AN ABSTRACT OF THE THESIS OF

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Title AGE-FECUNDITY RELATIONSHIPS IN THE STRIPED SEAPERCH EMBIOTOCA LATERALIS FROM YAQUINA BAY OREGON

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A study was conducted at Yaquina Bay, Oregon, to determine the age-fecundity relationships in the striped seaperch Embiotoca lateralis. A questionnaire was sent to California, Oregon, and Washington to ascertain what regulations were in effect, and the value of the family Embiotocidae with regard to the sport and commercial harvest. The questionnaire revealed that no state maintained a systematic account of each species landed, and further life history data appeared desirable for sport and commercial species.

Fish were collected from March 20 to August 21, 1960, with 140 females and 26 males being collected for analysis by hook and line or 125-foot experimental gill net. Scales were imprinted on cellulose acetate cards or mounted between glass slides. The catch was measured in centimeters of standard length and weighed in grams. From 123 females, 2, 654 embryos were obtained, and a maximum of 22 embryos per female was measured in millimeters of standard length.

The estimated time of annulus formation in most scales was from March 15 to June 12. Second and third annuli were primarily laid down in March and April, with the probable peak of annulus formation for females of ages IV, V and VI in May. Length-frequencies were presented by age-class and sex. Eighty-one females of age-class III dominated the sample. Females of age-classes II and III attained greater average lengths than males. In age-class II, average weights for females were slightly greater than those for males. Both sexes generally mature for the first time in their third year of life.

Length-weight, and length-number of embryos per female, for females of age-classes III-IV, were expressed by the regression equation $Y_c = a + b (X)$. High correlations for length-weight were obtained. Additional females were needed to evaluate that age when weights would digress. Females of age-class V produced the most embryos per unit increase in length; this rate declined in age-class VI. The largest number of embryos produced by an age class was 1, 431, in age-class III. The average number (in parentheses) of embryos produced per female of each age class, was: II (17); III (18); IV (21); V (30); VI (31) and VII (32). The most prolific female was seven years old and contained 45 embryos

Sixteen diminutive embryos were collected in 10 out of 128 mature females. Most older females were thought to have ovulated

earlier than younger females, for their embryos were generally larger than embryos of younger females. However, embryos from younger females could reach the approximate mean size of embryos of older females, but at a later date. Birth of embryos began about June 12 and ended in late July. Embryos averaged about 50 mm in standard length at birth.

Suggestions are given for management of the striped seaperch.

AGE-FECUNDITY RELATIONSHIPS IN THE STRIPED SEAPERCH *EMBIOTOCA LATERALIS* FROM YAQUINA BAY, OREGON

by

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INTRODUCTION

This study of the age-fecundity relationship of the striped seaperch, Embiotoca lateralis Agassiz, was undertaken with the aim of furnishing life history information vital to the management of this viviparous, marine sport species. This research complements the age and growth study of Sivalingam (9, 53 p.). Field work was carried out at Yaquina Bay, Oregon, from March 20 to August 21, 1960.

As the striped seaperch is found in marine and brackish water from Port Wrangel, Alaska, to northern Baja, California (11, p. 64), a questionaire was sent to California, Oregon and Washington, the three states most concerned with the management of this and similar species, to ascertain what regulations were in effect, and the status of this family in regard to the sport and commercial harvest, Table 1, p. 2-4. Of the three states queried, California appears to be managing surfperch more adequately than either Oregon or Washington, but no state maintains a systematic account of the individual species landed, both sport and commercial. Further life history data for each species of Embiotocidae making up the sport and commercial catch appears desirable.

Table 1a. A survey of the sport and commercial fishery regulations, the catch, and the status of the family Embiotocidae in California.

State	Sport fishery data	Commercial fishery data	Market increase in past five years	Danger of over-utilization at the present time?
	Fifteen of the 19 species found in saltwater have some sport value (4, p. 60-63). Limit: From a line drawn due west from the north boundary of San Luis Obispo County north said line; 25 perch. South of said line; 10 of all species except 25 *Cymatogaster aggregata* (3, p. 29).	Eight species of the 15 species listed under sport fish regulations are of commercial importance. Most species are only listed as saltwater perch in landing statements. Northern California: A closed season from May 1-July 15. Commercial landings in 1959: 212,746 pounds (4, p. 60-63).	?	Sport: In southern California as to seasonal limitations -- no negative result at the present time. 1/ With what little is known, none of the species are at the present time in danger of over-use (4, p. 60-63).

1/ Ripley, William Ellis, Assistant Chief, Marine Resources Branch. Personal Communication. State of California, Department of Fish and Game, 722 Capital Avenue, Sacramento 14, California, June 25, 1962

Table 1b. A survey of the sport and commercial fishery regulations, the catch, and the status of the family Embiotocidae in Oregon.

State	Sport fishery data	Commercial fishery data	Market increase in past five years?	Danger of over-utilization at the present time?
Oregon	No information available to indicate the need for a limit or season.[2/] Perch do support an important recreational fishery in Oregon bays and surf areas (7, p. 5).	No regulations concerning commercial landings--may be considered a latent fishery.[2/] Average annual landings of all species from 1928-1949 was 24, 800 pounds (7, p. 5). Market demand is variable, often light. No record of surfperch landings for 1961.[2/]	No[2/]	?

[2/] Van Hyning, Jack M., Assistant Director of Research. Personal Communication. State of Oregon, Fish Commission, Research Laboratory, Route 1, Box 31A, Clackamas, Oregon, July 24, 1962.

Table 1c. A survey of the sport and commercial fishery regulations, the catch, and the status of the family Embiotocidae in Washington.

State	Sport fishery data	Commercial fishery data	Market increase in past five years?	Danger of over-utilization at the present time?
Washington	Minor importance and there are no limits or seasons as to weight or to the number taken. The two species commonly taken are *Phanerodon furcatus* in the surf and *Rhacochilus vacca* in Puget Sound.[3]	Gear: Willapa Bay--closed March 1- June 30 for drag seine gear. Grays Harbor--legal all year for all gear. May 15-August 14--illegal to land perch with any type of gear in Puget Sound--seine gear mesh should not be less than 1-1/4 inches stretch measure (put into effect September, 1960). *Phanerodon furcatus* and *Embiotoca lateralis* are the two species in greatest demand. Landings in 1961: 176, 691 pounds. [3]	Yes [3]	?

[3] DiDonato, Gene, Fisheries Biologist. Personal communication. State of Washington, Department of Fisheries, 4015 20th Avenue West, Seattle 99, Washington, July 3, 1962.

