State of California
The Resources Agency
Department of Fish and Game

LIFE HISTORY AND CATCH ANALYSIS OF THE BLUE ROCKFISH (*Sebastodes mystinus*) OFF CENTRAL CALIFORNIA, 1961 - 1965

By

Daniel J. Miller
Melvyn W. Odemar
Daniel W. Gotshall

MRO Reference No. 67-14

Marine Resources Operations
Department of Fish and Game
411 Burgess Drive
Menlo Park, California

1967

This work was performed as part of Dingle-Johnson Project California F 19 R, title "Blue Rockfish Management Study" supported by Federal Aid to Fish Restoration Funds.

TABLE OF CONTENTS

INTRODUCTION

The blue rockfish, Sebastodes mystinus, is one of the more important marine sport species of central and northern California. This species was first in landings by numbers and second by weight during the 1957-61 sport fishery survey, Dingell-Johnson project F12R (Miller and Gotshall, 1965). Not only did the 1957-61 survey demonstrate the overall importance of this species, but it produced evidence during the study period that the blue rockfish was declining in numbers and size at the major fishing areas.

Prior to 1961, only a brief life history study on the blue rockfish had been published (Wales, 1952). In 1961, the Blue Rockfish Management Study (Dingell-Johnson project F19R), was initiated.

The first consideration in this study was the pragmatic application of available funds. Our approach was to concentrate on developing accurate methods of aging, tagging, catch analysis, to determine recruitment; and to complete as many life history studies as possible. Mortality rates and yield estimates were not considered at the onset as we had no prior knowledge of sub-populations nor did we have reliable aging and tagging techniques.

This paper presents the results of the following special studies on the blue rockfish:

1. A catch analysis of the partyboat and skiff fisheries which considered species composition, length composition, catch-per-hour estimates, and total catch and effort at the major ports.

2. A scale study that produced techniques of aging, age composition of the Monterey catch, growth rates, and age at first maturity.

3. A tagging study which provided information on movements, sub-populations, and growth.

4. A serology study to determine evidence of sub-populations.

5. A maturity and fecundity study to determine spawning periods and number of eggs spawned annually by one female.

6. A food analysis study (Gotshall, Smith, and Holbert, 1965).

7. Computation of a weight-length curve.

8. Determination of mortality of discarded blue rockfish.

9. A reef ecology study including tagging of all species in the inshore aggregate and trapping of juveniles of all species.

10. Location of nursery areas of young blue rockfish and a recruitment survey.

11. Evidence of overfishing and recommend possible corrective measures.

Blue rockfish range from Santo Tomas, Baja California to the Bearing Sea. However, the principal fishery and most likely the area of greatest abundance occurs from Bodega Bay to Avila. Over a five-year period, the major California blue rockfish ports were at Princeton, Monterey, and Morro Bay (Table 1, Figure 1).

Aging techniques, tagging and trapping of juveniles, maturity and fecundity studies, discard mortality, a reef ecology study, and age composition of the sport catch were conducted at Monterey. This area was chosen for most of the special studies because of the intensive year-round partyboat and skiff fisheries, readily available nursery areas in calm water, and harbor facilities for a research skiff.

The blue rockfish is but one species in an aggregate comprising a multi-species fishery. Several species can be caught at the same time and place, with varying preferences of one species over the other. Hence, analysis of this fishery is complex. For any one species, the catch-per-hour value and percent composition of the catch are affected by several variables. Collection of reliable catch data was thus of primary importance, and the major research effort was expended on partyboat and skiff sampling programs.

Methods for each specific study will be described with the results of that study. All fish lengths are total length measurements. Common and scientific species nomenclature is taken from Roedel (1962).

BLUE ROCKFISH SPORT FISHERY

The 1958, 1959, and 1960 partyboat and skiff data from the Northern California Marine Sport Fish Survey (Miller and Gotshall, 1965) were incorporated into this analysis. From 1961 through 1964, party boats were sampled at Princeton, Santa Cruz, Monterey, Morro Bay, and Avila. Bodega Bay samples were taken from 1961 through 1963.

Skiffs were sampled at all launching sites from Bodega Bay to Avila, excluding those inside Tomales Bay, San Francisco Bay, Pedro Point, and Moss Landing. At most skiff launching sites, total effort was obtained from business records and logs. At Santa Cruz and Monterey boat harbors, fishing effort was determined by computing week-day and week-end averages by month.

Partyboat log records of effort and catch by major fish groupings by port are tabulated monthly by the biostatistical unit at Terminal Island. A check on the accuracy of these log reports was made in 1960, and their reliability determined (Miller & Gotshall, 1965). Lingcod, cabezon, salmon, striped bass, and rockfishes were recorded accurately. Miscellaneous species such as mackerels and kelp greenling were not reliably reported. Catch composition data obtained by sampling were used to compute numbers of the miscellaneous species and to separate the major category, rockfish, into species.

A minimal number of sampling days was chosen for each sampling unit, and the days were mechanically picked, i.e., every other Saturday or

Number and Percentage of Rockfish, Blue Rockfish, Lingcod, Salmon, and Total Fish in
The Partyboat Catch from Bodega Bay to Avila, 1960 - 1964

	No. Rockfish*	Percent of Port Total	No. Blue Rockfish	Percent of Port Total	No. Lingcod	Percent of Port Total	No. Salmon	Percent of Port Total	Total Catch
1960									
Bodega Bay	31,468	94.6	10,849	32.6	1,044	3.1	235	0.7	33,277
Princeton	119,042	94.3	53,776	42.6	5,907	4.7	55	T	126,213
Año Nuevo	10,282	83.9	7,570	61.8	1,831	15.0	0	0.0	12,249
Santa Cruz	94,839	94.4	12,612	12.6	2,421	2.4	519	0.5	100,458
Monterey	146,687	92.8	79,995	50.6	4,038	2.6	951	0.6	158,026
San Simeon	1,112	95.4	242	20.8	36	3.1	0	0.0	1,166
Cayucos	11,008	98.2	1,973	17.6	140	1.3	4	T	11,206
Morro Bay	207,770	94.0	39,152	17.7	8,352	3.8	273	0.4	221,095
Avila	50,413	95.1	9,103	17.2	1,295	2.4	697	1.3	52,995
Total	672,621	93.9	215,272	30.0	25,064	3.5	2,734	0.4	716,685
1961									
Bodega Bay	20,932	90.9	1,526	6.6	930	4.0	359	1.6	23,035
Dillon Beach	654	87.6	Not sampled		49	6.6	7	0.9	747
Farallon	31,219	94.2	6,528	20.0	1,618	3.9	0	0.0	33,131
Princeton	50,994	84.3	14,991	24.8	6,313	10.4	66	0.1	60,478
Año Nuevo	11,277	89.5	5,922	47.0	1,164	9.2	23	0.2	12,606
Santa Cruz	52,918	92.2	6,737	11.7	1,904	3.3	641	1.1	57,415
Monterey	94,492	91.4	23,688	22.9	1,931	1.9	2,733	2.6	103,398
San Simeon	22,172	97.0	Not sampled		617	2.7	2	T	22,855
Cayucos	9,108	95.0	1,224	12.8	152	1.5	3	T	9,589
Morro Bay	158,841	92.6	21,890	12.8	4,937	2.9	191	0.1	171,610
Avila	47,961	94.6	Not sampled		869	1.7	997	2.0	50,714
Total	500,568	92.0	82,506	17.5**	20,484	3.8	5,022	0.9	545,578

TABLE 1 (cont.)

Number and Percentage of Rockfish, Blue Rockfish, Lingcod, Salmon, and Total Fish from Bodega Bay to Avila, 1960 - 1964

	No. Rockfish*	Percent of port total	No. Blue rockfish	Percent of port total	No. lingcod	Percent of port total	No. salmon	Percent of port total	Total catch
1962									
Bodega Bay	18,213	89.2	4,786	23.4	748	4.0	782	3.8	20,428
Dillon Beach	253	74.4	Not sampled		47	13.8	14	4.1	340
Farallon	34,404	94.4	9,056	25.1	1,504	4.2	110	0.3	36,430
Princeton	52,191	89.7	24,822	42.6	4,472	7.7	70	0.1	58,213
Año Nuevo	14,705	81.0	8,770	48.3	3,174	17.4	0	0.0	18,147
Santa Cruz	58,460	84.7	4,986	7.2	788	1.1	1,670	2.4	69,010
Monterey	116,313	92.2	19,024	15.1	2,723	2.2	1,074	0.9	126,100
San Simeon	9,803	97.1	2,292	22.7	218	2.2	0	0.0	10,095
Morro Bay	226,849	92.8	66,003	27.0	7,408	3.0	59	T	244,468
Avila	41,479	94.1	11,875	26.9	742	1.7	746	1.7	44,059
Total	572,670	91.0	151,614	24.1**	21,824	3.5	4,525	0.7	627,290
1963									
Bodega Bay	26,443	92.5	5,398	18.9	866	3.0	434	1.5	28,586
Dillon Beach	324	80.0	Not sampled		21	5.2	14	3.5	405
Farallon	30,788	89.6	4,700	13.7	1,088	3.2	2,272	6.6	34,380
Princeton	80,537	89.8	19,041	21.2	3,680	4.1	3,680	4.1	89,733
Año Nuevo	11,443	83.2	5,731	41.7	1,778	12.9	0	0.0	13,760
Santa Cruz	22,909	87.3	5,005	19.1	521	2.0	233	0.9	26,255
Monterey	153,382	95.4	80,206	49.9	2,588	1.6	311	0.1	160,740
Morro Bay	221,228	88.1	60,880	24.3	9,218	3.7	154	T	251,042
Avila	38,626	90.5	6,429	15.4	908	2.2	582	1.4	41,672
Total	585,680	89.0	187,390	29.0**	20,668	3.2	7,680	1.1	646,573

TABLE 1 (cont.)

Number and Percentage of Rockfish, Blue Rockfish, Lingcod, Salmon, and Total Fish from Bodega Bay to Avila, 1960 - 1964

	No. rockfish*	Percent of port total	No. Blue rockfish	Percent of port total	No. lingcod	Percent of port total	No. salmon	Percent of port total	Total catch
1964									
Bodega Bay	18,955	86.3	Not sampled		776	3.5	1,306	5.9	21.974
Farallon	14,617	93.7	425	2.7	833	5.3	77	T	15,607
Princeton	42,646	80.2	6,443	12.1	2,528	4.8	26	T	53,146
Año Nuevo	8,051	82.2	3,897	39.8	1,510	15.4	1	T	9,789
Santa Cruz	62,622	72.8	3,618	4.2	375	0.4	573	0.7	86,024
Monterey	83,511	92.2	47,061	52.0	1,890	2.1	904	1.0	90,579
Morro Bay	173,881	87.6	35,631	17.9	8,872	4.5	1,097	0.6	198,556
Avila	30,114	85.8	8,592	24.5	1,184	3.4	2,002	5.7	35,095
Total	434,397	85.2	105,667	21.6**	17,968	3.5	5,986	1.2	510,770

* Includes Blue Rockfish.
** Percentage of Ports Sampled.

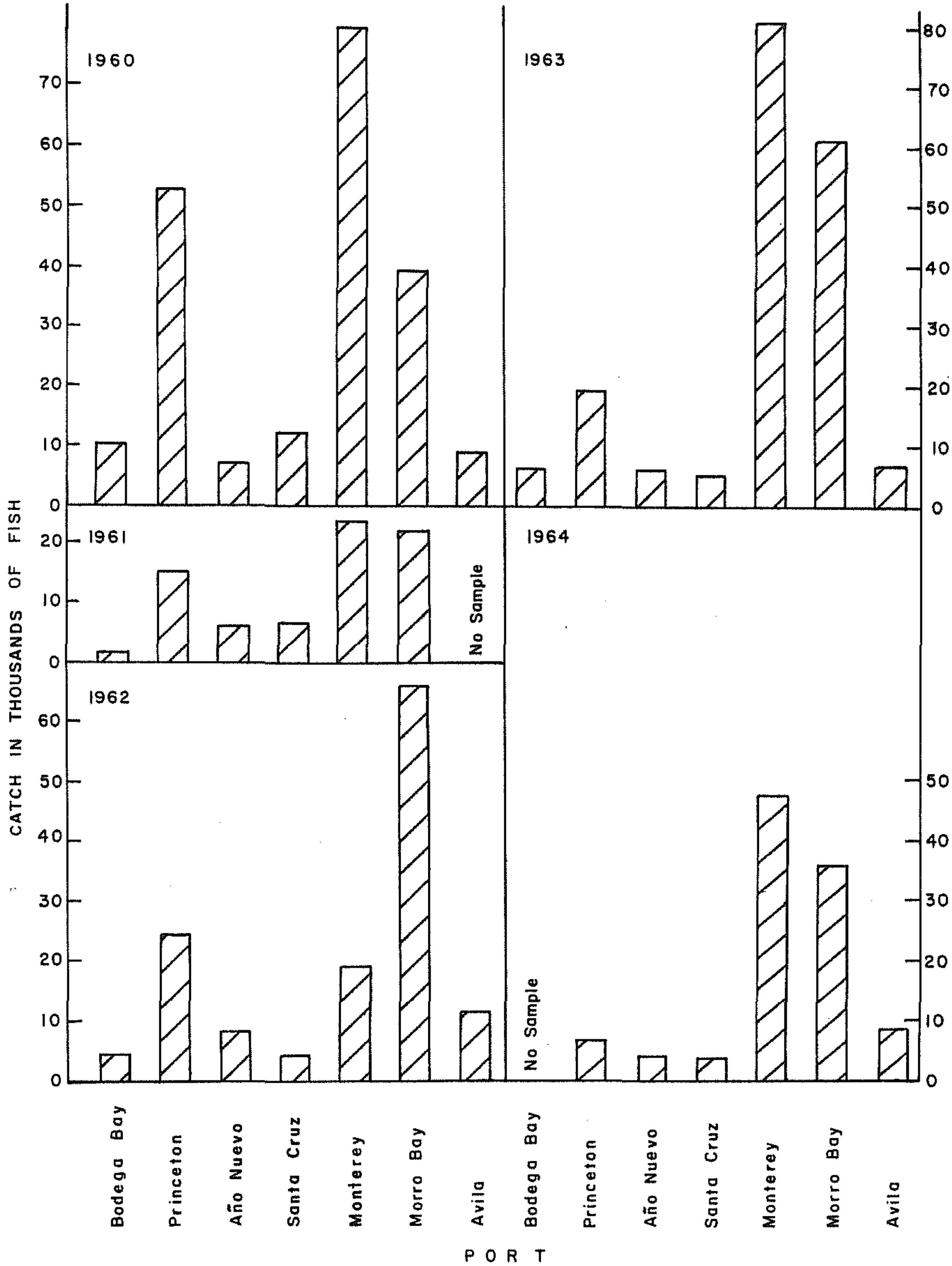


Figure 1. Partyboat Blue Rockfish catches, Bodega Bay to Avila, 1960-1964.

alternate Saturday and Sunday, etc. If there was no sport activity on a picked day due to storm or if no fishermen were present, the next active fishing day was chosen. Since species composition was the object of sampling, this judgment censusing did not result in bias.

The Inshore Aggregate

A description of the blue rockfish fishery can only be done in the context of an aggregate catch of several species frequenting the inshore rocky reef and adjacent sand bottom areas. This "inshore aggregate" includes lingcod, cabezon, kelp greenling, white croaker, several shallow-water flatfishes, and about 30 species of rockfish. On the same fishing trip, sand or mud bottom forms, such as the white croaker and Pacific sanddabs, often were taken with rock frequenting species, and it was not always possible to separate catches by bottom type while sampling. Therefore, all these must be included in the catch analysis of an inshore bottom species.

Results of the 1957-61 sportfish survey demonstrate the significance of the sport inshore aggregate bottomfish fishery and the value of the blue rockfish in this aggregate (Table 2). By method, partyboats accounted for 50 percent of the inshore aggregate catch during this period; the skiff fishery for a little over 18 percent; and the pier and shore fisheries for 19.2 and 11.4 percent, respectively. However, the bulk of the pier and shore catches consisted of a "shoreline aggregate" made up of surfperches, jacksmelt, striped bass, the true smelts, and species, such as blennies, commonly taken in tide pools.

Rockfish was the dominant group in the inshore aggregate for all methods combined, contributing nearly 63 percent of the total; however, blue rockfish alone contributed 21 percent of the total catch. White croaker contributed 20 percent of the total catch, but 76 percent of this species was taken in the pier catch.

Since over 94 percent of all sport-caught blue rockfish were landed by partyboat and skiff fishermen, only these two fisheries were surveyed during this study.

Partyboat Log Records

Partyboat log data have been compiled since 1947. The bottomfish fishery, represented by the partyboat rockfish catch, is a relatively new fishery peaking in the mid-1950's, then declining to lower levels (Figure 2). In the Crescent City-Avila area, there was a slight increase in the total number of rockfish landed during 1962 and 1963 over 1961. Except for a slight rise in 1963, rockfish catch-per-day values for the area have declined from 1958 through 1964.

California salmon catches (king and silver combined) have fluctuated widely from 1947 through 1964 (Figure 2). In 1957, salmon landings declined

TABLE 2

Number and Percent of Inshore Aggregate Species and Total Fish Caught and Percent Composition by Method in the Marine Sport Fish Catch, Oregon to Point Arguello, 1957-61

Species	PIER No.Fish	PIER % of Inshore Aggre.	SKINDIVING No.Fish	SKINDIVING % of Inshore Aggre.	SHORE No.Fish	SHORE % of Inshore Aggre.	PARTYBOAT No.Fish	PARTYBOAT % of Inshore Aggre.	SKIFF No.Fish	SKIFF % of Inshore Aggre.	TOTAL No.Fish	TOTAL % of Inshore Aggre.
Rockfishes	11,899	4.4	9,790	60.1	35,317	21.7	674,678	95.4	157,257	60.5	888,941	62.6
% by Method	1.3		1.1		4.0		75.9		17.7		100.0	
Blue Rockfish*	563*	0.2*	3,076*	18.9	14,239*	8.8*	215,197*	30.4*	67,310*	25.9*	300,385*	21.2*
% by Method	0.2		1.0		4.7		71.7		22.4		100.0	
Lingcod	1,312	0.5	2,923	18.0	3,045	1.9	25,240	3.6	14,874	5.7	47,394	3.3
% by Method	2.8		6.1		6.4		53.3		31.4		100.0	
Greenlings	1,207	0.4	2,250	13.8	65,238	40.1	521	0.1	3,465	1.3	72,681	5.1
% by Method	1.7		3.1		89.8		0.7		4.8		100.1	
Flatfishes	22,735	8.3	32	0.2	14,456	8.9	4,486	0.6	27,371	10.5	69,080	4.9
% by Method	32.9		0.5		20.6		6.5		39.5		100.0	
Cottids	16,971	6.2	1,282	7.9	29,661	18.2	1,676	0.2	5,336	2.1	54,926	3.9
% by Method	30.9		2.3		54.1		3.0		9.7		100.0	
White Croaker	218,206	80.1	0	0.0	14,899	9.2	750	0.1	51,618	19.9	285,473	20.2
% by Method	76.4		0.0		5.2		0.3		18.1		100.0	
Total Inshore Aggregate	272,330	100.1	16,277	100.0	162,616	100.0	707,351	100.0	259,921	100.0	1,418,495	100.0
% by Method	19.2		1.1		11.4		50.0		18.3		100.0	
Total All Others	761,733		5,338		862,300		93,030		77,250		1,799,651	
GRAND TOTAL of all species	1,034,063		21,615		1,024,916		800,381		337,171		3,218,146	
% by Method	32.1		0.7		31.8		24.9		10.5		100.0	

* Blue rockfish included in Rockfish Figures

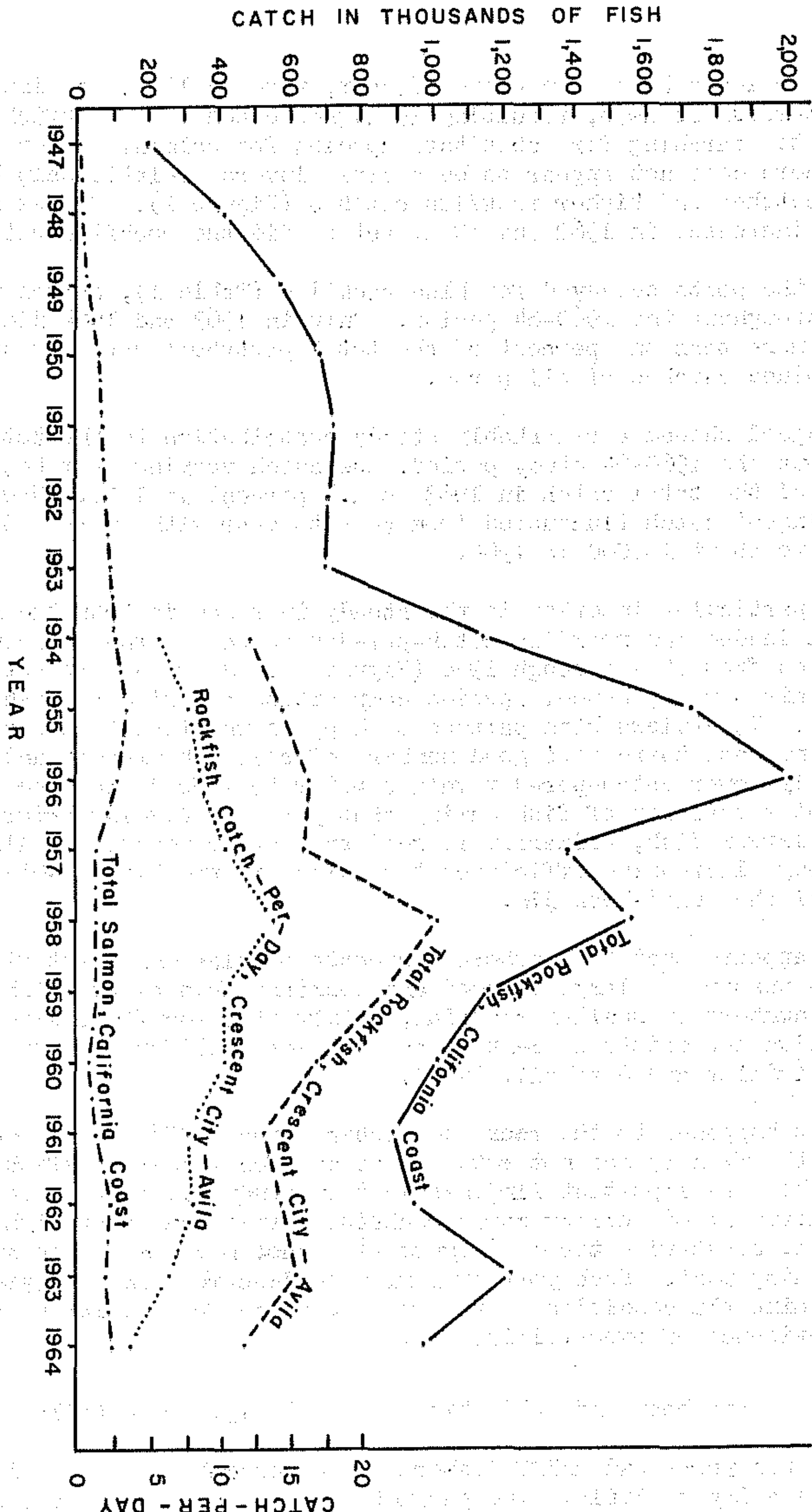


Figure 2. California Partyboat Rockfish and Salmon Landings, 1947-1964; Total Blue Rockfish and Total Rockfish Partyboat Landings, 1954-64, (Crescent City-Avila); and Average Rockfish Catches Per Day, 1954-64 (Crescent City-Avila).

sharply followed by a lower-level fishery through 1964. An increased effort for bottomfish in 1958, resulting in higher catches of rockfish, partially was due to searching for substitute species for salmon. Other than in 1958, there does not appear to be a close inverse relationship between low salmon catches and higher rockfish catches (Figure 2). For example, salmon catches increased in 1962 and 1963, but so did the rockfish catches.

At the ports surveyed for blue rockfish (Table 1), salmon was a minor group throughout the 1960-64 period. Only in 1963 and 1964 did salmon make up more than one percent of the total partyboat catch by number for the combined catches of all ports.

Lingcod showed a remarkably steady contribution to the total catch throughout the 1960-64 study period, the catch varying from between 3.2 percent of the total catch in 1963 to 3.8 percent in 1961. However, the sport lingcod catch fluctuated from year to year with over 25,000 landed in 1960 to about 18,000 in 1964.

Of particular interest is the steady increase in both the number of rockfish landed and rockfish catch-per-day values in the Crescent City-Avila area from 1954 through 1958 (Figure 2). Sampling was not conducted during this period; hence, species composition and size of fish are not recorded. Interviews with partyboat skippers who fished during this period indicate there were good numbers of rockfish present and the relatively lower catch-per-day values prior to 1958 do not necessarily represent a scarcity of fish during that period. Fishing prior to 1958 was for larger fish, primarily lingcod and larger rockfish. Also, a major gear change increasing efficiency took place in the late 1940's with the advent of the multi-hook jig.

It appears that the inshore aggregate populations first yielded adequate numbers of large lingcod and rockfish, but as the fishery intensified, greater numbers of smaller rockfish, mainly blue rockfish, were landed. Such a condition now exists in central and northern California inshore aggregate catches (Miller and Gotshall, 1965).

What happened to the rockfish fishery since 1958 is more complex, because the fishery has not returned to one for larger rockfish and lingcod. One of the more important findings in this study was that there is apparently little movement of shallow water rockfish between adjacent fishing ports. Therefore, coast-wise trends (Figure 2) cannot necessarily be applied to each fishing port. Each port area must be described and analyzed separately to determine the condition of the inshore aggregate population and to detect evidence of over-utilization.

Partyboat and Skiff Fisheries: Bodega Bay - Avila

The partyboat and skiff fisheries are described for each locality from Bodega Bay to Avila. The parameters of analysis are: species composition, catch-per-hour of all bottomfish (including blue rockfish), catch-per-hour, length frequency, and mean annual sizes of the blue rockfish.

Lingcod catch-per-hour and length-frequency data were collected but will not be presented in this paper.

Bodega Bay

Skiff Fishery - The blue rockfish skiff catch was insignificant, with copper rockfish, lingcod, brown rockfish, and jacksmelt the more common species (Table 3).

Partyboat Fishery - The species composition showed a shifting of the first place species each year (Table 4). These changes could be due to many reasons, including shifting of fishing areas, population increase or decrease of one species over the other, etc. Our analysis does not yield evidence of the reasons.

In the partyboat catch, blue rockfish dropped from first place in 1960 to fifth place in 1961, and back to second place in 1962 and 1963. Catch-per-hour values followed the same erratic pattern, the lowest appearing in 1961 (Figure 3). The dominant species in 1961, copper rockfish and brown rockfish, were larger fish and were probably preferred over the blue rockfish.

Blue rockfish size composition was made up of relatively large fish throughout the study period, fluctuating around 330 mm (Figure 4). Only here and at the Farallon Islands did the average size and percentage of fish over 300 mm remain fairly stable or increase over the study period.

Considering the large sized blue rockfish and lack of any downward trend in the catch-per-hour values, it is probable that the blue rockfish stocks here are not being fully utilized or at least are not being adversely affected by the present fishing intensity level.

Farallon Island Area

Skiff Fishery - None for bottomfish.

Partyboat Fishery - The Farallon Island fishery is conducted from boats operating out of ports in the San Francisco Bay area and Princeton. From 1961-1964 about 70 percent of the bottomfish catch around these islands was made on boats from Princeton.

The fishery is essentially of yellowtail rockfish, blue rockfish, and lingcod. Bocaccio, olive rockfish, and rosy rockfish also appear in most of the catches. Even though the catch-per-day of all bottomfish declined from 1963 to 1964, it remained higher than at any other fishing area surveyed. This decrease may be due to a decline in numbers of blue rockfish, as the catch-per-hour dropped from over 0.62 per hour in 1962 to 0.05 in 1964 (Figure 5). In 1962, blue rockfish made up about 25 percent of the catch, but only 3.9 percent in 1964 (Table 4).

