AN ABSTRACT OF THE THESIS OF

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Title: ECOLOGY OF THE STRIPED SEAPERCH, EMBIOTOCA LATERALIS, IN YAQUINA BAY, OREGON

Abstract approved: Redacted for Privacy
Dr. Carl E. Bond

A study was conducted at Yaquina Bay, Oregon, from November, 1962, to November, 1963, to provide information on the life habits of the striped seaperch (Embiotoca lateralis Agassiz). Included were distribution, reproduction and development, age and growth, food habits, habitats, and movements.

During the months of July, August, and September, 1963, 142 fish were tagged with Petersen disks. Ten fish (seven percent) were recovered and all were recaptured in the areas from which they were originally tagged. This indicated that a homing instinct might be present. The tags used were not satisfactory because they caused lesions at the point of attachment.

Striped seaperch were captured near rocky banks, piling, and along the edges of mud flats. A total of 562 striped seaperch was captured for use in this study. A small otter trawl was used to

capture 530 specimens, while angling resulted in the capture of 32 fish. Adult fish were captured only in areas that consistently had salinities greater than 26 ppt and temperatures below 16 C.

Using scale analysis and direct observation, both males and females were found to mature sexually during their third year of life. The most prolific female was in age-class VII and contained 36 embryos. The oldest female was in age-class VIII. The oldest males were in age-class VII.

Sexually mature males were captured during the third week of September. In early December, females contained diminutive embryos. The mating season and fertilization apparently occurred within this period.

Ages of 98 female and 96 male striped seaperch were determined by scale analysis. The average lengths, average weights, and back-calculated average lengths at time of annulus formation were determined. Males had a larger average length than females in age-classes II, III, IV, and V, while females had a larger average length than males in age-classes VI and VII. The lengths for age-class I were equal for both sexes. Males had a larger average weight than females in age-classes II, III, IV, and V. Females had a larger average weight than males in classes I, VI, and VII.

The length-weight relationships were determined for 231 females and 194 males and were expressed by the equation:

$\log W = \log c + n \log L$. For females the equation was: $\log W = -4.67638 + 3.00695 \log L$. For males the equation was: $\log W = -4.85225 + 3.07918 \log L$.

Monthly food samples taken from striped seaperch from March through November, 1963, revealed that amphipods of the genera *Ampithoe* and *Anisogammarus* occurred in 90.6 percent of the stomachs. Mussels, barnacles, surface insects, isopods, and shrimp were found in a large percentage of the stomachs.

An angler survey on Yaquina Bay was conducted from August, 1963, through July, 1964, by the Department of Agricultural Economics and the Department of Fisheries and Wildlife at Oregon State University. Based on data from this survey, striped seaperch were fourth in importance by weight in the bay fishery and fifth in importance in numbers caught.

Ecology of the Striped Seaperch, *Embiotoca lateralis*, in Yaquina Bay, Oregon

by

Charles Einar Gnose

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INTRODUCTION

Purpose of Study

With the increased popularity of sport fishing, more anglers are making use of Pacific Coast marine and estuarine waters. Knowledge concerning the fish that inhabit these waters is meager. The purpose of this study was to provide information concerning some of the life habits of one of these sport species, the striped seaperch (*Embiotoca lateralis* Agassiz) in Yaquina Bay, Oregon.

Increased utilization almost always presents the problem of maintaining stable populations of the species exploited. Information from ecological studies gives insight into some of the determining factors that are necessary to the establishment of a plan of management for marine and estuarine fishes.

Factors Investigated

My initial effort was the determination of the local distribution of striped seaperch. Following this, scales and stomachs were collected for use in age, growth, and food habit studies. Information was gathered also on reproduction and behavior. The study on behavior was augmented by a tagging program.

An angler census helped to determine the value of the striped seaperch to man. This survey also brought out information regarding the kinds and importance of other fish taken by anglers in Yaquina Bay.

Field work was commenced in November, 1962, and continued until November, 1963, the greater portion being done within the period from May through October, 1963.

Description of Study Area

The Yaquina River is a small stream which arises in the Coast Range of mountains in Lincoln County, Oregon, about 30 miles in a direct line from the Pacific Ocean. It empties into Yaquina Bay at the city of Toledo, Oregon, and eventually flows into the Pacific Ocean at Newport, Oregon.

Yaquina Bay is a portion of a tidal estuary which extends its tidal influence approximately 25 miles up the Yaquina River from the bar at the bay entrance. Although the U.S. Engineer Department (1912) delineates the bay as extending from the bar to about 3-1/2 miles upstream, I will refer to it as the section from Toledo downstream. The bay is approximately one mile wide, one-half mile below the town of Yaquina. From Yaquina to Toledo, the width of the bay varies from 400 to 1,200 feet.

At many places along the edges of the bay, sand and mud flats appear at low tide. Rocky banks comprise the remainder of the shore line.

Two of the main uses of the bay are for recreation and shipping. A road located along the north shore provides easy access for anglers, clam-diggers, boaters, and water skiers. Boat liveries are located at various places along the bay. The channel of the river is deep enough so that large lumber and oil barges can travel between Newport and Toledo.

Attempts made to study the river near the bar at the entrance of the bay and near Toledo were not only futile, but were also destructive to equipment. Therefore, my study was concentrated in the section from the Newport Bridge to Oysterville (Figure 1).

Taxonomy and Description of the Striped Seaperch

The striped seaperch (*Embiotoca lateralis* Agassiz) is a member of the family Embiotocidae. The main characteristics of this family are discussed by Tarp (1952). Those characteristics which are important ecologically and for recognition are: (1) a laterally compressed, oblong or ovate body, covered with cycloid scales; (2) a single dorsal fin with a sheath of scales along its base, separated from the body scales by a furrow; and (3) females bear live young.

As reported by Tarp (1952), the family Embiotocidae consists

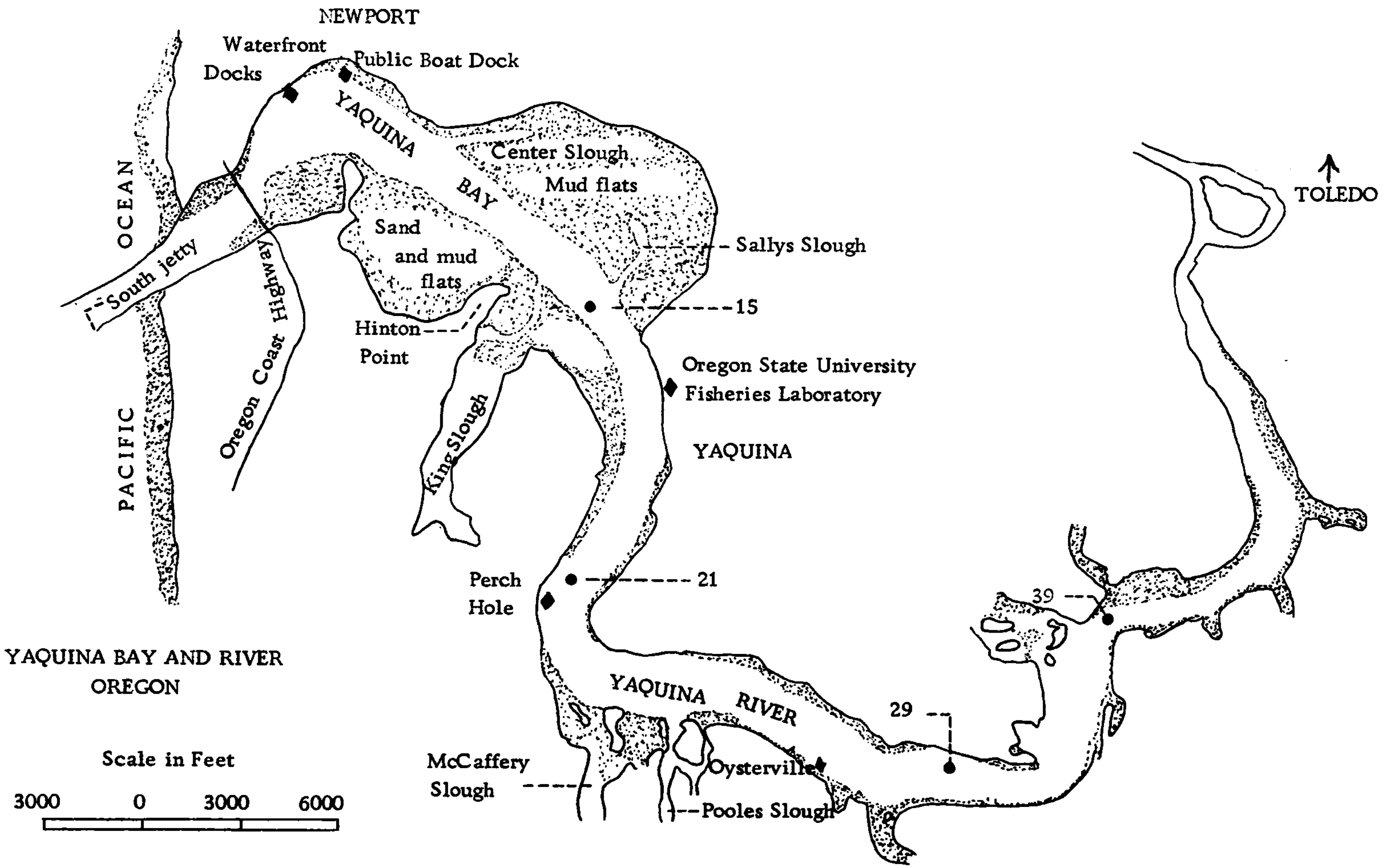

Figure 1. Yaquina Bay and River, Oregon. Numbers 15, 21, 29, and 39 are the sampling stations where weekly salinity and temperature samples were taken.

of 23 species in 12 genera. The American Fisheries Society (1960) revised the list of members of this family in the United States and Canada and reported 20 species in 11 genera. According to this list, and with the two species that are found in the Far East, the family Embiotocidae today contains 22 species in 13 genera. Only one freshwater species is known.

