# A PROGRESS REPORT

of

# INVESTIGATIONS OF THE NATIVE OYSTER IN YAQUINA BAY, OREGON

Covering the period
July 4 to September 15, 1939

by

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Oregon Agricultural Experiment Station
Corvallis, Oregon

Cooperating with

The Fish Commission of the State of Oregon

and

The Lincoln County Court



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## INTRODUCTION

An investigation of the native oyster in Yaquina Bay was begun on July 4, 1939, by the Oregon Agricultural Experiment Station in cooperation with the Fish Commission of the State of Oregon and the Lincoln County Court. This study was inaugurated by Governor Charles A. Sprague for the purpose of ascertaining facts which might serve as a basis for the rehabilitation of this oyster fishery, and as a basis of management for a sustained annual yield of the native oyster in Yaquina Bay.

The preliminary work in July, August and the first part of September, which was largely a reconnaissance of the Yaquina Bay

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*1. We wish to express our sincere thanks to the many persons in Lincoln county who cooperated with us in the work during this summer. Everyone asked for assistance was most helpful and cooperative. We are particularly indebted to Mr. Dow Walker, Yaquina, for the use of a house boat laboratory, boat, and many other aids; Mr Delbert C. Miller, Winant, for his counsel and the results of his many observations of the native oyster gained over a long period of years as a practical oysterman; Mr. Ellsworth Rosselle, employee of the Oregon Oyster Company, for his cooperation and actual aid in tonging specimens from the oyster beds; Judge Franklin Gilkey for his interest in the investigations; Mr. Robert D. Shirmer, Yaquina, for pointing out certain important problems; Mr. George Lewis, Oysterville, for supplying of some materials needed in cultch bags; Mr. Pete Rassmussen, Yaquina, for his general help. Many of the pictures used in this report were taken by Dr. F. P. Griffiths, Oregon State College.

oyster area, revealed many biological as well as human relationship problems to be solved in connection with this particular fishery. It was deemed advisable to devote all efforts to determining facts having direct bearing upon the practical aspects of oyster culture in the Yaquina Bay area. This has resulted in the collection of biological and ecological data during the last two and one-half months which should be of importance in the rehabilitation and future management of the native oyster in Yaquina Bay. Much of the data given in this report is incomplete because of the short time the investigations have been under way. Consequently, further studies must be conducted before definite recommendations for management of this particular oyster fishery may be given with certainty.

The emphasis of the investigations thus far was to ascertain under what conditions the oyster larvae set on cultch in Yaquina Bay. In other locations in which the native oysters, Ostrea lurida, have been studied; namely, California, Washington and British Columbia, the native beds of this species were found to thrive mainly in relatively shallow water at low tide; whereas the natural beds in Yaquina Bay are covered with from 8 to 30 feet of water at low tide. This difference in natural habitat makes much of the published information concerning the native oyster not applicable to the Yaquina Bay area.

An understanding of the factors influencing larval setting and seasonal time and rate of setting has been long recognized as of paramount importance in practical oyster culture, for the setting period is considered in most oyster areas of the world as the critical period in the life cycle of the oyster. Advocates of good oyster culture methods have long emphasized the placing of cultch (shells, cement-coated structures, brush, etc.) in the water just before the maximum of the larval setting period, in order to have the surface of these objects as clean as possible. Efficiency of the cultch is reduced by accumulation of silt or organic growth on the surface. Hopkins (1937) working with the native oyster in Puget Sound, Washington, stated ".... shells had lost one-third of their efficiency as spat collectors in nine days, even during the time when the water was most free from fouling materials and organisms".

# A GENERAL LIFE HISTORY OF THE NATIVE OYSTER

In order to assure a clear understanding of the experimental work undertaken in the summer of 1939, the following general life history of the Native Oyster, Ostrea lurida Carpenter, was compiled largely from studies made in Washington, California, and British Columbia, supplemented with observations from Yaquina Bay. Much of the data used in this section has been taken from the investigations of Joseph Stafford (1913 and 1914), A. E. Hopkins (1937), Paul Bonnot (1935, 1936, 1937) and C. R. Elsey (1933).

The native oyster, figure 1, which is also known in the Puget Sound area of Washington as the Olympia oyster of the Pacific Coast, inhabits a few bays or protected harbor areas from Queen Charlotte Sound, British Columbia, to San Diego Bay in California. In Oregon this species is found in Netarts Bay, Tillamook County, and Yaquina Bay, Lincoln County, which is the most important native oyster-producing area in the State. At one time this oyster was present in tremendous numbers in Coos Bay, as dredging operations for deepening the channel have uncovered large quantities of shell. Possibly other bays in the state produced this oyster, but , because of changed ecological conditions or because of a catastrophe such as the "big fire" which occurred before white settlement, the species may have been extirpated from a number of areas.

In 1864, R. P. Carpenter described this species as "the shape of edulis, texture dull, lurid, olivaceous, with purple stains". There are a number of morphological differences in this oyster that appear in response to the habitat in which grown. For example, the mantle

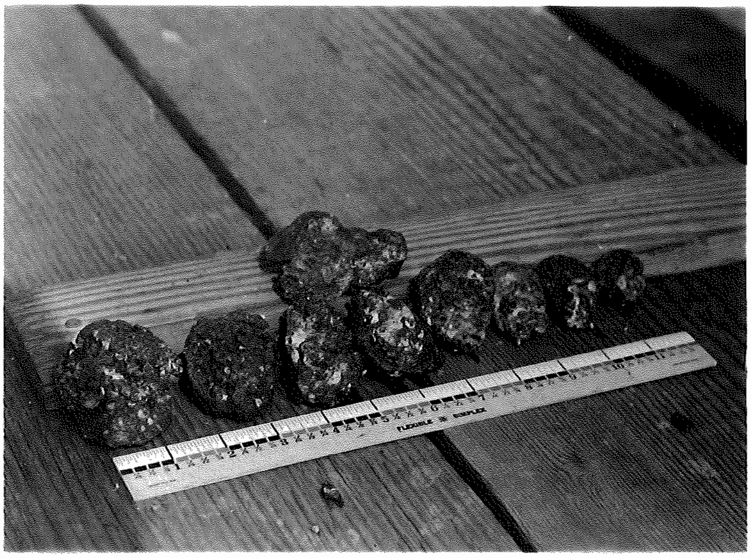


Figure 1

Native Oysters, showing age classes, 1 to 4 years (right to left).

Figure 2

Weekly Fresh Cultch Bag

of this species in Puget Sound is dark, while in Yaquina Bay the mantle has a pinkish cast. The appearance of the shell as well as the "meat" were noted as differing in various locations in Yaquina Bay. Apparently, such differences are the results of ecological conditions under which the oysters grow.

