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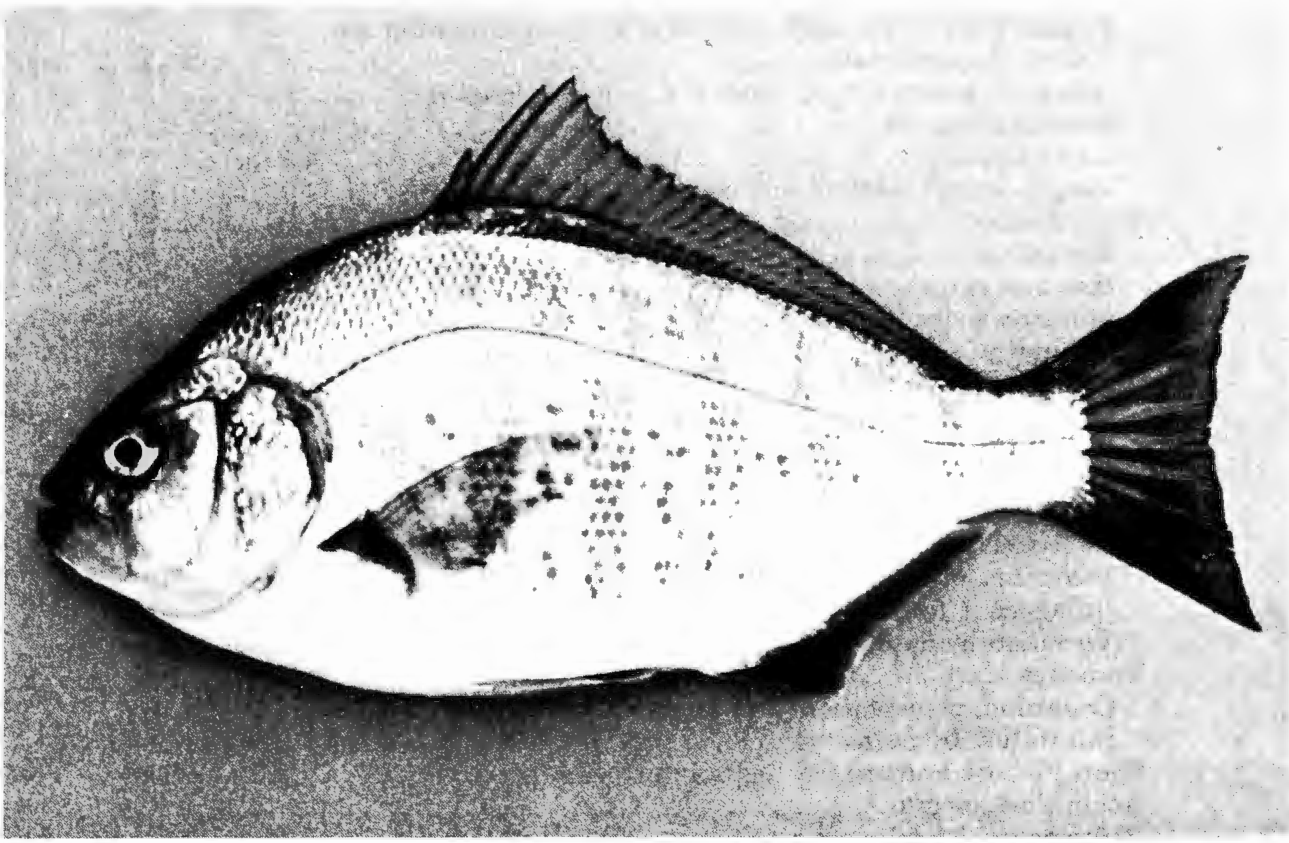

A mature female redtail surfperch, *Amphistichus rhodoterus*, collected at Copalis Beach, Washington (total length, 278 mm).

Biology of the Redtail Surfperch *(Amphistichus rhodoterus)* from the Central Oregon Coast

by

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Abstract

Data on certain aspects of the life history of the redtail surfperch, *Amphistichus rhodoterus*, were collected along the central coast of Oregon, from April 1967 through April 1969. Annulus formation occurred during February through June, usually earlier in young than in older fish. The longest of 774 surfperch captured was 375 mm in total length, the heaviest weighed 1,125 g, and the oldest was in age-group IX. Females older than age group II grew faster than males of the same ages. Males first matured at ages II and III and females at ages III and IV. Sex ratios appeared to be 1:1. Mating occurred from late December to early January, and the young were born from July through September. The number of embryos per female ranged from 1 to 39 (mean, 13.3) and increased linearly with the length and weight of the females. Mean size of embryos was positively correlated with size of the female throughout the gestation period. Estimated mortality of embryos was slightly more than 1%. Food of fish from the surf zone included crustaceans (by far the most important group in both frequency of occurrence and total volume) and (in order of decreasing importance) fishes, mollusks, and polychaetes. Parasites of the redtail surfperch were immature nematodes (Anisakinae); the digenetic trematode, *Genitocotyle acirra*; the monogenetic trematode, *Diclidophora* sp.; and the copepods, *Caligus* sp., *Clavella* sp., and *Argulus catostomi.*

The redtail surfperch, *Amphistichus rhodoterus*, is one of the largest surf-dwelling members of the family Embiotocidae in the sport fishery along the coast of northern California, Oregon, and Washington. The species ranges from Monterey Bay, California, to Vancouver Island, British Columbia (Clemens and Wilby 1961; Tarp 1952). It is commonly caught by sport fishermen along rocky outcrops, jetties, sandy beaches, and (from April through September) in bays. Life history information on the redtail surfperch is sparse (Miller 1960).

Because the species is among the many marine inshore and estuarine fishes and shellfishes that have been given scant attention, little basic life history information is available to permit conservation agencies to formulate sound management decisions (U.S. Bureau of Sport Fisheries and Wildlife 1959; McHugh 1966; Stroud 1971). The sparsity of knowledge about the surf-dwelling forms has been attributed to the difficulty in sampling this habitat (Schaefer 1967).

This study of the redtail surfperch was concerned with various aspects of the life history, including age and growth, length-weight relation, age and size at sexual maturity, fecundity, food, and parasites.

General Materials and Methods

The field work was conducted from April 1967 through April 1969 from Oregon State University's Marine Science Center, Newport, Oregon. The study area included Alsea and Yaquina Bays and the connecting surf zone, along about 23 km of the central coast of Oregon in Lincoln County (Fig. 1). This section of coastline consisted mostly of sandy beaches except for one large rocky outcropping at Seal Rock.

The planned sampling schedule called for semimonthly collections involving equal effort for a 2-year period. Because stormy weather and heavy surf reduced the success of sampling during the fall and winter, however, the frequency of sampling

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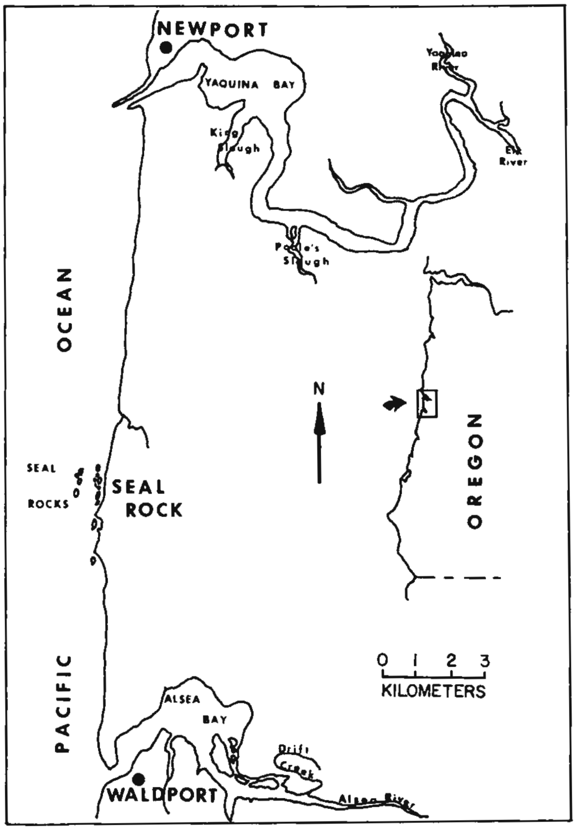

Fig. 1. Area from Alsea to Yaquina Bays along the central Oregon coast where the life history of the redtail surfperch was studied.

varied from once a month to as often as six times a month.

The fish were captured with gill nets, an otter trawl, and hook and line. Gill nets were used in bays only during the summer when surfperch were abundant there. The two 30.5-m monofilament nylon gill nets used were 1.8 m deep and contained four 7.3-m panels of graded mesh. Mesh sizes (stretched measure) were 5.1, 7.6, 10.2, 12.7 cm in one net and 3.8, 6.4, 8.9, and 11.4 cm in the other. The gill nets produced more fish per hour of effort than any other method of collection and caught fish of all ages, except young of the year.

The otter trawl, which had a 4.9-m headrope and a 1.3-cm mesh liner in the cod end was used mainly during the late summer and early fall in unsuccessful attempts to capture young of the year. The trawl was towed at about 2 to 3 knots behind a 4.9-m runabout boat powered by an 18-horsepower outboard motor.

Because of rough water, the only gear that worked well in the surf during the entire 2-year period was hook and line. The most successful baits were the ghost shrimp *(Callianassa californiensis)* in the estuary, and the orange mantle of the sea mussel *(Mytilus californianus)* in the surf.

During the spring of 1970 and 1971, 20 redtail surfperch were collected by hook and line at Copalis Beach, Washington. Since the 18 females in the catch had well-developed embryos but were not near parturition, their fecundity was determined for comparison with that of fish from the Oregon collections.

Age and Growth

Collection and Preparation of Scales

About 30–40 scales were taken from each fish from an area about four scale rows below the lateral line, obliquely posterior to the origin of the dorsal fin. A key area for scales was used primarily because of the high proportion (>20%) of regenerated scales found in surfperch. However, scales taken from a key area (this study; Wydoski and Bennett 1973) yielded a spread of points in the body-scale relation similar to that derived from key scales in other embiotocids (Gordon 1965; Wares 1971). Impressions of three or four nonregenerated scales were made on 7.6- × 12.7-cm cellulose acetate cards with a hydraulic scale press that applied a pressure of 2,285 kg/cm^2 at 100 C for about 5 min. Ages were determined from the scale impressions; anteriolateral radii from the focus to successive annuli were measured on the screen of a portable Eberbach microprojector at 27 X. Fish were advanced to the next higher age group on 1 January, as suggested by Hile (1948).

Applicability of the Scale Method of Age Determination, and Scale Characteristics

The three primary conditions that must be satisfied to ensure the soundness of the scale method of back-calculating the length of fish at successive years of life (Van Oosten 1929) were met by the redtail surfperch: (1) The number of scales remained constant throughout the life of the fish. Three series of scale counts were made on each of 30 young and 30 adult redtail surfperch—along the lateral line, from the origin of the dorsal fin to the lateral line, and from the origin of the anal fin to the lateral line. The counts for all fish were essentially equal and the nuclear area or focus of nonregenerated scales from young fish was structurally identical with that of scales of adult fish. (2) The growth of the scale was proportional to the growth in length of the fish. Measurements of scales (made along the anteriolateral radius because the relatively greater clarity of the annuli along this axis facilitated measurement) and fish lengths of 773 surfperch collected between April 1967 and April 1969 yielded the regression equation $Y = 0.44X - 12.42$, where Y = anteriolateral scale radius in millimeters (X 27) and X = total length in millimeters. The correlation coefficient was 0.952. (3) Annuli were formed once each year. They became evident between February and June (Fig. 2), the time apparently being influenced by size and age of fish: the smaller and younger fish tended to form annuli in February or March and the larger and older fish in May or June.