A year after he had described the family Embiotocidae, Louis Agassiz (1854) described Embiotoca lateralis. A complete synonymy of this species is found in Tarp (1952).

The most distinctive feature of the striped seaperch is coloration. A reddish-copper color forms the basic body hue, turning into a darker brownish-copper above the lateral line. A series of approximately 15 horizontal, blue stripes are found below this line. Several less prominent blue stripes are found above the line. The species name lateralis, refers to the lateral blue striping. The head and opercle are decorated by several loosely organized bright blue bars. The abdomen is colored a comparatively dull orangish-copper, with faint blue stripes running through it. Approaching the breast area, the dull tone of the abdomen gets progressively brighter. The breast itself is a bright orangish-copper color. The fins are the same hue as the body, but often have brown tips and edges.

Because of the distinctive coloration, striped seaperch are known by several common names. In the vicinity of Yaquina Bay, in addition to the accepted name of striped seaperch, they are also known as blue, rainbow, and squaw perch.

Coloration is the primary method of recognition in the field. This is especially true in Yaquina Bay where none of the other six species of surfperch which frequent the area has a similar color pattern. In other locations, the striped seaperch may be confused with several other seaperch. According to Tarp (1952), several characteristics are used as differentiating criteria. In striped seaperch, the dorsal spines number 12 or less. The sum of the anal and dorsal rays equal 45 or more. There is no definite row of small scales along the posterior half of the base of the anal fin. A frenum is found on the lower lip.

Range of the Striped Seaperch

The present-day distribution of the embiotocids has its center of dispersal in central and southern California. From California the species radiate north and south to limits in southern Alaska and central Baja California (Tarp, 1952). Twenty species are found along the Pacific Coast within these limits. The only embiotocids not found along the Pacific Coast of the United States and Canada are two species which live in seas surrounding Japan, Korea, and Chefoo, China.

Temperature appears to be the environmental limiting factor for the family (Tarp, 1952). The striped seaperch is one of three species of embiotocids that is able to tolerate the entire range of temperatures found within the limiting boundaries.

DISTRIBUTION WITHIN STUDY AREA

Methods

Specimens of striped seaperch were obtained by angling and by use of a small otter trawl known as a shrimp try-net (Figures 2 and 3). The wings of the otter trawl were constructed of nylon netting with a stretch mesh of 1-1/2 inches. The 5-foot long cod end was lined with nylon netting of 1/2-inch stretched mesh.

The otter trawl was pulled by a 16-foot fiberglass boat with a 10-horsepower outboard motor. Each drag of the trawl was approximately 150 yards long. The trawling distance varied according to the stage of the tide. At low tide, the dragging distance was shortened because the fish were concentrated, and the net fished more efficiently. Because of the limited horsepower of the motor, the net was usually pulled with the tide.

Information gathered by trawling was limited to those areas through which the net could successfully be towed. The possibility exists that striped seaperch lived in rocky and shallow areas that were inaccessible to the trawl. Another likelihood is that even where the net could be towed the fish might have been able to avoid the trawl.

A tagging program was undertaken to help ascertain movements of the fish. One-hundred-forty-two fish, ranging in fork length from

Figure 2. Angle-view of shrimp try-net.

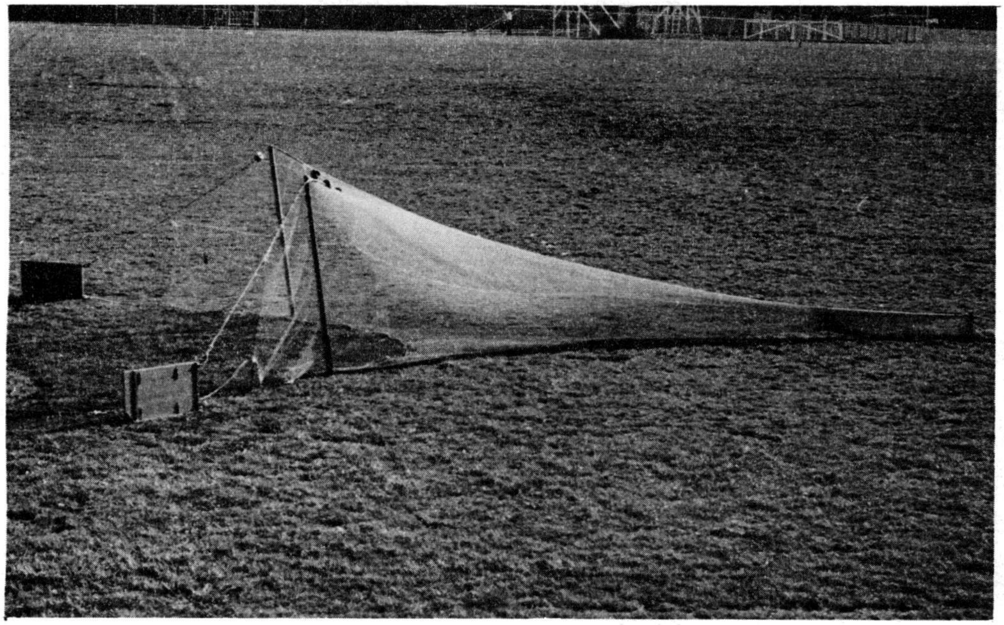

Figure 3. Side-view of shrimp try-net.

105 to 315 millimeters and from 20 to 779 grams in weight, were tagged with two, round, white, 1/2-inch disks called Petersen tags. The two discs were held together by a nickel pin inserted through the back of the fish near the junction of the spinous and soft portion of the dorsal fin.

The tag used was not satisfactory. All perch that were recovered had large sores on their backs that were evidently caused by the rubbing and movement of the tags and pin. Loss of tags could have taken place, but the sores did not appear to be serious enough to cause tagging mortality. Morgan (1961) observed a similar reaction to the tag. Of the ten fish recovered, four had been tagged for a month and six had been tagged for two or three weeks.

Fish used for the tagging program were obtained by use of the otter trawl. Immediately upon pulling the net into the boat, the fish were emptied into a large washtub from which the striped seaperch were quickly sorted into a second tub of fresh bay water. The water in the tub was changed often in order to maintain adequate temperature and oxygen supply. When the tub became crowded with fish, they were transferred to a live-box at the Oregon State University Fisheries Laboratory where subsequently they were tagged and released.

Information obtained from the angler survey also was used in determining the movements of the fish. The movements were determined according to when and where anglers caught the fish.

The salinity and temperature data were collected by the Department of Oceanography at Oregon State University during 1963. Once a week, water samples were taken at several sampling stations in the bay. These stations are designated by the numbers 15, 21, 29, and 39 in Figure 1. At each station, salinity was determined by a conductivity-temperature-indicator (CTI) at each meter of depth. A water sample was collected from the surface and bottom with a Van Dorn sampler for analysis of salinity by titration to compare with the CTI results. Temperature data were collected with the CTI and surface observations were made with a bucket thermometer. Tidal fluctuations were not taken into consideration. Thus, Figures 4 and 5 give only a generalized picture of the salinities and temperatures during a one-year period. The weekly data were averaged to obtain monthly means.

Habitats and Local Distribution

Salinity, temperature, and availability of food were found to have the most important influence on the local distribution of the striped seaperch. Striped seaperch were captured in rocky areas and along the edges of mud flats (Table 1). Because of inadequate sampling methods, no samples were taken directly on the mud flats at high tides.

