OCCASIONAL PAPERS

OF THE

BERNICE PAUAHI BISHOP MUSEUM OF POLYNESIAN ETHNOLOGY AND NATURAL HISTORY

Vol. VII, No. 9

WITH FIGURES I-VI

EDIBLE MOLLUSCA OF THE OREGON COAST

BY

CHARLES HOWARD EDMONDSON

HONOLULU, HAWAII
BISHOP MUSEUM PRESS
1920

Acknowledgment is due the United States Bureau of Fisheries under whose direction investigations recorded in this report were conducted during the period from August, 1917, to May, 1919, inclusive.

THE AUTHOR.

Edible Mollusca of the Oregon Coast.[1]

By Charles Howard Edmondson.

INTRODUCTION.

The Oregon coast from the mouth of the Columbia River to California presents an exceedingly varied contour. Low, flat, sandy beaches alternate with rugged headlands while the shore line is indented by numerous bays and inlets of greater or less extent. A number of rivers of considerable size, draining the Coast Range Mountains, flow into the Pacific within the boundaries of the state, their waters influenced by the daily tides for several miles from the ocean. Most of them expand into broad, shallow bays near their mouths and some of them are characterized by extensive mud flats on one or both sides of the channel which make ideal habitats for numerous forms of marine or brackish water organisms. In many places the coast is paralleled by fringing chains of rocks representing remnants of a former shore line, now serving as footholds for such fixed organisms as have become adapted to the full sweep of the waves.

As the physical features of any coast line determine the types of animals and plants that are distributed along it, so the organisms of the open beaches differ considerably from those found in the protected bays and mouths of rivers or along the rocky shores.

The habitat conditions in the tidal zone along the northwest coast are such that numerous lamellibranchs have become established and are maintaining themselves more or less successfully. Of this number there are about a dozen, besides the western oyster,[2] Ostrea lurida Carpenter, which have already been recognized, to some extent at least, as fit for human food.

The following list of clams and mussels represents the bivalves, exclusive of the oyster, of the Oregon coast which have entered into the food economy of the people of the state in some slight degree: Siliqua patula Dixon, commonly known as the "razor clam"; Mya arenaria Linnaeus, the "long neck clam" or "eastern mud clam"; Paphia staminea (Conrad), called the "little neck clam" or "hard clam"; Schizothaerus nuttalli Conrad, locally known as the "Wash-

[1] The investigations recorded in this paper were conducted while the writer was a member of the teaching staff of the University of Oregon.

[2] For a discussion of the oyster see page 23 of this paper.

ington clam" or the "great blue clam"; Saxidomus giganteus Deshayes, sometimes called the "butter clam", wrongly called the "quahog" at Netarts Bay; Cardium corbis Martyn, universally known as the "cockle"; Macoma nasuta Conrad, the "bent nose clam", called at Newport the "oyster clam"; Pholadidea penita (Conrad), a rock borer, commonly but wrongly called the "rock oyster"; Mytilus edulis Linnaeus, the smaller and smoother of the two common sea mussels, and Mytilus californicus Conrad, the larger and rougher sea mussel. Besides these may be mentioned species of pecten which undoubtedly exist off the coast of Oregon, beyond the low tide line, but nothing is known at the present time regarding the distribution of the beds or their abundance.

That the Indians made extensive use of clams and mussels along the northwest coast even before the advent of the white man is a matter of general knowledge. Along the Oregon shore, from Seaside in Clatsop County to southern Curry County, great heaps of shells or "kitchen middens" are common sights. Many of them are very old, some are covered with earth and vegetation, and others with shrubs and trees of considerable size. Without thoroughly investigating the contents of these mounds it was observed that they are composed primarily of shells of types of molluscs found living in the same vicinity at the present time.

Although there is a somewhat general apathy of people toward fresh clams and mussels as food, probably due largely to unfamiliarity with them, and a very universal tendency to neglect things that are commonplace, the writer has observed a marked increase in the use of these sea products by the people of the northwest during the past few years. Statistics relative to the shore fisheries of clams and mussels of the Pacific coast states for the year 1915, as recorded by Radcliffe[3] in a report of the United States Bureau of Fisheries, are as follows:

California.	Value.
Hard clams	$ 17,583
Soft clams	18,107
Mussels	2,326
Total	$ 38,016

[3] Radcliffe, Lewis. Fisheries Industries of the United States. Appendix X to the Report of the U. S. Commissioner of Fisheries for 1918. Document No. 875, p. 1-167.

Oregon.	
Razor clams	$ 10,900
Soft clams	3,041
Total	$ 13,941
Washington.	
Hard clams	$ 12,191
Razor clams	56,446
Soft clams	150
Mussels	83
Total	$ 68,870
Total for the three states	$120,827

The same report indicates the following value of canned clam products of the Pacific coast states for the year 1915:

Oregon.	Value.
Clams and clam juice	$ 40,509
Washington.	
Clams and clam juice	218,550
Total	$259,059

Although not setting forth the value of the canned molluscan product of California for the year 1915, the report states "that considerable quantities of abalone were canned in San Diego and Monterey Counties and a small pack of mussels was put up in Del Norte County".

The actual importance of clams and mussels as food products is much greater, however, than indicated by the census report. On the Oregon coast large quantities of clams are consumed locally, no record of which is kept. Clam digging is an attractive employment for crowds of visitors who are fortunate enough to be able to spend a few days or weeks at the beaches. In recent years many have taken advantage of the opportunity offered while at the beach and have canned a winter's supply of clams for their own use. A cannery designed primarily for the purpose of putting up minced clams has been in operation at Tillamook City, Oregon, for a num-

ber of years. The activity of the enterprise, however, is dependent upon the inclination of the diggers to supply the cannery with clams. During the salmon fishing season it is practically impossible to get men to dig clams, as higher wages can be made in the fishing boats.

At nearly all of the towns on the Oregon coast where clam beds are accessible there are one or two men who devote at least a portion of their time to digging clams for local demands or nearby markets. Fish markets usually handle supplies of fresh clams for the convenience of the local trade.

Through the courtesy of Dr. A. D. Howard, of the United States Biological Station at Fairport, Iowa, some careful tests were recently made by a factory of that locality to determine the possibility of the utilization of the shell of Saxidomus giganteus in the manufacture of buttons. The conclusion was that this shell, like those of most marine molluscs, is too hard and brittle for that purpose.

GENERAL DISTRIBUTION OF THE EDIBLE CLAMS AND MUSSELS ON THE OREGON COAST.

1. Siliqua patula Dixon.

Among the bivalves inhabiting the ocean beaches of our northwest coast, which have become recognized as food products either locally or in more distant markets, the razor clam is, in the opinion of many, of chief value. This clam is still abundant on the Washington coast north of the mouth of the Columbia River in spite of the inroads made upon it by the canneries. A seasonal restriction limiting the activities of the clam canneries to a few months during each year has, no doubt, been a factor in stabilizing the razor clam on the Washington beaches.

On the Oregon coast Siliqua patula has for many years maintained itself in abundance north of Tillamook Head in Clatsop County where large quantities of the clams may still be taken during the year at periods of low tides. Until about six years ago beds of razor clams of considerable size were known to exist at many points throughout the entire coast of Oregon. There apparently occurred, however, a sudden depletion of the species along the sandy

beaches south of Tillamook Head, a satisfactory cause for which has not been ascertained. It is very probable that many influences contributed to this depletion. The changing character of the beaches may account for its total extermination in certain localities. Some beds of clams of considerable extent are known to have been either destroyed or forced to migrate into deeper water by the sand in which they lived being washed away by the action of the waves, while others may have been smothered by the sudden addition of sand. Continual digging together with possible unfavorable spawning seasons may, in other instances, have depleted the species.