Elsey (1933), working in British Columbia, prepared the following identification table which will separate the native oyster from the two introduced species present in Yaquina Bay; namely, the Pacific or Japanese oyster, Ostrea gigas, and the Eastern oyster, Ostrea virginica. Certain observations regarding the Japanese and Eastern oysters in Yaquina Bay were made this summer and will be given later in this report. Elsey's table follows:

TABLE 1

| | Ostrea lurida | Ostrea virginica | Ostrea gigas |
|---|---|---|---|
| Popular names | Native or Olympia | Eastern or Atlantic | Japanese or Pacific |
| Marketable age | 3-5 years | 3-5 years | 2-4 years |
| Length (as marketed) | $1\frac{1}{2}$ in. - 2 in. | $3\frac{1}{2}$ in. - 4 in. | $4\frac{1}{2}$ in.-6 in. |
| Concentric growth checks | Indistinct | Clearly outlined | Very prominent and laminated |
| Radial grooves | Usually almost absent | Shallow | Very deep |
| Outer shell color | Usually yellowish grey, sometimes purple | Typically yellowish brown | Usually tinted with purple, old specimens mouse grey |
| Muscle scar inside shell | Clearly outlined but lacking pigment | Distinctly outlined dark purple | Not clearly outlined and light mauve |
| Larval state | Carried in mantle cavities for 14-17 (*2) days and have appearance of fine sand | Free-swimming | Free-swimming |
| Chief characteristic of larva | Prominent rounded umbo on left valve | Prominent pointed umbo on left valve | Prominent pointed umbo on left valve |

Spawning duration of the native oyster in different areas has a variable seasonal length, probably depending largely upon prevailing temperature conditions. On the coast of southern California (Coe, 1931), spawning may continue for a period of about seven months; in Humbolt Bay (Bonnot, 1937), May through July; and in Puget Sound (Hopkins, 1937), through May into August, with an occasional gravid oyster found as late as October. McMillin in 1931 reported finding the first eggs in native oysters in Caffrey Slough, Yaquina Bay, on May 28, and the first larvae in oysters on June sixth of that year. Since the present investigations did not begin until July 4, 1939, the beginning dates for spawning could not be determined for this year. Records are being kept so as to ascertain when spawning ceases during this season. A plankton tow made in the center of oyster grounds

*2. More recent investigations (Coe, 1931 (a) ) have shown that the development stage of eggs and larvae in the mantle is 10 to 12 days.

on July 4, 1939, revealed many oyster larvae present in the water. This would indicate that much spawning had taken place at least 10 or 12 days previously.

The beginning time and duration of spawning may vary within the same body of water, depending upon climatic conditions which control the temperature of the water. Local oyster men believe that spawning takes place at different times in various parts of Yaquina Bay because they are of the opinion that temperatures vary in different sections. This has not been, as yet, definitely substantiated.

Hopkins (1937) reported that before spawning begins, "the critical temperature for spawning may be placed at about 13 degrees C., possibly 12.5 to 13 degrees C".

Market-size oysters, three or four years of age, may produce broods of 250,000 to 300,000 larvae. The number of larvae depends largely upon the size of the producing oyster. Generally each individual produces one brood of larvae each year, and in some years single individuals may produce a second brood.

In Humbolt Bay and in Puget Sound, the larval setting appears to take place generally at two distinct periods in summer. This would indicate that setting was induced in two or more waves, depending upon optimum ecological conditions such as tides, temperatures, salinity, etc.

The native oyster, like the European species, Ostrea edulis, of commercial importance, is hermaphroditic and ova-viviparous. Germ cells, sperm and eggs are generally produced first when the oyster is one year old, or at the beginning of the second year of life. Each individual is alternately male and female, and the eggs of one oyster are fertilized by sperm of another, although germ cells of both sexes may be found in the glands of some individuals, for the sex products of one phase may not be entirely discharged before the next stage begins.

The eggs are held in the mantle chamber, where they are fertilized by sperm from other individuals. The sperm are discharged in clusters known as "sperm balls" which are made up of 250 to more than 2,000 sperm. In contact with salt water the matrix disintegrates, allowing each sperm to swim free. The eggs, after fertilization, are retained in the mantle cavity for a period of time, possibly 10 to 12 days, probably depending upon the temperature conditions prevailing at that time. During this period the eggs undergo embryonic development to the stage known as the straight-hinged larvae. The larvae at this stage possess shells or valves on which the dorsal borders are straight, in contrast with the umbo developed in the hinge region while in the free-swimming larval form. The larvae at the time of being discharged into the sea water, are 180 to 185μ long.

The larvae then go through a free-swimming stage in the water before setting upon some favorable object known as cultch. At the time of setting, the larvae are approximately 320μ long. The free-swimming stage lasts at least one month or longer, depending upon the temperature and other ecological conditions of the water. Consequently, the embryonic and post-embryonic development, from fertilization to setting of the larvae extends over a period of approximately a month and a half or longer.

# SETTING OF OYSTER LARVAE

## Larval Setting Season in 1939

As a basis for practical "seed catching operations", it is necessary that seasonal time and rate of larval setting be ascertained. If such information could be correlated with measurable ecological conditions, then there would be the possibility of predicting to within a few days the time of maximum larval attachment to cultch, providing such maximum or maxima periods exist in Yaquina Bay. With this information available to oyster men, a greater "take of young oysters" (spat) would be secured than would be the case providing cultch was placed in the water on a "guess basis".

Information available regarding the larval setting of the native oyster in Yaquina Bay at the beginning of operations on July 4, 1939, came from two sources:

(1) Local oystermen. The consensus was that there were two general setting maxima; the first occurring in late June, if the season was advanced, or if climatic temperature conditions were below normal occurring in the fore part of July. A second noticeable setting period occurring sometime in August was reported to be the normal condition. In addition, the intensity of larval setting was believed to vary in seasonal time in different locations on the oyster grounds.

(2) H. C. McMillin's unpublished report. This investigator, working for the United States Bureau of Fisheries, made studies of the larval setting conditions in Yaquina Bay during 1931. His complete report regarding this phase of the study follows:

"The short period of general setting was not found in Yaquina Bay in 1931. The first set was found on July 25 when one was taken from the experimental dike, and another from the Oysterville Flats at the Multnomah boom. Both were in fresh cultch bags. By August 1, a light set was down. About 90 per cent of the shells were blanks (without set); seldom more than one spat could be found in one shell. Setting continued slowly; by the middle of August, less than 50 per cent of the shells were blanks, and in the shipyard channel a fair set could be seen. Outside the shipyard, the total set was about equal to all other oysters on the ground. Experiments with cultch bags indicate that setting takes place at all levels in Yaquina Bay just as it does in Oyster Bay, Elkhorn Slough, and other places where it has been tried. Owing to the lateness of the light set, the results obtained from cultch bag experiments are not considered of importance."

The seasonal time and the rate of setting in Yaquina Bay from July 10 to September 15, 1939, was determined by placing "fresh cultch bags", figure 2, in the water periodically, at designated stations. The method employed was modeled after Hopkins (1937) studies in Puget Sound and Bonnot's (1936) investigations at Humbolt Bay, California. The fresh cultch bags were made of wire cloth, $\frac{1}{4}$ inch mesh, in which approximately 150 clean, native shells were placed. Each shell bag was suspended in water by means of a rope from a floating dock, to a depth of four to seven feet under the surface. The shells changed at weekly intervals were selected on the basis of uniformity of size. Two overlapping series of bags were placed at each station. Shell bags were lifted on Tuesday and Friday, new shells added, and the old shells examined. In this manner, a fresh bag was placed at each station every three or four days, and there were two bags at each station from July 10 to September 1. During September, only one series of cultch bags was used, for there was every indication that larval setting had practically ceased by September 1. This series of bags used in September was placed on September 1 and removed September 15.

Figure 3

Multnomah Loading Dock, used as Station 1

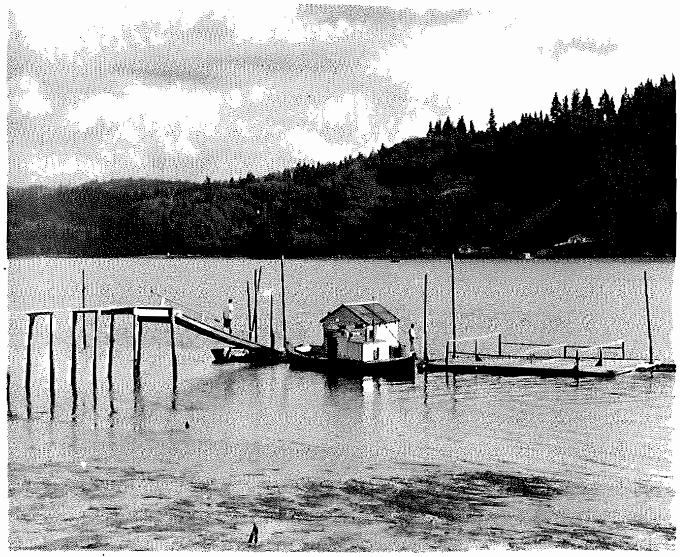


Figure 4

Miller's Dock, used as Station 2

Figure 5

McIntyre's Dock, used as Station 3

The three main stations used for this study were as follows:

<u>Station 1</u>. Multnomah Loading Dock, figure 3. This structure is located in the lower section of the native oyster grounds on the west bank of the bay.