METHODS

Collection of Specimens

Specimens for this research were obtained from Yaquina Bay, Oregon, from March 20 through August 21, 1960; Figure 1, page 6, and Table 10, Appendix, pages 40-41. A total of 166 Embiotoca lateralis, 140 females and 26 males, was studied. Figure 1 illustrates the areas where collections were made. The number applied to each location indicates its value as an area in which to catch striped seaperch; 1, 2, etc., in decreasing value. The areas were selected also as to their location, physical characteristics and biological aspects, e.g., area 3 was chosen to see what species of surfperch inhabited the upper part of the bay where there is reduction in salinity, the bottom is of mud, and the banks are of rock or mud flat. The two types of gear used to obtain fish were hook and line and an experimental gill net.

Hook and Line Gear

This gear consisted of two dropper hooks above a 1-1/2 ounce sinker, monofilament line and spinning rod and reel. The chief bait, and the most successful, was the mud shrimp, Upogebia pugettensis; when fresh bait became scarce, commercially packed frozen shrimp was used. Other fresh marine animals were tried but they were

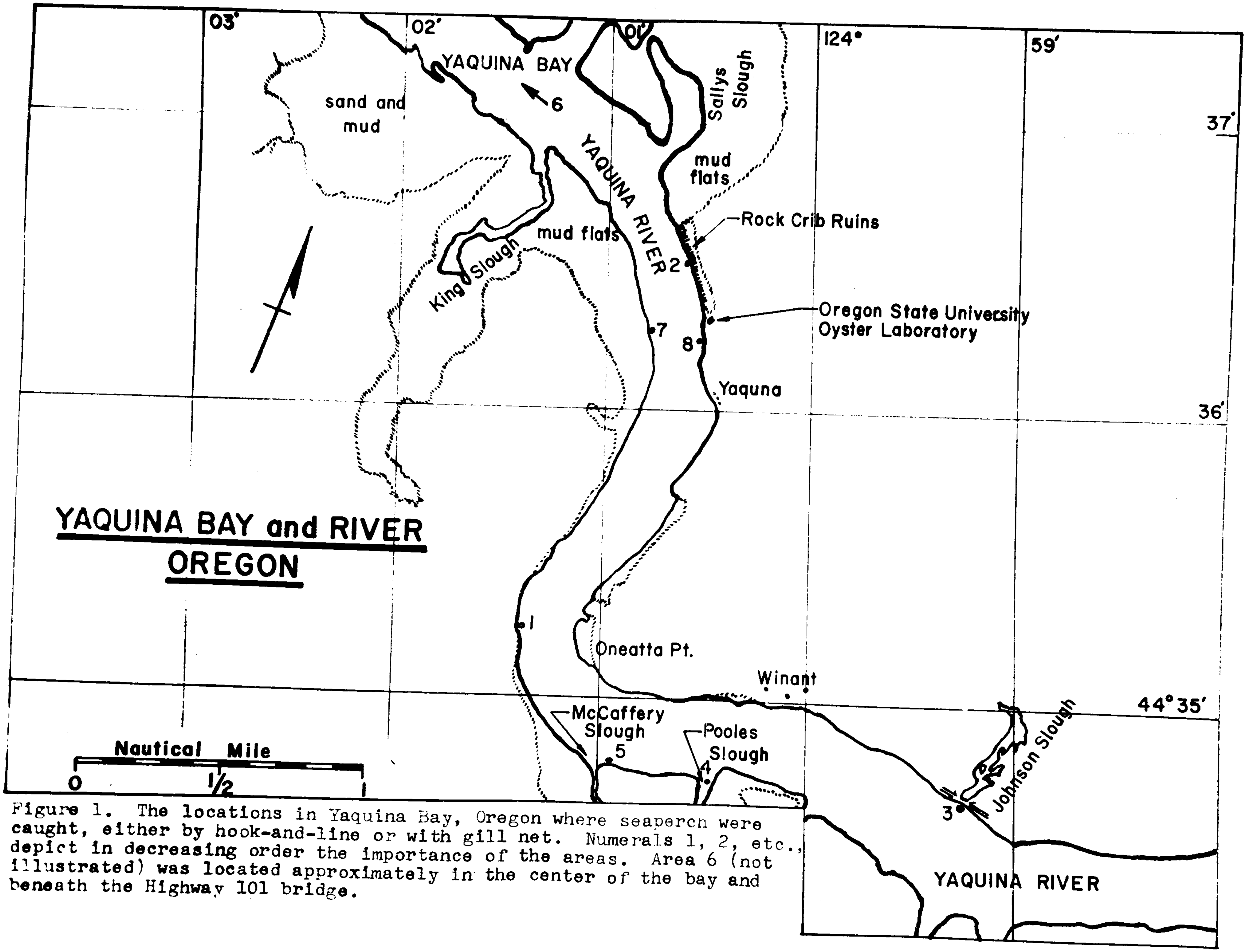

Figure 1. The locations in Yaquina Bay, Oregon where seaperch were caught, either by hook-and-line or with gill net. Numerals 1, 2, etc., depict in decreasing order the importance of the areas. Area 6 (not illustrated) was located approximately in the center of the bay and beneath the Highway 101 bridge.

either too difficult to obtain, or too easily removed from the hook by fish or tidal currents.

Fourteen fishermen used the same type of gear and fished at various times during the 39-day fishing effort, Table 10, Appendix, pages 40-41. Information in Table 10 also points out that on 11 days no striped seaperch were taken; that in March, April, May, June, July and August the following approximate percentages of catch were obtained: 8; 31; 43; 13; 2 and 3, respectively. A few male and female fish were not analyzed, or some females were released during the time tests were being run on the swimming ability of their embryos. Fishing success per unit of effort was not assessed. From about June 14 to the end of the study, fishing success diminished. On many days thereafter, only one or two striped seaperch were caught by two or three fishermen fishing from three to six hours. Seasonal fluctuations of the catch in bays for several species of surfperch has been reported for central and northern California, with the best catches occurring from March through June (4, p. 61). The ratio of female to male striped seaperch caught was estimated to be 4.5:1, rather than the approximate ratio of 5.5:1 as indicated in Table 10, Appendix, pages 40-41.

From about June 18 to August 21, a drastic change in foraging habits occurred. The fish no longer fed on an incoming and slack high tide, but foraged on outgoing tides in area 1, opposite and across the bay from Oneatta Point, and area 2, off of the rock jetty which extends down-bay from the site of the former Oregon State University Fishery Laboratory. This same phenomenon was noted in area 4, at the mouth of Pooles Slough, a few days after June 18.