The fishery here is in fairly deep water, and large yellowtail rockfish are the desired fish; therefore, the catch may not represent a true picture

TABLE 3 (con't)

Rank:	First		Second		Third		Fourth		Fifth	
Port and Year	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total
Monterey										
1959	Blue Rockfish	57.9	Pacific Sanddab	12.1	Pacific Mackerel	5.0	Rosy Rockfish	2.8	Jacksmelt	2.5
1961	Pacific Sanddab	29.8	Blue Rockfish	25.2	Rosy Rockfish	10.7	Jacksmelt	4.5	Gopher Rockfish	3.6
1962	Blue Rockfish	30.4	Pacific Sanddab	28.3	Rosy Rockfish	5.1	Petrale Sole	4.0	Canary Rockfish	3.6
1963	Blue Rockfish	39.1	Pacific Sanddab	13.1	Olive Rockfish	6.4	Rosy Rockfish	6.0	Yellowtail R.	4.0
1964	Pacific Sanddab	39.4	Blue Rockfish	13.7	Sablefish	10.0	Black Rockfish	4.3	Rosy Rockfish	2.9
Pacific Grove										
1963	Blue Rockfish	48.5	Pacific Sanddab	16.1	Black-&-Yellow R.	7.1	Black Rockfish	5.6	Jacksmelt	5.3
Cayucos										
1959	Blue Rockfish	25.6	Gopher Rockfish	15.9	Copper Rockfish	8.8	Cabezon	7.9	Black-&-Yellow R.	7.2
Morro Bay										
1959	Blue Rockfish	25.6	Gopher Rockfish	13.3	Olive Rockfish	7.9	Copper Rockfish	7.9	Cabezon	6.8
1963	Blue Rockfish	23.4	Gopher Rockfish	11.1	Pacific Sanddab	9.4	Lingcod	7.6	Black Rockfish	5.8
1964	Pacific Sanddab	35.0	Blue Rockfish	18.8	Black Rockfish	7.4	Gopher Rockfish	3.8	Sand Sole	3.3
Avila										
1959	Gopher Rockfish	21.1	Blue Rockfish	15.3	Copper Rockfish	12.6	Vermilion	6.5	Canary Rockfish	6.1
1964	Blue Rockfish	21.4	Gopher Rockfish	17.7	Brown Rockfish	16.5	Black-&-Yellow R.	5.5	White Croaker	5.4

TABLE 4

The Five Most Numerous Species Landed in the Partyboat Catch Annually From 1957 Through 1964 at the Major Ocean Partyboat Ports From Bodega Bay to Avila, California

Rank:	First		Second		Third		Fourth		Fifth	
Port and Year	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total
Bodega Bay										
1960	Blue Rockfish	32.6	Black Rockfish	26.0	Copper Rockfish	12.9	Brown Rockfish	11.3	Canary Rockfish	6.2
1961	Copper Rockfish	24.9	Brown Rockfish	21.3	Canary Rockfish	17.1	Black Rockfish	11.3	Blue Rockfish	6.6
1962	Black Rockfish	23.6	Blue Rockfish	23.4	Copper Rockfish	13.5	Canary Rockfish	11.0	Brown Rockfish	9.5
1963	Black Rockfish	26.6	Blue Rockfish	18.9	Canary Rockfish	15.0	Copper Rockfish	13.5	Brown Rockfish	8.8
Farallon Isls.										
1961	Yellowtail R.	59.8	Blue Rockfish	20.0	Lingcod	3.9	Bocaccio	3.6	Copper Rockfish	2.6
1962	Yellowtail R.	52.1	Blue Rockfish	25.1	Bocaccio	5.1	Olive Rockfish	4.7	Lingcod	4.1
1963	Yellowtail R.	39.3	Olive Rockfish	16.5	Blue Rockfish	13.7	Rosy Rockfish	9.4	Lingcod	3.2
1964	Yellowtail R.	66.5	Rosy Rockfish	8.6	Lingcod	7.6	Olive Rockfish	4.4	Blue Rockfish	3.9
Princeton										
1960	Blue Rockfish	42.6	Yellowtail R.	22.3	Black Rockfish	5.9	Canary Rockfish	5.0	Lingcod	4.7
1961	Blue Rockfish	24.8	Black Rockfish	15.5	Yellowtail R.	15.0	Lingcod	10.4	Bocaccio	6.3
1962	Blue Rockfish	42.6	Black Rockfish	13.4	Yellowtail R.	11.0	Canary Rockfish	8.4	Lingcod	7.6
1963	Blue Rockfish	21.2	Yellowtail R.	18.4	Canary Rockfish	13.6	Black Rockfish	11.0	Brown Rockfish	10.4
1964	Brown Rockfish	16.2	Yellowtail R.	14.0	Blue Rockfish	12.1	Black Rockfish	11.7	Copper Rockfish	10.9
Año Nuevo										
1960	Blue Rockfish	61.8	Lingcod	15.0	Copper Rockfish	5.7	Canary Rockfish	4.4	Yellowtail R.	2.5
1961	Blue Rockfish	47.0	Black Rockfish	11.2	Copper Rockfish	9.3	Lingcod	9.2	Gopher Rockfish	4.6
1962	Blue Rockfish	48.3	Lingcod	17.5	Black Rockfish	12.7	Gopher Rockfish	4.7	Canary Rockfish	4.4
1963	Blue Rockfish	41.7	Lingcod	12.9	Black Rockfish	6.7	Gopher Rockfish	6.8	Copper Rockfish	6.1
1964	Blue Rockfish	39.8	Lingcod	15.4	Canary Rockfish	7.0	Yellowtail R.	6.9	Black Rockfish	5.8
Santa Cruz										
1959	Blue Rockfish	52.4	Yellowtail R.	17.4	Pacific Mackerel	5.3	Canary Rockfish	5.2	Greenspotted R.	2.8
1960	Yellowtail R.	47.3	Blue Rockfish	12.6	Widow Rockfish	8.9	Canary Rockfish	7.6	Greenspotted R.	3.7
1961	Yellowtail R.	47.0	Blue Rockfish	11.7	Canary Rockfish	6.7	Bocaccio	6.5	Greenspotted R.	4.6
1962	Chilipepper	27.5	Yellowtail R.	19.7	Greenstriped R.	7.5	Blue Rockfish	7.2	Canary Rockfish	5.1
1963	Yellowtail R.	33.3	Blue Rockfish	19.1	Greenspotted R.	7.7	Canary Rockfish	5.3	Sablefish	4.9
1964	Chilipepper	50.4	Sablefish	16.5	Blue Rockfish	4.2	Greenspotted R.	3.9	Bocaccio	3.5

TABLE 4 (con't)

Rank:	First		Second		Third		Fourth		Fifth	
Port and Year	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total	Species	Percent of Total
Monterey										
1960	Blue Rockfish	50.9	Yellowtail R.	18.2	Olive Rockfish	5.6	Rosy Rockfish	5.2	Bocaccio	3.8
1961	Yellowtail R.	30.1	Blue Rockfish	22.9	Rosy Rockfish	11.0	Olive Rockfish	7.2	Bocaccio	6.3
1962	Yellowtail R.	33.3	Blue Rockfish	15.1	Rosy Rockfish	10.0	Olive Rockfish	9.3	Bocaccio	7.7
1963	Blue Rockfish	49.9	Olive Rockfish	13.7	Yellowtail R.	12.0	Rosy Rockfish	5.3	Widow Rockfish	4.9
1964	Blue Rockfish	52.0	Widow Rockfish	12.9	Yellowtail R.	10.4	Rosy Rockfish	3.9	Olive Rockfish	3.8
San Simeon										
1960	Olive Rockfish	34.7	Blue Rockfish	20.8	Vermilion R.	9.3	Copper Rockfish	7.4	Gopher Rockfish	7.1
1962	Olive Rockfish	29.3	Blue Rockfish	22.7	Vermilion R.	10.2	Copper Rockfish	8.8	Gopher Rockfish	8.2
Cayucos										
1960	Yellowtail R.	17.7	Blue Rockfish	17.6	Olive Rockfish	11.7	Vermilion R.	10.4	Bocaccio	10.3
Morro Bay										
1957	Blue Rockfish	50.0	Olive Rockfish	23.6	Greenspotted R.	3.9	Yellowtail R.	2.4	Copper Rockfish	2.1
1958	Blue Rockfish	50.6	Olive Rockfish	14.9	Yellowtail R.	5.3	Vermilion R.	4.6	Bocaccio	3.8
1959	Blue Rockfish	39.4	Yellowtail R.	11.7	Olive Rockfish	10.5	Vermilion R.	5.9	Bocaccio	5.2
1960	Blue Rockfish	17.9	Yellowtail R.	14.4	Olive Rockfish	13.1	Bocaccio	11.1	Vermilion R.	9.7
1961	Yellowtail R.	14.1	Bocaccio	13.3	Blue Rockfish	12.8	Olive Rockfish	9.0	Vermilion R.	8.7
1962	Blue Rockfish	27.0	Yellowtail R.	18.2	Olive Rockfish	8.0	Bocaccio	5.9	Greenspotted R.	5.6
1963	Blue Rockfish	24.3	Yellowtail R.	14.7	Olive Rockfish	8.4	Gopher Rockfish	6.3	Vermilion R.	5.2
1964	Widow Rockfish	18.7	Blue Rockfish	17.9	Yellowtail R.	10.8	Olive Rockfish	7.6	Bocaccio	6.7
Avila										
1959	Yellowtail R.	19.4	Blue Rockfish	13.3	Vermilion R.	13.1	Copper Rockfish	9.9	Canary Rockfish	8.1
1960	Vermilion R.	16.7	Blue Rockfish	12.3	Copper Rockfish	11.7	Gopher Rockfish	10.8	Lingcod	8.8
1961	(Not Sampled)	--		--		--		--		--
1962	Blue Rockfish	27.0	Gopher Rockfish	18.6	Yellowtail R.	16.9	Copper Rockfish	6.4	Vermilion R.	4.3
1963	Yellowtail R.	21.2	Blue Rockfish	15.4	Gopher Rockfish	10.1	Copper Rockfish	8.7	Olive Rockfish	6.8
1964	Blue Rockfish	24.5	Gopher Rockfish	19.3	Yellowtail R.	10.7	Brown Rockfish	8.0	Copper Rockfish	3.9

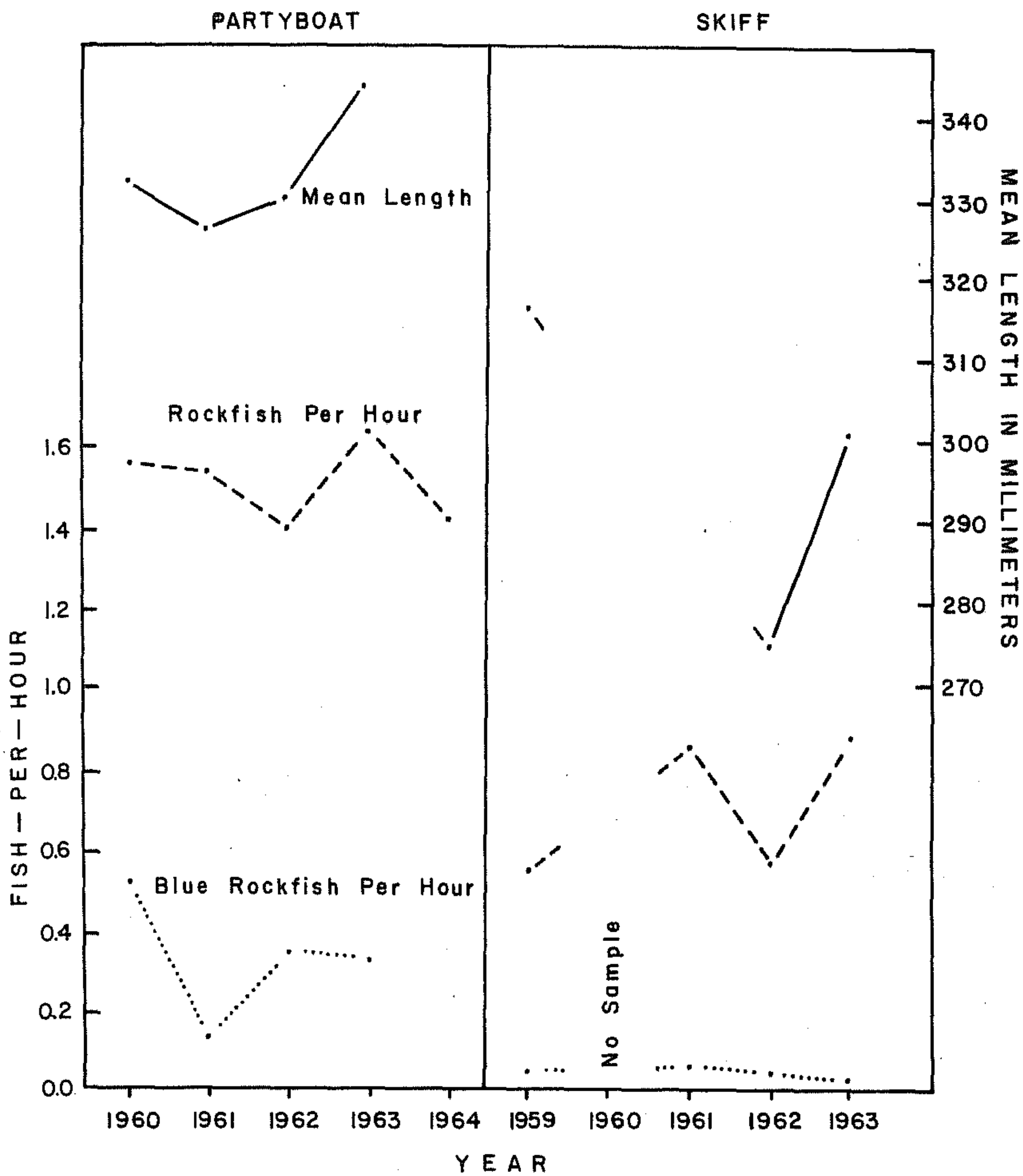


Figure 3. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Bodega Bay, 1960-1964.

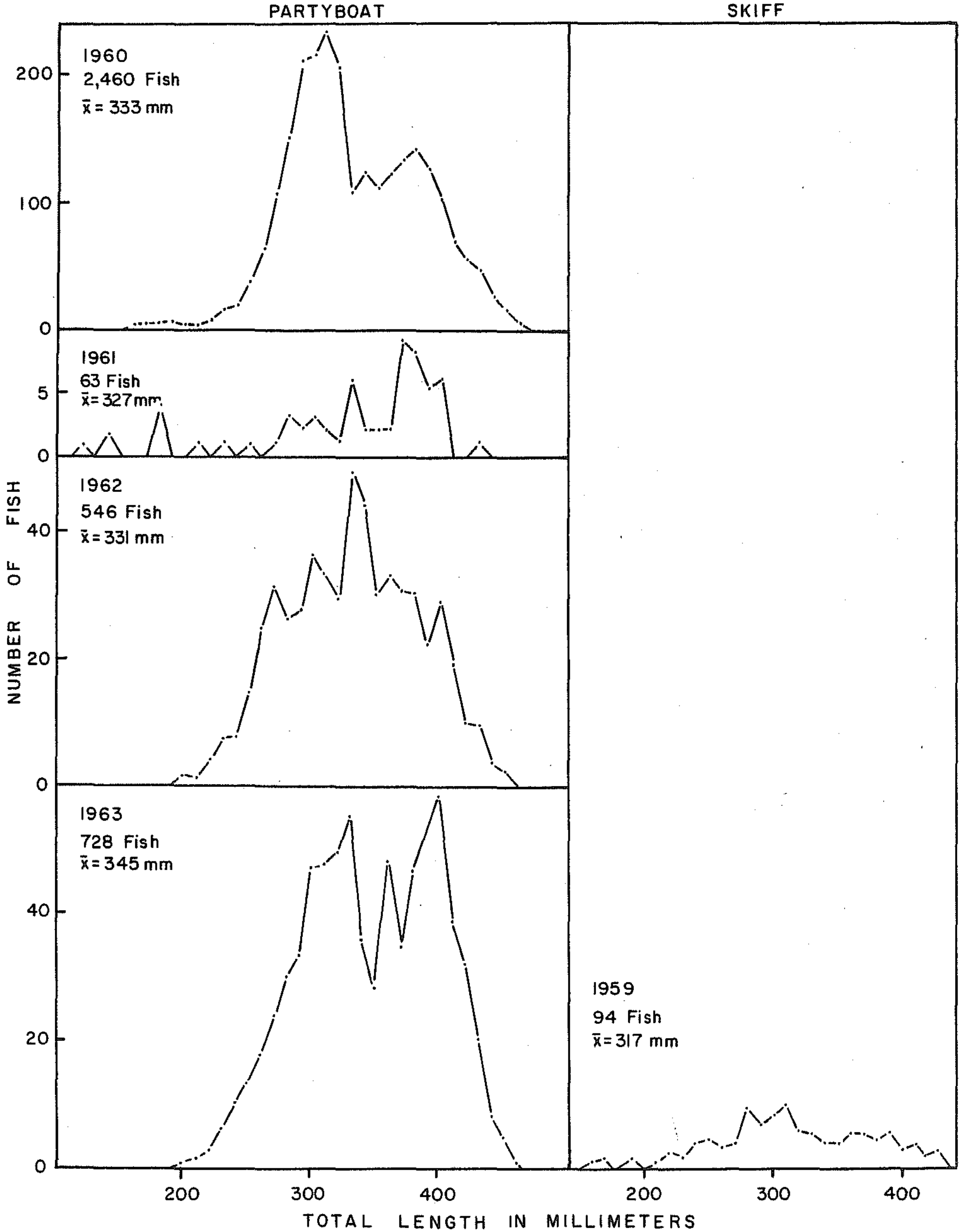


Figure 4. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat and Skiff Catches at Bodega Bay, 1959-1963.

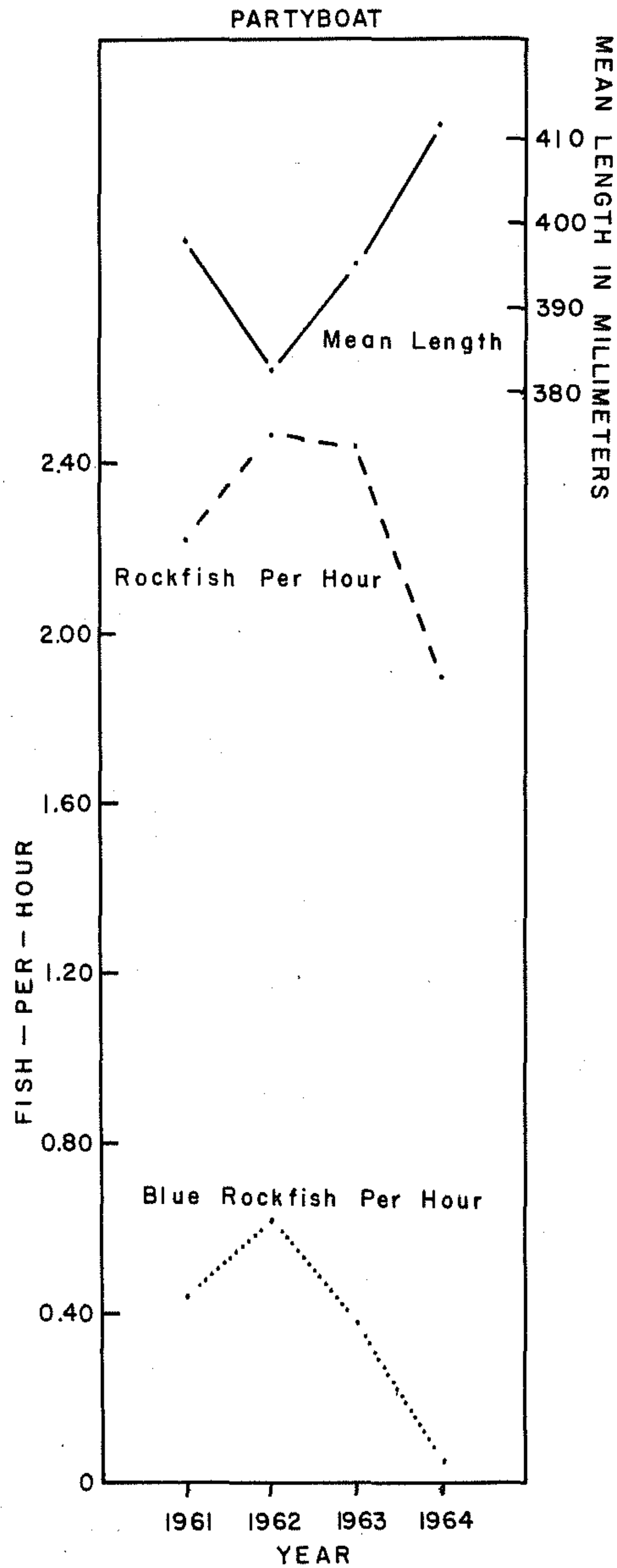


Figure 5. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at the Farallon Islands, 1961-1964.

of the total blue rockfish population around these islands. Tagging operations from a research vessel disclosed the presence of smaller blue rockfish in the shallow reef areas on the west side of the main island. We do not know whether recruitment of the fished, deeper water, adult blue rockfish concentrations originates from these shallow areas, or drifts or wanders in from coastal nursery areas. None of the 175 fish tagged here were returned.

This is the only area surveyed where blue rockfish average 400 mm or more in length (Figures 5 & 6).

Princeton

Skiff Fishery - The skiff fishery here is conducted by two groups of fishermen. A relatively small number of fishermen bring in large catches of white croaker, while the other larger group of fishermen prefer lingcod, copper rockfish, brown rockfish and blue rockfish caught on nearby rocky reefs. Blue rockfish is a minor species in the skiff catch and its landings fluctuate widely in numbers from year to year (Table 3).

Partyboat Catch - Blue rockfish dominated the partyboat catch in this area. The fishing occurs at three locations. In the deep-reef areas 8-10 miles offshore, yellowtail rockfish, blue rockfish, and large lingcod are most common. In the shallow-reef areas off Montara, canary rockfish, blue rockfish, and black rockfish are taken, while in the shallow-reef areas off Martin's Beach to Pigeon Point, blue rockfish, brown rockfish, copper rockfish, and black rockfish are common.

Following the catch-per-hour curve for total rockfish from 1960-1964 (Figure 7), we see a low level in 1961 and 1962 with a decided increase in 1963 and 1964. Blue rockfish catch-per-hour values, on the other hand, rose in 1962 but decreased in 1963 and 1964, the inverse of total rockfish values. The decrease in relative abundance of blue rockfish may be due in part to an increase in the catch of more preferred, larger rockfish.

Average sizes and the length-frequency polygons (Figure 8) indicate a decrease in the number of older blue rockfish, especially in 1964. There appeared to be an increase of smaller fish into the fishery in 1962 and 1964.

In 1962, a mode of young fish was evident at around 240 mm. In 1963, the mode was around 265 mm; and in 1964, around 280 mm. In 1964, another mode of young fish appeared at around 220 mm. If these younger fish were sought by fishermen, and field observations indicated they were, then these influxes of young fish were not of considerable strength because catch-per-hour values continued to decline after 1962. From 1960 to 1964, the number of blue rockfish over 350 mm has shown a marked decrease.

Año Nuevo Island

Skiff Fishery - This fishery is very small and was not surveyed.

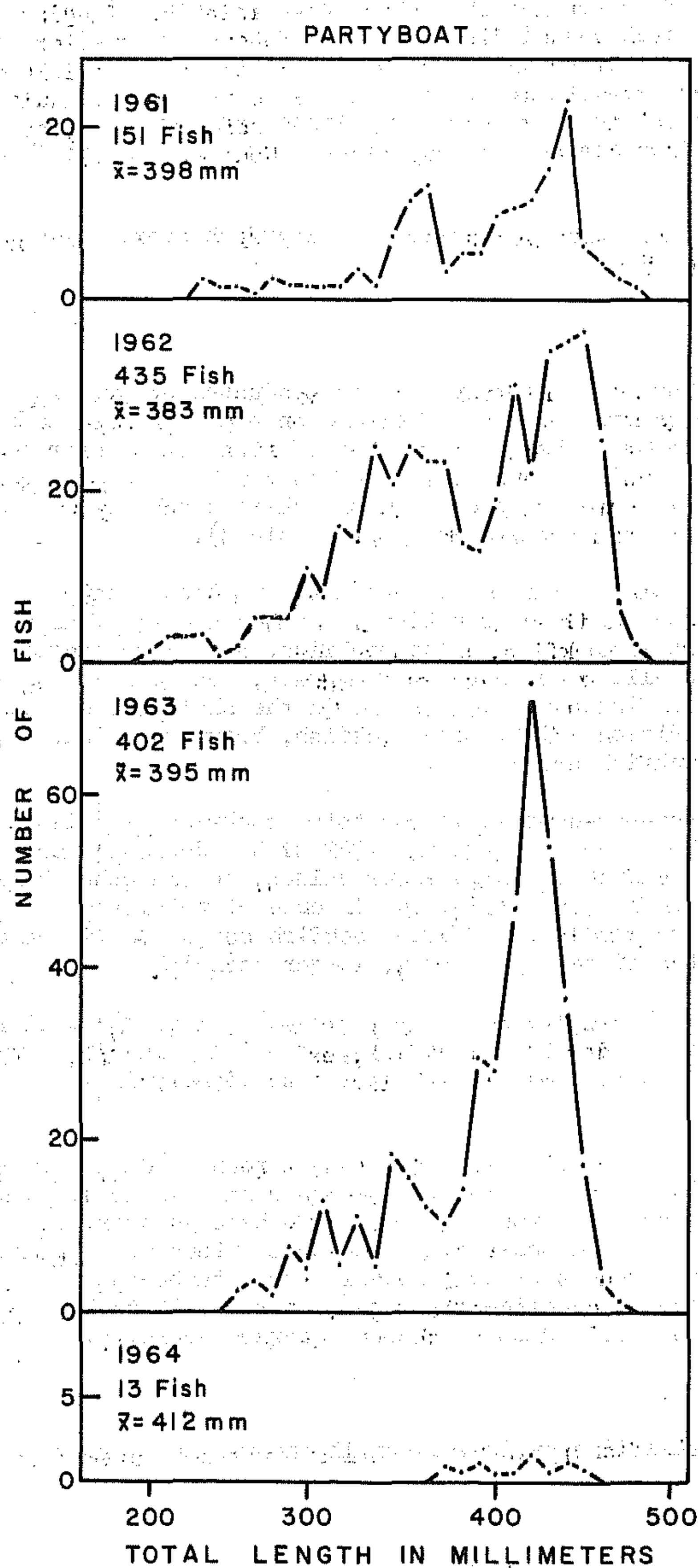


Figure 6. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat Catch at the Farallon Islands, 1961-1964.

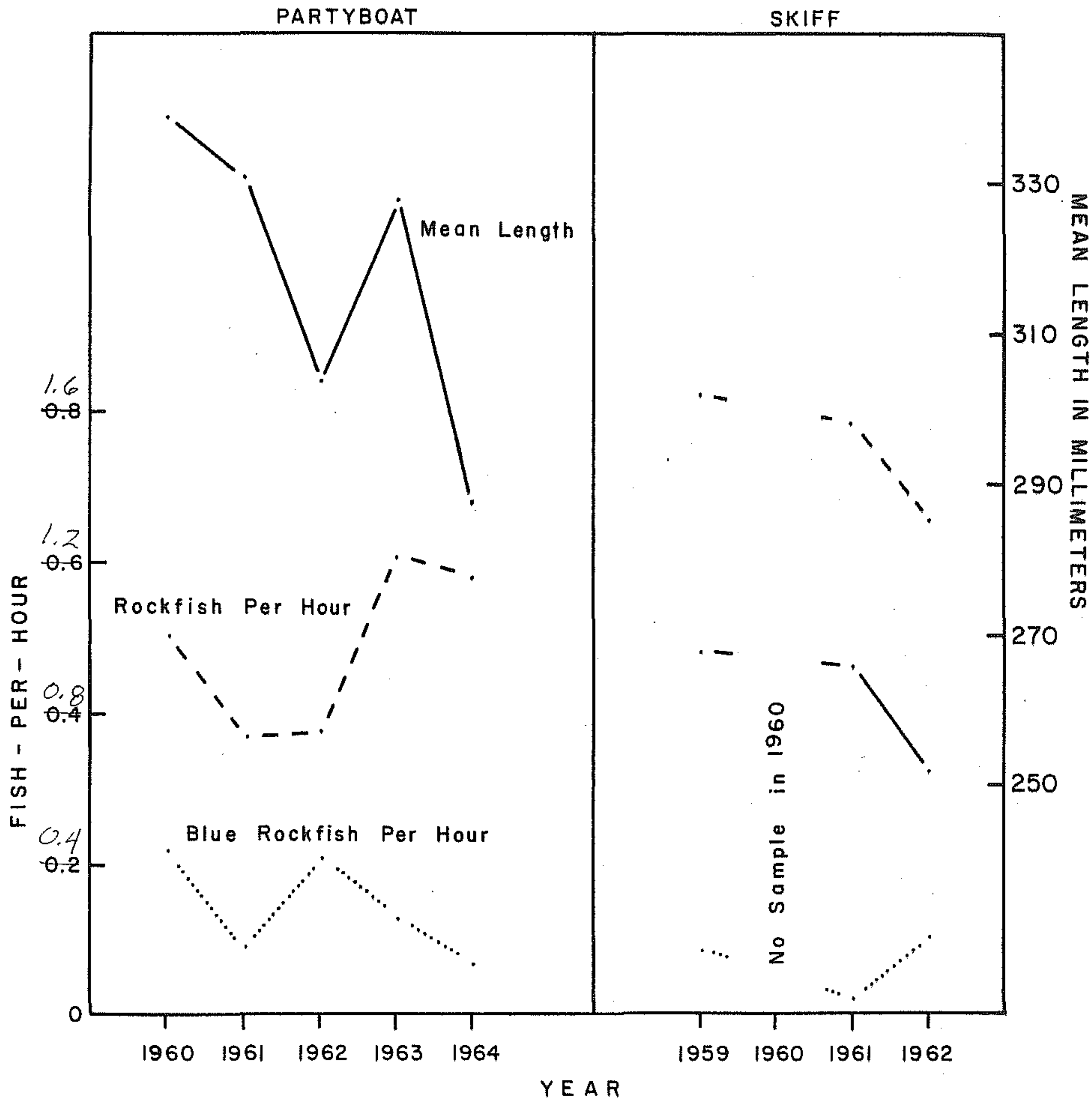


Figure 7. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Princeton, 1960-1964.