<u>Station 2</u>. Miller's Dock, figure 4. This structure is situated at about the middle section of the oyster grounds on the north bank (Winant) across the river from the buildings of the Oregon Oyster Company (Oysterville).

<u>Station 3</u>. McIntyre's Dock, figure 5. This dock is located in the upper section of the oyster grounds on the south side at McIntyre's Point.

These stations were selected because they are located in the three main portions of the oyster grounds; namely upper grounds (station 3), middle grounds (station 2), and lower grounds (station 1).

After the cultch bags were taken from the water and the shells were dried, the "spat" (attached larvae) were located on the smooth, inner surface of the shell by means of a binocular microscope, figure 6, Figure 7 shows enlarged spat, several weeks old, on the inner surface of native oyster shell. Since the outer surface of the shell is rough, making spat of a week old or less difficult to locate with accuracy, the number of attached larvae were not recorded on that surface. However, the number of spat on the outer and inner surfaces of many shells was counted and the results indicated that the findings of Hopkins (1937), who used Japanese oyster shells, also apparently held in the case of native shells. He found that 35 per cent of the larvae attached to the inner surface, while 65 per cent adhered to the outer surface. From this data, coupled with counts on the inner surface of each shell, it was possible to ascertain the number of spat per shell in the fresh cultch bags.

Figure 6

Locating "Spat" on Native Oyster Shell

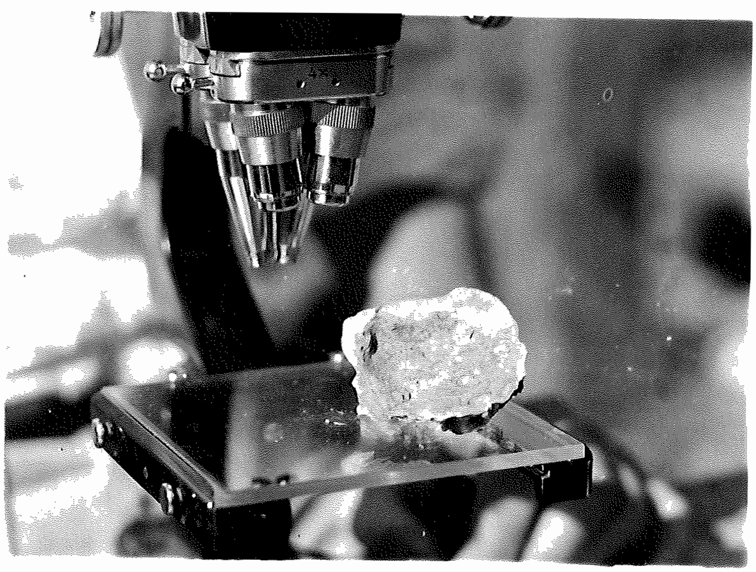


Figure 7

Enlarged "Spat", Several Weeks Old, on Inner Surface of Native Oyster Shell

The total number of spat on one-hundred shells in each bag was computed. The results of these counts are given in Table 2.

TABLE 2

Number of Spat Attached to Shells in Wire Baskets at the Three Stations, 1939

| Date Placed | Date Removed | Number of Days | Number of Spat per 100 shells Station 1 | Station 2 | Station 3 | Number Spat per 300 shells -all stations |
|---|---|---|---|---|---|---|
| July 10 | July 14 | 4 | 0 | 0 | 0 | 0 |
| July 10 | July 18 | 8 | 0 | 0 | 0 | 0 |
| July 14 | July 21 | 7 | 0 | 0 | 0 | 0 |
| July 18 | July 25 | 7 | 0 | 0 | 0 | 0 |
| July 21 | July 28 | 7 | 6 | 14 | 11 | 31 |
| July 25 | Aug. 1 | 7 | 54 | 43 | 163 | 260 |
| July 28 | Aug. 5 | 7 | 20 | 17 | 37 | 74 |
| Aug. 1 | Aug. 8 | 7 | 23 | 54 | 48 | 125 |
| Aug. 5 | Aug. 11 | 7 | 0 | 23 | 20 | 43 |
| Aug. 8 | Aug. 15 | 7 | 149 | 71 | 154 | 374 |
| Aug. 11 | Aug. 18 | 7 | 23 | 23 | 9 | 55 |
| Aug. 15 | Aug. 22 | 7 | 4 | 3 | 9 | 16 |
| Aug. 18 | Aug. 25 | 7 | 20 | 9 | 43 | 72 |
| Aug. 22 | Aug. 29 | 7 | 6 | 3 | 0 | 9 |
| Aug. 25 | Sept. 1 | 7 | 0 | 0 | 0 | 0 |
| Aug. 29 | Sept. 8 | 10 | 0 | 0 | 0 | 0 |
| Sept. 1 | Sept. 15 | 14 | 0 | 0 | 0 | 0 |
| Total Spat All Stations | | | 305 | 260 | 494 | 1059 |

The counts per shell or per 100 shells were less than those found in most cases by Hopkins (1937) in Puget Sound and Bonnot (1936 & 1937) in Humbolt Bay. Their comparative differences in numbers cannot be taken as difference in oyster abundance between the three areas (Yaquina Bay, Puget Sound, and Humbolt Bay) because both of these investigators used the much larger shells of the Japanese Oyster, while the small sized shells of the native oyster were used in the Yaquina Bay studies. The use of the native shells was necessitated as they were the only kind available in sufficient quantities.

Significant observations from the fresh cultch bag studies were as follows:

(1) During the time that the bags were in place at the three stations, July 10 to September 15, spat were not found until July 26 or 27. Spatting had apparently ceased by August 25.

(2) During the spatting period, July 26 or 27 to August 25, spatting was continuous over a period of approximately 30 days.

(3) Within this continuous spatting period, two maxima larval setting periods were noted:

(a) The first maximum spatting period occurred between July 25 and August 1.

(b) The second maximum spatting period occurred between August 8 and August 15.

(4) There appeared a marked correlation between maxima spatting periods and the extreme tidal "run outs" during low water of the Spring Tides. The greatest amount of spatting appears to take place in the series of extreme low tides occurring during "Spring Tides". This probably happened about the time that the low "Spring Tides" were decreasing to the zero mark and just before the minus stages were encountered. Before a definite statement regarding a positive correlation of the stage of low water of the "Spring Tides" and maxima larval setting in Yaquina Bay may be made, at least another year's study of this phase of the problem will be needed.

(5) Generally, but not always, the rate of spatting was uniform at the three main stations on the same dates. When an increase in number of spat was encountered at one station there was generally an increase at the other two stations. Conversely, a decrease in numbers of spat at one station was correlated with a decrease at the other two stations. This would indicate that ecological conditions, yet undetermined, affecting

spatting operate simultaneously over the entire oyster ground.

Since the investigations and work regarding the seasonal rate of spatting was not begun until July 10, this summer's work did not definitely prove the presence of an early larval setting period. Although all local oystermen interviewed believed that there had been a setting period previous to July 10, the indications were that no spatting preceded July 26 or 27. This indication of the lack of an earlier spatting season was based upon the following:

(1) The spat on shells suspended in water continuously from July 18 until September 12, 1939 were not noticeably smaller in size than any spat observed on shells tonged from the middle oyster grounds on September 12. Many of the tonged shells had been in the water over one year.

(2) McMillin (1931) reported that in 1931 "the first set was found on July 25 when one was taken from the experimental dike from the Oysterville Flats at Multnomah boom". This statement is interesting in the light of the fact that the first recorded spatting in 1939 occurred on July 26 or 27.

