1919): 177-190 m, off San Nicolas Island, California (LACM 40-99.6); height 15.0 mm.

Rhodopetoma renaudi (Arnold, 1903)

Figure 1.25C

Drillia renaudi Arnold, 1903: 208, pl. 8, f. 5.

Clathrodrillia renaudi: Oldroyd, 1927:70.

Spirotropis (*Typhlomangelia*) *renaudi*: Grant and Gale, 1931:549, pl. 26, fig. 29.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 23 LACM lots.

Description. Shell slender, light brown, small for genus; shoulder flat to slightly concave; spiral sculpture of peripheral carination on lower third of early whorls, higher on final whorl; axial sculpture of oblique nodes cresting on carination, usually obsolete on final whorl. Length 11-16 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 562537.

Distribution. San Miguel Island (34°N) to Cortes Bank, California (32.5°N).

Habitat. 130-390 m, soft bottoms.

Remarks. This species, which was described originally from Pleistocene material, was reported living at San Pedro by Dall (1921). It is here assigned to *Rhodopetoma*.

Rhodopetoma renaudi is characterized by its relatively small size, mid-whorl carination and noded sculpture on the carination, particularly on the early whorls. It differs from *R. diaulax* in its smaller size, longer canal, and finer periostracum.

Subfamily Crassispirinae Morrison, 1966

Diagnosis. Shell small to medium-sized; canal short, anal sinus on shoulder, parietal callus usually well developed; protoconch paucispiral. Radula with marginal teeth of wishbone type or long flat teeth with accessory limb.

Remarks. Numerous genera occur in tropical, shallow-water habitats. Despite the lack of the parietal callus characteristic of most genera, the following genus is placed in Crassispirinae on characters of the short canal, sinus on shoulder, paucispiral protoconch and long, flat marginal teeth. See definition of subfamily given by Taylor *et al.* (1993:159).

Genus *Pseudotaranis* McLean, 1995

Pseudotaranis McLean, 1995. **Type species** (OD): *Mangelia* (*Taranis*) *strongi* Arnold, 1903. Northeastern Pacific.

Diagnosis. Shell small, spire high, anterior canal short, whorls 6. Axial sculpture lacking, spiral sculpture of 2 cords emerging on teleoconch and 3 cords on base; anal sinus shallow, at periphery and coinciding with uppermost cord; lip not projecting. Protoconch paucispiral, of 1.2 low, rounded whorls. Radula of marginal teeth attached to membrane; teeth of long, flat type.

Remarks. Authors prior to 1971 used *Taranis* Jeffreys, 1870, for the type species, but the presence of a radula precludes placement in that genus (Powell, 1966:55). Earlier (McLean, 1971) I illustrated the radula and assigned it to *Antiplanes* (*Rectisulcus*) [now in Cochlespirinae]. *Pseudotaranis* differs in having the sinus more shallow, the lip less protracted, the canal shorter, and the protoconch lower and more compressed. The radula lacks the vestigial rachidian tooth and the marginals are not of the bifurcated type indicated for *Antiplanes* by Kantor and Sysoev (1991:122).

In addition to the type species, there is one other species in this genus: *Pseudotaranis hyperia* (Dall, 1919), as treated here.

Some specimens of both species may have the periostracum of the base with a light pigmentation, in sharp contrast to the more darkly pigmented periostracum of the spire and upper portion of the body whorl.

Pseudotaranis strongi (Arnold, 1903)

Figure 1.25D

Mangelia (*Taranis*) *strongi* Arnold, 1903:215, pl. 9, fig. 7 [Pleistocene].

Taranis strongi: Dall, 1921:83.—Oldroyd, 1927:151.—Grant and Gale, 1931:572, pl. 26, fig. 37.

Antiplanes (*Rectisulcus*) *strongi*: McLean, 1971:120, fig. 40 [radula].

Pseudotaranis strongi: McLean, 1995:81.

Borsonia inculta Moody, 1916:54, pl. 1, figs. 2a, 2b [Upper Pliocene].

Taranis incultus: Grant and Gale, 1931:572.

Material Examined. Not represented in the Santa Maria voucher collection. Other material examined: 45 lots in the LACM collection.

Description. Shell small, spire elevated; anterior canal short; whorls 6, shoulder concave; spiral sculpture of 2 projecting cords per whorl, 2 defining base and 3 fine cords on canal; axial sculpture of fine growth lines; sinus shallow, centered on uppermost cord; lip not greatly produced. Protoconch paucispiral of 1.2 low, rounded whorls. Periostracum dark brown, often light colored on base; shell cream colored. Radula as described for genus. Length 12-15 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 162549. *Borsonia inculta*: Upper Pliocene, Fourth and Broadway, Los Angeles; holotype: UCMP: 11091.

Distribution. Biorka Island, Alaska [LACM 87-361.2] (56.0°N), to Islas San Benito, Baja California [LACM 41-51] (28°N).

Habitat. Soft bottoms, 100-400 m.

Remarks. This species is characterized by its strongly projecting spiral cords. Most specimens have the apex deeply eroded. The shell varies in breadth and strength of the spiral cords.

Pseudotaranis hyperia (Dall, 1919)

Figure 1.25E

Antiplanes hyperia Dall, 1919:35, pl. 9, fig. 6.—Oldroyd, 1927:87, pl. 3, fig. 2.

Pseudotaranis hyperia: McLean, 1995:81.

Material Examined. California: Santa Maria Basin, Phase I, sta. 53, 196 m (1). Other material: 14 lots in the LACM collection.

Description. Shell small, spire elevated; anterior canal short, whorls 5; spiral sculpture of 2 low cords per whorl, 2 defining base and about 5 low cords on canal; axial sculpture of fine growth lines; sinus shallow, centered on uppermost cord; lip not greatly produced. Protoconch eroded in material on hand. Periostracum olive green, often light colored on base; shell cream colored. Length 12-17 mm.

Type Locality and Type Specimens. Drakes Bay, Marin County, California, 30 fathoms. Holotype: USNM 212330.

Distribution. Fort Bragg, Mendocino County [LACM 71-138] (39.5°N), to Cortes Bank, California [LACM 41-123] (32.5°N).

Habitat. Soft bottoms, 130-270 m.

Remarks. This species has not previously been discussed; references to the name have been checklist entries that repeated Dall (1921).

Pseudotaranis hyperia is more slender and with spiral cords more subdued than *P. strongi*. The fact that it has a more restricted distribution than that of *P. strongi* provides an argument in support of separation at the species level. The two species are also separated bathymetrically; *P. incultus* occurs in lesser depths where distributions of the two species overlap.

Family Conidae Fleming, 1822

Diagnosis. Shell coniform or turriform. Odontophore lacking, radular membrane lacking; radula of hollow marginal teeth only; venom gland present.

Biology. The coniform and turriform snails grouped here are capable of injecting venom into their prey through hollow teeth that are used one at a time like hypodermic needles. There are exceptions, as some have lost the radula [for example the subfamily Taraninae].

Remarks. Taylor *et al.* (1993:160) placed all turriform groups having the hollow marginal teeth ("the higher turrids" of previous authors) into a family that also includes the Conidae of previous classifications. Subfamilies recognized in the newly defined Conidae are Clathurellinae, Conorbinae, Coninae, Oenopotinae, Mangeliinae, Daphnellinae and Taraniinae.

Subfamily Clathurellinae H. and A. Adams, 1858

Diagnosis. Shell turriform, sculpture primarily spiral. Radula with awl or harpoon-shaped marginal teeth, the tooth cavity opening terminally at the proximal end.

Remarks. Taylor *et al.* (1993:160) included in this loosely defined subfamily three turriform groups treated as subfamilies by McLean (1971): Borsoniinae, Mitrolumninae, and Clathurellinae, instead recognizing less formal groups: the bathytomid, borsoniid, clathurellid, mitromorphid, and tomopleurid groups. A more meaningful classification awaits knowledge of anatomy of more genera.

Genus *Borsonella* Dall, 1908

Borsonella Dall, 1908. **Type species** (OD): *Pleurotoma* (*Borsonia*) *dalli* Arnold, 1903; not *Pleurotoma dalli* Verrill and Smith, 1882; = *Borsonella omphale* Dall, 1919.

Diagnosis. Shell size small to medium (length 12-30 mm), sinus on shoulder, columella with broad shield and strong to weak plication; sculpture spiral, with axial ribs or nodes; shell surface with adherent glossy brown periostracum; minute sculpture of vermicular markings in oblique rows. Protoconch paucispiral. Operculum lacking. Radular teeth of slender, simple marginals with expanded bases.

Remarks. *Borsonella* species may be distinguished from other turriform genera by the minute, oblique, vermicular pattern of sculpture, which has been mentioned in most species-level descriptions, but until now has not been emphasized as a generic character. The broad columellar shield is also characteristic. The strength of the columellar plait may depend on the viewing angle; if the shell is rotated to look deeper within, the plait will appear stronger. Radular teeth of *Borsonella* species were figured by Powell (1966:60, text figs. E114-117).

The type species of *Borsonella* was misidentified by Powell (1966:60, pl. 8, fig. 14), an error that traces back to Dall (1908:258, pl. 13, fig. 9), who misidentified Arnold's (1903) species *B. dalli*. Moreover, as indicated above, Arnold's name is preoccupied, but the actual type of *B. dalli* (USNM 162534) is a good match for the specimen of *B. omphale* Dall, as illustrated here. Dall's illustration of *B. dalli* is here identified as *B. coronadoi* (Dall, 1908).

The species of *Borsonella* are well represented in southern California but have been poorly known and neglected in recent literature, with only one figured by Abbott (1974). The LACM collection contains numerous lots, which has enabled the following review of the six species occurring in depths between 100 and 400 m in southern California. There are other species from greater depths that are not treated here. Four of the following were first named from Pleistocene material by Arnold (1903) and again named from living material by Dall, who did not realize the extent to which the Pleistocene species described by Arnold would likely be still living. Grant and Gale (1931) placed many names in synonymy but did not illustrate them. Each species exhibits a range of variation that has made species resolutions difficult. Species are arranged here in decreasing order of abundance in the LACM collection.

Borsonella bartschi (Arnold, 1903)

Figure 1.26A

Pleurotoma (*Borsonia*) *bartschi* Arnold, 1903: 200, pl. 9, f. 1

Borsonia bartschi: Grant and Gale, 1931:545, pl. 26, figs. 27, 28.

Borsonella bartschi: Oldroyd, 1927:93.—Abbott, 1974:268 [listed].

Borsonella civitella Dall, 1919:302 [unfigured].—Oldroyd, 1927:94.—Abbott, 1974:268 [listed].

Borsonella nicoli Dall, 1919:39, pl. 12, fig. 1.—Oldroyd, 1927:95.—Abbott, 1974:268 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 45 LACM lots.

Description. Shell slender, shoulder concave, axial sculpture of about 10 elongate, oblique nodes, projecting at periphery; oblique vermiform sculpture apparent under magnification; profile of spire convex from whorl to whorl; columellar plait strong to moderately developed. Length 18-23 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 162535. *Borsonella civitella*: off Point Loma, San Diego County, California, 71-75 fathoms; lectotype **(here designated)**: USNM 209034. *Borsonella nicoli*: SW of San Nicolas Island, California, 158 fathoms; holotype: USNM 198925.

Distribution. San Miguel Island (34°N) to San Diego, California (32.5°N).

Habitat. 140-260 m, soft bottoms.

Remarks. *Borsonella bartschi* is recognized by its persistent axial nodes and moderately slender profile with the spire profile convex from whorl-to-whorl. No justification for the proposal of the synonyms *B. civitella* and *B. nicoli* was given by Dall; holotypes of both are well within the variation exhibited by this species.

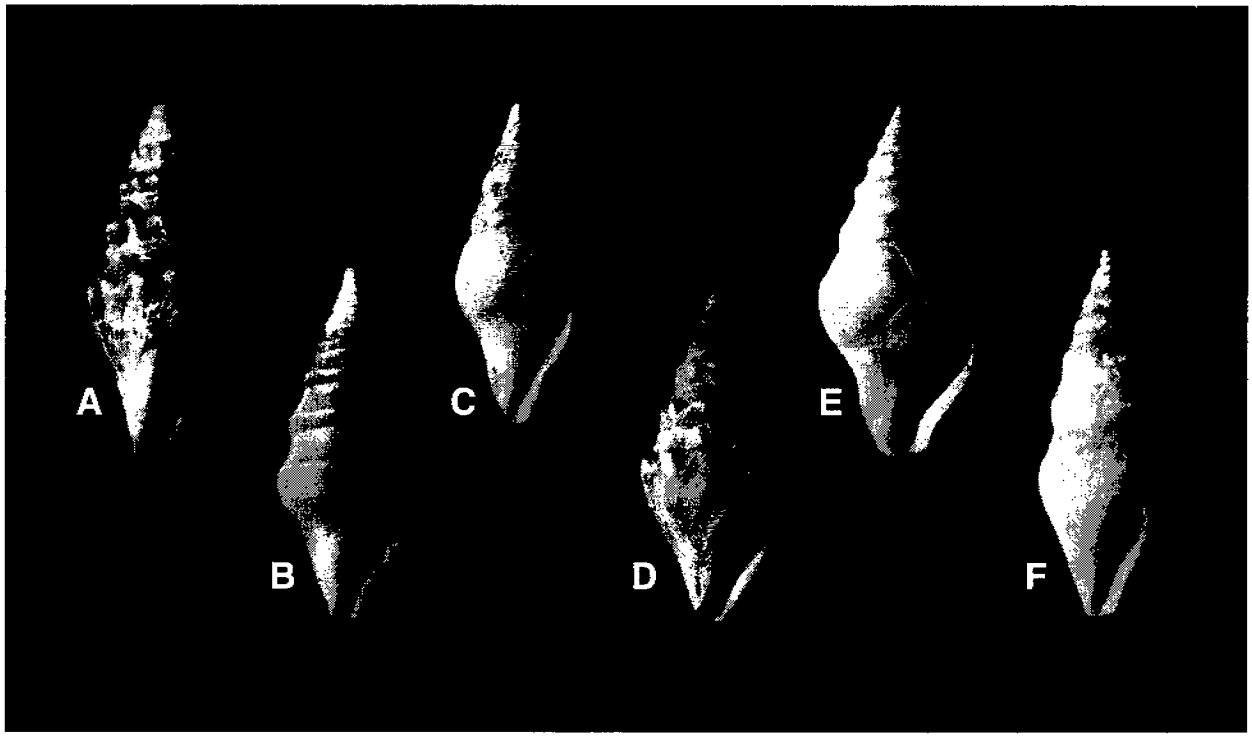


Figure 1.26. Conidae. **A.** *Borsonella bartschi* (Arnold, 1903): 214-234 m, SE of Santa Catalina Island, California (LACM 40-125.11); height 21.0 mm. **B.** *Borsonella coronadoi* (Dall, 1908): 229-240 m, Cortes Bank, California (LACM 41-114.3); height 22.0 mm. **C.** *Borsonella omphale* Dall, 1919: 274-311 m, off Pyramid Cove, San Clemente Island, California (LACM 39-126.3); height 19.8 mm. **D.** *Borsonella merriami* (Arnold, 1903): 104 m, S of Santa Rosa Island, California (LACM 41-172.12); height 18.1 mm. **E.** *Borsonella hooveri* (Arnold, 1903): 511-530 m, NW of Tanner Bank, California (LACM 77-250.24); height 21.1 mm. **F.** *Borsonella pinosensis* Bartsch, 1944: 119-165 m, off Emerald Bay, Santa Catalina Island, California (LACM 39-5.7); height 24.8 mm.

Borsonella coronadoi (Dall, 1908)

Figure 1.26B

Borsonia (*Borsonella*) *coronadoi* Dall, 1908: 277, pl. 14, f. 2.

Borsonella coronadoi: Oldroyd, 1927:91.—Abbott, 1974:268 [listed].

Borsonella nychia Dall, 1919: 38, pl. 12, f. 2.—Oldroyd, 1927:94.—Abbott, 1974:268 [listed].

Borsonia nychia: Grant and Gale, 1931:546.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 42 LACM lots

Description. Shell slender to moderately broad, shoulder concave; axial sculpture of faint nodes on peripheral cord of early whorls, obsolete on final whorl; peripheral cord on spire strongly projecting on lower third of whorl, but higher on penultimate and final whorl. Oblique vermiform striae well marked. Collumellar plait well developed. Length 17-22 mm.

Type Locality and Type Specimens. Islas Coronados, Baja California, 34 fathoms; holotype: USNM 110608. *Borsonella nychia*: Off Point Loma, San Diego County, California, 101 fathoms; lectotype **(here designated)**: USNM 208891.

Distribution. San Miguel Island (34°N), California, to Islas Coronados, Baja California (32.5°N).

Habitat. 90-300 m, soft bottoms.

Remarks. This is another abundant member of the genus in southern California. It is characterized by a concave shoulder, weak nodes on early whorls, a strong peripheral carination and a strong columellar plication. Broad and slender forms are known; these forms would be considered separate species were it not for the fact that most specimens are of moderate width. The slender form was described as *Borsonia* (*Borsonella*) *coronadoi*. Dall (1908, pl. 16, fig. 9) illustrated the relatively broad typical form of this species, incorrectly identified as *Borsonia* (*Borsonella*) *dalli* Arnold, 1903, a preoccupied name that is here synonymized with *Borsonella omphale*.

Borsonella omphale Dall, 1919

Figure 1.26C

Pleurotoma (*Borsonia*) *dalli* Arnold, 1903: 201, pl. 6, f. 2 [not *Pleurotoma dalli* Verrill and Smith, 1882].

Borsonia (*Borsonella*) *dalli*: Dall, 1908: 275 [not pl. 13, fig. 9].

Borsonella dalli: Oldroyd, 1927:91 [not. pl. 6, fig. 8, copy Dall, 1908].

Borsonella omphale Dall, 1919: 38, pl. 12, f. 4.—Oldroyd, 1927:90, pl. 19, fig. 6.—Abbott, 1974:268.

Spirotropis (*Borsonella*) *omphale*: Grant and Gale, 1931:552.

Borsonella angelena Hanna, 1924:158 [new name for *Pleurotoma dalli* Arnold, 1903].—Abbott, 1974:268.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 10 LACM lots.

Description. Shell of medium profile, whorls rounded, shoulder area flat or only weakly concave; spiral sculpture of weak peripheral angulation, low on whorl and best developed in early whorls; axial sculpture of low projections on peripheral angulation, best developed on early whorls. Oblique vermiform striae present. Columellar plait weakly developed, visible if shell is rotated. Length 16-21 mm.

Type Locality and Type Specimens. *Borsonella dalli*: San Pedro, California, Pleistocene; holotype: USNM 162534. *Borsonella omphale*: Off Point Loma, San Diego County, California, 78 fathoms. Holotype: USNM 209174.

Distribution. Drakes Bay, Marin County [USNM 212324] (38°N) to San Clemente Island, California (33°N).

Habitat. 100-200 m, soft bottoms.

Remarks. This species is characterized by its lack of a strongly concave shoulder, its tall spire, slender profile and minimal spiral and axial sculpture, compared to other species of *Borsonella*.

As noted above, Arnold's original name for this species is preoccupied. Hanna (1924) provided a replacement name, but that was not needed, because Dall's (1919) name *Borsonella omphale* is a synonym that takes precedence.

This species is the type species of *Borsonella*. Although previous authors have misidentified the type species, the concept of the genus does not change.

Borsonella merriami (Arnold, 1903)

Figure 1.26D

Drillia merriami Arnold, 1903: 207, pl. 8, f. 7.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 8 LACM lots.

Description. Shell relatively broad; shoulder markedly concave; axial sculpture of about 10 vertically oriented nodes projecting at periphery and persisting at all growth stages. Profile from whorl to whorl straight. Columellar plait weakly developed, visible if shell is rotated. Length 16-27 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 162536 [not USNM 561571, which also is labeled "type"].

Distribution. Santa Rosa Island (34°N) to San Clemente Island, California (32.5°N).

Habitat. 70-290 m, soft bottoms.

Remarks. This is another species described by Arnold (1903) from the Pleistocene of San Pedro that is here reported to occur in the living fauna.

This species is characterized by its broad profile that is straight from whorl to whorl, prominent axial nodes that may be elongate without being oblique, and weak development of the columellar plait in mature shells.

Borsonella merriami differs from *B. bartschi* in its broader profile. The spire profile from whorl to whorl is straight rather than convex. Although mature specimens have a poorly developed plait, the plait is evident on immature specimens.

Borsonella hooveri (Arnold, 1903)

Figure 1.26E

Pleurotoma (*Borsonia*) *hooveri* Arnold, 1903: 201, pl. 10, f. 1

Spirotropis (*Borsonella*) *hooveri*: Grant and Gale, 1931:550.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 5 LACM lots.

Description. Shell profile broad, aperture large, nearly half length of shell; shoulder area straight to convex; spiral sculpture of peripheral angulation on lower third of whorl, becoming faint in mature specimens; axial sculpture of weak nodes on peripheral angulation of early whorls. Oblique vermiform sculpture present. Columellar plait of moderate strength, visible if shell is rotated. Length 15-21 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: USNM 162533.

Distribution. Santa Catalina Island (33.5°N) to Cortes Bank, California (32.5°N).

Habitat. 150-500 m, soft bottoms.

Remarks. This species was described from Pleistocene material but is here recognized in the living fauna. It is a rare species characteristic of depths greater than those of the other species treated here.

Borsonella hooveri is characterized by its relatively long aperture (nearly half the length of the shell), inflated whorls and lack of a concave shoulder area; mature specimens may have a peripheral carination, but the shoulder area is flat and the carination is higher on the whorl than that of *B. coronadoi*.

The Pleistocene type specimen of *Borsonella hooveri* is not fully grown; it measures 12.8 mm in height.

Borsonella pinosensis Bartsch, 1944

Figure 1.26F

Borsonella pinosensis Bartsch, 1944:63 [unfigured].—Abbott, 1974:268 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 5 LACM lots.

Description. Shell slender, tall-spired, whorls weakly rounded, shoulder with narrow constriction centered on upper third of whorl; periphery rounded; axial sculpture of vertical nodes on early whorls, becoming obsolete on final whorl; sinus on shoulder, moderately deep. Oblique vermiform striae present. Columellar plait weakly developed, visible if shell is rotated. Length 21-27 mm.

Type Locality and Type Specimens. Off Point Piños, Monterey County, California, 49-50 fathoms. Holotype: USNM 210634.

Distribution. Point Piños, Monterey County (36.5°N), to Santa Catalina Island, California (33.5°N).

Habitat. 90-300 m, soft bottoms.

Remarks. This species is figured for the first time and the distribution is extended from the type locality. It most closely resembles *Borsonella omphale*, from which it differs in its greater length, more slender profile and having the constriction on the uppermost third of the whorl. This species as well as *B. omphale* are the only members of *Borsonella* known to occur off central California as well as southern California.

Genus *Ophiodermella* Bartsch, 1944

Ophiodermella Bartsch, 1944. **Type species** (OD): *Pleurotoma inermis* Reeve, 1843. Northeastern Pacific.

Diagnosis. Shell fusiform, whorls rounded, suture moderately impressed; axial and spiral sculpture equally developed, producing square cancellations with beads at intersections; sinus on shoulder, moderately deep, U-shaped, its position marked by sinuous axial ribs; lip protracted below sinus; canal long; protoconch paucispiral, of 1.5 separated and rounded whorls.

Biology. Shimek (1983) studied the biology of *Ophiodermella inermis* and *O. cancellata*. Both species feed exclusively on different species of owenid polychaetes. The paucispiral protoconch is indicative of direct development, although Shimek (1983:306) reported that the late veliger stage is mobile and feeds actively for up to five weeks.

Remarks. Three species are known in the northeastern Pacific and each is treated here.

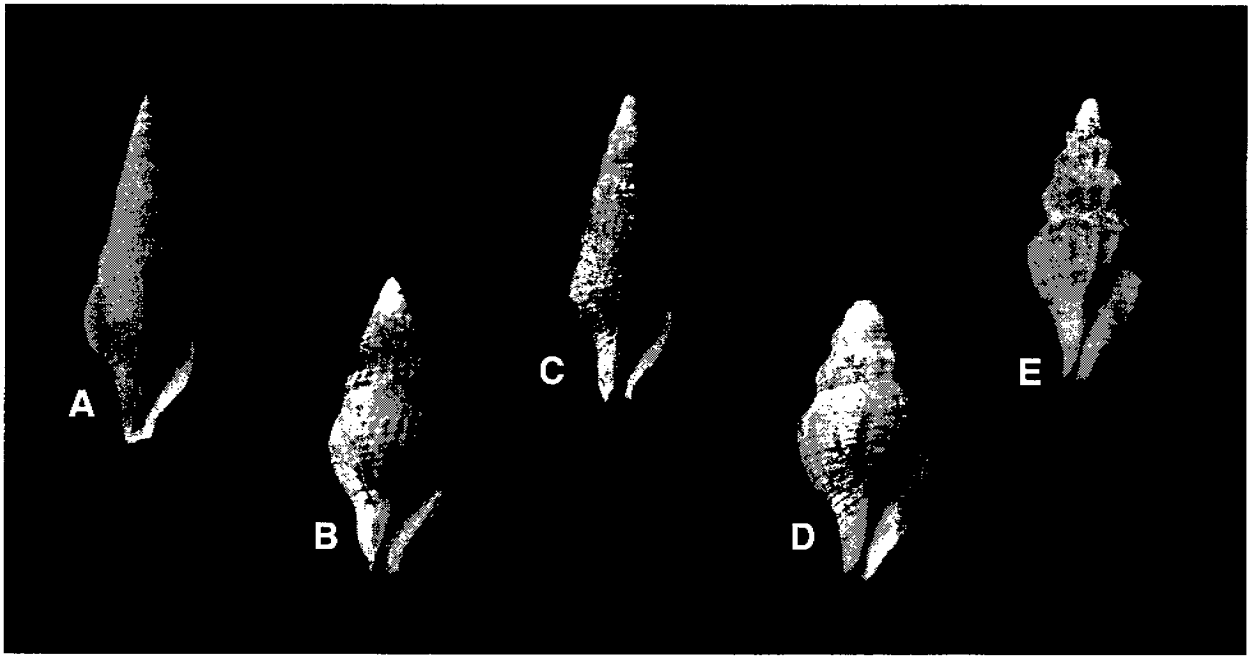


Figure 1.27. Conidae. **A.** *Ophiodermella inermis* (Reeve, 1843): 18 m, off San Diego, California (USNM 110644, holotype of *halcyonis*); height 23 mm. **B.** *Ophiodermella cancellata* (Carpenter, 1864): 198-199 m, off Long Point, Santa Catalina Island, California (LACM 41-164.21); height 8.5 mm. **C.** *Ophiodermella fancherae* (Dall, 1903): 86-95 m, NW of Anacapa Island, California (LACM 41-47.17); height 10.0 mm. **D.** *Kurtzina beta* (Dall, 1919): 102 m, off Point Año Nuevo, San Mateo County, California (USNM 206554, holotype); height 5.0 mm. **E.** *Kurtzia arteaga* (Dall and Bartsch, 1910): 22-27 m, off Point Loma, San Diego County, California (USNM 150993, holotype of var. *roperi*); height 6.5 mm.

Ophiodermella inermis (Reeve, 1843)

Figure 1.27A

Pleurotoma inermis Reeve, 1843 [1843-44], pl. 8, fig. 64.—Keen, 1966:271, pl. 47, fig. 9 [holotype].

Ophiodermella inermis: Shimek, 1983:281, fig. 1A.

Drillia incisa Carpenter, 1864:657.—Palmer, 1958:226.

Moniliopsis incisa: Dall, 1919:28, pl. 12, fig. 7.

Surcula ophioderma Dall, 1908: 247 [unnecessary new name for *Pleurotoma inermis* Reeve].

Moniliopsis incisa var. *ophioderma*: Grant and Gale, 1931:566.

Ophiodermella ophioderma: McLean, 1978:54, fig. 30.2

Turris (*Surcula*) *halcyonis* Dall, 1908: 248.—Dall, 1919:28, pl. 8, fig. 1.

Ophiodermella montereyensis Bartsch, 1944:62 [unfigured].

Material Examined. Not represented in the voucher collection. Other material: 197 lots in the LACM collection.

Description. Shell large, whorls 8, nearly flat-sided on first 4 whorls, weakly rounded on later whorls; axial and spiral sculpture strong on immature specimens, becoming faint on mature specimens; protoconch of 1.5 separated and rounded whorls; shell light brown with axial flamules of brown under brown periostracum. Length 25-40 mm.

Type Locality and Type Specimens. Bahía Magdalena, Baja California Sur, Mexico. Holotype: NHML 79.2.26.98 *Drillia incisa*: Neah Bay, Clallam County, Washington; lectotype (here selected): USNM 12630. *Turris halcyonis*: Coronado Beach, San Diego County, California, 10 fathoms; holotype USNM 110644. *Ophiodermella montereyensis*: Monterey Bay, California, 13 fathoms; holotype: USNM 214251.

Distribution. Skidegate, Queen Charlotte Islands, British Columbia [LACM 73-78] (53°N) to Rancho Inocentes, Baja California Sur [LACM 71-19] (24.5°N).

Habitat. Soft bottoms, intertidal to 70 m.

Remarks. Although usually credited to Hinds, Keen (1966:271) showed that the name of the type species *inermis* was first published by Reeve. Dall's replacement name *Surcula ophioderma* was unnecessary because "*Drillia inermis* Partsch, 1843" was not a published name, as shown by Cernohorsky (1975:318).

Some authors have treated the northern form named *incisa* as a species distinct from the more southern *Ophiodermella inermis*, but there is no justification for doing so, even at the subspecific level.

The name *Turris halcyonis* Dall, is based on more slender offshore forms. Small specimens of *Ophiodermella inermis* are brown, thereby differing from *O. cancellata* and *O. fancherae*. Specimens occurring in the intertidal zone tend to be large and may have worn sculpture, whereas those from deeper water are more slender and more crisply sculptured.

Ophiodermella cancellata (Carpenter, 1864)

Figure 1.27B

Drillia cancellata Carpenter, 1864: 658 [unfigured].