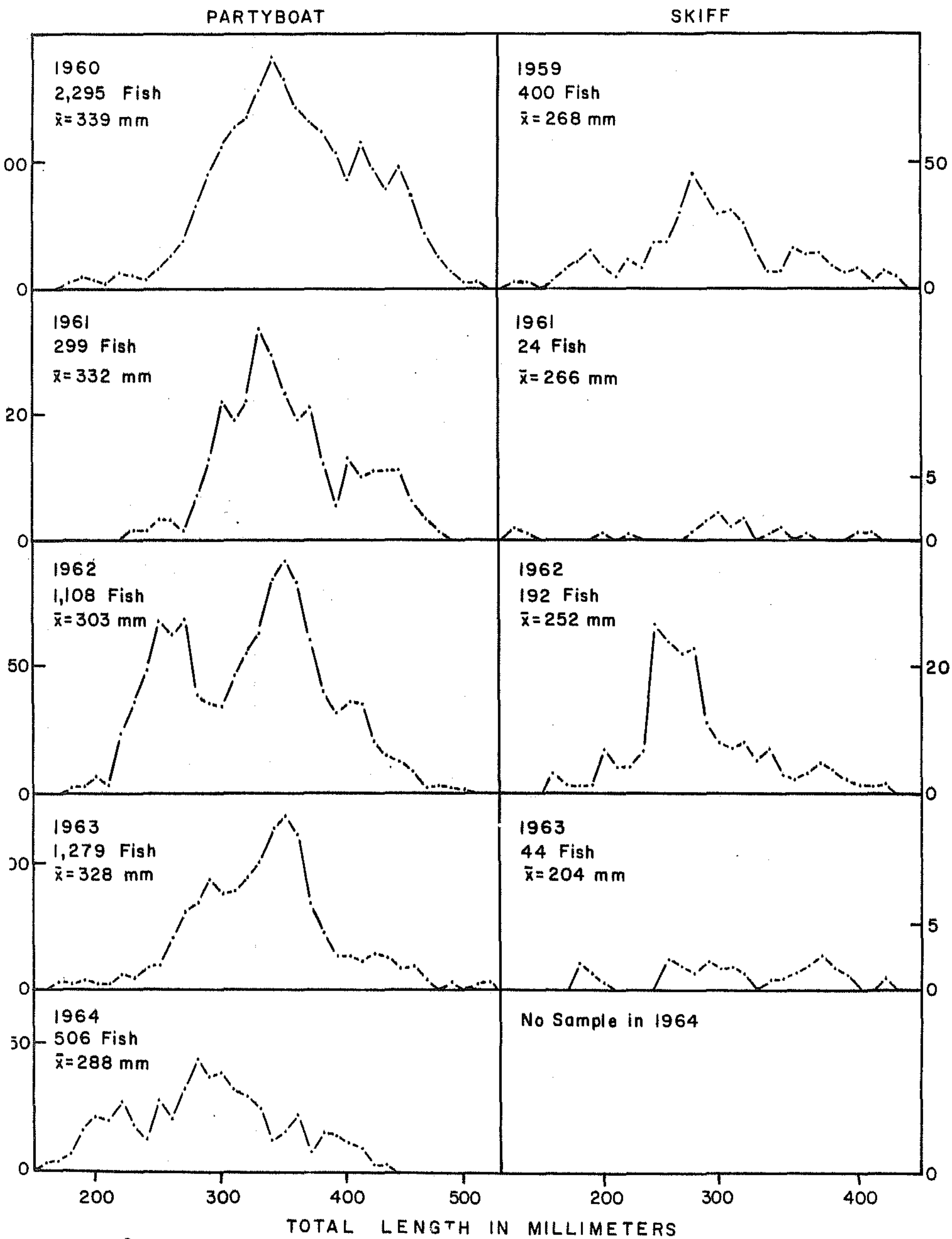


Figure 8. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat and Skiff Catches at Princeton, 1960-1964.

Since 1964, a few skiffs from the new Santa Cruz harbor ventured to Año Nuevo, and increased skiff effort can be expected in the future.

Partyboat Fishery - Even though blue rockfish far outnumbered all other fish caught, lingcod was the most sought fish. Most of the fishing effort was expended at several small rocky reefs. Our tagging results indicate some movement between these reefs, but little movement away from the general area. Of the 25 tag recoveries from this area, only one had moved from Año Nuevo to the Pescadero reef area, a distance of about 15 miles.

The ratio of catch-per-hour values between bottomfish and blue rockfish is comparatively uniform; however, the trends for both indicate a gradual decrease in the catch (Figure 9). Interviews with partyboat operators indicate a decline in 1965 of both size and numbers of blue rockfish.

Length frequency polygons of the catch at Princeton and Año Nuevo are quite similar. A group of young fish around 240 mm in length entered the fishery in 1962 and remained the dominant group through 1964 (Figure 10), and, as at Princeton, this influx of younger fish was not of exceptional strength for the catch-per-hour values continued to decline.

Santa Cruz

Skiff Fishery - Two segments make up the bottomfish skiff fishery; i.e. fishermen plying nearby reef areas in quest of lingcod and rockfish, and those, stopping at random, finding themselves either over sandy bottom catching white croaker and sanddabs, or over rock bottom.

White croaker and blue rockfish have been the most frequently recorded species (Table 3). A slight increase in catch-per-hour (Figure 11) and a drop in the average size (Figures 11 & 12) indicated an influx of young blue rockfish into the fishery in 1962. However, these young fish were weak in numbers because the catches remained at low levels in 1963 and 1964.

In 1964, we recorded the type habitat (reef or sandy bottom) over which the catch was made. A more detailed description of this reef ecology study is given in the section on Monterey Reef Areas. It should be mentioned here that about 21 percent of the blue rockfish were caught on South Rock, the reef where most of the partyboat catch was made in 1958 and 1959.

Total skiff catches were computed for the 1959, 1963, and 1964 fisheries at Santa Cruz, Capitola, and Monterey (Table 5). The combined Capitola and Santa Cruz skiff catches made up 41.7, 57.2, and 44.5 percent of the area's total bottomfish catch (partyboat plus skiff catch) in 1959-60, 1963, and 1964, respectively. Año Nuevo-caught fish are not included in the partyboat figures. In 1964, more than half the blue rockfish landed in this area were by skiff fishermen (Table 5).

Length-frequency polygons of the skiff catch show comparable modal characteristics to the partyboat catch frequencies (Figure 12), but have more fish less than 200 mm represented.

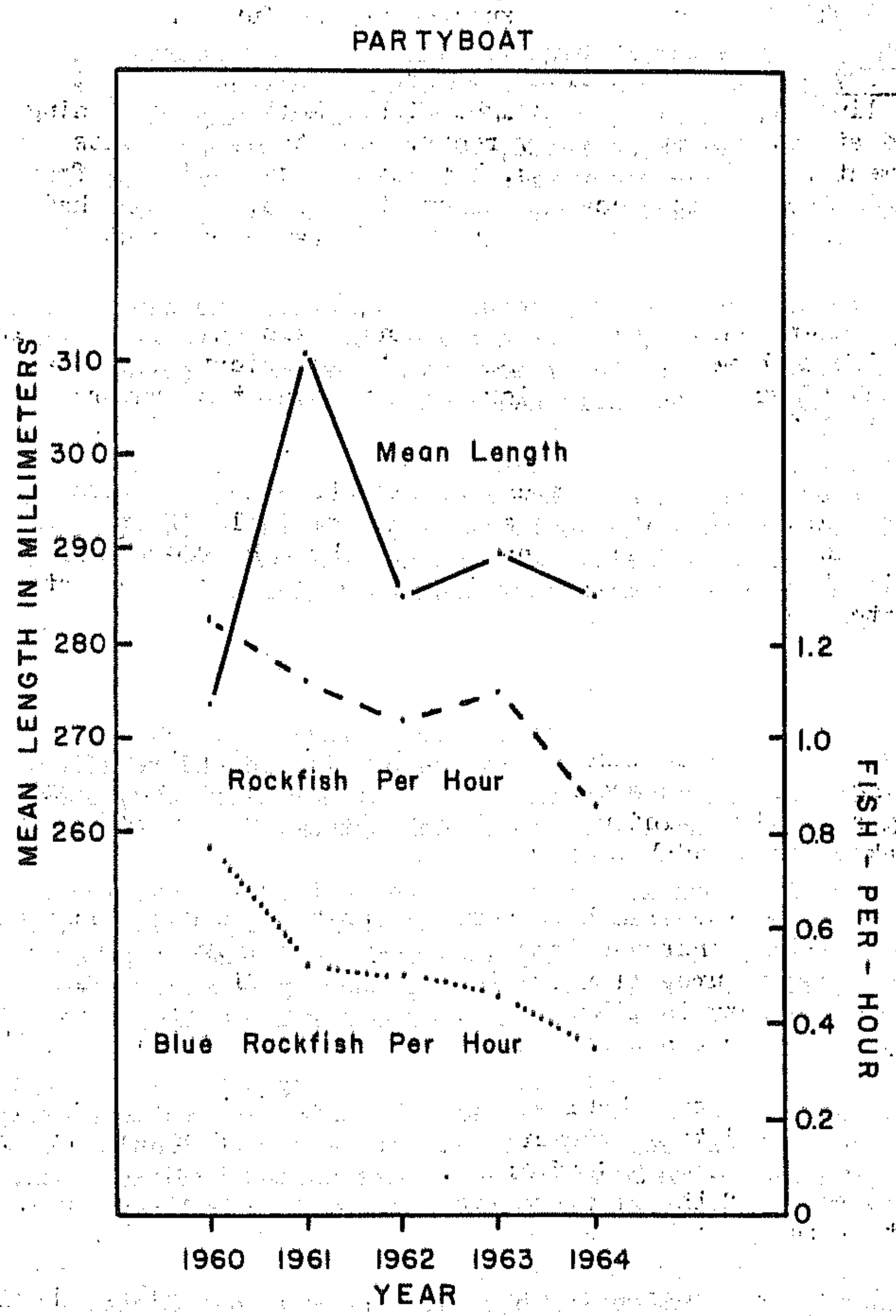


Figure 9. Total Rockfish and Blue Rockfish Catch-Per-Hour (C/H) and Annual Mean Lengths of Blue Rockfish in the Partyboat Catch at Ano Nuevo Island, 1960-1964.

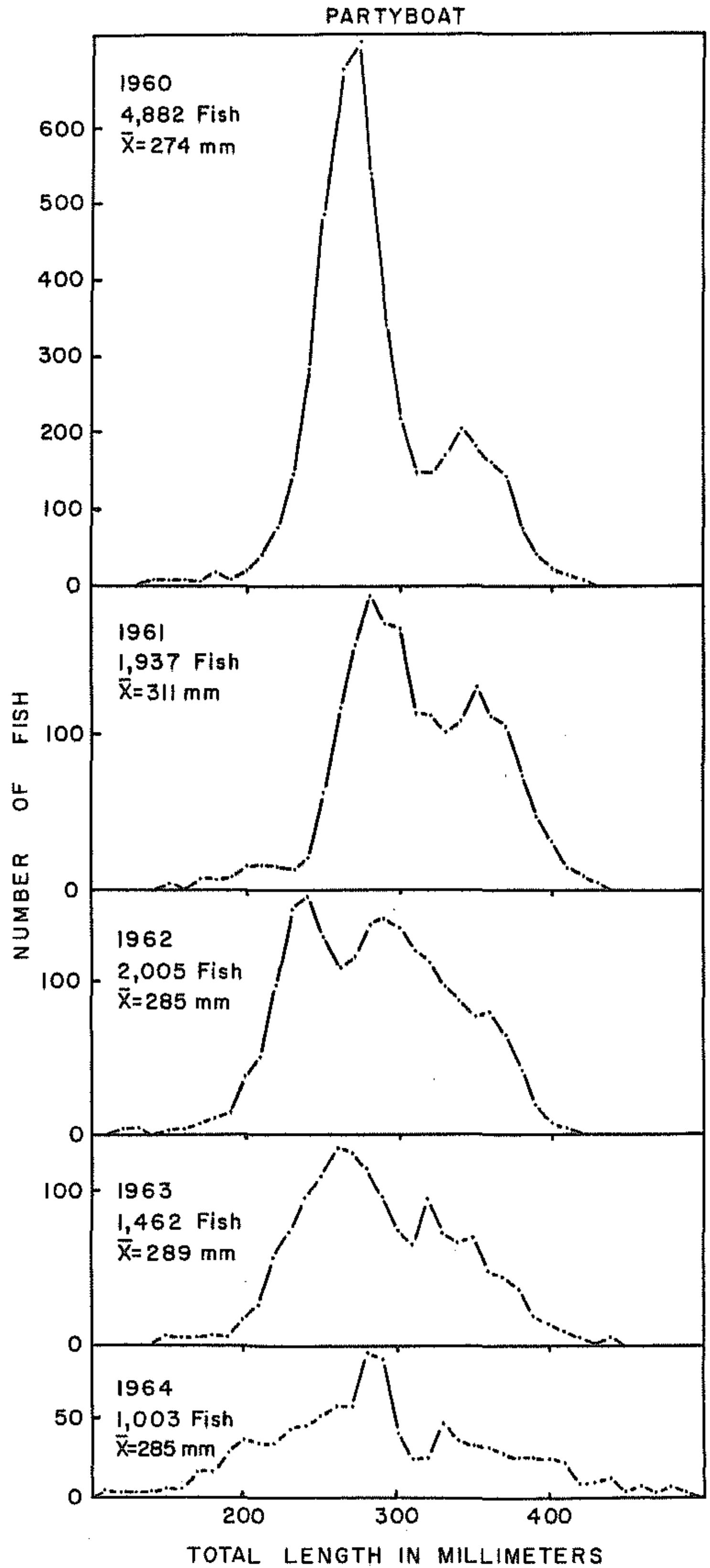


Figure 10. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat Catch at Año Nuevo Island, 1960-1964.

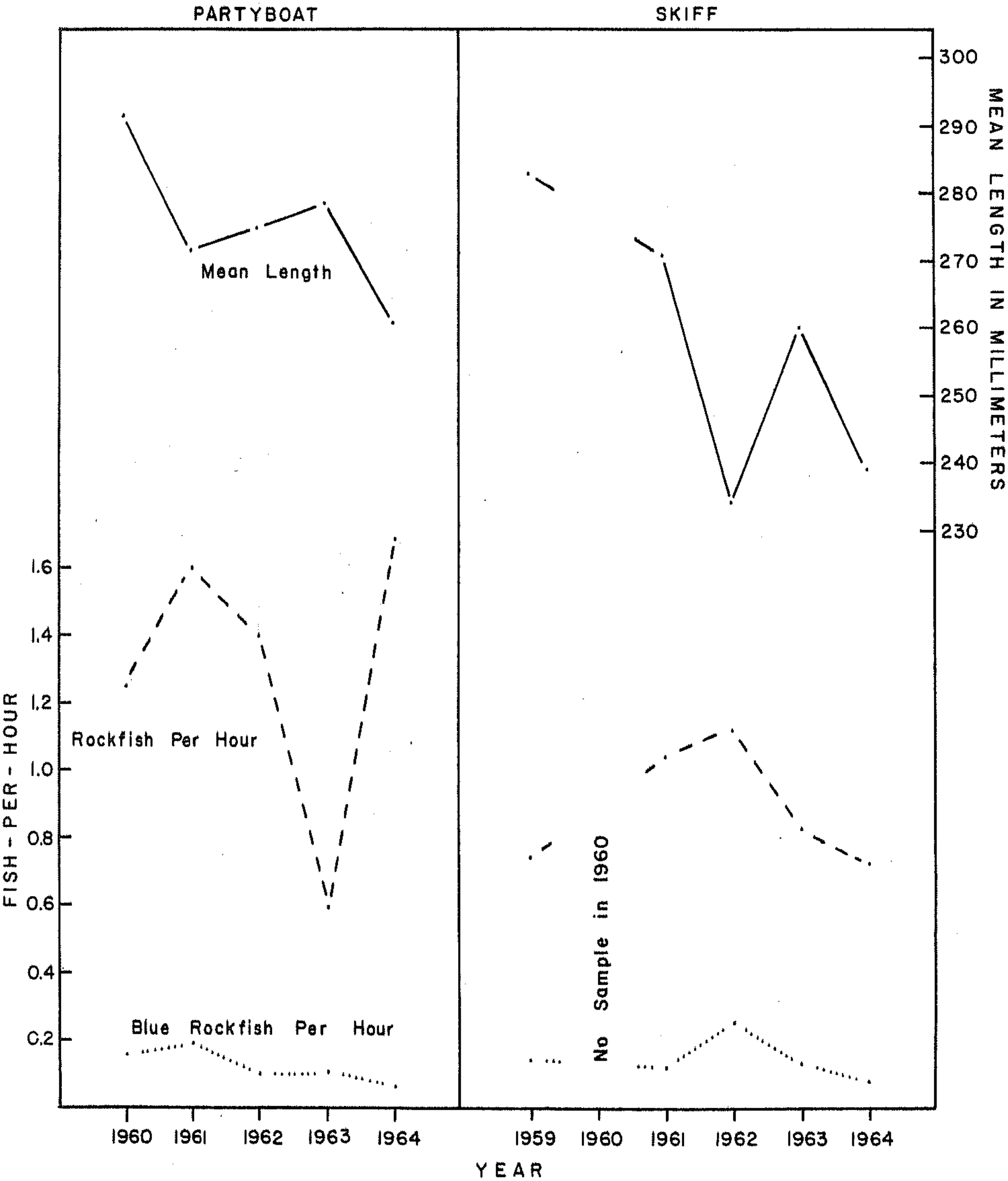


Figure 11. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Santa Cruz, 1959-1964.

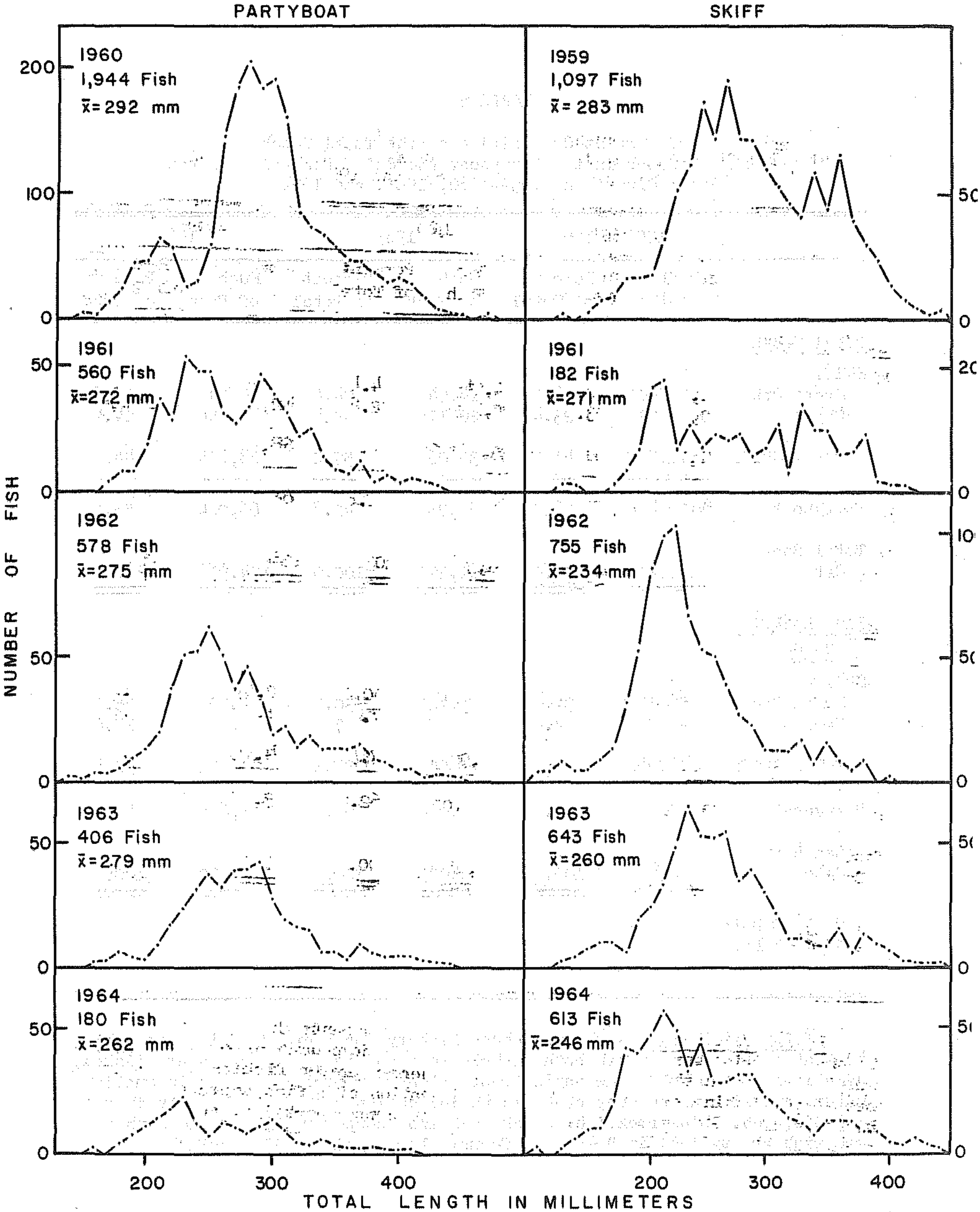


Figure 12. Length Frequency Polygons, Mean Annual Size, and Number of Blu Rockfish Sampled in the Partyboat and Skiff Catches at Santa Cruz, 1959-1964.

TABLE 5

Number and Percent Composition of the Total Catch and Blue Rockfish Catch in the Partyboat and Skiff Fisheries in the Santa Cruz Area, 1959-1960, 1963, and 1964

	1959 - 1960		1963		1964	
	Number of Fish	Percent of Total	Number of Fish	Percent of Total	Number of Fish	Percent of Total
Total Catch						
Skiff						
Santa Cruz	*31,419	18.3	14,948	24.4	26,540	19.6
Capitola	40,318	23.4	20,114	32.8	42,354	24.9
Total Skiff	*71,737	41.7	35,062	57.2	68,894	44.5
Partyboat	**100,458	58.3	26,255	42.8	86,024	55.5
Total Boat Catch	172,195	100.0	61,317	100.0	154,918	100.0
Blue Rockfish Catch						
Skiff						
Santa Cruz	*7,146	34.6	2,422	30.3	2,701	35.2
Capitola	* 902	4.4	576	7.2	1,351	17.6
Total Skiff	*8,048	39.0	2,998	37.5	4,052	52.8
Partyboat	**12,612	61.0	5,005	62.5	3,618	47.2
Total Boat Catch	20,660	100.0	8,003	100.0	7,670	100.0

* 1959 Data
** 1960 Data

Partyboat Fishery - The partyboat fishery for Santa Cruz is comparable to that at Princeton where both inshore reef and deep-bank areas are fished, sometimes both on the same day's trip. Fishermen prefer fishing in shallower water, and fishing on deep banks is an indication of a fish scarcity in the inshore area. Blue rockfish, black rockfish, copper rockfish, and gopher rockfish are typical inshore reef forms. Large yellowtail rockfish, chilipepper, bocaccio, sablefish, and greenspotted rockfish are typical deep-bank forms.

There has been relatively little inshore fishing here since 1959, and yellowtail rockfish dominated the catch in 1960, 1961, and 1963, and chilipepper in 1962 and 1964 (Table 4). Spot checks in 1965 revealed chilipepper and sablefish as the principal species.

Catch-per-hour values for total rockfish varied considerably from year to year (Figure 11). In 1963, the catch was low; 0.60 fish-per-hour compared to a more common value of around 1.40 fish-per-hour during the previous three years and in 1964. In 1963, not only was blue rockfish low in abundance, but yellowtail rockfish also declined.

Santa Cruz blue rockfish catch-per-hour values remained the lowest for all ports surveyed from 1960-1964. Also, the smallest annual mean size of partyboat caught blue rockfish (262 mm) was recorded here in 1964 (Figure 11).

The increase in mean size of blue rockfish in 1962 and 1963 reflects the annual growth increment of the influx of young fish that first entered the fishery in 1960. In 1960, fish in this group were about 200 mm in length. These fish remained the dominant modal group in 1961, 1962, and 1963 (Figure 12). In 1964, this group declined in importance and another group of young fish about 230 mm long appeared. Evidently the blue rockfish stocks here now are dependent on incoming young fish, with practically no backlog of large adult fish. The magnitude of recruitment seems to be small and has not revived the fishery.

Capitola

Only skiff fishing was conducted here for bottomfish. Blue rockfish is a minor species with white croaker, jacksmelt, and grass rockfish the principal species. Most of the blue rockfish landed here were taken on reefs near Santa Cruz. Blue rockfish averaged around 225 mm in 1962 and 285 mm in 1959 and 1960 (Figure 13). The total number of blue rockfish landed has ranged from 600-1,300 fish per year (Table 6).

Monterey

There is a variety of fishing areas near Monterey. There are extensive inshore rocky reefs, sand, gravel, and mud-bottom areas, and several deep-bank reefs. Some of the rocky areas are sandstone shelf, while others are steep granitic outcrops which form underwater cliffs and pinnacles. Kelp beds are extensive from the quiet waters off Cannery Row to the turbulent shoreline between Point Piños and Carmel.

Both the skiff and partyboat fisheries were intensively surveyed. Total catch estimates and age composition of the skiff and partyboat catches were determined for 1964. Skiff activity at Pacific Grove (summer months

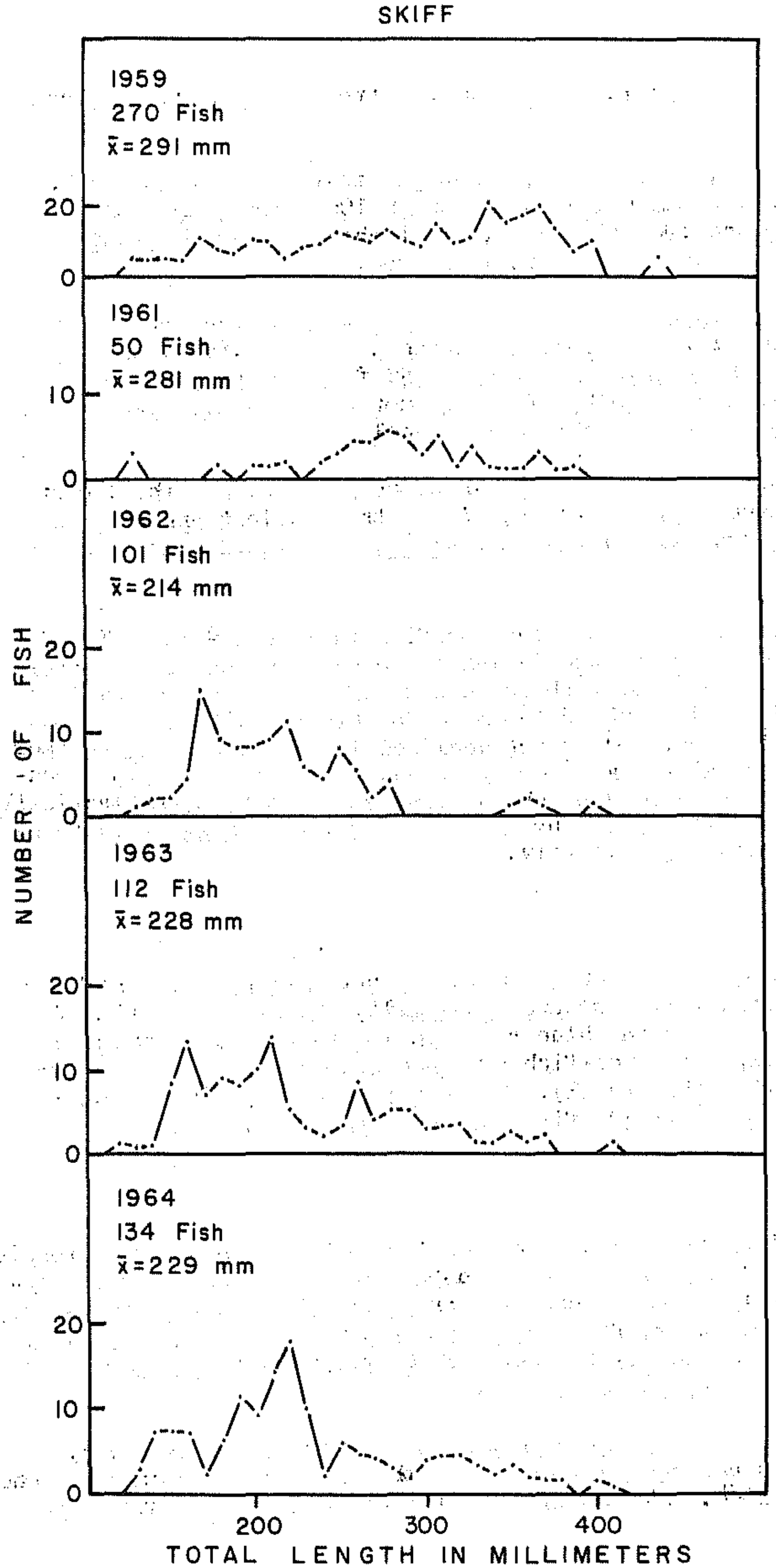


Figure 13. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Skiff Catch at Capitola, 1959-1964.

only) was included in the Monterey figures. Of the combined total of partyboat and skiff caught fish, the skiff catch made up 32.6, 13.9, and 32.2 percent in 1959-60, 1963, and 1964, respectively (Table 6).