That the razor clam has never been wholly extinct in recent years south of Tillamook Head is evidenced by the fact that a few individuals have been taken each year in scattered localities along the coast. Whether the clam is able to migrate and establish itself in deep water below the line of low tide when unsuitable conditions arise in the more shallow water of the littoral zone is at the present time unknown.

During the summer of 1919 it was apparent that the razor clam was increasing in numbers at certain points along the Oregon coast, and its reappearance was noted in several localities where it had not been observed for a number of years. Beaches south of Tillamook Head from which the razor clam has been taken in small numbers during the past two or three years are located as follows: north of Netarts Bay; within Netarts Bay; between Netarts Bay and Cape Lookout (Figure I); north of Yaquina Head; Agate Beach; between Yaquina and Alsea Bays; north of Heceta Head and north of the mouth of the Siuslaw River. Possibly the species may have been taken at other, unreported points. The next few years may see this valuable clam establishing itself in increasing numbers on certain beaches where it was once very abundant. In such localities it should be unmolested for a year or two in order that it may increase in such numbers as to assure a stability of the species.

A state law prohibiting the shipment of clams from Clatsop County during the period from June 20th to September 20th of each year has been in effect for a number of years. This restriction does not, in the opinion of the writer, and apparently was not

intended to serve as a material check upon the actual taking of clams during the closed season mentioned above. The tourist season at the popular resorts of Seaside and Gearhart is at its height during the summer months. A greatly increased population at the beaches results in a very great destruction of both mature and immature razor clams for local consumption. Inexperienced diggers often crush the shells and fail to take the animals from the sand, or mutilate them in their strenuous efforts and cast them away as useless. Disregard of size of clams taken results in the destruction of many small individuals which should have been given a chance to mature. This constant strain upon the species has probably been offset, however, by repeated successful spawning seasons, as the clams on this beach are about as plentiful at the present time as in previous years. Nevertheless, there is little in the present restrictions and practice to serve as a guarantee against possible depletion of the species in the future.

2. Paphia staminea (Conrad).

The "little neck clam" is frequently seen in the markets of Portland and other inland cities of the northwest, the greatest supply coming from the gravel beds of the southern shores of Puget Sound. The species is well distributed, however, along the northwest coast and in Oregon occurs in the larger bays as Tillamook, Netarts, Yaquina and Coos (Figures I, II, IV). It is not the dominant species in any of these localities but may be taken in considerable numbers from the gravel beds of Netarts Bay and from the mud flats of Coos Bay south of Empire City. Dredging operations in 1919, for the purpose of deepening the channel of Yaquina Bay, largely destroyed the clam beds on the north shore of the bay above the town of Newport. Among other species commonly found here was Paphia staminea. This species is not found in sufficient quantities in any locality on the coast of Oregon to supply more than a limited local demand.

3. Schizothaerus nuttalli Conrad.

The "Washington clam" is a species of wide distribution on

the west coast. It thrives well and reaches a large size in Washington and Oregon where the species has taken possession of nearly all of the prominent bays. On the Oregon coast it is especially abundant in Netarts Bay, where it is the dominant species, being well protected in the gravel beds. This clam is also abundant in the mud flats of Yaquina River on both sides of the channel between the towns of Yaquina and Newport. The species is a conspicuous one in the coastal waters of Oregon, where conditions are favorable for it, as far south as Coos Bay (Figures I, II, IV). Winchester Bay at the mouth of the Umpqua River is well supplied with this clam but it is entirely wanting in the tide flats of the Siuslaw River.

Schizothaerus nuttalli is very short lived when removed from the water and, therefore, is chiefly used as food locally. Quantities of this species, however, are canned by tourists on visiting the coast during the summer and carried away for future consumption. This is also one of the species made use of by the cannery at Tillamook City in the preparation of minced clam products.

4. Mya arenaria Linnaeus.

The "long neck clam," which was transported from the Atlantic coast many years ago, probably with oyster spat, has become well adapted to conditions in many localities on the Pacific coast where it inhabits the mud flats of bays and rivers often advancing up the latter several miles from the ocean but always remaining within the influence of salt water. The species has established itself on the Oregon coast in nearly all of the protected bays and many of the rivers from Coos Bay northward. In the Siuslaw River, between the towns of Florence and Acme about 4½ miles from the ocean, are very extensive beds and the finest specimens of Mya arenaria that have come under the writer's observation in the northwest (Figure III). Here on both sides of the channel, but mostly on the north shore, large areas of mud flats are exposed during even a moderately low tide. Many of the shells of clams taken here measure more than six inches in length. This locality supplies the local demand as well as the markets of the upper Willamette Valley towns. Although the species has

prospered in the Siuslaw River since its introduction about forty years ago, there are certain local conditions which may in time work toward its depletion. The North Fork, a tributary of the Siuslaw River of considerable size, pours its fresh waters, after a period of heavy rainfall, over the tide flats occupied by the clams. During times of unusually high water the tide flats are sometimes flooded continuously for several weeks at a time permitting much silt and sand to be deposited on the surface of the clam beds. During the latter part of December 1917 and throughout January, 1918, excessive rainfall caused exceedingly high water in both the Siuslaw River and its tributaries, as a result of which the clam beds were washed by comparatively fresh water for nearly four weeks. When examined at the end of January 1918, a very high percentage of the young clams, then from 20 to 30 mm. in length, were dead. They were alive and in good condition when examined in December 1917 just before the heavy rainfall. A dense layer of fine sand from ½ in. to 2 in. deep covered the surface of the clam beds after the recession of the high water, smothering, in my opinion, the younger and weaker individuals. Clams attaining a length of 50 mm. or more apparently were able to withstand these unusual conditions and survived but practically all of the smaller individuals were destroyed.

Beds of Mya arenaria of considerable size are found in the mud flats on the east side of Coos Bay opposite North Bend, from which source local markets are supplied. The species also inhabits certain tide flats of the Yaquina River above the town of Yaquina several miles from the ocean, and has gained a foothold in other bays and rivers along the northern half of the Oregon coast.

5. Saxidomus giganteus Deshayes.

Although this species has been taken at several points along the Oregon coast and its shells may be found scattered along the beaches, it has accumulated in but one locality in sufficient numbers to be considered of economic importance. This clam is a characteristic one of Netarts Bay where formerly it was recognized as an abundant species (Figure I). During recent years, however, a gradual depletion of the species has been going on,

whether due to demands of local consumption or other causes has not been ascertained. The clam has never been widely marketed from Netarts Bay owing to the lack of transportation facilities from that locality to inland points, but it is a popular species for local use.

Saxidomus giganteus has also been taken in small numbers from the gravel of the north shore of Yaquina Bay. As a result of recent dredging operations in that bay there is, however, scarcely a possibility that the species may have escaped extermination. The species also occurs at Sunset Bay and no doubt may be found along the open beaches in other localities. It is characteristic of the ocean beaches or the sand and gravel beds of bays with very direct circulation from the ocean.

6. Cardium corbis Martyn.

This species is a common form in the larger bays and on the tide flats of some of the rivers of Oregon. It may be considered an abundant species in Tillamook Bay where it furnishes a source of supply for the cannery in Tillamook City which operates intermittently during the year. The species is also abundant on the mud flats of Yaquina River between the towns of Yaquina and Newport, especially on the south side of the channel. It also occurs in Netarts Bay, Coos Bay and other localities along the coast being commonly associated with Schizothaerus nuttalli and Paphya staminea (Figures I, II, IV).