The time of annulus formation varies considerably in the Embiotocidae, and (disregarding possible generic differences) appears to be directly associated with latitude (Table 1). Annulus formation, as indicated by new growth on the scale margin, tends to occur earlier in southern than in northern waters.

The scales of redtail surfperch, like those of certain other embiotocids, have distinctive markings other than annuli. The birthmark or "metamorphic annulus" described by Hubbs (1921) and reported by Carlisle et al. (1960), Gordon (1965), Swedberg (1965), Wares (1971), and Anderson and Bryan (1970) was present on the scales of both males and females; it was clear in some fish but almost undetectable in others.

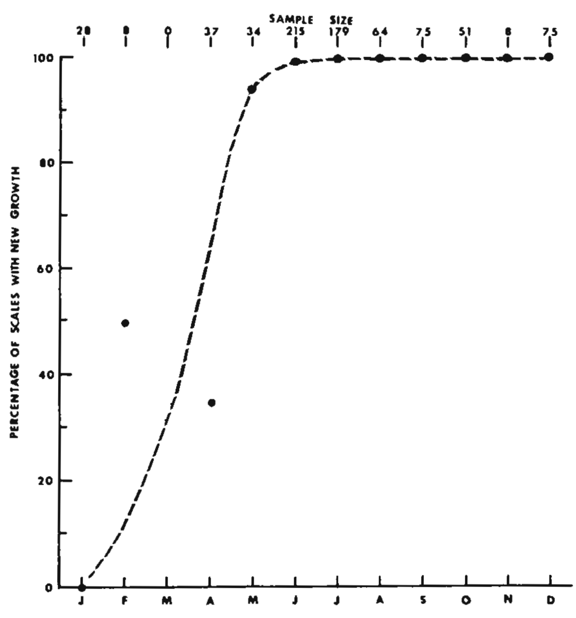

Fig. 2. Percentage of redtail surfperch with new growth on scale margin in different months. (Data from all age groups are combined. Line from January to April, drawn by inspection, based in part on sample size.)

Spawning checks, also reported by the authors cited above, were observed only in females during the present study. The first three spawning checks were clear in most fish but later ones were not. Perhaps in the later years of life the checks were incorporated with true annuli, or were not formed by older females. Although the checks were similar to true annuli, they were less distinct and lacked the feature of "cutting over" of circuli in the lateral field. Not all young mature females had spawning checks. Gordon (1965) also reported that these checks were lacking in some specimens of a related species, the shiner perch *(Cymatogaster aggregata)*. Male redtail surfperch lacked spawning checks, presumably because the gonads ripened during the winter, after seasonal growth had ceased.

Relations Between Total, Standard, and Fork Lengths

All measurements of fish (other than embryos) in the present paper are expressed in terms of total length, the length generally used by sport fishermen and by the regulatory agencies that establish minimum legal lengths. Standard length was applied to the measurement of embryos because the form of the caudal fin changes as the embryo develops. For comparison of our findings with the published work of other investigators, we calculated equations by standard linear regression analysis for the conversion of total length to standard or fork lengths. The calculations were made from total lengths grouped in 1-cm intervals. The standard length equation (standard length = 0.81 total length - 5.29, $r = 0.999$) was derived from measurements of 178 female and 154 male redtail surfperch ranging from 77 to 366 mm in total length. The fork length equation (fork length = 0.95 total length - 5.09, $r = 0.999$) was derived from measurements of 450 female and 333 male surfperch, 77 to 375 mm long.

Growth in Length

Consistency tests were conducted to determine the adequacy of scales for age determination. The senior author (Reader I) studied the scale impressions from 776 redtail surfperch and assigned ages twice. The second author (Reader II) studied the same scale impressions once. Assessment of ages by Reader II agreed with those by Reader I for 78% of the scale samples at the first reading; the second assessments by Reader I agreed with 86% of those made by Reader II. Reader I assigned the final age to fish for which age determinations by the two readers disagreed.

To aid in interpreting scale features, we collected otoliths from 108 fish representing age groups 0-VIII

Table 1. *Time of annulus formation in various Embiotocidae at different locations along the Pacific coast, southern California to northern Washington.*

Species	Locations	Time of annulus formation	References
Amphigonopterus aurora	Southern California	December	Hubbs (1921)
Micrometrus minimus			
Amphistichus argenteus	Southern California	September-April	Carlisle et al. (1960)
Cymatogaster aggregata	Northern California	March or April	Anderson and Bryan (1970)
Phanerodon furcatus			
Amphistichus rhodoterus	Central Oregon	February-June	(Present study)
Embiotoca lateralis	Central Oregon	March-June	Swedberg (1965)
Rhacochilus vacca	Central Oregon	May	Wares (1971)
Cymatogaster aggregata	Northern Washington	May	Suomela (1931) and Gordon (1965)
Embiotoca lateralis	Northern Washington	December-May	Sivalingam (1953)

(range in total length, 77-339 mm). Agreement between the final ages determined from scales and from otoliths was 96%.

Back-calculations of length were based on a computer program described by Reed (1968). The mean back-calculated and mean empirical lengths were similar for males and females of age groups I and II; however, those for females of age III and older were greater than those for males of corresponding ages. The differences in length between the sexes increased progressively with age (Table 2). This change in growth rate was correlated with age at

Table 2. *Calculated total lengths (mm) at the end of each year of life for different age groups of redtail surfperch from the Oregon coast, 1967-69.*

Sex and age	Number of fish	Calculated total length at each annulus								
		1	2	3	4	5	6	7	8	9
Females										
I	44	109								
II	92	102	169							
III	117	99	153	216						
IV	88	106	161	208	253					
V	46	103	154	201	246	276				
VI	34	106	167	215	258	286	307			
VII	21	101	158	213	260	294	315	332		
VIII	5	97	173	231	277	303	328	342	357	
Average length		103	160	211	254	284	312	334	357	
Increment		103	57	51	42	30	28	23	22	
Number of fish		447	403	311	194	106	60	26	5	
Males										
I	29	113								
II	69	101	171							
III	99	102	155	210						
IV	54	107	161	209	242					
V	30	104	164	206	241	264				
VI	27	105	159	205	238	263	279			
VII	14	100	158	208	238	263	279	291		
VIII	4	104	159	207	237	262	281	294	307	
IX	1	95	173	227	262	289	301	313	328	333
Average length		104	161	208	240	264	280	293	312	333
Increment		104	57	47	32	23	16	13	19	22
Number of fish		327	298	229	130	76	46	19	5	1

sexual maturity. This type of differential growth by sex also occurs in other embiotocids: pile perch, *Rhacochilus vacca* (Wares 1971); shiner perch, white seaperch, *Phanerodon furcatus*, and walleye surfperch, *Hyperprosopon argenteum* (Anderson and Bryan 1970); and silver surfperch, *Hyperprosopon ellipticum* (Wydoski and Bennett 1973). In one exception to this trend, male striped seaperch, *Embiotoca lateralis*, grew faster than females (Gnose 1968).

Lee's phenomenon of an apparent decrease in the growth rate from back-calculation of lengths at the end of each growing season (Ricker 1958) was not observed in redtail surfperch (Table 2), possibly partly because the exploitation of this species is low. This phenomenon was also lacking in the pile perch (Wares 1971), and in silver surfperch (Wydoski and Bennett 1973), but was reported for the older females in shiner perch, white seaperch, and walleye surfperch (Anderson and Bryan 1970). Anderson and Bryan suggested that the selection of the faster growing young fishes in the sport fishery in Humboldt Bay may be a partial explanation for this phenomenon in these three species.

Female redtail surfperch in our collections ranged in weight from 5 to 1,125 g, and males from 6 to 620 g. The mean weights for males and females in age groups 0, I, and II were closely similar. In age group III and older, however, the average weights of females exceeded those of males.

Age Frequencies

Age group III was dominant in the collections for both males and females (Fig. 3). In the surf, the mode for males collected was age group III and the mode for females, age group II; in the estuary, both males and females were mainly in age group III. In total numbers captured, females exceeded males in all age groups except 0 and IX. In the estuary females outnumbered males in fish of all age groups captured, whereas in the surf the males predominated in all age groups except I (Fig. 3).

The true age frequency distribution of redtail surfperch is not known. The age frequencies in Fig. 3 do not necessarily represent the age composition of the fish from this area because the frequencies reflect the selectivity of the collection devices used (which were selective in capturing fish in age group II and older), and habitats sampled. Behavior, as influenced by sex, age, and maturity, was also an important factor affecting the age composition of the sample.

The young were apparently born in the estuary, since the majority of females (61% of 262) captured in the estuary during the summer were either gravid or spent. However, otter trawling that captured many young embiotocids of other species revealed no concentrations of young redtail surfperch. Either the young were in areas that could not be sampled because of obstacles, or they returned quickly to the surf. On one occasion, we visually identified young redtail surfperch in the shallow surf at Beverly Beach, north of Newport. During the same time that gravid females were prevalent in the estuary, males predominated in the surf several miles from the mouth of the estuary. Sampling the surf zone with nets that might have produced young fish was not feasible, primarily because this zone was often extremely rough. Schaefer's (1967) attribution of the paucity of published information about fishes in-

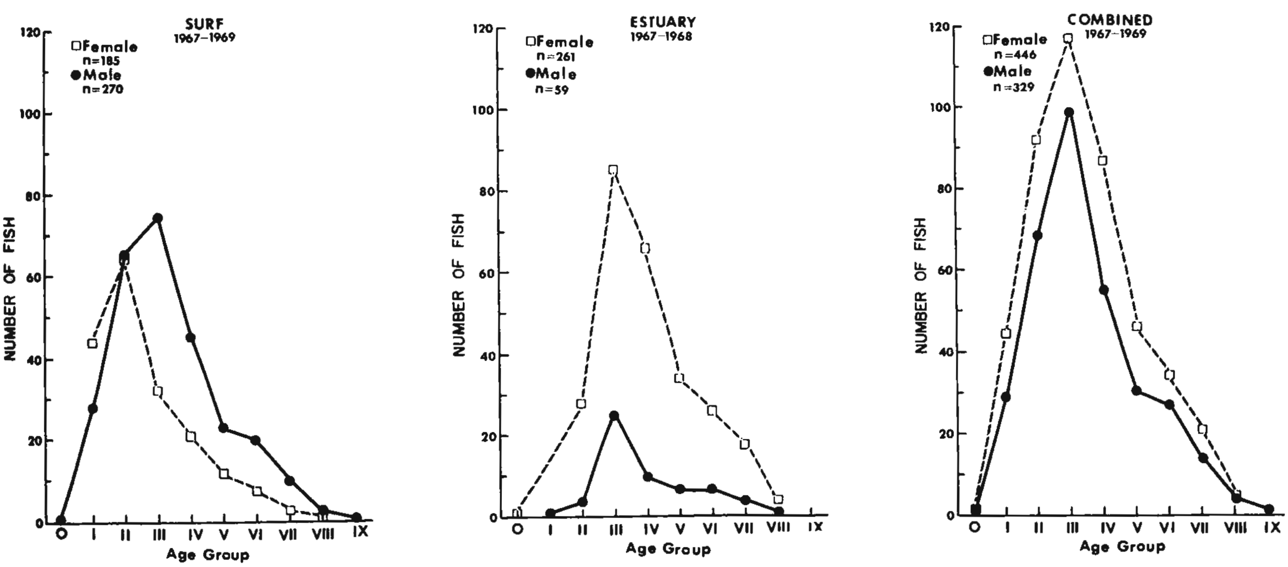

Fig. 3. Age frequency distribution of redtail surfperch collected along the central Oregon coast, 1967-69.

habiting the surf zone to the difficulty in sampling this habitat is certainly applicable to the Oregon coast.

