Title
Fish Bulletin No. 109. The Barred Surfperch (Amphistichus argenteus Agassiz) in Southern California

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FISH BULLETIN No. 109
The Barred Surfperch (Amphistichus argenteus Agassiz) in Southern California

By
JOHN G. CARLISLE, JR.,
JACK W. SCHOTT
and
NORMAN J. ABRAMSON
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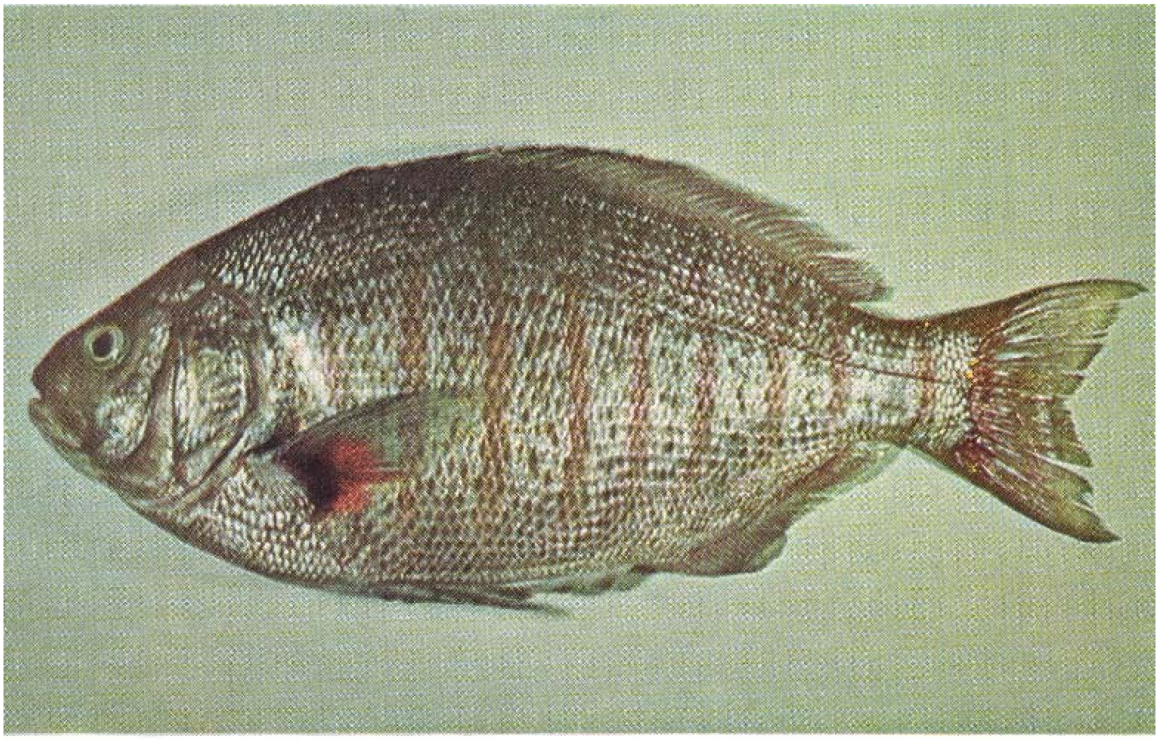

Barred Surfperch, *Amphistichus argenteus*, photograph by Jack W. Schott.

ACKNOWLEDGMENTS

The Surf Fishing Investigation received a great deal of help in the conduct of its field work. The arduous task of beach seining all year around was shared by many members of the California State Fisheries Laboratory staff; we are particularly grateful to Mr. Parke H. Young and Mr. John L. Baxter for their willing and continued help throughout the years.

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Many others gave help and advice, notably Mr. John E. Fitch, Mr. Phil M. Roedel, Mr. David C. Joseph, and Dr. F. N. Clark of this laboratory.

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Mr. Robert Vile of the Ocean Fish Protective Association gave the project both support and help.

To these and the many others who helped, the project members are exceedingly grateful.

JOHN G. CARLISLE, JR.
January 1960

1. INTRODUCTION

The surf fishing investigation was begun when a need for more knowledge of the most important surf species became apparent.

Discussions held with surf fishermen and biologists familiar with surf fishing conditions, indicated an apparent decline in fishing success. As a first step, a study was made to determine the most important game species in the fishery. A preliminary survey indicated that these were barred surfperch, Amphistichus argenteus, California corbina, Menticirrhus undulatus, spotfin croaker, Roncador stearnsi, yellowfin croaker, Umbrina roncador, and opaleye, Girella nigricans. The latter was not studied by the project because it is more truly a rocky shore dweller than a surf inhabitant.

The essential life histories of the four remaining species (hereafter designated project species) were studied. A voluntary catch record system and a creel census were used to provide information on the relative importance of each and fishing success along the entire southern California coast.

This information was needed before steps could be taken to insure sound management of the resource.

The results of the surf fishing investigation will appear in two separate publications: this bulletin on barred surfperch and a later one on California corbina, and spotfin and yellowfin croakers.

The present paper deals almost exclusively with the barred surfperch, family Embiotocidae, the most important species to the surf fisherman. Barred surfperch range from Bodega Bay, central California, to Santa Rosalia Bay, central Baja California. Although found primarily in or near the breaking surf along sandy beaches they were captured by project personnel in 15 fathoms of water in Santa Monica Bay during June 1957. A trawl boat operator reported that he took large barred surfperch regularly in 40 fathoms off Morro Bay during the winter. Ulrey and Greeley (1928) had previously reported one trawled from 28 fathoms in Santa Monica Bay.

2. COLLECTION OF MATERIAL BY BEACH SEINE

During the 44-month period, February 1953 to September 1956, beach seining was conducted at 11 different localities between El Capitan and North Island (Figures 1, 2, and 3). Four hundred and fifty-one hauls

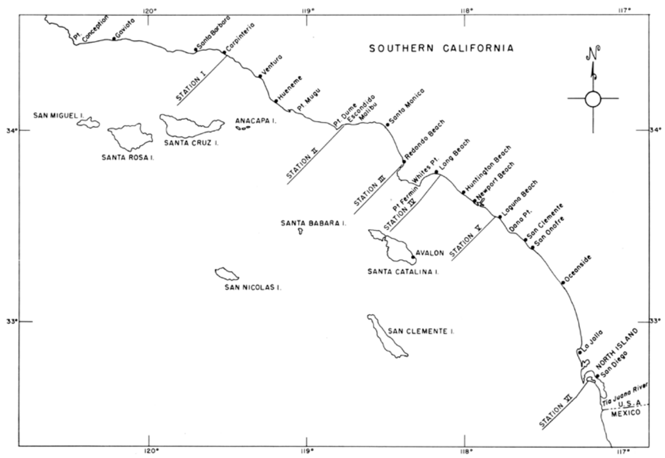

FIGURE 1. Chart of Southern California, showing regular beach seining stations.

FIGURE 1. Chart of Southern California, showing regular beach seining stations

FIGURE 2. Jeep, trailer, surf skiff, and field equipment. *Photograph by Jack W. Schott.*

FIGURE 2. Jeep, trailer, surf skiff, and field equipment. Photograph by Jack W. Schott

FIGURE 3. Ready for trip through surf to set beach seine. *Photograph by Jack W. Schott.*

FIGURE 3. Ready for trip through surf to set beach seine. Photograph by Jack W. Schott

were made in 114 days of seining. Laboratory material and fish for tagging were obtained by this method.

In all, 71 different species of fish were taken and the estimated catch for all hauls totaled 128,000, an average of 284 per haul. Small catches were counted and large catches were estimated (Figure 4). Samples of the four project species were saved from these hauls for future study. Many others were tagged and returned alive to the water along with the remaining nonproject fish. California corbina, California halibut, Paralichthys californicus, and walleye surfperch, Hyperprosopon argenteum, appeared in over half of all hauls made and barred surfperch

FIGURE 4. A typical beach seine set. *Photograph by Charles F. Crawford.*

FIGURE 4. A typical beach seine set. Photograph by Charles F. Crawford

Date 22 Aug. 1955
Place Belmont Shore
Surface Water Temp.
Bottom Water Temp. 0820 20.6°C 0920 20.8°C 1010 21.2°C 1115 21.5°C 1300 22.5°C

Tide
High ____ High ____
Low 1201 Low ____

CALIFORNIA FISH AND GAME	#1—TIME		#2—TIME		#3—TIME		#4—TIME		#5—TIME	
SURF FISH INVESTIGATIONS	No.	RANGE	No.	RANGE	No.	RANGE	No.	RANGE	No.	RANGE
Roncador stearnsii — Spotfin	2	11-13"			2/5	6-8" 11-14"	1	15"		
Umbrina roncador — Yellowfin	1	6"			5	6-8"				
Menticirrhus undulatus — Corbina	10	12-14"	2/5	2-3" 10-15"	10	12-14"	2	14"	5	12-14"
Seriphus politus — Queenfish	20	5-6"	10	5-6"	12	5-6"	11	5-6"	3	5-6"
Genyonemus lineatus — Kingfish	50	5-7"	40	5-7	35	5-7"	25	5-7	40	5-7"
Cheilotrema saturnum — Black Croaker										
Cynoscion nobilis — White Sea Bass	1	13"			2	12-13"				
Cymatogaster aggregata — Shiner Perch	2	4"			5	4"			1	4"
Amphistichus argenteus — Barred Perch	8	10-12"	2/13	3-4" 8-12"	2/28	2" 6-12"	16	8-12"	14	8-12"
Rhacochilus vacca — Pile Perch	1	4"	2	6-8"	3	6-8"	1	9"	1	9"
Phanerodon furcatus — Pacific White Perch	8	6-10"								
Embiotoca jacksoni — Black Perch										
Rhacochilus toxotes — Rubberlip Perch										
Brachyistius frenatus — Kelp Perch										
Anisotremus davidsoni — Sargo	2	12"								
Girella nigricans — Opaleye										
Paralichthys californicus — Calif. Halibut	2/8	3-6" 12-14"	1/10	4" 8-16"	3/8	3-6" 8-16"	12	9-12"	3	8-16"
Leptocottus armatus — Sculpin	2	6"	1	5"	3	6"	2	5-6"	2	6"
Pleuronichthys coenosus — C-O Turbot										
Hypopsetta guttulata — Diamond Turbot	1	10"	2	9-10"			1	10"		
Citharichthys sordidus — Sand Dab										
Citharichthys stigmaeus — Speckled Sand Dab										
Atherinops affinis — Top Smelt	1	[illegible]			3	7"				
Atherinopsis californiensis — Jack Smelt	2	5-9"	2	5-9"	3	8-9"	2	8-10"	1	10"
Leuresthes tenuis — Grunion	2	8"			3	8"				
Anchoa compressa — Deep-bodied Anchovy	2	4"			3	5"				
Anchoa delicatissima — Slough Anchovy	3	6	2	5-6"			4	5-6"		
Engraulis mordax mordax — Northern Anchovy	50	4-5"	20	4-5"	10	4-5"	75	4-5"	35	4-5"
Porichthys myriaster — Midshipman										
Heterostichus rostratus — Kelpfish										
Paralabrax clathratus — Kelp Bass										
Paralabrax nebulifer — Sand Bass										
Syngnathus leptorhynchus — Bay Pipefish	2	12"			1	12"				
Fundulus parvipinnus — Killifish										
Urobatus haleri — Round Stingray	13	8"	2	8-[illegible]	3	6-8"	23	[illegible]	5	6-9"
Gymnura marmorata — Butterfly Stingray	1	18"								
Holorhinus californicus — Bat Stingray	3	18-20"	1	30"						
Rhinobatos productus — Shovelnose Guitarfish	2	24"	5	20-24	8	20-24"	10	20-24	5	20-30
Goby										
Bubble Shells	1	3"								
Mussels										
Shrimp										
H. argentum — Walleye	10	4-6"	15	4-6"	23	4-6"	5	4-6"	25	4-6"
M. minimus — Dwarf perch	1	3"			1	3"				

FIGURE 5. Field sheet used for recording beach seine hauls.

FIGURE 5. Field sheet used for recording beach seine hauls

TABLE 1

Beach Seine Catch for 44-Month Period February 1953 to September 1956
451 Hauls—114 Beach Seining Days

Common name	Species	Number of fish	Frequency of occurrence	Fish per haul	Percent catch of project species
1. Northern anchovy	*Engraulis mordax*	45,400	85	100.7	
2. Queenfish	*Seriphus politus*	23,500	177	52.1	
3. **Barred surfperch**	*Amphistichus argenteus*	**10,463**	**364**	**23.2**	**73.1**
4. Walleye surfperch	*Hyperprosopon argenteum*	10,380	231	23.0	
5. Shiner perch	*Cymatogaster aggregata*	5,960	190	13.2	
6. Topsmelt	*Atherinops affinis*	4,558	164	10.1	
7. Staghorn sculpin	*Leptocottus armatus*	2,849	183	6.3	
8. White croaker	*Genyonemus lineatus*	2,660	104	5.9	
9. **California corbina**	*Menticirrhus undulatus*	**2,515**	**254**	**5.6**	**17.6**
10. Deepbody anchovy	*Anchoa compressa*	2,504	145	5.6	
11. Slough anchovy	*Anchoa delicatissima*	2,099	79	4.7	
12. Jacksmelt	*Atherinopsis californiensis*	1,973	103	4.4	
13. White seaperch	*Phanerodon furcatus*	1,877	125	4.2	
14. California grunion	*Leuresthes tenuis*	1,698	35	3.8	
15. Round stingray	*Urolophus halleri*	1,517	142	3.4	
16. California halibut	*Paralichthys californicus*	1,415	238	3.1	
17. Shovelnose guitarfish	*Rhinobatos productus*	1,212	196	2.7	
18. **Spotfin croaker**	*Roncador stearnsi*	**1,137**	**128**	**2.5**	**7.9**
19. Dwarf perch	*Micrometrus minimus*	725	97	1.6	
20. Bay pipefish	*Syngnathus leptorhynchus*	651	89	1.4	
21. Diamond turbot	*Hypsopsetta guttulata*	543	161	1.2	
22. California killifish	*Fundulus parvipinnis*	450	28	[1]1.0	
23. White seabass	*Cynoscion nobilis*	420	94	0.9	
24. California thornback	*Platyrhinoidis triseriata*	280	67	0.6	
25. California pompano	*Palometa simillima*	212	6	0.5	
26. **Yellowfin croaker**	*Umbrina roncador*	**201**	**53**	**0.4**	**1.4**
27. Pile perch	*Rhacochilus vacca*	190	51	0.4	
28. California butterfly ray	*Gymnura marmorata*	128	51	0.3	
29. Black perch	*Embiotoca jacksoni*	86	33	0.2	
30. Kelpfish	*Heterostichus rostratus*	74	27	0.2	
31. California barracuda	*Sphyraena argentea*	58	6	0.1	
32. Leopard shark	*Triakis semifasciata*	58	30	0.1	
33. Pacific sardine	*Sardinops caerulea*	53	8	0.1	
34. Bat stingray	*Myliobatis californicus*	46	27	0.1	
35. Brown smoothhound	*Rhinotriacis henlei*	41	20	less than 0.1	
36. Calico surfperch	*Amphistichus koelzi*	39	16	do.	
37. Opaleye	*Girella nigricans*	38	21	do.	
38. Gray smoothhound	*Mustelus californicus*	35	13	do.	
39. Pacific sanddab	*Citharichthys sordidus*	31	21	do.	
40. Slim midshipman	*Porichthys myriaster*	24	15	do.	
41. C-O turbot	*Pleuronichthys coenosus*	15	11	do.	
42. Kelp bass	*Paralabrax clathratus*	14	11	do.	
43. California sargo	*Anisotremus davidsoni*	12	4	do.	
44. California needlefish	*Strongylura exilis*	11	4	do.	
45. Senorita	*Oxyjulis californica*	9	1	do.	
46. California angel shark	*Squatina californica*	9	8	do.	
47. One-spot fringehead	*Neoclinus uninotatus*	9	7	do.	
48. Bay goby	*Lepidogobius lepidus*	8	4	do.	
49. Fantail sole	*Xystreurys liolepis*	8	6	do.	
50. Rockfish	*Sebastodes* sp.	8	3	do.	
51. Kelp perch	*Brachyistius frenatus*	8	4	do.	
52. Sand bass	*Paralabrax nebulifer*	3	3	do.	
53. Spotted bass	*Paralabrax maculatofasciatus*	3	2	do.	
54. Speckled sanddab	*Citharichthys stigmaeus*	3	3	do.	
55. Electric ray	*Torpedo californicus*	3	3	do.	
56. Rubberlip perch	*Rhacochilus toxotes*	2	2	do.	
57. Rainbow seaperch	*Hypsurus caryi*	2	2	do.	
58. Silver surfperch	*Hyperprosopon ellipticum*	2	1	do.	
59. Black croaker	*Cheilotrema saturnum*	2	2	do.	
60. Pacific jack mackerel	*Trachurus symmetricus*	2	2	do.	
61. Halfbeak	*Hyporhamphus unifasciatum*	2	2	do.[2]	
62. Monterey spanish mackerel	*Scomberomorus concolor*	2	1	do.[2]	
63. California hornshark	*Heterodontus francisci*	1	1	do.	
64. Diamond stingray	*Dasyatis dipterurus*	1	1	do.	
65. Curlfin turbot	*Pleuronichthys decurrens*	1	1	do.	
66. California tonguefish	*Symphurus atricauda*	1	1	do.	
67. Ragfish	*Icichthys lockingtoni*	1	1	do.	
68. Green jack	*Caranx caballus*	1	1	do.	
69. Pink seaperch	*Zalembius rosaceus*	1	1	do.	
70. Sculpin	*Scorpaena guttata*	1	1	do.	
71. Cabezon	*Scorpaenichthys marmoratus*	1	1	do.	

[1] Alamitos and Newport Bays, one from Belmont Shore.
[2] Newport back-bay.
Project species in boldface.

TABLE 1
Beach Seine Catch for 44-Month Period February 1953 to September 1956 451 Hauls—114 Beach Seining Days.

occurred in over 80 percent. Catches were recorded for each net haul on a field data, sheet listing 39 species of fish. Additional spaces were provided for other species (Figure 5).

Barred surfperch made up 73.1 percent of the catch of the four project species, 23.2 fish per haul, followed by California corbina, 17.6 percent, 5.6 fish per haul; spotfin croaker, 7.9 percent, 2.5 fish per haul; and yellowfin croaker, 1.4 percent, 0.4 fish per haul (Table 1).

The catch of project species varied greatly depending upon locality (Table 2). The largest average catches of barred surfperch were made at Redondo Beach, Emerald Bay and Santa Monica. The catch of California corbina was three times as good at Belmont Shore as any other locality. Belmont Shore also produced the most spotfin croaker per haul. Although the largest average catch of yellowfin croaker was made at Redondo Beach, the importance of the area may have been overemphasized by a few good catches.

This study gives an idea of the relative abundance of the various species at 11 localities, but does not offer a completely comparative record because of the different nets used. Availability of personnel to pull the net governed the choice of net on many occasions. Also, new nets made and put into use varied somewhat from those previously used.

Regardless, the proportion of species in the catch probably was maintained, giving an accurate indication of the populations of fishes in the surf.

Barred surfperch were the third most numerous fish captured. More than 10,000 were taken in 364 hauls. The northern anchovy, Engraulis mordax, was the most abundant but the 45,000 individuals occurred in only 85 beach seine hauls (Table 1).

Two of the project species, barred surfperch and California corbina, ranked first and second in number of occurrences (Table 1). In numbers of individuals, the perch ranked third and corbina ninth (Table 1).

3. RELATIONSHIP OF BEACH SEINING SUCCESS FOR THE PROJECT SPECIES TO HEIGHT OF TIDE

The inshore abundance of barred surfperch and the various surfliving croakers is related to many environmental and physiological factors including breeding habits, water temperature, stage of tide, time of day, and presence of food organisms. Stage of tide appears to be one of the most important factors.

The lower range of the tide, both incoming and outgoing, provided the most successful seining for project species. Catches dropped off greatly with the approach of high tide, and increased again as the tide fell.

The average catch of project species per net haul regardless of tide was 26.8 fish. Incoming tides with an average of 29 project fish per haul were only slightly more productive than outgoing tides with 25 per haul (Table 3).

Only a period of intensive sampling, April 1953 through October 1954, was used for this comparison. Over 7,000 project fish were taken in 262 hauls during these 19 months (Table 3).

TABLE 2
Seining Success for the Four Project Species by Locality

Station	Number of hauls	Length of net (feet)	Barred surfperch: Successful hauls	Barred surfperch: Number taken	Barred surfperch: Catch per haul	Corbina: Successful hauls	Corbina: Number taken	Corbina: Catch per haul	Spotfin croaker: Successful hauls	Spotfin croaker: Number taken	Spotfin croaker: Catch per haul	Yellowfin croaker: Successful hauls	Yellowfin croaker: Number taken	Yellowfin croaker: Catch per haul
El Capitan	2	65	0	0	0	0	0	0	0	0	0	0	0	0
Goleta	7	140	7	106	15.1	0	0	0	0	0	0	0	0	0
Carpinteria R.S.	3 4 30	140 100 65	32	487	13.2	2	2	*	0	0	0	5	2	*
Escondido Beach R.S.	14 6	100 65	20	475	23.8	1	1	*	0	0	0	1	1	*
Santa Monica	5	100	5	229	45.7	1	10	2.0	0	0	0	0	0	0
Redondo Beach R.S.	62 2	100 65	64	3,593	56.1	27	78	1.2	0	0	0	19	110	1.7
Alamitos Bay	14	100	0	0	0	3	3	0.2	2	2	0.1	0	0	0
Belmont Shore R.S.	8 199 2	140 100 65	204	4,288	20.5	200	2,331	11.2	109	1,080	5.2	26	78	0.4
Emerald Bay (Laguna)	25	100	25	1,193	47.7	14	82	3.3	0	0	0	0	0	0
Newport Bay	4 41 8	140 100 65	0	0	0	1	1	*	16	54	1.0	5	7	0.1
North Island (San Diego)	8	65	7	92	11.5	5	7	0.9	1	1	*	0	0	0

R.S. indicates routine station.
* indicates numbers below 0.1.

