
SMITHSONIAN INSTITUTION LIBRARIES


SMITHSONIAN INSTITUTION LIBRARIES

STATE OF CALIFORNIA
FISH AND GAME COMMISSION

FISH BULLETIN No. 4

The Edible Clams, Mussels and Scallops of California

BY

FRANK W. WEYMOUTH
of Stanford University, California

Contribution No. 22 From the State Fisheries Laboratory

CALIFORNIA STATE PRINTING OFFICE
SACRAMENTO
1920

CONTENTS

6453

FIG. 1. Digging Pismo clams, Oceano. The surf is breaking about the digger at the extreme left.

STATE OF CALIFORNIA
FISH AND GAME COMMISSION

Fish Bulletin No. 4 SACRAMENTO, CALIFORNIA January 10, 1921

INTRODUCTION

The present paper has two purposes. First, it is an attempt to estimate the economic importance to the state of the bivalves here treated by putting on record the extent and position of the available mollusk producing grounds, the number and abundance of the edible species, and by contributing to a knowledge of their life histories lay the foundation for such protective legislation as may in the future be found necessary. Secondly, it proposes to make available to the camper and amateur naturalist a means of identifying the more common and important bivalves. During the last few years several agencies, chief among which are the development of the automobile and the extension of good roads, have greatly increased the number of people reaching the woods, the mountains and the sea. The campers at the seashore should realize the possibilities of food in the clams, mussels and other bivalves of the California coast, for these animals are at their best when freshly taken. It is hoped that the key and the figures here presented will enable any one to recognize the forms met with on this coast and that the accounts of their habits and use will make it possible to find and to utilize a source of food now distinctly neglected. By directing the attention of the camper to the interesting adaptations and beauties of these little known animals, his pleasure in the great out of doors will be correspondingly increased.

Nearly five hundred species of bivalves are known from the west coast of America north of Mexico. Many of these are, of course, too small or too rare to be of possible food value. The following key will serve to identify the forms treated in the present paper, which includes, it is believed, all those to be met with in the markets or likely to be dug for food, but it must be remembered that many others, usually less abundant or less conspicuous, will be found on this coast. As far as known this is the first key to the bivalves of the coast that has been published and the task of selection has proved to be a difficult one.

In treating the species the nomenclature and order given by Dall* has been followed except in the matter of the use of subgeneric names in which the usage of the writer differs.

*Checklist of the Recent Bivalve Mollusks of the Northwest Coast of America, etc. Southwest Museum, 1916.

Some idea of the economic importance of the California mollusks may be gathered from the amounts marketed during the past four years, according to statistics gathered by the Fish and Game Commission:

	1916 Pounds	1917 Pounds	1918 Pounds	1919 Pounds
Abalone	----------	748,853	602,919	759,208
Pismo clam	186,654	489,175	665,684	417,515
Soft-shell clam	563,822	422,857	356,043	324,824
Sea mussel	----------	334,412	48,319	35,095
Cockle	86,187	104,792	44,933	24,777
Washington clam*	41,992	35,000	86,000	44,496
Bay mussel	----------	13,616	----------	----------
Totals	----------	2,147,771	1,803,898	1,605,910

*Estimated. The return for "mixed clams" was divided between the Washington clam and the soft-shell in the proportion of two to one. The statistics of the native and Eastern oyster are omitted as they are reported by number, not weight.

To these must be added the clams used locally by residents and campers, a quantity not possible to estimate accurately but which would nearly double the yield of certain species and includes a number of forms not listed above.

The present paper is a result of the policy of the Fish and Game Commission to investigate the marine resources of California. In 1910 Mr. Will F. Thompson traversed the entire coast north of San Francisco and made a careful survey of this region. In 1916 Dr. Harold Heath of Stanford University made an examination of the California coast south of San Francisco. In 1916 Mr. Carl L. Hubbs, now of the University of Michigan, Ann Arbor, Michigan, collected in the same region. In the spring of 1919 the writer made a survey of the southern part of the state, particularly that portion from San Pedro south, which had not previously received much attention, and in the fall of the same year reexamined San Francisco and Humboldt Bays. The present paper represents the data collected by all these workers and has been put in its present form by the writer with the advice and assistance of Mr. Thompson. For the plates, key and the general discussion of distribution the writer is responsible. Locality records where resting on the authority of a single observer are initialed, otherwise they are to be considered as matters of general knowledge or are the observation of the present writer. To various deputies of the Fish and Game Commission and to many clam diggers the writer wishes to acknowledge his indebtedness for uniform courtesy in furnishing information and material. Thanks are due Mrs. Oldroyd of Stanford University for the opportunity of examining her collection and for material. The work has been done partly at the State Fisheries Laboratory at Long Beach and partly at the Hopkins Marine Station of Stanford University at Pacific Grove; to Dr. W. K. Fisher, Director of the latter institution, the writer wishes to express his appreciation of the facilities extended. Acknowledgment is here made to Alice Jenkins Weymouth for assistance in the preparation and revision of the manuscript of the present paper.

LIST OF THE EDIBLE BIVALVES OF CALIFORNIA

	Scientific name	Common name	Other names
1.	*Ostrea lurida* Carpenter	Native oyster	
2.	*Pecten circularis* Sowerby	Scallop	Fan shell
3.	*Hinnites giganteus* Gray	Rock scallop	Rock pecten
4.	*Anomia peruviana* d'Orbigny	Rock oyster	
5.	*Monia macroschisma* Deshayes	Rock oyster	
6.	*Mytilus californianus* Conrad	Sea mussel	
7.	*Mytilus edulis* Linnaeus	Bay mussel	
8.	*Modiolus rectus* Conrad	Horse mussel	
9.	*Cardium quadragenarium* Conrad	Spiny cockle	
10.	*Cardium corbis* Martyn	Cockle	
11.	*Cardium elatum* Sowerby	Giant cockle	
12.	*Tivela stultorum* Mawe	Pismo clam	
13.	*Amiantis callosa* Conrad	Sea cockle	
14.	*Saxidomus nuttalli* Conrad	Washington clam	Butter clam Money-shell
15.	*Saxidomus giganteus* Deshayes	Washington clam	Same as above
16.	*Chione fluctifraga* Sowerby	Hard-shell cockle	
17.	*Chione undatella* Sowerby	Hard-shell cockle	
18.	*Chione succincta* Valenciennes	Hard-shell cockle	
19.	*Paphia tenerrima* Carpenter	Thin-shelled cockle	
20.	*Paphia staminea* Conrad	Rock cockle	Little-neck Hard-shell Tomales Bay cockle Rock clam
21.	*Tellina bodegensis* Hinds	Tellen	
22.	*Metis alta* Conrad	Metis	
23.	*Macoma nasuta* Conrad	Bent-nosed clam	Mud clam
24.	*Macoma secta* Conrad	White sand clam	
25.	*Semele decisa* Conrad	Flat Clam	
26.	*Psammobia californica* Conrad	Sunset shell	
27.	*Psammobia edentula* Gabb	Sunset shell	
28.	*Sanguinolaria nuttalli* Conrad	Purple clam	
29.	*Donax californica* Conrad	Wedge shell	
30.	*Donax laevigata* Deshayes	Common wedge shell	Bean clam
31.	*Tagelus californianus* Conrad	Jackknife clam	Razor clam
32.	*Solen sicarius* Gould	Jackknife clam	Razor clam
33.	*Solen rosaceus* Carpenter	Jackknife clam	Razor clam
34.	*Siliqua lucida* Conrad	Razor clam	Razor shell Sea clam
35.	*Siliqua patula* Dixon	Razor clam	Same as above
36.	*Spisula sp.*	Dish shell	
37.	*Schizothaerus nuttalli* Conrad	Gaper	Summer clam Horse clam Otter-shell
38.	*Mya arenaria* Linnaeus	Soft-shell	Soft clam Long clam Mud clam
39.	*Platyodon cancellatus* Conrad		
40.	*Panope generosa* Gould	Geoduck	
41.	*Zirfaea gabbi* Tryon	Piddock	Borer
42.	*Parapholas californica* Conrad	Borer	Piddock
43.	*Pholadidea penita* Conrad	Rock clam	Borer Piddock

INTRODUCTION TO KEY—GENERAL ANATOMY OF BIVALVES

In order to use the key the following facts concerning the structure of these animals must be borne in mind. All are protected by two similar shells or *valves* (hence the term *bivalves*), which are formed on the right and left sides of the animal, the back or dorsal side being that where the valves are joined together. This shell which is so striking a feature of these animals is the product of the *mantle*, a soft structure also characteristic of this group. This covers the animal as the flyleaves cover the body of a book and by its activity secretes the valves of the shell which thus come to occupy the position of the covers of the book. If we think of a book with limp leather covers which bend over to meet each other around the edges and imagine the flyleaves doing the same thing, the picture is a very complete one. In the simplest form of the mantle the edges are free except on the back where the hinge is located, corresponding to the arrangement in a book, and the sea water may then enter the cavity enclosed by the mantle at almost any place; this is the condition, for instance, in the oyster. In all bivalves the food consists of microscopic plants and animals obtained from the water which is made to flow through the mantle cavity by the beating of myriads of fine hair-like *cilia* that whip the water along. From the water they also obtain by means of the gills the oxygen necessary for respiration.

In most of the bivalves, however, the mantle edges are not everywhere open but are fused together at certain points. Two openings are thus formed at the posterior or hinder end of the body and through these the water currents enter and leave the body, the inhalent opening lying nearer the lower side and the exhalent nearer the upper or hinge side. The mantle surrounding these openings is often, as in the case of the common clams, developed into two tubes, sometimes separate and sometimes united so as to appear as one tube but with two cavities, and it is through these that the clam obtains its water when buried in the sand or mud. These form the "neck" or, more properly, *siphons* of the clam; it will be seen that these are in no way related to the neck of other animals, the clam's "head" being at the opposite end. Of the other organs of the body inclosed by the mantle, it will be sufficient to mention the *foot*, a muscular organ which can be protruded between the edges of the mantle and shell either at the anterior or "head" end, or at the ventral side, and by means of which the animal burrows or moves about.

The inner surface of the empty shell shows certain marks where the soft portions of the body were attached, so that from the shell alone many facts concerning the anatomy can be made out. There are usually two large scars near either end of the valve marking the points where the two muscles that close the shell were attached, the *posterior adductor muscle* near the siphonate end and the *anterior adductor muscle* near the opposite or anterior end (see figure 3, page 8). Though in most forms these two muscles and their scars are of about the same size, there are species, such as the common mussel, in which one is much reduced in size (see figure 5, page 10), and others, such

as the oyster or scallop, in which only one adductor, the posterior, is left (see figure 2, page 8). A line connects the lower sides of these scars when there are two and since here the mantle or pallium was attached, it is called the *pallial line*. In forms with siphons this line is folded near the posterior end, forming a notch which varies in depth with the size of the siphon and is called the *pallial sinus*. These sinuses, corresponding to the position of the siphons, are found at the posterior or hinder end; to distinguish the right and left valves, therefore, it is only necessary to hold the shell with the hinge up and the siphonate end toward one, when the right valve will correspond to the right hand and the left to the left hand.

The outer surface of each valve shows a prominence, near the point where the two shells are joined, known as the *umbo* (see figure 3). Around this are found more or less distinct concentric lines, called growth lines, marking what were once the margins of the shell. The valves are usually covered with a horny layer or *periostracum* which in old or wave worn shells may largely or wholly disappear. The valves are flexibly united and opened by a tough rubbery *ligament*. This is really composed of two parts, one of which is always outside, while the second is either folded within this, when the ligament is said to be *external*, or may lie between the edges of the shell, when it is sometimes called a cartilage and said to be *internal*. In any case the ligament as a whole works against the muscles and tends to open the shell; for this reason the shells of dead clams gape. The ligament is usually posterior to the umbo and therefore nearer the siphonate end; on the same side there is in some shells a depression called the *escutcheon* (see figure 11, page 12), and in some a similar area called *lunule* in front of the umbo.

Often tiny soft-shelled crabs are found within the mantle cavity of clams or other bivalves; these are commonly known as "oyster crabs" from the fact that they are found in the oyster, or "pea crabs" from their minute size and rounded shape. They are not crabs that the clams have eaten (the food of all clams is microscopic) but are adult and fully formed crabs (as is shown by the presence of eggs on many specimens) that find shelter within the clam and perhaps filch their food from the clam's supply. Such a relationship of "host" and "guest' (here, to be sure, an uninvited "guest")is found in other cases and is known as "commensalism" in distinction from "parasitism" where the "host" is harmed. The presence of these crabs in no way injures the clams for food—in fact, the oyster crabs are esteemed by some a great delicacy, though it is seldom that enough may be obtained to furnish more than a taste.

The usage followed in regard to common names deserves a word of explanation. There are but a handful of common names in the English language for shellfish—clam, mussel, cockle, scallop, oyster—and hence particular species have to be distinguished as "hard clams" and "soft clams," "little-necked clams" and the like. The use of these names is often so local that they have no significance; what is a "hard shell" in one part of the state becomes a "paper shell" when contrasted with other species in a different part of the state.

All available common names have been carefully considered and a single name selected with regard to (1) actual use (no "manufactured" names have been introduced), (2) appropriateness and (3) distinctiveness so that confusingly similar names may be avoided. If the common names are to be of any use there must be uniformity and it is earnestly requested that the names here proposed be used, for even though they seem strange to some, all have been carefully considered and represent, as far as possible, names in actual use.

KEY TO THE EDIBLE BIVALVES OF CALIFORNA

The figures are partially diagrammatic and all, except as noted, are placed in the same position, that is, with the dorsal or back side up, the ventral or lower side down, the anterior or head end to the reader's left and the posterior or hinder end to the right. As most represent the interior of the shell this must then be the right valve. The following reference letters are used for all:

aa—anterior adductor muscle scar.
bs—byssal scar.
bn—byssal notch.
c—cartilage.
cp—cartilage pit.
e—escutcheon.
l—ligament.
m—membrane (covering hinge region.)
pa—posterior adductor muscle scar.
pl—pallial line.
ps—pallial sinus.
r—rib.
u—umbo.

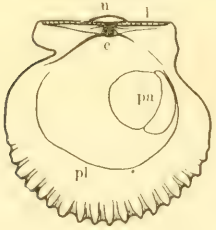


FIG. 2. *Pecten circularis.* One-half natural size.

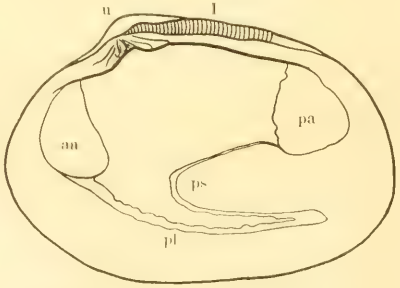


FIG. 3. *Saxidomus nuttalli.* One-half natural size.

a. Only one adductor muscle (the posterior) present; mantle edges not fused, hence no siphon or pallial sinus; adults either rigidly attached, usually by shell, or entirely free and capable of swimming actively, always lying on one side, never burrowing. (See Fig. 2; compare with aa and Fig. 3).

b. Valves unlike, the right with a deep notch, apparently a hole, for the passage of a byssus by which it is attached.

Rock oysters

c. Left valve with two muscle scars (adductor and byssal muscle); shell light but not delicate, surface of shell roughened, not translucent.

Monia macroschisma

p. 26; pl. 3, figs. 1, 2

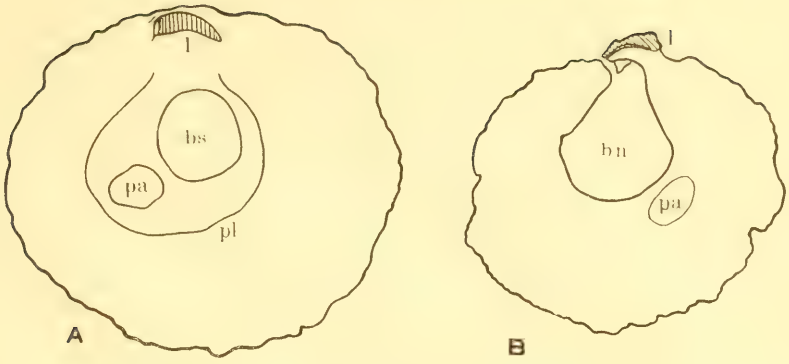


FIG. 4. *Monia macroschisma*. Two-thirds natural size. (A) Interior upper or left valve. (B) Interior lower or right valve.

cc. Left valve with four muscle scars (one adductor, three byssal muscles); shell very delicate, smooth textured and usually translucent, rarely taken between tides.

Anomia peruviana

p. 26; pl. 3, fig. 3

bb. Valves similar or unlike, without byssal notch.

c. Shell irregular, without radiating ribs or lateral projections on either side of umbo, permanently attached by left valve; mantle without eyes; flesh white or tinged with greenish; found in colonies or masses.

Oysters *Ostrea* p. 24

cc. Shell with radiating ribs and lateral projections or "ears" on either side of the umbo; regular in shape and free for at least part of adult life; margin of mantle with numerous minute eyes; flesh tinged with orange or red; found separate and free during early adult life at least.

Scallops

d. Free and regular in shape for entire life, interior of hinge area not purplish; shells light; capable of swimming actively.

Pecten circularis

p. 24; pl. 1, figs. 1, 2

dd. Free and regular for part only of adult life, later attached by right valve, which retains pattern of young free shell; interior of hinge area purplish; shells heavy and thick.

Hinnites giganteus

p. 25; pl. 1, fig. 3; pl. 2, figs. 1, 2

aa. Two adductor muscles present; adult either attached by flexible byssus, moving by means of muscular foot or burrowing, usually not lying on one side, never attached by shell (in forms here treated), nor swimming (except Solen). (See fig. 3)

b. Posterior adductor large, anterior small, umbo near anterior end of shell; mantle edges fused at only one point, forming an exhalent siphonal aperture; no pallial sinus; adults attached to firm objects, or anchored in mud, by byssus, never lying on one side; never moving when adult; shells brown or shiny black.

Mussels

c. Umbo at extreme (attached) end; shells not bearded; shiny black, usually found in "beds" attached to rock or the like.

Mytilus

p. 26; pl. 3, fig. 1; pl. 1, figs. 1, 2

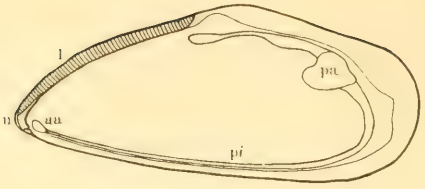


FIG. 5. *Mytilus californianus.* One-half natural size.

cc. Umbo near, but not at, extreme end; shells frequently bearded; brown, usually solitary, in mud or gravel.

Modiolus

p. 27; pl. 4, fig 3

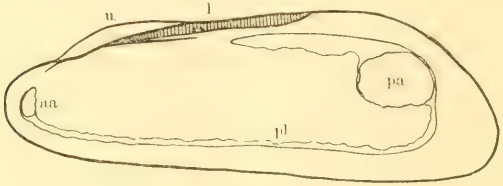


FIG. 6. *Modiolus rectus.* One-half natural size.

bb. Adductor muscles equal or nearly so; umbo not at end of valve in forms here treated (except Solen); mantle edges fused in at least two places forming two siphonal apertures, which are usually prolonged into siphonal tubes; adults without byssal attachment; usually capable of moving about by means of the foot; all capable of burrowing to some extent and habitually doing so; color of shells various; never black.

True clams

c. Valves closing completely, or at least with no marked gaping, siphons completely retractile and not visible in the closed shell.

d. Shells thick and strong, animal symmetrical with similar valves, siphons usually united and short; if burrowing not lying on one side.

e. Siphons extremely short, not projecting beyond shell when extended; no pallial sinus; not burrowing deeply. (See Fig. 7; compare with Fig. 8).

Cockles *Cardium*

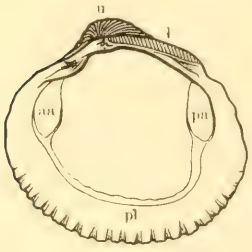


FIG. 7. *Cardium corbis.* One-half natural size.

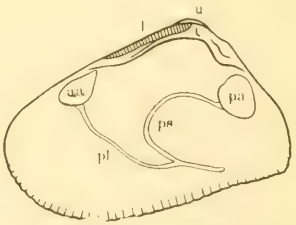


FIG. 8. *Donax laevigata.* One and one-half times natural size.

f. Radiating ribs conspicuous and sharply raised above surface.

g. Ribs roughened.

C. corbis

p. 28; pl. 5, fig. 2

gg. Ribs with rows of spines.

C. quadrigenarium

p. 28; pl. 5, fig. 1

ff. Ribs faint and gently rounded.

C. clatum

p. 29

ee. Siphons short or moderate, a pallial sinus present; burrowing more or less deeply.

f. Size small, valves crenulate or toothed on inner surface of margins, teeth interlocking in closed shell; siphons separate; pallial sinus reaching about half way from posterior to anterior muscle scar.

Wedge shells *Donax*

g. Umbo central.

D. californica

p. 47; pl. 16, fig. 1

gg. Umbo much nearer posterior end.

D. laevigata

p. 47; pl. 16, fig. 2

ff. Size moderate or large, valves usually smooth at margins, sometimes roughened but without regular crenulations; siphons united.

g. Pallial sinus deep, reaching more than half way to anterior muscle scar. (See Fig. 9; compare with Fig. 10.)

h. Valves with radiating ribs.

Paphia

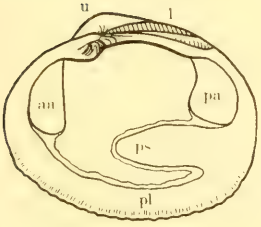


FIG. 9. *Paphia staminea*. One-half natural size.

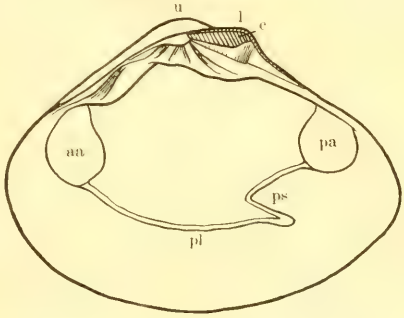


FIG. 10. *Tivela stultorum*. One-half natural size.

i. Valves about round in outline, ribs prominent, concentric ridges faint; pallial sinus reaching somewhat more than half way to anterior scar; valve margins roughened.

Rock cockle *P. staminea*

p. 38; pl. 10, fig. 2

ii. Valves elongated, ribs small but distinct, concentric ridges more prominent than ribs; pallial sinus reaching $\frac{2}{3}$ of distance to anterior muscle scar; valve margin smooth.

Thin-shelled cockle *P. tenerrima*

p. 38; pl. 10, fig. 1

hh. Valves without radiating ribs, concentric ridges distinct; pallial sinus reaching $\frac{2}{3}$ of distance to anterior muscle scar.

Washington clams *Saxidomus*

i. Concentric ridges bold and prominent.

S. nuttalli

p. 35; pl. 7, figs. 1, 2

ii. Concentric ridges finer and less conspicuous.

S. giganteus

p. 35; pl. 8, figs. 1, 2

gg. Pallial sinus small, reaching not more than half way to anterior muscle scar. (See Fig. 10.)

h. Ligament external, valves heavy with moderate or thick edges.

i. Valves smooth, very heavy, with marked glossy, persistent periostracum; pallial sinus reaching less than one-third way to anterior muscle scar; found in clear sand on open beaches.

Pismo clam *Tivela stultorum*

p. 29; pl. 6, figs. 1, 2

ii. Valves marked with concentric ridges and sometimes ribs.

j. No radiating ribs, concentric ridges low, rounded, occasionally dividing into two, covered with a heavy, glossy, persistent periostracum; pallial sinus reaching about half way to anterior muscle scar; valve margin smooth; shell white.

Sea cockle *Amiantes callosa*

p. 34; pl. 5, fig. 3

jj. Radiating ribs present, concentric ridges not smoothly rounded nor dividing, with thin, grey, easily detached periostracum; pallial sinus small, not deeper than diameter of posterior muscle scar; valve margin roughened; shell greyish.

Hard-shell cockles *Chione*

k. No distinct lunule or escutcheon, ribs more prominent than concentric ridges in posterior ⅓ of valve; pallial sinus acute.

C. fluctifraga

p. 37; pl. 9, fig. 1

kk. Distinct lunule and escutcheon present, concentric ridges usually more prominent than ribs in all parts of valve; pallial sinus rounded.

l. Numerous thin, concentric ridges, ribs everywhere small and inconspicuous.

C. undatella

p. 37; pl. 9, fig. 2

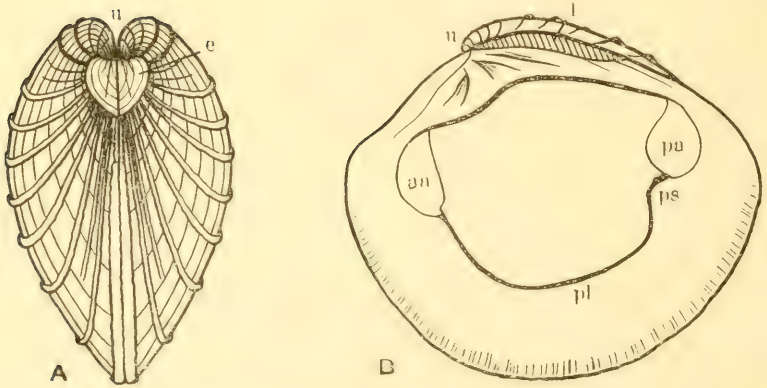


Fig. 11. *Chione succincta*. One and one-third times natural size. (A) Exterior anterior end. (B) Interior right valve.

ll. Concentric ridges heavier and less numerous, ribs at posterior end more distinct than elsewhere but not more conspicuous than ridges.