Experimental Gill Net

An experimental gill net approximately 125 feet in length was fished at an oblique angle to the current. Each time the net was set it was placed far enough from the shoreline so that during low tide the net would be underwater. The gill net was used in an attempt to catch a greater range of age classes of fish than were taken by hook and line. The hook and line method was employed during daylight hours only, but the gill net was used according to three plans: sets were made overnight, from low tide at night to low tide in daylight, or from low tide to high tide in the daytime. Overnight and low tide-to-low tide sets caught fish, but the results were poor because the seaperch taken were badly damaged, presumably by two species of crabs, *Cancer magister* and *Cancer productus*. In addition, tidal currents brought large quantities of algae, sticks and branches, which were encrusted with shellfish, into the net. Also, deterioration of internal organs by autolysis often was encountered in gill-netted fish. On April 16 and 17 (overnight), 15 striped seaperch were caught in area 1. A set made May 21 and 22 (overnight) caught no seaperch; this set was made near the shoreline in area 8, approximately 40 yards up-bay from the Oregon State University Fishery Laboratory site. On June 11, 12 striped seaperch were taken in area 2 (low tide-to-low tide), but were too deteriorated for use. On June 12 (low tide-to-high tide), 12 striped seaperch were netted in area 2.

Handling of Specimens

Handling Upon Capture

Fish captured during March and April were usually examined two to eight hours after being caught. From May to August 21, captured fish were immediately put into plastic poultry bags, the air pressed out, and the bags tightly closed with wrapper wire or rubber bands. The fish were generally transferred from Yaquina Bay by automobile 56 miles to the Oregon State University Pacific Cooperative Water Pollution and Fisheries Research Laboratories located on Oak Creek, near Corvallis, Oregon. Those fish that were placed in plastic bags were usually frozen until they could be adequately examined. Fish were measured to the nearest tenth of a centimeter in standard length. Weights were taken in grams and rounded to the nearest tenth of a gram. The embryos and ovary were included in each weighing.

Embryos from a few fish were used to determine the approximate time of birth in June and July. Tests were performed immediately after a female was captured and she began to extrude embryos (some embryos were forced out of the female by pressing on the abdomen). The embryos were placed over the side of the boat and into seawater of variable salinities, depending upon tidal influx and outflow from the Yaquina River. Both females and embryos used during these experiments were released.

Preparation of Scales for Age Determination

Prior to, and during scale analysis, the following references were used: Creaser (5, p. 1-83); Hubbs (6, p. 198); Sivalingam (9, p. 13-20) and Suomela (10, p. 24-29).

From each fish a scale sample was taken from an area below the first dorsal spine and just below the lateral line. When possible at least five good scales were prepared and mounted from each scale sample. A high incidence of regenerated scales was observed.

Solutions of "Chlorox," "Joy" detergent and warm water were used in cleaning the scales. The soaking period for the Chlorox solution was quite critical, for if the scales soaked too long the circuli began to disintegrate. The detergent could not be completely rinsed from the scales, thus preventing the scales from adhering to the mounting tape. Warm water was the most satisfactory soaking solution tried. The mucous and debris could be easily brushed off the scales, and the scales could even be soaked overnight. Cleaned scales were mounted upon wrapping tape or freezer tape with the sculptured side out. The freezer tape was favored over the wrapping tape, for the large, thick scales could be pressed flat on the freezer tape and would generally remain in this position without curling. Tapes were numbered and stuck to cellulose acetate cards, three inches by five inches and 0. 020 inches in thickness. The tape number was also inscribed in the acetate beneath each pressed row of scales. The research division of the Oregon State Game Commission provided use of a scale press which was operated at a thermostatically controlled temperature of 155° F., in both platens. A pressure range between 5, 500-6, 000 psi., was maintained from five to six minutes.

Some scales did not imprint properly. The poor impressions in the acetate cards were thought to be caused by placing both large and small scales on the same acetate card, since both large or small scales would at times imprint improperly. When this occurred, new scales were prepared and mounted between two glass slides which were held together by transparent tape. Some of the thicker scales could be mounted and read more easily when mounted between glass slides.

A binocular microscope (with a substage mirror), an Eberbach scale projector, and a "Ray-O-Scope" microprojector were used in reading the scales. Scale samples were read at least four times, with a maximum of nine readings. Approximately 10-30 days were allowed to pass before the next period of scale reading began. Each time the scales were read a new reading pattern was used. Scale readings were compared at the end of the third, fourth and ninth reading periods.

Care of Ovary and Embryos

Figure 2, page 13, depicts the structure of the ovary of *Embiotoca lateralis*. The ovary contains two internal and separated sacs, as described by Blanco (2, p. 382), except that the ovaries examined in this study usually contained six pockets or compartments, whereas Blanco reported that his specimens usually contained five compartments.

The ovaries were removed from each female by making an incision from the anus anteriad to the pectoral girdle. The anus was encircled and then brought forward and out of the way of the ovary. An incision around the urogenital opening was completed and the ovary raised to a 90°-angle. The two blood vessels leading forward from the horns were then snipped off. A half hitch of thread was then wrapped around the terminus of the ovary just above the urogenital