TABLE 2
Seining Success for the Four Project Species by Locality

TABLE 3

Seining Success for Project Species Related to Height of Tide April 1953 - October 1954 (19 months)

Incoming Tide 29.0 Fish/Haul

Range in feet		Mid-point	No. fish	No. hauls	Av. fish per haul
0.0	0.9	0.45	945	17	55.6
1.0	1.9	1.45	594	20	29.7
2.0	2.9	2.45	979	30	32.6
3.0	3.9	3.45	548	26	21.1
4.0	4.9	4.45	278	20	13.9
5.0	5.9	5.45	17	3	5.7
Totals			3,361	116	29.0

Outgoing Tide 25.0 Fish/Haul

Range in feet		Mid-point	No. fish	No. hauls	Av. fish per haul
6.9	6.0	6.45	7	1	7
5.9	5.0	5.45	184	10	18.4
4.9	4.0	4.45	446	27	16.5
3.9	3.0	3.45	888	29	30.6
2.9	2.0	2.45	1,090	40	27.3
1.9	1.0	1.45	539	17	31.7
0.9	0.0	0.45	502	22	22.8
Totals			3,656	146	25.0
Grand totals			7,017	262	26.8

TABLE 3

Seining Success for Project Species Related to Height of Tide April 1953 – October 1954 (19 months)

4. RELATIONSHIP OF BARRED SURFPERCH SEINE CATCH TO WATER TEMPERATURE

Barred surfperch catch per beach seine haul, a measure of inshore abundance, and water temperature were compared to determine if there was any relationship between the two.

Catch and temperature data from 31 days of seining at Belmont Shore (Long Beach) were examined (Table 4, Figure 6). These data cover the period from November 10, 1953 to August 15, 1956. Seining ordinarily began about 9 a.m. and continued past midday. Surface temperature was measured in water about two feet deep while each seine haul was in progress. Within-day temperatures appeared to be highly correlated so daily mean temperatures were used for all days when four or more seine hauls were completed. Thus, the means are of individual haul temperatures taken within approximately the same time period for each day used.

There is no obvious relationship between catch per haul and temperature (Figure 6). Additional data below 16 degrees C and above 21.5 degrees C might alter the picture. However, temperatures are seldom found in this area outside this range.

TABLE 4

Barred Surfperch Catch Per Beach Seine Haul and Mean Water Temperatures Belmont Shore, Long Beach, California

Mean temperature degrees C.	Number of hauls	Catch per haul	Date			Mean temperature degrees C.	Number of hauls	Catch per haul	Date		
			Yr.	Mo.	Day				Yr.	Mo.	Day
12.8	4	9.0	56	1	18	18.1	4	2.5	55	8	23
13.7	4	17.5	56	1	6	19.0	5	32.8	55	5	19
14.0	5	7.6	54	1	14	19.3	4	1.5	55	9	1
16.1	7	10.0	54	2	3	19.4	5	31.0	55	6	29
16.2	5	51.4	54	5	7	19.8	5	23.2	54	9	24
16.3	7	16.3	54	4	1	19.8	4	1.0	55	9	7
16.6	4	22.7	54	5	11	19.9	5	32.0	55	9	22
16.9	4	37.5	55	10	14	20.0	7	36.0	54	6	3
16.9	4	16.2	55	10	19	20.1	5	31.0	55	6	23
17.2	4	5.2	54	11	22	20.4	6	14.2	55	7	28
17.3	4	16.2	55	11	9	20.6	4	5.7	56	7	18
17.4	5	31.4	55	11	1	21.2	5	30.0	55	8	9
17.7	6	10.2	53	11	10	21.3	6	40.8	55	7	6
17.8	4	19.5	55	9	29	21.3	4	6.3	56	8	15
17.9	4	101.2	55	10	28	23.0	5	14.8	54	8	6
18.1	6	9.0	54	10	26						

TABLE 4

Barred Surfperch Catch Per Beach Seine Haul and Mean Water Temperatures Belmont Shore, Long Beach, California

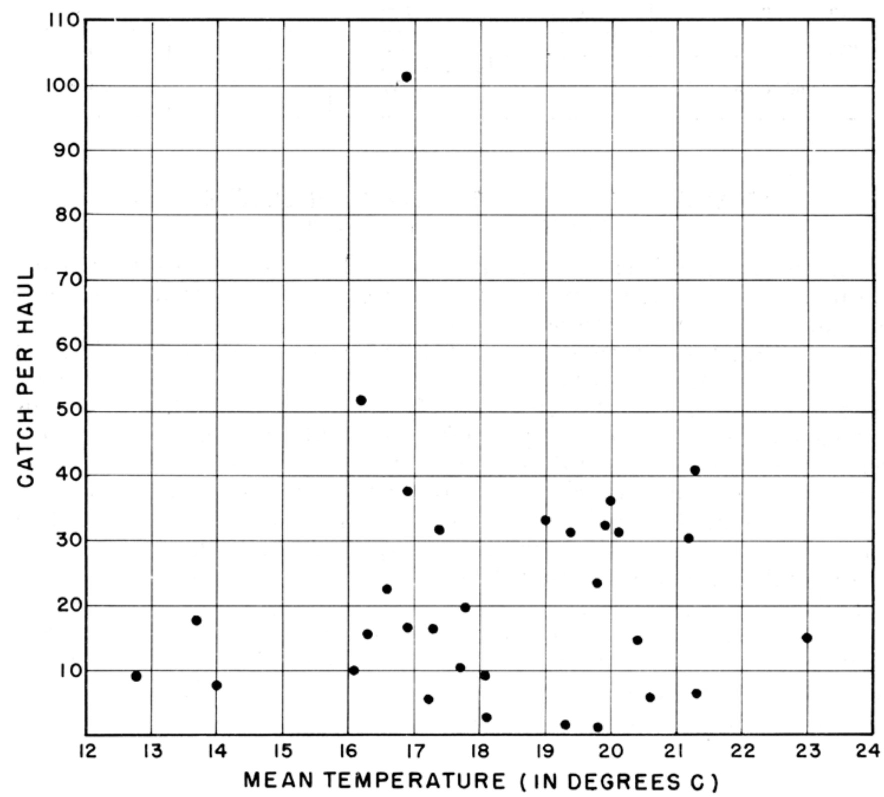

FIGURE 6. Daily barred surfperch catch-per-beach-seine-haul, and daily mean temperature Belmont Shore, November 10, 1953 to August 15, 1956.

FIGURE 6. Daily barred surfperch catch-per-beach-seine-haul, and daily mean temperature Belmont Shore, November 10, 1953 to August 15, 1956

5. SCUBA DIVING OBSERVATIONS

Many underwater observations were made with self-contained underwater breathing apparatus (SCUBA) (Figure 7). Beach seines and gill nets were observed in operation, surveys were made to locate suitable areas for seining, and habits and habitats of project species were studied.

When the beach seines were pulled rapidly, the lead-line rode off the bottom, as much as 18 inches with the 60-foot net and six to eight inches with the 140-foot net. Subsequently, pulling was always done very slowly. Areas of undesirable net stress or strain were noted during seining operations. Correcting such items did much to improve the effectiveness of the nets.

The hang of gill nets was also observed so that alterations could be made if necessary.

Surveys were made to find suitable bottom for beach seining. Species relationships, schooling habits, and preferred depths were observed and noted. However, because of wave action and turbidity, the surf did not usually lend itself well to diving observations. No project species were observed on many dives although they were known to live in the area. On these occasions the habitat was studied.

The four species, when observed, were found to be very active, and generally left the area occupied by the divers. Barred surfperch were most frequently observed and very often were schooling with walleye

FIGURE 7. John G. Carlisle, Jr., left, and Jack W. Schott prepare for SCUBA dive. *Photograph by John E. Zoeger.*

FIGURE 7. John G. Carlisle, Jr., left, and Jack W. Schott prepare for SCUBA dive. Photograph by John E. Zoeger

surfperch. Barred surfperch swam off immediately when they noticed the divers but the walleye surfperch showed no alarm, even though approached within a foot. California corbina were seldom observed in water deeper than four feet.

It was noted consistently that there is a rich zone of life, both vertebrate and invertebrate, at the juncture of sandy and rocky substrates. Generally, one or more of the project species, and numerous other surf species were found near these substrate junctures.

6. MATURITY AND FECUNDITY OF BARRED SURFPERCH

6.1. Viviparity

Females of the family Embiotocidae carry their eggs, and later embryos, in the ovary, or more properly, a sac-like enlargement of the oviduct (Figure 8). The young at birth are well developed and independent.

The yolk is greatly reduced in this family. Members of some other viviparous families, such as the Scorpaenidae which give birth to thousands of tiny young, continue to be nourished after birth from relatively large yolk sacs.

6.2. Copulation

Copulation has been observed for some embiotocids (Rechnitzer and Limbaugh, 1952). Limbaugh (personal communication) observed copulating barred surfperch in the aquarium at Scripps Institution of Oceanography, La Jolla. He described the process as follows: "Adults mated in the aquarium during November 1955. The mating pair were much darker than the 20 to 30 nonbreeding individuals in the same tank. The female was the largest in the tank. Her dark color, while

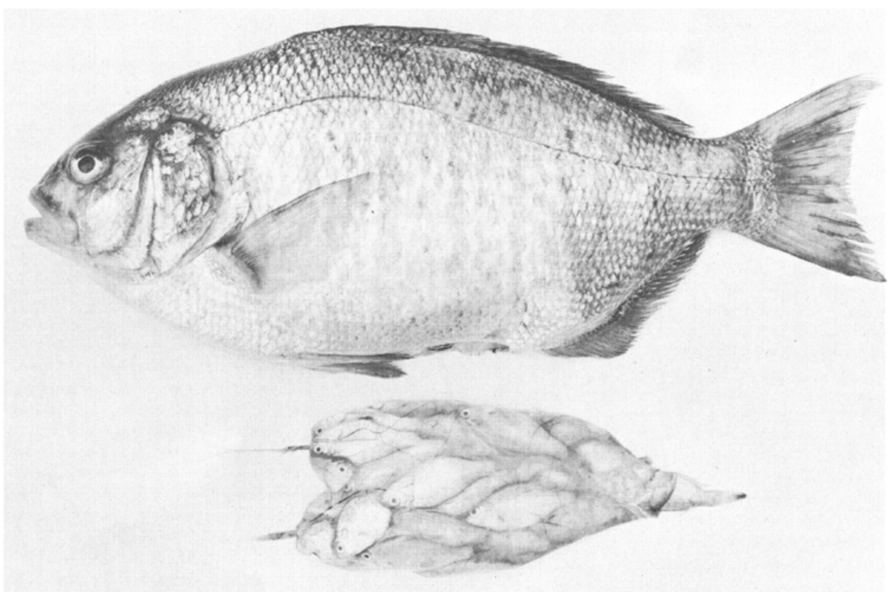

FIGURE 8. Female barred surfperch showing embryos in place in excised oviduct. *Photograph by Jack W. Schott.*

FIGURE 8. Female barred surfperch showing embryos in place in excised oviduct. Photograph by Jack W. Schott

probably related to breeding behavior, might possibly have been related to an infection which had conspicuously shortened her fins. She was quite dark below. The male was especially dark below and on the head. During courtship, the male continually pursued the female, using his anal fin to caress her face and his dorsal to caress her genital area. He moved almost continually in a figure eight pattern bringing his anal fin gland in contact with her head as often as he could. He frequently passed under her and with a great deal of accuracy brushed her genital area with his dorsal fin. Occasionally he would attempt to bring the tubercles of the anal gland to her urogenital opening. This was accomplished by tilting his body as he swam parallel to her. Once he turned completely over, swimming on his back. The action was usually too fast to observe, ... [except] in a few cases. The male showed no serious signs of aggressive behavior.... The female seemed passive or occasionally annoyed during courtship. Sometimes the female would roll completely over in order to avoid genital contact" (Figures 9 10 11 12).

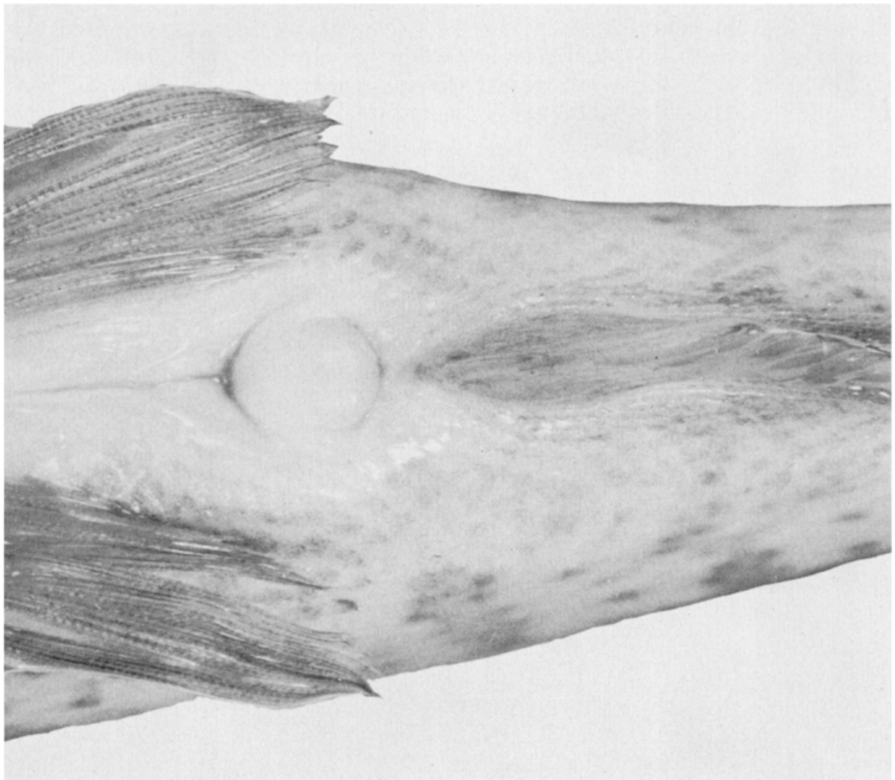

FIGURE 9. Ventral view of male barred surfperch, showing the bulbous genital organ. The anus is the long groove anterior to this. Separate genital and urinary openings lie within the crescentic slit posterior to the genital organ. The genital opening is on the bulb and may be erected or rotated to a terminal position for transferring sex products to the female. The urinary opening is posterior to the genital opening.
Photograph by Jack W. Schott.

FIGURE 9. Ventral view of male barred surfperch, showing the bulbous genital organ. The anus is the long groove anterior to this. Separate genital and urinary openings lie within the crescentic slit posterior to the genital organ. The genital opening is on the bulb and may be erected or rotated to a terminal position for transferring sex products to the female. The urinary opening is posterior to the genital opening. Photograph by Jack W. Schott

6.3. Embryonic Life

Important details in the embryonic life of some embiotocids have been known for more than a half century (Eigenmann, 1894).

Barred surfperch bear eggs and embryos between 10, thin, highly vascular, ovarian sheets. These are bathed by a nutritive fluid, from which the embryos probably receive both nourishment and oxygen.

Interchange of gases is aided by vascular dermal folds or extensions between the vertical fins of the embryos. These give the impression of greatly elevated fins. Some interchange, at least of gases, probably takes place through the skin. Actual feeding of the embryo probably begins when the yolk is used up.

Some embryos lie with their heads aligned anteriorly, and others with their heads aligned posteriorly, thus conserving space. This results in some being born head first and others tail first.

6.4. Fecundity

Fecundity of the live-bearing embiotocids is very low compared to most egg-spawning fishes. It is assumed that survival is high and wide fluctuations in year classes are absent. No matter by what method the adults are captured, there is a strong possibility that some of the embryos will be aborted, especially as they approach term. Thus, fecundity values probably are minimal.

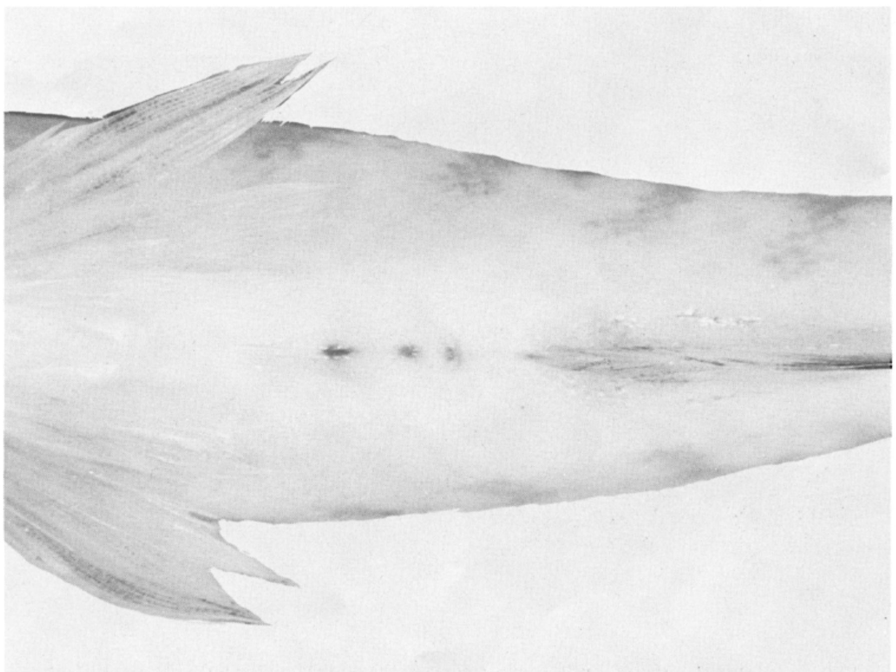

FIGURE 10. Ventral view of female barred surfperch, showing excretory and genital openings. From left to right: anus, genital opening and urinary opening. *Photograph by Jack W. Schott.*

FIGURE 10. Ventral view of female barred surfperch, showing excretory and genital openings. From left to right: anus, genital opening and urinary opening. Photograph by Jack W. Schott

FIGURE 11. Lateral view of male barred surfperch showing modified anal fin and bulbous genital organ. *Photograph by Jack W. Schott.*

FIGURE 11. Lateral view of male barred surfperch showing modified anal fin and bulbous genital organ. Photograph by Jack W. Schott

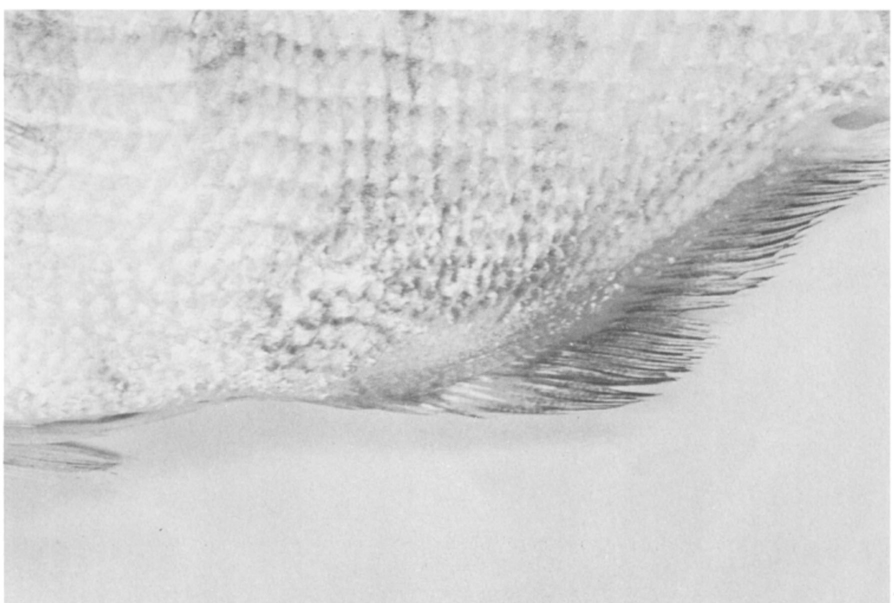

FIGURE 12. Lateral view of female barred surfperch. *Photograph by Jack W. Schott.*

FIGURE 12. Lateral view of female barred surfperch. Photograph by Jack W. Schott

FIGURE 13. Teams of biologists sampling catch at annual barred surfperch derby Redondo Beach. *Photograph by Florence M. Harrison.*

FIGURE 13. Teams of biologists sampling catch at annual barred surfperch derby Redondo Beach. Photograph by Florence M. Harrison

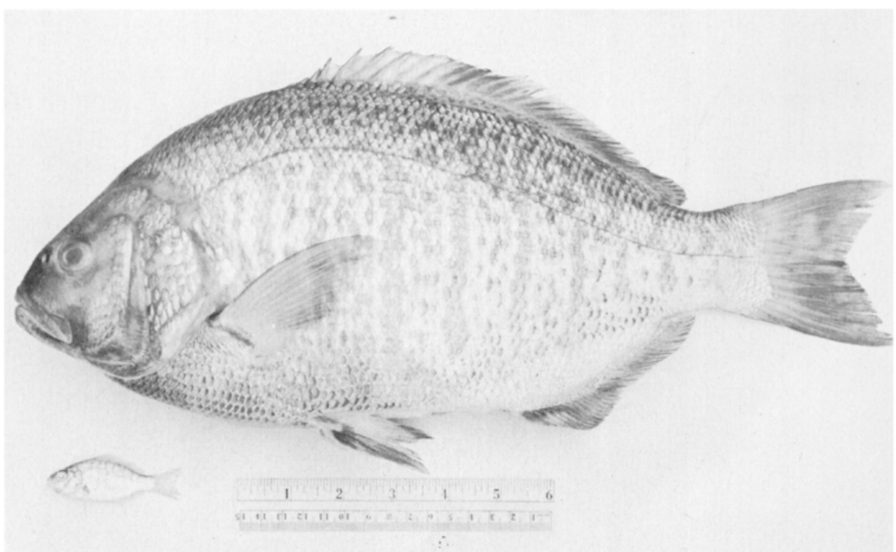

FIGURE 14. Female barred surfperch and term embryo. *Photograph by Jack W. Schott.*

FIGURE 14. Female barred surfperch and term embryo. Photograph by Jack W. Schott

Maturity and fecundity samples were taken by hook and line, at barred surfperch derbies (Figure 13), beach seining, and by trawl netting.