TABLE 6

Number and Percent Composition of the Total Catch and Blue Rockfish Catch in the Partyboat and Skiff Fisheries in the Monterey Area, 1959-1960, 1963, and 1964

	1959 - 1960		1963		1964	
	Number of Fish	Percent of Total	Number of Fish	Percent of Total	Number of Fish	Percent of Total
Total Catch						
Skiff	*76,462	32.6	25,879	13.9	42,944	32.2
Partyboat	**158,026	67.4	160,740	86.1	90,579	67.8
Total Boat Catch	234,488	100.0	186,619	100.0	133,523	100.0
Blue Rockfish Catch						
Skiff	*44,291	35.6	10,112	11.1	5,883	11.1
Partyboat	**79,995	64.4	80,206	88.9	47,061	88.9
Total Boat Catch	124,286	100.0	90,318	100.0	52,944	100.0

* 1959 Data
** 1960 Data

Skiff Fishery - Each year, blue rockfish and Pacific sanddabs have been the most commonly caught fishes. Both species are highly desired and each has exhibited major fluctuations in abundance and/or availability. In 1961, 1962, and 1964, sanddabs were plentiful and each year made up about 30 percent of the skiff catch (Table 3).

The 1959 skiff and 1960 partyboat blue rockfish length frequencies were almost identical in range and modal distribution (Figure 14), indicating an abundance of large fish throughout the inshore reef areas during these years. In 1961, both fisheries witnessed an influx of young

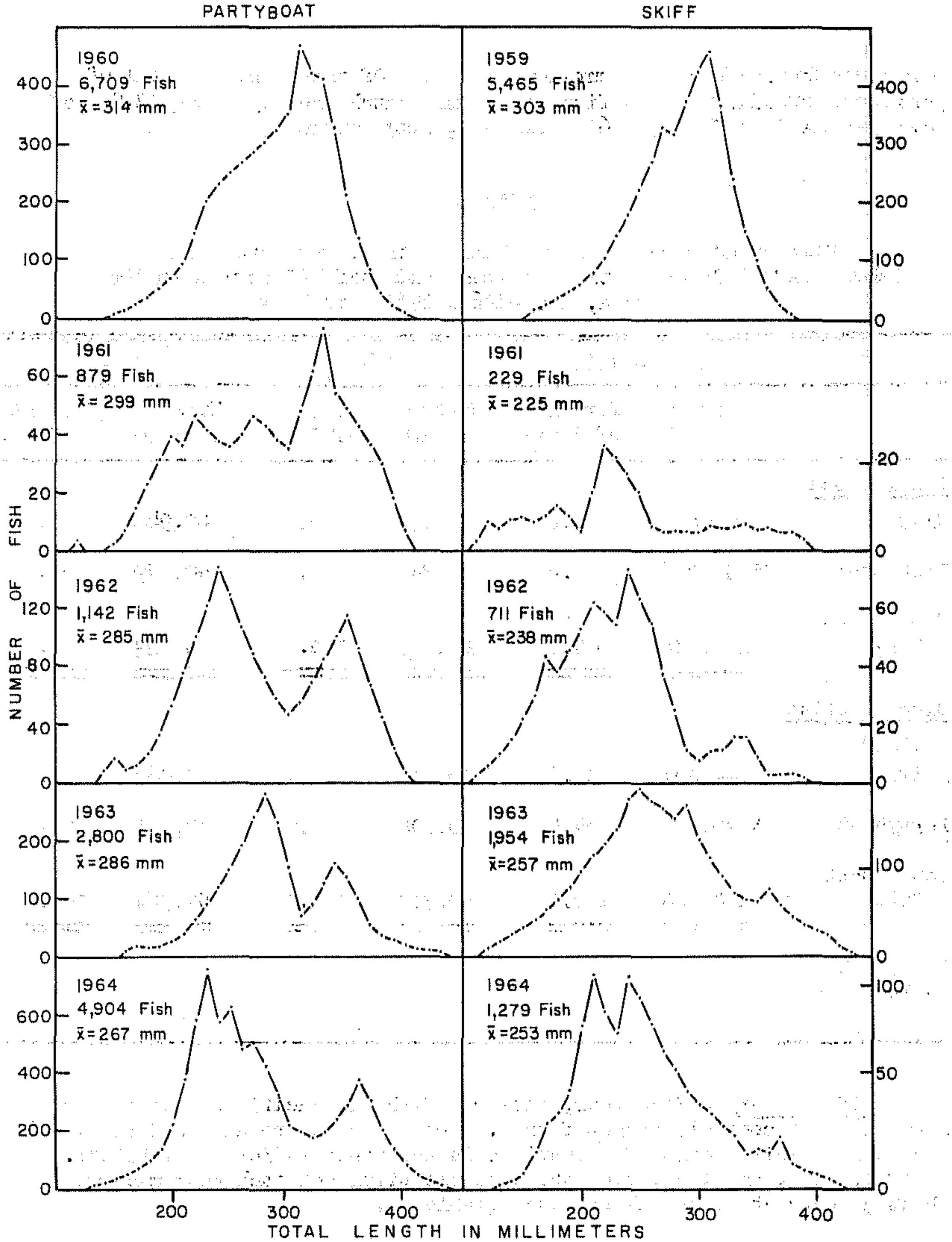


Figure 14. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat and Skiff Catches at Monterey, 1959-1964.

fish with the skiff fishery taking smaller fish than in the partyboat fishery. Since 1961, length-frequency analysis of the skiff catch reveals a sharp drop in fish over 250 mm.

The increase in catch-per-hour and percentage of blue rockfish in the total catch in 1962 was due to young blue rockfish entering the skiff fishery. Apparently in 1962, the major concentrations of these small fish were within the localities frequented only by skiff fishermen and not by the partyboat fishermen (Figure 15).

In 1963, these young fish, now around 270 mm in the partyboat and 265 mm in the skiff fishery, were more abundant in both fisheries. In 1964, the skiff fishery showed a sharp decline in the blue rockfish catch-per-hour, whereas the partyboat catch-per-hour values remained high. This indicated continued movement of blue rockfish to the deeper reef areas usually outside the range of skiff fishermen.

Partyboat Fishery - The condition of the blue rockfish fishery is different here than at any of the other ports surveyed. As at all other heavily-fished areas, the older fish have declined in numbers and young fish have entered the fishery when they are around 200-230 mm long. At Princeton, Santa Cruz, and Morro Bay, the influx of these groups has not materially revived the fishery, but at Monterey these young fish appear in large numbers as indicated by the marked increase in catch-per-hour values in 1963 and 1964 (Figure 15). Blue rockfish was the principal species in 1960 with most of the catch consisting of large fish over 300 mm. In 1961, these large fish continued to dominate the catch, but a new modal group appeared at around 205 mm. Catch-per-hour values declined in 1961, and for the first time at Monterey, yellowtail rockfish became the principal fish. Yellowtail rockfish again were dominant in 1962, and the young blue rockfish, now with a modal peak around 240 mm, outnumbered the older blue rockfish. In 1963 and 1964, yellowtail rockfish decreased in importance and large catches of blue rockfish were recorded.

The partyboat bi-modal length-frequency polygon (Figure 14) present throughout the four year period 1961-1964 can be explained in part by the nature of the fishery. Most partyboats fish on nearby reefs, but if fishing is poor, partyboat operators may run south to Carmel Bay, Point Lobos, or Yankee Point where larger blue rockfish are found. Most of the fish in these larger modal groups are from this southern fishing area. In the skiff length-frequency polygons, there has been no strong mode above 300 mm since 1961 because skiffs rarely run to Carmel Bay or south of Point Lobos.

Cayucos

The skiff fishery was sampled here in 1959. Blue rockfish was the primary species, followed by gopher rockfish, copper rockfish, and cabezon (Table 3).

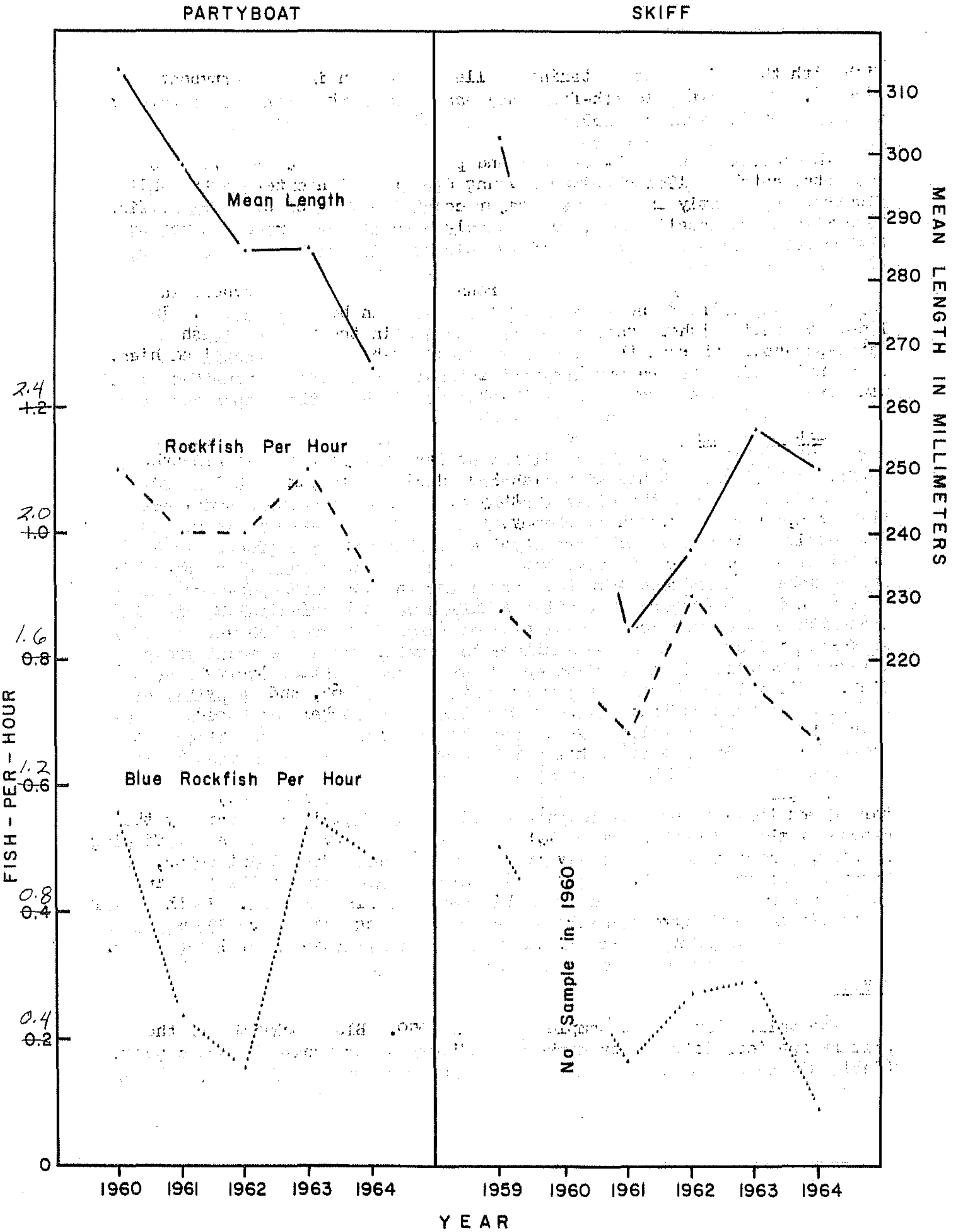


Figure 15. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Monterey, 1959-1964.

Morro Bay

Skiff Fishery - Blue rockfish is a minor species in the skiff catch and only the partyboat fishery will be described in detail.

Partyboat Fishery - Partyboat sampling was conducted from 1957 through 1964. For 1957, 1958, and 1959, only species composition of the catch was determined. During 1957 and 1958, blue rockfish contributed about 50 percent of the catch each year (Table 4). In 1960, blue rockfish yielded only about 18 percent of the catch, and during the following four years fluctuated at a low level from less than 10 percent in 1961 up to 27 percent in 1962.

Catch-per-hour values fluctuated from 1960 to 1964 with an increase occurring in 1962, then decreasing again in 1963 and 1964 (Figure 16).

The mean average size of blue rockfish decreased from around 337 mm in 1960 to 294 mm in 1963 (Figures 16 & 17). Compared to blue rockfish lengths at Monterey, Santa Cruz, and Año Nuevo landings, these fish were relatively large. The striking picture of modal changes in the length frequency polygons demonstrates a decline in large adults, but the incoming younger fish are maintaining the fishery.

The presence of large numbers of widow rockfish in 1964 was a surprise to partyboat operators (Table 4). Evidently, large numbers were readily available; however, the catch-per-hour of total rockfish (Figure 16) declined, demonstrating a decline in total numbers of rockfish, including blue rockfish. Unless a strong incoming group of young fish appears, the catch of blue rockfish may be expected to decline.

Avila

Skiff Fishery - There is an intensive skiff fishery here but we have only two years' data, 1959 and 1964, and cannot indicate trends. The average size of sport-caught blue rockfish decreased from 328 mm in 1959 to 284 mm in 1964 (Figure 18). Catch-per-hour values increased from 0.15 fish-per-hour in 1959 to 0.22 fish-per-hour in 1964.

Partyboat Fishery - The partyboat fishery has been primarily of blue rockfish, yellowtail rockfish, and gopher rockfish. Sampling at Avila was erratic, and in some years samples were collected only in the summertime.

Length-frequency polygons show a similar pattern to those for the Morro Bay landings (Figure 19). The single, large modal group around 350 mm in 1960 changed to a bi-modal distribution in 1962 with the smaller fish dominating the catch by 1964.

In 1964, it appears smaller fish, nearing 300 mm in length, were sufficiently numerous to uphold the catch-per-hour values.

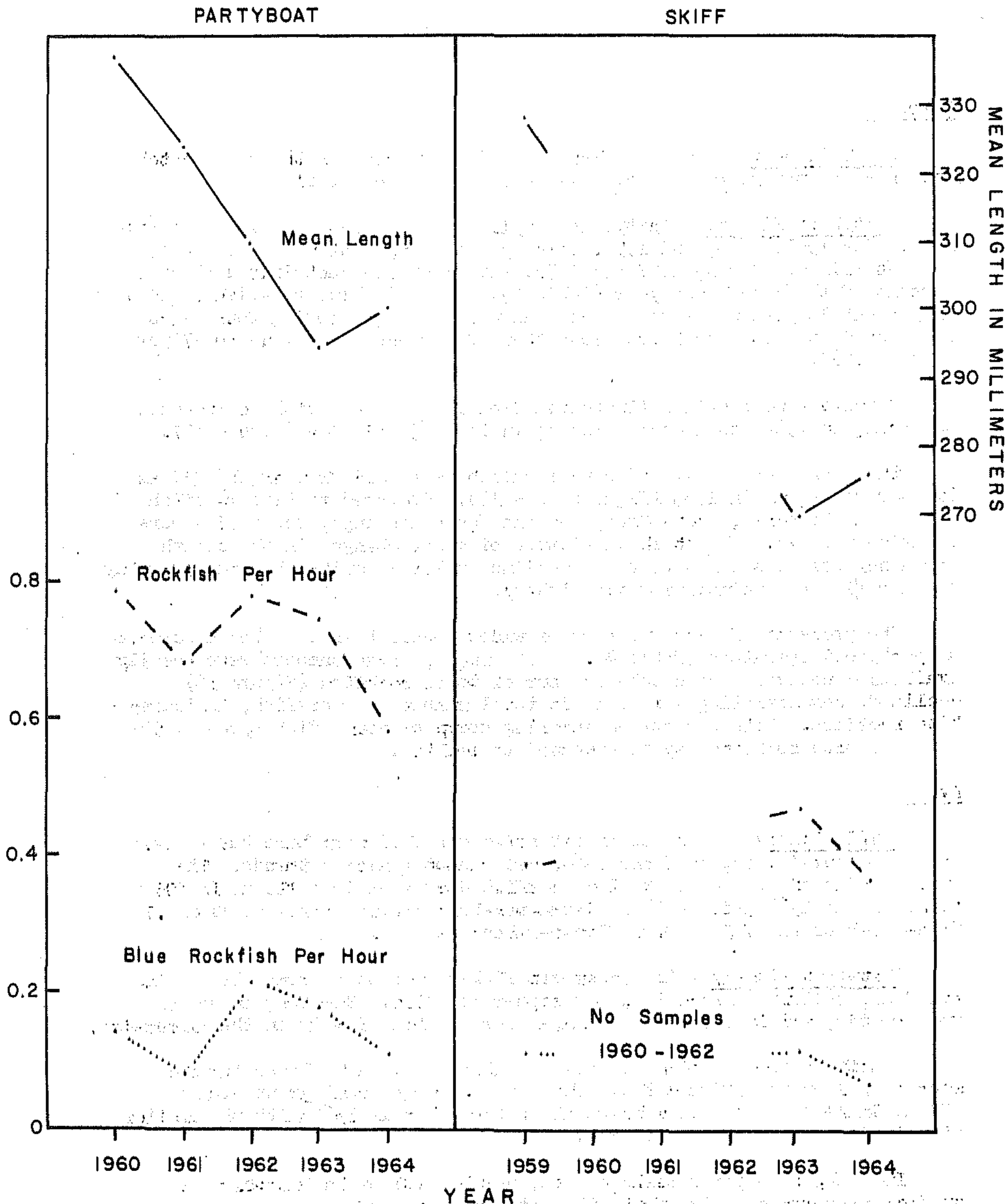


Figure 16. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Morro Bay, 1959-1964.

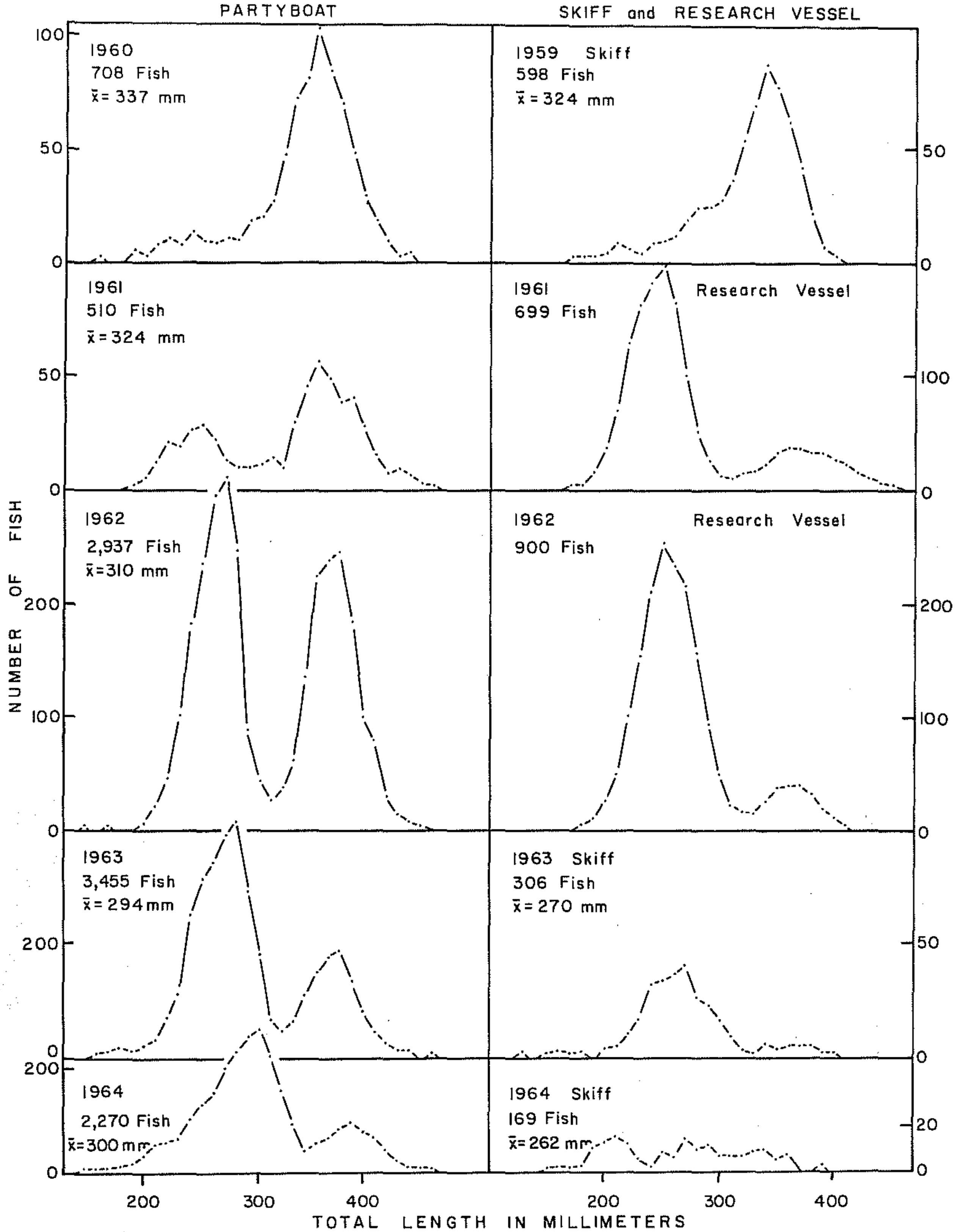


Figure 17. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat and Skiff Catches and on Research Vessel Cruises in the Morro Bay Area, 1959-1964.

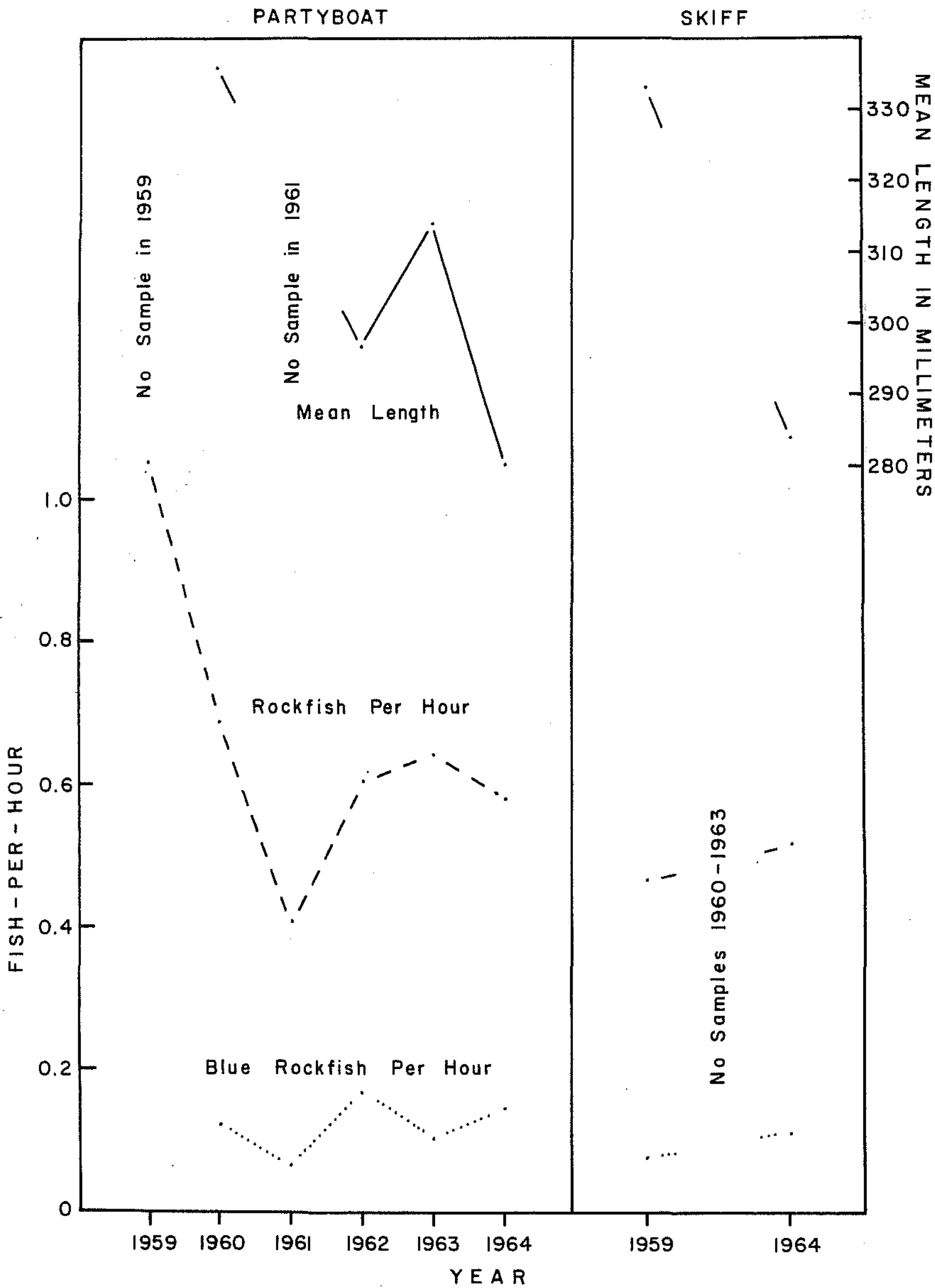


Figure 18. Total Rockfish and Blue Rockfish Catch Per Hour and Annual Mean Lengths of Blue Rockfish in the Partyboat and Skiff Catches at Avila, 1959-1964.

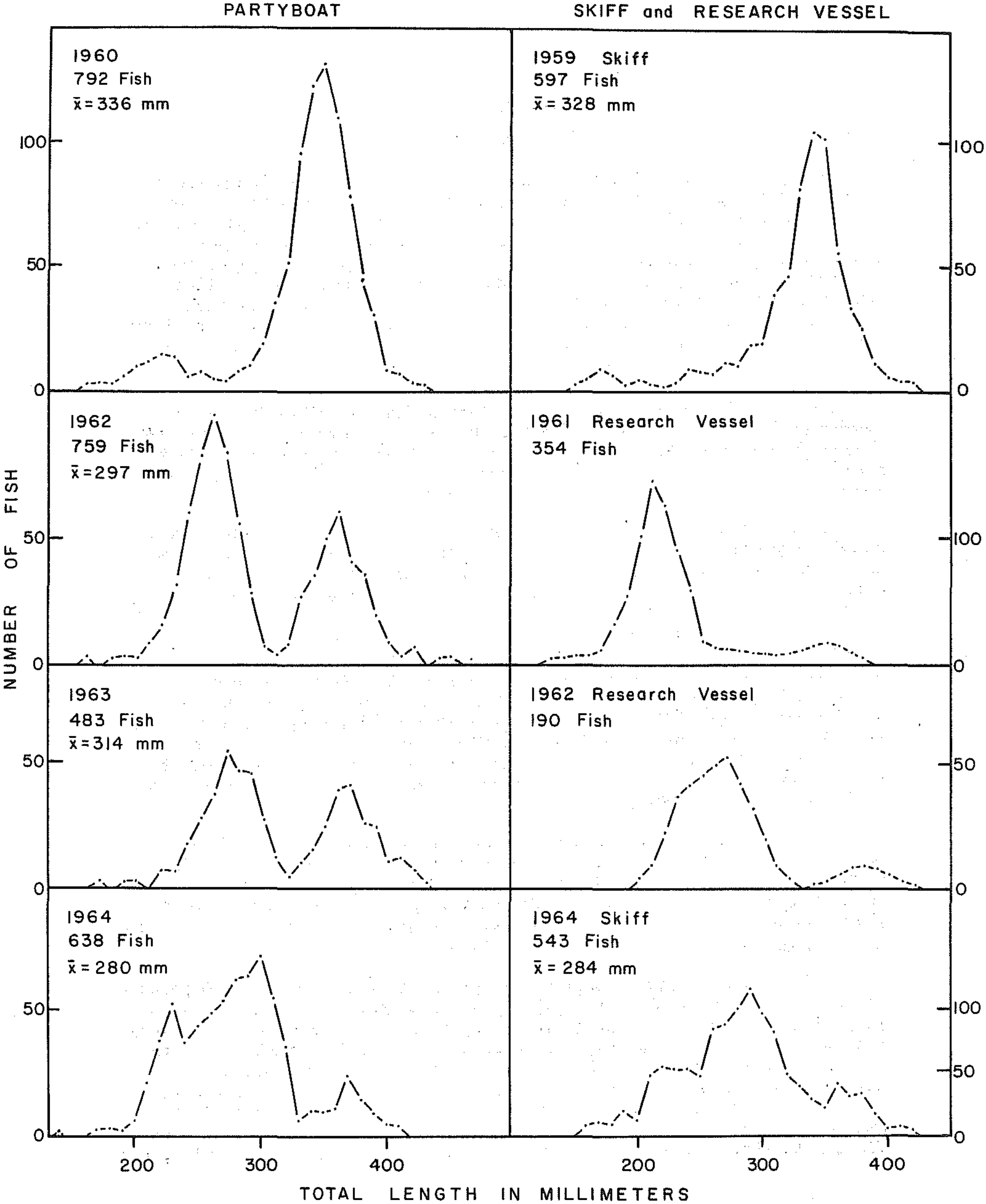


Figure 19. Length Frequency Polygons, Mean Annual Size, and Number of Blue Rockfish Sampled in the Partyboat and Skiff Catches and on Research Vessel Cruises in the Avila Area, 1959-1964.

