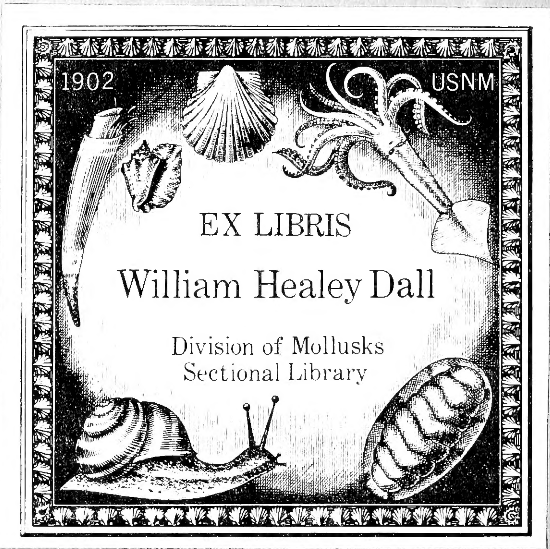
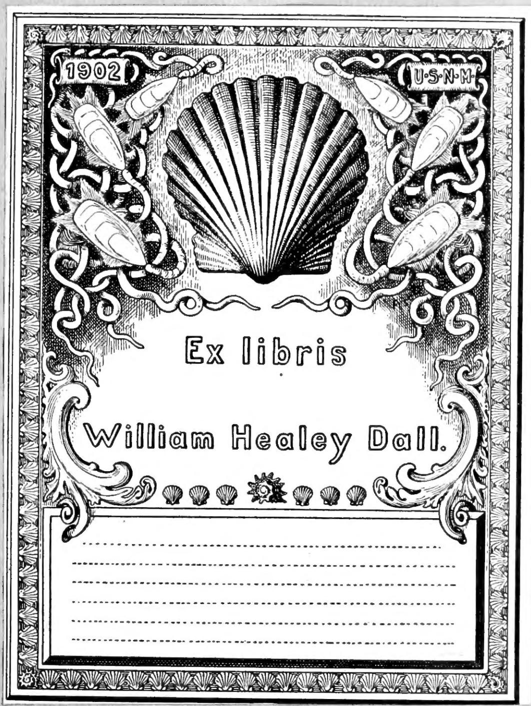

1902
USNM
EX LIBRIS
William Healey Dall
Division of Mollusks
Sectional Library


1902
U·S·N·M·
Ex libris
William Healey Dall.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
ZOOLOGY

Vol. 14, No. 2, pp. 199-452, pls. 14-60 September 12, 1918

MOLLUSCAN FAUNA FROM SAN FRANCISCO BAY

BY

E. L. PACKARD

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

UNIVERSITY OF CALIFORNIA PUBLICATIONS

Note.—The University of California Publications are offered in exchange for the publications of learned societies and institutions, universities and libraries. Complete lists of all the publications of the University will be sent upon request. For sample copies, lists of publications or other information, address the MANAGER OF THE UNIVERSITY PRESS, BERKELEY, CALIFORNIA, U. S. A. All matter sent in exchange should be addressed to THE EXCHANGE DEPARTMENT, UNIVERSITY LIBRARY, BERKELEY, CALIFORNIA, U. S. A.

WILLIAM WESLEY & SONS, LONDON
Agent for the series in American Archaeology and Ethnology, Botany, Geology, Physiology, and Zoology.

ZOOLOGY.—W. E. Ritter and C. A. Kofoid, Editors. Price per volume, $3.50; beginning with vol. 11, $5.00.

This series contains the contributions from the Department of Zoology, from the Marine Laboratory of the Scripps Institution for Biological Research, at La Jolla, California, and from the California Museum of Vertebrate Zoology in Berkeley.

Cited as Univ. Calif. Publ. Zool.

Volume 1, 1902-1905, 317 pages, with 28 plates $3.50
Volume 2 (Contributions from the Laboratory of the Marine Biological Association of San Diego), 1904-1906, xvii + 382 pages, with 19 plates $3.50
Volume 3, 1906-1907, 383 pages, with 23 plates $3.50
Volume 4, 1907-1908, 400 pages, with 24 plates $3.50
Volume 5, 1908-1910, 440 pages, with 34 plates $3.50
Volume 6, 1908-1911, 478 pages, with 48 plates $3.50
Volume 7 (Contributions from the Museum of Vertebrate Zoology), 1910-1912, 446 pages, with 12 plates $3.50
Volume 8, 1911, 357 pages, with 25 plates $3.50
Volume 9, 1911-1912, 365 pages, with 24 plates $3.50
Volume 10, 1912-1913, 417 pages, with 10 plates $3.50
Volume 11, 1912-1914, 538 pages, with 26 plates $5.00
Volume 12 (Contributions from the Museum of Vertebrate Zoology), 1913-1916, 558 pages, with 22 plates $5.00
Volume 13, 1914-1916, 529 pages, with 39 plates $5.00

Vol. 14. 1. A Report upon the Physical Conditions in San Francisco Bay, Based upon the Operations of the United States Fisheries Steamer "Albatross" during the Years 1912 and 1913, by F. B. Sumner, G. D. Louderback, W. L. Schmitt, E. C. Johnston. Pp. 1-198, plates 1-13, 20 text figures. July, 1914 .... 2.25

2. Molluscan Fauna from San Francisco Bay, by E. L. Packard. Pp. 199-452, plates 14-60. September, 1918 .... 3.25

Vol. 15. Introduction. Dependence of Marine Biology upon Hydrography and Necessity of Quantitative Biological Research. Pp. i-xxiii. June, 1916 .... .25

1. Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California, 1901 to 1912, compiled and arranged under the supervision of W. E. Ritter by Ellis L. Michael and George F. McEwen. Pp. 1-206, 4 text figures and map. July, 1915 .... 2.25

2. Continuation of Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1913-1915), compiled and arranged under the supervision of W. E. Ritter, by Ellis L. Michael, Zoologist and Administrative Assistant, George F. McEwen, Hydrographer. Pp. 207-254, 7 figures in text. November, 1916 .... .50

3. Summary and Interpretation of the Hydrographic Observations made by the Scripps Institution for Biological Research of the University of California, 1908 to 1915, by George F. McEwen, Hydrographer. Pp. 255-356, plates 1-38. December, 1916 .... 1.00

Index in preparation.

Vol. 16. 1. An Outline of the Morphology and Life History of *Crithidia leptocoridis*, sp. nov., by Irene McCulloch. Pp. 1-22, plates 1-4, 1 text figure. September, 1915 .... .25

2. On *Giardia microti*, sp. nov., from the Meadow Mouse, by Charles Atwood Kofoid and Elizabeth Bohn Christiansen. Pp. 23-29, 1 figure in text.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
ZOOLOGY

Vol. 14, No. 2, pp. 199-452, pls. 14-60 September 12, 1918

MOLLUSCAN FAUNA FROM SAN FRANCISCO BAY

BY
E. L. PACKARD

CONTENTS

NOTE.—Species marked with asterisk (*) were not obtained by the Survey.

INTRODUCTION

The United States Fisheries Steamer "Albatross" was commissioned in October, 1911, by the Bureau of Fisheries, to make a biological survey of San Francisco Bay. The operations were directed by a board consisting of Dr. F. B. Sumner, naturalist, Professor C. A. Kofoid, of the University of California, and Commander G. H. Burrage, U. S. N., succeeded by Lieutenant-Commander H. B. Soule, U. S. N. The field work began on January 30, 1912, and continued until April 7, 1913, when the last dredge haul was made.

A portion of the results of this survey dealing with the physical conditions within San Francisco Bay has been published in a joint paper by Dr. F. B. Sumner, Dr. G. D. Louderback, Mr. W. L. Schmitt, and Mr. E. C. Johnston (1914). Discussions and detailed data are given regarding the temperature, salinity, depth of the water, and the character of the bottom for the various stations occupied by the "Albatross." These data serve as the basis for ecological studies now being made of the different groups of marine organisms obtained during the survey.

The molluscan material obtained by the various types of dredges employed, and by shore collecting at a limited number of localities, was preserved in alcohol or formalin and shipped to the Zoological Laboratory of the University of California. The dredging material was divided into two classes, herein designated the "qualitative" or the "quantitative," depending upon whether the collection was made by one of several common types of dredges or by the orange-peel bucket dredge, which was employed here for the first time for biological purposes. The records of these quantitative hauls are included in this paper, but these data are incorporated only in part in the discussions.

The qualitative material has been made the basis for this paper. The mollusks from each station were identified, measured, counted, and their condition noted. The identifications have been facilitated by comparison with a typical set from the collection that had been determined by Dr. W. H. Dall and Dr. Paul Bartsch, of the United States National Museum. The maximum, minimum, and modal lengths for each species were recorded for each station. A record of the number of specimens (of the number of valves in the case of dead pelecypods) was likewise made for each species. The condition of each specimen, i.e., whether it was living at the time of dredging, or was represented by a worn shell, was also noted.

In the systematic portion of this paper no attempt has been made to give a complete synonymy for each species, but at least one reference includes such a synonymy. The synonyms listed include the names under which the species was originally described and the more common ones found in the literature dealing with the region of San Francisco. Complete titles of works cited may be found in the bibliography at the end of this paper.

The original descriptions of the species are quoted whenever it seemed practicable. For those that were originally described in a foreign language, a subsequent description by an author who has given a concise diagnosis of the form in English is used. The dimensions given are the minimum and maximum length of all the specimens of the species which were obtained by the Survey.

The italicized type in the parentheses following the number of the dredging station indicates the number of living specimens of the species obtained at that station, while the arabic number indicates the number of valves, in the case of pelecypods, or the number of specimens of other mollusks that were dead at the time of dredging.

This catalogue of species includes the forms taken by the Survey and those that have been reported from San Francisco and vicinity by other workers. Zittel's *Textbook of Palaeontology,* 1912, Eastman translation, has been used primarily for the classification employed.

The asterisk following a station number indicates that a part or all of the specimens of the designated species from that station were determined by Dr. Dall; the dagger indicates those that were determined by Dr. Bartsch.

The known range of the species along the coast has either been compiled or has been taken directly from an author to whom credit has been duly given. The recent paper by Dall (1916*a*) has been made the basis of the range of the Pelecypoda. The range of the Gastropoda is as yet less well known.

Charts have been prepared showing the local distribution of eighteen of the more common species. Localities at which a particular species was taken alive are indicated on an outline map of San Francisco Bay by a dot, while those at which only shells were taken are indicated by a circle.

The illustrations of the species are reproduced from photographs taken by Mr. H. Hollinger and retouched by Mrs. Louise Nash. In a few instances specimens from near-by localities have been substituted for the poor ones represented in the collection of the Survey. Such cases are noted in the explanation of the plates.

This study has been pursued under the direction of Professor Charles A. Kofoid, to whom the writer is greatly indebted for many suggestions and criticisms. Gratitude is due Dr. Francis B. Sumner for his criticisms of the paper and for valuable assistance given during the progress of the work. The author wishes to acknowledge his indebtedness to Dr. William H. Dall, who has reviewed the manuscript, and who together with Dr. Paul Bartsch has determined specimens representing nearly the complete fauna. Mr. Waldo L. Schmitt and Mr. Edward C. Johnston as naturalists on the "Albatross" have assisted the writer in many ways.

REVIEW OF THE LITERATURE

The conchological literature contains many references to San Francisco Bay and immediate vicinity, scattered through foreign and American papers. A number of exploring expeditions entered the bay of San Francisco in the early part of the last century. Their biological collections were often studied in Europe, and consequently a considerable number of our local mollusks has been described by foreign authors.

These early papers were carefully reviewed by Philip P. Carpenter (1856*a*) in a paper entitled, "Report of the present state of knowledge with regard to the mollusca of the West Coast of North America." Seven years later (1863) a second paper appeared under the title, "Supplementary report on the present state of our knowledge with regard to the mollusks of the West Coast of North America." In these papers a number of preliminary descriptions of molluscan species were given. The detailed descriptions were subsequently published in various scientific publications, of which the *Proceedings* of the Zoological Society of London is perhaps the most important. Frequent reference to San Francisco is made in these papers in connection with the ranges of certain species, but any comprehensive faunal survey of this region is lacking.

The list of more recent conchological papers dealing with the Californian region is a long one. With a few exceptions their contributions to the conchology of San Francisco Bay and vicinity have been made rather incidental to considerations other than that of making a faunal survey of this region. The more important of such contributors are: Cooper, Stearns, Tryon, Pilsbry, Dall, Keep, Raymond, Wood, Arnold, Berry, Bartsch, Clark, and Orcutt. Recognition of the contributions of these, as well as of many others, is noted in the systematic portion of this paper.

Two articles have been published in which lists of the local fauna are given. The first of these, by Wood and Raymond, appeared in 1891 under the title, "Mollusks of San Francisco County," together with a supplementary note (Wood, 1891) entitled, "Additional mollusks of San Francisco Bay." These papers give the marine and land forms collected by the authors within the region designated. The second paper (Blankinship and Keeler, 1892), although not devoted primarily to conchology, as might be inferred from the title, "On the natural history of the Farallon Islands," is of interest since it contains a list of a number of marine mollusks compiled by Dr. J. C. Cooper.

ENVIRONMENT OF THE MOLLUSCAN FAUNA

SAN FRANCISCO BAY

Physical.—The physical and biological environments found within the waters of San Francisco Bay will be discussed briefly before the fauna is considered, so that certain peculiarities of molluscan distribution may be more easily interpreted. The data upon which the following discussion is based are taken from the comprehensive paper entitled, "A report upon the physical conditions in San Francisco Bay, based upon the operations of the United States Fisheries' Steamer 'Albatross' during the years 1912 and 1913," by F. B. Sumner, G. D. Louderback, W. L. Schmitt, and E. C. Johnston (1914).

San Francisco Bay is "an irregular body of water surrounded by marshes and prolonged into estuaries . . . extending from the mouth of Sonoma Creek at the extreme northern end to the mouth of the so-called 'Coyote River' at the extreme southern." As thus defined it includes San Pablo Bay. It has a length of 52 statute miles and a maximum width of 11.5 miles and an estimated area of 400 square miles.

The Sacramento and San Joaquin rivers empty into the upper part of San Francisco Bay through Carquinez Strait. There are several small streams, most of which are intermittent, that contribute considerable volumes of water to the bay during the rainy season. The total discharge of these streams affects the temperature and salinity of the waters of the bay, besides bringing in sediments that are in part deposited within San Francisco Bay.

The depth of San Francisco Bay ranges up to 63 fathoms encountered in the narrower portion of Golden Gate. It has been shown by Sumner *et al.* (p. 21) that only 18.4 per cent of the total area of the bay has a depth greater than 5 fathoms. The mean depth has been computed to be 22.7 feet. The deeper waters are found in the middle division of the bay within the Golden Gate and in Raccoon Strait just north of Angel Island. The deeper waters of the upper and lower divisions of the bay are confined to narrow central channels.

It may be well to define here the divisions of the bay since these terms will appear frequently throughout the paper. Sumner *et al.* (1914, p. 22) recognize three divisions of San Francisco Bay. The "upper" one includes San Pablo Bay; the "middle" one extends from a line passing through the points of San Pedro and San Pablo to a line drawn from the Ferry Building to the Goat Island Light; the third or "lower" division lies to the south of this latter line.

The mean tidal range for the entire bay throughout the month is given as 4.52 feet. The actual extremes during the course of the year are much greater, ranging from 0.4 to 7.8 feet at Fort Point within the Golden Gate.

The rate of the tidal currents was determined for a number of localities to be about 1.4 knots per hour at a distance of a few feet below the surface. It was estimated that the mean rate of water flow over the entire bottom was between 0.67 and 0.75 knots per hour. In Golden Gate and Raccoon Strait the currents are strong enough to scour the bottom, leaving only the coarser sediments.

The mean annual temperature for the entire bay is 12°91C. The highest recorded temperature is 20°6C and the lowest is 6°C. The highest of the regional means for the year was obtained in the lower division of the bay and the lowest in the middle segment. A seasonal range of 12°65C occurs in the northern end of the bay, decreasing to 4°92C at the Golden Gate and rising to 11°18C at the southern end. These extremes of temperature are perhaps of less importance in determining the distribution of marine organisms than are those prevailing at the times of the year that coincide with the reproductive periods of the different species.

In the above-mentioned report it has been shown that there are considerable seasonal variations in the temperatures within the different regions of the bay. During February the temperatures are quite uniform for the entire bay, being at that time lower than are those of the ocean outside the Golden Gate. During the latter part of April and early May the waters at either end of the bay are warmer than in February, whereas those of the middle division are colder than they are at the earlier period. At the next period, the latter part of July, a rise of temperature is noted, the Golden Gate remaining the coolest region of the bay. During this period the temperature of the bay is higher than that of the ocean off San Francisco. In the early part of October a general decrease in the temperature is evident, and at this period, as well as in the early part of May, the oceanic temperatures are nearly the same as those of the bay. In late November a general uniformity of temperatures somewhat lower than those of the open ocean prevails throughout the bay. The lowest temperatures of the year occur in January, at which time the waters of the middle division are the warmest, while those of San Pablo Bay are the coldest. Both during this month and in February the waters of the bay are colder than are those of the ocean.

From the standpoint of the mollusk, these temperatures may not be as important as are the bottom temperatures. Yet it is not improbable that the temperature of a higher stratum is more significant in determining the distribution of the mollusk, for it is in the higher stratum that the larval stages are generally passed. The annual range of the bottom temperature for the entire bay is 8°35C. The bottom and surface temperatures are more nearly alike in the winter than in the summer.

The salinity of San Francisco Bay ranges from 3.25 to 33.27 per mille. The mean for the entire bay for the year was found to be 27.48. The regional annual mean is less than 16 per mille in Carquinez Strait, while it reaches as high as 31 just within the Golden Gate. As might be expected, the seasonal range is greatest in San Pablo Bay, which receives the discharge of the Sacramento and San Joaquin rivers, reaching a minimum at the Golden Gate and increasing but slightly toward the lower end of the bay. The seasonal minimum mean salinity for the entire bay occurs in April and May and the maximum in October, according in general with the high and low water stages of the Sacramento and San Joaquin rivers. The bottom salinity for the entire bay is greater than the mean surface salinity throughout the year, the difference between the two being greater during April and May, when the surface salinity is the lowest for the year.

An examination of the bottom conditions of the bay reveals a diversified character such as might be expected by one familiar with the geographic features of this region. Materials ranging from large angular stones to fine muds are represented. San Pablo Bay is muddy except for a small area at the lower end of Carquinez Strait. Mud occurs also in local areas within the middle division, but in the deeper water explored by the Survey the bottom is arenaceous. The bottom within the Golden Gate is composed in the main of sand and gravel, but in places the currents are so strong that they prevent the accumulation of little except gravel. The lower division of the bay is predominantly muddy. At some localities within the lower and middle segments the bottom appears to be paved with shells of *Ostrea lurida* and *Mya arenaria*. The distribution of the different types of bottoms is admirably shown by Sumner *et al.* (pl. 5).

Chemical analyses have been made of bottom samples from a number of stations. They show that the percentage of free or combined nitrogen is higher in the upper and lower divisions of the bay.

Biological.—The different biological environments under which the mollusks of San Francisco Bay are living cannot be definitely described. The materials obtained by the operations of the "Albatross" are now being studied by specialists. When the different reports are completed it may be possible to recognize certain relationships between the distribution of some of the mollusks and that of other groups of animals or plants. The relative abundance of the plankton, which probably serves as the most important food supply of the pelecypods, undoubtedly varies somewhat within the different regions of the bay. Recent studies made by Mr. E. P. Rankin show that the number of species and individuals of diatoms decreases as one passes from the middle to the upper division of the bay. If these data were plotted, relationships of some of the bivalves to distribution might be expected, unless everywhere within the bay the plankton is present in quantities above the requirements of the mollusks. The latter is likely to be the case, since Professor Kofoid's studies show that the plankton of the bay is relatively rich.

For the predatory gastropods the optimum habitat is, of course, determined by the presence of their prey. Thus the distribution patterns of *Urosalpinx* and *Ilyanassa* are similar to those of the native and eastern oysters.

THE OPEN OCEAN

The investigations of the "Albatross" outside the Golden Gate were confined, during this Survey, to the waters lying between the San Francisco Peninsula and the Farallon Islands, with the exception of a single bottom sample taken west of the Farallones. Excepting this latter locality, the water ranged in depth from 8½ to 68 fathoms. Just outside the Golden Gate is a shoal, known as the "Bar," upon which depths of only 5 fathoms are encountered at a distance of five miles offshore.

The annual mean temperature for the ocean off San Francisco is given by Sumner *et al.* (1914, p. 52) as 12°86C. The range for the years is about 3°C, the lowest temperatures occurring in April and the highest in October. The mean annual salinity for the offshore stations is 34.04 per mille.

No attempt has been made to make a detailed investigation of the character of the offshore bottom. The field descriptions of the samples obtained from each dredge haul indicate that the bottom is predominantly of a dark greenish sand.

GENERAL CHARACTER OF THE FAUNA

The molluscan fauna taken by the Biological Survey within San Francisco Bay and adjacent waters comprises 112 species and 2 varieties. These are distributed among 3 classes representing 49 families and 78 genera. A little over 50 per cent are bivalves. The gastropods are represented by 47 species and 1 variety, the scaphopods by 2 species, and the chitons by 6 species and 1 variety.

This number of species and varieties obtained by the Survey includes only about 65 per cent of the known molluscan fauna of these waters. The catalogue of species (p. 245) contains 173 species and 13 varieties that have been collected by the Survey, or previously reported from San Francisco Bay, San Francisco County, or the Farallon Islands. It is probable that the marine fauna is still larger, for there is a considerable number of species that are known to occur both north and south of this region. The following list as compiled includes 118 such species which may be found in the vicinity of San Francisco.

Incomplete List of Molluscan Species Whose Ranges Include San Francisco But Have Not as Yet Been Reported From This Region

Pelecypoda*
- Acharax agassizi Dall
- Acharax johnsoni Dall
- Adula californiensis Philippi
- Adula diegensis Dall
- Axinopsis sericatus Carpenter
- Axinopsis virdis Dall
- Calyptogenia pacifica Dall
- Cardium californiense Deshayes
- Cardita subquadrata Carpenter
- Cooperella subdiaphana Carpenter
- Crenella columbiana Dall
- Crenella decussta Montagu
- Cummingia lamellosa Sowerby
- Cuspidaria apodenia Dall
- Cuspidaria chilensis Dall
- Dermatomya tenuiconcha Dall
- Diplodonta orbella Gould
- Entodesma inflatum Conrad
- Glycymeris migueliana Dall
- Kellia suborbicularis Montagu
- Leda acuta Conrad
- Leda conceptionis Dall
- Leda minuta Fabricius
- Leda penderi Dall
- Lima subauriculata Montagu
- Lyonsia gouldi Dall
- Macoma calcarea Gmelin
- Macoma expansa Carpenter
- Macoma incongrua Martens
- Macoma inflatula Dall
- Macoma inquinata var. arnheimi Dall
- Macoma quadrana Dall
- Mactra californica Conrad
- Malletia pacifica Dall
- Marcia kennerlyi (Carpenter) Reeve
- Martesia xylophaga C. B. Adams
- Miodontiscus prolongatus Carpenter
- Modiolus flabellatus Gould
- Musculus olivaceous Dall
- Mya intermedia Dall
- Mytilimeria nuttali Conrad
- Nucula linki Dall
- Ostrea palmula Carpenter
- Pandora bilirata Conrad
- Pandora punctatus Conrad
- Panope generosa Gould
- Panope generosa var. solida Dall
- Paphia staminea var. laciniata Carpenter
- Paphia staminea var. spatiosa Dall
- Pecten alaskense Dall
- Pecten hindsi var. navarchus Dall
- Pecten tillamookense Arnold
- Pecten vancouverense Whiteaves
- Phacoides annulata var. densilineata Dall
- Pholadidea penita var. concamerata Deshayes
- Pholadidea rostrata Valenciennes
- Psammobia californicus Conrad
- Psephidia lordi Baird
- Rochefortia tumida Carpenter
- Semele rubropicta Dall

* Compiled from Dall (1916*a*).

Sphenia fragilis Carpenter
Sphenia ovoidea Carpenter
Spisula falcata (Gould)
Tindaria gibbsi Dall
Tindaria kennerlyi Dall
Tindaria martiniana Dall
Thracia beringi Dall
Thracia curta Conrad
Thyasira barbarensis Dall
Thyasira bisecta Conrad
Thyasira excavata Dall
Thyasira trisinuata var. polygona Jeffreys
Tivela stultorum Mawe
Transennella tantilla Gould
Turtonia minuta Fabricus
Vesicomya lepta Dall
Vesicomya ovalis Dall
Venericardia crebricostata Krause
Venericardia ventricosa Gould
Yoldia beringiana Dall
Yoldia montereyensis Dall
Yoldia orcia Dall
Yoldia sanesia Dall

Gastropoda*

Acmaea incessa (Hinds)
Acmaea triangularis Carpenter
Acmaea instabilis (Gould)
Bittium eschrichti (Middendorff)
Calliostoma annulatum (Martyn)
Calliostoma canaliculatum (Martyn)
Calliostoma variegata Carpenter
Cerithiopsis columna (Carpenter)
Chrysodomus kelletti (Hinds)
Columbella tuberosa (Carpenter)
Crepidula dorsata Broderip
Crepidula excavata Broderip
Epitonium indianorum (Carpenter)
Fossarus compacta (Carpenter)
Fossarus fenestratus (Carpenter)
Galerus mammillaris (Broderip)
Hipponix cranioides (Carpenter)
Lacuna solidula (Lovèn) Carpenter
Lazaria subquadriata (Carpenter)
Melanella compacta (Carpenter)
Murex trialatus (Sowerby)
Murex nuttalli (Conrad)
Murex (Ocinebra) foveolata (Hinds)
Nassa californiana (Conrad)
Odostomia angularis Dall and Bartsch
Odostomia oregonensis Dall and Bartsch
Odostomia tenuisculpta (Carpenter)
Pachypoma inequale (Martyn)
Phorcus pulligo (Martyn)
Puncturella cucullata (Gould)
Solariella cidaris (A. Adams)
Tritonium oregonense (Redfield)
Trophon disparilis (Dall)
Trophon scitulus (Dall)
Trophon gracilis (Perry)

* This list has been compiled from various authors.

This long list will probably be modified as the different faunas are studied more intensely. However, it suffices to show that the known fauna of this region is considerably less than the actual fauna.

The discrepancy between the number of known forms and the number obtained by the Survey is due in part to the fact that little attention was given to shore collecting. Mollusks were obtained, however, at the following shore stations: Bonita Point, Sausalito, Fort Point, Key Route Pier (Oakland), Point Richmond, Red Rock, and McNear's Landing.

In the discussions that follow only the material obtained by the Survey will be considered unless the contrary is stated. As a matter of convenience the fauna obtained in the open ocean off the Golden Gate will be designated as the "outside" fauna in contrast to the "bay" fauna.

The outside fauna consists of 62 (+ 6?) species, of which 34 are pelecypods, 32 are gastropods, and 2 are scaphopods. Forty-six per cent of this fauna was not obtained within San Francisco Bay. This great difference between the two faunas is not due to depth, but presumably to other factors, such as decreased salinity, fluctuating temperatures, and varied bottom conditions peculiar to partially enclosed waters. The mollusks that are restricted in our records to the ocean off San Francisco are indicated in the following list of the outside fauna by an asterisk.

Molluscan Fauna Obtained in the Open Ocean Off San Francisco

Acila castrensis (Hinds)*
Actaeon punctocoelatus (Conrad)*
Acteocina cerealis (Gould)*
Astralium triumphans Philippi*
Barleeia subtenuis Carpenter*
Bathytoma carpenteriana Stearns*
Bittium subplanulatum Bartsch*
Cadulus fusiformis Philippi*
Cancellaria crawfordiana Dall*
Cardium corbis (Martyn)
Cardium (Protocardia) centifilosum Carpenter*
Chrysodomus tabulatus Baird*
Columbella gausapata Gould
Crepidula nivea Adams?
Cuspidaria californica Dall*
Dentalium indianorum Linnaeus*
Epitonium sawinae (Dall)
Eunaticina oldroydi (Dall)
Hinnites giganteus Gray
Lacuna porrecta Carpenter
Leda hamata Carpenter*
Leda taphria Dall
Lyonsia californica Conrad
Macoma indentata Carpenter*
Macoma inquinata Deshayes?
Macoma nasuta (Conrad)?
Macoma yoldiformis Carpenter*
Mangilia angulata Carpenter*
Marcia subdiaphana (Carpenter)*
Melanella (Eulima) micans (Carpenter)*
Modiolus politus Verrill and Smith
Murex (Ocinebra) interfossa (Carpenter)*
Mya arenaria Linnaeus
Mya (Cryptomya) californica (Conrad)
Mytilus edulus Linnaeus
Nassa fossata (Gould)
Nassa mendica Gould
Nassa perpinguis Hinds
Nucula tenuis (Montagu)*
Odostomia franciscana Bartsch
Olivella intorta Carpenter
Olivella pedroana Conrad*
Ostrea lurida Carpenter
Pandora filosa (Carpenter)*
Paphia staminea (Conrad)
Phacoides annulatus (Reeve)*
Phacoides tenuisculptus (Carpenter)
Polinices draconis (Dall)
Polinices lewisi (Gould)
Psephidia ovalis Dall
Siliqua nuttalli (Conrad)
Solen sicarius Gould
Tellina buttoni Dall?
Tellina carpenteri Dall*
Tellina salmonea (Carpenter)
Thais emarginata var. ostrina (Gould)
Thais lamellosa (Gmelin)
Thyasira gouldi (Philippi)*
Turbonilla keepi Dall and Bartsch*
Turbonilla franciscana Bartsch*
Turris (Bela) tabulata Carpenter*
Turris incisa Carpenter*
Turris perversa (Gabb)*
Volvula cylindrica Carpenter*
Xylotrya, sp.
Yoldia cooperi Gabb*
Yoldia ensifera Dall*
Zirfaea gabbi Tryon

It will be seen that the gastropods comprise approximately 50 per cent of the outside fauna. This proportion is greater by 12 per cent than obtains within the bay. A consideration of the entire known fauna as catalogued below shows that the univalves exceed the bivalves by about 4 per cent. It is not evident why the proportion of gastropods should be greater in the outside than in the bay fauna.

The waters outside the Golden Gate are more favorable to a varied molluscan life than are those within San Francisco Bay. This is shown by the greater average number of species per station than obtains in any of the regions of the bay. The most productive station, as far as species are concerned, is D 5789, only a short distance southeast of the Farallon Islands. This station yielded 25 species of mollusks that were represented by living specimens. This is more than twice the number (12) taken at a single station within the bay. The record of this most productive outside station is given below (table 1).

TABLE 1

RECORD OF THE MOST PRODUCTIVE OUTSIDE STATION (D 5789)

	No. of living specimens	No. of shells
Acila castrensis	3	1
Acteocina cerealis	3	2
Actaeon punctocoelatus	2	....
Bathytoma carpenteriana	15	2
Cadulus fusiformis	104	....
Cancellaria crawfordiana	14	....
Cardium centifilosum	2	4
Columbella gausapata	11	1
Chrysodomus tabulatus	3	1
Cuspidaria californica	6	3
Dentalium indianorum	50	....
Epitonium sawinae	1	1
Leda hamata	4	....
Leda taphria	5	....
Macoma yoldiformis	1	1
Mangila angulata	......	5
Marcia subdiaphana	15	4
Melanella micans	3	....
Modiolus politus	1	....
Mytilus edulis	31	....
Nassa perpinguis	74	62
Pandora filosa	3	3
Phacoides annulatus	......	6
Phacoides tenuisculptus	2	3
Polinices draconis	1	1
Volvula cylindrica	7	2
Yoldia ensifera	7	4

The average number of species represented by living specimens per station is 6.7. This is not the average per dredge haul, for in the majority of cases two hauls were made at a station. Unfortunately the author's records do not give the requisite data upon which to base the more accurate average. This number is twice as great as the same average for the entire bay and over three times as great as obtains in the upper division of the bay, where conditions are least favorable to a varied molluscan life.

The relative abundance of mollusks in the different regions may be approximated by taking the average number of living specimens per station. In the list given above of station D 5789, 368 living specimens were recorded. These were obtained by dragging a 12-foot Agassiz trawl a distance of one mile and then covering the same course with a 19-inch boat dredge. It is not presumed that this number of living specimens could be considered as representing all of the individuals living within the area covered by the dredging operations. However, the average of a number of such stations gives a figure that has a comparative significance. When the number of living specimens only are considered it is found that the average per station for the region outside the Golden Gate is 74.4. This is but little larger than that for the lower division of the bay (70), but it is about three times as large as that for the upper division (26.3).

When these figures are compared with the average number per dredge haul for the "quantitative" stations of any two of these regions, different ratios are obtained. The average number of living individuals per haul (orange-peel bucket dredge) for the upper division of the bay is 4, while that for the lower is 27.9. This ratio is only about one-half of that obtained above. Obviously these quantitative results are the more accurate since they are based upon the actual numbers of mollusks living upon equal areas. Thus it appears that the figures obtained by the first method can give only a very general idea of the relative abundance of the mollusks living within a given area.

The fauna from San Francisco Bay comprises 81 species and varieties, 43 of which are pelecypods, 31 gastropods, and 7 chitons. In the list of the bay fauna given below those species that were taken exclusively within the bay are followed by an asterisk.

Fifty-nine per cent of the species listed below were taken exclusively within San Francisco Bay. This percentage would be somewhat decreased had collections been made along the littoral outside the Golden Gate. Nevertheless the relatively small percentage of forms common to the two contiguous regions is noteworthy. A number of the forms listed below were rarely taken. Such species obviously have little significance in such a study. Therefore it has seemed advantageous to prepare a list of the more common species.

MOLLUSCAN FAUNA OBTAINED WITHIN SAN FRANCISCO BAY

Acmaea patina Eschscholtz*
Acmaea persona Eschscholtz*
Adula stylina Carpenter*
Acteocina cerealis (Gould)?
Anomia peruviana d'Orbigny*
Arca transversa Say*
Calliostoma costatum (Martyn)*
Cardium corbis (Martyn)
Columbella gausapata (Gould)
Crepidula convexa Say*
Crepidula nivea Adams
Entodesma saxicola (Baird)*
Epitonium hindsi (Carpenter)*
Ischnochiton dentiens (Gould)*
Fissuridea aspera (Eschscholtz)*
Gemma gemma var. purpura Lea*
Hinnites giganteus Gray*
Ilyanassa obsoleta (Say)*
Kellia laperousi (Deshayes)*
Lasaea rubra (Montagu)*
Lacuna porrecta Carpenter
Lacuna unifasciata Carpenter*
Lacuna variegata Carpenter*
Leda taphria Dall
Littorina planaxis (Nuttall)*
Littorina scutulata Gould*
Lyonsia californica Conrad*
Macoma balthica (Linnaeus)
Macoma inquinata (Deshayes)
Macoma nasuta (Conrad)
Margarites pupilla (Gould)*
Modiolus politus Verrill and Smith?
Modiolus rectus Conrad*
Monia macroschisma (Deshayes)*
Mopalia ciliata Sowerby*
Mopalia kennerleyi var. swani Carpenter*
Mopalia muscosa Hinds
Mopalia wosessenski Middendorff*
Murex (Ocinebra) interfossata (Carpenter)?
Murex (Ocinebra) lurida (Middendorff)*
Mya arenaria Linnaeus
Mya (Cryptomya) californicus Conrad
Mytilus californicus Conrad*
Mytilus edulis Linnaeus
Nassa fossata (Gould)
Nassa perpinguis Hinds
Nassa mendica Gould
Odostoma franciscana Bartsch
Olivella biplicata Sowerby*
Olivella intorta Carpenter
Ostrea elongata Solander*
Ostrea lurida Carpenter
Paphia staminea (Conrad)
Paphia tenerrima (Carpenter)*
Pecten latiauritus Conrad*
Petricola carditoides (Conrad)*
Phacoides tenuisculptus (Carpenter)
Pholadidea penita (Conrad)*
Pholas pacificus Stearns*
Polinices draconis (Dall)
Polinices lewesi (Gould)
Psephidia ovalis Dall
Saxicava arctica (Linnaeus)*
Saxicava pholadis (Linnaeus)
Saxidomus nuttalli Conrad*
Schizothaerus nuttalli (Conrad)*
Siliqua nuttalli (Conrad)
Spisula catilliformis Conrad*
Solen sicarius Gould
Tegula funebrale (A. Adams)*
Tellina bodegensis Hinds*
Tellina buttoni Dall
Tellina salmonea (Carpenter)
Tonicella lineata (Wood)*
Trachydermon raymondi Pilsbry*
Thais emarginata var. ostrina (Gould)
Thais lamellosa (Gmelin)
Turbonilla franciscana Bartsch
Turris incisa (Carpenter)*
Urosalpinx cinereus (Say)*
Xylotrya, sp.
Zirfaea gabbi Tryon

The more common or prevalent species may arbitrarily be defined as those that were taken at one-fourth or more of the stations of any given group of stations, as suggested by Sumner *et al.* (1913, p. 69). In the following list (table 2) the prevalent species for the different divisions of San Francisco Bay are given.

TABLE 2

PREVALENT SPECIES FOR THE ENTIRE BAY (QUANTITATIVE HAULS) AND FOR EACH OF THE THREE DIVISIONS

Prevalent species	Upper	Lower	Middle	Entire Bay (quantitative hauls)
Cardium corbis	....	×	×	×
Macoma balthica	×	×	×	×
Macoma inquinata	....	....	×	×
Macoma nasuta	×	×	×	×
Mya arenaria	×	×	....	....
Mya californica	×	×	×	×
Mytilus edulis	×	....	×	×
Ostrea lurida	....	×	×	×
Paphia staminea	....	....	×	....
Schizothaerus nuttalli	....	....	×	....
Thais lamellosa	....	....	×	×
Zirfaea gabbi	....	....	×	×

The distribution of these prevalent species, together with six others that occurred at ten or more stations, has been plotted upon outline maps of San Francisco Bay. Localities at which a particular species was taken alive are indicated on the plates (42–55) by a dot, while those at which only shells were taken are indicated by a circle. These charts show at a glance the approximate ranges of the species within the bay. It will be noted that the distribution patterns differ quite widely.

The most productive station within San Francisco Bay from the standpoint of the number of species is D 5796, situated north of Angel Island within Raccoon Strait. The species listed on the following page were obtained at this locality.

This list is not entirely comparable to that given in table 1 of the most productive outside station, for the largest number of determined species and the largest number represented by living specimens were not here obtained at the same station. At D 5781 twelve different living specimens were dredged.

A study of the ranges of the known fauna as listed in the catalogue of species gives some suggestion as to the position of the fauna in relation to climatic zones. One hundred and twenty-nine species and varieties are known to range north of San Francisco, whereas 154 occur south of that place. These figures are of less value in determining the relationships of the fauna to other West Coast faunas than are those derived according to a method used by Sumner *et al.* (1911, p. 184). Those authors compare the number of "predominantly northward ranging" species with the number of southward ranging forms. They define "predominately northward ranging" species as one, "whose range (in latitude) to the northward on our coast is at least twice as great as is its range to the southward." Applying this method to our fauna as catalogued gives 77 species as predominantly northward ranging; 55 as predominantly southward ranging; 37 whose known ranges are nearly equal to the north and south of San Francisco; 14 which are known only from San Francisco, and 11 species that cannot properly be classified, since their ranges are imperfectly known. This indicates, if the faunas north and south of San Francisco are about equally well known, that the local fauna has closer affinities with the northern fauna than with that to the south.

Two new species of mollusks have been discovered as a result of the dredging operations of the "Albatross." They have been described by Dr. Bartsch under the names of *Odostoma franciscana* and *Turbonilla franciscana.*

The molluscan fauna of this region includes several exotic species, most of which have inadvertently been introduced with young oysters

TABLE 3

RECORD OF THE MOST PRODUCTIVE BAY STATION (D 5796)

	No. of living specimens	No. of shells
Cardium corbis	17	18
Columbella gausapata	0	5
Mya californica	0	10
Macoma inquinata	0	5
Macoma nasuta	0	3
Monia macroschisma	0	1
Mytilus edulis	0	1
Nassa fossata	0	1
Nassa mendica	0	2
Ostrea lurida	0	10
Paphia staminea	0	1
Schizothaerus nuttalli	0	2
Siliqua nuttalli	3	1
Tellina salmonea	0	2
Thais lamellosa	1	27
Zirfaea gabbi	0	1

from the Atlantic coast. One of these, *Arca transversa* Say, has not heretofore been reported from the West. It is represented in the Survey collections by a number of old valves. Living specimens have not as yet been taken, so it is not certain that this common Atlantic form is now living within San Francisco Bay. *Australium triumphans* Philippi was dredged alive just outside the Golden Gate. Although the locality lies within the course of oceanic traffic, the probabilities are against the dredging of a single specimen that may have been carried across the Pacific and then dropped from the bottom of the ship. If this species is exotic, it presumably has established itself within these waters. The eastern oyster, *Ostrea elongata* Solander, more generally known as *O. virginica,* is grown within San Francisco Bay. It does not reproduce, at least sufficiently for economic purposes, so young oysters are introduced from the east to replenish the beds, depleted by the annual harvest. *Mya arenaria* Linnaeus, the "soft shelled" or "mud clam," is thought to be exotic. It is not known to be circumpolar in distribution and does not occur native in Puget Sound. That it is not indigenous to San Francisco Bay appears to be indicated by the lack of shells of this edible clam in the undisturbed Indian shell mounds that occur in the vicinity of the bay. *Urosalpinx cinereus* Stimpson was first noted by Stearns (1894, p. 94). It is now abundant in the lower division of the bay in the vicinity of Point San Mateo, where it plays havoc with the oysters. Another predatory gastropod, *Ilyanassa obsoleta* Say, first appeared in 1909, according to Keep (1911). As yet it is confined to the southern part of the bay, where it is associated with the preceding species. *Modiolus demissus* (Dillwyn), another eastern form, was first reported by Stearns in 1899. It has now established itself in these waters, and it is occasionally found in the San Francisco markets. The venerid, *Gemma gemma* var. *purpura* Lea, known here since 1899, now occurs in great numbers within the shallow waters along the southeastern shores of the bay.

The tubular bottom samples have revealed the fact that conditions have not been equally favorable to molluscan life during different periods of time. Sumner *et al.* (1914, pl. 6) have shown that in certain regions of the bay, notably south of Hunters Point, in the lower division, the stratified samples contain layers of shell, covered by a superficial deposit of nearly pure mud. Of the ten sections shown in diagram for the region south of that point only one (H 5300) is represented as having an appreciable amount of calcium carbonate (shell) at the surface, while nine of them show considerable percentages of lime at depths from 40 to 140 centimeters. In the other divisions of the bay the tubular samples are, with a very few exceptions, nearly uniform in respect to the lime content from the top to the bottom. In the lower extremity of the bay five of the ten sections show shells only in the middle portion of the sample, indicating a change from an unfavorable to a favorable and then back again to a comparatively unfavorable environment for the mollusks. At two of the five remaining stations the sampling apparatus did not penetrate to the shell horizon, which appears to be quite extensive in that region.

The reason for such fluctuating conditions is not evident. Were it not for the bottom stratum of relatively limeless mud the present unfavorable conditions might be attributed to some factor introduced as a result of the proximity of the cities of San Francisco, Oakland, and Alameda. These changes may be due to the variations in the silting up of the basin of deposition, whereby during certain periods deposition proceeded at too rapid a rate to favor abundant molluscan life. Such variations in sedimentation might be expected as a result of local diastrophic movements, such as are indicated by changes of level registered by the Indian shell mounds around the bay. Or pos-

TABLE 4

FAUNA OBTAINED IN CAVITIES IN ROCKS AT STATIONS D 5845 AND D 5846

Rock numbers*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Dimensions in inches	9 × 7 ×	5 × 4 × 2½	12 × 8 × 5	....	7½ × 5½ × 4½	4 × 5 × 3	12 × 8 × 5	8 × 5 × 5	7 × 7 ×	12 × 6½ × 3	12 × 8 × 6	9 × 5½ × 4	6 × 7 × 4	10 × 9 × 6	14 × 5 × 7	18 × 9 × 11	13 × 7½ × 6½	5 × 4½ × 3
Weight in pounds	14½	2	20	2	6½	2½	16¼	6	6	8¾	19	8	5	14¼	19½	61¼	18½	[illegible]
Species																		
Crepidula nivea	----	----	----	----	----	----	----	×	----	----	----	----	----	----	----	----	----	----
Entodesma saxicola	----	×	----	----	----	----	----	----	----	----	----	----	----	----	----	×	----	----
Kellia lapuerosi	----	----	×	----	----	----	----	×	----	×	----	----	----	----	×	×	×	----
Hinnites giganteus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	×	----	----
Macoma inquinata	----	----	----	----	----	----	----	----	----	----	----	----	----	×	----	----	----	----
Paphia staminea	----	----	----	----	----	----	----	----	×	----	×	----	----	----	----	----	×	----
Pholas pacificus	----	----	----	×	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pholadidea ovoidea	----	----	----	----	----	†	----	----	----	†	----	----	----	----	----	----	----	----
Pholadidea penita	----	×	----	×	----	----	----	----	----	----	×	----	×	×	----	----	×	----
Petricola carditoides	×	----	----	----	----	----	×	×	----	×	×	×	×	----	×	×	----	----
Ostrea lurida	----	----	----	----	----	----	----	----	----	----	----	----	----	×	----	----	----	----
Saxicava arctica	----	----	----	----	×	----	----	×	----	----	----	----	----	----	----	----	----	----
Zirfaea gabbi	----	----	----	----	----	----	----	----	----	----	----	----	----	×	----	----	----	----

* Rocks 1–6 inclusive; came from station D 5845, the others from D 5846.
† Living specimens.

sibly they are due in part to the effects of hydraulic mining, which, according to Davidson, resulted in the deposition of 60 feet of mud within San Francisco Bay. Dall in a personal communcation states that "the changes (diminution) of the fauna (molluscan) since my first dredgings in 1865 are notorious among local collectors."

The dredging of pholadid specimens at unusual depths within the Golden Gate leads to a special investigation with the view of determining the bathymetric range of these forms. Dredge hauls were made with the oyster dredge at stations D 5845 and D 5846 within the outer portion of the Golden Gate. A number of boulders representing a variety of rock types were obtained. The rocks that had been bored by mollusks were measured, weighed, and then broken in order to obtain the enclosed mollusks. Rocks number 1 and 7 were serpentine, number 16 being a gray schist. The remainder of the rocks that had been bored were sandstone or shale, presumably of Franciscan Jurassic age, such as occur along the shores of the Golden Gate.

Within old pholadid borings were found a number of molluscan species, several of which are not commonly considered as nestlers. These included *Zirfaea gabbi, Macoma inquinata, Ostrea lurida,* and *Hinnites giganteus.* The last species was found in a large pholadid boring, in which it had become imprisoned and to which it had attempted to conform but eventually had been killed by its restricted quarters.

The fauna from the different rocks is given in the accompanying table (4), together with the rough dimensions and weights of each boulder.

Living pholads were obtained in rocks number 6 and 10 at a depth of 59 fathoms. The boulders from which these specimens were taken are too large and too irregular to have been moved from shallower water during the life of the mollusk. This occurrence indicates a bathymetric range for these borers considerably greater than is generally attributed to them, especially by geologists who commonly employ them as indicators of ancient strand lines. Even these figures do not represent the maximum range for members of the family, since Dall informs the writer that a specimen has been taken from a depth of 1270 fathoms.

DISTRIBUTION OF THE MOLLUSKS

General Distribution

Our knowledge of the benthos is largely derived from various types of dredgings. Under the ordinary methods a dredge is hauled along the bottom for a distance often measured in miles. Obviously such a haul may traverse a diversified bottom and the fauna from several types of bottoms becomes mixed. Such a commingling has to some extent been minimized in this survey by making the dredge hauls in the majority of cases less than a mile in length. The different environmental conditions of San Francisco Bay are now accurately known from the published analyses of the bottom samples and the other hydrographic data obtained by the Survey.

A system of dredging that offers greater possibilities for biological purposes has been employed by Peterson (1914, p. 5) within the Cattegat, and still another by Sumner in this Survey, whereby a numerical census of the life of a small area was obtained. The orange-peel bucket dredge (see Sumner *et al.*, 1914, p. 7) had not previously been used for biological work. It is evident that "its chief advantage lies in the taking of comparatively large masses of mud from a single spot, and particularly in the penetrating power of the apparatus, which renders possible the capture of deeply burrowing annelids, lamellibranchs, etc." The results of this phase of the Survey are summarized below. The occurrences of the species taken by means of this dredge are given in the catalogue of species, and these data have been used in the plotting of the distribution charts (pls. 42–59).

In order to analyze the environment of a species, it is necessary to consider the factors that in any way might react with the organism, causing it during its own life or during a number of generations to better adapt itself to its surroundings. From the standpoint of the Mollusca, these factors are numerous and little understood. The ecologist is generally unable to trace the processes of adjustment of a species to its environment as the palaeontologist apparently can do from a study of successive horizons. He must, therefore, content himself with observations upon the degree of perfection of the adjustment between the animal and its environment at a definite period of time.

If a bivalve is modified, for instance, according to one biological theory, as a result of the impact of its environment or through selective processes for successive generations, there should be a definite relationship between its structures and certain factors in its optimum habitat. Such coördinations as these ought to be revealed through a detailed study of the distribution of the animal. But such adjustments of the organism to habitat might vary according to what has been termed the plasticity of species toward changes, and, in addition, to other causes, according to the length of time in which the species has been subjected to the present conditions. Not all of the species listed in this paper are specifically of the same age, as is indicated by their palaeontologic histories. Therefore it is improbable that all of them, or even a majority of them, have become specialized in the same degree. Thus all would not be so nearly adjusted to a particular habitat that their spatial distribution would be a function of any one type of environment. It is quite unlikely, then, that the distribution patterns, such as shown on plates 42 to 59, of all of the species could be interpreted with the same facility. On the other hand, it is not surprising to note that certain species have become, for some reason, so specialized that they now appear to be distributed according to one or more factors of their environment. Of course, certain other hypotheses bearing upon speciation and dispersal would not all yield these conclusions.

The separation of a single factor from the diversified environment and the determination of its effects upon an organism is attended with difficulties even to the biologist who can bring his subjects into the laboratory under controlled conditions. The student of marine Mollusca seldom controls the environments with which he deals. His conclusions as to the importance of a factor are obtained by indirect methods. They involve the elimination of certain important factors and the studying of the effects of those that remain.

Some of these factors governing distribution are: the depth of the water; temperature; salinity; character of the bottom; the food supply, and other biological factors, including organisms which may not be beneficial to the species under consideration.

Influence of Depth

The influence of depth upon a marine organism is a result of the interaction of several factors, including pressure, temperature, light, access to food supply, and gaseous content of the water. The pressure at the deepest part of the Golden Gate exceeds that of ten atmospheres. It is improbable that this interferes greatly with the molluscan life, for not only does the intertidal species *Columbella gausapata* live under such conditions but *Nassa perpinguis,* another shallow water form, was dredged from a depth twelve times as great at the station west of the Farallon Islands. Temperature in general decreases with depth, but within the comparatively shallow waters of San Francisco Bay other factors interfere in such a way as to cause the average mean bottom temperature during a portion of the year to exceed that of the surface by 0°2C.

Light penetrates oceanic waters to a depth of about 100 fathoms sufficiently to assist in the metabolism of plants. The components of sunlight do not all reach such depths. Some, like the red rays, are thought to be effective but little below 7 fathoms, while the blue and green rays extend to much greater depths. Engelmann (1883) and others maintain that the quality of light determines the distribution of green, brown, and red algae. Light becomes a factor in determining the distribution in depth of any mollusk living directly or indirectly upon a particular type of algae. However, lack of data regarding the distribution of the algae within the local waters prevents the further consideration of this matter.

Dissolved gases play a conspicuous rôle in the life of the benthos. The amount of gas held in solution in sea water is in a large measure a function of the pressure. Tidal currents, of course, prevent the stagnation of any considerable portion of a water body. As a result of such movements of the water an essential gas, as oxygen, becomes distributed even within the depths. In the same manner a harmful gas such as hydrogen sulphide, generated from the decay of organic matter, is prevented from accumulating. Although we have no direct evidence, it is probable that the mean rate of water-flow over the bottom of the bay, as computed by Sumner *et al.* (1914, p. 28), is sufficiently high, so that neither the lack of oxygen nor the excess of a harmful gas has much significance to the mollusk living within San Francisco Bay, except locally near the mouths of sewers.

Three bathymetric zones are recognized within the region covered by this report. They are the littoral, or intertidal, the laminarian, including practically all of the "Albatross" dredging stations, and the deep water zone represented by a single haul made in 815 fathoms off the continental shelf west of the Farallon Islands.

The littoral zone of San Francisco Bay varies considerably as to physical conditions. The narrow, rocky benches bordering a portion of the Golden Gate and many of the islands of the bay, contrast strongly with the wide mud flats in the vicinity of the estuaries and in front of the lowlands. These areas are subject to the same extremes of temperature as the adjacent land, whenever the tide is out. The life at one time may be bathed in fresh water and at another covered by salt water. Unfortunately these factors have not been investigated by this Survey.

There has been no attempt to make a complete biological survey of the intertidal region, although it covers 13.6 per cent of the bay (Sumner *et al.*, 1914, p. 20). The collecting stations mentioned above were for the most part on rocky shores. A notable exception to this is the Key Route Pier (Oakland) locality, where specimens were taken from the piles and the mud flats near by. Along the rocky shores at the high-tide mark the two species of *Littorina* and the various members of the Acmaeidae are the most conspicuous mollusks. Those localities, as in the case of the flats bordering the marsh lands, are lacking in suitable objects for support, and abound in specimens of *Cerithidea californica.* Farther down the beach, near the low tide mark, several of the burrowing clams occur in the sandy or muddy localities, while *Thais* and the chitons occupy a similar position on the rocky beaches.

The following species were taken by the Survey only at the shore stations: *Acmaea patina, Lacuna unifasciata, Littorina planaxis, Mopalia kennerlyi* var. *swani, Saxicava pholadis, Tegula funebrale, Tonicella lineata, Trachydermon dentiens,* and *T. raymondi.* It is probable that these species are not restricted to the littoral zone, but that they represent a few of the more characteristic forms of that region. The fauna of the littoral, of course, includes a considerable number of species that range into the adlittoral zone.

The laminarian zone, within San Francisco Bay, is not divisible into definite subzones upon the basis of the molluscan life. However, it is of interest to note a few of the species that were dredged exclusively in the shallower portion of the bay. In no case is it possible to state that the depth factor is responsible for this apparent distribution. An area equal to about three-fourths that of the entire bay is comprised within the limits of the low-tide mark and that of the six fathom line. Out of the 47 species that were taken by the Survey at depths ranging from 0 to 6 fathoms, only five were restricted to that depth. These are: *Anomia peruviana, Arca transversa, Calliostoma cossatum, Margarites pulloides,* and *Murex interfossa.* All of these were rarely dredged, so in their records have little significance.

About forty species were taken at depths ranging from 6 to 16 fathoms. None of them obtained exclusively within that depth was dredged at more than one station. Thus there appears also in this case to be no definite relationship between distribution and depth of water. Eighty-three species and varieties were dredged at depths between 16 and 68 fathoms. About 50 per cent of these forms were taken by the Survey exclusively at these depths. Since nearly 50 per cent of these restricted species are listed only from the outside fauna, it is probable that some other factor besides depth is the controlling one.

The deep water fauna is represented by the following species: *Columbella gausapata, Epitonium* cf. *hindsi, Leda hamata, Nassa perpinguis,* and *Pandora filosa.* They were obtained by means of the "Albatross" bottom sampling apparatus in 815 fathoms of water west of the Farallon Islands. As will be noted, two of these species have been listed from shallow water.

It is evident that the three bathymetric zones represented within the waters covered by this report can not be divided into distinct subzones upon the basis of the presence or absence of certain mollusks. The very few species that according to our records are restricted to the particular depths considered above were either rarely dredged or had a distribution such as to suggest that some other factor besides depth was more important. It is not unlikely, however, that detailed quantitative studies would show that the relative abundance of individuals of a given species varies with depth, from a maximum which would give a clew to the optimum depth for the species under consideration. With such data available it might be possible to recognize several bathymetric zones.

INFLUENCE OF TEMPERATURE

Temperature has long been recognized as a factor in determining the distribution of marine organisms, but the manner in which it operates in restricting the range of the life of the benthos is a much disputed point. It appears probable that no one principle is equally applicable in even a majority of cases. The northward and southward ranges of mollusks are no doubt determined in some way by the temperatures of the waters in which they live. Unfavorable temperatures may react upon the mollusk so as to interfere with its reproductive activities or to hinder the development of its larvae.

The reproductive periods of a comparatively few mollusks are known and none that belong to this fauna are known to the writer. Unfortunately little information is obtainable from the operations of the "Albatross," for dredge hauls were not made between the dates of May 28 and October 15. None of the specimens collected at other times was examined with this in view. The reproductive period of *Macoma nasuta*, one of the most common bivalves, extends over a considerable portion of the year. This seems to follow from the fact that a number of living specimens less than ten millimeters in length were dredged during the months of January to May and again in October.

It is presumed by Sumner *et al.* (1911, p. 178) that a considerable proportion of the marine invertebrates of Woods Hole reproduce in the winter. It is possible that the same statement would hold for the region of San Francisco, especially since the winter temperatures are much higher in these local waters. If the majority reproduce in the spring and summer, and if the low temperatures interfere with the reproductive functions and early development of the mollusk, the temperature factor should be recognized through a consideration of the distribution of the predominantly southward ranging species.

In the following lists the predominately northward and southward ranging species are given for reference.

Predominantly Northward Ranging Species Taken by the "Albatross"

Acila castrensis
Acmaea patina
Acmaea persona
Adula stylina
Amphissa corrugata
Calliostomia costatum
Cardium corbis
Cardium centifilosum
Chrysodomus tabulatus
Cuspidaria californica
Columbella gausapata
Dentalium indianorum
Entodesma saxicola
Fissuridea aspera
Hinnites giganteus
Ischnochiton dentiens
Kellia laperousi
Lacuna porrecta
Littorina planaxis
Littorina scutulata
Lyonsia californica
Macoma balthica
Macoma inquinata
Macoma nasuta
Macoma yoldiformis
Mangilia pupilla
Marcia subdiaphana
Melanella micans
Monia macroschisma
Mopalia ciliata
Mopalia muscosa
Mopalia wossenssenski
Murex interfossa
Murex lurida
Mya arenaria
Mya californica
Mytilus edulis
Mytilus californicus
Nucula tenuis
Nassa mendica
Ostrea lurida
Pandora filosa

Paphia staminea	Saxicava pholadis
Paphia tenerrima	Schizothaerus nuttalli
Petricola carditoides	Siliqua nuttalli
Phacoides annulatus	Tegula funebrale
Phacoides tenuisculptus	Tellina salmonea
Pholadidea penita	Thais lamellosa
Pholadidea ovoidea	Thyasria gouldi
Polinices lewisi	Trachydermon raymondi
Psephidia ovalis	Turris incisa
Saxidomus nuttalli	Yoldia encifera
Saxicava arctica	Zirfaea gabbi

Predominantly Southward Ranging Species Take by the "Albatross"

Acteocina cerealis	Leda taphria
Actaeon punctocoelatus	Leda hamata
Anomia peruviana	Modiolus politus
Barleeia subtenuis	Modiolus rectus
Bathytoma carpenteriana	Nassa perpinguis
Bittium subplanatum	Olivella intorta
Cancellaria crawfordiana	Pecten latiauritus
Epitonium hindsi	Polinices draconis
Epitonium sawinae	Turbonilla keepi
Lasea rubra	Volvula cylindrica
Lacuna unifasciata	Yoldia cooperi

If such a list be compared with the list of prevalent species of the outside fauna (table 5) it is found that 46 per cent of the prevalent species are predominantly southward ranging, whereas only 39 per cent are northward ranging.

TABLE 5

Prevalent Species in the Outside Fauna

Bathytoma carpenteriana	Olivella intorta
Columbella gausapata	Olivella pedroana
Epitonium sawinae	Pandora filosa
Leda taphria	Phacoides tenuisculptus
Mangilia angulata	Siliqua nuttalli
Nassa perpinguis	Tellina salmonea

This high percentage of southern forms occurring in the outside fauna is significant and may be emphasized in another way. Of the 22 predominately southward ranging species taken by the Survey, 10 or 45 per cent are restricted in their known local distribution to the open ocean. Four others were rarely taken within the bay. Thus nearly 60 per cent of the predominately southward ranging species taken by the Survey are either restricted to or occur almost exclusively in the waters outside the Golden Gate. It is also found that the majority of the entire outside fauna as known from the "Albatross" collections are predominately southward ranging.

This condition may be contrasted with the scarcity of southern forms within San Francisco Bay. The list of prevalent species for the bay (table 2) and for the different divisions of the bay does not contain a single predominately southward ranging form. Each of these prevalent species is predominately northward ranging. The bay fauna as a whole also has a northern aspect.

There appears to be little if any difference in the distribution of the few southern species that live in the bay, although there is a considerable seasonal range of temperature in the different divisions of the bay. It is perhaps more than a coincidence that the middle division of the bay is the richest faunally, and that it is the coldest section of the bay during the summer months.

This distribution of southern forms outside the Golden Gate and of northern forms within San Francisco Bay is surprising when it is recalled that the water of the bay is relatively warmer in the summer than that of the open ocean. In other words, cold summer temperatures do not appear to be an important factor in limiting the northward range of the southern species. If it can be shown, however, that the same species reproduce during the winter months, the conclusion would be that the relatively cold water of the bay prevents the development of their larvae, and therefore limits them in their distribution to the warmer waters of the open ocean. Regardless of the value of such a supposition, it is evident that the distribution of the southward ranging species is in some way dependent upon the winter temperature conditions, and not upon that of the summer.

The southward range of the northern species might be expected to be in some way limited by the warm waters. Such species would be expected to comprise the major portion of outside fauna, for the summer temperature of the open ocean is lower than that of the bay, but such is not the case. These forms are in the warmer waters of the bay. However, they are most abundant in the middle division of the bay, which at this season is the coldest portion of the bay. If the winter conditions are considered, it is found that the northern species are in the colder waters of the bay instead of the warmer water of the open ocean. The effect of temperature in limiting these species is obscure unless it may be assumed that they reproduce in the winter and that the colder bay waters are more suitable for the development of their young than the warmer water of the open ocean. Such conclusions as to the breeding habits of the molluscan species have little value, unless it be that they stimulate much needed investigation along these lines.

The occurrence of the predominately southward ranging species in the open ocean and their general absence from San Francisco Bay indicates that their distribution is in some way determined by the winter temperature. It is to be presumed that temperature acts in some way upon the reproductive activities of the mollusks. On the other hand, the northern species occur more abundantly within the bay, which during the winter months is relatively colder than the open ocean. This suggests that the warm water of the winter in some way limits the southern range of the northern species.

INFLUENCE OF SALINITY

Salinity is especially significant as a factor in determining the distribution of marine invertebrates in such regions as estuaries or salt marshes. The Sacramento and San Joaquin rivers reduce the salinity of the Carquinez Strait at the upper end of San Pablo Bay to an annual mean of less than 16 per mille. In this same region at hydrographic station H 5975 the seasonal range of bottom salinity lies between 13.35 and 19.14 per mille. Nevertheless this low salinity does not impose an effective barrier to *Macoma balthica, M. nasuta, Mya arenaria,* nor *Mytilus edulis.* Still farther up the stream at stations D 5760 and D 5761 the conditions are unfavorable to even these hardy species. They are likewise absent at D 5759, at the mouth of Napa Creek. It is evident that in these cases it is the minimum salt concentration that determines the distribution of these mollusks.

Estuarine conditions exist also at station D 5766, within Alameda Channel. Since but little fresh water empties into this inlet, the salinity is presumably much the same as at the nearest hydrographic station, H 5008, which is typical for that portion of the lower division of the bay. It is not surprising to find that the fauna from that inlet is also typical of the lower bay, and that it includes species not dredged within Carquinez Strait.

These few species that are capable of living in water of such low salinity cannot be properly designated as brackish water forms, for they occur abundantly in other regions where the salinity is high. All excepting *Mya arenaria* are prevalent species within the middle division of the bay, where the mean annual salinity is nearly twice as great as it is in Carquinez Strait. These species represent the more adaptable forms of the entire fauna. Their general distribution throughout the bay shows that they can adjust themselves to diverse environments. It is not surprising, therefore, to note that they have a wide geographic range, two being circumpolar in distribution.

The true brackish water fauna of San Francisco Bay has not been investigated in this Survey. It is not unlikely that the species *Ceritheridea californica* would be found to be restricted to brackish water, since it occurs in the salt marshes bordering the bay and was not taken by the Survey in the bay proper.

The molluscan fauna from San Pablo Bay is meager in comparison to that from the other divisions of the bay. The prevalent species here are among those listed as prevalent also within the lower and middle segments. However, a number of those that are prevalent in the latter regions are not abundantly represented in the upper division. *Cardium corbis,* for instance, was taken at only four hauls within the latter division. A glance at the distribution charts of the more common species (pls. 42 to 59) shows that in the majority of cases the species are represented as extending up into the lower end of San Pablo Bay. This distribution may be best explained by the salinity factor. The other factors are not equally applicable, for neither the character of the bottom nor the temperature changes so markedly in the vicinity of Point San Pablo as do the curves for salinity. (See Sumner *et al.*, 1914.)

The distribution of *Mytilus californicus, Spisula catilliformis,* and *Tellina bodegensis* within the outer portion of the Golden Gate is not as easily explained. These forms are known to be abundant in the adlittoral zone along the open ocean. There the temperatures are, for the most part quite similar to those given above for the waters off San Francisco. Such conditions probably prevail to a lesser extent in the outer portion of the Golden Gate.

Influence of the Character of the Bottom

The character of the bottom is a factor of considerable importance in determining the distribution of mollusks. It is evident that solid objects are necessary for the attachment of sessile pelecypods such as *Ostrea, Hinnites,* or *Monia.* A support of some sort is essential to the limpets, and usually to the chitons. Mud may interfere with the respiratory currents of some species, while it represents the optimum habitat of certain burrowing forms. Thus a close correspondence between the occurrence of certain species and the distribution of a particular type of bottom is to be expected.

Information regarding the character of the bottom was obtained by the Survey from four sources. The least accurate of these consisted of taking notes at the time the haul was made of the content of the dredge. Often this procedure was attended with difficulty, especially when the dredge contained materials of a composite nature. This method is, of course, inaccurate if the bottom is diversified. A considerable portion of the bottom from a definitely known locality, together with the life upon it, was secured by means of the orange-peel bucket dredge. The other two methods were even more satisfactory. Stratified sections, in one case nearly 170 centimeters long, were obtained by means of the "Albatross" bottom sampling apparatus and the Ekman tubular bottom sampler.

Physical and partial chemical analyses have been made of such tubular samples for 79 stations within San Francisco Bay. An instructive chart has been made by Sumner *et al.* (1914, pl. 5), on which by a system of shaded sectors of circles the proportions of the different types of sediments are shown for these stations on an outline map of the bay. These data have been made the basis for the discussions that follow.

The data obtained at those stations only at which the bottom conditions are definitely known are considered in this section. In a few instances the position of a dredging station at which a sample was obtained was lacking. In such a case it is approximately the same as that of a hydrographic station at which a sample was taken. The position of the dredging and the hydrographic stations were declared identical, therefore, if a part or all of the dredging course was within 0.3 of a nautical mile from the latter. This distance was chosen for convenience. It represents the approximate equivalent of the radii of the circles used on plate 5, as mentioned above, to designate the character of the bottom. This chart when superimposed upon one showing the location of the dredging stations readily gives the hydrographic equivalent of any desired position.

These 72 stations at which both bottom samples and faunas were obtained may be divided into six groups, representing different types of bottom. The terms "mud" and "sand" are used in the same sense as used by Sumner *et al.* (1914, p. 92). Sand includes material that will pass through a 2-millimeter sieve, yet does not remain in suspension in water for any considerable period. These groups may be characterized as follows:

Group 1—Mud: not less than 90 per cent of mud.

Group 2—Mud and sand: not less than 50 per cent of mud or 10 per cent of sand.

Group 3—Sand: not less than 90 per cent of sand.

Group 4—Sand and mud: not less than 50 per cent of sand or 10 per cent of mud.

Group 5—Sand and gravel: not less than 50 per cent of sand or 10 per cent of gravel.

Group 6—Gravel, shells, or stone: total of these equalling not less than 90 per cent.

Group 7—Gravel and sand: not less than 50 per cent of gravel or 10 per cent of sand.