One hundred and four of 132 females longer than 165 mm. standard length[2] were found to contain embryos in all stages of development, measuring from 2.0 to 33.7 mm. Eighty-two of the 104 gravid females were taken on hook and line February 20, 1955, along the entire southern California coast. The remaining 22 were taken at various times by beach seine along some of the same sections of the coast. Embryos at birth probably measure between 42.0 and 53.0 mm. (Figure 14). There is a possibility that young as small as 42.0 mm. taken by beach seine had been aborted in the net.

There seems to be no difference in size of males and females before birth, although an occasional "out-sized" or very small abnormal embryo was found.

Twenty-six of the females taken during the latter part of February contained immature eggs; one, mature eggs with embryos; and one was spent. The egg-carrying females ranged in size from 186 mm. to 283 mm. However, only two were longer than 243 mm. All of these females bearing eggs were taken north of Oxnard, suggesting that birth occurs later to the northward. Water temperature is probably a controlling factor.

Seasonal progression of embryo growth, as determined from monthly beach seine and drag boat samples, will be discussed later.

The 82 gravid females in the February 1955 sample yielded 3,475 embryos. When present, 10 embryos were measured from each female.

Tests showed that any one random sample varied only slightly from any other random sample taken from the same ovary. Therefore, the mean of a sample of 10 embryos was used to represent the mean length of all embryos present (Figure 15).

The average number of embryos for all females was 33.4. In those shorter than 250 mm. the average was 23.6, while in those longer than 250 mm. it was 46.2 (Table 5). They varied from four embryos in a female measuring 178 mm. to 113 in one measuring 285 mm. This large female weighed 1,115 grams and the weight of her ovaries was 204 grams, almost one-fifth of total weight. The largest female in the sample was 362 mm. and the smallest 165 mm.

6.5. Size at First Maturity

Barred surfperch reach maturity in their second year of life when about 130 mm. in length, shortly before the second ring is formed on the scales.

6.6. Number of Embryos Related to Size of Female

The number of embryos increases with increase in size of the parent (Figure 16). (The trend line on this figure was fitted by eye.) Ages one through nine are represented by the sample. This relationship of number to size was also found in Micrometrus aurora (Hubbs, 1921).

[2] Standard length is used throughout unless otherwise stated.

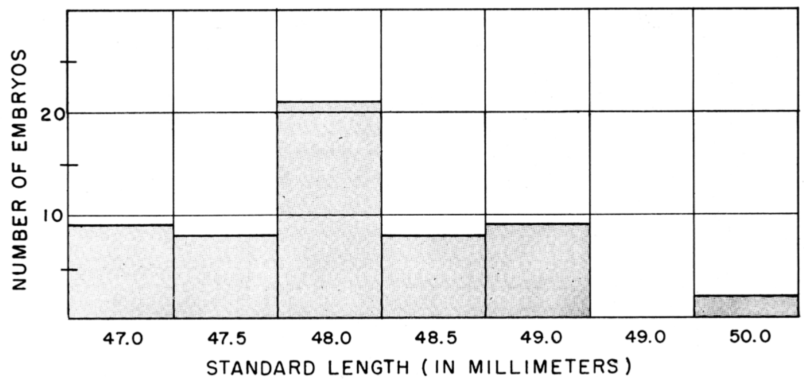

FIGURE 15. Length frequencies of 57 embryos from a 293 mm. female barred surfperch.

FIGURE 15. Length frequencies of 57 embryos from a 293 mm. female barred surfperch

TABLE 5

Number of Embryos by Length of Female

Shorter than 250 mm.

Standard length mm.	Number of females	Average number of embryos[1]
165	1	14.0
178	1	4.0
183	1	11.0
189	1	13.0
193	1	22.0
194	1	19.0
197	1	13.0
200	1	31.0
201	1	14.0
205	1	25.0
206	1	23.0
208	1	12.0
210	1	19.0
212	1	20.0
215	1	13.0
216	1	12.0
218	1	26.0
219	1	24.0
220	1	16.0
221	2	17.5
222	4	20.0
223	3	29.0
224	1	16.0
225	2	29.0
227	1	42.0
229	1	26.0
230	2	22.5
232	6	26.0
233	3	30.0
234	3	29.0
235	1	26.0
236	1	40.0
237	1	24.0
238	1	13.0
241	1	25.0
242	1	41.0
243	1	32.0
245	1	7.0
247	2	37.0
248	1	38.0
249	1	22.0
Total	59	
Average		23.6

Longer than 250 mm.

Standard length mm.	Number of females	Average number of embryos
250	2	26.5
252	1	21.0
253	2	43.5
255	1	27.0
256	1	37.0
257	2	43.5
260	2	40.0
261	2	34.0
262	1	32.0
264	1	57.0
267	2	42.5
269	1	28.0
271	1	53.0
272	2	34.5
273	3	45.5
275	1	75.0
280	2	31.0
285	1	113.0
289	1	39.0
290	2	42.0
293	1	57.0
297	2	63.5
298	3	60.5
300	1	38.0
304	1	38.0
310	1	56.0
313	1	35.0
321	1	88.0
326	1	56.0
350	1	66.0
362	1	43.0
Total	45	
Average		46.2

[1] Minimal figure because of aborting upon capture and removal from water.

TABLE 5

Number of Embryos by Length of Female

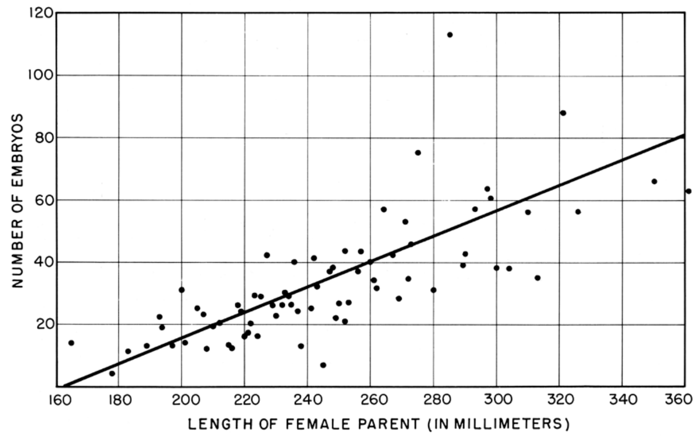

FIGURE 16. Number of barred surfperch embryos related to length of female parent, trend line fitted by eye.

FIGURE 16. Number of barred surfperch embryos related to length of female parent, trend line fitted by eye

6.7. Larger Females Bear Young Earlier

A random sample of 100 females taken in February showed that larger females bear young earlier than do smaller ones. Fifty-nine were shorter than 250 mm. and 43 (73 percent) of these contained embryos while the other 16 still carried eggs. of 41 longer than 250 mm., 39 (95 percent) carried embryos and only two (5 percent) carried eggs.

6.8. Development of Eyes and Scales

The eyes of barred surfperch become pigmented at about 5.5 mm. The scales form, principally along the lateral line and around the eyes, when the embryo reaches about 11.0 mm.

E. L. Triplett of the University of California, Santa Barbara, who is studying the embryology of the barred surfperch, states, by personal communication, that the gestation period for this species is about five months.

A mature 232 mm. female, taken in early October 1956, carried fertile eggs. In this fish, and in others carrying eggs, there were a great many more eggs present in the ovarian folds than would be expected to develop into embryos. Frequently several hundred eggs were observed, while the greatest number of embryos counted was 113.

6.9. Season

Barred surfperch are born from about mid-March, at least through July (one spent female was taken at the end of February).

Some evidence was found that the season is earlier to the south.

6.10. Average Monthly Growth of Embryos

In order to show average monthly growth of embryos, samples of mature females were taken whenever possible. However, during the summer mature females were not always available. Samples were taken by beach seine, trawl, and hook and line. The trawl work in 1956 and 1957 fortunately provided samples during months for which data were scanty. Some of the fish taken on the trawler were caught in water as deep as 15 fathoms (90 feet).

Data, accumulated over several years, show average embryo length increasing from 6.7 mm. in December to as much as 50.9 mm. in May (Figure 17).

In May 1956, embryos from a sample of five female perch from Santa Monica averaged only 18.9 mm. This is inconsistent with other data. The range in average size of embryos from these five fish was from 9.0 mm. to 35.0 mm. An entirely satisfactory explanation cannot be offered. A single fish taken in May 1954, gave an embryo size of 44.5 mm.

Two additional samples were obtained on May 8 and 9, 1957. In one sample of 15 mature females, 14 were spent and one had embryos averaging 52.0 mm. In a second sample, of 14 females, 12 were spent and two had embryos averaging 50.4 mm. The average for these three fish was 50.9 mm.

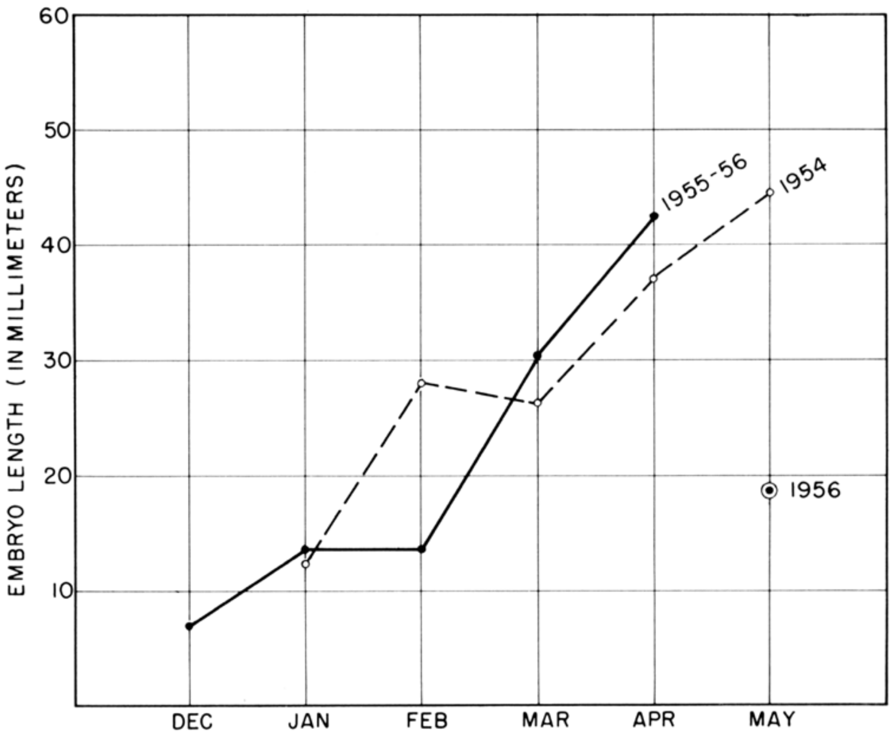

FIGURE 17. Average monthly growth of barred surfperch embryos.

FIGURE 17. Average monthly growth of barred surfperch embryos

7. AGE AND GROWTH

7.1. General Information

of the 19 marine embiotocids found along the California coast, only the reef perch, Micrometrus aurora, has been aged (Hubbs, 1921). At the inception of this project little was known about the problems of age determination of barred surfperch.

7.2. Sampling Methods

The specimens used for age and growth were secured by beach seining at six localities along the southern California coast from Pt. Conception to the Mexican Border and by hook and line fishing between Guadalupe, just north of Pt. Conception, and the Mexican Border. Most samples of hook and line fish were obtained at a barred surfperch fishing derby sponsored annually by sportfishermen of Redondo Beach.

In all, 3,407 fish were sampled. Locality of capture, total length, standard length, weight, and sex were noted for each fish. By size, 2,695 were smaller than 180 mm. standard length and 712 were 180 mm. or larger. Most of the large fish were from the perch derby sampling.

Data from all of these fish were used to calculate the length-weight relationship and the total length-standard length conversion factors; fewer specimens were used in the length frequency analysis.

Most of the fish used in the age work were captured in 1954 by beach seining. A few were seined in November and December 1953 and in January and February 1955, and 500 adults from February perch derbies were also used.

7.3. Use of Otoliths, Bones and Length Frequencies

The concentric rings on otoliths were not sharp and distinct and reliable ages could not be determined for older fish. Among the bones examined, the pelvic girdle exhibited the most satisfactory marks for age determination (Figure 18). Although the pelvic bones were easily

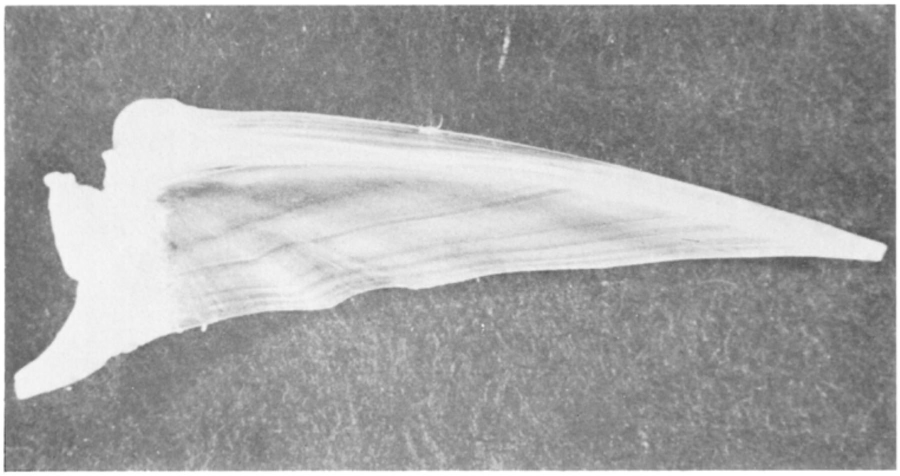

FIGURE 18. Pelvic girdle of a six-ring male barred surfperch captured February 21, 1956, 254 mm. standard length, photographed in infra-red light. *Photograph by Jack W. Schott.*

FIGURE 18. Pelvic girdle of a six-ring male barred surfperch captured February 21, 1956, 254 mm. standard length, photographed in infra-red light. Photograph by Jack W. Schott

removed without excessive mutilation of the fish (an important factor in sampling a fisherman's catch), the additional time required in their preparation prior to storage prevented their exclusive use. For this reason, only a representative sample of bones was taken for correlation with scale readings.

Length frequencies were of no value for aging fish older than 12 months.

7.4. Scale Structure

Barred surfperch scales are of a modified cycloid type, roughly oval in outline, and with a slightly convex anterior margin. The focus in very small scales is centrally located, but with an increase in growth and age it becomes eccentrically positioned. This is the result of progressively greater growth in the anterior scale field than in the posterior field.

The direction of growth of the circuli is marked by winter rings and accessory checks. These marks are manifest by crowding of circuli (Figure 19), termination of circuli (Figure 20), sigmoid waves in the circuli (Figures 21 and 22), and by diffuse optical lines (Figure 23).

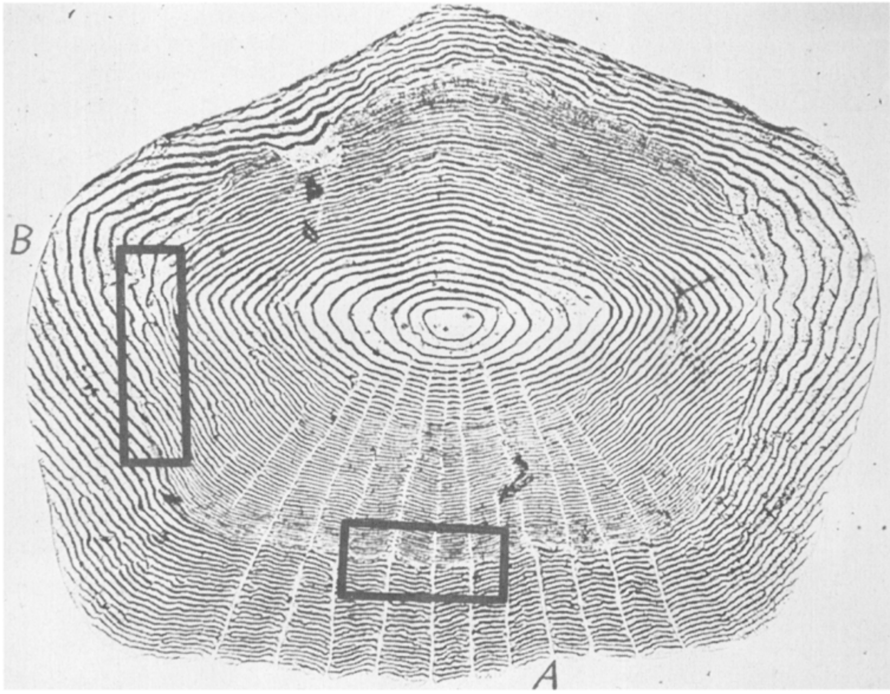

FIGURE 19. A one-ring scale from a barred surfperch 117 mm. standard length, captured on May 21, 1954. At the winter ring note the crowding of circuli before resumption of spring growth (A), and the continuity of circuli through ring area (B). *Photograph by Jack W. Schott.*

FIGURE 19. A one-ring scale from a barred surfperch 117 mm. standard length, captured on May 21, 1954. At the winter ring note the crowding of circuli before resumption of spring growth (A), and the continuity of circuli through ring area (B). Photograph by Jack W. Schott

Frequently a few circuli at the winter ring area were observed continuing their direction of growth while adjacent circuli exhibited terminations (Figure 20).

Identification of a winter ring was not confined to recognition of a single specific mark or characteristic. Frequently the presence of a ring was indicated by several vague, indistinct, or discontinuous clues, and interpretation was possible only after exploiting the potentials of illumination and slide maneuvers.

With some regularity a ring is formed on barred surfperch scales shortly after birth. It is not formed on the scales of all, so it may reflect the inability of most fish to make immediate adjustment to the postnatal environment (Figures 24 and 25).

Because of the difficulty in evaluating many of the scales, particularly those of older fish, a problem of scale rejection arose. The error created by discarding substantial numbers was considered to be of greater magnitude than the error resulting from reading all scales of the collection.

7.5. Materials and Methods

A comparison was made of scales from various body areas to determine where consistently good ones could be found (Figure 26). The most uniform scales were located at midbody depth just posterior to a

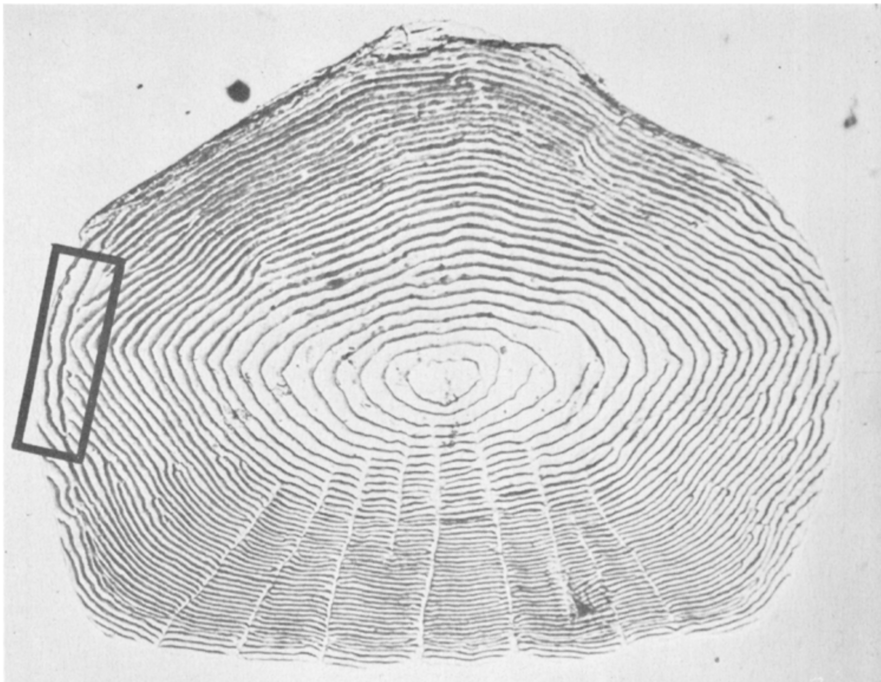

FIGURE 20. A one-ring scale from a barred surfperch captured December 16, 1953, 85 mm. standard length. In the blocked area observed the series of circuli terminations at the winter ring and new growth of circuli in a different direction. *Photograph by Jack W. Schott.*

FIGURE 20. A one-ring scale from a barred surfperch captured December 16, 1953, 85 mm. standard length. In the blocked area observed the series of circuli terminations at the winter ring and new growth of circuli in a different direction. Photograph by Jack W. Schott

line drawn between the first dorsal spine and the posterior base of the pectoral fin. Scales used for age determination of a particular fish were selected from a batch of 8 to 10 that had been removed from this area. The selected scales were carefully cleaned and mounted between glass slides and were allowed to dry before reading.

Best reading and evaluation was obtained with a stereoscopic microscope and transmitted light. A fluorescent desk lamp equipped with two 15-watt tubes proved a most satisfactory light source. The light was positioned about eight inches from the substage mirror at an angle of approximately 20 degrees.

Faint and confusing rings were frequently integrated and rendered perceptible by slide rotation and by producing a stroboscopic effect by rapidly manipulating the substage mirror (Figure 23).