Experiments with Monthly Cultch Bags

Cultch bags constructed of one inch hexagonal wire mesh, approximately two feet long and six inches wide, were filled with about 200 clean native shells, figure 8. These bags, known as "monthly cultch bags" were suspended from the floating docks at stations 1, 2, and 3 for the purpose of ascertaining if a "commercial set" of oyster larvae could be secured in this manner, but on an enlarged scale.

These bags were first suspended on July 18, 1939, one at each station. On August 18, the monthly bags were raised from stations 2 and 3. The bag at station 1 was allowed to remain in the water until

Figure 8

Monthly Cultch Bag

August 29, at which time spatting had apparently ceased. From each of these bags, 100 shells were selected at random and the spat present on the inner surface of each shell were counted and recorded. In order to be conservative in making a total count of spat per shell, the number of attached larvae found on the inner surface was multiplied by two to secure the total spat occurring on both the inner and outer surfaces of each shell. The results of these spat counts are given in frequency Tables 3, 4, and 5.

TABLE 3

The Frequency Table of Spat
on 100 Shells from Monthly Bag Suspended from Station 3
July 18 to August 18, 1939

| Number of Spat per shell | Frequency |
|---|---|
| 0 | 4 |
| 2 | 20 |
| 4 | 22 |
| 6 | 17 |
| 8 | 15 |
| 10 | 5 |
| 12 | 8 |
| 14 | 4 |
| 16 | 4 |
| 18 | 0 |
| 20 | 2 |
| 22 | 0 |
| 24 | 1 |
| 26 | 0 |
| 28 | 1 |
| Total Shells | 100 |

Total spat on 100 shells = 670

Average spat per shell = 6.7

TABLE 4

A Frequency Table of Spat
on 100 Shells from Monthly Bag Suspended from Station 2
July 18 to August 18, 1939

| Number of Spat per shell | Frequency | |
|---|---|---|
| 0 | 30 | |
| 2 | 20 | Total spat on 100 shells = 322 |
| 4 | 20 | |
| 6 | 19 | |
| 8 | 4 | Average spat per shell = 3.22 |
| 10 | 5 | |
| 12 | 1 | |
| 14 | 1 | |
| Total Shells | 100 | |

TABLE 5

A Frequency Table of Spat
on 100 Shells from Monthly Bag Suspended from Station 1
July 18 to August 29, 1939

| Number os Spat per shell | Frequency | |
|---|---|---|
| 0 | 49 | Total spat on 100 shells = 186 |
| 2 | 25 | |
| 4 | 13 | |
| 6 | 6 | Average spat per shell = 1.86 |
| 8 | 6 | |
| Total Shells | 100 | |

Monthly cultch bags were again placed at stations 2 and 3 on August 18 and at station 1 on August 29, the dates that the first series were taken from the water. Results from the second series are not available for they are still in the water at this date, September 15.

Significant items in regard to observations concerning monthly cultch bag experiments are as follows:

(1) A commercial set was secured at stations 2 and 3 and not at station 1. Definite information covering a standard for a commercial set of the native oysters is not available, except in an indirect way. Local oystermen at Yaquina Bay are of the opinion that one spat per native shell is a satisfactory set; however, this seems too low when mortalities encountered to the adult stage are considered. Galtsoff, Prytherch, and

McMillin (1930) reporting on studies of spatting with the Eastern oyster on the Atlantic Coast stated: "In bags, Number 1 and 2, where the setting was comparatively light, it was found that 66.5% and 70% of the shells, respectively, had collected a satisfactory set of more than four spat per shell." Comparatively, the shell surface of the eastern oyster is considerably greater than that of the native oyster. Until further information is available, an arbitrary standard of <u>three spat per native oyster shell will be considered as the minimum satisfactory commercial set</u>. Further investigation may prove this arbitrary standard to be unreliable.

(2) The lack of a satisfactory set of spat at station 1 was accounted for on the ground that the spatting surfaces of the shells were greatly reduced by the attachment of young barnacles. The indications were quite definite that the "young barnacle set" is a limiting factor for a commercial set in the region of station 1, particularly if the placing of cultch preceded by several days the maxima of spatting periods. In this connection, there were many indications that barnacles (species as yet undetermined) in many parts of the entire oyster grounds are inimical to setting of native oysters. On many occasions, shells of various species of mollusks tonged from the oyster grounds were heavily coated with barnacles, and no young or old oysters were present. There was every indication that if barnacles could be controlled in native oyster areas of Yaquina Bay, that a greatly enhanced native oyster fishery would result. In this connection, it was interesting to note that some of the local oystermen of long years experience in Yaquina Bay remarked that the barnacles were more numerous in recent years than was formerly the case.

Experiments with Strung Shells

For the purposes of ascertaining some of the important setting habits of the native oyster in Yaquina Bay, oyster shells were strung on wire, figure 9, and submerged perpendicularly from floating docks. Some of the objectives of this experiment with strung shells were:

1. To determine the spat collecting efficiency of upper surfaces in comparison with under side surfaces.

2. To determine if the amount of spatting was influenced by variations in water depth.

3. To determine if a commercial set of spat could be obtained by the use of strung shells suspended from floating docks. This method is used in Japan and elsewhere.

On July 18, one string of shells was placed in the water at station 3. On the same date two strings of shells were placed at station 2.

The two strings of shells were removed from station 2 on August 14, which was shortly after or about the end of the second maxima spatting period as disclosed by the weekly fresh cultch experiments. One of these strings of shells was suspended from a floating dock at Yaquina, figure 10, which is about one-half mile below the lower limits of the oyster grounds, for the purpose of determining if spat would live or grow in the lower parts of Yaquina Bay. Examination of this string on September 15, thirty-two days after moving to Yaquina, revealed that the spat were still alive and increasing in size. This observation may have much significance, when coupled with further investigations, for extending plantings of the native oyster to now unproductive areas in the bay.

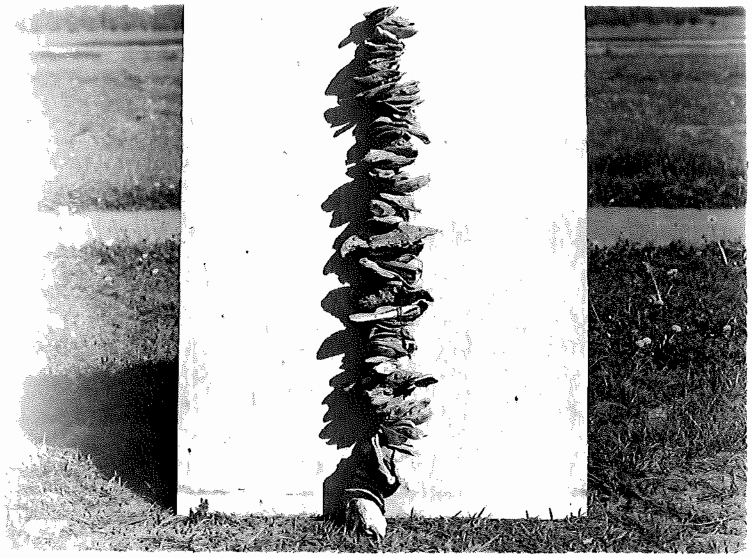


Figure 9

A String of Shells, Japanese and Eastern Oysters, Before Being Placed in Water

Figure 10

Floating Dock at Yaquina, Near Oyster Laboratory

The spat on the other string of shells from station 2 were counted on the smooth side of each shell. In counting the spat, the shell used as cultch was recorded as to depth from the surface of the water and also whether the smooth surface was up, or the smooth surface down. The results of these counts on the smooth surface of the shells are given in tabulated form, in Table 6.