Ophiodermella cancellata. Shimek, 1983:281, fig. 2C.

Pleurotoma vancouverensis E. A. Smith, 1880: 286 [unfigured].

Surcula rhines Dall, 1908: 248 [unnecessary new name for *Drillia cancellata*].

Moniliopsis rhines: Dall, 1919:28, pl. 8, fig. 5

Moniliopsis chacei Berry, 1941:6, pl. 1, f. 2.

Material Examined. Not represented in the voucher collection from Santa Maria Basin. Other material: 30 lots in the LACM collection.

Description. Shell small, whorls 6, rounded, axial and spiral sculpture producing coarse clathrate pattern; protoconch of 1.5 separated and rounded whorls; shell white under thin, nearly transparent periostracum. Length 11-12 mm.

Type Locality and Type Specimens. Puget Sound, Washington. Type material not located by Palmer (1958:226). *Pleurotoma vancouverensis*: Vancouver Island, British Columbia; syntypes: NHML: 1880.6.23.9-10. *Moniliopsis chacei*: Middle Pleistocene, Lomita Marl, Hilltop Quarry, San Pedro, California; holotype: SBMNH 34515.

Distribution. Kachemak Bay, Alaska [LACM 57-11.44] (59.5°N), to Tanner Bank, California [LACM 76-313] (32.5°N).

Habitat. Sandy bottoms, 50-500 m. Specimens from southern California are recorded from depths below 200 m.

Remarks. This species is characterize by its small size, inflated whorls and coarse cancellate sculpture. Palmer (1958:225) showed that Dall's replacement name *Surcula rhines* was unnecessary, although his illustration (Dall, 1919) was a good representation of a typical specimen.

Ophiodermella fancherae (Dall, 1903)

Figure 1.27C

Mangilia fancherae Dall, 1903:172.

Moniliopsis fancherae: Dall, 1919:28, pl. 8, fig. 3

Moniliopsis incisa var. *fancherae*: Grant and Gale, 1931:567.

Ophiodermella fancherae: Skoglund, 1994:127, fig. 1.

Material Examined. Santa Maria Basin, Phase II, sta. R-4, 92 m (2). Other material: 68 lots in the LACM collection.

Description. Shell small, whorls 6, nearly flat-sided; early whorls with peripheral carination; spiral cord of shoulder weak; mature sculpture finely clathrate, protoconch of 1.5 separated and rounded whorls; shell white to tan under light brown periostracum. Length 8-17 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, 50 fathoms. Lectotype (here selected): USNM 109303.

Distribution. Off Point Piños, Monterey California [LACM 59-98] (36.5°N), to Bahía San Bartolomé, Baja California Sur [LACM 40-2] (27°N); also known in the Gulf of California (Skoglund, 1994:127).

Habitat. Soft bottoms, 50-200 m.

Remarks. This species is also small but much more slender than *Ophiodermella cancellata*. Confusion in the literature is due to Dall's later figure said to be *Moniliopsis fancherae* (1921, pl. 6, fig. 3), which does not agree with the holotype and is evidently based on a specimen of *O. cancellata* (Carpenter, 1864). Specimens of *O. fancherae* can be separated from immature examples of the more slender offshore form of *O. inermis* in being more slender and lighter in color than *O. inermis*. The specimen from the Gulf of California figured by Skoglund (1994, fig. 1) is the largest known specimen at 17.7 mm in length.

Subfamily Mangeliinae Fischer, 1884

Diagnosis. Shell small, fusiform, anterior canal short; axial and spiral sculpture well developed; anal sinus on shoulder; outer lip usually swollen, sometimes denticulate, operculum lacking. Marginal teeth of radula hollow, with solid base, some with semi-enrolled shaft; tooth canal open laterally.

Remarks. Most have elaborate multispiral protoconchs, indicative of planktotrophic veligers. Generic descriptions emphasize differing kinds of protoconch sculpture.

Genus *Kurtzina* Bartsch, 1944

Kurtzina Bartsch, 1944. **Type species** (OD): *Mangelia* (*Kurtziella*) *beta* Dall, 1919. California.

Diagnosis. Shell small, with spiral and axial sculpture and midwhorl carination; sinus shallow, not bordered with callus; lip not thickened. Protoconch relatively large, whorls 3, tip immersed, second protoconch whorl smooth, third with cancellate sculpture with beaded intersections.

Remarks. There are two species, the type species and *Kurtzina cyrene* (Dall, 1919) in the Panamic province (see McLean *in* Keen, 1971:749).

Kurtzina beta (Dall, 1919)

Figure 1.27D

Mangilia (*Kurtziella*) *beta* Dall, 1919: 64, pl. 22, fig. 4

Mangilia beta: Oldroyd, 1927:135.

Kurtziella (*Kurtzina*) *beta*: McLean *in* Keen, 1971, fig. 1792.

Material Examined. California: Santa Maria Basin, Phase I, sta. 22, 99 m (1); sta. 52, 98 m (1); Phase II, sta. R-8, 90 m (12). Other material: 127 lots in the LACM collection.

Description. Whorls 4, spiral cords even, with nearly equal interspaces; spiral cords numerous on shoulder, microscopically beaded, producing an overall frosted effect. Length: 5 mm.

Type Locality and Type Specimens. Off Point Año Nuevo, San Mateo County, California, 56 fathoms. Lectotype (here selected): USNM 206554.

Distribution. Point Año Nuevo, San Mateo County, California (37°N), to Isla La Plata, Ecuador [LACM 34-317] (1°S).

Habitat. Soft bottoms, 20-150 m.

Remarks. This species is common throughout its range.

Genus *Kurtzia* Bartsch, 1944

Kurtzia Bartsch, 1944. **Type species** (OD): *Mangelia arteaga* Dall and Bartsch, 1910. California.

Diagnosis. Shell small, with axial and spiral sculpture and midwhorl carination; sinus well marked, lip thickened. Protoconch of three whorls, tip immersed, second whorl smooth, third with cancellate sculpture; axial ribs of protoconch more numerous than those of teleoconch.

Remarks. This genus resembles *Kurtzina*, except that the lip is thickened and the anal sinus is also well defined. The multiwhorled protoconch is indicative of development with a planktotrophic veliger stage.

Kurtzia arteaga (Dall and Bartsch, 1910)

Figure 1.27E

"*Mangelia sculpturata* (Dall, 1887)."—*of* Arnold, 1903: 214, pl. 6, fig. 17.

Mangelia arteaga Dall and Bartsch, 1910: 11, pl. 2, fig. 4.—Oldroyd, 1927:140.

Kurtzia arteaga: McLean *in* Keen, 1971:754, fig. 1810.

Mangelia (*Kurtziella*) *arteaga roperi* Dall, 1919 :64, pl. 22, fig. 5.—Oldroyd, 1927:140.

Kurtzia gordoni Bartsch, 1944:65 [unfigured].

Material Examined. California: Santa Maria Basin, Phase I, sta. 22, 99 m (1); sta. 73, 98 m (1); Phase II, sta. R-4, 92 m (3); sta. PJ-13, 144 m (1). Other material: 174 lots in the LACM collection.

Description. Shell small, elongate with long anterior canal. Aperture length less than half length of shell, outer lip thickened, posterior notch broad, shallow. Suture deeply impressed. Protoconch of 1.5 smooth whorls, protoconch II with 2 spiral threads and curved axial ribs. Mature sculpture of strong peripheral carination and less prominent spiral cord; base with numerous spiral cords; strong axial ribs extend from suture to suture and across base; fine axial and spiral striae produce a frosted surface throughout teleoconch. Length 7-10 mm.

Type Locality and Type Specimens. Barkley Sound, Vancouver Island, British Columbia, 8-34 fathoms. Lectotype (**here selected**): USNM 211605. *Mangelia arteaga roperi*: Off Pt. Loma, San Diego County, California; 12-15 fathoms; holotype: USNM 150993. *Kurtzia gordoni*: Off Santa Cruz, California, 43-46 fathoms; holotype: USNM 331115.

Distribution. Vancouver Island, British Columbia (49°N), throughout the Gulf of California and south to the Gulf of Tehuantepec, Mexico (15°N).

Habitat. Common on soft bottoms, 20-90 m. Nothing is known about the feeding biology of this species.

Remarks. This is the type species of the genus. None of the synonyms are worthy of recognition as geographic subspecies and none have come into general usage.

Genus *Crockerella* Hertlein and Strong, 1951

Crockerella Hertlein and Strong, 1951. **Type species** (OD): *Clathurella crystallina* Gabb, 1865. California.

Diagnosis. Shell small (7-13 mm), white under thin periostracum; microscopic sculpture throughout of extremely minute pustules; anterior and posterior canals deeply notched and bordered with callus; outer lip thickened but smooth within; sculpture both axial and spiral; protoconch paucispiral, projecting and elongate, with deep suture, of 1.5-2 whorls, smooth except last half whorl with a faint carination. Radula of long, slender marginals without barbs, tooth bases expanded.

Biology. The paucispiral protoconch is indicative of direct development or at least a very short planktonic stage, unlike such related genera as *Clathurella* and *Glyphostoma*, which have multispiral protoconchs indicative of planktotrophic development. The radula was illustrated by Powell (1966:109, fig. E143).

Remarks. This genus may be distinguished from all others treated here by its deep anal sinus with raised borders. The genus is speciose in the offshore waters of southern California, but like *Borsonella* has been neglected and poorly understood. Most of the species described by Dall were figured but the illustrations were not copied by Oldroyd (1927) and Abbott (1974). To my knowledge, the extremely microscopic pustular sculpture is noticed here for the first time.

As is the case with *Borsonella*, the type species (*Clathurella crystallina* Gabb) of *Crockerella* has been misidentified, owing to the fact that Gabb's holotype has never been figured. The specimen illustrated by Dall (1919, 1921), and by Abbott (1974), is here identified as *Crockerella lowei* (Dall), a name that Dall had dismissed as a synonym of *Clathurella crystallina*. The genus *Crockerella* has previously been used in the literature only for the species *crystallina*. Despite this misuse of the name, the concept of the genus does not change. Nine species are treated here; all but one of the names are allocated to *Crockerella* for the first time.

Species are arranged here in decreasing order of abundance in the LACM collection. The diagnoses do not repeat the generic characters of the large siphonal notch and anal sinus, and the microscopic pustular sculpture.

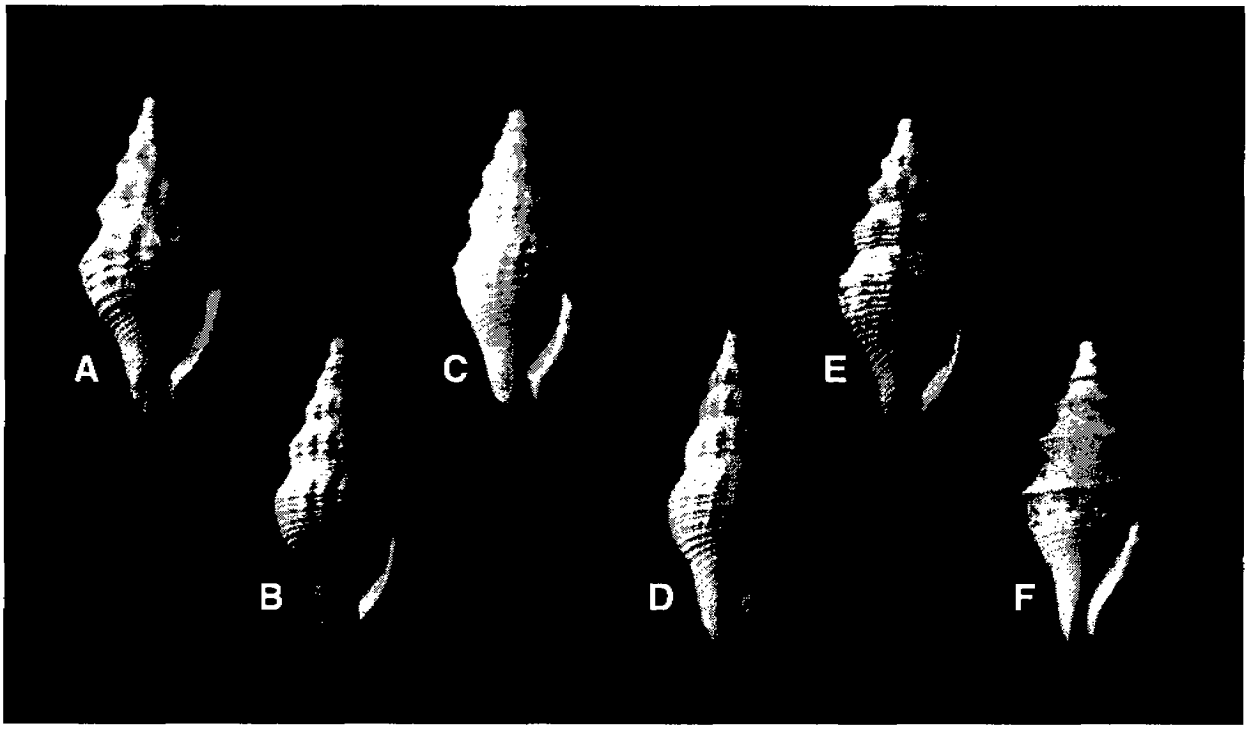


Figure 1.28. Conidae. **A.** *Crockerella lowei* (Dall, 1903): 95 m, S of East Point, Santa Rosa Island, California (LACM 41-326.5); height 9.9 mm. **B.** *Crockerella lowei* (Dall, 1903): 96 m, off San Miguel Island, California (LACM 75-412.2); height 9.2 mm. **C.** *Crockerella crystallina* (Gabb, 1865): 101 m, E of Santa Rosa Island, California (LACM 41-327.6); height 8.6 mm. **D.** *Crockerella eriphyle* (Dall, 1919): 247-256 m, SW of Balboa, Orange County, California (LACM 41-6.3); height 11.8 mm. **E.** *Crockerella tridesmia* (Berry, 1941): 196 m, E of Long Point, Santa Catalina Island, California (LACM 41-146.6); height 10.2 mm. **F.** *Crockerella evadne* (Dall, 1919): 91 m, off Redondo Beach, Los Angeles County, California (LACM 17351); height 9.0 mm.

Crockerella lowei (Dall, 1903)

Figures 1.28A,B

Clathurella lowei Dall, 1903:172 [unfigured].

"Philbertia crystallina (Gabb, 1865)."—*of* Dall, 1919:62, pl. 13, fig. 1.—Dall, 1921:79, pl. 6, fig. 4.—Oldroyd, 1927, pl. 3, fig. 5.

"*Clathurella crystallina* Gabb, 1865."—*of* Abbott, 1974:283, fig. 3294.

Philbertia hesione Dall, 1919:54 [unfigured].—Oldroyd, 1927:130.

Glyphostoma hesione: Abbott, 1974:283 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 27 LACM lots.

Description. Shell profile broad, whorls 4; shoulder broad, smooth, flat to somewhat concave; axial ribs projecting at periphery and usually extending toward base; spiral cords narrow, overriding axial ribs; base with numerous spiral cords. Length 9-12 mm.

Type Locality and Type Specimens. Off Avalon, Santa Catalina Island, California [from label]. Holotype: USNM 109302. *Philbertia hesione*: off Santa Rosa Island, California, 53 fathoms; holotype: USNM 211333.

Distribution. San Miguel Island (34°N) to San Clemente Island, California (33°N).

Habitat. 80-250 m, soft bottoms.

Remarks. This species is characterized by its relatively broad profile, broad shoulder, prominent axial ribs and angulate periphery. Shortly after the description of *Clathurella lowei*, Dall dismissed it as a synonym of *C. crystallina* Gabb, the type of which had not been figured. Dall (1919, 1921) figured this species under the name *C. crystallina*. Now there is need for a name for a species that is larger and of broader profile than *C. crystallina*, and the name *Crockerella lowei* is here resurrected from synonymy, taking precedence over the unfigured *Philbertia hesione* Dall, a later synonym.

There is extensive variation in the strength and spacing of the axial ribs and spiral cords, as shown by the two extremes of sculpture illustrated here. The shell, however, retains a relatively broad profile and a peripheral carination and does not exhibit the fine clathrate sculpture of *Crockerella crystallina*.

Crockerella crystallina (Gabb, 1865)

Figures 1.28C

Clathurella crystallina Gabb, 1865:184.—Grant and Gale, 1931:607.—Abbott, 1974:283 [not fig. 3294].—Coan and Bogan, 1988:278.

Philbertia crystallina: Dall, 1919:62 [not pl. 13, fig. 1].—Dall, 1921:79 [not pl. 6, fig. 4].—Oldroyd, 1927:129[not pl. 3, fig. 5, copy Dall, 1921].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 25 LACM lots.

Description. Shell profile slender, whorls four; shoulder narrow, smooth, slightly concave; axial ribs numerous, oblique, low, narrow, not extending across base; spiral cords three at periphery and visible on early whorls, the middle the most projecting, producing sharp, oblique cancellations with the axial sculpture; base with numerous spiral cords. Length 8-9 mm.

Type Locality and Type Specimens. Santa Catalina Island, California, 40 fathoms. Holotype: UCMP 15959.

Distribution. Santa Rosa Island, California (34°N), to Isla Todos Santos, Baja California (32°N).

Habitat. 50-210 m, soft bottoms.

Remarks. The hallmark of this species is the relatively small size, narrow profile, and clathrate sculpture. Axial ribs are numerous but not thick or strongly projecting.

This is the type species of *Crockerella*, figured here for the first time. Dall's illustrations of 1919 and 1921 and that of Abbott (1974) that purport to be this species represent *C. lowei*. The holotype of *Clathurella crystallina* has not been figured. The specimen illustrated here is very similar to the holotype.

Crockerella eriphyle (Dall, 1919)

Figure 1.28D

Mangilia eriphyle Dall, 1919: 69 [unfigured].—Oldroyd, 1927:136.

Mangelia eriphyle: Abbott, 1974:279 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 14 LACM lots.

Description. Shell profile narrow, whorls 5; shoulder narrow, smooth except for growth increments; whorls rounded at periphery; axial ribs 10-12 per whorl, oblique, extending below level of anal sinus; spiral cords narrow, overriding axial ribs; base with numerous spiral cords. Length 10-12 mm.

Type Locality and Type Specimens. Off Santa Rosa Island, California, 53 fathoms. Lectotype **(here selected)**: USNM 211326.

Distribution. Santa Cruz Island (34°N) to Cortes Bank, California (32.5°N).

Habitat. 80-250 m, soft bottoms.

Remarks. This species is characterized by its slender profile, relatively large size, rounded periphery, and broadly spaced axials. It is more slender than *Crockerella lowei* and does not have the angulate periphery of that species.

Crockerella eriphyle is figured here for the first time. The lectotype shell (the largest in the original lot) is not illustrated here because the shell is broken in front.

Crockerella tridesmia (Berry, 1941)

Figure 1.28E

Clathurella (*Glyphostoma*) *tridesmia* Berry, 1941:8, pl. 1, f. 3.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 13 LACM lots.

Description. Shell profile moderately broad, whorls 4; periphery angulate; shoulder broad, appearing smooth, but bearing numerous sharply incised spiral striae; axial ribs broad; spiral sculpture of broad cords below shoulder and on base, separated by deeply incised grooves of lesser width. Length 9-11 mm.

Type Locality and Type Specimens. San Pedro, Los Angeles County, California, Pleistocene. Holotype: SBMNH 34518.

Distribution. Santa Rosa Island (34°N) to Cortes Bank, California (32.5°N).

Habitat. 100-500 m, soft bottoms.

Remarks. This species is characterized by its broad shoulder, smooth except for well-marked, incised striae, and the more prominent spiral sculpture of the body whorl and base, which is separated by deep spiral grooves. No other species has the spiral cords separated by such deep grooves.

Described from Pleistocene deposits, but here recognized in the living fauna. This is a species characteristic of greater depths (300-500 m) than those recorded for other species of *Crockerella*.

Crockerella evadne (Dall, 1919)

Figure 1.28F

Mangilia evadne Dall, 1919: 69, pl. 23, f. 2.—Oldroyd, 1927:137.

Spirotropis ? evadne: Grant and Gale, 1931:548.

Mangelia evadne: Abbott, 1974:279 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 7 LACM lots.

Description. Shell profile narrow, whorls 4.5; shoulder broad, smooth, flat; sculpture dominated by sharply projecting peripheral angulation with raised cord at crest; base with relatively few, low spiral cords. Length 8-12 mm.

Type Locality and Type Specimens. Off Santa Rosa Island, California, 53 fathoms. Holotype: USNM 211334.

Distribution. Santa Cruz Island (34°N) to Redondo Beach, Los Angeles County, California (34°N).

Habitat. 90-230 m, soft bottoms.

Remarks. This species is characterized by a single projecting carination. Some specimens have oblique, narrow axials below the carination on the early whorls, but these become obsolete in the final whorl.

There is an error in the original measurements: the holotype is 7 mm in length, not 12 mm.

Crockerella conradiana (Gabb, 1869)

Figure 1.29A

Clathurella conradiana Gabb, 1869 (1866-69):7, pl. 1, fig. 12.—Grant and Gale, 1931:606, pl. 26, fig. 11.

Mangilia (*Clathurella*) *conradiana*: Arnold, 1903:210.

Glyphostoma conradiana: Oldroyd, 1927:126.

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 4 LACM lots.

Description. Shell profile slender, whorls 5; shoulder narrow, concave, sculpture of about 10 thick and strongly projecting axial ribs, overridden by relatively few spiral cords; base with relatively few spiral cords. Length 10-13 mm.

Type Locality and Type Specimens. Santa Barbara, California, Pleistocene. Holotype not located at UCMP.

Distribution. Santa Rosa Island, California (34°N), to Isla Todos Santos, Baja California (32°N).

Habitat. 25-240 m, soft bottoms.

Remarks. The shell is characterized by its slender profile and relatively few but very strong axial ribs. The species was first described from Pleistocene deposits, but was reported living by Dall (1921:179). It remains very scarce in collections. I have not seen live-collected specimens, although the specimens are sufficiently fresh appearing to indicate that the species is a member of the living fauna.

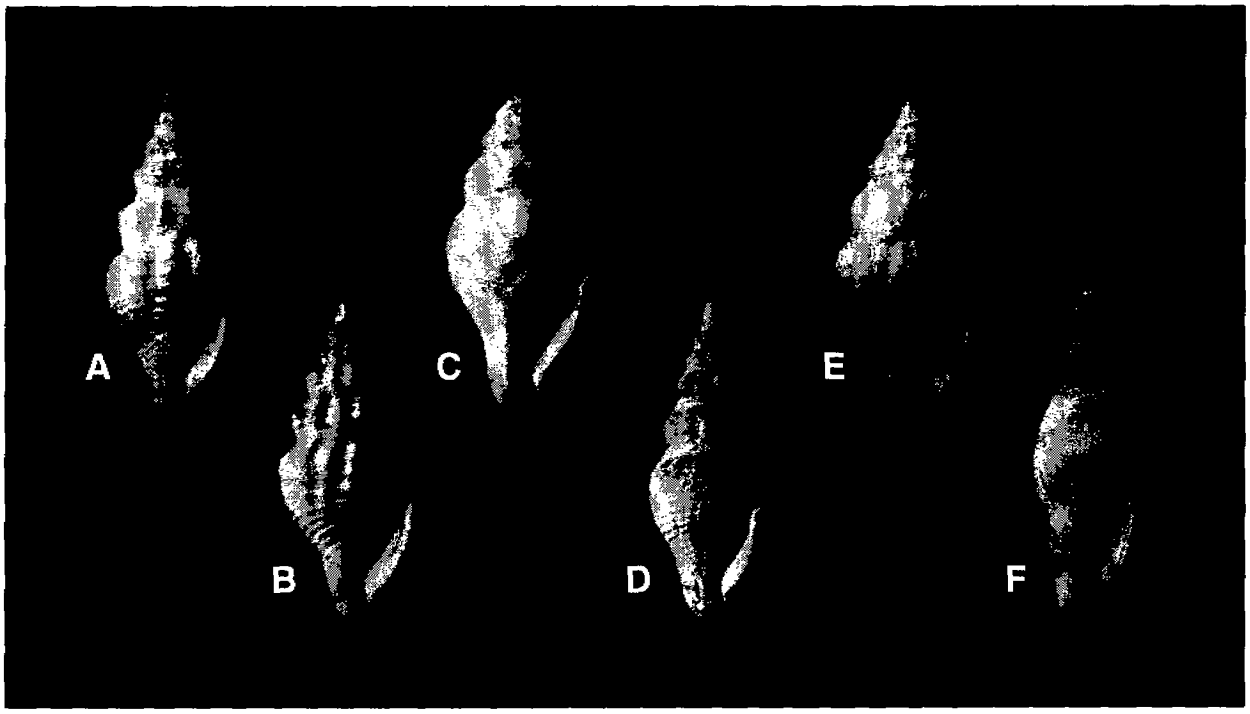


Figure 1.29. Conidae. **A.** *Crockerella conradiana* (Gabb, 1869): 55 m, off Santa Catalina Island, California (LACM 151660); height 10.4 mm. **B.** ***Crockerella scotti*** **McLean, new species**: 100 m, Santa Barbara Channel, California (LACM 2776, holotype); height 11.5 mm. **C.** *Crockerella philodoce* (Dall, 1919): 439-488 m, off Long Point, Santa Catalina Island, California (LACM 41-182.3); height 9.5 mm. **D.** *Crockerella cymodoce* (Dall, 1919): 59 m, off Goleta, Santa Barbara County, California (LACM 75-463.2); height 12.6 mm. **E.** *Crockerella castianira* (Dall, 1919): 104-113 m, SE of Bennett Point, San Miguel Island, California (LACM 41-176.7); height 11.6 mm. **F.** *Daphnella clathrata* Gabb, 1865: 219 m, off Isla Vista, Santa Barbara County, California (LACM 74-70.1); height 19.9 mm.

Crockerella scotti McLean, new species

Figure 1.29B

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material in addition to type lot (none live-collected): LACM 41-48.15, NW Anacapa Island, California, 88-93 m (1); LACM 40-111.20, off Redondo Beach, Los Angeles County, California, 176-219 m (1).

Description. Shell profile broad, whorls 5. Protoconch paucispiral, tip small, elevated, whorls 1.5, last half whorl with strong carination on lower third of whorl. First and second teleoconch whorls with carinate profile; whorl profile of later whorls rounded below concave shoulder. Shoulder broad, concave, bearing faint spiral striae but no axial sculpture. Axial ribs 11-12, of similar strength on final whorl, lip with stronger axial rib behind edge. Spiral cords 3 on early whorls; body whorl with 9 spiral cords including those on base and canal; cords broad, straplike, overriding axial ribs and with narrower, well-defined interspaces. Fine pustular sculpture of genus apparent only under high magnification. Anterior and posterior canals deeply notched and bordered with callus. Height 11.5 mm (holotype).

Type Locality and Type Specimens. Santa Barbara Channel (34°N, 119°W), California, 100 m, *Velero* IV, sta. 23247, 10 November 1975. 9 mature and 1 immature specimens, none live-collected. Holotype LACM 2775, 6 paratypes LACM 2776, 1 paratype CAS 102984, 1 paratype SBMNH 142896, 1 paratype USNM 887575.

Distribution. San Miguel Island (34.0°N) to Redondo Beach, Los Angeles County, California (33.8°N).

Habitat. 85-220 m, soft bottoms.

Remarks. This species is characterized by its strong axial ribs and relatively broad profile. In breadth it is comparable to *Crockerella lowei*, but it has much more pronounced ribs than known for that species. In strength of axial ribs it resembles *C. conradiana*, from which it differs in having a broader profile and in having more numerous axial ribs.

The name honors Paul Scott of the Santa Barbara Museum of Natural History.

Crockerella philodoce (Dall, 1919)

Figure 1.29C

Mangilia philodoce Dall, 1919:66, pl. 22, fig. 7.—Oldroyd, 1927:139.

Mangelia philodoce: Abbott, 1974:279 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 3 LACM lots.

Description. Shell profile of medium breadth, whorls 4, rounded at periphery; suture not deeply impressed; shoulder scarcely defined; axial ribs weak, crossed by narrow spiral cords. Anal sinus relatively broad. Length 7-10 mm.

Type Locality and Type Specimens. Off Point Piños, Monterey County, California, 65-203 fathoms. Holotype: USNM 208916.

Distribution. Off Point Piños, Monterey County (36.5°N), to Santa Catalina Island, California (33.5°N).

Habitat. 120-490 m, soft bottoms.

Remarks. This species is characterized by its rounded whorls, subdued axial and spiral sculpture and relatively broad anal sinus.

This is the second report of this species, which is now known from the holotype and three LACM lots of single specimens reported here. The holotype and the specimen illustrated here have eroded apices, but there is one immature specimen that has the characteristic protoconch that confirms the assignment to *Crockerella*. The original illustration of the holotype was enhanced, adding missing portions of the shell, as was commonly done for illustrations made at the USNM for publications by Dall and by Bartsch.

Crockerella cymodoce (Dall, 1919)

Figure 1.29D

Glyphostoma cymodoce Dall, 1919:54, pl. 17, fig. 6.—Oldroyd, 1927:127.—Abbott, 1974:283 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 1 LACM lot.

Description. Shell profile slender, whorls 5; shoulder broad, marked with incised striae; sculpture of about 10 strongly projecting axial ribs, overridden by spiral cords of alternating strength. Anal sinus deep, bordered by callus; lip thickened, crenate at edge to match spiral sculpture. Length 11-13 mm.

Type Locality and Type Specimens. Santa Barbara, California [depth not cited]. Lectotype (here selected): USNM 150569.

Distribution. Monterey (36.5°N) [Dall, 1921] to Santa Barbara, California (34.5°N).

Habitat. 60 m, soft bottoms.

Remarks. This species is characterized by its relatively strong axial ribs and spiral sculpture of alternating strength, and the pronounced tubular aspect of the anal sinus. In its strength of sculpture it recalls some tropical species of *Glyphostoma*, but it has the protoconch of *Crockerella*, not *Glyphostoma*.

The specimen figured here (from 59 m off Goleta, Santa Barbara County, California) is the only specimen other than the holotype that I have seen. It comes from a locality very close to the original type locality.