Length-Weight Relation and Condition

The length-weight relation for redtail surfperch was satisfactorily described by the formula $\log W = \log a + b \log L$ (or $W = aL^b$) where W = weight in grams, L = length in millimeters, and a and b are empirically determined constants. Regressions of weight on length were computed separately by sex (Fig. 4) and then combined. The regression for males was $\log W = 3.08 \log L - 4.96$ ($r = 0.993$; $n = 450$), and for females, $\log W = 3.14 \log L - 5.09$ ($r = 0.994$; $n = 333$). Since the weights of males and females of similar lengths were equal (Fig. 4), the weights of redtail surfperch can best be estimated from the combined data for both sexes. The regression for the combined data was $\log W = 3.12 \text{ Log } L - 5.04$ ($r = 0.993$; $n = 783$).

The relative robustness or condition (K) for redtail surfperch was determined by the formula $K = \frac{W\ 10^5}{L^3}$ where W = weight in grams and L = total length in millimeters. We calculated condition factors for 333 male and 450 female redtail surfperch, using the computer program described by Reed (1968). Comparisons of condition were made between age groups as well as between the sexes by month of collection.

In general, male surfperch appeared to have a slightly higher condition factor than females (Fig. 5; Table 3). However, the differences were not significant. The range in condition factor of females exceeded those of males in July, when the embryos were growing rapidly (Fig. 5). The low part of the range resulted from the inclusion of immature females in the analysis. By August, many females had given birth, and this relation was correlated with the low mean value and the low extreme in the range of condition. The increase in the mean for September depicted the rapid recovery of spent females. The condition for both sexes was low from January through May and increased in June (Fig. 5) when all age groups showed new growth on their scale margins (Fig. 2).

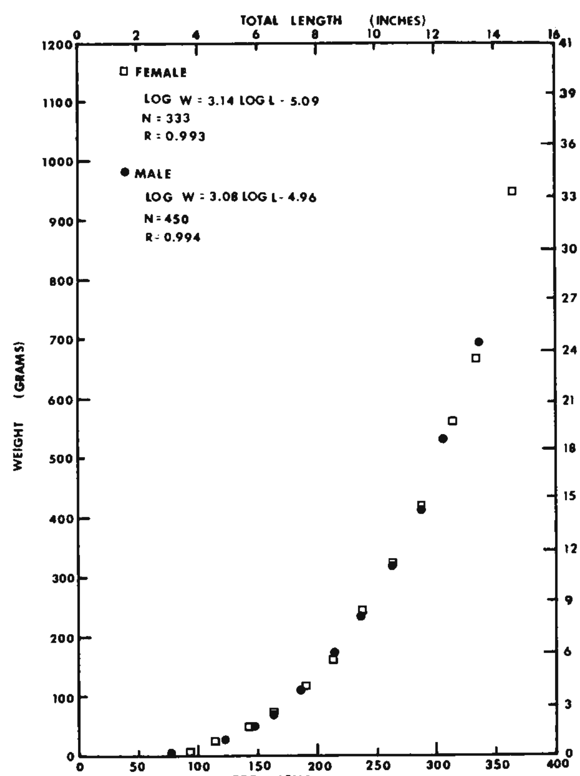

Fig. 4. Length-weight relation of male and female surfperch collected along the central Oregon coast, 1967-69.

Reproduction

Sex Ratios

The sexes were determined externally on the basis of differences in the anal fins, and verified by dissection. The anterior lobe of the anal fin becomes modified into a bulbous genital organ in maturing males. The bilobed appearance is easily recognized in 2-year or older males longer than 150 mm and accurately separates sexes throughout the year. This characteristic was not reliable, however, for yearlings or young of the year (shorter than 150 mm).

Although the combined samples from the estuary and the surf indicated a preponderance of females, 95% confidence intervals calculated by the method of

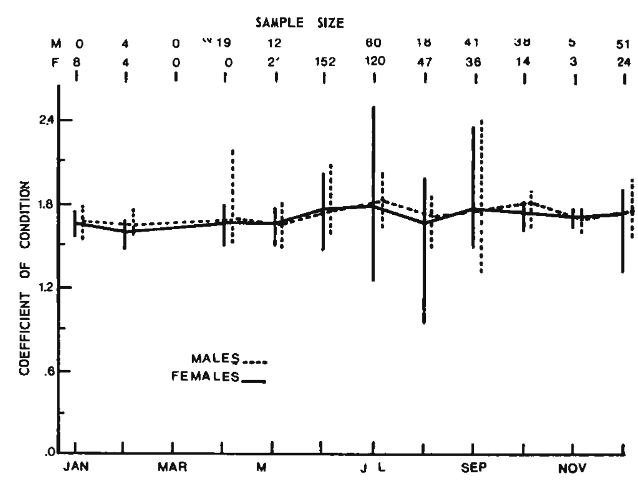

Fig. 5. Mean coefficient of condition, by month, for 450 female and 333 male redtail surfperch collected along the central Oregon coast, 1967-69. (Vertical lines show ranges.)

Table 3. *Mean condition factor, by age group and sex, for redtail surfperch from the Oregon coast, 1967-69.*

Age group	Males			Females		
	Number of fish	Condition factor Mean	Condition factor Range	Number of fish	Condition factor Mean	Condition factor Range
0	1	1.31	—	1	0.91	—
I	29	1.75	1.48-1.96	44	1.73	1.46-1.87
II	69	1.78	1.53-1.98	92	1.75	1.46-1.94
III	99	1.79	1.41-2.41	116	1.77	1.25-2.50
IV	54	1.77	1.48-2.19	87	1.79	1.55-2.14
V	30	1.79	1.53-1.98	46	1.77	1.51-2.37
VI	27	1.79	1.56-2.06	34	1.80	1.51-2.03
VII	14	1.76	1.58-1.99	21	1.87	1.61-2.07
VIII	4	1.85	1.70-1.91	5	1.97	1.59-2.22
IX	1	1.80	—	—	—	—

Simpson et al. (1960) overlapped the 50% point, except for age group IV (Table 4). The combined data, therefore, did not indicate a departure from the theoretical 1:1 sex ratio.

Females predominated among fish from the estuary and males among fish from the surf (Table 4). The greater percentage of females taken in the estuary suggested the likelihood that many females spawn in the estuary. Since numerous and repeated 15-min gill net sets demonstrated that redtail surfperch entered the estuary during incoming tide and returned to the surf just as the tide turned, it seems likely that gravid females enter the estuary at high tide to bear their young. Miller and Gotshall (1965) stated, "the best catches occur in the Spring when they concentrate for spawning in harbors and estuaries of larger rivers as well as the surf line."

The greater percentages of males in the surf may have reflected the sampling location. The Seal Rocks were chosen as a sampling location because the rocks provided the collectors a refuge from the rough surf and made year-round sampling possible. The location was about 12 km from the mouth of the estuary. Although the catch included many immature females, few gravid females nearing parturition were taken at this location; possibly gravid females tended to remain near the mouth of the estuary. The possibility that males feed more aggressively at this time can be discounted because gravid females are caught easily by hook and line in the estuary and make up the majority of anglers' catches.

Size and Age at Sexual Maturity

Male surfperch ripen, and mating occurs, in winter; the young are born during the following summer. Because macroscopic examination of the gonads in

Table 4. *Percentage females among redtail surfperch collected from the surf or in estuaries along the central Oregon coast, 1967-69 (CI = 95% confidence interval).*

Age group	Surf			Estuary			Combined		
	Number of fish	Percent females	CI	Number of fish	Percent females	CI	Number of fish	Percent females	CI
0	1	0.0	—	1	100.0	—	2	50.0	—
I	72	61.1	(49.9-72.3)	1	0.0	—	73	60.3	(49.1-71.5)
II	129	49.6	(41.0-58.2)	32	87.5	(76.1-98.9)	161	57.1	(49.5-64.7)
III	106	30.2	(21.4-39.0)	110	77.3	(69.5-85.1)	216	54.2	(47.5-60.9)
IV	66	31.8	(20.6-43.0)	76	86.8	(79.2-94.4)	142	61.3	(53.3-69.3)
V	35	34.3	(18.6-50.0)	41	82.9	(75.2-98.4)	76	60.5	(49.6-71.4)
VI	28	28.6	(11.2-46.0)	33	78.8	(64.9-92.7)	61	55.7	(43.4-68.0)
VII	13	23.1	(0.0-59.0)	22	81.8	(64.8-98.8)	35	60.0	(43.7-76.3)
VIII	4	25.0	—	5	80.0	(34.0-100.0)	9	55.6	(18.5-92.7)
IX	1	0.0	—	—	—	—	1	0.0	—

other seasons was not a reliable indicator of state of maturity, the relation of size and age to sexual maturity was based only on females collected from April through August and males collected from October through February.

The identification of mature females in each age group (Table 5) was based on the presence of either embryos or recently spent ovaries. Enlarged and flaccid spent ovaries could easily be distinguished from small and firm ovaries of immature fish.

Table 5. *Relation of size and age to sexual maturity in redtail surfperch from the central coast of Oregon.*

Sex and age	Total length (mm)	Total number of fish	Percent mature
Females			
II	170-219	50	0.0
III	200-209	1	0.0
	210-219	2	0.0
	220-229	10	0.0
	230-239	26	0.0
	240-249	32	15.6
	250-259	14	28.6
	260-269	7	42.9
	270-279	4	100.0
Total		96	16.7
IV	200-209	1	0.0
	230-239	3	0.0
	240-249	3	33.3
	250-259	10	80.0
	260-269	9	88.9
	270-309	47	100.0
Total		73	87.7
V	240-249	1	0.0
	260-319	35	100.0
Total		36	97.2
VI	290-339	28	100.0
VII-VIII	310-379	23	100.0
Males			
I	150-189	15	0.0
II	170-179	1	0.0
	180-189	2	0.0
	190-199	1	0.0
	200-209	4	50.0
	210-219	11	90.9
	220-229	8	87.5
Total		27	70.4
III	210-269	50	100.0
IV-IX	260-339	31	100.0

Although sexual maturity was attained by most female redtail surfperch at the end of their fourth year of life, nearly 17% (all 240 mm long or longer) matured as 3-year-olds (Table 5). No females shorter than 240 mm, but all those longer than 270 mm, were mature. Although the percentage of total mature females in each age group gives a general indication of the relation of age to maturity, both size and age influence maturity. Thus, the percentage of mature females in each 10-mm length interval from 240-249 mm to 260-269 mm was more than twice as great in age group IV as in age group III. In all age groups, all fish 270 mm or longer were mature. These data are in agreement with Woodhead's (1960) report that faster growing fish mature earlier and provide additional evidence that both age and rate of growth influence sexual maturity.

The mature males in each group were identified by the enlarged testes during September through January. During the other months, size of testes was not a reliable indication of maturity.