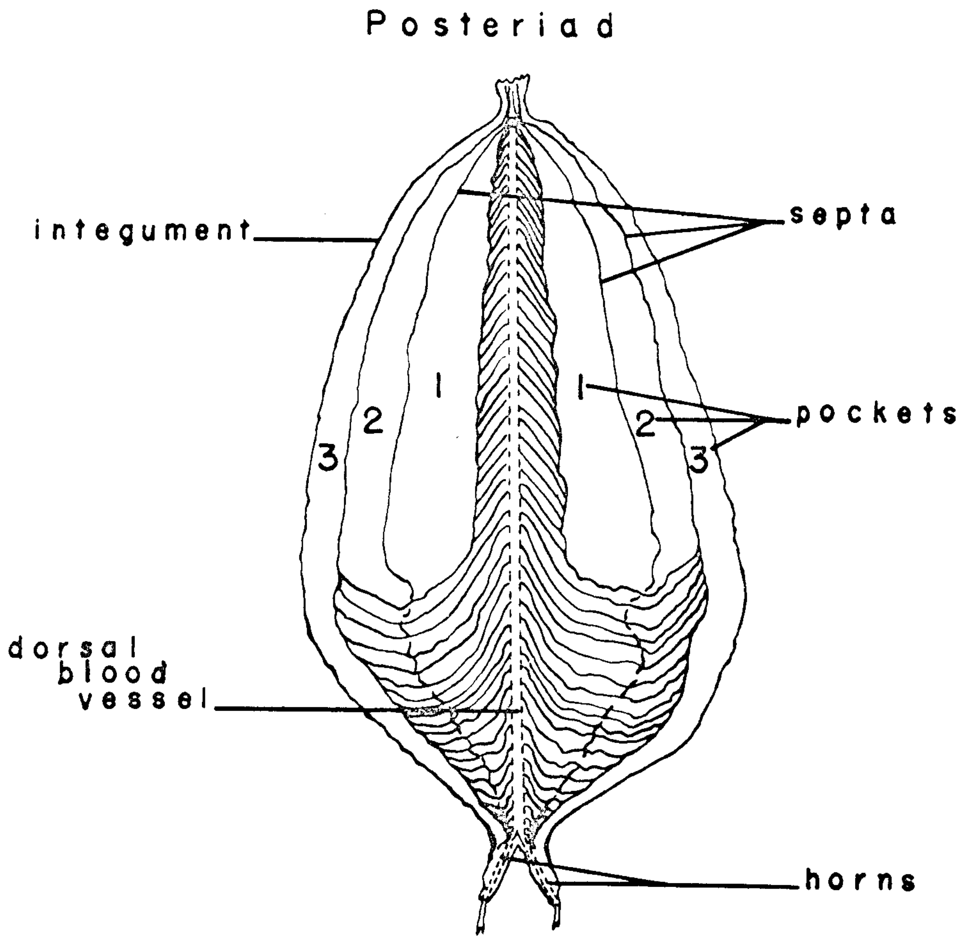

Figure 2

VENTRAL VIEW OF OVARY-OPENED

opening and a numbered tag attached. Ovaries were then preserved in a solution of ten percent formaldehyde. Ovaries were opened for examination of embryos at the ventral surface from the posterior end, making a shallow cut with scissors to the crotch of the horns.

The embryos in each ovary were enumerated and then measured. The number of embryos to be measured from each fish was figured by taking the sum of all embryos collected and dividing this number by the sum of the female fish from which they were taken. For example:

$$\frac{\text{2, 654 embryos}}{\text{123 females with embryos}} = \text{22 embryos to be measured per female}$$

If a fish was thought to have lost any embryos, neither that fish nor its young was figured in the total. When a fish contained 22 embryos, or less, all of the young were measured. Embryos were placed in a vertical row upon a sheet of paper, and while being viewed under the low power of a dissecting microscope, holes were punched in the paper at points corresponding to standard length. If the external or internal structure of an embryo was not clear under the low power, then the moist embryo, which was stuck to the paper, was held before a 60-watt light bulb and the holes punched. Measurements of the embryos to the nearest tenth of a millimeter were then taken by measuring between the punch holes with a millimeter scale.

RESULTS

Age and Growth

Interpretation of otoliths and scales in studies of age and growth of embiotocids by Suomela (10, p. 6) and Sivalingam (9, p. 11) led both investigators to the conclusion that the otoliths were too difficult to read in the older age classes. Both consequently relied upon the scale method for determining age and growth.

Age by Scale Analysis

Hubbs (6, p. 200) studied the scale structure of *Amphigonopterus aurora*, and described the "metamorphic annulus" or birthmark which is found on the scales of both sexes. It is a zone distinguished by fine, closely spaced circuli laid down soon after birth in the summer and resembles the winter marks found on the scales of older fish. Embryos not having attained the metamorphic annulus have concentric and evenly spaced circuli from the focus to the scale margin.

In his study of *Cymatogaster aggregata*, Suomela (10, p. 8) found that the dorsal and ventral fields of a scale did not show evidence of a birthmark.

Hubbs (6, p. 199) noted the peculiarity of doubling of annuli in *Embiotoca lateralis* and *Micrometrus minimus*, but seldom in

Amphigonopterus aurora. Doubling of annuli was found on the scales of female fish and was described as a winter check and a spawning check. The spawning check was between two winter marks, and was less distinct, but similarly formed in relation to the winter checks.

In this investigation, the metamorphic annulus was found on the scales of both sexes, and spawning checks occurred on the scales of female striped seaperch. Neither the metamorphic annuli nor the spawning checks were counted as year marks.

Annulus formation, as described by Hubbs (6, p. 198-200), occurred during the winter months for Amphigonopterus aurora and Micrometrus minimus in southern California.

Suomela (10, p. 8-10) concluded that Cymatogaster aggregata formed its first annulus during May in its second year of life, but he could not establish the time of formation for subsequent annuli because of small sample sizes.

In Sivalingam's study of the striped seaperch, the time of annulus formation was not exactly known because no fish were collected between December and May. He figured that the new annulus was formed between December and March (9, p. 28).

Scales for the present study were collected prior to annulus formation, during formation, and after formation in age-classes I-VII. The time of annulus formation in most scales examined spanned the period from March 15 to June 12. Table 2, page 17, summarizes the data for several age classes. The time of annulus formation for three females of age-class VII could not be evaluated. The last few annuli and spawning checks of these three fish were in close proximity to one another and near the scale margins.

Although the number of female fish represented in Table 2 is small, there appears to be a relationship between age and time of annulus formation. The second and third annuli usually were laid down in March and April, whereas the probable peak of annulus formation for females of ages IV, V and VI was May. Time of formation for males of age-classes IV-VI could not be established because too few specimens were collected.

Table 2. Estimated time of annulus formation derived from scale analysis.

Age	Number[1/]	Sex	Period of annulus formation	Probable peak of annulus formation
I	1	M[2/]	March ?	?
II	11	M	February 27-May 10	March and April
	10	F	March 10-May 4	March and April
III	12	M	March 10-May 3	March and April
	37	F	March 10-June 12	April
IV	31	F	April 10-June-?	May
V	17	F	April 10-June 12	May
VI	10	F	March 13-June-?	May

1/ Some age classes contain fish that had almost, or had already, attained their current annulus.

2/ Male = (M) and female = (F).

Age classes for all striped seaperch used in the study are presented in Table 3, p. 19. The 81 female fish of age-class III

Table 3. The age, length-frequency of female (F) and male (M) *Embiotoca lateralis* from Yaquina Bay, Oregon.