Crockerella castianira (Dall, 1919)

Figure 1.29E

Clathrodrillia castianira Dall, 1919:15, pl. 2, fig. 1.

Clathurella castianira: Abbott, 1974:283 [listed].

Material Examined. Not represented in the Santa Maria Basin voucher collection. Other material examined: 1 LACM lot.

Description. Shell profile broad, whorls 4; shoulder concave, narrow; shoulder angulation high on whorl, above periphery; axial ribs strong, numerous; spiral cords broad, overriding axial ribs; separated by narrower interspaces, 3 cords exposed on penultimate whorl; base with numerous spiral cords. Length 10-11.5 mm.

Type Locality and Type Specimens. Off Cape San Martin, Monterey County, California, 218 fathoms. Holotype: USNM 214246.

Distribution. Cape San Martin, Monterey County (36°N), to San Miguel Island, California (34°N).

Habitat. 100-400 m, soft bottoms.

Remarks. This species is characterized by a broad profile, a narrow, concave shoulder and moderately strong axial and spiral sculpture. It differs from all forms of *C. lowei* in having broad rather than narrow spiral cords and in having a high shoulder. All forms of *C. lowei* have a midwhorl angulation.

Two specimens are now known, the holotype and one LACM specimen from 104-113 m, SE of Bennett Point, San Miguel Island, California, which is a good match for this species (Figure 1.27E). The holotype is badly eroded, missing the protoconch and the first two teleoconch whorls. Dall's illustration of the holotype was reconstructed to show sculpture on the second teleoconch whorl that is not there. In doing so, an error was made in showing too many axial ribs on the second teleoconch whorl, judging from the lesser number on the LACM specimen.

Subfamily Daphnellinae Deshayes, 1863

Diagnosis. Small to large; anal sinus at suture, reversed L-shaped, sculpture usually cancellate, often with smooth shoulder. Protoconch usually multispiral, usually diagonally cancellate. Operculum absent. Radular teeth with large solid base, barbed or unbarbed tips, opening laterally at the base.

Remarks. This is another large subfamily, in which there are genera with exceptions to all the diagnostic characters (Taylor *et al.*, 1993:162)

Genus *Daphnella* Deshayes, 1863

Daphnella Deshayes, 1863. **Type species** (SD Herrmannsen, 1847): *Pleurotoma lymnaeformis* Kiener, 1839-40. Caribbean.

Diagnosis. Shell with rounded whorls and fine reticulate sculpture; axial ribs becoming obsolete on final whorl; anterior end truncate, lip flaring, thickened in some species; protoconch diagonally reticulate.

Biology. The multispiral protoconch is indicative of an extended planktotrophic veliger stage.

Remarks. This is a widespread tropical genus occurring in shallow water.

Daphnella clathrata Gabb, 1865

Figure 1.29F

Daphnella clathrata Gabb, 1865: 185.—Oldroyd, 1927:150.—Grant and Gale, 1931:542, pl. 25, figs. 23, 24.—Hertz, 1980:97, figs. 1-5.—Coan and Bogan, 1988:278.

Material Examined. California: Santa Maria Basin, Phase I, sta. 2, 200 m (1); sta. 4, 393 m (1). Other material: 18 lots in the LACM collection.

Description. Shell of moderate size, slender; whorls 5, rounded; aperture nearly half length of shell; sinus deep, at suture; axial and spiral sculpture coarsely clathrate on early whorls, changing to numerous spiral cords on final whorl; protoconch of 3.5 diagonally reticulate, dark brown whorls. Length 15-20 mm.

Type Locality and Type Specimens. Santa Catalina Island, 60 fathoms. Holotype: UCBP 15960.

Distribution. Santa Maria Basin (35.5°N), to Isla Cedros, Baja California [LACM 71-158] (28°N).

Habitat. Soft bottoms, 40-150 m.

Remarks. *Daphnella clathrata* is the only species of the genus yet known from California. It is more characteristic of deeper water than are the tropical species. Hertz (1980) discussed the species in detail.

Acknowledgments

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2. THE OPISTHOBRANCHIA

by

Terrence M. Gosliner[1]

Introduction

The Opisthobranchia traditionally have been considered as one of three subclasses of gastropod mollusks. However, recent phylogenetic investigations (Haszprunar, 1988; Gosliner, 1991, 1994) have demonstrated that the subclass Prosobranchia is paraphyletic. Not all of the descendants of the common ancestor are included in that taxon, since some are considered opisthobranchs and others are contained within the Pulmonata. For this reason, gastropod classification has undergone fundamental restructuring. There is general consensus that opisthobranchs and pulmonates are more closely related to each other than to other gastropod taxa. Together, the opisthobranchs and pulmonates are united into the Euthyneura. The Euthyneura are part of a larger gastropod taxon, the Heterobranchia, which includes the Pyramidellidae, Architectonicidae, Mathildidae, Rissoellidae, and Valvatidae. Details of phylogeny of the Heterobranchia have not been precisely determined at present. It appears that the Opisthobranchia, as presently constituted, is monophyletic (Gosliner, 1981).

The Opisthobranchia consists of approximately 5,000 described species. This almost exclusively marine taxon represents a morphologically diverse group, containing shelled snails, intermediate forms and completely shell-less slugs. Shell reduction and loss has occurred repeatedly and independently within different lineages. This fact accounts for much of the morphological diversity of this taxon.

Traditionally, the Opisthobranchia has been divided into five major orders of benthic snails and two additional orders of holoplanktonic organisms. The ranks for all of these orders are likely not equivalent. At least one order, the Cephalaspidea, probably is paraphyletic and is not diagnosed by any shared derived features. For this reason, taxa formerly included in the Cephalaspidea are here considered at the family level.

In general, opisthobranch mollusks can be readily identified to species by their external morphology. The shape of the body and color pattern are essential to identification, especially in the brightly colored nudibranchs. For this reason, it is far easier to identify living or freshly fixed material, in which many of these features are preserved. Preserved material can also be identified, but dissections of the mouth parts and details of reproductive anatomy are often required. Since most of the present material has been preserved for long periods of time, every attempt has been made to differentiate species on the basis of external features that are retained in preservation. In some cases, internal features of the shell (when present) and radular teeth must also be examined to insure correct identification.

The opisthobranchs of the shallow temperate Pacific coast of North America have been reasonably well studied. Behrens (1991) provides color photographs of living animals of some 217 species of opisthobranchs from Alaska to the outer coast of Baja California. This review permits the identification of living material, including 26 undescribed species.

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The opisthobranch species inhabiting North American waters below 100 m depth remain poorly studied. Chamberlain and Behrens (1980) recorded five species of opisthobranchs from deep water off San Luis Obispo County, California. Other reports of deeper water opisthobranchs are scattered in the literature (eg. Willett, 1944, MacFarland, 1966). Most of the taxa recorded are shelled species, known only from dead shells. In several instances the familial and generic status of these species remains in doubt, because morphological features of preserved animals are required for more refined systematic placement. In these cases, shell morphology alone does not permit proper systematic placement.

The present material from the Santa Maria Basin includes well preserved specimens of 28 species of opisthobranchs. Of these, half have never been described morphologically, including seven likely undescribed species not previously recorded from the Pacific coast of North America. Two genera, *Parvamplustrum* and *Holoplocamus*, were previously known only from the Atlantic. Thus, description of this material adds significantly to our primary knowledge of the opisthobranch fauna of the Pacific coast of North America.

Morphology

The most obvious morphological difference between different opisthobranchs is the presence, absence, and form of the shell. The ancestral shell of opisthobranchs is similar to that found in caenogastropods. In this instance, the shell is external and thickly calcified, with a well elevated spire that extends beyond the body whorl. This form of shell is generally found in species of Acteonidae, Ringiculidae, some species of *Acteocina* and isolated representatives of several other opisthobranch taxa. In more derived opisthobranchs that still retain an external shell, the spire is sunken completely within the body whorl. This bulloid shell is present in a wide array of opisthobranchs and has been derived independently at least four different times within the Opisthobranchia. Many other opisthobranchs retain an internal shell that is situated on the dorsal surface, directly underneath the dorsal epithelium. Sometimes the shell is visible through the translucent epithelium, but in other instances dissection may be required to observe the shell. In most cases, an internal shell is a relatively flattened, thinly calcified plate. As in the case of the bulloid shell, internal shells have been independently derived in several distinct groups of opisthobranchs.

Other external features can be used to differentiate taxa. Many less derived opisthobranchs have a body divided into a cephalic head shield and a posterior shield. These two portions of the body are usually flanked by a pair of lateral parapodia. Other more modified taxa have a pair of chemosensory rhinophores situated on the dorsal surface of the head. In the case of the Notaspidea, Anaspidea, and many Sacoglossa, the rhinophores are rolled rather than solid. In other sacoglossans and all nudibranchs the rhinophores are solid. The rhinophores may be smooth or ornamented with lamellae, annulae, or papillae. In notaspideans, a single pinnate gill is situated on the right side of the body. In nudibranchs, gills are arranged in a wide variety of fashions, including a simple circle in most dorids and linear gills along the edge of the notum is most Dendronotacea.

In some instances, internal features provide essential information for identifying and differentiating species. The most diagnostic features include the morphology of the jaws and whether chitinous rodlets are present or absent. If rodlets are present their form may be important in differentiating closely related species. Probably the most important feature used in differentiating species of opisthobranchs is the structure of the rasping teeth situated within the buccal mass. These teeth are arranged in distinct patterns forming the complex structure of the radula. In many instances, a central or rachidian row of teeth is present, while in others these teeth are entirely absent. The central region is generally flanked on either side by lateral teeth that are variable in form and arrangement. Often individual species will have a specific number of rows of lateral teeth within the radula.

In some less derived opisthobranchs, the region at the posterior end of the esophagus is enlarged to form a muscular gizzard. Within the gizzard are a series of distinct chitinous or calcareous plates. Their relative size and shape are often characteristic and species specific.

Opisthobranchs are largely hermaphroditic and have complex arrangements of reproductive organs. The structure of these organs is important in determining the systematic placement of many taxa. Owing to the difficulty in determining reproductive morphology, its utility in species identifications has been de-emphasized for the purposes of this study.

Collection and Fixation

Opisthobranchs can be collected by most standard collection methods though soft-bodied species can be damaged during collection and sorting. The preferred method of collection of epifaunal species is directly by hand or trawling. Living soft-bodied opisthobranchs should be retained in salt water, as this causes less damage to specimens. Infaunal material can be collected by a variety of dredging and coring methods. Careful and prompt sorting will minimize damage to specimens. It is important to make color notes or photographs of living or fresh material, as color is important in distinguishing closely related species.

Once material has been sorted and documented, specimens should be relaxed by gradually adding an 8% solution of magnesium chloride to a shallow dish containing just enough sea water to cover the specimens. Addition of magnesium chloride should take place over a period of 8-12 hours to ensure reduced contraction of specimens upon fixation. Probing of specimens is necessary to ascertain whether they are properly anesthetized. If specimens contract or move when probed, more time must be allowed before specimens are fixed. Specimens should be fixed in buffered 10% formalin or Bouin's fixative. The latter will dissolve shells, but provides better fixation of soft tissues. Ideally, if shelled specimens are sufficiently abundant, lots should be split and some representatives should be placed in 75% ethyl alcohol, while the remainder should be fixed in Bouins. Unbuffered formalin will also dissolve shells, especially if they are left in formalin for extended periods of time. After 24-48 hours, specimens can be transferred from fixative to 75% ethyl alcohol for long-term storage.

Laboratory Methods

Most opisthobranchs are relatively small, less than 30 mm in length. Detailed morphological examination of living and preserved specimens requires use of a dissecting microscope. In order to examine details of the morphology of the jaws, radula and gizzard, specimens must be dissected. To examine these structures, the muscular buccal mass and gizzard are carefully removed from the animal and placed in a 10% solution of sodium or potassium hydroxide for approximately 24 hours.

Dissection of specimens is generally conducted using a dissecting microscope, together with ultra fine forceps or minute insect needles. Tissue can be teased away from the remaining hard parts using minute insect needles. The remaining labial cuticle, radula, and gizzard plates should be thoroughly rinsed in distilled water. Permanent slides then can be prepared by light staining with dilute acid fuchsin and mounted in aqueous mounting medium or by gradual dehydration in alcohol, emersion in xylene and mounting in balsam. Gizzard plates should not be mounted in acidic aqueous mounting media as this rapidly dissolves the calcium carbonates present in some plates. Specimens for scanning electron microscopy should be air-dried on a round microscope coverslip after removal from distilled water.

Glossary

Aperture. Opening of the shell into which the animal may retract.

Body whorl. The largest and terminal spiral whorl of the shell.

Bulloid spire. A shell in which the earlier whorls are entirely surrounded by the body whorl.

Cephalic lobes. Paired sensory projections on the dorsal surface of the cephalic shield.

Cephalic shield. The anterior portion of the body of certain bubble snails used to burrow through soft substrate.

Elevated spire. A shell in which the earlier whorls project posteriorly from the level of the body whorl.

Half row. The radular teeth forming a row on either side of the central portion of the radula.

Jaws. Chitinous structures used for grasping and cutting food, which are situated at anterior end of buccal mass.

Lateral teeth. The radular teeth situated on either side of the central portion of the radula. Inner lateral teeth are often of different form than outer ones. This may be a gradual or abrupt transition of tooth form.

Notum. The dorsal surface of the animal.

Operculum. The trap door that may cover the aperture of the shell when the animal is completely retracted. In most opisthobranchs the operculum is absent. It is retained in many members of the Acteonidae and a few members of some other taxa. When present in opisthobranchs it is a thin, oblong, chitinous plate.

Punctate sculpture. Shell texture consisting of a series of irregular pits within the surface of the shell. A unique derived feature of opisthobranchs retained in many taxa.

Radula. Ribbon of chitinous teeth used for rasping food.

Radular formula. A numerical depiction of the arrangement of radular teeth. Expressed in the following fashion: a-b × c.d.e.d.c. The first numbers (a-b) indicate the number of radular rows times the number of teeth per row. In the above example, c represents the number of outer lateral teeth, d the number of inner lateral teeth, and e the rachidian teeth. A zero indicates that none of that particular type of teeth is present in that radula, For example, the number of rachidian teeth is expressed as either 1 or 0, depending on whether a rachidian row is present or absent.

Rachidian teeth. The single line of teeth occupying the central region or rachis of the radula.

Velar tentacles. Appendages that may be present along the anterior and lateral margins of the head.

List of Opisthobranch Species

Family Acteonidae
- *Rictaxis punctocaelatus* (Carpenter, 1864)
- *Acteon* sp.

Family Hydatinidae
- *Parvamplustrum* sp.

Family Cylichnidae
- *Cylichna diegensis* (Dall, 1919)
- *Acteocina harpa* (Dall, 1871)
- *Acteocina eximia* (Baird, 1863)

Family Philinidae
- *Philine polystrigma* (Dall, 1908)
- *Philine* sp. 1
- *Philine* sp. 2

Family Aglajidae
- *Aglaja ocelligera* (Bergh, 1893)
- *Aglaja* sp.

Family Gastropteridae
- *Gastropteron pacificum* Bergh, 1893

Family Retusidae
- *Retusa xystrum* Dall, 1919
- *Volvulella californica* Dall, 1919
- *Volvulella panamica* Dall, 1919

Family Diaphanidae
- *Diaphana californica* Dall, 1919

Family Pleurobranchidae
- *Berthella californica* (Dall, 1900)
- *Pleurobranchaea californica* MacFarland, 1966

Family Aldisidae
- *Aldisa sanguinea* (Cooper, 1863)

Family Chromodorididae
- *Cadlina flavomaculata* MacFarland, 1905

Family Polyceratidae
- *Holoplocamus* sp.

Family Goniodorididae
- *Okenia* sp.

Family Dendronotidae
- *Dendronotus frondosus* (Ascanius, 1774)

Family Tritoniidae
- *Tritonia festiva* (Stearns, 1873)
- *Tritonia diomedea* Bergh, 1894

Family Arminidae
- *Armina californica* (Cooper, 1863)

Family Tergipedidae
- *Cuthona rolleri* Behrens and Gosliner, 1988

Family Aeolidiidae
- *Aeolidiella chromosoma* (Cockerell and Eliot, 1905)
- *Cerberilla mosslandica* McDonald and Nybakken, 1975

Key to Opisthobranch Species

1A. Shell external 2
1B. Shell internal or absent 12

2A. Shell spire elevated above body whorl 3
2B. Shell spire bulloid 8

3A. Shell with punctate sculpture 4
3B. Shell without punctate sculpture, though spiral lines may be present 6

4A. Shell with alternating black and white bands ..... *Rictaxis punctocaelatus*
4B. Shell uniformly white 5

5A. Radula with numerous minute denticulate teeth; all identical in shape and size ..... *Acteon* sp.
5B. Radula with 5 teeth per half-row; outer teeth more elongate juvenile ..... *Rictaxis punctocaelatus*

6A. Posterior end of foot bifurcate ..... *Diaphana californica*
6B. Posterior end of foot undivided 7

7A. Edges of whorls straight ..... *Acteocina harpa*
7B. Edges of whorls curved ..... *Acteocina eximia*

8A. Shell with elongate, pointed posterior end 9
8B. Shell flat or rounded posteriorly 10

9A. Outer lip joining apex of posterior extension ..... *Volvulella californica*
9B. Outer lip joining base of posterior extension ..... *Volvulella panamica*

10A. Shell with numerous longitudinal ridges ..... *Retusa xystrum*
10B. Shell smooth or with spiral lines 11

11A. Cephalic lobes bifid ..... *Parvamplustrum* sp.
11B. Cephalic lobes rounded ..... *Cylichna diegensis*

12A. Shell internal 13
12B. Shell absent 19

13A. Shell with punctate sculpture 14
13B. Shell smooth or with simple growth lines 17

14A. Gill present on right side of body ..... *Berthella californica*
14B. Gill hidden within posterior cavity ..... genus *Philine* 15

15A. Gizzard plates absent ..... *Philine* sp. 2
15B. Gizzard plates present 16

16A. Shell with posterior flange ..... *Philine* sp. 1
16B. Shell rounded posteriorly ..... *Philine polystrigma*

17A. Posterior shield rounded posteriorly ..... *Gastropteron pacificum*
17B. Posterior shield with rounded posterior lobes 18

18A. Shell occupying most of posterior shield cavity ..... *Aglaja* sp.
18B. Shell occupying only posterior third of cavity ..... *Aglaja ocelligera*

19A. Circle of gills present on back of animal 20
19B. Circle of gills absent 23

20A. Gills retractile into pit 21
20B. Gills not retractile 22

21A. Radular teeth short, variable in form ..... *Cadlina flavomaculata*
21B. Radular teeth all elongate with pectinate denticles ..... *Aldisa sanguinea*
22A. Velar tentacles present ..... *Holoplocamus* sp.
22B. Velar tentacles absent ..... *Okenia* sp.

23A. Gills absent, animal with cerata 24
23B. Gills present in some form 26

24A. Body dorsoventrally flattened ..... *Cuthona rolleri*
24B. Body not dorsoventrally flattened 25

25A. Rhinophores smooth, cylindrical ..... *Cerberilla mosslandica*
25B. Rhinophores bulbous, lamellate ..... *Aeolidiella chromosoma*

26A. Single pinnate gill present along right side of body ..... *Pleurobranchaea californica*
26B. Gills otherwise 27

27A. Gills situated on ventral side between mantle and foot ..... *Armina californica*
27B. Gills branched, situated along lateral margins of notum 28

28A. Velar tentacles branched ..... *Dendronotus frondosus*
28B. Velar tentacles unbranched 29

29A. Notum smooth ..... *Tritonia festiva*
29B. Notum with low tubercles ..... *Tritonia diomedea*

Descriptions of Species

Family Acteonidae

Genus *Rictaxis* Dall, 1871

Type Species: *Tornatella punctocaelata* Carpenter, 1864.

Diagnosis. Shell well calcified with elevated spire and punctate sculpture. Operculum present or absent. Jaws with well-developed rodlets. Radular formula 5.0.5. Radular teeth elongate with small cusps. Reproductive system androdiaulic. Penis armed or unarmed.

Rictaxis punctocaelatus (Carpenter, 1864)

Figures 2.1A, 2.2A, 2.3A

Tornatella punctocaelata Carpenter, 1864:139.
Rictaxis punctocaelatus: Dall 1871:136.

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta. 21, rep. 3 (1), dissected; off Point Sal, Sta PJ-9, rep. 1 (1).

Description. Living animal translucent white (Figure 2.1A). Shell white with alternating black bands in mature individuals. Juveniles with uniformly white shell (Figure 2.2A). Spire moderately elevated. Aperture wide, elongate. Body whorl with numerous rows of fine punctations. Thin coriaceous operculum visible along surface of foot of juvenile specimens. Operculum absent in adults. Jaws with triangular to linear rodlets. Radular formula 27-35 × 5.0.5. (Figure 2.3A). Inner 3 teeth per half row short with multifid cusps. Outer 2 rows of teeth with long denticulate cusps. Outermost tooth denticulate in juveniles, more elongate, smooth in mature specimens.

Biology. *Rictaxis punctocaelatus* is known from intertidal mud and sand flats to at least 100 m depth. This species, like other members of the family, feeds on polychaete annelids.

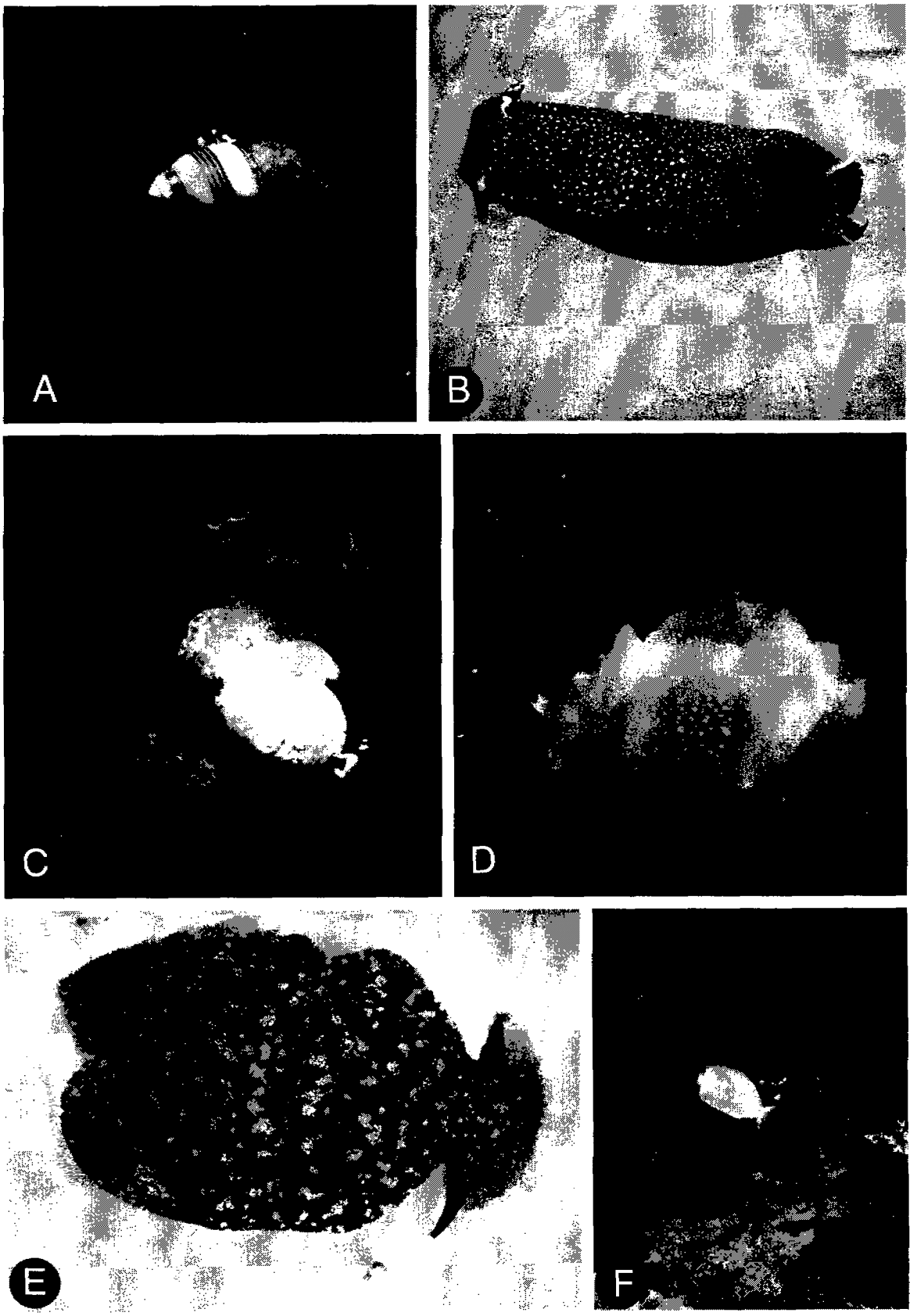

Figure 2.1. Living animals **A.** *Rictaxis punctocaelatus* (Carpenter, 1864). **B.** *Aglaja ocelligera* (Bergh, 1893). **C.** *Gastropteron pacificum* Bergh, 1893. **D.** *Berthella californica* (Dall, 1900). **E.** *Pleurobranchaea californica* MacFarland, 1966. **F.** *Diaphana californica* Dall, 1919.

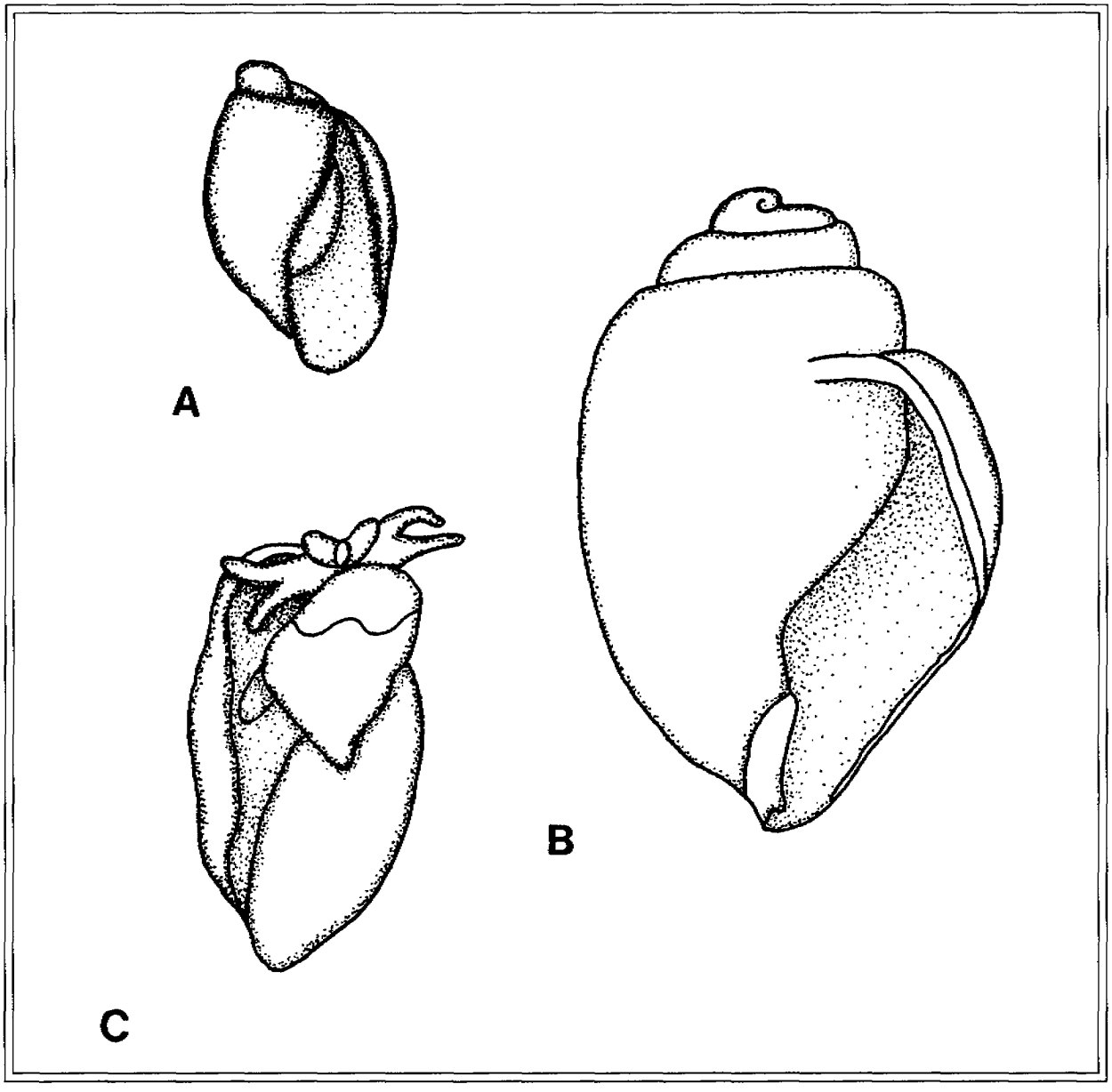

Figure 2.2. **A.** *Rictaxis punctocaelatus* (Carpenter, 1864), juvenile shell, × 40. **B.** *Acteon* sp., shell, × 30. **C.** *Parvamplustrum* sp., preserved animal, × 80.

Remarks. Dall (1871) described *Acteon punctocaelatus* as the type species of the genus *Rictaxis*. Though the subgeneric distinction was originally based on conchological features, Marcus (1972) determined that the radula of several species, including *R. punctocaelatus*, was significantly different from that of other acteonids. *Rictaxis* is characterized by a radula with five rows of elongate teeth with numerous small denticles along the main cusp. A rachidian row of teeth is absent. In juvenile specimens, such as the material examined here, the cusp of the outer lateral tooth is short and bears denticles. In older specimens the cusp is more elongate and lacks denticles.