In a few instances where the percentage of a certain type of material at a station lies within 1 or 2 per cent of a certain group to which it logically belongs it has arbitrarily been included in that group. Such cases are indicated in the list below by means of an asterisk. In this list the dredging stations, or their equivalent when necessary, of the localities at which precise bottom data are available, are given. The number in the right hand column refers to the bottom group to which the station belongs.

These stations are quite uniformly distributed throughout the bay, and may therefore be considered as representative of the bottom conditions prevailing within San Francisco Bay.

Upon the basis of the above groupings (table 6), it may be calculated that at 18 per cent of the 72 stations mud (group 1) was encountered, while at 12.5 per cent sand (group 3) was found, and at 9.7 per cent of the stations gravel and stones (group 6) prevailed. If groups 1 and 2 are considered together it is found that the bottom was prevailingly muddy at 43 per cent of these stations, prevailingly sandy at 44.3 per cent, and gravelly at 12.4 per cent. It is of interest to consider the character of the bottom by regions. In San Pablo Bay a prevailingly muddy bottom occurs at 53.3 per cent of these stations within that region and a predominately sandy one (groups 3, 4, and 5) at 46.6 per cent. Mud was encountered at 33.3 per cent and sand at 6.6 per cent. These figures may be compared with those for the lower division of the bay. In that region a prevailingly muddy bottom occurs at 77.6 per cent and a predominately sandy one at 22.2 per cent of the stations. Pure mud occurred at 7 out of the 18 stations within this region, but at none of the stations was the bottom com-

TABLE 6

STATIONS AT WHICH BOTTOM SAMPLES WERE TAKEN

Upper Division

Dredging stations†	Hydrographic stations	Bottom groups	Dredging stations†	Hydrographic stations	Bottom groups
D 5761	....	4	D 5780	....	1
D 5760	....	3	D 5719	H 5287	1
D 5794	....	4	D 5716	H 5286	2
D 5793	....	4	D 5758	....	2
D 5759	....	1	D 5752	....	2
D 5816*	....	4	D 5715	H 5285	1
D 5722	H 5289	4	D 5820	H 5285	1
D 5817	H 5289	4			

Middle Division

D 5709	....	3	D 5743	....	4
D 5824	H 5304	2	D 5744	....	2
D 5449	....	2	D 5745	....	3
D 5756	....	2	D 5755	....	5
D 5747	....	1	D 5746	....	3
D 5826	H 5302	2	D 5762	....	7
D 5798	H 5302	2	D 5829A*	....	5
D 5703	H 5301	2	D 5773	....	6
D 5799	H 5301	2	D 5700	....	5
D 5705	H 5300	4	D 5701	....	7
D 5825	H 5300	4	D 5775	....	6
D 5718	H 5300	4	D 5774	....	6
D 5796	....	3	D 5713	....	3
D 5741	(D 5796)	3	D 5779	....	4
D 5742	(D 5796)	3	D 5778	....	5
D 5795	(D 5796)	3	D 5808*	....	....
D 5763	....	4	D 5809	....	6
D 5828	H 5299	4	D 5843*	....	....
D 5739*	....	4	D 5842*	....	....
D 5740	....	4			

Lower Division

D 5831*	....	....	D 5839	H 5309	1
D 5832†	....	4	D 5729	H 5310	4
D 5833	....	1	D 5836	H 5310	4
D 5766	....	1	D 5730	H 5311	1
D 5803	H 5307	2	D 5838	H 5311	1
D 5724	H 5307	2	D 5781	....	2
D 5725	H 5307	2	D 5783	(D 5848)	2
D 5835	H 5308	2	D 5848	....	2
D 5728	H 5309	1	D 5847A	....	1

* The dredging stations numbered D 5831–5841 inclusive, are quantitative stations.
† The stations are taken in order from the upper to the lower end of the bay.

prised of pure sand as defined above (group 1). It is noteworthy that in both of these divisions gravel was lacking. In such places as in the vicinity of Point San Mateo an abundance of old shells offers ample support to the invertebrates requiring it. The middle division is predominately sandy. At 53.5 per cent of the stations within this region the bottom may thus be characterized. At 23 per cent it is prevailingly muddy and at 22.9 per cent it is predominately gravelly. Mud was encountered at only one station within this division, sand at 8 or 20.5 per cent, and gravel at 7 stations.

The correlation of these physical conditions with the distribution of certain of the molluscan species may now be undertaken. Lists of the prevalent species for the different types of bottoms, as grouped above, have been prepared. These lists are based upon the occurrence of identifiable specimens of the different species, and not solely upon the occurrence of living specimens. In some instances this procedure may lead to incorrect conclusions, for it is evident that dead shells may be transported considerable distances by various agents, of which tidal currents and hermit crabs are conspicuous. It will be noted in the table given below that several of the species occur in six or more of the groups. These species whose distribution appears to be unrelated to a particular type of bottom are: *Cardium corbis, Macoma nasuta, Mya californica, Mytilus edulis,* and *Ostrea lurida.* It is rather surprising to note that *Mytilus edulis* should be taken alive from a pure mud bottom. In the following table column 7 has undue weight, for the group has too few stations to have any real significance.

A bottom of sand or of mud is not as favorable to a varied molluscan life as is one comprising two or more types of materials. This easily anticipated conclusion follows from a comparison of the average number of species per station represented by living specimens for a particular bottom group. These averages are two or less for mud (2.0) and sand (1.3), whereas they are about three for the other groups. This may also be shown by referring to the list of prevalent species for the bottom groups. There it is seen that the larger numbers are in the groups comprising two or more types of materials. This is presumably due to the greater number of environments at such localities.

The records of the Survey indicate that a muddy bottom supports a larger number of mollusks than does a sandy or gravelly one. The average number of living individuals per stations for the muddy bottoms (groups 1 and 2) is 38.4, whereas it is 20.6 for the sandy (groups

3, 4, and 5), and only 9.4 for the gravelly ones. The average for sand (group 3) is but 5.4, which is only about one-ninth that for pure mud. That such localities are relatively barren of molluscan life also appears from the consideration of the average number of species per station for group 3. This has been shown above to be considerably less than for the other types of bottoms.

TABLE 7

PREVALENT SPECIES FOR THE DIFFERENT TYPES OF BOTTOM

	Mud 1	Mud and sand 2	Sand 3	Sand and mud 4	Sand and gravel 5	Gravel 6	Gravel and sand 7
Cardium corbis	×	×	×	×	×	×	×
Columbella gausapata	----	----	----	----	×	----	----
Hinnites giganteus	----	----	----	----	----	----	×
Macoma balthica	×	×	----	×	----	----	----
Macoma inquinata	----	×	×	×	×	×	----
Macoma nasuta	×	×	×	×	×	×	×
Monia macroschisma	----	----	----	----	×	×	----
Mopalia ciliata	----	----	----	----	×	×	----
Mopalia muscosa	----	----	----	----	----	×	----
Mya californica	×	×	×	×	×	×	×
Mya arenaria	×	×	----	×	----	----	----
Mytilus californicus	----	----	----	----	----	×	----
Mytilus edulis	×	×	×	×	×	----	×
Nassa fossata	----	----	----	----	----	×	----
Nassa perpinguis	----	----	----	----	×	----	----
Nassa mendica	----	----	----	----	×	×	----
Ostrea lurida	×	×	×	×	×	×	×
Psephidia ovalis	----	----	----	----	×	----	----
Paphia staminea	----	----	----	----	×	×	×
Petricola carditoides	----	----	----	----	----	×	----
Pholadidea penita	----	----	----	----	?	----	----
Saxicava arctica	----	----	----	----	×	----	×
Saxidomus nuttalli	----	----	----	----	----	×	----
Schizothaerus nuttalli	----	----	×	----	×	×	----
Siliqua nuttalli	----	----	----	----	×	----	----
Spisula catilliformis	----	----	----	----	----	×	----
Solen sicarius	----	----	----	×	----	----	----
Tellina buttoni	----	----	----	----	----	----	×
Tellina salmonea	----	----	×	----	×	----	×
Thais lamellosa	----	----	----	----	×	×	×
Turbonilla franciscana	----	----	----	×	----	----	----
Xylotrya, sp.	----	----	----	----	×	----	----
Zirfaea gabbi	----	----	----	----	×	×	----

In this section an attempt has been made to segregate a few of the more important factors from the diversified environments in which the mollusk lives. Depth as far as the local fauna is concerned does not appear to have any great significance in determining the distribution. The deeper waters of the Golden Gate yield faunas nearly identical with those obtained from the shallower. The apparent restriction, in a few instances, to certain bathymetric zones appears to be due to other factors. Low salinity certainly prevents the marine mollusks from ranging much above the lower end of Carquinez Strait. It appears to be the most conspicuous factor in accounting for the meagerness of the San Pablo Bay fauna in contrast to those from the other divisions of the bay. It is not improbable that low salt concentration prevents certain species like *Spisula catilliformis* and *Mytilus californicus* from entering the Golden Gate farther than Fort Point. The importance of temperature is more uncertain. The greater percentage of predominately southward ranging species in the outside fauna may be due to the more uniform temperature for the year, or possibly it is to be correlated with the relatively warmer temperature during the winter months, which may later be found to correspond to the reproductive periods of the majority of the molluscan species. The influence of the bottom upon the distribution of the mollusks is the most conspicuous of the factors considered. As has been noted, certain forms are capable of living under a variety of conditions of bottom. Several of them were shown to be able to endure marked extremes of temperature and salinity as well. A composite bottom, comprising two or more types of materials, offers a greater variety of local conditions, and it supports, therefore, a greater number of molluscan species than the other types. It is seen that mud supports the greater number of individuals per station, but this may be due in part to the fact that the dredge sinks deeper in the softer sediments, and thus obtains a more complete representation of the life from such a bottom.

QUANTITATIVE ANALYSIS OF THE FAUNA

Forty-three dredge hauls were made within San Francisco Bay by means of the orange-peel bucket dredge. Such a type of dredge had not previously been used for biological purposes.

This apparatus has an advantage over the various types of trawl dredges in that it permits the taking of large masses of mud from a single spot, besides rendering possible the capture of deeply burrowing organisms. Its capacity is 2.5 cubic feet, and it encloses a circular area of 7.8 square feet.

The material collected by means of this apparatus was carefully sorted and all of the macroscopic organisms were preserved in formalin or alcohol. The record of the molluscan material include the following items: the name of the species, the number of individuals of each species, the condition of each specimen at the time of dredging, and the maximum, minimum, and modal lengths of each species from each haul.

The fauna obtained in this manner comprises 23 pelecypods and 12 gastropods. This number represents about 43 per cent of the bay fauna.

The list of prevalent species given on page 221 includes the most adaptable forms found in the local fauna. These species have a general distribution throughout the bay, being also conspicuous because of the wide geographic ranges, which in several instances are circumpolar.

It has been shown in another paper (Packard, 1918) that the average quantitative haul is richer in bivalves (4.8) than in univalves (1.0). On the average 45.4 living mollusks occur within the area covered by the jaws of the orange-peel bucket dredge. The most productive haul yielded 16 species, 4 of which were represented by living specimens. The relative abundance of molluscan species and individuals for the different divisions of the bay was found to be 2.3 species per haul in the upper bay, 7.5 in the middle, and 6.9 in the lower, or 21.5 individuals per haul in the upper, 315 in the middle, and 107.5 in the lower bay.

The mollusks obtained in the quantitative hauls show little relationship in distribution to depth, although the average number of living individuals is greater in the deeper portion of the bay. However, this has little significance, since the deeper hauls were made within the middle division of the bay, where this apparent relationship may be accredited to other factors. The character of the bottom is an important factor in distribution. It can be shown that the number of individuals per unit area is largely dependent upon the particular type of bottom. A bottom characterized by sand and shells yields on an average 174 individuals, while a bottom of mud and shells yields only 82.5. This conclusion does not harmonize with the one given above (p. 240) that the muddy bottom supports the larger number of mollusks. This discrepancy may be due to the trawl dredge not sinking deep enough in sand to capture a representative fauna.

A comparison of the lists of the species obtained from the several types of bottoms shows that most of the species were taken from more than one type of bottom. This indicates that the mere occurrence upon a particular type of bottom does not necessarily prove that such a bottom represents its normal habitat. The relative abundance per unit of area for the different types of bottom probably more nearly indicates the optimum habitat of a given species. Thus the average per haul for each species should give some clew to the most favorable environment of that species. *Cardium corbis, Macoma nasuta, Mya arenaria,* and *Zirfaea gabbi* are, according to such reasoning, predominately mud dwellers. On the other hand, *Mya californica, Macoma balthica, M. inquinata, Ostrea lurida,* and *Thais lamellosa* predominate on the sandy bottoms. Here again the conclusion drawn from the quantitative work does not agree with that based upon the qualitative hauls. It has already been stated (p. 239) that *Cardium corbis, Macoma nasuta, Mya californica,* and *Ostrea lurida* do not show a distribution pattern that appears to be related to any particular type of bottom. In this case it is not unlikely that the latter conclusion is the more nearly correct.

A standard specimen curve, showing the number of living individuals obtained at the dredging stations that are the equivalent of the hydrographic stations of the regular series, has been made in order to compare it directly with the temperature and salinity curves published by Sumner *et al.* The specimen curve shows little relationship with the mean annual salinity curve. The seasonal range of salinity curve (Sumner *et al.*, 1914, p. 68, fig. M) shows a certain correspondence with the specimen curve, indicating that there is in general an increase in the number of living individuals per haul with decrease in the annual range of salinity. One of the six curves showing the mean salinity for the different periods of the year suggests that the low salt concentration during the period from April 23 to May 6 may possibly be a factor limiting the abundant molluscan life to the middle and lower divisions of the bay.

This same specimen curve when compared with the published temperature curves for the same stations shows that the regions where the annual range is high are low in the number of mollusks. It also indicates that the cooler regions of the bay during the summer months support a greater number of specimens per unit area. However, these apparent relationships are not considered as being necessarily causal ones.

The quantitative work by Rankin and Kofoid indicate that the plankton of the bay is everywhere rich enough to supply the mollusk with the requisite amount of food.

The conclusions of the quantitative work parallel in the main those derived from the less accurate qualitative work; the differences in results are generally to be accounted for on the basis of the differences of procedure followed in the two cases.

SUMMARY

San Francisco Bay receives the discharge of the Sacramento and San Joaquin rivers. This affects the salinity, temperature, and the bottom conditions prevailing within those waters. These factors have elsewhere been shown to vary considerably within the bay, producing a number of environments. Only the more important physical factors have been considered in this paper.

The molluscan fauna taken by the Survey comprises 112 species and 3 varieties. This number equals but 65 per cent of the reported fauna from San Francisco and immediate vicinity.

The fauna obtained in the open ocean off San Francisco comprises 64 determined species, of which 30 are pelecypods, 32 gastropods, and 2 scaphopods.

A consideration of the average number of species per station indicates that the waters of the open ocean are more favorable to a varied molluscan life than those of the bay. The average number of individuals represented by living specimens per station is more than three times as great in the group of stations in the former region as it is within the upper division of San Francisco Bay.

The fauna obtained by the Survey within San Francisco Bay comprises 81 species and varieties, of which 43 are pelecypods, 31 gastropods, and 7 chitons. Fifty-nine per cent of this fauna was taken exclusively within those waters.

Since 76 species of the entire fauna obtained by the "Albatross" are predominately northward ranging, whereas only 53 are predominately southward ranging, the San Franciscan fauna appears to be more closely related to the northern one.

Two new molluscan species that were taken by the Survey have been described by Dr. Bartsch (*Odostomia franciscana* Bartsch and *Turbonilla franciscana* Bartsch). Two heretofore unreported exotic species were obtained by the "Albatross."

The three bathymetric zones represented in these waters are not divisible into subzones upon the basis of the molluscan life.

The large proportion of the predominantly southward ranging species are restricted to the waters of the open ocean, where the winter temperatures are higher than they are in the bay.

The influence of salinity may be noted within Carquinez Strait, where the low salt concentration acts as an effective barrier to the marine species. The salinity factor is considered to be the major one in accounting for the meagerness of the fauna from the upper in contrast to that from the other divisions of the bay.

The character of the bottom appears to have the greatest significance in determining the local distribution of the mollusks. The stations at which both precise bottom data and faunas were obtained are grouped into seven classes, each representing a particular type of bottom. The lists of prevalent species for these bottom groups shows that the distribution of several of the species is unrelated to any particular type of bottom. There are other species, however, that are characteristically found upon one of these types of bottoms.

A bottom of pure sand or pure mud is not as favorable to a varied molluscan life as is one comprising two or more types of materials. A mud bottom appears to support a larger number of living individuals than does any of the other types. Sand is shown to be the least favorable to an abundant molluscan life.

CATALOGUE OF SPECIES

This catalogue includes the forms taken by the Survey and those that have previously been reported from San Francisco Bay and the adjacent waters outside the Golden Gate. The synonyms given include the name under which the species was described and the more common ones found in the literature dealing with the Mollusca of the San Francisco region. The dimensions given represent the maximum and the minimum lengths of all of the specimens obtained by the Survey. The italicized number in the parenthesis following the number of the dredging station indicates the number of living specimens obtained at that station, while the arabic number indicates the number of valves in the case of the pelecypods, or the number of specimens of other shell-bearing mollusks that were dead at the time of the dredging. In a few cases the specimens were not counted, only an estimated number being given. Occasionally a fragment that could be determined specifically is recorded by the letter "f".

PELECYPODA

NUCULACEA

NUCULIDAE

Nucula Lamarck

Nucula tenuis (Montagu)

Plate 14, figure 4

Arca tenuis Montagu (1808), pl. 29, fig. 1.
Nucula tenuis, Gould (1841), p. 155.

Description.—This species was originally described as follows: "Shell sub-cordate, smooth, white, covered with an olivaceous epidermis: umbo very small: beaks slightly inflected, and placed near to one end. Inside smooth, white, and somewhat nacred; margin thin and entire: hinge pectinated with about fifteen elevated teeth placed within the margin, six on one side and nine on the other, divided by a small concave plate that projects inward. Greatest diameter a quarter of an inch; the length not quite so much."

Length, 4 to 8 mm.

Occurrence.—At stations D 5787 (*9*), D 5786* (*2*), and D 5788 (*1*, 2).

This mollusk was dredged by the Survey in the vicinity of the Farallon Islands, at a depth ranging between 39 and 68 fathoms from a bottom comprised of dark greenish sand.

Range.—Circumpolar. Arctic Sea to Coronado Island, California (Dall).

Acila Adams

Acila castrensis (Hinds)

Plate 14, figures 1 and 2

Nucula castrensis Hinds (1843*b*), p. 98.
Acila castrensis, Carpenter (1863), p. 664; Gabb (1869), p. 102; Arnold, R. (1903), p. 95.

Description.—This species was described by Arnold, R. (1903), as follows: "Shell small, trigonal, convex, of medium thickness; umbones posterior to the center, turned posteriorly; anterior end longer than posterior, rounded; posterior end short, truncated; surface divaricately sculptured; hinge with prominent internal cartilage-pit and numerous sharp teeth on each side."

Length, 4 to 11 mm.

Occurrence.—At stations D 5785 (*1*, 1), D 5788* (*15*), D 5789* (3).

As far as is known this species has not hitherto been reported from this region. It is restricted to the collections from the open ocean. Living specimens were dredged off San Francisco by the Survey at

*Specimens for stations thus designated were determined by Dall.

three localities, being the most abundant at station D 5788. It is associated with *Nucula tenuis* at two of these stations. Dredged in depths ranging from 39 to 68 fathoms on bottoms composed of fine dark green sand.

Range.—Bering Sea to San Diego, California (Dall).

LEDIDAE

Leda Schumacher

Leda hamata Carpenter

Plate 14, figure 5

Leda hamata Carpenter (1863), p. 644; Arnold, R. (1903), p. 97, pl. 17, fig. 4.

Description.—This species was described by Arnold (1903) as follows:

''Shell small, elongate, trigonal, convex, thin; umbones anterior, turning slightly toward the posterior end; short, rounded anteriorly; much lengthened, narrowed and abruptly truncated posteriorly; surface sculptured by strong, concentric raised lines; a raised band, strongly transversely sculptured by continuations of the concentric ridges, passes from the umbo, around the escutcheon, to the posterior end; on the interior of the posterior end is an elongated, raised process; escutcheon deep-set, smooth.''

Length, 3 to 10 mm.

Occurrence.—At stations D 5785 (*2*), D 5789 (*4*), west of Farallon Islands (*1*).

This species has been obtained by the Survey at three dredging stations outside the Golden Gate. It was taken in depths, ranging from 39 to 815 fathoms, on bottoms that are predominately sandy.

Range.—Puget Sound to Panama (Dall).

Leda navisa Dall

Leda navisa Dall (1916*b*), p. 395.

Description.—This species is described by Dall as follows:

''Shell elongate, arcuate, inequilateral, with slender recurved rostrum and well-marked smooth impressed escutcheon, but no lunule; base convexly arcuate, rostrum obliquely truncate, anterior end evenly rounded; beaks obscure, 5.5 mm. from the anterior end; sculpture of numerous sharp concentric low ridges, with wider flat interspaces, obsolete toward the rostrum; anterior teeth about twelve, posterior about twenty, the resilifer minute, subumbonal, not projecting; interior chalky, a small medial ridge near the end of the rostrum. Height, 7; length, 16; diameter, 5 mm.''

This species was obtained by a previous survey in 191 fathoms of water off the Farallon Islands.

Range.—Known only from the vicinity of the Farallon Islands, which is the type locality for the species.

Leda taphria Dall

Plate 14, figures *7a*, *7b*, and 8

Leda taphria Dall (1897*a*), p. 7, pl. 2, figs. 6 and 8.
Leda coelata Hinds, Carpenter (1863), p. 644; Arnold, R. (1903), p. 98, pl. 17, fig. 5.

Description.—This species is described by Arnold (1903) as follows:

"Shell small, trigonal, oblong and rounded in front, produced and pointed behind; surface sculptured by numerous sharp, concentric, raised lines; umbones central, turned toward posterior end; escutcheon long, narrow and concentrically striated; hinge with prominent internal cartilage-pit, and about twenty sharp teeth on each side; pallial line with a small sinus; umbonal area with a linear impression joining the anterior adductor."

Length, 4 to 20 mm.

Occurrence.—At stations D 5772 (*1*), D 5785* (*10*, 7), D 5786 (*5*, 3), D 5787 (*2*, 1), D 5789 (*5*), D 5790 (*1*), D 5791 (*3*, 6), D 5792 (*2*, 1).

Carpenter lists this species from this region. Living specimens were dredged by the Survey at eight stations, all but one of which are situated outside of the Golden Gate. The exception is a single living specimen recorded from station D 5772, near Sausalito. The depth of the water at that station is but $1\frac{1}{4}$ fathoms, whereas those occurring in the open ocean lived in water ranging from 19 to 68 fathoms. The bottom consists of fine dark, green sand, which differs markedly from the soft mud bottom found at D 5772. This species appears to be more abundant than *Leda hamata*, with which it is associated.

Range.—Bodega Bay to San Diego, California.

Yoldia Müller

Yoldia cooperi Gabb

Plate 14, figure 9

Yoldia cooperii Gabb (1865), p. 189; Gabb (1869), p. 31, pl. 9, fig. 54; Arnold, R. (1903), p. 99.

Description.—The following is the original description of this species as given by Gabb (1865):

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

Gabb confused the terms posterior and anterior as applied to this shell. These words should be interchanged in the above description.

Length, 55 mm.

Occurrence.—At station D 5788* (*1*).

This species is represented in the ''Albatross'' collections, by a single specimen, that was dredged alive outside the Golden Gate, in 68 fathoms and on a bottom composed of a dark green sand.

This specimen differs somewhat from the type of the species which is in the collections of the Department of Palaeontology of the University of California, in that it is less produced anteriorly.

Range.—San Francisco to San Diego, California.

Yoldia ensifera Dall

Plate 14, figure 6

Yoldia ensifera Dall (1897*a*), p. 9, pl. 2, fig. 4.

Description.—This species was originally described by Dall (1897) as follows: ''Shell large, thin, compressed, with a brilliant olivaceous periostracum, usually showing darker and lighter zones; valves nearly equilateral, moderately convex, rostrate, subarcuate; sculpture of fine lines of growth more or less evident, and on the anterior two-thirds of the shell numerous irregularly fluctuating, distant, incised grooves (like those of *Y. scissurata*) which are absent on the posterior third; base arcuate, anterior dorsal profile rounded evenly from the beaks; a slight inward wave of the margin is visible anteriorly near the pedal gape; lunule absent; the escutcheon impressed, and the posterior dorsal margins of the valves, projecting vertically, blade-like, and slightly pouting; rostrum pointed, slightly recurved, beaks low, inconspicuous; valves internally whitish; pallial sinus deep, rounded; chondrophore wide, hardly projecting; teeth narrow A-shaped, slender, about 30 in front of and 24 behind the chondrophore.''

Length, 10 to 30 mm.

Occurrence.—At stations D 5785 (*1*), D 5789 (*7*, 4).

This species has not before been reported from this immediate vicinity. The two stations at which it was dredged are outside the Golden Gate. Living specimens were dredged at depths ranging from 39 to 46 fathoms on a bottom composed of fine, dark green sand.

Range.—Southeastern Alaska to San Luis Obispo, California (Dall).

Arcacea

ARCIDAE

Arca Lamarck

Arca transversa Say

Plate 14, figures 3*a* and 3*b*

Arca transversa Say (1822), p. 269; Gould (1841), p. 96; Sumner, Osborn, Cole, and Davis (1913), p. 684, chart 132.

Scapharca transversa, Dall (1898*c*), p. 645.

Description.—This species is described by Gould (1841) as follows:

"Shell transversely oblong, rhomboidal, with from thirty-two to thirty-five ribs placed at nearly the length of their own diameters distant from each other. Apices separated by a long narrow space, and situated at the termination of the posterior (anterior) third of the length of the hinge margin; extremities of the hinge margin angulated; anterior (posterior) edge, the superior half rectilinear; posterior (anterior) edge rounded; inferior edge nearly rectilinear, or very obtusely rounded; on the hinge space, one or two angulated lines are drawn from the apex diverging to the hinge edge."

Length, 12 to 25 mm.

Occurrence.—At stations D 5781* (4), D 5811 (5), D 5813 (1).

This species is represented by several old valves obtained from three dredging stations at the extreme southern portion of the bay. It is an eastern species that has not hitherto been reported from this coast. It was probably introduced with the eastern oyster, with which it is associated. No living specimens have as yet been obtained, so it is not certain that it has gained a foothold in these waters.

Range.—San Francisco Bay.

Glycymeris Da Costa

Glycymeris subobsoleta (Carpenter)

Axinea subobsoleta Carpenter (1846*b*) p. 425.

Description.—Professor H. A. Clark of the University of Oregon has kindly translated the original Latin description as follows:

"Shell similar to *A. septentrionalis*, slightly inequilateral, not tumid, umbones obtuse, broad, quite prominent; ash-colored, variegated with reddish chestnut; epidermis thick, somewhat laminated; ventral and posterior margins quite rounded, anterior margin produced, dorsal straight, sculptured by subobsolete radiating grooves, often disappearing dorsally; ventral margin strongly and anterior and posterior internal margins slightly crenulated; cardinal plate subangular, with a few strong, compressed teeth; abductor scar chestnut-colored; ligament furrowed."

This species was not taken by the Survey, although it has been reported from the local waters.

Range.—Vancouver Island to Santa Cruz, California (Orcutt).

Ostracea

OSTREIDAE

Ostrea Linnaeus

Ostrea lurida Carpenter

Plate 14, figures 10*a* and 10*b*, and plate 42

Ostrea lurida Carpenter (1863), p. 645; Carpenter (1865*c*), p. 137; Wood and Raymond (1891), p. 55; Dall (1898*c*), p. 687; Arnold, R. (1903), p. 102.

Ostrea lurida var. *laticaudata* Nuttall, Carpenter (1863), p. 646.

Description.—Arnold's (1903) description of this variable species is as follows:

"Shell of medium size, irregular, suborbicular, ellipsoidal, or elongated; surface laminated and sometimes irregularly plaited; beak prominent; hinge toothless."

Length, 3 to 60 mm.

Occurrence.—At stations D 5700 (4), D 5701 (2), D 5702* (6), D 5711 (2), D 5712 (10), D 5713 (14), D 5714 (3), D 5725 (3), D 5727 (5), D 5730 (1), D 5732 (1), D 5738 (1), D 5741 (2), D 5742 (3), D 5744 (1), D 5754 (6), D 5755 (15), D 5764 (*6*, 13), D 5766 (30), D 5767 (*4*, 24), D 5768 (*208*, 35), D 5779 (1), D 5780 (1), D 5781 (*18*, 22), D 5782 (*17*, 19), D 5783 (*12*, 8), D 5784 (*20*, 44), D 5792 (2), D 5793 (2), D 5794 (7), D 5795 (9), D 5796 (10), D 5800 (7), D 5801 (3), D 5802 (1), D 5805 (1), D 5808 (2), D 5810 (*77*, 50), D 5811 (116), D 5812 (*57*, 51), D 5813 (*41*, 70), D 5814 (60), D 5821 B (1), D 5824 B (6), D 5825 B (2), D 5826 A (*f*), D 5826 B (large numbers), D 5827 (2), D 5827 A (2), D 5727 B (1), D 5829 (1), D 5829 A (21), D 5832 (large numbers), D 5833 (large numbers), D 5835 (large numbers), D 5836 (2), D 5839 (2), D 5841 (several), D 5843 (1), D 5846 (1), D 5847 (500), D 5848 (200), D 5849 (4), Standard Oil Pier, Richmond (*4*), Red Rock (*6*, 11), Sausalito (1), and questionably at D 5729, D 5731, D 5746, D 5773, D 5798, D 5799, D 5809.

This native oyster has been reported by various writers under several varietal names from the vicinity of San Francisco. It is a hardy species, having a general distribution within the bay besides occurring in the shallower waters outside the Golden Gate. It is apparently restricted by the distribution of a type of bottom that affords a suitable support for the young. The relatively small number of localities at which shells were obtained is due largely to the fact that the operations of the "Albatross" were confined to the deeper region of the bay. Living specimens were dredged in depths ranging from less than 1 to 4 fathoms. Shells were encountered frequently within the Golden Gate in 19 fathoms. The shells being light are quite easily shifted by the currents from the shallow waters to regions of deeper water, thereby accounting in part for great numbers of dead specimens dredged at certain localities.

This species is associated with *Ostrea elongata* (*O. virginica*), which has been introduced from the East. The western species possesses a much thinner shell than does the eastern form. The denticulate hinge-margin and the more elongate adductor muscle scar also serve to distinguish *O. lurida*.

It is used quite extensively as food for man, being harvested in the lower portion of the bay by several oyster companies.

Range.—Sitka, Alaska, to Cape Lucas, Lower California (Dall).

Ostrea elongata Solander

Plate 15, figures 3*a* and 3*b*

Ostrea elongata Solander (1786), p. 151; Dall (1914*a*), p. 1.

Ostrea virginica Gmelin, Gould (1841), p. 137.

Description.—This oyster was described by Gould (1841) in the following words:

"Shell narrow, elongated, gradually widening, moderately curved, for the most part with a long and pointed beak at the apex, and rounded at the other extremity. Upper valve, the smallest, flattest and smoothest surface; when not worn, presenting everywhere leaf-like scales, of a somewhat leaden color. The hinge presents the usual channel in the beak of the lower valve, longer or shorter according to the age of the shell, and marked with lines exhibiting the successive removes of the cartilage; and in the upper valve we have the corresponding elevation, which is also continued back to the point of the shell. The muscular impression is nearly central, of a dark chestnut, or sometimes dark violet color."

Length, 10 to 100 mm.

Occurrence.—At stations D 5781 (*11*, 15), D 5782 (*5*, 23), D 5808 (1), D 5810 (1), D 5811 (9), D 5812 (10), D 5814 (*2*, 6).

This is the eastern edible oyster which is grown here from seed oysters shipped from the East. This species does not reproduce to any extent in these waters.

Range.—Known on the Pacific Coast from San Francisco Bay and Puget Sound, where it has been introduced.

Pectinacea

PECTINIDAE

Hinnites Defrance

Hinnites giganteus Gray

Plate 17, figures 1*a* and 1*b*

Hinnites giganteus Gray (1826), p. 103; Wood and Raymond (1891), p. 55.
Pecten giganteus, Arnold (1906), p. 93, pl. 29, figs. 1, 2, 2*a*.

Description.—Arnold (1906) described this species as follows:

"Shell averaging about 75 millimeters in altitude, usually not quite so long as high, irregular, inequivalve, generally inequilateral on account of attachment to irregular surface; shell quite thick; margins smooth. Right valve more ventricose than left, ornamented by 9 to 18 narrow, irregular, prominently squamose ribs, between which in the flat interspaces are less prominent raised lines similarly sculptured; hinge line more than one-half length of disk; ears subequal, and more or less prominently sculptured by fine, squamose, radiating lines; byssal sinus sometimes visible. Left valve less ventricose than right, otherwise similar. Hinge rather narrow and heavy; fosset deeply excavated, oblique, narrow, and angular; hinge is dark purple in living shells."

Length, 7 to 75 mm.

Occurrence.—At stations D 5701 (1), D 5702 (f.), D 5712 (1), D 5735 (1), D 5795 (2), D 5800 (2), D 5827 A (f.), D 5843 (2), D 5846 (*1*, 2), and questionably at D 5773, D 5801.

This common West Coast species was reported by Wood and Raymond (1891) from San Francisco. It has been taken by the Survey at eight stations. It is restricted in its distribution to the open waters outside the Golden Gate and the middle portion of San Francisco Bay west of Alcatraz and north of Angel Island. The only living specimen was obtained at station D 5846 at a depth of 10 fathoms on a stony bottom. Shells were obtained in depths up to 19 fathoms from bottoms which were prevailingly stony.

This correlation with a rocky bottom is due to the fact that this species becomes sessile at any early age, attaching itself to some foreign object.

Range.—Aleutian Islands to Magdalena Bay (Dall).

Pecten Müller

Pecten hastatus Sowerby

Pecten hastatus Sowerby (1842–87), p. 72, pl. 22, fig. 236; Wood and Raymond (1891), p. 55; Arnold (1906), p. 108, pl. 41, fig. 4, pl. 42, figs. 1, 1*a*, 2, 2*a*.

Description.—Arnold (1906) described this species as follows:

"Shell averaging about 64 millimeters in altitude, slightly shorter than high, inequivalve, equilateral (except for ears), compressed and with serrate margins; base evenly rounded below; sides slightly concave above. Right valve with nine pairs of narrow, elevated, spiny ribs, along the sides of which are a pair of smaller spiny riblets; major interspaces much wider than ribs, concave-bottomed and ornamented by one or three thread-like, spiny, intercalary riblets; whole surface sculptured by microscopic imbricating lines, of which the spines on the ribs and riblets are only modifications; hinge line equal to one-half length of disk; ears unequal, the anterior being about two and one-half times the length of the posterior; anterior ear with seven or eight prominently spiny radials and minor riblets, and imbricating incremental lines; byssal notch deep and almost as wide as ear; posterior ear small, and sculptured by fine, spiny radials and imbricating incremental lines. Left valve with about nine narrow, very prominently spiny ribs; interspaces wide, concave-bottomed, and ornamented by a single prominent, central imbricated riblet, on each side of which are minor thread-like riblets; whole surface of disk with fine incremental sculpture as in right valve; ears similar to those of right valve except that the anterior one has more ribs and riblets and no byssal notch. Hinge with almost obsolete cardinal crura. Color, golden yellow to pink, the left valve being the darker.''

This species is occasionally found in the vicinity of San Francisco. It is not among the Survey collections. It is listed from this region by Wood and Raymond (1891).

Range.—Puget Sound to San Pedro, California.

Pecten latiauritus Conrad

Pecten latiauritus Conrad (1837), p. 238, pl. 18, fig. 9; Arnold, R. (1903), p. 111, pl. 12, figs. 2 and 2*a*; Arnold (1906), p. 115, pl. 46, figs. 2, 2*a*, 3, 3*a*.

Description.—This species was described by Arnold (1906) as follows:

''Shell averaging about 25 millimeters in altitude, about as long as high, inequivalve, compressed, inequilateral, disk obliquely produced posteriorly, thin; sides straight; margins smooth. Right valve more compressed than left, with 12 to 16 low, rather squarish ribs, separated by equal, more or less distinctly channeled interspaces; whole surface sculptured by numerous fine concentric lines; hinge line nearly as long as disk; ears subequal in length; anterior ear long and narrow, with 5 or 6 prominent radials and numerous fine concentric lines; byssal notch deep and distinctly separating ear from disk; posterior ear from rectangularly to acutely pointed, sculptured by obsolete radials and concentric lines. Left valve somewhat more convex than right, otherwise similar to it; anterior ear generally shorter and more prominently sculptured than posterior.''

Length, 7 to 8 mm.

Occurrence.—At stations D 5702 (1), D 5825 (1).

Two immature specimens of *Pecten* that appear to belong to this species were dredged within the middle division of the bay.

Range.—San Francisco, Monterey to San Diego, California (Orcutt).

ANOMIACEA

ANOMIDAE

Anomia Müller

Anomia peruviana d'Orbigny

Plate 15, figures *2a* and *2b*

Anomia peruviana d'Orbigny (1835–43), p. 673; Dall (1910*b*), p. 148, pl. 28, fig. 4.

Anomia lampe Gray, Arnold, R. (1903), p. 117.

Description.—Dall described this species as follows:

"Shell very thin, pearly; white or copper brown on the upper valve, bluish green internally and on the central part of the lower valve; sessile on other shells or smooth objects adhering by a prominent byssus which passes through a large hole in the lower valve. The scars of the muscles in an area on the inside of the upper valve form a nearly even straight row radiating from the direction of the hinge."

Length, about 26 mm.

Occurrence.—At station D 5811 (3).

Three worn valves dredged within the lower part of the bay have been referred to this species. Its association with the eastern oyster suggests the possibility of it being *Anomia simplex* d'Orbigny, an eastern form closely resembling our West Coast species. However, *Anomia peruviana* has recently been reported by Clark (1914, p. 25) from Bolinas Bay, so it is not improbable that it is living within San Francisco Bay. The specimens were obtained from a muddy bottom at a depth of 3 fathoms.

Range.—Bolinas Bay, California (Clark), Paita, Peru (Dall).

Monia Gray

Monia macroschisma (Deshayes)

Plate 15, figures *1a* and *1b*

Placunanomia macroschisma, Carpenter (1863), p. 646; Wood and Raymond (1891), p. 55.

Pododesmus macroschisma, Arnold, R. (1903), p. 116.

Description.—This species is described by Arnold (1903) as follows:

"Shell adherent, subequivalve, irregular, flattened; hinge with two thick, divergent, elongated lamella in the inferior, corresponding with two long pits in the upper valve; upper valve with only two muscular impressions; the pedal scar radiately striated; surface with incremental laminae and sometimes radial ridges."

Length, 15 to 80 mm.

Occurrence.—At stations D 5700 (1), D 5702 (2), D 5775 (*1*), **D 5795 (f.), D 5796 (1)**, D 5800 (2), D 5809 (f.).

This common bivalve has been reported by Carpenter and by Wood and Raymond from this region. Obtained by the Survey at six stations, which are restricted to the Golden Gate and Raccoon Straits. The single living specimen was dredged from a rocky bottom near the north shore of the Golden Gate in 10 fathoms of water. Shells were dredged in 12¾ to 53 fathoms. This being a sessile form it occurs only where suitable support exists, such as stones or large shells.

Range.—Unalaska to Lower California.

MYTILACEA

MYTILIDAE

Mytilus Linnaeus

Mytilus californianus Conrad

Plate 18, figure 2

Mytilus calfornianus Conrad (1837), p. 242, pl. 18, fig. 15; Carpenter (1863), p. 643; Wood and Raymond (1891), p. 55.

Description.—This species was described by Conrad (1837) as follows: "Shell ovate elongated, inflated; anterior margin straight; posterior side emarginate; ribs not very numerous, slightly prominent, broad, rounded; lines of growth very prominent."

Length, 2 to 90 mm.

Occurrence.—At stations D 5776 (2), D 5808 (1), D 5809 (1), D 5842 (1), Presidio shore (*149*), Bonita Point (*12*, 1).

This common edible mussel has been reported by various authors from this region. It appears to be restricted to the intertidal areas outside the Golden Gate, extending inward as far as Fort Point and Lime Point. Living specimens were obtained by the Survey only at the shore stations at Bonita Point and Fort Point. Shells were dredged at three stations in water ranging in depth from 3½ to 53 fathoms.

Range.—Unalaska, Aleutian Islands, to Socorro Island (Dall).

Mytilus edulis Linnaeus

Plate 15, figure 4; plate 43

Mytilus edulis Linnaeus (1758), p. 705; Carpenter (1863), p. 643; Dall (1898*c*), p. 788; Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 118.

Mytilus edulis var. *glomeratus* Gould, Carpenter (1863), p. 643.

Mytilus trossulus Gould (1850), p. 344.

Description.—Arnold (1903) describes this species as follows: "Shell of medium size, wedge-shaped, rounded behind, thin; surface smooth, except for concentric, incremental lines; umbones terminal; dorsal margin slightly depressed in middle; hinge-teeth minute."

Length, 2 to 60 mm.

Occurrence.—At stations D 5705 (*1*), D 5709 (1), D 5710 (*1*, 1), D 5714 (7), D 5715 (2), D 5716 (*1*), D 5719 (*2*), D 5720 (5), D 5721 (*10*), D 5722 (*4*), D 5723 (1), D 5726 (2), D 5727 (*5*, 2), D 5728 (*1*), D 5729 (5), D 5730 (f.), D 5742 (1), D 5744 (9), D 5748 (f.), D 5749 (1), D 5751 (*6*), D 5752 (6), D 5753 (1), D 5754 (*1*), D 5755 (1), D 5756 (8), D 5757 (*1*, 5), D 5758 (2), D 5762 (*1*), D 5764 (*11*, 13), D 5765 (1), D 5766 (*13*), D 5767 (*24*, 1), D 5768 (*185*, 5), D 5769 (1), D 5773 (1), D 5776 (f.), D 5778 (*2*, 1), D 5780 (1), D 5781 (*150*), D 5782 (*162*, 1), D 5783 (*3*), D 5784 (*105*, 1), D 5789 (*31*), D 5790 (*5*), D 5793 (8), D 5794 (9), D 5795 (1), D 5796 (1), D 5805 (*1*), D 5810 (*18*, 1), D 5811 (*6*, 36), D 5813 (1), D 5815 B (3), D 5816 (*24*), D 5817 (*25*), D 5817 A (6), D 5817 B (*2*), D 5818 A (1), D 5819 (*4*), D 5821 A (f.), D 5821 B (f.), D 5822 B (3), D 5823 (1), D 5823 A (7), D 5824 A (f.), D 5824 B (1), D 5826 A (5), D 5826 B (f.), D 5830 A (*4*), D 5831 (5), D 5832 A (7), D 5833 (2), D 5839 (1), D 5841 (27), D 5847 (1), D 5848 (1), Standard Oil Pier, Richmond (*35*, 2), Red Rock (*85*), Key Route Pier, Oakland (*62*, 1), Cement sewer (numerous specimens), Sausalito (*31*, 1), Bonita Point (*72*, 1), and questionably at D 5739.

This circumpolar species, recognized by all conchologists writing of this region, is one of the most adaptable of our West Coast mollusks. It may be found attached by means of its byssus to almost any object in situations ranging from the brackish waters of Carquinez Strait to the saline waters of the open ocean. Living specimens were dredged in 46 fathoms, but the majority were obtained at depths of less than 4 fathoms.

Range.—Circumpolar, Arctic Sea south to San Diego, California.

Modiolus Lamarck

Modiolus demissus (Dillwyn)

Plate 18, figure 1

Modiolus demissus Dillwyn (1817), p. 314.

Modiola plicatula Lamarck, Gould (1841), p. 126; Dall (1889a), p. 38; Stearns (1899e), p. 86.

Modiolus demissus, Sumner, Osburn, Cole, and Davis (1913), p. 683.

Description.—Gould (1841) described this eastern mussel as follows:

"Shell transversely oblong-ovate, much elongated, narrow before and widening backwards, somewhat falciform or arched; beaks moderately prominent, not curving outwards, and nearly in contact, very near the anterior extremity, which is small and rounded; and the shell is much compressed at this part; the lower margin is generally curved or arched upwards, and gaping before the middle for the passage of the byssus; hinge margin straight, and ascending for about two-thirds the length of the shell so as to give it additional height, then, by a regular downward curve, it produces an obliquely rounded termination to the shell; a broad, elevated ridge crosses obliquely from the beaks to this termination, above which the shell is compressed; surface ornamented with numerous radiating, somewhat undulating, occasionally branching ribs, most conspicuous above and behind, very fine on the anterior third. Shell silvery-white, the muscular impressions and margins of a livid color; margin of the posterior half and anterior side crenulated by the ribs.''

This exotic species was first reported from a point ''three miles north of Stanford University'' by Stearns in 1899. Although it was not taken by the Survey, it is reported to occur within the lower division of the bay in sufficient numbers to be marketed occasionally. On the Atlantic coast, Sumner *et al.* (1911) report this species as being abundant along marshes and sandy shores.

Range.—Known on the Pacific Coast only from San Francisco.

Modiolus rectus Conrad

Modiola recta Conrad (1837), p. 243, pl. 19, fig. 1; Carpenter (1863), p. 643.

Modiolus rectus, Arnold, R. (1903), p. 120.

Description.—This species was originally described by Conrad (1837) as follows:

''Shell produced, smooth, thin, anterior margin elevated; posterior side cuneiform; color brown, with a broad pale strip extending from the beak towards the posterior margin; within very glossy and iridescent.''

Occurrence.—At station D 5723* (f.) and questionably at D 5723 (*3*), D 5738 (*8*), D 5828 B (1).

A fragment of a shell that was determined by Dall as belonging to this species was dredged by the Survey in the northern portion of the lower division of the bay. Several small living specimens have been referred to this species.

Range.—Puget Sound to Magdalena Bay, Lower California.

Modiolus politus Verrill and Smith

Modiola polita Verrill and Smith (1880), p. 400.

Description.—This species was originally described as follows:

''Shell thin, translucent, without sculpture; epidermis pale yellow, smooth and polished. Umbos prominent; hinge-line straight; posterior end broadly rounded, compressed; anterior end prolonged decidedly beyond the beak, narrow, rounded. Greatest length, 40; breadth, 21 mm.''

Length, 6 to 7 mm.

Occurrence.—At stations D 5788 (*1*), D 5789 (*1*), and questionably at D 5821.

This southern species is represented by two living individuals dredged from the dark green sands outside the Golden Gate at depths of from 46 to 68 fathoms. The specimen that was questionably referred to this species was dredged in 8 fathoms of water north of Angel Island.

Range.—Bodega Head, California, to Cerros Island, Lower California (Dall).

Modiolus modiolus (Linnaeus)

Mytilus modiola Linnaeus (1767), p. 1158.

Modiola modiola, Tryon (1873), p. 186, pl. 39, figs. 510, 511.

Description.—This species is described by Tryon as follows:

"Shell large, coarse, and solid, oblong, obliquely dilated; beaks tumid, obtusely angulated; basal margin concave, with a fissure for the byssus; surface coarsely marked by growth lines; epidermis thick, dark violaceous, blackish, or chestnut brown; within pearly. Animal dark-orange or reddish, edible."

This species was not obtained from these waters by the "Albatross," although it has been reported from this region by Cooper.

Range.—Arctic Sea to San Pedro, California (Dall), Atlantic Coast south to Cape Hatteras (Rogers).

Modiolus, sp.

Several immature specimens of *Modiolus* are among the collections. They have not been determined specifically.

Length, 3 to 10 mm.

Occurrence.—At stations D 5723 (*1*), D 5727 (*3*), D 5738 (*8*), Sausalito (1), Bonita Point (*1*).

DREISSENSIIDAE

Septifer Recluz

Septifer bifurcatus Reeve

Septifer bifurcatus Reeve, Carpenter (1863), p. 643; Cooper (1870*a*), p. 54; Dall (1898*c*), p. 789; Williamson (1898), p. 67; Arnold, R. (1903), p. 119; non *Mytlus bifurcatus* Conrad.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, wedge-shaped, equivalve, convex, rather thick, beaks pointed, terminal; surface sculptured by numerous strong, rounded, terminally bifurcating, radiating ridges, and fine concentric, incremental sulcations; margin corrugated; a small lamellar deck stretches across the interior of the shell near the umbo; teeth small."

The Farallon Islands is given as the most northern range of this species by both Carpenter (1863) and Cooper (1870). It was not obtained by the Survey.

Range.—Crescent City, California, to Gulf of California (Dall).

Adula H. and A. Adams

Adula falcata (Gould)

Lithodomus falcata Gould (1851), p. 87; (1862), p. 213.

Adula falcata, Carpenter (1863), p. 644; Cooper (1870*a*), p. 55.

Description.—The original description is in Latin, a free translation of which is given below:

Shell fragile, subcylindrical, curved, posterior side sloping; umbones strongly angulated, pearly; epidermis dull chestnut colored, with occasional bifurcate wrinkles. Umbones situated in the anterior octant, strongly curved, anterior side dilated, subglobose; posterior side curved, compressed, pointed, fringed above.

Both Carpenter (1863) and Cooper (1870) report this rock-boring mollusk from this region. Not found among the collections of the Survey, although it occurs abundantly along the rocky shores outside of the Golden Gate.

Range.—Coos Bay, Oregon, to San Diego, California (Dall).

Adula stylina Carpenter

Plate 18, figure 5

Adula stylina Carpenter (1863), p. 644 (1864*b*), p. 425.

Description.—The following is a translation by Professor Clark of Carpenter's Latin description of the species:

''Shell cylindrical, lithophagus-like, smooth, very thin, somewhat pointed, subnacreous, white, posterior end sometimes tinged with blue; epidermis shining, smooth, thick, dark brown; young shells typically modiolaraeform, umbones directed anteriorly; anterior dorsal margin slightly crenulated; adult shell with dorsal and ventral margins nearly parallel; anterior and posterior margins rounded; umbones worn, not conspicuous, situated about one-sixth the distance from the anterior to the posterior extremity; incrustation thin, porous, covering the posterior area diagonally, prolonged beyond the valves; internal ligament prolonged posteriorly; inner surface pale; posterior abductor scar pear-shaped, anterior larger, not impressed, oblong; anterior pedal scar large, circular, impressed; with a subumbonal callosity, conspicuous toward the pedal scar.''

Length, 14 mm.

Occurrence.—At station D 5809 (*1*).

This rock-boring mollusk is represented by a single specimen dredged from 53 fathoms in the outer portion of the Golden Gate.

Range.—Vancouver Island to San Diego, California (Orcutt).

Anatinacea

PANDORIDAE

Pandora Bruguière

Pandora filosa (Carpenter)

Plate 19, figures 2*a* and 2*b*

Kennerlia filosa Carpenter (1863), p. 638; (1864*c*), p. 602.

Pandora (*Kennerlia*) *filosa*, Carpenter (1865*a*), p. 55; Arnold, R. (1903), p. 124, pl. 18, fig. 3.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, planoconvex, elongate-oval, thin; umbones minute, about one-fourth length from anterior extremity; anterior and posterior dorsal margins straight, making an angle of 160 degrees at the umbo; ventral margin arcuate; posterior extremity long, narrowed and truncated at the end; anterior rounded up from base but making an angle with dorsal margin; a single prominent posterior, submarginal ridge runs from umbo to extremity on each valve, being nearer the margin in the flat valve; surface of both valves sculptured by numerous fine, concentric, incremental lines, and that of the right valve by fine radiating sulcations; left valve with a thin hinge ossicle; right valve with two ossicles, the anterior one being short."

Length, 10 to 18 mm.

Occurrence.—At stations D 5785 (*13*), D 5786 (*8*, 1), D 5787 (*1*), D 5788* (*3*), D 5789 (*3*, 3), and west of the Farallon Islands (*1*).

This species is restricted to the waters outside the Golden Gate. Living specimens were dredged in the vicinity of the Farallon Islands, being the most abundant at station D 5785. Dredged in depths ranging from 39 to 68 fathoms, and at one locality west of the Farallon Islands in 815 fathoms.

Range.—Nunivak Island, Alaska, to Point Abreojos, Lower California (Dall).

LYONSIIDAE

Lyonsia Turton

Lyonsia californica Conrad

Plate 18, figure 3

Lyonsia californica Conrad (1837), p. 248, pl. 19, fig. 21; Carpenter (1863), p. 638; Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 125.

Description.—Conrad's (1837) original description is as follows:

"Shell produced, equivalve; posterior side narrowed, truncated at the extremity; umbo inflated; epidermis with radiating striae. Length, one and a half inches."

Length, 19 to 22 mm.

Occurrence.—At stations D 5785 (1), D 5790* (*1*), D 5791 (1).

Wood and Raymond (1891) list this species from San Francisco. A single living specimen was dredged near the Farallon Islands by the Survey in 33 fathoms on a bottom composed of fine dark green sand.

Range.—Puget Sound, Washington, Todos Santos Bay, Lower California (Dall).

Entodesma Philippi

Entodesma saxicola (Baird)

Lyonsia saxicola Baird (1863), p. 70.
Entodesma saxicola, Carpenter (1863), p. 638.
Lyonsia (*Entodesma*) *saxicola,* Wood and Raymond (1891), p. 55.

Description.—The following description is adapted from the original description as given by Baird (1863):

Shell thin, brittle, ovate-oblong shape, gibbous in the center, produced anteriorly, compressed posteriorly and gaping.'' Beaks large, incurved. Ventral margin flexuous and gaping. Epidermis finely striated, of an olive color.

Length, 45 mm.

Occurrence.—At stations D 5845 (f.), D 5846 (2).

This species has been reported from the Farallon Islands by Carpenter (1863) and from San Francisco by Wood and Raymond (1891). Shells of this form were obtained by the Survey at two stations within the Golden Gate in 33 and 45 fathoms. The two weathered shells from station D 5846 were found associated with *Kellia laperousi* and *Petricola carditoides* as a nestler in pholadid borings.

Range.—Aleutian Islands (Dall.) to San Diego, California (Orcutt).

POROMYACEA

CUSPIDARIIDAE

Cuspidaria Nardo

Cuspidaria californica Dall

Plate 20, figure 3

Cuspidaria californica Dall (1886), p. 296.

Description.—This species was originally described as follows:

''Shell differing from *C. pectinata* by its smaller size and proportionally greater length; larger number of ribs (16–20, while *pectinata* averages 12–14); its straighter, longer rostrum with but two strong radiating lirae extending to the lower extreme (*pectinata* has none, or only several fine ones near the body of the valve); its less inflated shape and paler, more delicate epidermis.

Lon. of shell 7.0; of rostrum 2.5; alt. of shell 3.6; diam. 2.75 mm. Color yellowish white; ossicle as usual; buttress present in the right valve.''

Length, 7 to 15 mm.

Occurrence.—At station D 5789 (*6*, 3).

This form was dredged by the Survey at a single station outside the Golden Gate from a depth of 68 fathoms.

Range.—Puget Sound to San Diego, California (Dall).

Chamacea

chamidea

Chama Linnaeus

Chama pellucida (Broderip)

Chama spinosa, var., *pellucida* Broderip (1834), p. 150.

Chama pellucida, Carpenter (1863), p. 641; Cooper (1870*a*), p. 53; Arnold, R. (1903), p. 130; Keep (1911), p. 70.

Description.—The following is Arnold's (1903) description of this species:

''Shell of medium size; right valve (attached), exceedingly ventriose, rather thin; left valve nearly flat, thicker; surface of attached valve sculptured with numerous prominent, spiny frills; surface of upper valve with more numerous, small frills, which are sometimes spiny near the margin of the valve; hinge-teeth and muscle-impressions as in *C. exogyra.*''

Carpenter (1863, p. 641) reports this species from San Francisco and Cooper (1870*a*, p. 53) lists it from the Farallon Islands. It is not found among the Survey collections. Outside the Golden Gate it has been found within intertidal areas, both north and south of San Francisco.

Range.—Oregon to Chile (Dall).

Lucinacea

lucinidae

Phacoides (Blainville) Gray

Phacoides annulatus (Reeve)

Plate 19, figures 5*a* and 5*b*

Lucina annulatus Reeve (1851), pl. 4, fig. 17.

Lucina borealis, Carpenter (1863), p. 643.

Lucina acutilineata Conrad, Arnold, R. (1903), p. 131.

Phacoides annulatus, Dall (1901*b*), p. 828; Dall (1903*a*), p. 1379.

Description.—Arnold described this species as follows:

''Shell large, orbicular, only slightly convex, rather thin; umbones depressed, central; surface ornamented by numerous equal, equidistant, sharp, raised, concentric lines; interspaces show lines of growth; lunule small, but deeply impressed and distinct; two sharp cardinal teeth in each valve; lateral teeth nearly obsolete; anterior muscle impression much elongated.''

Length, 14 to 65 mm.

Occurrence.—At station D 5789 (6).

Several valves were obtained at a single station near the Farallones in 46 fathoms on a bottom of dark green sand. According to Dall, this species ranges in depth from 8 to 135 fathoms.

Range.—Alaska to Coronado Island, California (Dall).

Phacoides tenuisculptus (Carpenter)

Plate, 19, figures 1*a* and 1*b*

Lucina tenuisculpta Carpenter (1863), p. 642; (1865*a*), p. 57; Arnold, R. (1903), p. 133.

Phacoides tenuisculptus, Dall (1901*b*), p. 828, pl. 40, fig. 5.

Description.—Arnold (1903) describes this species as follows:

"Shell small, orbicular, deeply convex, thin; umbones prominent, central; surface sculptured by numerous fine, concentric lines and radiating striae; lunule prominent, the greater part being in the right valve; cardinal teeth small, laterals prominent; anterior muscle-impressions not as elongated as in *L. acutilineata* and others."

Length, 2 to 5 mm.

Occurrence.—At stations D 5785 (*3*, 2), D 5786* (*31*), D 5787 (4), D 5788 (*3*, 1), D 5789 (*2*, 3), D 5830 A (*4*), and questionably at D 5744, D 5825 A, D 5826 B, D 5828 B.

Living specimens are restricted to the collections from the open ocean, occurring abundantly at station D 5786 at a depth of 40 fathoms. Several shells were obtained in the middle portion of the bay that have been questionably referred to this species. This species lives on a fine-grained sand.

Range.—Bering Sea, Alaska, to Coronado Island, California (Dall).

THYASIRIDAE

Thyasira Leach

Thyasira gouldi (Philippi)

Plate 20, figure 5

Axinus Thyasira gouldi Philippi (1845–1846), p. 75.

Cryptodon flexuosus Carpenter (1863), p. 643.

Thyasra gouldi, Arnold, R. (1903), p. 135.

Description.—Arnold (1903) described this species as follows:

"Shell small, globular, posterior side augulated or furrowed; umbones much recurved; surface sculptured with fine incremental lines; lunule indistinct, depressed in front of beaks; ligament external, placed in a groove on the hinge-line and outside the hinge-plate; teeth wanting.

Length, 7 mm.

Occurrence.—A single valve was obtained from station D 5788*, outside the Golden Gate, in 68 fathoms on a bottom composed of pure sand.

Range.—Bering Strait to San Diego (Dall).

Leptonacea

LEPTONIDAE

Kellia Turton

Kellia laperousi (Deshayes)

Plate 19, figure 4

Chironia laperousi Deshayes (1839), p. 357; Carpenter (1863), p. 643; Wood and Raymond (1891), p. 55; Dall (1900*a*), p. 1155; Arnold, R. (1903), p. 137, pl. 18, figs. 7, 7*a*.

Description.—The following is Arnold's (1903) description of this species: "Shell of medium size, suborbicular, convex, thin; umbones slightly anterior, not prominent; surface sculptured by fine incremental lines which are slightly variable as to prominence; no lunule; each valve with one very prominent cardinal tooth; right valve with two posterior laterals, left with one; hinge-area lacking between cardinal and lateral teeth; muscle-impressions not distinct."

Length, 7 to 25 mm.

Occurrence.—At station D 5846 (*3*, 26).

This bivalve was dredged by the Survey only from the western portion of the Golden Gate.. Living specimens were there found nestling in pholadid borings at a depth of 45 fathoms. However, it is not so restricted, for Mr. A. L. Barrows reports this species in similar situations at low-tide mark on Goat Island.

Range.—Bering Sea to San Diego, California (Dall).

Rochefortia Velain

Rochefortia ferruginosa Dall

Rochefortia ferruginosa Dall (1916*b*), p. 411.

Description.—Dall described this species as follows:

"Shell small, white, thin, subdonaciform, compressed, invariably coated with a ferruginous layer like some species of *Axinulus,* inequilateral; anterior side longer, apical angle about 90; both ends rounded, base arcuate. Length, 4.5; height, .325; diameter, 1.5 mm."

San Francisco Bay is the type locality for this species. It was not taken by the Survey.

Range.—Known only from San Francisco Bay, which is the type locality for the species.

Lasaea Leach

Lasaea rubra (Montagu)

Cardium rubrum Montagu (1803), p. 83, pl. 27, fig. 4.
Kellia rubra, Gould (1841), p. 60, fig. 23.
Lasaea rubra, Dall (1899*c*), p. 881.

Description.—This species was described by Gould (1841) as follows:

"Shell minute, rather thick, sub-oval, very inequilateral, rather compressed; beaks rather prominent, and in contact, having before them a deeply excavated, elongated, smooth areola; ends broadly rounded, especially the posterior tip; basal margin scarcely curved and nearly parallel with the superior margin; surface marked with the lines of growth, eroded at the beaks, and covered with a purplish or dirty-brown rather thick epidermis. Within white and glossy; two muscular impressions and the palleal line directly connecting them, without any sinus, quite perceptible. Hinge consists, in the right valve, of a narrow, erect, central tooth, and an imperfect one each side, slightly detached from the edge of the valve; in the left valve, of a well-defined tooth on each side, barely separated from the edge of the valve, leaving a triangular vacancy between them to receive the central tooth of the opposite valve.

Length, 1 to 2 mm.

Occurrence.—At stations D 5766 (*2*), D 5771 (*1*), Presidio* (17). As far as is known this species has not been recorded from the vicinity of San Francisco. It is found in the Survey collection only from the middle and lower divisions of the bay. Living specimens were dredged from mud bottoms at depths of 3 and 3¼ fathoms. They were also taken at the shore station near the Presidio.

Range.—Vancouver, B. C., to Peru (Dall).

CARDIACEA

CARDIIDAE

Cardium Linnaeus

Cardium corbis (Martyn)

Plate 20, figures 1*a* and 1*b*, pl. 44

Pectunculus corbis Martyn (1784), pl. 28, fig. 2.
Cardium corbis Carpenter (1863), p. 642; Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 140; Keep (1911), p. 72, fig. 47.

Description.—This species was described by Arnold (1903) as follows:

"Shell large, subtrigonal, ventricose, thick; umbones prominent, anterior to center; surface ornamented with about thirty-seven prominent regular, squarish, close-set, radiating ridges, which are made more or less rugose by incremental ridges on their surface; near the posterior margin these ridges become more rounded and less prominent; between the ridges are equal, deep, canal-like grooves; margin crenulated; ligament short, external, prominent; each valve with one prominent cardinal tooth, and two laterals, one anterior and the other posterior; muscle impressions prominent, subequal."

Length, 2 to 75 mm.

Occurrence.—At stations D 5700* (*1*, 17), D 5701 (1), D 5702 (*4*, 19), D 5703 (*7*), D 5704 (*3*), D 5705 (*15*), D 5706 (*4*), D 5708 (*6*, 8), D 5709 (*3*, 3), D 5710 (2), D 5711 (2), D 5712 (3), D 5713 (6), D 5714 (*14*, 1), D 5715 (*1*), D 5723 (*2*, 5), D 5724 (*4*), D 5725 (*1*, 2), D 5726 (4), D 5728 (*2*, 1), D 5729 (*2*), D 5730 (3), D 5731 (*1*, 5), D 5732 (f.), D 5736 (f.), D 5737 (f.), D 5739 (*8*, 1), D 5740 (7), D 5741 (f.), D 5742 (13), D 5743 (*6*, 46), D 5744 (6, 5), D 5745 (*2*, 15), D 5746 (*2*, 2), D 5747 (1), D 5748 (3), D 5750 (f.), D 5751 (f.), D 5752 (3), D 5754 (*2*, 5), D 5755 (*32*), D 5756 (2), D 5757 (*29*, 1), D 5764 (*1*), D 5766 (*3*, 10), D 5767 (*3*, 8), D 5768 (*1*), D 5772 (*1*), D 5773 (3), D 5778 (*1*, 15), D 5779 (*2*, 8), D 5780 (*1*), D 5782 (*1*, 1), D 5784 (f.), D 5795 (*7*, 11), D 5796 (*17*, 19), D 5798 (1), D 5799 (1), D 5800 (16), D 5801 (*2*, 1), D 5802 (1), D 5803 (*2*), D 5808 (*1*), D 5809 (2), D 5821 A (*1*, 2), D 5821 B (*1*, 1), D 5822 B (3), D 5823 (*1*, 1), D 5823 A (51), D 5824 B (19), D 5825 (1, 4), D 5825 A (9), D 5825 B (1), D 5826 (3), D 5826 A (6), D 5826 B (5), D 5827 (12), D 5827 A (7), D 5828 (*1*), D 5828 B (16), D 5829 A (7), D 5831 (*1*, 2), D 5832 (2), D 5833 (29), D 5834 (4), D 5835 (2), D 5839 (1), D 5841 (11), D 5843 (1), D 5844 (1), D 5847 B (1).

This common West Coast cockle has been reported by a number of writers from this region. It has a general distribution, being more frequently taken within the middle division of the bay. Living specimens were dredged at forty stations in depths ranging up to 19 fathoms. About two-thirds of these hauls were made in less than 10 fathoms. It appears to be predominately mud-dwelling species, although it occurs on all types of bottom.

Range.—Bering Sea to San Diego, California (Dall).

Cardium (Protocardia) centifilosum Carpenter

Plate 20, figures 2*a*, 2*b*, 2*c*, and 2*d*

Cardium var. *centifilosum* Carpenter (1863), p. 642.

Protocardia centifilosa, Dall (1900*a*), p. 1113; Arnold, R. (1903), p. 142.

Description.—The following is Arnold's (1903) description of this species: "Shell small, suboval, ventricose, thin; umbones central, prominent, only very slightly bent; surface sculptured by numerous fine, close-set, rounded, radiating ridges, which are made slightly rugose by numerous fine, incremental lines on their surface; thin, sharp teeth in each valve; pallial sinus shallow, wide; margin beautifully and sharply serrate."

Length, 3 to 14 mm.

Occurrence.—At station D 5785* (2), D 5787 (*1*), D 5789 (*2*, 4). This species has seldom been taken north of Monterey Bay. It is restricted in the Survey collections to the vicinity of the Farallon Islands. Living specimens were dredged at two stations in 40 and 46 fathoms on a bottom of fine dark green sand.

Range.—The typical species, and the variety *C. richardsoni* (Whiteaves), ranges from Queen Charlotte Islands to Lower California (Dall).

Veneracea

VENERIDAE

Marcia (H. and A. Adams) Fischer

Marcia subdiaphana (Carpenter)

Plate 19, figure 3

Clementia subdiaphana Carpenter (1863), p. 640; (1865*a*), p. 56; Dall (1891), p. 185.

Description.—Dall (1891) characterizes this species as follows:

"The original specimens of this species were young and subdiaphanous. . . . The young shell is greenish, white, very thin and usually more elongated in proportion than the adult. Inside it (the adult shell) is of a dead chalk-white, with the muscular and pallial impressions polished."

Length, 5 to 20 mm.

Occurrence.—At stations D 5785 (*4*, 3), D 5786 (*2*), D 5789 (*15*, 4), D 5790 (*1*).

This northern species has not hitherto been reported from this vicinity. Living specimens were dredged at four stations in the vicinity of the Farallon Islands in 33 to 46 fathoms. The bottom is comprised of fine dark green sand.

In Puget Sound this species attains a size more than twice that of the largest specimen in our collections. In all other respects the forms are identical. It thus appears that this form diminishes in size toward the southern limit of its range. Several specimens in the collection of the Scripps Institution for Biological Research, obtained from the vicinity of the Channel Islands are in accord with this suggestion, being very diminutive in comparison to the Puget Sound forms.

The fossil species *Marcia oregonense* Conrad is very closely related to *Marcia subdiaphana.* If it is identical this form will take the name of the former.

Range.—Unimak Pass, Alaska to San Pedro, California.

Saxidomus Conrad

Saxidomus nuttalli Conrad

Plate 21, figure 2

Saxidomus nuttalli Conrad (1837), p. 249, pl. 19, fig. 12; Dall (1902), p. 391.
Saxidomus aratus Gould, Carpenter (1863), p. 641; Arnold, R. (1903), p. 151.
Saxidomus giganteus Deshayes, Dall (1902), p. 391.
Saxidomus squalidus Deshayes, Carpenter (1863), p. 641.