7. Macoma nasuta Conrad.

The "bent nose clam" not only does not find its way into the markets of the northwest but is usually neglected by those who have access to the beaches and frequently indulge in sea foods of the molluscan variety. The species, however, is a familiar one along the Oregon coast. Until recently it was very abundant in the gravel beds of the north shore of Yaquina Bay (Figure II). In this locality, where it is known as the "oyster clam," it is considered of excellent quality by the few who make use of it as food. Dredging operations in Yaquina Bay, as mentioned above, have here quite depleted the species along with

others. In 1919 the clam could still be obtained there but in fewer numbers than in former years. It may, however, regain its previous abundance as it is not much sought after and rarely disturbed. The species occurs in other localities both north and south of Yaquina Bay but its economic value as human food on the northwest coast may be considered almost negligible.

8. Pholadidea penita (Conrad).[4]

Distributed northward and southward on the Oregon coast from Nye Beach as the locality of greatest abundance is the rock borer, locally known as the "rock oyster," a bivalve mollusc of recognized food value. The sloping ledges of soft rock paralleling the shore line just off Nye Beach abound with this species. They can be reached during a moderately low tide and with an extremely low tide large areas are exposed. The species is taken at other points along the Oregon coast both north and south of this locality, but is nowhere else so easily accessible or obtained in such abundance. The mollusc is used as food quite extensively locally, especially during the summer months when many people visit this beach. Whether the species is being depleted or not cannot be ascertained at this time. Naturally great destruction of young and immature individuals occurs during the process of breaking the larger specimens out of the rocks. The inshore ledges of rock also seem to be quite well worked over but until more is known of the life history and rate of growth of the species nothing definitely can be asserted as to its stability or depletion.

9. Mytilus edulis Linnaeus.

This smaller and smoother of the two common sea mussels occurs along the entire Oregon coast wherever conditions will support it. It is not only found along the open ocean from Tillamook Head southward but is common in protected bays and frequently finds its way up rivers several miles from the ocean

[4] The Oregon coast is also within the range of a closely related species, Pholadidea ovoidea (Gould). A very large rock borer, probably Parapholas californica (Conrad), has been taken by the writer on the north shore of Yaquina Bay. It is a negligible factor, however, even in local food consumption, due to its scarcity.

but still within the influence of salt water. It thrives well in the Siuslaw River four miles from its mouth.

Although in unlimited quantities along the coast this species and the following one, aside from very insignificant local consumption, have not yet come to have any place in the list of human foods of the northwest.

10. Mytilus californicus Conrad.

The large, ribbed mussel is characteristic of the rocks and headlands which face the ocean receiving the full sweep of the waves. It is attached to the rocks just below high tide and seems to thrive best where the surf is strongest. The species is a common form on the rocky shores throughout the coast of Oregon from Tillamook Head southward. It is especially abundant north of Siletz Bay at a point opposite Devils Lake. Here chains of rocks which parallel the shore and are exposed at low tide have vast areas literally covered with this mussel. It is also very abundant between Netarts Bay and Cape Mears (Figure I), as well as in numerous other localities near the central and southern portions of the coast.

11. Pecten sp.

Whether pectens are well distributed off the northwest coast has not been fully determined. They have been dredged in considerable quantities from Puget Sound and have occasionally been taken off Newport on the Oregon Coast. They are, however, seldom if ever seen in the markets of the northwest and apparently little effort has been made to develop this phase of the fishing industry. To determine the possibilities of the pecten fisheries extensive surveys should be made along the entire coast and proper gear provided for the boats.

Those familiar with the importance of these bivalves on the Atlantic coast would welcome any efforts to add the pectens to our list of sea foods in the northwest.

MARKET POSSIBILITIES FOR FRESH PRODUCTS.

In order that clams and mussels may be satisfactory and

safe foods they should be obtained from uncontaminated localities and be prepared as soon as possible after having been taken out of their natural surroundings. There is no doubt that clams and mussels may be contaminated by growing in water polluted by sewage, or if too long out of water the micro-organisms they contain may release toxic elements which render the shellfish not only unfit but highly dangerous as food. Clams or mussels taken from near the mouths of sewers or rendered unsafe by other causes should not be used, or permitted in markets for sale any more than spoiled produce of other kinds.

If, however, they are taken from sanitary localities and are properly prepared soon after digging, or after having been adequately preserved by cold storage methods, clams and mussels will prove to be most excellent and nourishing food.

1. Mya arenaria Linnaeus.

Numerous experiments have resulted in the conclusion that of the bivalves mentioned above this clam has the greatest tenacity of life and will remain in an edible condition longer than any of the other species, after having been removed from the water. By icing the clam it has been kept alive for a period of 14 days after its removal from salt water. This would permit of its transportation for a considerable distance from the coast if the same were made under proper conditions. If kept at low temperature this species may remain in fit condition for food for as long as a week after having been taken out of the water.

Mya arenaria is abundant in the Siuslaw River and Coos Bay both of which are in direct connection by railroad with Willamette Valley points. The species may be expressed from the coast to many inland towns or even to Portland the same day it is taken from the water and will remain good for the markets for several days after reaching its destination.

2. Siliqua patula Dixon.

The markets of Portland are supplied during the open season with this species from the Clatsop County beaches, 4½ to 5 hrs. by express, or from the Washington beaches requiring

about the same time for transportation. If shipped at night the clams are in good condition for markets the next day, but they do not endure so long out of water as does Mya arenaria. If iced the razor clam will remain in an edible condition for about 36 hours. It is not practical, therefore, to ship this species any great distance from the coast and expect it to reach its destination in a marketable condition.

3. Schizothaerus nuttalli Conrad.

On account of its poor shipping qualities this clam is not a good one for other than local markets. The shell is thin and fragile being easily broken in transportation, and the clam is short lived after its removal from the water. The species will live three or four days if kept at low temperature but should be prepared for food as soon after digging as possible. It may be shipped from Coos Bay to Willamette Valley markets in from 8 to 12 hrs. by express and can be recommended as food the next day but seldom after that time. Shipments from Netarts Bay to Eugene, Oregon, not less than 15 hrs. by express, made during the winter months, sometimes came through in fair condition and at other times all of the clams perished on the way. In none of these shipments were they iced.

4. Paphia staminea (Conrad).

The "little neck clam" is one of the best of shippers due to the hardness of its shell, and is also a fairly long lived clam when removed from the water. Quantities of this species are to be found in the Portland markets being expressed from Olympia, Washington. It is often shipped as far south as Eugene, Oregon, from the southern shores of Puget Sound, reaching its destination in good condition and remaining in an edible condition for several days, sometimes lasting a week if placed on ice. The species is not found in sufficient numbers in any locality along the Oregon coast to make it worth while to attempt to supply the demands of a regular market. It is used quite freely, however, for local consumption wherever it can be obtained.

5. Cardium corbis Martyn.

This species is very short lived when removed from the salt water and, although it has a very hard shell, is a very poor market clam. It occurs in considerable abundance in both Tillamook and Yaquina Bays but its poor shipping qualities would make impractical attempts to market the species in a fresh condition at any great distance from either of the above localities. Its food value is chiefly a local one, although it is one of the chief sources of supply for the cannery at Tillamook City.

6. Saxidomus giganteus Deshayes.

Netarts Bay is the only locality on the Oregon coast in which this species can be obtained in any numbers and even there in 1919 the clam had become so depleted that comparatively few could be had. At the present time the supply is too meager to meet the demands of local consumers and the nearby markets of Tillamook City. This clam is one of the best of shippers, having a very hard, thick shell and is fairly long lived, the valves of the shell closing tightly preventing rapid evaporation of water. Measures should be taken toward the cultivation of this species in Netarts Bay and elsewhere, as it represents one of the best of our edible clams.