AGE STUDY

Aging Techniques

Wales (1952) investigated scales, otoliths, and bone structures for aging blue rockfish. Scales were determined the best; however, there was not much reliability placed on reading techniques. Our approach was similar. Scales, otoliths, and other hard skeletal structures were investigated. Otoliths and scales were taken from the same fish, aged, and the results compared. We found that with juvenile fish, otoliths were the best. Scales of 0-ring fish would often show several marks resembling an annulus. Otoliths of larger fish, however, were more difficult to read and, conversely, annuli of scales became clearer and more definite on fish older than 3 or 4 years.

Scales were mounted dry between glass slides and projected at 30 diameters in a scale image projector. Readings were made, then the same scales were read again by the same reader several days later. There was nearly 50 percent disagreement and further study was initiated to find ways to more accurately define a true annulus.

An intensive tagging study and analyzation of the length-frequency modal progression of a group of juvenile fish at the Monterey breakwater supplied information that enabled us to more accurately identify annuli. Tagged fish were recovered from several weeks to two years after release. Upon capture, scales and sometimes otoliths were taken from the fish and aged without the reader having knowledge of the size, sex, or date of capture. First readings revealed continued erroneous annulus identification. By back-calculations, it was possible to determine where true annuli should appear, especially on scales of fish that had spent one winter (period of annulus formation) before recapture. In nearly all cases where an error appeared, the fish were aged older than they should have been. False and true rings were thus identified. When two annuli were counted in a certain area where only one should exist, a detailed examination of all scale marks was made.

The difficulty arose from the common pattern described by Wales of the formation of two rings separated by a band of narrowly spaced circuli during one winter period. Wales chose the first (closest to the focus) whereas we chose the paired ring farthest from the focus. Posterior to this second ring, spacing of circuli becomes wider indicating an increased growth rate over a prolonged growing period.

Using the new ring criterion, disagreements ranged from 25-40 percent between two readers. This indicated less, but continued, uncertainty in recognizing an annulus. Growth increment data from other sources indicate a continued, but not serious, erroneous choice of false annuli. For the purpose of this investigation, the degree of accuracy was considered sufficient. Refined studies of mortality rates and comparative year-class strength over several years were not within the scope of this project. Studies of the general age composition of dominant modal groups, age at first maturity, longevity, and growth rates require age determination, and the small percentage of errors in reading scales do not materially affect conclusions.

Scales for aging the sport catch were collected only during the fall of the year when there would be no confusion with new rings. Skiff and partyboat samples were combined because tagging and length-frequency studies indicated both fisheries were utilizing the same stocks even though there was some separation in fishing localities; i.e., partyboat fisheries frequented rocky reefs in depths from 80-250 feet as far south as Yankee Point, and skiff fishermen frequented shallower areas and seldom ventured farther south than Cypress Point off Pacific Grove. Scale samples for maturity and growth studies were collected at Princeton, Monterey, and Morro Bay. Age composition of the sport catch was ascertained only for the Monterey fishery.

For each day's sample, scales were taken from two fish per centimeter group, regardless of sex. Samples were not taken at random for all days of the week. Partyboats were sampled usually on Saturdays and skiffs on Sundays, when large samples could be taken.

Age determinations of the 1963 and 1964 partyboat and skiff samples were collated into age-length frequencies by 1 cm groupings (Tables 7 & 8). These frequencies were then used to convert each of the partyboat and skiff total length-frequency samples taken during the time of scale collection into number of fish of each year class in each 1 cm category. The number of fish in each year class was tallied for the entire sampling period and the age composition of the total catch of each fishery computed for each year (Figure 20).

New Ring Formation

Blue rockfish spawn during winter, and it is necessary to determine ages of fish during and after spawning at a time when new rings might appear. Scales collected for determining age composition, maturity studies, and tagging experiments from November 1964 through March 1965 were examined carefully for new rings. The new rings first appeared in January when 5 fish out of 62 (8 percent) showed new ring formation. In February, 20 percent had new rings; and by March, 70 percent had new rings, some showing considerable growth.

At the rate new rings appear from February to March, it can be safely assumed that all new rings are formed by mid-April. May 1 is considered the annulus anniversary date.

Age Composition of Skiff and Partyboat Catches

Scales were taken from partyboat and skiff catches in 1963 and 1964. In 1963, 305 fish were aged from a total sample of 3,733 fish measured, 1,779 from the partyboat, and 1,954 from the skiff catch. In 1964, 254 fish were aged from a sample of 2,249 fish measured, 970 from the partyboat and 1,279 from the skiff catch.

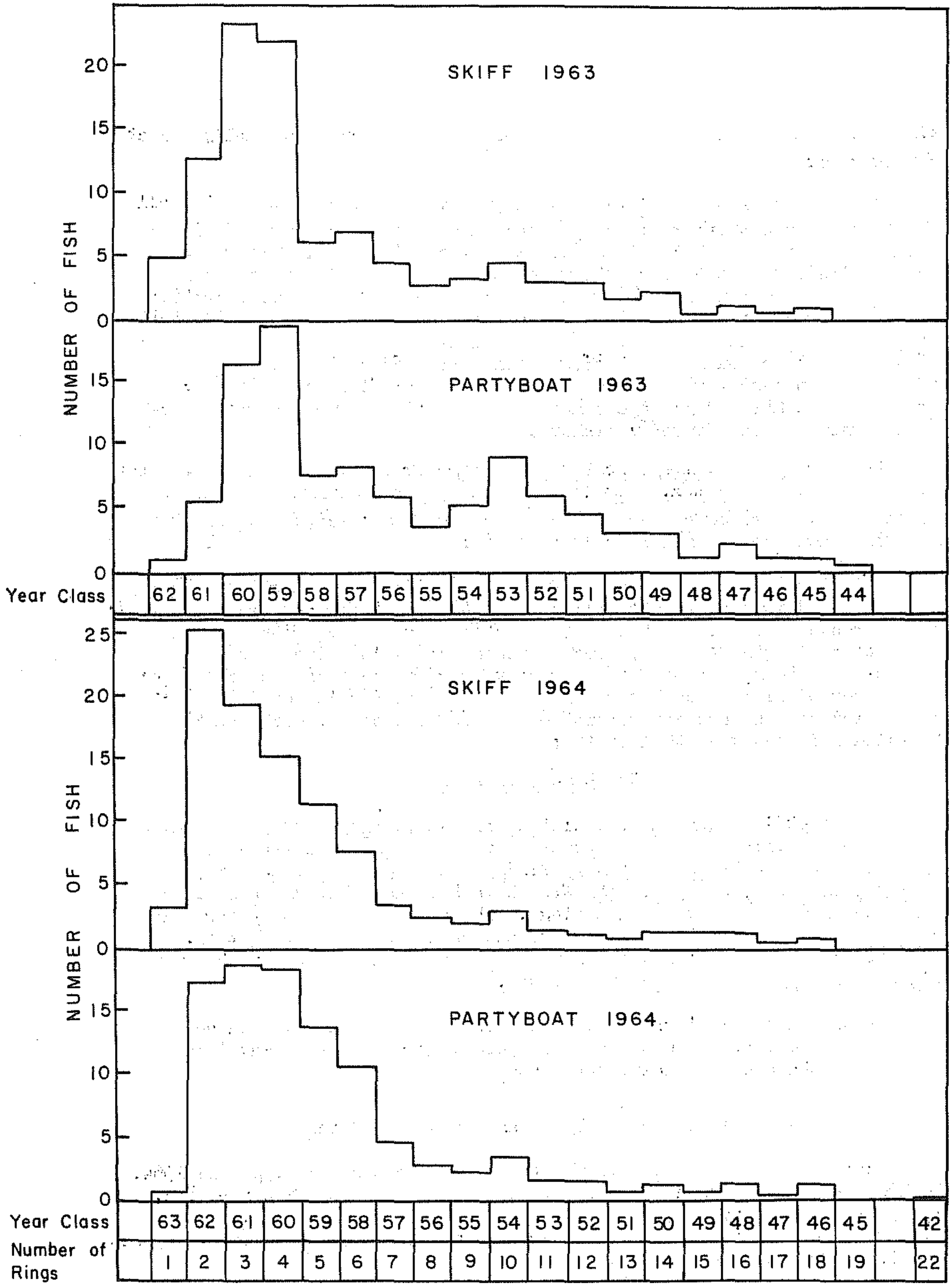


Figure 20. Age Composition of the Monterey Partyboat and Skiff Fisheries, 1963 and 1964.

TABLE 7

Age-Length Composition of Partyboat and Skiff Scale Samples by One-Centimeter Grouping at Monterey, 1963

Year Class	'62	'61	'60	'59	'58	'57	'56	'55	'54	'53	'52	'51	'50	'49	'48	'47	'46	'45	'44	
Rings	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
126-135	3																			3
136-145																				0
146-155	2																			2
156-165																				0
166-175	1	2																		3
176-185	2	1																		3
186-195		3																		3
196-205		3	4																	7
206-215			3	1																4
216-225		2	8	4																14
226-235		2	5	4	1															12
236-245		1	7	6																14
246-255			9	12																21
256-265			4	7	3	3														17
266-275			2	10	4	2	1	1	1	1	1									23
276-285			1	7	5	6	1			1										21
206-295			2	2	4	9	3	1	3	1	1									26
296-305					1	2	5	1	3			1								13
306-315						1	3	4	1	1		1								11
316-325							1	1		4		1								7
326-335							3	1	2	5	3	3								17
336-345								2	2	4	4	1	1			1				15
346-355									2	4	4	1	2							13
356-365							2		1	1	1	3	3	2	1	2				16
366-375											3	3	1	7	1					15
376-285										3		2				1	1	1		8
386-395													1	1		1		1		4
396-405													2	1		1	3		1	8
406-415												1		2			1			4
416-425																				0
426-435													1							1
Total	8	14	45	53	18	23	19	11	15	25	17	17	11	13	2	6	5	2	1	305

TABLE 8

Age-Length Composition of Partyboat Scale Samples by One-Centimeter Groupings at Monterey, 1964

Year Class	'62	'61	'60	'59	'58	'57	'56	'55	'54	'53	'52	'51	'50	'49	'48	'47	'46	'42	
Rings	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	22	Total
156-165	2																		2
166-175																			0
176-185																			0
186-195	1																		1
196-205	3																		3
206-215	3	4																	7
216-225	4	2	1																7
226-235	4	6	1																11
236-245	4	5	5	3	1														18
246-255		4	7	4	2	1													18
256-265		5	15	7	4														31
266-275		1	17	11	1		1		1	1									33
276-205		1	4	10	3					1									19
286-295			2	5	4	3	1	1		1	2								19
296-305				5	8	2	3				2								20
306-315				4	7	4													15
316-325					7	3	2	2											14
326-335					1	2		1	1			2							7
336-345						1		2	2	1			1						7
346-355							1		1		1								3
356-365									2	1			1						4
366-375									1				1	3	1				6
376-385								1							1				2
386-395													1	1					2
396-405																	1		1
406-415															2	1		1	4
Total	21	28	52	49	38	16	8	7	8	5	5	2	4	4	4	1	1	1	254

Three and four ring fish were of primary importance in both fisheries (Figure 20). The larger fish, forming a modal group around 300 mm, were 7 years and older, most of them 10-13 years. The dominant mode, around 250 mm, was comprised of 3-6 year olds. The strong 1962 year class (as 2-ring fish) made up nearly 25 percent of the skiff catch and over 17 percent of the partyboat catch in 1964. By comparison, the 1961 year class (as 2-ring fish) in 1963, only made up 13 percent of the skiff and 4 percent of the partyboat catch. However, the 1961 year class did show considerable strength in 1964, indicating this year class was not fully available in 1963.

Age-length frequencies of the combined partyboat and skiff samples show a considerable range in size within each age group (Tables 7 & 8). One of the greater size distributions of fish (196 - 295 mm) of the same age appeared in the 3-ring fish (1960 year class) in 1963.

GROWTH STUDIES

Blue rockfish growth data were derived from several sources, i.e., aging studies, tagged fish recoveries, progression of length-frequency modes of juvenile fish taken at the Monterey breakwater, and modal progressions in the sport catch at four ports.

Age-length Relationships

It is meaningless to construct a single growth curve for this species. Growth rates are variable and are influenced by sexual dimorphism, depth of schooling, and geographical location.

Growth rings on scales show a marked difference between calculated and observed lengths (Figure 21), the greatest appearing in the 2 to 6 year age groups. Observed age-length data must be used when comparing growth rates derived from length frequency and tagging data.

Differences in growth rates were found between partyboat-caught fish and those taken at the Monterey breakwater, those at the breakwater growing slower than the deeper-water fish (Figure 21).

Starting in the fourth year of life, males grow at a slower rate than females, for some, most likely, are beginning to mature sexually. By 10 years of age, partyboat caught females are, on an average, over 40 mm longer than males of the same age (Figure 22). Monterey breakwater fish did not remain in the breakwater area past 11 years of age. At the breakwater, the differences in length between males and females of the same age were not as great as in the partyboat samples (Figure 23). One reason may be that the majority of inshore fish are not yet sexually mature, and sexual dimorphism is not significant. The oldest female sampled was 23 years, the oldest male 14 years.

In spite of the small samples taken at Princeton and Morro Bay

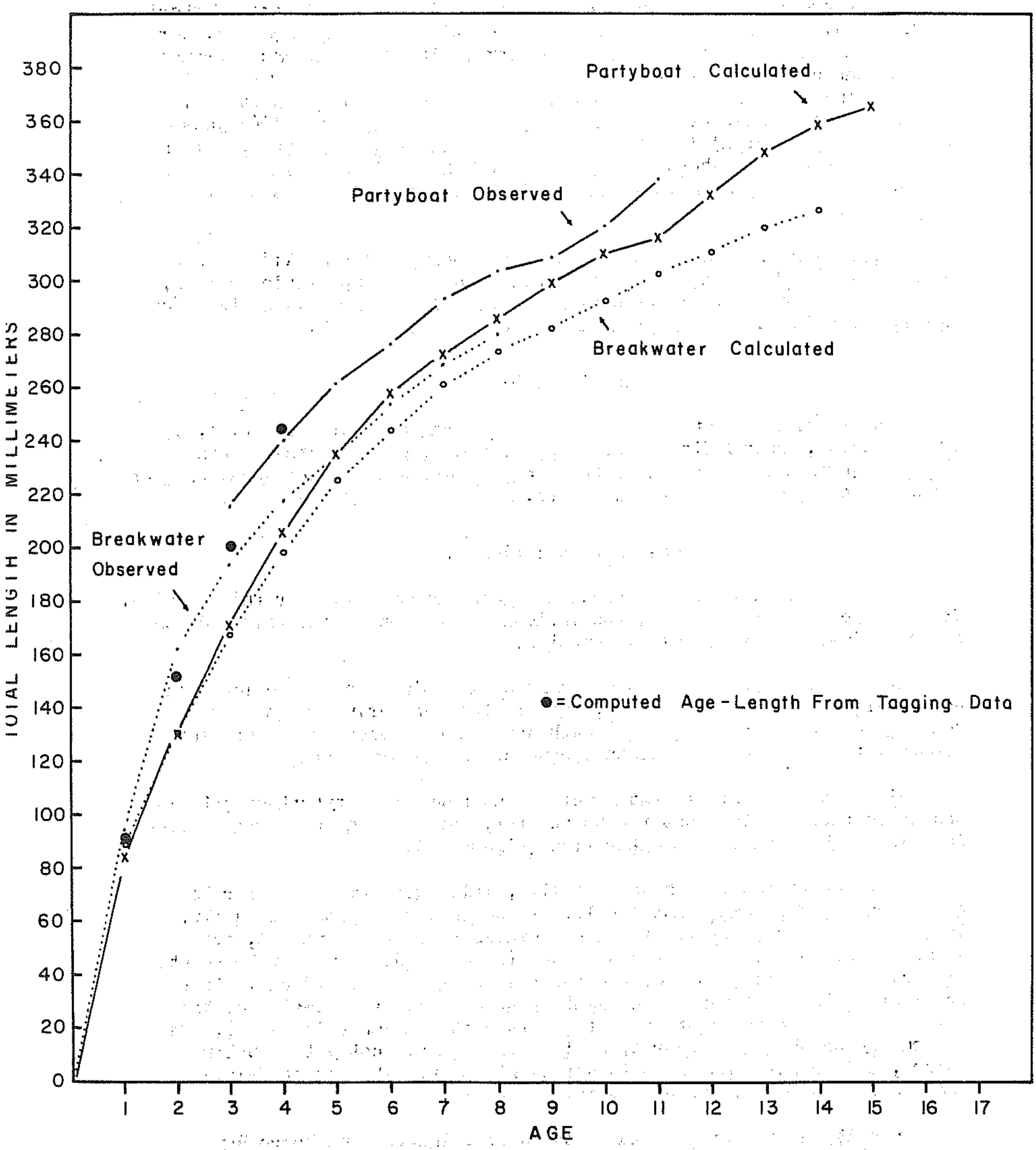


Figure 21. Age-Length Comparison Between Observed and Calculated Lengths of the Partyboat and Monterey Breakwater Scale Data.

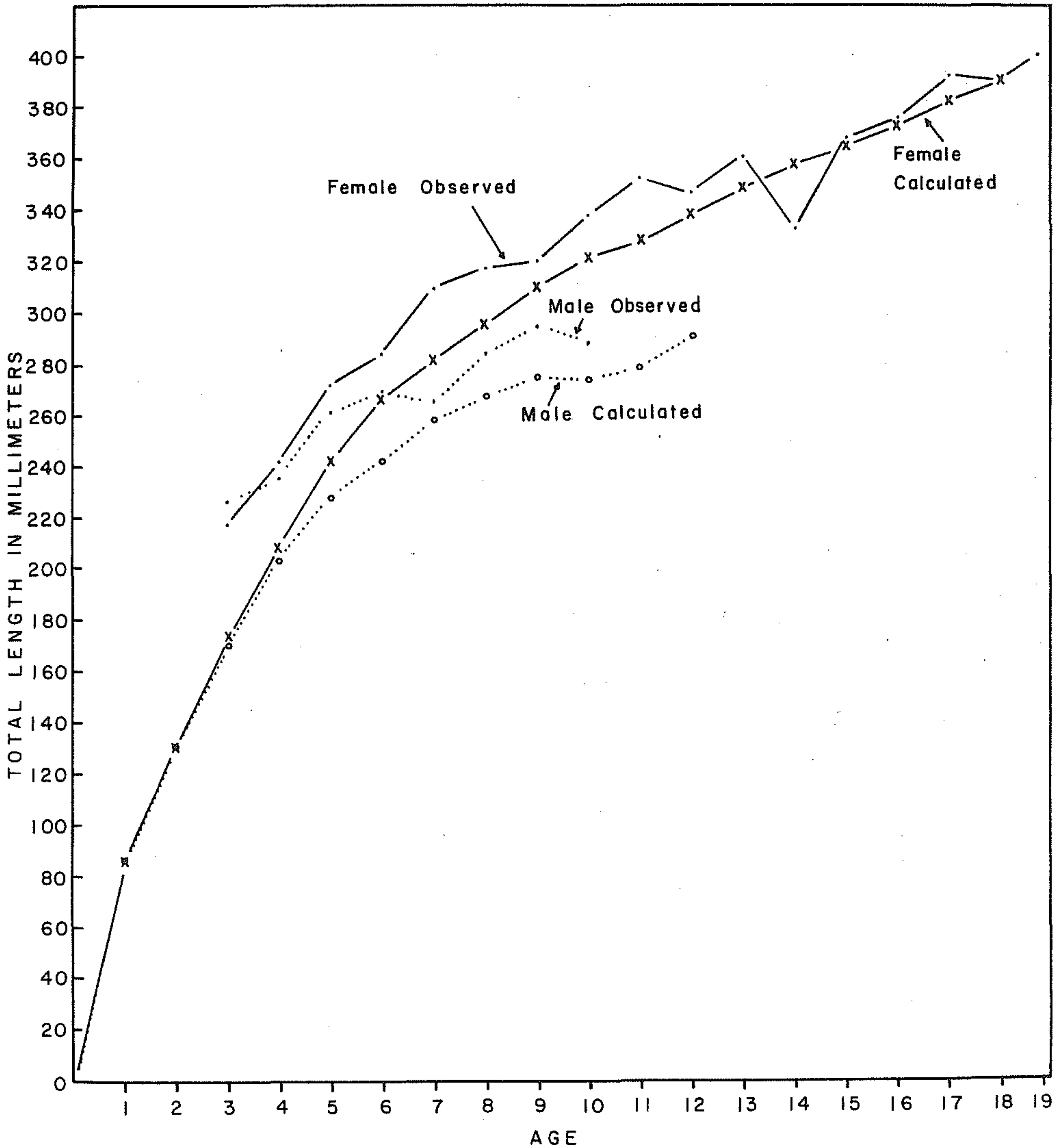


Figure 22. Age-Length Comparisons of Observed and Calculated Lengths of Males and Females in the Monterey Partyboat Catch, 1964.

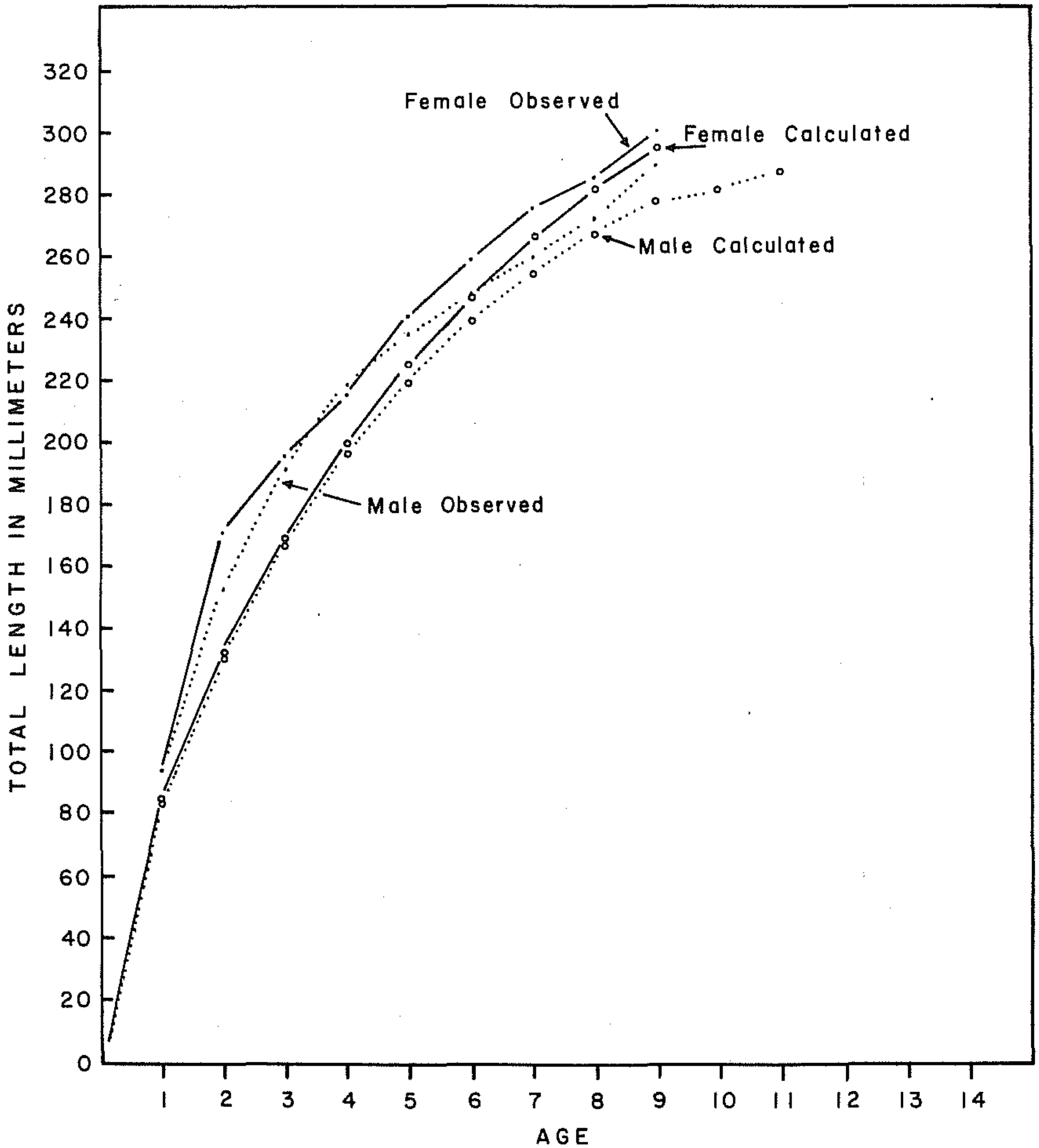


Figure 23. Age-Length Comparisons of Observed and Calculated Lengths of Males and Females in the Monterey Breakwater Samples, 1964.

(collected for maturity studies), there is an indication of a faster growth rate for fish at these ports than those at Monterey (Figure 24). Ten year old female fish at Princeton averaged around 360 mm compared to 340 mm and 320 mm for females (calculated lengths) at Morro Bay and Monterey, respectively. For the first six years, Morro Bay and Princeton fish were nearly the same size by age. Monterey fish showed a decreasing growth rate, commencing in the fourth year (Figure 24).

Juvenile Growth

First Year Growth

The first year growth rate was determined from weekly mean lengths of 0-age group blue rockfish collected at the Monterey breakwater. Between July 1963 and August 1965, 1,111 blue rockfish were collected at Monterey breakwater by traps, rotenone poisoning, and hook-and-line fishing. The majority of these fish were trapped. Only data for 1964 year-class fish were used in calculating growth rate because of their consistancy and continuity. Total lengths in millimeters were summarized weekly and the means used to calculate growth (Figure 25).

Length data for the 1963 year-class fish were inconsistant, probably because of the variety of collecting methods used and low level sampling intensity. Two samples of 1965 year-class fish were collected and these fish proved to be slightly smaller than those of 1964 (Figure 25).

Maximum and minimum sizes, which may represent growth rates of early and late spawned fish as well as demonstrate the magnitude of individual growth rate variation, were plotted.

The smallest blue rockfish and the first of the 1964 year-class was poisoned with rotenone and collected at the Monterey breakwater on April 18, 1964. This fish measured 50 mm. The last sample of the 1964 year-class was trapped on August 11, 1965, and the fish averaged 123 mm. Means of the lengths collected between April 1964 and mid-August 1965, indicated a linear growth rate (Figure 25).

Spawning activity was at its peak during the first week of February 1965, and all growth calculations were based on this period which represents the "birth date". Using this "birth date", the 50 mm fish collected on April 15, 1964, had a daily average growth rate of nearly 0.65 mm for the first 10 weeks. Average daily growth rates for the first 20 weeks of 1964 and 1965 year-class fish was 0.46 mm and 0.44 mm, respectively. In both 1964 and 1965, the first showing of the fish-of-the-year in the traps occurred 20 weeks after the assumed "birth date". By the first week of February 1965, one year from time of hatching, fish in the 1964 year-class averaged about 95 mm. An average daily growth rate of 0.26 mm for the first year is required to reach this length.

Mean lengths of 1964 year-class fish trapped at Point Santa Cruz, the tanker buoy reef off Seaside, Cannery Row at Monterey, and Pacific

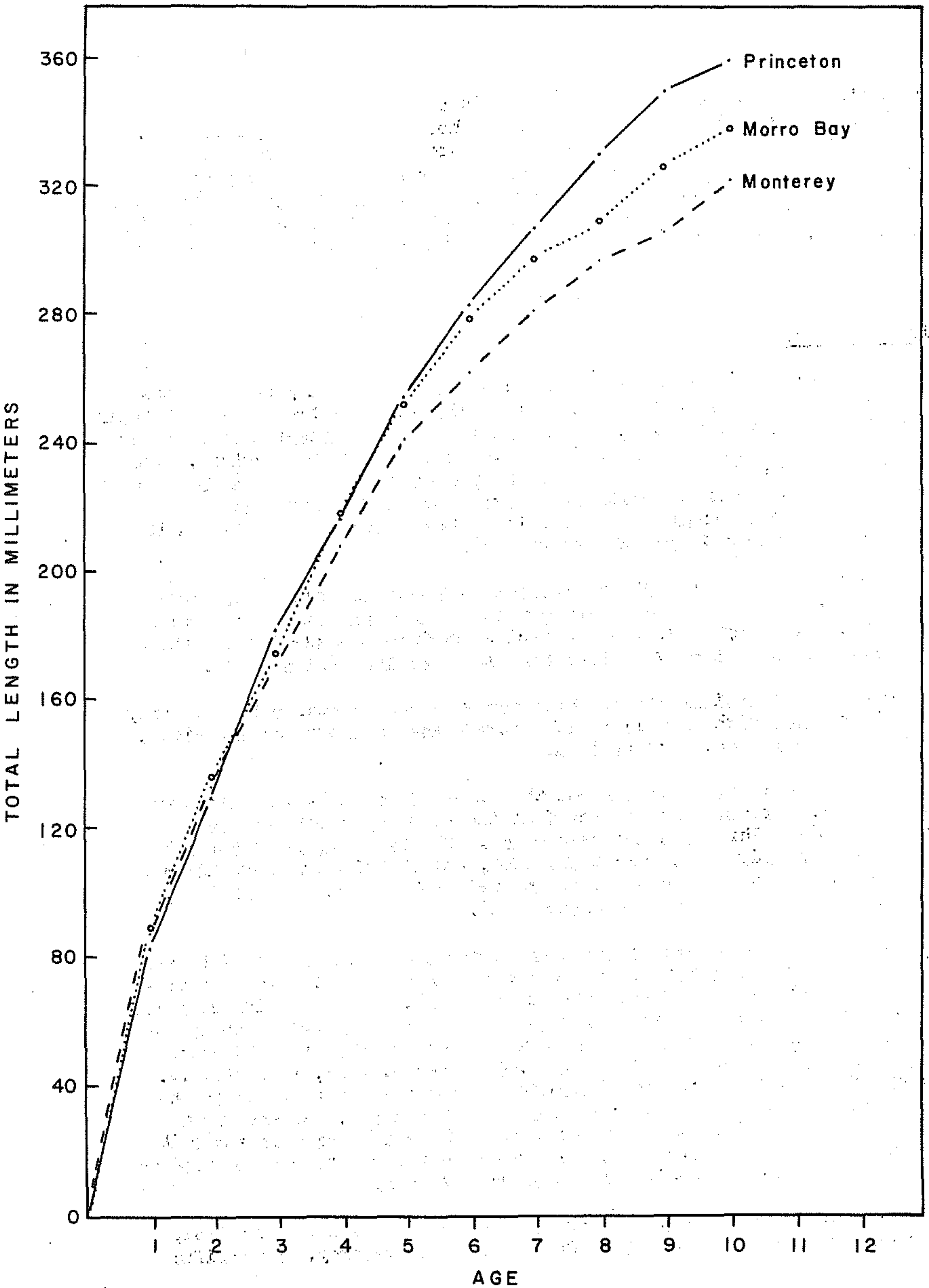


Figure 24. Age-Length Comparisons Between Monterey, Morro Bay, and Princeton Partyboat Caught Fish (Both Sexes Combined), 1964.