All scales were aged without knowledge of sex, length, or weight; however, reader bias was not eliminated because scale size alone was suggestive of age.

7.6. Validity of Age Determinations

At least 150 scales were checked by a second individual who was experienced in scale reading and there were very few discrepancies.

Four hundred pairs of pelvic girdles were serially numbered and by using a table of random numbers 92 were drawn. The age frequency distribution determined from the pelvic girdles was compared to the

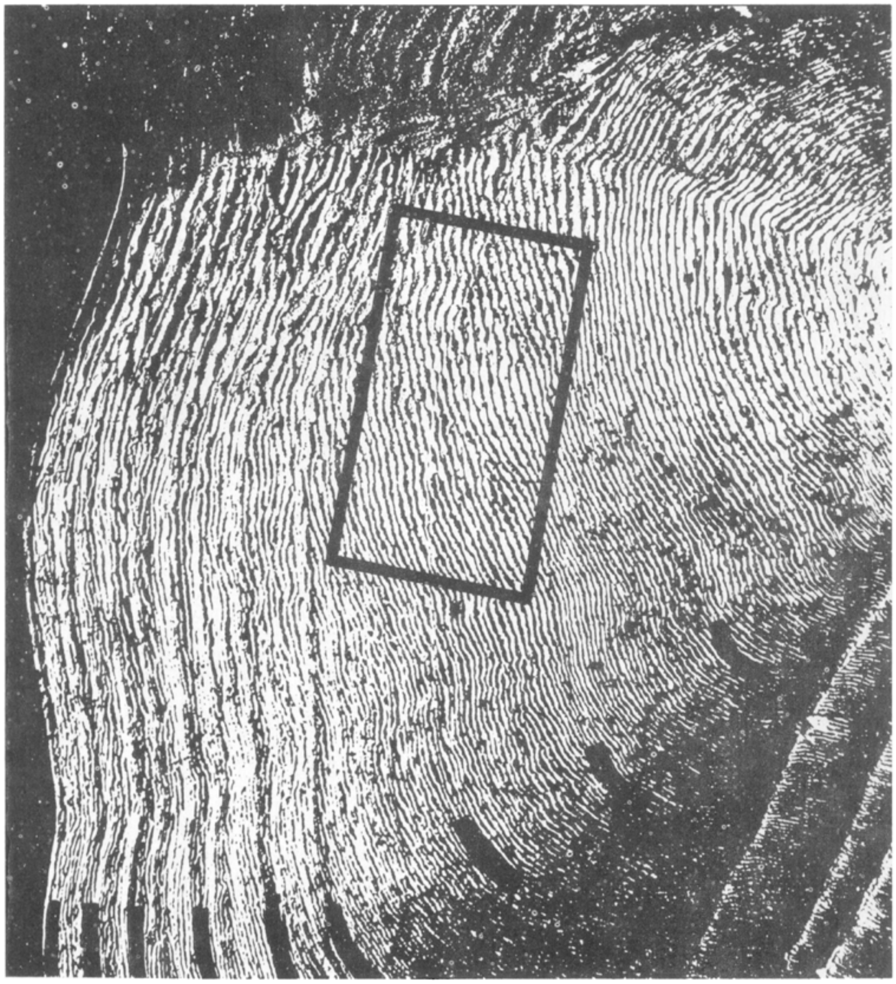

FIGURE 21. A nine-ring scale from a barred surfperch captured February 1, 1954, 335 mm. standard length. Observe the series of sigmoid shaped circuli and circuli terminations at the third winter ring, (see enlargement of blocked area, Figure 22). Distinct doubling of rings occurs after the fifth winter ring. This feature is best observed if the photograph is viewed from an 8-degree angle from the horizontal, viewed from bottom of photograph. *Photograph by Jack W. Schott.*

FIGURE 21. A nine-ring scale from a barred surfperch captured February 1, 1954, 335 mm. standard length. Observe the series of sigmoid shaped circuli and circuli terminations at the third winter ring, (see enlargement of blocked area, Figure 22). Distinct doubling of rings occurs after the fifth winter ring. This feature is best observed if the photograph is viewed from an 8-degree angle from the horizontal, viewed from bottom of photograph. Photograph by Jack W. Schott

age distribution from scales of the same fish. A chi-square test at the five percent level showed no significant difference in ages derived by either method.

After August, the appearance of progressively more scales having completed peripheral rings, demonstrated that these were winter rings and could be used for age determination (Figure 27 and Table 6). The peakedness (Figure 27) in the October–November plot of adults and in the December plot of the zero-ring age group may not represent a true value. It may be the result of either inadequate samples or a misinterpretation of winter rings.

TABLE 6

Age-length of Male Barred Surfperch

Standard length mm.	0	I	II	III	IV	V	VI
46–50	1	--	--	--	--	--	--
51–55	5	--	--	--	--	--	--
56–60	2	--	--	--	--	--	--
61–65	5	--	--	--	--	--	--
66–70	25	--	--	--	--	--	--
71–75	33	--	--	--	--	--	--
76–80	47	1	--	--	--	--	--
81–85	53	4	--	--	--	--	--
86–90	56	4	--	--	--	--	--
91–95	45	9	--	--	--	--	--
96–100	25	16	--	--	--	--	--
101–105	14	20	--	--	--	--	--
106–110	16	33	--	--	--	--	--
111–115	5	21	1	--	--	--	--
116–120	2	27	1	--	--	--	--
121–125	2	35	2	--	--	--	--
126–130	2	35	3	--	--	--	--
131–135	--	30	9	--	--	--	--
136–140	--	28	9	--	--	--	--
141–145	--	23	11	--	--	--	--
146–150	--	24	7	--	--	--	--
151–155	--	21	5	--	--	--	--
156–160	--	7	3	--	--	--	--
161–165	--	8	5	--	--	--	--
166–170	--	5	5	--	--	--	--
171–175	--	6	3	--	--	--	--
176–180	--	2	--	1	--	--	--
181–185	--	3	2	2	1	--	--
186-190	--	1	3	4	--	--	--
191–195	--	1	4	11	2	--	--
196–200	--	--	--	4	2	--	--
201–205	--	--	1	6	4	--	--
206–210	--	--	4	5	9	1	--
211–215	--	--	3	10	20	--	--
216–220	--	--	--	7	13	2	--
221–225	--	--	--	4	19	1	--
226–230	--	--	--	5	8	4	--
231–235	--	--	--	4	13	8	--
236–240	--	--	--	1	5	3	1
241–245	--	--	--	1	7	5	1
246–250	--	--	--	--	1	1	1
251–255	--	--	--	--	--	1	2
256–260	--	--	--	--	--	--	--
261–265	--	--	--	--	--	--	1
Total Number	338	364	81	65	104	26	6
Mean Length	85.7	128.2	156.9	208.8	220.9	234.6	249.0

TABLE 6
Age-length of Male Barred Surfperch

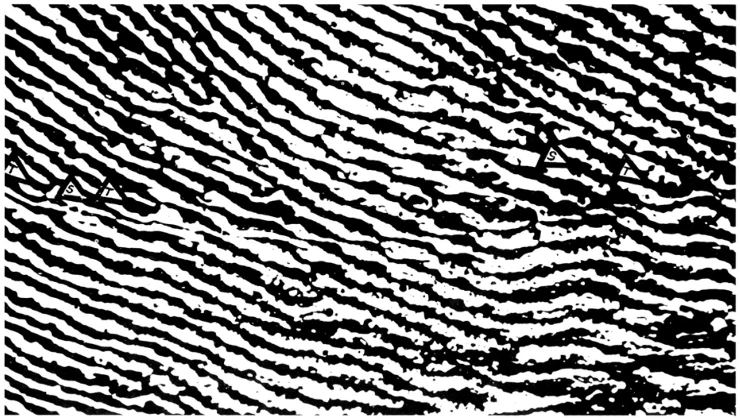

FIGURE 22. Enlargement of blocked area of figure 20. Dark lines are circuli. Observations: 1. Fewer circuli on left side of ring than on right because of circuli terminations, T. 2. Fewer circuli are found to the right of the winter ring (after the resumption of spring growth). 3. Circuli interspace and circuli are much thinner for a short distance where they follow and form the winter ring. 4. Some circuli are shallowly sigmoid, S, where they interrupt the scale pattern as they cross over the winter ring, (use a straight-edge to observe). *Photograph by Jack W. Schott.*

FIGURE 22. Enlargement of blocked area of figure 20. Dark lines are circuli. ***Observations:*** *1. Fewer circuli on left side of ring than on right because of circuli terminations, T. 2. Fewer circuli are found to the right of the winter ring (after the resumption of spring growth). 3. Circuli interspace and circuli are much thinner for a short distance where they follow and form the winter ring. 4. Some circuli are shallowly sigmoid, S, where they interrupt the scale pattern as they cross over the winter ring, (use a straight-edge to observe). Photograph by Jack W. Schott*

FIGURE 23. The two photographs A and B of an identical scale area demonstrate the difference in appearance of a scale resulting from a change in angle of light transmission from the substage mirror. Observe from 8-degree angle from horizontal, from bottom of photograph. *Photograph by Jack W. Schott.*

FIGURE 23. The two photographs A and B of an identical scale area demonstrate the difference in appearance of a scale resulting from a change in angle of light transmission from the substage mirror. Observe from 8-degree angle from horizontal, from bottom of photograph. Photograph by Jack W. Schott.

FIGURE 24. A natal ring on a zero-ring scale from a barred surfperch captured August 13, 1954, 96 mm. standard length. *Photograph by Jack W. Schott.*

FIGURE 24. A natal ring on a zero-ring scale from a barred surfperch captured August 13, 1954, 96 mm. standard length. Photograph by Jack W. Schott.

Nine hundred and eighty-four males (Table 6), and 1,142 females (Table 7) were aged by their scales. The greatest age encountered was six for males, 236 to 265 mm. long, and nine for females, 326 to 350 mm. long.

7.7. Growth

During the first year of life there is a marked seasonal difference in rate of growth. A variation also occurs among older fish, but is more readily observed in the new-born group because their sizes do not overlap those of other age groups.

Beginning in March, when the first new-born were taken with a beach seine, a monthly increase in length took place that was maintained through August (Figure 28). The rate dropped off from September to January. Because of inadequate numbers the mean lengths of the November and January samples probably are not representative. Retardation of growth during the fall and early winter was also reflected in the scales. A marked acceleration in growth had commenced by February and continued throughout the summer.

TABLE 7

Age-length of Female Barred Surfperch

Standard Length mm.	0	I	II	III	IV	V	VI	VII	VIII	IX
56–60	1	--	--	--	--	--	--	--	--	--
61–65	2	--	--	--	--	--	--	--	--	--
66–70	10	--	--	--	--	--	--	--	--	--
71–75	25	1	--	--	--	--	--	--	--	--
76–80	39	3	--	--	--	--	--	--	--	--
81–85	49	9	--	--	--	--	--	--	--	--
86–90	48	14	--	--	--	--	--	--	--	--
91–95	41	11	--	--	--	--	--	--	--	--
96–100	27	4	--	--	--	--	--	--	--	--
101–105	21	18	--	--	--	--	--	--	--	--
106–110	16	30	--	--	--	--	--	--	--	--
111–115	7	25	2	--	--	--	--	--	--	--
116–120	8	28	2	--	--	--	--	--	--	--
121–125	3	24	4	--	--	--	--	--	--	--
126–130	3	18	6	--	--	--	--	--	--	--
131–135	--	19	4	--	--	--	--	--	--	--
136–140	--	20	5	--	--	--	--	--	--	--
141–145	1	15	7	--	--	--	--	--	--	--
146–150	--	20	4	--	--	--	--	--	--	--
151–155	--	7	6	--	--	--	--	--	--	--
156–160	--	18	3	--	--	--	--	--	--	--
161–165	--	5	4	1	--	--	--	--	--	--
166–170	--	6	6	1	--	--	--	--	--	--
171–175	--	5	3	1	--	--	--	--	--	--
176–180	--	6	4	--	--	--	--	--	--	--
181–185	--	3	1	2	--	--	--	--	--	--
186–190	--	3	1	4	--	--	--	--	--	--
191–195	--	1	8	4	1	--	--	--	--	--
196–200	--	--	9	2	1	--	--	--	--	--
201–205	--	--	3	10	2	--	--	--	--	--
206–210	--	--	8	19	4	--	--	--	--	--
211–215	--	--	4	14	3	--	--	--	--	--
216–220	--	--	--	12	8	--	--	--	--	--
221–225	--	--	5	19	9	2	--	--	--	--
226–230	--	--	--	6	13	1	--	--	--	--
231–235	--	--	2	19	13	3	--	--	--	--
236–240	--	--	--	9	6	3	--	--	--	--
241–245	--	--	1	2	22	3	--	--	--	--
246–250	--	--	1	6	18	4	2	--	--	--
251–255	--	--	--	5	8	6	2	--	--	--
256–260	--	--	--	5	11	5	--	--	--	--
261–265	--	--	--	1	10	6	4	--	--	--
266–270	--	--	--	1	5	9	1	--	--	--
271–275	--	--	--	1	8	10	7	--	--	--
276–280	--	--	--	--	4	8	3	--	--	--
281–285	--	--	--	--	--	10	2	--	--	--
286–290	--	--	--	--	2	2	3	2	1	--
291–295	--	--	--	--	1	3	2	--	--	--
296–300	--	--	--	--	--	6	5	2	--	--
301–305	--	--	--	--	--	--	2	--	1	--
306–310	--	--	--	--	--	1	1	--	--	--
311–315	--	--	--	--	--	1	2	1	--	--
316–320	--	--	--	--	--	--	1	--	--	--
321–325	--	--	--	--	--	--	2	--	--	--
326–330	--	--	--	--	--	--	--	--	--	1
331–335	--	--	--	--	--	--	--	--	--	1
336–340	--	--	--	--	--	--	--	--	--	--
341–345	--	--	--	--	--	--	--	--	--	--
346–350	--	--	--	--	--	--	--	--	--	1
Total Number	301	313	103	144	149	83	39	5	2	3
Mean Length	89.9	126.5	171.8	221.3	243.3	268.2	284.1	297.2	296.0	337.0

TABLE 7

Age-length of Female Barred Surfperch

FIGURE 25. A two-ring scale from a barred surfperch captured October 8, 1954, 167 mm. standard length. Note the natal ring. *Photograph by Jack W. Schott.*

FIGURE 25. A two-ring scale from a barred surfperch captured October 8, 1954, 167 mm. standard length. Note the natal ring. Photograph by Jack W. Schott.

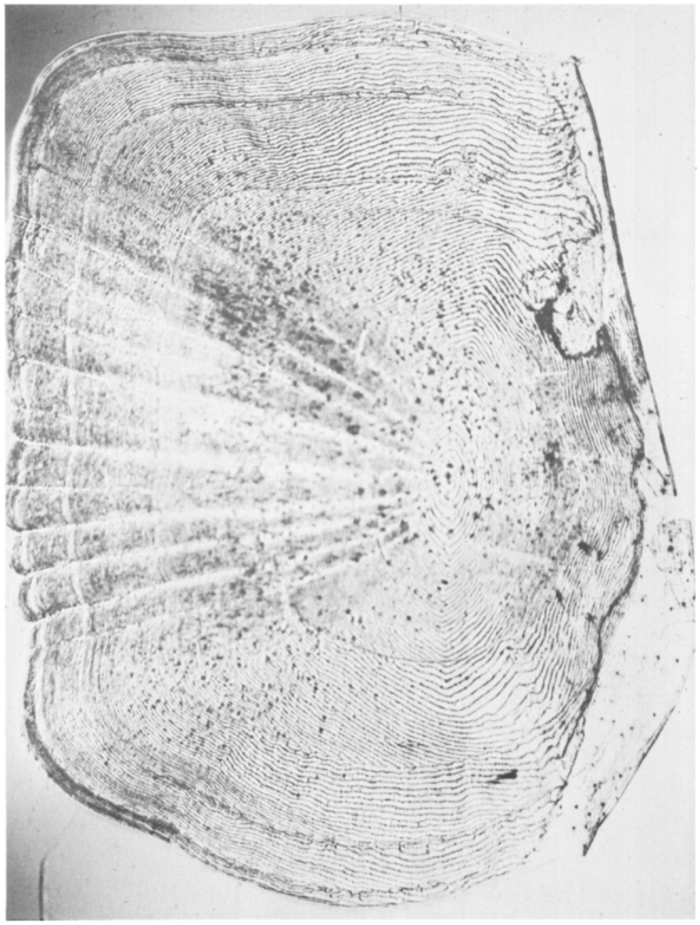

FIGURE 26. A four-ring scale from a barred surfperch captured February 21, 1954, 250 mm. standard length. *Photograph by Jack W. Schott.*

FIGURE 26. A four-ring scale from a barred surfperch captured February 21, 1954, 250 mm. standard length. Photograph by Jack W. Schott.

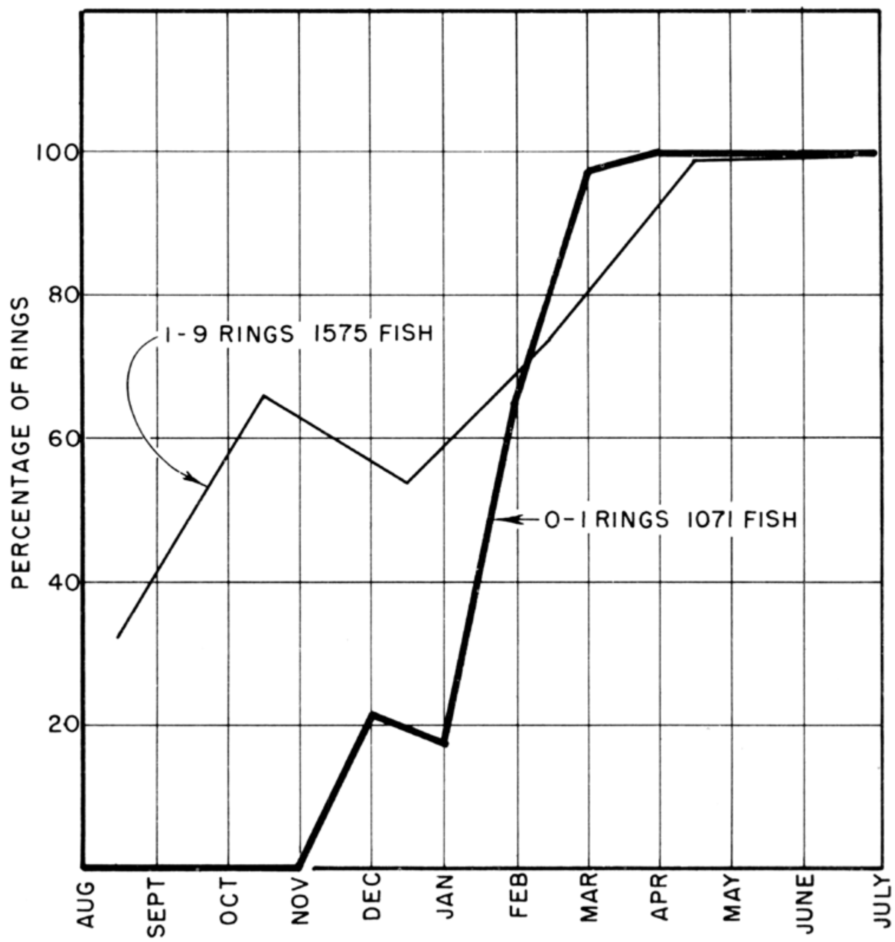

FIGURE 27. The percent of completed winter rings on scale of barred surfperch. The one to nine-ring age group is plotted at the midpoint of each two-month period and the zero to one-ring age group is plotted for each month.

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7.8. Weight-length Relationship

The weight of a fish increases approximately as the cube of the length. This relationship is expressed by $W = kL^a$ where W = weight, L = length, a = constant, and k = constant.

The constants k and a must be empirically calculated for each species. The exponent a can be expected to be three provided the fish grows isometrically and maintains a constant density. For the barred surfperch the calculated value was nearly cubic.

Mean weights were calculated for each 10 mm. interval of standard length (Table 8). A straight line relationship for each sex resulted when these data were plotted on log-log paper, but a slight difference existed between the slopes of the lines.

The weights of the females appear to increase at a slightly greater rate than do the weights of the males. This is demonstrated in the

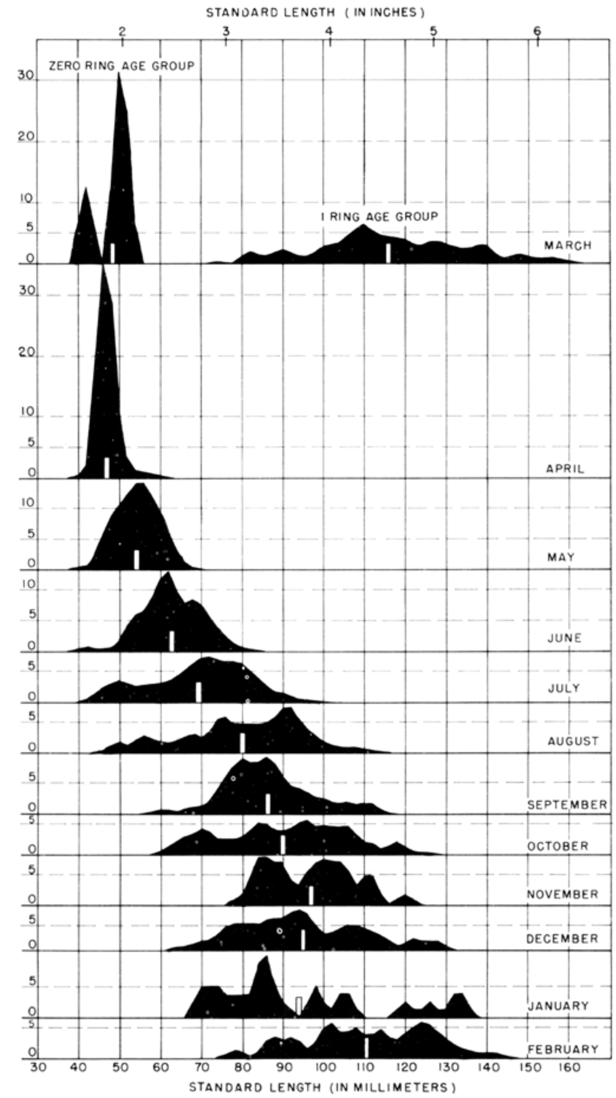

FIGURE 28. Progression of monthly means of free-living age zero barred surfperch. Weighted moving average by threes, plotted by percent. White rectangle is the arithmetic mean.