C. succincta

p. 37; pl. 9, figs. 3, 4

hh. Ligament internal, valves lighter, thin and sharp at edges. Size moderate or large, pallial sinus reaching ⅓ to ½ distance to anterior muscle scar.

Dish shell *Spisula*

p. 54

dd. Animal asymmetrical with valves unlike especially at siphonate end; shell usually thin and weak particularly at margins (least marked in *Semele* and *Tellina*); siphons separate, slender and very long; forms deeply burrowing in sand or mud where they are found lying on the side.

e. Ligament wholly external; pallial sinus united with pallial line; shells generally thin.

f. Shell elongated (about twice as long as wide), periostracum not conspicuous, shell not conspicuously thin, whitish with fine but very distinct and regular growth lines, siphonate end bent to the right.

Tellen *Tellina bodegensis*

p. 42; pl. 11, fig. 1

ff. Shell oval or round in outline, conspicuously thin, growth lines usually faint, always more or less irregular.

g. Shells without conspicuous periostracum, whitish.

h. Ligament depressed so as not to be visible from the side; siphonate end of shell not produced, valves deeply arched.

Metis *Metis alta*

p. 42; pl. 11, fig. 2

hh. Ligament not depressed, hence visible from the side; siphonate end of shell more or less produced, valves not deeply arched.

Macoma

i. Siphonate end of shell produced and bent to right; valves about equally arched, pallial sinus in left reaching anterior muscle scar; found in protected mud or muddy sand.

Bent-nosed clam *M. nasuta*

p. 43; pl. 11, fig. 3; pl. 12, figs. 1, 2

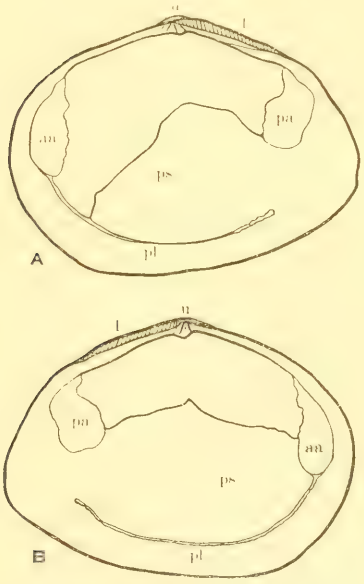


Fig. 12. *Macoma nasuta.* Natural size. (A) Interior right valve. (B) Interior left valve.

ii. Siphonate end of shell not produced; left valve much flatter than right, pallial sinus not reaching anterior muscle scar in either valve; found deep in loose exposed sand.

White sand clam *M. secta*

p. 44; pl. 12, figs. 3, 4, pl. 13; fig. 1

gg. Shell with distinct blue or purplish color and conspicuous glossy reddish brown periostracum; right valve much flatter than left; found in coarse sand or gravel.

Purple clam *Sanguinolaria nuttalli*

p. 46; pl. 14, figs. 2, 3

ee. Ligament in part external but with a larger internal part (cartilage); pallial sinus not united with pallial line; shell round in outline, fairly heavy, tinged with pink at margins.

Flat clam *Semele decisa*

p. 45; pl. 13, fig. 2

cc. Shell margins when closed gaping at points where siphon or foot or both are protruded, contracted siphon often projecting beyond closed shell.

d. Shell with anterior and posterior portions not obviously differing in surface markings, nor adapted for boring; hinge region without either membrane or accessory plates. (See fig. 13; compare with fig. 14.)

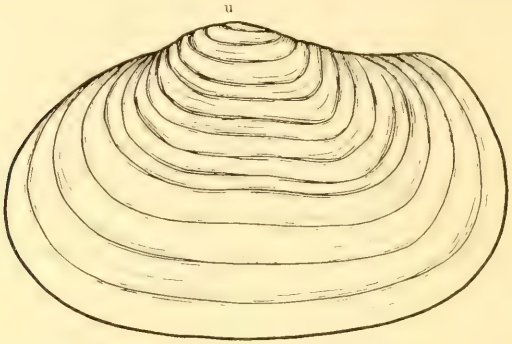


FIG. 13. *Panope generosa*. One-half natural size. Exterior left valve.

e. Ligament external.

f. Shell not markedly elongated (length not equalling three times the breadth); animal never moving freely up and down a permanent burrow.

g. Shells not exceptionally thin nor gaping markedly at anterior end to accommodate foot, periostracum not conspicuous, no internal rib; not found in clear sand on open beaches.

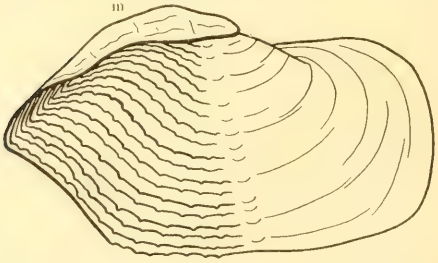


FIG. 14. *Zirfaea gabbi*. One-half natural size. Exterior left valve.

h. Valves gaping widely, particularly at siphonate end; pallial sinus small, not reaching over ⅓ of the way to the anterior muscle scar, not united with the pallial line; siphons united, extremely long and large, covered with thick dark epidermis.

Geoduck *Panope generosa*

p. 63; pl. 18, fig. 2

hh. Valves gaping moderately; pallial sinus large, reaching ⅓ to ½ of the way to the anterior muscle scar, united with pallial line; siphons separate, long, without heavy epidermis.

Sunset shells *Psammobia*

i. Shell oval (about one and a half times as long as wide), umbos nearly central.

P. californica

p. 45; pl. 14, fig. 1

ii. Shell elongated (about twice as long as wide), umbos much nearer anterior end.

P. edentula

p. 45

gg. Shell very thin and fragile, over twice as long as wide and gaping about equally at both ends, with conspicuous glossy periostracum, a marked rib on the interior of each valve extending from the umbo toward the free margin; found in clear sand on open beaches.

Razor clams *Siliqua*

p. 50; pl. 15, fig. 4

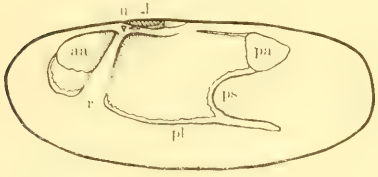


FIG. 15. *Siliqua*. One-half natural size.

ff. Shell strikingly elongated (length three or more times the breadth), with hinge margin and free margin parallel or nearly so, gaping about equally at both ends; animal moving freely up and down a permanent burrow.

Jackknife clams

g. Umbo central; siphons separate, long.

Tagelus californianus

p. 48; pl. 15, fig. 1

gg. Umbo at extreme anterior end, siphons united.

Solen

h. Animal of moderate size; shell slightly curved, about 4 times as long as wide, with yellowish periostracum; foot with dark pigment.

S. sicarius

p. 50; pl. 15, fig. 2

hh. Animal small; shell straight, about 5 times as long as wide, with slight transparent periostracum through which the flesh color of the shell usually shows; foot with little or no pigment.

S. rosaccus

p. 50; pl. 15, fig. 3

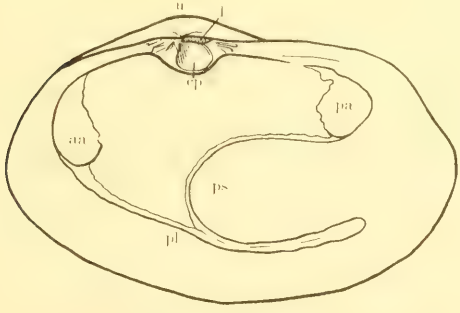


FIG. 16. *Schizothaerus nuttalli*. One-half natural size.

ee. Ligament internal, shell not strikingly elongated, without parallel margins; siphons with heavy dark epidermis.

f. Lower edge of pallial sinus united with pallial line; cartilage pits equal in the two valves; retracted siphons projecting beyond shell, tip with a pair of plates; umbo nearer the anterior end of the shell.

Gaper *Schizothaerus nuttalli*

p. 54; pl. 16, fig. 3

ff. Lower edge of pallial sinus not united with pallial line; cartilage pits unequal, that on the left valve on a conspicuous projecting tooth; retracted siphons usually not projecting beyond the shell, tip without plates; umbo not nearer the anterior end of the shell.

g. Umbo central; valves rounded and slightly gaping at the posterior (siphonate) end.

Soft-shell *Mya arenaria*

p. 56; pl. 17, figs. 2, 3

gg. Umbo nearer the posterior end of shell; valves truncated and widely gaping at posterior end.

Platyodon *Platyodon cancellatus*

p. 62; pl. 17, fig. 1

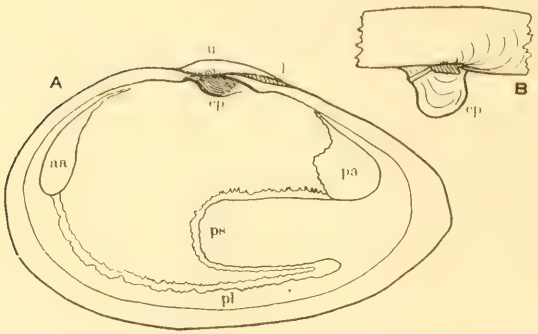


FIG. 17. *Mya arenaria.* One-half natural size. (A) Interior right valve. (B) Exterior of portion of left valve.

dd. Shell with anterior half sharply marked off from posterior, roughened and obviously adapted for boring in rock or clay; hinge region protected either by a membrane or by accessory plates. (See Fig. 14.)

e. Shell gaping widely at both ends throughout life; a membrane but no accessory plates covering hinge region.

Piddock *Zirfaea gabbi*

p. 63; pl. 18, fig. 1

ee. Shell of adult closing completely or gaping only moderately, siphons completely retractile, accessory plates present over hinge region.

f. Siphonal end of valve formed in large part by soft epidermal scales; accessory plates long and slender.

Borer *Parapholas californica*

p. 64; pl. 19, fig. 1

ff. Siphonal end of valve with epidermal scales which cover the firm shell; accessory plate short and triangular.

Rock clam *Pholadidea penita*

p. 64; pl. 19, fig. 2

ADAPTATION TO ENVIRONMENT AS ILLUSTRATED BY A SURVEY OF ANAHEIM SLOUGH

In few groups of animals is there such a close correlation between the habits, the structures and the physical conditions under which they live as is found in the bivalves. Being in most cases fixed or sedentary they must meet and satisfy the conditions of their immediate environment or they can not survive even for a day. This fact was pointed out by Thompson in his work on the British Columbia shellfish* and has proved equally clear in the present work. Not only does this striking adaptation appeal to every one interested in living things, and to whom the clam usually appears as an unresponsive obstructionist opposing its shell to all outside influences, but a knowledge of these relationships enables the clam digger, amateur or professional, to know where and how to find his supply, even in regions which are new to him.

We will first consider in a little more detail the basis of this nice adaptation to the physical surroundings and then attempt to put the facts in a more tangible form by studying the distribution in a typical bay. The primary thing with clams as with other animals is their relation to the food supply. For all bivalves this is the same—the microscopic animals and plants that abound in sea water. Of these the most important are the diatoms, tiny plants with beautiful shells of silica, so small that only giants among them may be seen with the naked eye, yet so numerous that in past geologic ages great beds thousands of feet thick have been laid down of their remains. The clam draws through its mantle cavity, by means of the current set up by the cilia lining it, a current of sea water; whatever organisms the water may contain are strained from it and used for food by the clam. The oxygen needed by the clam is also obtained from this stream of water. It is therefore clearly evident that the clam must have free access to the water. But those positions that assure a good supply of water are also those that expose the clam to the violence of the surf, if on the ocean beach, and to attacks by enemies. The whole story of its adaptation, then, is a recital of the ways that have been developed of getting protection from waves and foes without sacrificing the necessary supply of water.

In regard to habits, bivalves may be divided into four groups. They will be found either fixed, free, actively burrowing or in relatively permanent burrows. The mussel is a form found fixed to rocks exposed to the full force of the surf, yet so firmly anchored by its byssus of tough threads and protected by its firm shell that it seldom suffers from the violence of the waves. Here it is safe from all enemies that can not also weather the surf and is sure of an abundant supply of fresh water, which it takes into the open mantle cavity at almost any place. Other fixed forms are the oyster, which is found in more sheltered waters, the rock oyster and the rock scallop.

Among the bivalves the truly free forms are few—as a whole the group is not specialized for crawling or swimming, and those species that are active enough to maintain themselves without burrowing or attachment are the exception. The scallop is, however, free living. It

*Report of the B. C. Commissioner of Fisheries for 1912 p. I 37, 1913 p. R 103.

never burrows and only when young attaches itself by a byssus. The adult spends most of its time merely lying on the surface of the mud or sand. If displaced, or if the conditions become unfavorable, it can regain its position or move from an unfavorable one by a type of swimming unique among mollusks. The valves are clapped together and the expelled water forces the animal off in the opposite direction with a briskness of motion quite belying the conventional idea of the sluggish clam. As with the fixed forms its mantle is also widely open.

The great majority of the bivalves burrow, and though there are all degrees of the habit it is possible to divide them into two fairly well marked groups. The first group inhabits bottoms that are shifting and in this do not usually burrow deeply, trusting to their activity in burrowing to escape from their enemies and to maintain themselves when the bottom is changed by waves or currents. A good example of this is the cockle (*Cardium*). It has a long slender foot with which it burrows actively and thus keeps its feeding position at the surface even on exposed coasts. Few forms found in sand or mud have the mantle widely open. Water can enter or leave the mantle cavity freely only at the posterior end which reaches the surface of the mud. Here the mantle edges are partially united, forming two special openings, one for the inhalent and one for the exhalent current; this is the condition found in *Cardium*. But most burrowing species take a deeper position, and though this brings increased protection both from foes and from surf or currents, it removes the clam still farther from the water supply. Such supply is insured by the prolongation of the mantle surrounding the openings just mentioned into two tubes or a double tube, the siphon, through which water may still be obtained even though the clam is some distance from the surface. Of the short-siphoned actively burrowing type the Pismo and razor clams are the best examples.

Perhaps the larger number of clams live in relatively permanent burrows from which the adult never does or never can move. Such burrows, of course, must be deep enough to furnish protection and must be in a relatively permanent bottom. Some, like the great geoduck and the gaper, are found deep in the soft bottoms of sheltered bays; others, like some of the piddocks and *Platyodon*, dig into hard clays in which burrows may be maintained in more exposed places. Still others bore into rock so firm that heavy surf does not break down the burrows nor strong currents wash them away; such is the rock borer *Parapholas*. In a related form not considered in the present paper the burrow is made in wood to the great damage of piles and ships. This is the familiar teredo.

From the foregoing types of habit among the bivalves may be seen how widely varying are the ways in which they have adjusted themselves to the same problem, that of combining the greatest protection from waves and foes with the amplest supply of necessary food-bearing water. Though the huge geoduck, with its great bulk of heavy siphons buried a yard deep in the sheltered mud and quite incapable of any more activity than pulling in its siphons, is very different in structure and habits from the actively swimming scallop, both have inherited, from lines of successful ancestors, successful though diverse methods of solving the problems of food and protection.

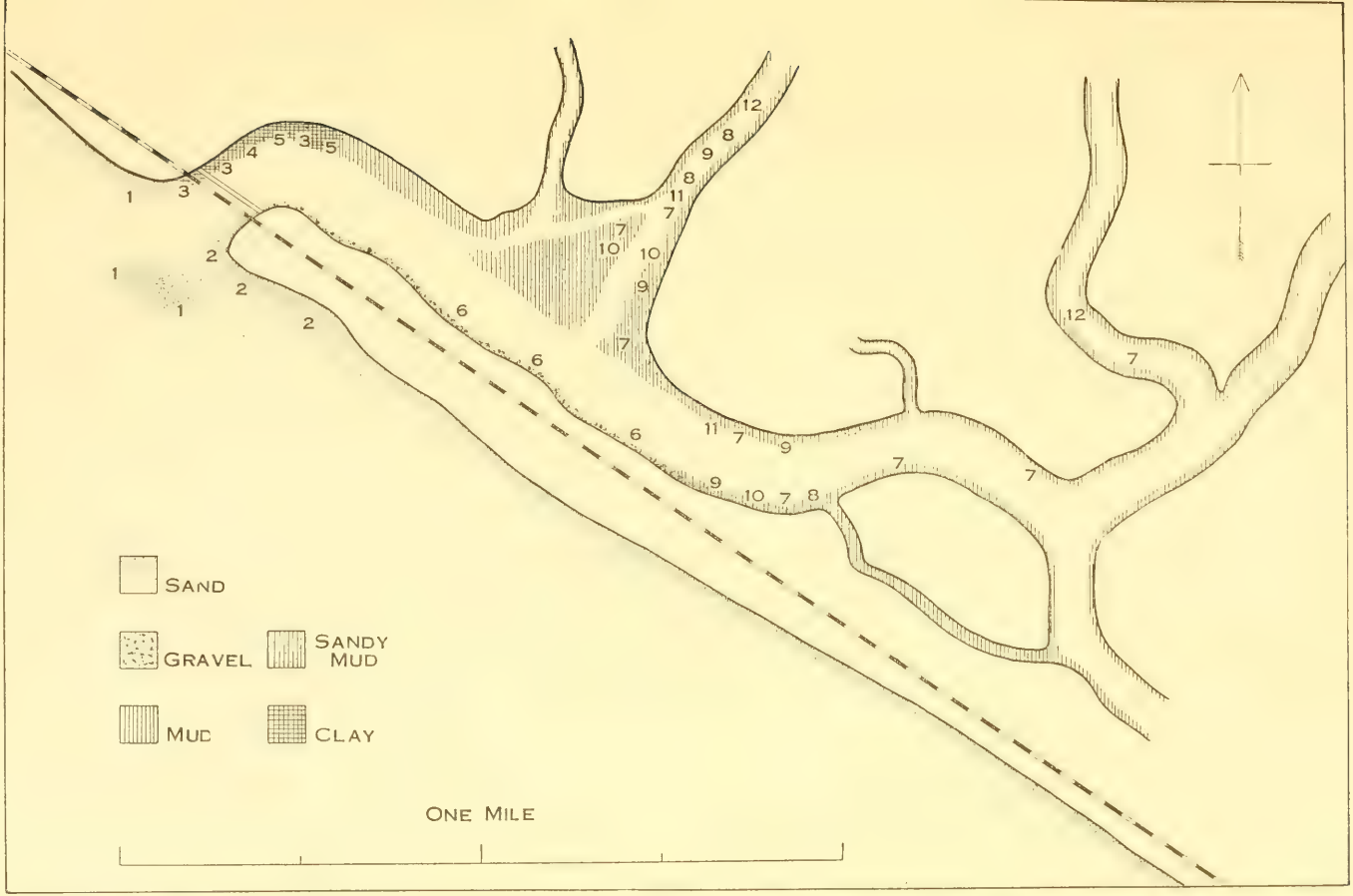


FIG. 18. Sketch Map of Anaheim Slough, California. High tide level is represented by a solid line, character of bottom bared by extreme low tide indicated by hatching or stippling. Approximate distribution of species indicated by figures as follows: 1, Pismo; 2, Wedge shell; 3, Piddock; 4, *Platyodon;* 5, Gaper; 6, Purple clam; 7, Bent-nosed clam; 8, Rock cockle; 9, Hard-shell cockle; 10, Jackknife clam; 11, Scallop; 12, Oyster.

To show a series of characteristic forms in a typical setting, Anaheim Creek, a small intermittent stream emptying into San Pedro Channel about six miles south of Long Beach, will serve. Like most small streams in this part of the coast, it ends in an intricate system of sloughs in a marsh and finally empties into the ocean through an enlarged lagoon-like portion about three-quarters of a mile in length sheltered behind a long sand spit. This portion with some of the larger connecting sloughs is shown in the sketch map (figure 18), which will be found to differ from the condition shown on the usual maps because of the changes occurring in such locations since the earliest surveys.

The outer beaches on either side of the entrance are of sand slightly coarser than that forming the extensive beach from which Long Beach takes its name. South of the entrance, prolonging the sand spit enclosing the lagoon and probably formed by the same forces, is a bar turning the entrance channel well to the north. The outer end of this has been built up to some height and at certain stages of the tide forms an island separated by a shallow channel from the tip of the spit, though at the lowest tides it may be reached dry shod.

On this bar-island and in less numbers on the north-west point may be found some of the once far more abundant Pismo clam (*Tivela stultorum*). This form reaches a large size and has the stoutest shell of any form from this region, eminently fitting it to stand the pounding of the surf to which in these situations it is always exposed. But this thick shell alone would not insure survival, as the sand is changing to an extent that few persons realize, scoured out and deposited in various ways and to different extents by the varying phases of the tide and heights of the surf.* The siphons of this clam are short and its feeding position is not farther from the surface than its own length. Surf far less heavy than what is considered a "storm" often scours out sand enough to dislodge the clam at this depth or deposits a layer deep enough to bury it beyond reach of food. The clam is active, however, and by constant burrowing down to escape erosion, or up to reach the surface, maintains itself except in some of the heavier winter storms when it may be washed out and piled up in numbers on the higher beach too worn by the battering of the waves to dig in again.

Curiously enough the only other form maintaining itself on these exposed beaches is one with a thin and delicate shell, the razor clam (*Siliqua*), which, though not obtained on Anaheim beach, ranges throughout the state and was observed at Oceano. In this case the powers of burrowing are astonishing. Many amateur diggers, seeing a "neck" and failing to find even after prolonged digging the clam to which it belongs, are prone to think that it has dug away. This is usually a mistake as most adult clams can change their position only very slightly and slowly. In the case of the razor clam it is, however, entirely true that it "digs away" and if the first spade thrust does not cut off its retreat and turn it out on the sand the chase is usually a hopeless one. The elongated and slender form is well fitted for passing through the sand and the muscular foot can be extended with considerable force a distance of half the length of the shell and, dilating near the tip, can obtain so firm a grip on the sand that the

*Thompson. The Spawning of the Grunion. Fish Bulletin No. 3, California Fish and Game Commission. 1919. P. 15.

shell may be broken or partially pulled off before the foot is torn out of the sand. Small specimens dug out at Oceano buried themselves with eight or ten thrusts of the foot, a process taking in one case seven seconds from the time the clam, lying on the surface, first thrust out its foot until it disappeared. In fact the burrowing reaction is so deep-seated that when a small clam is cut in two by the shovel, the foot-bearing half will still rapidly bury itself. These details of its habits are given to show how a fragile-shelled clam may maintain itself, escaping, by its rapid and deep burrowing, the surf and the scouring of the waves.

Neither of these forms is found in the lagoon; even if transplanted, the Pismo clam will not live long in the quiet waters of a bay. The reason for this, our ignorance of its habits and needs does not permit us to answer, but the fact is well established by the experience of the clam diggers. These two species are the best examples found in California of the group of active burrowers previously mentioned.

Along the spit, particularly at the tip, in the shelter of the bar are found large numbers of a small clam, the wedge shell (*Donax laevigata*) very much in superficial appearance like a miniature edition of the Pismo. It has a firm stout shell and short siphons and, when feeding, is not buried beyond its own depth; since it seldom equals an inch in length, this leaves it at the surface. Its burrowing powers must be correspondingly great but it will be noticed that it is more abundant in slightly sheltered locations and often it is washed out and piled in windrows by the storms.

A diligent search shows no other forms above the low tide level on the outside. Within the lagoon the bottom is varied, as may be seen from the map. On the north side of the entrance and in the bight on the north in front of the summer cottages of Anaheim Landing, the sand is underlaid at varying depths by hard clay and farther along by a stiff blue mud.

This bottom, which can not readily be washed out or shifted, shelters a number of boring forms which offer good examples of bivalves found in permanent burrows. In the hard clay is found the piddock (*Zirfaea*), while farther along where the clay passes into mud are found many of a less truly boring form, *Platyodon*. All of these agree in occupying holes from which they never voluntary move and indeed could not move, as the hole in the clay is only large enough for the siphons, and far too small for the shell. Their only movement is the slow grinding apparently brought about by twisting the rough shell in its hole, which serves to enlarge the burrow to the extent required by the growth of the clam. From these safe shelters, in which their relatively thin and fragile shells are well protected, they thrust out siphons of a surprising length from the clay hole through the overlying sand. When one has dug through two or three feet of water-saturated and flowing sand, following the slender retreating siphons, he is willing to believe what is obviously impossible, that the clam is digging away, and he is thoroughly convinced that the clams are safe from all harm except the possible biting off of the siphon tips. The creek does not offer this kind of bottom at any other place and at no other place are the borers found, being quite incapable,

because of their feeble burrowing ability, of maintaining themselves in the shifting sand or mud.

The much larger gaper (*Schizothaerus nuttalli*) occupies the beach near these borers though the animals are usually found in the blue mud farther from the entrance rather than in the clay, as they are not true borers but require a firm and not too hard bottom into which they slowly burrow with increasing size, apparently seldom or never moving about. The great depth reached by the adult is easily spanned by the long fused siphons, the largest of any of the species here treated (except the geoduck), but discourages most diggers as flowing sand makes depths of two or three feet almost prohibitive.

Along the inner side of the sand spit separating the lagoon from the sea the bank is steeper and more abrupt than elsewhere and is formed of coarse sand mixed with some fine gravel and shells. This extends for rather more than half a mile; beyond this point there is a gradual change to black sand and then to black sandy mud. The coarse sand is inhabited almost exclusively by *Sanguinolaria nuttalli*, sometimes called the "purple clam," a thin-shelled form found at a depth of 12 or 13 inches lying not head downward, as do most clams, but on the right side. It reaches the surface by two long separate yellowish siphons, which are seldom seen, though the characteristic pair of holes may easily be located.