Standard length (centimeters)	Age class													
	I		II		III		IV		V		VI		VII	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M
12.2-14.1	0	1												
14.2-16.1			1	6										
16.2-18.1			9	4	1	1								
18.2-20.1			1	3	12	5								
20.2-22.1			2	0	40	4								
22.2-24.1					28	0	13	0						
24.2-26.1							3	1	8	0	1	0		
26.2-28.1									11	0	4	0		
28.2-30.1											3	1	2	0
30.2-32.1													1	0
Total:	0	1	13	13	81	10	16	1	19	0	8	1	3	0

dominate the sample.

Age and Length-Weight Relationships

All weights were derived from entire fish; hence, embryos influenced the weights of female fish from age-classes III-VII. Sivalingam used eviscerated striped seaperch in determining the weights of his fish (9, p. 6).

Average lengths and weights for fish of ages II-VII are shown in Table 4.

Table 4. Average standard length and weight for ages II-VII. (Number of observations in parentheses.)

	Female		Male	
Age	Average length (cm)	Average weight (gm)	Average length (cm)	Average weight (gm)
II	17.3 (13)	182.0	17.1 (13)	178.8
III	21.6 (81)	375.2	19.8 (10)	262.4
IV	23.3 (16)	484.9	----	-----
V	26.2 (19)	697.2	----	-----
VI	27.7 (8)	784.9	----	-----
VII	29.7 (3)	962.2	----	-----

Sexual dimorphism appears to exist in age-classes II and III. Females representing these two age classes attained greater average lengths than the males. The average weights for females were slightly greater than those for males in age-class II. Since females of older age classes contained embryos, further weight comparisons between sexes would be biased. Sexual dimorphism was discussed by Sivalingam (9, p. 34-36), who found that females grew faster than males throughout life, and that for both sexes, the greatest period of growth was between the second and third winters. After the third winter growth slowed down.

The same relationship appears to exist for females in this study with regard to the increase in standard length (Table 4, p. 19); although too few females of younger age classes were collected to enable a substantiation of this fact.

The relationship of age, standard length and weight was further explored through an analysis of regression (Table 5, page 21). The relationship between length and weight was linear and was expressed by the regression equation $Y_c = a + b\,(X)$, for age-classes III-VI (Figure 3, page 22). The figure Y_c is an estimate of the mean weight when a length is substituted for (X) in the regression formula. The letter "a" is a constant and is a point on the ordinate where the regression line crosses the Y-axis, assuming $(X) = 0$. The value "b" is termed the regression coefficient, and is a constant that is an estimate of the increase in weight per unit of length.

Relatively high correlations between length and weight were obtained for all age classes evaluated, considering of course, the small numbers of adults in most age classes. The rate of increase

Table 5. Length-weight regression estimates for females containing embryos.

Age class	Number sampled	Average standard length (cm) $\bar{x}$	weight (gm) $\bar{y}$	Correlation coefficient r	Regression formula $Y_c = a + b\,(X)$
III	73	21.6	375.3	0.94	- 618.95 + 46.03 (X)
IV	15	23.3	484.9	0.88	- 956.67 + 61.87 (X)
V	17	26.4	697.2	0.97	-2, 118.62 + 106.66 (X)
VI	8	27.7	784.9	0.76	- 733.89 + 54.83 (X)

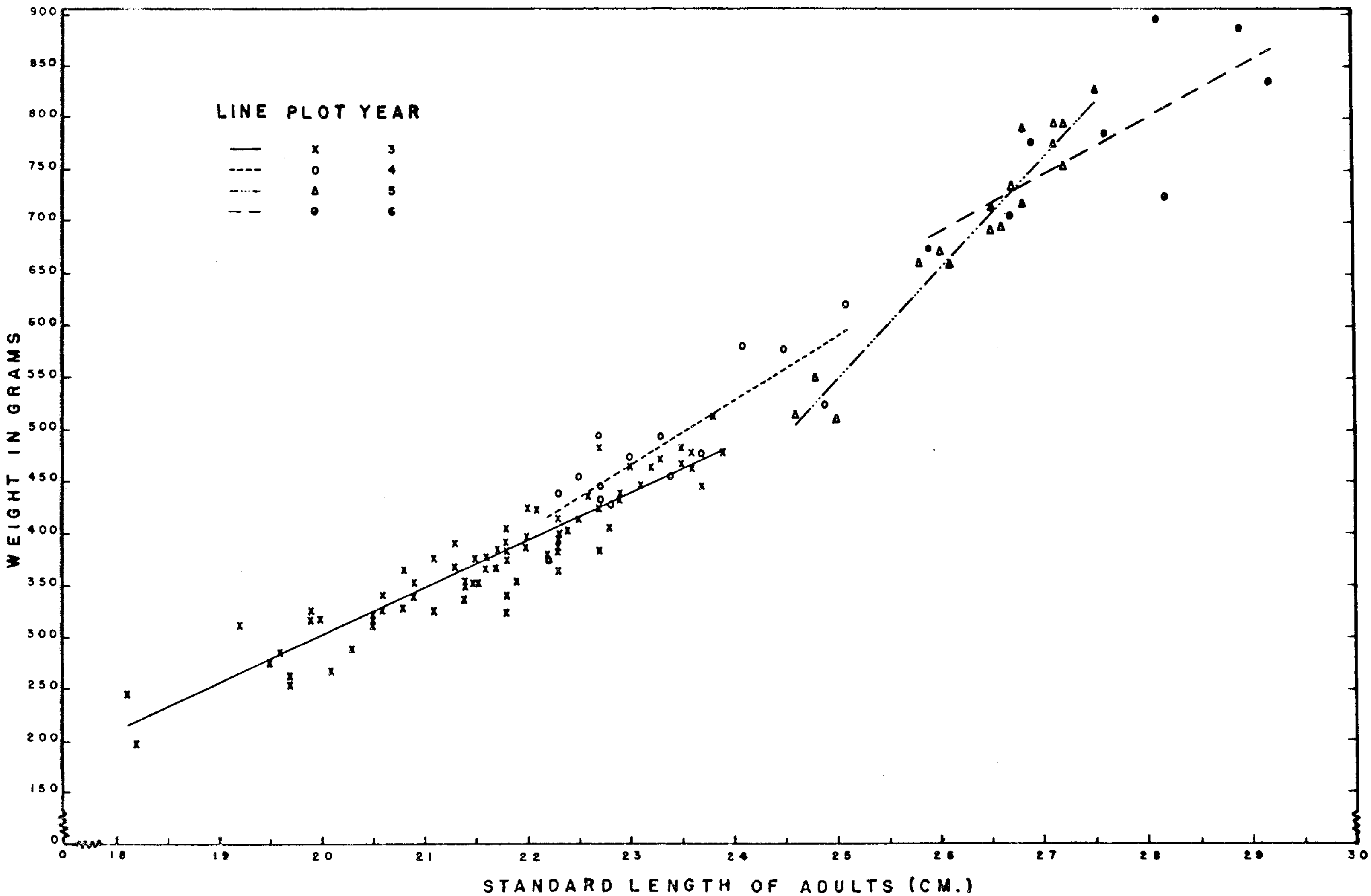

Figure 3. Age, length-weight relationship of striped seaperch from Yaquina Bay, Oregon, 1960. Lines fitted by regression equations given in text.