TABLE 6

A Frequency Table of Spat on Smooth Shell Surfaces from Station 2 in Relation to Depth and Position. In Water July 18 to August 14, 1939

| No. Spat per Smooth Surface | Frequency on Smooth Side Up | Frequency on Smooth Side Down | Total Frequency Up & Down Smooth Surfaces |
|---|---|---|---|
| ( 3 to 4 foot level) | | | |
| 0 | 4 | 0 | 4 |
| 1 | 4 | 2 | 6 |
| 2 | 3 | 3 | 6 |
| 3 | 1 | 3 | 4 |
| 4 | 0 | 1 | 1 |
| 5 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 1 | 1 |
| 8 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 1 | 1 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 1 | 1 |
| | 12 shells | 12 shells | 24 shells |

Total spat on smooth sides of 12 shells = 13

Average spat per smooth surface = 1.08

Total spat on smooth side of 12 shells = 50

Average spat per smooth surface = 4.17

Total spat on smooth sides of 24 shells = 63

Av. spat per smooth surface = 2.62

| No. Spat per Smooth Surface | Frequency on Smooth Side Up | Frequency on Smooth Side Down | Total Frequency Up & Down Smooth Surfaces |
|---|---|---|---|
| (4 to 5 foot level) | | | |
| 0 | 6 | 0 | 6 |
| 1 | 4 | 0 | 4 |
| 2 | 1 | 0 | 1 |
| 3 | 1 | 1 | 2 |
| 4 | 0 | 2 | 2 |
| 5 | 0 | 1 | 1 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 1 | 1 |
| 8 | 0 | 1 | 1 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 2 | 2 |
| 11 | 0 | 1 | 1 |
| 12 | 0 | 2 | 2 |
| 13 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 |
| 16 | 0 | 1 | 1 |
| | 12 shells | 12 shells | 24 shells |
| | Total spat on smooth sides of 12 shells = 9 | Total spat on smooth side of 12 shells=102 | Total spat on smooth sides of 24 shells=111 |
| | Average spat per smooth surface = .75 | Average spat per smooth surface = 8.5 | Av. spat per smooth surface = 4.62 |
| (5 to 6 foot level) | | | |
| 0 | 1 | 0 | 1 |
| 1 | 3 | 0 | 3 |
| 2 | 1 | 2 | 3 |
| 3 | 4 | 4 | 8 |
| 4 | 1 | 1 | 2 |
| 5 | 0 | 3 | 3 |
| 6 | 0 | 0 | 0 |
| 7 | 2 | 0 | 2 |
| 8 | 0 | 0 | 0 |
| 9 | 0 | 1 | 1 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 1 | 1 |
| | 12 shells | 12 shells | 24 shells |
| | Total spat on smooth sides of 12 shells = 35 | Total spat on smooth side of 12 shells=57 | Total spat on smooth sides of 24 shells = 92 |
| | Average spat per smooth surface = 2.92 | Average spat per smooth surface=4.75 | Av. spat per smooth surface = 3.86 |

The results of the spat counts on the smooth surface of string shells taken from the water at station 3, on August 22, 1939, are given in Table 7.

TABLE 7

A Frequency Table of Spat on Smooth Shell Surfaces from Station 3 in Relation to Depth and Position. In Water July 18 to August 22, 1939

| No. Spat per Smooth Surface | Frequency on Smooth Side Up | Frequency on Smooth Side Down | Total Frequency Up & Down Smooth Surfaces |
|---|---|---|---|
| ( 3 to 4 foot level) | | | |
| 0 | 5 | 0 | 5 |
| 1 | 3 | 1 | 4 |
| 2 | 1 | 1 | 2 |
| 3 | 2 | 2 | 4 |
| 4 | 0 | 0 | 0 |
| 5 | 1 | 3 | 4 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 2 | 2 |
| 8 | 0 | 2 | 2 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 1 | 1 |
| | 12 shells | 12 shells | 24 shells |
| | Total spat on smooth sides of 12 shells = 16 | Total spat on smooth side of 12 shells=66 | Total spat on smooth sides of 24 shells=82 |
| | Average spat per smooth surface = 1.33 | Average spat per smooth surface=5.5 | Av. spat per smooth surface =3.5 |

| No. Spat per smooth Surface | Frequency on Smooth Side Up | Frequency on Smooth Side Down | Total Frequency Up & Down Smooth Surface |
|---|---|---|---|
| | (4 to 5 foot level) | | |
| 0 | 2 | 0 | 2 |
| 1 | 1 | 1 | 2 |
| 2 | 3 | 1 | 4 |
| 3 | 5 | 2 | 7 |
| 4 | 0 | 2 | 2 |
| 5 | 1 | 2 | 3 |
| 6 | 0 | 1 | 1 |
| 7 | 0 | 0 | 0 |
| 8 | 0 | 1 | 1 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 2 | 2 |
| | 12 shells | 12 shells | 24 shells |
| | Total spat on smooth sides of 12 shells = 27 | Total spat on smooth side of 12 shells=61 | Total spat on smooth sides of 24 shells=88 |
| | Average spat per smooth surface=2.25 | Average spat per smooth surface=5.08 | Av. spat per smooth surface =3.66 |
| | (5 to 6 foot level) | | |
| 0 | 0 | 0 | 0 |
| 1 | 4 | 0 | 4 |
| 2 | 2 | 1 | 3 |
| 3 | 3 | 1 | 4 |
| 4 | 0 | 1 | 1 |
| 5 | 3 | 1 | 4 |
| 6 | 0 | 3 | 3 |
| 7 | 0 | 3 | 3 |
| 8 | 0 | 1 | 1 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 1 | 1 |
| | 12 shells | 12 shells | 24 shells |
| | Total spat on smooth sides of 12 shells = 32 | Total spat on smooth side of 12 shells=73 | Total spat on smooth sides of 24 shells=105 |
| | Average spat per smooth surface = 2.66 | Average spat per smooth surface=6.08 | Av. spat per smooth surface =4.37 |

Significant items in regard to strung shell experiments were as follows:

(1) The smooth side of shells that are up in relation to surface of

the water do not catch as many spat as is the case of the smooth sides that are down. This can be explained on the basis that the free swimming oyster larva generally swims in an inverted position and the foot used in adhering to cultch projects more or less upward. Consequently, the larva coming up from below a surface has a better opportunity of attaching than if coming downward. The fact that the larvae set with greater frequency on the under side of cultch was noted in Puget Sound by Hopkins (1937) who stated, "Larvae set most frequently on the under horizontal surface, while the fewest catch on the upper horizontal surfaces". The substantiation of this fact for Yaquina Bay conditions should be of importance if mechanical spat collectors are to be used on a commercial basis. Then efforts should be made to devise structures having large, horizontal surfaces.

(2) There is some indication that there is increased amount of spatting in Yaquina Bay as the water depth increases from the surface.

(3) A commercial set of larvae may be obtained in Yaquina Bay by stringing shells on wire, providing four spat per shell (Japanese or Eastern oyster shells) is considered as a satisfactory set. On the 144 shells used in these experiments (strung shells), the average number of spat per smooth surface was 3.77. Consequently, the average number of spat per shell, both surfaces, should have been at least 7.54.

Experiments with Cement-coated Spat Collectors

Three types of cement coated structures were used for the purpose of determining their practicability in Yaquina Bay. The three types were:

(1) Cement-coated egg case cartons. This type of spat collector is used extensively in the diked oyster areas of Puget Sound.