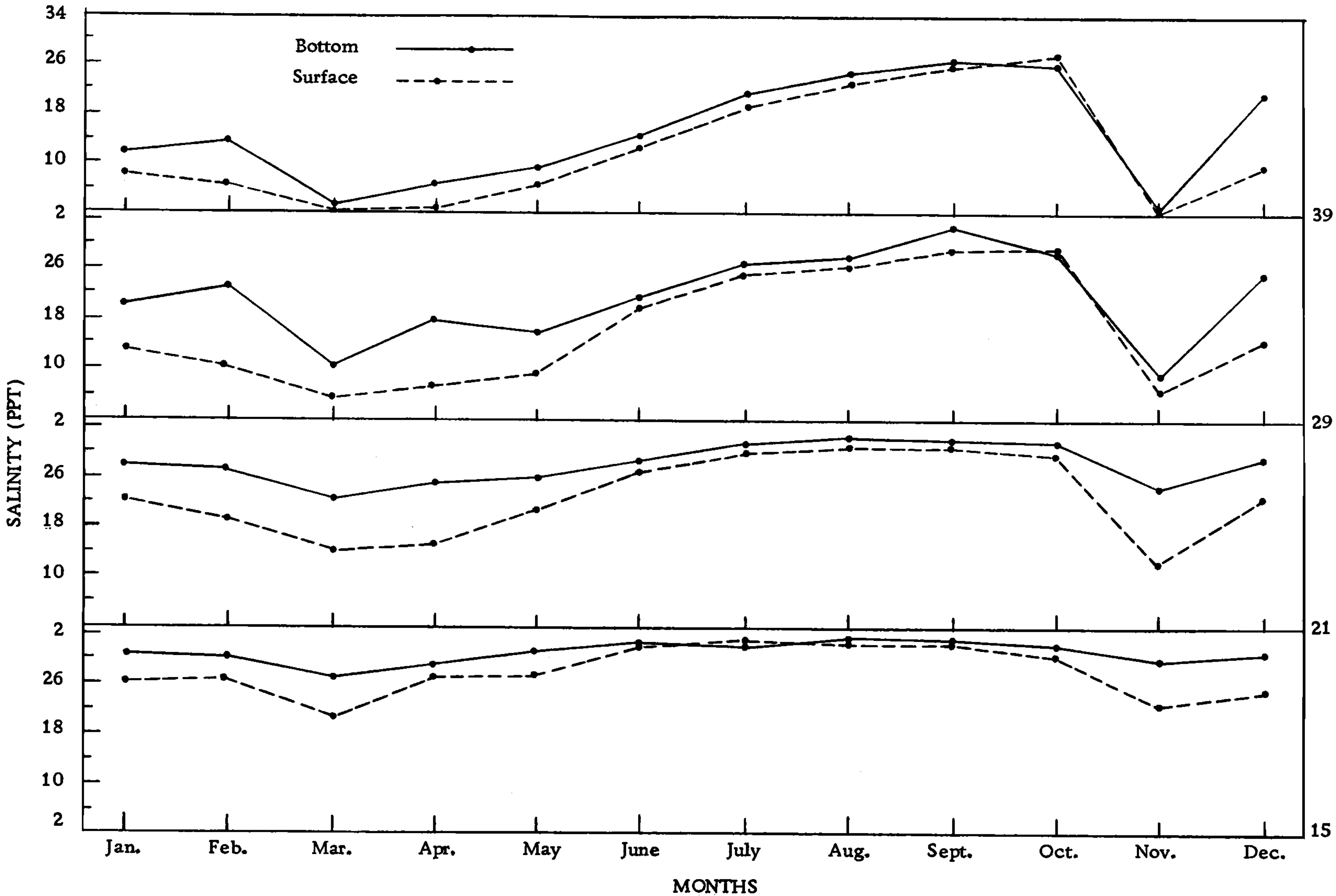

Figure 4. Average monthly salinities at four sampling stations in Yaquina Bay, Oregon, 1963. Untabulated data collected by Department of Oceanography at Oregon State University.

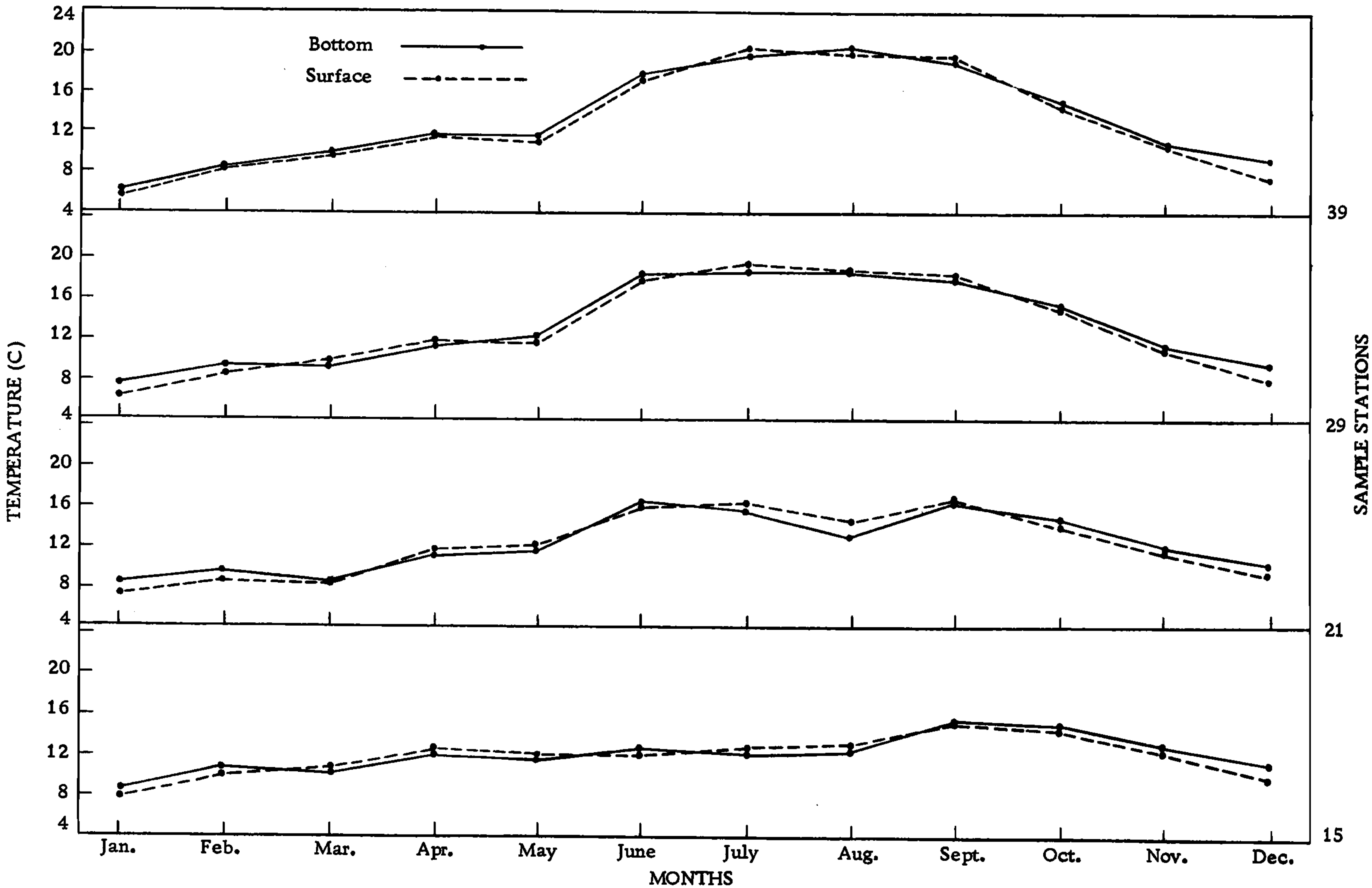

Figure 5. Average monthly temperatures at four sampling stations in Yaquina Bay, Oregon, 1963. Untabulated data collected by Department of Oceanography at Oregon State University.

Table 1. Locations and numbers of striped seaperch caught by otter trawl and angling from February through November, 1963, in Yaquina Bay, Oregon.