As the sand becomes muddy, another form appears which is also present on all other muddy shores, and therefore the most widely distributed species found in the lagoon and sloughs. This is *Macoma nasuta*, the "bent-nosed" or "mud" clam. The term "mud" clam is not distinctive, being applied to other forms, but "bent-nosed" is truly descriptive, as the clam, like *Sanguinolaria*, lies on the side, but in this case on the left side and the siphonate end is turned distinctly up, that is, toward the right, to accommodate the upward directed siphons, here also separate and long. Similar locations, namely flats of fine sand or mud in sheltered bays, are sure to yield the bent-nosed clam anywhere along the California coast.

The mud and muddy sand also shelters three species of "cockles," *Paphia staminea*, known as the rock cockle, and two species of *Chione* or hard-shelled cockles. The Chiones are just below the surface and in consequence the shells may often be seen in walking over the exposed flats. *Paphia*, on the other hand, though found on similar bottom, burrows deeper, usually six or more inches for those of moderate size. If the living clams are examined, it will be found that there is a corresponding difference in the length of the siphons and the same can be seen in the shells, the pallial sinus of *Paphia* reaching half way to the scar of the anterior adductor, while in *Chione* it is a mere notch (figures 9 and 11).

The firmer flats of relatively undisturbed fine, dark, muddy sand are also the home of an interesting small species of razor clam, *Tagelus*, the jackknife clam. This, like its relative of the open beaches, is an active burrower, but unlike it, lives in a smooth-lined permanent burrow which fits its enlongated cylindrical shell snugly. By means of its long muscular foot it moves up or down the burrow rapidly and at the bottom is well protected from enemies or the heat of the sun. When at the top of the burrow it is still about its own length from the

surface, with which it communicates by means of two slender separate siphons and, like *Macoma*, its presence is made known by pairs of holes at the surface (see figure 22).

A tiny nearly smooth species of *Cardium* is found at the surface with *Chione*, but the edible cockle (*Cardium corbis*) was not seen here though it occupies similar locations farther to the north.

The piles of the railroad and wagon bridges crossing the outlet furnish attachment for a limited number of sea mussels which are used locally as bait. In shallow water along the sloughs the native oyster is found wherever old shells or similar objects afford attachment. The two forms just mentioned represent, in this locality, the group of fixed mollusks.

The census of the inlet aside from species too small to be edible is completed by the scallop, *Pecten circularis*. At low tide it may be seen lying on its right side on the surface of the bare flats or in shallow water on a variety of bottom though not on the steep slopes of the spit or near the entrance. The fact that the scallop is less sharply restricted to a particular kind of bottom than are the other species just considered is due to its active habits, for this form is, as already stated, practically unique among bivalves in being able to swim through the water by clapping its valves together. In this way it moves about or turns over if placed wrong side up. Though it can not "swim" in the purposive manner of a fish, its movements serve to keep it in the proper feeding position, to keep off silt which would tend to bury it and to enable it to escape some of its enemies.

Practically all the species treated in the present paper are thus found in the waters of, or adjacent to, Anaheim Creek, and their relation to the physical conditions are illustrated in its main features. This may serve as a point of departure for those wishing to learn more of their habits or, if the principles are applied to other bays, the amateur clam digger may readily judge where to dig for his dinner.

DESCRIPTIONS OF THE EDIBLE BIVALVES OF CALIFORNIA

NATIVE OYSTER

Ostrea lurida Carpenter

The irregular, attached shells of the small native oyster are familiar to all. It occurs throughout the region treated in bays or lagoons that offer places for attachment, though in many localities the numbers are small. It seems nowhere to be used as extensively as it deserves. In Tomales Bay it is at present cultivated and investigations looking toward the further development of the industry are under way. For this reason no extensive treatment is here attempted.

The Eastern oyster (*Ostrea virginiana*) is raised in large amounts in San Francisco and Tomales bays from imported spat, but the species has never established itself on this coast.

SCALLOP

Pecten circularis Sowerby

Plate 1, figures 1 and 2

Other names—Pecten; fan shell.

Description—This bivalve may readily be recognized by the lateral projections on either side of the umbo, not present in any other form here treated, the well marked radiating ribs and grooves ending in points which alternate and interlock with those of the opposite valve. There is only one muscle (the posterior adductor) for closing the shell, but this is very large and well developed. Other scallops not greatly different in general appearance may be met with, of which *P. diegensis* may be mentioned. It differs in having the two valves unlike, one being nearly flat and the other markedly arched.

Habitat and habits—There are several species of scallops. This is the largest of those found in shallow water (except *diegensis*). It is very active, contrasting with the bivalves as we usually know them. At low tide it may be found lying on its right side on the sand left dry by the receding tide in bays or lagoons; it does not burrow, though sometimes the smaller specimens may be found fastened to a rock or dead shell by means of a byssus, like that of the mussel. But it is not completely at the mercy of the tides for it can swim about actively. This it does by clapping the valves of its shell together and forcing out the water between them in a sharp stream, the direction of which it can regulate by means of the mantle. When the shells are opened folds of the mantle extend in from either margin to meet and close off the interior. When the shell is shut the contained water is forced out where the mantle edge is least stiff and, as a result, the pecten will shoot off in the opposite direction. According to Kellogg* in the case of the Eastern forms the jet is forced out first next to one "ear" and then the other. If an animal is placed wrong side up in shallow water it will promptly right itself, and often at low tide it may be

*Shellfish Industries 1910, p. 336.

heard splashing about in little pools like a fish in an effort to escape. While the "swimming" is probably too much a matter of chance to amount to a migration, it serves in connection with the tides to distribute them over a variety of bottoms, and the scallop is found in sheltered waters wherever the current is not too swift.

To collect them, therefore, it is only necessary to wade about in shallow water at low tide and pick them up. They may also be taken with a dredge in shallow water, where abundant enough; this is the commercial method in use on the Atlantic coast.

Use—Usually only the big adductor muscle is eaten, the darker colored mantle being avoided, but this is a useless waste and all parts will be found edible, as in the oyster. It is generally agreed by epicures that the scallop is the finest flavored and most tender of all shellfish. The entire animal does not ship well on account of the poor closure of the shell, and as a result the "meats," as the adductor muscles are called, are usually shelled out on the grounds and shipped to market.

Distribution—Monterey, California to Payta, Peru (Dall). Living specimens were obtained in considerable numbers at Anaheim Creek, Newport Bay and False Bay. At Anaheim a launch was employed in dragging for them with a small oyster dredge and the "meats" were being shipped to Los Angeles. Farther north, though present, it is not abundant enough to be used.

ROCK SCALLOP

Hinnites giganteus Gray

Plate 1, figure 3; plate 2, figures 1 and 2

Other name—Rock pecten.

Description—This scallop is much larger than the preceding one, reaching a diameter of as much as six inches. In its younger stages it is free and symmetrical as are its smaller relatives, which it then resembles in general appearance, but it later becomes attached by its right valve to a rock or other support, and in its subsequent growth is irregular, being distorted by its surroundings. The shells may always be recognized by a deep purple color on the inside about the hinge.

Habitat and habits—In the young unattached stage its habits are similar to those of the other species. The adult is reported by Thompson (1913) as living in great numbers below tide line on the outer coasts of British Columbia in somewhat sheltered parts. It has been observed in corresponding positions on the rocky coast of Monterey Bay but never in great numbers. A curious habit reminiscent of its earlier swimming stage is retained by the attached adult. If disturbed it often shoots out a jet of water to a distance of several feet apparently by the same method of clapping together the valves used in swimming (W. F. T.).

Use—Not used as far as known in the region visited.

Distribution—Aleutian Islands to Magdalena Bay, Lower California (Dall).

ROCK OYSTERS

Anomia peruviana d'Orbigny

Plate 3, figure 3

Monia macroschisma Deshayes

Plate 3, figures 1 and 2

Description—These two species are similar enough to be treated together. They may be recognized by the more or less irregular form which, like the oyster, comes from their permanent attachment, though in this case the shell itself is not fastened to the rock. A strong muscular byssus passes through a deep notch in the right valve to fasten to the support.

Habitat and habits—Attached to stones between or below tides.

Use—The rock oysters are not, as far as known, used for food, though edible.

Distribution—*Monia* is found from Alaska into Lower California; *Anomia* southward from San Pedro (Dall). Shells are common along the beaches but because of their relative unimportance no special search was made for living specimens.

SEA MUSSEL

Mytilus californianus Conrad

Plate 4, figures 1 and 2

Description—This mussel reaches a large size, sometimes measuring more than eight inches. The valves are covered with a black glossy periostracum, which is usually worn away in the older parts of the shell. The surface is marked with concentric growth lines and faint radiating ribs but both vary greatly in different specimens.

Habitat and Habits—The sea mussel is found attached to the rocks of exposed reefs and headlands in dense "beds" extending from near high tide line to the level of the lowest ebbs. They do not flourish in quiet waters but reach their largest size where exposed to the full force of the surf of the open ocean. Here they lie closely crowded together and so firmly anchored by the tough threads of the byssus to the rock and to each other that the breaking of the waves fails to dislodge them.

Use—The sea mussel is an excellent food mollusk and properly prepared, as for instance by steaming, is not surpassed in flavor by any of our bivalves. Since they are widely distributed and very abundant they deserve an even greater use than is at present made of them. In their preparation particular care should be observed to follow the general rules laid down for selecting bivalves (see page 68). They should be sorted and only those capable of closing their shells promptly should be used. The exposure to sun and air of those at the higher levels often injures them and cases of poisoning have resulted from their use. All such danger, however, may be avoided by the simple precaution of gathering at low tide only those covered at other stages of the water.

The sea mussel is used extensively by the local inhabitants and is marketed to some extent. In the South they are also used as bait in surf fishing. They have been canned on a commercial scale at various points.

BAY MUSSEL

Mytilus edulis Linnaeus

Plate 3, figure 4

This form has been called "sea mussel" on the Atlantic coast to distinguish it from the fresh water mussels, but since it is not found on the outer coasts as is *M. californianus* the term "bay mussel" is preferred.

Description—This is a smaller form, seldom exceeding a couple of inches in length, smoother and less elongated than *M. californianus*. It is found within bays.

In Europe it is extensively cultivated and is an important food mollusk. It is often seen in the San Francisco markets.

HORSE MUSSEL

Modiolus rectus Conrad

Plate 4, figure 3

Description—The species of *Modiolus* may easily be distinguished from the other mussels of the coast by the fact that the umbo is not at the extreme end and that the color is not black but brownish. The shells are also either bearded or markedly ribbed. Several species reach a size great enough to make them of importance though none appear to be abundant. *M. rectus*, here figured, can be told by its elongated form; the others resemble *Mytilus edulis* in general shape. *Modiolus modiolus* is a large form found in deep water among gravel and rocks. *M. plicatus* is a smaller species that has been introduced from the Eastern coast to San Francisco Bay; it is found between tides on the mud flats. The numerous conspicious radiating ribs will serve to distinguish it from both *M. rectus* or *M. modiolus* which are without ribs but are bearded.

Habitat and habits—The horse mussels are generally solitary and are found partially buried in mud or gravel, to which they are anchored by the byssus. This fact will serve to separate them from the species of *Mytilus*, which occur in beds anchored to some solid object between tides.

Use—The use of the horse mussels as food was not observed. On the Atlantic coast they are eaten though considered inferior to *Mytilus edulis*.

Distribution—*Modiolus rectus* is found, according to Dall, from Bolinas Bay to Magdalena Bay, Lower California.

SPINY COCKLE

Cardium quadragenarium Conrad

Plate 5, figure 1

Description—The large size and spiny ribs of this species of *Cardium* will serve to identify it.

Use—Though of large size it is too seldom taken to be of economic importance and is included here merely for the sake of completeness.

Distribution—Found off shore from Santa Barbara southward.

COCKLE

Cardium corbis Martyn

Plate 5, figure 2

Description—This is the chief of the species of *Cardium* reaching an important size, and is the bivalve having the best claim to the term cockle. The valves are marked with numerous bold radiating ribs, separated by grooves which are prolonged at the margin to form interlocking points as in the scallop. Viewed from the end, the deeply arched shells give the animal a heart-shaped outline, and they are sometimes known as "heart shells."

Habitat and habits—In the North, this form is found on tide flats in bays or sounds, where it burrows barely beneath the surface, or may be seen lying on top of the sand. In California living specimens were found both in bays and on exposed beaches of coarse loose sand. It is a very active bivalve and corresponding to its habit of shallow burrowing, has a strong, elongated foot and no siphon tubes, the siphon holes being formed by fusion of the mantle margins at two points.

Use—An excellent food mollusk, commanding a good price in the market, it is not handled commercially in California because of its scarcity. For the same reason, there is little local use made of it.

Distribution—Though widely distributed in California it does not appear to reach the importance that it does on the tide flats of Puget Sound and the Gulf of Georgia. It was present in Humboldt Bay, Crescent City, Tomales Bay and on Humboldt Spits and in general where the rock cockle (*Paphia*) is found, though always in smaller numbers. In Elkhorn Slough emptying into Monterey Bay it is fairly abundant and of good size. Some were found in Morro Bay and between Oso Flaco Lake and Point Sal at the southern end of Oceano Beach, where they were taken with the Pismo clam. In the latter place the sand is coarser and softer than on Pismo Beach and apparently better fitted for rapid burrowing. Shells were obtained at various points south to San Diego and occasional reports of former beds were obtained but these seem to be of little importance.

GIANT COCKLE

Cardium elatum Sowerby

Description—This species is even larger than *Cardium quadragenarium* and is reported to reach a size of six inches. It is nearly round and the ribs are less conspicuous than in either of the other forms here treated.

Use—It is occasionally brought up by fishermen but though edible is of negligible importance.

Distribution—From San Pedro southward. Found off shore

PISMO CLAM

Tivela stultorum Mawe

Plate 6, figures 1 and 2

This form is the most important commercially that we shall have to consider, and is unique among our clams in having a distinctive common name.

Description—This large, heavy-shelled form is familiar to most Californians as it is very common in the markets. The valves are large, massive, thick and so hard on the outer surface as to dull a file rapidly. In size it exceeds most clams here considered, the gaper and the geoduck being the only forms to equal it. Specimens were measured having a length of seven inches and several larger examples weighing over four pounds (and hence longer) are recorded, one with an authenticated weight of 4 pounds 3 ounces. The weight of those exceeding the legal size of $4\frac{3}{4}$ inches is considerably less than this, averaging about $1\frac{1}{3}$ pounds. The color of the adult is a pale buckskin with some faint light purplish concentric markings, and this latter color is still more marked on the siphonate end. Occasional specimens, perhaps two or three in a hundred, show striking radiating stripes of light chocolate brown, running from the umbo to the margin and increasing in width with increase in size of the shell. They vary in width and arrangement in different parts of the shell and in the two valves. Among very small clams, this chocolate color is not rare, but no adults entirely brown were seen though some are reported. The pigment forming the rays is superficial, lying only in the outer part of the shell where it is deposited by the mantle, which apparently differs, in these cases, in pigment forming power in different parts. The shell is overlaid by a thick glossy periostracum, giving the valves an appearance of being varnished. In large specimens this wears off on the older portions about the umbo. The animal has a thin muscular foot of the plowshear shape and short siphons, separate at the tips.

Habitat and habits—The Pismo clam is sharply limited to exposed sandy beaches and if transplanted to the sheltered waters of bays, as is sometimes done by clam diggers to ensure a supply when tides are unfavorable, it does not thrive and soon dies. Here on the long beaches exposed to the constant pounding of the surf which its heavy shell fits it to withstand, it flourishes in what might be thought an unfavorable environment. Its abundance in the early days is a matter of common

knowledge and all have heard of its being plowed out by the farmers and picked up from the furrows unfortunately in part to be wastefully fed to hogs or chickens. Even in recent years, it has been abundant enough so that during the past four years (1916–1919) the beaches of Morro, Pismo and Oceano furnished yearly over 150,000 individuals weighing on the average over 200 tons.

Its heavy shell might protect it against the force of the surf but another danger, perhaps even greater, threatens it. Only those who know the beaches intimately realize to what an extent the sand is a

FIG. 19. Digging Pismo clams, Oceano. Digger returning with his fork and a "limit" of clams in his "drag."

changing thing. Pounded and scoured by the waves which act according to the tide now at this level and now at that, the surface of the beach trodden by the bather which seems so hard and to the casual eye so unchanging from day to day, is really in a state of constant flux, being now cut down and now built up sometimes to a depth of a few inches and sometimes to a foot or so. This and some of the work that deals with the wave action has been already referred to. Often during a month or an entire season one kind of action will predominate and the diggers who daily frequent the beach and study it as a sailor does the sea, can point out a stranded buoy or stump or rock now bare, that last season was covered, or which now can barely be seen though before it was conspicuous. Such erosion or filling amounting to several feet is common. Below tides the sand is even more at the mercy of the water. On the broad, gently shelving beaches where the

Pismo clam is most at home, the sand is piled up in offshore bars lying below ordinary low tide, though perhaps bared at extreme low ebbs, and usually separated from the exposed beach by channels varying from two or three to a dozen feet deep. These bars are relatively transient, some lasting for several months, while others may last but a single tide, being formed and scattered with amazing rapidity, if the waves and tides occur in the correct sequence. How destructive such changes may be, is seen in some winters when the heavy cutting surf washes out and rolls up the beach such numbers of the clams that windrows are found at high tide line. This occurred, for instance, in December, 1915. That the constant shifting of the apparently monotonous sands is not always fatal to this clam in spite of its stout shell is due to its constant activity. When new bars form and rise, the animals are found at the surface. When the bar is swept out it is seldom that more than a stray individual washes up and this can only mean that the clam is constantly and actively burrowing up or down to escape being buried too deeply to reach its supply of water or to avoid being completely dislodged and thrown to the mercy of the surf.

For this activity its large muscular foot with its thin knifelike edge is well fitted though its heavy shell is less readily drawn through the sand than is that of its neighbor on these beaches, the razor clam. Small individuals up to 30 or 40 mm. (1½ inches) bury themselves readily if thrown out on the firm wet sand just above the wash of the waves. Some watched on Oceano Beach were covered in 30 to 45 seconds. Adults find this more difficult but will bury themselves if they are covered with water and can get time between the waves which sweep them up and down the beach, to get a "foothold."

Another delicate adaptation is found in the siphons. These, as already stated, are short, a condition found in most actively burrowing forms. The exhalent tube is somewhat the shorter and its delicate, thin walled tip, rimmed with a few short tentacles, closes in a line parallel with the margins of the shell when no current is passing out. At other times, the current of water will prevent the entrance of sand. The inhalent siphon is somewhat enlarged at the tip and ends in a broad flat surface that to the first glance shows no opening. If one has the patience to examine this surface with a low power lens as the animal lies at rest in some little pool, it will be seen that the aperture is closed by a delicate system of branched tentacles so closely placed that while every sand grain dropped upon them is securely supported the water has free access to the mantle cavity through this living screen. As the water flowing over them nearly always contains some sand and at times is filled with whirling clouds of it, the value of this arrangement is obvious, since the supply of water bears both oxygen and food to the clam.

It was noted by Thompson* that the razor clam is found with the hinge toward the open ocean and he has suggested that this position bears some relation to the question of water supply to and from the siphons. The question of position was carefully studied in the Pismo clam and the same condition was found, the hinge being almost invari-

*Report on the Shellfish of British Columbia, Report of the B. C. Commissioner of Fisheries, 1913, p. R 108.

ably turned seaward. The testimony of the diggers, also, was to the effect that the clam was turned crosswise of the beach. Whether this position is related to the water supply or to wave action, there seems no data on hand to decide, but the fact is clear.

One should picture the Pismo clam, then, with its heavy strong shell shielding it from the blows of the surf, maintaining itself by ceaseless activity in sand that, wave driven, flows day and night and by means of its screened siphon tubes obtaining a stream of water from which it strains organisms too small to see, yet which, in the aggregate, form clam meat harvested yearly to the amount of hundreds of tons.

Though once present between tides in such immense numbers a digger might obtain all he wanted dry shod at low tide, continued fishing has

FIG. 20. Digging Pismo clams, Oceano. Diggers returning with clams. The automobile in the distance gives some idea of the width and levelness of the beach.

reduced these more easily reached individuals, and now the clammer must get his supply almost wholly from the bars just mentioned. Perhaps it may not be amiss to picture to the person who relishes the Pismo clam in chowder or soup how it is obtained. At low tide the clam digger in old clothes, slicker coat and pants and "sou'wester" and armed with a potato fork wades out to the bars. Here, he "feels" for the clams, thrusting the fork into the sand very much as in spading with a spading fork though without "turning up" the sand. The row of tines are usually turned across and not parallel with the water line to avoid "straddling" the clam and when a shell is struck it is lifted out. As the beaches are pure sand with very seldom a dead shell or stone, anything struck is pretty sure to be a clam. In order to leave the hands free, the clams are carried in a sack fastened to the

belt or over the shoulder or what is now more common, a long netted bag or "drag" with a light wooden hoop to hold the mouth open. This is usually fastened to the belt with a "snap" as there often arise occasions when the waves place a digger where fifty to eighty pounds of clams are a distinct embarrassment and must be quickly cast off.* The sack is long enough to rest on the ground so that the weight is not directly borne, but dragged along, hence the name (see figure 21).

As was before stated, the clams in the shallowest water are earliest cleaned out so that at this present time the lowest tide is the best, and

FIG. 21. Gear used in digging Pismo clams, Oceano. "Rake" with extension handle and rope by which it is pulled through sand, fork and "drag" with snap and belt.

other things being equal, the tallest man gets the most clams. As a result of this, the digger will be seen working far out from shore as shown in figure 1 and since on these exposed beaches the surf is never ceasing, it is not uncommon to see the combers break over the shoulder or even the head of the digger, though at other times he may be only waist deep. At times this may partake of the exhilaration of surf-riding with an anchor of clams to prevent being swept too far, but at sunrise of a foggy day with a cold wind whipping the spray from the breakers it is a life of exposure.

Another danger is also present. The channels separating the bars from the higher beach are often deeper than can be waded and with swift currents. Sometimes such a bar can be reached only at a single point where the channel is partially bridged by a spit and the location of this must be carefully kept in mind when returning from the bar.

*A case of drowning due to neglect of this precaution has occurred since writing the above lines.

When the tides come at two or three o'clock in the morning, lanterns are usually ranged on the beach to mark the route to the bar, a precaution very necessary since directions are surprisingly hard to tell in the fog and darkness.

Though under ordinary conditions the clam is found by "feeling" along, they may be located on undisturbed exposed bars or beaches by tiny holes overlying the siphons or sometimes a sunken area overlying the whole shell and apparently caused by its movements.

Use—The Pismo clam is a distinctively Californian bivalve and enjoys a high reputation as a food mollusk, being widely used in soups, chowders, fritters and baked in the half shell. The greater part of the shipments from the San Luis Obispo coast find their way to San Francisco and the bay cities or to Los Angeles. Here they are used by restaurants or cafes rather than retailed. In the South a very large proportion are used for bait in surf fishing.

Distribution—"Santa Cruz, California, and south to Socorro Island" (Lower California) Dall. It was found at Halfmoon Bay just south of San Francisco (Heath) and to some extent on nearly all favorable beaches south to the Mexican boundary. As previously explained, it may be expected on exposed sandy beaches particularly where the beach is wide and the slope gentle. At present a few are marketed from Monterey Bay but practically all come from Morro, Pismo and Oceano, where these conditions are best fulfilled. Formerly it was abundant on various more southern beaches near Carpinteria and at Long Beach, but these no longer yield it in commercial quantities. Recently (1919) some have been imported from Turtle Bay, Lower California.

Several attempts to transplant the Pismo clam to various points outside this range on the California and Oregon coast have been made, but as yet without marked success.

SEA COCKLE

Amiantis callosa Conrad

Plate 5, figure 3

Description—The valves of this form are very heavy and thick, recalling the Pismo clam, but the shell is less triangular, the umbo being directed anteriorly, and the outer surface is marked with prominent rounded concentric growth lines which occasionally branch, and is covered (at least in the adult) with a firm, smooth, shining, white periostracum. The pallial sinus is fairly deep, reaching about half way to the anterior muscle scar.

Habitat—It is found at extreme low tide on open beaches or near the entrance to bays but never in great abundance.

Use—Though edible it is far too scarce to be considered an economic species and is included here only because the large and beautiful shell is sure to be found and its identity questioned by the amateur digger.

Distribution—"San Pedro, Cal., to Gulf of Tehauntepec" (Dall). Shells were found farther north than this, being fairly abundant at Santa Monica, Playa del Rey and were common at Long Beach and at San Diego, but no living specimens were obtained.

WASHINGTON CLAM

Saxidomus

Plate 7, figures 1 and 2; plate 8, figures 1 and 2

Other names—Butter clam; money shell.

Two species of Saxidomus are recorded from California by Dall—a northern form, *S. giganteus*, ranging from Alaska to Monterey, and a southern form, *S. nuttalli*, found from Bolinas Bay to San Diego. The species are quite similar and some recent writers have united them as mere variations of one form.* The writer, on the basis of material examined, can not agree in this; the two species seem distinct but *S. nuttalli* extends farther north than Bolinas Bay, being found in Humboldt Bay and possibly in Puget Sound. The two species will be described separately but treated largely together, as they are not distinguished by the diggers and are marketed together. Neither are there distinctive common names for the two forms. Besides Washington clam the names butter clam and money shell are used in some localities. The name "Washington clam" is also applied to the gaper, *Schizothaerus*, perhaps more justly, but its local use for *Saxidomus* is said to have come from its resemblance to *Venus mercenaria* of the Atlantic coast, as noted by Indian chiefs at the time certain of them were in Washington, D. C., conferring with government officials. The name "money shell" came from the use of *Saxidomus* shells of pearly appearance and unusual thickness as money by the Indians of Bodega and Tomales bays.