The sympatric "*Rictaxis*" *painei* has a rachidian row of teeth and there is not an elongate cusp. In "*R*". *painei* there are eight lateral teeth per half row, as compared to five in species of *Rictaxis*. It is unlikely that *R. painei* should be considered as a member of this genus. This species does not fit readily into any acteonid genus, based on radular morphology. The generic position of this taxon remains open to question.

Rictaxis punctocaelatus differs from the four other acteonids recorded from off the California coast in having prominent alternating black and white bands on the shell. *Acteon traskii* also has alternating light and dark spiral bands on the shell, but the bands are not prominent. *Acteon traskii* also has a radula consisting of numerous minute radular teeth per half row. *Rictaxis painei* has a uniformly white or brown shell and a different radular formula. *Microgyphis estuarinus* and *M. breviculus* have uniformly white shells with a well developed siphonal furrow.

Type Locality and Type Specimens. San Diego, California; holotype (USNM 14914).

Distribution. Ketchikan, Alaska to Magdalena Bay, Baja California (Behrens, 1991), intertidal zone to 100 m.

Genus *Acteon* Montfort, 1810

Type Species: *Bulla tornatilis* Linnaeus, 1758.

Diagnosis. Shell well calcified with elevated spire and punctate sculpture. Operculum present. Jaws with well-developed rodlets. Radular formula 50-150.0.50-150. Radular teeth small with numerous small denticles. Reproductive system androdiaulic. Penis unarmed.

***Acteon* sp.**

Figures 2.2B, 2.3B-C

Material Examined. California, Santa Maria Basin, off Purisima Point, Sta. BSV 42, rep. 1 (1), dissected.

Description. Shell (Figure 2.2B) 3 mm long, uniformly white with 22 finely punctate spiral lines on body whorl. Shell with three whorls. Outer lip of shell broken. Animal with large operculum on foot. Jaws (Figure 2.3B) with multifid elements. Radula containing numerous (more than 50) teeth per half row. Teeth minute (Figure 2.3C), with 16-18 denticles along inner edge of tooth. Penis short, digitiform, with rounded apex.

Remarks. This species is a member of the genus *Acteon*, as the radula bears numerous rows of minute, finely denticulate teeth with many teeth per half row. It appears to be conchologically distinct from *Acteon traskii*. The aperture of *Acteon* sp. is wider and the whole shell is more squat than in *A. traskii*. Also, *A. traskii* is colored with rose bands that are absent in the present shell. It is possible that the present specimen is a juvenile of *A. traskii*, but the dissected animal appeared to be sexually mature. The shell is similar in shape to *Acteon panamensis* Dall, 1908, which is known only from a single shell collected in deep water from the Gulf of Panama. Further material is required to confirm the identity of this species.

Distribution. Thus far, this species is known only from the single specimen collected from the Santa Maria Basin.

Figure 2.3. **A.** *Rictaxis punctocaelatus* (Carpenter, 1864), radular teeth, × 1000. **B., C.** *Acteon* sp, **B.** jaw rodlets, × 3000. **C.** radular teeth, × 4000. **D.** *Parvamplustrum* sp., radular teeth, × 2000.

Family Hydatinidae

Genus *Parvamplustrum* Powell, 1951

Type Species: *Parvamplustrum tenerum* Powell, 1951.

Diagnosis. Shell weakly calcified, bulloid. Operculum absent. Jaw rodlets reduced to chitinous patches. Radular formula 1.0.1. Lateral teeth flattened, without denticles. Reproductive system androdiaulic. Penis unarmed.

Parvamplustrum sp.

Figures 2.2C, 2.3D

Material Examined. California, Santa Maria Basin, off Point Arguello and Point Conception; Sta. 61, rep. 1 (1); Sta 86, rep. 2 (1), dissected.

Description. Preserved animals minute (Figure 2.2C), less than 1 mm in length. Shell bulloid, often completely decalcified in formalin fixed material. Foot short, triangular, and acute posteriorly. Tentacles on sides of head bifid. Jaw with unarmed polygonal rodlets. Radular formula approximately 20 × 1.0.1. Lateral teeth (Figure 2.3D) curved and broad without denticles. Gizzard plates absent.

Remarks. The genus *Parvamplustrum* is known only from the type species, *P. tenerum* Powell, 1951, which is known only from the Atlantic (Powell, 1951; Marcus and Marcus, 1969; Gosliner, 1991). The present species represents the first record of the genus from the Pacific. It is similar to *P. tenerum* in all respects. More material needs to be examined to determine if the present specimens are conspecific with *P. tenerum*, or whether they represent an undescribed species. This is especially important since the shells of the present material are completely decalcified.

The genus *Parvamplusturm* is placed in the Hydatinidae, though the radular morphology and shell are different from other members of the family. Resolution of the familial status of this genus requires additional study.

Distribution. Thus far, this species is known only from the Santa Maria Basin.

Family Cylichnidae

Genus *Cylichna* Loven, 1846

Type Species: *Cylichna cylindracea* (Pennant, 1777).

Diagnosis. Shell bulloid, well calcified. Operculum absent. Jaws with multifid rodlets. Radular formula 3-12.1.1.1.3-12. Rachidian teeth bilobed, denticulate. Inner lateral teeth denticulate. Outer lateral teeth smooth. Gizzard plates 3, smooth, equal in size and shape. Reproductive system monaulic. Penis unarmed.

Cylichna diegensis (Dall, 1919)

Figures 2.4A, 2.5

Cylichnella diegensis Dall, 1919:300.

Cylichna diegensis: Abbott, 1974:315.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. 103, rep. 1 (2); Sta R-8, rep. 1 (5), 1 dissected; Sta PJ-17, rep. 3 (1).

Description. Shell bulloid (Figure 2.4A), external, 3-7 mm in length. Shell with fine spiral striae and brown periostrical lines at anterior and posterior ends, but absent from central region. Preserved animals uniformly light tan.

Jaws with multifid rodlets (Figure 2.5A). Radular formula 13 x 3-4.1.1.1.3-4. Rachidian teeth (Figure 2.5C) bifid, with 5-7 denticles on either side of tooth. Inner lateral teeth (Figure 2.5B) with 9-11 denticles on inner side of hook-shaped primary cusp. Outer lateral teeth curved with numerous fine denticles. Denticles absent from outermost tooth. Lenticular gizzard plates 3, (Figure 2.5D), of equal size and shape.

Biology. Little is known about the biology of *Cylichna diegensis*. Other members of the genus are known to feed on Formaminifera.

Remarks. The anatomy of *Cylichna diegensis* has not previously been described. *Cylichna diegensis* is similar in appearance to *Cylichna attonsa*. The two species are known to be sympatric from Santa Monica south to Baja California. It is appears that *C. diegensis* has sharper shoulders to its shell than *C. attonsa*. Internally, *C. diegensis* has 3-4 rows of outer lateral teeth per side while a single specimen of *C. attonsa* from British Columbia examined here has 6-7 rows of outer laterals per side. Both species are unusual in having denticles on the outer side of the cusp of the outer laterals. More material must be examined to ascertain whether *Cylichna diegensis* and *C. attonsa* are indeed distinct.

Type Locality and Type Specimens. Off Point Loma, San Diego, California, 98-191 fathoms; (USNM 209071).

Distribution. This species is known from Santa Monica, California to Baja California (Abbott, 1974).

Genus *Acteocina* Gray, 1847

Type Species: *Acteocina wetherelli* (Lea, 1833).

Diagnosis. Shell well calcified with elevated or bulloid spire. Operculum absent. Jaw rodlets reduced, multifid. Radular formula 1.1.1 or 1.0.1. Rachidian teeth bilobed, denticulate when present. Lateral teeth denticulate. Gizzard plates 3, unequal in size and shape. Reproductive system monaulic. Penis unarmed or armed.

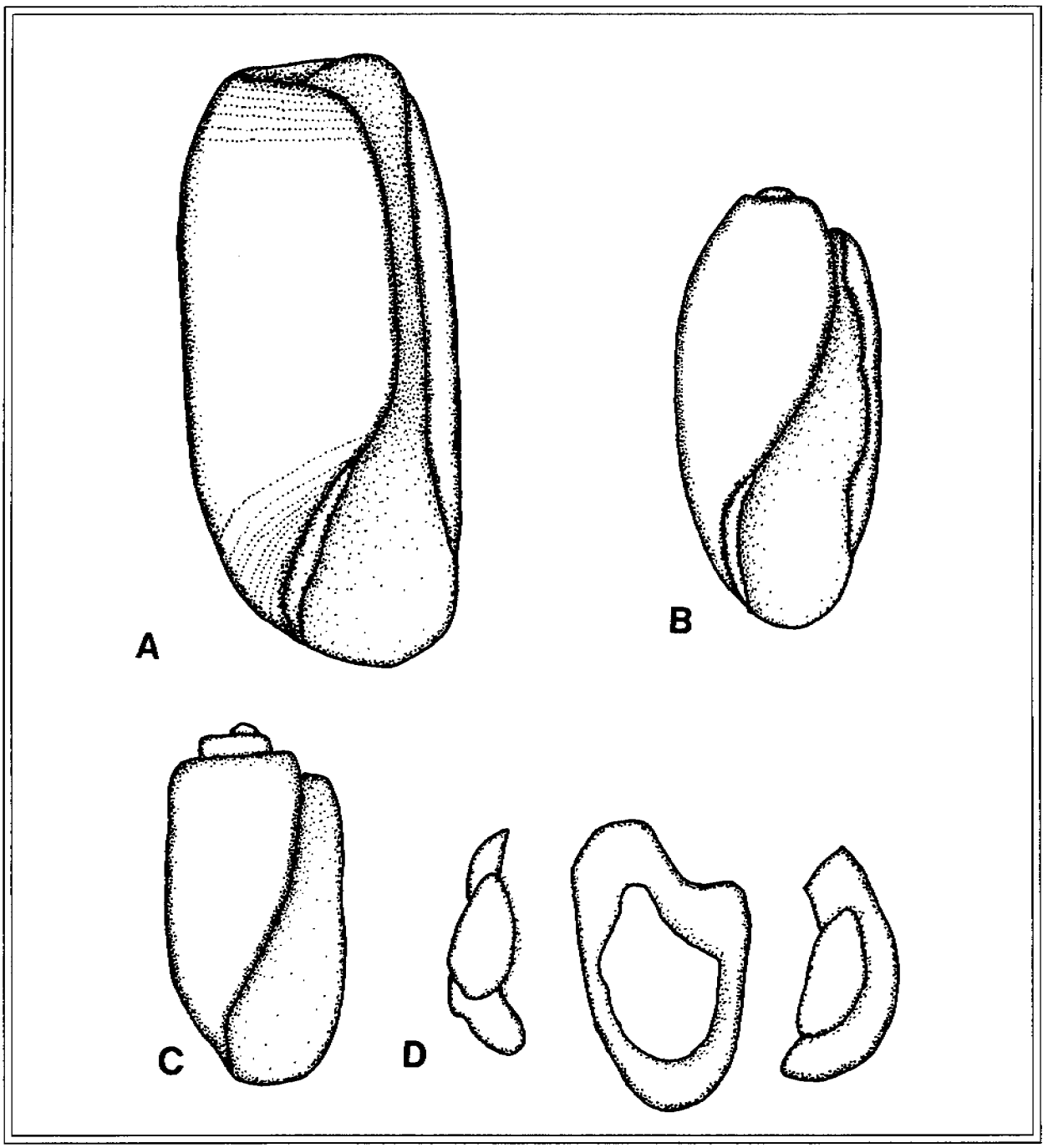

Figure 2.4. **A.** *Cylichna diegensis* (Dall, 1919), shell, × 20. **B.** *Acteocina eximia* (Baird, 1863), shell, × 10. **C., D.** *Acteocina harpa* (Dall, 1871), **C.** shell, × 40. **D.** Gizzard plates of holotype, × 25.

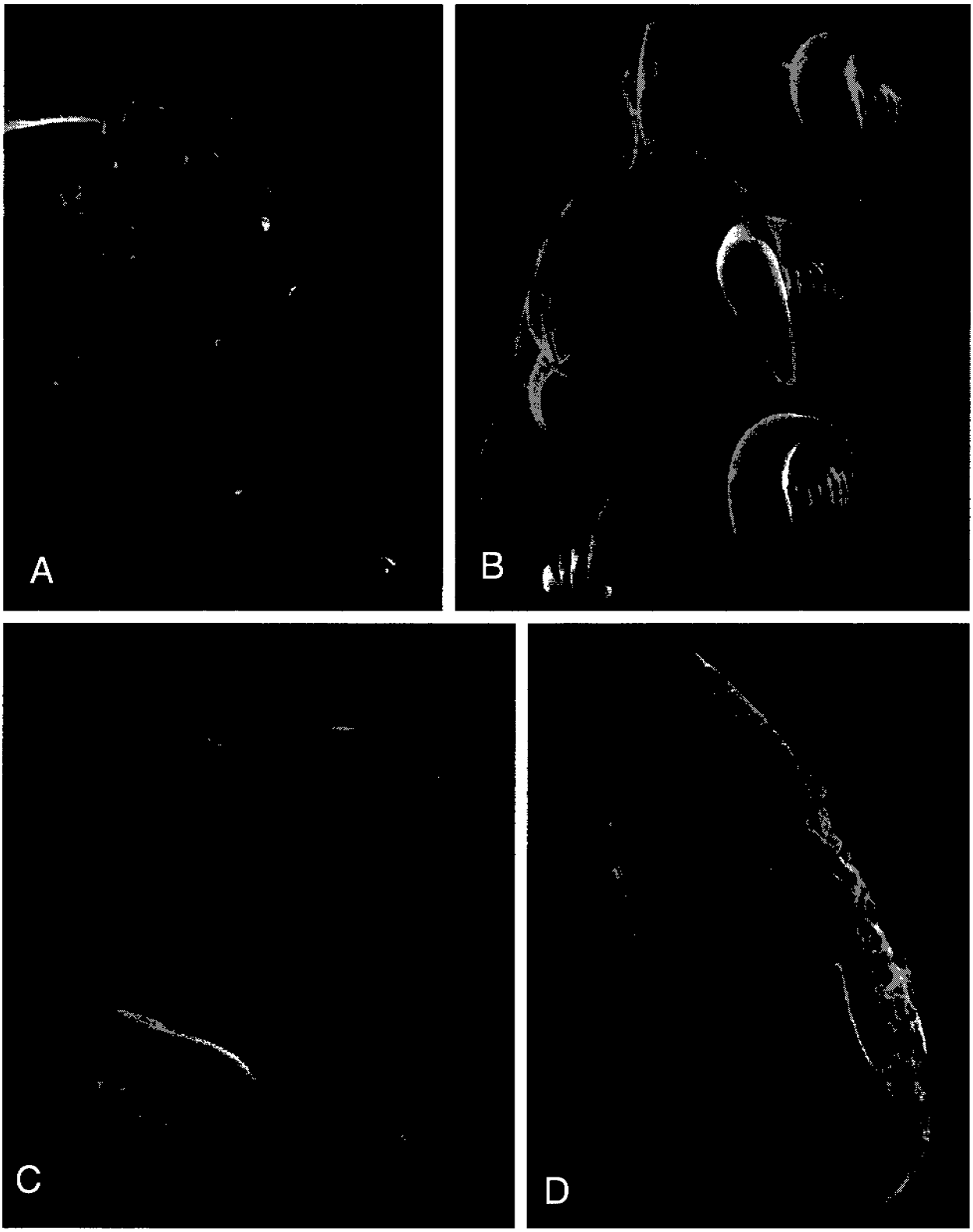

Figure 2.5. *Cylichna diegensis* (Dall, 1919). **A.** Jaw rodlets, × 3000. **B.** Lateral teeth, × 1000. **C.** Rachidian teeth, × 2000. **D.** Gizzard plate, × 150.

Acteocina harpa (Dall, 1871)

Figures 2.4C-D, 2.6A-B

Tornatina harpa Dall, 1871:136.

Utriculastra harpa: Thiele, 1925:239.

Acteocina (Coleophysis) harpa: Abbott, 1974:313.

Material Examined. California, Santa Maria Basin, off Morro Bay, Sta. 6 (1); off Point Conception, Sta. BRA 02 (1), dissected.

Description. Shell (Figure 2.4C) external, 1.5 mm in length. Shell with slightly elevated spire. Sides of shell parallel for most of their length. Aperture wide. Jaws with indistinct rodlets. Radular formula 12-17 × 1.1.1 Rachidian teeth (Figure 2.6A) bifid, with 3-4 denticles on either side of tooth. Inner lateral teeth (Figure 2.6B) with 9-10 coarse, elongate denticles on inner side of hook-shaped primary cusp. Gizzard plates dissolved in present, formalin fixed material. Gizzard plates of holotype examined in present study (Figure 2.4D). Plates unequal in size and shape. Dorsal plate largest. Lateroventral plates narrower, but asymmetrical.

Biology. Like other members of this genus, *Acteocina harpa* likely feeds upon foraminferans.

Remarks. The anatomy of *Acteocina harpa* has not previously been described. Owing to this lack of information, its generic and familial status has remained in question. *Acteocina harpa* is clearly a member of a complex of species that are characterized by having a single large heart-shaped gizzard plate and two smaller ones. The radular teeth of members of this complex have a prominent row of rachidian teeth and lateral teeth with a short flange containing large denticles. Other members of this complex from the Pacific coast of North America include *Acteocina inculta*, *A. carinata* and possibly *A. magdalensis*. Of these species, *A. harpa* has more asymmetrical gizzard plates and a rachidian tooth with few denticles. The shell of *A. harpa* is unique in having longitudinal incised lines on the body whorl of the shell. The other species of this complex appear to be restricted to intertidal and shallow subtidal waters.

Type Locality and Type Specimens. Monterey, California; holotype (USNM 56179).

Distribution. Forrester Island, Alaska to San Diego, California (Abbott, 1974).

Acteocina eximia (Baird, 1863)

Figures 2.4B, 2.6C-D

Bullina eximia Baird, 1863:67.

Tornatina eximia: Pilsbry, 1895:189.

Acteocina eximia: Strong, 1921:44.

Acteocina culcitella eximia: Willett, 1928:37.

Utriculastra culcitella: Marcus, 1977: 22, figs 71-76. Not Gould, 1852.

Cylichnella culcitella: Gosliner, 1979:87, fig.3. Not Gould, 1852.

Acteocina culcitella intermedia Willett, 1928: 37. New synonymy.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. 31, rep. 1 (1); Stat. PJ-15, rep. 1 (1), dissected; off Point San Luis, Sta. R-2, rep. 3 (1); off Purisima Point, Sta. R-4, rep. 2 (1); off Point Conception, Sta 85, rep. 1 (1).

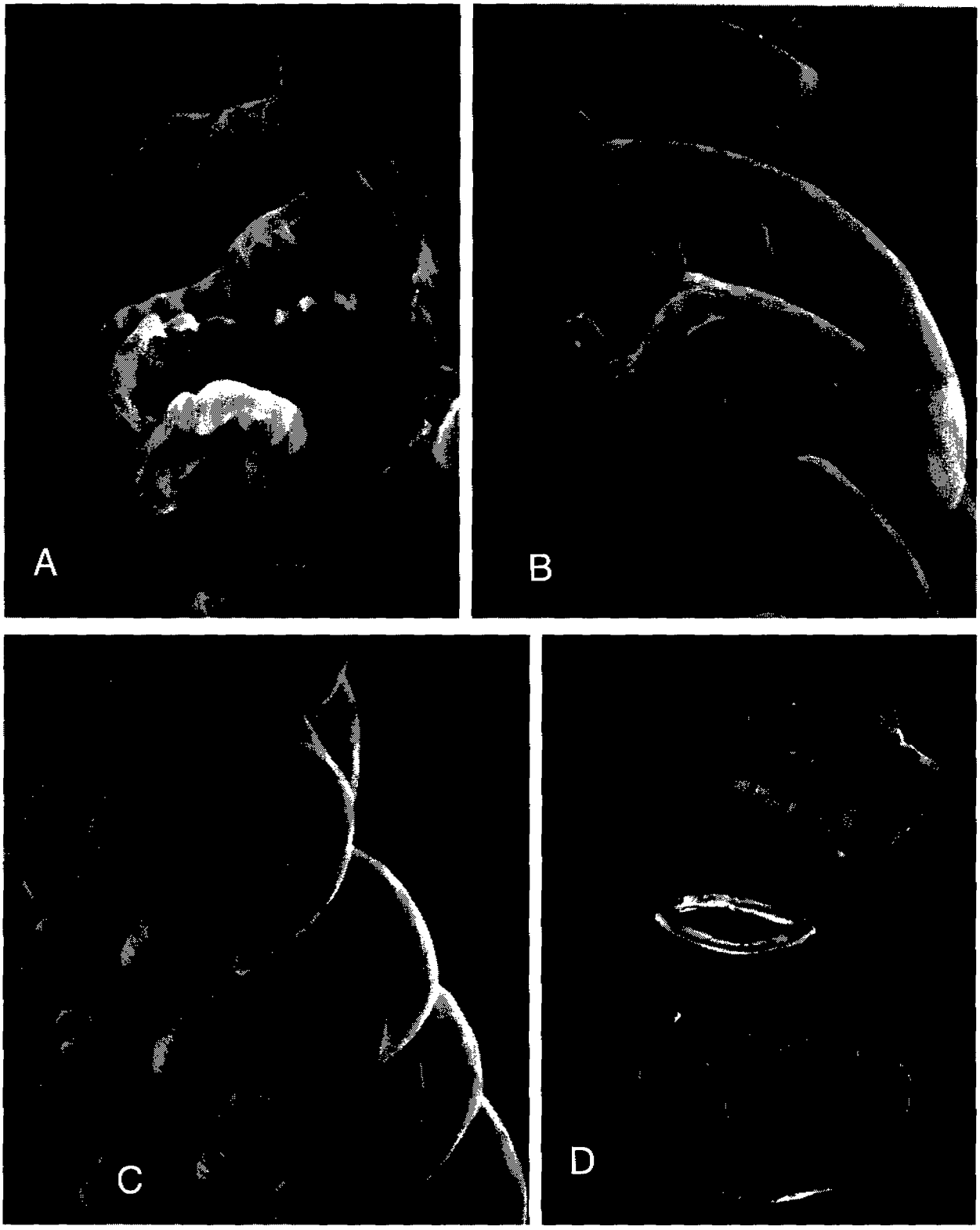

Figure 2.6. *Acteocina harpa* (Dall, 1871). **A.** Rachidian teeth, × 4000. **B.** Lateral teeth, × 3000. **C., D.** *Acteocina eximia* (Baird, 1863). **C.** Lateral teeth, × 1000. **D.** Gizzard plates, × 20.

Description. Shell (Figure 2.4B) external, well calcified, 4-10 mm in length. Spire slightly elevated from body whorl. Shell ornamented with numerous brown, spiral periostrical lines. Radular formula 19-28 × 1.0.1. Rachidian row of teeth absent or consisting of few vestigial teeth in some specimens. Inner lateral teeth (Figure 2.6C) curved with long central denticle. Thirty to 50 short denticles present along almost entire inner margin of tooth. Gizzard with 3 unequal plates (Figure 2.6D). Two plates large and concave on their dorsal surface. Single plate small, laterally compressed, concave.

Biology. This species appears to be restricted to depths exceeding 22 m. Foraminifera have been observed in the gizzard of some specimens and appear to be the primary food of this species.

Remarks. Members of this complex of *Acteocina* are characterized by having two large and one small gizzard plate. The rachidian row of radular teeth is greatly reduced and rachidians are either vestigial or entirely absent. The inner lateral teeth have small denticles along most of the inner margin. These denticles are not on an elevated flange as in species of the *Acteocina harpa* complex. Considerable confusion has surrounded the taxonomic status of this species and members of this species complex. Willett (1928) considered three subspecies of *A. culcitella*, *A. culcitella culcitella* (Gould, 1852), *A. culcitella eximia* (Baird, 1863), and *A. culcitella intermedia* Willett, 1928. *Acteocina eximia* was separated from specimens attributable to *A. culcitella* by Marcus (1977).

Gosliner (1979) considered the material regarded by Marcus as *A. eximia* and *A. culcitella* to represent a single species, based on examination of specimens with intermediate anatomy. Thus, the two species were united under the older name, *A. culcitella*. Subsequently, I have discovered that the syntypes of *A. culcitella* contained portions of dried animals. These were examined and it was determined that *A. culcitella* is anatomically distinct from all material considered by either Marcus or Gosliner as *A. culcitella* or *A. eximia*. The small gizzard plate of the syntypes of *A. culcitella* is dorsally flattened while that of *A. eximia* is laterally compressed. Thus, all specimens considered as *A. culcitella* or *A. eximia* by Marcus and Gosliner, must be regarded as *A. eximia*. *Acteocina culcitella* is known from shallow waters from the intertidal zone to approximately 10 m depth from Monterey south to San Diego, while *A. eximia* is known from depths exceeding 22 m in the northern part of its range (Vancouver Island) and as shallow as 60 m in southern California. Conchologically, *A. eximia* can be separated from *A. culcitella*. The spire is shorter in *A. eximia* and *A. culcitella* has a strong columellar pleat that is absent in *A. eximia*. The anatomy of *A. culcitella* is identical to that of *A. rolleri* (Marcus, 1977) and the latter represents a junior synonym of *A. culcitella*.

Type Locality and Type Specimens. Vancouver Island, British Columbia; paratype (BMNH 1869.3.21.78).

Distribution. Vancouver Island, British Columbia to San Diego, California.

Family Philinidae

Genus *Philine* Ascanius, 1772

Type Species: *Bulla aperta* Linnaeus, 1767.

Diagnosis. Shell internal bulloid to plate-like. Jaw rodlets absent. Radular formula 0-6.1.0-1.1.0-6. Gizzard teeth present or absent: when present, 3 in number. Reproductive system monaulic. Penis variable in shape, simple or elaborate.

Philine polystrigma (Dall, 1908), new combination

Figures 2.7A-C, 2.8A-B

Clistaxis? polystrigma Dall, 1908:246.

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta. 25, rep. 2 (1); Sta 25, rep. 3 (1), dissected, secondary voucher; Sta. R-3, rep. 3 (1), dissected; off Point Sal, Sta. PJ-13, rep. 3 (1); Sta. PJ-14, rep. 3 (1).

Description. Living animals 0.5-3.0 mm in length. Preserved animals uniformly light tan. Body divided into anterior head shield, posterior shield and lateral parapodia (Figure 2.7A). Anterior head shield anteriorly and posteriorly rounded. Posterior end of posterior shield rounded and terminating in a blunt lobe on either side. Shell internal, completely calcified, occupying almost all of posterior shield. Shell narrow with broad body whorl on columellar side. Shell with spiral, lightly punctate sculpture. Radular formula 16 × 1.0.1. Lateral teeth (Figure 2.8A) with elongate cusp and 25-30 fine, triangular denticles along the masticatory margin. Gizzard plates 3 (Figure 2.8B), of equal size and shape. Plates lenticular with thick prominent longitudinal ridge on dorsal side. Central nervous system (Figure 2.7B) euthyneurous. Penis (Figure 2.7C) simple with elongate convoluted prostate.

Biology. This species is found only from subtidal fine sediments where it is collected in dredge, core, and trawl samples. Members of this genus feed on hard shelled prey such as bivalves. Smaller species, such as *P. polystrigma*, feed almost exclusively on Foraminifera.

Remarks. *Clistaxis polystrigma* was described from a single specimen collected from San Diego Harbor (Dall, 1908). It has not been recorded since its original description. Dall was uncertain of the systematic status of this species. The dried holotype was rehydrated and examined in this study. The three equal, lenticular gizzard plates and radula with an inner lateral tooth per side clearly indicate this species is properly placed within the genus *Philine*. All of the anatomy of this holotype, including deeply punctate shell sculpture, shape of gizzard plates, and radula with a formula of 1.0.1, is consistent with specimens examined in this study.

Philine bakeri was described from a single shell collected off South Coronado Island. The shell is similar to the holotype of *P. polystrigma*. In 1944, Willett described *Philine californica* from a single shell collected off Redondo Beach (LACM 1075). He did not compare this species to other taxa. However, in comparing the holotype shells of *P. bakeri* and *P. californica* with that of *P. polystrigma*, it appears that they are all similar in shape and size. *Philine bakeri* and *P. californica* require further study and comparison with *P. polystrigma*.

Philine polystrigma is one of five philinids known from the temperate Pacific coast of California. Additional boreal species have been recorded from Alaskan waters (Lee and Foster, 1985). *Philine alba* Mattox, 1958 is readily distinguishable from *P. polystrigma* by its larger body size, smooth shell devoid of any distinct sculpture, proportionately smaller smooth gizzard plates, and simple penis with only a single, straight prostate. MacFarland (1966) and Behrens (1991) erroneously identified specimens of *P. alba* as *P. bakeri*.

Philine polystrigma is most similar to the sympatric species *Philine* sp. 1. The shell of *P. polystrigma* is narrower and more tightly coiled than that of *P.* sp. 1. Also, the shell of *P.* sp. 1 has much larger, deeper punctations to its sculpture. Internally, the radula of *P. polystrigma* has only a single row of lateral teeth on either side of the radula, while *Philine* sp. 1 has an additional outer row of teeth on either side. The gizzard plates of the two are similar in shape, though the mid-rib of the plate is thicker and broader in *P. polystrigma*. The penis of *P. polystrigma* is simple with elongate prostate. In *Philine* sp. 1, the penis is complex, with separate ejaculatory and prostatic portions.