7. Mytilus edulis Linnaeus.

8. Mytilus Californicus Conrad.

It has been the experience of the writer, as well as of others, that sea mussels cannot be preserved long in a fresh condition after being removed from the water. Field[5] was not able to keep Mytilus edulis in an ice chest longer than 24 hrs. but suggests that improved methods could probably be devised for preserving the species in cold storage for a sufficient length of time to enable it to reach inland markets.

With the indirect transportation facilities from Oregon coast points where the sea mussels are in greatest abundance, there is

[5] Field, I. A. The Food Value of Sea Mussels, Bulletin of the U. S. Bureau of Fisheries, Vol. 29, 1909, Doc. No. 742. Feb. 24, 1911.

slight possibility of these species becoming important fresh food products of inland markets in the near future. According to Field, cited above, the pickling of sea mussels has become an industry on the Atlantic coast, and as indicated by the census report, referred to in the introduction of this paper, they are being canned to some extent in California. The mussels of the Oregon coast have not found their way into the markets in any form and are used in very insignificant quantities by local consumers.

As it is evident that few of the clams and sea mussels of the northwest coast can be placed on inland markets as fresh products, it would seem, therefore, that methods of converting them into articles of trade locally might be employed to advantage. In the opinion of the writer, the clams of the Oregon coast are of insufficient quantity to enable any of the species to long stand the strain of being subjected to the usual demands of a cannery running at full capacity throughout the year and utilizing only these products. It is believed, however, that canneries of more general character, if the cost of equipment would permit, capable of handling not only clams and mussels but fish, berries and other produce during the seasons of the year, might be established and run on a paying basis in the vicinity of Netarts Bay, Yaquina Bay, on the lower Siuslaw River and on Coos Bay. Fish canneries are in operation at some of these points but none, I believe, are handling shellfish at the present time.

SPAWNING PERIODS AND GROWTH.

1. Siliqua patula Dixon.

As a result of microscopic examinations of the sex organs at different periods of the year it is evident that the razor clam spawns during the summer months. The exact limits of the period, however, have not been definitely determined at this time.

An examination of male clams on January 28th revealed the condition of the spermaries characteristic of this species during the winter months. Spermatocytes were observed to be in various stages of development but no mature spermatozoa could be detected. On May 10th spermatozoa were fully formed but showed

no activity at this time. On July 22nd, however, there was evidence that the species was in the midst of the spawning season. Spermatozoa were well formed, mature and very active. As in case of many other clams, ova may be detected in the females at any period of the year; on July 22nd, however, they were very large and well rounded, their maturity evidently corresponding with the maturity of the spermatozoa. On examining males and females September 4th it was observed that the bodies of both were spent, indicating that the spawning season was past.

After having examined the ovaries and spermaries of the razor clam throughout several successive years, it may be safely concluded that the species on the beaches of Clatsop County, Oregon, begins spawning in the early summer, probably about June 1st, and continues throughout July and August (Figure V, 1, 2, 3).

There are reasons to believe, however, that the period of spawning may vary somewhat from year to year. On September 4th, 1918, of the small razor clams found in the sand there were few under 30 mm. in length of shell, probably indicating a relatively early summer spawning for the species. On September 15th, 1919, however, small clams ranging from 8 to 20 mm. in length were very abundant, which may indicate a difference in the growing conditions during the two summers or that the spawning season was somewhat later in 1919 than in the preceding year.

2. Schizothaerus nuttalli Conrad.

Microscopic examinations of the ovaries and spermaries of the "Washington clam," conducted during the summer, winter and spring months, indicate that the spawning season of the species on the Oregon coast takes place during February and March (Figure V, 4, 5, 6).

Early in February well developed spermatozoa begin to appear in the spermaries with some activity noted. On March 26th, 1918, spawning was still in progress, the bodies of both males and females being well filled with the sex elements, the spermatozoa showing great activity and the ova evidently in a state of matur-

ity. On March 29th, 1919, however, both male and female clams were in a spent condition. There is probably some variation in the duration of the spawning season from year to year and, no doubt, a like variation under different conditions. My observations were made at Newport, Oregon, where the clams were taken from the protected tide flats of the Yaquina River.

The examination of males on July 31st did not reveal the presence of formed spermatozoa. It is quite clear that there is no summer spawning of this species on the Oregon coast. In September 1918, small clams about 50 mm. in length were quite abundant in the gravel beds of Netarts Bay. Although the rate of growth of Schizothaerus nuttalli has not been determined, it is very probable that these small clams may have resulted from the spawn of the previous spring.

3. Paphia staminea (Conrad).

There is some evidence to believe that the "little neck clam" has both a spring and a late summer spawning season on the Oregon coast. Examinations made at Newport on March 30th revealed ova and spermatozoa apparently in a state of maturity, the latter very active (Figure V, 7, 8, 9). The condition of the bodies of both males and females indicated that the spawning period was approaching. On September 22nd of the same year the species was examined at Coos Bay and found to be in a condition identical with that observed at Newport in March. The ova were to all appearances fully matured and the spermatozoa were very active.

On July 31st, 1918, well formed spermatozoa were found in this species at Netarts Bay but they were in a resting condition. I have not examined the species at Newport in September or at Coos Bay in March. In both localities, however, the clams were taken within protected bays and the variance in temperature of the two places cannot be great. It would appear, therefore, from our present incomplete knowledge, that Paphya staminea may spawn in both the spring and late summer seasons on this coast.

4. Mya arenaria Linnaeus.

The reproductive organs of this clam have been examined

each month throughout the year. In the Siuslaw River the species spawns during the late summer the period closing about the middle of September. Fully formed spermatozoa may be detected about the first of July while usually by the 15th of September the bodies of both males and females are in a spent condition. Later in the year and during the winter and spring months young, immature ova and spermatocytes in various stages of development are present. The height of the spawning season in this locality seems to be the latter part of August and the first week in September (Figure V, 10, 11, 12).

By the latter part of November young clams from 10 to 25 mm. in length may be found in the beds just under the surface of the mud beneath patches of eel grass. The eel grass serves as a hold-fast for the embryonic clams which cling to it by their byssus threads until they are of sufficient size to dig into the soft mud.

Kellogg[6] reports that the breeding season of Mya arenaria in Buzzards Bay extends from the latter part of May to the early part of August, reaching its height in late June or early July. Local conditions probably determine the spawning period of this species in each locality.

The rapid growth of Mya arenaria, especially when young, and the demonstration of the success of replanting depleted areas make this species a suitable one for experiments in clam culture. Rapidity of growth depends, naturally, upon a number of conditions such as the character of the bottom, currents, exposure between tides, amount of food, etc. It has been shown by Kellogg, as cited above, that clams from 1 to 1½ in. long when planted may reach a fair marketable size in one year's time.

Nightingale[7] has pointed out that clam culture will insure a uniform supply and restore depleted beds to their former productivity, and that clams artificially planted under favorable conditions will mature in from 9 to 14 months while in natural beds from 2 to 3 years may be required.

Measures should be taken to replant portions of the beds of

[6] Kellogg, J. L. Conditions governing existence and growth of the soft-shell clam (Mya arenaria). Part 29, Report of the U. S. Commissioner of Fisheries for year 1903. pp. 195-224.

[7] Nightingale, H. W. Concerning the Mortality of the Soft Clams at Essex, Mass. Economic Circular No. 16, U. S. Bureau of Fisheries, April 8, 1915.