Saxidomus nuttalli Conrad

Plate 7, figures 1 and 2

This is the larger of the two species. The shell is thick and firm, oval in outline and roughened on the outer surface by numerous concentric growth lines; within, it is white with slight touches of purple, particularly about the siphonate end. The siphons are united, long and completely retractile, though due to the slight gaping of the siphonate extremity of the shell they can usually be seen from the end. The pallial sinus is deep, corresponding to the size of the siphons.

Saxidomus giganteus Deshayes

Plate 8, figures 1 and 2

The general appearance of this species is similar to that just described but the shell is somewhat more circular in outline and smaller. The outer surface is much less rough, the growth lines being finer and lower; the white of the interior is without any tinge of purple. The flesh is whiter than that of *S. nuttalli*.

Habitat and habits—Since essentially similar, the habits of the two species may be described together. The stout shell, the moderately

*Packard, E. L. Molluscan Fauna of San Francisco Bay, University of California Publications in zoology, Vol. iv, no. 2, p. 269, 1918; Clark, B. L. Fauna of San Pablo Group of Middle California, University of California Publications, Geology, Vol. viii, 1915.

strong foot, and the siphons indicate the ability of this clam to live in diverse localities. The shell varies greatly in strength and thickness according to the locality. Some of the money shells obtained at Bodega Bay were half an inch in thickness, nine inches long, hard, and of great strength and weight for the species. Others from mud flats were sometimes very thin and easily broken. As a rule the shells are of a strength sufficient to stand rough handling, about four or five inches in length, and the valves hold moisture well enough to enable the clam to stand shipment for some distance. The siphons, although small, are long enough to enable the clam to bury itself beyond the reach of the ordinary surface enemies and of the effects of heavy waves, but are not of such bulk as to diminish the value of the clam as food. The species is in many respects intermediate between the surface dwelling cockle (*Cardium*), with its lack of a siphon and its great foot, and the sedentary, deeply burrowing soft shell (*Mya*) or gaper (*Schizothaerus*), with long siphons and small rudimentary foot, but bears some resemblance in habitat and characteristics to *Paphia staminea,* the rock cockle, or Tomales Bay cockle.

Distribution and use—The localities in which they are most markedly abundant are: Humboldt Bay, Crescent City Beach, Bodega Bay, Wilsons Creek, Tomales Bay, Bolinas Bay, and Drakes Estero.

As it is on the British Columbian and Alaskan beaches, the Washington clam is the most important one present in Humboldt Bay, being so abundant that a digger can gather from eight to twelve buckets full in a good low tide (1911). These are nearly all *Saxidomus giganteus,* though a small proportion of *S. nuttalli* are present among those marketed (December, 1919). The beds extend over the northern portion of South Humboldt Bay, between the entrance and Fields Landing. They are also found in North Humboldt Bay, but not as abundantly. The beds are found near low tide line, as a rule, in regions of high salinity, as are those of *Schizothaerus.* The clams lie about eight inches or less below the surface, and apparently move about in a very limited way, judging from the fact that they are found at the bottom of what the clam diggers term "holes," or softer places among the more viscous surrounding mud. In each of these "holes" are found frequently three or four individuals; these are captured by treading the mud for them and, when discovered, by utilizing a hook to bring them to the surface. Between ten and twenty men were, in 1911, making use of the species extensively for themselves or for the market.

In no other locality on the coast does this species assume a proportionate importance. In Bodega Bay the beds lie in the middle ground exposed by the tides, and along the western shore. In Tomales Bay the beds are neither extensive nor utilized commercially. In Bolinas Bay they are nearly gone, due, it is said, to the deposition of sand. Wilsons Creek, Shelter Cove and Crescent Beach have sparsely inhabited beds open to the ocean, not clearly defined nor of much importance. Judging from the fact that at one time the Indians came annually to camp at Tomales Bay in order to gather the Washington clam, they must have been far more abundant then, than at the time of the survey. At present the use of shells as money is restricted to the older Indians, but formerly it was general, extending along the whole coast beyond

Humboldt Bay at least, and inland. A heavy valve without discolorations was recently valued at fifty cents.

It is improbable that any further development of an industry based on this clam is to be expected. It is less hardy and of slower growth than *Mya* and hence less able to withstand excessive fishing. It is not a species as important to local inhabitants and tourists as it is to the commercial diggers in Humboldt Bay.

Between San Francisco and Santa Cruz occasional Washington clams are found in the sheltered coves but no valuable beds are present. In Elkhorn Slough emptying into Monterey Bay there is a more important bed. Here they are found mixed with the gaper (*Schizothaerus*) by which they are far outnumbered. No further beds of note occur until Morro Bay is reached when they are found, though less abundantly than the gaper. In both these latter localities as well as farther south only *Saxidomus nuttalli* was identified.

Shells were obtained from the beaches between Point Conception and Ventura and a single small specimen, apparently the young of this species, was found living on an old pile used as a buoy in Santa Barbara Bay (C. L. H.). Although between Santa Barbara and Santa Monica the beds were largely destroyed by the great storm of 1915, small numbers continue to exist, but at no point do they flourish in sufficient numbers to justify commercial digging. In False Bay, near San Diego, conditions remain unchanged, and the Washington clam is present. The beds, however, are not extensive and the yield is gradually growing less according to the reports of several observers (H. H.).

It can not be said, therefore, that the southern Washington clam is of commercial importance at present, although it contributes to the stock available for casual diggers.

HARD-SHELL COCKLES

Chione fluctifraga Sowerby

Plate 9, figure 1

Chione undatella Sowerby

Plate 9, figure 2

Chione succincta Valenciennes

Plate 9, figures 3 and 4

Description—These three species may conveniently be treated together as they differ but little, are often found together and are all equally edible. All are relatively small, measuring from two to two and a half inches in length, compact and rounded in outline, with firm heavy shells and short united siphons. The differences are chiefly in surface markings, as may be seen from the figures. *Chione fluctifraga* reaches the largest size, it has no lunule or heart-shaped depression just in front of the hinge and in it the radiating ribs are most conspicuous, being more prominent than the concentric growth lines on the siphonate or posterior end of the shell. The pallial sinus is larger than in the other species and sharply triangular instead of rounded. In both *Chione undatella* and *Chione succincta* there is a

conspicuous lunule and in both the concentric growth lines are more marked than the ribs. They differ in the number of the concentric ridges which are crowded in *C. undatella* and more widely separated in *C. succincta*. In the former the ribs are everywhere very inconspicuous while in *C. succincta* they the more marked at the siphonate end, thus approaching *C. fluctifraga*.

Habitat and habits—These species are similar to *Paphia* in their general habits, being found in bays in firm sand or sandy mud not too frequently disturbed by waves or strong tidal currents. As might be expected from the short siphons they do not burrow deeply, in fact the siphonate end of the shell may often be seen at the surface of the sand and the cockle thus picked up without any digging. In some cases they were observed at the side of a burrow belonging to another species. The Paphias found with them usually burrow to a depth of several inches.

Use—In the Los Angeles markets they rank next after the Pismo and rock cockle (*Paphia*) in importance and there are known as hard-shell cockles in contrast to the more brittle *Paphia* which is called a soft-shell or paper-shell cockle. They are used extensively with *Paphia* in Los Angeles and San Diego by the restaurants for chowders and soups. The flavor is excellent, though because of the flatter and thicker shell the proportion of meat is not as large as in *Paphia*.

Distribution—The Chiones are distinctly Southern forms, ranging from San Pedro into Mexico. *C. undatella* and *C. succincta* were obtained at Anaheim Slough, Newport Bay and San Diego; no specimens of *C. fluctifraga* were collected, though shells were found at San Diego.

THIN-SHELLED COCKLE

Paphia tenerrima Carpenter

Plate 10, figure 1

Description—This species reaches a fairly large size (3 to 4 inches) in this exceeding the following form, from which it may be told by the more elongated outline and the faint radial ribs which are less conspicuous than the concentric growth lines.

Distribution and use—Though of wide distribution this species does not appear to be abundant in California. Shells were obtained at Oceano (F. W. W.) and living specimens just south of Pital Point, Ventura County (C. H.), but it can not be considered as an economic species.

ROCK COCKLE

Paphia staminea Conrad

Plate 10, figure 2

Other names—Little-neck; hard-shell; Tomales Bay cockle; rock clam.

Description—The rock cockle is a clam of moderate size, seldom exceeding three inches in length, with deeply arched valves so that the whole animal is rounded in form and of fair weight for its size. The

shell is marked with bold radiating ribs recalling the true cockle (*Cardium*) though the shell is distinctly longer in proportion to its height. The foot is flattened and though strong is not as large as the finger-like foot of the cockle. It differs from *P. tenerrima* in showing comparatively faint growth lines and in having the inner margins of the valves roughened and not smooth.

Habitat and habits—It is not adapted by its form or burrowing powers to loose or rapidly shifting ground such as that occupied by the razor clam, but is still active enough to maintain itself on outer beaches as well as in enclosed waters. In the bays it is found in much the same situations as is the Washington clam (*Saxidomus*), never in beds of deep soft mud, but nearer the entrances of the bays and as a rule not far distant from low tide line. In firm mud banks it burrows to a depth of from three to eight inches though occasionally it is found at the surface. It does not inhabit pure sand through which its rough shape unfits it to move rapidly, but it is often met with wherever there is room for it to nestle in accumulated gravel and sand among the rocks in exposed situations. Along the outer coast it is therefore possible to judge fairly accurately of its distribution by the presence of firm beaches, such as those of small boulders mixed with gravel or coarse sand. It is capable of living in gravel or boulder beaches below low tide line; from such beaches live clams are frequently washed ashore, as is the case on the pure sand beaches off the Humboldt Bay spits and off Crescent Beach. Naturally, however, clams in such situations are only indirectly of commercial value through forming a source of supply of spawn for the neighboring exposed beaches.

Distribution and use—The following localities in Northern California contain beds large and well stocked enough to warrant more than casual digging. All were carefully inspected during good tides (W. F. T., 1910) except those in brackets, where the ground seemed favorable and local information reported the presence of the rock cockle.

Uhlrichs Ranch, near the Oregon Line.
Point St. George to Crescent City.
Nickel Creek (below Crescent City).
Damnation Creek, and between Damnation Creek and Wilsons Creek.
False Klamath Cove.
Patricks Point..
Trinidad, between one-half to one and one-fourth miles east.
Humboldt Bay.
Cape Fortunas.
Mussel Ranch (Cape Mendocino).
Morgans Point.
Shelter Cove, inside Point Delgada.
Abalone Point, near Westport.
Fort Bragg.
Bridgeport Landing, near Point Arena.
Irish Gulch.
Arena Cove.
[Iversons Landing].
[Haven's Neck].
Bowen's Landing.
Gualalla (or Walalla) Point, and Del Mar, two and one-half miles south.
[Russian River, both sides a mile distant, a few].

Stewards Point.
Bodega Bay, outside and along northeast side, sparingly.
[Duxberry Reef].
Scotty Creek, near Bodega, 3 miles north.
Between the Estero del Americano and Estero San Antonio.
Tomales Bay.
Point Reyes, inside southern point.

The distribution of *Paphia* is not, as may be seen from the above remarks, continuous along any portion of the coast, but the beds are of small extent and widely separated. It reaches its greatest abundance in bays such as Humboldt, Bodega and especially Tomales. On the outer coast it exists in very considerable numbers in the beach between Crescent City and Point George, more so toward the point. The remainder of the outer beds are of less importance. In Humboldt Bay the species approaches the Washington clam (*Saxidomus*) in possible commercial value and is found for the most part coextensive with it in South Humboldt Bay, but also to a lesser degree in North Humboldt Bay. Though used locally it was not found in the markets (F. W. W., 1919). In Bodega Bay it is dug along the northeastern side and is of sufficient importance to warrant digging commercially for shipment to San Francisco.

In Tomales Bay the rock cockle is found in the greatest abundance and here they are more important commercially than in any other bay on the California coast. The bay is long and narrow and the beaches, not of great width, are composed of boulders, gravel and sand and in some places mud, extending doubtless below low tide level. The clams are found on all these beaches which are gravelly or firm enough to offer suitable ground. On the northern side of the bay the best beds are between Marshals and the Arroya San Antonio, on the southern side they lie opposite these and for two miles towards the head of the bay from Inverness, although digging seems to be carried on elsewhere as well. There are also a few to be found just north of the entrance of the bay. The major part of the supply for the San Francisco market was drawn from Tomales Bay at the time of this survey (W. F. T., 1910; the same held true of the market in the fall of 1919. F. W. W.).

In California south of San Francisco *Paphia* is also a widely distributed reef and gravel bar species but is found in commercial quantities only at a few points. It was collected at the following points: about the Montara Light, in Elkhorn Slough (Monterey Bay), in numerous very limited beds between Monterey and Point Sur, between Piedras Blancas and San Simeon, between Cambria and Cayucos, the "Pecho" coast between Point Buchon and Point San Luis, along the southern end of the Point Sal reefs north of Casmalia, Purisima Point and on the numerous boulder and gravel bars along the entire mainland coast of the Santa Barbara Channel from Point Conception to middle Ventura County. They are present in the mud flats of Morro Bay, though apparently not abundant, and in El Estero near Carpinteria. At both Playa del Rey and Anaheim Slough they are dug for the market (1919, F. W. W.) as well as used by local residents and campers. The rock cockle was also found, though less abundantly, in False Bay and San Diego. In these southern points

it occurs, as previously stated, in company with the hard-shell cockle (*Chione*) with which it appears in the Los Angeles markets.

The methods used in collecting the clam are simple. On the beds in Humboldt Bay they are brought to the surface by the hooks that are used for the Washington clam, *Saxidomus*. Elsewhere they are dug with either spades, forks, hoes or short blades of steel, as happens to be convenient. In the beds open to the ocean the clams congregate in the small depressions or basins in the beds, seemingly because of the presence of water there during ebb tides. A skillful digger watches for such "pot-holes," and observes closely the presence of the material voided by the clam, which is usually to be seen wherever clams are present and sufficient time has elapsed since the disturbance of the water. In such places, a foot or two square, it is possible to collect as many as two dozen good sized clams, lying so close together that their valves touch. In the beds in the bays this distribution is perhaps not so obvious, but is still an aid to the digger. When not to be shipped immediately, the clams are frequently buried until wanted, under gravel in a place on which a slight amount of water stands but which is easily accessible, or they are placed in floating boxes.

The rock cockle is extensively used in Eureka, being preferred in some cases to any other species (W. F. T., 1910). At Crescent City the Indians occasionally peddle them, and the inhabitants and summer campers frequently gather messes for themselves. All the beds outside of Humboldt Bay are utilized in this fashion by occasional diggers, but at Bodega Bay they are dug for the market to some extent. As noted above, the greater part of the clams of this species in the San Francisco markets are gathered in Tomales Bay. In 1911, as many as fourteen people were employed there, some of them Indian squaws. From a bucket to a half sack was gathered by each during a good low tide, and traded for groceries at the local stores. From these the clams were shipped to market. About ninety sacks, averaging eighty pounds each, were shipped by express each month, a quantity which represented about 75 per cent of the clams taken from Tomales Bay.

The future of the beds is difficult to foresee. If, as seems probable, the species is found extensively below low tide line, the likelihood of exhaustion is lessened. On the outer coast it is unlikely that commercial digging will at any time be carried on in all the beds, and there are so many scattered individuals in small beds as to render their extinction difficult. The importance of these widely scattered small beds as centers of distribution of species is obvious. The temper of the inhabitants of every region is uniformly in favor of protection of the beds as a local attraction, especially those on the outer coast line.

The real danger of depletion is in the bays. Tomales Bay seemed, at the time of the investigation (W. F. T., 1910), to have been exploited to the fullest possible extent. The size of the clams found there was very small, the average length being but three-fifths that of the same species in Humboldt Bay, Bodega Bay and the outer coast line beds. Circumstantial reports as to the former large size of the clams were easily obtainable from storekeepers, diggers and local inhabitants. When an exceptionally low tide occurred, very large clams were to be

found at the lowest level reached, indicating that only where they were protected could they grow to full size. Furthermore, the size of the available clams grew steadily all through the season, according to almost universal testimony, and it is a well-known fact that this indicates the dependence of the fishery on the younger classes. If any large stock of clams persisted from year to year, the increase in growth on the average would not be so marked as to attract the attention of the diggers. The small size of the clam, then, would seem to be the result of intensive digging, rather than to be natural to the bay.

It is entirely improbable that a large industry could ever depend solely on the rock cockle, yet its beds will support a considerable trade in fresh clams; and will yield to the casual diggers on the outer coast, tourist or otherwise, a modicum of a very desirable food. It should add much to the attractiveness of the coast and to the sustenance of the scattered inhabitants.

TELLEN

Tellina bodegensis Hinds

Plate 11, figure 1

Description—This is a small species commonly but little exceeding two and a half inches in length. It may readily be recognized by its elongated flattened form and pure white shell, marked with very fine and regular growth lines. The siphonate end is bent to the right.

Habitat and habits—It is found on outer sandy beaches and is a strong, active clam.

Distribution—This species ranges throughout California but is nowhere abundant enough at present to be of commercial importance, though formerly it was found in the San Francisco markets. Shells were found on all the beaches of any extent between Morro Bay and middle Ventura County (C. H.), as well as along the outer beaches of the northern California coast (W. F. T.).

METIS

Metis alta Conrad

Plate 11, figure 2

Description—The shell of *Metis* is in general similar to some of its near relatives the Macomas, being thin, flat and unsymmetrical at the siphonate end. It may most easily be told from *Macoma secta*, the white sand clam, by the fact that the ligament, though external, is nearly concealed by the shell while in *Macoma* the ligament is very prominent in the profile view of the shell (see plate 12, figures 3 and 4).

Distribution and use—This species ranges from Santa Barbara southward. Shells were found at Playa del Rey, Long Beach and False Bay, but at no place, as far as observed, was it abundant enough to be used as food.

BENT-NOSED CLAM

Macoma nasuta Conrad

Plate 11, figure 3; plate 12, figures 1 and 2

Other name—Mud clam.

Description—The bent-nosed clam, to use the most distinctive common name of *Macoma nasuta*, is one of the smaller species, seldom exceeding two and a half inches in length and commonly much smaller. The general shape is oval, the siphonate end being, however, somewhat elongated and bent markedly to the right, a distinctive feature shared only by *Tellina bodegensis* among the common bivalves. The color is whitish though a variable amount of gray periostracum gives it a darker cast which is often accentuated by black or brownish stains from the mud in which the particular specimen may have been found. The valves are light and thin especially at the edges. The siphons are separate and very long.

Habitat and habits—This is the most common and widely distributed species in California. It is typically a form of the sheltered muddy bays and though it will invade sandy bottom to a certain extent, it is not found in gravel nor on exposed beaches. Practically every bay, lagoon or slough visited yielded the bent-nosed clam. It is a hardy species, flourishing under conditions speedily fatal to many other forms. This is particularly true of stale or brackish water which is encountered in small lagoons with little, or only intermittent, communication with the ocean, and its wide distribution undoubtedly depends on this hardiness.

The most favorable location is in fine mud little exposed to waves or current and it is regularly found in mud too soft for any other species. Here it lies at a depth of six or eight inches on the left side, the bend of the siphonate end thus corresponding to the habitual bend of the siphons when extended to the surface. The two siphons are of unequal length, the inhalent being much the longer and larger (see plate 11, figure 3.) Often in digging the siphons are severed and as they retain their power of motion for some time they resemble pale yellow worms in the mud.

Use—Though so generally abundant their use as food was not observed in any of the localities visited. In the "kitchen middins" of the Indians their shells are usually the most common of all species, showing them to have been a favorite form, perhaps because so easily obtained. They were formerly marketed in San Francisco by the Chinese. The following interesting account of the methods employed is taken from an article by the late John P. Fisher appearing in *California Fish and Game* for October, 1916 (p. 209):

"CLAMS IN SAN FRANCISCO BAY

"By JOHN P. FISHER.

"As a boy the writer lived on the shore of Islais Bay, an area of tidal flat on the western shore of San Francisco Bay at the mouth of Islais Creek.

"This tidal flat was in the neighborhood of a mile in length from north to south and at low tide about half a mile in width. The bottom was black mud of unknown depth, composed of alluvial washings from the old Spanish Potrero Nuevo, as carried down by Islais Creek.

"The shore line of this tidal flat was inhabited by a large number of Chinese engaged in the occupation of shrimp fishing and clam digging and it is with the clams dug by these Chinese that the writer would deal at this time.

"Up to 1876 but one species of clam was found in any quantity by these diggers and that was a white-shelled variety (*Macoma nasuta*), about two and one-half inches in greatest length. * * * Provided with a board 18 inches wide and four feet long with a strip one inch thick nailed across each end, the digger waded out on the mud flat at low tide, pushing a basket on this sled board ahead of him. On arriving at a suitable place, he pushed his hands and arms, held vertically in front of him, elbow deep into the soft mud and then turned up the mud toward himself; by straining this mud through his fingers he found the clams, which were placed in the basket. This was continued until the basket was full or the flood tide prevented further digging.

"Upon arriving at the camp with their catch of clams the diggers at once placed their catch in shallow water-tight boxes about 18 inches wide, 10 inches deep and 8 feet long, in one end of the bottom of which a hole was bored for draining purposes. A layer of clams 3 or 4 inches deep was placed in each box. The box was then partially filled with clean water from the bay and after 36 or 48 hours the clams were marketed, the water being changed each high tide. This clean water bath was intended to allow the clams to void all mud and sand contained in the stomach and render the clams edible.

"In 1876 the writer first noticed a few clams of another species (since identified as *Mya arenaria*). * * *"

Distribution—Found along the entire California coast.

WHITE SAND CLAM

Macoma secta Conrad

Plate 12, figures 3 and 4; plate 13, figure 1

Description—This form is distinctly larger, reaching as much as four inches in length. The valves are not obviously elongated at the siphonate end nor bent to one side as in the bent-nosed clam, but the two valves are different, the left being much flatter than the right. The valves are thin as in *Macoma nasuta*.

Habitat and habits—According to Thompson* in British Columbia it is found lying on its left side at a depth of a foot and a half in pure sand on the exposed portion of the larger flats. "The flesh of this species is very delicate, and when steamed is white and very little like a clam. The alimentary canal is invariably full of sand, however, and the utilization of this form awaits a method of ridding the animal of this." This could probably be done by holding for a time in tanks as described in the case of the bent-nosed clam.

Distribution and use—Living specimens were obtained only at Morro Bay, though the shells are common at many points and its range includes all of the California coast. As far as known it is not used at any point.

FLAT CLAM

Semele decisa Conrad

Plate 13, figure 2

Description—Though there are several species of this genus on the coast, only one, *Semele decisa,* reaches a size (two and a half to three inches) rendering it of use as food. The valves are nearly round in outline, firm and fairly heavy, little arched and different on the two sides at the siphonate end.

The ligament is fairly large and external, the cartilage larger and internal, being lodged in an oblique pit distinctly different from any other form here treated. The pallial sinus is large and rounded. Exteriorly the shell is roughened, giving a granular effect; it is faintly tinged with pink and shows more or less of a brown periostracum. Within, the valves are tinged with a faint purple particularly near the margins, making in all a very handsome shell.

Use—Its use was not observed, though in "Fisheries and Fishery Industries of the United States" (Washington, 1893, p. 708) it is listed as one of the Pacific coast edible species. It is not at present abundant enough to be of economic importance.

SUNSET SHELLS

Psammobia californica Conrad

Plate 14, figure 1

Psammobia edentula Gabb

These two species of *Psammobia* reach a size large enough to make possible their use as food, though neither are of importance in this regard.

Description—The valves are little arched and fit loosely together. The siphons are separate and very long and the pallial sinus is correspondingly large. The two species differ chiefly in size and shape.

*Report on the Clambeds of British Columbia. Report of the B. C. Commissioner of Fisheries, 1912, p. 41.

P. californica reaches a length of about three inches, it is oval, with the umbos nearly central; *P. edentula* is larger, measuring as much as five inches and is more elongated, being about twice as long as wide. This elongation comes chiefly on the siphonate end so that the umbos lie much nearer the opposite or anterior extremity.

Use—None were observed in any markets though it is not improbable that they are used to some extent locally.

Distribution—*P. californica* is found throughout the state, *P. edentula* from San Pedro southward.

PURPLE CLAM

Sanguinolaria nuttalli Conrad

Plate 14, figures 2 and 3

Description—This species is of fair size, some specimens reaching three and a half inches. The general appearance is similar to *Macoma secta*, the white sand clam, the valves being thin, especially at the edges, and the outline oval. As in *M. secta* the two valves are unlike, but in this case it is the right and not the left valve which is flattened. The siphonate end is not ridged as in *M. secta* but evenly rounded and bent slightly to the left. It differs most strikingly from all the Macomas in color, having a distinct purplish tinge within and without, though on the outer surface it is overlaid by a heavy varnish-like brown periostracum. The pallial sinus is very large and united with the pallial line; the siphons are separate and very long.

Habitat and habits—This form inhabits sheltered bays but unlike most of those already mentioned it is not found in mud or muddy sand but in sand or mixed gravel and sand. Here it burrows to the depth of a foot, where it lies on the right side with the flattened valve down and the convex valve up. Two long slender white siphons serve to furnish the clam its supply of water, and the pair of holes from one to three inches apart corresponding to these may readily be recognized on the surface. They are fairly active and an adult will bury itself if placed on watery sand. The sand from which they are dug is usually very soft from the presence of much water and they are most readily obtained by stirring the sand and gravel with short quick strokes of the shovel when they will float to the surface.