Description.—This species was described by Conrad (1837) as follows:

''Shell suboval; disk rough, with concentric striae, elevated on the posterior slope; posterior extremity truncated; colour white, with brown spots and stripes about the umbo and ligament margin.''

Length, 15 to 105 mm.

Occurrence.—At stations D 5701 (1), D 5702? (6), D 5703* (*1*), D 5779 (1), D 5801 (15), D 5827 (1), D 5827 A (1), D 5829 A (2), D 5842 (1), D 5843 (8), and questionably at D 5704, D 5744, D 5809, D 5825, D 5844.

This species has heretofore been considered as occurring mainly south of San Francisco. It has been thought to differ from a northern form known as *Saxidomus giganteus* in its more pronounced concentric ribbing and in the purple coloration of the interior of the shell. The identification of the specimens obtained by the Survey led to an examination of a large number of fossil and Recent specimens from various localities. Measurements and a detailed study of the prominent shell characters of the Recent specimens showed that there was such a commingling of characters as to indicate that the northern and southern forms were not separable. The purple coloration, thought to be characteristic of the southern form not only has been reported on specimens from Puget Sound but has since been found by the writer on a typical specimen of the northern form obtained from Sylvan, Washington. Dr. B. L. Clark and the writer in examining the Miocene forms found gradational types connecting forms as divergent as any occurring at the present time. Clark recognizes, therefore, but the one species in his recent paper (1915, p. 420).

The single living specimen was dredged in 8¼ fathoms in the middle division of the bay. This species occurs upon gravelly bottoms, being among the list of those prevalent for that bottom group. It is confined in its local distribution to the middle division of the bay, occurring more abundantly in the outer portion of the Golden Gate.

Range.—Aleutian Islands, Alaska to San Diego, California.

Paphia Bolten

Paphia staminea (Conrad)

Plate 21, figure 1*a* and 1*b*, pl. 45

Venus staminea Conrad (1837), p. 250, pl. 19, fig. 15.

Tapes staminea, Carpenter (1863), p. 641; Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 150, pl. 14, fig. 4; Dall (1902*a*), p. 397.

Description.—Conrad (1837) described this species as follows:

''Shell suboval, or suborbicular, convex, with numerous crowded radiating striae, and finer concentric lines, most distinct on the anterior side; posterior extremity direct; ligament margin nearly parallel with the base; colour variegated with yellowish and brown, and with brown angular spots; cardinal teeth compressed; sinus of palleal impression profound.''

Length, 2 to 75 mm.

Occurrence.—At stations D 5703 (*4*), D 5704 (*3*, 1), D 5705 (*6*), D 5706 (*4*), D 5712* (1), D 5713 (1), D 5723 (*6*, 1), D 5740 (*1*), D 5743 (*17*), D 5744 (*7*, 1), D 5762 (1), D 5767 (*2*), D 5772 (*1*), D 5773 (*1*, 1), D 5778 (1), D 5781 (*1*), 5795 (1), D 5796 (1), D 5800 (1), D 5808 (1), D 5823 A (3), D 5827 (1), D 5833 (*1*, 2), D 5840 (16), D 5842 (1), D 5843 (3), D 5846 (13), Standard Oil Pier, Richmond (1), Red Rock (2), Sausalito (*7*, 16), and questionably at D 5729, D 5736, D 5737, D 5754, D 5768, D 5845.

This edible clam is known on the West Coast by a number of varieties which have been redefined by Dall (1902). The typical form has been reported from these local waters by Wood and Raymond (1891). In speaking of this form Dall (1902, p. 397) states that it has fine even radial riblets and inconspicuous concentric sculpture, and that it has a yellowish-white color with purplish-brown maculations. The variety *P. straminea* var. *petiti* (Deshayes) lacks the maculations and has the sculpture markedly separated into areas. This form commonly occurs north of the Columbia River although it probably occurs farther south. The form *P. staminea* var. *laciniata* Carpenter, most common south of Monterey resembles the Columbia River form in the type of ribbing except that spines are developed at the intersections of the radial and concentric ribs. The northern form *P. staminea* var. *ruderata* (Deshayes) has very pronounced concentric sculpture. Another type which conforms in shape to cavities in rocks or pholadid borings in which it may happen to become imprisoned is known as *P. staminea* var. *orbella* Carpenter.

The specimens obtained by the Survey appear to belong to the typical form except for a few crude specimens found as nestlers in pholadid borings. These few are not considered separately in this report.

The distribution chart (plate 45) shows that this species is restricted to the middle and lower division of the bay. Living specimens were dredged at twelve stations in 1¼ to 10 fathoms, and shells were obtained at a number of other stations including several shore stations.

Range.—Typical form: Crescent City, California, to Socorro Island (Dall). Including varieties, Aleutian Islands to Socorro Islands (Dall).

Paphia staminea (Conrad) var. **ruderata** (Deshayes)

Chione ruderata Deshayes (1853), p. 136.

Venus staminea, var. *ruderata*, Wood and Raymond (1891), p. 55.

Paphia staminea, var. *ruderata*, Dall (1902*a*), p. 398.

Description.—Dall (1902*a*) described this variety as follows:

"This form, which is found chiefly in the north, is characterized by the turgidity and prominence of the concentric sculpture, which becomes more conspicuous than the radial ribs. Occasionally the shells are delicate and elegant, but usually specimens of this variety are rude and irregular, coarse and unattractive."

This variety is a northern form occasionally occurring as far south as San Francisco. Although it was listed from this region by Wood and Raymond (1891) it has not been recognized in the Survey collections.

Range.—Bering Sea to Lobitas, California (Dall).

Paphia staminea (Conrad) var. **orbella** (Carpenter)

Plate 19, figure 6

Paphia staminea var. *orbella* Carpenter, Dall (1902*a*), p. 398.

Description.—Dall (1902*a*) characterizes this species as follows:

"This variety comprised those specimens which have nestled in the borings of large Pholads of the coast, . . . and have been obliged to grow into an abnormal swollen and tumid shape. They are usually chalky and of a gray tint."

A number of specimens of *Paphia staminea* were found as nestlers in borings of pholads, some of these might easily be considered as belonging to this variety, yet for the purposes of this report they have not been listed separately.

Range.—Kodiak Island, Alaska to San Diego, California (Dall).

Paphia staminea Conrad var. **petiti** (Deshayes)

Venerupis petiti Deshayes (1839).
Tapes diversa Sowerby, Wood and Raymond (1891), p. 55.
Papia staminea var. *Petiti,* Dall (1902a), p. 398.

Description.—The following is Dall's (1902*a*) description of this variety: ". . . yellowish, chalky white or dull gray color without maculations, sculpture markedly separated into areas."

This variety has been reported from this region by several collectors. According to Dall (1902, p. 398) in its northern form being common north of the Columbia River.

Range.—Aleutian Islands to San Quentin Bay, Lower California (Dall).

Paphia tenerrima (Carpenter)

Plate 22, figures 1*a* and 1*b*

Tapes tenerrima Carpenter (1856*d*), p. 200; Carpenter (1863), p. 641; Wood and Raymond (1891), p. 55.
Paphia tenerrima, Dall (1902*a*), p. 399; Arnold, R. (1903), p. 151, pl. 14, fig. 6.

Description.—Arnold (1903) described this species as follows: "Shell large and thin, (?) oval, convex; surface sculptured by numerous low, sharp, concentric frills, and numerous fine, rounded, crowded, radiating lines, these latter being almost obsolete in some specimens; margin smooth, hinge long the middle one in the left valve prominently bifid; pallial sinus very deep and and narrow; three teeth in each valve, the anterior two rounded; no lunule."

Length, 8 to 12 mm.

Occurrence.—At stations D 5744 (2), D 5808 (2), and questionably at D 5779 (1).

This bivalve is listed by several collectors from this region. Only very immature specimens that have been referred to this species were obtained by the Survey. Two living specimens were dredged within the middle segment of the bay in 5¼ fathoms from a bottom composed of mud and sand.

Range.—Strait of Juan de Fuca, Washington, to San Quentin Bay, Lower California (Dall).

Venerupis Lamarck

Venerupis lamellifera (Conrad)

Venus lamellifera Conrad (1837), p. 251, pl. 19, fig. 19.
Rupellaria lamellifera, Carpenter (1863), p. 641.
Venerupis lamellifera, Dall (1902*a*), p. 400.
Petricola lamellifera, Arnold, R. (1903), p. 155.

Description.—This was originally described by Conrad (1837) as follows:

"Shell suboval, compressed; disks with about eight lamelliform concentric slightly reflected ribs, and very obscure radiating sulci; posterior extremity widely truncated; color white; palleal impression with a profound sinus."

Both Cooper and Dall mention this species as occurring on the Farallon Islands. It is not found in the Survey collections.

Range.—Farallon Islands to Lower California (Orcutt).

Gemma Deshayes

Gemma gemma (Totten) var. **purpurea** (Lea)

Cyrena purpurea Lea (1842), p. 106.
Gemma gemma, Stearns (1899*e*), p. 86.
Gemma gemma, Dall (1902*a*), p. 401.

Description.—This variety was described by Lea (1842) as follows:

"Shell rounded-triangular, equilateral, sub-inflated, somewhat thick, pale purple and partly white, with transverse striae; beaks prominent; margin not crenulated.

Distinguished from the *Venus gemma* by its equilateral form and want of crenulations on the margin. The beaks are rounded at the summit. It has usually a dark purple mark along the posterior margin, which gradually fades off, and the anterior portion of the shell is whitish. Occasionally, however, it is nearly all purple, but darker toward the posterior margin, and I have one specimen which is pinkish. The striae are perfectly regular and at even distances."

Length, 2 to 5 mm.

Occurrence.—At stations D 5723 (*1*), D 5754 (*5*), D 5771 (*1*), D 5828 A (*204*), D 5828 B (*12*), D 5840 (*8*, 8), north of Key Route Pier, Oakland, (*2500*), and questionably at D 5768, D 5810.

This exotic species was first reported by Stearns in 1899. It now occurs abundantly in the shallower waters within the lower division of the bay, occurring also along the eastern shores of the middle division. The record of a single specimen from the vicinity of Sausalito may indicate the present range of the species from the oyster beds near Point San Mateo, which represents the supposed center of dispersal for this form.

Range.—Known only on West Coast from San Francisco Bay.

Psephidia Dall

Psephidia ovalis Dall

Plate 20, figure 4

Psephidia ovalis Dall (1902*a*), p. 407, pl. 16, fig. 4.

Description.—The original description as given by Dall (1902) is as follows:

"Shell small, white, polished, oval, subcompressed; surface with obsolete concentric threads near the anterior base, but over most of the disk smooth;

beaks small and very low, at about the anterior third of the length; lunule elongated, extremely narrow, nearly as long as the anterior dorsal slope; escutcheon linear or none; interior white, the pallial sinus moderate, pointed; internal margin delicately striated; hinge well developed, like that of *P. lordi*, with three entire cardinals and no anterior lateral tooth.''

Length, 2 to 5 mm.

Occurrence.—At stations D 5705 (1), D 5739 (*11*), D 5743 (*7*), D 5755 (*1*), D 5773 (1), D 5785* (*11*, 4), D 5787 (*23*), D 5799 (*1*), D 5822 B (16), D 5825 A (*134*), D 5826 B (*32*), D 5828 A (*249*, 6), D 5828 B (*262*), D 5830 A (*4*, 20), and questionably at D 5756, D 5778, D 5779, Red Rock.

This species has not hitherto been reported as far south as San Francisco. It has been dredged by the ''Albatross'' only from the middle portion of the bay and the waters outside the Golden Gate. Living specimens were obtained at ten stations in depths ranging from 3½ to 40 fathoms, on bottoms which are predominately sandy.

Range.—Bering Sea to San Diego, California (Orcutt).

PETRICOLIDAE

Petricola Lamarck

Petricola carditoides (Conrad)

Plate 20, figures 6*a* and 6*b*

Saxicava carditoides Conrad (1837), p. 255, pl. 20, fig. 8.
Petricola carditoides, Arnold, R. (1903), p. 154.

Description.—This species was described by Arnold (1903) as follows:

''Shell of medium size and variable outline, generally oblong-oval, convex, thick; surface ornamented with fine, concentric, incremental lines, which sometimes form irregular ridges, and by fine, wavy, radiating lines; hinge-area prominent; three cardinal teeth in each valve, the anterior one smallest; margin smooth.''

Length, 14 to 45 mm.

Occurrence.—At stations D 5808 (2), D 5809 (2), D 5846 (*2*, 11), and questionably at D 5845.

This species has been listed from this region by Carpenter and subsequent writers. Dredged by the Survey from the western portion of Golden Gate in 43 to 53 fathoms. Living specimens found as nestlers in pholadid borings at a depth of 45 fathoms. Also found by Mr. A. L. Barrows in similar situations between the tides on the shore of Goat Island.

Range.—Vancouver Island to Lower California (Dall).

TELLINACEA

TELLINIDAE

Tellina Linnaeus

Tellina bodegensis Hinds

Plate 25, figure 5

Tellina bodegensis Hinds (1844*a*), p. 67, pl. 21, fig. 2; Dall (1900*b*), p. 304; Arnold, R. (1903), p. 158, pl. 15, fig. 8.

Description.—The following is Arnold's (1903) description of this species:

"Shell of medium size, elongated, narrow-ovate, rather thick; umbones posterior to center and pointing posteriorly; anterior portion of shell evenly rounded, the dorsal and ventral lines being nearly parallel; posterior dorsal margin depressed back of umbo, running off quite obliquely to a line which truncates the posterior end near the base; basal posterior angle nearly a right angle; basal line nearly straight; a prominent bifid cardinal tooth on each valve; pallial sinus long and narrow; generally thickened anteriorly."

Length, 48 mm.

Occurrence.—At station D 5843 (1).

This shell is listed by Wood and Raymond from San Francisco. It occurs commonly along the beaches both north and south of the Golden Gate, but is not known to occur within San Francisco Bay. A single valve was dredged in the vicinity of Mile Rock.

Range.—Queen Charlotte Island, B. C., to Gulf of California (Dall).

Tellina buttoni Dall

Plate 25, figures 7*a* and 7*b*

Tellina buttoni Dall (1900*b*), p. 320, pl. 4, figs. 12, 13; (1900*a*), p. 1036, pl. 47, fig. 18; Arnold, R. (1903), p. 157, pl. 16.

Angulus modestus? var. *obtusus* Carpenter (1863), p. 639.

Description.—This species was renamed, and redescribed by Dall (1900*b*) as follows:

"Shell elongated, subequilateral, compressed, polished, white, rounded before, slightly shorter and pointed behind, with a slight flexuosity; surface finely concentrically grooved, with wider interspaces, the sculpture stronger on the right valve and anteriorly; beaks low, inconspicuous; interior polished, white, with a well-marked thickened ray behind the anterior abductor scar; pallial sinus reaching the ray, confluent below."

Length, 8 to 15 mm.

Occurrence.—At stations D 5739* (2), D 5743 (*7*), D 5778 (1), D 5821 A (1), D 5825 A (*3*), D 5825 B (*1*), D 5830 A (*4*), D 5840 (*8*), and questionably at D 5787.

This species has not hitherto been reported from this region. It has been taken by the Survey only in the middle and lower divisions of the bay. Living specimens were dredged in 8½ to 11 fathoms from bottoms that were prevailingly sandy.

Range.—Lituya Bay, Alaska, to Guadalupe, Mexico (Dall).

Tellina carpenteri Dall

Plate 25, figures 10*a* and 10*b*

Tellina carpenteri Dall (1900*b*), p. 320, pl. 4, figs. 12 and 13.

Description.—Dall (1900*b*) writes that:

"Gmelin's species is also an *Angulus*, and therefore the Californian form (*Angulus variegatus* Carpenter) requires a new name." Dall also states that the "elevated internal ray is absent or obsolete."

Length, 10 to 12 mm.

Occurrence.—At station D 5788* (3).

This species has not hitherto been reported from this region. Three valves, which are referred to this species, were obtained by the Survey in 68 fathoms just south of the Farallon Islands.

Range.—Neah Bay, Washington, to Gulf of California (Dall).

Tellina salmonea (Carpenter)

Plate 25, figures 3*a* and 3*b*; pl. 46

Moera salmonea Carpenter (1863), pl. 639; (1864*b*), p. 423.

Angulus salmonea, Wood and Raymond (1891), p. 55.

Tellina salmonea, Dall (1900*b*), p. 302; Arnold, R. (1903), p. 157, pl. 13, fig. 7.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, suboval, convex, equivalve, inequilateral, thin; umbones anterior to center, small, sharp; anterior extremity short, rounded; posterior dorsal margin straight; posterior extremity acutely rounded; ventral margin evenly arcuate; surface glossy, ornamented with fine, concentric, incremental lines, and obsolete radiating scratches; cardinal tooth small, bifid; no lateral teeth; pallial sinus long, broad; one faint, internal, submarginal, posterior, radiating ridge."

Length, 4 to 16 mm.

Occurrence.—At stations D 5700 (8), D 5701 (*2*, 5), D 5702 (4), D 5708 (21), D 5710 (1), D 5711 (*2*, 2), D 5712 (11), D 5713 (*6*, 11), D 5731 (*34*, 600), D 5732 (*3*, 33), D 5735 (7), D 5736 (93), D 5737 (1), D 5738 (4), D 5741 (5), D 5746 (2), D 5776 (f.), D 5795 (7), D 5796 (2), D 5800 (*1*, 19), D 5801 (10), D 5809 (1), D 5821 A (*2*), D 5821 B (*2*, 3), D 5825 B (1), D 5826 A (1), D 5826 B (3), D 5827 (3), D 5827 A (4), D 5827 B (*2*), D 5829 A (*6*, 27), D 5834 (2), D 5841 (8).

This salmon-tinted shell has been reported by several collectors from San Francisco. It has been taken by the Survey at a number of stations both within and west of the Golden Gate. Living specimens were obtained at ten stations at depths of 6¼ to 17 fathoms, on bottoms that are predominantly sandy. The largest number of specimens were obtained at D 5731 at a depth of 16 fathoms and on a bottom of sand and gravel.

Range.—Kodiak Island, Alaska, to San Pedro, California.

Macoma Leach

Macoma balthica (Linnaeus)

Plate 25, figures 1, 2, and 9; pl. 47

Tellina balthica Linnaeus (1758), p. 677.

Macoma inconspicua Broderip and Sowerby, Carpenter (1863), p. 639; Wood and Raymond (1891), p. 55.

Description.—Professor Clark translates the original description as follows: "Shell of the size of the seed of the white lupine, somewhat delicate, very fragile, interior white, exterior flesh colored, of a rounded triangular shape."

Length, 3 to 35 mm.

Occurrence.—At stations D 5704 (1), D 5705 (*10*, 2), D 5706 (*2*), D 5710 (1), D 5715 (*2*), D 5716 (*10*), D 5717 (*21*), D 5719 (1), D 5720 (*15*), D 5729 (*1*, 1), D 5730 (*6*, 4), D 5739 (*3*), D 5740 (*1*), D 5743 (*39*), D 5749 (*6*, 7), D 5750 (*1*, 2), D 5751 (*7*), D 5754 (*13*), D 5756 (*2*, 1), D 5757 (*7*), D 5758 (*48*), D 5764 (2), D 5771 (*7*, 2), D 5780 (*42*, 30), D 5781 (*2*), D 5782 (*9*), D 5793 (*27*, 3), D 5794 (*4*, 6), D 5800 (*4*, 2), D 5802 (1), D 5810 (5), D 5811 (*1*, 8), D 5815 (1), D 5815 A (*1*), D 5816 (12), D 5816 B (*2*, 2), D 5818 A (8), D 5818 B (14), D 5819 (*1*, 5), D 5819 A (*3*, 2), D 5820 A (2), D 5820 B (9), D 5821, D 5825 A (*1*), D 5827 A (1), D 5830 B (*5*), D 5833 (128), Key Route Pier, Oakland (*9*, 4), and questionably at D 5744, D 5748, D 5762, D 5763, D 5821, D 5828 A, D 5831.

This prevalent species was taken by the Survey only within San Francisco Bay. It is very abundant in the middle division of the bay and was occasionally taken in the upper bay even in the freshened waters of Carquinez Strait.

Range.—Circumpolar, south to San Diego, California (Dall).

Macoma indentata Carpenter

Plate 25, figure 4

Macoma indentata Carpenter (1863), p. 639; Arnold, R. (1903), p. 161, pl. 16, fig. 1.

Description.—Arnold (1903) described this species as follows:

"Shell of medium size, rather narrow, suboval, compressed, thin; umbones slightly posterior to center; anterior end long and evenly rounded; posterior dorsal line straight; ventral line near posterior end indented, the posterior extremity being much projected and sharply rounded; fold prominent; ligamental area short, scooped out.''

Length, 25 mm.

Occurrence.—At station D 5791 (1).

This species is represented by a single valve dredged outside the Golden Gate in 29 fathoms. It rarely occurs north of Monterey, although Miss Bertha Challis informs the writer that it is found in Puget Sound.

Range.—San Francisco to Lower California (Dall).

Macoma inquinata (Deshayes)

Plate 23, figures 2*a*, 2*b*, 3*a*, and 3*b*; plate 24, figures 1*a* and 1*b*; plate 48

Tellina inquinata Deshayes (1854), p. 357; Carpenter (1863), p. 639; Wood and Raymond (1891), p. 55; Dall (1900*b*), p. 307; Arnold, R. (1903), p. 162, pl. 16, fig. 4.

Description.—Arnold (1903) described this species as follows:

''Shell of medium size, suboval, convex, thin, equivalve; umbones subcentral; anterior end dilated, rather prominently so in front of umbo of right valve; posterior end evenly arcuate from umbo and acutely rounded at posterior end about half way between dorsal and ventral margins; ligament of medium length, not prominent; two small cardinal teeth in each valve; pallial sinus does not reach anterior muscle-impression in the left valve.''

Length, 4 to 55 mm.

Occurrence.—At stations D 5700 (8), D 5702* (5), D 5705 (*2*), D 5708 (*2*, 1), D 5711 (9), D 5712* (16), D 5713 (13), D 5738 (2), D 5742 (5), D 5749 (7), D 5752 (*11*, 2), D 5755 (2), D 5763 (3), D 5773 (*4*, 7), D 5778 (5), D 5779 (11), D 5784 (1), D 5795 (16), D 5796 (5), D 5798 (2), D 5799 (2), D 5800 (15), D 5808 (1), D 5810 (1), D 5824 B (19), D 5825 (7), D 5725 A (7), D 5825 B (10), D 5826 (10), D 5826 A (4), D 5826 B (3), D 5827 (48), D 5827 A (49), D 5827 B (2), D 5828 B (3), D 5829 A (22), D 5832 A (3), D 5833 (7), D 5834 (7), D 5841 (3), D 5843 (4), Richmond (1), Sausalito (2), and questionably from D 5714, D 5731, D 5737, D 5766, D 5783, D 5846, D 5848, Red Rock.

This common species is questionably represented in the Survey collections from the open ocean and abundantly represented from the bay. It was dredged most frequently within the middle division of the bay from a variety of types of bottoms.

Range.—Bering Strait to Monterey, California (Dall).

Macoma nasuta (Conrad)

Plate 23, figures 1*a*, 1*b*, 1*c*, and 1*d*; pl. 49

Tellina nasuta Conrad (1837), p. 258.

Macoma nasuta Carpenter (1863), p. 639; Wood and Raymond (1891), p. 55; Dall (1900*b*), p. 307; Arnold, R. (1903), p. 163, pl. 16, fig. 3.

Description.—This species was originally described by Conrad (1837) as follows:

"Shell ovate, compressed, smooth but not polished; anterior side dilated; posterior side cuneiform, extremity truncated, much above the line of the base; fold carinated on the superior valve; beaks central, slightly prominent; epidermis extremely thin and deciduous, finely wrinkled, brown; pallial impression of the left valve joining the anterior cicatrix at its lower posterior angle."

Length, 3 to 70 mm.

Occurrence.—At stations D 5701 (2), D 5703 (*8*), D 5704 (*2*, 2), D 5705 (*17*), D 5706 (*16*, 2), D 5708 (*13*, 3), D 5709* (*8*, 37), D 5714 (*14*, 21), D 5715 (*1*, 1), D 5716 (2), D 5719 (6), D 5723 (*40*, 9), D 5724 (*4*), D 5725 (*28*, 7), D 5726 (*28*, 10), D 5727 (*4*, 17), D 5728 (3), D 5729 (*6*, 5), D 5730 (*4*, 3), D 5739 (*33*), D 5740 (*3*, 5), D 5742 (5), D 5743 (*52*, 8), D 5744 (*50*, 16), D 5745* (39), D 5746 (8), D 5748 (*1*, 6), D 5749 (f.), D 5750 (*10*, 1), D 5751 (*10*), D 5754 (*6*, 5), D 5755 (*3*, 2), D 5756 (*6*, 9), D 5757 (*4*), D 5758 (3), D 5763 (*3*, 7), D 5764* (*6*, 12), D 5766 (*1*, 2), D 5767 (f.), D 5771 (*3*, 3), D 5772 (*14*), D 5778 (7), D 5779 (19), D 5780 (10), D 5781 (*5*, 2), D 5795 (6), D 5796 (3), D 5798 (14), D 5799 (2), D 5800 (3), D 5801 (2), D 5802 (23), D 5803 (*24*, 12), D 5805 (10), D 5808 (3), D 5811 (*1*, 1), D 5816 (2), D 5819 (14), D 5819 A (*1*), D 5820 (2), D 5820 A (*1*, 2), D 5821 (2), D 5821 A (*2*), D 5822 (3), D 5822 A (*1*, 27), D 5822 B (*1*, 9), D 5823 (*39*, 2), D 5823 A (*1*, 18), D 5823 B (8), D 5824 (14), D 5824 A (*1*), D 5824 B (*12*, 63), D 5825 (*24*, 19), D 5825 A (*6*, 18), D 5825 B (132), D 5826 (13), D 5826 A (6), D 5826 B (*1*, 100), D 5827 (1), D 5827 B (4), D 5828 (18), D 5828 A (*3*, 3), D 5828 B (*1*, 2), D 5829 A (1), D 5830 (*2*), D 5833 B (*9*, 2), D 5831 (*2*, 8), D 5832 A (7), D 5833 (29), D 5834 (*1*, 40), D 5835 (*2*, 26), D 5836 (98), D 5839 (122), D 5841 (25), D 5843 (2), D 5847 (7), D 5847 B (94), D 5848 (*4*), D 5849 (*112*, 15), Standard Oil Pier, Richmond (3), Key Route Pier, Oakland (*4*, 1), McNeer's Landing (9), Sausalito (1), and questionably at D 5773, D 5786, D 5788.

This is one of the most common species of the molluscan fauna. It has a general distribution throughout the bay, adapting itself to a wide range of environmental conditions. Its distribution pattern appears to be unrelated to the distribution of any particular type of bottom.

Range.—Aleutian Islands, Alaska, to Lower California.

Macoma yoldiformis Carpenter

Plate 25, figure 6

Macoma yoldiformis Carpenter (1863), p. 639; (1865*a*), p. 55; Dall (1900*b*), p. 309; Arnold, R. (1903), p. 165, pl. 16, fig. 6.

Description.—Arnold's (1903) description of this species is as follows: "Shell small, subelliptical, compressed, very thin and fragile; umbones slightly posterior to center; anterior end evenly rounded, longer than posterior side, which is very faintly folded, biangular and more cuneiform; surface smooth, except for very fine incremental lines; ligamental area scooped out about one-half length of posterior end; teeth very small."

Length, 16 to 22 mm.

Occurrence.—At stations D 5785* (2), D 5786 (1), D 5789 (*1*, 1).

This bivalve has not been reported from this region by earlier collectors. It is restricted to the collections from the open ocean. A single living specimen was dredged by the "Albatross" in 46 fathoms on a bottom of fine dark green sand. Shells were dredged at two other stations at depths of 39 and 40 fathoms.

Range.—Strait of Juan de Fuca, Washington, to San Diego, California (Arnold).

Macoma secta (Conrad)

Plate 25, figure 8

Tellina secta Conrad (1837), p. 257.

Macoma secta, Arnold, R. (1903), p. 164, pl. 16, fig. 5; Dall (1900*b*), p. 309.

Description.—This species was originally described by Conrad (1837) as follows:

"Shell triangular or subelliptical, equilateral, thin, smooth and polished, covered with a very thin shining yellowish epidermis; umbonial slope angulated; posterior extremity broadly and obliquely truncated; cartilage short, thick, inserted on an elongated oblique rib-like callous; margin beneath the cartilage with an ovate gape, appearing as if cut or broken; color white within and without."

Carpenter reports this species from the Farallones. It is abundant along the beaches on the open ocean both north and south of the Golden Gate. No specimens were obtained by the Survey.

Range.—Vancouver Island to Gulf of California (Dall).

Solenacea

SOLENIDAE

Solen Linnaeus

Solen sicarius Gould

Plate 26, figure 1; plate 50

Solen sicarius Gould (1849d), p. 214; Carpenter (1863), p. 638; Arnold, R. (1903), p. 172.

Description.—The following is Arnold's (1903) description of this species: "Shell of medium size, elongated, transversely oblong, cylindrical, slightly falcate; beaks terminal; anterior extremity truncate obliquely at angle of about 30 degrees, somewhat everted, the portion posterior to a line across from the beak to the base, concave; posterior extremity rounded; dorsal edge rectilinear; ventral edge regularly arcuate; surface undulated by lines of growth; hinge with single, erect, recurved, triangular tooth in each valve."

Length, 18 to 73 mm.

Occurrence.—At stations D 5705 (*1*), D 5339 (*1*), D 5740 (*2*, 1), D 5743 (*1*), D 5744 (*9*, 1), D 5745 (*1*, 4), D 5746 (f.), D 5754 (*1*), D 5788 (4), D 5791* (1), D 5798 (f.), D 5799 (1), D 5825 (*1*), D 5828 A (*1*), and questionably at D 5764.

This razor clam was reported by Carpenter (1863) from San Francisco. It was taken by the "Albatross" only in the waters of the open ocean and the middle division of the bay. Living specimens were dredged within the Golden Gate in 5¼ to 18 fathoms, being more commonly obtained at less than 10 fathoms. These forms lived on bottoms comprised of muddy sand. Shells were encountered at a depth of 68 fathoms near the Farallon Islands. Since this bivalve burrows deeply in the sand and would rarely be captured in the trawl, it is probably much more widely distributed than is indicated above.

Range.—Vancouver Island to San Quentin, Lower California (Orcutt).

Siliqua Mergerle

Siliqua nuttalli (Conrad)

Plate 26, figures 2*a* and 2*b*

Solecurtus nuttalli Conrad (1837), p. 232, pl. 17, fig. 9.
Machoera patula Carpenter (1863), p. 638 (in part).
Siliqua patula Carpenter, Wood and Raymond (1891), p. 55.
Siliqua patula var. *nuttalli*, Arnold, R. (1903), p. 173.

Description.—This species was originally described by Conrad (1837) as follows:

"Shell oblong-oval, thin, fragile, compressed; posterior margin more obtusely rounded than the anterior; color white, obscurely rayed; epidermis horn color, with paler spots; beaks purple; cardinal teeth two in the right valve, lamellar, remote; in the left valve four; rib broad, oblique.''

Length, 15 to 65 mm.

Occurrence.—At stations D 5731 (3), D 5732* (12), D 5735 (2), D 5736 (1), D 5737 (f.), D 5739 (*1*, 1), D 5741 (*1*), D 5778 (2), D 5796 (*3*, 1), D 5807 (2), and questionably at D 5772, D 5808, and D 5809.

This clam was reported by Wood and Raymond (1891) from San Francisco County. It has been taken by the Survey in all but the upper division of the bay. Living specimens are restricted to the middle divisions in depths ranging from 18 to 19¾ fathoms. Known to occur along the shores of the open ocean. Since it burrows deeply the distribution pattern probably gives an imperfect idea of the actual distribution of this species. Judging from the data available, this clam prefers sandy bottoms.

Range.—Lituya Bay, Alaska, to Monterey, California (Dall).

MACTRACEA

MACTRIDAE

Spisula Gray

Spisula catilliformis Conrad

Plate 27, figures 1 and 2; plate 24, figure 2

Spissula catilliformis Conrad (1867), p. 193; Packard (1916), p. 285, pls. 17, 18, and 19.

Standella californica Conrad, Carpenter (1863), p. 640; Wood and Raymond (1891), p. 55.

Description.—Conrad (1867) described this species as follows:

''Suboval, inequilateral; anterior side slightly flattened or contracted; posterior side with an oblique shallow groove or fold; lines of growth coarse and prominent, lunule very long, elliptical; ventral margin tumid posteriorly; cardinal pit oblique, large; pallial sinus extending beyond the middle of the valve.''

Length, 90 to 100 mm.

Occurrence.—At stations D 5808 (1), D 5829 A (1), D 5842 (9), D 5843 (5).

This large clam has been reported from San Francisco by various collectors, often under the name of *Standella californica.* It is known to occur commonly along the beaches of the open ocean. In the collections of the Survey it is restricted to localities within the Golden Gate west of Fort Point. Shells were dredged at depths of 10½ to 33 fathoms on gravelly bottoms.

Range.—Straits of Juan de Fuca, Washington, to San Diego, California.

Schizothaerus Conrad

Schizothaerus nuttalli (Conrad)

Plate 28, figures 1*a* and 1*b*

Lutraria (Cryptodon) nuttalli Conrad (1837), p. 235, pl. 18, fig. 1.
Tresus nuttalli, Arnold, R. (1903), p. 178.
Schizothaerus nuttalli, Carpenter (1863), p. 640; Wood and Raymond (1891), p. 55.

Description.—This species was originally described by Conrad as follows: "Shell elliptical, slightly gibbous from beak to base; posterior side produced; ligament margin slightly declining, rectilinear, extremity obliquely subtruncated; umbo prominent; color white; epidermis very thin, brown, wrinkled on the margins."

Length, 7 to 130 mm.

Occurrence.—At stations D 5700 (2), D 5702* (4), D 5709 (*1*), D 5710 (f.), D 5712* (2), D 5713 (1), D 5732 (f.), D 5738 (f.), D 5740 (1), D 5749* (10), D 5766 (1), D 5778 (2), D 5795 (3), D 5796 (2), D 5798 (1), D 5801 (3), D 5808 (10), D 5809 (10), D 5821 B (1), D 5826 (3), D 5827 (3), D 5833 (f.), D 5827 A (2), D 5827 B (2), D 5828 B (f.), D 5829 A (3), D 5844 (6), Sausalito shore (*1*), and questionably at D 5752 and D 5760.

This species burrows deeply, and therefore was taken alive by the dredge but once. Specimens were taken by the Survey only at the outside stations and those within the middle portion of the bay. Shells were dredged from depths up to 60 fathoms.

Dall recognizes the variety *capax* Gould as ranging from Kadiak, Alaska, to San Francisco.

Range.—The typical species, including the Alaskan variety, ranges from Kadiak Island to Todos Santos Bay, Lower California.

Myacea

MYACIDAE

Mya Linnaeus

Mya arenaria Linnaeus

Plate 29, figures 1*a* and 1*b*, plate 52

Mya arenaria Linnaeus (1758), p. 670; Gould (1841), p. 40; Tryon (1873), p. 140; Stearns (1881), p. 362; Wood and Raymond (1891), p. 55.
Mya hemphilli Newcomb (1874), p. 415.

Description.—Gould (1841) described this species in the following terms: "Shell transversely ovate, subequilateral, convex, gaping at both ends, but more so at the posterior end where the valves curve outwards. Beaks small, epidermis rough, wrinkled, yellowish."

Length, 2 to 110 mm.

Occurrence.—At stations D 5714 (*4*, 9), D 5716 (39), D 5717 (*2*, 25), D 5718 (5), D 5719* (f.), D 5721 (*25*, 1), D 5722 (*1*, 4), D 5723 (*4*), D 5724 (*9*), D 5725 (1), D 5726 (5), D 5729 (*20*, 21), D 5730 (5), D 5747 (2), D 5749 (175), D 5750 (*8*, 18), D 5751 (*17*, 14), D 5754 (32), D 5757 (*1*, 20), D 5758 (*100*, 7), D 5864 (*3*, 9), D 5766 (*11*, 11), D 5767 (*9*, 56), D 5768 (f.), D 5771 (*3*, 3), D 5772 (1), D 5780 (*81*, 42), D 5781 (2), D 5782 (2), D 5784 (5), D 5787 (11), D 5793 (*8*, 6), D 5795 (17), D 5810 (35), D 5815 (*1*, 20), D 5815 A (*5*), D 5816 (15), D 5816 B (*3*), D 5817 (*1*, 2), D 5817 A (*96*, 118), D 5817 B (*1*, 15), D 5818 B (*10*, 9), D 5819 (48), D 5819 A (f.), D 5819 B (*3*, 4), D 5820 (5), D 5820 A (1), D 5822 A (187), D 5823 (*4*, 1), D 5823 B (*2*), D 5824 A (f.), D 5824 B (1), D 5825 A (1), D 5831 (1), D 5832 A (1), D 5833 (1), D 5834 (*1*), D 5841 (21), D 5847 (1), D 5847 B (4), McNeer's Landing (*1*, 29), Red Rock (1), Key Route Pier, Oakland (*8*), Sausalito (*1*, 7), Bonita Point (1), and questionably at D 5720, D 5727, D 5752 and D 5756.

This species was first noted by Newcomb in 1874 and named by him *M. hemphilli.* It has since been recognized as being the eastern species, and is presumed to have been inadvertently introduced. At present this edible clam has a rather wide distribution on the West Coast, occurring abundantly within San Francisco Bay and in other bays northward to Puget Sound. By some authors it is considered to have a circumpolar range extending southward into Alaskan waters. As yet it has not been reported from the Californian Pleistocene beds nor from the undisturbed kitchen middens of the San Francisco region. This bivalve has a general distribution within the bay, which is perhaps not correctly represented in plate 52 since it is a littoral or adlittoral species, which burrows deeply in mud or sand.

Range.—Victoria, B. C., to Monterey, California. Introduced from the Atlantic (Dall).

Mya (Cryptomya) **californica** (Conrad)

Plate 31, figures 2*a* and 2*b*, plate 53

Sphaenia californica Conrad (1837), p. 234, pl. 17, fig. 11.

Cryptomya californica, Carpenter (1863), p. 637; Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 180.

Description.—This species was originally described by Conrad (1837) as follows:

"Shell suboval, convex-depressed, with radiating striae; obscure, except towards the posterior extremity, where they are distinct; posterior margin obliquely truncated, rectilinear; beaks central, ligament margin arcuate; tooth much dilated, oblique; colour white; palleal impression without a sinus, but forming a right angle posteriorly.''

Length, 7 to 25 mm.

Occurrence.—At stations D 5700 (2), D 5701 (1), D 5702 (2), 5705 (*1*, 1), D 5708 (3), D 5710 (5), D 5712 (9), D 5713 (3), D 5714 (3), D 5715 (*5*), D 5718 (1), D 5719 (1), D 5723 (*2*), D 5724 (*2*), D 5726 (3), D 5727 (*4*, 11), D 5731 (5) D 5732 (4), D 5739 (6), D 5740 (4), D 5741 (1), D 5742 (25), D 5743 (2), D 5744 (4), D 5745 (21), D 5747 (*2*, 2), D 5752 (*1*, 3), D 5753 (1), D 5754* (5), D 5755 (2), D 5757 (*1*), D 5762 (5), D 5763 (6), D 5764 (3), 5765 (*4*), D 5767 (4), D 5768 (3), D 5771 (*2*, 9), D 5772 (*1*, 5), D 5772 (2), D 5778 (45), D 5779 (51), D 5784 (8), D 5795 (3), D 5796 (10), D 5798 (14), D 5800 (2), D 5808 (1), D 5817 A (9), D 5818 (1), D 5818 A (10), D 5818 B (3), D 5819 A (*6*, 2), D 5820 A (*1*), D 5821 A (*28*, 14), D 5821 B (23), D 5822 A (10), D 5822 B (*114*, 12), D 5823 A (*16*, 11), D 5823 B (*2*, 2), D 5824 A (*6*, 23), D 5824 B (*390*, 1935), D 5825 (18), D 5825 A (*1*, 87), D 5825 B (26), D 5826 (1), D 5826 A (195), D 5826 B (3), D 5827 A (5), D 5827 B (3), 5828 (*1*, 1), D 5828 A (1), D 5828 (414), D 5829 A (4), D 5832 A (46), D 5833 (*2*, 5), D 5834 (25), D 5835 (1), D 5836 (1), D 5841 (13), D 5847 (1), D 5747 B (8), Key Route Pier, Oakland (*12*), Sausalito (9), and questionably at D 5787, D 5794, D 5831.

This prevalent species was taken by the Survey both from the bay and open ocean. Its distribution differs from that of the preceding species in that old shells occur more abundantly within the Golden Gate and adjacent waters. It is not improbable that strong currents of the Golden Gate transport these light shells from the shallower to the deeper waters.

Range.—Chichagoff Island, Alaska to Topolobampo, Mexico (Dall).

Mya (Platydon) **cancellata** Conrad

Plate 29, figures 2*a* and 2*b*

Mya cancellata Conrad (1837), p. 236, pl. 18, fig. 2.

Platyodon cancellatus, Carpenter (1863), p. 637; Dall (1898c), p. 858; Arnold, R. (1903), p. 179.

Description.—This species was originally described by Conrad (1837) as follows:

''Shell subelliptical, ventricose, with numerous prominent, slightly undulated concentric striae; a slight furrow extends from beak to base; posterior side with radiating striae; obsolete, or wanting on the posterior slope; umbo prominent; posterior side short; cardinal tooth very erect, dilated, bimarginate.''

Carpenter (1863) mentions that this species was sold in the markets in San Francisco. It is known to occur as a borer in the rocks along the ocean beach, both north and south of the Golden Gate.

Range.—Bolinas Bay to Todos Santos Bay, Lower California (Orcutt).

SAXICAVIDAE

Saxicava Fleuriau

Saxicava arctica (Linnaeus)

Plate 30, figure 4

Mya arctica Linneaus (1767), p. 1113.

Saxicava arctica, Carpenter (1863), p. 637; Wood and Raymond (1891), p. 55.

Description.—Professor Clark translates the original description as follows: "Shell the size of a bean, rough, similar in appearance to *Arca noae*, pale, anterior end very obtuse, posterior end shorter, somewhat pointed; anterior part projects beyond the lines of growth as two distinct angles, somewhat pointed anteriorly. Milky colored internally; with scarcely any hinge."

Length, 3 to 25 mm.

Occurrence.—At stations D 5762 (1), D 5773 (*2*), D 5845 (2), D 5846 (*7*, 2).

Living specimens were dredged near Sausalito and within the Golden Gate west of Fort Point. In several instances this species was found as a nestler in pholadid borings.

Range.—Arctic Ocean to Panama (Dall).

Saxicava pholadis (Linneaus)

Plate 30, figure 5

Saxicava pholadis (Linnaeus), Carpenter (1863), p. 637; Keep (1911), p. 101.

Description.—This species is characterized by Keep (1911) as follows: "Shell small, thin, wrinkled and irregular. The beaks are near the front of the shell which is abruptly terminated. Ligament small, extending behind the beaks. Color ash white."

Length, 25 mm.

Occurrence.—At Sausalito (*1*).

This species is represented in the Survey collections by a single specimen that was obtained from the beach at low tide line.

Range.—Circumpolar; Bering Sea to Panama (Dall).

Panope Ménard

Panope generosa Gould

Panopea generosa Gould (1849d), p. 215.
Glycimeris generosa, Carpenter (1863), p. 637; Dall (1898*c*), p. 831; Arnold, (1903), p. 182.

Description.—In describing this species and its several varieties Dall (1898) gives the following description of the typical form:

"Shell large, rather thin, nearly equilateral, the beaks slightly anterior, the dorsal and ventral margins in the full grown shell parallel and nearly straight, the pedal margin evenly rounded, the nymph narrow, and the attached edge of the ligament very short; the pallial sinus wide and shallow."

Carpenter mentions this species among those occurring in this region. It is not represented in the Survey collections.

Range.—Puget Sound to San Diego, California (Dall).

Adesmacea

PHOLADIDAE

Pholas Linnaeus

Pholas pacificus Stearns

Pholas pacificus Stearns (1873), p. 81, pl. 1, figs. 5, 6, 6*a*, 6*b*, 6*c*.

Description.—This species was originally described by Stearns (1873) as follows:

"Shell oblong, beaks two-fifths of length of shell from anterior end; anterior end of valves triangular, pointed; anterior dorsal edge of valves reflected and folded down on the umbos; lower anterior margin curved, forming a large elliptic-oval gape; posterior end of valves squarely rounded; shell dull chalky white, sculptured in concentric lines, which anteriorly are laminated and posteriorly become extinct; valves radiately ribbed, which also become obsolete at the posterior end; at the intersection of the radiating and concentric lines the sculpture is pectinated; an area below the umbos nearly or quite destitute of sculpture, which varies much in prominence in different specimens; accessory plate sublanceolate and bent down on the beaks, anteriorly prolonged, but not wholly covering the ante-umbonal gape; figs. 6*a*, 6*b* (Stearns), show the variation in the shape of the dorsal plate in different specimens; interior of valves white, enameled; internal rib short, curved and flattened."

Length, 20 to 60 mm.

Occurrence.—At stations D 5810 (1), D 5818 (1), D 5818 B (1), D 5821 (f.), D 5824 (1), D 5839 (4), D 5845 (6).

The type specimen of this species was obtained from San Francisco Bay. This mud-borer has been obtained by the Survey at widely separated localities throughout the entire bay, in depths ranging from 1 to 10 fathoms from bottoms that are predominantly muddy.

Range.—San Francisco, to San Pedro, California.

Pholadidea Goodall

Pholadidea ovoidea (Gould)

Plate 30, figures 1*a*, 1*b*, 2*a*, and 2*b*

Pholas (*Parapholas*) *ovoidea* Gould (1851), p. 87.

Description.—Professor H. A. Clark has kindly assisted the writer in translating the original description:

Shell oval, somewhat solid, ashy colored, posterior end gaping widely and with a much produced epidermis; anterior ventral margin closed by a calcareous plate; beaks situated near the anterior third of the shell; valves divided by a median groove, anterior portion rounded, with concentric, radially striated layers, with a subcylindrical, roughened posterior portion, marked with distinct striae; cardinal region tapering, dilated toward the apex; with no auxiliary valves.

Length, 20 to 35 mm.

Occurrence.—At stations D 5808 (*1*), D 5846 (*1*, 4).

Living specimens of this species were dredged by the Survey at a depth of 50 fathoms, within the Golden Gate.

Range.—Bering Sea to Gulf of California (Dall).

Pholadidea penita (Conrad)

Plate 30, figures 3*a* and 3*b*

Pholas penita Conrad (1837), p. 237, pl. 18, fig. 7.

Parapholas penita, Carpenter (1856*a*), p. 210.

Pholadidea penita, Wood and Raymond (1891), p. 55; Arnold, R. (1903), p. 184.

Description.—This species was originally described by Conrad (1837) as follows:

''Shell ovate, elongated, contracted submedially and grooved; anterior side inflated, with decussating lines, the radiating striae having a granulated appearance, posterior side subcuneiform, extremity truncated, with a membranous expansion or appendage; apophysis oblique, slender, spoon-shaped at the extremity.''

Length, 15 to 70 mm.

Occurrence.—At stations D 5709 (1), D 5808 (*1*), D 5845 (3), D 5846 (5), Richmond* (*9*), Sausalito (7), Presidio (f.). Borings were found in rocks at D 5702 (?), D 5742, D 5801, D 5809.

This boring mollusk was taken by the Survey at seven stations within San Francisco Bay at depths ranging up to 50 fathoms. A living specimen was dredged from 43 fathoms.

Range.—Chirikoff Islands, Alaska to San Pedro, California (Dall).

Pholadidea penita (Conrad) var. **parva** (Tryon)

Penitella parva Tryon (1865), p. 39.

Pholadidea penita, var. *parva*, Wood and Raymond (1891), p. 55.

Description.—This variety was originally described by Tryon (1865) as follows:

"Shell small, ovate, inflated, rather thick. Surface divided by an oblique impressed rib, posteriorly to which it is concentrically striate, while anteriorly it is radiately ribbed.

The flexed dorsal margins are each covered with a thick irregularly shaped accessory valve, with a single central valve posterior to them. The latter is somewhat pentagonal, emarginate in front.

Hiatus filled by a heavy callus, which juts out somewhat into a point or beak, instead of preserving a rounded outline."

Only the typical form of this species was recognized among the collections of the Survey. The southern variety was found within this region by Wood and Raymond. This form burrows into *Haliotis* shells.

Range.—San Francisco, California (Wood and Raymond); San Pedro to Lower California (Dall).

Martesia Leach Gray

Martesia intercalata Carpenter, 1855, Maz. Cat.

Martesia intercalata Carpenter (1863), p. 637.

This small boring mollusk is found on the shell of *Haliotis*. The abalone to protect itself from the intruder secretes nacre, thus forming the much prized abalone blister.

Carpenter (1863) reports this from the Farallon Islands. Since no *Haliotis* was taken by the Survey this species was not found among the collections.

Range.—Farallon Islands to Catalina Island, California (Dall).

Zirfaea Leach

Zirfaea gabbi Tryon

Plate 32, figure 1, plate 54

Zirphaea gabbi Tryon (1863), p. 144, pl. 1. Phila. Acad. Proc. fig. 1.

Zirphaea crispata Leach, Gabb (1869), p. 52; Wood and Raymond (1891), p. 55.

Description.—This species was originally described by Tryon (1863) as follows:

"Shell large transverse, obliquely divided by a deep furrow proceeding from the umbonal apex to the basal margin and forming a corresponding rib on the internal surface of the valve. Posteriorly to the furrow the shell is marked only by growth lines which in crossing it are elevated into sharp ribs, in which character they are continued to the anterior margin. The posterior of the shell anterior to the radiating furrow is ornamented with numerous longitudinal ribs, approximating in pairs and rendered acutely scabrous at the intersections of the rib like growth lines.

Ventral anterior margin emarginate. Dorsal anterior margin reflected and closely appressed over the beaks. Posterior dorsal margin declining somewhat to the quadrately rounded posterior lateral end. Color white.''

Length, 12 to 120 mm.

Occurrence.—At stations D 5709 (f.), D 5711 (f.), D 5712* (f.), D 5713 (f.), D 5714 (2), D 5723 (2), D 5739 (1), D 5740 (f.), D 5742 (f.), D 5755 (f.), D 5764* (2), D 5767 (1), D 5796 (f.), D 5802 (2), D 5808 (f.), D 5809 (f.), D 5821 B (f.), D 5824 (2), D 5824 B (f.), D 5825 (13), D 5825 B (1), D 5826 (1), D 5826 A (f.), D 5827 (1), D 5827 A (2), D 5827 B (f.), D 5828 B (*10*, 10), D 5831 (*1*, 3), D 5833 (f.), D 5835 (f.), D 5836 (1), D 5839 (3), D 5841 (4), D 5842 (6), D 5843 (2), and questionably at D 5710, D 5778, Standard Oil Pier, Richmond.

This species is represented in the Survey collections by a number of old shells, which were taken within the middle division of the bay. Living specimens were dredged at two stations at depths of 10¼ and 13 fathoms.

Range.—Bering Sea to San Diego, California.

TEREDINEDAE

Xylotrya Leach

Xylotrya, sp.

Wood perforated by teredo borings was dredged at stations D 5700, D 5702, D 5709, D 5735, D 5766, D 5777, and 5808. Wood and Raymond (1891) report the species *X. setacea* from San Francisco Bay, which is undoubtedly the species living within these waters.

SCAPHOPODA

DENTALIIDAE

Dentalium Linnaeus

Dentalium indianorum Carpenter

Dentalium indianorum Carpenter (1863), p. 648.

Dentalium pretiosum Nuttall var. *indianorum*, Pilsbry and Sharp (1897–1898), p. 45, pl. 13, figs. 4, 5, 6, 8; Arnold, R. (1903), p. 186, pl. 8, fig. 4.

Description.—Arnold (1903) described this species as follows:

''Shell small, curved, tapering posteriorly, heavy; surface with fine incremental rings, and striated posteriorly; cross-section and aperture circular.''

Length, 10 to 25 mm.

Occurrence.—At station D 5789 (*50*) and questionably at D 5788 (2), D 5790* (*1*).

As far as is known this mollusk has not been reported from San Francisco. It was taken by the Survey only in the vicinity of the Farallon Islands. It ranges in depth from 33 to 68 fathoms. Living specimens were the most abundant at station D 5789 where they were associated with *Cadulus fusiformis.*

Range.—Strait of Juan de Fuca, Washington, to Santa Barbara, California (Cooper).

SIPHONODENTALIIDAE

Cadulus Philippi

Cadulus fusiformis Pilsbry and Sharp

Cadulus fusiformis Pilsbry and Sharp (1897–1898), p. 193.

Description.—This species was originally described as follows:

"Shell but little curved, long and slender, the greatest diameter contained about 9 times in the length of the shell; swelling hardly perceptible, the tube very gradually enlarging from the small apex to the beginning of the last third of the length, thence an equal size is maintained almost to the aperture, just before which it is gently but quite perceptibly contracted on all sides. Surface smooth and glossy, bluish-white, scarcely translucent, with oblique rings of more opaque white, and near the apex some longitudinal white lines; a pellucid ring bordering the lip-edge, behind which there is a short opaque white tract, passing gradually into the bluish and banded general color. Tube a mere trifle compressed vertically at the widest part. Aperture oblique, and (measured obliquely) a trifle longer than wide (in the ratio of 35–33); lip thin, sharp. Anal orifice circular and simple."

Length, 4 to 10 mm.

Occurrence.—At stations D 5785 (13), D 5786* (*74*), D 5788 (*16*), and D 5789 (*104*).

Living specimens of this species were dredged in 40 to 68 fathoms from a bottom composed of fine dark green sand.

Range.—Puget Sound to San Pedro, California.

AMPHINEURA*

LEPIDOPLEURIDAE

Lepidopleurus Risso

Lepidopleurus farallonis Dall

Lepidopleurus farallonis Dall (1902*b*), p. 257.

Description.—This chiton was originally described by Dall (1902*b*) as follows:

"Chiton small, thin, wide, with a low rounded back and yellowish-white color; girdle narrow, sparsely spiculose, with very short, fine bristly spicules; jugum hardly defined, with no obvious mucro; lateral areas slightly elevated

* For the most revent revision of this group see Berry, S. S., *Notes on West American chitons.* Proc. Calif. Acad. Sci. [4], 7. op. 229–248, 4 text figs. 1917.

and feebly concentrically rugose; anterior valve simple; posterior conspicuously mucronate and, behind the mucro, concave; surface entirely covered with minute ally from the mucromal points; pleural laminae short, subtriangular; ctenidial line reaching the fifth valve. Animal about 10; lat. 5.5; alt. 2 mm.''

Occurrence.—Dredged by the ''Albatross'' off the Farallon Islands during a previous survey at station 3104 in 391 fathoms.

This species has not been reported since it was first discovered.

ISCHNOCHITONIDAE

Tonicella Carpenter

Tonicella lineata (Wood)

Plate 34, figure 3

Chiton lineatus Wood (1815), p. 3, pls. 4–6.

Tonicella lineata Pilsbry (1892–1893), p. 42, pl. 11, figs. 25–28.

Description.—This species was described by Pilsbry as follows:

''Shell oblong, rather low, roundly arched or subcarinated. Surface smooth, shining, ground color light reddish. End valves concentrically marked with dark-brown lines bordered above with white, intermediate valves having similarly colored longitudinal lines, sloping obliquely backward, the ridge or jugum of each valve having a light triangle with a narrower dark one in the middle on some valves. Occasionally some valves are wholly dark brown unmarked.

Lateral areas scarcely raised; umbo of posterior valve in front of the middle.

Interior white, more or less tinged with rose color. Sutral plates broad, rounded; sinus deep and angular. Anterior valve with 8–10, median 1, posterior valve 8–10 slits. Teeth short, especially in the posterior valve, and blunt, in adults decidedly crenulated at the tips and obsoletely fissured outside. Eaves small.

Girdle leathery, apparently smooth and nude, brown in dried specimens.''

Length, 15 to 20 mm.

Occurrence.—Bonita Point* (3).

This species is represented in the Survey collections by three specimens from the shore station at Bonita Point. It had been previously been reported from this region by Wood and Raymond.

Range.—Bering Strait to Monterey, California (Pilsbry).

Ischnochiton Gray

Ischnochiton dentiens (Gould)

Chiton dentiens Gould (1846*a*), p. 145; (1862), p. 6.

Trachydermon dentiens, Dall (1878*b*), p. 323; Carpenter (1863), p. 649.

Ischnochiton dentiens, Pilsbry (1892–1893), p. 73, pl. 8, figs. 61–65.

Description.—Pilsbry (1892) describes this species as follows:

''Shell oval, rather elevated, dorsally angled, ash colored, closely and finely mottled with olive, and having a series of alternating olive and light spots upon the back edges of the valves along the sutures. These spots are often obscure or wanting, and in some specimens the ground color is a pale orange-flesh tint.

The valves are covered with a very minute sharp granulation, the granules small but well raised, and on the central areas of some specimens they are somewhat disposed to be arranged in longitudinal lines converging toward the dorsal ridge, this disposition usually stronger toward the lateral extremities of the valves. The lateral areas are a little raised, the diagonal lines separating them from the central areas rather distinct. The umbo of the posterior valve is median, somewhat raised, the slope behind it being depressed and concave.

The interior is either whitish stained with gray-green or quite green. The sutural plates do not project as far as usual, and on some valves they are emarginate in front. The jugal sinus is wide, angular, flat or encroached upon by the jugum. The anterior valves has 11 slits in the insertion plate, the intermediate valves 1, the posterior valve has 10 or 12, and some of the median teeth are bifid at the tip.

The girdle is narrow, gravelly, covered with minute scales.

The gills extend to the front end of the foot.''

Length, 8 mm.

Occurrence.—At Bonita Point (*1*).

Range.—Vancouver Island to San Diego, California.

Ischnochiton stearnsi Dall

Ischnochiton stearnsii Dall (1902*b*), p. 557.

Description.—This species was originally described by Dall as follows:

''Chiton of moderate size, yellowish or buff color; the girdle yellowish white, covered with subcylindric, blunt, smooth, close-set, large spines, the ends of which have a pebbly appearance, mixed with a smaller proportion of small but rather similar spinules; the ends of the large spines, when worn flat, have a pavement like aspect; back not heeled, but rather steeply rounded; gills ambient; intermediate valves with a dorsal angle of about 90°, the lateral areas prominent, with about five radial riblets in each, divaricating to seven or ten at the girdle margin, and cut into beads by numerous fine concentric furrows; pleural areas and jugum hardly differentiated, sculptured with fine, slightly irregular, longitudinal wrinkles, finer mesially; crossed by unconspicous, less elevated transverse lines; anterior valve with fine, beaded, divaricate radial riblets, the insertion plates and eves very short, smooth, not spongy with about 17 slits; the posterior valve with a small, low, subcentral mucro, from which two elevated lines extend to the margin, one on either side, forming two areas, and from which the wrinkled sculpture, less prominent on the anterior areas, diverges; posterior slits about 15, lateral slits 2, sinus rather wide, entire; pleural laminae rather wide and short lon. of animal about 25; lat. 15; alt. 6 mm.''

Occurrence.—Dredged by the ''Albatross'' off the Farallon Islands during a previous survey at station 3104 in 391 fathoms.

Ischnochiton cooperi Carpenter

Ischnochiton cooperi Carpenter, Pilsbry (1892–1893), p. 127, pl. 26, figs 27–30; Wood and Raymond (1891), p. 58.

Description.—The following is Carpenter's original manuscript description of this species as quoted by Pilsbry (1892):

''Shell oval and elevated, with angular dorsal ridge and straight side-slopes.

Sculpture like *I. mertensii.* Color olivaceous, or dull earthy brown, indistinctly clouded more or less with light blue, especially upon the side areas. The lateral areas are raised, and bear irregular rows of rounded pustules, the young having four rows, the adults 6 to 8. A strong lens reveals a fine, subobsolete granulation of the nearly flat surface between the pustules. The central areas have a fine but distinct and even radial striation, over which run acute narrow raised threads parallel to the dorsal ridge; upon the ridge these threads are seen to be more or less diverging, especially upon the second valve. The end valves are radially ridged, the ridges bearing elongated pustules, or showing scars where such pustules have been. Mucro low, flat.

Interior bluish, the valves marked under their umbones with dark olive. Head valve having 11, central valves 1, tail valve 11 slits; teeth roughened but rather sharp; eaves wide, dark, minutely punctulate, but solid, not spongy.

Girdle compactly covered with small imbricating, deeply striated scales.''

This chiton was collected by Wood and Raymond within this region. Not among the ''Albatross'' collections.

Range.—Bolinas Bay to Santa Cruz, California (Pilsbry).

Ischnochiton magdalenensis Hinds

Ischnochiton magdalensis Hinds (1844*a*), p. 54, pl. 19, fig. 1; Pilsbry (1892–1893), p. 62; Blankinship and Keeler (1892), p. 151.

Description.—This species has been redescribed by Pilsbry (1892) as follows: ''Shell elongated, rather narrow, generally faintly mottled with delicate olive on a light greenish blue or pinkish ground. Interior bluish white or pink. Lateral areas and end valves having radiating riblets, central areas finely pitted.

The lateral areas are distinctly raised, radiately delicately ribbed. Front slope of the anterior valve straight. Central areas having a more or less developed system of branching reticulating wrinkles producing oblong or diamond-shaped pits. Umbo of posterior valve central, but little projecting. Interior: sutural plates well developed, the sinus deep, angular. Anterior valve, having 10–13, central valve 2–4, posterior valve 10–12 slits.''

This species was reported from the Farallon Islands by Blankinship and Keeler.

Range.—Farallon Islands (Blankinship and Keeler); Monterey to Magdalena Bay (Pilsbry).

Nuttallina Carpenter

Nuttallina scabra Reeve

Nuttallina scabra Reeve (1847), pl. 17, fig. 106; Wood and Raymond (1891), p. 58; Keep (1904), p. 276; Pilsbry (1892–1893), p. 280.

Description.—This chiton was described by Pilsbry in the following terms: ''Shell similar to *N. californica,* but having the individual valves very much shorter in proportion to their width; the outer layer of the median valves produced at the sides anteriorly, curving broadly forward and laterally upon the sutural plates; the median ridge and sulci more or less obsolete. Tail valve shorter, with less posterior mucro. Color of valves lighter, more variegated.

End valves with the same equal sculpture, the tail valve with the mucro central and a little projecting.

Girdle rusty brown or alternately blackish and white; bearing rather sparsely scattered white spike-like spines, sometimes having one or two at each suture. Length 29, breadth 13 mill.''

This chiton is reported from this region by Wood and Raymond. It was not taken by the Survey.

Range.—Vancouver Island to Lower California (Orcutt).

Trachydermon Carpenter

Trachydermon hartwegi (Carpenter)

Chiton hartwegii Carpenter (1855), p. 231; Pilsbry (1894*a*), p. 45.

Tonicella hartwegii, Pilsbry (1892–1893), p. 45, pl. 14, figs. 81–85.

Chaetoplema hartwegii, Wood and Raymond (1891), p. 58.

Description.—The following is Pilsbry's description of this species:

''Shell oval, rather low, the dorsal ridge obtusely rounded; dull olive green, generally having a pair of lighter stripes on the ridge of each valve with a black blotch outside of the light dashes. Girdle rather narrow, dense, microscopically closely granulated.

The tail valve is convex as a whole, but the subcentral umbo is not conspicuous. The entire surface is very closely microscopically granulated, and bears larger wart-like granules irregularly scattered over the minute sculpture, these warts being much more numerous upon the lateral areas (which are otherwise rather ill-defined) and the terminal valves.

The interior is of an intense blue-green color. Sutural plates rounded, leaving a wide, angular sinus. Insertion plates shorter than the eaves, blunt, the anterior valve having the teeth bi- or tri-lobed, the posterior valve having them crenulated. Slits of anterior valve 10–11; median valves 1; posterior valves 9–12. Eaves spongy.

Gills extending forward to the front end of the foot.''

This species was reported by Wood and Raymond and by Pilsbry from this region. Not found by the Survey.

Range.—Vancouver Island to Magdalena Bay (Pilsbry).

Trachydermon raymondi Pilsbry

Trachydermon raymondi Pilsbry (1894b), p. 46.

Description.—This species was originally described by Pilsbry (1894) as follows:

''Shell longer and narrower than *T. hartwegii.* Back somewhat keeled, varying in elevation. Color (1) olivaceous green mottled with white, sometimes with dark lateral streaks as in *hartwegii,* sometimes ruddy at the ridge, or (2) uniform blackish, or (3) dark brown, uniform or with whitish flecks.

Valves rather strong, slightly beaked when unworn, the posterior (sutural) margin straight or slightly concave. Intermediate valves rather rounded where they join the girdle, scalloping the inner border of the latter; not distinctly divided into areas. Lateral areas hardly or not raised (the diagonal being indistinct) evenly sculptured with minute, equal granules. Central areas also evenly sculptured throughout with similar granules, slightly finer on the ridges.

Interior light blue, with darker stains at bases of the sutural laminae and behind the rather strong blue white valve callus. Sinus and sutural laminae as in *hartwegii*. Slits in valve i, 8; valves ii–vii, 1–1; valve viii, 11; teeth of end valves blunt, thick, but not distinctly bilobed. All teeth longer than the narrow, porous eaves.

Girdle narrow, black or with small whitish spots, leathery, very minutely papillose.''

A single small specimen was obtained by the Survey from Bonita Point. This species has not hitherto been reported from this region.

Range.—Victoria, B. C., to Monterey, California.

MOPALIIDAE

Mopalia Gray

Mopalia ciliata Sowerby

Chiton ciliatus Sowerby (1840), p. 289.

Mopalia ciliata, Wood and Raymond (1891), p. 58; Pilsbry (1892–1893), p. 303, pl. 64, figs. 64–73; Arnold, R. (1903), p. 343.

Description.—Pilsbry (1892) described this species as follows:

''Shell oblong, rather depressed, the dorsal ridge carinated (sometimes rounded), side-slopes straight or somewhat convex. Surface lusterless, finely sculptured, variously colored, usually either (1, typical coloring) verdigris green maculated with black or black-brown, the girdle yellow or (2) maculated with maroon and sometimes touched with rich chestnut on the ridge, or having some valves or parts of valves vivid scarlet, or scarlet mixed with olive and snow-white, or entirely white; or (3) light olive-buff with brownish girdle.

Valves somewhat beaked, the lateral areas bounded by a riblet, rather coarsely granulated, with larger granules along the posterior margin. Central areas sculptured with longitudinal, curving riblets somewhat granulated, much closer and finer on the dorsal ridge. Anterior valve having granose narrow radii, the intervals granulated. Posterior valve small, with posterior mucro, broadly emarginate or waved at the hinder margin.

Interior bluish-white or light blue-green. Sinus broad and rather rounded, spongy or roughened. Sutural plates arcuate. Anterior valve having 8 slits, median valves 1 slit. Posterior valve having a broad deep, rounded caudal sinus, and a single slit on each side.

Girdle wide, yellow or brown, generally notched behind, more or less sparsely clothed with curling strap-like brown hairs, which bear near their bases a bunch of minute, white, acute spines.''

Length, 7 to 20 mm.

Occurrence.—At stations D 5755 (*2*), D 5774† (*1*), D 5809 (*3*), and questionably at D 5775.

This chiton was taken alive by the Survey only within the middle division of the bay at depths ranging from 3½ to 53 fathoms and from bottoms that were predominantly gravelly or stony.

Range.—Shumagin Islands, Alaska, to San Diego, California (Orcutt).

Mopalia ciliata (Sowerby) var. **lignosa** (Gould)

Chiton lignosus Gould (1846*a*), p. 142.
Mopalia vespertina Gould, Carpenter (1863), p. 648.
Mopalia lignosa, Pilsbry (1892–1893), p. 299, pl. 63, figs. 58, 59.
Mopalia ciliata var. *lignosa*, Wood and Raymond (1891), p. 58.

Description.—Pilsbry (1892) described this form as follows:

"Shell oval, elevated, carinated or angular at the dorsal ridge, the side-slopes straight. Surface lusterless, apparently smooth; grayish, greenish or bluish with radiating streaks, lines and flammules of brown or purple-brown.

Under a lens the lateral areas appear nearly smooth; the central areas being closely and finely pitted all over. Girdle narrow, sparsely hairy.

Interior white and light blue."

This form has been listed from this region by Wood and Raymond. It was not taken by the Survey.

Range.—Vancouver Island to Monterey, California (Pilsbry).

Mopalia kennerleyi Carpenter var. **swani** Carpenter

Mopalia kennerleyi var. *swani* Carpenter (1864*b*), p. 426.
Mopalia wosnessenskii Middendorff var. *swani*, Wood (1891), p. 94.