Most male surfperch (70%) matured at the end of their second year of life and all were mature by the third year (Table 5). No male less than 200 mm long was judged to be mature. Although the number of males in age group II was relatively small, the influence of the rate of growth on maturity was indicated by the higher percentage maturity among the larger than among the smaller fish. No immature males of age group III or older were taken during the September-January period when maturity could be reliably determined on the basis of gross gonad appearance.

Size and age at first maturity varies among other species of embioticids. Male shiner perch were reported to be sexually mature during their first year of life (Hubbs 1921). Carlisle et al. (1960) reported that barred surfperch, *Amphistichus argenteus*, reach sexual maturity in their second year of life. The percentage of mature age II male striped seaperch was reported to be 23% by Swedberg (1965) and 32% by Gnose (1968). On the basis of relative gonad size, Wares (1971) reported that some male pile perch of age group II were sexually mature.

Maturity Index for Males

The weight of the testes increased in ripening males, but not in immature males, before the mating season. We used a maturity index similar to that used by Larimore (1957), Wares (1971), and Wydoski and Cooper (1966) to follow the seasonal development of the testes. The testes were weighed to the nearest 0.01 g. A maturity index or degree of development

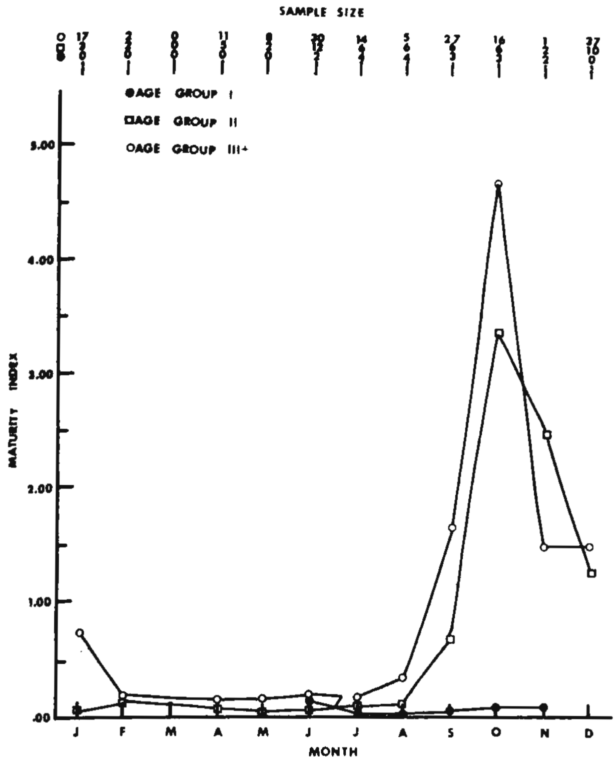

Fig. 6. The annual reproductive cycle of male redtail surfperch by age groups, as indicated by the mean maturity index (gonad weight divided by body weight X 100) for each month, 1967-69.

was determined for male redtail surfperch by applying the formula:

$$\frac{\text{Testes weight } (g)}{\text{Fish weight } (g)} \times 100$$

The annual development of the testes was measured by a mean maturity index calculated by month (Fig. 6). This development was subdivided further by calculating the mean monthly maturity index by age groups I, II, and III or older. Age group I contained no maturing fish; the low maturity index indicates the small size of immature testes. Because of the small sample and difficulty in judging maturity macroscopically (except at the peak of testes development), the maturity index for age group II was calculated separately. All fish of age group III or older examined during the peak of testis enlargement were judged to be mature. The points indicated by age groups III or older (Fig. 6) show the annual cycle of testicular development. Mature males were ripe (i.e., milt was readily emitted) in late December and early January, 2 months after the testes reached the peak maturity index.

Histological sections of testes that were collected on 13 January 1969 confirmed the stages of maturity from ripe to spent for different males, as judged from macroscopic examination. At the peak of enlargement, the weight of maturing testes amounted to about 4.5% of the body weight.

Although previous investigators reported that, in other embiotocids, spermatozoa may be stored in the female for a period of time before egg fertilization (Eigenmann 1892; Hubbs 1921; and Wares 1971), this phenomenon probably does not occur in redtail surfperch because the embryos are 7.9 to 10.5 mm long by the fourth month after mating, indicating that development of the eggs begins shortly after fertilization in this species.

Fecundity

The females were either brought back to the laboratory alive or placed in individual plastic bags so that any aborted embryos would be with the female that lost them. Females did not abort their embryos, even under the stress of increasing temperature, low dissolved oxygen, or both, unless they were nearing parturition. Because of the large volume of the coelom that was occupied by near-term embryos, any loss of embryos that did occur was probably caused by pressure from fish lying on top of recently killed females.

The ovary was dissected and the embryos were separated from the ovarian folds and preserved in 10% buffered formalin. Fecundity was then determined by direct count of embryos. A few females contained from one to several embryos that were much smaller than the rest. These were counted as malformed embryos because we believed that they would have died before birth.

The shape of the tails of the embryos changed progressively from round to square to forked as the embryos developed. Females containing embryos with forked tails were excluded from fecundity analysis because the embryos were nearing term and the possibility that some had been aborted was greater than in females whose embryos were less advanced. Females that contained less fully developed embryos appeared to retain their embryo complement rather well. Standard regression analysis was used to determine the relation of female size to number of embryos.

A total of 168 gravid females, 3 to 8 years old, yielded 2,239 embryos. The number of embryos per female ranged from 1 to 39 and averaged 13.3. The mean number of embryos per female increased from 7.4 for age group III to 33.7 for age group VIII (Table

Table 6. *Numbers of young produced by female redtail surfperch of different ages collected along the central coast of Oregon, 1967-69.*

Age group of female	Number of fish	Size of female: Mean length[a] (mm)	Size of female: Mean weight[a] (g)	Mean number of embryos[a]
III	16	257.8 (12.1)	298.3 (53.5)	7.4 (2.7)
IV	60	275.9 (13.4)	378.5[b] (59.9)	8.7 (3.5)
V	34	286.8 (14.6)	415.4 (63.9)	11.9 (4.1)
VI	27	316.4 (14.8)	583.3 (93.4)	18.4 (4.6)
VII	15	346.9 (19.9)	796.3 (146.5)	25.4 (8.7)
VIII	3	367.3 (4.6)	1005.0 (113.2)	33.7 (6.7)

[a] One standard deviation shown in parentheses.
[b] Mean weight based on 59 fish.

6). Of the 168 females, 12 contained from 1 to 9 (total of 28) malformed or diminutive embryos. If it can be assumed that such malformed embryos do not survive, embryonic mortality was about 1.3%.

Relation between Embryos and Size of Females

There was a positive linear correlation between the number of embryos and total length (Table 6; Fig. 7) and weight (Fig. 8) of females. Since the data for 1967 included fish that were taken from gill nets, we could not be certain that no embryos were aborted while the fish were in the net, however, the results for the 2 years were closely similar (Table 7). In Figs. 7 and 8, the data were restricted to those collected in 1968, when special care was taken to avoid any possible loss of embryos through abortion. Size appeared more important than age in determining the number of embryos per female. Females of about the same size but of different ages produced about the same number of embryos (Figs. 7 and 8), and within a given age group, small females tended to have fewer embryos than did large females. These data support the concept that growth rate is important in determining the reproductive potential of fish (Woodhead 1960).

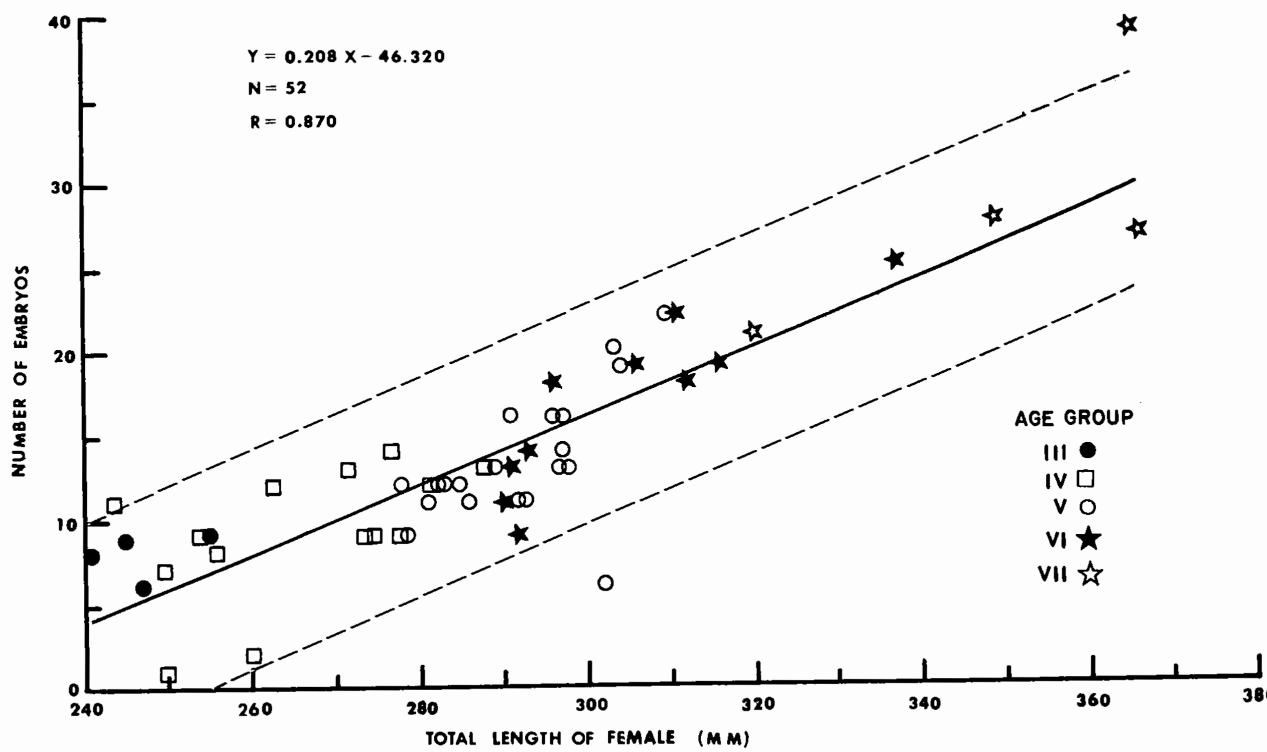

Fig. 7. Number of embryos produced by redtail surfperch of different lengths, central Oregon coast, 1968. (Dashed lines indicate the 95% confidence interval around the regression line.)