Use—The purple clam is ill adapted for shipping because of the thin shell, which is easily broken, particularly at the margin, allowing the water to escape. The valves are not held firmly closed as are those of the cockles. It was not seen in the markets but is used locally by tourists and campers, who esteem its fine flavor.

Distribution—A distinctly southern species, said by Dall to range from San Pedro to San Diego. A single shell was found at Playa del Rey; living specimens were taken at Anaheim Slough, Newport Bay and False Bay. The greater numbers were found at Anaheim Slough.

WEDGE SHELL

Donax californica Conrad

Plate 16, figure 1

Description—This species is of less importance than the following one and is described only to prevent confusion. It is a small form, but little exceeding half an inch, smooth and firm, with interlocking fine crenulations at the margin. It differs from *Donax laevigata*, which follows, chiefly in the nearly central position of the umbos.

Distribution—It ranges from San Pedro southward; specimens were obtained at Long Beach, Anaheim Slough, Newport Bay and False Bay. It seems to frequent more sheltered places than *D. laevigata*, being found near the entrance to bays and in similar locations not directly exposed to surf.

COMMON WEDGE SHELL

Donax laevigata Deshayes

Plate 16, figure 2

Other name—Bean clam.

Description—This is the smallest of the economic species, the largest specimen encountered measuring only an inch. The valves are heavy and strong, deeply arched and marked by indistinct radiating lines and concentric growth lines of varying degrees of distinctness. The form is strikingly different from any other species treated in the present paper in that the posterior or siphonate end is abruptly truncated or cut off, forming nearly a right angle at the umbos which thus come to lie near the siphonate end of the shell instead of centrally as in *D. californica*. The margins of the valves are heavily crenulated and these roughnesses interlock in the closed shell. The color varies from white to blue and purple being often conspicuously striped.

Habitat and habits—This species is, like the Pismo clam, found on exposed sandy beaches though it appears at times to prefer some slight degree of protection such as that afforded by a position near the entrance to a bay or behind a sand bar. Here they are found from mid-tide down to low water at the surface or only slightly buried. The siphons are separate and short, but little exceeding the width of the shell, and in consequence they can not feed at any great depth. Often on the exposed sand it will be found with the blunt siphonate end projecting nearly half the length of the shell above the surface. In many of the specimens the siphonate end is provided with a wisp of what appears to the clam diggers as "whiskers." These are in reality a group of small plant-like colonial animals called hydroids which have here found attachment as they might upon a rock and are not part of the clam. From a tabulation of the position of a large number of these clams is was found that the majority were placed "broadside" to the sea with the hinge directed either up or down the coast. Whether this plays some part in food getting or is of mechanical advantage in keeping the position in the surf could not be determined. Where present they are usually very abundant so that they may be sifted

from the sand in great numbers and after storms they are said to form windrows on the beach. They are apparently much less abundant than formerly, though at all times the numbers have varied from year to year.

Use—Though so small the wedge shell was formerly abundant enough to be used extensively for food, being sifted from the sand or scraped up from the windrows after heavy surf and sold in Long Beach and other southern towns. They were washed free of sand and used entire in the making of soup; the flavor is said to be excellent. The following extract * is of interest in this connection:

"Long Beach and Wilmington are connected by several miles of hard sand beach. At low tide the beach at many places is strewn with a small mollusk, the *Donax californicus* [apparently *Donax laevigata*], locally known as the small clam. The shells, which are prettily colored, average three-fourths of an inch in length. During 1895, favorable experiments having been made to utilize these clams for their liquor, a company was formed under the name of Pacific Coast Extract Company, and the business of putting up clam extract was begun. The extract is packed in glass and stone pint and quart packages and gallon jugs. The extract has met with a flattering reception, and encouraged the company to enlarge the business. The clams are gathered at low tide by boys, who use a small hand wagon holding but a few bushels. Clams and sand are shoveled into the wagon and covered with a wire screen. The wagon is then run into the surf, which washes out the sand, and the clams are sacked and sent to the factory. They weigh about 100 pounds to a bushel, which produces 1 gallon of extract. The shells are cracked and sold to poultry dealers. These shellfish are so plentiful that the same ground is worked over day after day; if the beach is gleaned one tide, the next leaves a fresh supply. The *Donax californicus* is found between Santa Barbara and San Diego, but not on the Atlantic coast."

No use was being made of them during the time of the present investigation (1919).

Distribution—It is said by Dall to range from Santa Barbara to Acapulco, Mexico. A living specimen was obtained much farther north at Oceano but they were not common. They were more abundant at Long Beach, near the mouth of Anaheim Slough and near False Bay.

JACKKNIFE CLAM

Tagelus californianus Conrad

Plate 15, figure 1

Other name—Incorrectly called razor clam.

Description—This and the two species of *Solen*, about to be described, are similar in general appearance, being very elongated and roughly cylindrical. *Tagelus* is the largest, reaching a length of from three to four inches. The valves are three or more times as long as wide, deeply arched so that the two together are almost cylindrical and of

*United States Commission of Fish and Fisheries. Commissioner's Report of 1896, Washington, D. C., 1898, p. 646.

nearly the same size throughout their length, a peculiarity which bears directly upon its habits. The umbos are central in position, the siphons separate and long.

Habitat and habits—*Tagelus* is a form inhabiting quiet bays, where it is found in mud or muddy sand. Unlike most clams it digs a smooth lined permanent burrow which its elongated cylindrical shell fits snugly and in which it moves readily up and down. A good idea of the burrow may be gained from figure 22. It extends vertically downward some 15 or 16 inches, thus reaching loose watery mud or sand. When at the top of the burrow the jackknife clam is about its own length from the surface, and the siphons reach the overlying water through two small holes ending an inch and a half or two inches

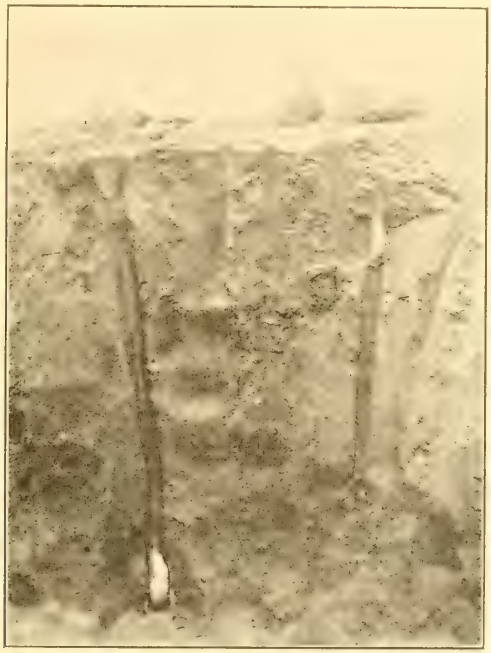


FIG. 22. The jackknife clam (*Tagelus*). The one on the right is at the top of the burrow, that on the left at the bottom. Note the two separate siphon holes at the top of the left burrow.

apart. If disturbed the clam pulls in its siphons and by means of its powerful foot rapidly retreats to the bottom of its burrow. If still followed it will commence to dig into the softer underlying mud or sand, though here its progress is not so rapid.

Use—The jackknife clam is said to have a fair flavor and is in many places very abundant, so that it may be considered a potentially valuable species. Its use as food, however, was not observed in any of the localities visited. At False Bay it was sold locally for bait by small boys who collected them in an ingenious fashion. A stout wire about the size of a pencil armed with an arrowhead made from an old file was thrust down the burrow as located by the siphon holes and

through or past the clam. It was then turned part way about so as to catch the shell on the barb and the unlucky clam drawn up from its burrow.

Distribution—*Tagelus* is a southern form ranging from Santa Barbara south. It was obtained at Santa Barbara (C. L. H.), Playa del Rey, Anaheim Slough, Newport Bay, False Bay and San Diego Bay.

Solen sicarius Gould

Plate 15, figure 2

Other name—Jackknife clam.

Description—*Solen sicarius* is similar to *Tagelus* in general appearance but differs strikingly in the position of the umbos, which are located at the extreme anterior end, an arrangement so characteristic as to identify this genus at once. It is not as large as *Tagelus* and the valves are slightly bent instead of being straight. The periostracum is glossy and gives to the shell a yellow color. The siphons are united and of moderate length.

Habitat and habits—*Solen sicarius* is a species of sheltered bays, where it is said to form burrows somewhat similar to *Tagelus*.

Use and distribution—This species was nowhere found in abundance and though edible can not be considered as of economic importance. It and the preceding species are sometimes confused with the true razor clam; when razor clams are reported from sheltered bays which they never inhabit it is safe to assume that *Solen* or *Tagelus* were the forms dug. Its range includes all of California and extends north into British Columbia.

Solen rosaceus Carpenter

Plate 15, figure 3

Description—This species is somewhat smaller than *S. sicarius*, reaching two to two and one-half inches and differs from it in having a straight shell slightly tinged with pink.

Habitat and habits—This form is found in the mud of enclosed bays. It is interesting as being capable of a kind of "swimming" though habitually found in burrows.

Use—It is of no economic importance and is treated merely because it is likely to be confused with related forms.

Distribution—*Solen rosaceus* is said to range from Santa Barbara south but was encountered only at San Diego.

RAZOR CLAMS

Siliqua lucida Conrad

Siliqua patula Dixon

Plate 15, figure 4

Other names—Razor shell; sea clam.

It is at present canned in Alaska and Washington and sold under the name sea clam though this term was not heard on the California coast.

This important form is represented by two closely related species in California, *Siliqua lucida,* ranging from Monterey south, and *Siliqua patula,* found from Monterey to Alaska. As there are no important differences one description will do for both.

Description—The razor clam reaches a length of from four to six inches but does not have the bulk of some other species because of its slender form. It is markedly elongated though not to the extent found in *Solen* and *Tagelus,* the valves are little arched and very thin and delicate; the periostracum is glossy and varnish-like in appearance. The foot is large and powerful, the siphons rather short and united except at the tip.

Habitat and habits—The razor clam is found in the same locations as is the Pismo clam, the pure sand beaches fully exposed to the ocean and by preference those that are broad and level. Though exposed to the same surf its valves are not massive as are those of the Pismo clam, but the most fragile of all the larger clams. This apparent contradiction finds its explanation in the surprising activity of this clam; its shell is specialized not for strength but for rapid progress through the sand where the heavy and bulky shell would be a hindrance. The method of burrowing, though not different in principle from that of other clams, is so highly developed that an account of it may be given. Some idea of their agility may be gained from the statement that small razor clams placed on wet sand have completely buried themselves by eight or ten movements of the foot in a period as short as seven seconds. That the reaction of digging is a deep-seated and fundamental one is shown by the fact that when a small specimen is cut in two by the shovel the foot-bearing end will in some cases bury itself almost if not quite as promptly as the uninjured animal. When first thrown out on the sand the burrowing movements of the foot may readily be seen though they are so rapid that it is hard to make out all the details. The foot is first extended by a series of movements until it projects half the length of the shell. This extension is accomplished by forcing blood into cavities in the foot, thus dilating it. As it is being extended the tip of the foot has a pointed shape; in this way it penetrates the sand readily. Having reached its full extent the tip continues to swell up until its cross section is greater than that of the shell. This crowds against the surrounding sand and when the muscles of the foot cantract, pulling the tip nearer the body, the shell moves more readily through the sand than does the foot and hence is drawn after it. Repeated in rapid succession this serves to take the animal out of harm's way. In fact, if the first spade thrust does not cut off the razor clam's retreat and turn it out on the sand it is almost hopeless to follow it. At times the young, at least, move horizontally just below the surface of the sand, burrowing along in the manner just described with the hinge uppermost and leaving a furrow in the sand often a foot in length. How extensively and for what purpose they thus move about is not known.

During its presence at the surface of the sand, the animal holds a vertical position, with the siphons projecting into the water or air above, and the valves usually oriented in a definite manner with relation to the water which flows over it, namely with the hinge toward

the open ocean (see pages 31 and 47). The certainty with which its vertical position is assumed evidences the acuteness of its balancing organs. When alarmed, as it easily is by a footstep or tap of a spade in its neighborhood, it digs rapidly downward with its large foot, and unless pursued, comes to rest a short distance below the surface but resumes its motion on being again alarmed. The method of capture illustrates the acute sensitiveness. It is necessary either to discover the clam while its siphons project and to dig it very quickly, or to tap the surface over it with a spade, when it will betray its presence by moving downward and causing a slight pit to appear in the sand over it. Usually two diggers work together, one carrying the sack into which he puts the clams, the other devoting his time entirely to digging.

The clam is able to withstand but little exposure to the air, despite the fact that it will project its siphon from the sand. It requires ground in which the water is retained to a great degree during ebb tides, not merely in order to live, but in order to move with facility. The sensitiveness of the animal probably is of great use to it in serving to warn it of heavy wave action, and its great activity enables it to escape the injurious effect of shifting sand. Thus it is fitted for life on the outer beaches, which must, however, be of pure sand, without pebbles or rocks which would break its shell, or hinder its motion, and deep enough to allow it some scope in its movements, while at the same time level enough to retain a substratum of water. It is not to be found in enclosed waters where the bottom is muddy and tenacious, nor in the slightly brackish water which is so often an accompaniment of such a bottom. Whether it is present in any number in sand banks below low tide level is a moot question, although such a state of affairs is indicated by the presence of shells on the beaches where no clams are to be caught. With these conditions in mind, it should not be hard to understand the peculiarly localized distribution of the species.

Distribution—*Northern California*: As stated, the form found north of Monterey is *Siliqua patula*.

In accordance with the character of the coast, there are found but three beds of these clams in northern California. The most northerly of these is just above Point St. George, near Crescent City, and extends from the Point proper to near the spit opposite Lake Earl. The clams are more abundant here than in any other locality. The sandy beach south of Crescent City is said to have been at one time abundantly stocked for a distance of about four miles, but it was found to be nearly bare of them; only with great difficulty were specimens obtained. The best known bed, however, is at Little River, but it is subject to a most energetic fishery by the inhabitants of the surrounding country, and hence is less abundantly stocked than the beach near Point St. George. The Little River beach appeared ideal for them, and local report had it that formerly the clams were very abundant. At the time they were examined (1910, W. F. T.) they were to be found from the mouth of Little River a distance of a mile and a half south, becoming progressively less numerous. Elsewhere along the coast cast up shells were to be picked up everywhere, especially along the beaches near Klamath River, Eel River, and the

Humboldt Bay spits, and on those of Ten Mile River, near Fort Bragg. Nevertheless, live clams could not be found above low tide line despite earnest search.

Southern California: The razor clam to be found to the southward of Monterey Bay belongs to a different species, *Siliqua lucida*, although its habits and general appearance are the same. No distinction is usually made.

It is a common form on the wide sand beaches of the outer coast. It is especially abundant on the fine beach off Morro Bay, where numbers are destroyed by the smashing of their fragile shells with the fork used by the clam diggers in probing for Pismo clams. The species is not at present very abundant at Pismo Beach near Oceano and Pismo, but is reported by clam diggers to have been much more common before the oil became a serious nuisance a few years ago. The most reliable of the statements to this effect was given by Mr. J. A. Beckett of Oceano (C. L. H.). When visited in 1919 small razor clams were common but the large ones were not abundant enough to be dug by the clammers. On one occasion, a number of the young were found killed by oil (F. W. W.). These clams are apparently rare on the short beaches at Point Sal Landing, in the shifting sand of the beach between the reefs of Point Sal and those of Point Purisima and between the reefs of Point Purisima and Point Arguello. None were obtained alive by digging at any of the above localities, but their occurrence, even off these beaches, most probably below low tide limits, is indicated by the fact that shells are washed up on the beaches. That they actually do occur well offshore is indicated by the fact that one was found among the stomach contents of a number of rock cods (*Sebastodes auriculatus*) which had been caught in about ten fathoms of water off Pismo Beach (C. L. H.). These clams are used only to a small extent locally.

Use—The razor clam enjoys a well-deserved reputation as a delicacy, being considered by many as the best of our edible clams. The meat is fine grained, white and of excellent flavor, and because of the thinness of the shells the waste is less than in any other economic species. It is ill adapted, however, for shipment, as even the most careful handling is sure to shatter the fragile shells and even unbroken shells close so incompletely that the moisture is not retained. In Alaska, Washington and Oregon, where they are more abundant, this fact has led to the canning of the razor clam near the beds, and at the present time it is one of the most common canned clams on the market. As already pointed out the beds in California are not extensive enough to support commercial exploitation. In the case of a cannery which was once established at Little River, such a protest was raised by the local inhabitants as to result in the passage of a law making it "unlawful to preserve in cans or other receptacles or to ship out of said county for commercial purposes, clams of any kind or character, produced or taken from any ground, waters or territory within the limits of the county of Humboldt." Undoubtedly there is no clam in California so highly valued by the local residents, and the beaches containing them are great local attractions which will be jealously guarded. This is undoubtedly as it should be, for the small

extent of the beds renders it entirely probable that even use by campers and tourists in addition to the local population will be sufficient to threaten their existence. The testimony everywhere was of depletion.

There appear to be few beaches favorable for the transplanting of this clam. The sandy beaches south of Humboldt Bay are too high and well drained, with too small an area. The same is true of most of the beaches in northern California. Small beaches alternating with rocky shores are usually not suitable because of the small depth of the sand, and the frequent presence of rocks.

In conclusion we may say that this fine clam is not abundant enough to support commercial digging; in northern California it will supply a limited local demand, south of San Francisco its possibilities and present use are still more limited.

DISH SHELL

Spisula sp.

At least two southern species of the genus *Spisula, S. catilliformis,* the dish-shell, and *S. hemphilli,* reach lengths of five or six inches and would be of economic importance if abundant enough. They have valves which are thin, particularly at the edges, the brownish periostracum is conspicuous and the ligament is internal. Their use has not been observed.

GAPER

Schizothaerus nuttalli Conrad

Plate 16, figure 3

Other names—Summer clam; horse clam; otter shell.

This species is known under a variety of names. The one here used refers to the gaping of the shell at the siphonate end; the term summer clam is due to the belief of the Indians that they are best during the summer months. It is occasionally confused with the geoduck.

Description—This is the largest clam in California waters with the exception of the real geoduck, which is nowhere abundant. The shell reaches a length of from six to eight inches and the clam may weigh as much as four pounds. The shell is thin and easily broken and incapable of closing completely enough to retain the moisture inside the valves. The great siphons can not be retracted entirely into the shells because of their length and size; their heavy epidermis affords them the protection which the shell fails to give. The foot is small and apparently of slight use to the adult. The shell may readily be recognized by its large size, gaping siphonate end, deep pallial sinus and internal ligament.

Habitat and habits—As might be inferred from its structure the clam is found deeply buried, lying from a foot and a half to three feet deep, depending upon the nature of the bottom, and usually in such localities that it is seldom left exposed at mid-tide. It is thus well out of harm's way while ample communication with the surface is

maintained by the huge siphons. Though the clam itself is usually imbedded in fairly permanent ground the siphons, perhaps because of their size and strength, are much less sensitive than those of most other species to drifting mud or sand and often the newly extended siphon will carry on its tip a plug of sand that it has forced out of the burrow. The siphon is closed at the will of the clam by two valves of horny epidermis, which serve as protection against marauders inanimate and animate. This special protection is not found on any other species here treated. The siphons still remain the most vulnerable part and are apparently eaten by fish that are quite unable to dig up the entire clam. Thompson reports* that siphon tips are common in the stomachs of the halibut and has informed the writer that these were chiefly from the gaper, as shown by the presence of the characteristic hard plates. Buried at such a depth, it would be hard to discover them unless they betrayed themselves, which they do by their habit of squirting out periodically a strong jet of water two or three feet into the air, especially, however, when alarmed. A bed of such clams may always be distinguished by this peculiar habit, or rather by the marked development of this habit, which is more or less widely spread among clams.

They are found both in the protected waters of bays and river mouths and along the rocky beaches of the outer coasts. Their large siphons and the depth at which they live seem to fit them to survive wherever they are able to find a firm and stable beach, whether it is rocky or not, but they are also able to dwell in the mud or firmer sand where they may remain more continuously in the water than *Mya*, the soft-shell. So they are to be sought along the edges of channels near low tide line, and also on the more exposed beaches where the shore line is firm and permanent enough. They do not seem to be able to withstand the low salinity which *Mya* is able to endure, however, and hence seem to be found near the entrances of bays or the mouths of channels.

Distribution—Although widely distributed it is particularly abundant at certain points, among which may be mentioned Uhlrich's (a ranch near the California-Oregon boundary), Crescent City, Wilsons Creek, Patricks Point, Trinidad, Humboldt Bay, Bodega Bay, Tomales Bay, Drakes Estero, Bolinas Bay, Elkhorn Slough (Monterey Bay), Morro Bay, Anaheim Slough, False Bay.

In North Humboldt Bay this clam is distributed over almost the whole available area save the most northerly part, in which *Mya* is abundant. It is found more especially on the central tidal flats, nearer the entrance than *Mya*. In South Humboldt Bay it occupies about the same relative position, not being found in the extreme southern end. The narrow central channels are of course in great part bare. None were found in the Eel River sloughs. In Bodega Bay the area of the beds is small, including only the central tide lands near the channels. There are a few beds on the outer coast between Bodega and Tomales bays. In Tomales Bay the principal beds lie between Sand Point and Toms Point, although they are found generally with the rock cockle, *Paphia staminea*. In Bolinas Bay they are not numerous. In Drakes Estero there was a small bed inside the eastern

*A Preliminary Report on the Life-History of the Halibut. Report of the British Columbia Commissioner of Fisheries, 1914, p. N 94.

spit. In Elkhorn Slough (Monterey Bay) there are beds of considerable extent on the east side not far from the mouth, which are worked by local diggers. At Morro Bay the gaper is common, one of the largest beds lying at the northern end of the bay opposite Morro Rock and not far from the entrance.

On the outer coast this species exists at numerous places, and its range and habitat is probably coextensive with that of *Paphia staminea*. Crescent City, Wilsons Point, Patricks Point, etc., are only representative localities. On the exposed coasts they are not to be found in the great abundance which characterizes their beds in some of the bays. The size is also small and the shell often worn from contact with rocks.

Use—The flesh of the gaper is not as highly prized as that of some of the other species of clams and for this reason is not so extensively used. The Indians formerly dried the siphons for food, saving them for winter use, when they are soaked over night and boiled. They are supposed to be at their best during the "black water" of July, August and September, and from this belief comes the popular name summer clam. In Morro Bay the siphons are also used although the bodies are neglected. The process of preparing them is said to have been introduced by the Japanese. The "necks" are cut off as far down as convenient and prepared by "skinning," quartering and frying, and are said to make a very tasty dish. It is locally reported that no apparent injury to the clam results from the loss of the siphons but this seems improbable and should be checked by direct observation (C. L. H.).

The poor repute of this clam seems to the writer to be unjustified. The meat is very sweet and of excellent quality and though the siphons are tough and require special treatment as suggested in hints on the use of clams (page 68) no part need be rejected. They are not likely to prove of great commercial value as the shells are easily broken and do not hold water well, making shipments of any distance impossible. Its use must therefore remain local, being confined to campers and residents.

SOFT-SHELL

Mya arenaria Linnaeus

Plate 17, figures 2 and 3

Other names—Soft clam; long clam; mud clam.

As far as it is possible to ascertain, *Mya arenaria* was introduced into our waters nearly half a century ago. It was first noted in San Francisco Bay, to which spat of the Eastern oyster had been transplanted, and it is very probable that it was brought in with shipments of that species. It appeared in Willapa Bay, Washington, about 1880, and since then has made itself at home in all suitable localities from the Gulf of Georgia in British Columbia, to San Francisco. As it lives inside the Artic Circle on the Atlantic side of our continent and in Europe, it may be expected to spread much farther to the north than is at present the case. The Indians of northern California have no name for it in their own languages, and one of the chiefs of the Indians in the vicinity of Eureka informed Mr. Thompson that the clam was

brought in by the white men, the Indians adopting the latter's name for it at the time. An old clam digger in Humboldt Bay, who had lived there since before 1868, could not remember having seen them until some years later than the time of the supposed introduction into San Francisco Bay.

Description—The soft-shell clam may reach a length over five inches though the majority are smaller. The shell is light and brittle, oval in general outline, with the siphonate end more pointed than the anterior. The color is commonly whitish, tinged gray by the thin periostracum, though it may be nearly black or rusty red from staining. The cartilage is internal and the cartilage pits are very unequal, that on the left being located on a conspicuous projecting tooth (see plate 17, figure 2). As this arrangement is found in no other clam except *Platyodon* it will usually serve to identify this species.

Habitat and habits—*Mya arenaria* is not found in beaches open to the sea. As an individual increases in age, it loses its ability to move with celerity and hence to care for itself when exposed. As a consequence storms which shift and overturn the beaches are fatal to the larger clams. Neither is it capable of renewing its communication with the surface of the ground when its siphon hole is choked by shifting sand or gravel, and it is dependent for its food on the minute particles brought in with the water through its siphons. The localities in which it is found are, therefore, those well protected and with a somewhat firm, or tenacious soil, in which a hole is semipermanent. As is the case with other clams, the water from which it strains its food must not be stagnant, but moving and full of minute life. Further than that it is not particular, for the water may be brackish or slightly salty, and the temperature may fall below the freezing point, yet be suitable if it yields food. Bearing these things in mind, the distribution should be easy to understand.