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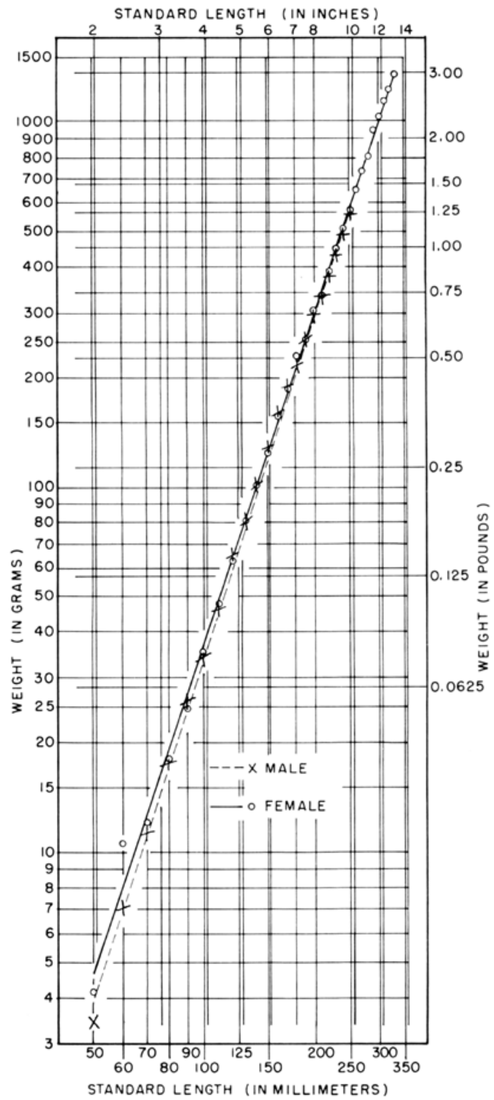

FIGURE 29. Barred surfperch regression of weight on length. Least squares lines fitted to log weight and log length. Mean weights plotted on mean lengths at each ten mm. class interval, 3,407 specimens.

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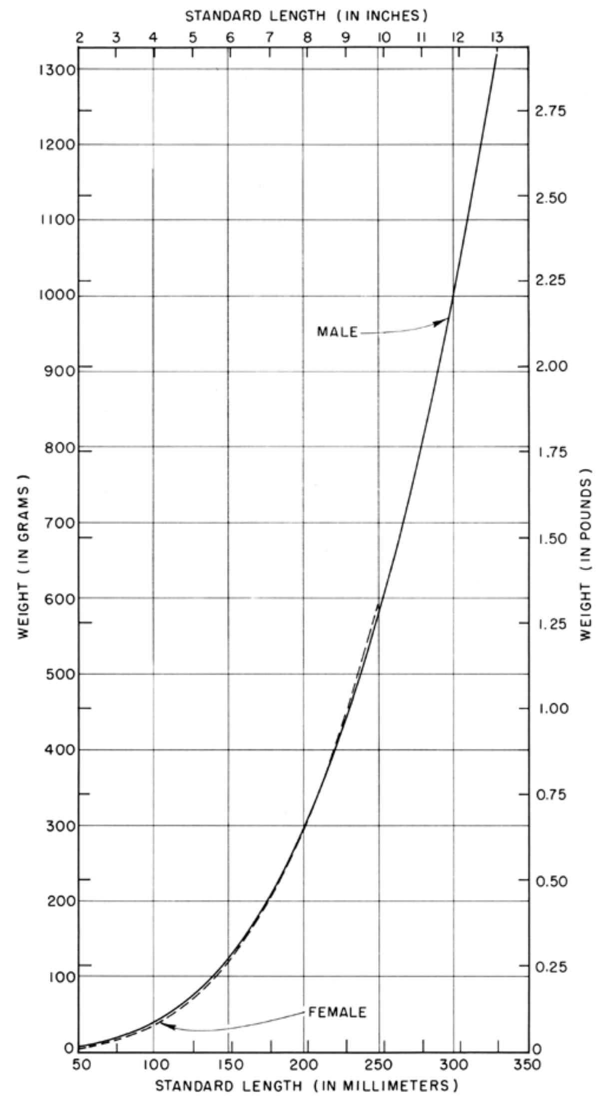


FIGURE 30. Weight-length relationship of male and female barred surfperch.

FIGURE 30. Weight-length relationship of male and female barred surfperch

regressions of log weight on log length calculated by the least squares method (Figure 29). For the males the equation for the straight line regression was $W = .0000214\ L^{3.1025}$, and for the females $W = .0000386\ L^{2.9914}$.

The weight-length curve calculated from the equations above demonstrates the great difference between male and female maximum weight and length (Figure 30).

The largest absolute weight increase occurred in the third year when the females averaged 269 mm. (10½ inches) and the males 208 mm. (8 3/16 inches) in total length (Figure 31).

Irregularities in increment between one age group and the next (Table 9) are probably a result of sporadic sampling, inadequate numbers, variations in spawning or marked differences in growth rates.

7.9. Age-weight and Age-length

Age-weight and age-length curves were calculated by Beverton's modification of the Bertalanffy growth equation (Figures 31 and 32).

Bertalanffy's theory of growth is based upon the significant physiological relationships of rate of anabolism and the rate of catabolism.

Beverton's modification of Bertalanffy's growth equation assumes that $W = kL^3$ exactly, that growth is isometric, and density does not change. The exponent for female barred surfperch weight on length regression is slightly less than three and for males slightly greater than three. However, the mean weights and lengths plotted against their respective ages (Figures 31 and 32) indicate that these data fit the calculated Bertalanffy growth curve with no significant difference.

TABLE 8

Mean Weights at Standard Length, 10 mm. Groupings of Barred Surfperch

Intervals of standard length mm.	Mean weight of ♂ in grams	Mean weight of ♀ in grams	Intervals of standard length mm.	Mean weight of ♂ in grams	Mean weight of ♀ in grams
45- 54	3.43	4.13	205-214	331.23	332.82
55- 64	7.07	10.57	215-224	365.02	385.26
65- 74	11.42	12.08	225-234	431.69	446.26
75- 84	17.79	17.77	235-244	489.66	509.87
85- 94	25.37	24.54	245-254	569.44	568.81
95-104	34.53	35.06	255-264	735.00	650.52
105-114	46.15	47.62	265-274	------	731.89
115-124	64.58	62.32	275-284	------	802.77
125-134	80.83	80.24	285-294	------	942.53
135-144	102.52	101.63	295-304	------	1,031.24
145-154	127.59	124.74	305-314	------	1,133.75
155-164	158.00	156.81	315-324	------	1,221.50
165-174	179.65	185.31	325-334	------	1,330.00
175-184	217.50	229.46	335-344	------	1,710.00
185-194	251.00	251.32	345-354	------	1,450.00
195-204	299.54	290.79			

TABLE 8

Mean Weights at Standard Length, 10 mm. Groupings of Barred Surfperch

The equation for the fitted Bertalanffy growth curve (weight at age) is

$$W_t = W_\infty \left[1 - e^{-K(t - t_o)}\right]^3$$

and for length at age is

$$L_t = L_\infty \left[1 - e^{-K(t - t_o)}\right]$$

FORMULA

In the above equations

$$W_\infty,\ L_\infty,\ t_o \text{ and } K$$

FORMULA

are parameters of the growth equation and *t* equals age in years (Beverton and Holt, in Graham, 1956, and Beverton, 1954).

The older males are not as long and do not weigh as much as females the same age (Figures 31 and 32) although weight at any given length remains approximately the same regardless of sex.

The heaviest fish observed was a pregnant female weighing 4¼ pounds. This fish, captured on hook and line at Ballona Creek, Los Angeles County, on February 1, 1954, was 16# inches in total length.

7.10. Conversion Factor

Most fishery workers use standard length in measuring fish, but total lengths are more easily understood by the layman. Subsequently, a factor for converting standard to total length was calculated with data from 3,407 fish of both sexes. After grouping these fish by two millimeter intervals, mean total lengths were plotted against mean standard lengths. The resulting scatter diagram indicated that two straight lines should be fitted to the data with the dividing point at 180 mm.; therefore two straight line regressions were calculated, one for sizes up to 178 mm. and one for sizes of 180 mm. and longer (Figure 33). For the

TABLE 9

Percent Weight Increase by Age of Scale-aged Barred Surfperch

Number of rings	Average standard length	Average weight grams	Percent weight increase	Percent length increase	Number of fish	Gram increase
♂						
0	85.7	24.1	------	------	338	------
I	128.2	86.0	256.9	49.6	364	61.9
II	156.9	155.8	81.1	22.4	81	69.8
III	208.8	333.5	114.1	33.1	65	177.7
IV	220.9	386.1	15.8	5.8	104	52.6
V	234.6	462.9	19.9	6.2	26	76.8
VI	249.0	579.3	25.1	6.1	6	116.4
					984	
♀						
0	89.9	29.1	------	------	301	------
I	126.5	85.6	194.2	41.0	313	56.5
II	171.8	202.8	136.9	35.8	103	117.2
III	221.3	405.3	99.9	28.8	144	202.5
IV	243.3	542.4	33.8	9.9	149	137.1
V	268.2	732.4	35.0	10.2	83	190.0
VI	284.1	884.9	20.8	5.9	39	152.5
VII	297.2	1,019.0	15.2	4.6	5	134.1
VIII	296.0	1,001.0	—1.8	—0.4	2	------
IX	337	1,496.7	49.5	13.9	3	------
					1,142	

TABLE 9

Percent Weight Increase by Age of Scale-aged Barred Surfperch

size group 42 to 178 mm. the equation was *Y* + .03124 + 1.2906*X*, and for the size group 180 to 350 mm. it was *Y* = 15.007 + 1.2054*X*. In these equations *Y* = total length and *X* = standard length.

A *t*-test on the slopes of the two lines indicated that they were significantly different. A *t*-value of 25.505 with 3,403 degrees of freedom was obtained. The five percent critical value of *t* is 1.96. Consequently, a single straight line cannot be assumed for the size range of the species.

The change in slope is probably a reflection of morphometric changes associated with first maturity.

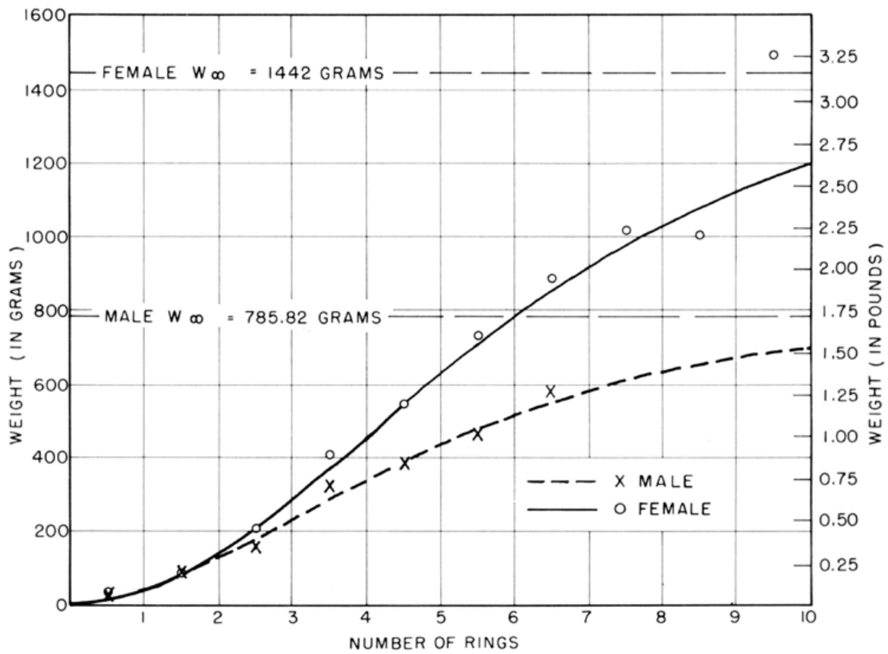


FIGURE 31. Average weight at ages zero to 10 of male (top) and female (bottom) barred surfperch and fitted Bertalanffy curve. Age in years plotted at midpoint of annual growth.

FIGURE 31. Average weight at ages zero to 10 of male (top) and female (bottom) barred surfperch and fitted Bertalanffy curve. Age in years plotted at midpoint of annual growth

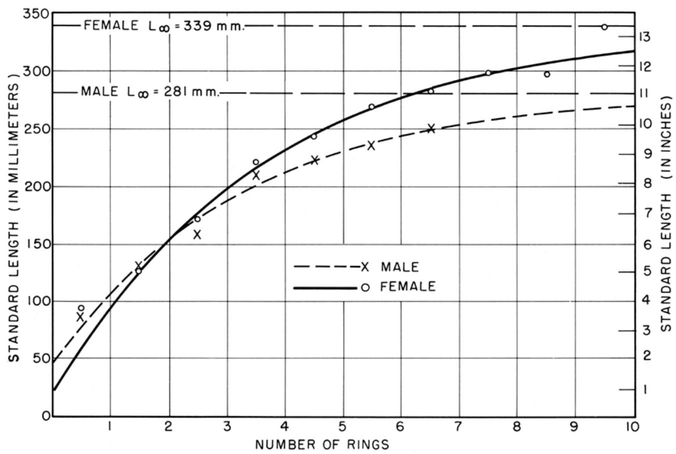


FIGURE 32. Average length at ages zero to ten of male (top) and female (bottom) barred surfperch and fitted Bertalanffy curve. Age in years plotted at midpoint of annual growth.

FIGURE 32. Average length at ages zero to ten of male (top) and female (bottom) barred surfperch and fitted Bertalanffy curve. Age in years plotted at midpoint of annual growth

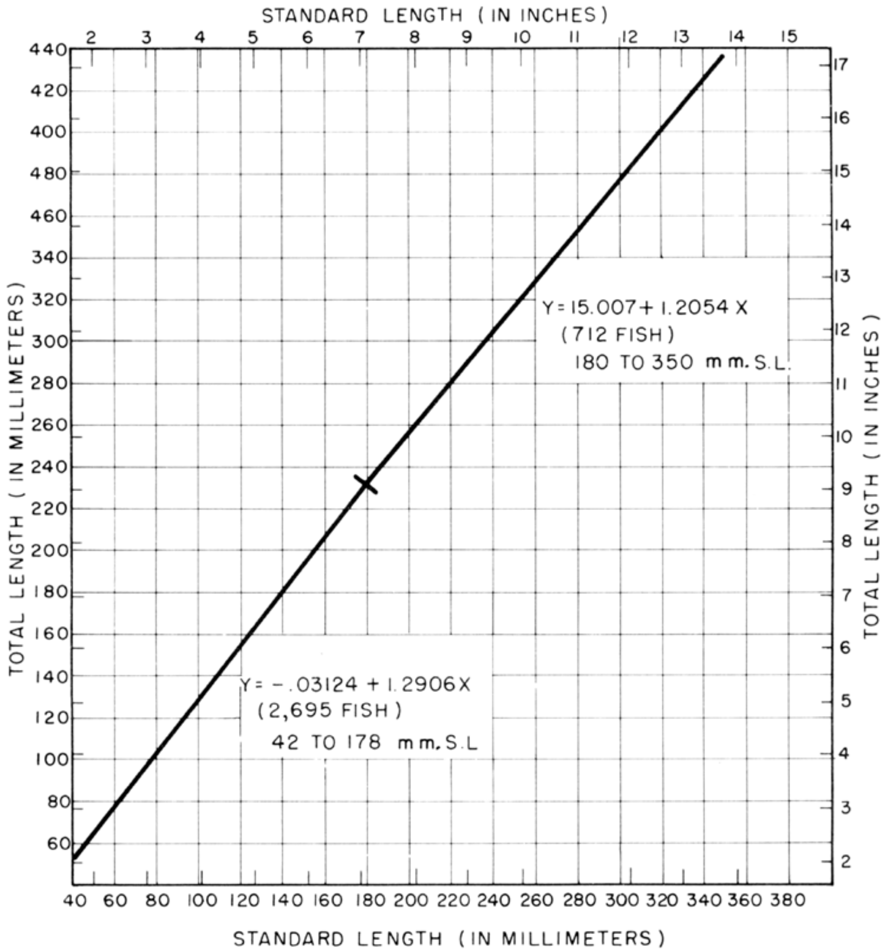


FIGURE 33. Total length-standard length relationship of barred surfperch.

FIGURE 33. Total length-standard length relationship of barred surfperch

8. FOOD HABITS

8.1. Methods

All stomachs used in the food study of the barred surfperch were taken from fish captured by beach seine the year around at Carpinteria, Escondido Beach (near Point Dume), Redondo Beach, Belmont Shore, Emerald Bay (near Laguna Beach), and North Island at San Diego.

No differences were found between content in the various parts of the intestinal tract and the stomach so only stomachs were used. In all, 479 formalin preserved stomachs were examined, from fish ranging from 51 mm. to 293 mm.

The stomachs were opened and the contents identified with the aid of a dissecting microscope. Organisms were separated, identified, and then measured volumetrically by water displacement. A quantity displacing 0.25 ml. or less was recorded as a "trace."

8.2. Food

Three hundred and forty-two, 71.4 percent, of the 479 stomachs examined contained some food, the rest were empty.

Their diet consisted almost entirely of sand crabs. Nearly all of the sand crab remains were the common Emerita analoga (Figure 34; a few were from a less common species, Blepharipoda occidentalis. By occurrence, sand crabs appeared in 90.4 percent of the stomachs containing food, and made up 92.9 percent of the food by volume (Table 10). The greatest quantity in a single stomach measured 27 ml., the average was 2.29 ml. The remaining seven percent of the volume consisted of razor clams (Solen rosaceus), bean clams (Donax gouldii), mussels (Mytilus sp.), crabs (*Cancer* sp.), eggs of grunion (Leuresthes tenuis), and eggs of topsmelt (Atherinops affinis). Polychaetes, amphipods, isopods, juvenile barred surfperch, and unidentified fish remains were also found. Bean clams were important in the diet when locally abundant. Many items appeared in trace amounts.

Organisms other than sand crabs were present in 33, 9.6 percent, of the stomachs containing food.

Among fish that had eaten, the number of stomachs containing sand crabs varied from 64.4 percent at Belmont Shore to 98.8 at Redondo Beach (Table 11).

No whole sand crab was found but the indigestability of the chitinous exoskeleton permitted positive identification. Volumes are obviously smaller than they would have been if the entire body of the sandcrab had been present.

Some common sand crabs, of about the sizes generally eaten by barred surfperch were measured from the head to the base of the curled-under tail. They varied in length from 30 to 45 mm. or about 1¼ to 1¾ inches and displaced from 2 to 11 ml., with a mean of 6. The 27 ml. of parts

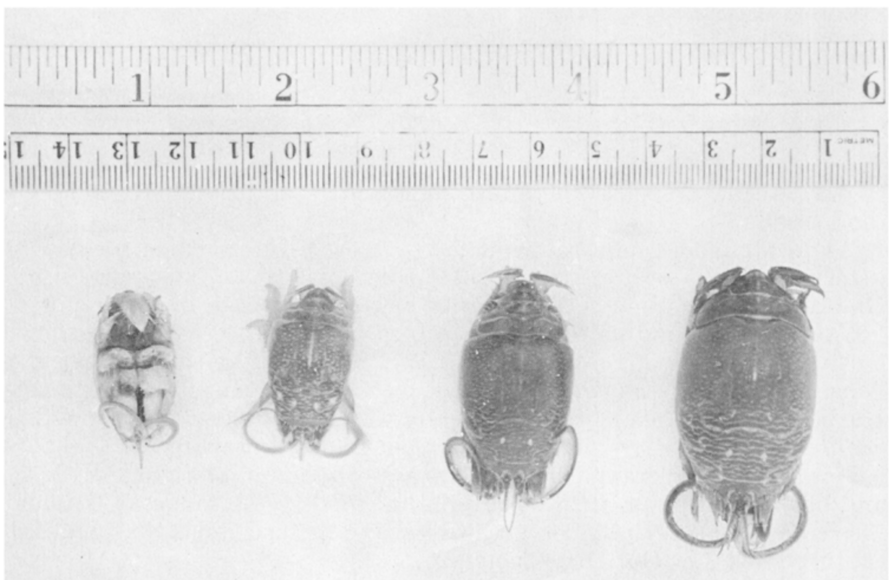


FIGURE 34. The common sand crab, *Emerita analoga. Photograph by Jack W. Schott.*

FIGURE 34. The common sand crab, Emerita analoga. Photograph by Jack W. Schott.