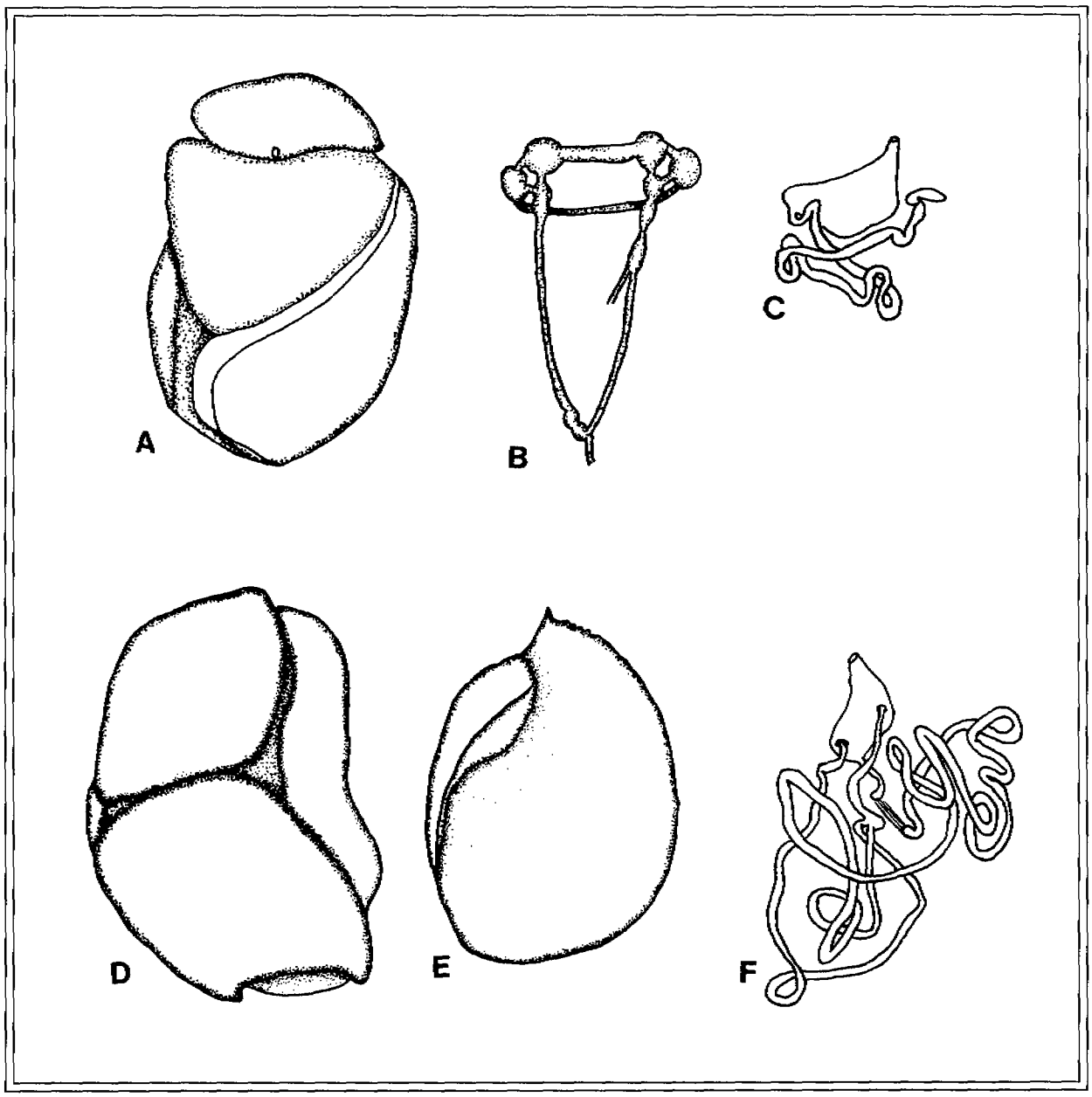

Figure 2.7. **A-C.** *Philine polystrigma* (Dall, 1908). **A.** Preserved animal, × 25. **B.** Central nervous system, × 40. **C.** Penis, × 40. **D-F.** *Philine* sp. 1, **D.** Preserved animal, × 15. **E.** Shell, × 20. **F.** Penis, 40.

Type Locality and Type Specimens. Off San Diego Harbor entrance, 50 fms; holotype (USNM 110649).

Distribution. This species is known from Santa Barbara to the Coronado Islands (Abbott, 1974).

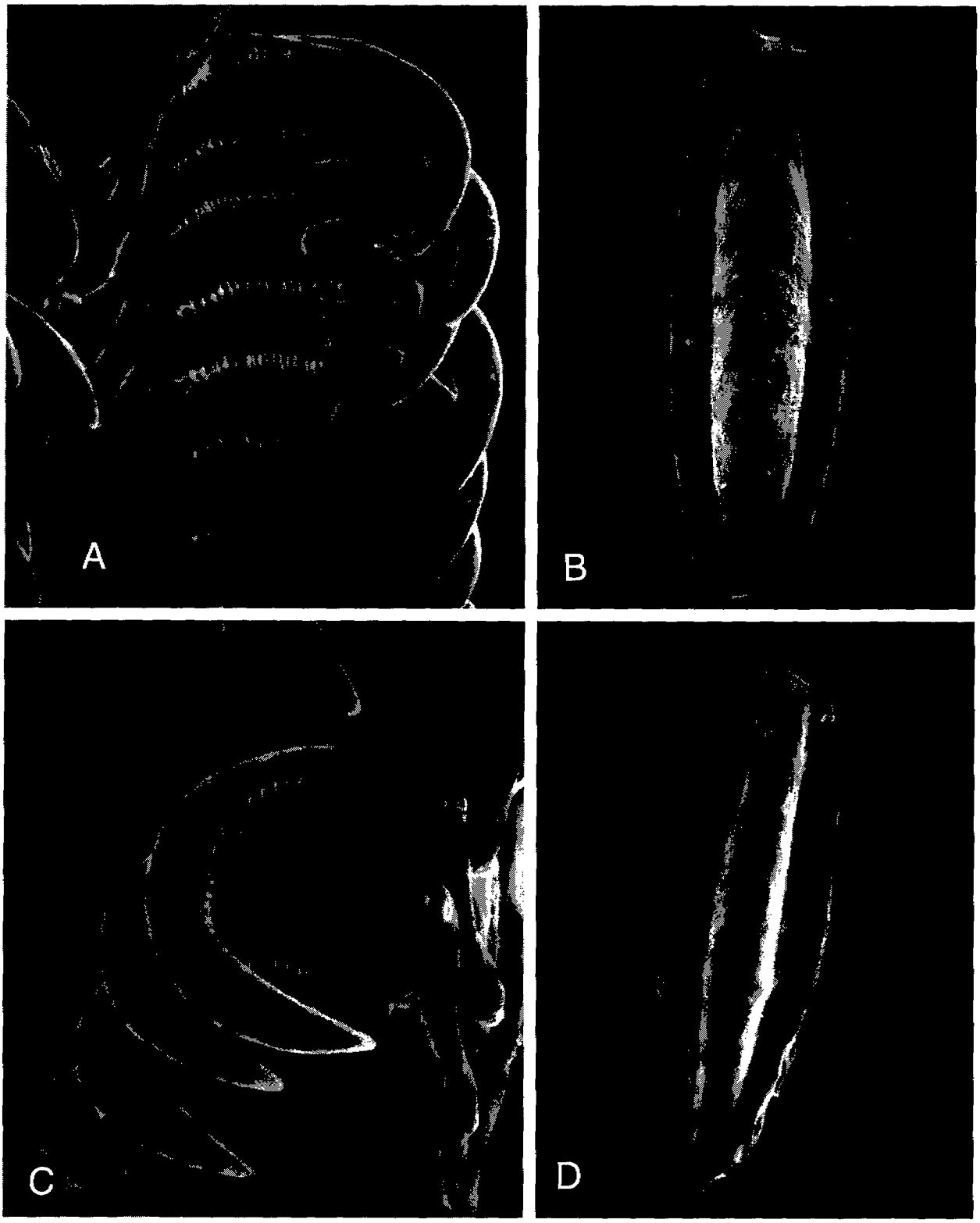

Figure 2.8. **A., B.** *Philine polystrigma.* **A.** Lateral teeth, × 700. **B.** Gizzard plate, × 50. **C., D.** *Philine* sp. 1, **C.** Lateral radular teeth, × 1200. **D.** Gizzard plate, × 70.

Philine sp. 1

Figures 2.7D-F, 2.8C-D, 2.9A

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta. 23, rep. 3 (2), one dissected, primary vouchers; Sta. 21, rep. 3 (1); Sta. PJ-2 (2); off Point Sal, Sta. PJ-8 (1); Sta. PJ-11 (1); Sta. PJ-15 (1); Sta. PJ-22 (1); Sta. R-8 (1) dissected.

Description. Preserved animals 1-5 mm in length, uniformly tan. Body divided into anterior head shield, posterior shield and lateral parapodia (Figure 2.7C). Anterior head shield anteriorly and posteriorly rounded. Posterior end of posterior shield rounded and terminating in a short, triangular lobe on either side. Lobes approximately equal in size.

Shell (Figure 2.7D) internal, completely calcified, occupying most of posterior shield. Shell flat, broad with obvious pitted, punctate sculpture (Figure 2.9A). Posteriormost portion of shell extended into pointed lobe. Columellar portion of shell narrow. Radular formula 15 × 1.1.0.1.1. Inner lateral teeth (Figure 2.8C) large curved, denticulate with 22-34 elongate denticles. Outer lateral teeth shorter and simple, without denticles. Gizzard plates (Figure 2.8D) 3, equal in size. Plates lenticular with prominent longitudinal ridge on dorsal side. Penis (Figure 2.7F) complex with separate ejaculatory and prostatic ducts. Prostate extremely elongate and convoluted. Penial papilla simple, conical, unarmed.

Biology. This species is known only from fine soft sediments in 90-155 m of water (Dall, 1908; present study). Like *Philine polystrigma*, *Philine* sp. 1 probably feeds on Foraminifera.

Remarks. *Philine* sp. 1 is morphologically similar to the sympatric species *Philine polystrigma*. Specific differences are discussed above, and include different shell shape and sculpture, radular formula, gizzard plates, and penial morphology.

Distribution. This species is known only from the Santa Maria Basin (present study).

Philine sp. 2

Figures 2.9B-C, 2.10A

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta R-1 (1), dissected.

Description. Single specimen (Figure 2.10A) approximately 1 mm in length. Head shield short, rounded posteriorly. Parapodia short, not extending over head and posterior shields. Posterior shield elongate with elongate skirt-like posterior lobes. Shell internal, largely decalcified in specimen examined. Gizzard plates absent, thin walled crop present. Radular formula 13 × 6.1.0.1.6. Inner lateral teeth (Figure 2.9B) broad with hook-shaped cusp. No secondary denticles present on inner side of tooth. Outer lateral teeth narrower hook-shaped without secondary denticles. Penis with short bulbous prostate.

Remarks. This species appears to be undescribed. It is the only species along the Pacific coast with more than one outer lateral tooth per side of the radula. The only other species of *Philine* with as many rows of radular teeth is *P. pruinosa*. It differs in having a denticulate inner lateral tooth (Thompson, 1976). *Philine* sp. 2 is the only species of *Philine* along the California coast that lacks gizzard plates. Additional material is required before this species can be described.

Distribution. Thus far, *Philine* sp. 2 is known only from the Santa Maria Basin.

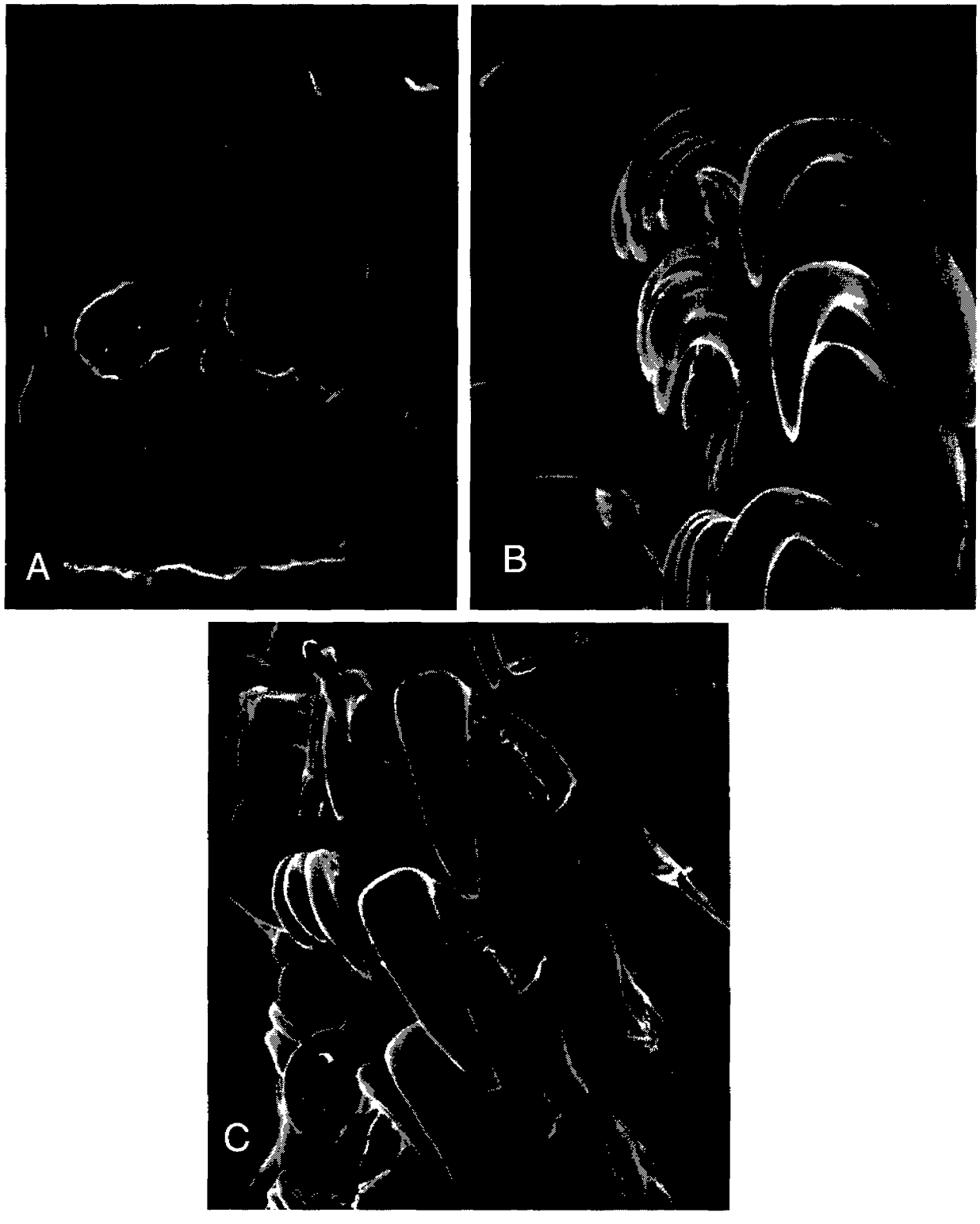

Figure 2.9. **A.** *Philine* sp. 1, shell sculpture, × 300. **B.** *Philine* sp. 2, radular teeth, × 700. **C.** *Gastropteron pacificum* Bergh, 1893, radular teeth, × 300.

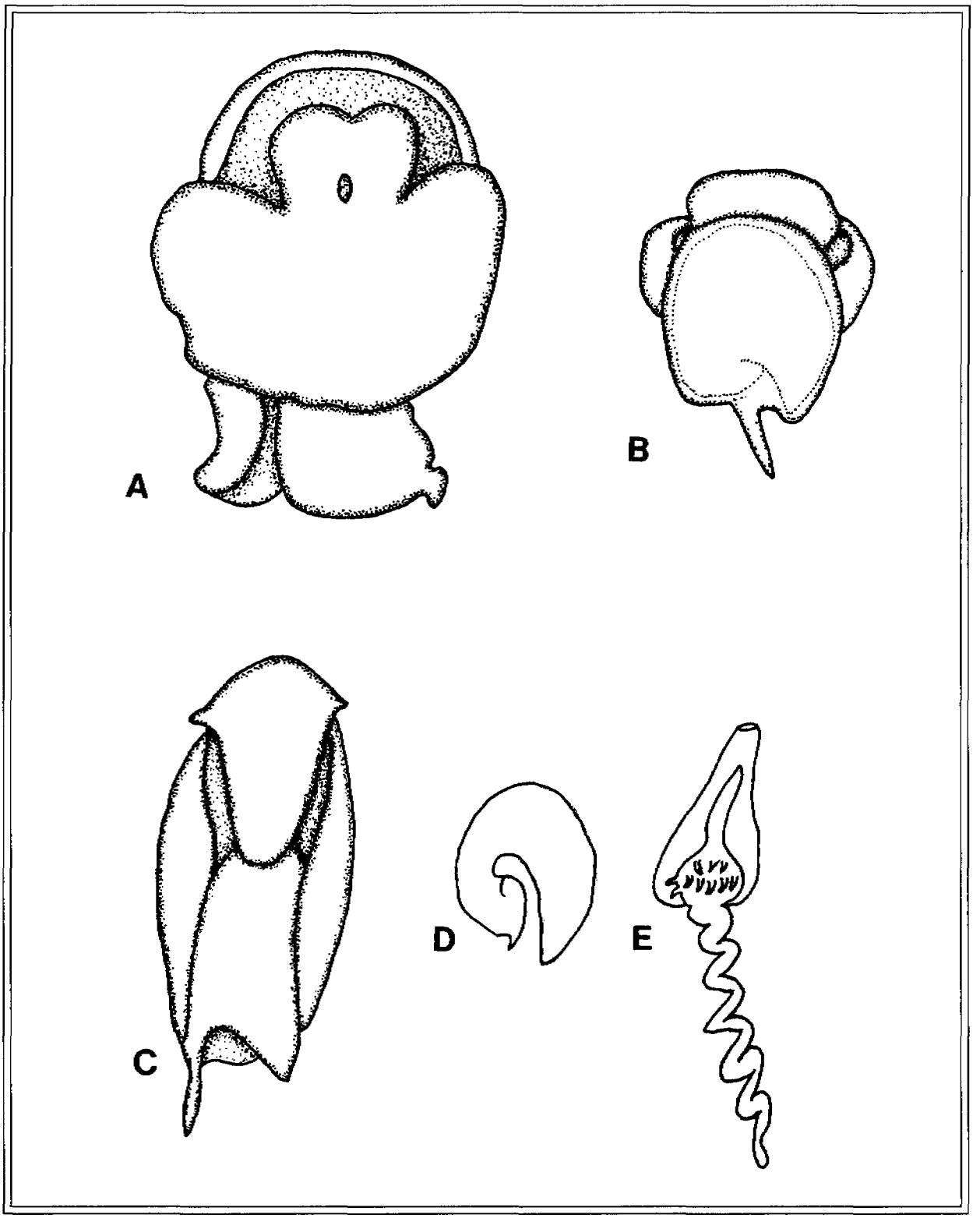

Figure 2.10. **A.** *Philine* sp. 2, preserved animal, × 80. **B.** *Aglaja* sp., preserved animal, × 40. **C.-E.** *Aglaja ocelligera* (Bergh, 1893). **C.** Preserved animal, × 5. **D.** Shell, × 10. **E.** Penis, × 10.

Family Aglajidae

Genus *Aglaja* Renier, 1807

Type Species: *Aglaja tricolorata* Renier, 1807.

Diagnosis. Shell an internal, completely calcified plate. Radula absent. Gizzard plates absent. Reproductive systems monaulic. Penis armed or unarmed.

Aglaja ocelligera (Bergh, 1893)

Figures 2.1B, 2.10C-E

Doridium ocelligerum Bergh, 1893a:133.—Bergh, 1894: pl 10, fig. 10; pl. 12, figs. 5,6.

Aglaja ocelligera: Pilsbry, 1896.—Rudman, 1974: fig. 13.—Gosliner, 1980:330, figs. 2, 14.

Doridium adellae Dall, 1894:73.—Pilsbry, 1896: pl. 9, fig. 22.—Gosliner, 1980: 330.

Chelidonura phocae Marcus, 1961:8, figs. 18-24.

Aglaja phocae: Rudman, 1974:207.

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta 21, rep. 3 (2), primary vouchers; Sta. PJ-1 rep. 3 (1); off Point Sal, Sta. PJ-15, rep. 3 (1).

Description. Living animals (Figure 2.1B, 2.10C) 3-20 mm in length and brownish black with small opaque white spots. Body divided into anterior head shield, posterior shield, and lateral parapodia. Anterior head shield anteriorly lobed with laterally directed projection on either side of body. Posterior end of head shield rounded. Posterior shield terminating in elongate "tail" on left side of body and shorter triangular lobe on right side. Lobe on left side may be greatly contracted in preserved material, but still visible. Shell (Figure 2.10D) internal, completely calcificed, occupying posterior portion of posterior shield. Radula and gizzard plates absent. Penis (Figure 2.10E) armed with row of cuticular spines. Prostate elongate, convoluted.

Biology. This species is common on intertidal mudflats and subtidal habitats consisting of fine sand or silt. This species is predatory on other invertebrates, though the precise feeding preferences remain unknown. Like other members of the Aglajidae, it ingests its prey whole by means of suction from its muscular buccal mass.

Remarks. This species is one of five aglajids known from the temperate Pacific coast of North America. It is the only species with a simple lateral lobe of the anterior portion of the head shield, a thin, completely calcified shell, and a penis with numerous chitinous spines. The three species of *Navanax* also present in the region have an anterior portion of the head shield with four distinct lobes. The posterior ends of the posterior shield are subequal in length as compared to the elongate left tail present in *A. ocelligera*. The three species of *Navanax* also have different shaped shells. In *Navanax aenigmaticus* and *N. inermis* the shell has a thin calcified portion and a broad membranous portion. In *N. polyalphos*, the shell is completely calcified, but broader than that of *A. ocelligera* (Gosliner and Williams, 1972). *Melanochlamys diomedea* has a simply rounded anterior portion of the head shield, blunt posterior ends of the posterior shield, and a shell that occupies most of the cavity of the posterior shield. The systematics and synonymy of *Aglaja ocelligera* were discussed by Gosliner (1980).

Type Locality and Type Specimens. Type locality not designated in original description. Type material unknown.

Distribution. This species is known from the Pacific coast of North America from Sitka, Alaska to Mission Bay, San Diego (Behrens, 1991).

Aglaja sp.

Figure 2.10B

Material Examined. California, off Purisima Point, Sta. R-4, rep. 1 (4); off Point Sal, Sta. R-8, rep. 2 (2); Sta. PJ-15, rep. 3 (1).

Description. Body uniformly whitish brown, 0.5-1 mm in length. Body divided into anterior head shield, posterior shield, and lateral parapodia (Figure 2.10B). Anterior head shield anteriorly rounded. Posterior end of head shield rounded. Posterior shield terminating in elongate "tail" on left side of body and shorter triangular lobe on right side. Lobe on left side may be greatly contracted in preserved material, but still visible. Shell internal, completely calcificed, occupying most of cavity of posterior shield. Radula and gizzard plates absent. Penis immature in all material examined.

Biology. Little is known about the biology of this species. One of the specimens examined had a large spionid polychaete filling the thin-walled crop.

Remarks. This species appears to be distinct from *A. ocelligera*. Although both species have an elongate filiform appendage on the left side of the posterior portion of the posterior shield, *Aglaja* sp. has a shell that occupies most of the posterior shield cavity. In *A. ocelligera*, the shell is a thin band that occupies only the posterior portion of the shield. While the present specimens are immature, it appears that they differ from *A. ocelligera*, based on conchological differences. Further study is required to confirm the distinctness of this species.

Distribution. Thus far, this species is known only from the Santa Maria Basin.

Family Gastropteridae

Genus *Gastropteron* Meckel, in Kosse, 1813

Type Species: *Gastropteron rubrum* Meckel in Kosse, 1813.

Diagnosis. Shell internal reduced to small, flat plate. Parapodia large, natatory. Siphon a simple tube. Radular formula 4-6.1.0.1.4-6. Inner lateral teeth denticulate. Outer laterals smooth. Reproductive system monaulic. Penis simple to complex.

Gastropteron pacificum Bergh, 1893

Figures 2.1C, 2.9C, 2.11A-B

Gastropteron pacificum Bergh, 1893b:303, pl. 16 fig. 28, pl. 17, figs. 10-26.

Gastropteron (*pacificum* Bergh var. ?) *cinereum* Dall, 1925: fig. 4.—Gosliner, 1984:243.

Gastropteron cinereum: Tokioka and Baba, 1964:206.

Material Examined. California, Santa Maria Basin, off Point San Luis and Point Sal, Sta 21, rep. 3 (1); Sta PJ-1 rep. 3 (2); Sta. PJ-6, rep. 1 (2); Sta. R-8, rep. 2 (1).

Description. Living animals (Figure 2.1C) 0.5-30 mm in length. Living animals whitish with scattered red-brown spots. Body divided into anterior head shield, posterior shield, and lateral parapodia. Anterior head shield rounded and slightly lobed anteriorly. Posterior end of head shield terminating in simple, folded siphon. Posterior shield rounded posteriorly, without lateral flagellum. Parapodia large, muscular, used for swimming. Gill situated on right side of posterior shield; consisting of approximately 15 pinnae. Anus

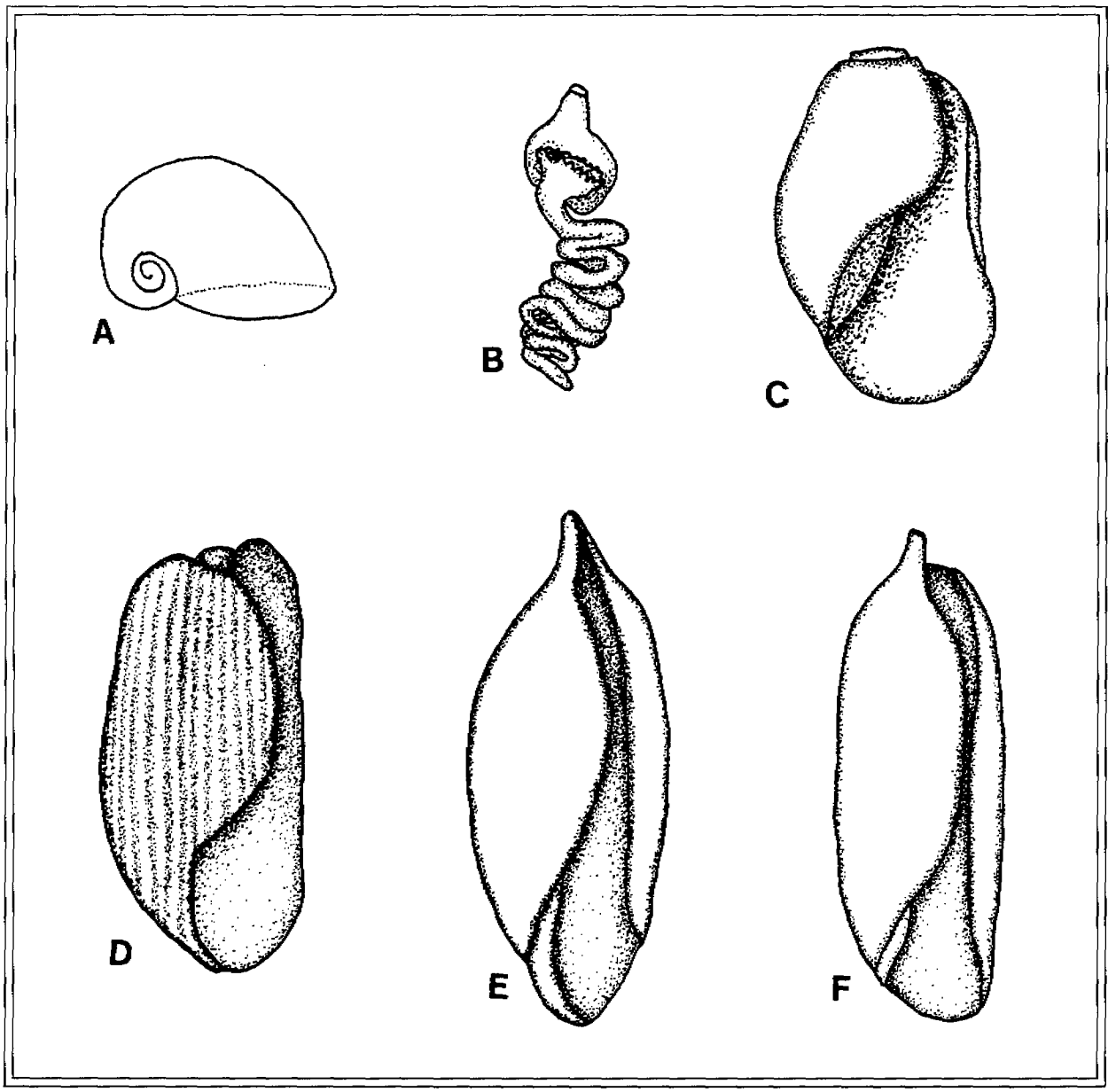

Figure 2.11. **A, B.** *Gastropteron pacificum* Bergh, 1893. **A.** Shell, after MacFarland, 1966. **B.** Penis, × 25. **C.** *Diaphana californica* shell, × 10. **D.** *Retusa xystrum* Dall, 1919, shell, × 50. **E.** *Volvulella californica* Dall, 1919, shell, × 25. **F.** *Volvulella panamica* Dall, 1919, shell, × 30.

situated near posterior end of gill. Shell (Figure 2.11A) internal, completely calcificed, occupying posterior portion of posterior shield. Radular formula 20-22 × 5-6.1.0.1.5-6. Inner lateral teeth large, denticulate (Figure 2.9C). Outer lateral teeth smaller, without denticles. Gizzard plates absent. Penis (Figure 2.11B) with row of cuticular papillae. Prostate elongate, highly convoluted.

Biology. *Gastropteron pacificum* is common subtidally to depths of 400 m, and occasionally found on intertidal mudflats. Like other members of the Gastropteridae, it is predatory on other invertebrates, though the precise food remains unknown. This species is often collected in plankton nets, owing to its propensity for swimming through the water column. However, it is primarily a benthic rather than a planktonic species.

Remarks. This species is the only gastropterid known from the Pacific coast of North America. Another species, *Gastropteron cinereum* Dall, 1925, has been shown to be a synonym of *G. pacificum* (Gosliner, 1984). It is readily distinguishable by its short, rounded posterior shield and large natatory parapodia.

Type Locality and Type Material. Aleutian Islands. Type material unknown.

Distribution. This species is known from the Pacific coast of North America from Alaska to Baja California (Behrens, 1991).

Family Retusidae

Genus *Retusa* Brown, 1827

Type Species: *Retusa obtusa* (Montagu, 1807).