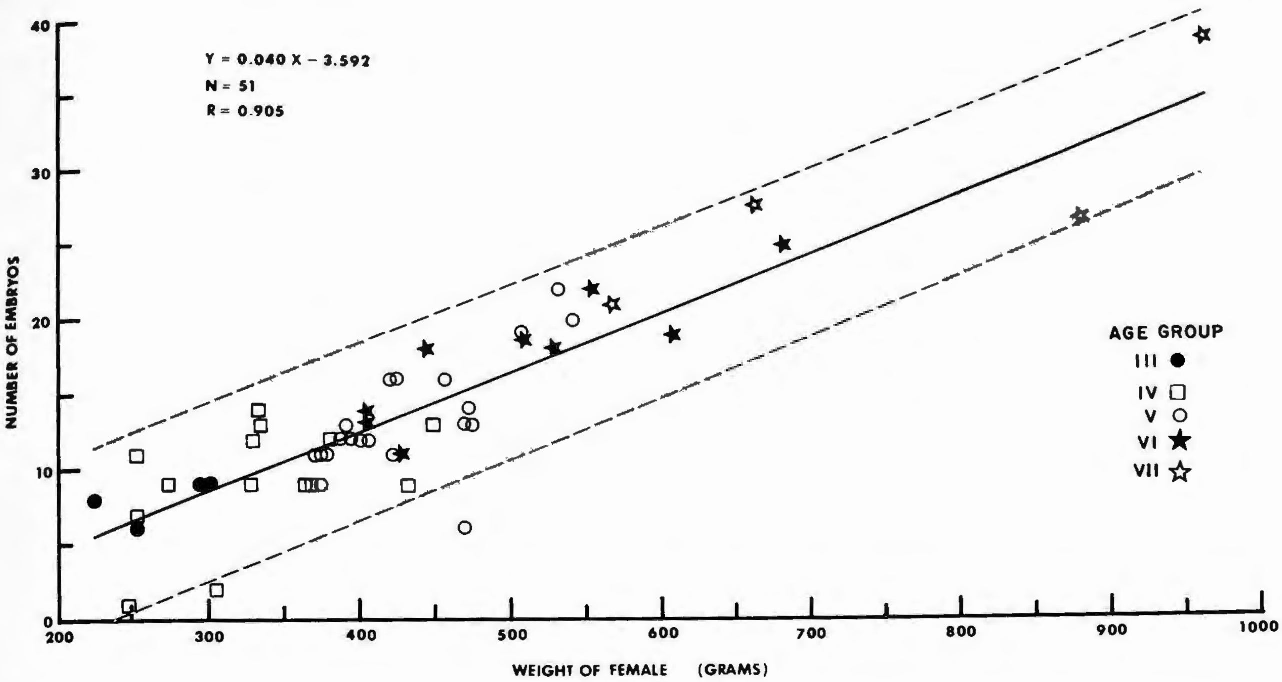

Fig. 8. Number of embryos produced by redtail surfperch of different weights, central Oregon coast, 1968. (Dashed lines indicate the 95% confidence interval around the regression line.)

The positive correlation between fecundity and increasing size of the female demonstrated here has also been reported for other species of embiotocids (Eigenmann 1892; Carlisle et al. 1960; Gordon 1965; Hubbs 1921; Suomela 1931; Swedberg 1965; Wares 1971; and Wilson and Millemann 1969). Carlisle et al. (1960) also reported that, in the barred surfperch, the larger females bear young earlier in the season than do the smaller ones.

The number of embryos produced by females of different sizes in Washington waters (Fig. 9) appears to be similar to that in Oregon (Figs. 7 and 8). The fish in the relatively small Washington sample were larger and older than those in the Oregon samples. Two additional females examined 23 May 1971 are not included in Fig. 9—one of age IV (278 mm long) that contained 12 embryos, and one of age V (301 mm long) that contained 20 embryos.

Growth of Embryos

The normal embryos were measured to the nearest 1 mm of standard length, from the tip of the snout to the hypural plate. The hypural plate is easily located in advanced embryos of this species because it is marked by a heavily pigmented spot, and in small transparent embryos, it can be easily seen under a dissecting microscope. The standard length of small embryos was measured with an ocular micrometer. The correction factor for shrinkage due to death (rigor mortis) or preservation, based on measurements of 158 embryos 13.7 to 34.7 mm long from 12 females that were in 10% buffered formalin for about 20 months, was 1.09 (i.e., fresh length = preserved length × 1.09). All embryos were weighed to the nearest 0.01 g after they were blotted dry with paper towels. The growth of embryos was followed throughout the gestation period.

Table 7. *Regression equations for the relation between fecundity and size of redtail surfperch collected along the central coast of Oregon, 1967-68.*

Year	No. of females	Independent variable	Regression equation	Correlation coefficient
1967	105	Total length (mm)	$Y = 0.218X - 51.319$	0.870
1968	52	Total length (mm)	$Y = 0.218X - 46.320$	0.870
1967	105	Weight (g)	$Y = 0.037X - 5.142$	0.850
1968	51	Weight (g)	$Y = 0.040X - 3.592$	0.905

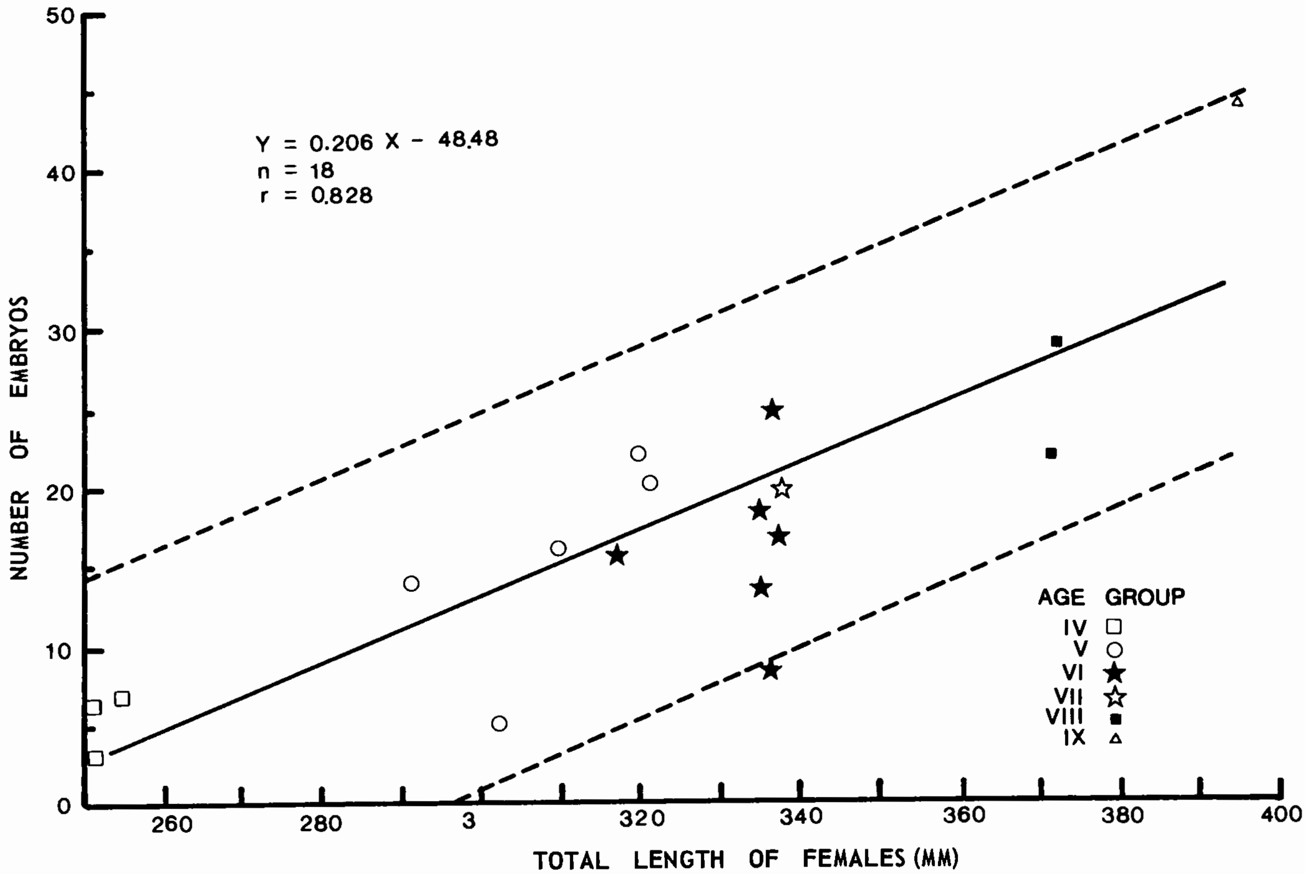

Fig. 9. Number of embryos produced by redtail surfperch of different lengths, Copalis Beach, Washington, 1970. (Dashed lines indicate the 95% confidence interval around the regression line.)

Gravid females were collected from April through August in 1967 and from April through September in 1968 (Table 8). All mature females collected in October were spent. The smallest embryo (7.9 mm long) was collected in April 1968, and the largest (63.9 mm long) in September 1968. Because the lengths of embryos were about the same on similar dates, data for the 2 years were combined in constructing a general growth curve (Fig. 10). The plotting of the total length of individual females against the mean standard lengths of their embryos, by month, indicated that the mean lengths of the embryos were more closely related to the lengths than to the ages of females (Fig. 11). Regression equations describing this relation were calculated for each month (Table 9). The correlation coefficients for this relation were significant at the 5% level in all months except April and May. Regression lines, determined by applying the regression equations and drawn through the individual points (Fig. 11), showed that the positive relation between female size and embryo size increased as the gestation period progressed.

The growth of embryos in redtail surfperch appeared to be identical in Oregon (Table 8 and Fig. 10) and Washington. The mean standard length for embryos from females taken at Copalis Beach, Washington, was 16.2 mm for 8 fish collected on 23 May 1970 and 24.8 mm for 10 fish collected on 20 June 1970. These values are reasonably close to those indicated by the growth curve in Fig. 10.

Size of the Young at Birth

To investigate the relation of mean size of the young at birth to size of female, we held 14 females of different sizes in individual tanks at the laboratory. Four of these fish gave birth to 6-14 young (Table 10). The periods of parturition were as short as 1 day (female No. 2) and as long as 14 days (female No. 4). The lengths of the three young born toward the end of the 14-day period were not significantly different from those of the seven born on the first day. The range in total length of 37 embryos was 66 to 83 mm (mean, 75.8) and the range in weight was 2.9 to 8.9 g (mean, 5.8). In this small sample, the mean size of young at birth was directly related to the length of the female (Table 10). (One might speculate that the

Table 8. *The growth of embryos in redtail surfperch captured along the central coast of Oregon during the gestation period, April-August 1967 and April-September 1968.*

Date	Number of females	Parent female[a]		Embryos[b]	
		Mean total length (mm)	Standard deviation	Mean standard length (mm)[c]	Range[d]
1967					
26 Apr	2	309.5	—	10.9	10.4-11.3
4 May	1	331.0	—	16.6	—
11 May	1	266.0	—	15.7	—
13 Jun	4	282.8	5.12	25.0	21.8-28.6
24-28 Jun	43	289.5	31.65	29.5	17.5-40.8
6 Jul	35	307.3	35.11	34.1	24.2-47.4
12 Jul	13	290.5	31.10	35.1	26.2-41.9
14 Aug	8	276.4	16.03	48.5	36.9-57.8
15 Aug	8	309.3	23.56	53.2	44.7-58.5
1968					
19-20 Apr	3	273.7	25.17	9.2	7.9-10.5
4-5 May	5	277.3	26.12	12.2	10.9-14.6
10 May	11	275.0	21.10	16.0	13.1-17.8
12 Jun	3	289.3	26.10	24.6	22.1-27.0
21 Jun	26	298.0	30.31	30.0	25.6-35.9
3-18 Jul	3	292.5	—	37.5	29.4-38.7
19-20 Aug	4	293.3	6.18	58.0	51.3-63.9

[a] Lengths of fresh fish.

[b] Lengths of embryos preserved in 10% formalin corrected to fresh lengths by application of the factor (X 1.09).