Mya arenaria in the Siuslaw River which in 1919 had become depleted. Judging from the experience of the past few years, the most suitable time for artificial culture in this locality is in November or early December, if high water does not prevent, when large numbers of small clams from 10 to 25 mm. in length are to be found near the surface of the mud under patches of eel grass. These should be replanted in depleted areas, the thinning out process permitting them to mature more rapidly than would be possible in the aggregated groups in which they are naturally found. The planting may be accomplished very rapidly by the use of a sharp pointed stick for making shallow holes in the mud into which the young clams are dropped siphon end up.

5. Cardium corbis Martyn.

The "cockle" is the only hermaphroditic clam coming under the observation of the writer on the Oregon coast. During the late fall and winter months it is rarely possible to distinguish the ova or spermatozoa in this species. The sex elements begin to appear in the spring, the spermatozoa being observed as early as March 29th at Newport, Yaquina Bay. Development of ova and spermatozoa continues through the summer, spawning apparently occurring from about the middle to the latter part of September. On September 22nd ova appeared to be mature and the spermatozoa were in a state of great activity. From October to March the reproductive organs pass through phases of reorganization, the oocytes and spermatocytes becoming differentiated in the early spring. Histological sections through the reproductive organs clearly show the spermaries massed about the ovaries (Figure V, 13, 14).

6. Pholadidea penita (Conrad).

An examination of the spermaries of males of this species on March 27th at Nye Beach revealed all stages of development, in the same individual, from early spermatocytes to fully developed spermatozoa. No activity of the latter, however, could be detected. On August 19th observations in the same locality indicated large, well developed ova and apparently mature spermato-

zoa but no activity of the latter. Insufficient observation through the year renders impossible an assertion, at this time, regarding the spawning season of this species on the Oregon coast (Figure VI, 1, 2, 3).

7. Saxidomus giganteus Deshayes.

The spawning period of this species has not been fully determined for the Oregon coast. Sections of the ovaries prepared in March, June and November show little difference in the development of the ova. Spermatozoa have been found to be fully formed in March, June and November but in no case have I observed them in an active condition. A closer examination throughout the year will be necessary to make a positive statement regarding the spawning season of this species.

The ova of Saxidomus are characterized by a very thick membrane which envelops each egg, and the large amount of connective tissue separating the follicles of the ovary are also distinctive features. The spermatozoa are elongate, curved, similar to those of Paphya staminea (Figure VI, 4, 5, 6, 7).

8. Macoma nasuta Conrad.

The spermatozoa of this species are mature and active during the latter part of March on the Oregon coast. Sections of the ovaries at this time indicate, however, a considerable number of immature ova. Spawning probably occurs in the late spring or early summer months (Figure VI, 8, 9).

9. Mytilus edulis Linnaeus.

On March 25th, at Yaquina Bay, the mantles of this species were found to be well filled with fully developed spermatozoa none of which, however, were in an active condition. Ova at this time were immature. Examination of the species at Sunset Bay on September 23rd indicated that the spawning season had just passed. At this time the bodies and mantles of the mussels were very soft and watery being in a spent condition. In both of these instances the specimens were taken from localities with exposure to the open ocean. The evidence seems to indicate that

the species spawns on the Oregon coast, under the above conditions, in the late summer. (Figure VI, 10, 11, 12).

Field[8] is of the opinion that the spawning period of Mytilus edulis on the northern Atlantic coast is determined largely by conditions of weather, specimens inhabiting protected bays spawning much earlier than those more exposed to the colder waters.

10. Mytilus californicus Conrad.

Examinations of this species have not been made with sufficient regularity throughout the year to determine the spawning season on the Oregon coast.

THE OYSTER SITUATION.

The western oyster, Ostrea lurida Carpenter, has become an important fisheries product of the state of Washington but is somewhat neglected on the Oregon coast. Along the Oregon shores there are no great water areas comparable to the lower Puget Sound, Gray's Harbor and Willapa Bay in Washington which furnish very suitable environments for oyster farming. The general belief that localities on the Oregon coast favorable to the propagation of oysters are very limited has contributed to the lack of development of this phase of the fisheries industry. For many years the Yaquina River has been the only source within the state supplying marketable oysters and the annual yield from these beds is very small. A report of the U. S. Bureau of Fisheries[9] places the total market value of oysters from the Yaquina River for the year 1915 at $725.00. Statistics for more recent years, if they were available, would doubtless show a material increase in the output and steps have been taken by the State Fish and Game Commission looking toward further improvements of conditions in the Yaquina River beneficial to the oyster industry.

The beds are located near the town of Oysterville (Figure 2) and lie, for the most part, in the channel of the river. Much eroded sediment is carried down the river resulting in the necessity of frequent tonging of the beds to prevent the oysters from

[8] See footnote page 16.
[9] See footnote page 4.

being smothered. Conditions for growth, however, seem to favor the oysters in this river as they reach a good size and a greater or less amount of spat is caught each season. Practically all of the oysters from the Yaquina beds are shipped in the shell to Portland's markets.

A closed season from May 15th to September 15th covers, in a general way, the spawning period of the oyster in this locality. Some fishermen, however, believe that spawning begins as early as May 1st and favor an earlier closed season.

Many years ago an attempt was made to establish the eastern oyster in the Yaquina River. Plantings were made and careful observations kept by the state biologist but the results were not encouraging and the project was later abandoned without assurance of the oysters propagating in these waters.

A small acreage of western oysters has existed for a number of years near the head of Netarts Bay in Tillamook County. This bay is a very shallow arm of the sea with practically no fresh water entering it. Conditions here are apparently not favorable to the oysters. The high salinity of the waters of the bay and lack of organic material which fresh water streams naturally carry into the ocean, together with lack of proper care of the beds, may account for the fact that the oysters in this locality are retarded in their development and very small in size. The annual output from the Netarts Bay beds is negligible. One may occasionally find small amounts on the nearby markets of Tillamook City but the source is incapable of supplying even local demands.

About four years ago plantings of the western oyster were made on a small scale by private parties in Coos Bay. The outlook of this experiment is encouraging. A satisfactory amount of spat has been caught each season since the plantings were first made. The beds are being expanded and, with proper care and attention, there is reason to expect that this project may develop into a profitable oyster industry.

That Coos Bay once supported the western oyster in abundance is evidenced by the great quantities of shells thrown out by the steam dredge in the process of deepening the channel. The

Indians state that the oysters were destroyed during the great forest fire which swept the Oregon coast more than eighty years ago.

After careful investigation of the entire coast of Oregon it is the belief of the writer that very favorable conditions are to be found in certain regions of Coos Bay for the propagation and growth of the western oyster. The chief objection found here, as in other bays of the state, is the muddy bottom which permits no support for the oysters. In many localities it will be found necessary to prepare proper foundations of stone or shell which will serve as clutch for spat and prevent the growing oysters from becoming smothered in the sediment.

It is to be hoped that those responsible for the development of the fisheries interests of the state will give increasing attention to the possibilities of the expansion of oyster culture in Oregon.