This form reported from this region by Wood appears to be but a doubtful variety of *M. kennerleyi.*

Range.—Typical species ranges from Unalaska to Monterey, California.

Mopalia muscosa (Gould)

Chiton muscosus Gould (1846*a*), p. 145.
Mopalia muscosa, Carpenter (1863), p. 648; Pilsbry (1892–1893), p. 295, pl. 63, figs. 46–48.

Description.—This species was described by Pilsbry (1892) as follows:

"Shell oval, elevated or depressed, the dorsal ridge more or less angular. Valves strong. Surface lusterless, finely sculptured with wavy, crenulated longitudinal riblets, often more or less obsolete. Color generally dull brown, blackish-olive or grayish, but sometimes bright orange, scarlet or vivid green.

"Median valves hardly beaked, the lateral areas slightly raised, granose, limited by a raised granose riblet. Central areas having close fine longitudinal riblets, with crenulated or latticed interstices, the riblets finer and converging on the ridge of the last 6 valves, diverging on the second valve, or strongly diverging on the ridge of all valves, like a series of superimposed Vs. Anterior valves having about 10 narrow radiating granose riblets, the intervals granose. Tail valve depressed with posterior mucro, the posterior slope very short, emarginate behind.

"Interior bluish-green, stained with lilac on the central callus. Anterior valve having 8, median 1 short slit, the teeth long, deeply striated outside and thickened or propped outside at the sides of the slits. Posterior valve having a rounded sinus behind, with one oblique slit on each side, the plate roughened outside near the slits. Sutural plates broad, the sinus extremely shallow and small.

"Girdle rather narrow, densely covered with round, curved or curled hairs. Gill row as long as the foot."

Length, 5 to 50 mm.

Occurrence.—At stations D 5773 (*3*), D 5774 (*1*), D 5845 (*1*), Presidio* (*12*), Sausalito (*1*), Bonita Point (*3*).

This species is represented in the Survey collections by several specimens that were taken within and along the shores of the middle division of the bay. They were dredged only at stations where the bottom was stony. A single living specimen was obtained in the outer portion of the Golden Gate at a depth of 33 fathoms.

Range.—Shumagin Island to San Diego, California.

Mopalia wosnessenski Middendorff

Mopalia wosnessenskii Middendorff (1847–1849), p. 119; Carpenter (1863), p. 648; Wood and Raymond (1891), p. 58.

Mopalia ciliata (Sowerby) var. *wosnessenskii* Pilsbry (1892–1893), p. 305, pl. 64, figs. 69–73.

Description.—Pilsbry (1892) described this species as follows:

"Shell elongated, the back roundly arched, not carinated; dull colored, varying from light olive or green to drab, generally with blackish patches on each side of the middle, and more or less mottled throughout with dusky. Sculpture much fainter than in typical ciliata. Girdle apparently lacking the white spicules described above."

Occurrence.—One valve was obtained from station D 5808*.

The single valve representing this species in the collection of the Survey was dredged from a rocky botton at a depth of 43 fathoms.

Range.—Sitka, Alaska, to San Francisco, California.

Placiphorella Carpenter

Placiphorella sinuata (Carpenter)

Mopalia sinuata Carpenter, Pilsbry (1892–1893), p. 303, pl. 62, figs. 95, 96, 97.

Placiphorella sinuata, Orcutt (1915), p. 73.

Description.—This chiton was described by Pilsbry as follows:

"Shell oblong, elevated and strongly carinated, the side-slopes straight. Color whitish, clouded with delicate blue-green and maculated with rich tawny brown.

"Median valves hardly beaked, the lateral areas not raised, but strongly defined by an elevated diagonal rib; sculptured with two oblique series of fine riblets forming a lattice pattern. Central areas having a series of longitudinal curved riblets converging toward the median keel, crossed by curved radiating threads a little finer and less prominent. Anterior valve having 8 (not counting the posterior sutural borders) strong radiating ribs narrower than the latticed intervals. Posterior valve depressed, the mucro being at the posterior third.

"Interior bluish-white. Sinus very small and narrow. Anterior valve having 8 slits, median 1 slit; teeth thickened outside at the edges of the slits. Posterior valve having a deep rounded median sinus behind (which is continued upward in a superficial excavation to the mucro) and a single slit on each side.

"Girdle rather narrow, leathery, "dusty" bearing a few hairs, with a rounded pore at each suture.

Length, 11½; breadth, 7 mill; divergence, 105°."

This species is reported from San Francisco Bay by Orcutt upon the authority of Newcomb. It was not taken by the Survey.

Range.—Puget Sound to San Francisco Bay (Pilsbry).

ACANTHOCHITIDAE

Katharina Gray

Katharina tunicata Wood

Chiton tunicatus Wood (1815), p. 11, pl. 2, fig. 1.

Katherina tunicata, Carpenter (1863), p. 648; Wood and Raymond (1891), p. 58; Pilsbry (1892–1893), p. 41, pl. 1, figs. 1–11.

Description.—This chiton was described by Pilsbry (1893) in the following words:

"Shell oblong, elevated, the valves mainly covered by the black, leathery girdle, a small cordate or flask-shaped area of a dark brown color, remaining exposed.

"The exposed portion is about one-third the entire width of the valve; it is broad behind, and often hollowed out by erosion, narrowing in front like the neck of a flask. The surface when not eroded shows a distinct, smooth and shining dorsal band, the sides (which are not divided into pleura and lateral areas) being microscopically densely punctuate. Anterior valve densely punctuate and having a few feeble radii. Posterior valve small.

"Interior white. Sutural plates enormously produced; the sinus very deep, squared and notched at the sides, exposing a projecting lobe of the extremely porous outer layer. Anterior valve having 7 or 8, central one slit, the insertion-plates extremely long, grooved outside from the short slits to the eaves. Posterior border of the black tegumentum broadly reflexed inward. Posterior valve elevated, vertical behind, with a broad median notch or sinus and a variable number (1–4) of small slits on each side."

This species was found within San Francisco County by Wood and Raymond. It is not among the Survey collections.

Range.—Aleutian Islands, Alaska, to Catalina Islands, California (Pilsbry).

Cryptochiton Middendorff

Cryptochiton stelleri (Middendorff)

Chiton stelleri Middendorff (1847–1849), p. 116.

Chiton (Cryptochiton) stelleri, Middendorff (1847), p. 93, pl. 1, figs. 1, 2.

Cryptochiton stelleri, Carpenter (1863), p. 648; Wood and Raymond (1891), p. 58; Pilsbry (1892–1893), p. 48, pl. 7, figs. 7–13, pl. 6, fig. 6.

Description.—Pilsbry (1893) described this species as follows:

"Oblong, rather depressed, the bilobed posterior outlines of the valves (in dry specimens) showing through the leathery integument, which completely covers the valves. Color a dull ferruginous or brick-red, very well preserved specimens being rendered much brighter by the closely placed fascicles of brilliant vermilion spines.

"The valves are wholly concealed, white or flesh-colored, entirely lacking the outer colored layer (tegumentum) of other chitons; their edges are more or less thinned and crenulated by radial striae. Anterior valve having the apex at the posterior third, and with 4 to 7 slits. Intermediate valves having the apex near the posterior third; formed of two large anterior lobes expanded at the sides, and two smaller, narrow posterior lobes. Posterior valve having the mucro posterior or near the posterior third; deeply sinused in the rear, and usually having a slit on each side of the sinus.

"Girdle leathery, thick, red, densely covered with countless minute fascicles of vermilion spinelets."

This common chiton occurs outside the Golden Gate, but as far as is known it has not been found within San Francisco Bay. It appears to be most abundant just below the low-tide line.

Range.—North Japan to Santa Barbara, California (Pilsbry).

GASTROPODA

ACMAEIDAE

Acmaea Eschscholtz

Acmaea asmi (Middendorff)

Patella asmi Middendorff (1847–49), p. 39, pl. 1, fig. 5.

Acmaea asmi, Carpenter (1863), p. 650; Pilsbry (1891), p. 19, pl. 6, figs. 38–39.

Description.—This species is described by Pilsbry (1891) as follows:

"Shell small, thin but strong and solid, elevated, conical, the base short-oval, apex erect, a little in front of the middle; slopes of the cone somewhat convex. Surface lusterless, usually corroded, smooth except for very fine radiating striae visible with the aid of a lens, but obsolete in adult shells. Color rusty black.

"Inside black, with a brown zone just outside the muscle-scar."

Carpenter (1863, p. 650) reported this species from the Farallon Islands, and San Francisco. It has not been recognized in the Survey collections.

Range.—Aleutian Islands, Alaska, to Turtle Bay, Lower California.

Acmaea limatula Carpenter

Acmaea limatula Carpenter, Dall (1914*b*), p. 14.
Patella scabra Reeve, Carpenter (1863), p. 650; Dall (1878*b*), p. 47; Pilsbry (1891), p. 13, pl. 3, figs. 38–49.
Patella spectrum Nuttall, Reeve (1855), pl. 29, fig. 76.

Description.—This form is described by Pilsbry as follows:

"Shell thin, rounded-oval, depressed; apex situated between the center and the anterior third; surface sculptured with close, fine, minutely scaly riblets, of which larger ones are placed at regular intervals. Color light yellow, indistinctly spotted (rarely striped in divaricating pattern) with brown."

Carpenter reports this species from the Farallon Islands and from San Francisco. It is not uncommon along the shores of San Francisco Bay and along the beaches outside the Golden Gate.

Range.—Vancouver Island to Lower California.

Acmaea patina Eschscholtz

Acmaea patina Eschscholtz (1829–1833), p. 19, pl. 24, figs. 7, 8; Carpenter (1863), p. 650; Pilsbry (1891), p. 11, pl. 2, figs. 34–37, pl. 9, figs. 6–14.
Acmaea patina var. *cumingii* Reeve, Dall (1871*a*), p. 249.

Description.—The following is Pilsbry's (1891) description of this species:

"Shell large, oval or rounded-oval, depressed-conic, the apex rounded and near the middle; slopes slightly convex. Surface obsoletely radiately striated, olive-gray, tessellated, or more rarely striped, with black.

"Inside white with an irregular brown central area and a rather wide dark or tessellated border."

Length, 14 to 38 mm.

Occurrence.—At Richmond (*11*), Red Rock (*5*, 2), Presidio (*5*), Sausalito (*7*), Bonita Point (*10*), at station D 5811 (1), and questionably at D 5796.

Carpenter (1863) lists this limpet from San Francisco. The only specimen referred to this species was dredged by the "Albatross" in one fathom of water within the lower portion of the bay.

Range.—Aleutian Islands, Alaska, to San Diego, California (Pilsbry).

Acmaea patina Eschscholtz var. **pintadina** (Gould)

Lottia pintadina Gould (1846*b*), p. 151; (1862), p. 9; Pilsbry (1891), p. 12, pl. 9, figs. 10–14.

Description.—This variety is characterized by Pilsbry (1891) as follows:

"This shell when young is dark olive closely dotted all over with white, the eroded apex black; when adult it is usually uniform dull slate-color outside with a ring of light around the black apical spot; inside it has a wide dark border, a large, irregular central dark patch, and generally is suffused with dark brown all over. Sculpture obsolete.''

This variety is reported by Pilsbry (1891) from San Francisco. The writer has not recognized it among the Survey collections.

Range.—San Francisco to Santa Cruz, California (Pilsbry).

Acmaea pelta Eschscholtz

Acmaea pelta Eschscholtz (1829–1833), p. 19, pl. 24, figs. 7–8; Dall (1871a), p. 247, pl. 17, fig. 36; Wood and Raymond (1891), p. 57; Pilsbry (1891), and pl. 3, figs. 51–56; Dall (1914*b*), p. 14.

Description.—This species is described by Pilsbry (1891) as follows:

''Rather large, solid, strong, with low coarse ribs, almost obsolete, or visible only posteriorly. Central dark spot of the interior rather small or wanting. Grayish-white, with numerous radiating black stripes, often divaricating or broken into a tessellated pattern.''

Dall (1871a) reported this from Black Point. It is indigenous to San Francisco County, according to Wood and Raymond. Not found among the Survey collections.

Range.—Sitka, Alaska, to San Diego, California (Cooper).

Acmaea persona Eschscholtz

Acmaea persona Eschscholtz (1829–1833), p. 20, pl. 24, figs. 1–2; Wood and Raymond (1891), p. 57; Pilsbry (1891), p. 15, pl. 2, figs. 25–26, and pl. 3, figs. 51–56; Dall (1914b), p. 14.

Description.—Pilsbry (1891) described this species as follows:

''Shell oval, apex pointing forward, posterior slope long, convex, anterior slope short. Sculptured with strong, rounded ribs, usually nodulous, but sometimes obsolete. Whitish, with stripes and zigzags of blackish-brown, or olive-green variegated and speckled with white. Margin crenated by the ribs.

''Inside white or stained with yellowish-brown, with a large central deep brown area, rarely absent; border articulated black and gray.''

Length, 5 to 33 mm.

Occurrence.—At Standard Oil Pier, Richmond (*1*), Presidio (*154*), Sausalito* (*108*), Bonita Point (*59*), at station D 5768 (14), and questionably from D 5762, D 5772.

This common limpet has been reported by several collectors for the vicinity of San Francisco. Although common along the beach, it was taken by means of the dredge at only three stations.

Range.—Sitka, Alaska, to Socorro Island.

Acmaea persona Eschscholtz var. **umbonata** (Nuttall)

Patella umbonata Nuttall, Reeve (1855), fig. 107.

Acmaea persona var. *umbonata,* Pilsbry (1891), p. 16, pl. 2, figs. 25–28; Dall (1914*b*), p. 14.

Description.—This variety is described by Pilsbry (1891) as follows:

"The prevalent form southward of San Francisco is an oval shell with rather spreading sides, the ribs narrow, interspaces wide and flat. Color dark olive to blackish, closely flecked with fine white dots, and usually having coarse white dashes also."

This species was recognized by Pilsbry (1891) as occurring at San Francisco. Not collected by the Survey.

Range.—San Francisco to San Diego (Pilsbry).

Acmaea scabra (Reeve)

Patella scabra Reeve (1855)), pl. 37, fig. 119; Carpenter (1863), p. 650; Dall (1878a), p. 47; Pilsbry (1891), p. 13, pl. 3, figs. 38–49.

Description.—This species is described by Pilsbry (1891) as follows:

"Shell thin, rounded-oval, depressed; apex situated between the center and the anterior third; surface sculptured with close, fine, minutely scaly riblets, of which larger ones are placed at regular intervals. Color light yellow, indistinctly spotted (rarely striped in divaricating pattern) with brown."

Carpenter reports this species both from the Farallones and from San Francisco. It is not uncommon along the shores of San Francisco Bay and on the beaches outside the Golden Gate.

Range.—Vancouver Island to Lower California (Dall).

Acmaea mitra Eschscholtz

Acmaea mitra Eschscholtz (1829–1833), p. 18, pl. 23, fig. 4.

Scurria mitra, Carpenter (1863), p. 650.

Acmaea mitra, Wood and Raymond (1891), p. 57; Pilsbry (1891), p. 24, pl. 3, fig. 50.

Description.—This species was described by Pilsbry (1891) as follows:

"Shell dull-white, aperture nearly circular, wider behind, in some young examples somewhat elongated, oval; form conical, apex erect, nearly central, blunt, smooth, posterior surface usually straight, but occasionally a little convex; exterior smooth, marked with very faint concentric lines of growth; devoid of epidermis; margin entire, polished, with a narrow semipellucid rim inside.

"Internally smooth or furnished with grooves radiating from the apex more or less strongly marked. Muscular impressions deep, strong, horseshoe shaped, with the marks of the anterior ends of the adductors rounded and broader than the rest, connected by a slender impressed line marking the attachment of the mantle. Young shells are often furnished with irregular riblets more or less strong, many or few in number, radiating from the apex, but stronger towards the margin. Color dead-white inside and out, often livid or tinged a fine pink or pea green from Nullipore, never wax-yellow or horny-pellucid as in the normal state of *Scurria scurra.*''

Both Carpenter (1863) and Wood and Raymond list this species as occurring in the neighborhood of San Francisco.

Regarding this variable form, Dall states (1914, p. 14) that ''*A.* var. *funiculata* Cpr. merges by imperceptible degrees into the later (*tenuisculpta*) and that with *A. mitra*''

Range.—Aleutian Islands to San Diego (Dall).

Lottia Gray

Lottia gigantea (Gray) Carpenter

Lottia gigantea (Gray) Carpenter (1865*c*), p. 140.

Lottia gigantea, Carpenter (1863), p. 650; Cooper, (1870*a*), p. 60; Dall (1871*a*), p. 260, pl. 15, fig. 20.

Scurria gigantea, Pilsbry (1891), p. 65, pl. 38.

Description.—This species was described by Pilsbry (1891) as follows:

''Shell large, solid, oval, depressed, the apex near the front margin; outer surface eroded, of a spongy texture, dull brown, gray toward the summit. Inside having a black rim around the margin, deep chestnut brown outside of the muscle-impression, which is strong, bluish or purplish-white. Central area chestnut brown, more or less mottled with white, rarely entirely white.''

This species is mentioned by Carpenter (1863) and by subsequent writers as occurring at both San Francisco and the Farallon Islands.

Range.—San Francisco, California, to Panama (Pilsbry).

Lepeta Gray

Lepeta concentrica (Middendorff)

Patella (*Crytobranchia*) *coeca* var. *concentrica* Middendorff (1851), p. 183, pl. 16, fig. 6.

Lepeta caecoides Carpenter (1863), p. 651.

Lepeta concentrica, Pilsbry (1891), p. 69, pl. 40, figs. 33–37.

Description.—Pilsbry (1891) described this species as follows:

''Shell depressed conical, apex directed forward; front slope one-third the length of the shell or a little less; surface faintly radiately striate (more distinctly so in young specimens), not decussated or granulose; light-brownish or greenish tinted.

''The outline is ovate, a little narrower in front; front slope slightly concave, posterior slope convex. The fine thread-like radiating striae are larger on the longer slope of the shell; they are not interrupted by concentric growth-lines, the latter being inconspicuous, or sometimes strongly impressed at intervals. Epidermis very thin, yellowish-brown, deciduous. Inside polished, white, the anterior terminations of the muscle-scar a little behind the apex. Edges of shell level, narrowly bordered with gray, especially in the young.''

The Farallon Islands is the type locality of this species. It was not obtained by the U. S. S. "Albatross."

Range.—Northern Japan to the Farallon Islands, California.

HALIOTIDAE

Haliotis Linnaeus

Haliotis cracherodi Leach

Plate 34, figure 1

Haliotis cracherodi Leach (1814–1817), p. 131; Carpenter (1863), p. 651; Cooper (1870*a*), p. 61; Pilsbry (1890), p. 79, pl. 10, figs. 52–53; Campbell (1891), p. 103.

Description.—The following is Pilsbry's (1890) description of this species: "Shell oval, convex, spire near the margin; surface almost smooth, but usually showing nearly obsolete spiral lirae. Perforations about 8, color greenish-black or dull purplish-black.

"An oval shell with the two sides equally curved, the back regularly convex, not carinated at the row of perforations; outside covered with a thick black layer. Surface smooth, except for spiral lirae which are sometimes wholly obsolete, and lines of growth. Spire low, near the margin. Inside smooth, silvery with red and green reflections; columellar plate not truncate below, sloping inward, its face concave; cavity of spire very small, almost concealed."

This abalone has been reported by several collectors from the Farallon Islands, and by Carpenter from San Francisco. It is not in the Survey collection. The specimen figured was obtained from Moss Beach, San Mateo County, California.

Range.—Farallon Islands to Cape St. Lucas, Lower California (Campbell).

Haliotis gigantea Chemnitz

Haliotis gigantea Chemnitz (1780–1795), p. 115, pl. 167, figs. 1610, 1611; Pilsbry (1890), p. 84, pl. 7, fig. 42; Campbell (1891), p. 103.

Description.—Pilsbry (1890) described this species as follows:

"It is of a rounded-oval outline, the back quite convex, highest in the middle. It is solid, but not very thick, reddish-brown, radiately streaked more or less with chocolate and green. The spiral cords are low but strong, and there are irregular but very strong wave-like obliquely radiating folds above. The perforations are situated in high tubercles upon a strong dorsal angle, below which the left side slopes steeply to the columellar margin; this slope has low spiral cords, waved or festooned below the row of holes, and it has also an obtuse ridge parallel with that row, not far below it. The spire is very small, quite low. Inside there are shallow spiral sulci and indentations at the positions of the cords and waves of the exterior. The nacre is light colored or silvery, to a high degree iridescent, reflections of emerald green and red predominating. The muscle attachment is smooth, but its posterior and lateral outlines are marked by a rugose line. Columellar plate wide, its face concave, sloping inward. Open perforations 4."

The mollusk was reported by Carpenter under the varietal name *kamtschatkana* as occurring both at San Francisco and the Farallon Islands. This abalone was not obtained by the Survey.

Range.—Kamtschatka to Monterey, California (Campbell).

Haliotis rufescens Swainson

Plate 33

Haliotis rufescens Swainson (1821–1822), p. 2; Carpenter (1863), p. 651; Cooper (1870*a*), p. 61; Pilsbry (1890), p. 82, pl. 20, fig. 11; Campbell (1891), p. 103.

Description.—Pilsbry (1890) described this species as follows:

"Shell large, heavy and solid, oval, not very convex; sculpture consisting of unequal spiral cords and threads and wide low radiating waves; color dull red; holes three or four.

"The shell is very large, sometimes attaining a length of 9 inches; it is thick and heavy, covered outside with a thick brick-red layer which projects at the edge of the lip, forming a narrow coral-red edge. The spiral cords are unequal in size, and finer than in *H. fulgens;* the waves of the surface are large and oblique. Below the rows of holes there is a depression, followed by a low ridge bearing usually large obtuse tubercles. The spire does not project above the general curve of the back. Inside the nacre is lighter than in either *H. fulgens* or *H. corrugata,* and the play of tints not so much broken. The colors are chiefly pink and light green, with here and there a small area of prussian blue. The muscle scar is large, peculiarly and variously striped with olive-brown, green and blue; a portion of it is roughened by coarse raised cords which take a spiral direction. The columellar plate is rather narrow, its lower part sloping inward somewhat. Perforations large, somewhat tubular, 3 or 4 open."

This mollusk has been reported from the Farallon Islands by Carpenter. The specimen figured was obtained from Point Reyes, Marin County.

Range.—Mendocino County to San Diego, California (Campbell).

Haliotis fulgens Philippi

Haliotis fulgens Philippi (1845–1846), p. 150; Pilsbry (1890), p. 81, pl. 12, figs. 61, 62.

Haliotis splendens Reeve, Carpenter (1863), p. 651.

Description.—The following is Pilsbry's (1890) description of this species:

"The form is oval, as in the other American Haliotis, the back quite convex. It is solid, but thinner than *H. rufescens.* The outside is a uniform dull reddish-brown. It is sculptured with rounded spiral lirae, nearly equal in size, 30 to 40 in number on the upper surface. At the row of holes there is an angle, the surface below it sloping almost perpendicularly to the columellar edge, and having an obtuse keel about midway. The spire does not project above the general curve of the back. Inside dark, mostly blue and green with dark coppery stains, pinkish within the spire; the muscle impression painted in a peculiar and brilliant pattern, like a peacock's tail. Columellar plate wide, flat, sloping inward. Cavity of the spire small, almost concealed. Perforations rather small, elevated, circular, about 5 in number.''

This species is associated with the preceding species, according to Carpenter. Pilsbry (1890) apparently overlooked Carpenter's citation when he considered the range of the species.

Range.—Farallon Islands (Carpenter), Monterey to Lower California (Pilsbry).

Haliotis assimilis Dall

Haliotis assimilis Dall (1878*a*), p. 46; Pilsbry (1890), p. 83, pl. 22, fig. 29; Blankinship and Keeler (1892), p. 151.

Description.—This species was defined by Pilsbry (1890) as follows:

''Shell short, oval, very convex, the spire short but projecting above the general outline of the back; surface spirally lirate and having low, rather obscure radiating waves; perforations five; inside silvery, with red, blue, and green reflections.

''The form is the same as in *H. corrugata,* except that the spire is more produced in the present species. It is solid and strong, but not very thick. The epidermis is dull reddish and greenish. Surface sculptured by numerous spiral cords, alternately larger and smaller, and obsoletely waved radiately. Below the row of holes is a shallow channel; the area between the row of holes and the columellar margin is spirally lirate, and has an obtuse carina in the middle. Inside light, nacre silvery, red and green; the muscle impression smooth . . . columellar plate rather narrow, not at all truncated below, sloping inward.''

The only record of this species occurring north of Monterey is that of Blankinship and Keeler's list of species from the Farallon Islands.

Range.—Farallon Islands; Monterey to San Diego, California (Campbell).

FISSURELLIDAE

Fissuridea Swainson

Fissuridea aspera (Eschscholtz)

Plate 34, figures 2*a* and 2*b*

Fissurella aspera Eschscholtz (1829–1833), p. 21, pl. 23, fig. 5.

Glyphis aspera, Pilsbry (1890), p. 214, pl. 36, figs. 28, 29, 30; Wood and Raymond (1891), p. 57.

Fissuridae aspera, Arnold, R. (1903), p. 338.

Description.—Pilsbry (1890) describes this species as follows:

''Shell ovate, narrower in front, conical, the slopes nearly straight or a little convex behind the middle. Sculptured with numerous radiating riblets, of which 30–34 are larger, the intervals between them bearing about three smaller ones; the whole decussated by close elevated concentric lirae, which are more or less scale-like and imbricating.

"Color soiled whitish, with numerous wide blackish rays. Inside white, hole-callus white, very abruptly truncated behind; margin deeply and sharply crenulated. Perforation short-oval, nearly circular, in front of the middle."

Height, 26 to 60 mm.

Occurrence.—At stations D 5702 (3), D 5713* (2), D 5800 (1), D 5808 (1), and questionably at D 5801 (1).

This keyhole limpet was first listed from the vicinity of San Francisco by Wood and Raymond (1891). It is represented among the Survey collections by several worn specimens obtained from the middle division of the bay in depths ranging from 13¾ to 43 fathoms.

Range.—Sitka, Alaska, to San Diego, California (Orcutt).

Fissurella Bruguière

Fissurella volcano Reeve

Fissurella volcano Reeve (1849), pl. 4, fig. 2; Carpenter (1863), p. 651; Pilsbry (1890), p. 156, pl. 62, figs. 16–18; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 340.

Description.—This species was described by Pilsbry (1890) as follows:

"Shell oval, usually a little narrower in front, the orifice a little in front of the middle, oblong, often obscurely tripartite, about one-eighth the length of the shell; surface with radiating unequal riblets, often subobsolete. Color pink-ashen with 13 to 16 purplish rays, often speckled near the summit. Inside white, smooth, frequently with a pink line bounding the callus around the perforation; border narrow, dark, alternately pink or purple and gray."

This species was found within the limits of San Francisco County by Wood and Raymond. It was not collected by the Survey.

Range.—Bolinas Bay, California, to San Hippolite Point, Lower California.

Megatebennus Pilsbry

Megatebennus bimaculatus (Dall)

Fissurellidaea bimaculata Dall (1871*b*), p. 132, pl. 15, fig. 7.

Clypidella bimaculata, Cooper (1888), p. 235; Arnold, R. (1903), p. 339.

Description.—This species was described by Dall (1872) as follows:

"Shell ellipsoidal when young, subquadrangulate, and a little narrower in front than behind, when adult. Aperture the same shape as the shell, slightly encroached upon in some specimens by a point on each side. External surface furnished with radiating, rounded costae, not bifurcating but widening slightly towards the margin. These are crossed by evident but not very strong lines of growth, which, in some individuals, are rather strong. Anterior declivity of the shell concave, sides flattened, posterior declivity rounded convex. Color whitish, with numerous radiating rays of brown or slate color, usually with a broad fasiculus of darker rays in the middle of each side extending from the apex to the margin, and occasional dark dots on the ribs. Shell occasionally entirely brown or slate color, with two darker rays on the sides. Epidermis none.

"Interior pure white, the two dark rays sometimes showing through the shell. Extreme outer edge finely denticulate or rounded and smooth, according to the stage of growth. Margin as a whole broad, smooth, differentiated from the rest of the surface by a wide, shallow groove. Margin of the aperture similarly bordered. Muscular impressions distinct, surface marked by fine radiating lines; polished. Anterior and posterior margins internally concave or emarginated, so that when laid upon a flat surface in the natural position the ends of the shell do not touch it."

According to Cooper (1888, p. 235), this species occurs at the Farallon Islands. It has not been found among the Survey collections.

Range.—Bolinas Bay to Santa Barbara, California (Dall).

TURBINIDAE

Astralium Link

Astralium triumphans (Philippi)

Plate 34, figures 4*a* and 4*b*

Trochus triumphans Philippi (1841), p. 8; Pilsbry (1888), p. 228, pl. 58, figs. 67, 68.

Description.—Pilsbry (1888) described this Japanese species as follows:

"Shell low-conic, imperforate, metallic brownish-purple above, nearly white below; whorls 6, slightly convex above; body whorl armed around the carinate periphery with long slender closed tubular radiating spines, about eight in number on the body-whorl, and which are reabsorbed as the growth advances leaving only short stumps to festoon the sutures; upper surface with close revolving series—generally eight to ten on the last whorl—of minute laterally compressed granules; base slightly convex, usually with a marginal row of granules, and several rows surrounding the central callus; aperture transversely ovate, angulate and channelled at peripheral carina, iridescent within; peristome sinuous above, umbilical region covered with a heavy callus; more or less stained with pinkish, somewhat excavated at center and spirally ridged."

Height, 10 mm.

Occurrence.—Near station D 5807* (*1*).

This Japanese species was dredged alive just outside the Golden Gate. It has not heretofore been reported from North America. Although the locality lies within the course of oceanic traffic, the probabilities are against the dredging of a single specimen that may have been carried across the Pacific and then dropped from the bottom of a ship. If this form is exotic, it presumably has established itself in these waters.

Range.—Japan. Known on the Pacific Coast only from San Francisco.

Leptothyra Carpenter

Leptothyra carpenteri Pilsbry

Leptothyra carpenteri, Pilsbry (1888), p. 247, pl. 39*a*, figs. 26–29; Arnold, R. (1903), p. 323.

Leptothyra sanguinea Carpenter, Gabb (1869), p. 85.

Leptonyx sanguinea Linnaeus, Keep (1892), p. 87, fig. 73.

Description.—This species was originally described by Pilsbry (1888) as follows:

"Shell small, globose, very solid, imperforate, spire conic, more or less depressed; suture moderately impressed; whorls 5, slightly convex, the last decidedly deflected toward the aperture, encircled by about fifteen subequal spiral lirae, separated by interstices about as wide as the ridges; incremental striae generally strongly developed, causing the lirae to appear nodose or somewhat irregular, and the interstices to appear pitted; aperture oblique, nearly white within, about half the length of shell; columella arcuate, base obsoletely uni- bi- or tri-dentate; color red, ashen or purple."

This species was reported from the Farallon Islands and from the vicinity of San Francisco by Carpenter (1863, p. 652). It was obtained in depths up to 20 fathoms. Not collected by the U. S. S. "Albatross."

Range.—Vancouver Island to Cape St. Lucas, Lower California (Pilsbry).

PHASIANELLIDAE

Phasianella Lamarck

Phasianella pulloides Carpenter

Phasianella pulloides Carpenter, Pilsbry (1888), p. 173, pl. 39, figs. 69–72; Blankinship and Keeler (1892), p. 151.

Description.—This species was defined by Pilsbry (1888) as follows:

"Small, pointed-oblong, somewhat solid, yellowish, pinkish or whitish, more or less clouded longitudinally with purple, dull pink or gray, marked with numerous narrow close revolving descending lines of purple, pink or drab, sometimes conspicuously flammulate below the sutures, and broadly transversely fasciate on base; whorls 5–6, closely coiled above, with shallow sutures, the last more rapidly descending, separated by a deep suture; aperture usually less than half the length of the shell, very oblique, short ovate, inner margin arcuate, umbilical region excavated and generally minutely perforate."

This species has been reported from this region by Blankinship and Keeler. It is not found in the Survey collections.

Range.—Farallon Islands to Catalina Island, California.

TROCHIDAE

Calliostoma Swainson

Calliostoma canaliculatum (Martyn)

Plate 36, figure 5

Calliostoma canaliculatum, Pilsbry (1889), p. 361, pl. 67, fig. 49; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 329.

Description.—Pilsbry (1889) described this species as follows:

"Conical with flat base, thin, light fawn colored with yellowish-white lirae; imperforate; surface of the whorls encircled by numerous sharply sculptured smooth, narrow, cord-like lirae, subequal or alternately smaller; base with 11 to 13 similar ones. On the upper whorls the lirae are fewer, and in well preserved individuals the second whorl is minutely beaded above. Spire conic, with nearly straight outlines; sutures impressed. Whorls 7–8, the last obtusely angular, flat beneath and impressed around the axis. Aperture oblique, rhombic, iridescent and sulcated inside; peristome thin, acute; columella straightened, not truncate below, dilated in a pearly iridescent pad above, bounded by an opaque white deposit."

This common shell occurs quite abundantly along the shores outside of the Golden Gate. It has been reported from this region by Wood and Raymond (1891). It was not obtained by the Survey.

Range.—Sitka, Alaska, to San Diego, California (Pilsbry).

Calliostoma costatum (Martyn)

Plate 36, figures 6 and 7

Calliostoma costatum, Carpenter (1863), p. 652; Pilsbry (1889), p. 362, pl. 16, figs. 6, 9; pl. 18, fig. 16.

Description.—This species was described by Pilsbry (1889) as follows:

"Shell conical, rounded at periphery, base flattened; imperforate; solid; dark chestnut colored, the spiral riblets lighter, apex dark, usually purple. Surface encircled by numerous spiral smooth riblets, their interstices closely finely obliquely striate; riblets usually 7 to 9 on the penultimate whorl, about 9 on the base. Spire conic; apex acute; sutures impressed. Whorls about 7, convex, the last rounded (or a trifle angled) around the lower part, slightly convex beneath; aperture rounded, oblique, outer lip fluted within, with a beveled opaque white submargin; throat pearly, iridescent; columella simple, arcuate."

Height, 9 to 11 mm.

Occurrence.—At station D 5770* (*2*).

Carpenter (1863) lists this species from the Farallon Islands. Two living specimens were dredged by the Survey near the north shore of the Golden Gate at a depth of 5 fathoms. The bottom at that locality is characterized as being stony. This species occurs abundantly along the beaches of the open ocean.

Range.—Sitka, Alaska, to San Diego, California (Cooper).

Tegula Lesson

Tegula brunnea (Philippi)

Plate 36, figures 3 and 4

Trochus brunneus Philippi (1842–1855), p. 300, pl. 43, fig. 19.
Chlorostoma brunneum, Carpenter (1863), p. 652; Pilsbry (1889), p. 170, pl. 27, figs. 36–38; Arnold, R. (1903), p. 324.
Tegula brunnea, Keep (1911), p. 236.

Description.—This species was described by Pilsbry (1889) as follows:
"Shell imperforate, conical, solid, russet-yellow, brown, orange-colored or deep crimson; spire conic; sutures deeply impressed; whorls about 7, convex, smooth, obliquely lightly striate, the last sometimes obsoletely undulated or plicate below the suture; base depressed, deeply concave in the center; aperture very oblique; columella one or two toothed near the base; umbilical callus white; place of the umbilicus deeply excavated."

This is a very common intertidal species along the beaches both north and south of the Golden Gate. Not known to occur in San Francisco Bay. According to Carpenter, it also occurs at the Farallon Islands. No specimens were obtained by the Survey. The specimen figured came from Bolinas Bay, Marin County, California.

Range.—Cape Mendocino to San Diego, California (Cooper).

Tegula funebrale (A. Adams)

Plate 36, figures 1*a* and 1*b*

Chlorostoma funebrale A. Adams (1854), p. 316; Carpenter (1863), p. 652; Pilsbry (1889), p. 170, pl. 28, figs. 42–44; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 325.
Trochus moestus Jonas, Carpenter (1856*a*), p. 212.
Tegula funebrale, Keep (1911), p. 235.

Description.—This species was described by Pilsbry (1889) as follows:
"This species is similar to *C. gallina* in form and characters of the aperture. It is lusterless, purple or black, the apex usually eroded, orange-colored; the teeth of the columella are white; and there is never a yellowish streak at the base, as in the var. *tincta* of the last species (*C. gallina*). The whorls are spirally lirate, sometimes smooth except on the base, sometimes strongly lirate above. The suture is margined below by an impressed line, and by elevated, folicaceous incremental lamellae. This last feature may almost always be detected, although sometimes but very slightly developed."

Length, 7 to 36 mm.

Occurrence.—At Bonita Point (4)*.

This common intertidal species is associated with the preceding one. Carpenter (1863) and subsequent writers have reported this mollusk from San Francisco. It is represented in the Survey collections by four living specimens taken along the beach at Bonita Point.

The species *Trochus moestus* Jonas, a South American form, has been inadvertently listed from San Francisco.

Range.—Sitka, Alaska, to San Diego, California (Cooper).

Tegula montereyi (Kiener)

Trochus montereyi Kiener (1834–1856), pl. 33, figs. 1, 1*a*; Pilsbry (1889), p. 171, pl. 27, figs. 27, 28.

Chlorostoma montereyi, Blankinship and Keeler (1892), p. 153.

Description.—Pilsbry characterizes this species as follows:

"Shell umbilicate, strictly conical, rather thin, light olivaceous or pale corneous; spire conical, with nearly straight outlines; apex acute; sutures linear; whorls 7; flattened, encircled by numerous fine lines, which become obsolete on the lower whorl which shows usually very ill defined obliquely descending small folds, at right angles to the incremental striae; body whorl acutely angular at the periphery; base flat, spirally lirate; aperture subhorizontal; outer lip thin, margined with brown or corneous; columella subhorizontal, curved, toothed below middle, receding above, not spread around the umbilicus as in the other species; umbilicus funnel-shaped, rapidly becoming very narrow, white within, its edge defined by an angle."

This species was reported from the Farallon Islands by Blankenship and Keeler.

Range.—Bolinas Bay to San Nicolas Island, California (Pilsbry).

Margarites Leach*

Margarites lirulata Carpenter

Margarita lirulata Carpenter (1863), p. 653; (1865*a*), p. 61; Dall (1871*b*), p. 128; Pilsbry (1889), p. 296, pl. 65, figs. 81, 82, and 87.

Gibbula parcipicta Carpenter (1863), p. 653.

Gibbula succincta Carpenter (1863), p. 653.

Description.—Pilsbry (1889) described this species in the following words:

"Shell umbilicate, globose-conical solid, lusterless or slightly shining, purplish, unicolored, or with large radiating white patches above, or around the periphery, or spiral darker lines, or spiral articulated lines. Surface either with (1st) a few (2–4) strong lirae above, their interspaces smooth, the base with about 8 concentric lirulae, or (2nd) more numerous narrow irregular lirulae above, those of the base still smaller, or (3rd) the spiral sculpture obsolete, surface smooth or nearly so above and beneath. The spire is more or less elevated, apex obtuse; suture impressed, sometimes sub-canaliculate; body-whorl convex beneath; aperture oblique, oval-rhomboidal, very brilliantly iridescent within, but the acute peristome has a rather broad marginal band of opaque white; columella simple, umbilicus tubular, with incremental striae within."

This species is listed by Carpenter (1863) under the name of *Gibbula succincta* from San Francisco and the Farallon Islands. Not obtained by the Survey.

*For authority for changing the spelling of the genus see Dall (1915*b*, p. 112).

Range.—Sitka, Alaska, to San Diego, California (Pilsbry). Todos Santos Bay (Hemphill).

Margarites pupilla (Gould)

Plate 36, figure 10

Trochus pupillus Gould (1848*b*), p. 91.

Margarita pupilla Carpenter (1863), p. 653; Pilsbry (1889), p. 295, pl. 44, figs. 29–32; Arnold, R. (1903), p. 333, pl. 10, fig. 15.

Description.—Arnold (1903) described this species as follows:

"Shell small, ovate-conic, rather solid; whorls five, convex, flattened slightly above, forming a narrow, tabulate band just below suture; body-whorl obtusely angulated; surface sculptured with small, flattened, subequal, equidistant, revolving ribs, five on the upper whorls; interspaces ornamented by fine, oblique, incremental lines; base of body-whorl nearly flat, and ornamented with numerous fine, revolving lines, which become coarser near umbilicus; suture deeply impressed, distinct, aperture circular; columella somewhat arcuate; umbilicus small, groove-like; outer lip sharp, nacreous layer on inner lip."

Height, 3 mm.

Occurrence.—At stations D 5773 (*1*).

This shell is listed by Carpenter (1863) from the Farallon Islands. The only specimen in the Survey collections was dredged alive near Lime Point within the Golden Gate in 3 fathoms from a stony bottom.

Range.—Alaska to Catalina Islands, California (Cooper).

EULIMIDAE

Melanella Bowdich*

Melanella (Eulima) **micans** (Carpenter)

Plate 36, figure 11

Eulima micans Carpenter (1863), p. 659; (1865*a*), p. 63; Tryon (1886*c*), p. 272, pl. 64, figs. 29, 30; Arnold, R. (1903), p. 269, pl. 9, fig. 12.

Description.—Tryon (1886) described this species as follows:

"Straight, white, semipellucid, shining; whorls flattened, the last oblong oval; aperture narrowly oval, outer lip somewhat straight and scarcely thickened."

Height, 6 to 8 mm.

Occurrence.—At stations D 5785 (*1*), D 5788* (*1*), D 5789 (*3*).

This small gastropod is not mentioned in the lists of species from the vicinity of San Francisco. It is apparently restricted in distribution to the open oceanic waters. Living specimens were obtained by the Survey in the vicinity of the Farallon Islands from depths ranging from 39 to 68 fathoms, the bottoms being composed of fine dark green sand.

Range.—British Columbia to San Diego, California (Keep).

---

* For change in generic name see Dall (1915*b*),

PYRAMIDELLIDAE

Turbonilla Risso

Turbonilla (Pyrgolampros) franciscana Bartsch

Plate 36, figures 8 and 9

Turbonilla (Pyrgolampros) franciscana, Bartsch (1917), p. 645, pl. 42, fig. 2.

Description.—This species was originally described by Bartsch, as follows:

"Shell elongate conic, flesh colored excepting a broad chestnut band, which covers the median third of the last whorl. This dark band really consists of two chestnut colored zones, the anterior of which embraces half the band, while the posterior is equal to one-fourth of the dark area; the two being separated by a zone of a little lighter shade, which is as wide as the posterior zone. Nuclear whorls decollated in all the specimens seen. Postnuclear whorl rather high between the sutures, feebly shouldered at the summit, and slightly constricted at the periphery. Early postnuclear whorls marked by low, rounded, broad, almost vertical axial ribs, which are wider than the shallow impressed spaces that separate them. On the later whorls the axial ribs become quite obsolete. On the first of the postnuclear whorls, there are eighteen of these ribs; on the second to fourth, twenty; on the fifth they become decidedly feeble and on the remainder they are not at all differentiated. In addition to the axial sculpture, the surface of the shell is marked by very fine, wavy, closely spaced spiral striations. Periphery of the last whorl well rounded. Base moderately long, well rounded, marked by lines of growth and spiral striations comparable to those on the spire. Aperture broadly oval; outer lip thin, showing the color markings within. Columella curved, somewhat twisted and slightly revolute; parietal wall glazed with a thin callus."

The type, and seventeen specimens, Cat. No. 214435, U. S. N. M., was dredged by the U. S. S. "Albatross" at station D 5743, in 10–15½ fathoms, on very fine sand and mud bottom, San Francisco Bay, California. The type has lost the nucleus and probably the first of the postnuclear turns. The eight remaining measure: length 6.8 mm., diameter 2 mm.

There are three additional lots of specimens in the collection of the U. S. National Museum, likewise dredged by the U. S. Bureau of Fisheries Steamer "Albatross" in San Francisco Bay. These are Cat. No. 214433, 3 specimens, from station D 5729 in 4¾ fathoms on sandy mud bottom. Cat. No. 214436, 4 specimens from station D 5703 in 8½ fathoms on mud bottom.

This species belong to the obsoletely sculptured group of *Pyrgolampros*, embracing *halistrapta, pesa, rinella, lituyana, oregonensis.*"

Height, 3 to 6.8 mm.

Occurrence.—At stations D 5703 (*5*, 1), D 5704 (1), D 5705 (3), D 5723 (*6*), 5729† (*2*), D 5740 (*7*, 1), D 5743† (34), D 5744 (27), D 5854 (11), D 5763 (*4*), D 5764 (*3*, 1), D 5781 (*1*), D 5785 (1), D 5786 (1), D 5799 (*4*), D 5822 B (40), D 5825 A (66), D 5826 A (1), D 5828 B (64), D 5830 A (*12*), D 5831 (*2*), D 5836 (24), D 5839 (48), D 5840 (*8*), Sausalito (1).

This new species was dredged at two of the outside stations and at 23 stations within the middle and lower divisions of the bay. Living specimens were taken in depths up to 13 fathoms and a single shell from 40 fathoms. It occurs on bottoms that are prevailingly sandy.

Range.—Known only from San Francisco which is the type locality of the species.

Turbonilla keepi Dall and Bartsch

Plate 36, figures 12*a* and 12*b*

Turbonilla keepi Dall and Bartsch (1909), p. 71, pl. 5, fig. 1.

Description.—This species was described by Dall and Bartsch (1909) as follows:

"Shell elongate-conic, yellowish-white with a brown band about two-fifths the width of the space between the sutures, immediately below the summits, and one about one-third as wide, a little anterior to the middle of the remaining light area. Posterior half of base a little lighter brown than the bands between the sutures, grading into white on the anterior half. (Nuclear whorls decollated.) Postnuclear whorls slightly shouldered, flattened, somewhat contracted at the periphery, marked by strong, well rounded, almost vertical axial ribs, of which there are 22 upon the fourth to sixth, 24 upon the seventh to ninth, 26 upon the tenth, and 30 upon the penultimate turn. Intercostal spaces a little narrower than the ribs, well impressed. Sutures strongly impressed, rendered sinuous by the strong terminations of the axial ribs at the summits of the whorls. Periphery of the last whorl well rounded. Base moderately long, well rounded. Entire surface of spire and base marked by numerous, very closely crowded, wavy, spiral striations. Aperture large; posterior angle acute; outer lip thin, showing the external sculpture and color bands within; columella very oblique, almost straight and slightly revolute."

Height, 6 to 11 mm.

Occurrence.—At stations D 5785 (*1*), D 5786 (*2*), D 5826 A (64). This small univalve has not before been taken as far north as San Francisco. It is restricted in the Survey collections to the waters of the open ocean. Living specimens were dredged in 39 to 40 fathoms from a sandy bottom.

Range.—San Francisco; Catalina Island to San Diego, California (Dall and Bartsch).

Odostomia Fleming

Odostomia franciscana Bartsch

Plate 36, figures 15 and 16

Odostomina (*Evalea*) *franciscana* Bartsch (1917), p. 665, pl. 45, fig. 7.

Description.—This species was recently described by Bartsch (1917) as follows:

"Shell thin, broadly elongate conic, yellowish white. Nuclear whorls small, deeply imbedded in the first of the succeeding turns, about which the tilted edge of the last volution only projects. Postnuclear whorls inflated, well rounded, feebly shouldered at the summit, marked by almost vertical, very feeble, incremental lines and exceedingly fine, closely spaced spiral striations. Suture moderately constricted. Periphery of the last whorl very feebly angulated. Base short, inflated well rounded, with a very narrow umbilical chink. Aperture large; posterior angle acute; outer lip thin; inner lip strongly curved, somewhat reflected and provided with a strong, oblique fold at its insertion; parietal wall glazed with a thin callus.''

The type and three specimens, Cat. No. 214431, U. S. N. M., were collected at the U. S. Bureau of Fisheries Station D 5729, in San Francisco Bay, on sticky, nearly black, mud in 4¾ fathoms. Cat. No. 214432, U. S. N. M., contains four additional specimens also from San Francisco Bay, dredged at U. S. Bureau of Fisheries Station D 5781, on coarse sand, pebbly and shell bottom, in 9¾–16 fathoms.''

Height, 3 to 4 mm.

Occurrence.—At stations D 5729† (7), D 5764 (*4*), D 5781† (*4*), D 5785 (*1*, 1), D 5786 (2), D 5785 (4), D 5788 (1), D 5810 (28), D 5836 (24), D 5839 (16), and questionably at D 5794, D 5836.

As yet this new species is known only from the lower and middle divisions of the bay and from the open ocean in the vicinity of the Farallon Islands. Specimens were dredged in depths ranging from 1¾ to 68 fathoms on bottoms varying from pure sand to pure mud.

Range.—Known only from San Francisco, which is the type locality of the species.

Odostomia farallonensis Dall and Bartsch

Odostomia farallonensis Dall and Bartsch (1909), p. 221, pl. 27, fig. 7.

Description.—This species was originally described as follows:

''Shell very elongate-ovate, deeply umbilicated, light yellow. Nuclear whorls very deeply immersed. Postnuclear whorls very slightly rounded in the middle between the sutures, more strongly so near the anterior end and toward the summit. Summit strongly narrowly tabulate. Periphery of the last whorl inflated. Base very strongly suddenly rounded, widely and deeply umbilicated. Entire surface marked by numerous fine, closely spaced, spiral striations. Aperture broadly ovate, posterior angle obtuse, outer lip thin; columella very slender, strongly curved, revolute, provided with a deep fold a little below its insertion; parietal wall glazed with a thin callus.''

Occurrence.—This species was dredged by the ''Albatross'' during a previous survey at station D 3180 off the Farallon Islands.

Range.—Known only from the Farallon Islands which is the type locality for the species.

[**Odostomia gravida** Gould]

Odostomia gravida Gould, Wood and Raymond (1891), p. 57; Dall and Bartsch (1909), p. 212, pl. 25, fig. 7.

This species was reported from this region at a time before the specific distinctions now made were so well recognized. It is not improbable, therefore that Wood and Raymond confused this southern species with some other form. Dall and Bartsch (1909) found this species only at Santa Barbara, California.

Odostomia inflata Carpenter

Odostomia inflata Carpenter (1863), p. 658; Dall and Bartsch (1907), p. 524, pl. 47, fig. 8; (1909), p. 201, pl. 23, fig. 7.

Description.—This species was described by Dall and Bartsch as follows:

"Shell ovate, white. Nuclear whorls decollated. Postnuclear whorls inflated, gently curved over the anterior two-thirds of the whorl between the sutures and more strongly so on the posterior third, this portion forming an evenly curved shoulder. Extreme summit of the whorls slightly flattened and narrow, rendering the sutures well marked. Periphery of the last whorl subangulated. Base attenuated, rather suddenly contracted below the periphery, which gives the space between the periphery and the umbilical area a concave aspect. Entire surface marked by fine lines of growth and many fine, closely placed spiral lirations, five of which are a little stronger than the rest and divide the space between the sutures into subequal areas. There are about 30 of these threads upon the last turn between the summit and the periphery and about 60 on the base. Aperture very large, patulous anteriorly; outer lip thin at the edge but very thick within; columella decidedly curved, and revolute, reinforced to the very edge by the attenuated base, provided with a strong oblique fold at its insertion."

According to the original description, this species occurs in cavities in shells of Haliotis at the Farallon Islands and at San Francisco. The specimen was not found in the Survey collections, by Dr. Bartsch, who kindly examined all of the specimens belonging to this genus.

Occurrence.—Neah Bay, Washington (Dall and Bartsch); Farallon Islands (Carpenter).

EPITONIIDAE

Epitonium Bolten

Epitonium cerebricostatum (Carpenter)

Scalaria cerebriscostata Carpenter (1863), p. 660; Wood and Raymond (1891), p. 57.

Scala cerebriscostata, Arnold, R. (1903), p. 263.

Description.—Arnold (1903) described this species as follows:

"Shell turreted, thin; spire consists of eight convex whorls, each with fourteen to eighteen slightly oblique, sharp, thin, reflected, transverse varices; varices show a slightly coronated appearance at the shoulder; suture deep and distinct. Deflection 22 degrees.

Some of the specimens have only slightly reflexed varices, and the amount of coronation varies in different individuals."

Wood and Raymond recognized this species within the limits of San Francisco County. It was not found among the Survey specimens. These authors also list the eastern form *E. groenlandica* Perry.

Range. — San Francisco (Wood and Raymond) to San Diego (Cooper).

Epitonium hindsi (Carpenter)

Plate 36, figures 14*a* and 14*b*

Scalaria hindsi Carpenter (1856*c*), p. 165.

Scala hindsi, Arnold, R. (1903), p. 364.

Description.—Arnold (1903) described this species as follows:

"Shell small, turreted, thin; whorls eight, evenly convex; varices eight to twelve, sharp, thin, sometimes reflexed, very prominently coronated just anterior to suture; suture deep, distinct; aperture subcircular; lip slightly thickened; inner lip slightly incrusted."

Height, 5 to 10 mm.

Occurrence.—At stations D 5712 (*1*), D 5724 B (*2*), D 5833 (*128*), fishing grounds west of Golden Gate* (1), west of Farallon Islands (*1*).

This southern species has not hitherto been reported from these local waters. It is sparingly represented among the Survey collections at stations within the bay and outside the Golden Gate. Living specimens are recorded from depths ranging from 8¾ to 815 fathoms, on bottoms which are predominantly sandy.

Range.—Bodega Bay, California to Panama (Orcutt).

Epitonium sawinae (Dall)

Plate 36, figure 13

Scala sawinae Dall (1903*b*), p. 175.

Description.—This species was originally described as follows:

"Shell small, elongate, sub-acute, with ten or more whorls; nucleus of three smooth polished whorls; subsequent whorls smooth, with about 19 low, sharp, slightly reflected varices which entirely cross the whorl; at the shoulder these are slightly spinose; aperture rounded ovate, entire, with a small spine at the shoulder angle and a less conspicuous one at the inner base of the aperture; there is no trace of a basal cord or disk, and no spiral sculpture. Length, 10.5; diameter of aperture, 2.5; max. diameter of last whorl, 4.0 mm. A broken specimen with three more whorls seems to have measured 24 mm. in total length when perfect, and 8 mm. in diameter."

Height, 3 to 16 mm.

Occurrence.—At stations D 5785* (*21*, 6), D 5786 (*10*), D 5787 (*2*), D 5788 (3), D 5789 (*1*, 11), D 5790 (3), D 5833 (1).

This southern species has heretofore been found only at its type locality within the Santa Barbara channel. It is represented in the Survey collections mainly from the stations outside the Golden Gate. Living specimens were dredged from a bottom of dark greenish sand at depths ranging from 39 to 46 fathoms.

Range.—San Francisco to Coronado Islands, California.

LITTORINIDAE

Littorina Ferussac

Littorina planaxis (Nuttall) Philippi

Plate 35, figures 4 and 8

Littorina planaxis (Nuttall) Philippi (1842–1851), pl. 4, fig. 16; Tryon (1887*b*), p. 248, pl. 43, figs. 55, 56; pl. 44, fig. 57; Wood and Raymond (1891), p. 57.

Description.—This species was described by Tryon (1887) as follows: "Whorls convex, rapidly increasing, smooth or very minutely spirally striate, light chocolate color, shining, under a thin olivaceous epidermis, speckled and spotted irregularly with white, interior chocolate color, with a white band near the base; columella broadly excavated, yellowish brown."

Height, 3 to 14 mm.

Occurrence.—At Bonita Point (*13*, 2), and questionably at D 5742.

This littoral species was reported by Carpenter (1863) from the Farallon Islands and from San Francisco where it has been found by subsequent writers. It is a common form upon the rocks or piles at or above high-tide level. It is represented in the Survey collections by specimens from the beach at Bonita Point and questionably at one dredging station within the middle division of the bay.

Range.—Sitka, Alaska (Cooper); Lower California (Orcutt).

Littorina scutulata Gould

Plate 35, figures 2 and 3

Littorina scutulata Gould (1848*a*), p. 83 (1863), p. 53; Carpenter (1863), p. 656; Tryon (1887*b*), p. 250, pl. 45, figs. 98–103.

Description.—The following is Tryon's (1887) description of this species: "Faintly striate with spiral impressed lines, olivaceous chestnut or chocolate color, including aperture, sometimes not variegated, but usually with longitudinal zigzag white markings, sometimes broken up into spots, and frequently with an articulated white and chestnut band on the periphery."

Height, 2 to 9 mm.

Occurrence.—At stations D 5739 (1), Key Route Pier, Oakland (63), Standard Oil Pier, Richmond (*29*), Red Rock (*11*), Presidio (*60*), Sausalito (*2*), Bonita Point* (*162*, 3).

Carpenter (1863) and subsequent writers have listed this species in association with the larger form previously considered. A single weathered specimen was obtained by the dredge in 18 fathoms of water. The distribution of the living shell is very general occurring upon rocks or piles at or just above the reach of the waves along the shores of the entire bay as well as those outside the Golden Gate.

Range.—Sitka, to Cape San Lucas, Lower California (Orcutt).

Lacuna Turton

Lacuna porrecta Carpenter

Lacuna porrecta Carpenter (1863), p. 656; (1864*b*), p. 429; Arnold, R. (1903), p. 303.

Description.—Arnold (1903) described this species as follows:

"Shell small, white; spire not much elevated; whorls three, convex; body-whorl very slightly angulated; suture distinct; aperture ovate; lip effuse; umbilical chink large. . . . Distinguishable by large umbilical chink, depressed spire, large angle at apex, and effuse outer lip."

Height, 2 to 4 mm.

Occurrence.—At stations D 5731 (*3*), D 5797* (*1*).

Wood and Raymond (1891) found this small gastropod within San Francisco County. It has been obtained by the Survey at two dredging stations, one being outside the Golden Gate in 16 fathoms on a sand and gravel bottom and the other, within the middle division of the bay in 8½ fathoms on a pure sand bottom.

Range.—Vancouver Island, B. C., to San Francisco, California.

Lacuna unifasciata Carpenter

Lacuna unifasciata Carpenter (1856*d*), p. 205; (1863), p. 656; Keep (1911), p. 205.

Description.—Keep (1911) described this small littoral species as follows:

"Externally it is brown and glossy, with the color broken into dots on the keel of the body-whorl. The aperture is semi-lunar in shape, and the flattened columella has a small umbilical fissure from which circumstance it receives its generic name."

Height, 2 to 3 mm.

Occurrence. — At Bonita Point* (*8*), and questionably at the Presidio.

This species is recorded from this region by Carpenter (1863) and by subsequent writers. Obtained by the Survey only at the shore station at Bonita Point.

Range.—Farallon Islands to San Diego (Carpenter).

Lacuna variegata Carpenter

Lacuna variegata Carpenter (1863), p. 656; (1864*b*), p. 428; Tryon (1887*b*), p. 266, pl. 50, fig. 58.

Description.—Tryon (1887) describes this species as follows:

"Thin, expanded in front, periphery rounded or obtusely augulated, smooth, polished, fulvous, irregularly strigate with chestnut, with frequently a peripheral band of white spots, and sometimes another below the suture."

Height, 1 to 3 mm.

Occurrence.—At stations D 5711 (*2*), D 5740 (*1*), Presidio (*19*)*, Bonita Point (*52*).

This species has not hitherto been recorded from the vicinity of San Francisco. It is restricted in the Survey collections to the middle division of the bay. Living specimens were very abundant at the shore station on both shores of the Golden Gate and at a single dredging station at a depth of 8½ fathoms from a bottom of sand and shells.

Range.—Vancouver Island, B. C., to San Diego, California (Tryon).

CAPULIDAE

Hipponix Defrance*

Hipponix antiquatus Linnaeus

Hipponix antiquatus Linneaus (1766–1768), p. 1259.

Hipponyx antiquatus, Tryon (1886*b*), p. 134, pl. 40, figs. 93–99.

Amalthea antiquatus, Blankinship and Keeler (1892), p. 153.

Description.—This species was defined by Tryon as follows:

"White, apex posterior, concentrically rudely, closely laminated, more or less distinctly radiately striated; epidermis pilose."

This form was listed from the Farallon Islands by Blankinship and Keeler. Not found among the Survey collections.

Range.—Farallon Islands to Lower California (Orcutt).

Crepidula Lamarck

Crepidula convexa Say

Plate 35, figures 5 and 6

Crepidula convexa Say (1822), p. 227; Tryon (1886*b*), p. 125, pl. 36, fig. 10; Sumner, Osborn and Cole Davis (1913), p. 722, chart 184.

Crepidula convexa Say var. *glauca* Say, Stearns (1899*a*), p. 81.

Description.—Tryon (1886) described this species as follows:

"Convex, with somewhat trigonal outline, high back and obliquely beaked apex; whitish or glaucous radiately lined with chestnut spots, with sometimes larger nebulous chestnut-purple markings."

Length, 3 to 12 mm.

---

*For change in the spelling of the genus see Dall (1915*b*, p. 104).

Occurrence.—At stations D 5768 (*8*, 10), D 5781 (*5*, 3), D 5782* (*6*, 12), D 5783 (*1*, 2), D 5784 (*1*, 4), D 5810 (67), D 5811 (1, 12), D 5847 (1).

This species has been introduced inadvertently along with the seed oysters from the Atlantic. The large number of living specimens obtained at or in the vicinity of the oyster beds at the southern end of San Francisco Bay indicates that this exotic species has gained an assured foothold within these local waters. It was first recognized on this coast by Stearns (1899a) under the name of *C. convexa* var. *glauca* Say.

It has been dredged by the Survey in the southern portion of the bay, in the vicinity of the oyster beds, and at one locality off the Alameda shore. Living specimens were obtained on gravel or shell bottoms in depths ranging from 1 to 4 fathoms. It commonly occurs attached to a living oyster.

This form differs from the West Coast species *Crepidula adunca* in having a higher apex which is more centrally located than in the western form.

Range.—San Francisco, California, Nova Scotia to Florida.

Crepidula nivea Adams

Plate 35, figures *7a* and *7b*, plate 55

Crepidula nivea Adams, C. B. (1852), p. 234; Keep (1911), p. 208.

Crepidula navicelloides Nuttall, Carpenter (1863), p. 654.

Description.—This species was originally described as follows:

"Shell ovate-elliptic; rather thick; within snow white; without dingy white, sometimes with a faint tinge of brown; very irregularly concentrically more or less wrinkled, with very distinct striae of growth; apex turned more or less to the right, moderately prominent, marginal; septum longitudinally sub-angular, with a deep sinus at the left and a shallow one at the right; margin thick, exhibiting striae of growth. . . ."

Length, 3 to 25 mm.

Occurrence.—At stations D 5708 (*1*), 5712 (1), D 5723 (*1*, 1), D 5744 (*1*), D 5756 (*1*), D 5764 (*3*), D 5766 (*4*), D 5767 (*53*, 11), D 5868 (*67*, 3), D 5781 (*32*), D 5782* (*7*, 3), D 5783 (1), D 5784 (*1*, 105), D 5810 (*8*, 2), D 5811 (1), D 5813 (*1*, 1), D 5817 (*3*), D 5817 B (*1*) D 5846 (*6*), Standard Oil Pier, Richmond (*6*), Red Rock (*2*), and questionably at D 5737, D 5833.

This mollusk has been reported from the Farallon Islands and San Francisco Bay. Living specimens were obtained by the Survey at 17 stations quite generally distributed from the lower extremity of the bay to the upper portion of San Pablo Bay. It was frequently found associated with *Ostrea lurida.*

Range.—Puget Sound to Panama.

Crucibulum Schumacher

Crucibulum spinosum (Sowerby)

Calyptraea spinosa Sowerby (1820–1824), pl. 23, figs. 4, 7.

Crucibulum spinosum Carpenter (1863), p. 654; Tryon (1886*b*), p. 118; Arnold (1903), p. 306.

Description.—Arnold (1903) described this species as follows:

"Shell conical, elevated, apex rather acute, slightly curved, smooth, subcentral; surface ornamented with numerous rounded, radiating ridges, and sometimes with concentric rows of spires; concentric lines of growth visible; a cup-shaped lamina is attached along a line on one side of the interior of the shell; inner surface smooth; rim thin; aperture nearly circular."

Carpenter mentions this species as occurring on the Farallon Islands. No specimens were obtained by the Survey.

Range.—Farralon Islands to San Diego (Carpenter).

NATICIDAE

Polinices Montfort

Polinices draconis (Dall)

Plate 38, figures 2*a* and 2*b*

Lunatia draconis Dall (1903*b*), p. 174.

Description.—Dall originally described this species as follows:

"Shell depressed, solid, cream color, sometimes with a ferruginous or livid tinge, with six whorls; nuclear whorl very small, smooth; later ones with an obscure, nearly obsolete spiral sculpture like flattened-out threads, over which run microscopic, close-set, spiral striae: suture with the whorl in front of it feebly channeled and the excavation bounded by an obsolete thread; top of the whorls flattened, part of the base bordering the umbilicus also flattish, the remainder of the whorl rounded, turgid; umbilicus wide and deep, its walls excavated and closely spirally striated aperture oblique, semi-lunate, outer lip thin, base rounded; the angle where the lip meets the body filled with a smooth white callus, the anterior angle of the pillar lip also thickened."

Height, 13 to 60 mm.

Occurrence.—At stations D 5787 (f.), D 5788 (*2*), D 5789 (*1*, 1), D 5790 (*1*), D 5843 (1), Fishing ground west of Golden Gate (*15*), and questionably at D 5718, D 5763 D 5811, D 5842.

Dall (1903d) reports this species from the Farallon Islands from a depth of 37 fathoms. Determinable specimens of this form were obtained by the Survey only from the open ocean. It was dredged at depths ranging from 3 to 68 fathoms on bottoms comprised of fine dark green sand. Several fragments of shells that have been doubtfully referred to this species were dredged at several localities within San Francisco Bay. These may, however, belong to *P. lewisi* which is known to occur within the bay. The fragment from station D 5811, may have been brought here along with the eastern oysters with which it was found associated.

Range.—Farallon Islands to Catalina Islands, California (Dall).

Polinices lewisi (Gould)

Plate 38, figure 1

Natica lewisii Gould (1847), p. 239.

Lunatia lewisii Tryon (1886*a*), p. 35, pl. 13, figs. 11, 12; pl. 9, fig. 70.

Polynices lewisii Arnold, R. (1903), p. 315, pl. 10, fig. 4.

Description.—This univalve was described by Tryon (1886*a*) as follows: "Conical globose, obsoletely spirally striate, yellowish white or brownish white; whorls obliquely sloping above with, in old specimens, an obtuse angle on the shoulder, defined by a slight concave constriction above and below it; interior chocolate white; umbilicus narrow and deep, with a tongue-shaped, chocolate-tinged callus extending partly over it from above."

Height, 30 to 75 mm.

Occurrence.—At stations D 5702 (1), D 5731 (1), D 5737* (2), D 5795 (1).

This large predaceous gastropod has not hitherto been reported from the vicinity of San Francisco. Shells were dredged by the Survey in 10½ to 19 fathoms within Raccoon Straits, the Golden Gate and in the open ocean.

Range.—Strait of Juan de Fuca, Washington, to San Diego, California (Cooper).

Eunaticina Fischer

Eunaticina oldroydi (Dall)

Plate 35, figures 10*a* and 10*b*

Sigaretus oldroydi Dall (1897*b*), p. 85.

Eunaticina oldroydi, Dall (1899*a*), p. 85.

Description.—Dall (1897*b*) originally described this species as follows: "Shell large, thin, naticoid, with a short spire and 3–4 inflated whorls; color pale brown, livid on the spire, fading to waxen on the base; surface sculptured with extremely fine wavy spiral striae; aperture ample, oblique, the outer lip thin, a little patulous, the body covered with a thin callus, the pillar lip obliquely cut away, wide near the junction with the body, the basal part of the margin receding; umbilicus large, pervious, its walls covered with a thin, silky, brown wrinkled epidermis."

Height, 24 mm.

Occurrence.—A single specimen from the Fishing Grounds* west of the Golden Gate was obtained by the Survey at a depth of 3 fathoms.

Range.—Drake's Bay to San Pedro, California (Dall).

RISSOIIDAE

Barleeia Clark

Barleeia subtenuis Carpenter

Barleeia subtenuis Carpenter (1863), p. 656; Tryon (1887*c*), p. 393, pl. 60, fig. 73.

Description.—This species was described by Tryon as follows:

"Thin, subpellucid, corneous-chestnut; with 4 normal whorls, flatly convex, with distinct suture; lip acute."

This species is reported by Carpenter as occurring at the Farallon Islands. A single worn specimen was dredged by the Survey outside the Golden Gate which may possibly represent this species.

Range.—Farallon Islands to San Diego California (Carpenter).

CERITHIIDAE

Cerithiidea

Cerithidea californica (Haldeman)

Plate 39, figures 8*a* and 8*b*

Cerithium californicum Haldeman (1840–1845), no. 1.

Cerithium sacrata Gould, Carpenter (1863), p. 655; Tryon (1887*a*), p. 162, pl. 33, figs. 69–72.