Diagnosis. Shell with elevated or bulloid spire. Operculum present or absent. Jaws and radula absent. Gizzard teeth 3, equal or subequal, tuberculate. Reproductive system monaulic. Penis simple, unarmed.

Retusa xystrum Dall, 1919

Figures 2.11D, 2.12A-B

Retusa xystrum Dall, 1919:297.

Material Examined. California, Santa Maria Basin, off Point San Luis and Point Sal, Sta. 21, rep. 2 (20); Sta. 21, rep. 1 (18); Sta. R-1, rep. 1 (2), rep. 3 (4); off Purisima Point, Sta. R-8, rep. 1 (2).

Description. Shell (Figure 2.11D) external, bulloid, with numerous longitudinal striae (Figure 2.12A). Shell 1.0-1.5 mm long. Jaws and radula absent. Gizzard plates (Figure 2.12B) unequal; one plate wider than other 2. Plates with rounded tubercles. Largest tubercle situated on inner side of each plate.

Biology. Little is known about the biology of *Retusa xystrum*. Other species of *Retusa* are known to feed on foraminiferans.

Remarks. *Retusa xystrum* its poorly known and its anatomy was undescribed prior to this study. It has not been adequately compared to *R. galapagana* Dall, 1919, known only from the Galapagos, *R. carpenteri* Hanley, 1859, known from Mazatlan, Mexico, and *R. paziana* Dall, 1919, known from the Gulf of California from San Luis Gonzaga Bay to La Paz. These species are all very similar conchologically to *R. xystrum*, but their anatomy remains unknown. Further investigation is required to establish the systematics of the eastern Pacific *Retusa* spp.

Some workers place species with similar shell morphology within the genus *Sulcoretusa*. At present this division is based solely on conchological features. More information regarding retusid anatomy is required before this division can be substantiated.

Type Locality and Type Specimens. San Diego, California; holotype, (USNM 273985).

Distribution. This species is known from San Pedro to San Diego, California (Dall, 1919).

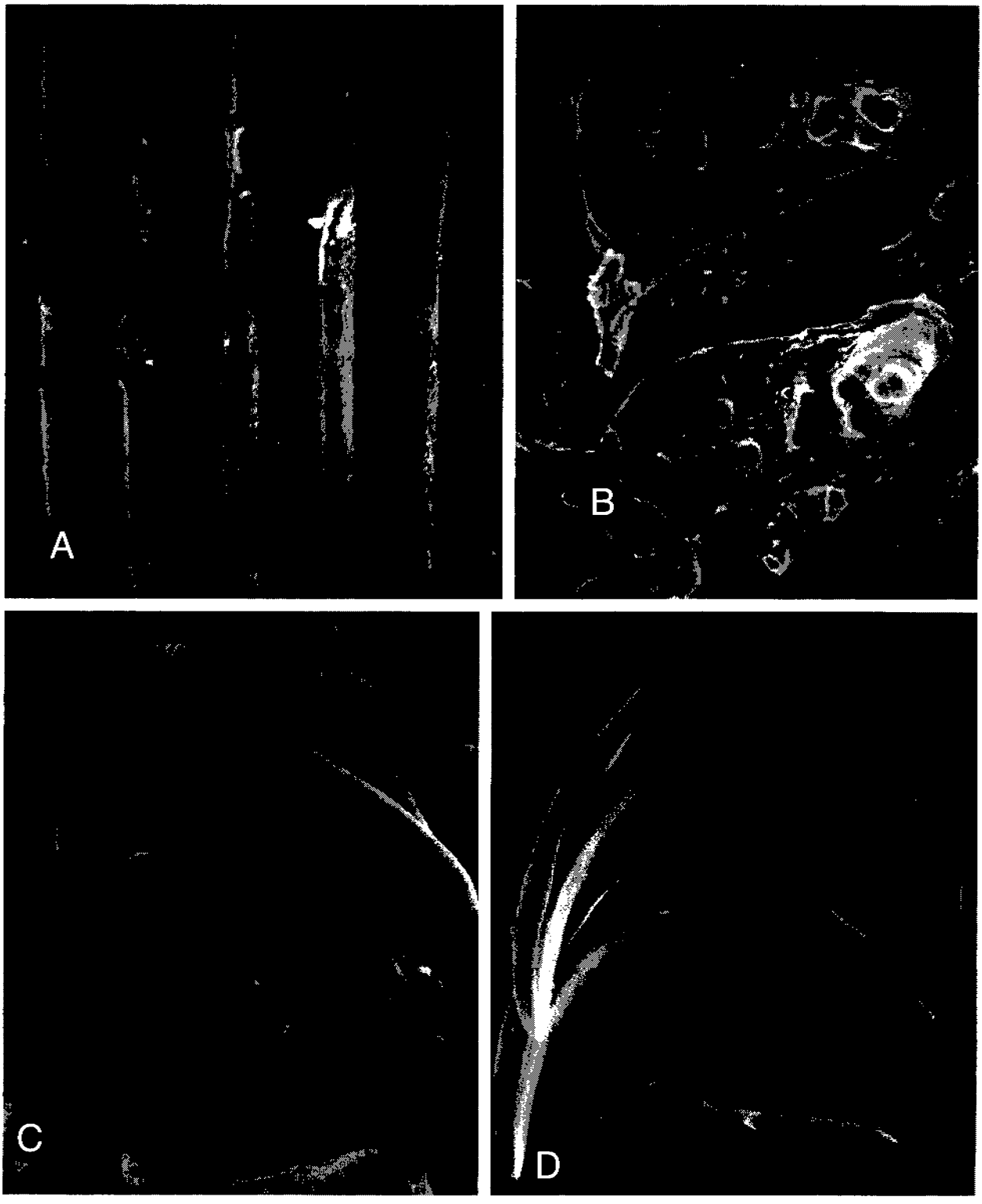

Figure 2.12. **A., B.** *Retusa xystrum* Dall, 1919. **A.** Shell sculpture, × 500. B. Gizzard plates, × 400. **C., D.** *Diaphana californica* Dall, 1919. **C.** Rachidian teeth, × 1500. **D.** Lateral teeth, × 1500.

Genus *Volvulella* Newton, 1891

Type Species: *Volvulella acuminata* (Brugière, 1792).

Diagnosis. Shell bulloid, acutely pointed posteriorly. Operculum absent. Jaws, radula and gizzard plates absent. Reproductive system monaulic. Penis simple.

Volvulella californica Dall, 1919

Figure 2.11E

Volvulella californica Dall, 1919:298.

Material Examined. California, Santa Maria Basin, off Point Estero, Point Sal, and Point Arguello, Sta. 3, rep. 1 (1); Sta. 61, rep. 1 (1); Sta. R-8, rep. 1 (1); Sta. R-8, rep. 2 (1).

Description. Shell (Figure 2.11E) 1-3 mm in length, smooth, without sculpture, widest in middle, tapered at both ends. Posterior projection acute, elongate. Operculum, jaws, radula, and gizzard plates absent.

Biology. Little is known about the biology of this species. The present material was collected from 90-345 m depth.

Remarks. Abbott (1974) suggested that *Volvulella californica* may be a "fat" form of *V. cylindrica*. *Volvulella californica* is consistently devoid of sculpture and pyriform in shape, while *V. cylindrica* has sculpture and is far more cylindrical. *Volvulella panamica* (see following description) is also cylindrical in shape, but differs from both *V. californica* and *V. cylindrica* in that the posterior end of its outer lip begins at the base of the posterior spine rather than at its apex.

Type Locality and Type Material. Off Santa Rosa Island, California, 53 fms.; holotype (USNM 211303).

Distribution. Santa Cruz, California to Todos Santos Bay, Baja California (Abbott, 1974).

Volvulella panamica Dall, 1919

Figure 2.11F

Volvulella panamica Dall, 1919:298.

Volvulella tenuissima Willett, 1944:71, pl. 14, fig. 1.—Keen, 1971.

Material Examined. California, Santa Maria Basin, off Point San Luis, Point Sal, and Point Conception, Sta. 80, rep. 2 (1); Sta. 86, rep.1 (1); Sta. 79 (1); Sta. R-1, rep. 1 (2); Sta. R-8, rep. 1 (1); Sta. R-8, rep. 2 (4); Sta. R-8, rep. 3 (3).

Description. Shell (Figure 2.11F) cylindrical, 2.5-5 mm in length, shell smooth, devoid of sculpture, with prolonged posterior projection. Posterior end of outer lip originating at base of posterior projection. Jaws, radula and gizzard plates absent.

Biology. Little is known about the biology of this species. The present material is from 90-197 m depth.

Remarks. Differences between this and other sympatric species are discussed above under *Volvulella californica*. The present material represents a northern range extension from Redondo Beach, California.

Type Locality and Type Specimens. Panama Bay, 60 m; holotype (USNM 212654).

Distribution. Santa Maria Basin, California to Panama (Abbott, 1974, present study).

Family Diaphanidae

Genus *Diaphana* Brown, 1837

Type Species: *Diaphana minuta* (Brown, 1827).

Diagnosis. Shell thinly calcified. Spire slightly elevated or bulloid. Operculum absent. Jaws reduced. Radular formula 1.1.1. Rachidian teeth bilobed, denticulate. Lateral teeth elongate with minute denticles. Gizzard plates absent. Reproductive system monaulic. Penis simple or complex.

Diaphana californica Dall, 1919

Figures 2.1F, 2.11C, 2.12C-D

Diaphana californica Dall, 1919:299-300.

Material Examined. California, Santa Maria Basin, off Point San Luis, Sta. 21, rep. 2 (1), secondary voucher; Sta. PJ-1, rep. 3 (2); Sta. PJ-19, rep. 2 (2); Sta. PJ-22, rep. 2 (1), dissected.

Description. Living animal as in Figure 2.1F. Shell (Figure 2.11C) with slightly elevated spire, 1-5 mm in length. Anterior portion of outer lip flared. Jaws reduced, without distinct armature. Radular formula 13 × 1.1.1. in one small specimen examined. Rachidian teeth (Figure 2.12C) with 2 denticle bearing lobes, each with approximately 20 denticles. Lateral teeth (Figure 2.12C) curved. Minute denticles present along outer edge of tooth. Penis complex, with elongate prostate.

Biology. Little is known about the biology of species of *Diaphana*. They appear to be carnivorous and are found under rocks with a well developed growth of a variety of colonial animals. *Diaphana californica* is found from tide pools to subtidal depths. Specimens in this study were collected from 49-167 m depth.

Remarks. Species of *Diaphana* have been recorded as having smooth lateral teeth. This is an artifact of poor resolution of light microscopy. Scanning electron micrographs clearly show denticulations of the outer lateral teeth in all species that have been examined by this means (Gosliner, 1994). *Diaphana brunnea* Dall, 1919, described from Kodiak Island, Alaska, may be a synonym of *D. californica*. Further study is required to resolve their taxonomy.

Type Locality and Type Material. Long Beach, California; holotype (USNM 130561).

Distribution. Cape Arago, Oregon to Coronados Islands, Baja California (Behrens, 1991).

Family Pleurobranchidae

Genus *Berthella* Blainville, 1825

Type Species: *Berthella plumula* (Montagu, 1803).

Diagnosis. Shell internal, flattened, with punctate sculpture. Gill external, without tubercles. Jaw elements smooth to multifid. Radula broad with many smooth teeth. Rachidian teeth absent. Reproductive system diaulic. Penial gland present. Penis unarmed.

Berthella californica (Dall, 1900)

Figures 2.1D, 2.13A-B, D, 2.14A

Pleurobranchus californicus Dall, 1900:92.

Pleurobranchus chacei Burch, 1944.—MacFarland, 1966:84.

Pleurobranchus californicus denticulatus MacFarland, 1966:84, pl. 5. figs. 1-5, pl. 13, figs. 25-34, pl. 16, fig. 12.

Berthella californica: Lance, 1966:71.—Gosliner and Bertsch, 1988:46, figs. 1A, 2,3.

Berthella denticulatus: Lee and Foster, 1985:442.

Material Examined. California, Santa Maria Basin, off Point Buchon, Sta. BRA 13 rep. 4, (1), dissected.

Description. Living animals (Figure 2.1D) white to brown with scattered opaque white spots covering the dorsal surface. Gill external, situated on right side of body. Shell internal, covering most of dorsal surface. Shell (Figure 2.14A) with numerous irregular rows of punctate sculpture (Figure 2.13A). Jaws with numerous rows of triangular rodlets, with (Figure 2.13B) or without a series of denticles along margin. Radular formula 34 x 26.0.26 in specimen examined. Innermost teeth (Figure 2.13D) with bifid cusp. Outer teeth more elongate.

Biology. Most species of *Berthella* feed on compound tunicates. *Berthella californica* is found in rocky habitats from intertidal pools to about 20 m depth (Bertsch and Gosliner, 1988). The present specimen was dredged from 88.5-100.5 m depth.

Remarks. Gosliner and Bertsch (1988) have reviewed the morphology and systematics of eastern Pacific species of *Berthella*. The only sympatric species, *Berthella strongi*, differs in its coloration and radular and reproductive morphology.

Type Material and Locality. San Pedro, California, holotype (USNM 107893).

Distribution. Point Craven, Alaska to Coronados Islands, Baja California (Behrens, 1991).

Genus *Pleurobranchaea* Leue, 1813

Type Species: *Pleurobranchaea meckelii* Leue, 1813.

Diagnosis. Shell absent. Gill situated on right side of body. Anterior margin of velum tuberculate. Notum and foot broad. Rhinophores well separated. Jaws with multifid rodlets. Radular teeth elongate with acute bifid cusp. Reproductive system diaulic. Penis armed or unarmed.

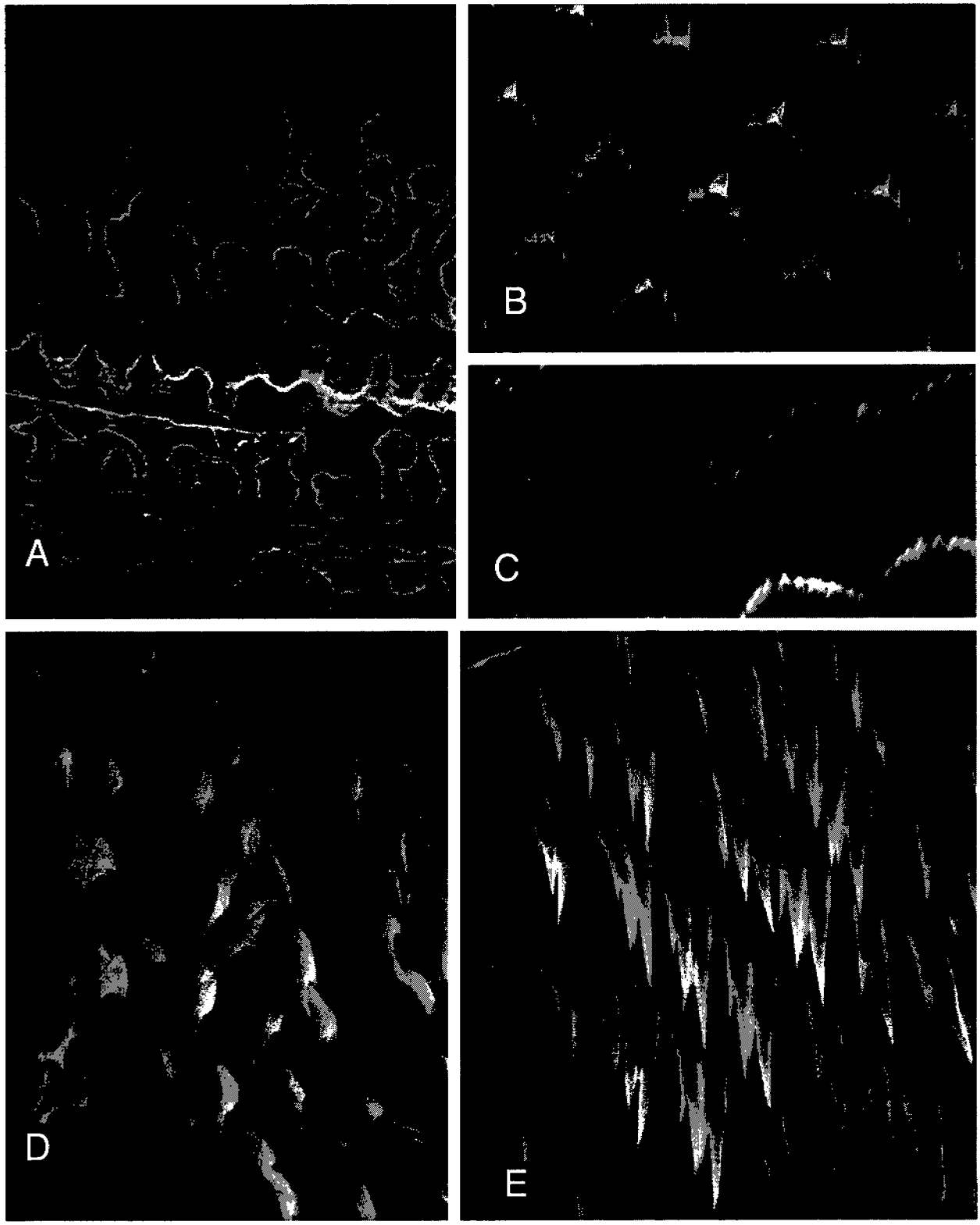

Figure 2.13. **A, B.** *Berthella californica* (Dall, 1900). **A.** Shell sculpture, × 300. B. Jaw rodlets, × 1500. **C.** *Pleurobranchaea californica* MacFarland, 1966, jaw rodlets, × 1200. **D.** *Berthella californica* (Dall, 1900), inner radular teeth, × 200. **E.** *Pleurobranchaea californica* MacFarland, 1966, radular teeth, × 500.

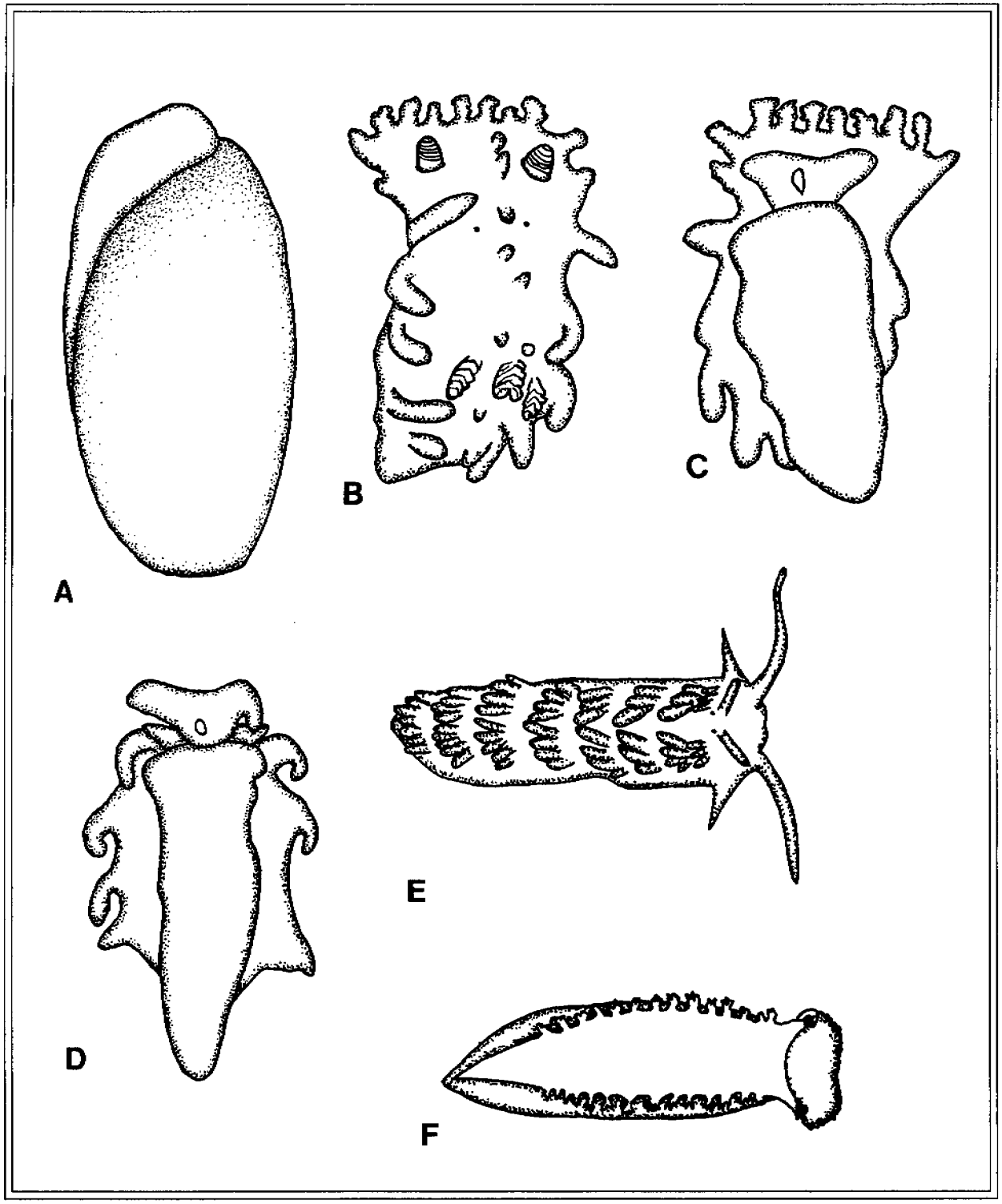

Figure 2.14. **A.** *Berthella californica* (Dall, 1900), shell, × 30. **B., C.** *Holoplocamus* sp. **B.** dorsal view of preserved specimen. **C.** Ventral view of preserved specimen, × 40. **D.** *Okenia* sp., ventral view of preserved specimen, × 65. **E.** *Cerberilla mosslandica* McDonald and Nybakken, 1975, living animal. **F.** *Tritonia diomedea* Bergh, 1894, living animal.

Pleurobranchaea californica MacFarland, 1966

Figures 2.1E, 2.13C, E

Pleurobranchaea californica MacFarland, 1966:94-101. pl. 15, figs. 16-28, pl. 17, figs. 1-17.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta PJ-6, rep. 1 (1); Sta. PJ-6, rep. 2 (1), dissected; Sta. PJ-7, rep. 2 (1); Sta. R-4, rep. 1 (1).

Description. Living animals (Figure 2.1E) 3-210 mm. Body brown with translucent and opaque white patches. Rhinophores well separated. Anterior margin of head with numerous papillae. Foot elongate, extending well beyond notum posteriorly. Gill pinnate, situated on right side of body. Shell absent. Jaw platelets (Figure 2.13C) polygonal with numerous denticles along anterior margin. Radular formula 22-52 × 38-145.0-1.38-145. Lateral teeth (Figure 2.13E) with elongate (in juvenile specimens) or rudimentary cusp (in mature specimens). Penis muscular, unarmed.

Biology. *Pleurobranchaea californica* is a voracious carnivore and feeds primarily on sea anemones and other opisthobranchs. It is very opportunistic and feeds on a wide variety of prey. It is found from 10-400 meters depth and is one of the most common subtidal opisthobranchs in soft substrate habitats.

Remarks. The systematics of *Pleurobranchaea* was reviewed by Marcus and Gosliner (1985). *Pleurobranchaea californica* was placed in its own subgenus, *Macfarlandaea*, based on the fact that it has lateral teeth with a rudimentary cusp. Willan (1987) stated that this separation was unnecessary. I concur with his rationale for disregarding the subgeneric separation, especially since juvenile specimens have well-developed bifid teeth as in other members of the genus. *Pleurobranchaea californica* is the only member of the genus present along the Pacific coast of North America. It differs from other sympatric pleurobranchids in lacking an internal shell.

Type Locality and Type Specimens. San Francisco, outside Golden Gate, southeast of Farallon Light, California; syntypes: (USNM 5775225; CASIZ 021594, 024055, 029179, 067460, 067462, microscope slides 089256-089266).

Distribution. Port Orford, Oregon to San Diego, California (Behrens, 1991).

Family Aldisidae

Genus *Aldisa* Bergh, 1878

Type Species: *Doris zetlandica* Alder and Hancock, 1854.

Diagnosis. Notum with low rounded tubercles. Rhinophoral and gill pockets ringed with tubercles. Labial tentacles reduced into broad oral pad. Jaws reduced to thin labial cuticle. Radular teeth extremely elongate with denticles along margin and at apex. Reproductive system triaulic. Penis lined with rows of chitinous spines.

Aldisa sanguinea (Cooper, 1863)

Figures 2.15A, 2.16A-B

Doris (*Asteronotus*) *sanguinea* Cooper, 1863:204.

Aldisa sanguinea: MacFarland, 1966:169, pl. 25, fig. 8, pl. 29, fig. 11, pl. 35, figs. 17-22.—Millen and Gosliner, 1985: figs. 2, 4A, 6I, 13.

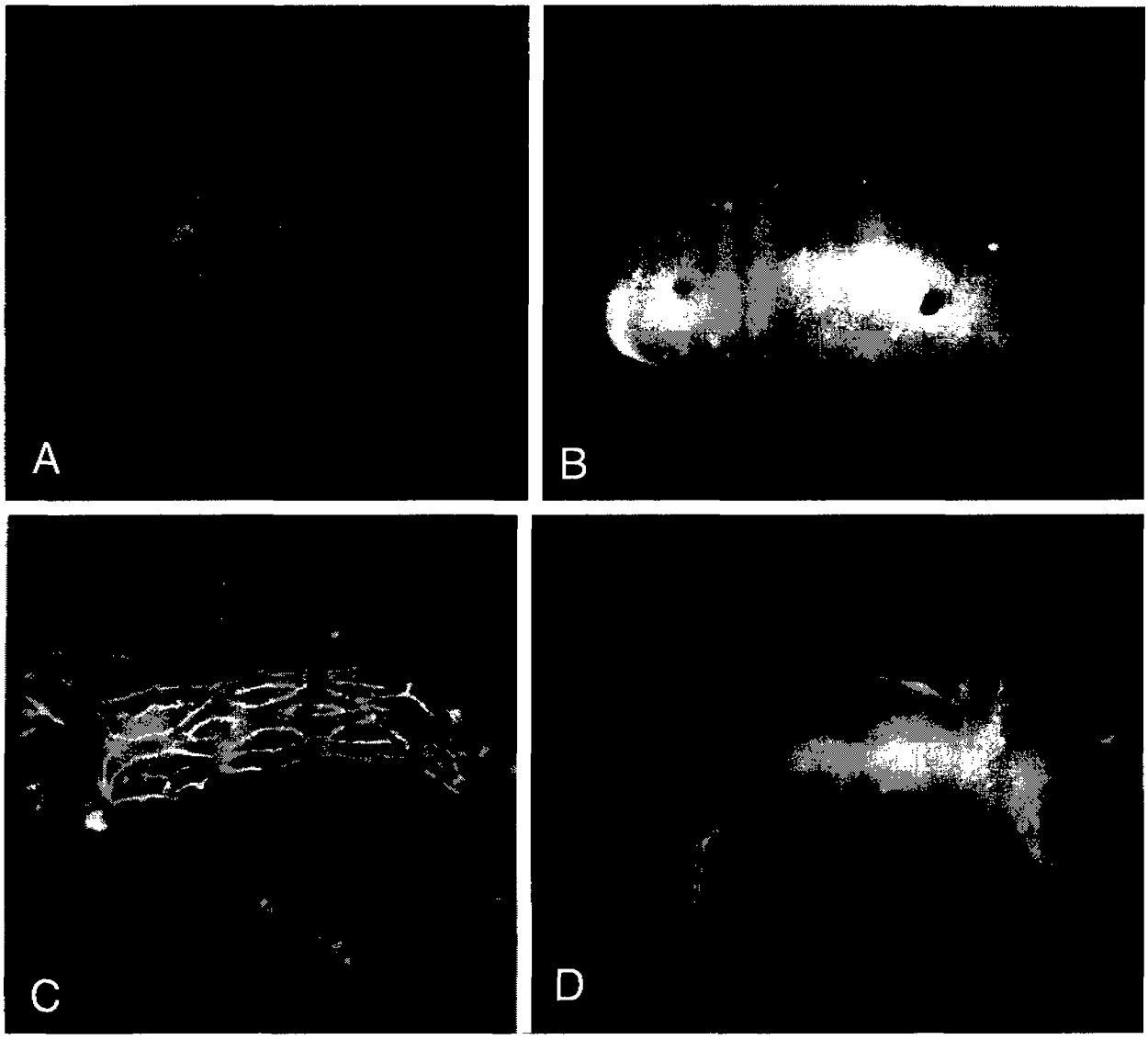

Figure 2.15. Living animals. **A.** *Aldisa sanguinea* (Cooper, 1863), **B.** *Cadlina flavomaculata* MacFarland, 1905. **C.** *Tritonia festiva* (Stearns, 1873). **D.** *Dendronotus frondosus* (Ascanius, 1774).

Material Examined. California, Santa Maria Basin, off Point Conception, Sta. BRA 2, rep. 1 (1), dissected.

Description. Living animals (Figure 2.15A) up to 20 mm in length. Color bright red orange with 2 large mid-dorsal darker spots, occasionally with tan flecks forming a T-shaped mark anterior to gills. Notum covered with low rounded tubercles. Oral tentacles reduced, forming a broad area anterior to foot. Jaws without rodlets. Radular teeth numerous, elongate (Figure 2.16A) with numerous denticles along apical margin and along inner side (Figure 2.16B). Penis armed with several rows of hook-shaped barbs.

Biology. This species feeds on sponges of the genera *Ophlitaspongia* and *Hymendesmia* (Behrens, 1991). It is found from intertidal rock pools to a depth of 80 m.