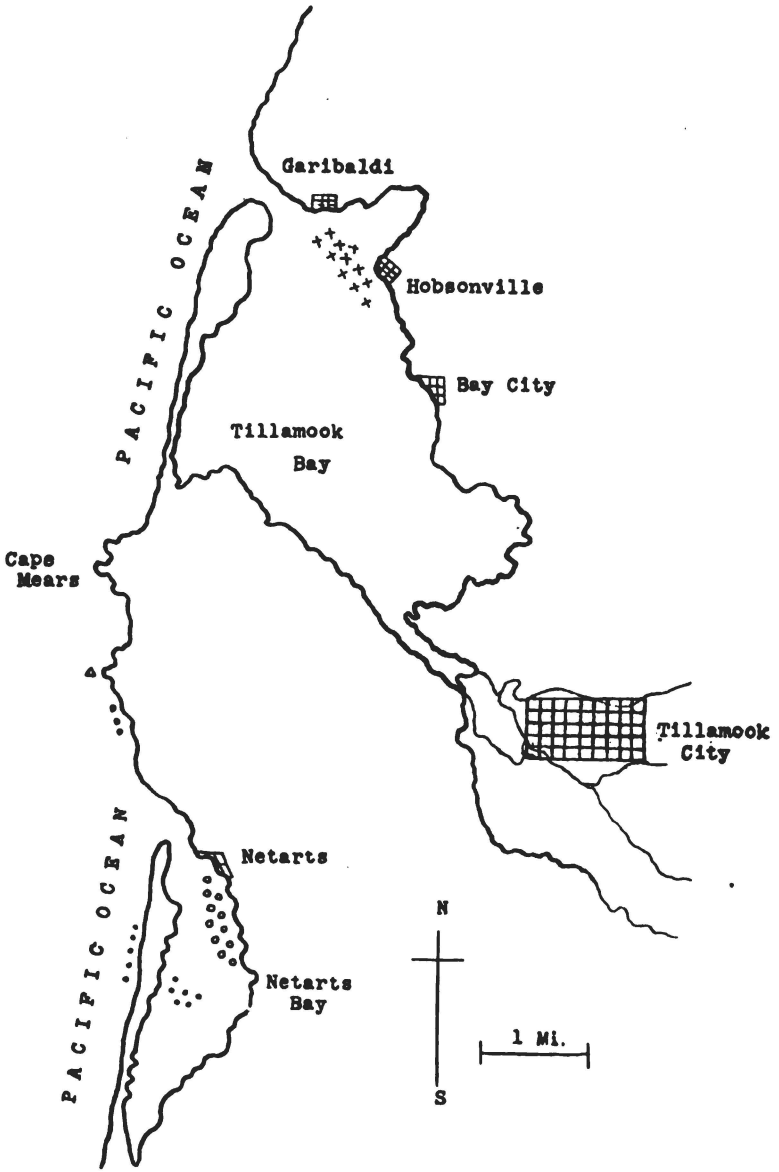

Figure I. Distribution of shellfish in Tillamook Bay, Netarts Bay and along adjacent shores. (×) Beds of Cardium corbis Martyn in Tillamook Bay. (O) Area abundantly supplied with Schizothaerus nuttalli Conrad, a small quantity of Saxidomus giganteus Deshayes and scattering numbers of Cardium corbis Martyn and Paphia staminea (Conrad). (●) Siliqua patula Dixon is known to occur within Netarts Bay in small numbers, and in 1919 reappeared on the ocean beaches both north and south of the mouth of the bay. (△) Large beds of Mytilus californicus Conrad cover the rocks south of Cape Mears.

Toward the south end of Netarts Bay is a small area of the western oyster, Ostrea lurida Carpenter. The production is slight.

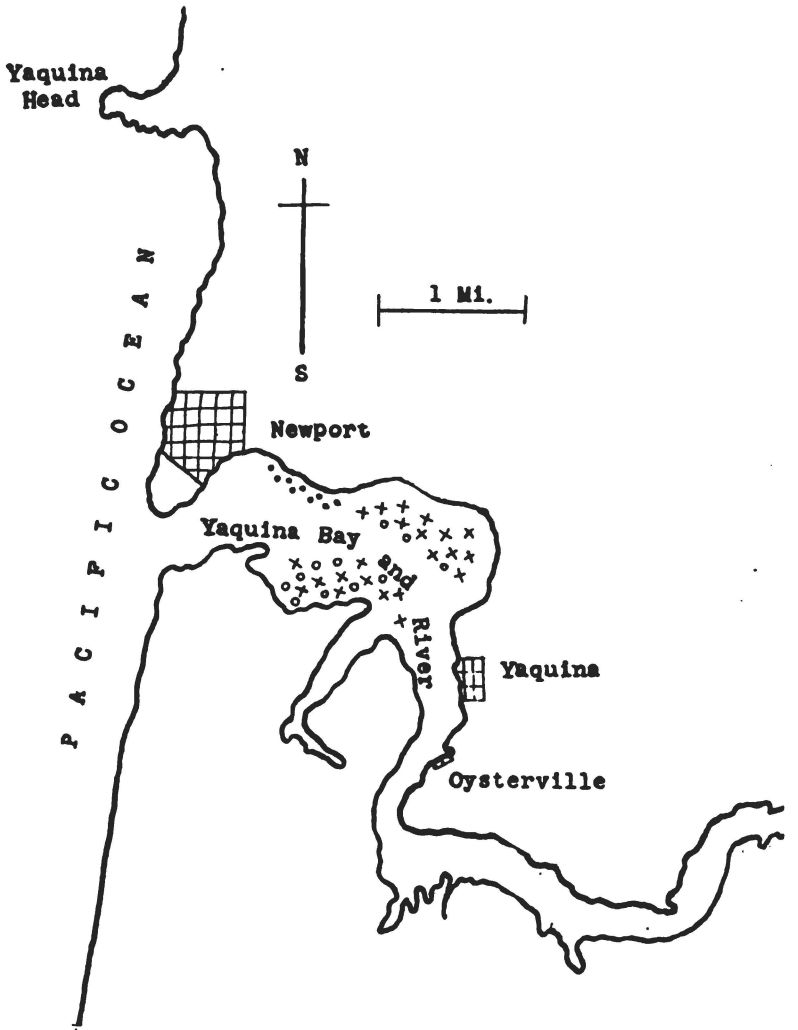

Figure II. Distribution of shellfish in Yaquina Bay and River. (× O) Beds of Schizothaerus nuttalli Conrad and Cardium corbis Martyn, the latter principally on the south side of the channel. (●) Scattering numbers of the above species together with Paphia staminea (Conrad), Macoma nasuta Conrad and Saxidomus giganteus Deshayes. The latter is rarely taken here. The beds on the north shore of the bay were largely destroyed in 1919 by dredging operations.
Mya arenaria Linnaeus occurs in the river above the town of Yaquina and beds of the western oyster, Ostrea lurida Carpenter, are located in the channel of the river near Oysterville.