Locations	Months										
	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Above Pooles Slough											0
Across from Pooles Slough					3						3
Across from Perch Hole					4					3	7
Perch Hole					8		13	11			32
McCaffery Slough to Perch Hole					14		4	3			21
Mud flats below Station 21 and across from Yaquina				4	57	19	27	2	5		114
Mud flats across from O.S.U Fisheries Laboratory				5	46	114	67	22			254
O.S.U. Fisheries Laboratory			12			6	4	5			27
Mud flats in vicinity of King Slough				20			1	1			22
Sand and mud flats below Hinton Point			9			2	3				14
Mud flats in vicinity of Center and Sallys sloughs						12		24			36
Waterfront docks	12	7				9					28
South jetty		2				1	1				4
Totals	12	9	21	29	132	163	120	68	5	3	562

Adult striped seaperch were never found above Pooles Slough during this study although Swedberg (1965) found them there. Juveniles and young-of-the-year were not found above Oysterville. Temperature and salinity appear to be directly related to this distribution. Measurements of salinity and temperature taken during the course of this study indicate that striped seaperch in Yaquina Bay are found most often in water having a salinity of approximately 32 ppt and a temperature near 13 C. During the first six months of the year, at stations 29 and 39, salinities were below 26 ppt (Figure 4) which appeared to be unfavorable for habitation by striped seaperch. With the exception of the month of June, during the same period, temperatures at stations 29 and 39 were below 16 C (Figure 5) which appeared to be favorable enough to permit striped seaperch to live in these areas. During this study, adult striped seaperch were found only in the area below Pooles Slough that consistently had salinities greater than 26 ppt and temperatures below 16 C. In July at stations 29 and 39, when salinities began to increase, temperatures had already reached a level (approximately 19 C) that was higher than that frequentedby the perch. In October, when temperatures began to approach a favorable plateau, salinities started to decline. Temperature and salinity are involved in a constant incongruity so as to restrict most of the striped seaperch to that area of the bay below Pooles Slough.

Physical factors in the region above Pooles Slough are associated with the lack of abundance of the types of food that are preferred by the fish. High temperatures and unfavorable substrata in this area might tend to retard the development of eel grass which harbors amphipods and isopods. Barnacles and mussels are not abundant in these localities. Because fish tend to occupy areas where there is an abundance of food, lack of food could conceivably be another reason why striped seaperch are not numerous above Pooles Slough.

Below Pooles Slough, pilings, rocky banks, and eel grass flats seemed to be the favorite habitats of the striped seaperch. The rock jetties at the entrance to Yaquina Bay provided similar habitat. The salinity is relatively stable (approximately 31 ppt) in this area and perch are found here both on high and low tides.

Anglers report that striped seaperch are caught in the vicinity of the docks along the waterfront at Newport only on high tide. This indicates that either the perch move into this area only during high water, or their feeding habits are associated with the tides. Such is the case up the bay where fish move into the numerous rock and piling areas on the incoming tide. The species is not restricted to piling and rocks, but also might go onto the mud flats at high tide to feed. High tide not only brings deeper water, but also changing salinity patterns. This enables fish to move into areas not favorable on low tide.

On the north side of the bay the main beds of eel grass are found on the mud flats around Center and Sallys sloughs. Striped seaperch are abundant near these flats (Table 1). On the south side, a large sand and mud flat extends from 600 yards on the ocean side of the Newport Bridge, upriver 2.2 miles to Hinton Point (Figure 1). Striped seaperch are scarce in this area. Above Hinton Point, a large mud flat extends 1.9 miles upriver. King Slough is located in this area which is frequented by a great number of striped seaperch.

On the north side of the bay, across from the mud flat above Hinton Point there are rocky banks and several moorages in addition to the sand and mud flats surrounding Sallys Slough. Indications from anglers catches are that striped seaperch do inhabit these areas seasonally, but trawl catches were not as great as on the other side of the bay.

In discussing habitats, the limitations of the sampling gear must be brought forth. Because a shrimp try-net is designed to travel along the floor of the sea, and because the net can easily be ripped by foreign objects, places containing rocks, logs, and other debris were eliminated from the sampling scheme. Also, the net as rigged did not work effectively in deep water. Operation of the net on the mud flats at high tide was not successful. On the incoming tide, the boat was hard to control and the net picked up large quantities of debris.

Because of the limitations of the net and the lack of success of anglers at low tide, few low tide habitats were discovered. Of those found, the most prominent was in the moderately deep (approximately six feet) to the shallow water (approximately two feet deep) along the edge of the mud flats where the bottom drops off into the bay channel. My opinion is that the perch go onto the mud flats at high tide to feed. As the water runs out, they follow the water line down and when the tide is completely out, they establish themselves in the water just off the edge of the mud flats. Most of the fish were captured just above Hinton Point and along the edges of the mud flats which surround Center and Sallys sloughs (Table 1).

Regarding the lack of fish below Hinton Point, I believe that scarcity of eel grass is one reason for this. On this mud and sand flat, especially towards the lower part, the eel grass thins out and algae takes its place. Food appears to be less abundant here. Therefore, I concluded that these factors were responsible for the fish not being as numerous here as in other habitats up the bay.

Juvenile striped seaperch and young-of-the-year did not seem to be affected by changes of the tide. They were found in all trawling locations both on low and high tides. Adult perch were not caught on low tide in the place known as the "perch hole" (Figure 1), although young perch were caught here at all stages of the tide.

Bay fishermen reported taking small catches of perch in the vicinity of King Slough when the tide was out. During low tide, most of the perch reported were caught under a lumber loading dock, approximately 400 yards upriver from the Newport Bridge. Catches were also reported by anglers who fished off the rock jetties leading into the bay.

I am of the opinion that when the tide goes out, the change in salinity in the upper part of the bay above station 21 is great enough to become one of the reasons why adult striped seaperch seek other habitats. Frolander (1964) showed that in the upper bay at stations 29 and 39 on August 9 and 10, 1963, the salinity dropped an average of 9.5 ppt when the tide went out. This change might be significant enough to be one factor in causing the fish to seek other habitats.

Not enough data were collected to determine whether or not striped seaperch inhabit all the sloughs that are part of the bay. Because of the quantity of debris found in the bottom of the sloughs, it was impossible to use the trawl in all areas. Anglers have caught striped seaperch in King, Center, and Sallys sloughs. No evidence was obtained from McCaffery and Pooles sloughs.

The distributive limits of striped seaperch established by Parrish (1966) and Beardsley (1966) are similar to those established in this study, except that they failed to find the species as far upstream during August. During the months of March through August, 1960, Swedberg (1965) consistently captured adult striped seaperch one mile upriver from Pooles Slough. This was much farther upstream than striped seaperch were captured during my study.

Movements

Because of the lack of substantial facts, no definite conclusions can be made about the movements of striped seaperch in Yaquina Bay. The only definite statements that can be made are the result of the tagging program.

During the months of July, August, and September, 142 fish were tagged with Petersen disks. Most were captured near the edges of the mud flat in the area across from the Fisheries Laboratory and in the vicinity of Center Slough. All were released at the laboratory.

The sample recaptured (10 fish or seven percent) was not large enough to produce any conclusive information. From the few fish that were recaptured, it appears that a homing instinct might be present. All fish were recaptured in the general area from which they were originally caught. The recoveries followed a pattern observed in a previous study (Morgan, 1961). Morgan was in charge of a salmon tagging program in Siletz Bay, located 20 miles north of

Yaquina Bay. The fyke nets used to obtain salmon incidentally took numbers of viviparous perch. During the period from August 20, to October 23, 1954, a total of 1,887 surfperch were captured and tagged. Of this number, 397 were striped seaperch. Two-hundred-sixty-two of these, or 65.9 percent were recovered by the fyke nets. Two fish were recovered by anglers. One, at liberty for nine months, was caught in the bay. The other was recovered in the ocean about three miles north of the Siletz Bay entrance.

Morgan (1961) states that during the tagging period, the pile perch (Rhacochilus vacca) appeared to be emigrating from the bay while striped seaperch were more of a resident population. Recoveries of tagged perch were confined to Siletz Bay itself and to an area three miles north of the bay. This suggests a local population in the area with no extensive coastwise migration or mixing between bays.

Seasonal movements were probable, but on the basis of my data no definite conclusions can be made. The only evidence I have is that from November, 1962, through March, 1963, I did not catch any fish with the otter trawl or anglers did not report any catches of striped seaperch above the public boat moorage at Newport.

Tidal movements were also evident. However, because of the lack of data I cannot state how extensive these movements were. The only evidence I can offer is that angling for striped seaperch at the "perch hole" and along the rocky banks near this area and near the Fisheries Laboratory was successful only at high tide.

REPRODUCTION AND DEVELOPMENT

Methods

The scales that were used to determine the age at maturity of female striped seaperch were taken from just above the lateral line in front of the origin of the dorsal fin. They then were dry-mounted between two slides and sealed with cellophane tape. Before mounting, the scales were soaked in a solution of diluted detergent for six to eight hours after which they were rinsed in warm water and the mucus and debris brushed from them. Six scales were mounted on each slide.

A Ray-O-Scope microprojector was used to examine the scales. Each sample was read at least three times with a maximum of six readings.

Sex Recognition

The sex of a striped seaperch can be differentiated by both internal and external characteristics. Internal characteristics must be used until the fish is a year old. After this, external features start to develop and both internal and external characteristics can be used.

Females possess a single oblong-shaped ovary that lies near the posterior end of the dorsal wall of the body cavity. Males have two oblong testes lying approximately in the same position as the ovary in the female. All sizes and ages of striped seaperch exhibit this characteristic.