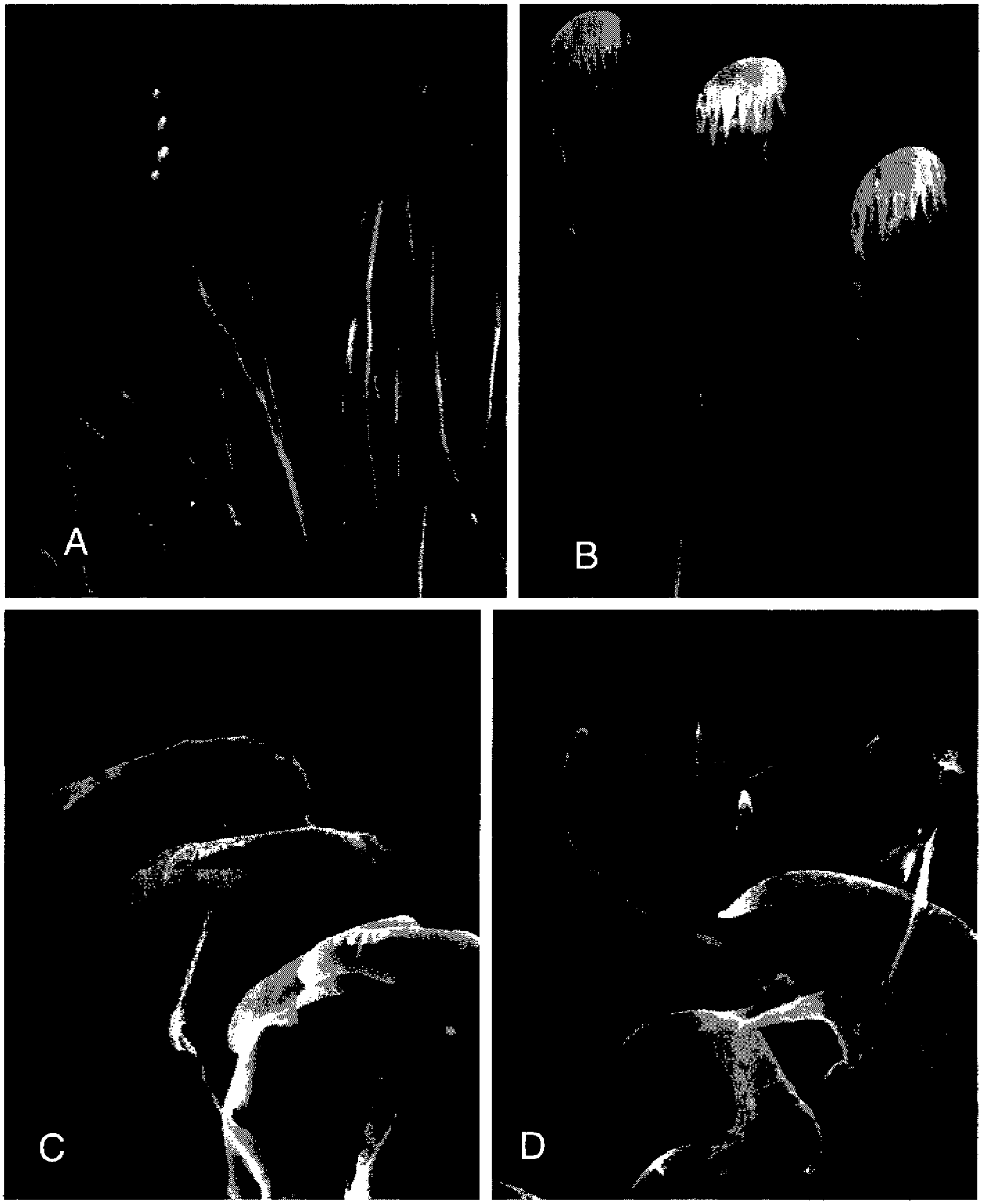

Figure 2.16. **A, B.** *Aldisa sanguinea* (Cooper, 1863), radular teeth, × 500. **C., D.** *Okenia* sp. **C.** Inner lateral teeth, × 1500. **D.** Outer lateral teeth, × 3000.

Remarks. The taxonomy of the eastern Pacific species of *Aldisa* was reviewed by Millen and Gosliner (1985). Four species are known from the Pacific coast of North America, yet *A. sanguinea* is the only species found south of Trinidad Head, in extreme northern California. *Aldisa cooperi* is similar to *A. sanguinea* in having orange body color, but differs in having a series of small dark dots rather than a pair of large ones. It also has internal differences of the radula and reproductive system (Millen and Gosliner, 1985).

Type Locality and Type Specimens. San Diego Bay, California. Type material unknown.

Distribution. *Aldisa sanguinea* is known from Coos Bay Oregon, to the Gulf of California (Behrens, 1991).

Family Chromodorididae

Genus *Cadlina* Bergh, 1879

Type Species: *Doris laevis* Linnaeus, 1767.

Diagnosis. Notum with low rounded tubercles. Labial tentacles auriculate. Defensive glands present along margins of notum. Jaw rodlets bifid. Radular teeth cuspidate. Rachidian tooth well developed with multifid cusps. Inner and outer lateral teeth denticulate. Reproductive system triaulic. Penis with rows of chitinous spines.

Cadlina flavomaculata MacFarland, 1905

Figures 2.15B, 2.17A-C

Cadlina flavomaculata MacFarland, 1905:43-44; 1966: pl. 23, fig. 1; pl. 29, fig. 17, pl. 33, figs. 12-21.

Material Examined. California: Santa Maria Basin, off Point Arguello and Point Conception, Sta. BRC 1 (1); Sta. BRA 6, rep. 2 (1), dissected.

Description. Living animals (Figure 2.15B) to 20 mm in length. Color white with submarginal ring of defensive glands. Rhinophores dark brown to black. Body ovoid. Gills white, bipinnate. Marginal yellow ring present. Notum tuberculate. Oral tentacles reduced, auriculate. Jaws present, with numerous bifid rodlets (Figure 2.17A). Radula broad. Radular formula 89 × 15.1.15. Rachidian teeth (Figure 2.17B) denticulate with 4 primary cusps. Inner lateral teeth with inner and outer denticles on side of primary cusp. Outer lateral teeth (Figure 2.17C) with 5-12 denticles on outer side of primary cusp. Outer laterals increasingly long and with more denticles towards outer edge. Penis armed with rows of hooks.

Biology. *Cadlina flavomaculata* feeds on sponges of the genus *Aplysilla* and is found from the intertidal zone to 200 m depth (Behrens, 1991). Present specimens were dredged from 60-70 m depth.

Remarks. *Cadlina flavomaculata* is one of five sympatric members of the genus present along the Pacific coast of North America, It is the only species with dark rhinophores and white gills. The only other species with dark rhinophores is *C. limbaughorum*, which also has dark gills. Dark rhinophoral pigment is often retained in preserved specimens. Radular differences distinguish the various species of *Cadlina* (McDonald, 1983).

Type Locality and Type Specimens. Monterey Bay, California; holotype (USNM 181287).

Distribution. *Cadlina flavomaculata* is known from Vancouver Island, British Columbia, to Bahía Tortugas, Baja California (Behrens, 1991).

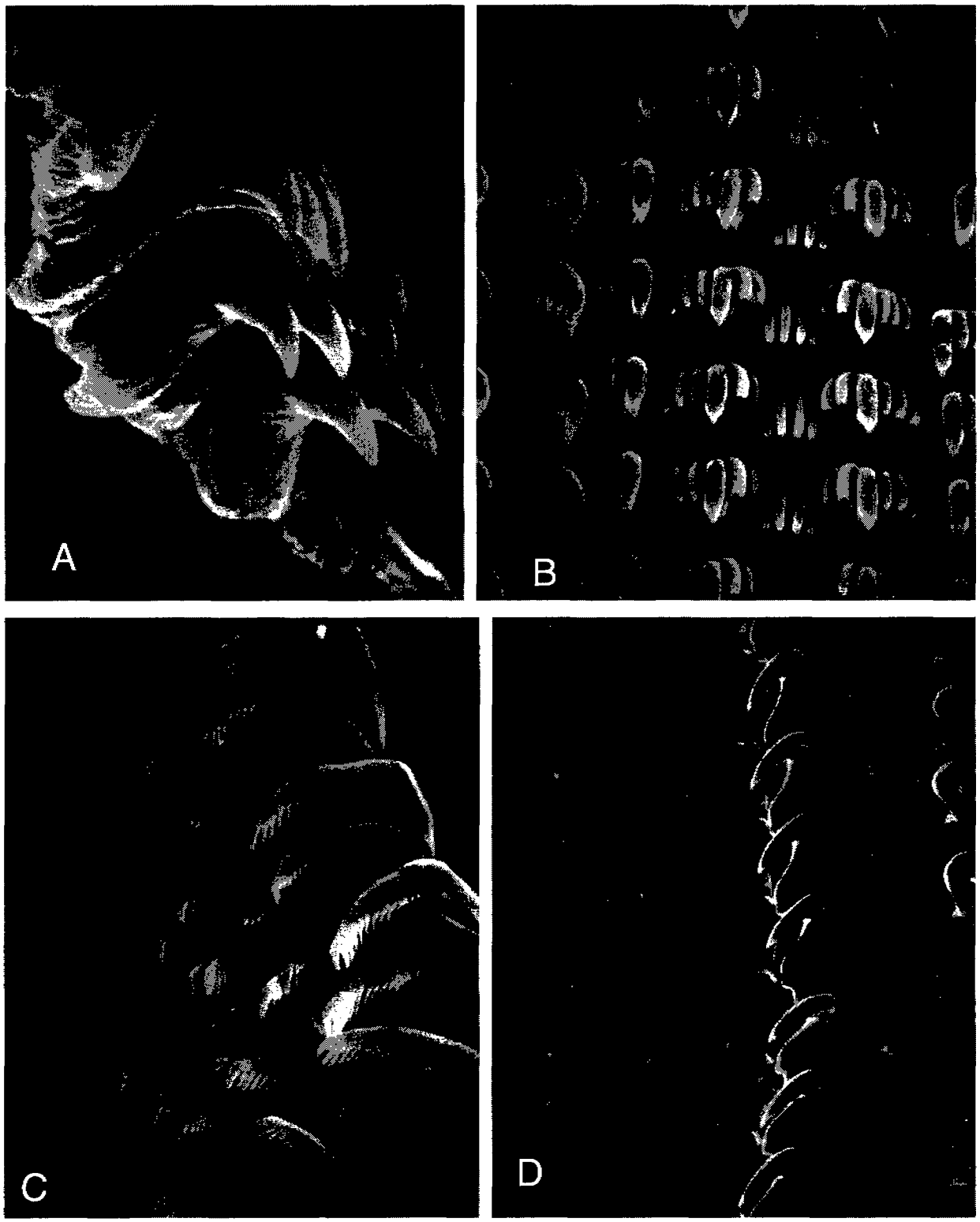

Figure 2.17. **A.-C.** *Cadlina flavomaculata* MacFarland, 1905. **A.** Jaw rodlets, × 5000. **B.** Central portion of radula, × 1000. **C.** Outer lateral teeth, × 1000. **D.** *Holoplocamus* sp., radular teeth, × 400.

Family Polyceratidae

Genus *Holoplocamus* Odhner, 1926

Type Species: *Holoplocamus papposus* Odhner, 1926.

Diagnosis. Body elongate, limaciform, with scattered notal and velar appendages. Jaws reduced. Radular formula: 7-8.2.1.1.2.7-8. Rachidian consisting of paired papillate plates. Inner lateral teeth hook-shaped. Outer laterals flattened plates. Reproductive system triaulic. Penis armed with hooks.

Holoplocamus sp.

Figures 2.14B-C, 2.17D

Material Examined. California, Santa Maria Basin, off Morro Bay and Purisima Point, Sta. 6, rep. 1 (1); Sta. BRA-6, rep. 1 (1), dissected.

Description. Preserved animals 0.5-1.5 mm in length. Body elongate with 11-15 spiculate velar tentacles and 4-6 lateral appendages per side of body (Figure 2.14B,C). Gills 3, unipinnate to bipinnate. Mouth flanked by pair of elongate tentacles. Labial cuticle thin, coriaceous, without well developed rodlets. Radular formula 30 × 7-8.2.1.1.2.7-8. Rachis (Figure 2.17D) covered by divided pair of papillate plates. Innermost lateral teeth small, hook-shaped. Second lateral teeth larger, with simple hook-shaped cusp. Outer lateral teeth simple, quadrangular.

Biology. Nothing is known about the biology of this species. It has been collected from both hard and soft substrate stations.

Remarks. The present material differs from all other polycerids described from the Pacific coast of North America. Two species have a somewhat similar radular formula. *Laila cockerelli* also has similar radular teeth, except that the second laterals all have a bifid cusp (McDonald, 1984). *Issena pacifica* (Bergh, 1894) has simple, non-spiculate appendages and a rachis with an undivided central plate. The present material has a radula that is almost identical to *Holoplocamus papposus* (Odhner, 1926), known from the Subantarctic Atlantic. *Holoplocamus papposus* has many more lateral appendages and dorsal papillae than the present specimens. More material is required to compare this apparently undescribed species with other taxa.

Distribution. Thus far, this species is known only from the Santa Maria Basin.

Family Goniodorididae

Genus *Okenia* Menke, 1830

Type Species: *Doris elegans* Bronn, 1826.

Diagnosis. Body broad to elongate with notal and velar appendages. Jaws usually with chitinous elements. Radular formula: 1.1.0.1.1. Inner lateral teeth larger than outer laterals. Reproductive system triaulic. Penis armed with rows of spines.

Okenia sp.

Figures 2.14D, 2.16C-D

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. 35, rep. 3 (1), dissected.

Description. Preserved specimen (Figure 2.14D) 1 mm in length. Notum with 3-4 papillae present along either lateral margin of notum. Gills 4, arranged in semicircular fashion. Labial cuticle without prominent platelets. Radular formula 18 × 1.1.0.1.1. Inner lateral teeth (Figure 2.16C) large, curved with 7-8 denticles on inner side of tooth. Outer lateral teeth (Figure 2.16D) narrow, bicuspid.

Biology. Nothing is known about the biology of this species. The single specimen was found in 548 m depth.

Remarks. Three other species of *Okenia* have been recorded from the temperate Pacific coast of North America. *Okenia vancouverensis* and the introduced *O. plana* both have a more rounded body and more elongate appendages than *Okenia* sp. and *O. angelensis*. *Okenia angelensis* has an inner lateral tooth with more denticles than *O.* sp. Also the outer lateral tooth is round and arched with a simple hook-shaped denticle, while that of *O.* sp. is narrow and bifid. The radular teeth of *O.* sp. are most similar to *O. impexa*, known from the western Atlantic (Marcus, 1957).

Distribution. Thus far, this species is known only from the single specimen collected from the Santa Maria Basin.

Family Dendronotidae

Genus *Dendronotus* Alder and Hancock, 1845

Type Species: *Amphitrite frondosa* Ascanius, 1777.

Diagnosis. Animals elongate with numerous branched gills along margins of notum. Rhinophores with cup-shaped sheath with 1 or more branched papillae. Velum with 4-16 branched tentacles. Jaws well developed with several row of denticles along masticatory margin. Radula with triangular, denticulate rachidian. Lateral teeth elongate, denticulate. Reproductive system diaulic. Penis unarmed.

Dendronotus frondosus (Ascanius, 1774)

Figures 2.15D, 2.18A

Amphitrite frondosa Ascanius, 1774:155-158, pl. 5, fig. 2.

Dendronotus venustus MacFarland, 1966:271-280, pl. 40, fig. 2, pl. 46, figs. 9-12, pl. 47, figs. 1, 2, pl. 49, fig. 6, pl. 50, fig. 3, pl. 52, figs. 3-6.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. PJ-1, rep. 3 (1) dissected; Sta. PJ-23, rep. 3 (1).

Description. Animals to 50 mm in length. Living animal (Figure 2.15D) translucent gray, white, brown, or yellowish, with opaque white or yellowish spots. Gills 4-7 per side of body, highly ramified. Rhinophores with numerous branches on apex of sheath and at least 1 large branch on side of sheath. Velum with single row of 3-4 highly branched tentacles per side of body. Jaws strong, chitinous, with series of denticles along short masticatory margin. Radular formula 24-49 × 7-15.1.7-15. Rachidian teeth (Figure 2.18A) broad with 8-10 elongate denticles on either side of triangular cusp. Lateral teeth thin, acutely pointed with 2-6 denticles along outer edge.

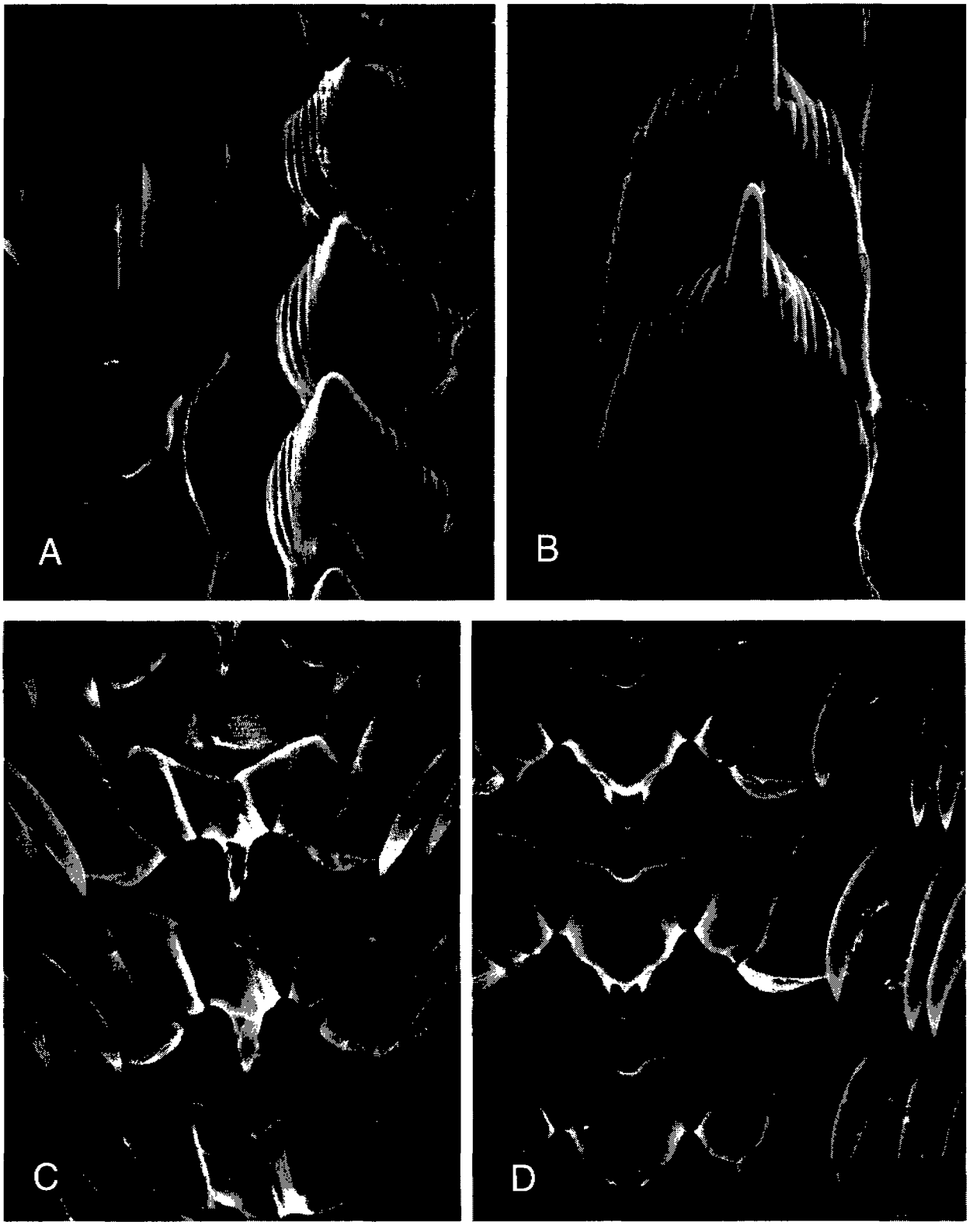

Figure 2.18. Radular teeth. **A.** *Dendronotus frondosus* (Ascanius, 1774), × 700. **B.** *Cuthona rolleri* Behrens and Gosliner, 1988, × 1000. **C.** *Tritonia festiva* (Stearns, 1873), × 1000. **D.** *Tritonia diomedea* Bergh, 1894, × 700.

Biology. *Dendronotus frondosus* feeds on a wide variety of thecate and athecate hydroids. It appears to prefer species of *Tubularia* and campanularids.

Remarks. *Dendronotus frondosus* and *D. subramosus* MacFarland, 1966 are the only brownish dendronotids found south of British Columbia. The two are immediately separable by the degree of branching of the gills, appendages on the rhinophore sheaths and velar tentacles. All of these structures are more highly branched in *D. frondosus* than in *D. subramosus*.

Type Locality and Type Specimens. Norway, type material unknown.

Distribution. Circumboreal, Europe, Russia, Japan, Pacific coast of North America (Behrens, 1991).

Family Tritoniidae

Genus *Tritonia* Cuvier, 1798

Type Species: *Tritonia hombergi* Cuvier, 1803.

Diagnosis. Body broad to slender. Numerous branched gills present along margins of notum. Rhinophores with cup shaped sheath surrounding series of radial lamellae. Velum with 4-30 simple tentacles. Jaws well developed with several row of denticles along masticatory margin. Rachidian teeth quadrate with trifid cusp. Lateral teeth curved to elongate, denticulate or smooth. Reproductive system diaulic. Penis unarmed or armed.

Tritonia festiva (Stearns, 1873)

Figures 2.15C, 2.18B

Lateribranchiaea festiva Stearns, 1873:77-78, fig. 1.

Tritonia reticulata Bergh, 1882:239-250, p. 8, figs. 7-20, pl. 9, figs. 1-12, pl. 10 figs. 1-10.

Sphaerostoma undulata O'Donoghue, 1924:3-6, pl. 1, figs. 1-4.

Tritonia festiva: Johnson and Snook, 1927:491, pl. 7, fig. 5.

Duvaucelia festiva: MacFarland, 1966:218-226, pl. 39, figs. 1-6, pl. 43, figs. 10-19, pl. 44, fig. 2, pl. 45, figs. 7,8.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. PJ12, rep. 1 (1), dissected.

Description. Living animals (Figure 2.15C) up to 30 mm in length. Body translucent white to yellowish, with network and circles of opaque white. Notum smooth. Velum with 4-6 filiform tentacles on either side of frontal veil. Gills 11-15 per side of body. Jaws elongate, chitinous with elongate masticatory margin, bearing several rows of denticles. Radular formula 32-57 × 15-49.1.1.1.15-49. Rachidian teeth trifid (Figure 2.18C). Inner lateral teeth arched with or without series of fine denticles along outer margin. Outer lateral teeth all elongate, narrow, curved.

Biology. *Tritonia festiva* feeds on pennatulaceans and gorgonians.

Remarks. *Tritonia festiva* is most similar to *T. myrakeenae* and *T. diomedea*. It differs externally by its translucent white color with opaque white network of lines and circles. It has 4-6 velar tentacles per side, while *T. diomedea* has 5-15 and *T. myrakeenae* has 3-4. *Tritonia festiva* and *T. diomedea* have far more ramified gills than *T. myrakeenae*. The notum of *T. myrakeenae* and *T. festiva* are smooth, while that of *T. diomedea* is covered with low tubercles.

Type Locality and Type Specimens. Pt. Piños, Monterey, California. Type material unknown.

Distribution. Japan, Kachemak Bay, Alaska to Coronados Islands, Baja California (Behrens, 1991).

Tritonia diomedea Bergh, 1894

Figures 2.14F, 2.18D

Tritonia diomedea Bergh, 1894:146-150, pl. 2. figs. 3, 10, 11, pl. 3, figs. 6-10, pl. 4, figs. 1, 5.

Duvaucelia gilberti MacFarland, 1966:235-243, pl. 30, figs. 1, 2, pl. 43, figs. 27-36, pl. 44, fig. 5, pl. 45, fig. 6.

Tritonia exsulans Bergh, 1894:150-152, pl.3, figs. 11, 12, pl. 4, fig. 6.

Material Examined. California, Santa Maria Basin, off Purisima Point, Sta. BRA 13, rep. 4 (1), dissected.

Description. Living animals up to 215 mm in length. Living animals white, pink or red in color. Notum with numerous low tubercles. Velum (Figure 2.14F) with 5-15 filiform tentacles on either side of the frontal veil. Gills 11-15 per side of body. Jaws elongate, chitinous with elongate masticatory margin, bearing several rows of denticles. Radular formula 29-69 × 21-95.1.1.1.21-95. Rachidian teeth trifid (Figure 2.18D). Inner lateral teeth arched, with or without series of coarse denticles along outer margin. Outer lateral teeth short, curved. Inner teeth more elongate towards outer edge.

Biology. *Tritonia diomedea* appears to feed exclusively on pennatulaceans at subtidal depths.

Remarks. *Tritonia diomedea* grows much larger than other sympatric species of *Tritonia*. It differs from the other large north Pacific tritoniid, *Tochuina tetraquetra* (Pallas, 1788), in having less pronounced notal tubercles and far fewer gills. There are significant radular and reproductive differences as well.

Type Locality and Type Specimens. San Diego Bay and Santa Barbara Island, California. Type specimens unknown.

Distribution. Aleutian Islands, Alaska to Bay of Panama; Manatee Bay, Florida (Behrens, 1991).

Family Arminidae

Genus *Armina* Rafinesque, 1814

Type Species: *Armina tigrina* Rafinesque, 1814.

Diagnosis. Notum curved with series of longitudinal ridges. Rhinophores close together, anterior to edge of notum, with radially arranged lamellae. Jaws well developed with several rows of denticles along masticatory margin. Rachidian teeth multicuspidate, quadrangular. Lateral teeth curved, with or without denticles.

Armina californica (Cooper, 1863)

Figures 2.19A, 2.20A-B

Pleurophyllidia californica Cooper, 1863:203-204.

Armina californica: MacFarland, 1966:198-206, pl. 38, figs. 1-6, pl. 43, figs. 37-44, pl. 44, figs. 6, 7.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. PJ-2, rep. 1 (1), dissected.

Description. Living animals (Figure 2.19A) up to 70 mm. Color dark gray to brown with numerous pink to white longitudinal ridges. Rhinophores anterior to edge of notum, with longitudinal folds. Gills numerous, ventral, situated between edge of notum and foot. Jaws chitinous, with 4 rows of denticles (Figure 2.20A) along elongate masticatory margin. Radular formula 25-52 × 33-80.1.1.1.33-80. Rachidian

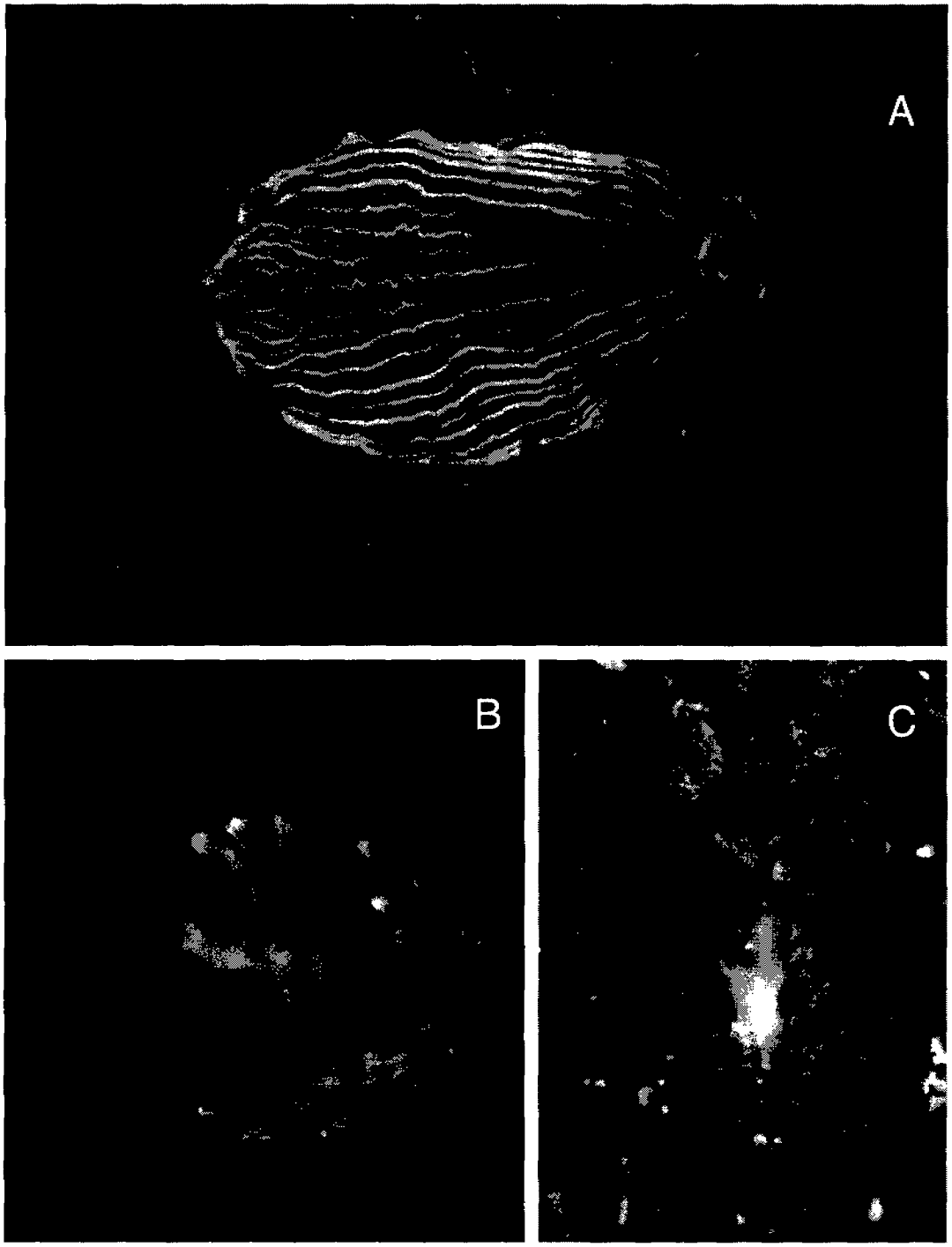

Figure 2.19. Living animals. **A.** *Armina californica* (Cooper, 1863). **B.** *Cuthona rolleri* Behrens and Gosliner, 1988. **C.** *Aeolidiella chromosoma* (Cockerell and Eliot, 1905).

teeth (Figure 2.20B) acutely pointed with prominent medial cusp and 3-4 lateral denticles per side. Inner lateral tooth thick, curved. Outer lateral teeth hook-shaped with small denticle on outer side of inner 21 teeth. Outer 12 teeth simple, curved, without additional denticle.