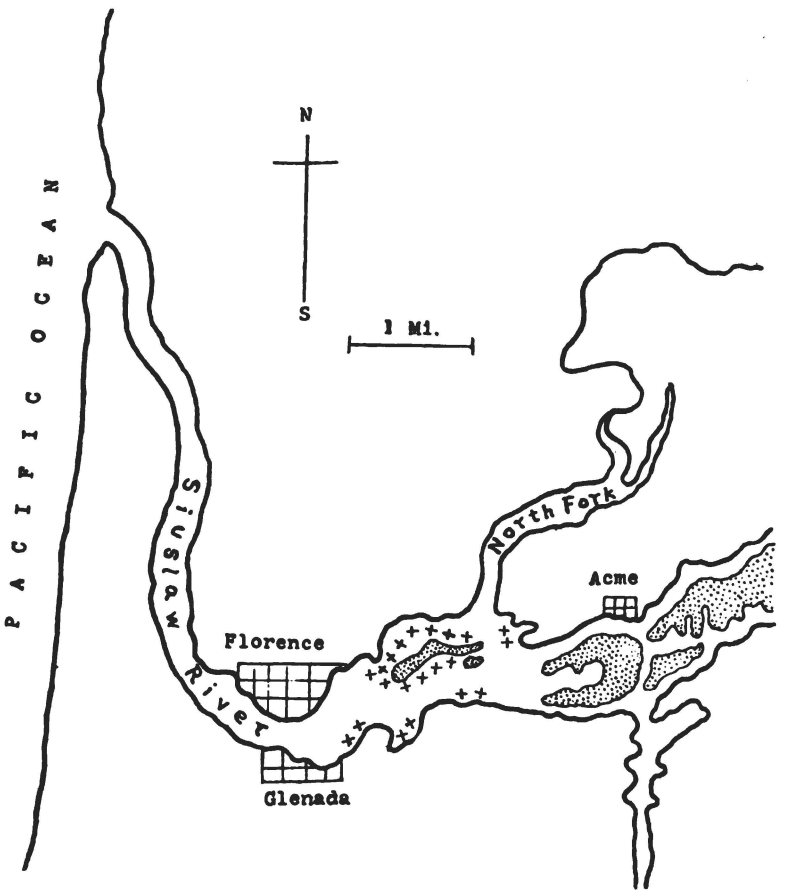

Figure III. Distribution of Mya arenaria Linnaeus in the Siuslaw River. (×) The beds chiefly on the north side of the channel between the towns of Florence and Acme.

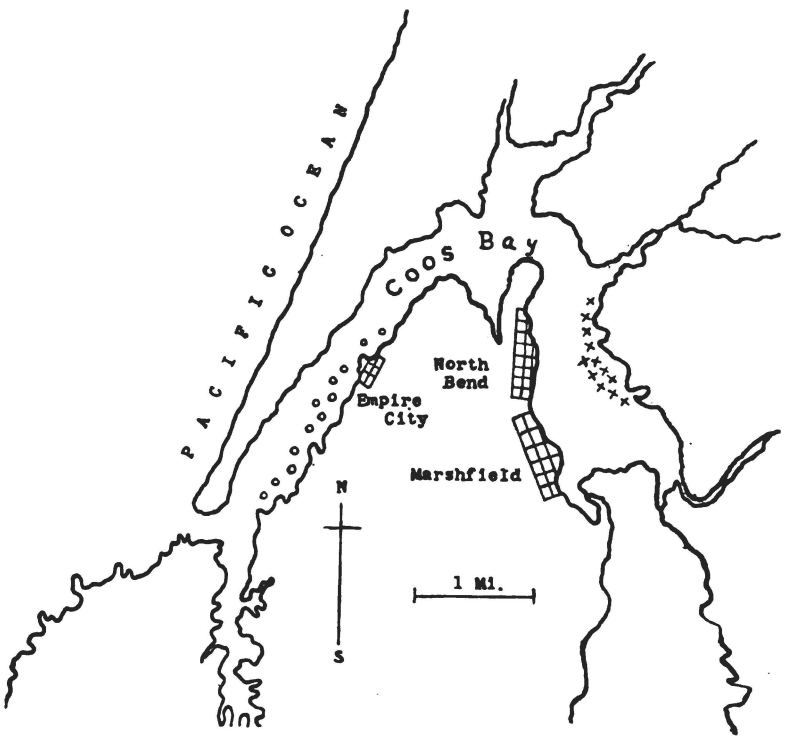

Figure IV. Distribution of clams in Coos Bay. (×) Principal beds of Mya arenaria Linnaeus opposite North Bend. (O) Scattered along the east shore of the bay below Empire City are considerable numbers of Paphia staminea (Conrad), Cardium corbis Martyn and Schizothaerus nuttalli Conrad.

Figure V. Explanation: 1. Siliqua patula Dixon. Mature spermatozoon, July 22nd. h, head; mp, middlepiece; f, flagellum. Length of head and middlepiece .004 mm. 2. Siliqua patula Dixon. Mature ovum, July 22nd. n, nucleus; nc, nucleolus. Diameter 0.125 mm. 3. Siliqua patula Dixon. Section of follicle of spermary, July 22nd. Greatest length 0.6 mm. 4. Schizothaerus nuttalli Conrad. Mature spermatozoon, March 30th. Letter reference as in 1. Length of head and middlepiece .005 mm. 5. Schizothaerus nuttalli Conrad. Section of follicle of spermary, March 30th. Greatest length 0.6 mm. 6. Schizothaerus nuttalli Conrad. Section of follicles of ovary almost spawned out, March 30th. 7. Paphia staminea (Conrad). Section of follicle of spermary, March 30th. Greatest length 0.5 mm. 8. Paphia staminea (Conrad). Ovum approaching maturity, March 30th. Letter reference as in 2. Diameter 0.12 mm. 9. Paphia staminea (Conrad). Mature spermatozoon, March 30th. Letter reference as in 1. Length of head and middlepiece .008 mm. 10. Mya arenaria Linnaeus. Mature spermatozoon, September 4th. Letter reference as in 1. Length of head and middlepiece .004 mm. 11. Mya arenaria Linnaeus. Developing phases of spermatocytes from a group of four cells to a small follicle of many cells. The earlier stages more highly magnified than the latter. 12. Mya arenaria Linnaeus. Mature ovum, September 4th. Letter reference as in 2. Diameter 0.12 mm. 13. Cardium corbis Martyn. Hermaphroditic condition shown. Follicles of spermary surrounded by follicles of ovary. August 29th. Greatest length of sperm follicle 0.4 mm. 14. Cardium corbis Martyn. Mature spermatozoon, August 28th. Letter reference as in 1. Length of head and middlepiece .008 mm.

Figure VI. Explanation. 1. Pholadidea penita (Conrad). Fully developed spermatozoon, March 27th. h, head; mp, middlepiece; f, flagellum. Length of head and middlepiece .005 mm. 2. Pholadidea penita (Conrad). Section of follicle of spermary, March 27th. Greatest length 0.6 mm. 3. Pholadidea penita (Conrad). Section of follicle of ovary, March 27th. Greatest length 0.5 mm. 4. Saxidomus giganteus Deshayes. Fully formed but not active spermatozoon, November 29th. Letter reference as in 1. Length of head and middlepiece .008 mm. 5. Saxidomus giganteus Deshayes . Section of follicle of spermary, November 29th. Greatest length 0.65 mm. 6. Saxidomus giganteus Deshayes. Ovum enclosed in a dense membrane and developing from the wall of a follicle, November 29th. f, follicle; m, membrane; n, nucleus; nc, nucleolus. Long diameter of ovum 0.125 mm. 7. Saxidomus giganteus Deshayes. Ovum approaching maturity, June 12th. Letter reference as in 6. Diameter of ovum 0.125 mm. 8. Macoma nasuta Conrad. Mature spermatozoon, March 31st. Letter reference as in 1. Length of head and middlepiece .006 mm. 9. Macoma nasuta Conrad. Section of follicle of ovary, March 31st. Greatest length 0.5 mm. 10. Mytilus edulis Linnaeus. Section of follicle of spermary from mantle, March 25th. Greatest length 0.4 mm. 11. Mytilus edulis Linnaeus. Fully formed spermatozoon, March 25th. Letter reference as in 1. Length of head and middlepiece .005 mm. 12. Mytilus edulis Linnaeus. Section of follicle of ovary from mantle, March 25th. Greatest length 0.4 mm.