Males have an organ on the anterior portion of the anal fin, which is in some manner concerned with the act of copulation (Tarp, 1952). The structure has the general appearance of an oval flask. The belief exists that this structure acts as a device to hold the ventral fins of the female so that close contact of the ventral surfaces can be maintained when copulation is in progress. Females do not have such a structure on the anal fin.

In all 52 pregnant females that were captured during this study, a peculiar characteristic was observed during their later stages of pregnancy. Their normal bright coloration became dull and faded and they had a drab appearance. The explanation for this could lie in some physiological function connected with pregnancy. However, this characteristic cannot be used to differentiate between the sexes because some males also exhibited a faded-out quality, which might have been caused by habitat and diet. Of the 37 males captured during May, June, and the first week of July, the period that drab females were observed, four (11.1 percent) of the males also displayed a faded coloration. After giving birth, most females regained their bright coloration.

Attainment of Sexual Maturity

The methods of determining whether or not a fish was sexually mature were the same as those used by Swedberg (1965). If the gonads were swollen and not long and thin, or if they contained milt, the fish was considered to be mature. A female was considered to be mature if she contained embryos or if a spawning check was found on her scales.

My findings did not disclose any mature females in age-class II. Of the 59 females in age-classes III through VIII, all matured after their third scale annulus was laid down, except for four fish which matured after their fourth annulus was formed. Swedberg (1965) found three females in age-class II that were mature and only one female of age-class III that was immature. Sivalingham (1953) discovered that females with less than three annuli in their scales did not contain embryos. The evidence of Sivalingham agrees with that of Hubbs (1921).

Regarding the maturity of males, my data and that of Swedberg (1965) are almost identical. Of 13 males in age-class II, I found all but four to be immature. Of the same number of males in age-class II, Swedberg found that all but three were immature. In my sample, all 52 males in age-classes III and above were mature. Swedberg found one immature fish in age-class III.

Fecundity

Swedberg (1965) discusses the fecundity of the striped seaperch in Yaquina Bay in much detail. His data showed that females of age-class V produced the most embryos per unit increase in standard length. The rate of increase declined in females of age-class VI. Females of age-class III produced 54 percent of the embryos used in this study.

The generalization is often made that in a fish population, the largest females produce the greatest number of young. According to Table 2 and Figure 6, this generalization is valid for Yaquina Bay. However, in this study, there were a number of examples where larger females contained fewer embryos than smaller females (Table 2 and Figure 6).

In this study, the most prolific female was seven years old and contained 36 embryos. The largest number of striped seaperch embryos found by other authors are as follows: Swedberg (1965), 45; Sivalingham (1953), 54; Blanco (1933), 92; Hubbs (1921), 26; and Eigenmann (1892), 80.

Mating and Breeding Seasons

During the third week of September, sexually mature males were captured. Conceivably, the mating season could have been in

Table 2. Number of embryos according to size and age of female striped seaperch from Yaquina Bay, Oregon, 1963.

Fork length (mm)	Age class	Number of embryos
225	III	16
229		12
235		15
242	IV	14
248		10
250		20
255		17
257		18
258	V	15
260	III	17
260		19
263	IV	11
263	V	20
265		14
267	IV	19
271	V	19
273		13
276	IV	29
279	V	20
283		23
285		16
285		27
293		19
295	VI	20
304		29
311		19
311		19
312	VII	29
325		34
334		36

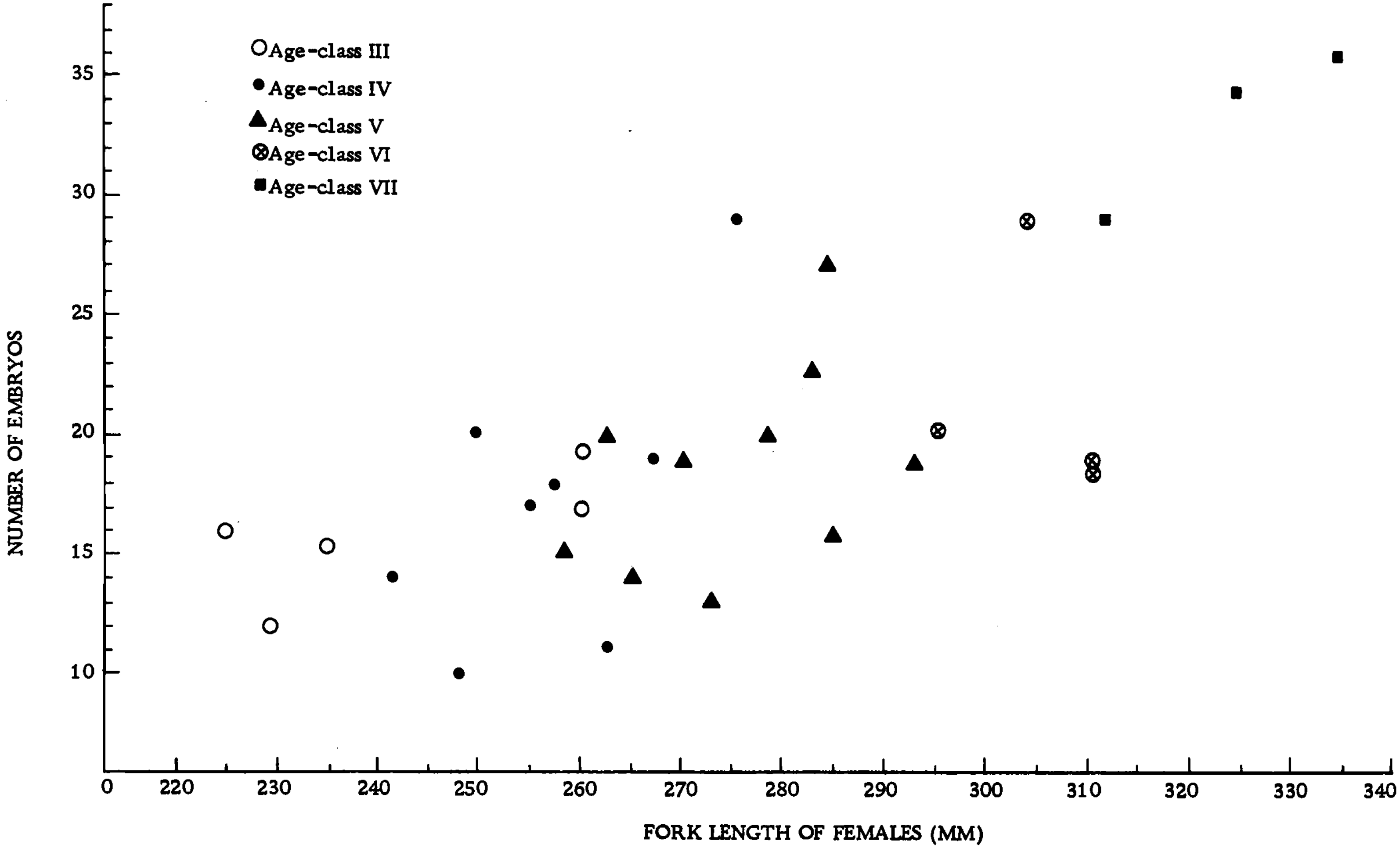

Figure 6. Number of embryos according to size and age of female striped seaperch from Yaquina Bay, Oregon, 1963.

progress at this time. Because of a lack of specimens, the determination could not be made as to whether or not fertilization takes place immediately or if the spermatozoa are retained in the female. In early December, females contained diminutive embryos.

Because embryos were fully developed and young-of-the-year were captured in the trawl during the last week of May and the month of June the conclusion can be drawn that in 1963, the season of parturition took place during this period. By the first day of July, all mature females captured had given birth to their young.

AGE AND GROWTH

Methods

The scale method (Lagler, 1956) was used for the analysis of age and growth. Measurements of fork length were recorded to the nearest millimeter. Weights were recorded to the nearest gram. All weights were taken by using the entire fish. Therefore, the weight of pregnant females was influenced by the number and size of the developing embryos.

Age

The scales of striped seaperch exhibit a "metamorphic annulus" or birthmark. It is a zone distinguished by fine, closely spaced circuli laid down soon after birth in the summer (Hubbs, 1921).

Swedberg (1965) discovered that different age classes of striped seaperch in Yaquina Bay formed an annulus on their scales from February through the second week of June.

According to the results of my scale analysis, there was one female of age-class VIII. The other females were in age-classes I through VII. Swedberg (1965) reported the oldest females to be in age-class VII and the oldest males to be in age-class VI. I discovered four males in age-class VII.

Table 3. Number of striped seaperch in age-classes I - VIII, as determined by analysis of scales from 194 specimens.

Age-class	I	II	III	IV	V	VI	VII	VIII	Total
Females	21	18	12	10	17	13	6	1	98
Males	31	13	15	12	13	8	4	0	96
Total	52	31	27	22	30	21	10	1	194

Length

The average length at time of capture, according to age class of the 194 specimens used in the scale analysis, is given in Table 4.