[c] Unweighted average of mean lengths of embryos produced by individual females.

[d] Range is given as a mean for individual females.

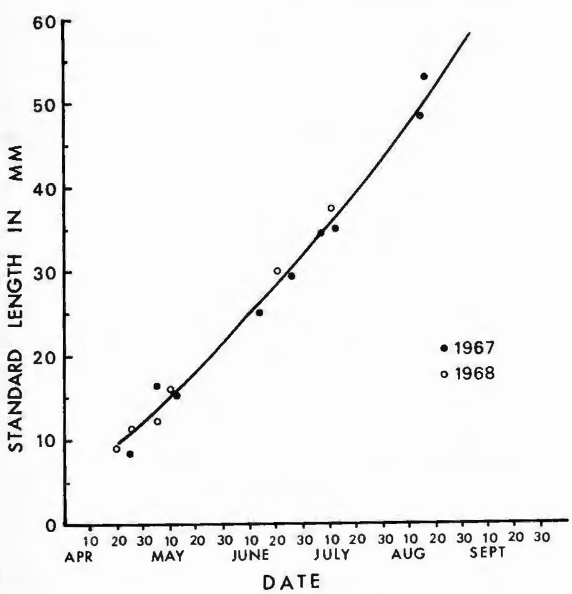

Fig. 10. Generalized growth curve for embryos of redtail surfperch from the central Oregon coast, 1967-68. (The points were plotted from the data in Table 8; the curve was fitted by inspection.)

larger the young, the greater the probability of survival.)

Only two young-of-the-year redtail surfperch were collected in the field during this study; a female on 22 August 1967 that was 82 mm long and weighed 5 g and a male on 9 September 1968 that was 77 mm long and weighed 6 g. The fish were probably born within a relatively short time before capture; both were collected during the period of parturition and were about the same length as the young delivered by females in the laboratory.

Time of Birth

Young surfperch were born along the central coast of Oregon from late July through September, judging by the percentage of newly spent females captured during each month. Only 2% of the mature females captured in July were spent, as compared with 100% in October. The high percentage of spent fish (83%) among mature females in the September collections suggests that the peak period of parturition was during late August and early September.

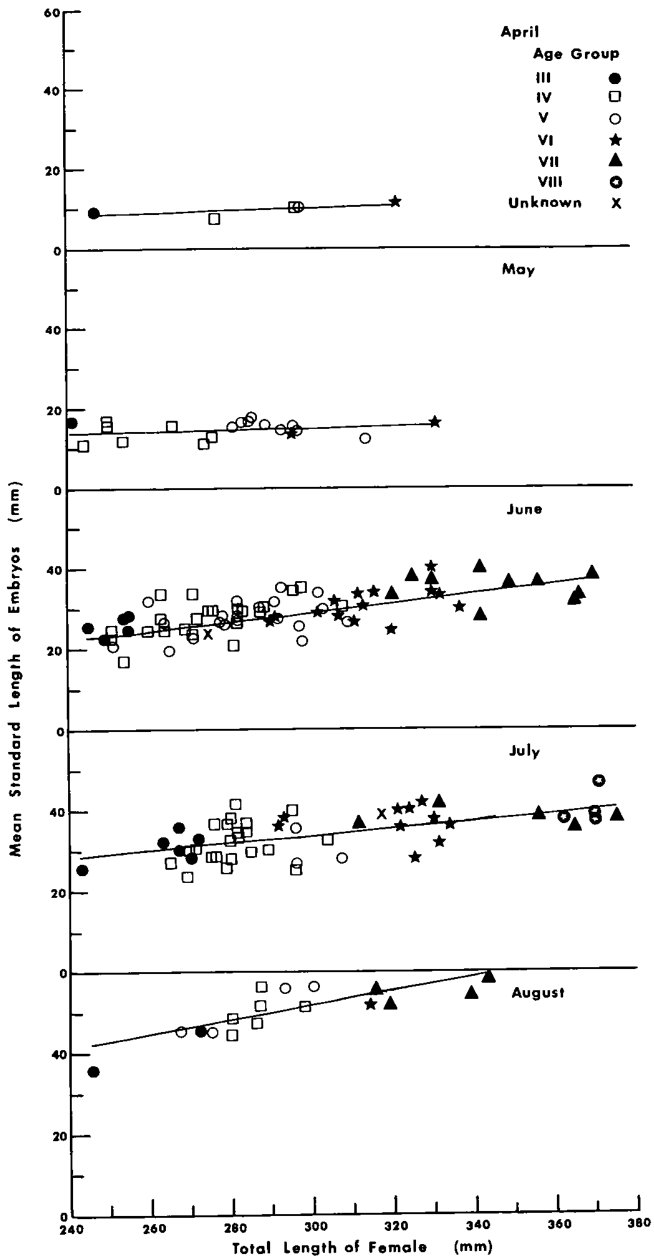

Fig. 11. Variation in the mean size of embryos during the gestation period of redtail surfperch, central Oregon coast, 1967-68. (See Table 9 for regression equations.)

The times of parturition for Embiotocidae may begin as early as March and end as late as September, and appear to vary geographically and by species (Table 11). July is included in the period for five of seven species that have been studied.

Food

Collection and Preservation of Stomachs

Inasmuch as the digestive tracts of embiotocids is not clearly divided into a stomach and intestine by a pyloric valve, the "stomach" in this study refers to the portion of the alimentary canal between the opening of the esophagus and the apex of the first bend in the canal (following Gordon 1965 and Wares 1971). The two ends of the stomach were clamped with hemostats, the section was excised, and several milliliters of fixative—40 ml of commercial formalin per liter of 50% isopropyl alcohol (Gotshall et al. 1965)—were injected into it to stop digestion. Stomachs were preserved in the same fixative until examination. The food items and fragments were identified and sorted under a binocular microscope. After each food item was identified, its volume was measured to the nearest 0.1 ml. Analyses were made volumetrically and by frequency of occurrence, and the results were grouped by month of collection and size of fish.

Stomachs examined came from 335 redtail surfperch—226 from the surf, the 109 from the estuary—collected from June 1967 to October 1968. Of the stomachs from fish captured in the surf, 13.3% were empty and 1.2% contained only bait; for fish captured in the estuary, these percentages were 39.5 and 11.9, respectively.

Although taxons were identified as closely as possible to the specific taxonomic groups, only pieces of some organisms were found and digestion was sometimes too far advanced to permit identification of specific organisms. Identifications of food organisms were based on Barnes (1963) for levels

Table 9. *Regression equations for the relation of embryo size to female size during the gestation period. (Data from 1967 and 1968 are combined.)*

Month	Number of females	Regression equation	Correlation coefficient	t-test value[a]	df
April	5	$Y = 0.036X - 0.499$	0.750	1.96	3
May	19	$Y = 0.012X + 11.538$	0.131	0.55	17
June	76	$Y = 0.104X - 1.171$	0.639[b]	7.18	74
July	51	$Y = 0.087X + 8.072$	0.567[b]	4.81	49
August	17	$Y = 0.176X - 0.677$	0.773[b]	4.71	15

[a] Procedure to the t-test followed Alder and Roessler (1960).

[b] Significant at 5% level.

above family and Light (1954) for other taxa.

Most food of redtail surfperch comprised eight major categories: Polychaeta, Mollusca, Cirripedia, Isopoda, Amphipoda, Decapoda, fishes, and miscellaneous. The last-named category consisted of items such as sand grains, wood, pieces of shells, algae, eggs, and unidentified objects, as well as incidental hydroids, tube worm cases, peanut worms, and bryozoans.

This highly diversified diet is accounted for, in part, by the adaptations of redtail surfperch for feeding on benthic and drifting organisms. Their body form and quick swimming movements allow them to capture food effectively in the surging surf zone. Their well-formed jaw teeth enable them to feed on sessile food organisms and the strong pharyngeal teeth permit crushing of hard foods. No doubt these surfperch are, in general, opportunistic feeders, since they live in a habitat that is almost continuously turbid from wave action. On one occasion surfperch were fly caught from a highly turbid surf more readily with an artificial fly made of bright fluorescent red yarn than with a hook baited with mussel mantle, suggesting that sight plays an important role in their feeding. The wave action loosens food organisms and the sand settles between waves, allowing the perch to feed by sight.

Frequency of Occurrence and Total Volume

The diet of redtail surfperch captured in the surf consisted of crustaceans, fishes, mollusks, and polychaetes, in decreasing order of importance (Fig. 12). Crustaceans as a group were most important in both frequency of occurrence and total volume. Decapods, which made up the most important single food category, were found in more than 71% of the stomachs containing food and made up nearly 40% of the total volume. Although the frequency of occurrence of fish was equal to that of polychaetes and less than that of mollusks, fish were considered second in importance because they made up a greater percentage of the food volume. Mollusks were ranked third because they were found in a larger percentage of stomachs than polychaetes, although the total volume was nearly equal. In frequency of occurrence, decapods, amphipods, isopods, and cirripeds were the important and common groups of crustaceans. As a percentage of the total volume, the rank of the last three of these organisms was reversed: cirripeds, isopods, and amphipods.

Stomachs from 53 surfperch captured in the estuary contained primarily decapods and fishes, each of which occurred in more than 40% of the stomachs and made up more than 40% of the food volume; a small percentage of the stomachs contained amphipods and mollusks (Table 12).

Influence of Fish Size on Food

Decapods were found in about two-thirds or more of the stomachs from all lengths of surfperch up to 300 mm taken from the surf (Fig. 13). The percentage dropped in fish larger than 300 mm. The feeding of these large fish appeared to be even more opportunistic and less selective than that of smaller fish. As fish increased in length from 100 to 300 mm, they ate progressively fewer isopods and polychaetes (Fig. 13). Among fish more than 300 mm long a larger percentage contained polychaetes. Amphipods had been eaten by about three-fourths of the fish 101-150 mm long and about one-third of the fish longer than 150 mm. In general, the large surfperch ate larger foods and slightly more fish than did the smaller ones. Mollusks and cirripeds occurred in about 25% of the stomachs, the percentage changing little with size of the fish.

Table 10. *Date of birth and size of the young of four redtail surfperch held in the laboratory, 1968.*

Date of birth	Size of young[a] Standard length (mm)	Total length (mm)	Weight (g)
	Female 1 (281 mm long, 505 g, age VI)		
Aug. 20	50	67	3.15
20	49	66	2.94
20	52	69	3.58
26	54	70	3.50
26	53	69	3.55
26	53	70	3.62
	Mean: 51.8 (1.94)	68.5 (1.64)	3.39 (0.28)
	Female 2 (286 mm long, 500 g, age IV)		
Aug. 20	56	73	4.72
20	58	75	5.18
20	58	74	4.80
20	57	76	4.89
20	59	77	5.37
20	56	74	4.73
20	60	77	5.59
	Mean: 57.7 (1.50)	74.9 (1.57)	5.04 (0.34)
	Female 3 (292 mm long, 520 g, age IV)		
Aug. 26	58	75	5.20
26	58	76	5.78
26	58	75	5.42
26	58	74	5.30
26	58	76	5.70
28	60	77	5.88
28	59	76	5.82
28	60	77	5.90
28	59	76	5.72
29	58	76	5.50
29	59	76	5.60
29	58	75	5.50
29	59	78	6.20
29	58	75	5.50
	Mean: 58.6 (0.75)	75.9 (1.03)	5.64 (0.27)
	Female 4 (294 mm long, 419 g, age V)		
Sept. 6	64	83	8.00
6	64	81	7.62
6	64	81	8.03
6	63	79	7.30
6	64	80	7.53
6	67	82	7.90
6	64	81	7.58
17	62	79	7.15
19	61	78	8.17
19	66	83	8.90
	Mean: 63.9 (1.73)	80.7 (1.70)	7.82 (0.50)

[a] Standard deviations in parentheses.