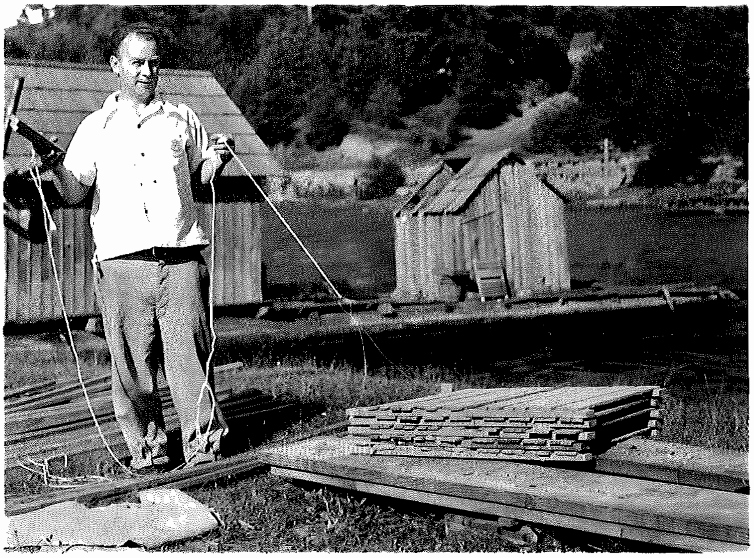


Figure 11

Modified Type of Humbolt Bay Spat Collector

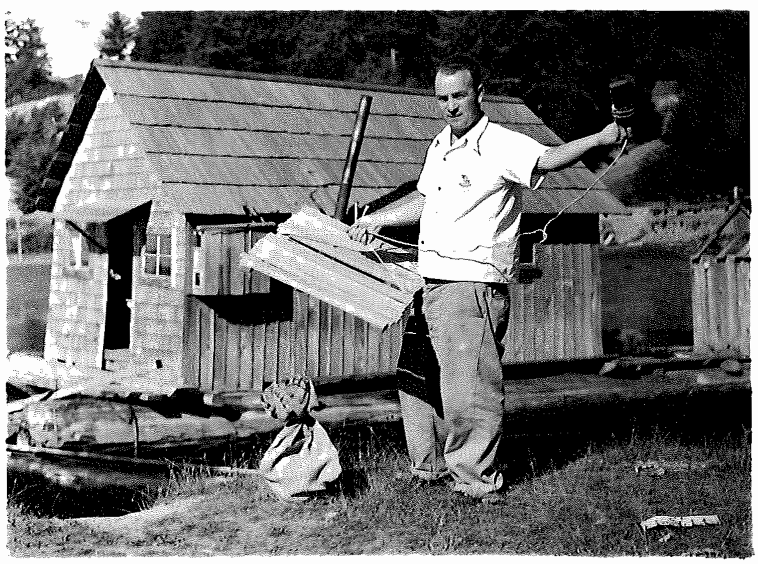


Figure 12

Single-Layer Spat Collector

(2) Modified type of Humbolt Bay Spat Collector, figure 11. This collector, made of lathe and coated with cement, is used in some of the oyster dikes of Humbolt Bay.

(3) Single Layer Spat Collector, figure 12. This collector consisted of a single layer of lathes of a Humbolt collector with a weight attached to the undersurface in such a manner that the main structure floated about two feet from the bottom, in a horizontal position. A rope leading from the upper surface of the collector terminated at the surface of the water in a wooden float.

In the main, these cement-coated spat collectors were found to be unsatisfactory under Yaquina Bay conditions.

The cement-coated egg crate cases were submerged in wooden crates suspended from floating docks at water depths varying from 3 to 5 feet. Within a few days after placing in the water, these cartons became so heavily coated with algae and silt as to be rendered practically useless as cultch. Further investigations with this type of collector will be made in 1940, for there is now evidence that the algae menace to cultch may be overcome by methods discussed in the section "Problems of Algae Control".

Fifteen Humbolt Spat Collectors were submerged in various parts of the oyster gounds. Wooden floats attached to a rope marked their locations in the water. Of these fifteen collectors, only four were recovered by September 15. The losses were caused by a variety of operations taking place in the oyster grounds, namely:

(1) Logging operations, in which timbers were pulled from the shore at McIntyre's Point into the water, destroyed some of the collectors. An observation made in connection with this logging was that great amounts

of silt were stirred up in the water. This resulted in dirty cultch over a relatively large area. Definitely, logging operations of this type in or near the oyster ground should be prohibited during the spawning and spatting seasons of the native oyster.

(2) Fish Netting Operations. A number of these spat collectors were caught in salmon gill nets and probably bait nets used by Tuna boats. Therefore, this type of collector is not compatible with fishing operations in the oyster grounds. There may be locations in the area in which nets are not used because of submerged snags where Humbolt Spat Collectors might be placed.

(3) Power boats. Some of floats and ropes were destroyed by the propellors of boats.

The four recovered Humbolt Spat Collectors have not as yet been closely examined for spat; however, cursory observations have indicated that a large number of oyster larvae were attached.

Approximately 40 single layer collectors were placed in various water locations from Mill Four Reef (approximately one-half mile above the upper limits of the oyster grounds) to the lower limits of the oyster beds. It was hoped that these collectors, placed at intervals over the entire oyster grounds, would serve as a means of determining spatting conditions in the different areas. At extreme low tide, September 14, a search was made for these collectors. Only one could be found. The experiments with this type of collector proved a complete failure from which no conclusions could be made.

Observations from Natural Shell Cultch

In most of the natural oyster beds in Yaquina Bay, large accumulations of shells are present. This cultch is composed largely of the shells of cockles, Cardium sp; the eastern soft shell clam, Mya arenaria; the gaper clam, Schizothaerus nuttallii; mussels, Mytilus edulis; and oysters (native, Japanese and a few Easterns). Most of these shells, if in the water a year or longer, are greatly reduced in spat collecting efficiency by the attachment of barnacles, sponges, and bryozoans. Improved methods of handling tonged shells could undoubtedly be devised so that increased spatting would result.

General observations to date indicate that the native oyster shell is far more effective for spat collecting than other kinds of shell found on the bottom. Apparently, sufficient native oyster shells have not always been returned to the oyster grounds for best results in production. Most of the shells from native oysters sold in Newport, Toledo, and in possibly other localities have not been returned to the oyster grounds as cultch. This may be a very significant item in regard to the decline of native oysters in Yaquina Bay. Definite management practices regarding native oyster shells as cultch should be instituted at once.

Problem of Algae Control

In the collection of spat by means of suspended shell bags, strung shells and other types of near surface collectors, a definite fouling problem was encountered. These collectors, in a few days' time, were thoroughly coated with an algae growth, Entomorpha sp. In addition this algae served as a collector of silt and other foreign material so that soon the collectors (usually shells) were so coated as to be of practically no value as spat catchers.

This algae, extending in range over the whole of the native oyster area, is especially prevalent in the summer months, July and August, when most of the spatting in the Yaquina Bay area takes place.

Figure 13

Showing Variation in Fouling on Shells

String on left exposed to sunlight and string on right hung where no direct light was received

Figure 14

Several Typical Shells from the Above Strings

Shells on left were exposed to sunlight.

It seems quite probable, therefore, that this algae tends to become a limiting factor on setting of oyster larvae in the upper surface areas of Yaquina Bay.

Three strings of Eastern and Japanese oyster shells were hung from Miller's Dock (Station 2) on August 15, 1939. A board from the floor was removed and two of these strings were hung in the current under the dock where they received no direct light. The third string was hung in the usual manner at the end of the dock, in the current, and exposed to sunlight.

After two weeks the shells were examined. The shells receiving no sunlight appeared almost as clean as when put down, but the string exposed to direct sunlight was badly fouled.

On September 15, 1939 all three strings were lifted for final inspection. The two strings which had received no sunlight proved to be remarkably clean and free from fouling organisms and materials. The string hung in the sunlight was coated to such an extent as to preclude larval setting. This is emphasized in figures 13 and 14.

In explanation it may be concluded that the algae, being a green plant and requiring a certain amount of sunlight in the essential process of chlorophyll manufacture, was unable to survive in the semi-darkness under the dock. On the other hand the third string which was hung in the sunlight afforded optimum conditions for algae growth.

This experiment may prove to be the direct means of solving the spat collecting problem in the shallow and near surface areas of the bay.