Table 4. Average fork length, according to age class, of 98 female and 96 male striped seaperch. (Number of observations in parentheses.)

	Average length (mm)							
Age class	I	II	III	IV	V	VI	VII	VIII
Females	139(21)	183(18)	221(12)	257(10)	271(17)	298(13)	312(6)	341(1)
Males	131(31)	191(13)	224(15)	259(12)	285(13)	293 (8)	296(4)	--

Males had a larger average length than females in age-classes II, III, IV, and V. The average length was larger for females than males in age-classes I, VI, and VII. Sivalingham (1953) discovered that females grew faster than males throughout life. My data from the measured lengths of the specimens at time of capture do not agree with his conclusions.

In order to further evaluate the length of striped seaperch, back calculations of lengths at previous ages were made for the 98 female and 96 male specimens used in the tabulations of the average lengths for Table 4. The direct-proportion formula with correction factor was used. This formula is:

$$L' = C + \frac{S'}{S} (L - C)$$

where L' = length of fish when annulus was formed
C = length of fish when scales begin to grow
S' = distance from focus to outer edge of annulus
L = length at time of capture
S = distance from focus to anterior edge of scale
(Rounsefell and Everhart, 1953).

Table 5 shows the average length at each annulus of the 194 specimens used in the scale analysis.

Table 5. Average fork length at each scale annulus as determined by back calculations of body lengths of 98 female and 96 male striped seaperch. (Number of observations in parentheses.)

	Average length (mm)							
Annulus	I	II	III	IV	V	VI	VII	VIII
Females	109(98)	159(77)	202(59)	236(47)	264(37)	288(20)	305(7)	334(1)
Males	109(96)	164(65)	209(52)	245(37)	268(25)	278(12)	285(4)	--

Males had a larger average length than females in age-classes II, III, IV, and V. The average length for females was larger than for males in classes VI and VII. The length for age-class I was equal. With the exception of age-class I, the average length of striped seaperch for each age class as determined by back calculations was the same as the average length determined by direct observation.

Weight

The average weight at time of capture, according to age class, of the 98 female and 96 male striped seaperch used in scale analysis is given in Table 6.

Table 6. Average weight, according to age class, of 98 female and 96 male striped seaperch. (Number of observations in parentheses.)

	Average weight (gms.)							
Age class	I	II	III	IV	V	VI	VII	VIII
Females	60.0(21)	138.8(18)	229.7(12)	391.4(10)	460.9(17)	579.2(13)	719.0(6)	798.0(1)
Males	53.3(31)	155.9(13)	251.3(15)	398.3(12)	512.9(13)	566.6(8)	621.5(4)	--

Males had a larger average weight than females in age-classes II, III, IV, and V. Females had a larger average than males in classes I, VI, and VII. Females were weighed in their entirety and if they were pregnant the weight of the young added to the total body weight.

Using the average weights given in Table 6, the weight of male and female striped seaperch is found not be be a steady progression from one age class to another.

Length-Weight Relationships

Weight of fishes may be considered a function of the length.

The relationship of the length and weight follows approximately the cube law relationship expressed by the formula, $K = W/L^3$, in which W is the symbol for weight and L the symbol for length (Rounsefell and Everhart, 1953). This relationship may be more satisfactorily expressed by the formula: $W = cL^n$, in which W = weight, L = length, and c and n are constants. This equation can be interpreted logarithmically as $\log W = \log c + n \log L$. The logarithmic expression was used in this study.

The number of observations used for computing the regression equations was 231 females and 194 males. Age classes were not taken into consideration in the computation of the equations.

For females the regression equation was:

$$\log W = -4.67638 + 3.00695 \log L$$

The equation is diagrammed in Figure 7. Table 7 shows the weight of female striped seaperch at selected fork lengths as computed by the regression equation.

Table 7. Length-weight relationship, according to regression formula: $\log W = -4.67638 + 3.00695 \log L$, of 231 female striped seaperch captured in Yaquina Bay, Oregon, during 1962 and 1963.

Fork length (mm)	Weight (gms.)
75	9.2
100	22.8
150	73.6
200	174.9
250	342.1
300	591.8
350	940.8

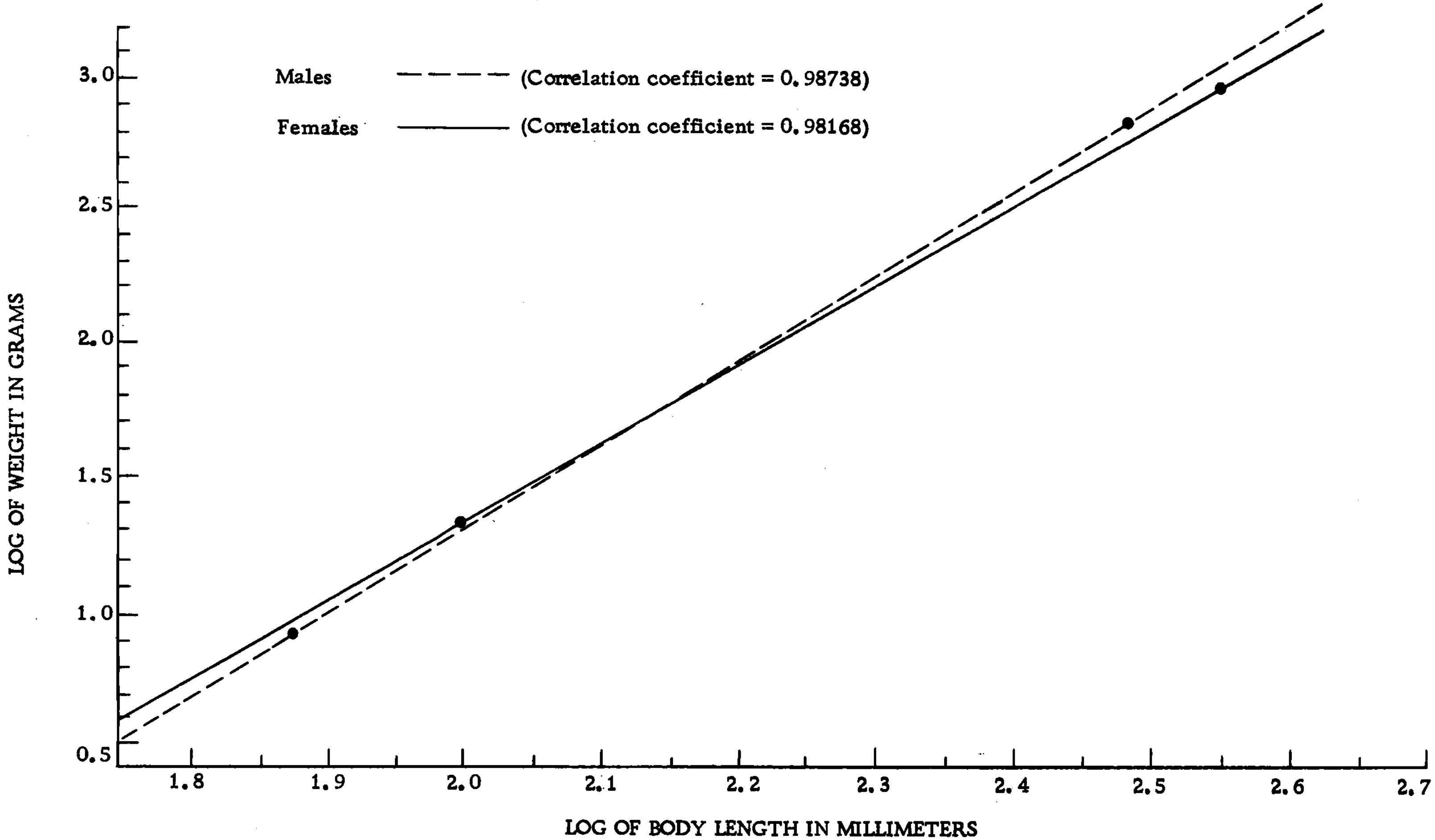

Figure 7. Length-weight relationship for 231 female (log W = -4.67638 + 3.00695 log L) and 194 male (log W = -4.85225 + 3.07918 log L) striped seaperch captured in Yaquina Bay, Oregon, during 1962 and 1963.

For males the regression equation was:

$$\log W = -4.85225 + 3.07918 \log L$$

The equation is also diagrammed in Figure 7. The weight of male striped seaperch at selected fork lengths as computed in the regression equation is shown in Table 8.

Table 8. Length-weight relationship, according to regression formula: $\log W = -4.85225 + 3.07918 \log L$, of 194 male striped seaperch captured in Yaquina Bay, Oregon, during 1962 and 1963.