in weight for the different age classes appeared to be in close relationship, except for age-class V (Table 5, page 21 and Figure 3, page 22). The high "b" value for age-class V is probably a reflection of either a large number or large size of embryos contained in the females.

Only two females in age-class II held embryos, and these had almost attained their third annulus. The three gravid females in age-class VII (Table 4, page 19) averaged 962.2 grams in weight, indicative of an increase in average weight over age-class VI females. Additional specimens representing age-class VII, and older age classes, would have to be obtained to evaluate that age at which weights would digress.

Sexual Maturity and Breeding

Sexual Maturity

In specimens collected from Yaquina Bay the reproductive organs were examined for indications of sexual maturity. If the gonads of the male were swelled, not long and thin, the fish was considered to be mature (1, p. 371-372). A female was considered to be mature if its ovary contained embryos. Of 13 males in age-class II all were immature except three, and two of these had almost completed formation of a third annulus. Only one male of age-class III (16.7

centimeters long) was immature. All other males were mature. Of 13 females in age-class II, 10 were immature. Two mature females of age-class II had almost attained a third annulus. One spawned female of age-class II (18. 5 centimeters long) was collected August 12. Only one female of age-class III (19. 7 centimeters long) was immature. Both sexes generally mature for the first time in their third year of life in Yaquina Bay. Sivalingam found that in Washington females with less than three annuli in their scales did not contain embryos (9, p. 15).

Breeding

Although the literature contained several accounts of the breeding activity of embiotocids, there were few descriptions specific to *Embiotoca lateralis*. Blanco (2, p. 380) thought that the species copulated from June to August in Puget Sound, Washington. He believed that the spermatazoa were retained in the ovary until September when fertilization took place. Breeding activity was not observed in Yaquina Bay, for the water was generally too turbid to permit observation.

Number of Embryos

Knowledge of the fecundity of a known age class can be used in making annual population estimates and in setting harvest limits.

Several authors have investigated the fecundity of embiotocids. Hubbs (6, p. 195); Rechnitzer and Limbaugh (8, p. 42) and Triplett (12, p. 438-439) have written that older females were more prolific than young females.

The relationship of age, standard length and number of embryos was studied in the sample from Yaquina Bay, utilizing regression analysis (Table 6, p. 26). The relationship between length and number of embryos per female was linear and was expressed by the regression equation $Y_c = a + b (X)$, for age-classes III-VI (Figure 4, page 27). The figure Y_c is an estimate of the average number of embryos per female when a standard length is substituted for (X) in the regression formula. The letter "a" is a constant and is a point on the ordinate where the regression line crosses the Y-axis, assuming (X) = 0. The value "b" is termed the regression coefficient, and is a constant that is an estimate of the increase in number of embryos per unit of length.

B-values in Table 6, page 26, were +2.69 for age-class IV, +4.50 for age-class V and +2.75 for age-class VI. These b-values indicate that females of age-class V produced the most embryos per unit increase in standard length, and the rate of increase began to decline in females of age-class VI. However, regression lines in Figure 4, page 27, show a general trend of increase in number of embryos produced for each increase in standard length of female

Table 6. Standard length-number of embryos regression estimates for females.

Age class	Number sampled	Average length (cm) $\bar{x}$	Average number of embryos $\bar{y}$	Correlation coefficient r	Regression formula $Y_c = a + b\ (X)$
III	73	21.6	18.4	0.65	-17.51 + 1.66 (X)
IV	15	23.3	20.9	0.74	-41.89 + 2.69 (X)
V	17	26.4	30.0	0.58	-88.02 + 4.50 (X)
VI	8	27.7	30.9	0.55	-40.28 + 2.57 (X)