Cerithidea californica, Dall (1892), p. 277; Arnold, R. (1903), p. 296.

Description.—Arnold (1903) described this species as follows:

"Shell turreted; apex decollated; whorls nine or ten, slightly convex, ornamented with three or four spiral ridges and numerous transverse ridges, the two sets varying in prominence; suture impressed, distinct; aperture subquadrate; outer lip effuse, thickened, broadly rounded below, and slightly produced in a columellar beak; inner lip straight above this beak."

Carpenter (1863) reports this species from San Francisco Bay; although it is not found among the Survey collections, it is known to occur within San Francisco Bay along the shores of Lake Merritt and in the brackish waters near Belmont and Mill Valley.

Range.—Baulinas Bay to Mazatlan, Mexico (Tryon).

Bittium Leach

Bittium eschrichti (Middendorff) var. **montereyense** Bartsch

Bittium filosum Carpenter, Arnold, R. (1903), p. 292; Blankinship and Keeler (1892), p. 153.

Bittium eschrichti var. *montereyense* Bartsch (1911), p. 387.

Blankinship and Keeler (1892) report this species under the name of B. *filosum,* as occurring at the Farallon Islands. That name has now been superceded by that of *B. eschrichti,* which is a northern form represented in the southern waters by the variety *montereyense.* It is probable that those authors obtained the variety instead of the typical species.

The same authors list the species *B. armillatum* Carpenter from the Farallon Islands, but that form is now thought to be an extinct species.

Range.—Northern California to Cape San Lucas, Lower California.

Bittium subplanulatum Bartsch

Plate 41, figures 5*a* and 5*b*

Bittium subplanulatum Bartsch (1911), p. 395, pl. 57, fig. 5.

Description.—This species was originally described by Bartsch (1911) as follows:

"Shell broadly elongate-conic, milk white. Nuclear whorls a little more than one, well rounded, smooth. The first of the post-nuclear whorls well rounded, marked by three spiral cords, one of which is at the summit, another on the middle of the whorl, while the third is a little above the suture. The succeeding turns show four spiral cords, of which the one at the summit is a little less strong than the rest; the remaining three divide the space between the sutures into four equal parts. Beginning with the fourth whorl, intercalated cords make their appearance between the primary ones, so that on the last whorl we have an intercalated cord and sometimes two between all the primary cords; these, however, are never quite as strong as the principal ones. In addition to the spiral cords, the whorls are marked by decidedly curved, slender, well rounded, almost vertical, axial ribs, which are scarcely indicated on the first turn, while 14 of them occur upon the second and third, 16 upon the fourth, 18 upon the fifth and sixth, 22 upon the seventh, 24 upon the eighth, and 26 upon the penultimate turn. The intersections of the spiral cords and axial ribs form weakly developed, rounded tubercles which are truncated on their posterior margin, while spaces enclosed between them are very shallow quadrangular pits. Sutures strongly constricted. Periphery and base of the last whorl well rounded, marked by slender, spiral cords, of which those immediately below the periphery are the strongest and are truncated on the posterior margin, sloping gently anteriorly. Of these cords, seven occur on the base of the type. Aperture rather large, irregularly oval, channeled anteriorly; posterior angle acute; outer lip thin, rendered sinuous by the external sculpture; columella decidedly oblique, strongly curved, and reflected."

Length, 7 mm.

Occurrence.—At station D 5788 (1).*

The only specimen referred to this species, was dredged by the Survey in the vicinity of the Farallon Islands in 68 fathoms from a bottom of fine dark green sand.

Range.—San Francisco to Point Loma, California.

CERITHIOPSIDAE

Cerithiopsis Forbes

[**Cerithiopsis,** sp.]

The similarity of the names of the eastern species *C. tubercularis* (Montagu) with that of *C. tuberculoides* Carpenter apparently confused Cooper, also Blankinship and Keeler in reporting the former species from the Farallon Islands. Since Carpenter's form has a known range such as to make it improbable that it occurs as far north it is possible that those authors obtained *C. columna* Carpenter, which is known to have a range such as to include these waters.

CYPRAEIDAE

Trivia Gray

Trivia californica Gray

Trivia californica Gray, Tryon (1885*b*), p. 202, pl. 22, figs. 18, 19, 20, 37; Blankinship and Keeler (1892), p. 153.

Description.—This form has been redefined by Tryon as follows: "Ovate, rather globose; ribs distant, dorsal impression faint, whitish, teeth whitish."

This species has been reported from the Farallon Islands by Cooper and by Blankinship and Keeler. It is not among the Survey collections.

Range.—Farallon Islands (Cooper); San Diego, California (Orcutt).

Erato Risso

Erato vitellina Hinds

Erato vitellina Hinds (1844*a*), pl. 13, figs. 22, 23; Tryon (1883*c*), p. 10; Blankinship and Keeler (1892), p. 153.

Description.—Characterized by Tryon (1883) as follows: "Obesely ovate, aperture rather wide, dark red, lighter on the thickened lip-margin."

This species is known from this region only through the report of Blankinship and Keeler.

Range.—San Francisco (Blankinship and Keeler); southern California to Acapulco, Mexico (Tryon).

OVULIDAE

Pedicularia Swainson

Pedicularia californica Newcomb

Pedicularia californica Newcomb (1864), p. 121; Tryon (1885*a*), p. 242, pl. 1, fig. 4.

Description.—The following is the description given by Tryon:

"Depressly globose, crimson colored, minutely transversely striated, above rounded, below broadly rounded; lip expanded, semicircular; columella thick, dilated within, straight; aperture elongately subovate; extremities broadly notched."

This species is indigenous to the Farallon Islands according to Cooper. It was not obtained by the Survey.

Range.—Farallon Islands to Monterey, California (Orcutt).

COLUMBELLIDAE

Columbella Lamarck

Columbella gausapata Gould

Plate 41, figures 1*a* and 1*b*; pl. 56

Columbella gausapata Gould (1849*c*), p. 170; Arnold, R. (1903), p. 239, pl. 10, fig. 8.

Astyris gausapata, Keep (1892), p. 35, fig. 15.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, rather heavy; spire elevated; apex acute; whorls seven, slightly convex; body-whorl ventricose, slightly angulated; whorls smooth except for delicate incremental lines; sutures depressed, distinct; columella recurved and striated on outside with faint spiral ridges and grooves; aperture elongate-ovate; canal prominent, slightly curved; outer lip thickened with a row of spirally elongate denticles; inner lip smooth."

Height, 3 to 10 mm.

Occurrence.—At stations D 5703 (*27*), D 5706 (*7*), D 5721 (2), D 5723 (*35*), D 5739 (*13*), D 5740 (*12*, 4), D 5743 (*45*), D 5754 (*5*), D 5755 (*5*), D 5772 (*14*), D 5775 (*1*), D 5778 (*2*), D 5785 (*hundreds*), D 5786 (*hundreds*), D 5787 (*hundreds*), D 5788 (*41*), D 5789 (*11*, 1), D 5790 (*hundreds*), D 5791 (*hundreds*), D 5792 (*hundreds*), D 5796 (5), D 5798 (*2*), D 5799 (*6*), D 5802 (*12*), D 5803 (*1*), D 5805 (*20*), D 5825 (*1*), D 5825 A (2), D 5825 A (15), D 5828 B (8), D 5830 (*3*), D 5840 (8), Fishing Grounds west of Golden Gate (*6*), Bonita Point (*2*), Sausalito (*7*).

Although this is a very common species along the beaches of the open ocean it has not been listed from the vicinity of San Francisco by previous writers. It has a general distribution occurring in

Carquinez Strait, in the middle and lower division of the bay as well as in the vicinity of the Farallon Islands. Living specimens were taken along the shore at several localities and at depths ranging up to 68 fathoms. This species occurs most frequently upon a bottom that may be characterized as muddy sand.

Range.—Alaska to San Diego, California (Cooper).

BUCCINIDAE

Amphissa H. and A. Adams

Amphissa corrugata (Reeve)

Plate 41, figures 4*a* and 4*b*

Buccinum corrugata Reeve (1846–1847), pl. 4, fig. 110.
Truncaria corrugata, Carpenter (1863), p. 662.
Amphissa corrugata, Tryon (1883b), p. 197, pl. 63, fig. 66; Arnold, R. (1903), p. 241.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, solid, fusiform; spire elevated; apex acute; whorls seven, slightly convex, with about eighteen to twenty rather wavy, slightly oblique, rounded, transverse ridges extending from suture to suture; spiral ornamentation consists of numerous fine raised lines in the interspaces between the transverse ridges; suture impressed, distinct aperture rhomboidal, narrow; outer lip lirate within; inner lip incrusted, smooth; canal short, recurved; pillar spirally lined externally."

Carpenter (1863) reported this species from this region. Obtained from a depth of 40 fathoms. Not obtained by the Survey.

Range.—Sitka, Alaska, to Monterey, California (Tryon).

Cantharus Bolten

Cantharus, sp.

Wood and Raymond (1891) report the tropical species *C. gemmatus* Reeve from these local waters. It is probable that those authors confused Reeve's species with some other similar form.

Chrysodomus Swainson

Chrysodomus dirus (Reeve)

Plate 37, figure 3

Buccinium dirus Reeve (1846–1847), pl. 62, no. 92.
Euthria dira, Tryon (1881), p. 151, pl. 72, figs. 232, 233.
Chrysodomus dirus, Carpenter (1863), p. 664.

Description.—This species was described by Tryon (1881) as follows:

"Upper whorls longitudinally plicate, plicae becoming evanescent on the body-whorl; whole surface deeply engraved with narrow revolving channels, making the interstices appear as though covered with revolving, flat-topped ribs; sometimes these ribs are divided by an impressed line into pairs. Grayish brown, revolving ribs darker; aperture yellowish brown, ribbed within and stained darker in the interstices at the lip.''

Carpenter (1863) reported this common intertidal species from this region. It was not taken by the Survey.

Range.—Sitka, Alaska, to Monterey, California (Tryon).

Chrysodomus tabulatus Baird

Plate 37, figure 2

Chrysodomus tabulatus Baird (1863), p. 66; Carpenter (1863), p. 663; Arnold, R. (1903), p. 228, pl. 7, fig. 6.

Neptunea tabulata, Tryon (1881), p. 121, pl. 49, figs. 284, 286.

Description.—Arnold (1903) described this species as follows:

''Shell large, fusiform; spire elevated; apex subacute; whorls eight, sharply angulated and keeled above, forming a rimmed spiral table; surface ornamented with revolving ridges of alternating size; suture very deeply impressed; aperture pyriform; outer lip thin, smooth; inner lip incrusted; canal long, narrow, curved backwards; columella twisted, spirally ridged.''

Length, 25 to 78 mm.

Occurrence.—At station D 5789* (*3*, 1).

This gastropod has not hitherto been reported from the vicinity of San Francisco. Several living specimens were dredged by the ''Albatross'' in the vicinity of the Farallon Islands at a depth of 46 fathoms from a bottom composed of fine dark green sand.

Range.—Strait of Juan de Fuca, Washington, to Catalina Island, California (Cooper).

NASSIDAE*

Nassa Lamarck

Nassa fossata (Gould)

Plate 35, figures 12*a* and 12*b*; plate 57

Buccinum fossatum Gould (1849*b*), p. 152; (1862), p. 67.

Nassa fossata, Tryon (1882*a*), p. 55, pl. 17, figs. 316, 318; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 232.

Description.—Arnold (1903) described this species as follows:

''Shell small, conical; spire elevated; apex subacute; whorls seven, convex; body-whorl ventricose; ornamentation of fourth and fifth whorl consists of five or six strong, nodose, spiral ridges which increase in number by intercalation on the lower whorls; the prominence of the nodes varies inversely with the number of ridges, the ridges on the body-whorl being nearly smooth and alternating large and small; the ridges near the angle of the whorl reach the greatest

*Dall (1917, p. 575) has recently shown that the name *Alectrion* should be used for the ''reticulate species (of *Nassa*) with little or no callus, no hump, and simple or nearly simple outer lips . . .''

prominence; suture deeply impressed, distinct; aperture ovate; outer lip thickened and denticulated by ends of revolving internal ridges; inner lip incrusted, the incrustation spreading over part of body-whorl and columella; columella short, curved, spirally striated, and grooved deeply next to body-whorl; anterior sinus short, broad, recurved.''

Height, 4 to 38 mm.

Occurrence.—At stations D 5714 (1), D 5739 (1), D 5743 (*1*), D 5744* (*1*, 3), D 5747 (*1*), D 5754 (*3*), D 5772 (*22*), D 5788 (*18*, 2), D 5792 (1), D 5796 (1), D 5803 (*4*), D 5808 (7), D 5809 (8), D 5811 (1), D 5821 (*1*), D 5821 A (*1*), D 5823 (*1*), D 5824 B (1), D 5825 (f.), D 5829 A (1), D 5833 (1), Fishing Grounds west of Golden Gate (*6*), Richmond (1), and questionably at D 5710, D 5724, D 5730, D 5763, D 5764, D 5785, D 5786, D 5790, D 5812.

This mollusk was first reported from this region by Wood and Raymond (1891). It is common along the beaches of the open ocean, and has been taken by the Survey at a number of stations within the middle and lower divisions of the bay as well as outside the Golden Gate. Living specimens were dredged in 1¼ to 68 fathoms, being most frequently taken at a depth less than 10 fathoms. There appears to be but little correlation between the distribution of this predaceous gastropod and the type of bottom upon which it was taken.

Range.—Strait of Juan de Fuca, Washington, to Cerros Island, Lower California (Dall).

Nassa mendica Gould

Plate 35, figure 9; plate 58

Nassa mendica Gould (1849*b*), p. 155; (1862), p. 70; Carpenter (1863), p. 662; Tryon (1882*a*), p. 56, pl. 17, figs. 370–232; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 233.

Description.—The following is Arnold's (1903) description of this species: ''Shell small, conical; spire elevated; apex acute; whorls seven, convex; ornamented with a varying number of transverse ridges and a few less prominent spiral ridges; suture deeply impressed, distinct; aperture subquadrate; outer lip thin, smooth on edge, but denticulated remote from margin; inner lip incrusted; columella curved, spirally striated, and separated from body-whorl by deep groove; canal short, recurved.''

Height, 4 to 18 mm.

Occurrence.—At stations D 5704 (*6*), D 5705 (*4*), D 5706 (*7*, 4), D 5712 (1), D 5739 (*4*), D 5740 (3), D 5741 (1), D 5755 (1), D 5772 (*6*), D 5773 (*14*), D 5775 (*3*), D 5777 (1), D 5779 (1), D 5781 (*1*), D 5791 (*1*, 1), D 5796 (2), D 5808 (1), D 5725 A (3), D 5827 B (1), D 5828 B (*7*, 1), D 5734 (1), and questionably at D 5701, D 5785, D 5797.

Both Carpenter and Wood and Raymond recognized this species from the vicinity of San Francisco. It is recorded at twenty-one of the "Albatross" stations, having a distribution pattern similar to that of *Nassa fossata*. Living specimens were obtained only within the middle division of the bay at depths ranging from 1¼ to 29 fathoms. A variety of bottom types are represented at these stations. The species appears to prefer the muddy localities in preference to the sandy ones.

Range.—Sitka, Alaska, to San Diego, California (Cooper).

Nassa perpinguis Hinds

Plate 35, figure 13

Nassa perpinguis Hinds (1844*a*), p. 36, pl. 9, figs. 12, 13; Tryon (1882*a*), p. 56, pl. 17, fig. 319; Arnold, R. (1903) p. 234.

Description.—This species is described by Arnold (1903) as follows:

"Shell small, conical; spire elevated; apex subacute; whorls seven, convex, abruptly truncated at posterior margin, forming a spiral table; ornamentation consists of sharp, spiral ridges with slightly wider interspaces, and posteriorly sloping transverse ridges, the whole giving a decidedly cancellate appearance to the surface; suture deeply impressed, distinct; aperture subovate; inner portion of aperture ridged by spiral sculpture; outer lip thin; inner lip thinly incrusted; columella twisted and spirally ornamented; groove on upper part of columella prominent; canal short, curved."

Height, 3 to 33 mm.

Occurrence.—At stations D 5754 (*4*), D 5755 (1), D 5785 (*24*, 12), D 5786 (*10*, 3), D 5787* (*22*, 9), D 5789 (*72*, 48), D 5790 (2), D 5791 (*5*, 9), D 5792 (*8*, 3), D 5826 B (1), D 5841 (1), and west of the Farallon Islands (*3*).

According to Cooper, San Francisco is the northern limit of the range of this species. Restricted to stations from the open ocean and the middle division of the bay, except for a single specimen near the Ferry Building at San Francisco. Living specimens were dredged at depths ranging from 4½ to 815 fathoms on bottoms that are predominantly sandy.

Range.—San Francisco, California, to Lower California (Cooper).

Ilyanassa Stimpson

Ilyanassa obsoleta (Say)

Plate 35, figures 11*a* and 11*b*

Nassa obsoleta Say (1822), p. 232.

Ilyanassa obsoleta Tryon (1882*a*), p. 60, pl. 18, figs. 347–349; Sumner, Osburn, Cole, and Davis (1913), p. 710, chart 168.

Description.—Tryon (1882) described this eastern species as follows:

"Chocolate-brown or olive, with occasionally a faint, lighter colored central band; deep chocolate within the aperture, with a central white band."

Height, 7 to 23 mm.

Occurrence—At stations D 5811 (*4*), D 5814 (*1*), near Key Route Pier*, Oakland (*36*).

This eastern species, probably introduced with "seed" oysters, was first found upon the oyster beds near Alameda in the year 1909 by Keep (1911). It was obtained by the Survey at two localities in the vicinity of Point San Pedro and near the Key Route Pier, Oakland. At the more southern locality it was associated with the oysters, upon which it undoubtedly preys. It occurs at a depth of 1 fathom on a mud-shelly bottom.

Range.—San Francisco, California.

MURICIDAE

Murex Linnaeus

Murex carpenteri (Dall)

Pteronotus carpenteri Dall (1899d), p. 138.

Murex carpenteri, Orcutt (1915), p. 93.

Description.—Dall originally described this species as follows:

"Shell trilate, reddish brown, with obscure spiral lines of darker brown, the aperture whitish with a darker throat, nucleus brownish, whorls about eight, the last much the largest; suture distinct, appressed, intervarical surface smooth or obscurely spirally striate, the apical whorls with reticulate threading; the last two or three whorls with a single obscure nodulosity on the periphery between the varices; varices continuous up the spire; posterior face of the varices smooth with obscure radial ridges which slightly crenulate the margin, in adolescent shells; but in full grown ones there are about five rather wide, low radial ridges, each of which terminates in a digitation of the margin; anterior faces of the varices with a profuse, close-set crenulate imbrication, which in fully grown shells show radial depressions corresponding to the ridges on the back of the varix; digitations excavated in a shallow manner anteriorly, terminating in somewhat blunt projections, thin and sharp edged; aperture small, oval, with a continuous, raised, smooth margin with denticulations; canal closed, moderately wide, bent to the right in front, a disused smaller canal bordering its posterior two-thirds on the left. Length of shell 57, of last whorl from the suture 42; width including varices 35, width of aperture 9.5; length of aperture, 13 mm."

This species, according to Orcutt (1915), occurs at the Farallon Islands.

Range.—Farallon Islands to San Diego, California (Orcutt).

Murex (Ocinebra) **interfossa** (Carpenter)

Plate 37, figures 1*a* and 1*b*

Ocinebra interfossa Carpenter (1863), p. 663; Tryon (1880), p. 131, pl. 39, fig. 484; Arnold, R. (1903), p. 255.

Description.—Tryon (1880) described this species as follows:

"Shell narrower and more shouldered than the last species, the lattice of revolving lirae and longitudinal ribs coarser and more elevated; canal short, closed."

Height, 8 mm.

Occurrence.—At station D 5770 (1).

This species has been reported by Carpenter from the Farallon Islands and by Wood and Raymond from San Francisco. A single shell was dredged by the Survey within the middle division of the bay in 5 fathoms.

Range.—Sitka, Alaska, to San Diego, California (Cooper).

Murex (Ocinebra) **lurida** (Middendorff)

Plate 37, figures 4*a* and 4*b*

Tritonium luridum Middendorff (1847–1849), p. 150, pl. 4, figs. 4, 5.

Ocinebra lurida, Carpenter (1863), p. 663; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 256.

Description.—This species was described by Arnold (1903) as follows:

"Shell of medium size, fusiform; whorls six, convex, slightly angulated near posterior margin; upper whorls with several transverse ridges; surface ornamented with numerous rounded, raised lines; suture deeply impressed, distinct; body-whorls not extraordinarily ventricose; aperture subovate; outer lip thickened, denticulated; inner lip incrusted; columella widened; umbilicus subperforate; canal narrow, sometimes with overgrowing lips."

Height, 10 to 14 mm.

Occurrence.—At stations D 5770 (*1*), Bonita Point* (*3*, 1).

Carpenter and subsequent writers list this species as occurring in the vicinity of San Francisco. It is represented in the Survey collections by a single living specimen dredged near Bonita Point at a depth of 5 fathoms, and by four specimens obtained from the near-by rocky shore.

Range.—Sitka, Alaska, to San Pedro, California.

Urosalpinx Stimpson

Urosalpinx cinereus (Say)

Plate 37, figures 8*a* and 8*b*

Urosalpinx cinereus Say (1822), p. 236.

Urosalpinx cinereus, Stearns (1899*b*), p. 112; Tryon (1880), p. 152, figs. 487, 489, and 493.

Description.—Tryon has described this species as follows:

"Usually light brown or yellowish, rarely with several revolving indistinct, rufous bands. Within the aperture varying from light flesh-color to dark salmon, chocolate or purple."

Height, 6 to 27 mm.

Occurrence.—At stations D 5781 (*17*, 13), D 5782 (*6*), D 5783 (*17*, 1), D 5784 (*11*, 9), D 5795 (1), D 5810 (*12*), D 5811 (*2*, 12), D 5812 (*1*, 2), D 5813 (*2*), D 5814 (*4*, 8), D 5847 (2), and questionably at D 5773.

Stearns (1894) was the first to recognize this exotic species within San Francisco Bay. This is the oyster drill, which plays so much havoc on the oyster beds. It is abundant in the lower division of the bay in the vicinity of Point San Mateo. Living specimens were dredged in 1 to 4 fathoms from bottoms composed of mud and shells.

Range.—Known on the Pacific Coast only in the vicinity of the beds of *Ostrea elongata*. Maine to Florida (Tryon).

THAISIDAE Dall

Thais Bolten

Thais lamellosa (Gmelin)

Plate 40, figures 1, 2, 3, 4, 5, 5*a*, 6, 7, 8; plate 59

Buccinum lamellosum Gmelin, Linnaeus (1788–1793), p. 3498.

Purpura crispata Chemnitz, Carpenter (1863), p. 662; Arnold, R. (1903), p. 261.

Thais (Nucella) lamellosa, Dall (1915a), p. 563.

Description.—The following is Arnold's (1903) description of this species:

"Shell fusiform, thick; spire elevated; apex subacute; whorls five to seven, convex or angulated, with one or more prominent spiral ridges on angular part of whorl; suture impressed, distinct; aperture ovate to elliptical; outer lip effuse, generally denticulate; inner lip incrusted, smooth; canal short, curved backwards; umbilicus subperforate."

Height, 4 to 60 mm.

Occurrence.—At stations D 5700 (*10*, 5), D 5701 (1), D 5702 (*39*, 24), D 5708 (*10*, 24), D 5714 (*2*, 12), D 5723 (14), D 5724 (1), D 5737 (2), D 5753 (1), D 5755 (1), D 5773 (*1*, 7), D 5775 (3), D 5779 (2), D 5781 (*3*), D 5795 (*6*, 23), D 5796 (*1*, 27), D 5800 (13), D 5801 (*6*, 8), D 5802 (1), D 5808 (*1*, 17), D 5809 (*2*, 45), D 5812 (*1*), D 5821 B (2), D 5823 A (1), D 5824 B (425), D 5825 (*1*), D 5825 B (1), D 5826 (2), D 5826 A (60), D 5826 B (10), D 5827 (18), D 5827 A (21), D 5827 B (7), D 5828 B (7), D 5829 (1), D 5829 A (40), D 5831 (1), D 5832 A (3), D 5833 (14), D 5834 (1), D 5841 (13), D 5843 (2), Red Rock (*53*, 14), Sausalito (2), and questionably D 5712, D 5731, D 5732, D 5736, D 5797, D 5798.

This prevalent species has a general distribution within the middle and the lower divisions of the bay. It is characteristically a littoral species and would show a different distributional pattern from that given on plate 46, had the shores of the bay been investigated.

Range.—Aleutian Islands, Alaska, to Monterey, California, with varieties ranging farther south.

Thais lamellosa (Gmelin) var. **septentrionalis** (Reeve)

Purpura septentrionalis Reeve (1846), pl. 10, fig. 50.

Purpura crispata Chemnitz var. *septentrionalia*, Tryon (1880), p. 175, pl. 54, fig. 166; Wood and Raymond (1891), p. 57.

This smooth form occurs abundantly in the region of San Francisco Bay. No attempt was made to separate it from the typical form as found in the Survey collections.

Range.—Northward from Santa Barbara, California.

Thais lamellosa (Gmelin) var. **franciscana** Dall

Thais lamellosa (Gmelin) var. *franciscana* Dall (1915*a*), p. 565.

Description.—This variety was described by Dall in the following words: "Shell subfusiform, heavy, with a subconic spire shorter than the aperture, laminae reduced to obsolete low imbrications or usually none; whorls flattened behind the shoulder; major spirals low, feeble, two on penultimate whorl, or more on the last whorl; minor spirals obsolete or none; aperture large, the outer lip flaring, umbilical chink usually distinct but closed."

This variety was not recognized until after the fauna had been determined. The variations within this species are illustrated on plate 40. Of the specimens figured, the following may be considered as belonging to this variety (pl. 40, figs. 5*a* and 5*b*).

Range.—Known only from San Francisco Bay, which is the type locality for the species.

Thais lima (Martyn)

Purpura lima Martyn, Tryon (1880), p. 175, pl. 54, fig. 159; Wood and Raymond (1891), p. 57.

Description.—Tryon (1880) described this species as follows:

"Its characteristic appearance is due to a considerable number of narrow, elevated revolving ribs, which are alternately larger. The shell is usually so thin that the external ribs form corresponding sulcations within the aperture. The suture is frequently channeled, color light brown, more or less banded and clouded with a deeper tint."

This species was not found in the collections dredged by the "Albatross." Wood and Raymond (1891) reported it from San Francisco County.

Range.—California to Alaska (Tryon).

Thais emarginata (Deshayes)

Purpura saxicola var. *emarginata* Deshayes, Carpenter (1863), p. 62; Wood and Raymond (1891), p. 57.

Purpura emarginata, Tryon (1880), p. 175, pl. 53, fig. 156.

Thais emarginata, Dall (1915a), p. 5.

Description.—Tryon characterized this species as follows:

"When the revolving ribs of *saxicola* or *ostrina* become broken up into nodules, the result is *P. emarginata* Desh., which is typically a very distinct looking shell, but connected by minute gradations with the smoothest *ostrina.*"

Wood and Raymond recognized this species from this region. It was not obtained by the Survey.

Range.—San Francisco to Santa Rosa, California.

Thais emarginata (Deshayes) var. **ostrina** (Gould)

Plate 39, figures 2, 3, 4, and 5

Purpura ostrina Gould (1853), p. 244; (1862), p. 225.

Purpura saxicola var. *ostrina,* Carpenter (1863), p. 662; Tryon (1880), p. 174, pl. 53, fig. 154; Wood and Raymond (1891), p. 57.

Thais emarginata var. ostrina, Dall (1915*a*), p. 570.

Description.—Gould (1853) described this variety as follows:

"Small shell, solid, broad-ovate, purplish, banded with brown lines, generally in pairs, faintly marked with the lines of growth, and sometimes with obtuse revolving ribs. Whorls four or five obtusely angular posteriorly, convex, the last comprising most of the shell, very smooth, simple; pillar broadly flattened, regularly arcuate, chestnut-colored; aperture livid chestnut, paler near lip."

Height, 8 to 20 mm.

Occurrence.—At Presidio* (66), Bonita Point (24), and questionably from stations D 5732, D 5786, D 5808, D 5809.

This form has been recorded both by Carpenter and Wood and Raymond from the vicinity of San Francisco. Determinable specimens referable to this variety were obtained by the Survey only at the shore stations. Fragments that probably belong to this species were dredged within the Golden Gate and in the vicinity of the Farallon Islands.

Range.—Tillamook, Oregon, the type locality, to Santa Barbara, California (Yates).

FUSIDAE

Fusinus Rafinesque

Fusinus luteopictus (Dall)

Fusus luteopictus Dall, Arnold, R. (1903), p. 225.
Fusus cinerus Say, Blankinship and Keeler (1892), p. 153.

Description.—Arnold (1903) described this species as follows:

"Shell small, fusiform; whorls five, convex, crossed by nine rounded ridges which reach their maximum development on the middle of the whorl; surface ornamented with three or four prominent spiral lines, with finer ones sometimes intercalated; suture appressed; aperture subovate; outer lip not thickened, with internal spiral lines; inner lip incrusted; columella short; canal very short, narrow."

Specimens of this species were reported to have come from San Francisco by Carpenter, also by Blankinship and Keeler (1892) page 153. Not represented in the Survey collections.

Range.—Farallon Islands to San Diego, California (Arnold).

Fusinus harfordi (Stearns)

Fusus (*Chrysodomus?*) *harfordi* Stearns (1873), p. 79; Dall (1891), pp. 178–179, pl. 6, fig. 6.

Description.—This species was described by Stearns (1873) as follows:

"Shell solid, elongate, regularly fusiform; spire elevated, whorls six or seven, moderately convex, slightly flattened (in outline) above, with a groove or channel following the suture; color, chocolate brown; surface marked by numerous narrow revolving costae, which alternate in prominence on the body whorl, and longitudinally by fine incremental striae, and on the upper whorls by obtusely rounded ribs of more or less prominence; aperture ovate, about one-half the length of the shell, polished, white and finely ribbed within (the outer lip in perfect specimens is probably finely crenulated); canal short, nearly straight."

Dall (1891) reports this from this region. Not dredged by the "Albatross."

Range.—Mendocino County, California, to the Farallon Islands (Dall).

VOLUTIDAE

Mitra Lamarck

Mitra idea Melvill

Mitra idea Melvill (1893).
Mitra maura Swainson, Carpenter (1863), p. 661; Arnold, R. (1903), p. 222.

This species was referred to the Peruvian form *Mitra maura* (= *M. orientalis* Gray) by Carpenter and most subsequent authors. Although it has been reported from the Farallon Islands, it was not taken by the Survey.

Range.—Farallon Islands to San Diego, California (Arnold).

OLIVIDAE

Olivella Swainson

Olivella biplicata Sowerby

Plate 37, figures 5*a* and 5*b*

Olivella biplicata Sowerby (1825), p. 33; Tryon (1883*a*), p. 87, pl. 34, fig. 58; Wood and Raymond (1891), p. 57; Arnold, R. (1903), p. 219.

Description.—The following is Arnold's (1903) description of this species: "Shell small, subcylindrical; spire only slightly elevated; apex subacute; whorls five or six, flat, smooth, except for very fine incremental lines; suture appressed, very distinct; body-whorl convex, but nearly flat near outer lip; aperture elongate-triangular; outer lip thin, nearly straight; inner lip thickly incrusted, the incrustation forming quite a ridge; columella completely incrusted around lower portion, two prominent plications."

Height, 10 to 25 mm.

Occurrence.—At stations D 5755 (*1*), D 5765 (*1*), D 5776* (*1*), D 5809 (5), and questionably at D 5777.

This large olive shell was first reported from this region by Wood and Raymond (1891). It is restricted in the Survey collections to four stations within the middle division of the bay. It was dredged in depths ranging from 1¾ to 3½ fathoms from bottoms comprised of sand and stones.

Range.—Strait of San Juan de Fuca, Washington, to San Diego, California (Cooper).

Olivella intorta Carpenter

Plate 37, figure 7

Olivella intorta Carpenter (1856*b*), p. 207; Arnold, R. (1903), p. 220.

Description.—This species was described by Arnold (1903) as follows: "Shell small, subovate; spire elevated, solid; whorls five, flat, smooth; suture appressed, very distinct; body-whorl ventricose, smooth; aperture long, narrow, widening anteriorly; outer lip thin; inner lip incrusted, incrustation thick, forming callus on body of middle whorl near aperture; columella with smooth incrustation over lower portion, and one prominent, sharp plait on lower side."

Height, 5 to 16 mm.

Occurrence.—At stations D 5731 (37), D 5732 (6), D 5733 (*5*, 1), D 5734 (*6*), D 5735 (*23*, 1), D 5737 (*45*, 1), D 5788 (*7*), D 5790 (1), D 5708 (7), and questionably at D 5738.

This southern species has not hitherto been reported as far north as San Francisco. It is restricted in the Survey collections to localities outside the Golden Gate, with the exception of one station west of Fort Point. Living specimens were dredged at depths of 7¾ to 68 fathoms from bottoms that are predominantly sandy. Not associated at any haul with the preceding species.

Range.—San Francisco; Santa Cruz, California, to Lower California (Dall).

Olivella pedroana (Conrad)

Strephona pedroana Conrad (1855), p. 327, pl. 6, fig. 51.
Olivella boetica Carpenter, Tryon (1883*a*), p. 71, pl. 17, figs. 28–31, 34.
Olivella pedroana, Arnold, R. (1903), p. 221.

Description.—The following is the description of this species as given by Tryon (1883):

"Spire moderately elevated, sharp-pointed, body-whorl oval; red-brown or gray, fasciculated upon a white band at the suture; body-whorl maculated or with zigzag markings, and sometimes a white central band, fasciole white, tip of spire frequently dark-tinted."

Height, 3 to 13 mm.

Occurrence.—At stations D 5785 (*14*), D 5786 (*9*, 3), D 5787 (*1*), D 5790 (*143*), D 5791 (*1*, 1).

This is the first known record of this species from the vicinity of San Francisco. It was dredged by the "Albatross" only in the vicinity of the Farallon Islands at depths ranging from 29 to 40 fathoms from a bottom composed of dark green sand.

Range.—Strait of Juan de Fuca, Washington, to San Diego, California (Cooper).

CANCELLARIIDAE

Cancellaria Lamarck

Cancellaria crawfordiana Dall

Plate 39, figures 9*a* and 9*b*

Cancellaria crawfordiana Dall (1891), p. 182, pl. 6, fig. 1; Keep (1911), p. 137, fig. 110.

Description.—Dall (1891) originally described this species as follows:

"Shell elongated, slender, with six moderately rounded whorls, reticulately sculptured and covered when fresh with a rather coarse brown fibrous epidermis; whorls transversely sculptured with from fourteen to twenty narrow, clear-cut, moderately elevated, even, slightly flexuous ribs, crossing the whorls, but less prominent anteriorly and separated by wider interspaces. The only other transverse sculpture is of lines of growth; spiral sculpture of (between the sutures nine to ten) narrow, flat-topped, strap-like elevated cingula, with wider excavated interspaces, rather uniformly spread over the whorl, but more distant near the shoulder, and on the earlier whorls somewhat sharper and relatively more prominent. Between the cinguli, and rarely on them, are a few obscure, revolving lines. On the canal the cinguli become rounded, smaller, and obscure. The surface under the dehiscent epidermis is polished pale brown, with a somewhat chalky substratum easily corroded. The upper whorl or two have lost most of this layer in the specimen figured and the nucleus is lost. The suture is deep, but not channeled. The canal has no constriction behind it. The aperture is rather long, the outer lip but slightly reflexed and a little fluted by the spiral sculpture. Inside there are a few faint and obscure lirae. The throat is pure white; the body callus, tinged with pale pinkish brown. The anterior angle of the aperture is nearly canaliculate, and produces a perceptible siphonal fasciole. The pillar is straight and strong, with two plaits; the posterior stronger, both oblique and rather low. The angular edge of the pillar, though not elevated, might by some be taken as an obscure third plait. At the end of the plaits on the callus of the pillar are a number of small shelly pustules like those on *C. cassidiformis.*''

Height, 27 to 35 mm.

Occurrence.—At station D 5789 (*14*).

This is near the known northern range of this gastropod. It was obtained by the Survey at a single station near the Farallon Islands. The depth at that station was 46 fathoms, and the bottom was described as being composed of fine dark green sand.

Range.—Drake's Bay to San Diego, California (Dall).

PLEUTOTOMIDAE

Turris Bolten

Turris incisa Carpenter

Plate 41, figures 2*a* and 2*b*

Drillia incisa Carpenter (1863), p. 657; (1865*a*), p. 62; Arnold, R. (1903), p. 205.

Description.—This species has been described by Tryon (1865) as follows: ''Shell in general form like the preceding species (*T. inermis*), but smaller, the whorls somewhat more rounded; cinereous, with reddish chestnut revolving lines.''

Height, 25 mm.

Occurrence.—At station D 5791 (1), and questionably at D 5835.

This species has not before been recorded from the vicinity of San Francisco. The single determinable specimen in the Survey collections was dredged in 29 fathoms in the open ocean near the Farallon Islands.

Range.—Strait of Juan de Fuca, Washington, to Santa Cruz, California (Cooper).

Turris perversa (Gabb)

Plate 41, figures 3*a* and 3*b*

Pleurotoma (*Surcula*) *perversa* Gabb (1865), p. 183; Gabb (1869), p. 6, pl. 1, fig. 10.

Turris perversa, Dall (1909), p. 26, pl. 5, fig. 5.

Description.—This species was originally described by Gabb (1865) as follows:

"Shell sinistral, elongate sub-fusiform, apex acute, sometimes slightly bent, nuclear whorls two, very convex, loosely twisted and white; whorls eleven or twelve, slightly convex; color a reddish brown, somewhat lighter on the middle of the whorl; aperture narrow, canal short, inner lip moderately encrusted with a white callus, brown on the outer margin; columella twisted; outer lip acute, sinus rounded, shallow, broad and adjoining the suture."

Height, 20 to 40 mm.

Occurrence.—At stations D 5785* (1), D 5790 (1).

According to Carpenter, this region falls within the range of this species, but it appears not to have been reported from the vicinity of San Francisco. It is represented in the Survey collections by two specimens from the open ocean, dredged at depths of 33 and 39 fathoms from a sandy bottom.

Range.—Vancouver Island, B. C. (Cooper), to Lower California (Dall).

Turris (Bela) **tabulata** (Carpenter)

Plate 39, figure 1

Mangelia tabulata Carpenter (1863), p. 658.

Description.—Carpenter described this species as follows:

"Stout, strongly shouldered, coarsely cancellated. Pillar abnormally twisted."

Height, 3 to 11 mm.

Occurrence.—At stations D 5785 (1), D 5786 (5), D 5788* (*2*, 2).

This species was dredged by the Survey only in the vicinity of the Farallon Islands. Living specimens were obtained from a sandy bottom at a depth of 68 fathoms.

Range.—Vancouver Island to Todos Santos Bay, Lower California.

Bathytoma Harris and Barrows

Bathytoma carpenteriana (Gabb)

Plate 37, figure 6

Pleurotonia (*Surcula*) *carpenteriana* Gabb (1865), p. 183; (1869), p. 72, pl. 1, fig. 8; Dall (1909), p. 27, pl. 4, fig. 8.

Description.—Dall described this species as follows:

"Shell ovate-fusiform, solid, of five or more whorls; sculpture chiefly with fine close-set spiral threads subequal in size, with linear interspaces, and almost obsolete above the shoulder; whorls moderately convex, above the rounded shoulder moderately excavated with a closely appressed suture; axial sculpture of rather inconspicuous incremental lines, most evident between the suture and the shoulder, where they are concavely arcuate in harmony with the wide, shallow anal sinus; aperture ovate-elongate, with a short canal and smooth pillar often obscurely thickened mesially."

Height, 17 to 75 mm.

Occurrence.—At stations D 5785* (*1*), D 5787 (*1*), D 5788 (*1*), D 5789 (*15*, 2), D 5792 (1).

It is restricted in the Survey collections to the open ocean. Living specimens were dredged in 39 to 68 fathoms from a bottom composed of fine dark green sand.

Range.—Tomales Bay, California, to Cerros Island, Lower California (Dall).

Mangilia Risso

Mangilia angulata Carpenter

Plate 39, figures 10*a* and 10*b*

Mangilia angulata Carpenter (1863), p. 658; Arnold, R. (1903), p. 212, pl. 7, fig. 9.

Description.—This species was described by Arnold (1903) as follows:

"Shell small, turreted, elongate-fusiform; apex acute; whorls six, broad and angular, angle being slightly posterior to middle; sculpture consists of ten prominent, rather sharp, transverse ridges which reach maximum prominence on angle of whorl; suture deeply impressed, distinct, aperture oblique, narrow, elliptical, drawn out anteriorly into a short, narrow canal; outer lip thin; simple, arcuate; inner lip smooth."

Height, 2 to 10 mm.

Occurrence.—At stations D 5785 (*26*, 3), D 5786* (*5*, 3), D 5787 (1), D 5789 (1), D 5790 (*3*), D 5791 (6), D 5792 (*16*).

This species has not thus far been recorded from the vicinity of San Francisco. It was dredged by the "Albatross" only in the vicinity of the Farallon Islands at depths ranging from 19 to 46 fathoms on bottoms composed of fine dark green sand.

Range.—Puget Sound, Washington, to San Diego, California.

CONIDAE

Conus Linnaeus

Conus californicus Hinds

Conus californicus Hinds (1844*a*), p. 7, pl. 1, figs. 3, 4, 5; Tryon (1884), p. 17, pl. 4, figs. 62, 63; Cooper (1888), p. 236; Arnold, R. (1903), p. 199.

Description.—Arnold (1903) described this species as follows:

"Shell double-conical; spire compact, elevated; apex subacute; whorls seven or eight, flat, smooth, except for incremental lines; suture irregular, appressed; body-whorl conical, subangular anteriorly, spirally ornamented with fine lines, which are most prominent on lower part of whorl; aperture long, narrow, slightly wider anteriorly; outer lip thin, bulging anteriorly; obsolete posterior sinus."

This uncommon species was reported from the Farallon Islands by Cooper. It is not represented in the Survey collections.

Range.—Farallon Islands to San Diego, California (Arnold).

ACTAEONIDAE

Acteon Montfort

Acteon punctocoelatus (Carpenter)

Plate 41, figure 6

Tornatella punctocoelata Carpenter (1863), p. 646.
Rictaxis punctocoelata Dall (1871*b*), p. 136, pl. 15, fig. 12.
Acteon punctocoelata Arnold, R. (1903), p. 189, pl. 9, fig. 6.

Description.—Arnold (1903) has described this species as follows:
"Shell small, elongate, elliptical, thin; spire small, conical; whorls three or four, convex; sculpture consists of numerous fine, spiral impressed lines; body-whorl slightly ventricose; aperture acutely angular above, rounded below; outer lip thin, simple; columella projecting beyond the line of the anterior margin, or truncate obliquely; one sharp, columellar plait."
Height, 5 to 8 mm.

Occurrence.—At stations D 5785 (*1*), D 5786 (*1*), D 5789 (*2*), D 5791* (*5*).

Carpenter (1863) mentions this species as occurring at the Farallon Islands. It has been obtained by the Survey only in the vicinity of those islands. Dredged from a fine dark green sand bottom in 29 to 46 fathoms.

Range.—San Francisco to San Diego, California (Cooper).

ACTEOCINIDAE

Acteocina Gray

Acteocina cerealis (Gould)

Plate 41, figures 8*a* and 8*b*

Bulla (Tornatina) cerealis Gould (1853), p. 278, pl. 14, fig. 9.
Tornatina cerealis, Pilsbry (1893), p. 188, pl. 50, figs. 39, 40; Arnold, R. (1903), p. 189, pl. 10, fig. 5.

Description.—Pilsbry (1893) described this species as follows:
"Shell cylindrical, with very short spire, light brown. Surface smooth except for curved growth-striae. Aperture long, narrow, somewhat widened below, the outer lip arched forward; columella rather straight, oblique, with a spiral fold."
Height, 3 to 10 mm.

Occurrence.—At stations D 5785* (*19*), D 5786 (*2*), D 5788 (*4*), D 5789 (*3*).

This southern species has not hitherto been recorded as far north as San Francisco. It is represented in the Survey collections by a few specimens from the waters west of the Golden Gate. Living specimens were dredged at depths ranging from 39 to 68 fathoms on bottoms composed of fine dark green sand.

Range.—San Francisco to San Diego, California.

Volvula A. Adams

Volvula cylindrica Carpenter *

Plate 41, figures *7a* and *7b*

Volvula cylindrica Carpenter (1863), p. 647; Arnold, R. (1903), p. 191, pl. 4, fig. 2.

Description.—Arnold (1903) described this species as follows:

"Shell small, cylindrical; flattened in middle and with margin almost parallel, swelling out anteriorly; suddenly narrowed behind, running out into short, narrow, umbilicated point; aperture length of shell; very narrow posteriorly, gradually broadening into subovate opening at anterior end; surface smooth, except for faint lines of growth parallel to margin of shell."

Height, 3 to 9 mm.

Occurrence.—At stations D 5785 (*3*), D 5786 (*1*, 1), D 5788 (*15*), D 5789 (*7*).

This also is a southern species not before reported this far north. Associated with the preceding species.

Range.—San Francisco to San Diego, California.

GADINIIADAE

Gadinia Gray

Gadinia reticulata (Sowerby)

Mouretia reticulata Sowerby (1835), p. 6.

Rowellia radiata Carpenter, Cooper (1870*b*), p. 319.

Gadinia recticulata, Dall (1870), p. 11, pl. 2, figs. 1–9, pl. 4, figs. 1, 2, and 3; Arnold, R. (1903), p. 197.

Description.—This species was described by Arnold (1903) as follows:

"Shell conical; apex central, smooth, blunt; surface sculptured by numerous rounded, radiating ridges, made somewhat nodose by concentric, elevated lines of growth; aperture slightly ovate; inner surface smooth; lip smooth, effuse; color white."

This species has been found within this region only by Cooper (1871).

Range.—Farallon Islands (Cooper), Lower California (Carpenter).

* The species figured is Cylichna alba Brown there is no Volvula figured.

LITERATURE CITED

ADAMS, A.

1854. Descriptions of twenty-seven new species of shells from the collections of Hugh Cuming. Proc. Zool. Soc. London, **1854**, 311–317.

ADAMS, C. B.

1852. Catalogue of shells collected at Panama with notes on their synonymy, station, and habitat. Ann. Lyceum Nat. Hist. New York, **5**, 229–549.

ARNOLD, A. F.

1903. The seabeach at ebb tide; a guide to the study of the seaweeds and the lower animal life found between tide marks (New York, Century), xi + 490, pp. 85 pls. and many figs. in text.

ARNOLD, R.

1903. The palaeontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro. Mem. Calif. Acad. Sci., **3**, 1–419, pls. 1–37.

1906. The Tertiary and Quaternary pectens of California. U. S. Geol. Surv., Professional Paper, **47**, 1–264, pls. 1–53, 2 figs. in text.

BAIRD, W.

1863. Descriptions of some new species of shells, collected at Vancouver Island, and in British Columbia by J. K. Lord, naturalist to the British North American Boundary Commission, . . . 1858–1862. Proc. Zool. Soc. London, **1863**, 66–70.

1864. Remarks on a species of shell belonging to the family Dentaliidae, with notes on their use by the natives of Vancouver Island and British Columbia. Proc. Zool. Soc. London, **1864**, 136–138.

BARTSCH, P.

1911. The recent and fossil molluscs of the genus *Bittium* from the west coast of America. Proc. U. S. Nat. Mus., **40**, 383–414, pls. 51–58.

1917. Descriptions of New West American marine mollusks and notes on previously described forms. Proc. U. S. Nat. Mus., **52**, 637–681, pls. 42–47.

BERRY, S. S.

1907. Molluscan fauna of Monterey Bay, California. Nautilus, **21**, 17–22, 34–35, 39–47, 51–52.

BINNEY, W. G.

1864. Bibliography of North American conchology previous to the year 1860. Part I. American authors. Misc. Coll., **5**, vii + 650.

1869. *Idem.*, Part II. Foreign authors. *Ibid.*, **9**, ii + 302.

BLAINVILLE, H. DE.

1868. Taret, *Teredo*. Dict. Sci. Nat., **52**, 259–270.

BLANKINSHIP, J. W., and KEELER, C. A.

1892. On the natural history of the Farallon Islands. Zoe, **3**, 114–165. Mollusca determined by J. G. Cooper.

BLOOMER, H. H.

1905. The anatomy of certain species of *Siliqua* (*patula* Dixon) and *Ensis*. Proc. Malac. Soc. London, **6**, 193–196, pl. 12.

BRODERIP, W. J.

1834. Description of some species of *Chama*. Proc. Zool. Soc. London, **1834**, 148–151.

Broderip, W. J., and Sowerby, G. B.

1829. Observations on new or interesting Mollusca, contained . . . in the Museum of the Zoological Society. Zool. Jour., **4**, 359–379, pl. 9; **5**, 46–51, pl. 3; Suppl. pl. 40. *See* Gray, J. E., 1839, for other plates.

Button, F. L.

1902. West American Cypraeidae; with a prefatory note by L. St. G. Byne. Am. Jour. Conch., **10**, 254–258.

Campbell, J. H.

1891. Mollusca of the United States: *Haliotis.* Nautilus, **4**, 101–104.

Carpenter, P. P.

1855. Descriptions of (supposed) new species and varieties of shells, from the California and west Mexican coasts, principally in the collection of H. Cuming. Proc. Zool. Soc. London, **1855**, 228–235.

1856*a*. Report of the present state of our knowledge with regard to the Mollusca of the west coast of North America. Rep. Brit. Assoc. Adv. Sci., **1856**, 159–368, pls. 6–9.

1856*b*. Monograph of the shells collected by T. Nuttall on the Californian coast, 1834–35. Proc. Zool. Soc. London, **1856**, 209–229.

1856*c*. Description of new species of shells collected by T. Bridges in the Bay of Panama and its vicinity, in the collections of Hugh Cuming. *Ibid.,* **1856**, 159–166.

1856*d*. Descriptions of shells from the Gulf of California, and the Pacific coasts of Mexico and California. *Ibid.,* **1856**, 198–208.

1863. Supplementary report on the present state of our knowledge with regard to the mollusks of the west coast of North America. Rep. Brit. Assoc. Adv. Sci., **1863**, 517–686.

1864*a*. Descriptions of new marine shells from the coast of California. Proc. Calif. Acad. Sci., **3**, 155–159, 175–177.

1864*b*. Diagnoses of new forms of Mollusca, from the Vancouver District. Ann. Mag. Nat. Hist., (3) **14**, 423–429. *Also in* Proc. Zool. Soc. London, **1865**, 201–204.

1864*c*. Contributions toward a monograph of the Pandoridae. Proc. Zool. Soc. London, **1864**, 596–603.

1864*d*. Diagnoses of new forms of Mollusca, collected at Cape Lucas, Lower California, by S. Xantus, Ann. Mag. Nat. Hist., (3) **13**, 311–315, 474–479; **14**, 45–49.

1865*a*. Diagnoses specierum et varietatum novarum molluscorum, prope sinum Pugetianum a Kennerlio Doctore, nuper decesso, collectorum. Proc. Acad. Nat. Phila., **17**, 54–64.

1865*b*. Diagnoses of new forms of Mollusca from the Vancouver District. Ann. Mag. Nat. Hist., (3) **15**, 28–32.

1865*c*. Diagnoses des mollusques nouveaux provenant de Californie et faisant partie du musée de l'institution Smithsonienne. Jour. de Conch., **12**, 129–149.

1865*d*. Descriptions of new marine shells from the coast of California, Part III. Calif. Acad. Nat. Sci., **3**, 207–224.

1865*e*. Diagnoses of new forms of Mollusca from the west coast of North America, first collected by E. Jewett. Ann. Mag. Nat. Hist., (3) **15**, 177–182, 339–340, 394–399.

1866. On the *Acmaeidae* of the Vancouver and California province. Am. Jour. Conch., **2**, 332–348.

1872. Mollusks of western North America embracing the second report made to the British Association; reprinted with a general index. Smithsonian Misc. Coll., **10**, i–xii, 1–325.

Chemnitz, J. H.

1780–1795. Neues systematisches Conchylien Cabinet (Martini, F. H. W. 1769–1777) fortgesetzt. (Nürnberg, Raspe), **4–5**, pls. 122–193; **6–11**, pls. 1–213.

Clark, B. L.

1914. The marine fauna of Bolinas Bay, California. Nautilus, **28**, 25–28.

1915. Fauna of San Pablo group of middle California. Univ. Calif. Publ. Geol., **8**, 385–572, pls. 42–71.

Conrad, T. A.

1837. Descriptions of new marine shells from Upper California, collected by Thomas Nuttall. Jour. Acad. Nat. Sci. Phila., **7**, 227–268, pls. 17–20.

1848. Description of two new genera and new species of recent shells. Proc. Acad. Nat. Sci. Phila., **4**, 121.

1855. Descriptions of the fossil shells. Rep. Expl. and Surveys Railroad Route Pac. Ocean, **5**, appendix, art, 2, pp. 317–329, pls. 2–9.

1867. Catalogue of the family Mactridae. Am. Jour. Conch., **3**, app. 30–47.

Cooper, W.

1862. Nine new California marine Mollusca. Proc. Calif. Acad. Sci., **2**, 202–207.

1863. On new and rare Mollusca inhabiting the coast of California. *Ibid.*, **3**, 56–60, fig. 14.

1870*a*. Notes on the Mollusca of Monterey Bay, California. Am. Jour. Conch., **6**, 42–70.

1870*b*. Note on *Gadinia* and *Rowellia*. *Ibid.*, **6**, 319–320.

1888. Catalogue of Californian fossils. Seventh Ann. Rep. State Mineralogist for 1887. (Sacramento, Calif., St. Min. Bur.), pp. 221–308.

1892. *See* Blankenship, J. W., and Keeler, C. A.

Dall, W. H.

1869. Materials for a monograph of the family Lepetidae. Am. Jour. Conch., **5**, 140–150.

1870. Materials for a monograph of the family Gadiniidae. *Ibid.*, **5**, 8–22.

1871*a*. On the limpets with reference to the species of the west coast of America, and to a more natural classification of the group. *Ibid.*, **6**, 227–282, pls. 14–17.

1871*b*. Diagnoses of sixty new forms of mollusks from the west coast of America and the north Pacific Ocean, with notes on others already described. *Ibid.*, **7**, 93–160, pls. 13–16.

1871*c*. Note on *Gadinia*. *Ibid.*, **7**, 192–193.

1872*a*. Notes on California Mollusca. Proc. Calif. Acad. Sci., **4**, 182–183.

1872*b*. Preliminary descriptions of new species of mollusks from the northwest coast of America. *Ibid.*, **4**, 270–271, 302–303.

1874. Catalogue of shells from Behring Strait. *Ibid.*, **5**, 246–253.

1877*a*. Preliminary descriptions of new species of mollusks from the northwest coast of America. *Ibid.*, **4**, 302–303, pl. 1, fig. 6.

1877*b*. On the California species of *Fusus*. *Ibid.*, **7**, 1–5.

1878*a*. Descriptions of new shells from California. Proc. U. S. Nat. Mus., **1**, 46–47.

1878*b*. Report on the limpets and chitons of the Alaskan and Arctic regions, with descriptions of genera and species believed to be new. *Ibid.*, **1**, 281–344, pls. 1–5, 4 figs. in text.

1881. On the genera of chitons. *Ibid.*, 4, 279–291.

1886. Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico (1877–78) and in the Caribbean Sea (1879–80), by the U. S. Coast Survey Steamer ''Blake,'' Lieut. Commander C. D. Sigsbee, U. S. N., and Commander J. R. Bartlett, U. S. N., commanding: XXIX. Mollusca: Part I. Brachiopoda and Pelecypoda, Bull. Mus. Comp. Zool. Harvard College, **12**, 171–318, pls. 1–9.

1889*a*. A preliminary catalogue of the shell-bearing marine mollusks and brachiopods of the southeastern coasts of the United States. Bull. U. S. Nat. Mus., **37**, 1–221, pls. 1–74.

1889*b*. Preliminary report on the collection of Mollusca and Brachiopoda obtained in 1887–88 by the U. S. Fish Commission Steamer ''Albatross.'' Proc. U. S. Nat. Mus., **12**, 219–362, pls. 5–14.

1890. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 1–200, pls. 1–12.

1891. Scientific results of explorations by the U. S. Fish Commission Steamer ''Albatross'': XX. On some new or interesting west American shells obtained from the dredging in 1888, and from other sources. Proc. U. S. Nat. Mus., **14**, 173–192, pls. 5–7.

1892. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 201–473, pls. 13–22.

1894*a*. On the Species *Mactra* from California. Nautilus, **7**, 136–138, pl. 5.

1894*b*. Synopsis of the Mactridae of North America. *Ibid.*, **8**, 25–28, 39–43.

1895*a*. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 474–570.

1895*b*. Diagnoses of new species of mollusks from the west coast of America. Proc. U. S. Nat. Mus., **18**, 7–20.

1896. New species of *Leda* from the Pacific coast. Nautilus, **10**, 1–2.

1897*a*. Notice of some new or interesting species of shells from British Columbia and the adjacent region. Bull. Nat. Hist. Soc. Brit. Columbia, **2**, 1–18, pls. 1–2.

1897*b*. New west American shells. Nautilus, **11**, 85–86.

1898*a*. On a new species of *Fusus* from California. *Ibid.*, **12**, 4–5.

1898*b*. Synopsis of the Recent and Tertiary Psammobidae of North America. Proc. Acad. Nat. Sci. Phila. **1898**, 57–62.

1898*c*. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 571–947, pls. 23–35.

1898*d*. Synopsis of the Recent and Tertiary Leptonacea of North America and the West Indies. Proc. U. S. Nat. Mus., **21**, 873–897.

1899*a*. Note on *Sigaretus oldroyi*. Nautilus, **13**, 85.

1899*b*. Synopsis of the Solenidae of North America and the Antilles. Proc. U. S. Nat. Mus., **22**, 107–112.

1899*c*. Synopsis of the Recent and Tertiary Leptomacea of North America and the West Indies. Proc. U. S. Nat. Mus., **21**, 873–898, pls. 87–88.

1899*d*. A new species of *Pteronotus* from California. Nautilus, **12**, 138–139.

1900*a*. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 948–1218, pls. 36–47.

1900*b*. Synopsis of the family Tellinidae and of the North American species. Proc. U. S. Nat. Mus., **23**, 285–326, pls. 2–4.

1901*b*. Synopsis of the Lucinacea and the American species. *Ibid.*, **23**, 779–883, pls. 39–42.

1902*a*. Synopsis of the family Veneridae and of the North American Recent species. *Ibid.*, **26**, 335–412, pls. 12–16.

1902*b*. Illustrations and descriptions of new, unfigured, or imperfectly known shells, chiefly American, in the United States National Museum. *Ibid.*, **24**, 499–566, pls. 27–40.

1903*a*. Contributions to the Tertiary fauna of Florida. Trans. Wagner Free Inst. Sci., **3**, 1219–1654, pls. 48–60.

1903*b*. Diagnoses of new species of mollusks from the Santa Barbara Channel, California. Proc. Biol. Soc. Washington, **16**, 171–176.

1907. Three new species of *Scala* from California. Nautilus, **20**, 127–128.

1909. The Miocene of Astoria and Coos Bay, Oregon. U. S. Geol. Surv. Professional Paper, **59**, 1–216, pls. 1–23.

1910*a*. Summary of the shells of the genus *Conus* from the Pacific coast of America. Proc. U. S. Nat. Mus., **38**, 217–228.

1910*b*. Report on a collection of shells from Peru, with a summary of the littoral marine molluscs of the Peruvian zoological province. *Ibid.*, **37**, 141–294, pls. 20–28.

1914*a*. Notes on the west American oysters. Nautilus, **28**, 1–3.

1914*b*. Notes on some west coast Acmaeas. Nautilus, **28**, pp. 13–15, 1914.

1915*a*. Notes on the species of the molluscan subgenus *Nucella* inhabiting the northwest coast of America and adjacent regions. Proc. U. S. Nat. Mus., **49**, 557–572, pls. 74–75.

1915*b*. A monograph of the molluscan fauna of the *Orthaulax pugnax* zone of the Oligocene of Tampa, Florida. Bull. U. S. Nat. Mus., **90**, 1–173, pls. 1–26.

1916*a*. Checklist of the Recent bivalve mollusks of the northwest coast of America from the polar sea to San Diego, California. (Los Angeles, Southwest Museum), pp. 1–44.

1916*b*. Diagnoses of new species of marine bivalve mollusks from the northwest coast of America in the collection of the United States National Museum. Proc. U. S. Nat. Mus., **50**, 393–417.

1917. Summary of the mollusks of the family Alectrionidae of the west coast of America. Proc. U. S. Nat. Mus., **51**, 575–579.

DALL, W. H., and BARTSCH, P.

1907. The pyramidellid mollusks of the Oregonian faunal area. Proc. U. S. Nat. Mus., **33**, 491–534, pls. 54–58.

1909. A monograph of the west American pyramidellid mollusks. Bull. U. S. Nat. Mus., **68**, 1–258, pls. 1–30.

DESHAYES, G. P.

1839. Nouvelles especes de Mollusques, provenant des côtes de la Californie, du Mexique, du Kamtschatka, et de la Nouvelle Zelande. Rev. de Zool., **1839**, 356–361.

1841. *Idem.*, Mag. de Zool., **1841**, pls. 25–29, 34–40, 43, 45, 47, 48.

1843. *Ibid.*, **1843**, pl. 82.

1853–1854. Catalogue of the Conchifera or bivalve shells in the collection of the British Museum. (London, Taylor): I, Veneridae, Cyprinidae and Glauconomidae, 1–216 (1853); II, Corbiculidae, 217–292 (1854).

1854. Proceedings of the Zoological Society of London, **1854**, p. 357.

DILLWYN, L. W.

1817. Descriptive catalogue of Recent shells, arranged according to the Linnaean method; with particular attention to the synonymy. (London, Arch), xii +1092 pp.

Dixon, G. (= Beresford, W.).
1789. A Voyage around the world, but more particularly to the northwest coast of America; performed in 1785, 1786, 1787, and 1788, in the "King George" and "Queen Charlotte," Captains Portlock and Dixon. (London, Goulding), i–xxix, 360–477, pls. 1–17, 5 maps.
D'Orbigny, A. D.
1835–1843. "Mollusques" *in* Voyage dans l'Amerique meridionale, 1826–1833, **5**, part 3, pp. i–xiiii, 1–758, pls. 1–86.
Dunn, F. W.
1892. Coleoptera and Mollusca of the ocean beach at San Francisco. Zoe, **2**, 310–312.
Eastman, C. R.
1900. Textbook of palaeontology, by Karl A. von Zittel; trans. and ed. by C. R. Eastman. (New York, Macmillan), **1**, x + 706, 1476 figs. in text.
1913. *Ibid.*, ed. 2 rev., **1**, x + 839, 1594 figs. in text.
Edwards, C. L.
1913. The abalones of California. Pop. Sci. Mo., **82**, 532–550, [19] figs. in text. *Also in* Ann. Rep. Smithson. Inst., **1913**, 429–438, pls. 1–10.
Engelmann, T. W.
1883. Farbe und Assimilation. Bot. Zeit., **41**, 1–17.
Eschscholtz, J. F.
1829–1833. Zoologischer Atlas, enthaltend Abbildungen und Beschreibungen neuer Thierarten, während des Flottcapitains von Kotzebue zweiter Reise um die Welt auf der Russisch-Kaiserlichen Kriegsschlupp "Predpriaetie," . . . 1823–1826. (Berlin, Reimer): Heft 1, 17 pp., pls. 1–5, 1829; Heft 2, 13 pp., pls. 6–10, 1829; Heft 3, 18 pp., pls. 11–15, 1829; Heft 4, 19 pp., pls. 16–20, 1831; Heft 5 (hrsg. v. M. H. Rathke), 28 pp., pls. 21–25, Mollusca, pls. 9, 15, 19, 23 and 24.
Gabb, W. M.
1864. Triassic and Cretaceous fossils. Geol. Surv. Calif., Palae., **1**, 55–243, pls. 9–32.
1865. Descriptions of new species of marine shells from the coast of California. Proc. Calif. Acad. Sci., **3**, 182–190.
1869. Cretaceous and Tertiary fossils. Geol. Surv. Calif., Palae., **2**, 1–299, pls. 1–36.
Gould, A. A.
1840. Report on shells from California. Am. Jour. Sci., **38**, 396.
1841. Report on the Invertebrata of Massachusetts, comprising the Mollusca, Crustacea, Annelida and Radiata (Cambridge, Folsom), xiii + 373 pp., 213 figs. on [15] pls.
1846*a*. Descriptions of new species of shells collected by the United States Exploring Expedition commanded by Charles Wilkes, U. S. N., Proc. Boston Soc. Nat. Hist., **2**, 142–145.
1846*b*. *Ibid.*, **2**, 148–152.
1847. *Ibid.*, **2**, 237–239.
1848*a*. *Ibid.*, **3**, 83–85.
1848*b*. *Ibid.*, **3**, 89–92.
1849*a*. *Ibid.*, **3**, 118–121.
1849*b*. *Ibid.*, **3**, 151–156.
1849*c*. *Ibid.*, **3**, 169–172.
1849*d*. *Ibid.*, **3**, 214–218.
1850. *Ibid.*, **3**, 343–348.

1851. Descriptions of a number of California shells, collected by Maj. Wilhaur Rich, and Lieut. Thomas P. Green, U. S. N., *Ibid.*, **4**, 87–93.

1853. Mollusks of the U. S. Explor. Exp., 1852, **12**, 1–497. (Philadelphia). Parts I–VIII separately paged.

1862. Otia Conchologica, descriptions of shells and mollusks, from 1839 to 1862. (Boston, Gould), 1–256 pp.

1870. Report on the Invertebrata of Massachusetts; ed. 2, comprising the Mollusca, edited by W. G. Binney (Boston, Wright), viii + 540 pp., pls. 1–27.

GOULD, A. A., and CARPENTER, P. P.

1856. Descriptions of shells from the Gulf of California, and the Pacific coasts of Mexico and California. Part II. Proc. Zool. Soc. London, **1856**, 198–208.

GRAY, J. E.

1826. On a recent species of the genus *Hinnita* of De France, and some observations on the shells of the monomyaires of Lamarck. Ann. of Philos., **28**, 103–106.

1839. Molluscous animals and their shells *in* Richardson *et al.*, Zoology of Captain Beechey's Voyage, pp. 101–155, pls. 33–44.

1847. On the genera of the family Chitonidae. Proc. Zool. Soc. London, **1847**, 13–70.

HALDEMAN, S. S.

1840–1845. Monograph of the Limiades or other fresh water univalve Mollusca of the United States, including notices of species in other parts of North America (Philadelphia). Parts I–VIII separately paged.

HINDS, R. B.

1843*a*. Descriptions of new shells from the collection of Capt. Sir Edward Belcher, R. N., C. B. Proc. Zool. Soc. London, **1843**, 36–46.

1843*b*. Descriptions of new species of *Nucula* from the collections of Sir Edward Belcher, C. B., and Hugh Cuming. *Ibid.*, **1843**, 97–101.

1844*a*. The zoology of the voyage of H. M. S. "Sulphur," under Capt. Sir Edward Belcher, 1836–1842. (London, Smith), **2**, Mollusca, 21 pls.

1844*b*. Descriptions of the new species of *Triton*, *Solarium*, and *Corbula*. Proc. Zool. Soc. London, **1844**, 21–26.

JONAS, J. H.

1846. Molluskologische Beiträge. Abh. aus d. Gebiete d. Naturwiss. Hamburg, **1**, 99–130, Taf. 7–11, 1846. *Cf. also* Proc. Zool. Soc. London, **14**, 34–36, 1846; and Ann. Nat. Hist., **18**, 121–123, 1846.

KEEP, J.

1887. West coast shells: A familiar description of the marine, freshwater, and land mollusks of the United States found west of the Rocky Mountains (San Francisco, Bancroft), 1–230, pl. 1, 182 figs. in text.

1891. Mollusks of the San Francisco markets. Nautilus, **4**, 97–100.

1892. West coast shells: A familiar description of the marine, freshwater, and land mollusks of the United States, found west of the Rocky Mountains (San Francisco, Carson), 1–230, pl. 1, 182 figs. in text.

1901. Exotic mollusks in California. Nautilus, **11**, 114–115.

1904. West American shells: A description in familiar terms of the principal marine, fresh-water, and land mollusks of the United States found west of the Rocky Mountains, including those of British Columbia and Alaska. (San Francisco, Whitaker), pp. 1–360, pl. 1, 303 figs. in text.