Oyster larvae at time of setting do not require direct light. Hopkins (1937) reported as follows: "In other experiments, it was demonstrated that larvae set as well by night as by day, and in all cases that the lower surfaces of horizontal planes receive almost all the spat. It is therefore obvious that light is not an orienting factor in setting behavior of larvae of this species".

A few larvae (spat) were found attached to shells hung under the dock, although these shells were placed in the water after the peak of the "spatting" season had passed.

In Puget Sound and many other native oyster areas, most of the spat are caught in collectors occupying the upper surface or shallow areas.

Concerning the light factor necessary to the growth of this algae, it is significant that this plant is scarce near the bottom of the deeper portions of Yaquina Bay where the native oyster beds naturally occur.

## SPAWNING AND LARVAL OBSERVATIONS

### Spawning

By the time the investigations commenced on July 4, 1939, much of the native oyster spawning had been completed. A number of oysters tonged from the middle grounds were opened and examined at various times during the remainder of the summer. The tabulated results of these observations are given in Table 8.

TABLE 8

Spawning Data of Native Oysters, 1939

| Date | No. Oysters Opened | No. *3 "Spawners" | No."Spawned Out" *4 | Per Cent "Spawners" | Per Cent "Spawned Out" | Location |
|---|---|---|---|---|---|---|
| 7/28/39 | 19 | 2 | 7 | 10.1 | 36.8 | Middle Grounds |
| 8/5/39 | 50 | 3 | 30 | 6.0 | 60.0 | " |
| 8/11/39 | 25 | 1 | 16 | 4.0 | 64.0 | " |
| 8/18/39 | 14 | 1 | 4 | 7.1 | 28.8 | " |
| 8/25/39 | 25 | 0 | 14 | .0 | 56.0 | " |
| 8/31/39 | 9 | 0 | 1 | .0 | 11.1 | " |
| 9/7/39 | 25 | 0 | 4 | .0 | 16.0 | " |
| 9/14/39 | 25 | 1 | 3 | 4.0 | 12.0 | " |

### Observations of Free-Swimming Larva

At various times during July, August and September, plankton hauls were made in a number of locations in Yaquina Bay and the times of operations were generally observed in relation to the stages of the tide. These hauls were made with a standard plankton net of No. 20 bolting silk, at a depth of one to three feet from the surface of the water. Each haul was of five minutes duration. The contents collected in each plankton haul were examined under a binocular microscope and a relative estimate of number of native oyster larvae were made. The tabulated data regarding the plankton hauls is given in Table 9.

*3 Spawners noted as having larvae in mantle cavity.
*4 Spawned out individuals thin and watery in appearance. Usually brownish and unappetizing in appearance.

TABLE 9

Data Regarding Relative Number of Native Oyster Larvae in Plankton Hauls, 1939

| Date | Hour | Location of Haul | Relative Numbers of Oyster Larvae | Stage of Tide |
|---|---|---|---|---|
| July 4 | | Off McIntyre Point-Stat.3 | Numerous | Ebb |
| July 14 | 9 am | Lower Grounds - Stat. 1 | Scarce (two) | Flood |
| July 14 | 10:15 am | Off McIntyre Point-Stat.3 | Average | Flood |
| July 14 | 12:30 pm | Middle Grounds, Stat. 1 | Slightly below av. | Ebb |
| July 21 | ? | Middle Grounds, Stat. 2 | Numerous | Ebb |
| July 21 | ? | Off McIntyre Point,Stat.3 | Average | Ebb |
| July 26 | ? | Off Yaquina (3/4 mile below oyster grounds) | None | Ebb (1 hour) |
| July 26 | 9:45 am | Upper end of oyster grounds | Numerous | Flood |
| July 26 | 10 am | Shipyards, upper grounds | Average | Flood |
| July 26 | 10:10 am | Off McIntyre's Point | Average | Flood near high water |
| July 26 | 10:25 am | Middle grounds, in front Oregon Oyster Co. | Scarce (1) | Flood near high water |
| July 26 | 11:15 am | Eddy of Boones Island | Scarce (2) | Ebb just after high water |
| July 26 | 11:30 am | Off Idlewild Point | Scarce (1) | " |
| July 26 | 11:40 am | Opposite Station 1 Lower Grounds | None | " |
| July 26 | 11:50 am | Lower limits of oyster grounds | None | " |
| Aug. 2 | 8:15 am | Off Yaquina (3/4 mile below oyster grounds) | None | Flood just after low water |
| Aug. 2 | 8 am | Off Yaquina (½ mile below oyster grounds) | None | " |
| Aug. 2 | 9:08 am | Lower grounds, Stat. 1 | Average | " |
| Aug. 2 | 9:20 am | Eddy of Boones Island | Average | " |
| Aug. 2 | 9:35 am | Caffrey Slough | None | " |
| Aug. 2 | 10:00 am | Middle Grounds | Numerous | " |
| Aug. 2 | 10:35 am | Middle Grounds, off Ore. Oyster Co. | Average | Flood |
| Aug. 2 | 11:05 am | Off McIntyre Point-Stat.3 | Average | Flood |
| Aug. 2 | 11:15 am | Shipyards, upper grounds | Average | " |
| Aug. 2 | 11:40 am | Mill Four Reef-3/4 mile above upper limits of oyster grounds | Numerous | " |
| Aug. 11 | 2:30 pm | Upper limit of oyster grounds | Average | Ebb |
| Aug. 11 | 3:00 pm | Off McIntyre Point,Stat.3 | Average | " |
| Aug. 11 | 3:15 pm | Middle grounds,Stat. 1 | Below average | " |
| Aug. 22 | ? | Middle Grounds, Stat. 1 | Scarce (1) | Ebb just before low water |
| Aug. 22 | ? | Off McIntyre Point, Stat.3 | Scarce (3) | " |
| Aug. 22 | ? | Lower Grounds, Stat. 1 | None | Flood |
| Sept. 7 | am | Lower Grounds, Stat. 1 | None | Ebb |
| Sept. 7 | am | Middle Grounds, Stat. 2 | None | High tide |
| Sept. 7 | am | Upper Grounds, Stat. 3 | None | Flood |

Significant items disclosed by plankton haul studies were as follows:

(1) Oyster larvae appeared to be carried back and forth over the oyster grounds by the tidal currents. Very few larvae were present in water over oyster grounds after tide had been flooding for some time. During ebb tide, larvae were apparently carried back over the middle and lower grounds.

(2) Oyster larvae were found approximately 3/4 of a mile above the upper limits of the oyster ground after the tide had been flooding for some time. This observation was important because the river area above the oyster grounds must be taken into consideration in the management of oyster grounds proper, for inimical conditions there may result in destruction of larvae.

(3) No oyster larvae could be found below the lower limits of the oyster grounds, even during ebb tide or low tide. Some factor or factors apparently stop the movement of oyster larvae below lower limits of the oyster grounds.

# THE JAPANESE OYSTER IN YAQUINA BAY

The exotic Japanese oyster, Ostrea gigas, is found in Yaquina Bay. The principal beds lie near the center of the native oyster grounds on the south side of the bay, a short distance below Oysterville. This area, which is relatively shallow, is known as the King's Ground.

The first Japanese oysters were introduced into the Yaquina Bay about 1894 by Dr. M. M. Davis. Dr. Davis was unable at that time to secure spat and the oysters were shipped from Japan in the adult form. Dr. Davis estimated the cost at time of planting to be about $1.00 per oyster. These oysters were placed at the mouth of Pool's Slough, near the center of the native oyster grounds, and there grew to immense size. However, no record of any reproduction from this planting has ever been found.