Biology. *Armina californica* feeds exclusively on pennatulaceans of the genera *Renilla* and *Stylatula*. It is found from the low intertidal to at least 200 m depth.

Remarks. *Armina californica* is the only arminid known from the temperate Pacific coast of North America. In the southern part of its range, it is sympatric with the arminid, *Histiomena convolvula*, which lacks longitudinal ridges of the notum and is more brightly colored.

Type Locality and Type Specimens. San Diego Bay, California. Type material unknown.

Distribution. *Armina californica* is known from Kayak Island, Alaska to the Gulf of Panama (Behrens, 1991).

Family Tergipedidae

Genus *Cuthona* Alder and Hancock, 1855

Type Species: *Aeolis nana* (Alder and Hancock, 1842)

Diagnosis. Body slender to broad. Anterior end of foot generally rounded, but rarely with elongate tentacles. Oral tentacles short. Rhinophores commonly smooth but rarely annulate. Anus situated anterodorsally to first post-cardiac ceratal row. Jaws well developed with single row of denticles along masticatory margin. Radular uniseriate with cuspidate teeth. Reproductive system diaulic. Penial gland present. Penis unarmed or armed with tubular stylet.

Cuthona rolleri Behrens and Gosliner, 1988

Figures 2.18B, 2.19B

Cuthona rolleri Behrens and Gosliner, 1988:262-266, figs. 1-4.

Material Examined. California, Santa Maria Basin, off Point Sal, Sta. R-7, rep. 1 (1), dissected.

Description. Living animals (Figure 2.19B) up to 15 mm in length. Color translucent white. Ceratal cores salmon pink. Body dorsoventrally flattened. Foot wide. Rhinophores smooth, well separated. Cerata large, arranged in longitudinal rows well elevated from notum. Jaws thick, chitinous with single row of denticles on the masticatory margin. Radular formula 21-31 × 0.1.0. Radular teeth (Figure 2.18B) with large, triangular primary cusp and 5-7 denticles flanking either side.

Biology. Little is known about the biology of this species. Most specimens have been found on intertidal mud flats. The present specimen, collected from 575 m depth, represents the first subtidal record of this species.

Remarks. *Cuthona rolleri* is immediately identifiable by its dorso-ventrally flattened body with elongate cerata.

Type Locality and Type Specimens. Morro Bay, California; holotype, (CASIZ 064894), paratypes (CASIZ 064895, 064896).

Distribution. *Cuthona rolleri* was previously known from Piedras Blancas to Morro Bay, San Luis Obispo County, California. The present specimen extends the range southward to Point Sal, Santa Barbara County. It also considerably extends the bathymetric range of the species to 575 m depth.

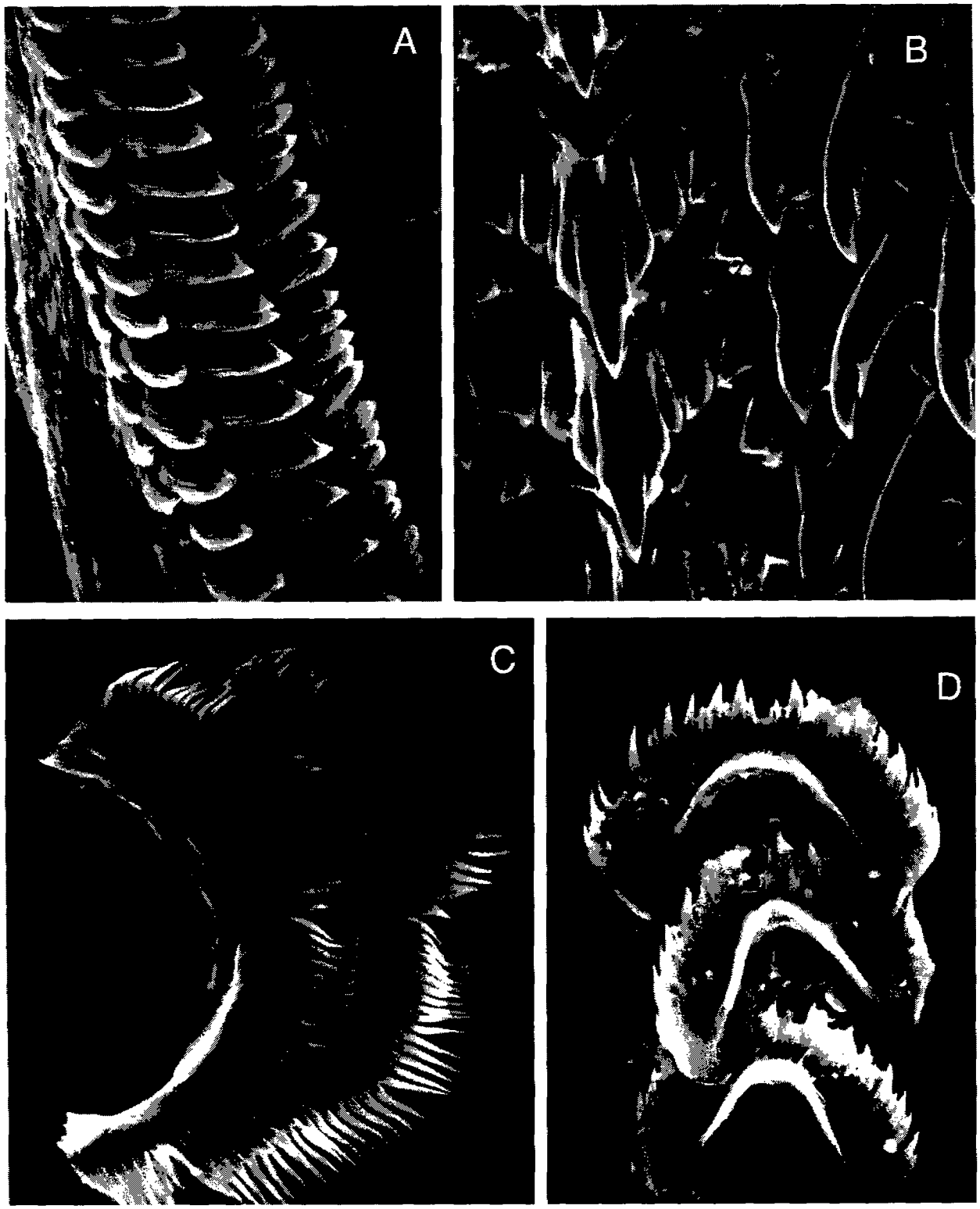

Figure 2.20. **A., B.** *Armina californica* (Cooper, 1863). **A.** Jaw rodlets, × 1000. B. Central radular teeth, × 700. **C.** *Aeolidiella chromosoma* (Cockerell and Eliot, 1905), radular teeth, × 500. **D.** *Cerberilla mosslandica* McDonald and Nybakken, 1975, radular teeth, × 700.

Family Aeolidiidae

Genus *Aeolidiella* Bergh, 1867

Type Species: *Aeolis glauca* Alder and Hancock, 1848.

Diagnosis. Body broad. Anterior end of foot rounded or with elongate tentacles. Oral tentacles long. Rhinophores commonly smooth but rarely annulate or perfoliate. Anus situated posterior to first post-cardiac ceratal row. Jaws well developed with single row of denticles along masticatory margin or with smooth masticatory margin. Radula uniseriate with pectinate teeth, with medial indentation. Reproductive system diaulic. Penis unarmed.

Aeolidiella chromosoma (Cockerell and Eliot, 1905)

Figures 2.19C, 2.20C

Spurilla chromosoma Cockerell and Eliot, 1905:51-52.

Aeolidiella chromosoma: Gosliner, 1985:257, fig. 15B.

Material Examined. California, Santa Maria Basin, off Purisima Point, Sta. BRA 16, rep. 1 (1), dissected.

Description. Living animals (Figure 2.19C) up to 25 mm in length. Color translucent white to yellowish with orange and opaque white markings on head and notum. Cerata gray to brown, with opaque white spots. Rhinophores bulbous, with diagonally slanted lamellae. Foot broad. Anterior corners of foot elongate, tentacular. Jaws thick chitinous, with smooth masticatory border. Radular formula 19 × 0.1.0 in single specimen examined, 21-24 in previously recorded material. Radular teeth (Figure 2.20C) pectinate, arched with up to 30 denticles on either side of triangular medial denticle.

Biology. *Aeolidiella chromosoma* feeds on sea anemones, though specific prey have not been identified.

Remarks. *Aeolidiella chromosoma* is most similar to *A. olivae* MacFarland, 1966. The two differ in their color. *Aeolidiella olivae* has reddish rhinophores and cerata, while those of *A. chromosoma* are drab gray or brown. The two differ slightly in their radular morphology with *A. olivae* having fewer denticles on the teeth.

Type Locality and Type Specimens. San Pedro, California. Type material unknown.

Distribution. This species is found from Morro Bay to the Gulf of California (Behrens, 1991).

Genus *Cerberilla* Bergh, 1873

Type Species: *Cerberilla longicirra* Bergh, 1873.

Diagnosis. Body broad. Anterior end of foot with elongate tentacles. Oral tentacles long. Rhinophores smooth, short. Anus situated posterior to first post-cardiac ceratal row. Jaws well developed with single row of denticles along masticatory margin or with smooth masticatory margin. Radula uniseriate with pectinate teeth often with unevenly elongate denticles. Reproductive system diaulic. Penis unarmed.

Cerberilla mosslandica McDonald and Nybakken, 1975

Figures 2.14E, 2.20D

Cerberilla mosslandica McDonald and Nybakken, 1975:378-382, figs. 1, 2.

Material Examined. California, Santa Maria Basin, off Point San Luis and Point Sal, Sta. R-3, rep. 1 (1); Sta. R-8, rep. 3 (2), one dissected.

Description. Living animals (Figure 2.14E) up to 9 mm in length. Body translucent white, encrusted with reddish brown pigment. Cerata brownish with white apices. Cerata congested in many linear rows. Rhinophores smooth. Anterior margins of foot elongate. Jaws thin, coriaceous, with smooth masticatory border. Radular formula 10 × 0.1.0. Radular teeth (Figure 2.20D) evenly curved with elongate, pectinate denticles.

Biology. Members of the genus *Cerberilla* feed on cerianthid anemones and other sand and mud dwelling coelenterates. They burrow below the surface of sand and mud. McDonald and Nybakken (1975) found this species at 17-70 m depth. The present material was found in slightly deeper water (90 m depth).

Remarks. Two other eastern Pacific Aeolidiidae are similar to *Cerberilla mosslandica* in having smooth rhinophores. Both *Aeolidiella indica* and *Aeolidia papillosa* are known only from shallow rocky habitats. *Cerberilla mosslandica* differs from both of these species in having elongate anterior margins of the foot.

Type Locality and Type Specimens. Off Moss Landing, Monterey Bay, California; holotype, (CASIZ 020365); paratypes (CASIZ 020366).

Distribution. Monterey Bay to La Jolla Submarine Canyon, California (Behrens, 1991).

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Appendix

Lists and Maps of Stations

Table A.1. Position of soft-substrate stations taken during the Phase I Reconnaissance.

Station	Latitude	Longitude	Depth (m)
1	35°27.86'N	121°05.33'W	98
2	35°27.70'N	121°06.52'W	200
3	35°27.07'N	121°10.20'W	291
4	35°26.56'N	121°14.93'W	393
5	35°25.77'N	121°21.69'W	585
6	35°20.88'N	120°59.62'W	109
7	35°20.65'N	121°02.57'W	197
8	35°20.00'N	121°06.58'W	308
9	35°19.48'N	121°10.06'W	398
10	35°18.28'N	121°18.65'W	591
11	35°17.80'N	121°22.13'W	690
12	35°15.03'N	120°57.31'W	98
13	35°14.54'N	120°59.77'W	197
14	35°14.15'N	121°02.04'W	299
15	35°13.98'N	121°04.54'W	393
16	35°12.23'N	121°16.29'W	591
17	35°11.61'N	121°22.55'W	654
18	35°09.08'N	120°56.55'W	197
19	35°08.93'N	120°59.66'W	296
20	35°15.72'N	121°04.68'W	396
21	35°06.11'N	120°44.82'W	49
22	35°05.85'N	120°50.23'W	99
23	35°05.60'N	120°55.18'W	195
25	35°05.07'N	121°00.75'W	390
26	35°04.38'N	121°15.99'W	590
27	35°04.30'N	121°19.27'W	611
28	35°04.22'N	121°19.65'W	603
30	34°54.19'N	120°47.07'W	98
31	34°53.76'N	120°52.96'W	200
32	34°53.56'N	120°56.81'W	297
33	34°53.43'N	120°59.66'W	396
34	34°53.15'N	121°04.40'W	492
35	34°52.96'N	121°10.30'W	548
36	34°52.77'N	121°15.37'W	492
38	34°49.81'N	120°52.66'W	197
39	34°49.53'N	120°56.85'W	294
40	34°49.24'N	121°00.81'W	392
41	34°48.35'N	121°19.14'W	495
42	34°48.04'N	120°47.50'W	100
43	34°46.59'N	120°52.92'W	197
45	34°44.91'N	120°59.59'W	395
46	34°41.22'N	121°13.56'W	597
47	34°41.99'N	121°10.81'W	378
48	34°45.11'N	120°52.85'W	196
49	34°45.03'N	120°56.31'W	290
50	34°37.80'N	121°01.66'W	591
52	34°39.56'N	120°47.64'W	98
53	34°37.69'N	120°50.38'W	196
54	34°36.57'N	120°52.02'W	396
55	34°33.66'N	120°56.31'W	590
56	34°30.32'N	121°01.02'W	900

Table A.1 (Continued)

Station	Latitude	Longitude	Depth (m)
58	34°34.35′N	120°45.18′W	99
59	34°33.65′N	120°47.18′W	216
60	34°33.25′N	120°48.34′W	275
61	34°33.01′N	120°48.89′W	345
62	34°30.46′N	120°52.13′W	582
63	34°26.29′N	120°58.08′W	930
64	34°33.15′N	120°40.90′W	59
65	34°31.27′N	120°43.27′W	107
66	34°30.46′N	120°44.55′W	201
67	34°30.29′N	120°45.50′W	282
68	34°29.24′N	120°45.99′W	390
69	34°22.88′N	120°54.20′W	927
70	34°29.67′N	120°43.70′W	200
71	34°29.04′N	120°44.01′W	306
72	34°28.41′N	120°44.76′W	401
73	34°28.21′N	120°36.80′W	98
74	34°26.84′N	120°38.61′W	201
75	34°26.08′N	120°39.65′W	293
76	34°25.59′N	120°40.98′W	387
77	34°22.62′N	120°44.02′W	578
78	34°18.78′N	120°49.30′W	762
79	34°24.12′N	120°28.32′W	98
80	34°22.86′N	120°28.34′W	196
81	34°21.26′N	120°28.83′W	294
82	34°18.71′N	120°29.55′W	394
83	34°17.20′N	120°30.20′W	444
84	34°13.54′N	120°31.19′W	394
85	34°25.88′N	120°16.31′W	113
86	34°24.45′N	120°17.02′W	197
87	34°21.60′N	120°17.11′W	299
88	34°17.89′N	120°16.86′W	393
89	34°13.79′N	120°16.56′W	471
90	34°09.44′N	120°16.30′W	375
91	34°11.73′N	120°07.43′W	540
92	34°08.70′N	120°07.50′W	444
93	34°07.63′N	120°07.51′W	357
96	34°22.91′N	120°05.42′W	296
94	34°24.54′N	120°05.47′W	96
95	34°23.70′N	120°05.47′W	198
97	34°22.28′N	120°05.49′W	393
98	34°12.87′N	120°05.59′W	561
99	34°11.22′N	120°05.86′W	540
100	34°08.67′N	120°05.50′W	443
101	34°07.51′N	120°05.65′W	357
102	34°59.71′N	120°48.22′W	99
103	34°59.63′N	120°53.56′W	197
104	34°59.45′N	120°56.49′W	294
105	34°59.23′N	120°59.60′W	392
106	34°58.95′N	121°04.42′W	492
107	34°58.65′N	121°15.08′W	573
108	34°58.21′N	121°17.88′W	492

Note: Sample labels from the Soft-substrate stations have several identification codes which include a station number, sample type, replicate number, and analysis type. These are as follows: 001 to 200 = the range of station numbers; BSS = Benthic Sediment Single (i.e., a non-replicated station); BSR = Benthic Sediment Replicate (three replicates taken at this station); BSV = Benthic Sediment Variance (subsamples); 01-09 = replicate numbers; TX = a taxonomy sample. Sample labels having the designation BRA, represents a sample from rocks taken as part of the hard bottom survey.

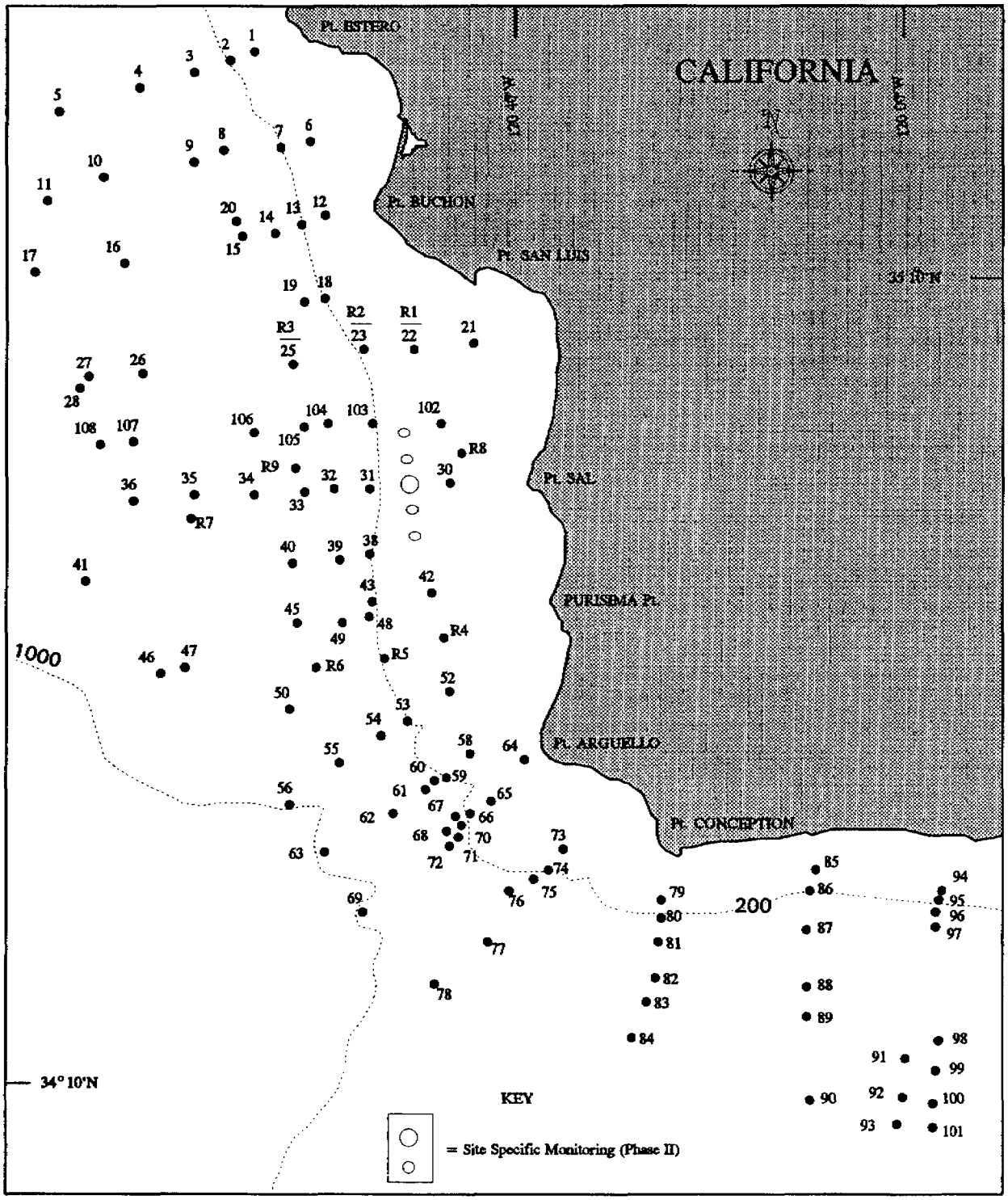

Figure A.1. Map showing location of soft substrate stations from Phase I and Phase II MMS Reconnaissance and Monitoring Programs.

Table A.2. Location of soft-substrate stations taken during the Phase II Monitoring Program.

Station	Latitude	Longitude	Depth (m)
R-1	35°05.83'N	120°49.16'W	91
R-2	35°05.50'N	120°53.40'W	161
R-3	35°05.30'N	121°00.90'W	409
R-4	34°43.01'N	120°47.39'W	92
R-5	34°42.69'N	120°50.83'W	154
R-6	34°41.40'N	120°57.90'W	410
R-7	34°52.90'N	121°10.30'W	565
R-8	34°55.30'N	120°45.87'W	90
R-9	34°53.68'N	120°59.12'W	410
PJ-1	34°55.79'N	120°49.91'W	145
PJ-2	34°55.32'N	120°49.59'W	142
PJ-3	34°56.26'N	120°49.58'W	138
PJ-4	34°56.26'N	120°50.24'W	150
PJ-5	34°55.32'N	120°50.24'W	152
PJ-6	34°54.71'N	120°49.91'W	148
PJ-7	34°55.79'N	120°48.60'W	123
PJ-8	34°56.87'N	120°49.91'W	142
PJ-9	34°55.79'N	120°51.23'W	169
PJ-10	34°53.63'N	120°49.91'W	147
PJ-11	34°57.95'N	120°49.91'W	136
PJ-12	34°55.58'N	120°49.91'W	145
PJ-13	34°56.01'N	120°49.91'W	144
PJ-14	34°55.79'N	120°49.26'W	134
PJ-15	34°55.79'N	120°50.57'W	155
PJ-16	34°55.03'N	120°48.99'W	130
PJ-17	34°56.56'N	120°48.98'W	126
PJ-18	34°56.56'N	120°50.84'W	158
PJ-19	34°55.03'N	120°50.84'W	167
PJ-20	34°50.38'N	120°49.91'W	148
PJ-21	35°01.23'N	120°51.15'W	143
PJ-22	34°55.25'N	120°49.93'W	143
PJ-23	34°56.33'N	120°49.90'W	143

Table A.3. Sampling dates of MMS Phase II Monitoring Program.

Cruise	Date
1-1	October 1986
1-2	June 1987
1-3	May 1987
1-4	July 1987
2-1	October 1987
2-2	January 1988
2-3	May 1988
3-1	October 1988
3-2	May 1988

Table A.4. MMS Phase I - Locations of hard-substrate transects.

Station	Beginning Latitude	Longitude	End Latitude	Longitude	Depth (m)
1 A/B	34°24.454′N	120°01.876′W	34°24.464′N	120°00.878′W	69-73.5
1 C/D	34°24.076′N	120°00.443′W	34°24.184′N	120°01.480′W	73.5-78
2 A/B	34°11.377′N	120°29.318′W	34°11.289′N	120°28.774′W	110-126
2 C/D	34°10.984′N	120°28.094′W	34°10.780′N	120°27.554′W	120-123
4 A/B	34°27.539′N	120°40.364′W	34°28.162′N	120°40.189′W	168-237
6 A/B	34°30.246′N	120°35.555′W	— —.—	— —.—	54-63
6 C/D	— —.—	— —.—	34°30.421′N	120°34.315′W	54-63
13 A/B	34°42.570′N	120°47.899′W	34°42.107′N	120°48.253′W	92-100
13 C/D	34°42.556′N	120°48.147′W	34°42.974′N	120°47.424′W	88.5-100.5
14 A/B	34°43.589′N	120°49.093′W	34°42.826′N	120°48.370′W	96-105
14 C/D	34°43.244′N	120°49.406′W	34°42.893′N	120°48.822′W	105-117
16 A/B	34°46.544′N	120°50.197′W	34°45.912′N	120°49.726′W	91.5-123
17 A/B	34°49.382′N	120°50.768′W	34°49.600′N	120°50.688′W	160.5-168
19 A/B	34°47.833′N	120°51.425′W	34°47.097′N	120°50.793′W	148.5-177
20 A/B	34°46.470′N	120°50.289′W	34°46.140′N	120°49.885′W	90-130.5
21 A/B	34°47.335′N	120°45.903′W	34°47.548′N	120°46.123′W	75-90
22 A/B	34°50.365′N	120°48.221′W	34°50.990′N	120°48.365′W	114-115.5
23 A/B	34°49.868′N	120°47.393′W	34°50.003′N	120°47.480′W	93-102
25 A/B	35°05.662′N	120°47.562′W	35°06.036′N	120°47.652′W	64.5-72
26 C/D	35°11.586′N	120°55.556′W	35°11.555′N	120°55.233′W	108-111
27 A/B	35°20.906′N	120°59.657′W	35°21.035′N	120°59.603′W	96-126
28 A/B	35°21.539′N	120°59.641′W	35°21.867′N	120°59.299′W	96-105
29 A/B	35°27.864′N	121°05.331′W	35°27.805′N	121°05.277′W	102-106.5

Table A.5. MMS Phase II - Locations of hard-substrate photosurvey stations.

Station	Latitude	Longitude	Depth (m)
PH-E	34°30.26′N	120°42.76′W	119
PH-F	34°30.81′N	120°42.36′W	105
PH-I	34°29.96′N	120°41.68′W	107
PH-J	34°29.82′N	120°41.82′W	117
PH-K	34°29.37′N	120°42.26′W	160
PH-N	34°29.21′N	120°42.05′W	166
PH-R	34°29.11′N	120°42.67′W	213
PH-U	34°31.48′N	120°43.51′W	113
PH-W	34°31.52′N	120°45.86′W	195

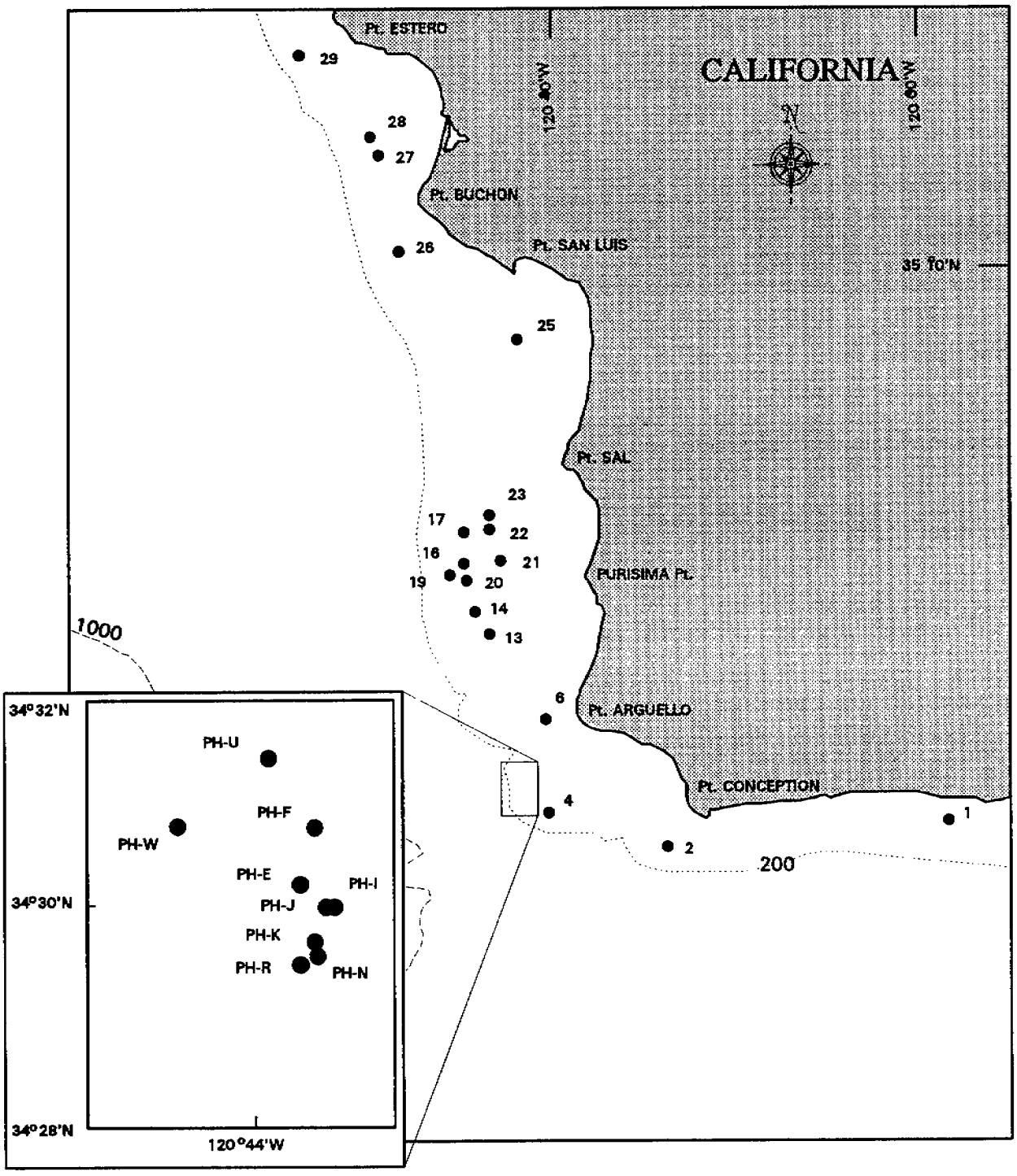

Figure A.2 Map showing locations of hard substrate stations from Phase I and Phase II MMS Reconnaissance and Monitoring Programs.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.