TABLE 10

Occurrence and Volume of Items Found in Stomachs of 371 Barred Surfperch

Food by occurrence			Food by volume		
Type of food	Occurrence	Percent of stomachs	Type of food	Volume in ml.	Percent of food
Sand crabs	309	90.4	Sand crabs	713.30	92.90
Grunion eggs	24	7.0	Unidentified fish	23.00	3.00
True crabs	6	1.8	Razor clams	13.50	1.80
Razor clams	5	1.5	True crabs	5.67	0.70
Clamshells	5	1.5	Grunion eggs	4.50	0.60
Amphipods	5	1.5	Polychaetes	3.00	0.40
Bean clams	4	1.2	Barred surfperch, juv.	3.00	0.40
Unidentified fish	3	0.9	Amphipods	1.00	0.10
Topsmelt eggs	2	0.6	Unidentified seaweed	0.50	0.05
Isopods	2	0.6	Bean clams	0.50	0.05
Unidentified seaweed	2	0.6	Clamshells	Trace	
Barred surfperch, juv.	1	0.3	Topsmelt eggs	Trace	
Sea urchin test	1	0.3	Isopods	Trace	
Polychaetes	1	0.3	Mussels	Trace	
Mussels	1	0.3	Sea urchin test	Trace	
Total	371	----------	Totals	767.97	100.00

TABLE 10

Occurrence and Volume of Items Found in Stomachs of 371 Barred Surfperch

TABLE 11

Percent of Barred Surfperch Feeding on Sand Crabs at Five Southern California Localities

Station	Stomachs containing food	Stomachs containing sand crabs	Percent feeding fish with sand crabs
Carpinteria	33	32	97.0
Escondido	40	34	85.0
Redondo Beach	82	81	98.8
Belmont Shore	59	38	64.4
Emerald Bay (Laguna)	128	124	96.9
Total stomachs	342	309	90.4

TABLE 11

Percent of Barred Surfperch Feeding on Sand Crabs at Five Southern California Localities

found in one stomach therefore represented at least five, inch-long sand crabs.

As in all food studies of wild fishes, there is no positive method of determining the occurrence of soft-bodied, easily digested organisms. One can only mention the possibility of their presence in the diet.

The only outstanding difference in food habits between areas is shown by fish from Belmont Shore (Table 12) Sampling at this locality was done within the breakwater which protects the Los Angeles-Long Beach Harbor. It is an area of relatively calm water, with very little surf. The open beach areas are by contrast continuously washed by light to heavy surf. Sand crabs probably are less abundant at Belmont Shore, and barred surfperch turn more to other foods. Fish taken at Belmont Shore had consumed a much greater variety of food items than had fish captured at other stations (Table 12).

TABLE 12

Food of Barred Surfperch Shown by Station

	Station				
	Carpinteria	Escondido	Redondo Beach	Belmont Shore	Emerald Bay (Laguna)
Empty	29	7	29	50	22
Containing food	33	40	82	59	128
Sand crabs	32	34	81	38	124
True crabs	--	--	--	4	2
Amphipods	--	--	4	1	--
Isopods	--	--	--	--	2
Polychaetes	1	--	--	--	--
Bean clams	--	--	--	2	1
Razor clams	--	--	--	6	--
Mussels	--	--	--	1	--
Clam shell	4	--	--	--	--
Fish remains	--	--	--	1	3
Grunion eggs	--	6	--	18	--
Topsmelt eggs	--	--	--	2	--
Unidentified seaweed	--	--	--	2	--

TABLE 12

Food of Barred Surfperch Shown by Station

Barred surfperch taken offshore by otter trawl had eaten relatively fewer sand crabs, and more fishes, cancer crabs, and razor and other clams than those taken in the surf.

Three of four stomachs from fish trawled off Malibu contained cancer crab parts and one, sand crabs. Thirty-one of 42 fish taken outside the surf off Belmont Shore in water as deep as eight fathoms had eaten some food. Seven stomachs from these 31 fish contained sand crabs; five, cancer crabs; seven, razor clams; six, parts of bivalve shells (unidentifiable); one, unidentified eggs; seven, unidentifiable fish remains; and one, unidentifiable organic matter.

9. CHARACTERISTICS OF THE SPORTSMAN'S CATCH

One of the objectives of this investigation was to obtain information on the characteristics of the southern California surf fishing catch. Southern California surf fishing catch is defined as all fish taken on sandy beaches of the open coast between Point Conception and the Mexican border by fishermen. Characteristics of special importance include species composition, seasonal variation, and the trend of angling success. Prior to the initiation of this project no surf fishing catch data were available.

Although catch data were collected for several species, only data pertaining to barred surfperch are presented here.

9.1. The Catch Record System

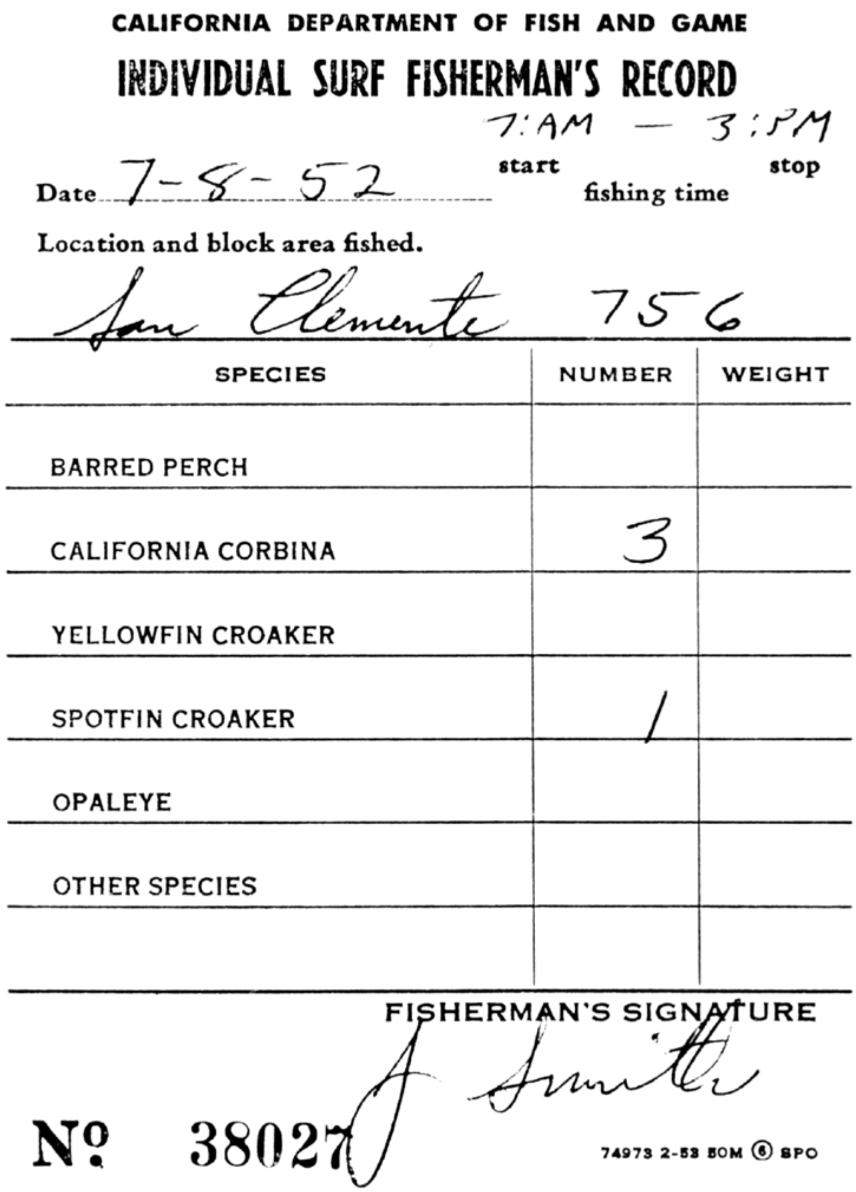
It was decided at the beginning that the only feasible method of collecting catch information within the limits of manpower available would be a system of voluntarily submitted catch records.

Forms for recording the desired information were printed in 25-page booklets (Figure 35) and distributed to surf fishermen through sportsmen's clubs and bait and tackle shops. Fishermen could deposit completed forms at the bait shops or they could mail them directly to the Department of Fish and Game. A chart showing California Fish and Game block areas was printed on the inside cover of the booklets (Figure 36). To stimulate the interest of surf fishermen and to describe the importance of the catch records, talks were given before sportsmen's groups and publicity was obtained from newspapers. Organized sportsmen's groups promised their co-operation.

The catch record system was in operation from January 1, 1952, to September 30, 1956. About 14 percent of the 2,328 records submitted during this period were unusable because of such omissions as time, area, or date fished. Records were also unusable when they indicated that angling had been from piers, breakwaters, rocky shores, or in bays, rather than in the surf.

Records were tabulated separately for each of the four regions into which the total project area had been divided. The boundaries of the regions were:

Region	*Boundaries*	*Nearby Landmarks*	*Descriptive Title*
I	120°30'W-119°00'W	Pt. Conception-Pt. Mugu	Ventura Region
II	119°00'W-118°20'W	Pt. Mugu-White Point	Santa Monica Region
III	118°20'W-117°40'W	White Point-Dana Point	Newport Beach Region
IV	117°40'W-117°08'W	Dana Pt.-Tia Juana River	Oceanside Region



CALIFORNIA DEPARTMENT OF FISH AND GAME

INDIVIDUAL SURF FISHERMAN'S RECORD

Date 7-8-52 — start 7:AM, stop 3:PM fishing time

Location and block area fished.

San Clemente 756

SPECIES	NUMBER	WEIGHT
BARRED PERCH		
CALIFORNIA CORBINA	3	
YELLOWFIN CROAKER		
SPOTFIN CROAKER	1	
OPALEYE		
OTHER SPECIES		

FISHERMAN'S SIGNATURE J Smith

Nº 38027

74973 2-53 50M ⑥ SPO

FIGURE 35. Page from catch record booklet.

FIGURE 35. Page from catch record booklet

The regions were designed so that the coastline of each would be roughly inversely proportional to its estimated surf angling intensity, thus data were adequate for analysis in lightly fished areas.

9.2. The Catch of Contributing Surf Fishermen

9.2.1. Species Composition of the Reported Catch

The percentage contribution of each of the project species, was computed by region. Nonproject species such as opaleye, walleye surfperch, white seaperch, pile perch, black perch, California sargo, jacksmelt, white croaker, and sharks and rays were grouped into the single category "nonproject species" by region. Project species comprised a majority of the reported catch in all regions except Santa Monica where they amounted to only 33 percent. In the Oceanside region project species constituted 95 percent of the reported catch (Table 13).

Barred surfperch was the most frequently caught species in all regions. They contributed a decreasing proportion of the catch of project species from north to south. This proportion ranged from 99.8 percent in the Ventura region to 57.9 percent in the Oceanside region. California corbina was second in numerical importance among project species except in Santa Monica where the spotfin croaker catch was greater.

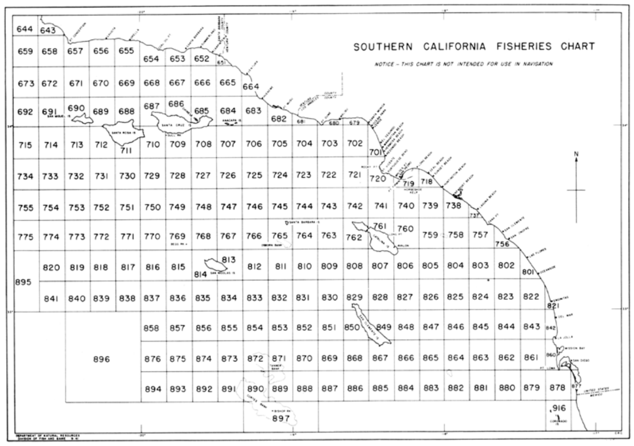


FIGURE 36. Chart showing Fish and Game block areas.

FIGURE 36. Chart showing Fish and Game block areas

TABLE 13

Species Composition of the Reported Surffisherman Catch, January 1, 1952, to September 30, 1956

Region	Barred surfperch		California corbina		Spotfin croaker		Yellowfin croaker		Nonproject species		Totals	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Ventura	466	74.8	1	00.2	0	00.0	0	00.0	156	25.0	623	100.0
Santa Monica	1,252	28.9	4	00.1	175	04.0	1	*00.0	2,905	67.0	4,337	100.0
Newport Beach	252	43.5	46	07.9	37	06.4	34	05.9	210	36.3	579	100.0
Oceanside	561	55.0	256	25.1	110	10.8	42	04.1	51	05.0	1,020	100.0
Totals	2,531	....	307	....	322	....	77	....	3,322	....	6,559	....

* Less than 0.1%.

TABLE 13

Species Composition of the Reported Surffisherman Catch, January 1, 1952, to September 30, 1956

Yellowfin croaker contributed the smallest percentage of the reported catch of project species in all regions. It can be seen that the maintenance of an adequate barred surfperch population is of great importance to the surf fishery.

9.2.2. Seasonal Variation in the Barred Surfperch Catch

To indicate seasonal changes in the catch, bimonthly, four-year catch-per-hour statistics were computed for each region. Each statistic consisted of the reported bimonthly catch between October 1, 1952, and September 30, 1956, divided by the corresponding number of hours fishing effort. Catch-per-hour reached definite peaks during the December–January period in the Oceanside, Newport Beach, and Santa Monica regions. The peak figures were 3.01, 0.99, and 0.56 barred surfperch per hour, respectively (Table 14). The catch-per-hour declined during the spring and summer in these regions, but was supplemented by a catch of other species. In the Ventura region catch-per-hour remained at a relatively high level during the entire year, and barred surfperch provided the bulk of the catch through all seasons.

9.3. Trend of the Barred Surfperch Catch-per-hour

Annual catch-per-hour statistics were computed for each of the four regions so that the trend of fishing success could be followed. These figures represent the reported catch for the year, divided by the number of hours fishing effort. The years represented by these statistics begin on October 1, so that each includes a full fishing season. Because data were not available prior to January 1, 1952, it was necessary to extrapolate in order to produce a statistic for the 1951–52 period. This extrapolated figure was computed by multiplying the catch-per-hour for January 1, to October 1, 1952, by the ratio: mean yearly catch-per-hour, 1952-53 to 1955-56 / mean catch-per-hour, January 1 to October 1, 1953 to 1956

The catch-per-hour data are shown in Table 15. The highest catch-per-hour, 1.91, was reported in the Ventura region during the 1954–55 season. The lowest, 0.14, occurred during the 1952–53 season in the Santa Monica region. For each region it was higher for the 1955–56 season than for the 1951–52 season. In general, the success of the reporting fishermen was upward insofar as numbers of barred surfperch were concerned. One exception was the Oceanside region, where catch-per-hour declined for the two years 1954–55 and 1955–56.

9.4. Evaluation of the Catch Records

9.4.1. Sources of Error

The voluntary system of reporting catches was not ideal from a statistical viewpoint, but it seemed the only usable method of collecting these data. Such a system makes severe demands on the subject matter knowledge of the interpreter of the data. Our greatest concern during the analysis was whether or not an appreciable amount of systematic error was present. This may consist of either error in sampling, error in measurement, or both.

TABLE 14

Bimonthly Barred Surfperch Catch-Per-Hour from Voluntary Catch Records, October 1, 1952 to September 30, 1956

Region		October-November	December-January	February-March	April-May	June-July	August-September
Ventura	No. fish	119	10	303	164	102	34
	No. hours	105.5	12.0	342.5	202.2	92.0	45.5
	Catch/hr.	1.13	0.83	0.88	0.81	1.11	0.75
Santa Monica	No. fish	360	300	198	115	64	35
	No. hours	814.5	536.5	507.8	661.8	522.7	1,283.3
	Catch/hr.	0.44	0.56	0.39	0.17	0.12	0.03
Newport Beach	No. fish	14	78	10	0	6	55
	No. hours	33.0	78.8	63.5	12	68.0	143.8
	Catch/hr.	0.42	0.99	0.16	0.00	0.09	0.38
Oceanside	No. fish	26	104	201	64	61	80
	No. hours	33.5	34.5	231.0	130.5	98.5	292.5
	Catch/hr.	0.78	3.01	0.87	0.49	0.62	0.27

TABLE 14

Bimonthly Barred Surfperch Catch-Per-Hour from Voluntary Catch Records, October 1, 1952 to September 30, 1956

TABLE 15

Barred Surfperch Catch Data from Voluntary Records, Years Begin October 1

	Region				
	Ventura	Santa Monica	Newport Beach	Oceanside	Totals
1951-52					
Catch per hour*	0.36	0.26	0.24	0.39	
1952-53					
Trips	52	543	25	88	708
Hours	234.8	1,821.3	110.0	385.0	2,551.1
Number of fish	90	253	23	125	491
Hours per trip	4.52	3.35	4.40	4.37	
Catch per hour	0.38	0.14	0.21	0.32	
1953-54					
Trips	35	479	23	59	596
Hours	135.0	1,548.0	126.3	225.8	2,035.1
Number of fish	181	542	60	260	1,043
Hours per trip	3.86	3.23	5.49	3.83	
Catch per hour	1.34	0.35	0.48	1.15	
1954-55					
Trips	17	150	23	22	212
Hours	55.0	490.0	105.8	75.8	726.6
Number of fish	105	94	33	79	311
Hours per trip	3.24	3.27	4.60	3.45	
Catch per hour	1.91	0.19	0.31	1.04	
1955-56					
Trips	91	134	15	24	264
Hours	374.9	463.8	57.0	134.0	1,029.7
Number of fish	356	183	47	71	657
Hours per trip	4.12	3.46	3.80	5.58	
Catch per hour	0.95	0.39	0.82	0.53	

* Computed, see text.

TABLE 15

Barred Surfperch Catch Data from Voluntary Records, Years Begin October 1

By systematic error of sampling we refer to sampling a population (sampled population) which does not coincide with the population we wish to measure (target population). In this case target population is defined as the catches from the totality of southern California surf fishing trips made during this study. Error of measurement would have resulted if our correspondents reported inaccurate numerical data or misidentified the species caught. It is likely that sampling error was the more important in this case, because the sampled population contained a larger percentage of catches made by experienced and proficient anglers than did the target population. Anglers may also have neglected to report poor fishing trips. Either type of error would have caused our statistics to be biased and henceforth we will refer only to the net effect of such errors.

9.4.2. The Sample Survey

A plan was devised to detect systematic error in the voluntary catch record data of a single year. This plan involved a sample survey of the surf fishing catch and comparing the results with corresponding data from the voluntary catch records.

The survey was conducted during the year beginning October 1, 1955, and throughout the project area. Four days per month (approximately one day to each region) were required to survey the southern California beaches. The survey was conducted on successive weekdays each month; the first day of each month's survey was randomly selected. Each fisherman observed by the interviewer was asked what hour he started fishing, and note was made of the catch, tackle, and bait used.

The population sampled by the survey may be defined as the catches of the totality of weekday surf fishing trips in progress within the survey area and between 8 a.m. and 8 p.m. This does not coincide with the target population; however, it is believed that differences between the catch-per-hour data of the target population and of the population sampled by the survey were slight. If differences occurred, they were probably of a nature such that the sampled population had a higher catch-per-hour than the target population. This assumption is based on field observations which indicated that a smaller percentage of novices fished on weekdays than on weekends. Consequently, if a test indicates that the catch-per-hour of the population sampled by the voluntary record system exceeded that of the population sampled by the field survey, we can assume that catch-per-hour data from the voluntary records exceeded those of the target population.

9.4.3. Tests for Bias in the Voluntary Catch Records

Paired, barred surfperch catch-per-hour statistics covering at least several months were available for each region. One member of each pair was from the voluntary catch records and the other member was from the sample survey. To compare the two samples a distribution-free test, the Statistical Sign Test (Dixon and Mood, 1946) was used. This test is based on the signs of the differences between paired observations and requires only the assumption of independence of differences between paired observations, a condition believed satisfied.

The hypothesis that the two methods sampled barred surfperch catch-per-hour from the same population was tested against the alternative that the voluntary records sampled from a population of higher catch-per-hour. The hypothesis was tested at a significance level of 0.07. This significance level was chosen after examination of power curves of the test indicated that it offered a reasonable compromise between Type I and Type II errors. It would have been desirable, but was not possible, to increase the sample size and reduce both types of error.

To perform the test, the sample survey catch-per-hour for a given month and region was subtracted from the corresponding voluntary catch-record statistic. The number of negative differences is denoted by the letter r. Twenty-nine pairs of observations were available, of which two were ties. Following the recommendation of Dixon and Mood (*op. cit.*), one tie was treated as a positive difference and the other as a negative difference. The paired observations are shown in Table 16.

Reference to *Tables of the Binomial Probability Distribution* (United States National Bureau of Standards, 1952) showed the rejection region of the test to be r [<] 10. The result of the test was $r = 10$. Consequently, the hypothesis was rejected. We conclude, then, at the seven percent level of significance that the voluntary record estimates of barred surfperch catch-per-hour are positively biased with respect to estimates from the sample survey. It follows that the voluntary records produced upwardly biased estimates of the target population catch-per-hour during the year of the survey.

The individual regions were not tested separately because of small sample sizes. The data (Table 16) showed that in the Oceanside region the number of negative differences exceeded the number of positive differences by only one. The converse was true of the Santa Monica region. These two regions accounted for the rather weak rejection of the null hypothesis.

Positive bias in the voluntary records could be present in three forms. Voluntary-record catch-per-hour statistics might exceed the corresponding target population statistics either by a fixed constant or by a variable, positively or negatively correlated with the target population catch-per-hour. It was not possible to determine the form of the positive bias for catch data that were collected.

To investigate other characteristics of the population sampled by the voluntary catch records, the species composition was compared with the species composition of the sample survey catch. The catch of each region for the year of the survey was classified by species and sampling method. Chi-square was used to test for homogeneity of the two sampled populations with respect to catch composition. Species were grouped when necessary in order that expected values would be greater than four. Chi-square was significant at the 5 percent level for each of the four regions (Table 17). We conclude that the populations sampled by the two methods are not homogeneous in catch composition.

By comparing observed with expected values (Table 17), it was found that the barred surfperch contribution to the sample survey catch was larger than expected, while it formed a smaller than expected proportion of the voluntary-record catch. The converse was true for the nonproject species. This implies that if the voluntary-record barred surfperch catch-per-hour was positively biased, then the catch-per-hour for nonproject species had an even greater positive bias.