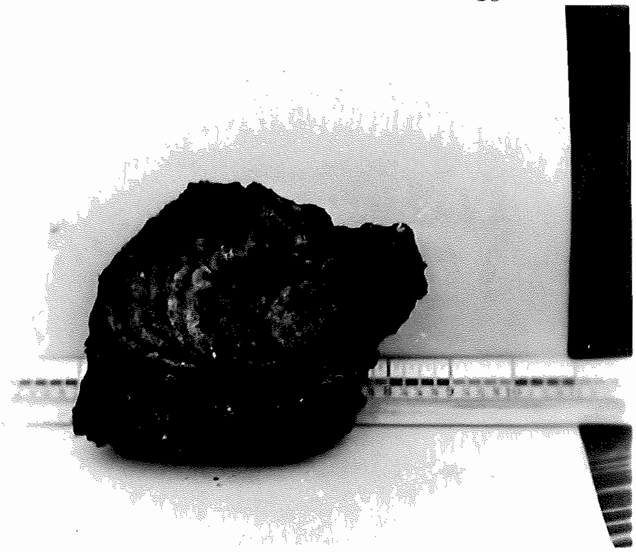
In recent years the Oregon Oyster Company has made many plantings of Japanese oyster spat in the shallow water of the King's Ground. Here these oysters make a rapid growth and reach marketable size at about the age of 18 months after planting. Japanese oysters, grown in the shallow water of this area,produce very thin shells, which, due to breakage, prohibits shipping to distant markets. Consequently, only enough Japanese oysters are marketed to supply the local demand. This same oyster grown in the deeper water of the channel produces a fine heavy shell, but generally exhibits a slower growth rate.

Apparently, this oyster has reproduced to some extent in the Yaquina Bay area. At extreme low tide, specimens were found on the north bank, opposite Poole's Slough, lying among the rocks. One speciman, figure 15, shows the left valve attached to a rock. Spat procured from Japan arrive

Figure 15

Japanese Oyster Resulting from Reproduction in Yaquina Bay

Collected Sept. 14, 1939. Note attachment to rock.



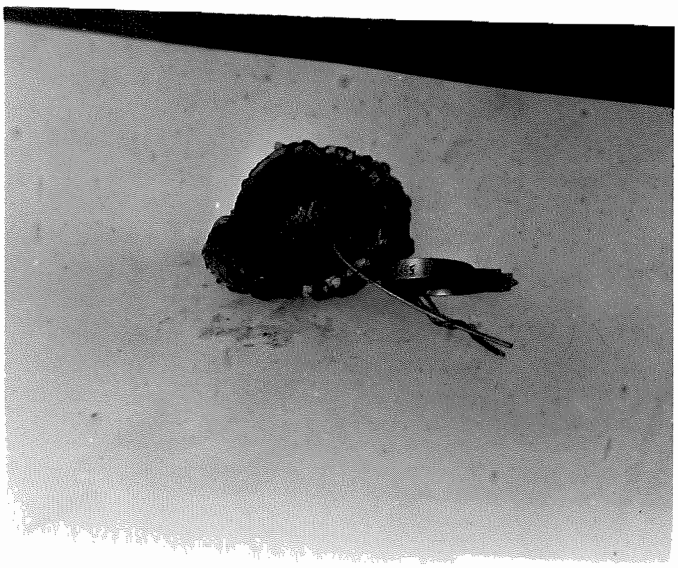


Figure 16

Native Oyster Shell Used in "Spat" Mortality Studies

Figure 17

Oyster Laboratory and Mud Flat Suggested as a Diked Area

attached to scallop or oyster shells. No record of any planting of Japanese oysters in this particular area could be found.

<u>It is recommended that the raising of Japanese Oysters within the limits of the native oyster beds be discontinued, because reproduction in future years may result in habitat competition between this oyster and the native species.</u> There is a possibility that growing of Japanese oysters in other areas of the bay may adversely affect the survival of the native oyster.

## THE EASTERN OYSTER IN YAQUINA BAY

About 1894, Messers Toner, Wilcox and Dr. M. M. Davis planted a carload of Eastern oysters, Ostrea virginica, at the mouth of Poole's Slough in Yaquina Bay. Since that time many additional plantings have been made. The Eastern oyster in this area makes an excellent growth and is noted for its fine flavor. However, no record of Eastern oyster reproduction in Yaquina Bay has ever been found.

The Oregon Oyster Company has made frequent plantings of Eastern oysters in 20 to 30 barrel lots. These oysters, imported from the Atlantic coast, are planted in the adult size and held here only until needed for the market. According to Mr. Rosselle, employee of the Oregon Oyster Company, mortality on the Eastern Oyster held for market usually averages about five per cent. However, this year, in July and August, about 50% of the planted Eastern oysters died. The reason for the loss has not yet been determined.

Holding of Eastern oysters in the native oyster area apparently does not adversely affect the native oyster. Although not evident at this time, the possibility exists that predators, parasites, or diseases may be brought in with Eastern Oysters from the Atlantic coast. These might adversely affect the native oyster.

## FALL AND WINTER INVESTIGATION

The following is a brief description of the investigations now being undertaken which are to be continued during the winter and early spring months.

(1) Mortality Studies of 1939 Spat. There are some indications that the main limiting factor of the native oyster in the Yaquina Bay is not the lack of oyster larvae, but of inimical factors operating upon larvae and young oysters, following spatting. In this study, spat counts are being made upon large numbers of shells. A pictorial record is made of shell and the shells are numbered with monelmetal numbered tags, figure 16. The shells are returned to the oyster grounds in wire baskets and examined at intervals. This study should give definite mortality records of spat and may disclose causes of losses.

(2) A Study of Oystering Operations. A close study of cultural methods now used in Yaquina Bay is being made and will be continued for some time.

(3) Oyster Population Studies. Counts of oysters, by age classes, will be made in various zones of the whole oyster area during the fall and winter months.

(4) Chemical and Physical Studies. During the rainy period of winter, salinity studies will be made for the purpose of ascertaining if reduced salinity limits the upper extension of the oyster grounds. During the time of freshets, the effects of silting will be noted on adult oysters as well as the young oysters of the year.

(3) Dike Investigations. There is a mud flat, figure 17, located at Yaquina near the oyster laboratory situated below the lower limits of the native oyster grounds. This area may have possibilities for oyster production if the native oyster can be grown in this part of the lower bay. About 50 feet of diking materials would make this tide land of approximately two acres available for this investigation and other important studies. The cost of labor and materials for construction should not exceed $250.00. If this money, labor, and material can be obtained, construction work should be done this winter.

A summary of the winter and spring studies will be made in a progress report on April 30, 1940. Data regarding water temperatures as influenced by tidal action and some observations of oyster enemies have been made. Information thus far accumulated is not sufficient to justify reporting at this time.

# CONCLUSIONS

1. The native oyster in Yaquina Bay, although similar to the same species in Puget Sound, differs markedly in relation to habitat and environmental conditions.

2. The native oyster in Yaquina Bay exhibits maxima periods of larval setting. These periods may be determined in advance by experimental methods.

3. Increased native oyster production may be obtained by timely and localized placing of cultch in relation to maxima larval setting periods.

4. A satisfactory larval set may be obtained on strung shells or shell bags suspended from floating docks.

5. Larval setting in 1939, apparently, covered a period of one month, from about July 25 to August 25.

6. Algae growth, which is a limiting factor in larval setting on cultch in shallow water, may be minimized by excluding direct sunlight.

7. Excessive barnacle growth on all types of cultch markedly reduces spatting surface and limits maximum oyster production.

8. The native oyster shell forms the most important natural cultch existing in Yaquina Bay.

9. A definite policy of returning shells of native oysters to the area should be established.

10. Proof of Japanese oyster reproduction was found in Yaquina Bay.

11. The Eastern Oyster, although grown in Yaquina Bay for many years, apparently has never reproduced in this area.

12. The raising of Japanese Oysters, due to possible habitat and food competition with the native oyster, should be discontinued in Yaquina Bay.

13. It is now believed that native oysters may be grown below the present limits of the oyster grounds in the lower bay.

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