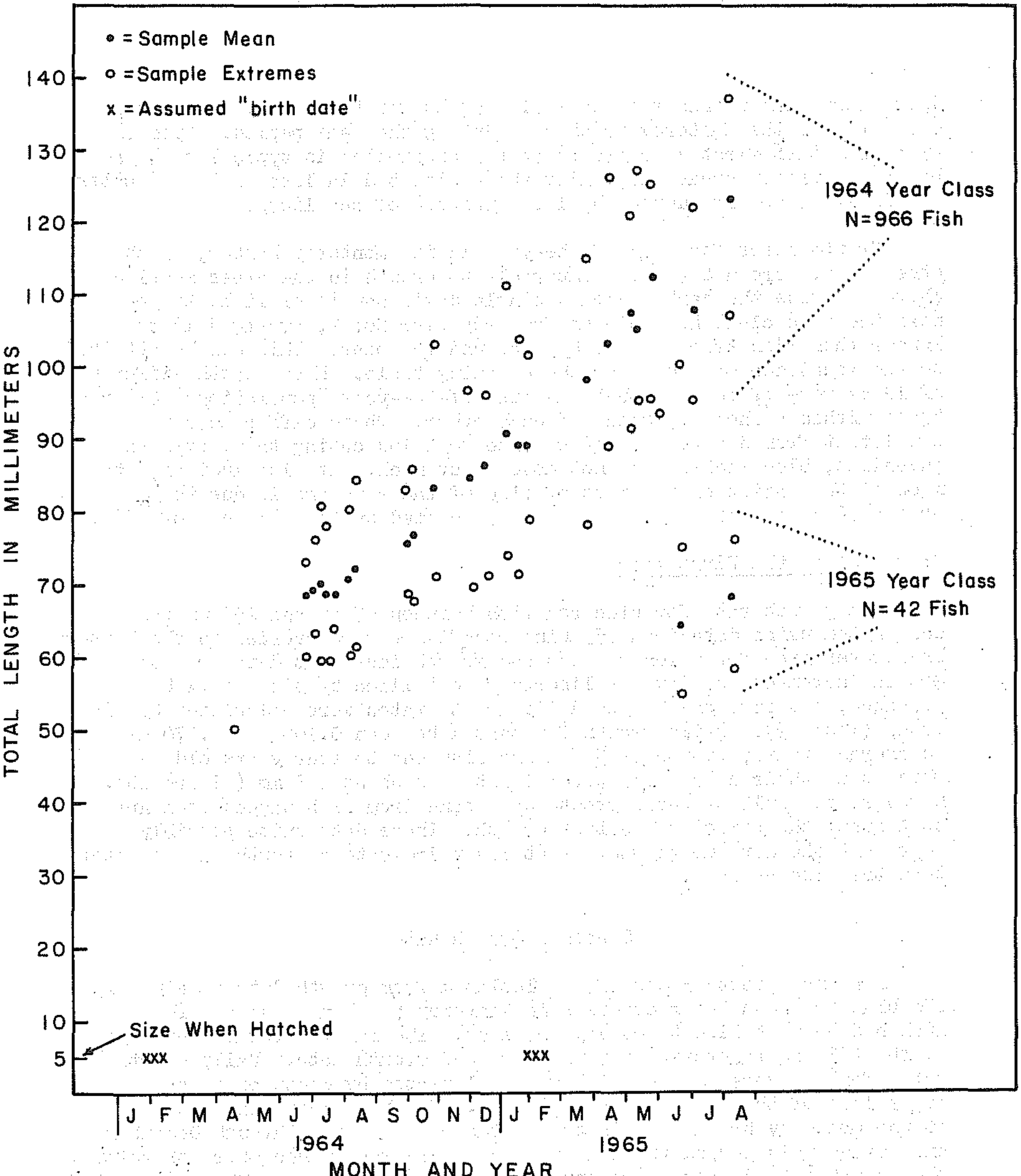


Figure 25. Scatter-Diagram of Means of Blue Rockfish Samples by Day Trapp at the Monterey Breakwater and Inside Monterey Harbor, 1962-19

Grove were well within the range of lengths for the 1964 year-class fish collected at the Monterey breakwater during the same period. From this, we assume that first year growth at the breakwater is typical of Monterey Bay area nursery areas, including those situated in less protected water and in areas not frequented by large numbers of sea lions.

Growth rates for fish-of-the-year inside Monterey harbor, on the other hand, were not always comparable to growth in the areas mentioned above. Inside the harbor area a single day's sample of fish, trapped near the fish cleaning table on Monterey Pier No. 2, averaged 13 mm longer than fish trapped elsewhere around the pier. This can be attributed to the abundance of food near the cleaning table. Mean length differences of 10 mm were often found between fish-of-the-year "populations" taken by traps within a short distance of each other. These differences were consistant from day to day and week to week indicating that, even as juveniles, blue rockfish do not move about much. It also indicates that much of the variation in sizes of fish of the same age is due to abundance or scarcity of food within the area frequented by these groups of fish.

Growth After the First Year

The growth rate for blue rockfish between 95 mm and 250 mm was calculated using data from 253 blue rockfish tag recoveries in the Monterey breakwater area for which we also had growth increment data from aging. Growth increment and days at liberty were tallied by size of fish when released, and from these data daily growth rates were calculated by size group (Table 9). Daily growth fluctuated between 0.108 and 0.170 mm with an average yearly growth of 54 mm for fish one to four years old, at which time their calculated total length was about 243 mm (Figure 26). However, the bulk of these growth data came from fish tagged from April to August, the period of fastest growth. These data quite possibly represent the maximum growth, or at least indicate a growth rate greater than the true average.

Seasonal Growth Rate

Seasonal growth rates were calculated from growth data obtained from 156 blue rockfish tag recoveries in Monterey breakwater area. These fish had been at liberty 60 days or less. The 156 recoveries were part of the 253 tag recoveries for which we had growth data. Daily growth rates for recovered tagged fish were calculated by month of release regardless of the size of fish involved. Few blue rockfish were tagged at the Monterey breakwater in the months of September through December, and during this period the only usable return was in December; therefore, the growth data do not represent all months (Figure 27). When calculated monthly, the average growth ranges from a low of -0.049 mm/day in January to a high of 0.253 mm/day in April. When negative growth increments were first encountered, they were considered anomalies due to either mis-measurements or to the effects of tagging. However, in the final analysis these negative increments were found to be of significance. When compared with data on the seasonal feeding habits of blue rockfish (Gotshall, Smith, and Holbert, 1965), a negative relationship exists between percent of empty stomachs and daily growth (Figure 27). The period of least growth, January and February, occurs when the percentage

TABLE 9

Daily Growth in mm. for 253 Blue Rockfish Tag Recoveries
At Monterey Breakwater Arranged by Total Length
At time of Release

T.L. in mm.	95-100	101-125	126-150	151-175	176-200	201-225	226-250
No. of Recoveries	7	59	86	64	24	11	2
Daily growth in mm.	.159	.165	.147	.170	.120	.108	.109

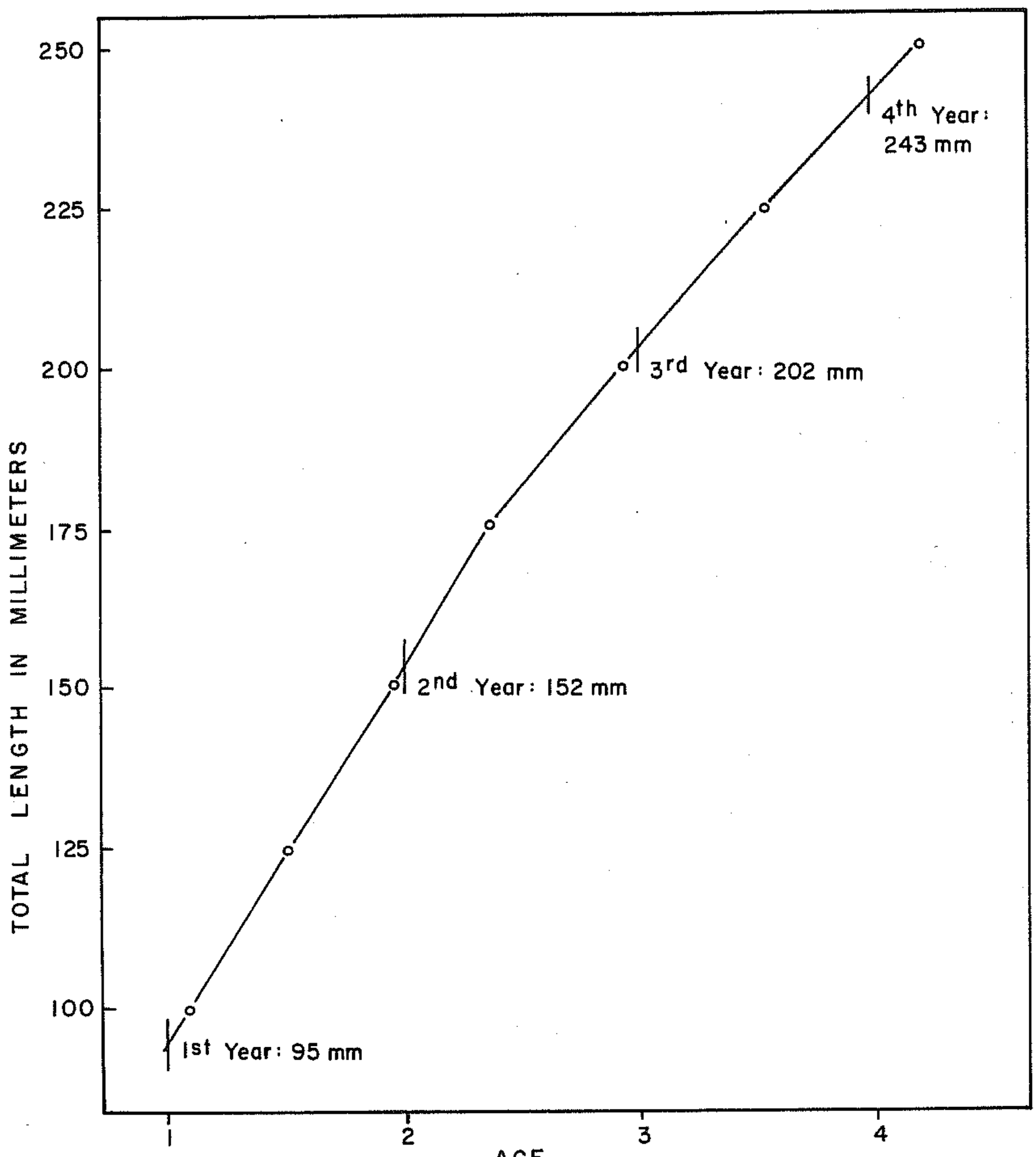


Figure 26. Calculated Growth Rate for 253 Blue Rockfish Tag Recoveries at Monterey Breakwater.

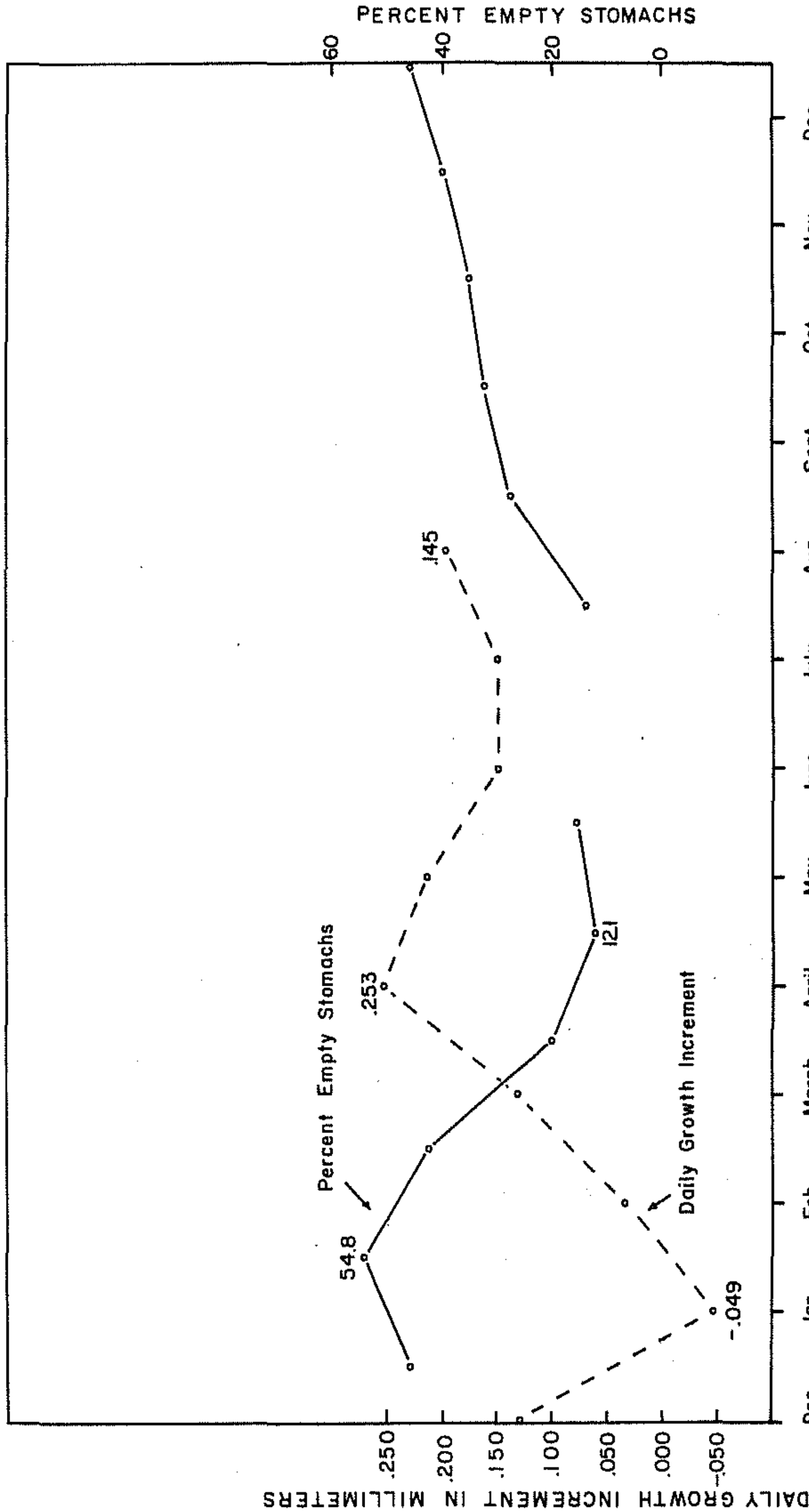


Figure 27. Percent Empty Stomachs and Monthly Growth Increment at Monterey, 1963-1964.

of empty stomachs is highest, while the period of maximum growth in April and May occurs when the percent of empty stomachs is minimal. The steady increase in percentage of empty stomachs from July to December is accompanied by a drop in the daily growth rate during this period (Figure 27).

The zooplankton on which blue rockfish feed are probably most abundant during and after periods of upwelling. In Gotshall, Smith, and Holbert, we read: "Bolin and Abbott (1963) indicated that heaviest plankton concentrations generally occur during and after periods of upwelling, and that in Monterey Bay the upwelling period is February through September. Skosberg (1936) believed the upwelling period in Monterey Bay extended from the middle of February through the end of July".

Length Modal Progression in the Sport Catch

Length modal progressions of sport-caught fish at Princeton, Año Nuevo, Santa Cruz, Monterey, Morro Bay, and Avila indicate a yearly growth increment comparable to those obtained from tag and scale data. The modal peaks of each of these groups were plotted and a composite size progression indicates a growth rate similar to one obtained from scale annuli calculations (Figure 28). These modal progressions must be considered of limited empirical significance, inasmuch as we do not know how representative the sport catch is of the total sub-population in each of the fishing areas. Since fish wander about in a local area, schools may intermingle then break up forming different-sized aggregations, etc. Since the dynamics of schooling by size are little understood for this species, apparent modal progressions from year to year may reveal important behavior patterns.

At six ports from Princeton to Avila, length modal progressions of young fish from year to year yielded significant growth patterns (Figure 29). These data were plotted at the mid-year points because samples were collected throughout the year and growth increments are added continuously. These modes thus represent the average size per calendar year.

These modal progression data indicate, as did scale aging data, that Princeton fish grow faster than those at Morro Bay and Monterey, with Monterey fish exhibiting significantly less growth per year. Monterey modal progressions indicate a growth of around 28 mm from age 3 to age 4 and 23 mm from age 4 to age 5. Monterey scale data (Figure 21) indicate growth of 33 and 22 mm for the 3 - 4 and 4 - 5 age periods, respectively. Growth increment from tagging date indicates a 40 mm growth from age 3 to age 4 (Figure 28), somewhat higher than those indicated by scale and modal progression data. This should be expected inasmuch as a disproportionate number of tag returns occurred during the fastest growing period from April to August.

The differences of modal composition between the Princeton, Monterey, and Morro Bay length frequencies (Figures 8, 14, and 17) certainly indicate a separation of fish stocks as well as variations in growth rates due to local conditions. The extreme range in size of year-old fish from 70 to 110 mm observed at the Monterey breakwater, and from 51

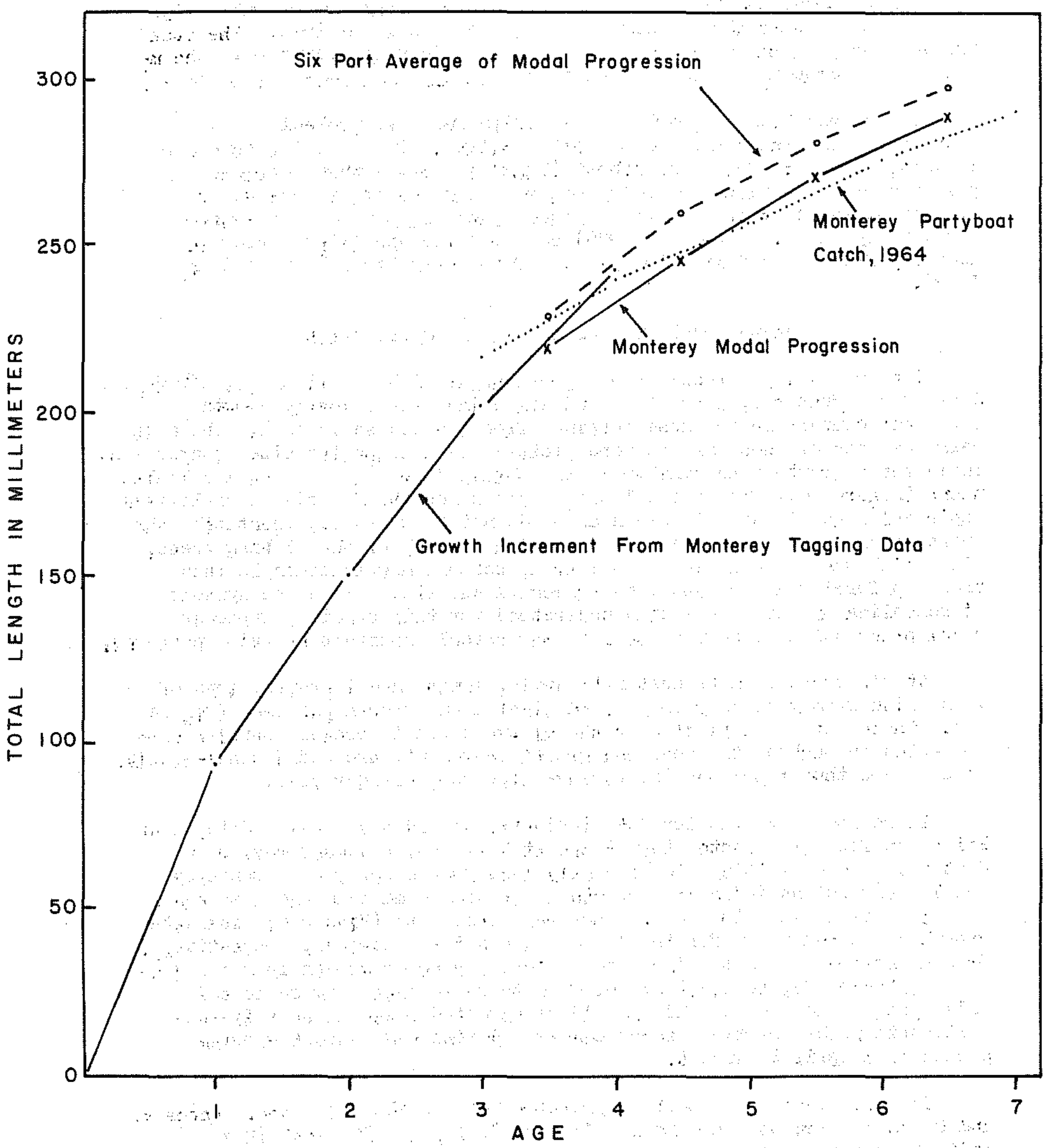


Figure 28. Comparisons of Growth Increment from Tagging Data, Modal Progressions of Sport Caught Fish, and Monterey Partyboat Catch Data.

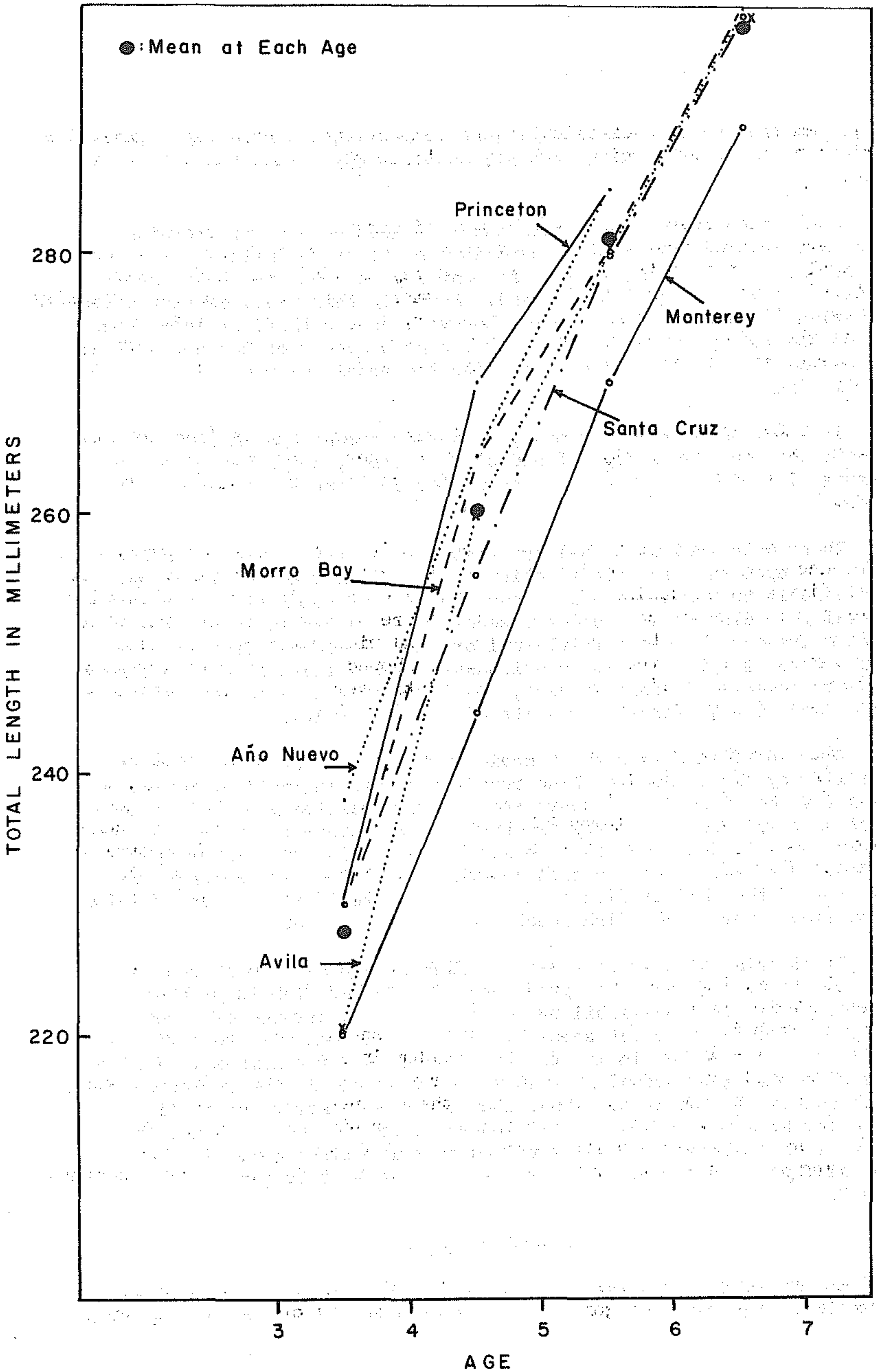


Figure 29. Growth Increment as Indicated by Modal Progressions at Six Port Areas from 1961 Through 1964.

to 120 mm from scale back-calculations demonstrates considerable individual variations in growth, which probably continue throughout the life of the fish.

Scale data reveal the significance of length-modal progressions. There are several year-classes contributing to these influxes of young (or small) fish into the catch. At Monterey in 1963, the modal group centered around 280 mm (220-300 mm). Normally this would consist primarily of 4-ring (1959 year class) fish. However, only a third of this group was of the 1959 year class. There was a good number of 3-ring, 5-ring, and 6-ring fish in this size range with the total age range from 2- to 11-ring fish.

In 1964, another strong mode, centering around 230 mm (200-280 mm) in both the Monterey partyboat and skiff catches, consisted of 2- to 12-ring fish with 2- to 5-ring fish making up about 60 percent of this group.

These data lead us to believe that fishing preference has greater influence upon the size distribution of the catch than availability. It is difficult to visualize how a concentration of small fish representing several year classes can suddenly become more available in an area where fishing pressure has been fairly uniform and widespread from shallow to deep water. Tagging results consistantly showed there were no movements of large numbers of fish; in fact, movements over 3 miles were uncommon (see pages 59 - 70 for full results of tagging study).

Blue rockfish follow the behavior pattern of most other fish in schooling by size. Smaller blue rockfish remain in shallow, rocky, kelp areas for the first 3 or 4 years and then progressively move into deeper water as they grow. Monterey breakwater data indicate movement of some larger spawning fish back into shallow areas during the winter spawning period. The skiff blue rockfish length frequencies also demonstrate presence of the smaller fish close to shore with decreased availability in shallow water as the fish reach 4 - 6 years of age.

Considering that skiff fishermen fish in depths from 10 feet to over 300 feet, the factor of preference for larger fish is probably a greater factor than availability in the sudden appearance of a modal group of fish in the catch samples. Skiff fishermen will take fish as small as 3 or 4 inches in length, but seldom in large numbers. Fish of this size will grow around 20 - 40 mm per year and in the following year, large numbers may be kept. Thus, when these concentrations of fish, schooling by size, attain a total length of around 200 - 220 mm, they become more desirable and are retained by skiff fishermen. In the following year, they are around 240 mm and are kept by partyboat fishermen as well.

LENGTH-WEIGHT

Length-weight data were collected for 278 blue rockfish with no corrections for state of gonad maturity or quantity of food in the gut.

When possible, the data were separated by sex as determined by external characteristics. Fifty-eight females ranging from 209 mm to 363 mm, 147 males ranging from 158 to 471 mm, and 73 fish down to 82 mm of undetermined sex were measured to the closest mm t.l. and weighed to 0.01 lb. When possible, two fish per centimeter group were weighed and measured.

The data were fitted by computer to the exponential equation $W = aL^b$, expressed logarithmically: $\text{Log } W = \text{Log } a + b \text{ Log } L$ where W = weight, L = length with a and b being constants (Figure 30). Standard errors and constants are listed in Table 10.