In the estuary, the percentage of decapods was higher in fish 200 to 300 mm long than in those of other lengths (Table 12). Judging from the relatively few stomachs with food available from the estuary, fish appeared to be an important food for surfperch of all sizes.

Variation by Date of Collection

The percentage of fish from the surf containing polychaetes was relatively high in May and October but low during the summer (Fig. 14). Mollusks were found in about 25% of the stomachs throughout most of the collecting season. Although cirripeds were in a low percentage of the stomachs in the spring, this group was found in more than one-third of the stomachs examined during the summer and fall. The percentage of stomachs with amphipods increased substantially in the spring and the percentage with isopods and amphipods again increased slightly in the late summer (Fig. 14). In June, decapods and fishes increased substantially in the stomach contents.

For redtail surfperch collected in the estuary in June and July of 1967 and 1968, primarily to collect data on reproductive biology, decapods and fish were the most important foods (Table 12).

Parasites

Collection, Preservation and Taxons Identified

Fish of all ages and of both sexes were examined for parasites shortly after they had been killed. The cavities, gills, and digestive tract were closely inspected for parasites.

Parasites were killed, fixed, and prepared for identification by the methods of Millemann (1967) and those recommended by Ivan Pratt, Department of Zoology, Oregon State University (personal communication). We used the statistic "infestation rate" (Wares 1971), which is defined as the total number of parasites found, divided by the number of fish examined. Parasites identified from 356 redtail surfperch collected along the Oregon coast, April 1968-April 1969, included the following eight forms:

Phylum Platyhelminthes
- Class Trematoda
  - Subclass Digenea
    - Family Bucephalidae (gills, intestine) (1)
    - Family Opecoelidae
      - *Genitocotyle acirra* (intestine) (2)

Table 11. *Time of parturition for various Embiotocidae at different locations along the Pacific coast, from southern California to southern British Columbia.*

Species	Location	Time of parturition	References
Amphistichus argenteus	Southern California	March-May	Carlisle et al. (1960)
Hyperprosopon argenteum	Southern California	March-May	Rechnitzer and Limbaugh (1952)
Amphistichus rhodoterus	Central Oregon	July-Sept.	(Present study)
Embiotoca lateralis	Central Oregon	May-Sept.	Swedberg (1965) and Gnose (1968)
Rhacochilus vacca	Central Oregon	May-Sept.	Wares (1971)
Hyperprosopon ellipticum	Central Oregon	July-Aug.	Wydoski and Bennett (1973)
Cymatogaster aggregata	Northern Washington	July-Aug.	Suomela (1931) and Gordon (1965)
Embiotoca lateralis	Northern Washington	June-July	Blanco (1938)
Cymatogaster aggregata	Southern British Columbia	June-July	Wiebe (1968)

Subclass Monogenea
Family Diclidophoridae
Diclidophora sp. (gills) (3)
Phylum Aschelminthes
Class Nematoda
Superfamily Ascaroidea
Family Heterocheilidae (liver, intestine) (4)
Subfamily Anisakinae (musculature) (5)
Phylum Arthropoda
Class Crustacea
Subclass Copepoda
Order Caligidea
Family Caligidae
Caligus sp. (body surface) (6)
Order Lerneopodidea
Family Lerneopodidae
Clavella sp. (gills, fins) (7)
Class Branchiura
Family Argulidae
Argulus catostomi (body surface) (8)

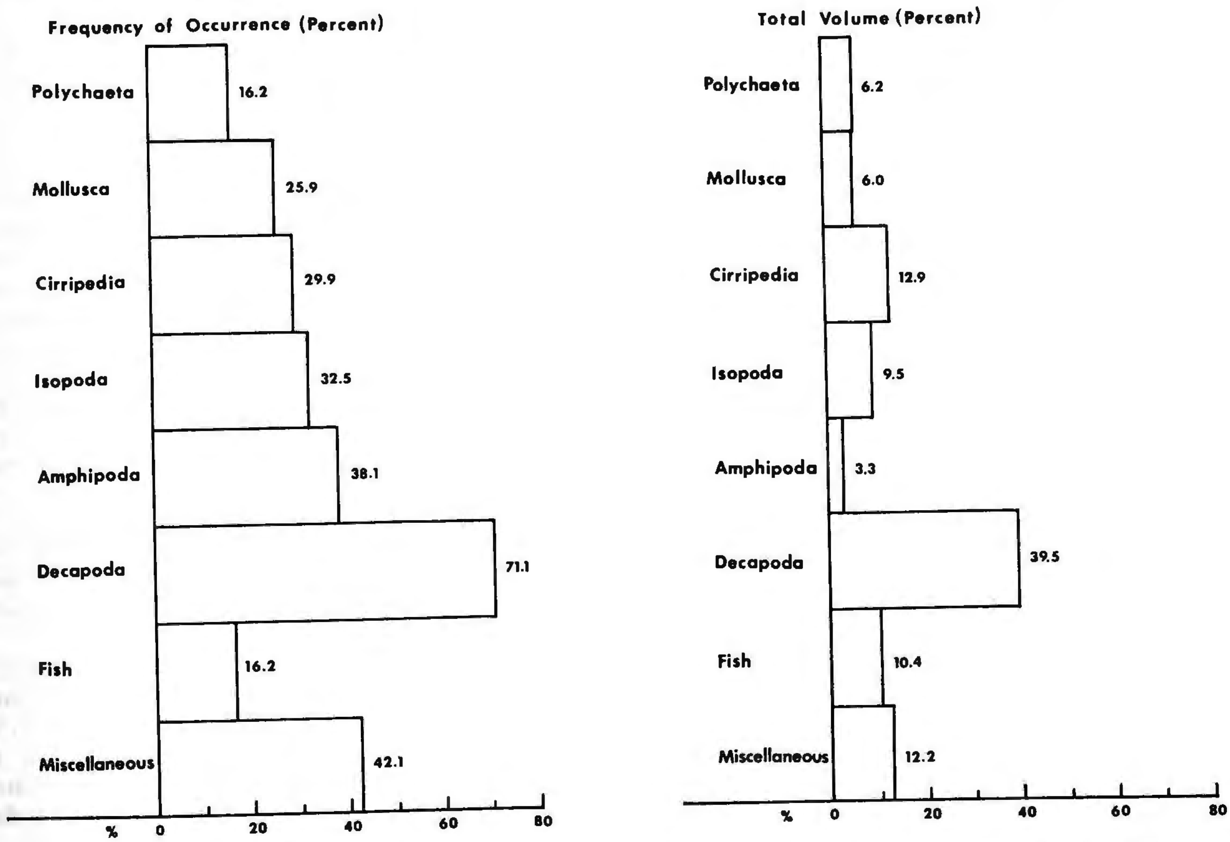

Fig. 12. Food of 193 redtail surfperch collected from the Oregon surf during June 1967 to October 1968.

Table 12. *Food of 53 redtail surfperch collected from Alsea Bay, Oregon, during June-July 1967 and 1968.*

Item	Food				
	Mollusca	Amphipoda	Decapoda	Fish	Miscellaneous
Frequency of occurrence (percent of total)	3.1	3.1	44.6	43.1	13.8
Percent of total volume	0.3	0.1	42.0	46.2	2.2
Percent frequency of occurrence by total length (mm)					
151-200	0.0	0.0	20.0	40.0	20.0
201-250	0.0	0.0	57.1	57.1	0.0
251-300	5.7	2.8	62.9	31.4	5.7
300-350	0.0	7.7	15.4	61.5	30.8
351-400	0.0	0.0	0.0	60.0	40.0
Percent frequency of occurrence by date of collection					
12-21 Jun 1968	0.0	0.0	20.0	20.0	15.0
27 Jun 1967	6.7	6.7	73.3	26.7	6.7
3-11 Jul 1968	0.0	0.0	50.0	50.0	0.0
6-12 Jul 1967	3.6	3.6	46.4	67.9	17.9

Infestation by Parasites

All of the 356 redtail surfperch examined were infected with one or more parasites belonging to three principal taxonomic groups: Trematoda, Nematoda, and Crustacea. Infestation by parasites did not appear to have harmed the surfperch that were examined.

The digenetic trematode, *Genitocotyle acirra,* was found in the intestine of each of the 170 fish examined that were 126 to 366 mm long. The number of parasites varied from a few to several hundred, generally increasing with size of fish. Digenetic trematodes of the family Bucephalidae are sometimes found as adults in the intestine and occasionally as metacercariae in the gills (Robert E. Olson, personal communication).

An adult monogenetic trematode, *Diclidophora* sp., was found on the gills of 132 of 356 redtail surfperch. It was also observed on the gills of silver surfperch and walleye surfperch. The most heavily parasitized redtail surfperch bore six of the parasites. The mean infestation rate for all fish was 0.48. In general, no seasonal trend could be detected in the infestation rate or percentage of fish that were infected with this monogenetic trematode (Table 13). However, the percentage of fish infected and the infestation rate both increased with fish size (Table 14) and the incidence and the infestation rate of this parasite also tended to increase with the age of the fish (Table 15). The life cycle of this unnamed species was studied in detail by Hanson (1973).

Nematoda were less common than the other parasites. Only 18 immature nematodes, mostly of the subfamily Anisakinae, were found in 13 of 276 fish. One nematode each was found in the liver, the musculature, and the mesentery; the rest were in the digestive tract.

Three genera of Copepoda were the most common parasites found on the redtail surfperch. Of these, *Caligus* sp. and *Argulus catostomi* were found on the body surface. *Caligus* sp. was found in two stages, either attached to the scales or free on the body surface. The highest number of copepods on the body surface was eight and the mean infestation rate was 0.70. *Caligus* sp. and *Argulus catostomi* were considered together for analysis because records were combined for parasites on the body surface of the fish. Infestation rate and percentage of fish infected showed no seasonal trends (Table 13). Both percentage of fish infested and infestation rate increased with increasing size (Table 14) and age (Table 15) of fish.