Fork length (mm)	Weight (gms.)
75	8.4
100	20.2
150	70.5
200	171.0
250	340.1
300	596.0
350	958.1

As shown in Figure 7 and Tables 7 and 8, the weight for females is larger than for males in lengths under 300 millimeters. Over this length the weight for males is greater than for females.

Swedberg (1965) and Sivalingham (1953) concluded that female striped seaperch grow faster than males throughout life. My data on average lengths, average weights, and on length-weight relationships indicate that the members of one sex do not grow faster than the other sex throughout their entire life spans.

FOOD AND FEEDING

Methods

Food samples were taken from striped seaperch during the first week of every month from March through November of 1963. Typically, trawling for the capture of perch from which stomach samples were taken started from the "perch hole" and proceeded to the mud flats just above Hinton Point and then to the mud flats surrounding Center and Sallys sloughs until approximately 20 samples were obtained.

Immediately upon capture, the entire stomach was removed from the fish and initially fixed in five percent formalin to prevent further digestion. After approximately two weeks, individual stomach contents were put into vials containing 75 percent ethyl alcohol.

The food samples were separated into component groups of organisms and identified to genus if possible. Final tabulations were made on the basis of the frequency of occurrence of each type of organism in the total number of samples.

Types of Food Eaten

Amphipods were the most frequently occurring food, appearing in 90.6 percent of the stomachs analyzed (Tables 9 and 10). Mussels, barnacles, surface insects, isopods, and shrimp were also found in over ten percent of the stomachs.

When designating the relative importance of the food items as determined by the frequency of occurrence method, the findings are often biased by the accumulation of remains of certain food organisms which are resistant to digestion. In this study, many of the organisms had body parts which are indigestible, particularly the mussels and barnacles. The shrimp found in the stomachs were the types (*Upogebia* sp. and *Callianassa* sp.) that are used as bait by fishermen. Undoubtedly some of the fish obtained the shrimp by stealing it from the hook of an angler.

Seasonal Variations

Since most of the stomach samples were obtained during the months of April through September, observations over an entire year were not made. During the months sampled, there were no seasonal variations in food habits discovered. The same kinds of organisms (Tables 9 and 10) were found during the entire sampling period.

Variations According to Size

When the fish are young, the probability exists that they are limited by the size of their mouths and the strength of their teeth

Table 9. Percentage occurrence of food items removed from the stomachs of 117 striped seaperch captured from Yaquina Bay, Oregon, during 1963.

Food material	Sampling dates									Percent of all samples combined
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	
Amphipods	100.0	98.3	100.0	94.7	81.8	82.4	93.3	100.0	50.0	90.6
Mussels	71.4	43.8	62.5	42.1	22.7	17.7	20.0	--	100.0	36.8
Barnacles	57.1	6.3	18.8	21.1	13.6	29.4	13.3	--	100.0	20.5
Surface insects	42.9	43.8	18.8	15.8	9.1	35.3	--	--	--	20.5
Isopods	71.4	6.3	6.3	10.5	18.2	23.5	13.3	--	--	16.2
Shrimp	14.3	--	6.3	26.3	36.4	5.9	6.7	--	--	14.5
Unidentifiable material	14.3	6.3	18.8	10.5	4.6	11.8	6.7	--	--	9.4
Snails	42.9	--	25.0	--	4.6	11.8	--	--	--	8.6
Clams	--	6.3	25.0	--	9.1	5.9	6.7	--	--	7.7
Polychaete worms	--	6.3	--	15.8	4.6	11.8	13.3	--	--	7.7
Algae	28.6	--	--	5.3	13.6	5.9	6.7	--	--	6.8
Crabs	--	6.3	--	--	--	5.9	13.3	--	--	3.4
Ectoprocts	--	--	6.3	5.3	4.6	5.9	--	--	--	3.4
Ostrocods	--	--	--	10.5	4.6	5.9	--	--	--	3.4
Cumaceans	28.6	--	6.3	--	--	--	--	--	--	2.6
Limpets	14.3	--	--	5.3	--	5.9	--	--	--	2.6
Hydrozoans	--	--	--	--	--	--	6.7	--	50.0	1.7
Number of stomachs analyzed[1]	7	16	16	19	22	17	15	3	2	
Mean size of fish in the sample (mm)	250	168	229	169	180	164	174	100	266	

[1] No empty stomachs were included in the total number analyzed.

Table 10. Percentage occurrence of food types from the stomachs of 117 striped seaperch captured in Yaquina Bay in 1963.

Food material	Number of samples[1]	Percent occurrence
Genus *Ampithoe*	106	90.6
Genus *Anisogammarus*	106	90.6
Genus *Mytilus*	30	25.6
Genus *Balanus*	24	20.5
Family Chironomidae	19	16.2
Genus *Idothea*	19	16.2
Genus *Botula*	16	13.7
Genus *Upogebia*	11	9.4
Class Polychaeta	9	7.7
Subkingdom Thallophyta	8	6.8
Genus *Littorina*	7	6.0
Genus *Clinocardium*	5	4.3
Genus *Cancer*	4	3.4
Genus *Membranipora*	4	3.4
Subclass Ostracoda	4	3.4
Order Cumacea	3	2.6
Genus *Macoma*	3	2.6
Family Staphilinidae	3	2.6
Genus *Calliostoma*	2	1.7
Class Hydrozoa	2	1.7
Family Tipulidae	2	1.7
Genus *Acmaea*	1	0.9
Genus *Amphissa*	1	0.9
Genus *Lacuna*	1	0.9
Genus *Searlesia*	1	0.9
Genus *Siliqua*	1	0.9

[1] No empty stomachs were included in the total number analyzed.

and jaws to eating small, relatively soft-bodied organisms. When a fish reaches a size of approximately 130 millimeters, the teeth and mouth appear to be large and strong enough so that barnacles and mussels can be broken off rocks and pilings. Mature fish have a well-developed set of pharyngeal teeth which act as a grinding organ to break-up the hard outer shells of organisms.

Stomach samples were taken from fish ranging in size from 58 to 319 millimeters fork length. The stomachs which were taken and found to be empty were not included in the analysis. Amphipods (*Ampithoe* spp. and *Anisogammarus* spp., Table 10) were discovered in all sizes. Of the 18 fish ranging up to a length of 90 millimeters, 17 (94.4 percent) contained amphipods. Of the 43 fish ranging to a length of 160 millimeters, 40 (93 percent) contained amphipods. Of the 117 stomachs analyzed, 39 samples (33.3 percent) from all sizes of fish were composed almost entirely of amphipods. Amphipods appeared to constitute almost the entire diet of the young-of-the-year and the one-year old fish.

Periodicity in Feeding

On several occasions, sampling was undertaken at dawn. The stomachs of 25 striped seaperch taken during these sampling periods were analyzed and found to be empty. These data suggest that striped seaperch do not usually feed at night. However, I emphasize that more than 25 samples are needed to make an absolute statement regarding night feeding. After approximately two hours of daylight, stomachs were taken which had an abundance of organisms in them. Full stomachs were found during all hours of the day. No samples were taken in the late evening.

RELATIONS TO MAN

Fisheries

Fishing for perch in Yaquina Bay is limited almost entirely to a sport fishery. No information is available on the existence of a commercial fishery.

Striped seaperch are one of the five species of surfperch that are included in the sport fishery. The others are white seaperch (*Phanerodon furcatus*), pile perch (*Rhacochilus vacca*), walleye surfperch (*Hyperprosopon argenteum*), and redtail surfperch (*Amphistichus rhodoterus*). Shiner perch (*Cymatogaster aggregata*) are kept by some anglers but their value in the sports fishery is negligible.

Information on the commercial landings of striped seaperch off the Oregon coast is not available. Morgan (1961) reports that the average commercial catch of all species of surfperch in Oregon from 1928 through 1949 was 24,800 pounds, ranging from 94,300 pounds in 1929 to 600 pounds in 1937. Statistics on the current landings of seaperch have not been published.

Angler Census

From August, 1963, through July, 1964, an angler survey was conducted jointly by the Department of Agricultural Economics and the Department of Fisheries and Wildlife in order to determine an estimate of the daily and total angling pressure on the bay. This survey is discussed in detail by Parrish (1966) and Stevens (1966), but information pertinent to the seaperch fishery will be considered here.

The results of the angler survey are more than adequately summarized by Parrish (1966):

> Analysis of the survey of anglers conducted at Yaquina Bay revealed that 3,260 sportsmen were interviewed and that they spent approximately 2,790 hours in quest of food fishes and invertebrates. These anglers harvested 325 pounds of chinook salmon, 155 pounds of coho salmon, 68 pounds of cutthroat trout, 9 pounds of steelhead, 271 pounds of Dungeness crabs, 1,880 pounds of clams and 3,249 pounds of miscellaneous fishes. Of the sportsmen interviewed, 24 fished for Dungeness crabs, 384 clammed, 198 angled for trout and steelhead, 387 angled for salmon and 2,267 angled for miscellaneous fishes. These angling effort statistics indicate the importance of miscellaneous fishes to the sports fishery in the bay.