TABLE 10

Constants and Standard Errors for Weight-Length Relationships by Sex for 278 Blue Rockfish

	N	Log a	b	Standard error of b	Standard error of estimate
Females	147	-6.99302	2.80779	.06407	.18168
Males	58	-7.47782	2.98849	.08862	.05325
Combined	278	-6.31687	2.53589	.02896	.20015

TAGGING STUDY

Methods

Several problems had to be overcome when the tagging study was being developed. The first involved the physoclistous swimbladder, which expands when the fish is brought to the surface. A second concern was the problem of handling these strong-spined fish quickly and safely. Finally, there was the selection of a tag that would remain in the fish's soft flesh and not cause undue mortality.

A method of deflating the swim bladder was developed in February 1961 (Gotshall, 1964) through experimentation aboard the Department of Fish and Game research vessel, N. B. SCOFIELD, and at Marineland of the Pacific, Palos Verdes.

To find a strength of an anesthetic that would anesthetize blue rockfish for as long as 30 minutes, and yet act quickly enough so as not to slow the tagging process, tests were conducted aboard the N. B. SCOFIELD with various concentrations of the anesthetizing agent MS-222 (methane tricanesulfonate). MS-222 was tested because most species of fish react

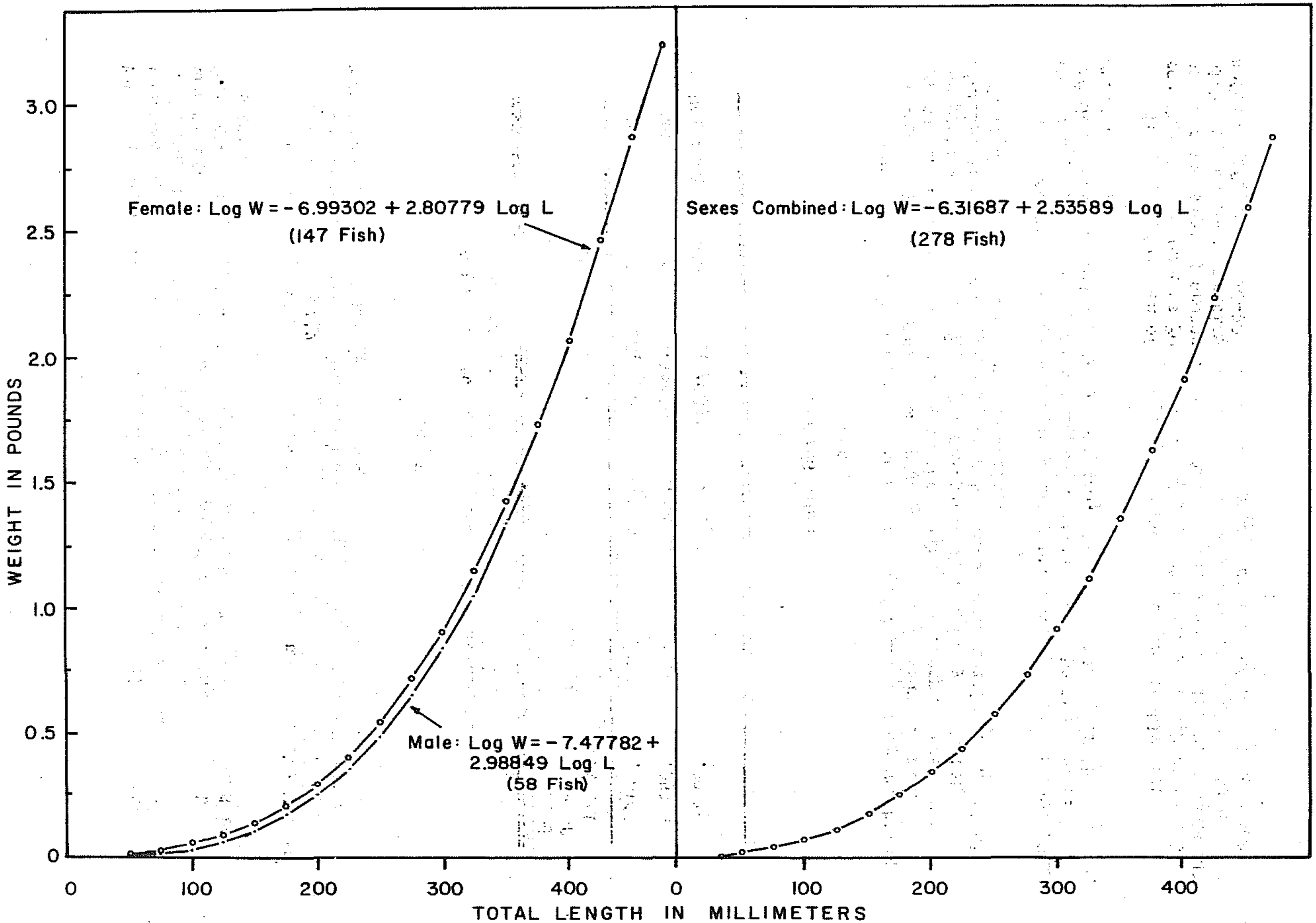


Figure 30. Blue Rockfish Weight-Length Relationship.

and recover rapidly from its effects (McFarland, 1960). Two methods of application were tested: (i) a treated sea-water bath, and (ii) direct application of MS-222 solution to the gills using a rubber syringe. The tests indicated that a sea-water bath of 1 gram MS-222 to 15 liters sea water (1:5,000) would best meet our requirements.

Several types of tags were tested on blue rockfish at Steinhart Aquarium, San Francisco. These tags included Peterson discs, dart tags, and spaghetti (plastic tubing) tags. Only one tag showed promise: a spaghetti tag consisting of a length of plastic tubing (Floy Tag & Mfg., Inc. #17 tubing) seven inches long with a piece of plastic tube one inch long tied crosswise on one end with a turban knot. The free end of the tube was attached to a stainless steel needle which was used to thread the tube through the fish. The tag was inserted posteriorly at a 45° angle starting on the right side just below the first three dorsal spines and above the lateral line, and emerging on the left side beneath the last spines. The plastic crossbar was tucked under the skin on the right side to serve as an anchor. The tag was then trimmed so that approximately 3 to 4 inches of tubing with the tag number and tagging agency initials protruded from the left side of the fish. We expected the entrance to heal, thus sealing in the tag. This so called "T" tag was used from July 1961 through February 1962, when it became apparent that the crossbar was working its way out of the flesh, thus preventing the wound from healing, and probably resulting in tag loss. Aquarium observations early in 1962 confirmed this. A new, more successful method of anchoring the tag was then devised and tested. This consisted of inserting a piece of stainless steel wire one inch long into one end of the plastic tubing and bending the wire and tube to form a hook. The wire diameter was slightly larger than the interior diameter of the tubing so that it fitted snugly. This tag was inserted the same way as the "T" type, but instead of leaving the hook buried in the flesh just under the skin, it was pulled through until it hooked on one of the dorsal spines. All of the fish since June 1962, have been tagged with this "hook" tag.

In 1963, when we began tagging fish under 150 mm, we modified the hook tag and insertion procedure to accomodate the smaller fish. We used a smaller diameter plastic tubing (Floy Tag & Mfg., Inc. #22 Tubing) with a correspondingly smaller diameter stainless steel wire. On the distal end the tag manufacturer attached a one-inch piece of their #17 tubing with the tag number (they were not able to apply numbers or letters to the #22 tubing). In the modified tag, the wire was left protruding about two inches from the tubing and was cut at an angle to produce a sharp point so it could be used as a needle. This tag was inserted from the left side at a 45° angle and pushed forward between the dorsal spines, emerging on the right side. The excess wire was cut off and the wire and tubing bent to form the hook, and then the hook was tucked into the wound and pulled back to catch on one of the spines. This way it was not necessary for the large #17 tubing to pass through the fish. When this tag was used on fish over 200 mm, we used a hypodermic needle, with the attachment end removed, for inserting the tag. The wire and tag were inserted in the needle, pushed through the fish as before, then the needle was removed.

In aquarium tests, the external wounds from the hook tags generally healed within two weeks. Field observations also indicated a similar healing period. In some recaptured fish, there was a mass of tissue around the hook, forming a capsule, usually containing pus. In a few of the recovered fish, we noticed that the flesh had actually adhered to the plastic.

We were able to tag fish as small as 80 mm with the modified hook tag.

Practically all of the fish tagged were caught on hook-and-line from party boats and Department research vessels. Most of the fish tagged at the Monterey breakwater were caught from the pier adjoining the breakwater.

In a typical tagging operation, the fish was removed from the hook, and, if necessary, the swim bladder deflated and the protruding stomach replaced. The fish was then placed in the MS-222 bath until anesthetized (belly up, fins not moving, reduced opercular activity), next it was measured, sexed, tagged, and put in a tub of fresh sea water until recovery, and finally released. When large numbers of fish were being caught, they were immediately put into the MS-222 solution and deflated just prior to tagging.

When the tagging program was initiated in July 1961, posters announcing the program and procedures for handling tagged fish were distributed along the coast. A $1.00 reward or plastic commendation card was offered for the return of tags.

Results

The primary objective of the coastal blue rockfish tagging program was to determine the extent to which blue rockfish move along the coast. Secondarily, we hoped to obtain growth information and some insight into the population dynamics of blue rockfish. The coastal blue rockfish tagging operation was initiated in February 1961, and was continued through October 1963. In all, 7,645 blue rockfish were tagged and released from Catalina Island to Fort Ross. Recoveries, as of December 1965, total 172 for a recovery rate of 2.3 percent (Table 11). Seven recoveries have been made by taggers, 4 by commercial fishermen, and the remainder by sport fishermen. The low percentage of returns is probably due to the four factors:

1. Fish not retaining tags (especially "T" tags).

2. Fish mortality due to immediate effect of handling, tagging, and deflation and long term effects caused by build-up of attaching organisms (hydroids and barnacles) on the tags, thus hampering the fish in movement and maintaining balance.

3. Blue rockfish populations in some areas may be considerably larger

TABLE 11

Number of Blue Rockfish Tagged, Number Recovered, and Total Lengths (Except Where Noted) From Fort Ross to Catalina Island February 1961 to October 1963

Area	No. Tagged	Length Range in mm by 2 cm group	Mean Length in mm	No. Recovered	Percent Recovered
Fort Ross - Bodega Bay					
1961	17	221-380*	315*	0	0.0
Total	17			0	0.0
Farallon Islands					
1961	19	321-440*	383*	0	0.0
1962	155	210-480	375	0	0.0
1963	1	250	250	0	0.0
Total	175			0	0.0
Point San Pedro - Pigeon Point					
1961	69	181-460*	285*	0	0.0
1962	540	141-440	269	2	0.4
1963	114	141-400	232	1	0.9
Total	723			3	0.4
Año Nuevo Island					
1961	178	161-420*	274*	9	5.1
1962	298	141-420	257	6	2.0
1963	160	161-400	273	10	6.3
Total	636			25	3.9
Santa Cruz					
1962	54	181-300	242	1	1.9
Total	54			1	1.9
Lovers Point - Yankee Point					
1961	626	81-400*	229*	20	3.2
1962	1108**	141-400	258	24	2.2
1963	173	161-360	264	18	10.4
Total	1907			62+	3.4
Yankee Point - Sierra Nevada					
1961	209	181-400*	300*	0	0.0
1962	1067	161-460	293	3	0.3
1963	3	++		0	0.0
Total	1279			3	0.2
Point Piedras Blancas - Avila					
1961	1061	121-460*	244*	19	1.8
1962	1230	181-420	269	53	4.3
Total	2291			72	3.1
Point Conception & Channel Islands					
1961	538	181-400*	297*	2	0.4
1962	6	241-300	270	0	0.0
1963	21	230-380	316	0	0.0
Total	565	230-380		2	0.
GRAND TOTAL	7647			168	2.2

* Fork Length
** Includes 5 Re-releases
\+ Includes 3 Recoveries with Tag No. Missing
++ Original Length Data Lost

than we suspected. Even though we tagged several hundred fish on one reef, this may have represented an insignificant part of the total population.

Even though the total return of tags was low, recoveries were considerably higher in areas of heavy sportfishing, i.e., Año Nuevo Island, Lovers Point to Yankee Point, and Point Piedras Blancas to Avila. As high as 21 percent of an individual day's tag releases was recovered in these areas.

Movements

The majority of fish recovered moved less than one mile, and many were recaptured in the same area as released (Table 12). Of the 168 fish recovered for which we have release and recovery data, 142 moved less than 1 mile or had limited, undetermined movement; 6 moved 1-2 miles; 7 moved 3-4 miles; 10 moved 5-6 miles; and 1 each moved 7, 12, and 15 miles.

The greatest migration was by a blue rockfish tagged September 12, 1962, one mile S.E. of Año Nuevo Island and recovered 147 days later off San Gregorio, a distance of 15 miles (Figure 31). This recovery was during a period of inclement weather and turbid water. The fish may have become separated from the school either because of being removed from the school when tagged, or, because of the turbid water, may have strayed to where it was recovered. The second longest movement originated in Estero Bay on September 28, 1963, and ended 332 days later near Point Buchon, a distance of 12 miles.

The record for days at liberty is approximately 1,130 days. This fish, tagged in the Cape San Martin area, had made no discernable movement; however, the recovery area data was vague and the fish may have moved a few miles. Another fish at liberty for 1,039 days near Point Buchon was recaptured from the area in which released.

On several occasions, fish released the same day in one school would be recaptured at a later date from the same school. In a single day, a partyboat fishing near Bluefish Cove, Point Lobos Reserve State Park, landed 8 tagged blue rockfish that had been released at Bluefish Cove; 6 of those fish had been at liberty 339 days, and 1 each for 379, and 687 days.

Tag Recovery by Area

Fort Ross - Bodega Bay and Farallon Islands - The Fort Ross - Bodega Bay area is not heavily fished by skiffs and partyboats, and with only 17 releases, it is not surprising that none was recovered (Table 11).

The Farallon Islands are fished by party boats when weather permits, but as yet this area is not heavily fished. The fishery is mostly for yellowtail rockfish , lingcod, and blue rockfish. None of 175 tags

TABLE 12

Distance Moved and Days at Liberty for 168 Tagged Blue Rockfish Recovered
From Half Moon Bay to Catalina Island

	Distance Moved in Miles								Days at Liberty													
Area Tagged	Uncertain or <1 mile	1-2	3-4	5-6	7	12	15	Total	1-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1199	1200-1299	Total Total
Pt. San Pedro-Pigeon Point		1	2					3			1	1	1									3
Año Nuevo Island	24						1	25	5	12	5	1	1		1							25
Santa Cruz	1							1	1													1
Lover's Point-Yankee Point	56	5	1	1				63*	12	10	2	24	2	5	6	2						63*
Yankee Point-Pt. Sierra Nevada	2		1					3		1			1							1		3
Pt. Piedras Blancas-Avila	59		2	8	1	1		71**	18	12	9	15	12	3		1			1			71**
Pt. Conception-Channel Islands			1	1				2	1	1												2
TOTAL	142	6	7	10	1	1	1	168	37	36	17	41	17	8	7	3			1	1		168
Percent of Total	84.5	3.6	4.2	6.0	0.6	0.6	0.6	100.1														

* Excluding 3 Recoveries With Tag Number Missing
** Excluding 1 With Recovery Data Missing

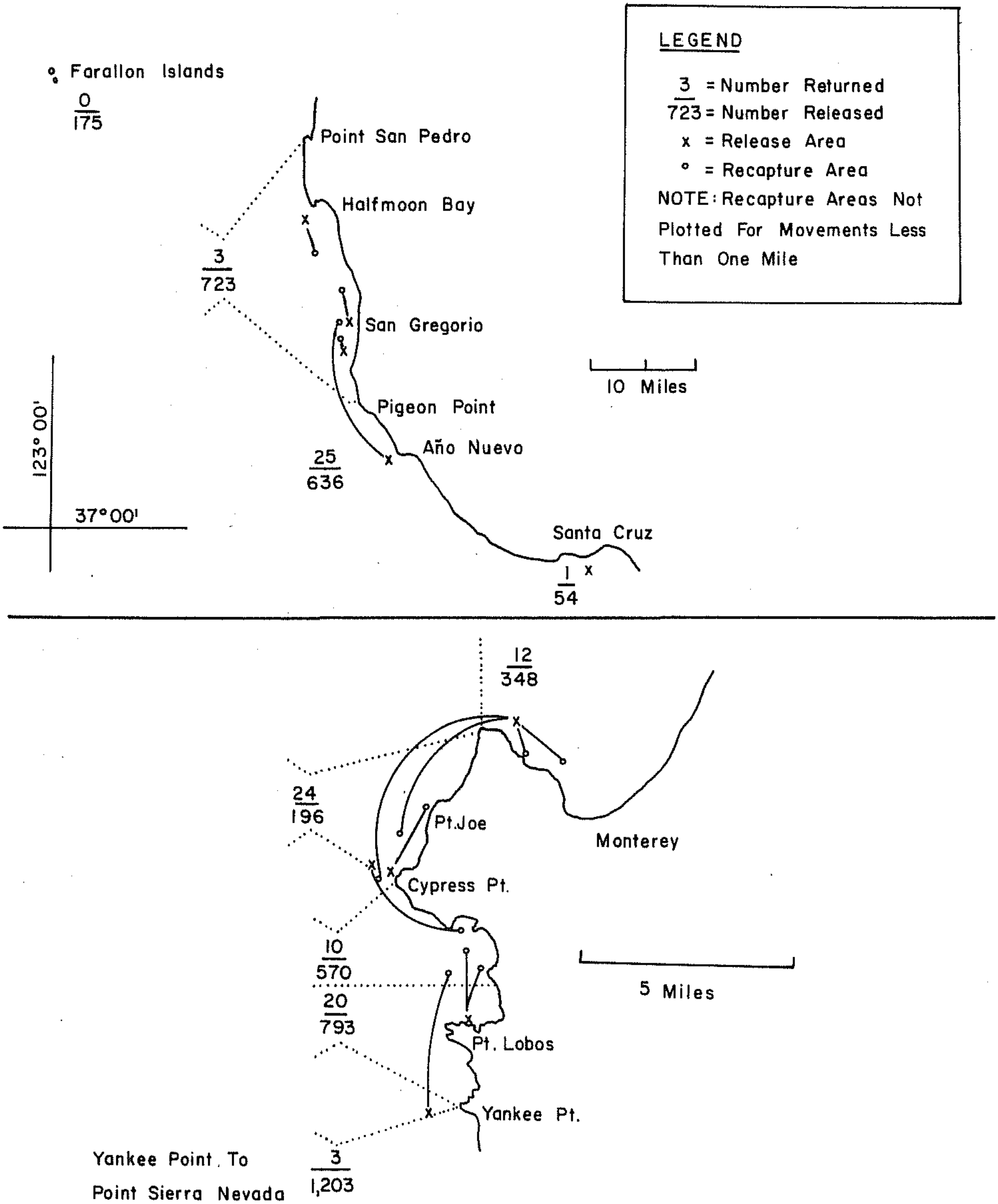


Figure 31. Blue Rockfish Tag Movements of Fish Released Between the Farallon Islands and Yankee Point.

released at the islands were recovered. The lack of an intensive sport fishery coupled with the small number of releases may account for the lack of tag returns from the Farallon Islands.

Point San Pedro - Pigeon Point - The Point San Pedro to Pigeon Point area is heavily fished by partyboats from Half Moon Bay. Much of the fishery is deep reef, and the partyboats roam over a large area. Tag returns were low for this area (0.4%) considering the high partyboat effort and high blue rockfish catch. This may indicate that there is a very large population of blue rockfish in this area and that we tagged an insignificant number of these fish. It is also quite possible that the populations of blue rockfish we tagged are not those being heavily fished by the partyboats. All recoveries exhibited little movement (Figure 31).

Año Nuevo Island - Tag recoveries near Año Nuevo Island were the highest overall (3.9%) of any area. The reefs adjacent to Año Nuevo Island are heavily fished by partyboats out of Santa Cruz. Of the 25 returns from this area, 24 had moved less than a mile, one 15 miles.

Santa Cruz - Few blue rockfish were tagged and released in the Santa Cruz area, mainly because of the low populations of these fish. One return was recorded with no movement.

Lover's Point - Yankee Point - The Lover's Point to Yankee Point area is extensively fished by partyboats, skiffs, and spearfishermen. Tag returns from this area were among the highest of all the areas (Table 11). No clear-cut migration patterns were evident, and the movements appeared to be random wanderings. Nearly 89% of the recovered tagged fish had moved less than one mile, and the largest movement recorded was five miles (Figure 31).

This section of the coast is typified by rocky headlands giving way to small rocky coves and sandy beaches. Extensive, rough reefs support luxurient growths of giant kelp (*Macrocystis* sp.) in protected areas, and bull kelp (*Nereocystis* sp.) in the more exposed areas out to about 60 feet of depth. The bottom quickly drops to several hundred fathoms in Carmel Bay, thus limiting the blue rockfish to a relatively shallow band close to shore. It appears that there is little exchange of fish from one area to another. The geography of the area is such that we were able to accurately pinpoint the exact areas of release and recovery. Some fish at liberty for more than one year were recaptured within a few yards of their release area.

Yankee Point - Point Sierra Nevada - The area from Yankee Point to Point Sierra Nevada is, for all practical purposes, untouched by ocean sport fishermen. Access is limited along this extremely rugged coast, and there are no harbors or facilities for launching skiffs. Monterey partyboats rarely venture south of Yankee Point. Of 1,203 tagged blue rockfish released in this area, only three were recovered (Figure 32). The only movement was from Yankee Point to Carmel Bay, a distance of 3 miles (Figure 31).

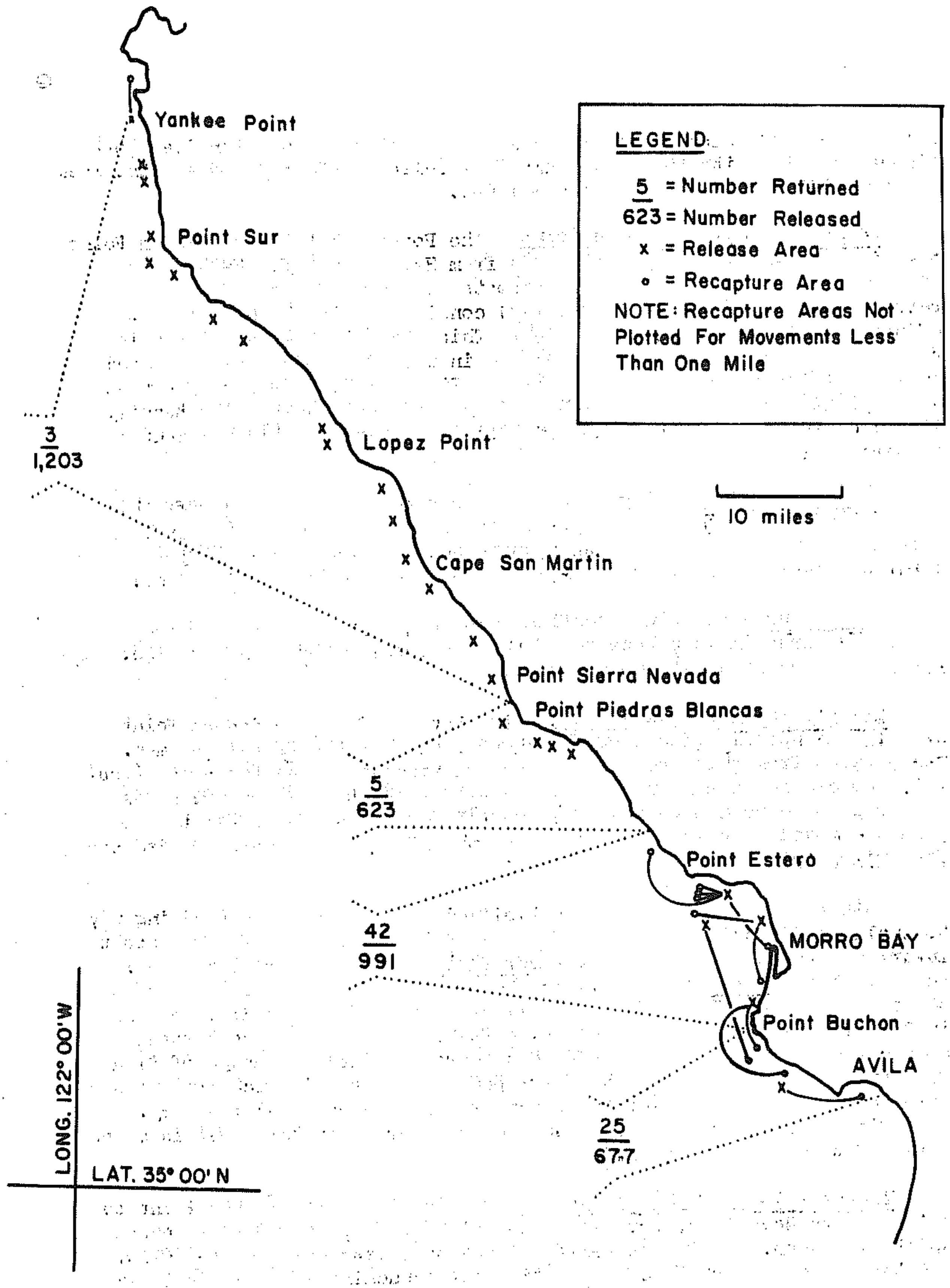


Figure 32. Blue Rockfish Tag Movements of Fish Released Between Yankee Point and Avila.

If the blue rockfish populations of Monterey and Morro Bay were lowered by the large sport fisheries of these areas, it was hoped that blue rockfish from the untapped populations of the Yankee Point to Point Sierra Nevada area would fill the void. Apparently, this cannot be expected.

Point Piedras Blancas - Avila - Nearly 2,300 tagged blue rockfish were released from Point Piedras Blancas to Avila with a total recovery of 72 (Figure 32). This area supports the largest bottom sportfish catch in northern and central California. Most of this fishery is in the Point Estero to Avila area which accounted for nearly 90 percent of the blue rockfish returns from Point Piedras Blancas to Avila. Tagged fish in this area exhibited more movement than in any other area. A movement pattern is discernable but whether or not this pattern is significant or merely the result of random movements is conjectural. Most fish released north of Cayucos moved north while most fish south of Cayucos moved in a southerly direction (Figure 32).

Point Conception and Channel Islands - Point Conception marks the southern limit of large coastal concentrations of blue rockfish. South of this point, the blue rockfish is much less common and is infrequently caught by sportfishermen. There are, however, large concentrations around San Miguel, Santa Rosa, and Santa Cruz Islands. Of the 565 blue rockfish tagged and released from Point Conception to Catalina, two fish were recovered. The recovered fish were from a group of 31 blue rockfish caught at San Miguel Island, tagged and then released at Isthmus Cove, Catalina Island, and had made movements of 3 and 6 miles each towards the northwest end of the island (Figure 33).

Conclusions

As adults, blue rockfish are non-migratory, i.e., make no latitudinal, coastal migrations. With 84.5 percent of the tag returns indicating movements of less than one mile (Table 12), it is reasonable to surmise that adult blue rockfish populations are basically discrete along the coast and that movement of juvenile and adult blue rockfish from one area to another is minimal. Quite likely, the few movements shown represent random dispersion. It is possible, however, that the pelagic larvae may be distributed along the coast, depending on inshore currents and other phenomena. The progeny of a particular reef's population may not necessarily constitute that reef's recruitment. No study was conducted to determine larvae distribution and movement.