Clavella sp. was found attached to the gills and fins of redtail surfperch. It was more numerous than any other parasite as shown by the high infestation rate of 1.76 on the fins (maximum number on one fish, 16) and 0.17 on the gills (maximum number on one fish, 9) (Tables 13-15). Although the percentage of fish

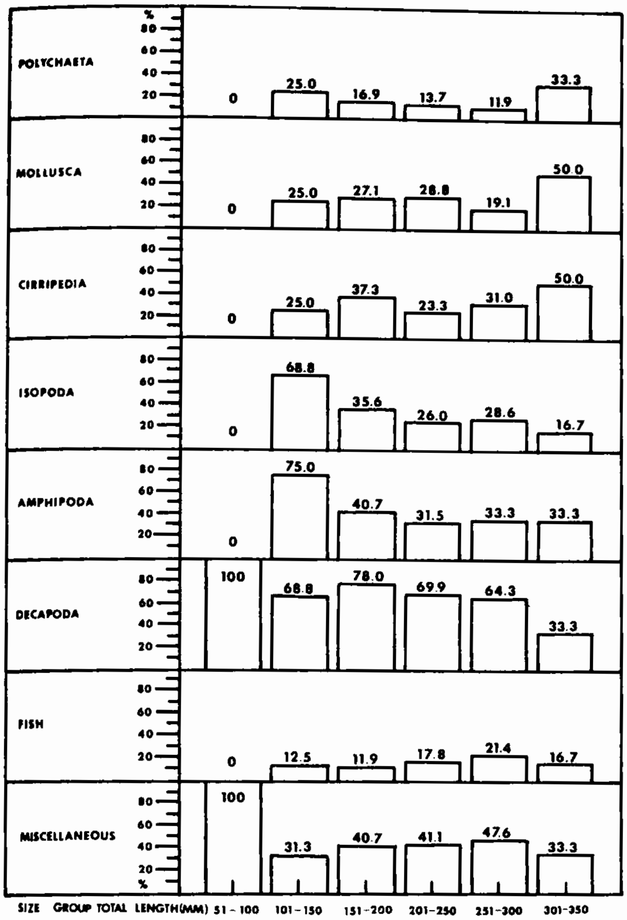

Fig. 13. Food of 193 redtail surfperch of different length groups collected from the Oregon surf, June 1967 to October 1968. (Numbers refer to the percent by frequency of occurrence.)

infested with *Clavella* on the fins did not change with the season, the infestation rate tended to be lower during June-September than during other periods (Table 13). No such trend could be detected for *Clavella* on the gills. No trends could be observed for either parasite location in the infestation rate or percentage of fish infected by size (Table 14) or age (Table 15) of the fish.

Sport Fishery Potential of Redtail Surfperch

Although the population of the United States increased 1.7% per year as an average of the period 1956-65, saltwater angling during this period increased 6.1% per year (Stroud and Martin 1968). In 1970, recreation in the form of saltwater angling in the United States supported about 113.7 million recreational days by 9.5 million anglers and generated more than $1.2 billion in gross business expenditure (Bureau of Sport Fisheries and Wildlife 1972). Crutchfield and MacFarlane (1968) correctly believed that saltwater fishery resources such as unexploited bottomfish can meet the increasing demand for recreational fishing and relieve pressure on species such as salmon and steelhead, which are more biologically limited in Washington State. Saltwater species such as the redtail surfperch may play an important role in the management of fishery programs in the future (Stroud 1968; Stroud and Martin 1968). In coastal fisheries of the Pacific Northwest, seasonal and geographical distribution of future fishing effort and the species that will be exploited can be expected to change.

Tourism plays an important role, along with the logging and commercial fishing industries, in the economy of the coastal cities of Oregon. After further research, Oregon's potential estuarine and inshore recreational fisheries can be publicized and developed to increase tourist trade and the economy of coastal cities. Oregon's coast is also readily accessible to the majority of Oregon's population inhabiting the Willamette Valley.

The redtail surfperch offers great recreational potential along the extensive sandy beaches of the Oregon coast because it is the most abundant species there. It supports a fairly sizable sport fishery in Washington and northern California. Baxter (1960) stated that it was the number one sport fish in the surf-angler's catch in northern California, and Miller and Gotshall (1965) reported that it was second to the barred surfperch by number in the catch for shore fishermen from Point Arguello, California, to Oregon in 1958-61. These authors also pointed out that the redtail surfperch was dominant in the sport fishery along the northern California coast (Oregon to Fort Bragg), and accounted for more than half of all ocean fish taken by hook and line in this area. Most of the Washington coast is composed of sandy beaches and the redtail surfperch is the main fish available for sport along this coastline. The junior author has observed as many as 100 surfperch fishermen along about 1.7 km of shoreline at Copalis Beach, Washington. Several of the fishermen said that fishing pressure has been gradually increasing along these beaches—an increase that appears to be associated with the immense sport fishery for razor clams along the Washington coast. Anglers dig for clams at low tide and fish for surfperch during the incoming tide. Cursory examination of the stomachs of redtail surfperch collected after low tides at Copalis Beach revealed large numbers of razor clam siphons. The presence of the siphons (as a result of poor digging by inexperienced clammers) apparently resulted in an effective "chumming" of the surf zone for surfperch.

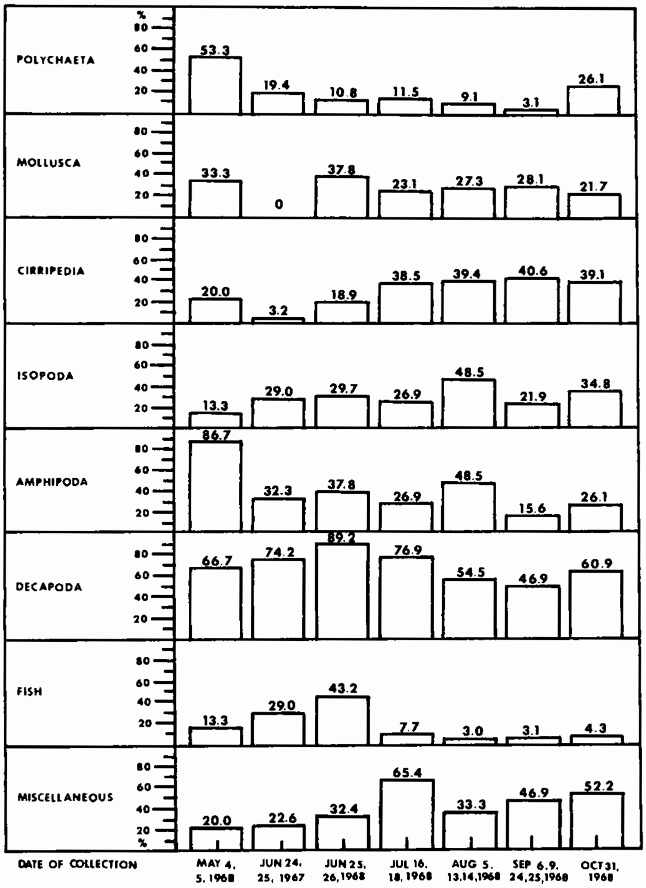

Fig. 14. Food of 193 redtail surfperch by date of collection, central Oregon coast, June 1967 to October 1968. (Numbers refer to the percent frequency of occurrence.)

While collecting specimens for this study, we kept records of catch per angler hour as part of an attempt to determine the sport fishery potential for the redtail surfperch. The catch on different dates (for about 1,500 h of angling) ranged from 0.08 to 1.85 fish per hour in Alsea Bay and from 0 to 4.17 in the surf zone. This wide range in catch rate was similar to that in northern California (Allen et al. 1970). The catch of redtail surfperch near the outfall of an atomic steam generation plant in Humbolt Bay, California, ranged from less than one to as many as four fish per angler hour (Allen et al. 1970), and this species ranked highest among those taken in that study. Miller and Gotshall (1965) reported an average catch of 0.48 fish per hour by shore fishermen from Oregon to Point Arguello, California, 1956-61.

With experience, a surf fisherman learns where, when, and how to fish this zone more effectively and his catches increase. Studies like the one reported here provide the information needed to publicize a relatively unexploited fishery and thereby provide an additional recreational outlet similar to that described for Long Island, New York by Briggs (1965).

In contrast to the fishery in the surf zone, overfishing could soon become a serious problem in the estuaries. When gravid female surfperch enter estuaries during high tide, presumably to bear their young, they are extremely vulnerable to anglers. This vulnerability, which occurs largely during midsummer, poses important management implications

Table 13. *Percentage of redtail surfperch infected with several parasites and infestation rate (IR)*[a] *for different months, central Oregon coast, 1968.*

	Diclidophera sp.			*Argulus, Caligus*			*Clavella* Fins			*Clavella* Gills		
Month	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR
Jan.	28	25	0.29	0	—	—	0	—	—	0	—	—
Feb.	7	29	0.29	0	—	—	0	—	—	0	—	—
Mar.	0	—	—	0	—	—	0	—	—	0	—	—
Apr.	31	36	0.45	2	100	1.00	5	100	3.20	0	—	—
May	31	36	0.45	22	50	0.73	31	55	2.39	2	100	2.50
Jun.	75	44	0.61	76	40	0.74	76	62	1.72	76	8	0.30
Jul.	42	50	0.55	42	31	1.05	42	67	1.95	42	2	0.02
Aug.	44	18	0.27	43	44	0.91	43	54	1.77	43	7	0.16
Sep.	50	38	0.60	50	36	0.64	50	52	1.82	50	6	0.18
Oct.	25	48	0.64	25	52	0.76	25	68	2.56	25	8	0.08
Nov.	9	11	0.11	0	—	—	0	—	—	0	—	—
Dec.	10	40	0.70	0	—	—	0	—	—	0	—	—

[a] Infestation rate is the total number of parasites divided by the number of fish examined.

Table 14. *Percentage of redtail surfperch infested with several parasites by length group and infestation rate (IR)[a], central Oregon coast, 1968.*

	Diclidophera sp.			*Argulus, Caligus*			*Clavella* Fins			*Clavella* Gills		
Length group	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR
76-100	1	0	—	1	0	—	1	0	—	1	0	—
126-150	17	12	0.12	18	33	0.39	19	53	1.68	18	11	0.17
151-175	42	2	0.02	32	28	0.34	31	65	1.52	32	9	0.09
176-200	58	29	0.34	30	20	0.37	31	77	2.42	28	11	0.21
201-225	58	33	0.38	46	26	0.46	49	80	3.94	47	13	0.64
226-250	44	45	0.68	26	39	0.81	31	55	1.29	21	5	0.05
251-275	56	52	0.73	44	55	1.09	44	57	1.55	38	0	—
276-300	51	55	0.82	40	50	0.98	42	36	0.74	32	6	0.13
301-325	18	56	0.72	16	81	2.31	16	63	2.25	13	0	—
326-350	7	14	0.14	5	80	1.80	5	40	0.40	6	0	—
351-375	2	0	—	2	100	3.00	2	50	0.50	2	0	—

[a] Infestation rate is the total number of parasites divided by the number of fish examined.

for various estuaries such as Alsea and Coos Bays in Oregon. Since these surfperch produce few young per female, an intensive fishery like that now developing on Alsea and Coos Bays could seriously reduce recruitment. Fishery management agencies along the Pacific coast should consider this potentially adverse effect if either the sport or commercial fishery for this species increases.

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Table 15. *Percentage of redtail surfperch infected with several parasites by age group and infestation rate (IR)[a], central Oregon coast, 1968.*

	Diclidophera sp.			*Argulus, Caligus*			*Clavella* Fins			*Clavella* Gills		
Age group	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR	Number of fish	Percent infected	IR
0	1	0	—	1	0	—	1	0	—	1	0	—
I	54	6	0.06	49	29	0.35	50	60	1.58	49	10	0.12
II	106	31	0.37	73	25	0.44	74	81	3.46	72	11	0.47
III	52	44	0.60	36	42	0.97	38	47	1.63	34	3	0.03
IV	53	57	0.85	36	64	1.25	40	63	1.43	25	0	—
V	39	46	0.64	33	42	1.03	35	40	1.20	26	4	0.04
VI	27	48	0.70	19	74	1.68	20	40	0.75	19	5	0.16
VII	14	36	0.50	8	75	1.50	8	63	1.63	7	0	—
VIII	2	100	1.50	1	0	—	1	0	—	1	0	—
IX	1	100	1.00	1	100	2.00	1	100	1.00	1	0	—

[a] Infestation rate is the total number of parasites divided by the number of fish examined.

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