TABLE 16

Computations for the Statistical Sign Test

	Voluntary catch records					Sample survey			
Month	Trips	Hours	Number of fish	Catch per hour x	Sign of $x - y$	Catch per hour y	Number of fish	Hours	Trips
Ventura Region									
Oct. '55	3	12.5	3	0.24	+	0.22	4	18.4	7
Nov. '55	1	2.5	10	4.00	+	0.91	40	43.9	20
Dec. '55	--	No data	--	--		0.54	8	14.8	11
Jan. '56	--	No data	--	--		0.11	1	9.5	4
Feb. '56	8	31.7	85	2.68	+	1.04	17	16.3	10
Mar. '56	29	128.5	105	0.82	+	0.24	16	67.6	26
Apr. '56	17	62.7	43	0.69	+	0.43	11	25.6	15
May '56	18	77.0	55	0.71	+	0.00	0	15.7	10
Jun. '56	7	20.0	46	2.30	+	0.32	12	37.4	7
Jul. '56	8	40.0	9	0.22	—	0.52	5	9.7	2
Aug. '56	--	No data	--	--		1.40	12	8.6	3
Sep. '56	--	No data	--	--		2.82	70	24.8	9
Santa Monica Region									
Oct. '55	14	35.5	43	1.21	+	0.33	36	108.7	55
Nov. '55	16	47.5	25	0.53	—	1.17	14	12.0	11
Dec. '55	1	3.5	10	2.86	+	1.00	76	75.9	29
Jan. '56	14	56.0	25	0.45	—	0.91	26	28.7	13
Feb. '56	13	62.1	33	0.53	+	0.10	3	30.8	16
Mar. '56	20	78.0	18	0.23	+	0.21	1	4.8	8
Apr. '56	14	31.0	3	0.10	—	1.00	12	12.0	6
May '56	20	62.2	12	0.19	+	0.14	1	7.3	4
Jun. '56	8	39.0	2	0.05	—	0.36	6	16.5	6
Jul. '56	9	35.5	9	0.25	+	0.16	5	31.7	14
Aug. '56	5	17.0	3	0.18	—	0.64	19	29.5	11
Sep. '56	--	No data	--	--		0.07	1	14.7	8
Newport Beach Region									
Oct. '55	2	6.5	2	0.31	+	0.19	1	5.2	4
Nov. '55	1	4.0	5	1.25	+	0.33	1	3.0	3
Dec. '55	1	6.0	8	1.33	+	0.67	16	23.8	8
Jan. '56	--	No data	--	--		--	No data		
Feb. '56	--	No data	--	--		0.59	23	38.9	17
Mar. '56	--	No data	--	--		0.78	10	12.8	8
Apr. '56	--	No data	--	--		0.60	12	20.1	7
May '56	--	No data	--	--		0.32	8	24.8	7
Jun. '56	2	13.5	0	0.00	—	0.48	9	18.7	7
Jul. '56	--	No data	--	--		0.17	4	23.6	13
Aug. '56	4	16.0	0	0.00	Tie	0.00	0	12.4	11
Sep. '56	5	11.0	32	2.91	+	0.19	5	25.8	11
Oceanside Region									
Oct. '55	--	No data	--	--		0.46	7	15.2	9
Nov. '55	--	No data	--	--		2.69	18	6.7	6
Dec. '55	--	No data	--	--		1.84	18	9.8	4
Jan. '56	--	No data	--	--		--	No data	--	--
Feb. '56	9	51.5	38	0.74	—	1.22	24	19.7	12
Mar. '56	8	59.0	31	0.53	+	0.34	1	2.9	2
Apr. '56	--	No data	--	--		0.81	3	3.7	3
May '56	--	No data	--	--		0.87	2	2.3	3
Jun. '56	2	15.0	0	0.00	Tie	0.00	0	20.6	11
Jul. '56	5	8.5	2	0.23	—	9.24	11	45.2	20
Aug. '56	--	No data	--	--		0.09	3	31.8	11
Sep. '56	--	No data	--	--		1.69	48	28.4	13
Totals	264	1,033.2	657	--	$r = 10$	--	620	1,060.3	495

TABLE 16

Computations for the Statistical Sign Test

TABLE 17

Tests for Homogeneity of Populations Sampled by Two Methods for Species Composition of the Catch

Ventura Region

	Barred surfperch	Nonproject species	Totals
Sample survey	196(169.7)	10(36.3)	206
Voluntary catch records	356(382.3)	108(81.7)	464
Totals	552	118	670

$d.f. = 1 \quad \chi^2 = 33.4$
$\chi^2_{.05(1)} = 3.841$

Santa Monica Region

	Barred surfperch	Nonproject and spotfin croaker	Totals
Sample survey	200(137.8)	152(214.1)	352
Voluntary catch records	183(245.2)	443(380.9)	626
Totals	383	595	978

$d.f. = 1 \quad \chi^2 = 71.9$

Newport Beach Region

	Barred surfperch	California corbina	Nonproject and yellowfin	Totals
Sample survey	89(65.7)	20(9.7)	32(65.7)	141
Voluntary catch records	47(70.3)	0(10.3)	104(70.3)	151
Totals	136	20	136	292

$d.f. = 2 \quad \chi^2 = 70.7$
$\chi^2_{.05(2)} = 5.991$

Oceanside Region

	Barred surfperch	California corbina	Spotfin croaker	Yellowfin croaker	Nonproject species	Totals
Sample survey	135(121.3)	15(27.1)	8(6.5)	3(5.9)	18(18.3)	179
Voluntary catch records	71(84.7)	31(18.9)	3(4.5)	7(4.1)	13(12.7)	125
Totals	206	46	11	10	31	304

$d.f. = 4 \quad \chi^2 = 21.27$
$\chi^2_{.05(4)} = 9.488$

NOTE: Expected values in parentheses.

TABLE 17

Tests for Homogeneity of Populations Sampled by Two Methods for Species Composition of the Catch

The differences in species composition indicate that the population sampled by the voluntary catch records contained many catches from areas other than open, sandy beaches. Catches from rocky shores, bays, and piers have undoubtedly entered the voluntary records despite the attempt to delete them.

9.4.4. Effect of Systematic Error on the Trend in Barred Surfperch Catch-per-hour

Although systematic error appears to be present in the catch-per-hour data, it does not necessarily follow that the trend of fishing success as measured by these data is not valid. If the positive bias remained constant over the several years, the trend would be unchanged. If the positive bias was a variable, positively correlated with the target population catch-per-hour, it would have increased with catch-per-hour. In this case any trend in the target population would be accentuated by the sample data. Neither of these two types of bias could have caused the sample data to exhibit an upward trend when the target population was in a downward trend.

9.5. Discussion and Conclusions

As a method for obtaining estimates of the actual barred surfperch catch-per-hour, voluntary catch records leave much to be desired. However, the data cannot be interpreted as indicating a decline in the trend of catch-per-hour. This interpretation is based on the assumption that over the years that data were collected the positive bias was either a constant, a positively correlated variable, or if a negatively correlated variable, not of enough magnitude to reverse the target population trend. Examination of the catch-per-hour figures for the year of the sample survey shows no indication of the bias being a negatively correlated variable (Table 16).

The species composition of the reported catch shows that barred surfperch make a larger numerical contribution to the catch than any of the three other project species. In fact, they make about as large a contribution as all other species combined. This is not shown in the voluntary-record data because systematic error apparently has caused an underestimation of the proportion of the catch contributed by barred surfperch.

The voluntary records show the peak fishing to be in the December–January period. This is essentially correct although from year to year the peak season may vary by one month.

10. MOVEMENTS

Information regarding the movements of a species of fish is a prerequisite to effective management of that species. Such information should reveal whether the species comprises separate, nonmixing stocks or whether there is a limited or free interchange of fish between different geographic areas. Management practices would differ in the two cases.

10.1. General Information on Tagging and Tag Recoveries

To obtain data on barred surfperch movement, 1,987 fish were tagged at 13 localities between Goleta and San Diego from July 3, 1952, to November 30, 1956. These 13 areas were: Goleta, Carpinteria, Oxnard, Escondido Beach, Malibu, Santa Monica, Redondo Beach, Long Beach, Seal Beach, Sunset Beach, Laguna Beach, Doheny Beach, and North Island, San Diego. of the 1,987 fish, 1,632 were tagged and released in the Long Beach area (Table 18).

More than three-fourths of the fish tagged were captured outside the surf zone in an otter trawl. The remainder, with the exception of one fish taken in a lampara net and a few caught by hook and line, were captured in a beach seine operated from shore. Trawl-caught fish accounted for a majority of the tag releases at Long Beach and for all of the releases at Seal Beach, Sunset Beach, and Oxnard. Fish taken in the otter trawl and with the lampara were tagged and released as far as one mile offshore. All others were released from the beach.

10.2. Tags

Petersen discs, tied with monofilament nylon (Young, *et al.*, 1953), and "spaghetti" tags of polyvinyl chloride tubing with a crimped-on Petersen disc were used. The tubing was No. 20, XTE 30, manufactured by Irvington Varnish and Insulator Company, Irvington, New Jersey.

Monofilament nylon-Petersen disc tags were affixed through the supraoccipital bone on the croakers (Figure 37) and the barred surfperch, while the California corbina was tagged below and slightly posterior to the insertion of the first dorsal fin.

"Spaghetti" tags were placed at the posterior end of the second dorsal fin on all four project species (Figure 38). The Petersen disc

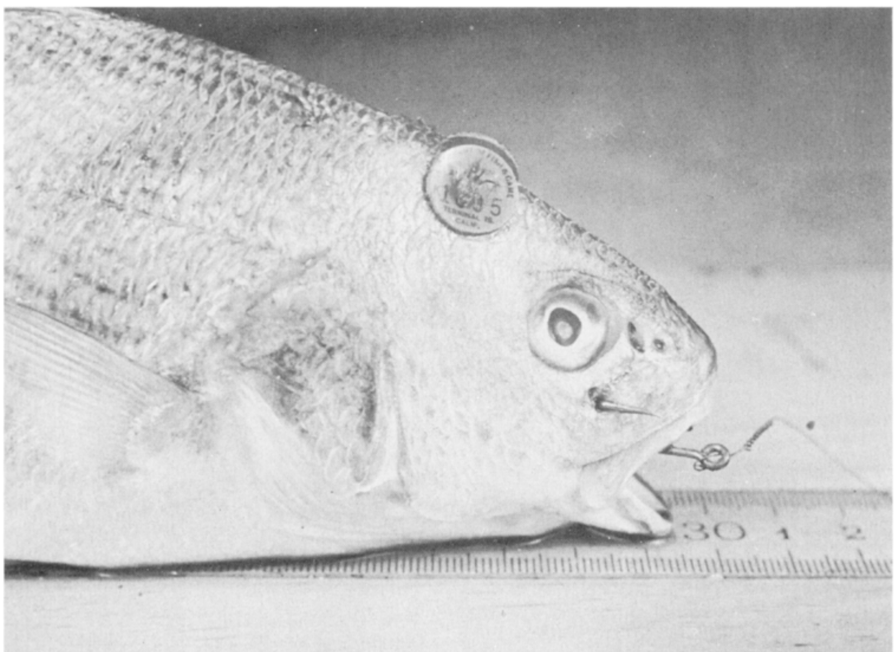


FIGURE 37. Petersen disc head tag, on yellowfin croaker recovery. *Photograph by Frederick B. Hagerman.*

FIGURE 37. Petersen disc head tag, on yellowfin croaker recovery. Photograph by Frederick B. Hagerman.

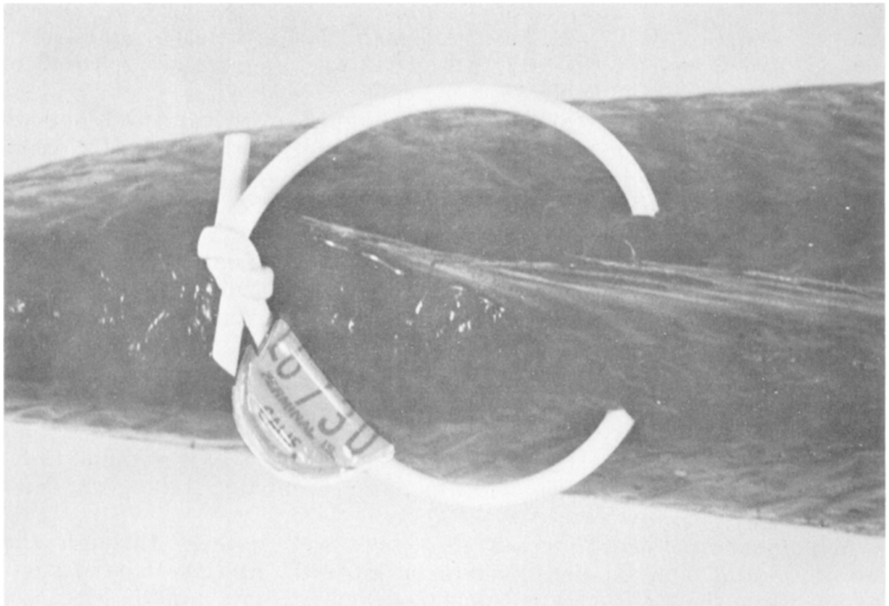


FIGURE 38. "Spaghetti" tag with crimped-on Petersen disc, on California corbina. *Photograph by Jack W. Schott.*

FIGURE 38. "Spaghetti" tag with crimped-on Petersen disc, on California corbina. Photograph by Jack W. Schott.

was heated in boiling water and bent so that it fit snugly around the 11-inch lengths of vinyl tubing or "spaghetti." This tag could be attached much more rapidly than the nylon attached Petersen discs. Both tags sometimes caused soreness around the wounds, and the tubing tag had the added disadvantage of collecting hydroids especially on the attached disc. The hydroids caused wear and soreness on the caudal peduncle and upper lobe of the caudal fin. This was particularly true of the barred surfperch.

The Petersen disc-nylon tag was retained by a spotfin croaker as long as three years in an aquarium. The "spaghetti" tag was retained for five months in an aquarium by barred surfperch. After this time predation by other fishes had killed off all fish used in the experiment. In analyzing the data, releases for a given area have been combined regardless of the type of tag used or the method of capture. It is assumed that this method of handling the data does not affect the nonquantitative characteristics of movement.

Included are data on tags recovered through March 1957. Two hundred and nine of the 1,987 tagged fish were recovered at least once. either with the sampling gear, commercial gear, or by surf fishermen. of the 91 which we recaptured in our sampling gear, 90 were rereleased. Seven of these eventually were recaught by anglers. In all, 124 tagged fish were taken by surf fishermen. A single tagged fish was recaptured in a commercial lampara net.

10.3. Direction of Movement

Only tagged fish recaptured more than one mile from the release point were considered to have moved out of the tagging area. A tabulation was made of the number recovered by fishermen upcoast (generally northwest) and downcoast (generally southeast) from the tagging area (Table 18). The shortest water distance between the point of release and point of recovery was measured in nautical miles. This resulted in a minimum estimate of the distance a tagged fish had actually traveled.

Tag recoveries indicated movement from only three of the release areas: Escondido Beach, Sunset Beach, and Long Beach. of three fish recovered from the Escondido Beach releases, one was caught three miles downcoast and the other two were retaken in the tagging area (Figure 39). of three recoveries made from the Sunset Beach releases, two had traveled upcoast three miles and five miles respectively, and one was captured five miles downcoast. Fishermen recovered 98 of the tagged barred surfperch released in the Long Beach area: 56 within the tagging area, 41 downcoast, and one upcoast. Long Beach releases were recovered as far as 15 miles downcoast at Newport Beach. The single upcoast recovery was made at Santa Monica, 31 miles from the point of release.

Quantitative characteristics of movements cannot be properly described due to inadequate data on surf fishing intensities along the coast. For example, if sampling gear recoveries were added to angler recoveries, the number of tagged fish taken at the Long Beach area would increase from 56 to 139, while the number of recaptures outside the tagging area would remain the same. This results from the extra fishing intensity generated by the sampling gear. It can be seen that estimates of the relative numbers of fish moving in different directions cannot be made from tag returns unless fishing intensity information is available with which to adjust the data.

While accurate estimates of surf fishing intensities are not available, the survey of the southern California surf fishery made monthly from October 1955 to September 1956, indicated that fishing intensity in the Long Beach area was lower than in downcoast areas. Consequently, recoveries by anglers in the Long Beach area, as a percentage of all angler recoveries, probably underestimate the number of tagged fish that remained in the area.

It should be noted that the Long Beach tagging area is downcoast from both an adjacent industrial harbor and a rocky coastline, neither of which is considered typical barred surfperch habitat. This may account for the lack of recoveries on beaches to the north of Long Beach.

10.4. Time at Liberty and Distance from Long Beach to Points of Recovery

To determine the relationship that exists between the release-to-recovery time interval and the distance between points of release and recovery, time and distance data were plotted for each fish tagged in the Long Beach area and recaptured by hook and line (Figure 40). The time interval used included the day of release and of recapture.

TABLE 18

Release and Recovery Data for 1,987 Tagged Barred Surfperch

RELEASE							RECAPTURE									
Place of release	Date Yr.	Date Mo.	Date Day	Method of capture	Tag type	No. released	No. recaptured	Date Yr.	Date Mo.	Date Day	No. of fish	Place of recapture	Movement* Miles	Movement* Direction	Recapture gear	Days out
Goleta	53	7	28	Beach seine	Petersen disc	7	2	53	11	16	1	Goleta	0	....	Hook & line	112
								53	11	18	1	do.	0	....	do.	114
Carpinteria	52	8	8	Beach seine	Petersen disc	17	2	52	8	8	1	Carpinteria	0	....	Hook & line	16
								53	1	25	1	do.	0	....	do.	171
	53	9	23	do.	do.	2	0									
	53	12	16	do.	do.	6	1	54	1	10	1	do.	0	....	do.	26
	54	3	9	do.	do.	6	1	54	3	21	1	do.	0	....	do.	13
Oxnard	56	11	27	Trawl	Tubing	58	2	56	12	16	2	Oxnard	0	....	Hook & line	20
	56	11	28	do.	do.	46	1	56	12	2	1	do.	0	....	do.	5
Escondido Beach	52	7	9	Beach seine	Petersen disc	3	2	52	11	23	1	Escondido Beach	0	....	Hook & line	138
								52	12	9	1	do.	0	....	do.	154
	53	12	8	do.	do.	6	1	53	10	5	1	Malibu Beach	3	Down	do.	55
Malibu Beach	52	7	9	Beach seine	Petersen disc	18	0									
Santa Monica	56	2	8	Beach seine	Tubing	15	0									
	56	5	24	Trawl	do.	5	0									
Redondo Beach	55	8	15	Beach seine	Petersen disc	3	1	55	9	22	1	Redondo Beach	0	....	Hook & line	39
	55	9	14	do.	do.	8	3	55	11	2	1	do.	0	....	do.	50
								55	11	4	1	do.	0	....	do.	52
								55	11	12	1	do.	0	....	do.	60
	56	4	8	Hook & line	Tubing	7	1	56	5	24	1	do.	0	....	do.	47
Long Beach	53	6	28	Beach seine	Petersen disc	8	0									
	53	8	11	do.	do.	2	1	53	11	10	1	Long Beach	0	....	Beach seine	92

TABLE 18

Release and Recovery Data for 1,987 Tagged Barred Surfperch

53	11	10	do.	do.	3	1	54	1	14	1	do.	0		do.	66
54	1	14	do.	do.	8	1	54	2	22	1	do.	0		Hook & line	40
55	5	19	do.	do.	2	1	55	11	27	1	Newport Beach	11	Down	do.	193
55	6	23	do.	do.	16	2	55	6	28	1	Sunset Beach	4	Down	do.	6
							55	7	5	1	do.	4	Down	do.	13
55	6	29	Beach seine	Petersen disc	16	1	55	7	7	1	Surfside	3½	Down	do.	9
55	7	6	do.	do.	2	0									
55	7	28	do.	do.	1	0									
55	8	9	do.	do.	4	1	55	9	2	1	Long Beach	0		do.	25
55	8	23	do.	do.	1	0									
55	9	22	do.	do.	5	1	55	10	26	1	do.	0		do.	35
55	9	29	do.	do.	16	2	56	1	22	1	do.	0		do.	116
							56	5	27	1	Seal Beach	2	Down	do.	242
55	10	14	do.	do.	16	2	55	11	1	1	Long Beach	0		Beach seine	19
							56	5	18	1	do.	0		Hook & line	[1]218
55	10	19	Beach seine	Double tagged[2]	5	0									
55	10	26	do.	Petersen disc	4	1	56	1	2	1	Long Beach	0		Hook & line	69
55	10	28	do.	do.	12	0									
55	11	1	do.	do.	15	1	56	11	1	1	do.	0		Beach seine	67
55	11	9	do.	do.	10	0									
55	11	9	do.	Tubing	15	1	55	12	10	1	do.	0		Hook & line	32
55	11	16	do.	do.	9	1	56	2	18	1	do.	0		do.	[3]95
55	11	23	do.	do.	23	0									
55	11	29	Lampara	do.	1	0									
55	12	14	Beach seine	do.	16	1	55	12	23	1	Long Beach	0		Hock & line	10
56	1	6	do.	do.	21	2	56	2	2	1	do.	0		Beach seine	28
							56	3	11	1	Bolsa Chica	7	Down	Hook & line	66
56	1	18	do.	do.	12	0									
56	2	2	do.	do.	9	0									
56	3	19	Trawl	do.	17	1	56	4	30	1	Long Beach	0		Trawl	43
56	3	20	do.	do.	35	2	56	3	26	1	do.	0		do.	7
							56	4	6	1	do.	0		do.	18
56	3	21	do.	do.	16	5	56	3	28	1	do.	0		do.	8
							56	3	31	1	do.	0		Hook & line	11
							56	4	4	1	do.	0		Trawl	15
							54	4	28	1	do.	0		Hook & line	39
							56	6	4	1	do.	0		do.	76
56	3	26	Trawl	Tubing	14	2	56	4	4	1	do.	0		Trawl	10
							56	6	26	1	do.	0		Hook & line	93
56	3	27	Trawl	Tubing	4	0									
56	3	28	do.	do.	20	3	56	4	4	1	Long Beach	0		Trawl	8
							56	4	5	1	do.	0		do.	9
							56	5	22	1	do.	0		Hook & line	[4]48

TABLE 18—Cont'd.