Distribution—The species is found in all the favorable estuaries, bays, river mouths and closed lagoons north of San Francisco on our coasts. Outside of San Francisco Bay the ground occupied is small in area, in comparison with the great extent of coast line. There are no great flats similar to those of the Atlantic coast, no great bays with extensive tidal areas. Just as the continental shelf is narrow and steep, so is the shore line narrow and open. Beds are found in the following localities: Lake Earl, Humboldt Bay, Big and Stone lagoons, in the mouths of the Eel, Big, and Navarro rivers, in the mouth of Ten Mile Creek, in Bodega Bay and Drakes Estero.

1. Lake Earl. The large closed lake north of Crescent City called Lake Earl has been said by a number of the local inhabitants to possess "razor clams." It is occasionally opened by the breaking through of the sand spit separating it from the ocean. When this occurs clams are said to exist on a limited portion of the shore. That this is *Mya* admits of no doubt, because of the presence of shells on the shore line, and from the nature of other closed lagoons on the coast. The bed is of course of no importance at present, as it is not subject to tidal flow, and the clams are small. If in time the lake is opened artificially, the beds will prove of some value to local users. The beds lie between Lake Earl and Lake Talawa.

2. Humboldt Bay. As may be seen by reference to the map, the bay is formed of two portions, called locally North Bay and South Bay. The northern part of the bay was at one time supplied with fresh water from Mad River, but the channel has since shifted and its mouth is now merely a slough. The bay is for the most part very shallow and at low tide the greater portion of the bottom is exposed save in the winding channels. These extend to the mouth of Mad River on the north

and to the extremity of the bay on the south. The great amount of area drained at each low tide produces results of great importance to edible shellfish, namely a great variation in temperature, very swift currents in portions, and a high salinity. The currents probably result in the destruction of a great amount of spawn, as a great deal must be washed out to sea. This may in part explain the distribution of the softshell clam. The currents in the long central part of the bay, and the narrow beaches left by them, prevent the formation of any extensive clam beds, so that there are only two parts of the bay of importance from our standpoint, namely, the two broad extremities. The bottom is a fine deep sticky mud, finest at the extremity of the bays, where deposition has at one time taken place and has not been subsequently eroded. The bay side of the spits are of a sandy character owing apparently to the carrying over of sand by the wind.

The distribution of the clams seems to differ in the two ends of the bay, due to the differences in depth, supply of fresh water, and manner of drainage. No important beds of clams are to be found in North Bay save the extensive ones of *Mya arenaria* along its northern shore. The extensive beds of clams in South Bay lie, in a fashion contrary to that of the clams in North Bay, along the edges of the tidal flats nearest the entrance, but this may be explained by the fact that the species are different and require different beds. Back of these beds on the margin of the flats in South Bay are found areas which may once have been occupied by the native species of clams now found only along the edges, as may be seen by the presence of great numbers of empty shells buried in natural positions. Far back, along the shore itself are found areas sparsely inhabited by living *Mya*. There is no apparent reason why the extensive intermediate flats now vacant could not be made use of for the growth of young transplanted *Mya* if such should be found profitable.

The beds of *Mya arenaria* in Humboldt Bay are the most important ones in the northern portion of California, the clams being dug extensively for the market. The bed used is that extending from the Mad River sloughs to the far eastern part of the bay. In no place are they in real abundance, as in San Francisco Bay, but they are scattered, sparsely in general, save along the slough-like channels. In ordinary tides, a stretch of beach about 500 yards wide and two or two and a half miles long is exposed. At the best a bucket full of clams may be dug within two square yards. The local diggers state that at one time the Mad River sloughs had an abundance of clams but they are not now of commercial importance. They were probably affected by the closure of the river. Along the flats forming the eastern side of the bay, between Indian Island and the Arcata shore, occasional *Mya* are found, but no beds which are used commercially. In South Humboldt Bay there are a few scattered along the shore line away from the channels, and a few in the shallower sloughs, but not enough to be considered of importance. Although it must be concluded that the supply of clams in Humboldt Bay is not extensive enough to yield a great supply, yet they are of good quality and capable of supplying enough clams for two or three diggers.

3. Big and Stone lagoons. Small areas populated by *Mya* exist in Big and Stone lagoons. No traces were found of clams in Freshwater Lagoon, nor of anyone who could vouch for their presence. These lagoons are somewhat of the type of Lake Earl, closed by a sandbar, with brackish water, and opened annually to the ocean by the winter rains. At the time they were visited, the difference in salinity between their waters and those of the ocean was very marked, the spits not being open. The shells of *Mya* found were of very small size.

4. Eel River. The sloughs of Eel River may be considered as providing a small supply of clams to augment that for the markets of Eureka. They are fairly accessible, but are not very abundant save in small areas. The beds lie along the narrow tidal slopes of the sloughs extending into the northern and southern extremities of the main slough (McNulties). Of these, Hawk and Seven Mile sloughs are the best. Along Eel River proper the beds are absent, because of the swift currents of fresh water. The shifting of the entrance to the river, which was at one time farther north than at present, has resulted in the formation of these sloughs. The sandy spit is easily shifted, and on digging into the beaches successive layers of mud and sand may be found, showing that previous shifts in the river have had extensive effects on the character of the beds. However, there is a moderate supply of *Mya* here, available if properly cared for, and capable of being increased to a considerable extent by culture. The diking off of the slough ends has resulted in the loss of some of the available area.

5. Mouth of Ten Mile River. There is found here a small bed of *Mya*, not of commercial importance. The available area is small, but the clams are occasionally dug by the local inhabitants.

6. Navarro River. A supply somewhat similar to that of Ten Mile River is found.

7. Big River. A number of beds are found in the bends of the river, where mud flats have been deposited, between a half to three miles from the mouth. They are much gathered for local use, but are not sold in the markets. The Chinese use

them constantly, and peddle them whenever possible, according to local report. It is said that two men can fill a sack during one low tide. The current of the river is slight, and the tides run far back.

8. Russian River. A bed is said to have at one time existed at the mouth, but to have been destroyed by the coming down of sand. The bed could not have been of large size, or of much importance.

9. Bodega Bay. The commercial production is small in comparison with the size of the bay. The beds lie on the eastern side, along the shore, and along the northern half of the west side. They are abundant enough to pay for digging, as in Humboldt Bay, and occasionally a digger comes from Tomales Bay or the local residents get them. The flats are very extensive in proportion to the size of the bay, but *Mya* inhabits for the most part the regions nearer the shore. The region is more important than the Eel River sloughs, although the clams are sparsely distributed.

10. Estero del Americano. Small beds are present, but the clams are not abundant enough to be of importance.

11. Tomales Bay. Beds of *Mya* exist near the head of the bay, behind a railroad embankment there and in the open bay, also near Milleton, Prestens Point, Toms Point, and toward Smiths Landing, all localities on the northeastern side of the bay. They are of some importance commercially, but are not extensive. Two clam diggers were working in the bay during 1912, and had nearly "cleaned out" the beds near the head of the bay in a short time, according to their statements.

12. Drakes Estero. As may be seen from the Coast and Geodetic Survey maps, the area available is not extensive. No commercial digging had been done at the time of their examination because of the ownership of the surrounding country by a single estate. The beds are not thickly populated, but might be improved by culture. Abbotts Lagoon on the north side of Point Reyes contains a small *Mya* bed.

It will be seen from the foregoing summary that the available area for the growth of *Mya arenaria* on our northern coast line is not great. Indeed, it is very doubtful whether it is capable of meeting more than local demands of a size such as exists, or may exist within a very few years. There were found in 1912 and 1913 but a total of nine or ten men who made any thoroughgoing attempt at commercial digging, and these men were perhaps too many to have made their

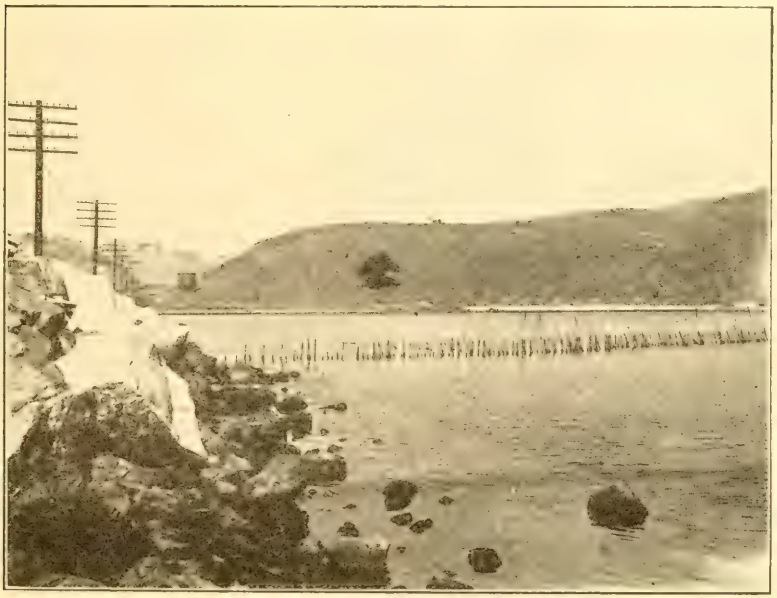


FIG. 23. Soft-shell clam "farm" just south of Bayshore, San Francisco Bay. The fence of stakes is to keep out the skates and encloses about six acres of mud flats.

living wholly from the beds even if the demand had afforded them the opportunity. There was no definite plan of culture or protection of the beds, as there is in San Francisco Bay and the only place in which there seemed a prospect of such was in Humboldt Bay and Tomales Bay. Conditions in this regard may have changed in recent years.

In conclusion it may be stated with some assurance, that the available resources of soft-shell clams in northern California are not great enough to bear much development in a commercial way, but are of considerable value to local inhabitants.

San Francisco Bay: In San Francisco Bay the soft-shell clam has almost completely displaced all of the native species and at the present time (1919) is the only form marketed. Though widely distributed, it suffers greatly from the attacks of fish, according to the clam diggers, skates (''stingarees'') and sharks. Though this was not directly observed, clam siphons were found in the stomachs of some California halibut by Mr. N. B. Scofield. The skates, which are apparently the chief offenders, are considered by the fishermen to be much more numerous than in former years and are said to make their appearance about April first and to stay until the rains begin in the fall. In order to have profitable digging it is necessary to fence against the skates; such a fenced ''farm'' may be seen in figure 23. Outside the fences only the young of the year are to be found, according to the diggers. Within the fences the soft-shell grows to a good size and is quite numerous, the only other species noticed in the digging being a few small bent-nosed clams.

Fig. 24. Digging soft-shell clams, Pinole, San Francisco Bay. Chinese digger with baskets.

In October, 1919, the main ''farms'' were at Bay Shore, where two men were employed, and at Pinole, where five Chinamen were digging (see figures 24, 25 and 26). The yield of clams was very good; according to one digger from 60 to 100 pounds of clams could be dug at one tide and at times both low waters in the day were utilized.

Cultivation—The hardiness and adaptability of this species and the results obtainable from mere fencing indicate that systematic ''farming'' such as has been practiced in some localities on the Eastern coast would be a very profitable enterprise and would make productive

acres of otherwise useless tide flats. Humboldt, Tomales, San Francisco, Morro and False bays are the chief bodies of water with extensive enough flats to permit of such an industry; the two northern bays are already stocked while Morro Bay though planted* shows little result and as far as known False Bay is entirely without *Mya*. *Mya* is characteristically a northern species but since on the Atlantic coast it extends as far south as Cape Hatteras, where the maximum ocean temperature is about 10° higher than at San Diego, there seems to be no reason why it should not thrive at any point on the California coast.

FIG. 25. Digging soft-shell clams at Pinole, San Francisco Bay. Chinese diggers at work on flat.

The stocking of properly fenced farms in these localities with small soft-shells would not be difficult and might prove to be a distinct addition to the resources of California. This species is without doubt the one best fitted for artificial propagation and fostering; most of the native commercial species may be protected but few may be extended or materially increased.

Use—The use of *Mya* is, next to the oyster, probably the most extensive of any shellfish on the Atlantic coast. In California the amount of *Mya* marketed is exceeded only by the Pismo clam and it is doubtless destined in time to surpass the latter. *Mya* is highly esteemed as a table mollusk, being suitable for preparation in many ways.

*In November, 1916, Dr. Heath planted 1800 individuals of *Mya* in Morro Bay. None have been found since and it is feared that they may have been eaten by skates.

PLATYODON

Platyodon cancellatus Conrad

Plate 17, figure 1

Description—This small species, reaching from two to two and a half inches in length, has received no distinctive common name. The valves are thin and fragile, expanded and enlarged at the anterior end and gaping conspicuously at the opposite extremity for the accommodation of the siphon. The surface is marked with fine regular lines of growth and overlaid with brownish gray periostracum. The cartilage pits are as in *Mya*, the left on a projecting spoon-like tooth; the siphons are united and of moderate length.

Habitat and habits—This species is related to the borers and its habits are in some degree intermediate between those of the mud-

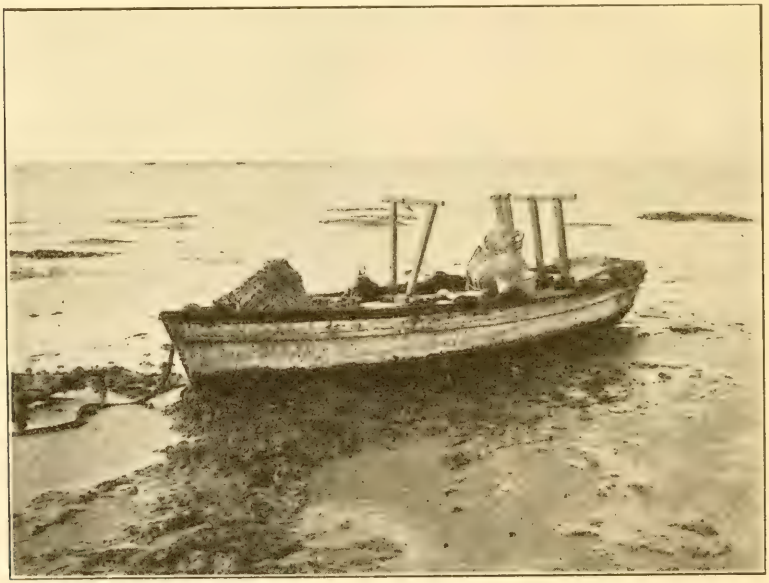


FIG. 26. Soft-shell clam "farm" at Pinole, San Francisco Bay. Boat of Chinese diggers with baskets and "mud sleds" for moving clams. The fence may be seen in the distance.

dwelling sedentary forms like the gaper (*Schizothaerus*) and *Mya* and the forms inhabiting rock. Those collected have been from bays, often near the entrance where the current is brisk, in hard stiff mud or clay, never in shifting mud or sand.

Use—Though reported to have been marketed at times, their use was not observed and no extensive beds were seen that would render them of probable commercial value, though their local use is quite possible.

Distribution—It is stated by Dall to be found from Bolinas Bay to San Diego. Specimens were obtained at Playa del Rey, Long Beach, Anaheim Slough and Newport Bay. Shells were found on nearly all the beaches from Point Conception to Ventura.

GEODUCK

Panope generosa Gould

Plate 18, figure 2

This huge bivalve, the largest of all known burrowing clams, has a distinctive common name taken from the Indians of the north where it is more common than in California. The "eo" of geoduck has the sound of "oi" in oil.

Description—The shell may reach a length of seven or more inches, the valves are rather light and fragile especially at the edges, and marked with broad rounded growth lines; the siphonate end gapes widely to accommodate the huge united siphons. The characteristic feature of the geoduck is not alone the massive siphons, which can not be even approximately retracted within the shell, but the disproportionate size of the entire body, which everywhere seems too big for the shell, the valves of which fail to meet by an inch or more in the living specimen. As a result the bulk of the animal is much greater than would be expected from the size of the shell; weights of as high as six and a half pounds are recorded.

Habitat and habits—This is a species of sheltered waters with unshifting bottom.

Use and distribution—The geoduck is an excellent food mollusk. The siphon, which is inclined to be tough, is suitable for soups and chowders while the remainder of the body is of fine flavor when fried or otherwise prepared. Though its range includes the entire California coast it is far from abundant. In fact it was obtained at only one place, Morro Bay. Because of its scarcity its economic importance is negligible.

BORERS

The following three species represent the most conspicuous of the forms burrowing into hard clay, shale and other soft rocks and known as borers, rock clams, boring clams or piddocks. Though used to some extent locally all are of slight economic importance.

Zirfaea gabbi Tryon

Plate 18, figure 1

Description—This is the largest of the borers, sometimes reaching a length of four and a half inches, which represents a considerable bulk, since the large siphon in a state of complete retraction projects at least the length of the shell. The valves, like those of the other borers, differ in the surface marking at the two ends. The anterior end is greatly roughened by the development of teeth on the margins of the projecting lines of growth, while the siphonate end is relatively smooth. The shell gapes widely at either end and the hinge area is protected by a pad-like membrane which, however, lacks the plates found in the two other species here described. The valves are thin and easily broken.

Habitat and habits—This species is oftenest found in stiff blue mud or clay in bays or in other partially sheltered places. If the tunnels are in clay and hence not subject to shifting by the currents they are common near the entrance to bays where the rush of the tides keeps the clay bare of sand and mud. They also inhabit reefs of suitable rocks even though exposed to strong surf.

Use—All these borers are much esteemed as food and though not observed in the markets are used to quite an extent locally, often being obtained from the reefs by the use of a pick or bar.

Distribution—*Zirfaea* is found along the entire California coast in suitable locations. It was obtained at Crescent City, from Elkhorn Slough, Monterey, from the reefs south of Carpinteria, from the clay banks of the sloughs of El Estero near Carpinteria, in the soft bituminous rock cliffs between Goleta and Santa Barbara, and all the reefs from Piedras Blancas to Ventura (C. L. H.). It was found in Morro Bay, in the clay of Anaheim Slough and at the entrance of False Bay (W).

Parapholas californica Conrad

Plate 19, figure 1

Description—This species is said to reach a length of three or more inches (Keep). The anterior end of the shell is roughened and nearly round while the siphonate end is abruptly smaller and ends in soft epidermal scales. The hinge region is protected by two long slender plates.

Use and distribution—It is used without distinction along with the other species of borers. It ranges from Monterey south. Specimens were obtained from the reefs at Point Sal, Point Conception, near Carpinteria and north of Ventura (C. L. H.).

Pholadidea penita Conrad

Plate 19, figure 2

Description—The anterior half of the shell is quite globular, the siphonate end tapers to a slightly gaping extremity covered with brownish epidermal scales. The accessory plate over the hinge region is triangular.

Use and distribution—This is found along the entire California coast in suitable locations. What has been said of the use of the other borers will apply here.

LIST OF CHIEF LOCALITIES ON CALIFORNIA COAST AND SPECIES FOUND AT EACH

The following is a list of the more important localities in California with the species of economic importance found at each. Only species actually used and abundant enough to be of value are listed.

Crescent City—The use of clams is strictly local. From Point St. George considerable numbers of razor clams are obtained. The rock cockle is found along the outer beaches.

Little River—The razor clam is taken in considerable numbers on the sandy beach at the mouth of Little River, and the locality is therefore somewhat famous among tourists and local inhabitants. Their commercial utilization is prevented by laws.

Humboldt Bay—The markets are supplied with the Washington clam (*Saxidomus*) and the soft-shell (*Mya*). The rock cockle (*Paphia*) and the gaper (*Schizothaerus*) are also abundant enough to be of economic importance but only the former is at present used. The razor clam is found to a limited extent on the outer beaches and used locally. Certain regions of the bay receive sewage and precautions should be observed in the use of mollusks from these parts.

Bodega Bay—The soft-shell is present in considerable amount, and the Washington clam is also important.

Tomales Bay—This is the chief source of rock cockles for the San Francisco markets. The Washington clam and the gaper are also found in Tomales Bay, but are chiefly used locally. The soft-shell is fairly abundant. Oyster beds are also present in the bay.

San Francisco Bay—Although the Washington clam and the gaper, as well as a number of other species, are present, only the soft-shell is marketed. Many localities, because of sewage, are unsafe sources of food mollusks.

Halfmoon Bay—Several species are present, but are used only locally. Borers are found in the reefs and at times some Pismo clams are taken. The Washington clam is present.

Monterey Bay—In the northern half of the bay near Aptos and Watsonville some Pismo clams are taken, but the amount is negligible. In Elkhorn Slough the Washington clam, the gaper, the cockle *Cardium* and the rock cockle *Paphia* are present, but are only used locally.

Morro Bay—The beaches north and south of the bay are, with the Pismo-Oceano beach, practically the only source of Pismo clams. The razor clam is also present, but used, if at all, only locally. Within the bay are the gaper (*Schizothaerus*), the Washington clam, some rock cockles (*Paphia*) and the geoduck. The soft-shell has been introduced, but has not as yet obtained a foothold; further plantings would be worth while.

Pismo-Oceano Beach—This beach, as stated, shares with Morro Beach the distinction of producing the entire market supply of Pismo clams. A few cockles (*Cardium*) are found and still more razor clams but these are only used locally.

Ventura—The coast near Ventura (Hueneme) produces some rock cockles (*Paphia*) for the Los Angeles markets.

Playa del Rey—A few rock cockles are dug here for local use.

San Pedro—This bay was once very rich in bivalves, but dredging operations and sewage have rendered it less productive.

Anaheim Slough—A fair amount of cockles (*Paphia* and *Chione*) and some scallops (*Pecten*) are shipped from this point to the Los Angeles markets. The purple clam (*Sanguinolaria*) and the gaper are used locally. The wedge-shell (*Donax*) and some of the borers are also present.

Newport Bay—Cockles (*Paphia* and *Chione*) and *Pecten* are present in profitable amounts, but seem to be used only locally. *Mya* might be introduced here.

False Bay—Cockles (*Paphia* and *Chione*), the scallop (*Pecten*), the gaper and the Washington clam are present, but beyond the cockles, which find their way into the San Diego markets, all appear to be used locally. It is a more favorable situation for the introduction of *Mya* than San Diego Bay, which receives enough sewage to make contamination possible.

San Diego Bay—Cockles and some other species are present, but are little used because of proximity to the city of San Diego.

WHERE TO LOOK FOR THE BIVALVES HERE TREATED

The following list summarizes what has been said in regard to the habitat of the various species. It should be used in connection with the foregoing list of localities or the range as given under each species. Less important or less characteristic species are in brackets.

SPECIES FOUND IN THE OCEAN OR OPEN BAYS

Attached to exposed rocks:
- Sea mussel

Attached to rocks in partially sheltered positions:
- Rock oysters
- Rock scallop

In burrows in exposed or partially sheltered soft rocks:
- Borers

Burrowing in exposed small sand or gravel beaches:
- Rock cockle (*Paphia*)
- *Psammobia*
- [Washington clam]
- [Gaper]

Burrowing in exposed pure sand beaches:
- Pismo clam
- Razor clam
- Wedge-shell
- Sea cockle (*Amiantis*), usually below low tide
- Tellen
- White sand clam (*Macoma secta*)
- [Cockle] (*Cardium corbis*)

SPECIES FOUND IN ENCLOSED BAYS

Attached to solid objects—rocks, shells, piles:
- Bay mussel
- Oyster

In burrows in hard clay, etc.:
- Borers (chiefly *Zirfaea*)
- *Platyodon*
- [Gaper]

Burrowing in gravel or coarse sand:
- Rock cockle (*Paphia*)
- Purple clam (*Sanguinolaria*)

Burrowing in sand:
- White sand clam (*Macoma secta*)
- Cockle (*Cardium corbis*)

Burrowing in muddy sand:
- Soft-shell (*Mya*)
- Rock cockle (*Paphia*)
- Washington clam
- Gaper
- Hard-shell cockle (*Chione*)
- Cockle (*Cardium corbis*)
- Horse mussel
- Jackknife clam
- Piddock (*Zirfaea*)
- [Bent-nosed clam] (*Macoma nasuta*)
- *Panope*

Burrowing in mud:
- Soft-shell
- Bent-nosed clam
- Jackknife clam
- Horse mussel

On surface of sand, gravel or mud if not too soft but not in channels where current is strong:
- Scallop
- [Cockle] (*Cardium corbis*)
- [Rock cockle] (*Paphia staminea*)
- [Hard-shell cockle] (*Chione*)

SPECIES FOUND IN BRACKISH WATER

Burrowing in mud:
- Soft-shell
- Bent-nosed clam

HINTS ON THE USE OF CLAMS

What species of bivalves are to be eaten? The chief edible species have been indicated in the preceding pages. In the absence of positive identification it may be remembered that no species is unfit for food if fresh and if taken from pure water. Many forms are too small to be used conveniently for food and some others, as the white sand clam (*Macoma secta*), have sand in the alimentary canal and are for this reason unpalatable, some are obviously of better flavor than others, but none are harmful or dangerous.

Of more importance than the species, are precautions in regard to the selection of the clams used. Like other meat they spoil readily and for this reason only fresh and living ones should be utilized. Fortunately this fact is very easily determined. The ligament of the bivalve shell will cause it to open if it is not held closed by the activity of the muscles, hence any shell that gapes and fails to close promptly when touched is dead or moribund and unfit for food. Only those tightly closed or closing promptly should be used or accepted from the markets.

Another point of importance is that of contamination. All bivalves, from their habit of feeding, in which great quantities of water are pumped through the body, are particularly prone to contamination if the water in which they live is polluted. For this reason it is unwise to use for food any clams or oysters coming from bays receiving sewage, or refuse from certain manufacturing plants. The State Board of Health has the power to close such areas and so protect the public. In no event should the clams or oysters be eaten raw unless there is the best of evidence that they come from a region where contamination is impossible.