1911. West coast shells: A description of the principal marine mollusks living on the west coast of the United States, and of the land shells of the adjacent regions. (San Francisco, Whitaker); rev. ed., pp. 1–346, 3 pls. 298 figs. in text.

KIENER, L. C.

1834–1856. Spécies générale et iconographie des coquilles vivantes, publiées par monographies, comprenant la collection du Muséum d'Histoire Naturelle de Paris, le Muséum Masséna, la collection Lamarck, celle de M. B. Delessert, et les découvertes le plus récentes des voyageurs. (Paris, Baillière), 138 livres, pls. 1–476.

LAMARCK, J. P. B. DE

1815–1822. Histoire naturelle des animaux sans vertèbres. Conchifera. (Paris, Verdiere), **5**, 411–613 (1818); **6**, pt. 1, pp. 1–343, pt. 2, pp. 1–232; **7**, 1–678.

1835–1836. *Ibid.*, ed. 2 rev. et augm. par. G. P. Deshayes et H. Milne-Edwards (Paris, Baillière), **6** (1835), iv + 600; **7** (1836), vi + 735; **8** (1838), [i] + 660.

LEA, H. C.

1842. Descriptions of eight new species of shells native to the United States. Am. Jour. Sci., **42**, 106–112, pl. 1.

LEACH, W. E., and NODDER, R. P.

1814–1817. Zoological miscellany, being descriptions of new or interesting animals. (London), 2 vols., 149 [150] pls; Mollusca, in 1814.

LINNAEUS, C. VON

1758. Systema Naturae: Regnum Animale; ed. 10, **1**, 1–824.

1766–1768. *Ibid., ed.* 12, pp. 1–1327. Mollusca, in 1767.

1788–1793. *Ibid.*, ed. 13, aucta, reformata, cura J. F. Gmelin. (Leipsiae, Beer), **1**, 1–4120.

1794. *Ibid.*, ed. 10, 1758, cura Societas Zoologicae Germanicae; iterum edita a MDCCCXCIV. (Lipsiae, Engelmann), iii + 824 pp.

LOCKINGTON, W. N.

1878. Rambles around San Francisco. Am. Naturalist, **12**, 505–512.

MARTYN, T.

1784. The universal conchologist. 4 vols, 16 pls, London.

MIDDENDORFF, A. T. VON

1847–1849. Beiträge zu einer Malacozoologie Rossica. 1, 2 und 3 Aufzählung und Beschreibung der zur Muresfauna Russlands gehörigen Einschaler und Zurischaler. Mem. Acad. Imp. St. Petersbourg, Nat. Sci., (6) **6**, 67–215, 330–516, 517–596, pls. 1–35. Also published separately (Leipzig, Voss), pt. 1, pp. 1–151, pls. 1–14, 1847; pt. 2, pp. 1–187, pls. 15–21, 1849; pt. 3, 1–94, pls. 22–35, 1849.

1848. Vorläufige Anzeige bisher unbekannter Mollusken, als Vorabeit zu einer Malacozoologica Rossica. Bull. Cl. Phys.-Math., Acad. Sci. St. Petersbourg, **6**, 113–122.

1851. Mollusken: Reise Nord. u. Osten Sibieriens, **2**, 163–508, pls. 8–30.

MONTAGU, G.

1803. Testacea Britannica; or Natural History of British Shells, marine, land, and freshwater. (London, J. White), **1**, 1–291; **2**, 293–600, 16 col. pls.

1808. Supplement to Testacea Britannica. (London, J. White), pp. 1–183, 17–30 pls.

NEWCOMB, W.

1864. Description of a new species of *Pedicularia*. Proc. Calif. Acad. Sci., **3**, 121–122; **4**, 322, pl. 1, fig. 9.

1874. Description of a new species of shell from San Francisco Bay. *Ibid.*, **5**, 415.

ORCUTT, C. R.

1915. Molluscan world, **1**, 1–208.

PACKARD, E. L.

1916. Mesozoic and Cenozoic Mactrinae of the Pacific coast of North America. Univ. Calif. Publ. Geol., **9**, 261–360, pls. 12–35.

1918. A quantitative analysis of the molluscan fauna of San Francisco Bay. Univ. Calif. Publ. Zool, **28**, 299–336.

PHILIPPI, R. A.

1841. *Trochus triumphans: Trochis chinensis*. Ber. Ver. Cassel, **5**, 8–9.

1842–1851. Abbildungen und Beschreibungen neuer oder wenig-gekannter Conchylien unter Behülfe mehrerer deutscher Conchyliologen. (Cassel, Fischer), **1** (1842–1845), 56 figs. in text; **2** (1845–1846), 242 pp., 6 pls., **3** (1847–1851), 251 pp., 6 pls.

1842–1855. Trochoideen (*Turbo, Trochus, Solarium, Rotella, Delphinula, Phasianella*): Conchylien Cabinet von Martini und Chemnitz; (2 aufl. von Küstz), **2**, pt. 2, pp. 1–98, pls. 1–19; pt. 3, pp. 1–372, pls. 1–50.

1845–1846. Diagnoses testaceorum quaorundam novorum. Zeitsch. Malakozool., **2**, 147–152, 1845; **3**, 97–106, 1846.

1845–1846. Bemerkungen über die Molluskan-fauna von Massachusetts. Zeitsch. f. Malakozool., **2**, 69–79.

1846. Kritische Bemerkungen über die von Eschscholtz aufgestellten Arten von *Acmaea*. Zeitsch. Malakozool., **3**, 106–108.

PILSBRY, H. A.

1888. Turbinidae and Trochidae. Man. Conch., **10**, 161–290, pls. 37–69.

1889. Trochidae, Stomatiidae, Pleurotomariidae, Haliotidae. *Ibid.*, **11**, 1–519, pls. 1–67.

1890. Stomatellidae, Scissurellidae, Pleurotomariidae, Scutellininae, Addisoniidae, Cocculinidae, Fissurellidae, Haliotidae. *Ibid.*, **12**, 1–323, pls. 1–65.

1891. Acmaedae, Leptetidae, Patellidae and Titiscanidae. *Ibid.*, **13**, 1–76, pls. 1–40.

1892–1893. Polyplacophora. *Ibid.*, 14, 1–350, pls. 1–68, 1892; **15**, 1–133, pls. 1–17, 1893.

1893. Opisthobranchiata. *Ibid.*, **15**, 134–436, pls. 18–61.

1894*a*. On *Chiton hertwegi* Cpr. and its allies. Nautilus, **8**, 45–47.

1894*b*. *Trachydermon raymondi* in British Columbia. *Ibid.*, **8**, 57.

1896. Notes on some west American chitons. *Ibid.*, **10**, 49–51.

1898*a*. Chitons collected by Dr. Harold Heath at Pacific Grove, near Monterey, California. Proc. Acad. Nat. Sci. Phila., **1898**, 287–290.

1898*b*. *Haliotis cracherodii* var. *californiensis* Swainson. Nautilus, **12**, 70–80.

PILSBRY, H. A., and JOHNSTON, C. W.

1892. Catalogue of the Fissurellidae of the United States. Nautilus, **5**, 102–107.

PILSBRY, H. A., and RAYMOND, W. J.

1898. Note on *Septifer bifurcatus* Conrad. *Ibid.*, **12**, 69–71.

Pilsbry, H. A., and Sharp, B.
1897–1898. Scaphopoda. Man. Conch., **17**, 1–280, pls. 1–39.

Reeve, L. A.
1839. Zool. Soc. cuvierienne, pp. —.
1846. Monograph of the genus *Purpura*. Conchologica Iconica, **3**, 113 pls.
1847. Monograph of the genus *Chiton*. Conchologica Iconica. **4**, 33 pls.
1846–1847. Monograph of the genus *Buccinum:* Conchologia Iconica, **3**, [30] pp., pls. 1–14.
1849–1850. Monograph of the genus *Fissurella*. *Ibid.*, **6** [1–34], pls. 1–16.
1851. Monograph of the genus *Lucina*. *Ibid.*, **6** [1–34], pls. 1–11.
1855. Monograph of the genus *Patella*. Conchologica Iconica, **8**, 42 pls.

Roberts, S. R.
1885. Monograph of the family Cypraeidae. Man. Conch., **7**, 154–241, pls. 1–23.

Rogers, J. E.
1908. The shell book. A popular guide to a knowledge of living mollusks, and an aid to the identification of shells, native and foreign. (New York, Doubleday), xxi + 485 + [96], 8 pls.

Say, T.
1822. An account of some of the marine shells of the United States. Jour. Acad. Nat. Sci. Phila., **2**, 221–248, 257–276, 302–325.

Solander, D. C.
1786. Catalogue of the Portland Museum.

Sowerby, G. B.
1820–1824. The genera of Recent and fossil shells. (London, Bohn), **1**, 1–550, 1 pl.; **2**, 279 pls.
1825. A catalogue of shells in the collection of the Earl of Tankerville, with an appendix describing new species. (London, Bohn), 9 pls.
1835. Character of and observations on new genera and species of Mollusca and Conchifera collected by Mr. Cuming. Proc. Zool. Soc. London, **1835**, 4–7, 21–23, 41–47, 49–51, 84–85, 93–96, 109–112.
1840. Descriptions of some new chitons. Mag. Nat. Hist., n. s., **4**, 287–294, pl. 1.
1842–1887. Thesaurus conchyliorum, or figures and descriptions of shells. (London, Van Voorst), 5 vols., 532 pls.

Stearns, R. E. C.
1866. List of shells collected at Baulines Bay, California, June, 1866. Proc. Calif. Acad. Sci., **3**, 275–276.
1867*a*. Shells collected by the U. S. Coast Survey Expedition to Alaska in the year 1867. *Ibid.*, **3**, 384–385.
1867*b*. List of shells collected at Bodega Bay, California, in June. *Ibid.*, **3**, 382–383.
1871. Descriptions of new California shells. Am. Jour. Conch., **7**, 172–173.
1872*a*. Description of a new species of *Monoceras*, from California, with remarks on the distribution of the North American species. *Ibid.*, **7**, 167–172.
1872*b*. Remarks on marine faunal provinces on west coast of America. Proc. Calif. Acad. Sci., **4**, 246–247.
1872*c*. A partial comparison of the conchology of portions of the Atlantic and Pacific coasts of North America. *Ibid.*, **4**, 271–273.

1873. Description of new marine mollusks from the west coast of North America. *Ibid.*, **5**, 78–82, pl. 1.
1881. *Mya arenaria* in San Francisco Bay. Am. Naturalist, **15**, 362–366.
1882. Verification of the habitat of Conrad's *Mytilus bifurcatus*. Proc. Acad. Nat. Sci. Phila. **1882**, 241–242.
1883. The edible clams of the Pacific coast, and a proposed method of transplanting them to the Atlantic coast. Bull. U. S. Fish. Comm., **3**, 353–362, 9 figs. in text.
1886. The *Teredo*, or ship-worm. Am. Naturalist, **20**, 131–136, 4 figs. in text.
1894. *Urosalpinx cinereus* in San Francisco Bay. Nautilus, **8**, 13–14.
1898. Notes on *Cythera* (*Tivella*) *crassatelloides* Conrad, with descriptions of many varieties. Proc. U. S. Nat. Mus., **21**, 371–378, pls. 23–25.
1899*a*. *Crepidula convexa* Say var. *glauca* Say, in San Francisco Bay. Nautilus, **13**, 8.
1899*b*. *Urosalpinx cinereus* in San Francisco Bay. *Ibid.*, **12**, 112.
1899*c*. Description of a new variety of *Haliotis* from California, with faunal and geographical notes. Proc. U. S. Nat. Mus., **22**, 139–142. *Also in* Nautilus, **12**, 106–107.
1899*d*. Abalone fishery in California—protective regulation. Nautilus, **13**, 81–82.
1899*e*. *Modiola plicatula* Lamarck, in San Francisco Bay. *Ibid.*, **13**, 86.
1900*a*. Exotic Mollusca in California. Science n. s., **11**, 655–659.
1900*b*. Notes on the Saxidomi of the west coast. Nautilus, **14**, 1–3.

SWAINSON, W.
1821–1822. Exotic conchology; or Figures and descriptions of rare, beautiful, or undescribed shells. (London, Bohn), pp. —.
1835. Observations on the analogies of the Mitranae. Proc. Zool. Soc. London, **1835**, 193–204.

SUMNER, F. B., OSBURN, R. C., COLE, L. J., and DAVIS, B. M.
1913. A biological survey of the waters of Woods Hole and vicinity. Bull. U. S. Bur. Fish., **31**, 1–860, 274 charts in text.

SUMNER, F. B., LOUDERBACK, G. D., SCHMITT, W. L., and JOHNSTON, E. C.
1914. A report upon the physical conditions in San Francisco Bay, based upon the operations of the United States Fisheries Steamer "Albatross," during the years 1913 and 1914. Univ. Calif. Publ. Zool., **14**, 1–198, pls. 1–13, 20 figs. in text.

TRYON, G. W., Jr.
1863. Contributions towards a monograph of the order Pholadacea, with descriptions of a new species. Proc. Acad. Nat. Sci. Phila., **15**, 143–146, pl. 1.
1865. Descriptions of new species of Pholadidae. Am. Jour. Conch., **1**, 39–40.
1867. Catalogue of Recent Mollusca belonging to the order Pholadacea. *Ibid.*, **3**, app., 1–21.
1873. American marine conchology . Philadelphia, pp. 1–208, pls. 1–44.
1880. Muricinae. Man. Conch., **2**, 73–158, pls. 9–41.
1881. Tritonidae, Fusidae, Buccinidae. *Ibid.*, **3**, 1–310, pls. 1–87.
1882*a*. Nassidae. *Ibid.*, **4**, 5–66, pls. 5–18.
1882*b*. Mitridae. *Ibid.*, **4**, 106–276, pls. 19–58.
1883*a*. Olividae. *Ibid.*, **5**, 59–100, pls. 14–36.
1883*b*. Columbellidae. *Ibid.*, **5**, 100–276, pls. 49–63.
1883*c*. Marginellidae. *Ibid.*, **6**, 5–64, pls. 2–13.

1884. Conidae. *Ibid.,* **6**, 3–150, pls. 1–31.

1885*a*. Pediculariidae. *Ibid.,* **7**, 241–242, pl. 1.

1885*b*. Manual of Conchology, **7**.

1886*a*. Naticidae. *Ibid.,* **8**, 1–100, pls. 1–29.

1886*b*. Calyptraeidae. *Ibid.,* **8**, 101–155, pls. 30–43.

1886*c*. Eulimidae. *Ibid.,* **8**, 258–293, pls. 68–71.

1887*a*. Cerithiidae. *Ibid.,* **9**, 112–228, pls. 19–39.

1887*b*. Littorinidae. *Ibid.,* **9**, 229–314, pls. 40–51.

1887*c*. Rissoiidae. *Ibid.,* **9**, 314–322, pl. 54.

Verrill, A. E., and Smith, S. I.

1880. Notice of the remarkable marine fauna occupying the outer banks off the southern coast of New England. Am. Jour. Sci., **20**, 390–403.

Williamson, M. B.

1893. On *Clementia subdiaphana* Cpr., in San Pedro Bay. Nautilus, **6**, 116.

1898. An interrogation in regard to *Septifer bifurcatus* Rves. and *Mytilus bifurcatus* Conr. *Ibid.,* **12**, 67–69.

Wood, W.

1815. General conchology, or a description of shells arranged according to the Linnean system. (London, Wood), lv + 246 pp., 59 pls.

Wood, W. M.

1891. Additional mollusks of San Francisco Bay. Nautilus, **5**, 94.

Wood, W. M., and Raymond, W. J.

1891. Mollusks of San Francisco County. *Ibid.,* **5**, 54–58.

1897. Bolinas, California, the conchologist's paradise. *Ibid.,* **11**, 49–54, [1] fig. in text.

Yates, L. G.

1890*a*. The Mollusca of Santa Barbara County, California. Bull. Santa Barbara Soc. Nat. Hist., **1**, 37–46.

1890*b*. New shells from the Santa Barbara Channel. *Ibid.,* 1, 46–48.

EXPLANATION OF PLATES

PLATE 14

Fig. 1. *Acila castrensis* (Hinds). × 2. Longitude 9.4 mm. Station D 5788.* Exterior of left valve.

Fig. 2. *Acila castrensis* (Hinds). × 2. Longitude 9.4 mm. Station D 5788.* Interior of right valve.

Fig. 3*a*. *Arca transversa* Say. × 2. Longitude 18.2 mm. Station D 5711. Exterior of right valve.

Fig. 3*b*. *Arca transversa* Say. × 2. Longitude 18.2 mm. Station D 5711. Interior of right valve.

Fig. 4. *Nucula tenuis* Carpenter. × 4. Longitude 5.5 mm. Station D 5785(?). Exterior of left valve.

Fig. 5. *Leda hamata* Carpenter. × 2. Longitude 10.5 mm. Station D 5785. Exterior of left valve.

Fig. 6. *Yoldia ensifera* Dall. × 1. Longitude 39.5 mm. Station D 5789.* Exterior of left valve.

Fig. 7*a*. *Leda taphria* Dall. × 2. Longitude 16 mm. Station D 5785. Exterior of right valve.

Fig. 7*b*. *Leda taphria* Dall. ×2. Longitude 16 mm. Station D 5785. Interior of left valve.

Fig. 8. *Leda taphria* Dall. × 2. Longitude 14 mm. Station D 5785. Dorsal view.

Fig. 9. *Yoldia corperi* Gabb. × 1. Longitude 54 mm. Station D 57. Exterior of right valve.

Fig. 10*a*. *Ostrea lurida* Carpenter. ×1. Longitude 51 mm. Interior of left valve.

Fig. 10*b*. *Ostrea lurida* Carpenter. × 1. Longitude 51 mm. Interior of right valve.


1
2
3a
5
4
3b
6
7a
9
7b
8
10a
10b

PLATE 15

All figures approximately natural size

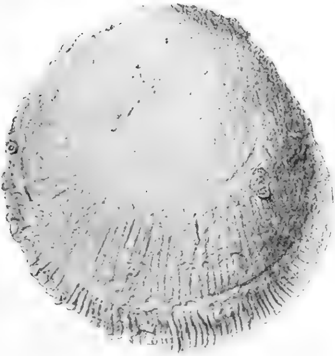
Fig. 1. *Monia macroschisma* (Deshayes). Longitude 61 mm. Bolinas. Exterior of upper, or left valve.

Fig. 2*a*. *Anomia peruviana* d'Orbigny. Longitude 24.8 mm. Station 5811. Exterior of upper, or left valve.

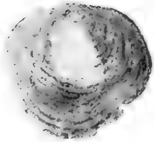
Fig. 2*b*. *Anomia peruviana* d'Orbigny. Longitude 24.8 mm. Station 5811. Interior of upper, or left valve.

Fig. 3*a*. *Ostrea elongata* Solander. Longitude 46 mm. Station D 5782. Interior of left valve.

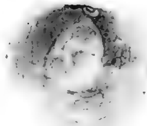
Fig. 3*b*. *Ostrea elongata* Solander. Longitude 46 mm. Station D 5782. Interior of right valve.



1



2a



2b

3a

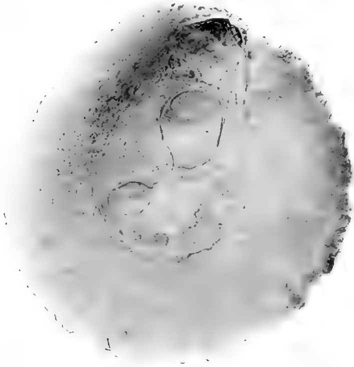
3b

PLATE 16

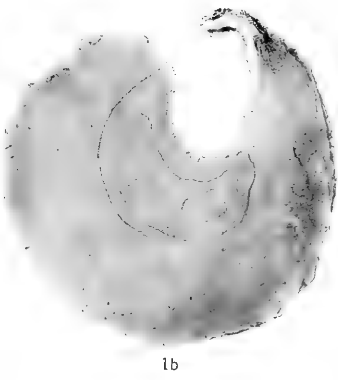
All figures approximately natural size

Fig. 1*a*. *Monia machroschisma* (Deshayes). Longitude 61 mm. Bolinas. Interior of upper, or left valve.

Fig. 1*b*. *Monia machroschisma* (Deshayes). Longitude 61 mm. Bolinas. Interior of lower, or right valve.



1a



1b

PLATE 17

All figures approximately natural size

Fig. 1*a*. *Hinnites giganteus* Gray. Longitude 70 mm. Bolinas Exterior of upper, or left valve.

Fig. 1*b*. *Hinnites giganteus* Gray. Longitude 70 mm. Bolinas. Exterior of lower, or right valve.

1a

1b

PLATE 18

All figures approximately natural size

Fig. 1. *Modiolus demissus* (Dillwyn). Longitude 77.2 mm. San Francisco Bay. Exterior of left valve.

Fig. 2. *Mytilus californianus* Conrad. Longitude 77 mm. Presidio. Exterior of left valve.

Fig. 3. *Lyonsia californica* Conrad. Longitude 22.4 mm. San Francisco, University of California Collection. Exterior of right valve.

Fig. 4. *Mytilus edulis* Linnaeus. Longitude 51.3 mm. Station D 5764. Exterior of left valve.

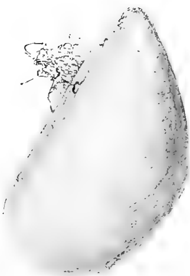
Fig. 5. *Adula stylina* Carpenter. Longitude 33.7. Moss Beach, San Mateo County, Collected by A. L. Barrows. Exterior of left valve.

Fig. 6. *Adula falcata* (Gould). Longitude 70 mm. Duxbury Reef, Bolinas. Exterior of left valve.

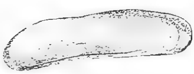
1

2

3



4



5

6

PLATE 19

Fig. 1*a*. *Phacoides tenuisculptus* (Carpenter). × 4. Longitude 3 mm. Station D 5786.* Interior of left valve.

Fig. 1*b*. *Phocoides tenuisculptus* (Carpenter). × 4. Longitude 3 mm. Station D 5786.* Exterior of left valve.

Fig. 2*a*. *Pandora filosa* (Carpenter). × 2. Longitude 17.3 mm. Station D 5785. Exterior of left valve.

Fig. 2*b*. *Pandora filosa* (Carpenter). × 2. Longitude 17.3 mm. Station D 5785. Exterior of right valve.

Fig. 3. *Marcia subdiaphana* (Carpenter). × 2. Longitude 14.6 mm. Station D 5786. Exterior of left valve.

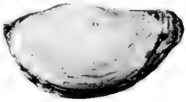
Fig. 4. *Kellia laperousi* (Deshayes). × 1. Longitude 24.4 mm. Station D 5846. Interior of right valve.

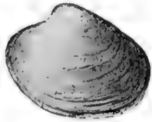
Fig. 5*a*. *Phacoides annulatus* (Reeve). × 1. Longitude 67 mm. Station D 5789. Exterior of right valve.

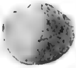
Fig. 5*b*. *Phacoides annulatus* (Reeve). × 1. Longitude 67 mm. Station D 5789. Interior of left valve.

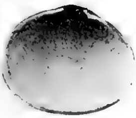
Fig. 6. *Paphia staminea* var. *orbella* (Carpenter). × 1. Longitude 23 mm. Station D 5846. Exterior of left valve. Found as a nestler in pholadid borings.


1a

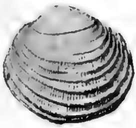

2a


3


1b


4


5a


6


2b

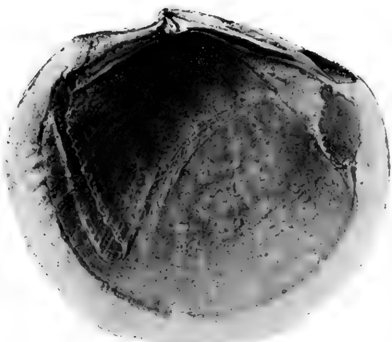

5b

PLATE 20

Fig. 1*a*. *Cardium corbis* (Martyn). × 1. Longitude 49 mm. Station D 5700. Dorsal view.

Fig. 1*b*. *Cardium corbis* (Martyn). × 1. Longitude 49 mm. Station D 5700. Exterior of left valve.

Fig. 2*a*. *Cardium* (*Protocardium*) *centifilosum* Carpenter. × 2. Longitude 10.5 mm. Station D 5785.* Exterior of right valve.

Fig. 2*b*. *Cardium* (*Protocardium*) *centifilorsum* Carpenter. × 2. Longitude 10.5 mm. Station D 5785.* Exterior of left valve.

Fig. 2*c*. *Cardium* (*Protocardium*) *centifilosum* Carpenter. × 2. Longitude 10.5 mm. Station D 5785.* Interior of left valve.

Fig. 2*d*. *Cardium* (*Protocardium*) *centifilosum* Carpenter. × 2. Longitude 10.5 mm. Station D 5785.* Interior of right valve.

Fig. 3. *Cuspidaria californica* Dall. × 2. Longitude 10 mm. Station D 5789.

Fig. 4. *Psephidea ovalis* Dall. × 5. Longitude 4.3 mm. Station D 5788.* Exterior of left valve.

Fig. 5. *Thyasira gouldi* (Philippi). × 4. Longitude 7 mm. Station D 5788.* Exterior of right valve.

Fig. 6*a*. *Petricola carditoides* (Conrad). × 1. Longitude 42.7 mm. Bolinas. Dorsal aspect.

Fig. 6*b*. *Petricola carditoides* (Conrad). × 1. Longitude 42.7 mm. Bolinas. Exterior of left valve.

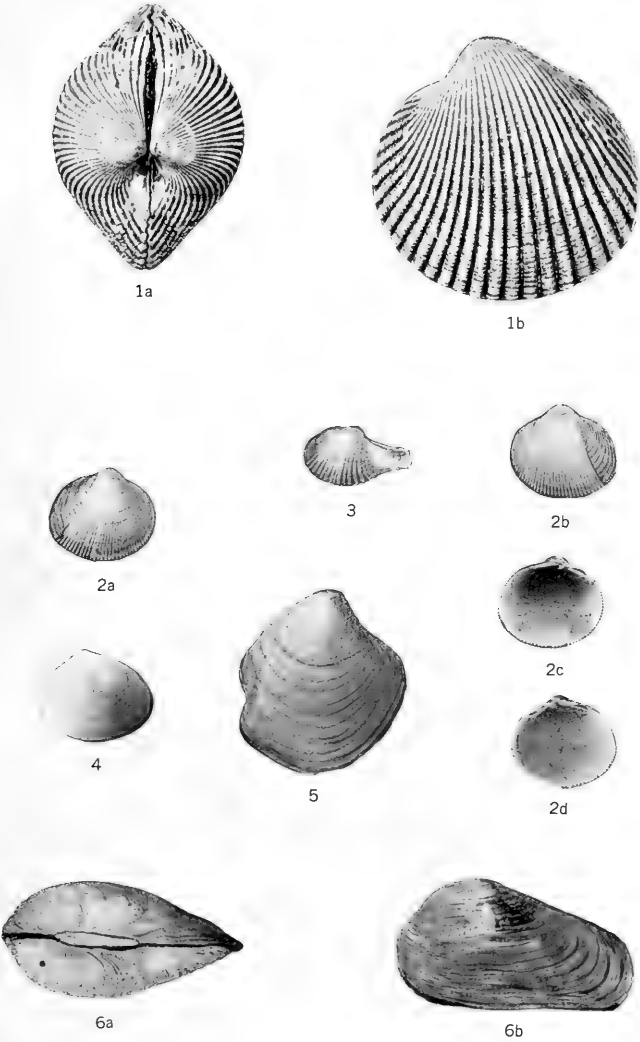

1a
1b
3
2b
2a
2c
4
5
2d
6a
6b

PLATE 21

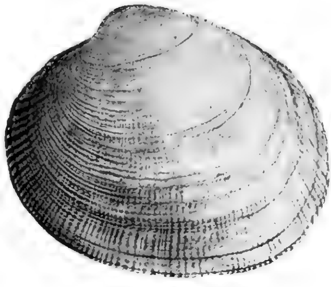
All figures approximately natural size

Fig. 1*a*. *Paphia staminea* (Conrad). Longitude 56 mm. Interior of left valve.

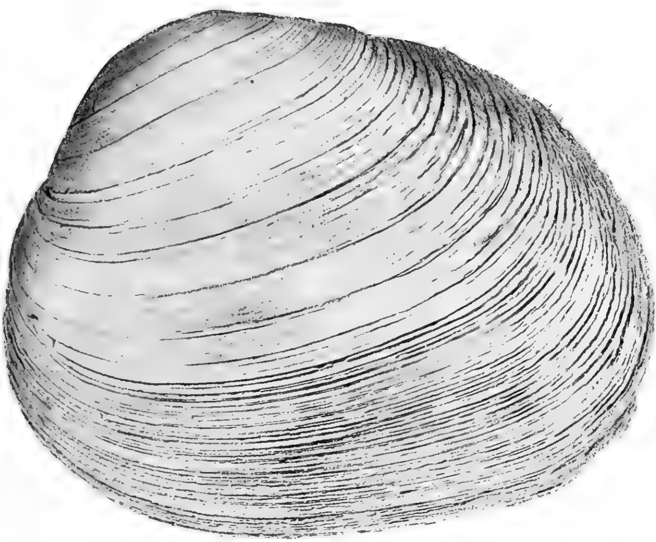
Fig. 1*b*. *Paphia staminea* (Conrad). Longitude 56 mm. Exterior of left valve.

Fig. 2. *Saxidomus nuttalli* Conrad. Longitude 111.6 mm. Pigeon Point. Exterior of left valve.

1a



1b



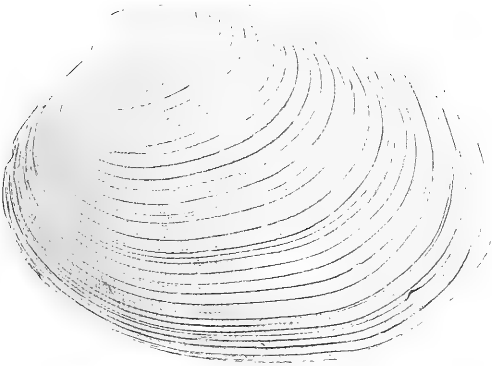
2

PLATE 22

All figures approximately natural size

Fig. 1*a*. *Paphia tenerrima* (Carpenter). Longitude 89 mm. Bolinas. Exterior of left valve.

Fig. 1*b*. *Paphia tenerrima* (Carpenter). Longitude 89 mm. Bolinas. Interior of left valve.



1a

1b

PLATE 23

Fig. 1*a*. *Macoma nasuta* (Conrad). Longitude 58.5 mm. Station D 5830. Exterior of right valve.

Fig. 1*b*. *Macoma nasuta* (Conrad). Longitude 58.5 mm. Station D 5830. Exterior of left valve.

Fig. 1*c*. *Macoma nasuta* (Conrad). Longitude 58.5 mm. Station D 5830. Interior of left valve.

Fig. 1*d*. *Macoma nasuta* (Conrad). Longitude 58.5 mm. Station D 5830. Interior of right valve. Compare the pallial sinus with that shown in figs. 1*c* and 2*c*.

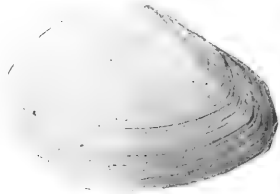
Fig. 2*a*. *Macoma inquinata* (Deshayes) (?). Longitude 57 mm. Exterior of right valve.

Fig. 2*b*. *Macoma inquinata* (Deshayes) (?). Longitude 57 mm. Interior of right valve.

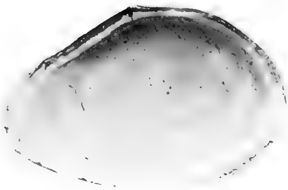
Fig. 3*a*. *Macoma inquinata* (Deshayes) (?). Longitude 55 mm. Exterior of left valve.

Fig. 3*b*. *Macoma inquinata* (Deshayes) (?). Longitude 55 mm. Interior of left valve.

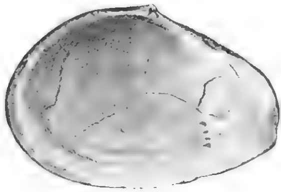
1a



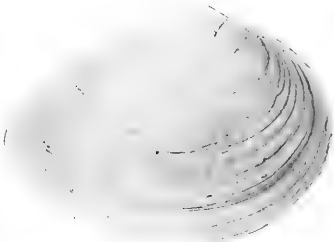
1b



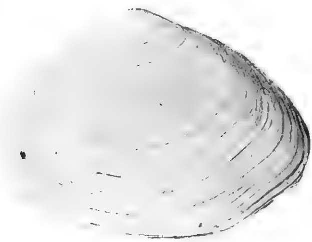
1c



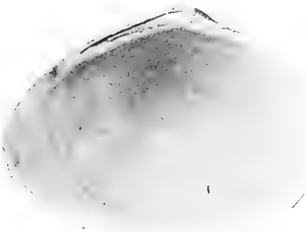
1d



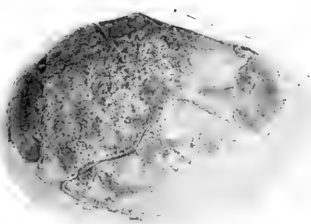
2a



3a



3b



2b

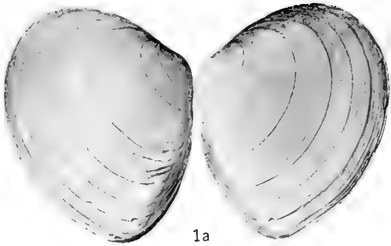
PLATE 24

All figures approximately natural size

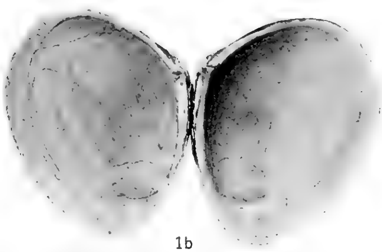
Fig. 1*a*. *Macoma inquinata* (Deshayes). Longitude 43.5 mm. Station D 5830.

Fig. 1*b*. *Macoma inquinata* (Deshayes). Longitude 43.5 mm. Station D 5830. Note the pallial sinus and compare with figs. 1*c* and 1*d*, plate 10.

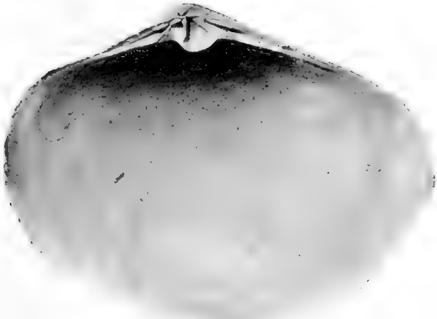
Fig. 2. *Spisula catilliformis* Conrad. Longitude 77 mm. University of California Collection. Note the hinge of this right valve.



1a



1b



2

PLATE 25

Fig. 1. *Macoma balthica* (Linnaeus). × 1. Longitude 21.6 mm. Station D 5717.* Exterior of right valve.

Fig. 2. *Macoma balthica* (Linnaeus). × 1. Longitude 28 mm. Station D 5717.*

Fig. 3*a*. *Tellina salmonea* (Carpenter). × 1. Longitude 13 mm. Station D 5800. Exterior of right valve.

Fig. 3*b*. *Tellina salmonea* (Carpenter). × 1. Longitude 13 mm. Station D 5800. Exterior of left valve.

Fig. 4. *Macoma indentata* Carpenter. × 1. Longitude 25 mm. Station D 5791. Exterior of right valve.

Fig. 5. *Tellina bodegensis* Hinds. × 1. Longitude 47.5 mm. Bolinas. Exterior of left valve.

Fig. 6. *Macoma yoldiformis* Carpenter. × 2. Longitude 15 mm. Station D 5785.* Exterior of left valve.

Fig. 7*a*. *Tellina buttoni* Dall. × 2. Longitude 16 mm. Station D 5739.* Exterior of right valve.

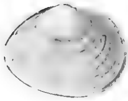
Fig. 7*b*. *Tellina buttoni* Dall. × 2. Longitude 15 mm. Station D 5739.* Interior of right valve.

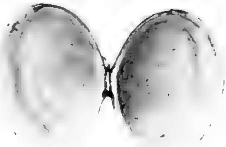
Fig. 8. *Macoma secta* (Conrad). × 1. Longitude 59 mm. Bolinas. Exterior of left valve.

Fig. 9. *Macoma balthica* (Linnaeus). × 1. Longitude 20 mm. Near Key Route Pier, Oakland. Exterior left valve.

Fig. 10*a*. *Tellina carpenteri* Dall. × 4. Longitude 12 mm. Station D 5788.* Interior of left valve.

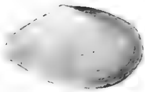
Fig. 10*b*. *Tellina carpenteri* Dall. × 4. Longitude 12 mm. Station D 5788*. Exterior of left valve.

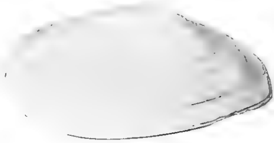

1a

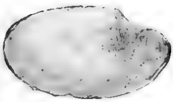

2

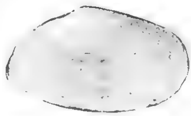

3a


3b


4

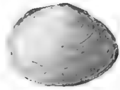

5

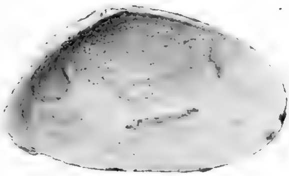

6


7a


7b


8


9


10a

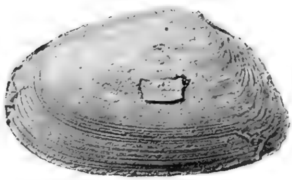

10b

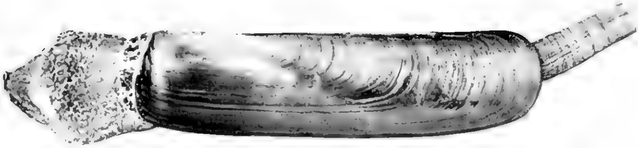
PLATE 26

All figures approximately natural size

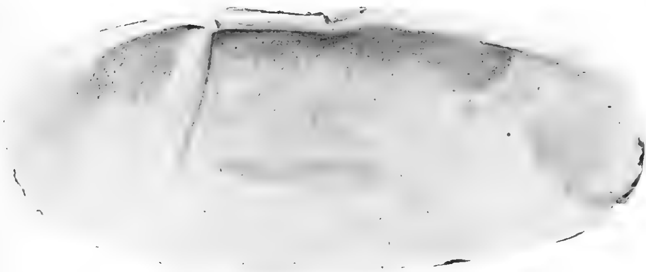
Fig. 1. *Solen sicarius* Gould. Longitude of shell 70.5 mm. Station D 5705. View of the left side, showing the foot and siphon extended.

Fig. 2*a*. *Siliqua nuttalli* (Conrad). Longitude 111.3 mm. Moss Beach, San Mateo County. Interior of right valve.

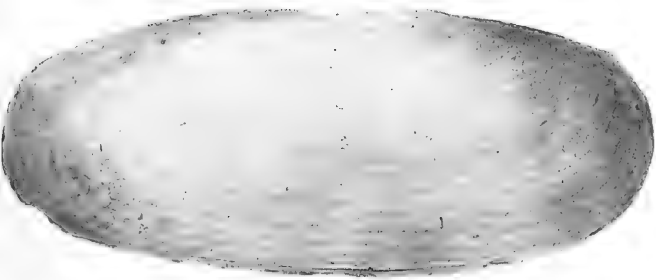
Fig. 2*b*. *Siliqua nuttalli* (Conrad). Longitude 111.3 mm. Moss Beach, San Mateo County. Exterior of right valve.



1



2a



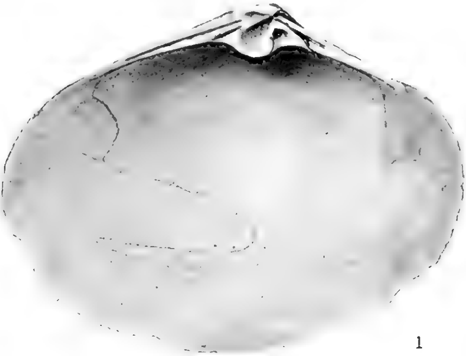
2b

PLATE 27

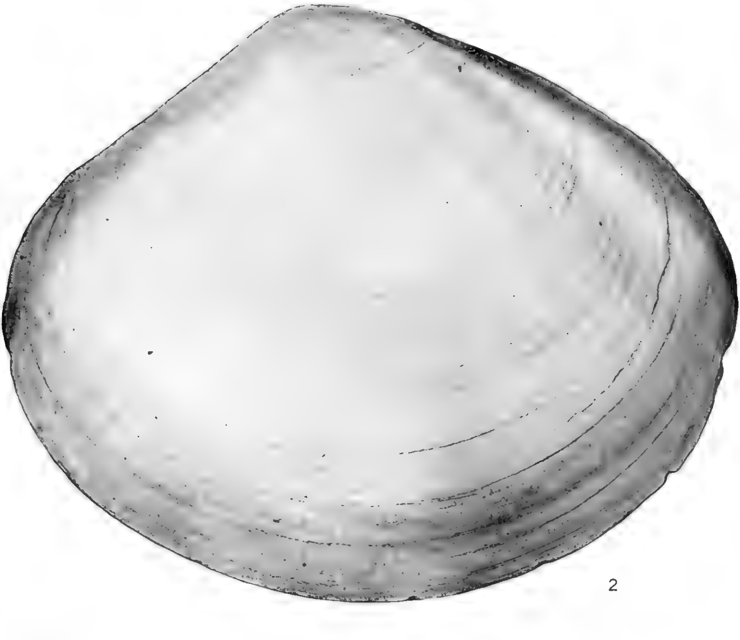
All figures approximately natural size

Fig. 1. *Spisula catilliformis* Conrad. Longitude 81 mm. University of California Collection. Note the hinge of left valve.

Fig. 2. *Spisula catilliformis* Conrad. Longitude 112.8 mm. University of California collection. Exterior of left valve.



1



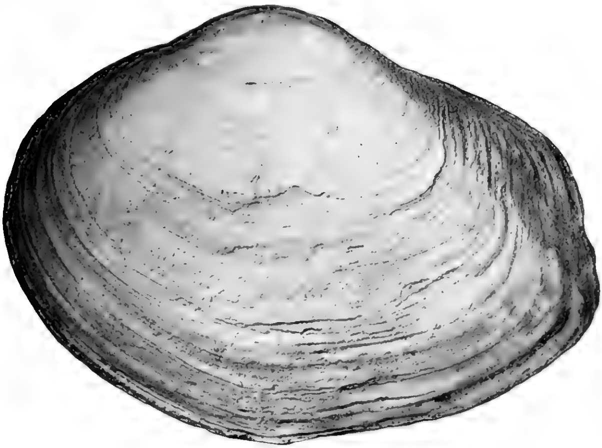
2

PLATE 28

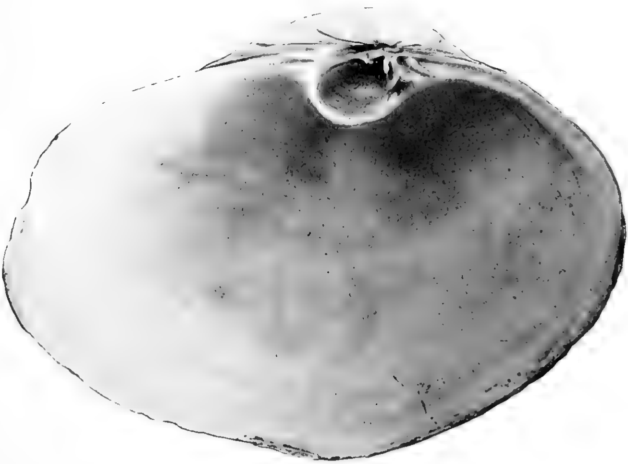
All figures approximately natural size

Fig. 1*a*. *Schizothaerus nuttalli* (Conrad). Longitude 110.5 mm. University of California Collections. Exterior of left valve of a small specimen.

Fig. 1*b*. *Schizothaerus nuttalli* (Conrad). Interior of left valve.



1a



1b

PLATE 29

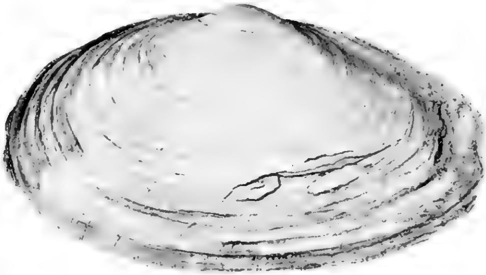
All figures approximately natural size

Fig. 1*a*. *Mya arenaria* Linnaeus. Longitude 84 mm. Fish Market, San Francisco. Exterior of left valve.

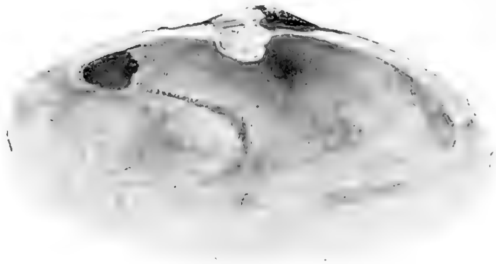
Fig. 1*b*. *Mya arenaria* Linnaeus. Interior of left valve.

Fig. 2*a*. *Mya* (Platydon) *cancellata* (Conrad). Longitude 55.4 mm. Bolinas. Exterior of both valves.

Fig. 2*b*. *Mya* (Platydon) *cancellata* (Conrad). Interior of both valves.

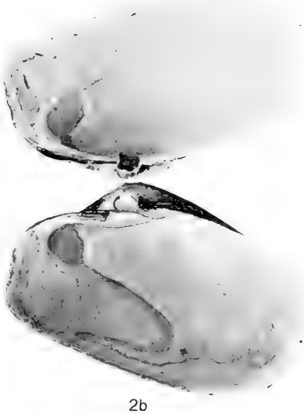


1a



1b

2a



2b

PLATE 30

Fig. 1*a*. *Pholadidea ovoidea* (Gould). × 1. Longitude 37 mm. Bolinas. Exterior of left valve showing siphons extended.

Fig. 1*b*. *Pholadidea ovoidea* (Gould). × 1. Dorsal view, showing siphons extended.

Fig. 2*a*. *Pholadidea ovoidea* (Gould). × 1. Longitude 19 mm. Ventral view of an immature specimen.

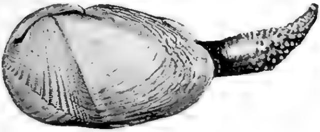
Fig. 2*b*. *Pholadidea ovoidea* (Gould). × 1. View of left valve of same specimen.

Fig. 3*a*. *Pholadidea penita* (Conrad). × 1. Longitude 50 mm. Bolinas. Exterior of left valve, showing siphons extended.

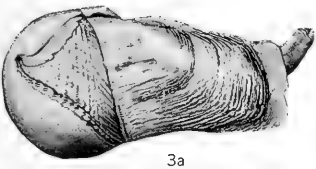
Fig. 3*b*. *Pholadidea penita* (Conrad). × 1. Dorsal view.

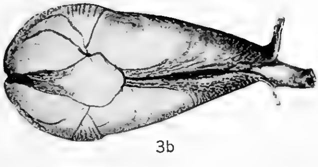
Fig. 4. *Saxicava arctica* (Linnaeus). × 2. Longitude 13 mm. Station 5700.* Exterior of left valve.

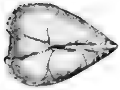
Fig. 5. *Saxicava pholadis* Linnaeus. × 1. Longitude 34.6 mm. Goat Island, San Francisco Bay, Exterior of left valve.

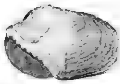

1a

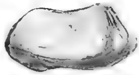

1b


3a


3b


2a


2b


4

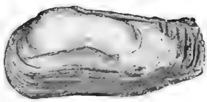

5

PLATE 31

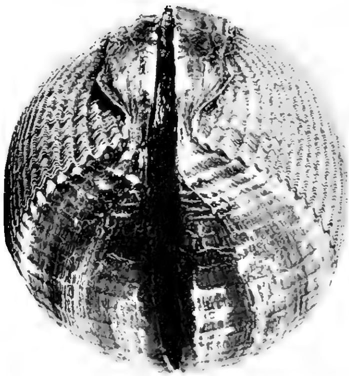
All figures approximately natural size

Fig. 1*a*. *Parapholas californica* (Conrad). Longitude 134 mm. From a photograph of a living specimen collected by A. L. Barrows at Moss Beach, San Mateo County, California. Anterior view.

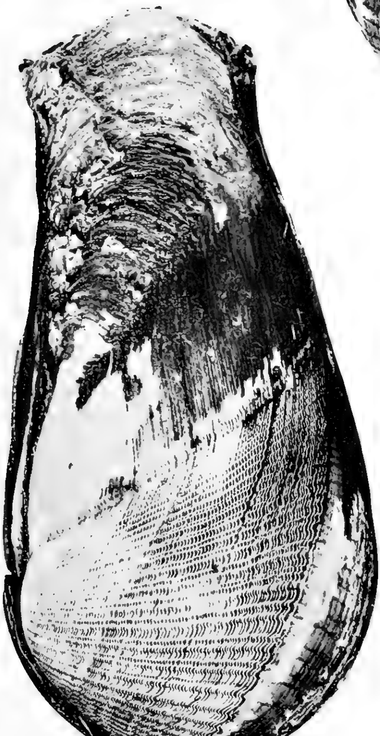
Fig. 1*b*. *Parapholas californica* (Conrad). Exterior of left valve of the same specimen.

Fig. 2*a*. *Mya (Cryptomya) californica* (Conrad). Longitude 25.5 mm. Station D 5825. Exterior of left valve.

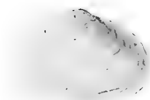
Fig. 2*b*. *Mya (Cryptomya) californica* (Conrad). Interior of left valve.



1a



1b



2a

2b

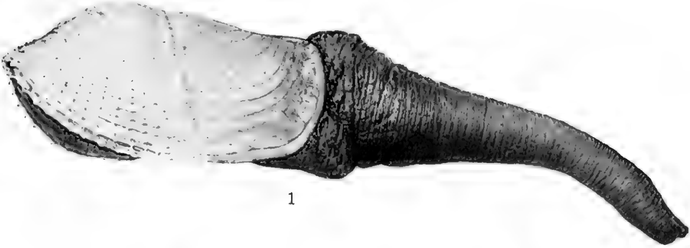
PLATE 32

All figures approximately natural size

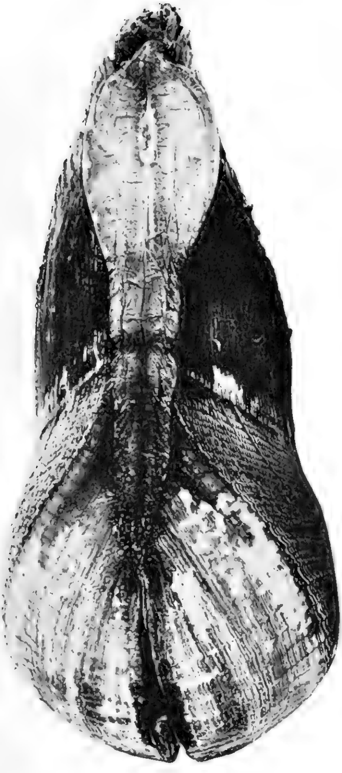
Fig. 1. *Zirfaea gabbi* Tryon. Longitude 56 mm. Exterior of left valve, showing siphons extended.

Fig. 2*a*. *Parapholas californica* (Conrad). Longitude 134 mm. From a photograph of a living specimen collected by Mr. A. L. Barrows at Moss Beach, San Mateo County. Ventral aspect.

Fig. 2*b*. *Parapholas californica* (Conrad). Dorsal aspect of same specimen.



1



2a

2b

PLATE 33

Approximately natural size

Haliotis rufescens Swainson. Longitude 125 mm. Bolinas. Exterior of the Red Abalone.

PLATE 34

Fig. 1. *Haliotis cracherodi* Leach. × 1. Longitude 85 mm. Half Moon Bay. Exterior of Black Abalone.

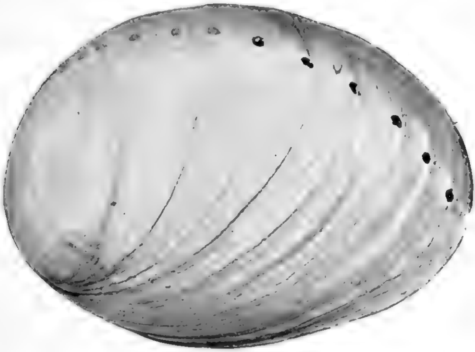
Fig. 2a. *Fissuridea aspera* (Eschscholtz). × 1. Longitude 40 mm. Bolinas Bay.

Fig. 2b. *Fissuridea aspera* (Eschscholtz). × 1.

Fig. 3. *Tonicella lineata* (Wood). × 1. Longitude 30.5 mm. Bonita Point.*

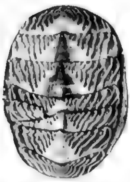
Fig. 4a. *Astralium triumphans* (Philippi). × 1⅓. Diameter of body whorl 17 mm. Near Station D 5807. Dorsal view.

Fig. 4b. *Astralium triumphans* (Philippi). × 1⅓. Ventral view.

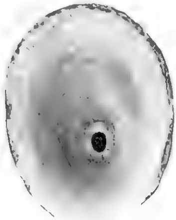


1

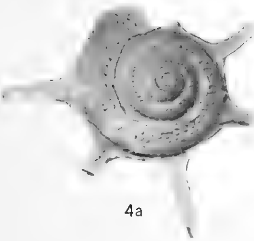
2a



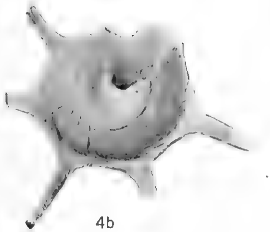
3



2b



4a



4b

PLATE 35

Fig. 1*a*. *Crepidula adunca* Sowerby. × 1. Altitude 8 mm. University of California Collection. Profile.

Fig. 1*b*. *Crepidula adunca* Sowerby. × 1. Maximum diameter 12.8 mm. View from above.

Fig. 2. *Littorina scutulata* Gould. × 4½. Altitude 8 mm. Presidio.*

Fig. 3. *Littorina suctulata* Gould. × 4½. Altitude 8.9 mm. Presidio.*

Fig. 4. *Littorina planaxis* (Nuttall) Philippi. × 1½. Altitude 15 mm. Bonita Point.

Fig. 5. *Crepidula convexa* Say. × 1. Maximum diameter 10.5 mm. Station D 5782.* From above.

Fig. 6. *Crepidula convexa* Say. × 1. Maximum diameter 11.6. Station D 5782.*

Fig. 7*a*. *Crepidula nivea* Adams. × 1. Maximum diameter 21.5 mm. Station D 5810 B. View from above.

Fig. 7*b*. *Crepidula nivea* Adams. × 1. Maximum diameter 21.5 mm. Station D 5810 B. Ventral view.

Fig. 8. *Littorina planaxis* (Nuttall) Philippi. × 1½. Altitude 13 mm. Bonita Point.

Fig. 9. *Nassa mendica* Gould. × 2. Altitude 11 mm. Station D 5773.

Fig. 10*a*. *Eunaticina oldroydi* Dall. × 1. Fishing Grounds West of the Golden Gate.* Basal view.

Fig. 10*b*. *Eunaticina oldroydi* Dall. × 1.

Fig. 11*a*. *Ilyanassa obsoleta* (Say). × 1. Altitude 21.4 mm. Near Key Route Pier, Oakland.*

Fig. 11*a*. *Ilyanassa obsoleta* (Say). × 1 . Altitude 21.4 mm.

Fig. 12*a*. *Nassa fossata* (Gould). × 1. Altitude 31 mm. Station D 5788.

Fig. 12*b*. *Nassa fossata* (Gould). × 1.

Fig. 13. *Nassa perpinguis* Hinds. × 1½. Altitude 12 mm. Station D 5786.

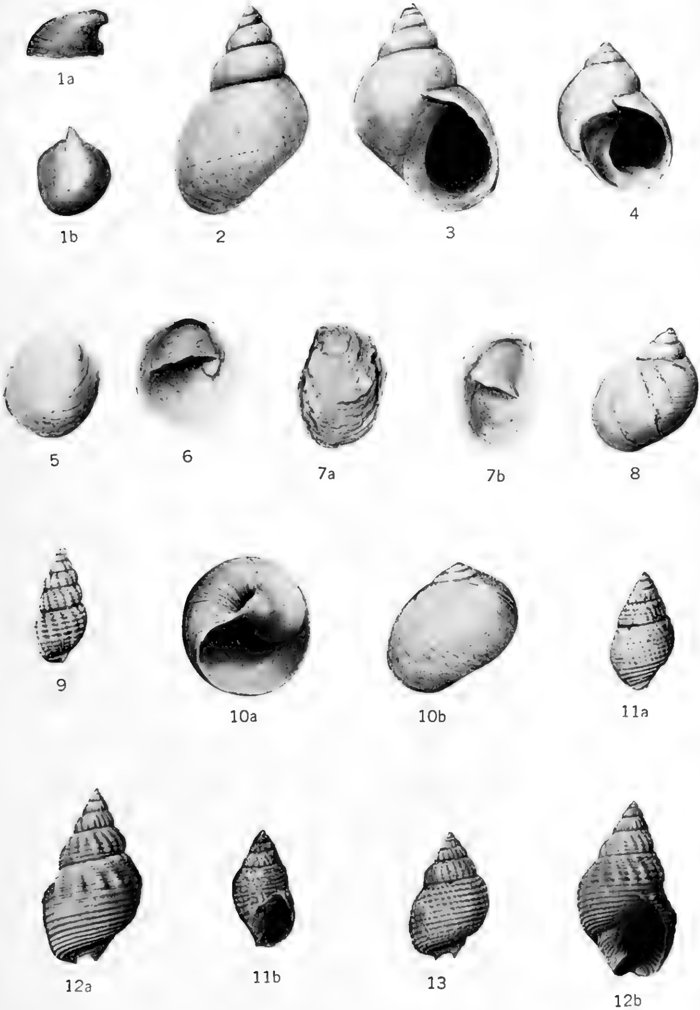

1a
1b
2
3
4
5
6
7a
7b
8
9
10a
10b
11a
12a
11b
13
12b

PLATE 36

Fig. 1*a*. *Tegula funebrale* (A. Adams). × 1. Altitude 33 mm. Bonita Point.*

Fig. 1*b*. *Tegula funebrale* (A. Adams). × 1.

Fig. 2. *Calliostoma annulatum* (Martyn). × 1. Altitude 25 mm. University of California Collection.

Fig. 3. *Tegula brunnea* (Philippi). × 1. Altitude 33 mm. University of California Collection.

Fig. 4. *Tegular brunnea* (Philippi). × 1. Altitude 21 mm. University of California Collection.

Fig. 5. *Calliostoma canaliculatum* (Martyn). × 1. Altitude 18 mm. Half Moon Bay.

Fig. 6. *Calliostoma costatum* (Martyn). × 2. Altitude 11 mm. Station D 5770. An immature specimen.

Fig. 7. *Calliostoma costatum* (Martyn). × 1. Altitude 19 mm. Station D 5770 B.*

Fig. 8. *Turbonilla franciscana* Bartsch. × 5. Altitude 5.6 mm. Station D 5743.* This species was recently described from this region.

Fig. 9. *Turbonilla franciscana* Bartsch. × 5. Altitude 5.8 mm. Station D 5743.*

Fig. 10. *Margarites pupilla* (Gould). × 5. Maximum diameter 3 mm. A small specimen.

Fig. 11. *Melanella* (*Eulima*) *micans* Carpenter. × 4. Altitude 7.3 mm. Station D 5788.*

Fig. 12*a*. *Turbonilla keepi* Dall and Bartsch. × 2. Altitude 10.6 mm. Station D 5785.*

Fig. 12*b*. *Turbonilla keepi* Dall and Bartsch. × 2.

Fig. 13. *Epitonium sawinae* (Dall). × 1¾. Altitude 15 mm. Station D 5785.*

Fig. 14*a*. *Epitonium hindsi* (Carpenter). × 2. Altitude 9.6 mm. Station D.

Fig. 14*b*. *Epitonium hindsi* (Carpenter). × 2.

Fig. 15. *Odostomia franciscana* Bartsch. × 4. Altitude 2.6 mm. Station D 5729.*

Fig. 16. *Odostomia franciscana* Bartsch. × 4. Altitude 2 mm. Station D 5729.*

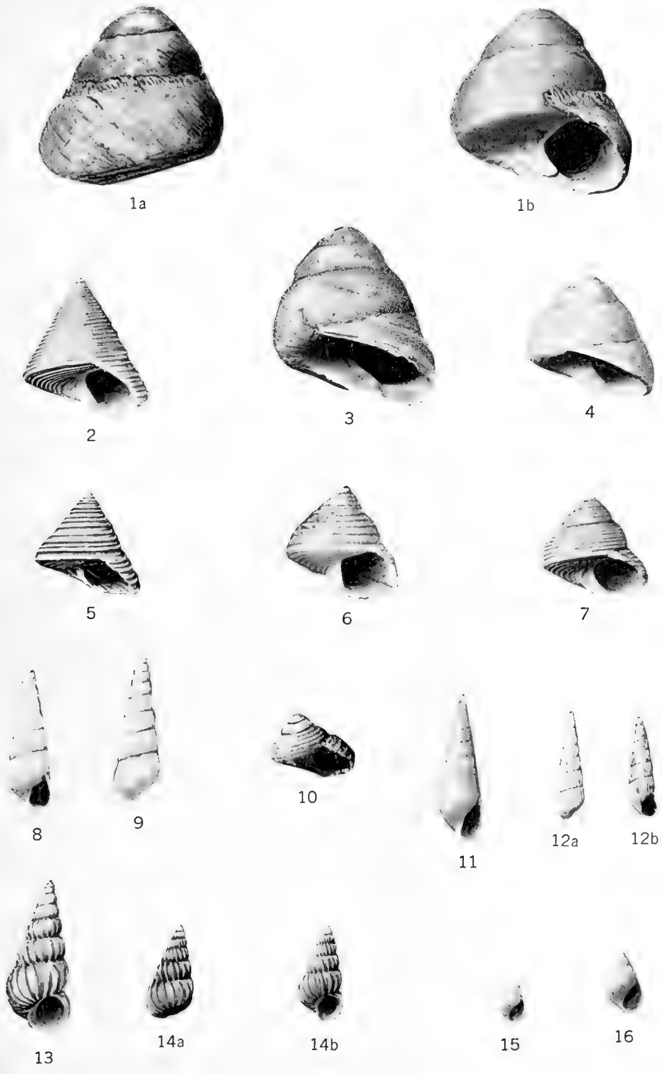

1a
1b
2
3
4
5
6
7
8
9
10
11
12a
12b
13
14a
14b
15
16

PLATE 37

Fig. 1*a*. *Murex* (*Ocinebra*) *interfossa* (Carpenter). × 4. Altitude 8 mm. Station D 5770.

Fig. 1*b*. *Murex* (*Ocinebra*) *interfossa* (Carpenter). × 4.

Fig. 2. *Chrysodomus tabulatus* Baird. × 1. Altitude 86 mm. Station D 5789.* The tip of the spire has been broken.

Fig. 3. *Chrysodomus dirus* Reeve. × 1. Altitude 40 mm. Pigeon Point.

Fig. 4*a*. *Murex* (*Ocinebra*) *lurida* (Middendorff). × 2. Altitude 13.5 mm. Bonita Point.

Fig. 4*b*. *Murex* (*Ocinebra*) *lurida* (Middendorff). × 2.

Fig. 5*a*. *Olivella biplicata* Sowerby. × 1. Altitude 22 mm. Station D 5731.

Fig. 5*b*. *Olivella biplicata* Sowerby. × 1.

Fig. 6. *Bathytoma carpenteriana* (Gabb). × 1. Altitude 77 mm. Station D 5788.

Fig. 7. *Olivella intorta* Carpenter. × 2. Altitude 11 mm. Station D 5735

Fig. 8*a*. *Urosalpinx cinereus* (Say). × 1. Altitude 21 mm. Station D 5787.*

Fig. 8*b*. *Urosalpinx cinereus* (Say). × 1.


1a
1b
2
3
4a
4b
5a
5b
6
7
8a
8b

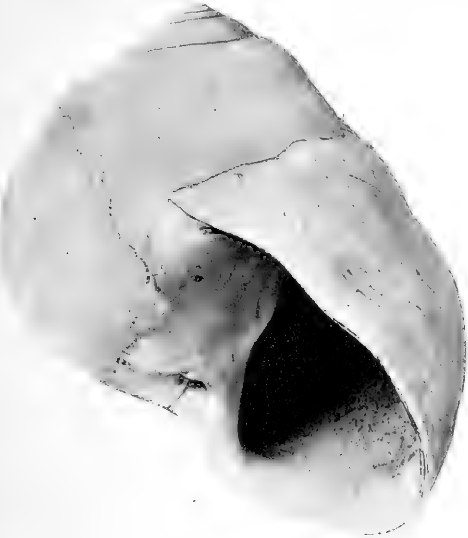
PLATE 38

All figures approximately natural size

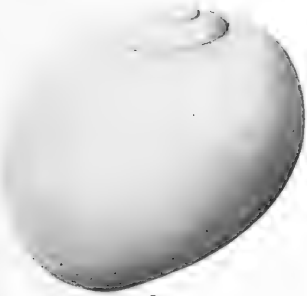
Fig. 1. *Polinices lewisi* (Gould). Slightly reduced. Altitude 112 mm. Station D 5738.

Fig. 2*a*. *Polynices draconis* (Dall). Slightly reduced. Altitude 56 mm. West of Golden Gate 30 fathom line.

Fig. 2*b*. *Polinices draconis* (Dall). Slightly reduced.



2b



2a

PLATE 39

Fig. 1. *Turris (Bela) tabulata* (Carpenter). × 4. Altitude 9 mm. Station D 5788.*

Fig. 2. *Thais emarginata* var. *ostrina* (Gould). × 1. Altitude 17 mm. Presidio.*

Fig. 3. *Thais emarginata var. ostrina* (Gould). × 1. Altitude 17.5 mm. Presidio.*

Fig. 4. *Thais emarginata* var. *ostrina* (Gould). × 1. Altitude 18 mm. Presidio.*

Fig. 5. *Thais emarginata* var. *ostrina* (Gould). × 1. Altitude 20 mm. Presidio.*

Fig. 6. *Monoceros engonatum* Conrad. × 1. Altitude 27 mm. Pigeon Point, San Mateo County.

Fig. 7*a*. *Murex foliatus* (Martyn). × 1. Altitude 58 mm. Bolinas.

Fig. 7*b*. *Murex foliatus* (Martyn). × 1.

Fig. 8*a*. *Cerithidea californica* (Haldeman). × 1. Altitude 38 mm. Lake Merritt, Oakland. Specimen from the collection of Professor Wm. S. Raymond.

Fig. 8*b*. *Cerithidea californica* (Haldeman). × 1.

Fig. 9*a*. *Cancellaria crawfordiana* Dall. × 1. Altitude 20.5 mm. Station D 5789.

Fig. 9*b*. *Cancellaria crawfordiana* Dall. × 1.

Fig. 10*a*. *Mangilia augulata* Carpenter. × 4½. Altitude 10 mm. Station D 5786.

Fig. 10*b*. *Mangilia augulata* Carpenter. × 4½.

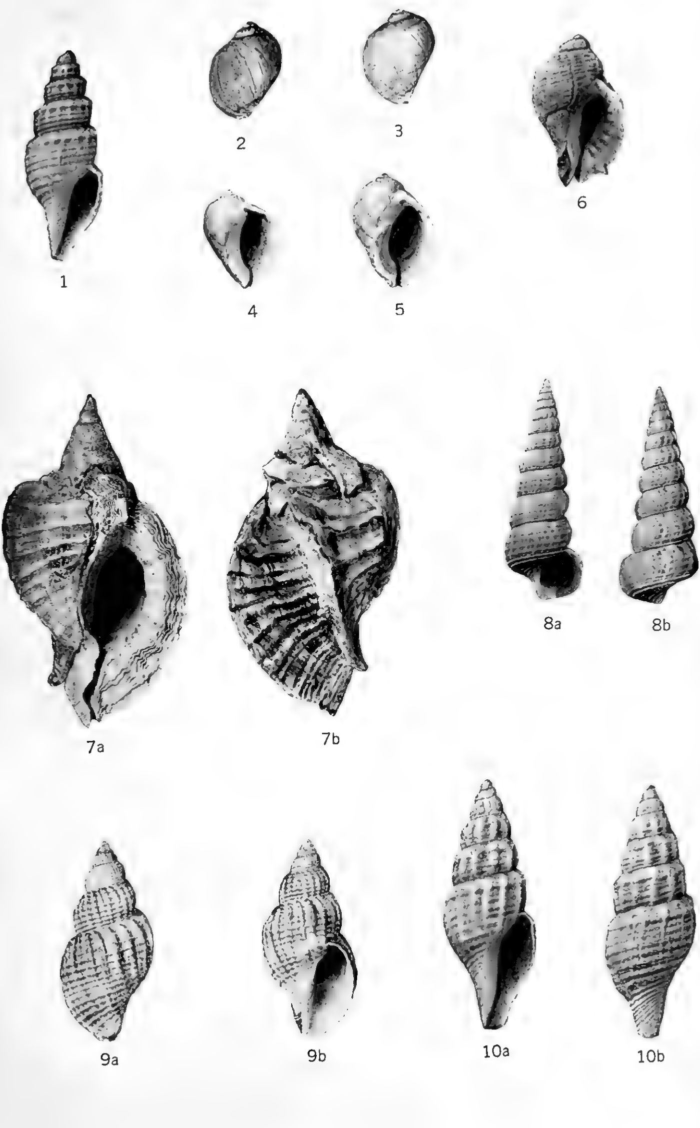

1
2
3
4
5
6
7a
7b
8a
8b
9a
9b
10a
10b

PLATE 40

All figures approximately natural size

Fig. 1. *Thais lamellosa* (Gmelin). Altitude 44 mm. Station D 5781. Tabulated and rough.