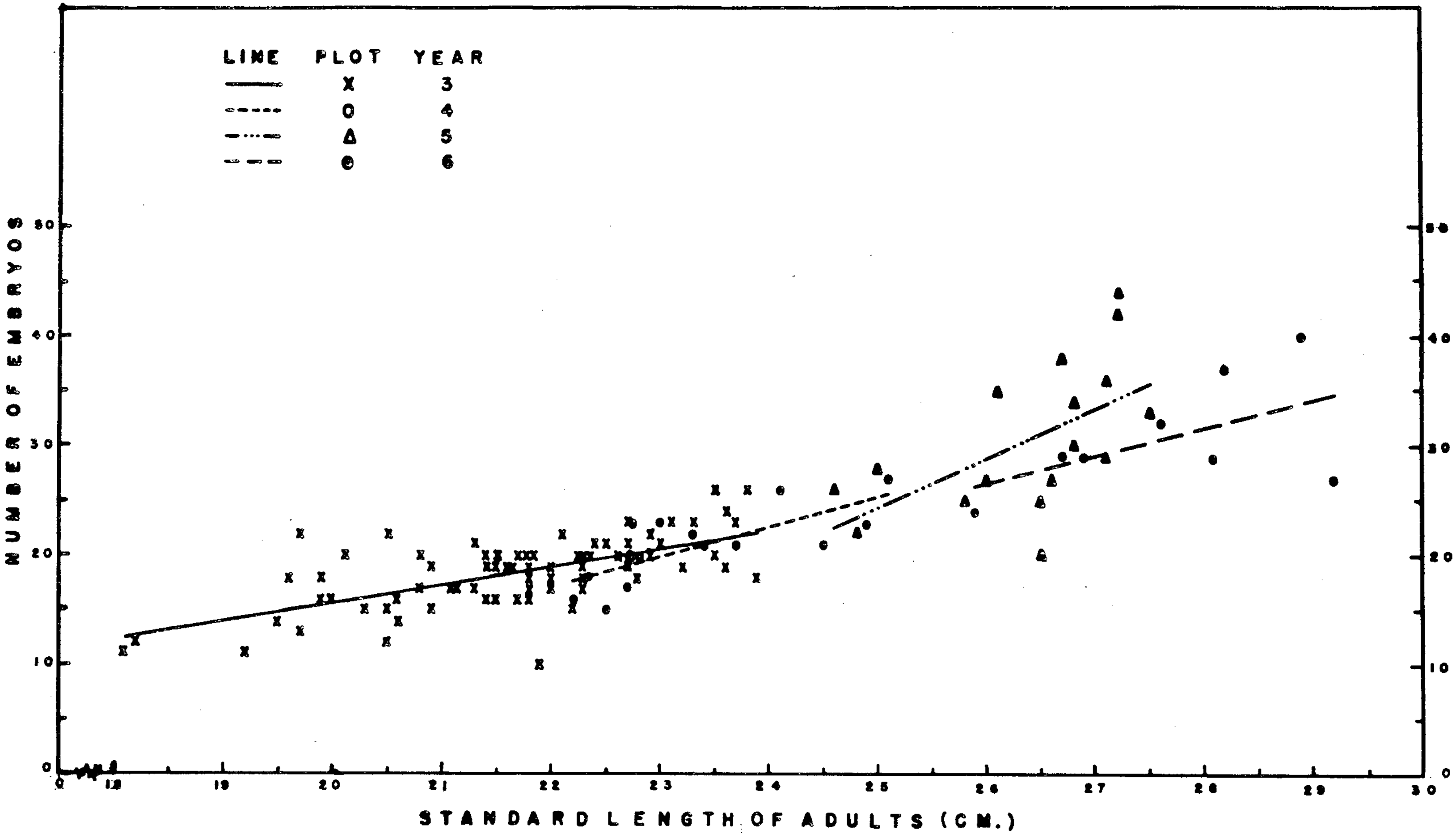

Figure 4. Age, length-fecundity relationship of striped seaperch from Yaquina Bay, Oregon, 1960. Lines fitted by regression equations given in text.

collected.

No doubt the collection methods were selective for fish older than age-class II, but if the numbers of females of the other age-classes taken in the samples truly represent the population in Yaquina Bay, then age-class III is the most important producer of young. Over half the total embryos collected in the study were produced by that age-class (Table 7, page 29). The average number (in parentheses) of embryos produced per female of each age class was II (17), III (18), IV (21), V (30), VI (31) and VII (32).

The most prolific female was seven years old, and contained 45 embryos. Blanco's counts varied from 18-92 embryos per female (2, p. 383-384), and Sivalingam found that a large female may contain 22-54 embryos (9, p. 6).

Table 7. Female-embryo relationships for each age class.

Item	Age class					
	II	III	IV	V	VI	VII
Number of females with embryos[1/]	2	78	15	17	8	3
Percentage of females with embryos	15	96	94	89	100	100
Number of embryos[2/]	34	1, 431	312	518	246	97
Percentage of embryos	1	54	12	20	9	4
Average number of embryos	17	18	21	30	31	32

1/ Does not include females which were immature, had lost embryos, or had spawned.

2/ Aberrant embryos were not included, nor were embryos of fish that were thought to have lost some embryos.

Growth of Embryos

Growth of embryos was limited to three aspects: the incidence and comparison between diminutive and normal sized embryos, the mean monthly increment in length of embryos, and the approximate time and size of embryos at birth.

Diminutive Embryos

The number of aberrant embryos produced by a population of striped seaperch is of importance in estimating mortality rates. Data presented in Table 8 shows that there were 16 small sized embryos found in 10 out of 128 mature females (123 females with all of their embryos and five females which were either spawned out or had lost some embryos).

Table 8. The incidence and comparison between diminutive and normal sized embryos.

Female		Diminutive embryos		Normal embryos
Age	Date collected	Number	Range in standard length (mm)	Mean standard length (mm)
VI	IV-12[1/]	1	(being absorbed)	28.4
IV	IV-17	1	---	31.2
III	IV-17	1	---	20.3
V	IV-23	1	15.8	30.0
III	V-1	5	10.6-11.5	24.8
V	V-10	3	11.8-19.3	38.6
III	V-15	1	24.6	31.1
III	V-15	1	29.7	35.6
III	V-15	1	---	30.1
III	VIII-7	1	(being absorbed)	(spawned out)

1/ The month-day.

Increment in Length of Embryos

Ovaries examined by Blanco (2, p. 380) in October and November contained eggs in late cleavage, blastula, gastrula and embryonic stages. In December he found embryos that measured one millimeter in total length. Sivalingam (9, p. 21) did not find embryos in the ovaries of fish collected during August to December, but did find embryos in fish collected during May through July. Sivalingam noted that embryos collected in May were of small size, but in July were fully developed.

For both females and their embryos mean standard lengths were obtained and grouped by the month collected and age class of the females (Table 9, p. 31). This was done to test the hypothesis that older females ovulated earlier than younger females, hence the older females should have the largest embryos. An anlysis of information exhibited in Table 9 shows that:

A. Generally, within age-classes III, IV, V and VI, females did not show successive monthly increments in length, but their embryos did.

B. Collections made in April, May and June showed that embryos were longer with each increment in age of the females, except embryos from females of age-class IV collected in April.

Table 9. Mean length of each age class of female and the mean length of their embryos for each month in which they were collected.

	Females			Embryos		
Month	Age class	No.	Mean standard length (cm)	No.	Mean standard length (mm)	s 1/
April	II	1	22.0 2/	19	27.0	0.97
May	II	1	20.5 2/	15	29.1	0.68
March	III	5	20.5	91	16.6	3.44
April	III	28	21.9	512	26.9	2.79
May	III	36	21.8	627	33.3	4.58
June	III	7 3/	21.1	110	44.9	4.09
July	III	1	21.4	19	51.5	0.94
April	IV	4	24.4	87	29.5	3.69
May	IV	7	23.1	137	33.5	3.24
June	IV	4	22.7	75	47.7	1.57
April	V	4	25.9	84	28.8	1.57
May	V	9	26.6	195	36.5	3.28
June	V	3 4/	26.5	66	48.9	2.16
April	VI	2	27.9	44	29.2	1.12
May	VI	6	27.6	132	36.7	4.47
April	VII	2	29.3	44	30.0	0.67
June	VII	1	30.4	12	51.6	1.53

1/ The letter s is the symbol for standard deviation.

2/ The fish had almost attained a third annulus.