At what season of the year should they be used? The presence of an "r" in the month is so ingenious and clinging a mnemonic trick that it is on everyone's tongue, but like some other sayings it is of no significance. The summer is the season least fitted for shipping as clams are readily affected by the heat and they are "poorest," in the phrase of the digger, immediately following the breeding season, but there is no time of year when they are unfit for food.

The first step in preparation concerns the shell. If the clam is intended for steaming it should be thoroughly cleaned, for other uses, it should be removed. Shelling is not difficult except in the case of forms with heavy valves such as the Pismo clam, which at first sight appears unassailable but with a little care a thin bladed knife can be forced between the valves and the big adductor muscles cut, after which the shell will open of its own accord. If, as sometimes happens, the mantle cavity contains sand or mud, it should be washed out, otherwise the liquor that drains off during cleaning should be saved.

What part of the clam is to be eaten? There is no more reason for rejecting any part of a clam than for rejecting any part of an oyster, and oysters are always eaten entire. Even the liver, the dark greenish or black mass near the hinge, which some people discard on account of its color, is rich in glycogen or animal starch, the source of the sweet taste of fried clams.

Some people make a practice of keeping the live clams for twelve to twenty-four hours in fresh water, as during that time more or less of the sand or mud that some forms contain will be rejected.

Clams may be prepared for the table in many and various appetizing ways. The chowders and soups for which the bivalves are justly famous are well known to all. A few tried recipes are given to suggest some of the less well known methods of preparation. For frying it is best to choose small and tender varieties such as the razor clam, rock cockle, or purple clam, but for baking, larger forms or less tender parts, such as the siphons of the gaper, will serve equally well, as here the chopper or meat grinder come into play to make a successful dish. For steaming the mussel is a favorite, closely followed by the soft-shell and rock cockle.

The following recipes may naturally be varied greatly according to the ingenuity and equipment of the cook. Whether he simply fry his clams in oil or butter after dredging them with flour and serve them as the *piece de resistance* of a camper's meal, or bake them *en casserole* with an elaborate sauce as an *entree* will obviously depend on the cook's initiative and the materials at his disposal.

Clam and Tomato Bisque

1 pint clams
⅔ cup clam liquor
⅓ cup soup stock
3 tablespoons flour*
2 tablespoons butter
1 tablespoon chopped onion
½ cup milk
1 cup stewed and strained tomatoes
Salt, pepper

Chop clams, barely cover with water and boil gently for ten minutes. Strain, reserving liquor. Cook butter with onion; when well browned add flour and blend with clam liquor and soup stock. Add milk, chopped clams, and when boiling point is reached pour in the strained tomatoes, which have been stewed with a pinch of soda in a separate kettle. Season and serve hot with croutons.

Fried Clams

1 pint clams
1¼ cups flour
¼ cup milk
½ cup clam liquor
2 eggs
Several slices bacon; salt; pepper

Clean clams, taking care not to throw away the liquor. Make a batter of the flour, milk and clam liquor, add eggs beaten until light. In this dip clams, season with salt and pepper and fry with bacon or in oil. Garnish if desired with lemon or parsley.

Fried Croquettes

1 pint clams
1 cup cold boiled potato or rice
1 teaspoon finely chopped parsley
1 tablespoon chopped onion
1 cup stale bread or cracker crumbs
Several slices of bacon
1 egg

For Sauce

4 tablespoons flour
2 tablespoons butter
¾ cup clam liquor
½ cup milk

*It should be borne in mind that a *tablespoon* is used in these recipes as a unit of measurement and should be *level,* not heaping or rounding.

This makes an excellent "left-over" dish, and is suggested when there are scraps to utilize or the clams are tough. The siphons of the large clams, as the gaper or geoduck, are excellent here, prepared as follows: Soak over night in cold water, scrape off skin, parboil, reserving liquor, and run through meat grinder together with potato and other "left-overs." In a frying pan place bacon, minced fine, with onion and cook five minutes. Add butter till mixture is well browned, then flour, pouring on gradually clam liquor and milk. To this sauce add clam and potato, mix thoroughly, and allow to cool. Shape into croquettes, dip in beaten egg, roll in crumbs and fry in deep fat.

Scalloped Clams

Butter a baking dish, and spread with cracker crumbs dotted with small lumps of butter. Cover with clams, sprinkle with salt and pepper. Repeat process, and pour over all one-half cup milk and the clam liquor. Cover top with the remaining crumbs well buttered. Bake one-half to three-fourths of an hour in a hot oven.

Savory Clams en Casserole

1 pint clams
½ pint mushrooms (fresh if obtainable)
4 tablespoons butter
4 tablespoons flour
½ cup mushroom liquor
1 cup clam liquor
½ cup milk or soup stock
Seasoning—thyme, sage, onion juice, parsley, salt and pepper.

Clean clams and parboil, reserving liquor. Clean mushrooms and cook two minutes. Drain liquor from mushrooms and mix with that of clams. Chop clams and mushrooms rather fine. Make a sauce with butter and flour, stirring until well browned, and pouring on gradually milk, mixed liquors and soup stock. Add seasoning, clams and mushrooms. Put all in a buttered baking dish, cover with buttered crumbs and brown in oven. Or serve on toast or in patty shells.

Steamed Mussels (or Clams)

This method is the one preferred for mussels and is often used for the soft-shell, rock cockle or hard-shell cockle; it is not so well adapted for large forms with big siphons. Separate, and select live unbroken mussels, clean by scraping with a dull knife or scrubbing with a stiff brush in several changes of water. Pour in a kettle with a tightly fitting lid two or three tablespoons of oil, season with a few slices of onion or a touch of garlic if desired, add cleaned mussels in the shell, cover tightly and steam over a hot fire until all shells open. Serve with lemon juice.

For campers the above may be varied by steaming over a small amount of sea water. If no covered kettle is at hand a pail covered with wet sea weed will serve.

Mussels left over from steaming may be pickled in vinegar and used when desired.

FISH AND GAME LAWS RELATING TO CLAMS

Certain of the more important edible species are protected by laws. The aim of all these laws is, by limiting the time of digging or the number of clams taken, to prevent the depletion of the supply and to maintain a group of breeding animals that will insure a future supply. If these laws are to accomplish their purpose, the Fish and Game Commission must have the cooperation not only of the commercial digger but also of the camper or local inhabitant. To this end the following extracts from the current laws are here reprinted for general information. These cover all the species at present protected by law, but as it is clear that any other forms would suffer equally from wanton destruction or the taking of young, good sportsmanship and regard for the common possession of the people of the state would demand that no clams be dug that are not made use of and that the young be returned to the beds.

"Every person who gathers or takes in any manner or destroys or has in his possession any clam known as the Pismo clam (*Tivela stultorum*) which shall measure less than four and three-quarters inches across its shell in the greatest breadth, or who, during any one calendar day, takes, gathers in any manner or has in his possession more than thirty-six of said clams, or who, between the first day of May and the thirty-first day of August, both dates inclusive, of any year, takes, catches or gathers any clams in fish and game district seventeen[1] is guilty of a misdemeanor.

"Every person who takes, gathers in any manner or has in his possession, or who ships, offers for shipment, sells or offers for sale any cockles or little-neck clams (*Tapes staminea*)[2] measuring less than one and one-half inches in its greatest breadth; every person who takes, catches or gathers in any manner any razor clam (*Siliqua patula*), except during a period of forty-eight hours beginning at the first low tide after the first high tide (large water) of the full moon of each month and for a period of forty-eight hours beginning at the first mean low tide after the first high tide (large water) of the new moon of each month, or who takes, catches or gathers in any way more than fifty of said razor clams (*Siliqua patula*) during any one calendar day is guilty of a misdemeanor.

"Every person who, during any one calendar day, takes, gathers in any manner, or has in his possession, or who ships, offers for shipment, sells or offers for sale, more than ten clams of the species *Schizothaerus nuttalli*, variously known as rubber-neck, big-neck or great Washington clam[3], is guilty of a misdemeanor.

"Every person who takes, catches or kills or has in possession any clam or clams taken from fish and game districts eight or nine, between the first day of May and the thirty-first day of August of any year, both dates inclusive; or who at any time ships or offers for shipment or receives for shipment or transportation, to any place outside the

[1]Monterey Bay.
[2]*Paphia staminea*, the rock cockle.
[3]Gaper.

limits of fish and game district one, any clam or clams of any species taken in fish and game districts seven, eight or nine*, is guilty of a misdemeanor.

"Every person violating any of the provisions of this section upon conviction thereof shall be punished by a fine of not less than twenty-five nor more than five hundred dollars or by imprisonment in the county jail in the county in which the conviction shall be had not less than ten days nor more than six months or by both such fine and imprisonment."

* Humboldt Co.

INDEX

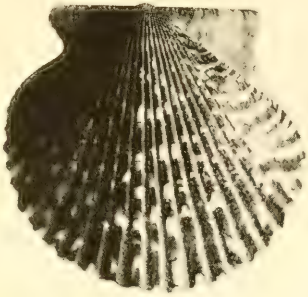
The more important references are in heavy-faced type

Plate 1

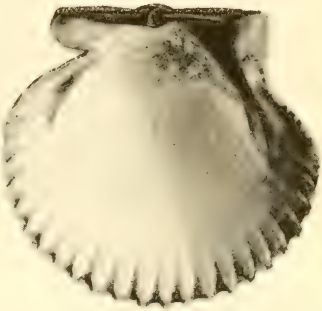
FIG. 1. *Pecten circularis* Sowerby; Scallop. Anaheim Slough. Three-quarters natural size. Exterior of upper (left) valve.

FIG. 2. *Pecten circularis*, same specimen as Fig. 1. Interior of lower (right) valve. Note the "ears" on either side of the hinge and the marginal teeth that interlock in the closed shell.

FIG. 3. *Hinnites giganteus* Gray; Rock scallop. Monterey Bay. Three-quarters natural size. Interior of the lower (right) valve. Note scar of the single (posterior) adductor muscle and pallial line without sinus.



1



2

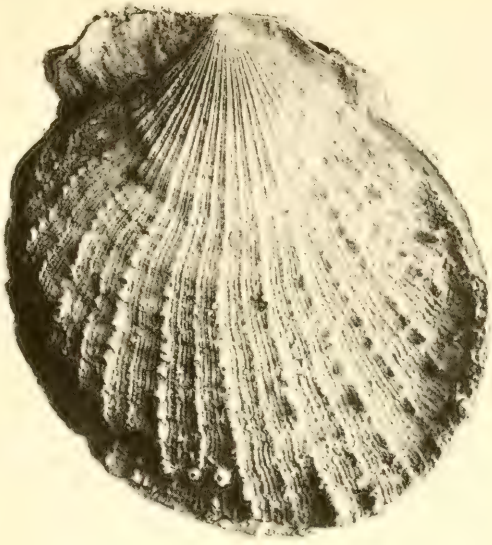
3

PLATE 1.

Plate 2

FIG. 1. *Hinnites giganteus* Gray; Rock scallop. Monterey Bay. Nearly natural size (9/10). Exterior of upper (left) valve.

FIG. 2. *Hinnites giganteus*, same specimen as Fig. 1. Exterior of lower (right) or attached valve. The symmetrical outline of the shell at the time of attachment is clearly shown.



1

2

PLATE 2.

Plate 3

FIG. 1. *Monia macroschisma* Deshayes; Rock oyster. Monterey Bay. Natural size. Exterior of upper (left) valve.

FIG. 2. *Monia macroschisma*, same specimen as Fig. 1. Exterior of lower (right) valve. Note the deep notch (apparently a hole) for the passage of a byssus.

FIG. 3. *Anomia peruviana* Orbigny; Rock oyster. San Diego. Two and one-half times natural size. Exterior of upper (left) valve.

FIG. 4. *Mytilus edulis* Linnaeus; Bay mussel. Humboldt Bay. Twice natural size. The byssus with adhering bits of stone, etc., is clearly shown.

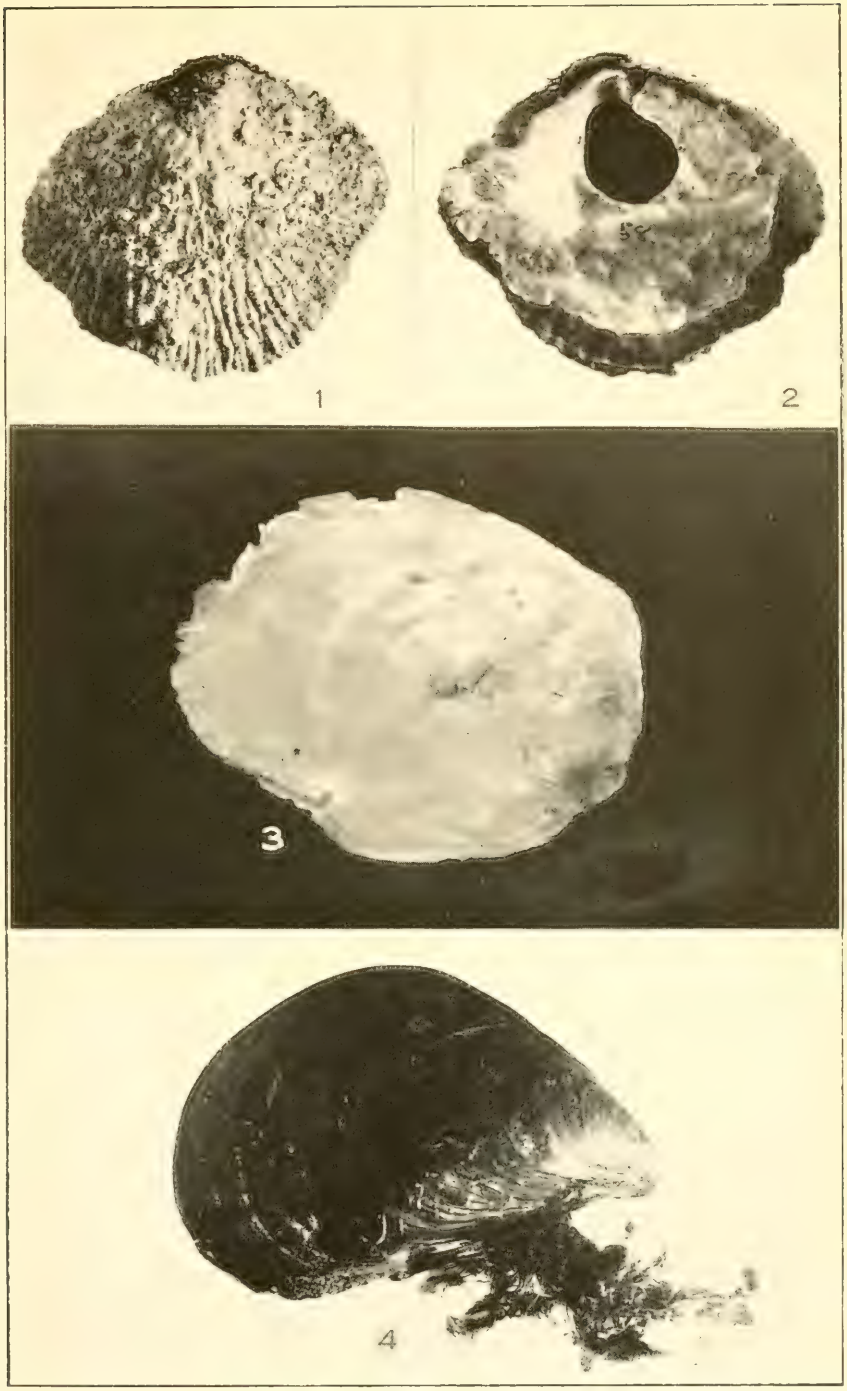


PLATE 3.

Plate 4

FIG. 1. *Mytilus californianus* Conrad; Sea mussel. Monterey Bay. Natural size. Exterior of right valve. Specimen of medium size. Note that erosion at the umbonal end has destroyed the black glossy periostracum.

FIG. 2. *Mytilus californianus* Conrad. Monterey Bay. One-half natural size. Interior of left valve of large specimen. Note dark scar of large posterior adductor muscle and smaller scar of anterior adductor in extreme umbonal end.

FIG. 3. *Modiolus rectus* Conrad; Horse mussel. Elkhorn Slough, Monterey Bay. Three-quarters natural size. The byssus is shown as well as the projecting bits of epidermis that give the anterior end a bearded appearance.

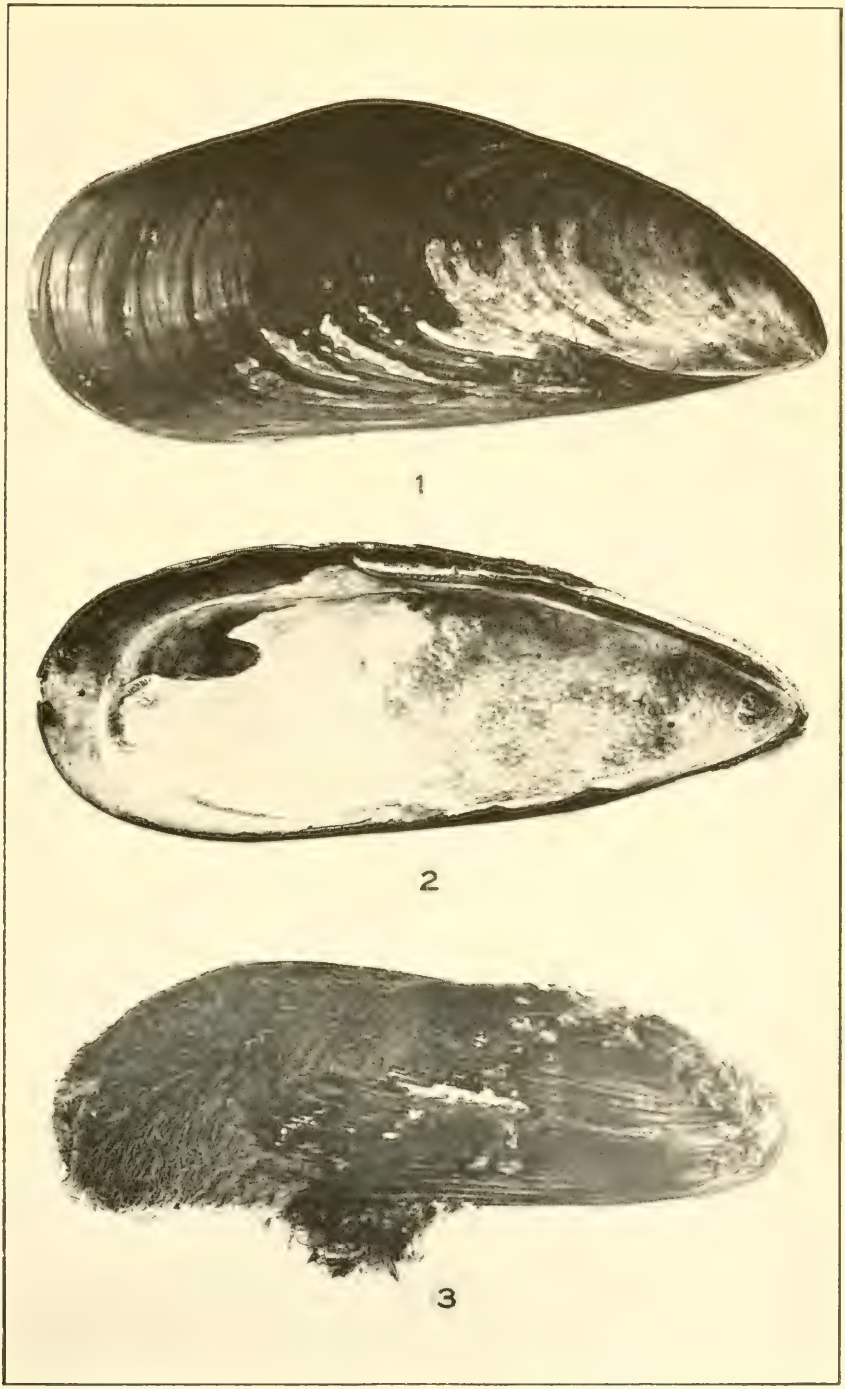


PLATE 4.

Plate 5

FIG. 1. *Cardium quadragenarium* Conrad. Off San Pedro in 20 to 30 fathoms. One-half natural size.

FIG. 2. *Cardium corbis* Martyn; Cockle. Elkhorn Slough, Monterey Bay. Natural size. Note the long slender foot projecting from between the valves.

FIG. 3. *Amiantis callosa* Conrad; Sea cockle. San Diego. Three-quarters natural size.

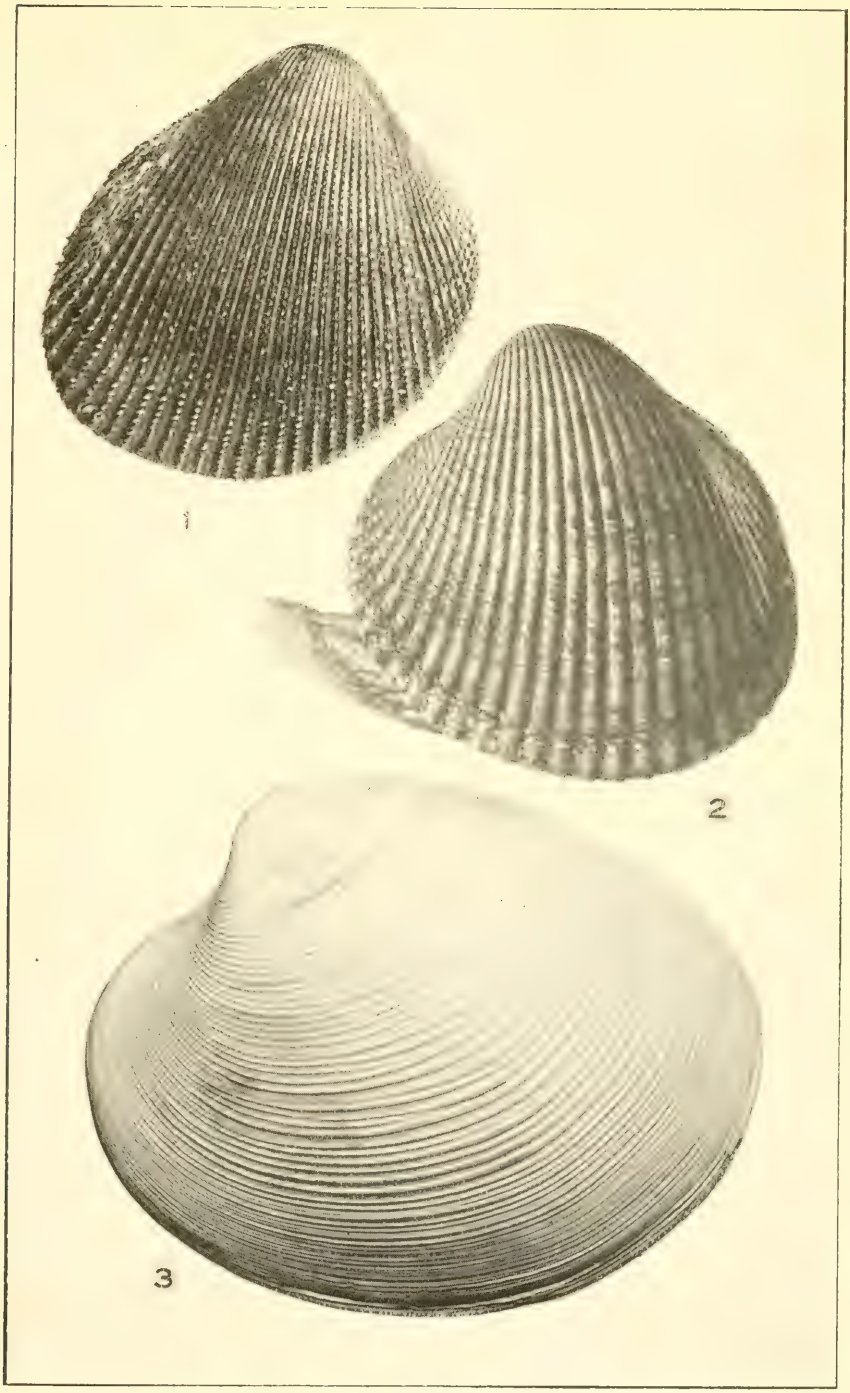


PLATE 5.

Plate 6

FIG. 1. *Tivela stultorum* Mawe; Pismo clam. Turtle Bay, Lower California. Natural size. Exterior right valve.

FIG. 2. *Tivela stultorum*. Oceano. Three-quarters natural size. Interior left valve.

1

2

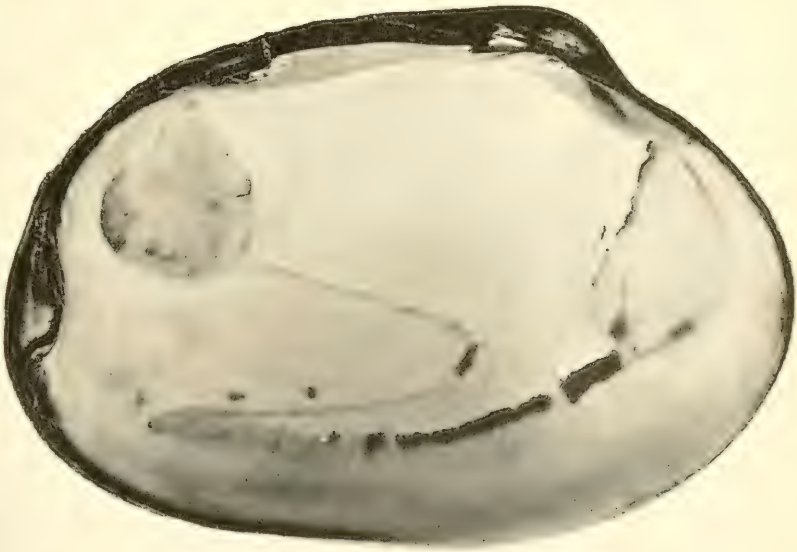
PLATE 6.