Fig. 2. *Thais lamellosa* (Gmelin). Altitude 45 mm. Station D. Cream-white and rough.

Fig. 3. *Thais lamellosa* (Gmelin). Altitude 44 mm. Banded and rough.

Fig. 4. *Thais lamellosa* (Gmelin). Altitude 41 mm. White and smooth.

Fig. 5*a*. *Thais lamellosa* (Gmelin). Altitude 52 mm. Station D 5801. White and smooth.

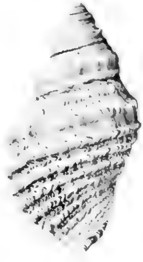
Fig. 5*b*. *Thais lamellosa* (Gmelin).

Fig. 6. *Thais lamellosa* (Gmelin). Altitude 38 mm. Red rock. Tabulated and smooth.

Fig. 7. *Thais lamellosa* (Gmelin). Altitude 37.5 mm. Station D 5796. Banded and smooth.

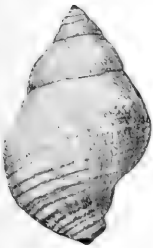
Fig. 8. *Thais lamellosa* (Gmelin). Altitude 38 mm. Station D 5796. Banded, smooth, high spire.

1



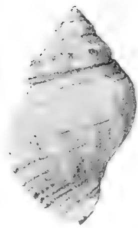
2

3

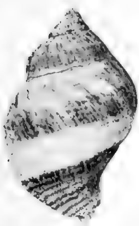


4

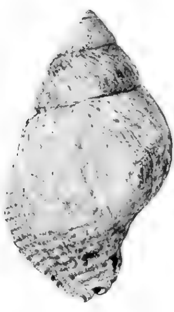
5a



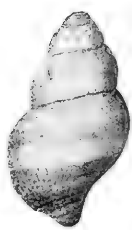
6



7



5b



8

PLATE 41

Fig. 1*a*. *Columbella gausapata* Gould. × 2. Altitude 9 mm. Station D 5790.

Fig. 1*b*. *Columbella gausapata* Gould. × 2.

Fig. 2*a*. *Turris incisa* Carpenter. × 2. Altitude 25.5 mm. Station D 5791. Enlarged to show detail.

Fig. 2*b*. *Turris incisa* Carpenter. × 1.

Fig. 3*a*. *Turris perversa* (Gabb). × 1¾. Altitude 19 mm. Station D 5785.*

Fig. 3*b*. *Turris perversa* (Gabb). × 1¾.

Fig. 4*a*. *Amphissa corrugata* (Reeve). × 2. Altitude 12 mm. Farallon Islands, University of California collection.

Fig. 4*b*. *Amphissa corrugata* (Reeve). × 2.

Fig. 5*a*. *Bittium subplanulatum* Bartsch. × 1½. Altitude 6 mm. Station D 5788.* Tip of spire broken.

Fig. 5*b*. *Bittium subplanulatum* Bartsch. × 1½.

Fig. 6. *Actaeon puncteoelatus* (Carpenter). × 1½. Altitude 8 mm. Station D 5791.*

* Fig. 7*a*. *Volvula cylindrica* Carpenter. × 2. Altitude 8.7 mm. Survey collection.

* Fig. 7*b*. *Volvula cylindrica* Carpenter. × 2.

Fig. 8*a*. *Acteocina cerealis* (Gould). × 2. Altitude 7.8 mm. Survey collection.

Fig. 8*b*. *Acteocina cerealis* (Gould). × 2.

* This is Cylichna alba Brown.

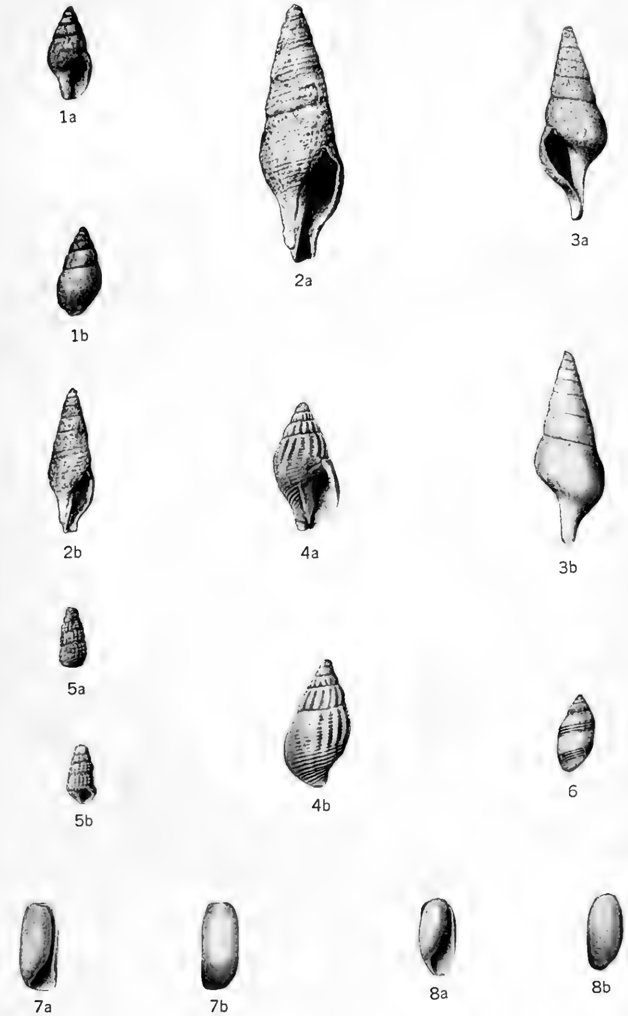

1a
2a
3a
1b
2b
4a
3b
5a
5b
4b
6
7a
7b
8a
8b

PLATE 42

Chart showing the distribution of *Ostrea lurida* Carpenter

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

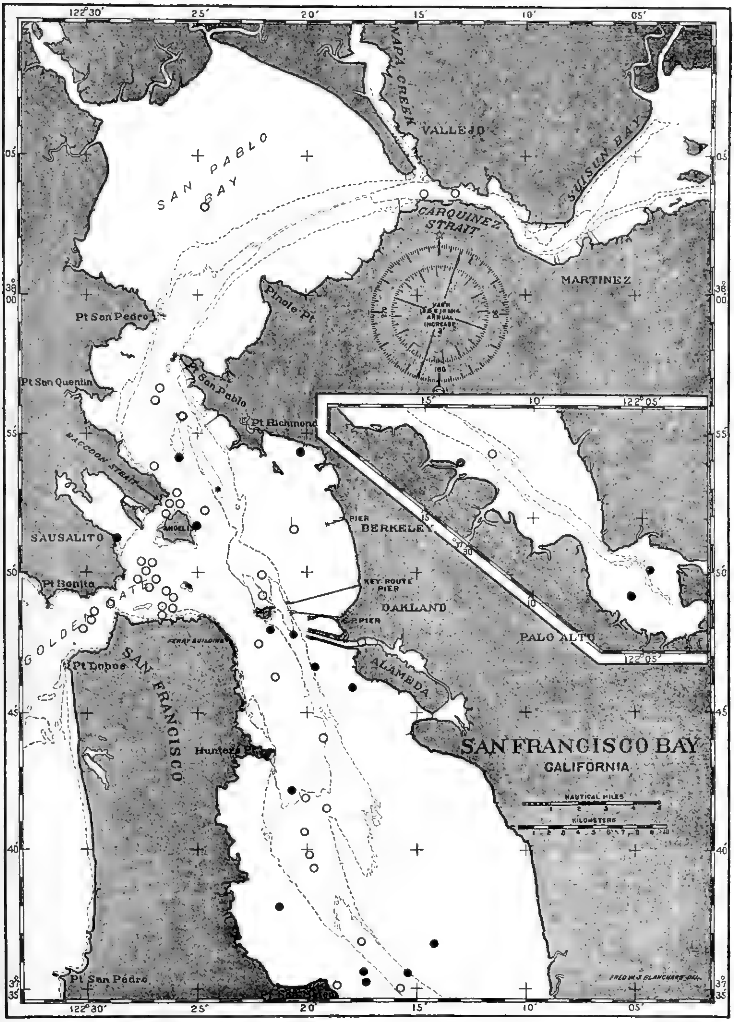

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
Pt Bonita
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
FERRY BUILDING
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
ALAMEDA
Hunters Pt
PALO ALTO
Pt San Pedro
NAUTICAL MILES
KILOMETERS

PLATE 43

Chart showing the distribution of *Mytilus edulis* Linnaeus

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

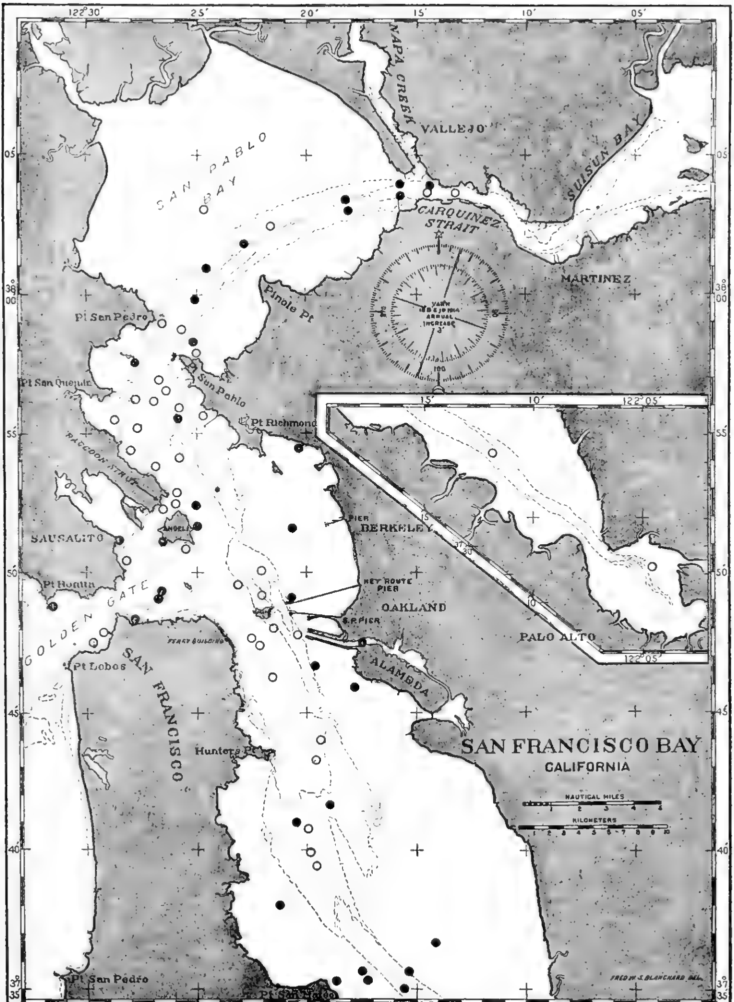

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
Pt Bonita
GOLDEN GATE
BERKELEY
PIER
KEY ROUTE PIER
S.P. PIER
OAKLAND
ALAMEDA
PALO ALTO
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD, DEL.
122° 30′
25′
20′
15′
10′
05′
122° 05′
38° 00′
55′
50′
45′
40′
37° 35′

PLATE 44

Chart showing the distribution of *Cardium corbis* (Martyn)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

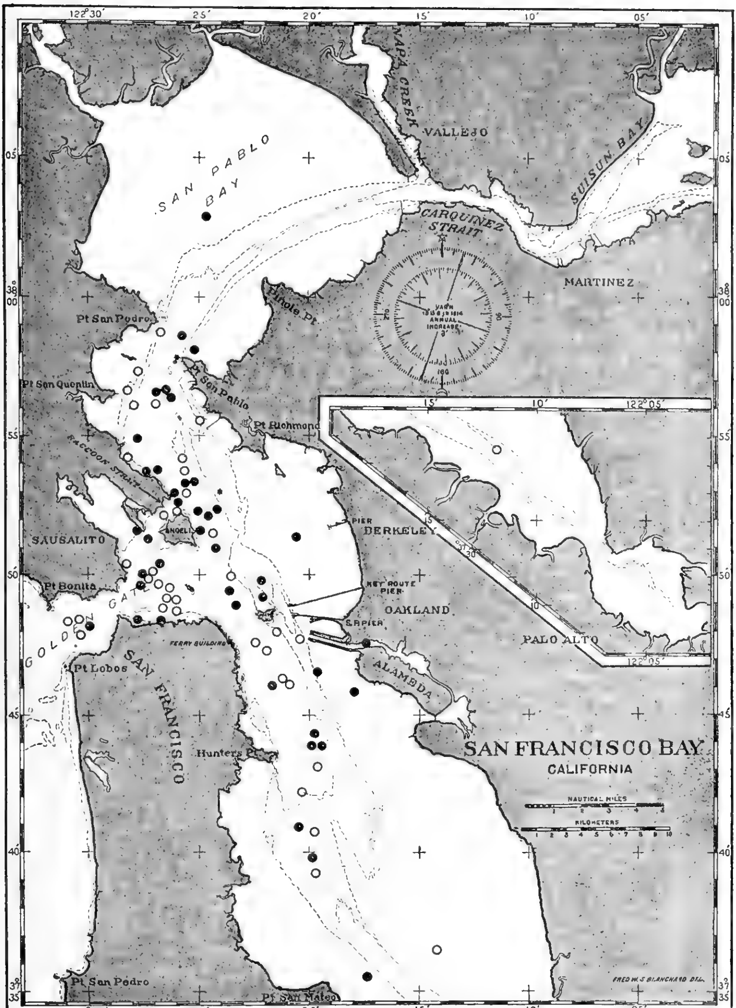

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
ANGEL I.
SAUSALITO
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
ALAMEDA
Hunters Pt
PALO ALTO
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD DEL.

PLATE 45

Chart showing the distribution of *Paphia staminea* (Conrad)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

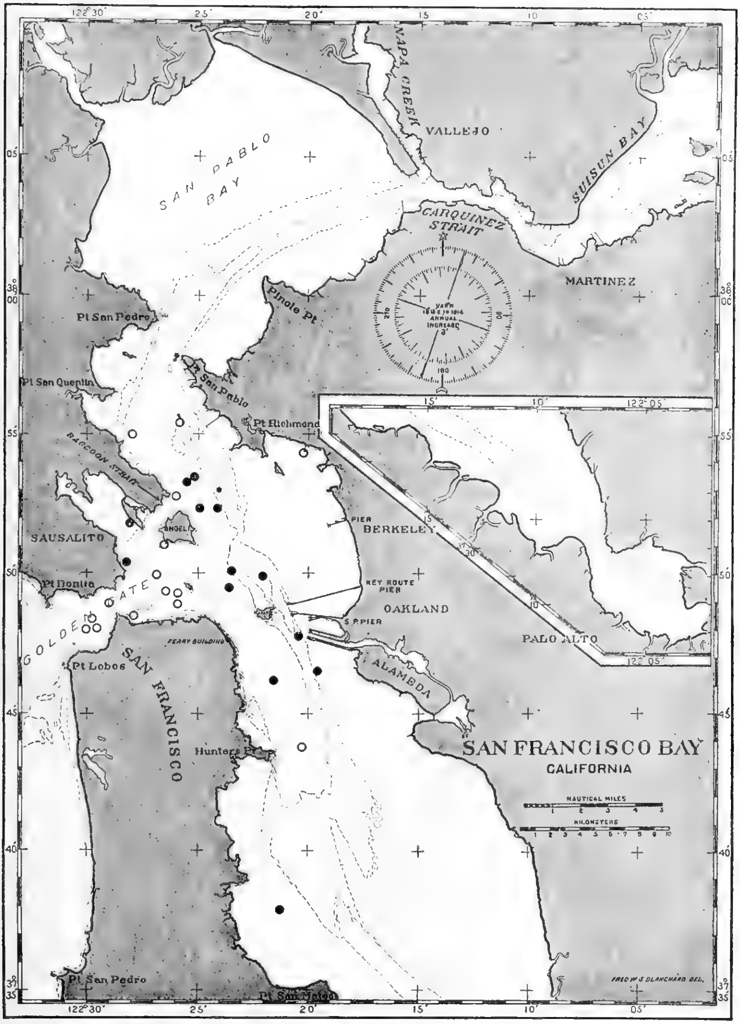

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
Pt Bonita
GOLDEN GATE
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
ALAMEDA
PALO ALTO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W S BLANCHARD DEL.

PLATE 46

Chart showing the distribution of *Tellina salmonea* (Carpenter)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

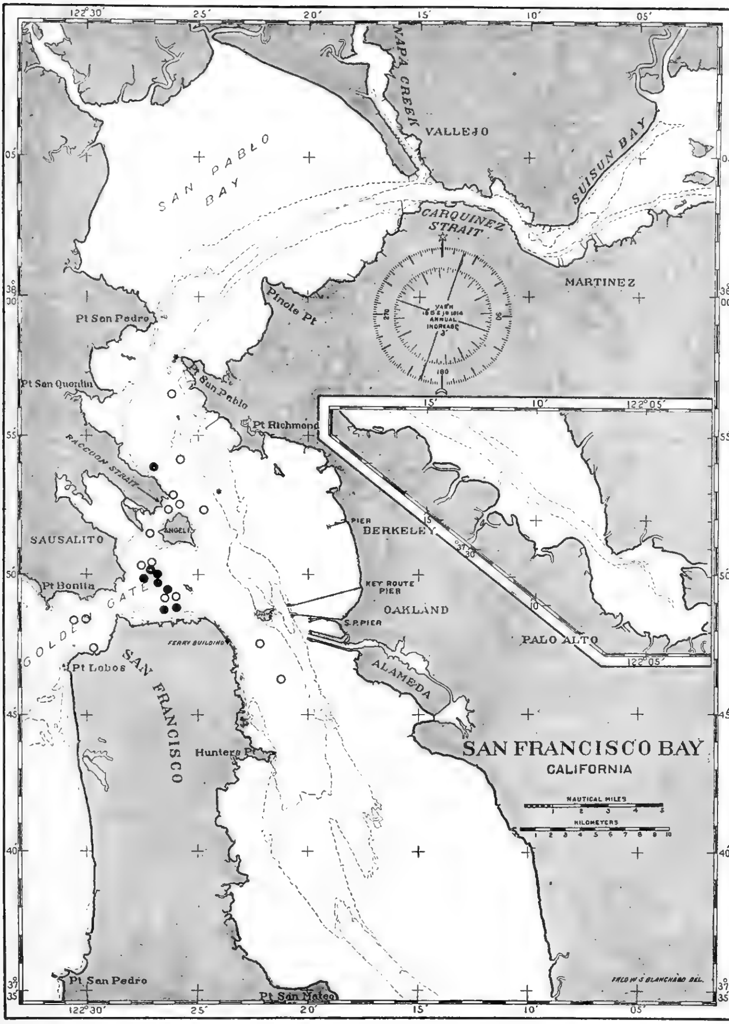

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
ANGEL I
SAUSALITO
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
ALAMEDA
PALO ALTO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W S BLANCHARD DEL.

PLATE 47

Chart showing the distribution of *Macoma balthica* (Linnaeus)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

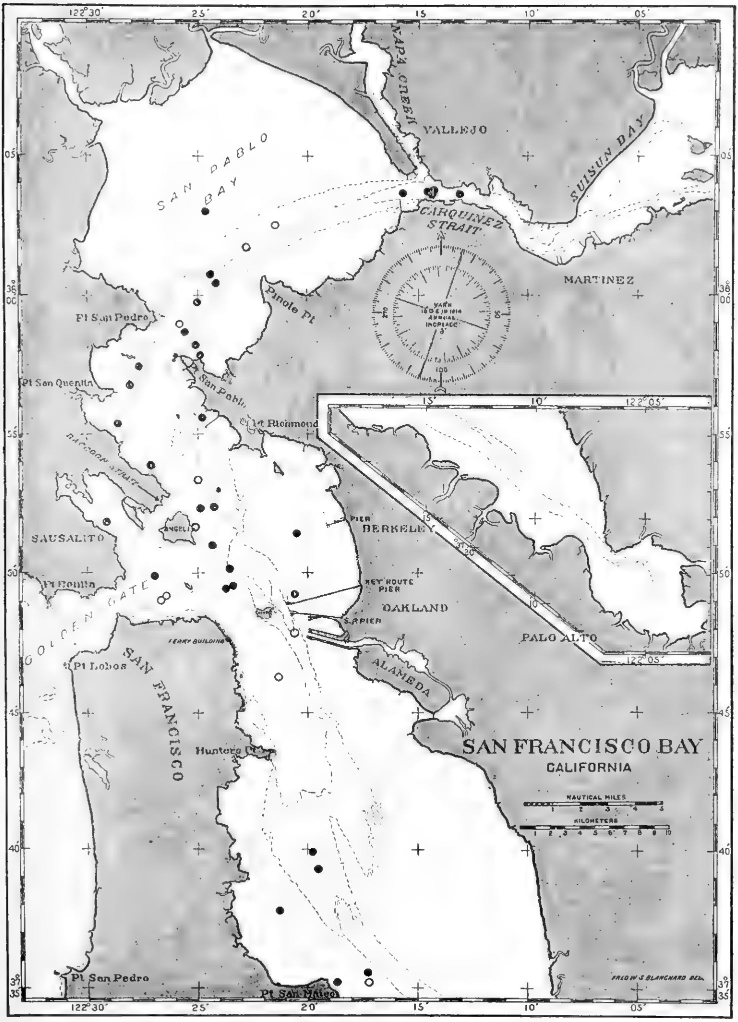

SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I
Pt Bonita
GOLDEN GATE
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
FERRY BUILDING
ALAMEDA
PALO ALTO
Pt Lobos
SAN FRANCISCO
Hunters Pt
Pt San Pedro
Pt San Mateo
SAN FRANCISCO BAY
CALIFORNIA
NAUTICAL MILES
KILOMETERS
FRED W S BLANCHARD DEL.

PLATE 48

Chart showing the distribution of *Macoma inquinata* (Deshayes)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

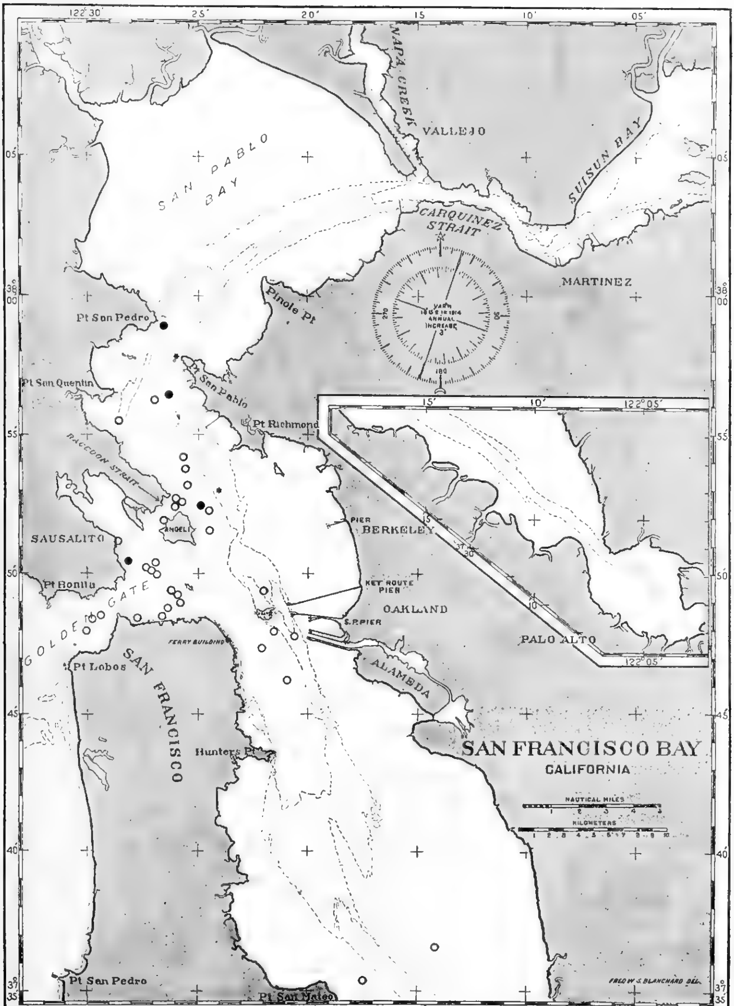

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
ANGEL I
SAUSALITO
Pt Bonita
GOLDEN GATE
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
ALAMEDA
PALO ALTO
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD DEL.
122°30′
25′
20′
15′
10′
05′
38° 00′
37° 35′

PLATE 49

Chart showing the distribution of *Macoma nasuta* (Conrad)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

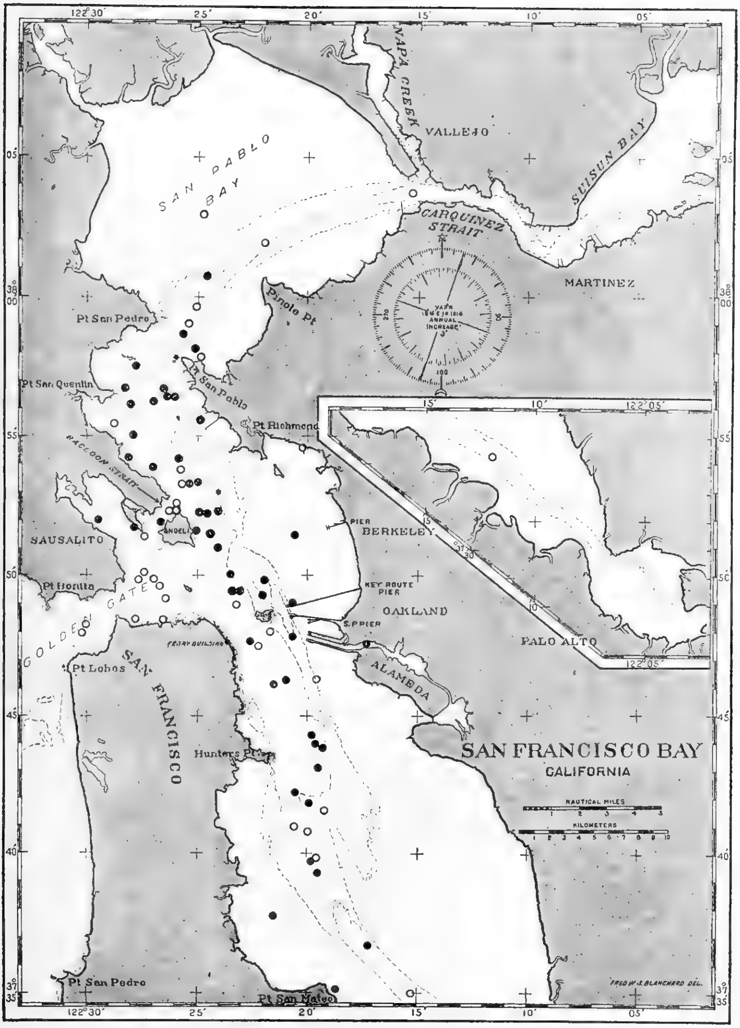

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
PALO ALTO
ALAMEDA
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD DEL.

PLATE 50

Chart showing the distribution of *Solen sicarius* Gould

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

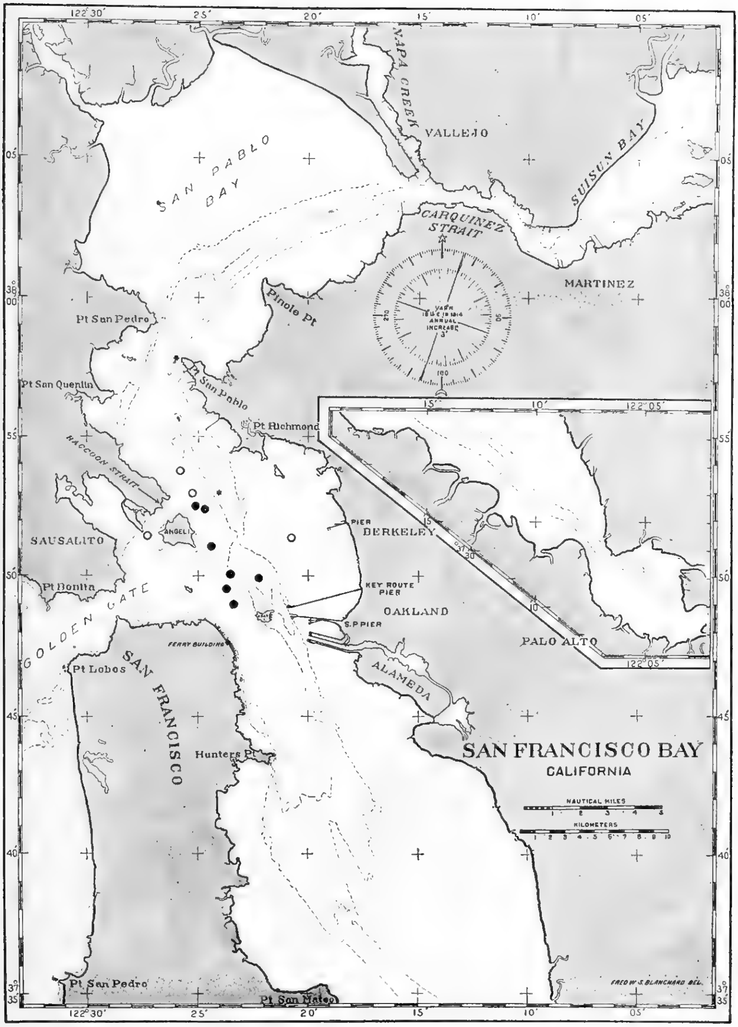

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
Pt Bonita
GOLDEN GATE
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
ALAMEDA
FERRY BUILDING
SAN FRANCISCO
Pt Lobos
Hunters Pt
PALO ALTO
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD DEL.

PLATE 51

Chart showing the distribution of *Schizothaerus nuttalli* (Conrad)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

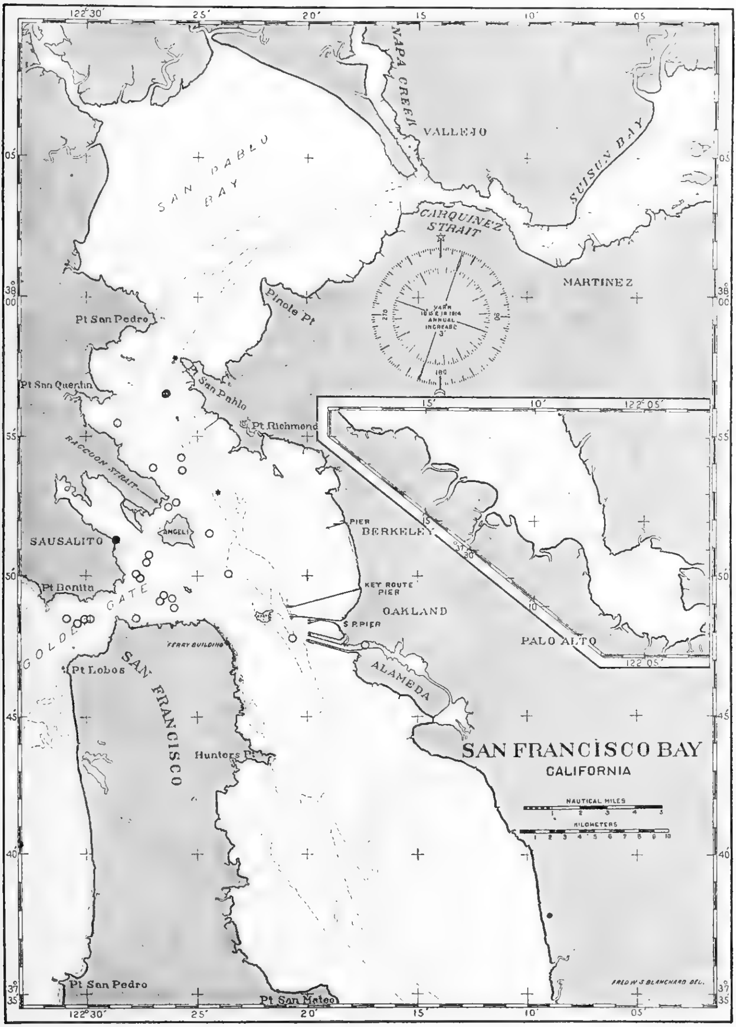

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
ANGEL I
SAUSALITO
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
ALAMEDA
PALO ALTO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
VAR'N 16°15' E IN 1914 ANNUAL INCREASE 3'
FRED W. S. BLANCHARD DEL.

PLATE 52

Chart showing the distribution of *Mya arenaria* Linnaeus

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

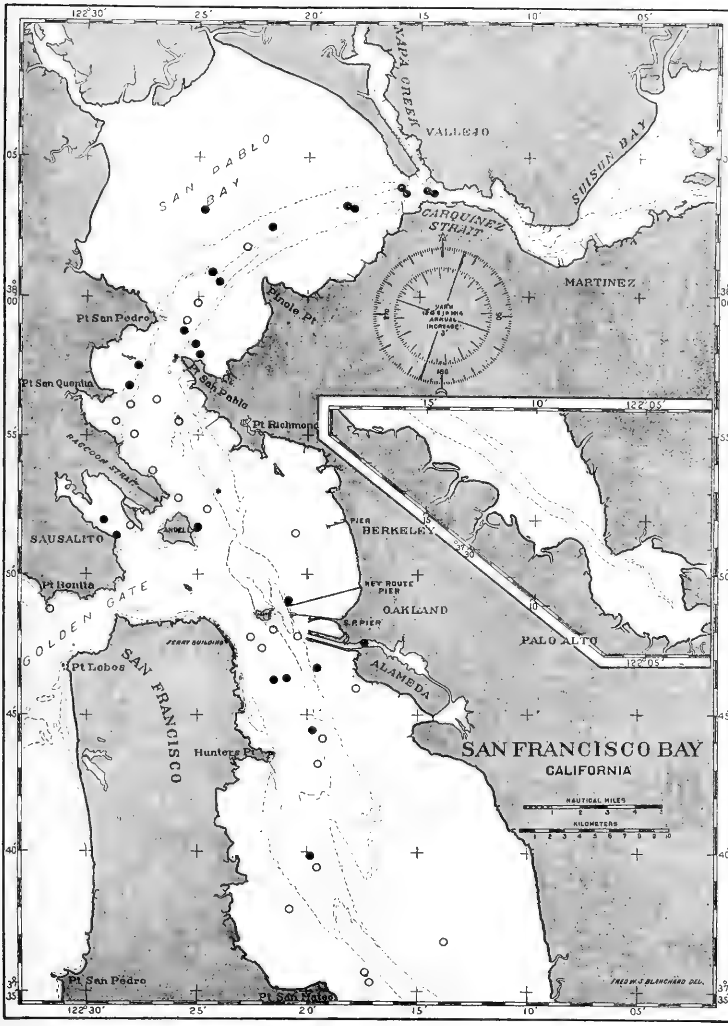

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
Pt Bonita
GOLDEN GATE
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
PALO ALTO
ALAMEDA
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W.S. BLANCHARD DEL.

PLATE 53

Chart showing the distribution of *Mya* (*Cryptomya*) *californica* (Conrad)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

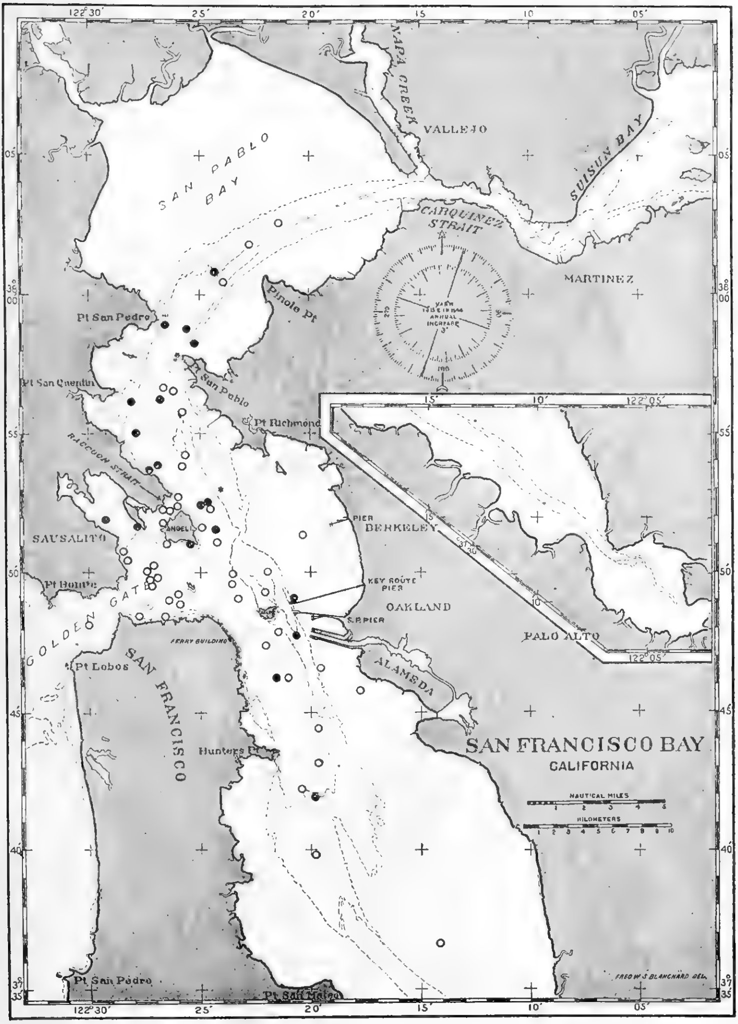

SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
PIER
BERKELEY
Pt Bonita
GOLDEN GATE
KEY ROUTE PIER
OAKLAND
S.P. PIER
PALO ALTO
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
ALAMEDA
SAN FRANCISCO BAY
CALIFORNIA
NAUTICAL MILES
KILOMETERS
Hunters Pt
Pt San Pedro
Pt San Mateo
FRED W. S. BLANCHARD DEL.

PLATE 54

Chart showing the distribution of *Zirfaea gabbi* Tryon

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)


SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
BERKELEY
OAKLAND
ALAMEDA
PALO ALTO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
122°30′
25′
20′
15′
10′
05′
122°05′
38° 00
37° 35

PLATE 55

Chart showing the distribution of *Crepidula nivea* Adams

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)


SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
Pt Bonita
GOLDEN GATE
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
ALAMEDA
PALO ALTO
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS

PLATE 56

Chart showing the distribution of *Columbella gausapata* Gould

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)


SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
S.P. PIER
Pt Bonita
GOLDEN GATE
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
ALAMEDA
PALO ALTO
Hunters Pt
SAN FRANCISCO BAY
CALIFORNIA
NAUTICAL MILES
KILOMETERS
Pt San Pedro
Pt San Mateo
FRED W S BLANCHARD, DEL.

PLATE 57

Chart showing the distribution of *Nassa fossata* (Gould)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

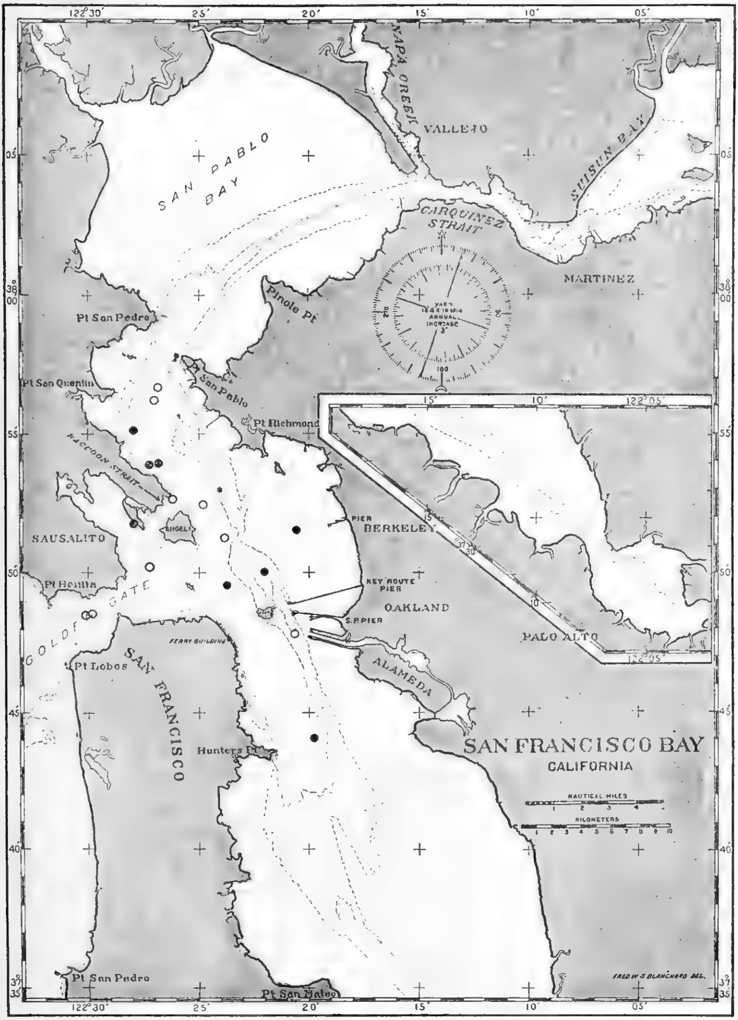

SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
Pt Bonita
GOLDEN GATE
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
ALAMEDA
PALO ALTO
Hunters Pt
SAN FRANCISCO BAY
CALIFORNIA
NAUTICAL MILES
KILOMETERS
Pt San Pedro
Pt San Mateo
FRED W S BLANCHARD DEL.

PLATE 58

Chart showing the distribution of *Nassa mendica* Gould

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

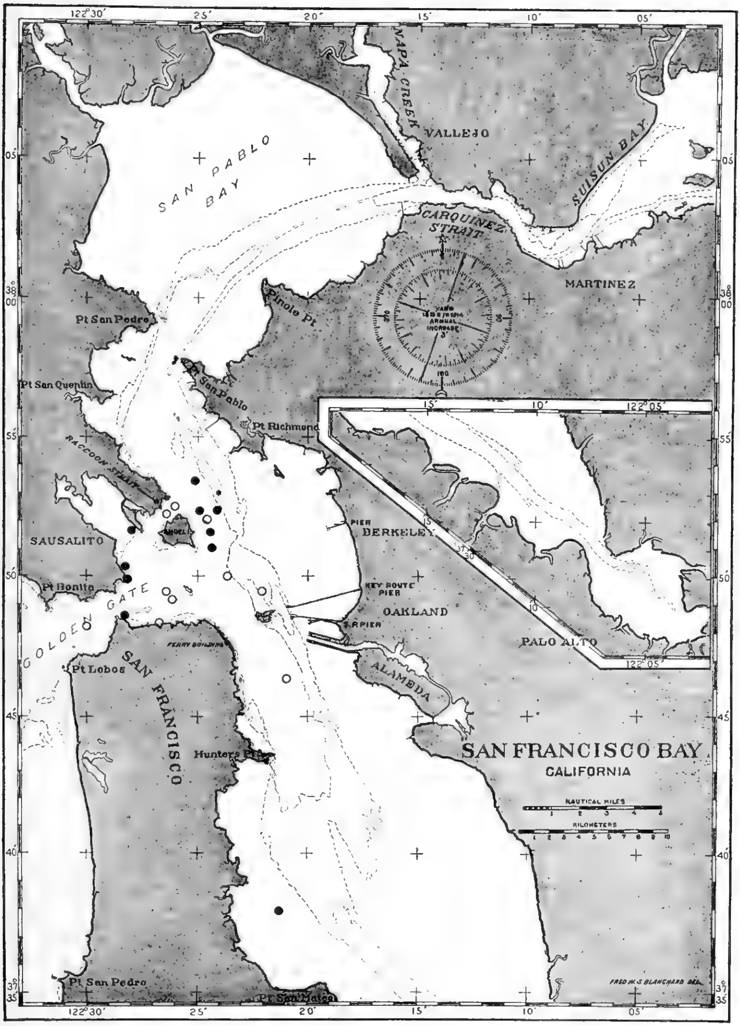

SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
ANGEL I.
BERKELEY
PIER
KEY ROUTE PIER
OAKLAND
Pt Bonita
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
FERRY BUILDING
ALAMEDA
PALO ALTO
Hunters Pt
SAN FRANCISCO BAY
CALIFORNIA
NAUTICAL MILES
KILOMETERS
Pt San Pedro
Pt San Mateo
FRED W. S BLANCHARD DEL.

PLATE 59

Chart showing the distribution of *Thais lamellosa* (Gmelin)

(The dot indicates the stations at which living specimens were dredged, and the circle indicates the stations at which only dead shells were obtained.)

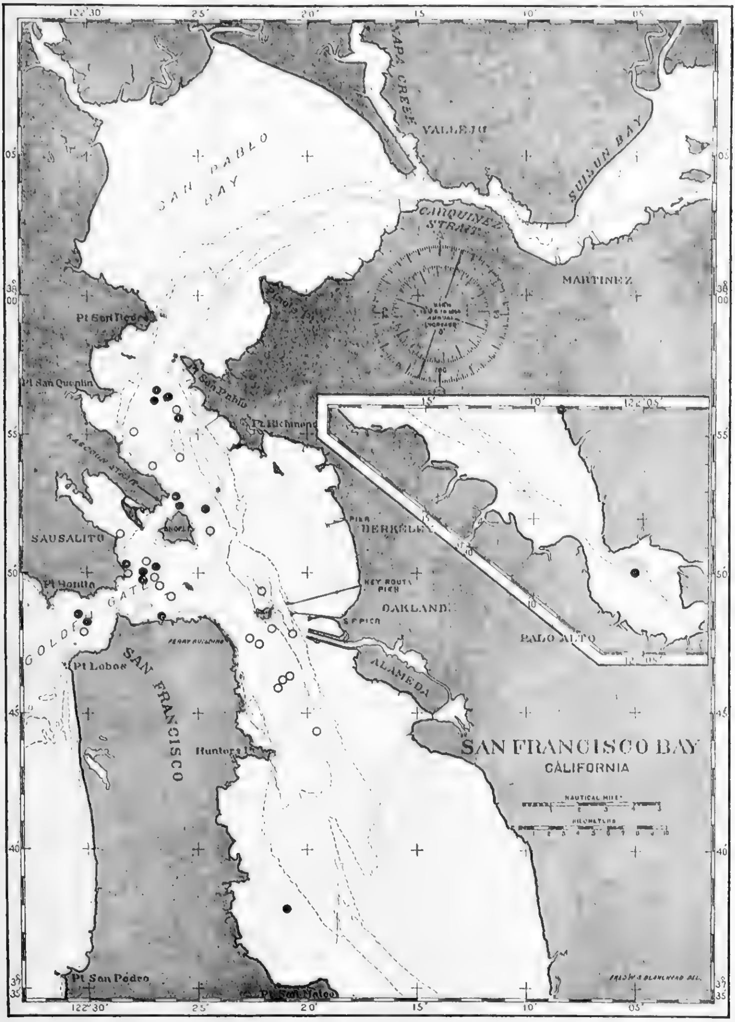
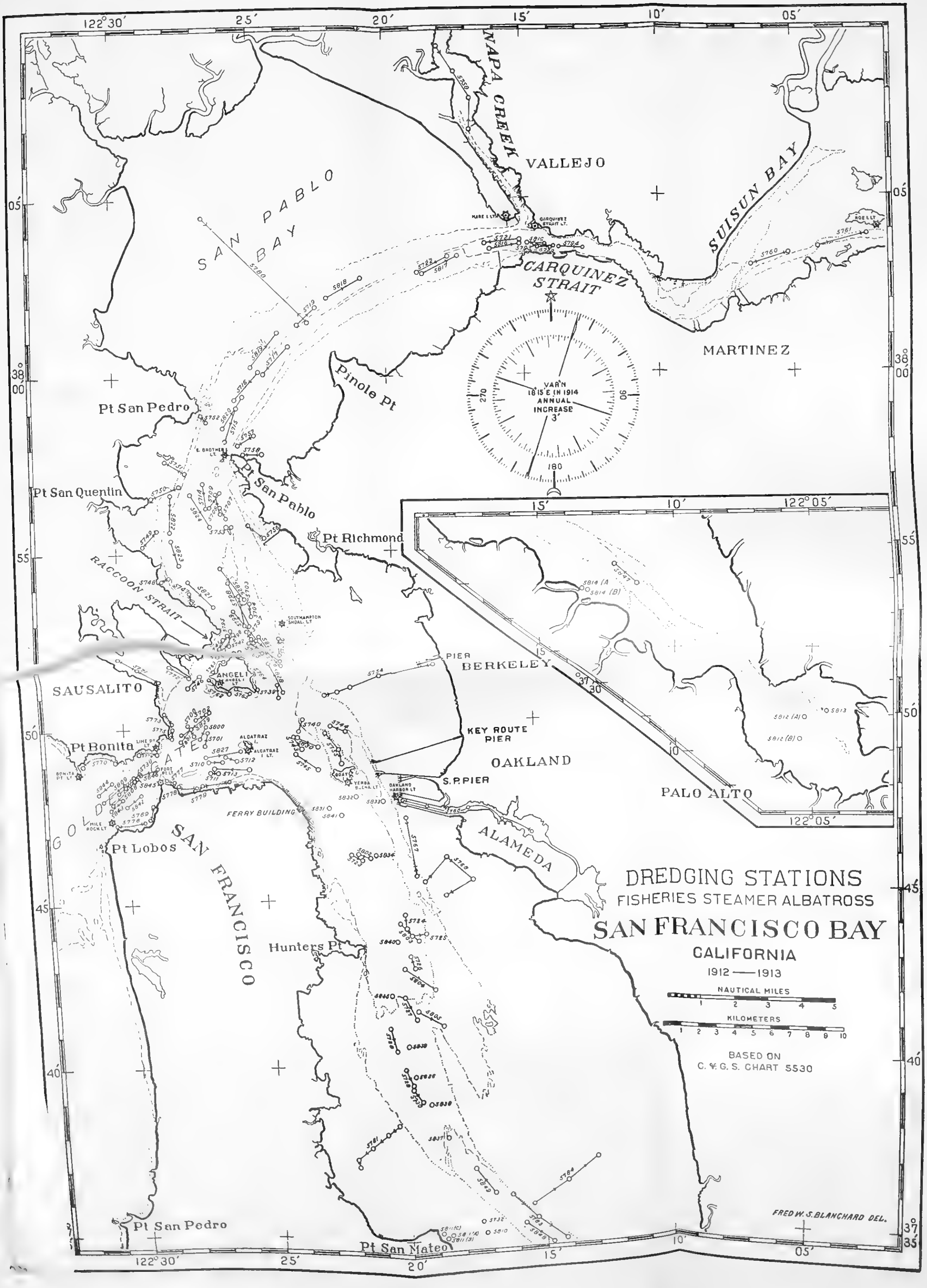

SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
BERKELEY
Pt Bonita
GOLDEN GATE
KEY ROUTE PIER
OAKLAND
S P PIER
PALO ALTO
Pt Lobos
SAN FRANCISCO
ALAMEDA
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
122°30'
25'
20'
15'
10'
05'

PLATE 60

Chart showing the distribution of "Albatross" dredging stations. (After Sumner *et. al.*, 1914.)


DREDGING STATIONS
FISHERIES STEAMER ALBATROSS
SAN FRANCISCO BAY
CALIFORNIA
1912 —— 1913
NAUTICAL MILES
KILOMETERS
BASED ON
C. & G. S. CHART 5530
FRED W. S. BLANCHARD DEL.
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
Pt Bonita
ANGEL I.
ALCATRAZ I.
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
FERRY BUILDING
GOLDEN GATE
Pt Lobos
SAN FRANCISCO
ALAMEDA
Hunters Pt
Pt San Pedro
Pt San Mateo
PALO ALTO
VAR'N 18 15' E IN 1914 ANNUAL INCREASE 3'

Carded

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
ZOOLOGY
Vol. 18, No. 13, pp. 299-336, plates 12-13, 6 figures in text April 20, 1918

A QUANTITATIVE ANALYSIS OF THE MOLLUSCAN FAUNA OF SAN FRANCISCO BAY

BY
E. L. PACKARD

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

UNIVERSITY OF CALIFORNIA PUBLICATIONS

Note.—The University of California Publications are offered in exchange for the publications of learned societies and institutions, universities and libraries. Complete lists of all the publications of the University will be sent upon request. For sample copies, lists of publications or other information, address the Manager of the University Press, Berkeley California, U. S. A. All matter sent in exchange should be addressed to The Exchange Department, University Library, Berkeley, California, U. S. A.

ZOOLOGY.—W. E. Ritter and C. A. Kofoid, Editors. Price per volume, $3.50; beginning with vol. 11, $5.00.

This series contains the contributions from the Department of Zoology, from the Marine Laboratory of the Scripps Institution for Biological Research, at La Jolla California, and from the California Museum of Vertebrate Zoology in Berkeley.

Cited as Univ. Calif. Publ. Zool.

Volume 1, 1902-1905, 317 pages, with 28 plates $3.50

Volume 2 (Contributions from the Laboratory of the Marine Biological Association of San Diego), 1904-1906, xvii + 382 pages, with 19 plates $3.50

Volume 3, 1906-1907, 383 pages, with 23 plates $3.50

Volume 4, 1907-1908, 400 pages, with 24 plates $3.50

Volume 5, 1908-1910, 440 pages, with 34 plates $3.50

Volume 6, 1908-1911, 478 pages, with 48 plates $3.50

Volume 7 (Contributions from the Museum of Vertebrate Zoology), 1910-1912, 446 pages, with 12 plates $3.50

Volume 8, 1911, 357 pages, with 25 plates $3.50

Volume 9, 1911-1912, 365 pages, with 24 plates $3.50

Volume 10, 1912-1913, 417 pages, with 10 plates $3.50

Volume 11, 1912-1914, 538 pages, with 26 plates $5.00

Volume 12 (Contributions from the Museum of Vertebrate Zoology), 1913-1916, 558 pages, with 22 plates $5.00

Volume 13, 1914-1916, 529 pages, with 39 plates $5.00

Vol. 14. 1. A Report upon the Physical Conditions in San Francisco Bay, Based upon the Operations of the United States Fisheries Steamer "Albatross" during the Years 1912 and 1913, by F. B. Sumner, G. D. Louderback, W. L. Schmitt, E. C. Johnston. Pp. 1-198, plates 1-13, 20 text figures. July, 1914 .... 2.25

Vol. 15. Introduction. Dependence of Marine Biology upon Hydrography and Necessity of Quantitative Biological Research. Pp. i-xxiii. June, 1916 .... .25

1. Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California, 1901 to 1912, compiled and arranged under the supervision of W. E. Ritter by Ellis L. Michael and George F. McEwen. Pp. 1-206, 4 text figures and map. July, 1915 .... 2.25
2. Continuation of Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1913-1915), compiled and arranged under the supervision of W. E. Ritter, by Ellis L. Michael, Zoologist and Administrative Assistant, George F. McEwen, Hydrographer. Pp. 207-254, 7 figures in text. November, 1916 .... .50
3. Summary and Interpretation of the Hydrographic Observations made by the Scripps Institution for Biological Research of the University of California, 1908 to 1915, by George F. McEwen, Hydrographer. Pp. 255-356, plates 1-38. December, 1916 .... 1.00

Vol. 16. 1. An Outline of the Morphology and Life History of *Crithidia leptocoridis*, sp. nov., by Irene McCulloch. Pp. 1-22, plates 1-4, 1 text figure. September, 1915 .... .25

2. On *Giardia microti*, sp. nov., from the Meadow Mouse, by Charles Atwood Kofoid and Elizabeth Bohn Christiansen. Pp. 23-29, 1 figure in text.
3. On Binary and Multiple Fission in *Giardia muris* (Grassi), by Charles Atwood Kofoid and Elizabeth Bohn Christiansen. Pp. 30-54, plates, 5-8, 1 figure in text.
   Nos. 2 and 3 in one cover. November, 1915 .... .30
4. The Cultivation of Tissues from Amphibians, by John C. Johnson. Pp. 55-62, 2 figures in text. November, 1915 .... .10

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
ZOOLOGY
Vol. 18, No. 13, pp. 299-336, plates 12-13, 6 figures in text April 20, 1918

A QUANTITATIVE ANALYSIS OF THE MOLLUSCAN FAUNA OF SAN FRANCISCO BAY

BY
E. L. PACKARD

CONTENTS

INTRODUCTION

Improved methods of procedure already applied in several different regions of the world have revealed many of the actual conditions under which the marine animal lives. Increased knowledge of such matters has been made possible, locally, through the Biological Survey of San Francisco Bay made by the United States Bureau of Fisheries.

The survey was made by the U. S. S. "Albatross" under the direction of a board consisting of Dr. F. B. Sumner, naturalist, Professor Charles A. Kofoid, and Commander G. H. Burrage, U. S. N., succeeded by Lieutenant-Commander H. B. Soule, U. S. N., during the years of 1912 and 1913. Much assistance has been received from Dr. Sumner and from Professor Kofoid, who upon Dr. Sumner's resignation has had supervision of the work. A report by Sumner, Louderback, Schmitt, and Johnston (1914) has been published in which the physical conditions of the waters of San Francisco Bay are ably presented. The data for each dredging station in that paper have served as the basis for the discussion of the Mollusca that follows.

A portion of the general results of the studies made upon the shell-bearing Mollusca dredged by the "Albatross" in San Francisco Bay lends itself for a separate treatment preliminary to a general discussion of the molluscan fauna as a whole, and is herein presented. These results have to do with the so-called "quantitative" stations or "orange-peel bucket dredge hauls," which comprise forty-three out of a much larger total number of dredgings.

The orange-peel bucket dredge had not been previously used for biological exploration. Other devices of somewhat similar character have been employed by Petersen (1913, p. 3) whereby a definite amount of the bottom material could be obtained, thereby giving a quantitative measure of the number of organisms living within a definite area at a given locality. The orange-peel bucket dredge, described and figured by Sumner *et al.* (1914, p. 7), has proved very efficient. Regarding it, the authors state: "Its chief advantage lies in the taking of comparatively large masses of mud from a single spot, and particularly in the penetrating power of the apparatus which renders possible the capture of deeply burrowing annelids, lamellibranches, etc." Its capacity is given as 2½ cubic feet. Since its diameter is 3.16 feet, it encloses a circular area containing 7.8 square feet.

The material collected by means of this apparatus was carefully sorted and all of the macroscopic organisms preserved in formalin or in alcohol. At those stations where a considerable amount of material was obtained the following method of procedure was employed. All of the molluscan material from such hauls was first passed over a sieve of 5 millimeters mesh. The shells that remained in the sieve were identified, counted, measured, and the condition of the specimens was noted. The measurements consisted of the maximum, minimum, and modal lengths for each species in the haul. The fine material which passed through the sieve was thoroughly mixed and then quartered after the manner of taking ore samples. A convenient sample was then sorted and subjected to the same type of analysis as out-lined above. This method of procedure when large masses of finely comminuted shells were concerned is not above criticism, yet it seemed to be the most practical method of treatment available.

Such a method gives excellent results for the larger mollusks and a fair representation for the smaller ones that are abundant, but it is slightly inaccurate for smaller shells, which are but sparsely represented in the fauna. Hence in the case of such forms as *Turbonilla, Odostomia,* or *Melanella* the figures given do not represent the actual numbers taken at a station.

The record based upon these methods shows for each species at each dredge haul the name, the number of individuals of each species (often approximate when these numbers were large), the conditions of the specimens at the time of dredging, and the maximum, minimum, and the modal lengths.

GENERAL DISTRIBUTION OF THE MOLLUSCA

Physical Characters of San Francisco Bay

Sumner *et al.* (1914, p. 22) recognized three physical and biological divisions of San Francisco Bay. The "upper" portion includes San Pablo Bay, the "middle" one extends from a line passing through the points of San Pedro and San Pablo to a line drawn from the Ferry Building to the Goat Island Light; the third or "lower" division lies south of the latter line.

The quantitative stations comprise forty-three hauls made with the orange-peel bucket dredge between the dates of December 9, 1912, and February 3, 1913. They were distributed from a point near the southern extremity of San Francisco Bay to Carquinez Strait. In the upper division of the bay twelve hauls were made at stations D 5815 to D 5820 inclusive. Twenty hauls at stations D 5821 to D 5830 inclusive were made within the middle portion; while eleven were made in the lower section of the bay at stations D 5831 to D 5841 inclusive. The position of these stations may be seen by referring to plate 12.

The physical conditions at these representative stations of San Francisco Bay are influenced largely by the surrounding topography. The Sacramento and San Joaquin rivers and several intermittent streams contribute considerable volumes of water to the bay. The total discharge of these streams affects the temperature and the salinity of the bay, besides bringing in sediment that is in part deposited within that basin.

The depth of water at the quantitative stations ranges from 4½ to 17 fathoms (8.3 to 31.3 meters). The mean tidal range for the entire bay throughout the month is given by Sumner *et al.* as 4.52 feet. The actual extremes during the course of the year are much greater, ranging from 0.4 to 7.8 at Fort Point within the Golden Gate. The rate of the tidal currents was determined for a number of localities to be about 1.4 knots per hour at a distance of a few feet below the surface. It was estimated that the mean rate of water flow over the entire bottom was between 0.67 and 0.75 of a knot per hour.

The mean annual temperature for the entire bay is 12°91C. The highest recorded temperature is 20°6C and the lowest is 6°0C; the highest of the regional means for the year was obtained in the lower division and the lowest in the middle division of the bay. A regional range of 12°65C occurs in the northern end of the bay, decreasing to 4°92C at Golden Gate and rising to 11°18 at the southern end. There is a considerable seasonal variation of temperature. During February the temperatures are quite uniform for the entire bay, being at that time lower than are those of the ocean outside the Golden Gate. During the latter part of April and early May the waters at either end of the bay are warmer than in February, whereas those of the middle divisions are colder than they are at the earlier period. At the next period the latter part of July a rise of temperature is noticed, the Golden Gate remaining the coolest region of the bay. During this period the temperature of the bay is higher than that of the ocean off San Francisco. In the early part of October a general decrease in the temperature is evident, and at this period, as well as in the early part of May, the ocean temperatures are nearly the same as those of the bay. In late November a general uniformity of temperature somewhat lower than that of the open ocean prevails throughout the bay. The lowest temperatures of the year occur in January, at which time the waters of the middle division are the warmest, while those of San Pablo Bay are the coldest. The waters of the bay are at this time and also in February colder than those of the ocean. The annual range of the bottom temperature for the entire bay is 8°35C. In the winter the bottom and surface temperatures are more nearly alike than in summer.

The salinity of San Francisco Bay ranges from 3.25 to 33.27 per mille. The mean for the entire bay for the year was estimated by Sumner *et al.* to be 27.48. The regional annual mean is less than 16 per mille in Carquinez Strait, while it reaches as high as 31 within the Golden Gate. As might be expected, the annual range is greatest in San Pablo Bay, reaching a minimum at Golden Gate and increasing but slightly toward the lower end of the bay. The minimum seasonal mean salinity for the entire bay occurs in April and May and the minimum in October. The bottom salinity for the entire bay is greater than the mean surface salinity throughout the year, the difference between the two being the greater during April and May, when the surface salinity is the lowest of the year.

A diversified bottom is encountered, the materials ranging from large stones within the Golden Gate to fine muds occurring characteristically at the extremities of the bay.

The Molluscan Fauna of San Francisco Bay

The molluscan fauna obtained by means of the orange-peel bucket dredge comprises twenty-three pelecypods and twelve gastropods. This list represents about 43 per cent of the entire molluscan fauna of the bay as obtained by the other types of dredges employed by the Survey. The species taken by means of the orange-peel bucket dredge are:

Cardium corbis (Martyn)
Gemma gemma, var. purpura Lea
Hinnites giganteus Gray
Macoma balthica (Linnaeus)
Macoma inquinata (Deshayes)
Macoma nasuta (Conrad)
Modiolus, cf. rectus Conrad
Monia macroschisma (Deshayes)
Mya arenaria (Linnaeus)
Mya california (Conrad)
Mytilus edulis Linnaeus
Ostrea lurida Carpenter
Phacoides tenuisculptus (Carpenter)
Paphia staminea (Conrad)
Pholas pacificus Stearns
Psephdia ovalis Dall
Saxidomus nuttalli (Conrad)
Schizothaerus nuttalli (Conrad)
Solen sicarius Gould
Spisula catilliformis Conrad
Tellina buttoni Dall
Tellina salmonea (Carpenter)
Zirfaea gabbi Tryon
Crepidula nivea Adams
Columbella gausapata Gould
Epitonium hindsi (Carpenter)
Epitonium sawinae (Dall)
Nassa fossata (Gould)
Nassa mendica (Gould)
Nassa perpinguis Gould
Odostomia franciscana Bartsch
Thais lamellosa (Gemelin)
Turbonilla franciscana Bartsch
Turbonilla keepi Dall and Bartsch
Turris, cf. incisa (Carpenter)

It will be noticed that nineteen genera of pelecypods and eight of gastropods are represented in this list.

Three of the genera are represented by two or more species: *Macoma* (3), *Tellina* (2), *Epitonium* (2), *Nassa* (3), and *Turbonilla* (2). The three species of *Macoma* occur quite abundantly and are of interest in as much as they are found together within the same dredge haul. Of these species, *M. balthica* was taken in 12 hauls, or at about 27 per cent of the total number of hauls; *M. inquinata* in 13, or 28 per cent of the total; while the third, *M. nasuta,* was taken in 26, or 56 per cent of the total. *M. balthica* and *M. nasuta* were taken together alive in three hauls. Shells of these two species were associated at two additional hauls. Specimens of *M. balthica* and *M. inquinata* were found together in three dredge hauls. Shells of *M. nasuta* and *M. inquinata* were taken together at 11 hauls. Specimens of all three species were taken at two localities. It is certain, then, that the more distantly related species *M. balthica* and *M. nasuta* live together within the restricted area covered by the jaws of the orange-peel bucket dredge, and it is probable that the more closely related species *M. nasuta* and *M. inquinata* may occur together within the same restricted area. Attention should, however, be called to the different distribution pattern of these three species resulting from the plotting of all of the known local occurrences upon outline maps of San Francisco Bay. Such a procedure shows that *M. inquinata* occurs almost exclusively in the middle division of the bay, whereas *M. balthica* and *M. nasuta* have a much more general distribution.

The quantitative hauls are too few in number to serve as a basis for conclusions regarding the areal distribution of any of the species. Therefore such studies are reserved for a fuller treatment in another paper.

The most common or the prevalent species of the quantitative hauls may be defined as those that occur at one-fourth or more of the hauls (See Sumner, Osborn, Cole, and Davis, 1913, p. 69).

This list of prevalent species is as follows:

Cardium corbis	19 hauls
Macoma balthica	12 hauls
Macoma inquinata	13 hauls
Macoma nasuta	26 hauls
Mya arenaria	17 hauls
Mya californica	28 hauls
Mytilus edulis	18 hauls
Ostrea lurida	14 hauls
Zirfaea gabbi	13 hauls
Thais lamellosa	15 hauls

Of these, only *Mya california* and *Macoma nasuta* were taken alive more than ten times.

These prevalent species include the most adaptable forms found in the local fauna. Most of them are distributed quite uniformly throughout the bay, being able to withstand easily the extremes of the diverse environments found within these waters. The hardiness of these species is attested also by their wide geographic distribution, showing a marked range of environmental conditions. It is not surprising, then, that *Macoma balthica* and *Mytilus edulis* have a general distribution within San Francisco Bay, when the same species are able to endure the rigors of the littoral zone of the North Sea, north Atlantic Coast, and western coast of North America. *Thais lamellosa* and *Zirfaea gabbi* also have wide ranges on the West Coast and are closely related to if not identical to Atlantic Coast species.