3/ One additional fish and its 18 embryos were excluded, for the embryos were partially deteriorated.

4/ One additional fish and its 25 embryos were excluded, for the embryos were partially deteriorated.

C. The largest embryos averaged 51.6 millimeters in standard length and were obtained from a female of age-class VII on June 12. The next largest embryos averaged 51.5 millimeters in standard length and were collected from a female of age-class III on July 3.

Data presented in points A, B, and C above indicate that most older females did ovulate earlier than did younger females, for their embryos were generally larger than embryos of younger females. This point was brought out by Triplett (12, p. 439) in his study of *Amphistichus argenteus*. However even the embryos from younger females could reach the approximate mean size of that obtained by the embryos of older females, but at a later date.

Birth of Embryos

Estimates of the time of birth of embryos were based upon their ability to swim against a slight tidal current. These tests were conducted from early June through July 13, although the first female to have lost embryos was of age-class IV and was collected on May 29 (this fish contained two embryos).

Tests were performed immediately after a female was boated and she began to extrude embryos. The embryos were placed over the side of the boat and into seawater. In early June embryos from a female exhibited various degrees of swimming ability. Usually the first two embryos extruded by the female, and subsequently placed overboard, swam near the surface of the water in a circle, with the head pointed upward. The other embryos exhibited less equilibrium and swam on their sides with undulating motions of the body. When placed in shallow water they settled to the bottom and lay on their sides. By June 18 most of the embryos taken from a female could swim in a circle, with their head pointed upward. None of the embryos tested at this time could maintain a normal swimming position. On July 3 the first few embryos released could swim against the tidal current in a normal manner, and slowly submerged out of sight. The remaining embryos could not maintain an upright position while swimming against the tidal current. On July 13 embryos from three large females were tested for their swimming ability. All embryos except the last few to be extruded, or taken from the females by pressing on their sides, could swim in a normal manner. The last few embryos swam with the head pointed upward and near the surface of the water. This concluded the tests, for no other females were obtained that contained healthy embryos.

Similar observations on the swimming ability of some other embiotocid embryos were observed in the laboratory by Triplett (12, p. 436-437).

Judging from the previous observations of test embryos, and the mean standard lengths of embryos recorded in Table 9, page 31, the birth of embryos probably began about June 12 and ended in late July. Morgan (7, p. 9) reported that the striped seaperch completed spawning before the first week in August in Siletz Bay, Oregon. The size of embryos at birth averaged about 50 millimeters, standard length.

SUMMARY

This study revealed the following points about the age, length and fecundity of _Embiotoca lateralis_, which may be applicable to other bays in which it inhabits, thus abetting further investigations of not only this species but other members of the family Embiotocidae

1. According to a questionaire which was sent to the three states most concerned with the management of embiotocids, California, Oregon and Washington, none of these states maintained a systematic account of individual species landed. Further life history data appeared to be desirable for those species making up the sport and commercial catch.

2. The time of annulus formation in most scales examined was estimated to be from March 15 to June 12.

3. The second and third annuli were primarily laid down in March and April, whereas the probable peak of annulus formation for females of ages IV, V and VI was May.

4. The most numerous sex and age class collected were female fish of age-class III.

5. Females of age-classes II and III attained greater average lengths than did males of the same ages.

6. Both sexes generally mature for the first time in their third year of life.

7. Females of age-class V produced the most embryos per unit increase in standard length, with this rate of increase declining in females of age-class VI.
8. Females of the numerically dominant age-class III produced 54 percent of embryos handled in the study.
9. The greatest efficiency of embryo production per unit of length was by females of age-class V.
10. The average number (in parentheses) of embryos produced per female of each age class, was: II (17), III (18), IV (21), V (30), VI (31) and VII (32).
11. The most prolific female was seven years old, and contained 45 embryos.
12. Sixteen diminutive embryos were collected from 10 out of 128 mature females.
13. Most older females were thought to have ovulated earlier than younger females, for their embryos were generally larger than embryos of younger females at a given date.
14. Birth of embryos began about June 12 and ended in late July. Embryos averaged about 50 millimeters in standard length at birth.

SUGGESTIONS FOR MANAGEMENT

The management of the striped seaperch should be based on further studies on age and growth and on seasonal and tidal movements, abundance, food habits, and the relationship of the striped seaperch to the ecology and life histories of other embiotocids inhabiting Yaquina Bay.

Regulations governing the catch should be related to abundance, seasonal and area availability, and angler, or commercial demand. Creel census should be conducted on all species, and as well, records kept of commercial landings (differentiated as to sex and species).

If a seasonal restriction is needed, it should be applied with the idea of protecting a certain percentage of female fish until they give birth to their offspring.

In the event of a greatly intensified fishery on the striped seaperch, a minimum length limit which would protect about half the females of age-class III should allow for sufficient reproduction. About 10 inches total length is suggested as the minimum limit.

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APPENDIX

APPENDIX

Table 10. The catch of Embiotoca lateralis from Yaquina Bay, Oregon, March 13-August 21, 1960.

Date		No. of each sex collected		Total fish	Percent
Month	Day	Female	Male[1/]	collected	of catch
March	13	0	0		
	20	4	4		
	21	2	3	13	8
April	2	0	0		
	3	0	2		
	12	5	0		
	13	0	0		
	16	1	0		
	17	28	5		
	23	10	0		
	24	0	0	51	31
May	1	13	3		
	7	5	0		
	10	5	1		
	11	10	0		
	14	1	1		
	15	17	1		
	22	2	2		
	29	5	0		
	30	4	0		
	31	1	0	71	43
June[2/]	7	1	0		
	11	1	0		
	12	12	2		
	14	1	0		
	15	1	0		
	16	0	0		
	18	4	0	22	13
July	2	0	0		
	3	2[3/]	0		
	8	0	0		
	13	2[4/]	0		
	20	0	0		
	27	0	0	4	2

Table 10. Continued.

Date		No. of each sex collected		Total fish collected	Percent of catch
Month	Day	Female	Male[1/]		
August	7	2	1		
	11	0	0		
	12	1	0		
	20	0	0		
	21	0	1	5	3
Total:	39	140	26	166	100

1/ A few males were not recorded.

2/ A gill net caught 12 striped seaperch on June 11, but they were too deteriorated for use. A few females were not recorded, but were released during the time tests were being run on the swimming ability of their embryos.

3/ One additional female was not recorded, but was released after testing the swimming ability of its embryos.

4/ Three additional females were not recorded, but were released after testing the swimming ability of their embryos.