Plate 7

FIG. 1. *Saxidomus nuttalli* Conrad; Washington clam. Bodega Bay. Five-sevenths natural size. Exterior left valve.

FIG. 2. *Saxidomus nuttalli,* same specimen as Fig. 1. Three-quarters natural size. Interior left valve. Note muscle scars and pallial line with pallial sinus.

1



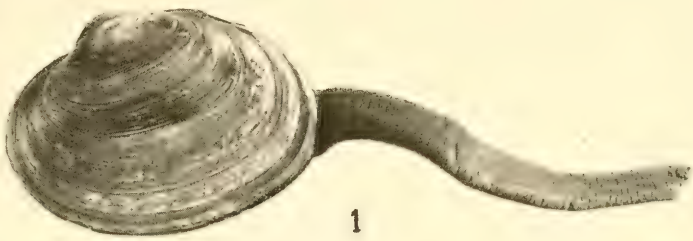
2

PLATE 7.

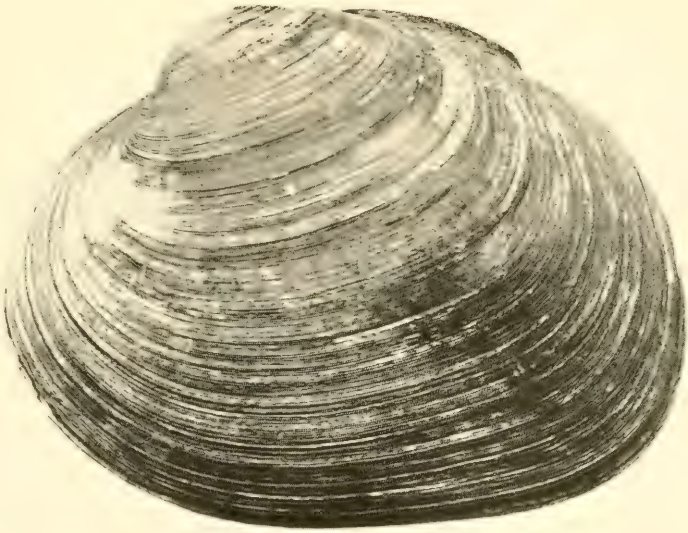
Plate 8

FIG. 1. *Saxidomus giganteus* Deshayes; Washington clam. Humboldt Bay. One-half natural size. Exterior left valve with extended siphon.

FIG. 2. *Saxidomus giganteus* Deshayes; Washington clam. Humboldt Bay. Natural size. Exterior left valve of second specimen.



1



2

PLATE 8.

Plate 9

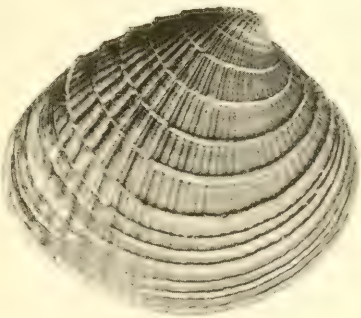
FIG. 1. *Chione fluctifraga* Sowerby; Hard-shell cockle. San Diego. Natural size. Exterior left valve.

FIG. 2. *Chione undatella* Sowerby; Hard-shell cockle. Anaheim Slough. Natural size. Exterior right valve.

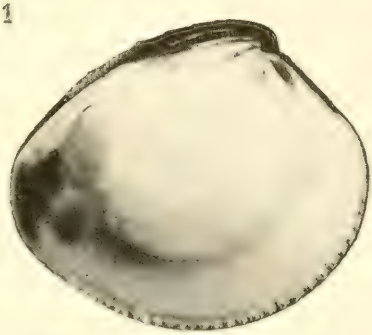
FIG. 3. *Chione succincta* Valenciennes; Hard-shell cockle. Anaheim Slough. Natural size. Exterior right valve.

FIG. 4. *Chione succincta*, same specimen as Fig. 3. Interior left valve.

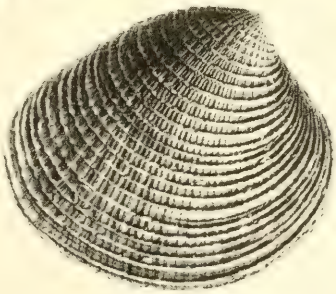
1



3



4



2

Plate 10

FIG. 1. *Paphia tenerrima* Carpenter. Oceano. Natural size. Exterior left valve.

FIG. 2. *Paphia staminea* Conrad; Rock cockle. Monterey Bay. Natural size. Exterior left valve.

1

2

Plate 10.

Plate 11

FIG. 1. *Tellina bodegensis* Hinds; Tellen. Crescent City. Natural size. Exterior left valve.

FIG. 2. *Metis alta* Conrad. San Pedro. Natural size. Exterior right valve.

FIG. 3. *Macoma nasuta* Conrad; Bent-nosed clam. Elkhorn Slough, Monterey Bay. One and one-half times natural size. Exterior of right valve with extended foot and siphons. The dorsal or exhalent siphon is much the shorter.

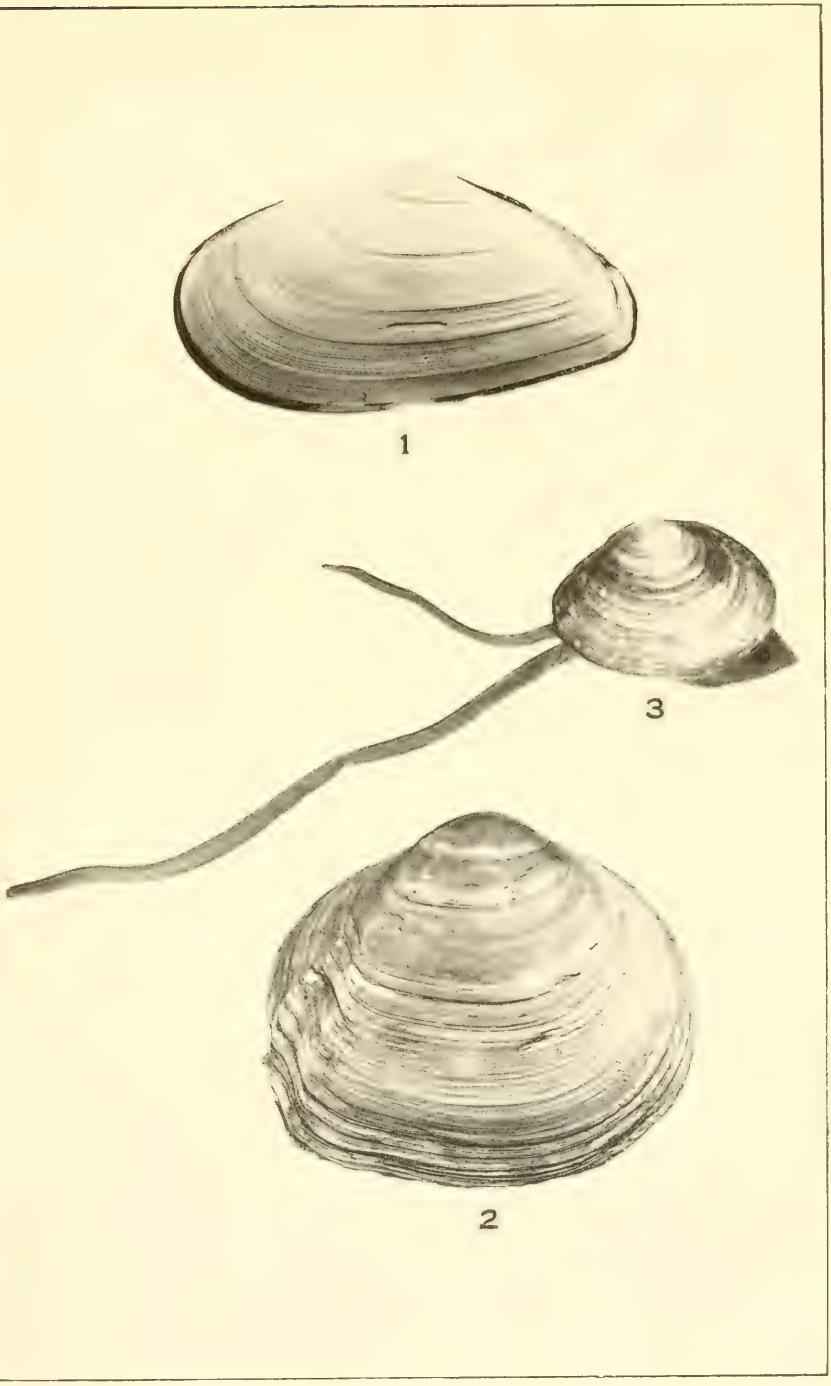


PLATE 11.

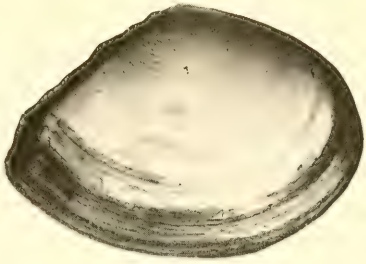
Plate 12

FIG. 1. *Macoma nasuta*. Morro Bay. Natural size. Exterior right valve.

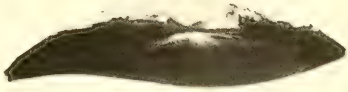
FIG. 2. *Macoma nasuta*, same specimen as Fig. 1. Dorsal view. Note that the siphonate end is bent toward the right.

FIG. 3. *Macoma secta* Conrad; White sand clam. Morro Bay. Natural size. Exterior right valve.

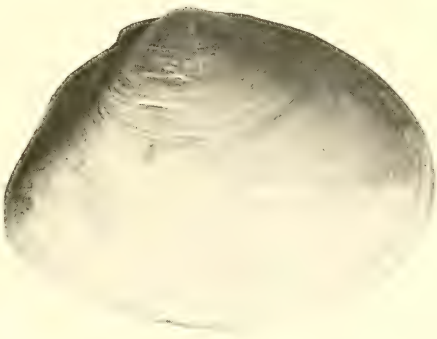
FIG. 4. *Macoma secta*, same specimen as Fig. 3. Dorsal view. Compare with *Macoma nasuta*.



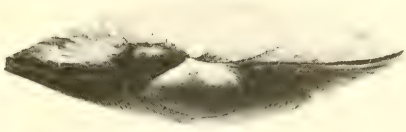
1



2



3



4

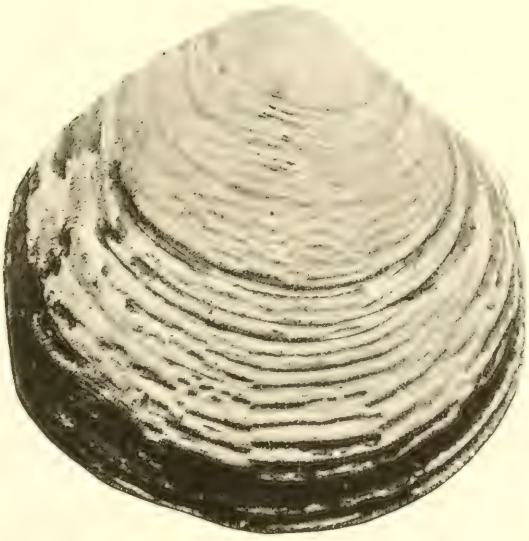
PLATE 12.

Plate 13

FIG. 1. *Macoma secta*. Long Beach. Natural size. Interior right valve. Note large pallial sinus.

FIG. 2. *Semele decisa* Conrad; Flat clam. False Bay. Natural size. Exterior of right valve.

1



2

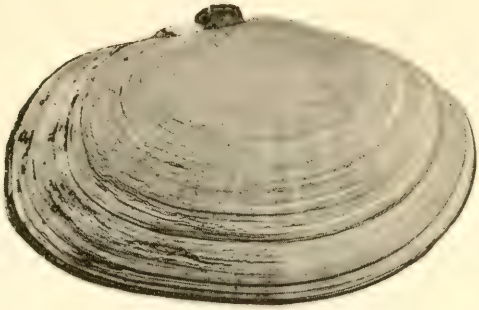
PLATE 13.

Plate 14

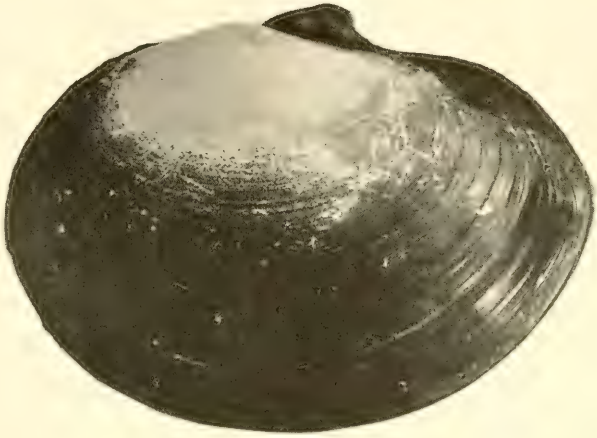
FIG. 1. *Psammobia californica* Conrad; Sunset shell. Monterey Bay. Natural size. Exterior of right valve.

FIG. 2. *Sanguinolaria nuttalli* Conrad; Purple clam. Anaheim Slough. Natural size. Exterior of left (upper) valve.

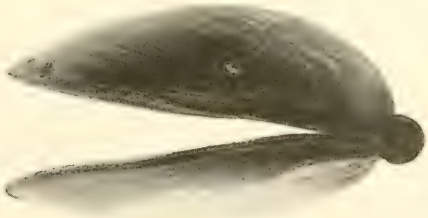
FIG. 3. *Sanguinolaria nuttalli*, same specimen as Fig. 2, viewed from the siphonate end. Note greater convexity of the left (upper) valve.



1



2



3

PLATE 14.

Plate 15

FIG. 1. *Tagelus californianus* Conrad; Jackknife clam. False Bay. Natural size. Exterior of left valve.

FIG. 2. *Solen sicarius* Gould; Jackknife clam. Elkhorn Slough, Monterey Bay. Natural size. Exterior left valve with extended foot.

FIG. 3. *Solen rosaceus* Carpenter. San Diego. Natural size. Exterior left valve with extended foot.

FIG. 4. *Siliqua patula* Dixon; Razor clam. Mouth of the Columbia River. Three-quarters natural size. Exterior of left valve with partially extended siphon.

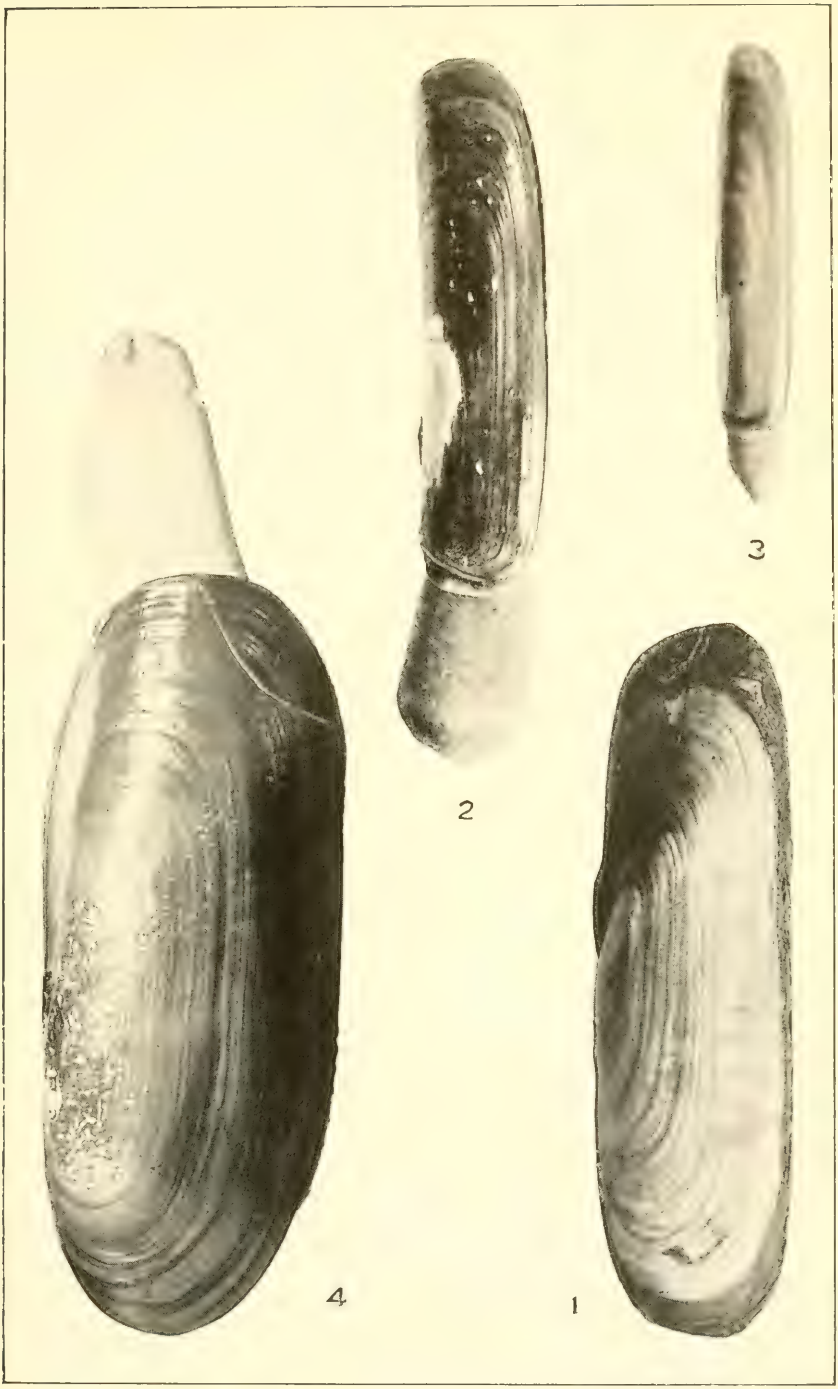


PLATE 15.

Plate 16

FIG. 1. *Donax californica* Conrad; Wedge shell. False Bay. Twice natural size. Exterior of left valve.

FIG. 2. *Donax laevigata* Deshayes; Wedge shell. Mouth of Anaheim Slough. Twice natural size. Exterior of left valve.

FIG. 3. *Schizothaerus nuttalli* Conrad; Gaper. Elkhorn Slough, Monterey Bay. One-quarter natural size. Exterior of right valve with extended siphon. Note plates at tip of siphon.

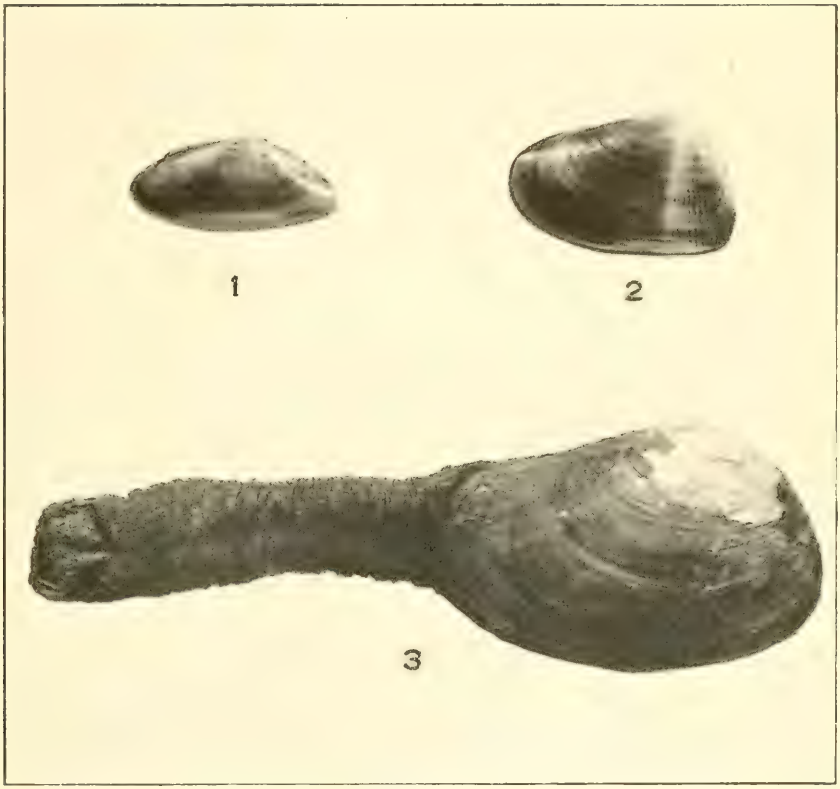


PLATE 16.

Plate 17

FIG. 1. *Platyodon cancellatus* Conrad. Anaheim Slough. Natural size. Exterior of right valve.

FIG. 2. *Mya arenaria* Linnaeus; Soft shell clam. Mouth of Big River. Three-quarters natural size. Dorsal view. Note the large spoon-shaped projection on the left valve for the internal ligament.

FIG. 3. *Mya arenaria*, same specimen as Fig. 2. Exterior of right valve.

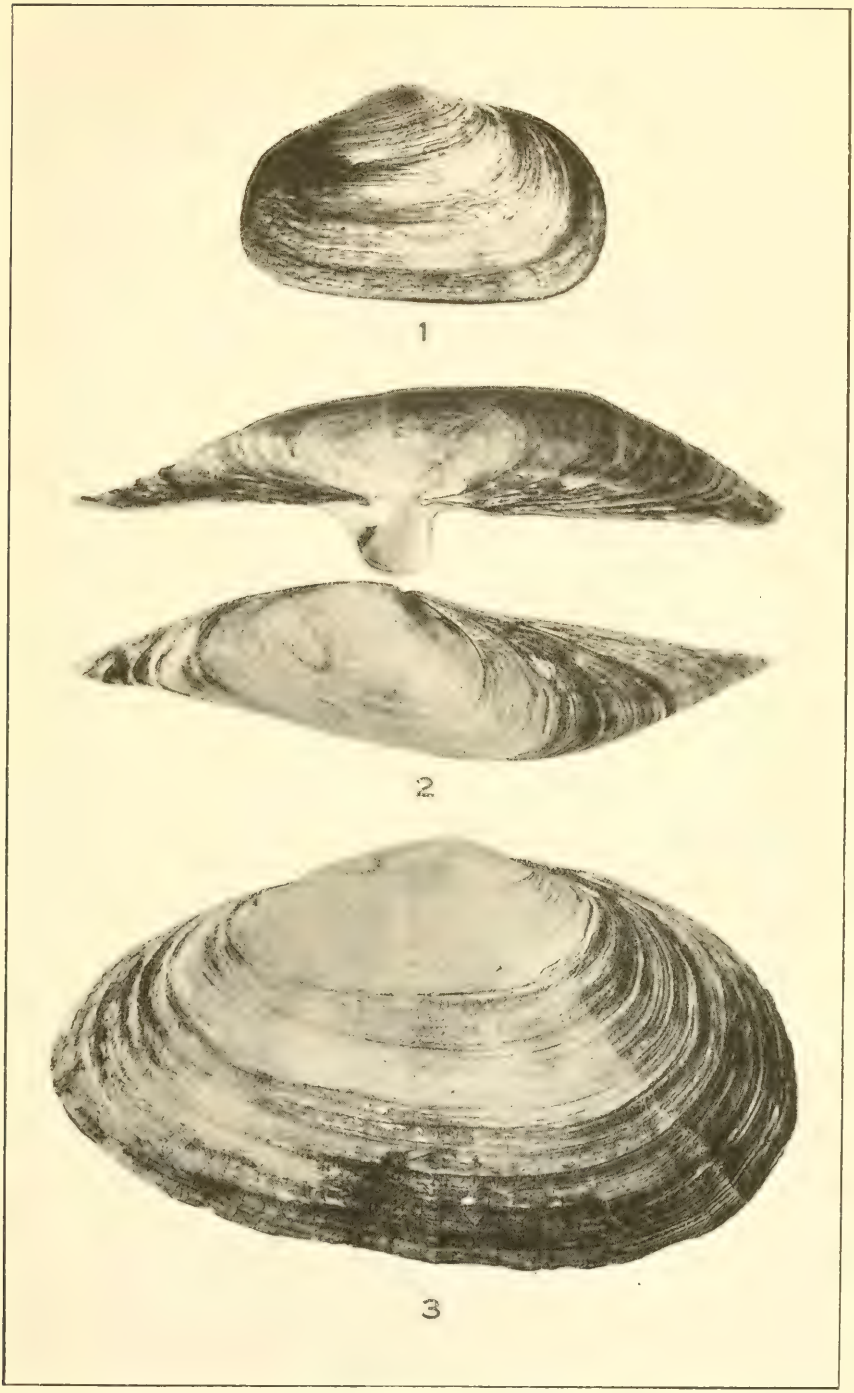


PLATE 17.

Plate 18

FIG. 1. *Zirfaea gabbi* Tryon; Piddock. Crescent City. One-half natural size. Exterior of right valve. The siphon is partially extended but is incomplete and the tip has been bent in preserving.

FIG. 2. *Panope generosa* Gould; Geoduck. Morro Bay. One-half natural size. Exterior of right valve with partially extended siphon. In life the mantle shows beyond the shell margin at all points.

Plate 18.

Plate 19

FIG. 1. *Parapholas californica* Conrad; Borer. Monterey Bay. Natural size. Exterior right valve.

FIG. 2. *Pholadidea penita* Conrad; Rock clam. Departure Bay, British Columbia. Natural size. Exterior of right valve.

1

2

PLATE 19.