The hours spent angling for miscellaneous fishes, the combined weight of the fishes caught, the pounds of fishes captured per angler hour and the percent weight of white, pile, striped, and walleye surfperch, kelp greenling (*Hexagrammos decagrammus*), and starry flounder (*Platichthys stellatus*) in the catch of the anglers interviewed is reported by month in Parrish (1966). He found that the largest number of angler hours (914.5) was recorded in August and the largest estimated catch (17,286.4 pounds) occurred in May.

White seaperch (552.3 pounds) were the most important species in the total yearly catch in pounds followed in order by starry flounders (506.5 pounds), pile perch (463.1 pounds), striped seaperch (353.6 pounds), kelp greenling (169.8 pounds) and walleye surfperch (45.1 pounds).

Summary

The main value of seaperch in Yaquina Bay is their part in the sports fishery. Of the total weight (3,248.5 pounds) of all species in the catch of anglers interviewed for a period of one year during 1963-64, 45.3 percent or 1,469.3 pounds was composed of surf-perch. Striped seaperch made up 10.8 percent (350.7 pounds) of the total weight (Table A1). Of the total number of 4,325 fish caught during the same period 1,397 or 31.6 percent were surfperch. Striped seaperch composed 7.2 percent or 319 of the total number of fish caught (Table A2).

According to the angler survey, striped seaperch are fourth in importance by weight and fifth in importance by number. If weight is the criteria used, white seaperch were of the greatest importance. Striped seaperch are valuable in the sport fishery in Yaquina Bay, but other species are just as important.

No information is available on whether or not there is a commercial fishery for seaperch in Yaquina Bay. The commercial fishery landings of surfperch along the Oregon coast are negligible and it may be considered a latent fishery (Swedberg, 1965).

SUMMARY

In summarizing this study, the following points about the life history and ecology of the striped seaperch were brought forth.

1. Striped seaperch were captured near rocky banks and along the edges of mud flats. The adults were found only in areas that consistently had salinities greater than 26 ppt and temperatures below 16 C.
2. A tagging program indicated that a homing instinct might be present. Only ten (seven percent) of the 142 fish tagged were recovered, which was not a large enough recovery to produce any conclusive information.
3. All 52 pregnant females that were captured exhibited a drab and faded pattern of coloration, which was duller than normal; this was observed also in a few males and non-pregnant females.
4. Both males and females mature sexually during their third year of life.
5. The most prolific female was in age-class VII and contained 36 embryos.
6. Sexually mature males were captured during the third week of September and in early December females contained diminutive embryos.

7. The oldest female captured was in age-class VIII. The oldest males were in age-class VII.

8. Males had a larger average length than females in age-classes II, III, IV, and V. Females had a larger average length than males in age-classes VI and VII. The lengths for age-class I were equal for both sexes.

9. Males had a larger average weight than females in age-classes II, III, IV, and V. Females had a larger average weight than males in age-classes I, VI, and VII.

10. The regression equation for the length-weight relationship of females was:

$$\log W = -4.67638 + 3.00695 \log L.$$

11. The regression equation for the length-weight relationship of males was:

$$\log W = -4.85225 + 3.07918 \log L.$$

12. Data concerning the average lengths, average weights, and length-weight relationships indicated that the members of one sex do not grow faster than the members of the other sex throughout their entire life spans.

13. Amphipods of the genera Ampithoe and Anisogammarus occurred in 90.6 percent of the 117 stomachs which were analyzed. Mussels were found in 36.8 percent and barnacles in 20.5 percent of the stomachs analyzed.

14. According to the angler survey taken in Yaquina Bay during 1963 and 1964, striped seaperch were fourth in importance by weight in the bay fishery and fifth in importance in numbers caught.

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APPENDIX

Table A1.[1] Number of angler hours and weight of miscellaneous fishes in the catch of the anglers interviewed each month for one year in Yaquina Bay, Oregon.[2]

		Total weight (lbs.)	Weight (lbs.) of each species in the monthly catch												
			Seaperch												
Date	Angler hours	of all species	Striped	White	Pile	Walleye	Redtail	Shiner	Starry flounder	Kelp greenling	Black rockfish	Pacific herring	Jack smelt	Ling cod	Miscellaneous species
Aug. - 63	877.5	282.0	11.3	25.4	42.3	8.5	0	0.14	81.8	42.3	25.4	0	5.6	8.5	31.0
Sept. - 63	914.5	329.5	16.5	16.5	32.9	1.7	0	0	29.7	13.2	72.9	0	0	23.8	123.6
Oct. - 63	31.3	14.25	0	1.0	0	0.1	0	0	10.5	2.6	0	0	0	0	0.7
Nov. - 63	1.5	0.25	0	0	0	0	0	0	0	0.25	0	0	0	0	0
Dec. - 64	65.4	263.75	31.7	39.6	0	1.1	0	0	7.9	5.3	7.9	0	73.9	0	96.5
Jan. - 64	72.2	82.75	28.1	37.2	9.9	0	0	0	1.7	2.5	0	0	0	0	3.3
Feb. - 64	118.3	149.5	9.0	5.2	22.4	12.0	2.0	0	3.0	10.5	10.5	0	74.0	0	1.1
Mar. - 64	316.2	113.0	20.3	19.2	7.9	7.9	4.3	0	25.2	18.1	4.1	0	5.5	0	0.5
Apr. - 64	393.1	438.25	61.4	39.4	166.5	1.3	14.8	0	92.0	35.1	23.8	2.0	0	0	1.8
May-64	443.5	692.25	103.8	228.4	145.4	0	18.0	0	131.1	6.3	1.8	58.0	0	0	0
June - 64	569.5	336.5	30.3	70.7	0	0.7	12.0	0.13	37.0	16.8	28.5	85.0	0.25	9.0	45.8
July - 64	1085.3	546.5	38.3	71.1	32.8	10.9	0.5	8.7	87.4	27.3	59.6	129.5	6.0	51.4	23.0
Total	4888.3	3248.5	350.7	553.7	460.1	44.2	51.6	8.97	507.5	180.25	234.5	274.5	165.25	92.7	327.3
Percentage of total			10.8	17.0	14.2	1.4	1.6	0.3	15.6	5.5	7.2	8.5	5.0	2.9	10.0

[1] This table is a revised and expanded version of Table 2 as found in Parrish (1966).

[2] Untabulated data not found in Parrish (1966) was obtained by the angler survey conducted jointly during 1963 and 1964 by the Department of Agricultural Economics and the Department of Fisheries and Wildlife at Oregon State University.

Table A2. Number of angler hours, number of anglers interviewed, and numbers of miscellaneous fishes in the catch of the anglers interviewed each month for one year in Yaquina Bay, Oregon.[1]

Date	Angler hours	Number of anglers interviewed	Number of fish caught	Number of each species in the monthly catch: Seaperch: Striped	White	Pile	Walleye	Redtail	Shiner	Starry flounder	Kelp greenling	Black rockfish	Pacific herring	Jack smelt	Ling cod	Miscellaneous species
Aug. - 63	877.5	489	289	17	29	31	7	0	5	43	112	17	0	20	2	6
Sept. - 63	914.5	230	200	16	24	27	2	0	0	15	45	55	0	0	7	9
Oct. - 63	31.3	15	8	0	1	0	1	0	0	3	3	0	0	0	0	0
Nov. - 63	1.5	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Dec. - 63	65.4	88	304	35	41	0	1	0	0	3	6	3	0	215	0	0
Jan. - 64	72.2	30	92	25	38	20	0	0	0	2	6	0	0	0	0	1
Feb. - 64	118.3	77	260	8	4	15	18	4	0	3	10	5	0	189	0	4
Mar. - 64	316.2	219	157	18	34	10	18	5	0	23	24	2	0	21	0	2
Apr. - 64	393.1	180	314	64	43	79	3	10	0	54	39	16	4	0	0	2
May - 64	443.5	205	598	77	181	80	0	13	0	77	9	1	157	0	0	3
June - 64	569.5	243	831	31	86	0	1	10	2	19	19	21	611	2	2	27
July - 64	1085.3	564	1271	28	94	21	22	1	97	54	46	82	717	86	16	7
Total	4888.3	2342[2]	4325	319	575	283	73	43	104	296	320	202	1489	533	27	61
Percentage of total				7.2	13.0	6.4	1.6	1.0	2.4	6.7	7.3	4.6	33.7	14.1	0.6	1.4

[1] Original data obtained by the angler survey conducted jointly during 1963 and 1964 by the Department of Agricultural Economics and the Department of Fisheries and Wildlife at Oregon State University.

[2] Of this total 1,116 anglers reported no catch.