TABLE 1

COMPLETE RECORD OF THE QUANTITATIVE HAULS

"Albatross" dredging stations	Number of species of Mollusca	Number of genera	Number of species represented by living specimens	Number of individuals living	Number of individuals dead	Total number of individuals	Number of species of Pelecypods	Number of species of Gastropods
D 5815 A	2	2	2	6	0	6	2	0
D 5815 B	1	1	0	0	3	3	1	0
D 5816 A	0	0	0	0	0	0	0	0
D 5816 B	2	2	2	5	2	7	2	0
D 5817 A	3	3	1	8	109	117	3	0
D 5817 B	3	3	3	4	15	19	2	1
D 5818 A	3	3	1	1	18	19	3	0
D 5818 B	4	4	1	10	39	49	4	0
D 5819 A	4	3	3	10	5	15	4	0
D 5819 B	1	1	1	3	4	7	1	0
D 5820 A	4	3	2	2	5	7	4	0
D 5820 B	1	1	0	0	9	9	1	0
D 5821 A	5	5	4	31	17	48	4	1
D 5821 B	11	11	2	3	37	40	10	1
D 5822 A	3	3	1	1	224	225	3	0
D 5822 B	6	6	2	115	83	198	5	1
D 5823 A	6	6	2	17	91	108	5	1
D 5823 B	3	3	3	13	2	15	3	0
D 5824 A	3	3	2	7	24	31	3	0
D 5824 B	11	10	3	404	2,566	2,970	8	3
D 5825 A	13	12	7	166	193	359	9	4
D 5825 B	9	8	1	1	189	190	8	1
D 5826 A	10	9	0	0	343	343	8	2
D 5826 B	10	9	2	33	126	159	8	2
D 5827 A	11	10	0	0	95	95	10	1
D 5827 B	10	9	1	2	24	26	8	2
D 5828 A	7	7	5	458	25	483	6	1
D 5828 B	13	12	6	298	527	825	9	4
D 5829 A	12	11	1	6	130	136	10	2
D 5829 B	0	0	0	0	0	0	0	0
D 5830 A	5	5	5	28	20	48	4	1
D 5830 B	2	1	2	17	2	19	2	0
D 5831	9	8	4	20	39	59	7	2
D 5832	8	7	0	0	69	69	7	1
D 5833	15	12	4	259	93	352	11	4
D 5834	8	7	2	2	80	82	6	2
D 5835	6	6	1	2	35	37	5	1
D 5836	6	6	0	0	158	158	4	2
D 5837	0	0	0	0	0	0	0	0
D 5838	0	0	0	0	0	0	0	0
D 5839	8	8	0	0	197	197	6	2
D 5840	5	5	3	24	72	96	3	2
D 5841	11	10	0	0	127	127	9	2
Average number per haul,			1.85	45.59	134.8	180.3	4.83	1.06

Table 1 shows that the average number of species of Pelecypoda per dredge haul is 4.83 as compared with 1.06 of Gastropoda. This preponderance of bivalves may be characteristic of inclosed waters, for it is considerably less, judging from the qualitative hauls alone, in the open waters just outside of the Golden Gate. The relative abundance of the forms is shown in the fourth column, where it is found that 45.59 living specimens were taken in the average quantitative haul representing the molluscan population of 7.8 square feet of bottom. These living specimens represent 1.85 species, showing that as a rule but a comparatively few forms live together at the same time within an area less than eight square feet. The largest number of living individuals dredged from a single locality is 458 at station D 5828 A, which is within the middle division of the bay just east of Angel Island (see pl. 12).

The number of dead shells, representing as they do the accumulation of a considerable period of time, have but little interest in a faunistic study. The shells, which are often heaped into veritable banks, may be transported by currents or various marine animals, of which the hermit crab is the most important. At certain localities the dredge was often completely filled with old valves of *Ostrea lurida* or *Mya arenaria.* Occasionally these hauls contained no living specimens of the species so abundantly represented by dead shells. This suggests a recent change in the physical conditions, at least in quiet waters, of such a nature as to be detrimental to that species. It is not improbable that the molluscan fauna of the bay is undergoing modifications due to the close proximity of the cities around the bay. The average number of dead shells per dredge haul is 134.8, which is far under the actual number that would be obtained if several of the above mentioned hauls of oyster shells had not been omitted.

Station D 5833 is the richest faunally of all the quantitative hauls. This most productive haul was made 0.3 of a mile west of the Oakland Harbor Light, within the lower division of the bay. The bottom was characterized by Sumner *et al.* (1914, p. 190) as being composed of 90.5 per cent of mud and 9.4 per cent of sand; the depth is 6¼ fathoms; and the haul was made January 21, 1913. The complete record of this haul is given in table 2.

TABLE 2

A Record of the Most Productive Quantitative Haul, Station D 5833

	Number of living individuals	Total number of individuals	Modal lengths in mm.
Cardium corbis	0	29	24
Macoma balthica	128	127	15
Macoma inquinata	0	7	38
Macoma nasuta	0	20	55
Mya arenaria	0	1	22
Mya california	2	7	11
Mytilus edulis	0	2	33
Ostrea lurida	0	many	....
Paphia staminea	1	3	10
Schizothaerus nuttalli	0	fragm.	....
Zirfaea gabbi	0	fragm.	....
Crepidula nivea	0	fragm.	....
Epitonium hindsi	128	128	3
Epitonium sawinae	0	1	....
Nassa fossata	0	1	22
Thais lamellosa	0	14	13

It is of interest to note the average size of a few of the prevalent species. Such data are tabulated below.

TABLE 3

The Average Size of the Living Specimens of Five Prevalent Species

Species	Number of specimens	Average length of specimens for all hauls in mm.	Maximum length of living specimens obtained in same hauls in mm.
Macoma nasuta	59	20	55
Cardium corbis	11	9	17
Mytilus edulis	4	8	17
Mya arenaria	33	25.8	80
Mya california	573	9.5	17

The averages as given above are rather low, due in part to the relatively large numbers of very young individuals. These figures, however, combined with those given elsewhere in this paper, make it possible to picture the molluscan life of a typical unit area, besides giving the approximate numbers and dimensions of the individuals living within such an area. It is also possible to estimate roughly the amount of organic matter represented by the mollusks, after once having established the average number and size of the individuals per unit area, and the ratio of the organic to that of the inorganic matter for each species.

A picture of the molluscan life of an average unit area, such as would be covered by the jaws of the orange-peel bucket dredge (7.8 square feet), may be obtained from a consideration of the data presented above.

This unit area within the upper division of the bay would yield two species, judging from the average number of species per dredge haul for that region. Similar averages for that portion of the bay indicate that such an area would support four living specimens and seventeen old shells.

The same area within the middle division would yield, according to the same line of reasoning, seven species, while the living individuals would number 80 and the old shells 235.

A similar area within the lower division would appear to yield six species, twenty-seven individuals and seventy-nine old shells.

The particular species represented within these three hypothetical areas can not be determined. It is probable that such an area depicting the average conditions would contain some of those species that have been listed as the prevalent species for the region considered. The commonest simple combination of species for the upper division, for instance, would be the two species most frequently dredged within that region, but such a combination out of a number of other possible combinations would rarely be obtained.

This difference in the abundance of the molluscan life within the different regions of the bay is shown in plate 13, where the circles of different sizes stand for the different species and the number of circles for the number of living individuals obtained in the average dredge haul for the designated divisions. No attempt has been made to show the number of old shells.

ECONOMIC CONSIDERATIONS

The molluscan fauna of San Francisco Bay and environs includes a number of edible pelecypods. The two local species most commonly found in the markets of the Bay region are *Mya arenaria,* the "soft-shelled," "mud" or "eastern clam," and *Paphia staminea,* the "hard-shell," or "butter clam." Other well known northern clams that occur in the vicinity of San Francisco include: *Saxidomus nuttalli, Schizothaerus nuttalli, Mytilus edulis, Mytilus californicus, Siliqua nuttalli, Ostrea elongata, Ostrea lurida, Panope generosa, Cardium corbis,* and *Pholadidea penita.* Two other Californian species, *Tivila crassatelloides* and *Chione undatella,* are frequently seen in the San Francisco markets, but they are southern species, the former, the Pismo clam, coming principally from San Luis Obispo County.

Mya arenaria is predominantly a mud-dwelling species, and occurs in sheltered localities on muddy or sandy beaches. It thrives under various conditions of temperatures and salinities. The extensive mud flats of San Francisco Bay afford a very congenial habitat for this exotic form, as is attested by its phenomenal increase since 1881, when it was first reported from this region. The Survey record shows that this species now has a general distribution within the bay, being especially abundant on the extensive tidal flats of the upper and lower divisions.

An excellent account of the developmental history and economic importance of this clam may be found in the reports of the Massachusetts Commissioners on Fisheries and Game. Since no detailed work has been published regarding this particular species on our coast, Belding's conclusions will be assumed to apply in general to our local forms. The following notes are drawn freely from the papers published by the Massachusetts Commissioners on Fisheries and Game (1916).

As is well known, this mollusk burrows deeply in the soil, lying at a depth of from six to twelve inches. When the tide is out the siphon is generally partly retracted, leaving an elliptical hole in the sand, but upon the return of the tide the siphon expands and a current of water is set up through the incurrent and excurrent tubes. The clam once having established itself and having grown to a length of about one and one-half inches, seldom moves, unless crowded out of its hole by more vigorous neighbors.

Belding and Lane show that after fertilization the larva passes through the well known stages leading up to the veliger, which is characterized by a thin shell. This stage is reached in about twenty-four hours after fertilization, the organism passively floating at or near the surface of the water. A few days later it develops a prodissoconch and a ciliated foot, when it settles to the bottom and attaches itself to a suitable support by means of a byssus. It develops rapidly and soon acquires the burrowing habits of the adult.

In favorable localities on the Atlantic Coast a length of 30.5 millimeters (1¼ inches) is attained by the end of three and one-half months. Belding and Lane (1916, pl. 9) claim that a clam that has reached a length of 25 mm. at the end of six months will measure 70 mm, at 1½ years, or 81.9 mm. at 2½ years, or 90.7 mm. at 3½ years. Such a growth expressed in terms of volume is equivalent to an increase from 1 to 23 bushels at 1½ years, 36.9 at 2½ or 47 at 3½ years. This clam reproduces on the Atlantic Coast at two years of age.

On the Massachusetts coast spawning occurs from June 1 to September 1. There is considerable local difference in the spawning season due to the fact that "spawning will not take place until the water has attained a warmth suitable for the development of young larvae" (Mass. Com'rs of Fisheries and Game, 1916, p. 105). It does not necessarily follow that the spawning season of San Francisco Bay would be the same time, for the water temperature may be suitable for reproduction during other months of the year. This problem should be investigated, since it has an economic as well as a scientific significance.

It is evident that the larval stage of the clam is the most critical period of its life. During this stage it is defenseless, subject to the varying conditions of surface temperature and salinity and to the tidal currents. If the young clams drift away from a suitable bottom they are destroyed in countless numbers, or the currents may sweep many together so that many more become attached within a small area than can possibly develop.

It is highly desirable to determine the localities within San Francisco Bay where the set is heavy from year to year, for such places would supply young clams for transplanting to localities less favorably situated as regards tidal currents.

Paphia staminea occurs commonly on sandy bottom. It, too, is a hardy form, occurring within estuaries as well as along the sandy beaches of the open ocean. Apparently San Francisco Bay does not afford as suitable conditions for the development of this clam as for the preceding species, since it was more rarely taken by the "Albatross".

Saxidomus nuttalli is not abundant within San Francisco Bay, occurring, according to the Survey records, only within the Golden Gate. This species is elsewhere more frequently taken from a sandy and gravelly bottom, into which it burrows deeply. It is found along the open ocean and within inlets within which the range of salinity is not great. This large clam is quite abundant along Oregon and Washington shores, where it is taken in considerable numbers. This species, together with the following, possesses a dark epidermis around the large muscular siphon, which detracts from the appearance of the clam and which must be removed before it is canned.

Schizothaerus nuttalli burrows very deeply in the muddy sand of the open ocean or bays. It was taken alive but once within San Francisco Bay, probably because the dredge failed to sink deep enough to capture it. This species occurs most abundantly at the low water mark and might be expected to occur sparingly along the low sandy beaches within the middle division of the Bay. It is known as the ''Washington'' or ''horse clam'' in the Puget Sound region, where it is now being utilized for clam nectar.

The mussels, represented by *Mytilus edulis* and *M. californicus,* are a sea food that has not as yet received the attention it deserves. *Mytilus edulis* occurs in varied environments wherever suitable supports abound. It is found attached to the rocks or piles mainly within the intertidal zone. These small mussels are occasionally found in local markets, where they command a good price. The large mussel, *M. californianus,* is seldom found in the markets, although it is used locally by people living near the beds. It comprised an important article in the diet of the local Indians, as is attested by the extensive shell mounds along the coast. Unlike the smaller mussels, this form lives only along the shores of the open ocean, attached to the rocks at or near low tide mark. It develops best at those places along the rocky shore where the waves are continually breaking over them. These mollusks can be easily harvested at extreme low tide by pulling them off the rock or scraping them off by means of a suitable tool. Such an industry properly regulated would add a considerable amount of sea food to the states of California, Oregon, and Washington.

Siliqua nuttalli, incorrectly named ''razor clam,'' occurs sparingly within the middle division of San Francisco Bay. It occurs typically within the pure sands along the open ocean. No record is available of this species occurring in commercial quantities in the vicinity of San Francisco, although it might be grown on almost any gently sloping outside beach, on which but little shifting of the sand occurs.

The eastern and the native oysters occur within San Francisco Bay. The former, *Ostrea elongata,* does not reproduce within these local waters. Therefore seed oysters are brought from the Atlantic Coast to replenish the beds depleted by harvest. The principal oyster beds located within the lower division of the bay are now being investigated by the United States Bureau of Fisheries, and therefore will not be further considered. The small native or ''Olympia oyster,'' *Ostrea lurida,* is a hardy species having a general distribution within the bay as well as in shallow waters outside of the Golden Gate. In places within the lower division of the bay these oyster shells literally pave the bottom. This small oyster is now extensively used throughout the coast.

Panope generosa is the largest of the West Coast clams. This northern form occurs only sparingly in the vicinity of San Francisco. It occurs on sandy or gravelly beaches near the low tide mark, where it burrows deeply.

Cardium corbis, the true cockle, is a hardy clam living under a variety of conditions from those of an estuary to that of the open ocean. It is perhaps predominantly a mud dweller, although it frequently occurs on sandy or gravelly bottoms. It is one of the easiest to procure, since it generally lies on the surface. Although this clam has the reputation of being tough, it is suitable for, and at present is being used, as minced clams. This species is large and lacks the thick, dark epidermis on the siphons, making it more desirable for mincing than similar sized or even larger clams, such as *Saxidomus nuttalli* or *Schizothaerus nuttalli.*

The rock-boring mollusk, *Pholadidea penita,* occurs quite abundantly in the softer rocks within the Golden Gate and along the ocean beach. It is said to be very palatable by those living near the rocks in which these, incorrectly called "rock oysters," live. As yet this clam has not been considered of economic importance, although it might well be investigated from that standpoint.

Besides these well known edible clams there are several native forms that might well serve as food if means for their cultivation were devised. One of these, the *Macoma nasuta,* occurs very abundantly on the muddy or sandy beaches along the bay. It is a very small clam, about the size of the native oyster, but it has a good flavor and is easily obtained, since it does not burrow deeply. The true "razor clam," *Solen sicarius,* is reported to be excellent. It is a deeply burrowing, sand-dwelling form that is difficult to obtain. It probably thrives best on the sandy beaches along the ocean front. *Spisula catilliformis* is represented in the Survey collections by a few specimens obtained from the Golden Gate. It is a large but rare clam that might possibly be successfully grown along the sandy beaches outside San Francisco Bay. Certain species of *Pecten* occur very abundantly in Puget Sound at depth of several fathoms. It is possible that the same or similar species may occur off the Golden Gate in quantities sufficient to have an economic significance. The dredgings of the "Albatross", however, failed to reveal any such beds at the few outside stations.

From the above discussion it is evident that the waters of San Francisco Bay and immediate vicinity offer suitable habitats for a number of edible clams. Only a few of these, however, are extensively used for food. Unfortunately data for the production of mollusks within California are available only for the year 1916. Even these data are incomplete, since they include only the figures for those clams handled by the wholesale dealers. The following figures have been kindly furnished by the Fish and Game Commission of California.

TABLE 4

PRODUCTION OF THREE SPECIES OF MOLLUSKS FOR THE YEAR 1916

Mya arenaria		
San Francisco Bay	161,891 lbs.	$8,094.55
Tomales and San Francisco Bay	366,939	18,346.95
Bodega Bay	19,702	985.10
Total	548,532	$27,426.60
Paphia staminea		
Bodega Bay	1,034 lbs.	$103.40
Saxidomus nuttalli		
Humboldt Bay	43,488 lbs.	$2,609.28

San Francisco Bay yields more than 161,000 pounds of *Mya arenaria*, having a value of over $8000. These figures represent only a small part of the actual yield, as may be seen by referring to table 4. The present yield of the bay is thought by many local clam dealers to be much less than it was ten or more years ago. There are, however, no figures available upon which to base an estimate of a former yield. The wholesale price of this clam ranges from 5 to 8 cents per pound, the average being about 6 cents. Figures are not available for the 1916 yield of *Paphia staminea* nor *Mytilus edulis*, which are occasionally harvested within San Francisco Bay. The hard shell clam brought in from Bodega Bay and elsewhere sells for 9 or 10 cents wholesale. The mussels frequently sell for as much as 12½ cents retail, under normal conditions of the market. The other clams mentioned above are rarely on the local market, and therefore the prices are variable, depending upon the sporadic supply. The market conditions even for the mud clams are rather unstable, due in part to the uncertainties of harvesting, which under present methods depend upon a favorable tide, since dredging methods are not yet employed.

The dredging operations of the "Albatross" within San Francisco Bay have yielded data from which rough estimates of the average numbers per acre of the different clams can be calculated.

Mya arenaria was taken alive at 8 out of the 43 quantitative hauls, and is represented by 32 living specimens, making an average per haul for the entire bay of .76. This would equal approximately 1.5 bushels per acre. This figure, however, representing the average for the bay, is obviously of little significance. If those stations having a sandy bottom are segregated, it is found that this type of bottom yields on the average 1.1 living specimens per haul, or the equivalent of approximately 2.2 bushels per acre, assuming that all were of marketable size. Even such a yield has no economic significance, since under favorable conditions a yield of 500 bushels per acre is not uncommon.

The quantitative dredge hauls indicate that *Paphia staminea* and *Saxidomus nuttalli* are even less abundantly represented within the adlittoral waters of San Francisco Bay.

The intertidal zone, having an area of approximately 17,344,000 acres, yields what clams are now obtained from the bay, since dredging is not at present locally employed. It is probable that at least 50 per cent of this acreage is suitable for the production of *Mya arenaria*. If this is so, the tidal zone of San Francisco Bay would undoubtedly support 4¾ billion bushels of *Mya arenaria*. If markets could be found for such an enormous amount of sea food, an industry involving millions of dollars might be established.

This clam has been transplanted and raised experimentally on the Atlantic Coast by the Massachusetts Commissioners on Fisheries and Game and on an economic scale by many eastern growers. The labor involved is slight. The planting consists of merely scattering the young clams, obtained from localities where the set is heavy, at a rate of fifteen to twenty per square foot. Six months or a year later, depending upon the size planted or the size marketed, these may be harvested. The investment need not be great. A boat and a set of digging tools is all that is necessary. The returns are as great as from an acre of cultivated land, since in Massachusetts the average yield per acre is given by Belding and Lane as $450.

Not all of the clams that are planted reach maturity. Losses may be due to overcrowding, whereby the clam is pushed out of its hole by its more vigorous neighbors, to shifting sand, mud or sea weeds, or to enemies such as the starfish or certain predaceous gastropods. The gastropods include *Polinices lewisi* and the exotic species *Urosalpinx cinereus* and *Ilynassa obsoleta*. It is to be hoped that the eastern winkles (*Lunatia heros* and *L. duplicata*), conspicuous enemies of *Mya*, will not be inadvertently introduced in San Francisco Bay along with the young oysters brought from the east.

It is probable that the tide flats of San Francisco Bay are best adapted to *Mya arenaria,* although certain beaches are perhaps more suitable to *Paphia staminea* or other local species not as well known to the public. Those adapted to the exposed ocean beach include *Siliqua nuttalli, Mytilus californianus, Solen sicarius, Saxidomus nuttalli, Schizothaerus nuttalli,* and *Cardium corbis.*

Such an industry as clam farming would not succeed without private control of the tide flats. This has been demonstrated along the Atlantic Coast, where suitable acreage is either sold or leased to the individuals. A law giving the exclusive rights to a certain proportion of the tidal areas ought not to be enacted until an investigation of the clam beds of the state has been made. Such an investigation would include a survey of the tide lands from the standpoint of tidal bottom, naturally productive or barren beds, their present fauna, their position as regards tidal currents, and their position as regards possible contamination from sewage. From such data as these it would be possible to determine what tracts were suitable for clam farming by the individual and what tracts should be retained as public property. The clamming industry would further profit by the determination of those localities where the natural set is heavy. Such localities should perhaps remain as public property in order that the young clams might there be obtained with which to transplant the barren areas. Other problems of interest to the clam farmer that such a survey would solve are the period of spawning, the local rate of growth of the different clams, and the season of maximum growth. These would enable the clammer to determine when to transplant the young and what sizes to use. Such an investigation might well include the market conditions, and especially the possibilities of canning the product. It might also be found that the demand for such sea food could be materially increased by a well organized advertising campaign.

The possibility of locating shell deposits within San Francisco Bay which might be dredged for their lime content has led to the preparation of table 5.

Eleven out of seventy-nine tubular bottom samples examined quantitatively by Sumner *et al.* show a lime content greater than 10 per cent. These samples were obtained from four regions, from the extreme upper to the lower end of the bay. One small and economically unimportant area occurs in Carquinez Strait, at station D 5816 A. Although the bottom sample shows a high percentage of lime, the orange-peel bucket dredge revealed only a few specimens of *Mya*. East of Point San Quentin the sample shows 12.26 per cent of lime at the surface, decreasing to about 10 per cent at a depth of 70.5 centimeters. A large number of specimens of *Ostrea lurida* were obtained at a near-by station. Again at stations D 5796 and D 5798 the lime content is fairly high, but at those stations the water is nineteen fathoms deep. The stony character of the bottom at station D 5702, which lies within the Golden Gate, would prevent dredging on a commercial scale.

TABLE 5

THE LIME CONTENT OF SOME OF THE TUBULAR BOTTOM SAMPLES

"Albatross" stations	Nearest dredging station	Percentage of lime	Depth of sample in cm.	Depth of water in fathoms
D 5816 A	D 5816 A	20.79	....	9
H 5301	D 5798	15.33	46–56	10
D 5796	D 5796	16.58	....	19
H 5129 C	D 5824	10.13	50.5–70.5	2
H 5129 D	D 5824	12.26	0–20	3.5
D 5702	D 5702	27.81	....	13
H 5306	D 5834	10.38	0–10	10
H 5309	D 5839	25.33	70–80	10
H 5310	D 5836	21.75	91–108	5
D 5783	D 5783	86.21	....	2
D 5847 A	D 5847 A	24.86	125–136	8.5
H 5312	D 5847 A	37.27	123.5–133.5	5

Large quantities of *Ostrea lurida* were dredged off the Oakland Harbor Light at D 5832 and D 5833. They were also obtained abundantly farther south at station D 5835. Besides surface deposits, Sumner *et al.* (1914, pl. 6) show that a layer of shells from 50 to 80 centimeters thick, extending from station H 5306 to H 5312, a distance of about sixteen miles, lies buried in the mud to a depth of about 50 centimeters. It is this old layer that contributes to the lime content noted in table 5 at stations D 5847 A, H 5129 C, H 5301, H 5309, H 5310, and H 5312. At all of these stations the water is less than ten fathoms deep, and the bottom is of a type of mud that might easily be dredged and then washed, leaving the concentrated shell. It is probable that the most extensive surface and subsurface deposits occur within a radius of five miles of Hunter's Point. A resurvey of those waters need not be expensive and might lead to the discovery of even greater deposits of shell than are now known.

FACTORS GOVERNING THE DISTRIBUTION OF THE MOLLUSCA

The previous sections of this paper dealt with the general distribution of the Mollusca and with the actual numbers of individuals living within a definite area. It now remains to investigate the distribution of the mollusks from the standpoint of their environment. Some of these governing distribution are: the physical character of the bottom; the salinity, temperature and depth of the water; the distribution of the plankton which serves as food; and other biotic factors including other organisms which may not be beneficial to the animal under consideration.

The limited number of quantitative hauls offers less conclusive evidence regarding the importance of some of these factors than do the more numerous qualitative dredge hauls made during the general survey of the bay. Petersen (1913, p. 5) has shown that the common dredge gives an entirely different picture of the benthos from that obtained by means of the quantitative type of dredge. The latter brings to the surface not only the organic matter from that locality but also the bottom materials upon which or in which the animals lived, thus giving a more correct idea of certain factors of their environment.

TABLE 6

The Relative Abundance of Molluscan Species and Individuals for the Different Sections of San Francisco Bay

	Average number of species per haul	Average number of genera per haul	Average number of species represented by living specimens	Average number of live individuals per haul	Average number of dead individuals per haul	Average total number of individuals per haul	Average number of species of pelecypods per haul	Average number of species of gastropods per haul	Average depth of hauls in fathoms
Entire bay	5.9	5.4	1.8	45.4	134.8	180.3	4.8	1.06	8.6
Upper bay	2.3	2.1	1.3	4.08	17.4	21.5	2.2	.08	7.8
Middle bay	7.5	7.0	2.4	80.0	235.9	315.9	6.1	2.2	9.9
Lower bay	6.9	6.2	1.2	27.9	79.0	107.0	5.2	1.6	8.3

A tabulation of data derived from table 1 shows in table 6 that the conditions within the different divisions of San Francisco Bay are not equally favorable to molluscan life. This analysis of these more restricted areas clearly shows that the middle division of the bay is a much more favorable habitat for the mollusk than either of the other two divisions. The lower section is much richer per haul than the upper in every respect, the average number of living individuals being nearly seven times as great. These differences as brought out in this table challenge investigation as to their causes.

There is such an inter-relation between the different factors that determine the distribution of animals of this class that it is difficult to determine the effect of any single one upon the molluscan life.

Reation to Depth

The effect of depth upon the distribution of the Mollusca is probably insignificant within these local waters. This conclusion is based more largely upon a study of the distribution of the entire fauna collected by the Survey than upon the results of this study. However, the following table is presented in which the averages per haul for four different bathymetric zones are given.

TABLE 7

The Relative Abundance of Species and Individuals for Different Bathymetric Zones

Depth in fathoms	Number of hauls	Average number of living individuals per haul	Average number of species per haul	
			Pelecypoda	Gastropoda
0 to 5	2	5.5	3.5	0.0
5 to 10	26	42.5	4.57	1.1
10 to 15	12	31.8	5.5	1.1
15 to 20	3	152.6	5.3	.6

This table suggests that the number of living individuals per dredge haul is greater with increase of depth. A similar correspondence is seen in the last column in table 6, where the greatest average depth for the quantitative hauls occurs in the middle division of the bay, which is there shown to be the richest faunally. This apparent bathymetric distribution may be due to other factors which are peculiar to the middle portion of the bay, in which most of the deeper hauls were made.

Relation to Type of Bottom

The character of the bottom is a recognized factor in determining the distribution of mollusks. In order to show the relative abundance of molluscan life on different types of bottoms, the following table has been prepared. Seven types of bottom have arbitrarily been recognized. This classification is based upon the physical analyses of the bottom samples, supplemented by the notes regarding the bottom made on shipboard at the time of dredging (see Sumner *et al.*, 1914, pp. 1, 111). At a number of stations the bottom was found to be composed of two or more types of materials. These have been classified according to predominance of one type over that of the others. For instance, a bottom which might be characterized as a muddy sand is herein designated as sand and mud. Since objects for support are essential to some mollusks, groups one and seven are considered in which shells comprise a conspicuous part of the bottom material. Of course in such a case the presence of shell generally indicates that conditions have long been favorable to molluscan life, therefore the larger numbers in such a group are not necessarily entirely due to the shell element in the composition of the bottom. The figures given are derived from table 1, and represent the averages per haul within the group under consideration.

TABLE 8

THE RELATIVE ABUNDANCE OF SPECIES AND INDIVIDUALS FOR THE DIFFERENT TYPES OF BOTTOMS

Character of bottom	Number of hauls	Average number species per haul	Average number genera per haul	Average number living individuals	Average number species of pelecypods	Average number species of gastropods
1. Pure mud	11	3.2	3.2	13.9	2.6	.6
2. Mud and sand	14	4.0	3.7	41.8	3.6	.4
3. Mud and shells	4	7.0	8.7	82.5	5.5	1.5
4. Sand and mud	5	9.8	8.8	33.8	7.8	2.0
5. Pure sand	1	5.0	5.0	28.0	4.0	1.0
6. Sand and gravel	4	8.25	7.5	2.0	7.0	1.2
7. Sand and shells	4	11.5	10.0	174.0	9.2	2.7

In interpreting these figures due allowance must be made for the fact that the different types of bottoms are not represented by equal numbers of hauls. When the number of living individuals is considered, it is seen that the greatest numbers were taken on bottoms characterized as being composed of sand and shells; while the second largest numbers come from bottoms of mud and shells. The pelecypods are represented by the larger number of species per haul from bottoms characterized as sand and shells, mud and shells being the next in importance as regards the number of species per unit area.

A study of the molluscan associations peculiar to these different types of bottoms shows several interesting relationships. The list of species occurring upon various types of bottoms is given below, the asterisk indicating that the specimen was dredged alive.

Species Occurring in Group 1: Pure Mud

Cardium corbis
Macoma balthica*
Macoma nasuta*
Mya arenaria*
Mya california*
Mytilus edulis*
Ostrea lurida
Paphia staminea
Pholas pacificus
Psephidia ovalis
Zirfaea gabbi
Epitonium hindsi
Odostomia franciscana
Turbonilla franciscana

Species Occurring in Groups 2 and 4: Mud and Sand

Cardium corbis*
Gemma gemma var. purpura*
Macoma balthica*
Macoma inquinata
Macoma nasuta*
Mya arenaria
Mya california*
Mytilus edulis*
Ostrea lurida
Phacoides tenuisculptus*
Pholas pacificus
Psephidea ovalis
Schizothaerus nuttalli
Solen sicarius
Tellina buttoni*
Tellina salmonea*
Zirfaea gabbi*
Crepidula niva*
Columbella gausapata
Nassa mendica
Nassa fossata*
Nassa perpinguis
Thais lamellosa*
Turbonilla franciscana

Species Occurring in Group 3: Mud and Shells

Cardium corbis
Gemma gemma var. purpura*
Macoma inquinata
Macoma nasuta*
Mya arenaria*
Mya california*
Modiolus, cf. rectus
Mytilus edulis
Ostrea lurida
Paphia staminea
Psephidea ovalis
Zirfaea gabbi*
Columbella gausapata
Epitonium hindsi?
Nassa fossata?
Nassa mendica*
Thais lamellosa
Turbonilla keepi

Species Occurring in Group 5: Pure Sand

Mytilus edulis*
Phacoides tenuisculptus*
Psephidea ovalis*
Tellina buttoni*
Turbonilla franciscana*

Species Occurring in Group 6: Sand and Gravel

Cardium corbis
Hinnites giganteus
Macoma balthica
Macoma inquinata
Macoma nasuta
Monia macroschisma
Mya california
Ostrea lurida
Saxidomus nuttalli
Schizothaerus nuttalli
Spisula catilliformis
Tellina salmonea*
Nassa fossata
Thais lamellosa
Zirfaea gabbi

Species Occurring in Group 7: Sand and Shells

Cardium corbis
Macoma balthica
Macoma inquinata
Macoma nasuta
Mya arenaria
Mya california*
Mytilus edulis
Ostrea lurida
Psephidia ovalis*
Schizothaerus nuttalli
Tellina salmonea
Zirfaea gabbi
Epitonium hindsi*
Epitonium savinea
Nassa perpinguis
Thais lamellosa
Turbonilla keepi

Most of the species listed above occur in several groups of quite dissimilar character. This would suggest that the occurrence of a species at a certain locality does not give a true idea of its ecological relationships. The relative abundance of a species within a dredge haul gives a clue as to the optimum environment for that species, and therefore may well serve as the basis for studies in faunal associations. For this reason the average per haul for each species has been calculated. The group in which the highest average falls would appear to represent that type of bottom best suited to the mollusk in question. Such a list is given below. The number of hauls is possibly too few to more than suggest the broad outlines of such molluscan associations.

The following species are arranged according to their relative abundance on the different types of bottom:

Group 1.	Pure mud
Living:	None
Dead:	Gemma gemma var. purpura Mya arenaria Psephidia ovalis Columbella gausapata Odostomia franciscana
Group 2.	Mud and sand
Living:	Cardium corbis Gemma gemma var. purpura Crepidula nivea
Dead:	Pholas pacificus
Group 3.	Mud and shells
Living:	Macoma nasuta Modiolus, cf. rectus Zirfaea gabbi
Dead:	Cardium corbis Zirfaea gabbi Turbonilla franciscana Turris incisus?
Group 4.	Sand and mud
Living:	Psephidia ovalis Tellina buttoni
Dead:	Mytilus edulis Ostrea lurida Nassa mendica
Group 5.	Pure mud
Living:	Phacoides tenuisculptus Turbonilla franciscana
Group 6.	Sand and gravel
Living:	Tellina salmonea
Dead:	Hinnites giganteus Macoma inquinata Monia macroschisma Saxidomus nuttalli Tellina salmonea Turbonilla keepi

Group 7.	Sand and shells
Living:	Mya californica
	Macoma balthica
	Epitonium hindsi
Dead:	Mya california
	Paphia staminea
	Epitonium hindsi
	Nassa fossata
	Nassa perpinguis
	Thais lamellosa

The above list shows several different associations of species. Of the prevalent species, *Cardium corbis, Macoma nasuta, Mya arenaria,* and *Zirfaea gabbi* appear to be predominantly mud-dwelling forms; while *Mya californica, Macoma balthica, M. inquinata, Ostrea lurida,* and *Thais lamellosa* may be classed as sand dwellers. Although these conclusions are tentative, because of the paucity of the hauls upon which they are based, they suggest the broad features of the different molluscan communities.

Relation to Salinity

In order to determine the influence of salinity upon molluscan distribution, a comparison of a curve showing the number of living mollusks for most of the quantitative stations with salinity curves for the equivalent hydrographic stations as published by Sumner *et al.* (1914) may be made. In these curves the stations are arranged along the horizontal axis, at distances proportionate to their relative positions in the bay. The average number of living mollusks from the several hauls made in the immediate vicinity of the hydrographic stations is represented along the vertical axis of the specimen curve.

There is apparently little correspondence between the areal density of the mollusks and the mean annual salinity. This is evident by referring to figure B.

It appears, however, that the mean annual salinity at stations D 5815 to D 5820 inclusive (left end of curve) is unfavorable to an abundant molluscan life. The specimen curve as well as the following table indicates that the average number of individuals per haul is greatest for those stations having a mean annual salinity between 28 and 30 per mille.

TABLE 9

Mean annual salinity	Group	Number of hauls	Average number living individuals
17.16–19.37	1	8	3.1
19.38–21.57	2	2	5.5
21.58–23.79	3	0	0.0
23.80–26.07	4	6	9.0
26.02–28.23	5	8	12.3
28.24–30.45	6	15	82.0
30.46–32.67	7	4	12.7

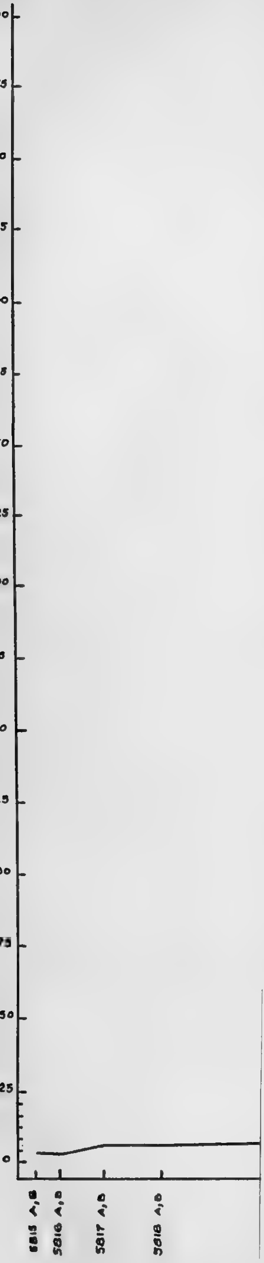


Fig. A—S

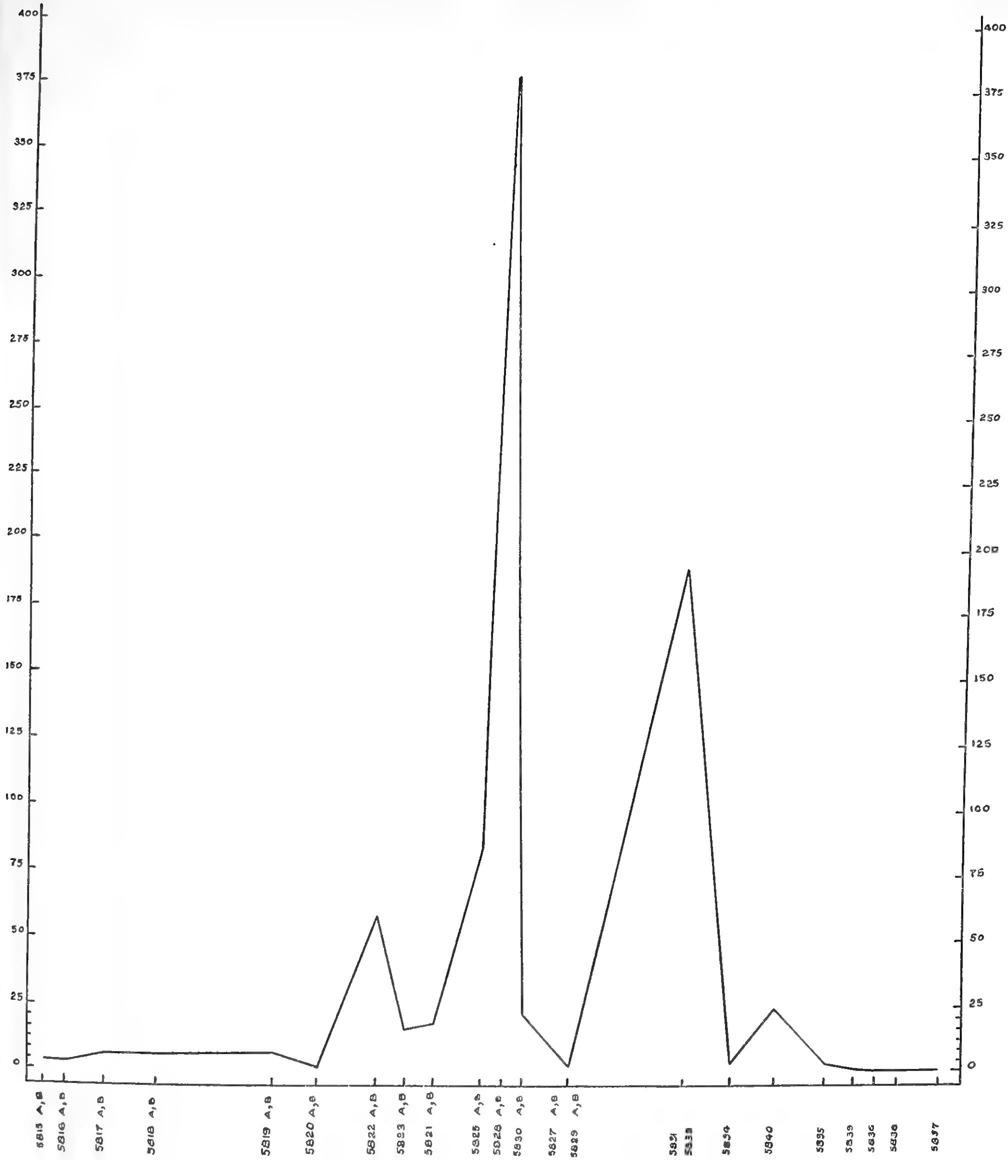


Fig. A—Specimen curve. Average number of living mollusks obtained at each station.

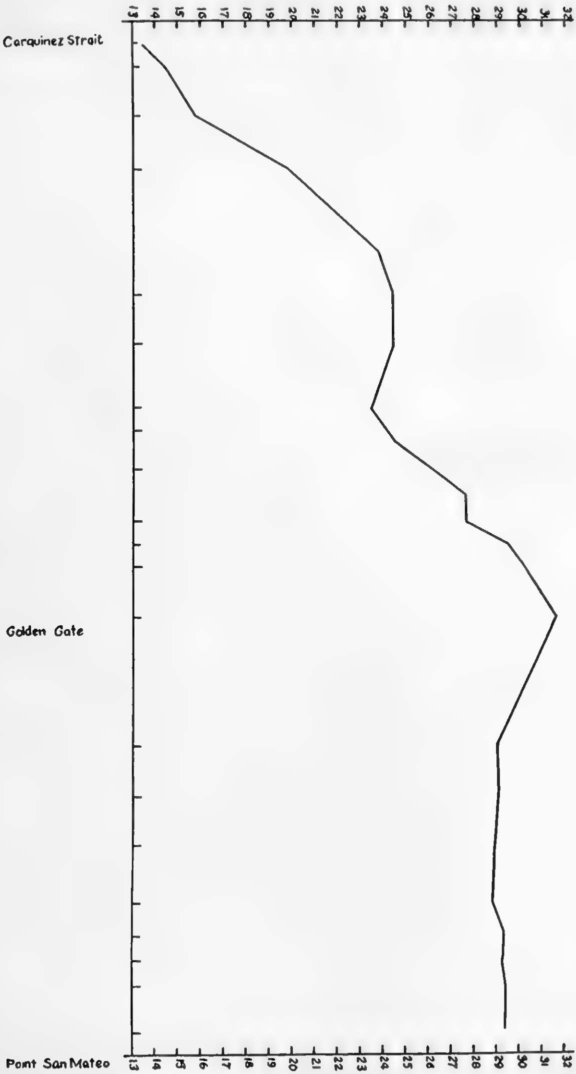


Fig. B—Mean annual salinity at each of the hydrographic stations of the regular series. (After Sumner *et al.*)

It is not improbable that the annual range of salinity is even more potent in determining the abundance of mollusks than is the mean annual salinity. A comparison of the specimen curve with the published curve indicating the annual range of salinity (Sumner *et al.*, fig. N, p. 69) shows only a general increase in the number of mollusks with decrease in range of salinity, for two of the highest points of the specimen curve fall within the area of high range in salinity.

The curves showing the distribution of salinities in the bay during April 23 to May 6 corresponds more closely with the specimen curve than does any of the others representing the salinities at other periods of the year.

The highest average number of mollusks per haul is found at those stations having a mean annual salinity between 28 and 30 per mille. If this represent the optimum salinity for the bay fauna, that portion of the bay having a salinity most nearly that of these figures should yield the largest number of mollusks per unit area. No portion of the upper bay satisfies such a condition, but the middle division does fulfil such a requirement and is also the richest faunally. The lower bay is found to hold an intermediate position both faunally and from the standpoint of salinity. However, since such a salinity is the rule in the middle portion of the bay and to a lesser extent in the lower division this apparent relationship may have but little significance. If the optimum mean annual salinity is high, as seems reasonable, it might be expected that the regions where the salinity is low at any period of the year will be low in the number of mollusks per unit area. Thus the inverse relationship shown in the curves (figures A and C) might have been foretold. It appears, then, that minimum salinity is one of the factors influencing the distribution of the local mollusks. The closer correspondence between the specimen curve and the minimum seasonal salinity curve than between any of the other curves showing the salinity for the other periods of the year tends to confirm such a statement.

RELATION TO TEMPERATURE

It is not improbable that the molluscan larvae are more susceptible to temperature control than is the adult mollusk. An investigation of the water temperatures during the periods of reproduction is desirable from the standpoint of the oyster culture as well as from that of pure science. Unfortunately data as to the reproductive periods of the local species are not available. Therefore only the more conspicuous effects of temperature can at present be determined.

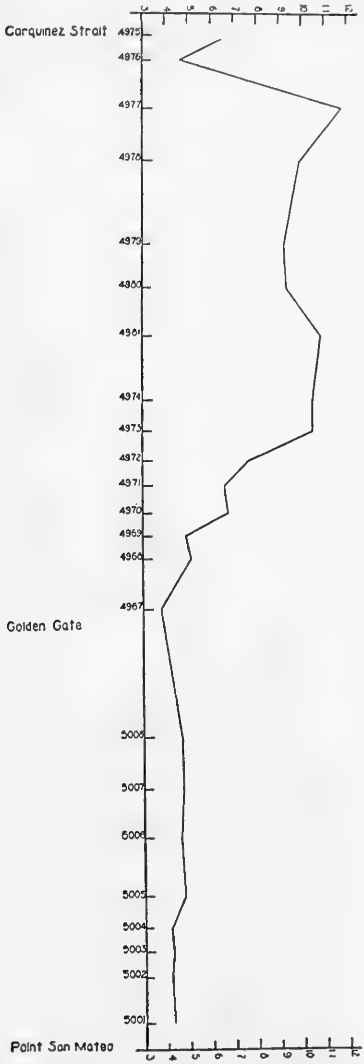


Fig. C—Seasonal range of salinity at each station. (After Sumner *et al.*)

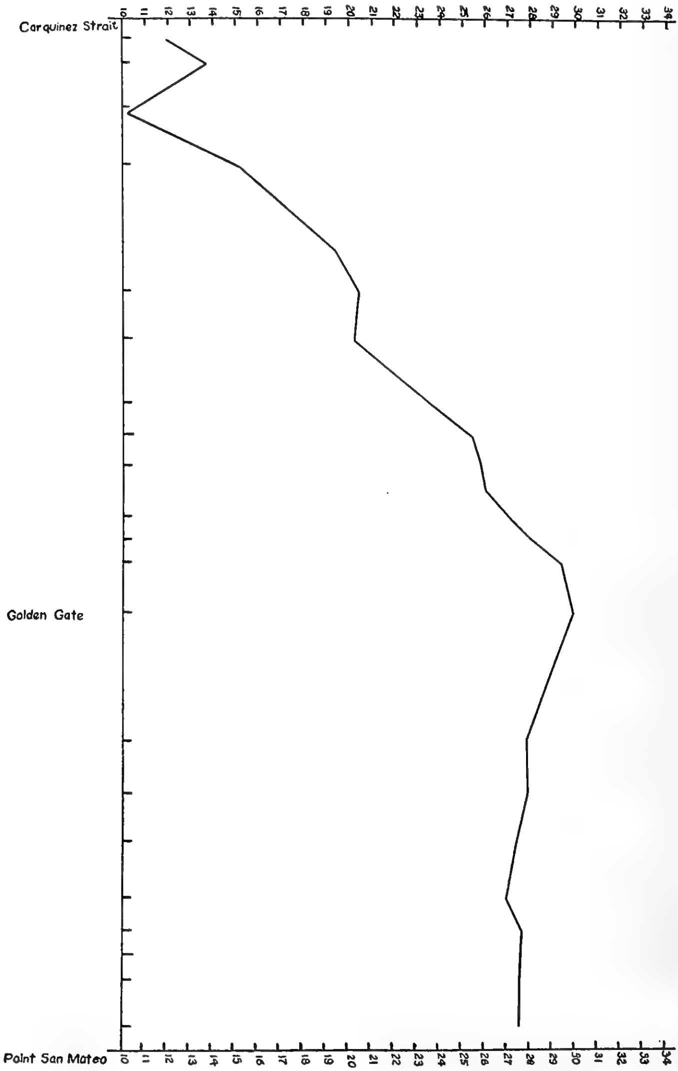


Fig. D—Distribution of the salinities of the bay during the period of April 23 to May 6. This represents the minimum seasonal salinity. (Adapted from Sumner *et al.*)

Curves similar to those just considered suggest the importance of the temperature factor. The mean annual temperature curve as published by Sumner *et al.* appears to have little significance when compared with the specimen curve. Table 9 indicates, however, that the larger number of living individuals per haul were obtained in regions of relatively low annual temperatures.

TABLE 10

Mean annual temperature	Groups	Number of hauls	Average number living individuals
11.98–12.35	1	6	134.5
12.36–12.73	2	13	41.0
12.74–13.11	3	14	42.4
13.11–13.49	4	6	3.3
13.50–13.88	5	4	0.0

It appears from figure E that those portions of the bay where the seasonal range of temperature is high are regions in which the areal density is relatively low. It is not certain, however, that this indicates a causal relationship.

The correspondence between the October and July temperature curves and that of the specimen curve indicates that more mollusks occur within a given area where the waters are cooler during those months. In this connection it is of interest to note that the bay fauna includes a majority of predominantly northward ranging species. However, it is not evident that the warm summer temperatures of the other divisions of the bay act as a barrier to these northern forms, for the open ocean during this period is cooler than that of the bay and yet it has a fauna showing a southern facies.

If the temperature factor is important in determining the local distribution of the mollusks, the greater areal density of the middle division of the bay may be due to the low seasonal range or to the low summer temperature.

This rather indefinite relationship between molluscan distribution and temperature may indicate that this factor is effective only during the reproductive periods of a particular mollusk. If these periods do not all fall within a single season, as seems rather improbable, it is not surprising that the influence of temperature is obscure.

Relation to the Available Food Supply

The plankton probably serves as the most important food supply of the pelecypods, which in turn become the main supply for the predaceous gastropods. The distribution of the plankton within San

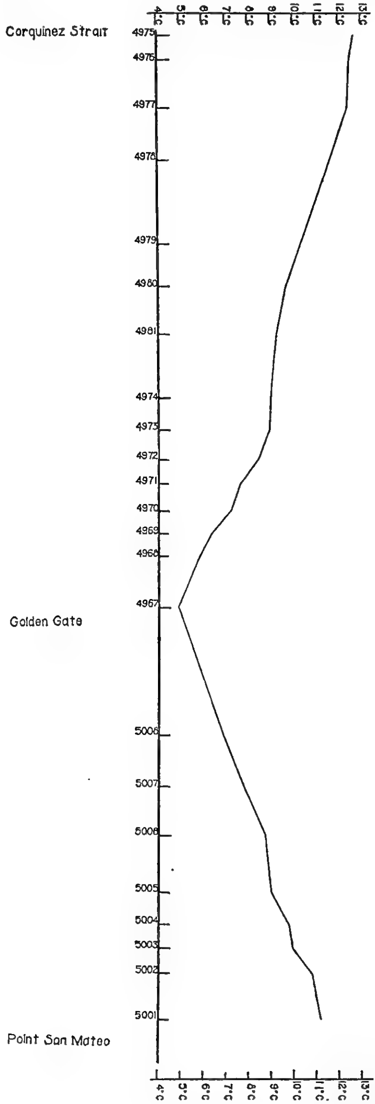


Fig. E—Seasonal range of temperature at each station. (After Sumner *et al.*)

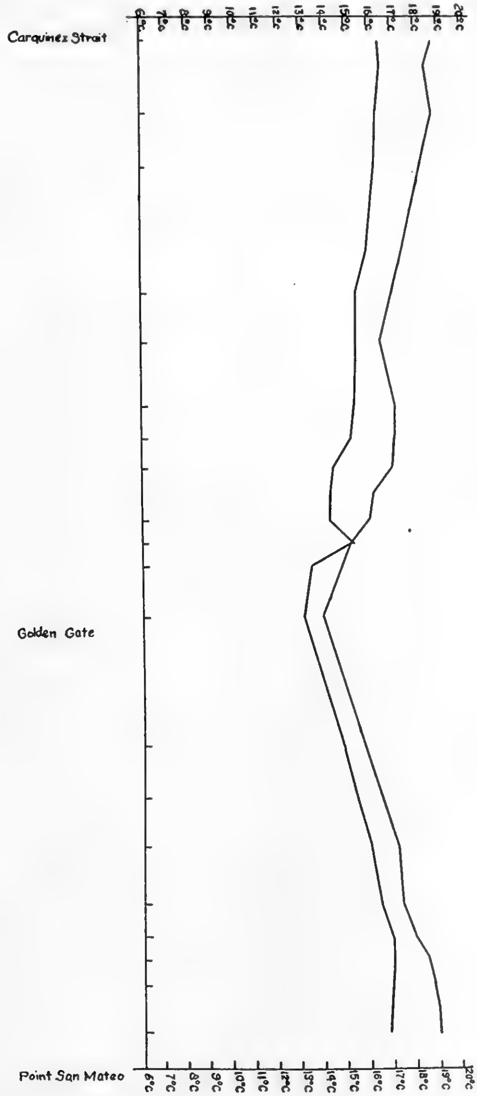


Fig. F—Distribution of bay temperatures. Upper curve, July 22–31; lower curve, October 7–12. (Adapted from Sumner *et al.*)

Francisco Bay might be a factor in determining the distribution of the mollusks if there were regions of relatively impoverished waters. That such conditions exist is suggested in the recent studies upon the diatoms made by Mr. E. P. Rankin. He shows that the number of species and individuals of these plants decreases as one passes from the middle to the upper division of the bay, and that the marine forms are not there replaced by fresh water species. The main channel through that arm of the bay is found to represent a region of impoverished water in comparison to that of the quieter and presumably more saline water near shore.

This distribution of the diatoms is paralleled in general by that of mollusks, as is shown by the relative number of species and individuals per haul for San Pablo Bay in comparison with the other regions of the bay (see p. 18). However, this apparent correlation is probably not due to the lack of food supply, for Professor Kofoid's studies show that the plankton of the bay is relatively rich; it is more probably due to the salinity, which is exceedingly variable within that region. It is thus evident that from the data at hand no definite conclusion regarding the relationship of the distribution of the plankton to that of the mollusks can be reached.

Relation to the Biotic Environment

The relation between the distribution of other forms of life and that of the Mollusca can only vaguely be suggested. From the standpoint of the food it seems that the distribution of the plankton when present in quantities above the requirements of the organism has little influence upon the occurrence of the mollusks. Until the Algae of this region are better known it is impossible to say that certain of the gastropods are not distributed according to the occurrence of certain of these plants. The distribution of some of the predaceous gastropods corresponds to that of their prey. Unfortunately no quantitative data are available regarding the distribution of the oyster drill, *Urosalpinx cinereus,* but qualitative studies show that it occurs most abundantly upon the oyster beds. The relation of the enemies of the mollusks and the distribution of several gastropods the shells of which are inhabited by hermit crabs can only be ascertained by a detailed study of the entire fauna and flora of the bay.

SUMMARY

The orange-peel bucket dredge, used for the first time for purposes of biological investigation, has been employed by U. S. S. "Albatross" at forty-three stations within San Francisco Bay.

Twenty-three species of Pelecypoda and twelve of Gastropoda were taken by means of this dredge. The ten species that were taken at more than one-fourth of the hauls represent the most adaptable forms of the molluscan fauna.

The middle division of the bay is a more favorable habitat for the Mollusca than either of the other two divisions.

Depth has little significance in determining the distribution of the local forms.

The character of the bottom is an important distributional factor. The most favorable bottom appears to be composed of sand and shells, the shells serving as supports for sessile forms.

A low salt concentration or a large annual range of salinity appear to be unfavorable to an abundant local molluscan life.

The regions in which the annual range of temperature is not great nor the maximum high during July and October support the larger number of mollusks per unit area. Nevertheless the significance of the temperature factor is obscure.

Several species of edible clams live within San Francisco Bay. Of these, *Mya arenaria* is most important. The present production of the bay is probably considerably less than it was a decade ago. The bay, under the improved methods of farming, would support an annual yield of more than four billion bushels of this clam. Such an industry should be established only after a detailed survey has been made and many of the outstanding problems solved. Laws should also be enacted which give private control to certain tracts suitable to clam farming.

APPENDIX

Table 11 is given in order to show the different groupings of the hauls that have been made in the preparation of this paper.

For further data regarding these stations and their location within San Francisco Bay the reader is referred to the often mentioned report by Sumner *et al.* (1914).

TABLE 11

Showing the Different Groupings of the Dredge Hauls

"Albatross" station numbers	Bottom groups	Temperature groups	Salinity groups	Depth groups	"Albatross" station numbers	Bottom groups	Temperature groups	Salinity groups	Depth groups
D 5815 A	2	4	1	2	D 5826 A	7	2	5	2
D 5815 B	2	4	1	3	D 5826 B	7	2	5	2
D 5816 A	1	3	1	2	D 5827 A	6	3	1	4
D 5816 B	1	3	1	3	D 5827 B	6	3	1	2
D 5817 A	2	4	1	2	D 5828 A	2	1	6	4
D 5817 B	2	4	1	2	D 5828 B	3	1	6	3
D 5818 A	1	2	2	2	D 5829 A	6	1	7	3
D 5818 B	2	2	2	1	D 5829 B	6	1	7	4
D 5819 A	2	2	4	2	D 5830 A	5	1	7	3
D 5819 B	2	2	4	2	D 5830 B	2	1	7	2
D 5820 A	2	3	5	3	D 5831	2	2	6	3
D 5820 B	2	3	5	2	D 5832	4	2	6	2
D 5821 A	2	2	5	2	D 5833	8	2	6	2
D 5821 B	2	2	5	2	D 5834	4	3	6	3
D 5822 A	1	3	4	1	D 5835	3	4	6	2
D 5822 B	1	3	4	2	D 5836	1	5	6	2
D 5823 A	3	3	5	2	D 5837	1	5	6	2
D 5823 B	3	3	5	3	D 5838	1	5	6	2
D 5824 A	1	3	4	3	D 5839	1	5	6	2
D 5824 B	7	3	4	2	D 5840	1	3	6	2
D 5825 A	4	2	6	2	D 5841	4	4	6	3
D 5825 B	4	2	6	3					

LITERATURE CITED

BELDING, D. L., and LANE, F. C.
1916. The shell fisheries of Massachusetts: their present condition and extent, *in* Mass. Comm. on fisheries and game, Report upon Mollusk Fisheries of Massachusetts, pp. 16–233.

MASSACHUSETTS COMMISSION ON FISHERIES AND GAME.
1916. Report upon Mollusk Fisheries of Massachusetts. 50th Ann. Rep., 234 pp., pls. 1–9, several text figures.

PETERSEN, C. G.
1913. Determination of the quantity of animal life on the sea-bottom. Ann. l'Inst. oceanographique, 10 figs. in text.

PETERSEN, C. G.
1915. Valuation of the sea. II. Rep. Danish Biol. Station, **21**, 1–44, app. 1–67, 6 pls., 3 charts.

SUMNER, F. B., OSBURN, R. C., COLE, L. J., and DAVIS, B. M.
1913. A biological survey of the waters of Woods Hole and vicinity. Bull. U. S. Bur. Fish., **31**, 1–860, 274 charts.

SUMNER, F. B., LOUDERBACK, G. D., SCHMITT, W. L., and JOHNSON, G. E.
1914. A report upon the physical conditions in San Francisco Bay, based upon the operations of the United States Fisheries Steamer "Albatross", 1912–1913. Univ. Calif. Publ. Zool., **14**, 1–198, pls. 1–13, 20 figs. in text.

STEARNS, R. E. C.
1881. *Mya arenaria* in San Francisco Bay. Am. Nat., **15**, 362–366.

EXPLANATION OF PLATES

PLATE 12

Dredging stations of the "Albatross" in San Francisco Bay. (After Sumner *et al*).


DREDGING STATIONS
FISHERIES STEAMER ALBATROSS
SAN FRANCISCO BAY
CALIFORNIA
1912 —— 1913
NAUTICAL MILES
KILOMETERS
BASED ON
C. & G. S. CHART 5530
FRED W. S. BLANCHARD DEL.
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
ANGEL I.
SAUSALITO
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
Pt Bonita
GOLDEN GATE
FERRY BUILDING
Pt Lobos
SAN FRANCISCO
ALAMEDA
Hunters Pt
PALO ALTO
Pt San Pedro
Pt San Mateo
VAR'N 18 15' E IN 1914 ANNUAL INCREASE 3'

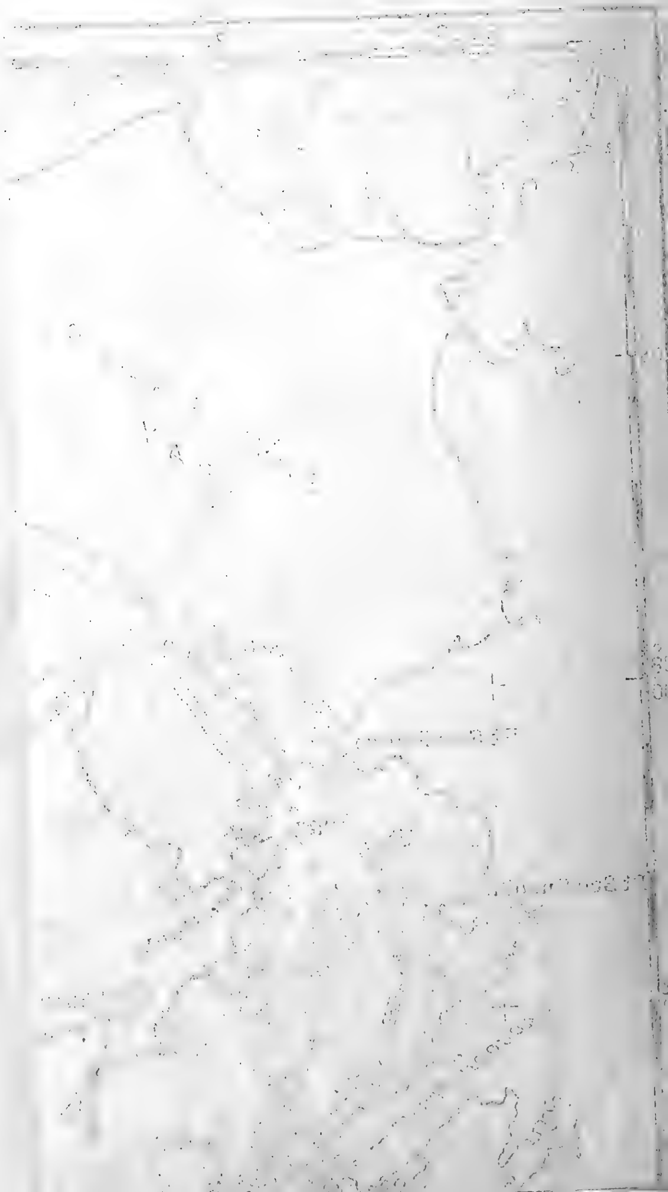
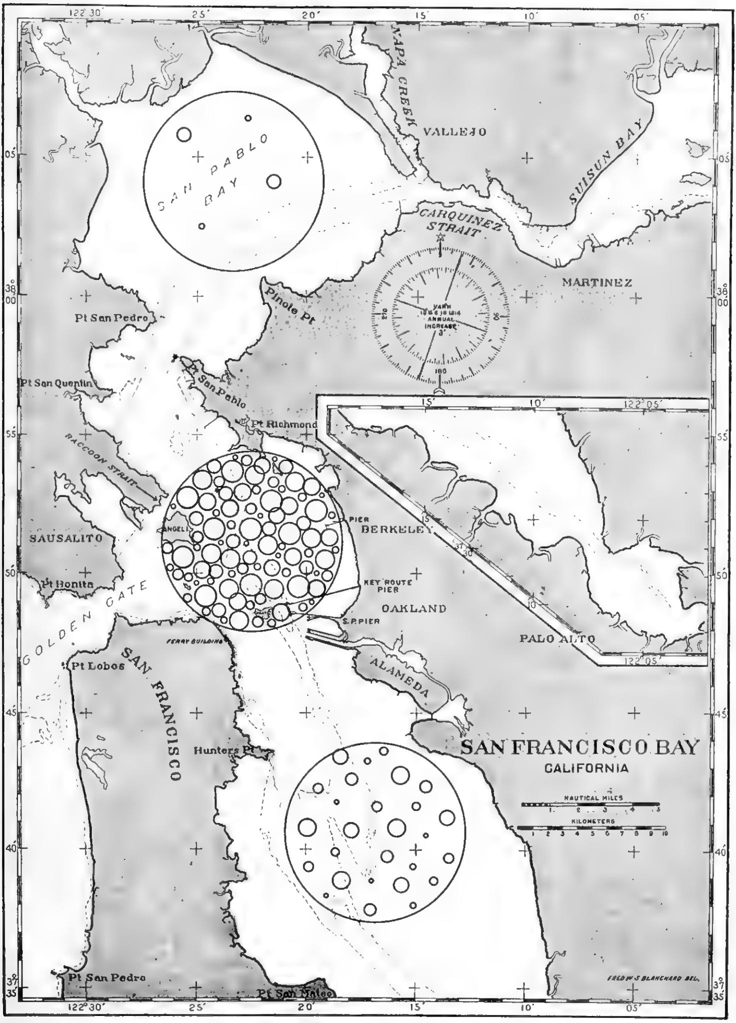


PLATE 13

Diagram showing the relative abundance of mollusks per unit area of 7.8 square feet within the three divisions of the bay. The circles of different size stand for the different species and the number of circles for the number of living individuals obtained in the average dredge haul for the indicated region. The number of old shells is not represented.


SAN FRANCISCO BAY
CALIFORNIA
SAN PABLO BAY
NAPA CREEK
VALLEJO
SUISUN BAY
CARQUINEZ STRAIT
MARTINEZ
Pinole Pt
Pt San Pedro
Pt San Quentin
Pt San Pablo
Pt Richmond
RACCOON STRAIT
SAUSALITO
Pt Bonita
GOLDEN GATE
PIER
BERKELEY
KEY ROUTE PIER
OAKLAND
S.P. PIER
FERRY BUILDING
ALAMEDA
PALO ALTO
Pt Lobos
SAN FRANCISCO
Hunters Pt
Pt San Pedro
Pt San Mateo
NAUTICAL MILES
KILOMETERS
FRED W. S. BLANCHARD DEL.

10. A Distributional List of the Amphibians and Reptiles of California, by Joseph Grinnell and Charles Lewis Camp. Pp. 127-208, 14 figures in text. July, 1917 .... .85
11. A Study of the Races of the White-Fronted Goose (*Anser albifrons*) Occurring in California, by H. S. Swarth and Harold C. Bryant. Pp. 209-222, 2 figures in text, plate 13. October, 1917 .... .15
12. A Synopsis of the Bats of California, by Hilda Wood Grinnell. Pp. 223-404, plates 14-24, 24 text figures. January 31, 1918 .... 2.00
13. The Pacific Coast Jays of the Genus *Aphelocoma*, by H. S. Swarth. Pp. 405-422, 1 figure in text. February 23, 1918 .... .20

Vol. 18.

1. Mitosis in *Giardia Microti*, by William C. Boeck. Pp. 1-26, plate 1. October, 1917 .... .35
2. An Unusual Extension of the Distribution of the Shipworm in San Francisco Bay, California, by Albert L. Barrows. Pp. 27-43. December, 1917. .20
3. Description of Some New Species of *Polynoidae* from the Coast of California, by Christine Essenberg. Pp. 45-60, plates 2-3. October, 1917 .... .20
4. New Species of *Amphinomidae* from the Pacific Coast, by Christine Essenberg. Pp. 61-74, plates 4-5. October, 1917 .... .15
5. *Crithidia Euryophthalmi*, sp. nov., from the Hemipteran Bug, *Euryophthalmus convivus* Stål, by Irene McCulloch. Pp. 75-88, 35 text figures. December, 1917 .... .15
6. On the Orientation of *Erythropsis*, by Charles Atwood Kofoid and Olive Swezy. Pp. 89-102, 12 figures in text. December, 1917 .... .15
7. The Transmission of Nervous Impulses in Relation to Locomotion in the Earthworm, by John F. Bovard. Pp. 103-134, 14 figures in text. January, 1918 .... .35
8. The Function of the Giant Fibers in Earthworms, by John F. Bovard. Pp. 135-144, 1 figure in text. January, 1918 .... .10
9. A Rapid Method for the Detection of Protozoan Cysts in Mammalian Faeces, by William C. Boeck. Pp. 145-149. December, 1917 .... .05
10. The Musculature of *Heptanchus maculatus*, by Pirie Davidson. Pp. 151-170, 12 figures in text. March, 1918 .... .25
11. The Factors Controlling the Distribution of the Polynoidae of the Pacific Coast of North America, by Christine Essenberg. Pp. 171-238, plates 6-8, 2 figures in text. March, 1918 .... .75
12. Differentials in Behavior of the Two Generations of *Salpa democratica* Relative to the Temperature of the Sea, by Ellis L. Michael. Pp. 239-298, plates 9-11, 1 figure in text. March, 1918 .... .65
13. A Quantitative Analysis of the Molluscan Fauna of San Francisco Bay, by E. L. Packard. Pp. 299-336, plates 12-13, 6 figs. in text. April, 1918 .... .40