TABLE 18—Continued

Release and Recovery Data for 1,987 Tagged Barred Surfperch

RELEASE								RECAPTURE								
Place of release	Date Yr.	Date Mo.	Date Day	Method of capture	Tag type	No. re-leased	No. recap-tured	Date Yr.	Date Mo.	Date Day	No. of fish	Place of recapture	Movement* Miles	Movement* Direction	Recapture gear	Days out
Long Beach—Continued	56	3	29	do.	do.	1	0									
	56	3	30	do.	do.	1	0									
	56	4	3	do.	do.	29	3	56	4	20	1	do.	0		Trawl	18
								56	5	24	1	Newport Beach	15	Down	Hook & line	52
								56	5	26	1	Long Beach	0		do.	54
	56	4	4	Trawl	Tubing	19	2	56	4	21	1	Huntington Beach	9½	Down	do.	18
								56	6	3	1	Newport Beach	13	Down	do.	61
	56	4	5	do.	do.	39	6	56	4	7	1	Long Beach	0		do.	3
								56	4	12	1	do.	0		Trawl	8
								56	4	17	1	do.	0		do.	13
								56	4	18	1	do.	0		do.	14
								56	5	22	1	Santa Monica	31	Up	Hook & line	48
								56	5	23	1	Seal Beach	2	Down	do.	49
	56	4	6	Trawl	Tubing	23	2	56	5	30	1	Long Beach	0		do.	55
								56	6	16	1	do.	0		do.	72
	56	4	9	Trawl	Tubing	6	0									
	56	4	10	do.	do.	3	0									
	56	4	11	do.	do.	1	0									
	56	4	12	do.	do.	3	0									
	56	4	17	do.	do.	28	0									
	54	4	18	do.	do.	6	0									
	56	4	19	do.	do.	9	1	56	4	21	1	Sunset Beach	5	Down	Hook & line	3
	56	4	20	do.	do.	10	0									
	56	4	23	do.	do.	3	0									
	56	4	30	do.	do.	11	3	56	5	14	1	Bolsa Chica	6	Down	Hook & line	15
								56	5	23	1	do.	6	Down	do.	24
								56	6	5	1	Seal Beach	3½	Down	do.	37
	56	7	10	Beach seine	Tubing	3	0									
	56	7	10	do.	do.	9	1	56	7	28	1	Long Beach	0		do.	11

TABLE 18—Cont'd.

56	8	1	do.	do.	18	3	56	8	12	1	do.	0	....	do.	12
							56	9	2	1	do.	0	....	do.	33
							56	9	9	1	do.	0	....	do.	40
56	8	2	Beach seine	Tubing	19	0									
56	8	8	do.	do.	17	0									
56	8	15	do.	do.	1	0									
56	8	22	do.	do.	2	0									
56	9	5	do.	do.	9	0									
56	11	2	Trawl	do.	13	5	56	11	9	1	Long Beach	0	....	Trawl	8
							56	11	23	1	do.	0	....	do.	22
							57	1	17	1	do.	0	....	Hook & line	[5]77
							57	1	28	1	do.	0	....	Trawl	88
							57	1	28	1	Seal Beach	1½	Down	Hook & line	88
56	11	8	Trawl	Tubing	37	8	56	11	9	2	Long Beach	0	....	Trawl	2
							56	11	14	1	do.	0	....	do.	7
							56	11	15	1	do.	0	....	do.	8
							56	11	16	1	do.	0	....	do.	9
							56	11	19	1	do.	0	....	do.	12
							56	12	21	1	do.	0	....	Hook & line	44
							57	2	19	1	do.	0	....	do.	[6]104
56	11	9	Trawl	Tubing	34	11	56	11	15	1	do.	0	....	Trawl	7
							56	11	16	1	do.	0	....	do.	8
							56	11	19	3	do.	0	....	do.	[7]11
							56	11	23	2	do.	0	....	do.	[8]15
							56	11	26	1	do.	0	....	do.	18
							56	11	29	1	Seal Beach	1½	Down	Hook & line	21
							56	12	27	1	do.	1½	Down	do.	49
							57	3	22	1	Long Beach	0	....	Trawl	134
56	11	14	Trawl	Tubing	71	9	56	11	15	1	Long Beach	0	....	Trawl	2
							56	11	19	3	do.	0	....	do.	6
							56	11	21	1	do.	0	....	do.	8
							56	11	23	1	do.	0	....	do.	10
							56	11	26	1	do.	0	....	do.	13
							56	11	30	1	Seal Beach	1½	Down	Hook & line	17
							57	1	12	1	Newport Beach	14	Down	do.	60
56	11	15	Trawl	Tubing	61	10	56	11	19	1	Long Beach	0	....	Trawl	5
							56	11	21	2	do.	0	....	do.	7
							56	12	2	1	Seal Beach	1½	Down	Hook & line	18
							56	12	21	1	Long Beach	0	....	do.	37
							57	1	5	1	Seal Beach	1½	Down	do.	52
							57	2	6	1	Long Beach	0	....	Trawl	[9]80
							57	2	18	1	do.	0	....	Hook & line	96
							57	3	11	1	do.	0	....	do.	117
							57	3	17	1	do.	0	....	do.	[10]123

TABLE 18—Cont'd.

TABLE 18—Continued

Release and Recovery Data for 1,987 Tagged Barred Surfperch

RELEASE								RECAPTURE								
	Date							Date					Movement*			
Place of release	Yr.	Mo.	Day	Method of capture	Tag type	No. re-leased	No. recap-tured	Yr.	Mo.	Day	No. of fish	Place of recapture	Miles	Direction	Recapture gear	Days out
Long Beach—Continued	56	11	16	Trawl	Tubing	71	13	56	11	19	1	do.	0		Trawl	4
								56	11	20	1	Seal Beach	1½	Down	Hook & line	5
								56	11	21	1	Long Beach	0		Trawl	6
								56	11	23	5	do.	0		do.	8
								56	11	26	1	do.	0		do.	11
								56	12	7	1	Seal Beach	1½	Down	Hook & line	22
								56	12	16	1	Long Beach	0		do.	31
								56	12	21	1	do.	0		do.	36
								57	1	31	1	do.	0		Trawl	77
	56	11	19	Trawl	Tubing	86	18	56	11	20	2	do.	0		do.	2
								56	11	21	4	do.	0		do.	3
								56	11	23	3	do.	0		do.	5
								56	11	28	1	Seal Beach	1½	Down	Lampara	10
								56	12	7	1	do.	1½	Down	Hook & line	19
								56	12	27	1	Long Beach	0		do.	39
								57	1	3	1	do.	0		do.	46
								57	1	12	1	Newport Beach	14	Down	do.	55
								57	1	28	1	Long Beach	0		Trawl	71
								57	2	14	1	do.	0		Hook & line	88
								57	2	25	1	do.	0		do.	99
								57	3	8	1	Seal Beach	1½	Down	do.	110
	56	11	20	Trawl	Tubing	7	0									
	56	11	21	do.	do.	106	17	56	11	23	6	Long Beach	0		Trawl	3
								56	11	26	3	do.	0		do.	6
								56	12	7	1	Seal Beach	1½	Down	Hook & line	17
								56	12	11	1	do.	1½	Down	do.	21
								56	12	27	1	Long Beach	0		do.	37
								57	1	12	1	Bolsa Chica	6	Down	do.	53
								57	1	17	1	Long Beach	0		do.	58

TABLE 18—Cont'd.

								57	1	21	1	Seal Beach	1½	Down	Hook & line	162
								57	1	26	1	do.	1½	Down	do.	67
								57	2	12	1	do.	1½	Down	do.	84
	56	11	23	Trawl	Tubing	92	8	56	11	28	1	Long Beach	0	....	do.	6
								56	12	21	1	do.	0	....	do.	29
								57	1	10	1	do.	0	....	do.	80
								57	1	12	1	Newport Beach	14	Down	do.	51
								57	1	12	1	Seal Beach	1½	Down	do.	51
								57	1	17	1	Long Beach	0	....	do.	56
								57	1	28	2	do.	0	....	Trawl	67
	56	11	26	Trawl	Tubing	25	2	57	1	28	2	do.	0	....	do.	64
	56	11	29	do.	do.	183	16	56	12	1	1	Seal Beach	1½	Down	Hook & line	3
								56	12	9	1	Long Beach	0	....	do.	11
								56	12	11	1	do.	0	....	do.	13
								56	12	18	1	Seal Beach	1½	Down	do.	20
								56	12	27	2	Long Beach	0	....	do.	29
								57	1	4	1	do.	0	....	do.	37
								57	1	12	1	Newport Beach	14	Down	do.	45
								57	1	28	1	Long Beach	0	....	Trawl	61
								57	1	28	1	Seal Beach	1½	Down	Hook & line	61
								57	2	17	1	Surfside	2½	Down	do.	81
								57	2	25	2	Long Beach	0	....	do.	89
								57	3	13	1	Seal Beach	1½	Down	do.	105
								57	3	20	1	Long Beach	0	....	Trawl	112
								57	3	25	1	do.	0	....	do.	117
	56	11	30	Trawl	Tubing	218	10	56	12	15	1	do.	0	....	Hook & line	16
								56	12	27	1	do.	0	....	do.	28
								56	12	30	1	do.	0	....	do.	31
								57	1	20	1	do.	0	....	do.	52
								57	1	25	1	do.	0	....	do.	57
								57	1	28	1	do.	0	....	Trawl	60
								57	2	6	1	do.	0	....	do.	65
								57	2	21	3	do.	0	....	Hook & line	84
Seal Beach	56	3	22	Trawl	Tubing	10	0									
	56	6	21	do.	do.	2	0									
	56	11	9	do.	do.	20	7	56	11	14	1	Seal Beach	0	....	Hook & line	6
								56	11	22	1	do.	0	....	do.	14
								56	12	2	1	do.	0	....	do.	24
								56	12	30	1	do.	0	....	do.	52
								57	3	22	2	do.	0	....	do.	134
								57	3	25	1	do.	0	....	do.	137

TABLE 18—Cont'd.

TABLE 18—Continued

Release and Recovery Data for 1,987 Tagged Barred Surfperch

RELEASE								RECAPTURE								
Place of release	Date Yr.	Date Mo.	Date Day	Method of capture	Tag type	No. re-leased	No. recap-tured	Date Yr.	Date Mo.	Date Day	No. of fish	Place of recapture	Movement* Miles	Movement* Direction	Recapture gear	Days out
Sunset Beach	56	3	23	Trawl	Tubing	3	0									
	56	3	29	do.	do.	4	0									
	56	3	30	do.	do.	5	0									
	56	4	2	do.	do.	11	1	56	4	17	1	Long Beach	5	Up	Trawl	16
	56	4	18	do.	do.	2	0									
	56	4	24	do.	do.	47	2	56	5	20	1	Huntington Beach	5	Down	Hook & line	27
								56	5	28	1	Seal Beach	2½	Up	do.	35
	56	4	27	do.	do.	9	0									
	56	11	7	do.	do.	4	0									
Laguna Beach	54	24	2	Beach seine	Petersen disc	11	0									
North Island	53	7	14	Beach seine	Petersen disc	9	0									
	54	1	7	do.	do.	8	1	54	1	17	1	Coronado Beach	0	....	Hook & line	11

* The distance moved is shown only where it exceeded one mile. Up refers to upcoast movement and down to downcoast movement.
[1] Previously recaptured by beach seine on November 9, 1955, at Long Beach.
[2] Experimentally double tagged with tubing tags and with nylon-attached Petersen discs.
[3] Previously recaptured by beach seine on February 2, 1956, at Long Beach.
[4] Previously recaptured by trawl on April 5, 1956, at Long Beach.
[5] Previously recaptured by trawl on November 19, 1956, at Long Beach.
[6] Previously recaptured by trawl on November 26, 1956, at Long Beach.
[7] One specimen previously recaptured by trawl on November 14, 1956, at Long Beach.
[8] One specimen previously recaptured twice by trawl at Long Beach. The dates were November 14, 1956, and November 21, 1956.
[9] Previously recaptured by trawl on January 28, 1957, at Long Beach.
[10] Previously recaptured by trawl on November 16, 1956, and on January 28, 1957, both times at Long Beach.
[11] Previously recaptured by trawl on November 26, 1956, at Long Beach.

TABLE 18—Cont'd.

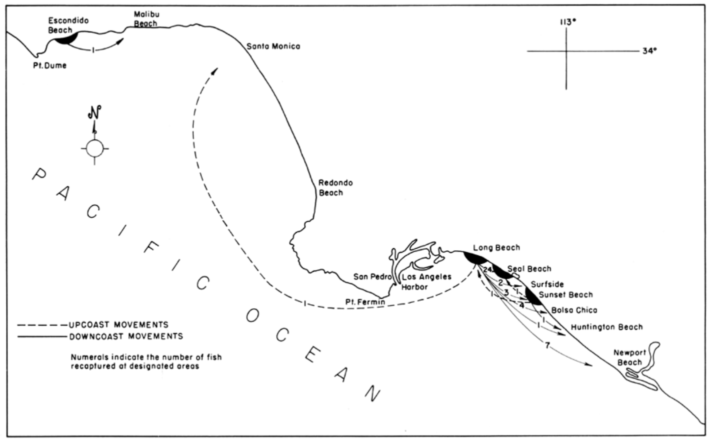


FIGURE 39. Movements of tagged barred surfperch based on tag recoveries.

FIGURE 39. Movements of tagged barred surfperch based on tag recoveries

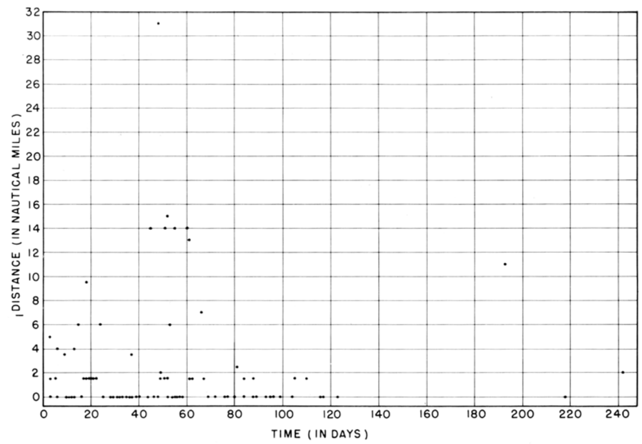


FIGURE 40. Distance moved and days at liberty for Long Beach tag releases. Angler recaptures only.

FIGURE 40. Distance moved and days at liberty for Long Beach tag releases. Angler recaptures only

The tagging area produced the majority of recaptures even after several months had elapsed. Moderate numbers of tagged fish were also recaptured in the Seal Beach area, one and one-half to three and one-half miles from the release point, for several months after tagging. The longest indicated movement, 31 miles, was made by a fish recaptured at Santa Monica 48 days after its release. Seven tagged fish were recaptured in the Newport Beach area, 11 to 15 miles from point of release. Release-to-recovery time intervals for these fish varied from 45 to 193 days. Four of the Newport Beach recoveries were caught on January 12, 1957, by a single fishing party. These fish had been released at Long Beach during a two-week period in the latter part of November 1956. The longest time at liberty for a barred surfperch was 242 days. This fish was recaptured in the Seal Beach area two miles from the point of release at Belmont Shore.

Distances between points of release and points of recapture did not appear to be related functionally to the time intervals over which the tagged fish were at liberty. Many barred surfperch seemed to remain in the tagging area throughout the period during which tags were recovered. However, some movement out of the area was definitely demonstrated. The four fish recaptured on a single day at Newport Beach suggested group emigration from the Long Beach area. There was, however, no indication that fish which left the tagging area followed a regular migratory pattern.

Almost 42 percent of the 98 tag recoveries made by anglers were taken more than one mile from the Long Beach release point. Most of these recoveries were made within 70 days (Figure 40). This degree of movement, if it occurred throughout the range of the species, would result in considerable mixing over an extended period of time. However, the information that is available on fishing intensities indicates that the amount of movement out of the tagging area was overestimated by the tag recovery data.

11. SUMMARY AND CONCLUSIONS

11.1. Beach Seining

Seventy-one different species of fish totaling 128,000 individuals were taken by beach seining.

Barred surfperch appeared in over 80 percent of all beach seine hauls, while California corbina, California halibut, and walleye surfperch appeared in more than half.

Barred surfperch made up 73.1, California corbina 17.6, spotfin croaker 7.9, and yellowfin croaker 1.4 percent of the catch of the four project species. Catch-per-haul of these four was 23.2, 5.6, 2.5, and 0.4 fish.

Abundance varied greatly from one locality to another.

The lower range of the tide, both incoming and outgoing, provided the most successful beach seining.

No relationship was found between water temperature and the inshore abundance of barred surfperch, as measured by catch-per-beach-seine-haul. The temperature range covered was from 16 degrees C. to 21.5 degrees C.

11.2. Diving Observations

SCUBA diving was employed to observe habitat, species relationships, habits, and operation of gear.

A rich zone of life, both vertebrate and invertebrate, was found at the juncture of sandy and rocky substrate.

11.3. Maturity and Fecundity

Barred surfperch carry their eggs, and later, embryos in a sac-like enlargement of the oviduct, made up of 10 thin, highly vascular ovarian sheets. These are bathed by a nutritive fluid, from which the embryos probably receive both nourishment and oxygen.

Interchange of gases and nourishment is aided by vascular dermal folds between the vertical fins of the embryos. Some interchange, at least of gases, probably takes place through the skin.

Embryos at birth probably measure between 42.0 and 53.0 mm.

There seems to be no difference in size between males and females before birth.

Birth may occur earlier in the southern part of the range, than in the north.

Barred surfperch females averaged 33.4 young per litter. For those shorter than 250 mm. the average was 23.6, and for those longer than 250 mm. it was 46.2. The range was from 4 to 113 embryos.

Barred surfperch mature at the end of their second year, at about 130 mm.

The number of embryos increased generally with increase in size of the female parent.

Barred surfperch drop their young from about mid-March at least through July.

Average embryo length showed an increase from 6.7 mm. in December to 50.9 mm. in May.

11.4. Age

Scales of barred surfperch were used to determine the ages of 984 males and 1,142 females.

Three females, 326 and 350 mm. standard length, were nine years of age. No males were encountered, during the course of the study, that were older than six years or longer than 265 mm. standard length.

Growth of barred surfperch is relatively fast from February through August but slows up from August through January.

The length-weight relationship approximately follows the classical formula $W = kL^3$ with the females increasing in weight at a slightly greater rate than do the males.

The weight-at-length relationship is about the same for the two sexes.

Significant differences exist in the total length-standard length relationship in fish longer than 180 mm. standard length and those shorter than 178 mm. Fish over 180 mm. standard length have proportionally shorter tails.

11.5. Food and Feeding

Four hundred and seventy-nine stomachs were examined from fish ranging in size from 51 to 293 mm.

Seventy-one percent of the stomachs contained some food.

Sand crabs were present in over 90 percent of all stomachs containing food, and made up over 90 percent of the food by volume.

Stomachs of fish taken offshore in deeper water contained a higher percentage of food other than sand crabs, than did those taken in the surf.

11.6. Characteristics of the Catch

A system for collecting southern California surf fishing catch data was in operation from January 1, 1952, to September 30, 1956. The records were voluntarily submitted by anglers on forms supplied by the Department of Fish and Game.

For analysis of the data, catches were stratified by origin. The four origins were Ventura, Santa Monica, Newport Beach, and San Diego.

of the project species, barred surfperch was most frequently caught followed by California corbina, spotfin croaker and yellowfin croaker. except in the Santa Monica region where more spotfin croaker than California corbina were reported.

The peak barred surfperch season was during the months of December and January except for the Ventura region where fishing was good the year around. The best fishing for a bimonthly period was reported from the Oceanside region. There, fishermen averaged 20 minutes fishing time for each barred surfperch taken during the December–January period.

During the years data were collected, barred surfperch catch-per-hour appeared to be in a generally upward trend. In each region the reported catch-per-hour was higher for 1955–56 than for the 1951–52 season.

To test the catch records for a suspected positive bias, a field survey of the surf fishing catch was conducted during the 1955–56 season. The survey results indicated that the voluntary catch records were positively biased and overestimated the quality of barred surfperch fishing. However, it was concluded that the positive bias was of a nature such that it did not cause the upward trend in catch-per-hour.

11.7. Movements

Between July 3, 1952 and November 30, 1956, 1,987 barred surfperch were tagged at 13 southern California localities. of these fish, 124 were recaught by surf fishermen and 91 were recaptured in the sampling gear. Most of the tagged fish were released in the Long Beach area.

Tagged fish were recaptured both upcoast and downcoast from tagging areas as well as within tagging areas. Because precise information on angling intensities is unavailable, it is not possible to make quantitative estimates regarding the movements of barred surfperch. It appeared that the rate of mixing between nonadjacent areas was low and that the fish did not move long distances in short periods of time. The longest movement was from Long Beach to Santa Monica, in 48 days, a distance of 31 miles. The longest time at liberty was 242 days. This recapture was made two miles from the Long Beach release point.

Tag recovery data indicate that some mixing occurred between areas.

Movement out of the tagging areas was demonstrated, and it is assumed that movement into tagging areas also took place.

12. MANAGEMENT RECOMMENDATIONS

There is no evidence of an undue strain on the stock of barred surfperch along the southern California coast. It is believed that the bag limit on this species and the closure to commercial fishing provide ample safeguards.

It is recommended that periodic checks be made on the fishery to determine whether or not it remains in its present healthy state.

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