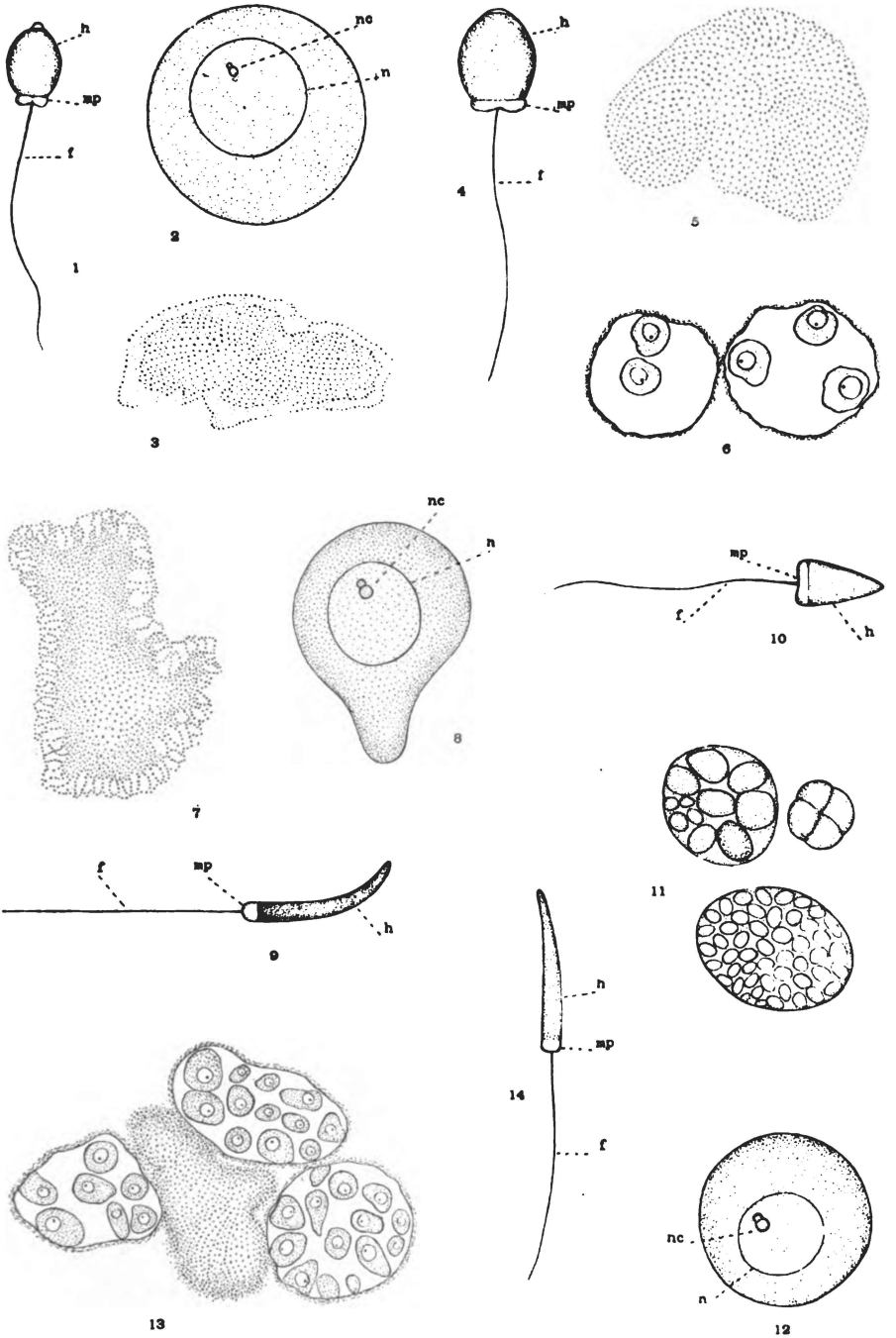

FIGURE V

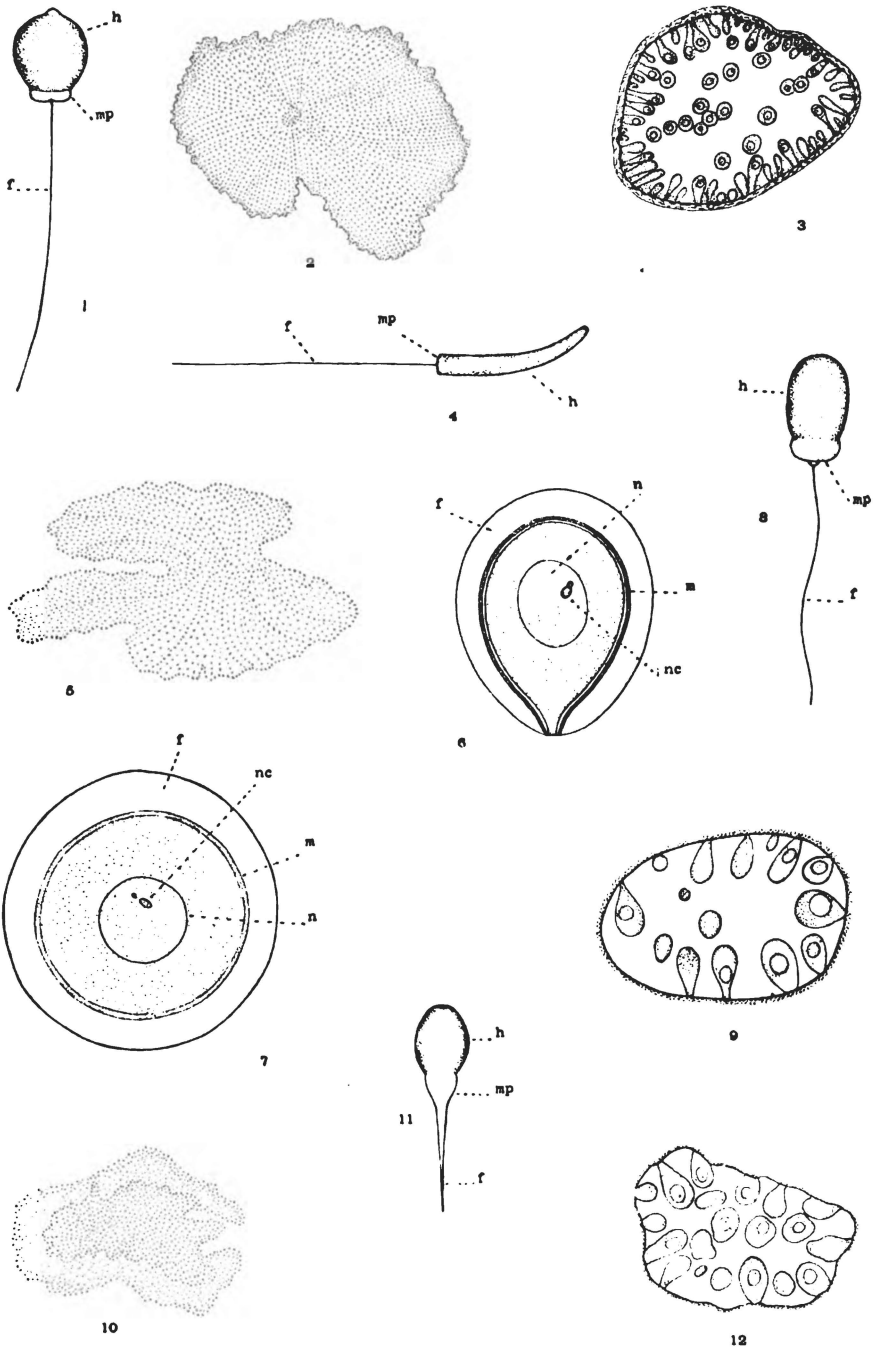

FIGURE VI.