Survival rates calculated from Ano Nuevo, Monterey, and Morro Bay area tag returns are 9.2, 25.1, and 20.4 percent, respectively (Gotshall, unpublished manuscript). Average survival rates were also derived from the 1963 and 1964 Monterey partyboat and skiff catch recoveries (Figure 20). The combined average survival rate from both fisheries was 77.4 percent. This value is almost three times that estimated from Monterey tag returns. The difference probably represents tagging mortality, tag loss, and non-return of tags. In other words, almost 66 percent of

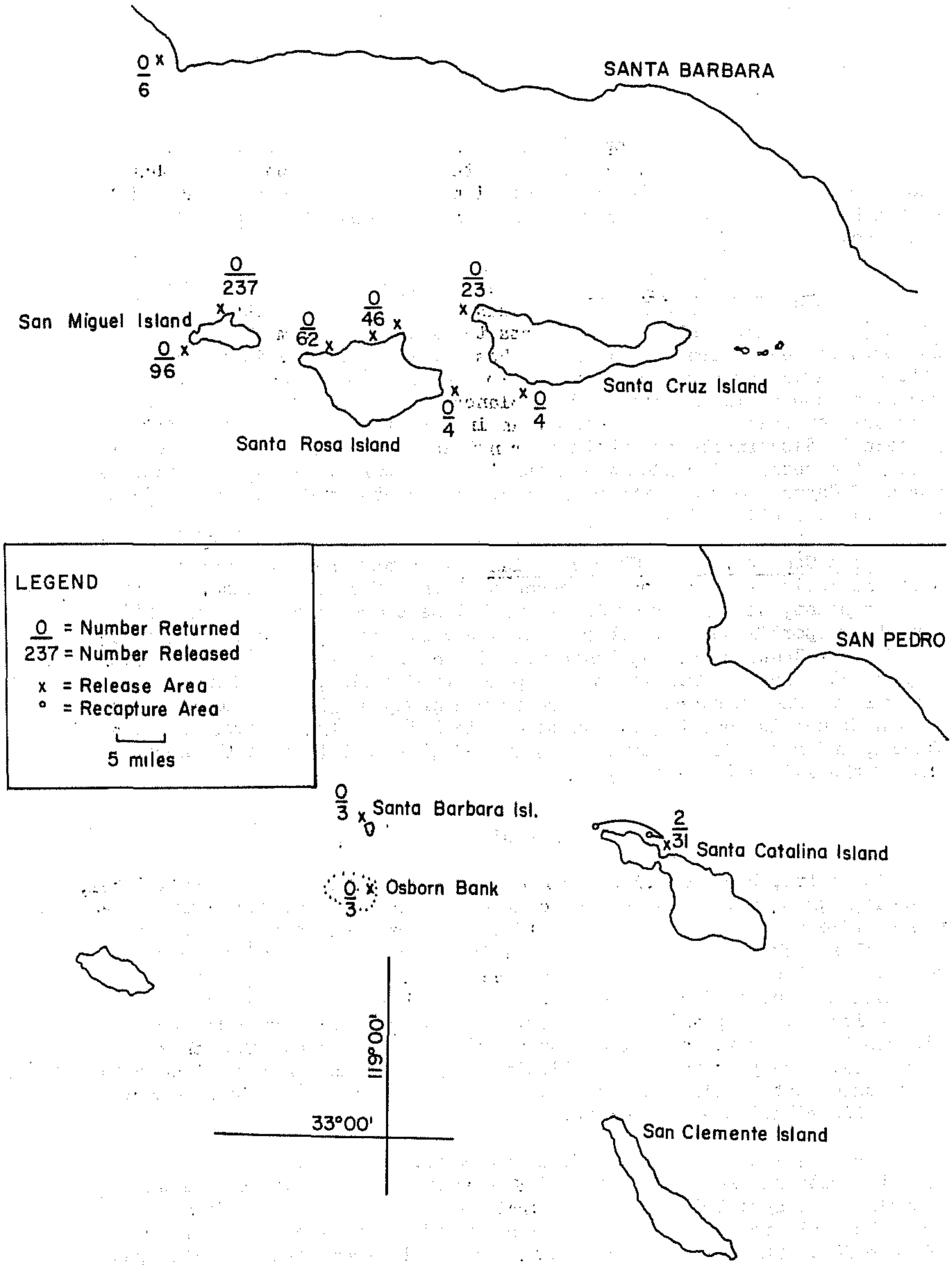


Figure 33. Blue Rockfish Tag Movements of Fish Released Between Point Conception and Catalina Island.

the potentially recoverable tagged blue rockfish in the Monterey area either died as a result of tagging, lost the tag, or were recovered but not reported.

SEROLOGY

Preliminary tag returns indicate blue rockfish are non-migratory. If so, and they are not prone to move randomly from one area to another, it may be that sub-populations exist which receive little recruitment from other stocks, thus becoming genetically separated from other sub-populations.

This genetic separation may manifest itself in erythrocyte antigens. Isolated sub-populations will often be characterized by the presence of select erythrocyte antigens in frequencies unique to that sub-population. In recent years, the existence of sub-populations of several species has been demonstrated through erythrocyte antigen studies. The knowledge of the presence or absence of sub-populations of blue rockfish would greatly effect any management program we might recommend. It was thus decided to initiate a serological study of the blue rockfish.

Methods and Materials

Blood samples were drawn from live blue rockfish taken near San Miguel Island, Monterey, Santa Cruz, Año Nuevo Island, Half Moon Bay, and the Farallon Islands. A 25-gauge needle was inserted into the branchial artery of the first gill arch or directly into the heart, and the blood was drawn into a hypodermic syringe containing approximately 1/2 cc of Alsevers' solution, an isotonic anti-coagulant. The blood was then stored in glass vials containing an equal volume of Alsevers' solution or with one drop of heparin solution per five cc of blood and kept at a temperature of less than 5°C. Most testing was done within 36 hours of collection and testing after 60 hours was avoided.

Fifty agglutination tests were run to compare the reactions of unwashed cells to cells washed three times in a saline solution. The agglutinations involving unwashed cells were more distinct, and it was decided to use unwashed cells in all agglutination tests.

Prior to testing, the blood samples were centrifuged for 15 minutes. Agglutination testing was done by the capillary tube method described by Chown (1944). Diluted serum was drawn by capillary action into a glass capillary tube (inside diameter 0.4 mm) followed by a small amount of heavy cell suspension. The tube was then stuck into clay at a 45° angle with the cells above the serum and kept at room temperature for one to two hours before reading. Reactions were scored on a relative scale with 4 denoting complete agglutination, 3, 2, 1, denoting lesser reactions and - (negative) denoting no agglutination. When there was no agglutination (negative reaction), the cells ran through the serum because of their greater density and formed a band at the bottom of the column. With a +4 reaction all cells agglutinate and form a band part way down the tube.

In partial agglutinations (3, 2, 1) some of the cells agglutinate and usually form a band part way down the tube while unagglutinated cells run to the bottom of the tube. At times, the agglutinated cells prevented the unagglutinated cells from reaching the bottom of the tube and a partial agglutination appeared as a +4. Conversely, agglutinated cells sometimes dropped to the bottom of the tube causing a partial agglutination to appear negative. For this reason, all reactions were read under 20X or greater magnification. Under magnification, unagglutinated cells can be seen to flow freely when the tube is rotated. To simplify the discussion of results, all reactions will be spoken of as being either positive or negative.

Results

Early in the study, tests were made to determine whether or not normal sera from guinea pigs, mice, or rabbits contained antibodies which would be useful in typing blue rockfish cells. Similar tests were conducted using commercial preparations of human anti-A and anti-B sera. Tests of 22 different blood samples with each of these five reagents yielded no positive reactions. Rabbit anti-blue rockfish serum was produced by injecting a live rabbit with pooled blue rockfish RBC's. The resultant anti-serum reacted positively with all blue rockfish tested down to serum dilutions of 1:32.

Normal sera of 28 blue rockfish have been tested against blue rockfish red blood cells with 4 sera giving no positive results. Of the remaining 24, some reacted positively with all cells while others gave some positive and some negative reactions. All positive reactions were evident down to serum dilutions of 1:4.

Normal sera of brown rockfish, canary rockfish, copper rockfish, yellowtail rockfish, vermilion rockfish, olive rockfish, black rockfish, bocaccio, white croaker, jack mackerel, and cabezon were also tested as possible reagents. The only non-reactant rockfish sera were bocaccio and black rockfish, both of which were tested against the same 18 blue rockfish and failed to produce a single positive reaction. Jack mackerel sera also failed to agglutinate erythrocytes of any of the 13 blue rockfish with which it was tested. The cabezon sera appeared rather fibrous and formed fibrous agglutinations with all cells tested. The serum was discarded after a few tests. White croaker and olive rockfish sera reacted very weakly and were not considered usable as reagents. Yellowtail rockfish and vermilion rockfish sera produced positive reactions for Morrel (unpublished) who initiated this study but were not tested by the authors.

The most encouraging results were from sera of brown rockfish, canary rockfish, and copper rockfish. Normal sera from these three rockfish were tested with 64 blood samples from Half Moon Bay and 19 from Monterey. Some positive reactions were evident to sera dilutions of 1:8, with dilutions of 1:2 giving best results. Brown rockfish and canary rockfish sera were more reactive to Half Moon Bay fish while copper rockfish serum was more reactive with Monterey fish (Table 13).

TABLE 13

Serological Reactions of Blue Rockfish Red Blood Cells with Brown, Copper, and Canary Rockfish Sera - All Sera Dilutions 1:2

	Brown Rockfish				Copper Rockfish				Canary Rockfish			
	+		-		+		-		+		-	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Half Moon Bay	10	(16)	56	(84)	4	(6)	60	(94)	23	(36)	41	(64)
Monterey	1	(5)	18	(95)	8	(42)	11	(58)	5	(26)	14	(74)

Repeated testing produced a high number of inconsistent results. Identical tests, run on two consecutive days, sometimes had conflicting results. In fact, identical tests run the same day sometimes produced conflicting results. Unsuccessful attempts were made to produce a specific reagent. Rabbit anti-blue rockfish serum was absorbed with cells of blue rockfish negative to the copper rockfish and brown rockfish sera, but which had reacted positively with the canary rockfish serum. The resultant serum was nonspecific. The results were not promising, and much more basic research on serological procedures would be necessary to continue. With the mounting evidence from scale and catch data that blue rockfish populations were separate along the coast, it was decided not to continue the serology study.

On the basis of this study, it appears that normal blue rockfish serum contains isoantibodies which can be used to demonstrate intra-specific variations in erythrocyte antigens. The data collected failed to identify any definite blood group systems, and lacks statistical significance. No two sera have produced reactions consistently alike or consistently inverse, and it is likely that more than one system is involved. However, with improved techniques, blood group systems may be defined for the blue rockfish.

REPRODUCTION

As in all Pacific rockfish of the family Scorpaenidae, blue rockfish development is ovoviporous with fertilization and embryonic development occurring within the paired ovaries of the female. Copulation has not been observed in Pacific rockfish. It has been hypothesized by De Lacy (1964) that copulation occurs before ovulation and the sperm are stored in the ovary until ovulation. This has been reported for Sebastes, a genus closely allied to Sebastodes, by Magnusson (1955) and Sorokin (1961).

Whether or not hatching occurs within the ovary or after extrusion from the female is somewhat questionable, but it is most widely accepted that hatching occurs when the ova containing the developed embryos are released. When released, the exposure to sea water acts as hatching stimulus and activates the larvae (Morris, 1956). The release of the embryo from the ovum must occur immediately upon exposure to sea water, judging from an underwater observation made at Monterey on February 2, 1965. A fish speared at the breakwater released embryos when hit by the spear. The fish appeared to release free swimming larvae and no ova were observed leaving the parent fish. Although this forcefully induced spawning was unnatural, it does show that if larvae do not hatch within the ovary, the larvae must hatch from the ova immediately upon contact with sea water. Hatched larvae were found within the ovaries of spawned and partially spawned fish (Figure 34), but quite often these were being reabsorbed.

Collection and Treatment of Ovaries

Ovaries were examined from 648 blue rockfish during November and December 1964, and January, February, March, June, July, and October of 1965. Areas sampled were: Morro Bay, Point Lobos Reserve State Park, Monterey, and Princeton. Fish were obtained by sampling partyboat catches, usually two fish per centimeter group, and by project personnel fishing from partyboats and skiffs. Fish were also obtained by spear fishing while SCUBA diving at Monterey breakwater and at Point Lobos Reserve. When possible, bi-monthly dives were made at Monterey breakwater from November 1964, to the end of the spawning season in March 1965. There was an abundance of mature blue rockfish at the breakwater, and fish of various sizes were easily taken by spear.

Ovaries were carefully removed from the fish and preserved in 10 percent formalin. Scales and sometimes otoliths were taken from most fish for age determination, and all fish were measured within 1 mm total length. When lack of time or other circumstances prevented us from saving ovaries from every fish sampled, and the maturity of a fish was obvious by the condition of the ovary, the stage of ovarian maturity was determined in the field. All ovaries not positively classifiable by macroscopic examination were saved for microscopic examination in the laboratory.

Maturity Determination by Ova Diameters

Maturity was based on ova diameter measurements in much the same way as was reported by Clark (1934). Preserved ova are usually irregularly shaped, which necessitates measuring along a random axis. Measurements were made under 60 magnifications with ocular micrometers calibrated at .033 and .034 mm per unit. The preserved ova were teased out onto a watch glass containing water and were measured as they came into view along the axes parallel to the graduations of the micrometer. Measurements were thus randomly made along all axis of the ova.

A minimum of 50 ova were measured from each ovary and the mean was

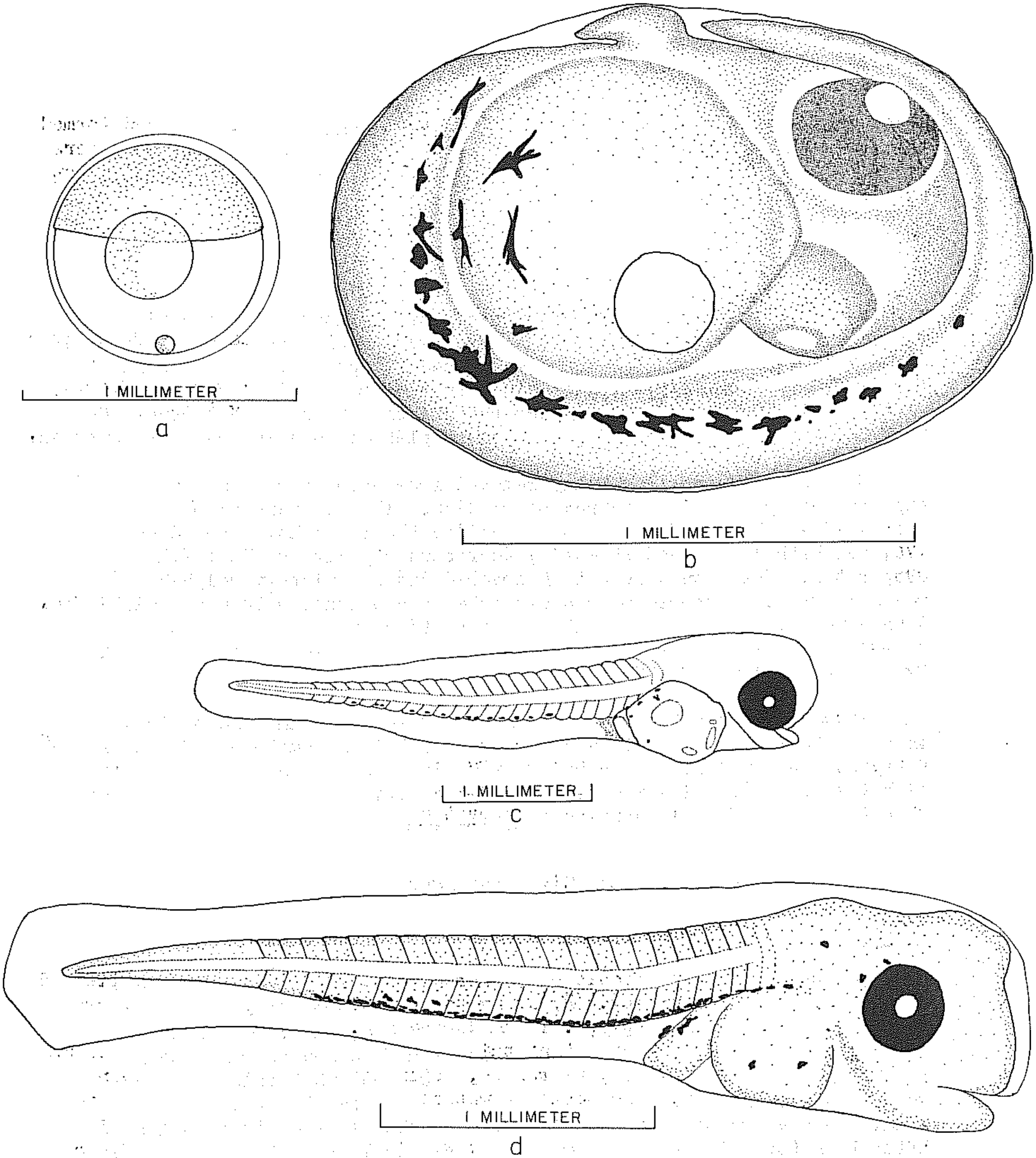


Figure 34. Larvae and Egg Drawings.

a. Cleared ovum undergoing gastrulization.
b. Advanced ovum nearing hatching stage.
c. Prematurely hatched larvae found within lumen of ovary prior to spawning.
d. Fully developed larvae found in lumen of recently spawned ovary.

calculated for each sample. These calculated means were plotted and formed the basis for maturity determination (Figure 35). When the mean diameters of all ova from an ovary fell below .300 mm, mean diameters of the largest ova in a sample were plotted.

Fecundity

Fecundity estimates were calculated for 11 mature blue rockfish ranging in size from 256 to 300 mm. The ovaries of five mature unfertilized fish and six fertilized fish were collected and preserved in 10 percent formalin. Fertilized fish (excluding "running ripe" fish) were preferred, as the ovulated ova were easily separated from excess ovary tissue. One ovary was used from each fish, as most samples did not include both ovaries.

Excess tissue was carefully removed from each ovary, and the entire egg mass was placed in a tarred petri dish. The ova were allowed to partially dry before weighing to stabilize their weight. The weight of ova, wet with 10 percent formalin, decreases rapidly as the formalin evaporates. The dishes were then covered and immediately weighed within one milligram. A sample of ova was taken and weighed within one milligram, then counted. The ratio of sample weight to sample count was used in calculating total count from total weight. The estimated count of one ovary was doubled for each fish.

Fecundity estimates ranged from 53,300 in a 256 mm fish to 233,700 in a 330 mm fish. Wales (1952) estimated a 405 mm female contained 524,000 embryos. In general, the number of eggs increased with the size of the fish (Figure 36). Blue rockfish fecundity estimates fell within the calculated fecundity of 10 species of Sebastodes (Phillips, 1964).

Maximum and Minimum Sizes and Ages of First Maturity

Females

The smallest spent female encountered, measuring 230 mm, was collected on July 2, 1965 at Monterey. By using the calculated daily growth increment of .253 mm during April, .212 mm during May, and .150 during June (Figure 27), it is calculated that this fish measured approximately 211 mm at the end of March. It is, therefore, estimated that this fish spawned when less than 220 mm. The smallest mature female blue rockfish (220 mm long, and 5 years old) encountered with ovaries in the first stages of maturation (ova diameters up to .33 mm) was collected at Monterey breakwater on November 5, 1964. A 227 mm, 5-year-old fish with mature, unfertilized ovaries was collected on February 28, 1965, at Monterey breakwater. However, this fish may not have been a potential spawner because of being unfertilized at such a late date.

The largest fish with immature ovaries was a 340 mm, 10-year-old female collected December 12, 1965, at Princeton. The size at which 50 percent of the females are mature is approximately 277 mm (Figure 37).

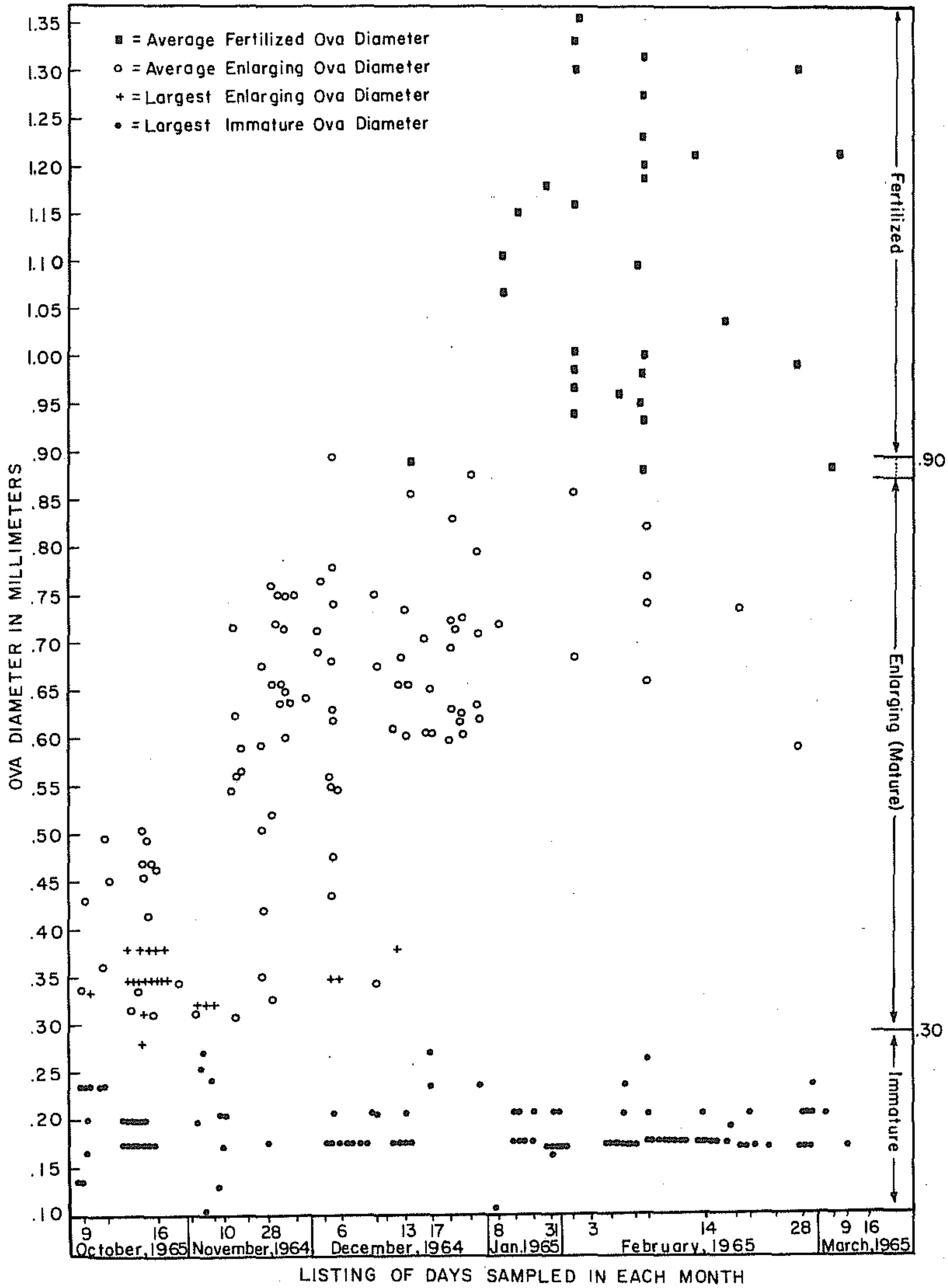


Figure 35. The Chronology of Ova Development of 340 Female Blue Rockfish and Sexual Maturity as Determined by Ova Diameters for 262 Female Blue Rockfish.

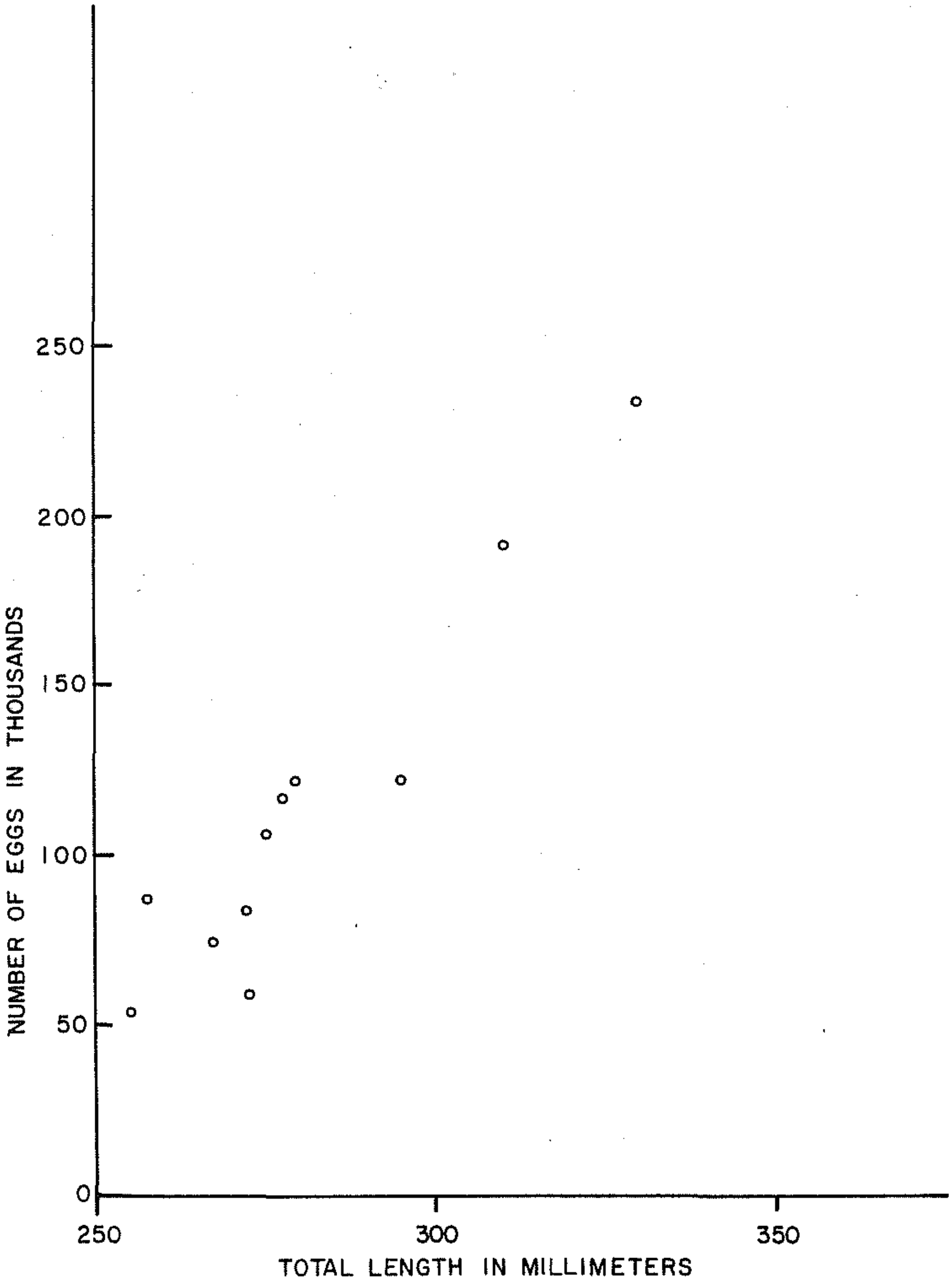


Figure 36. Numbers of Eggs Found in the Paired Ovaries of 11 Female Blue Rockfish Ranging from 256 mm to 330 mm t.l.

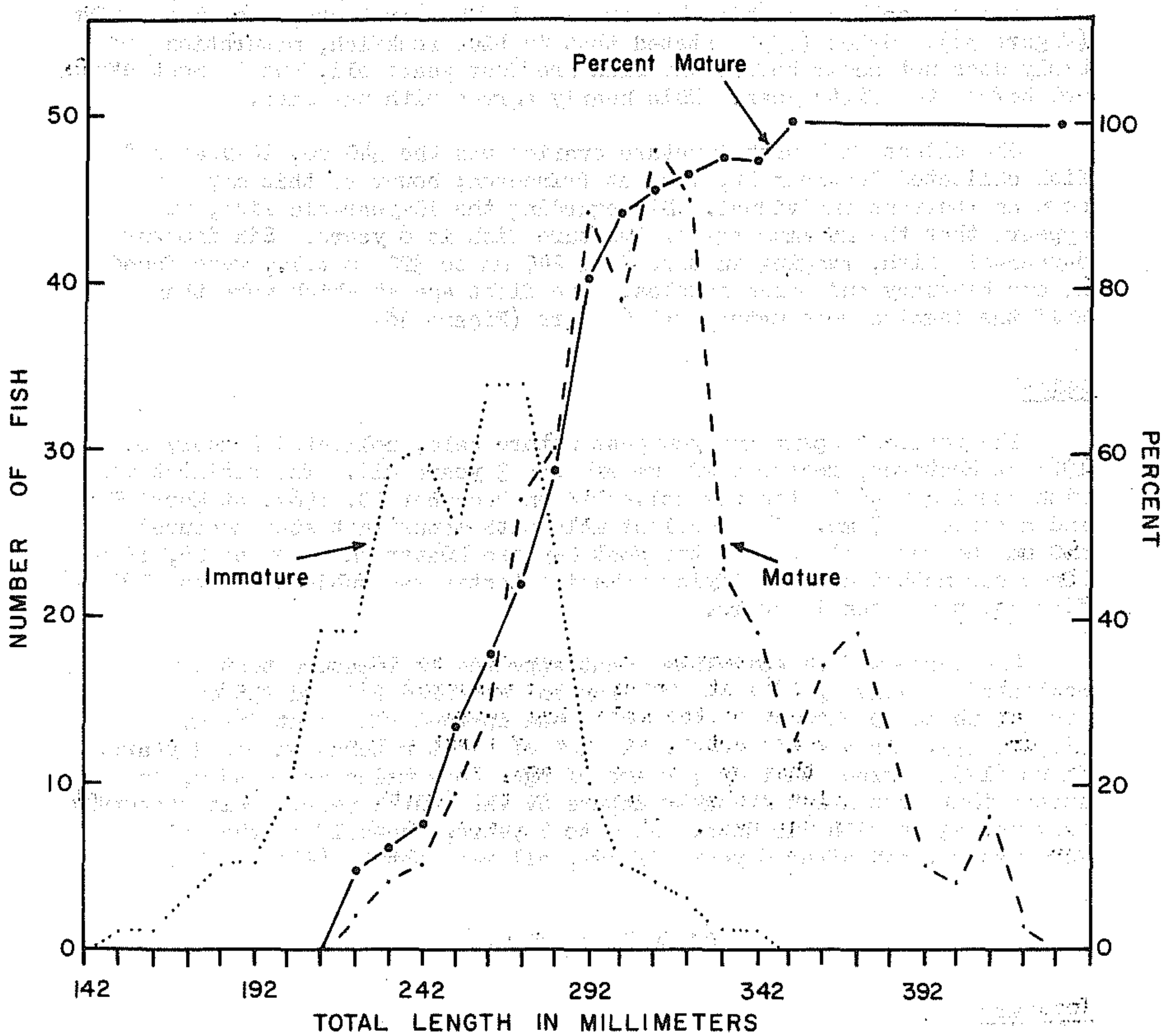


Figure 37. Sexual Maturity of 648 Female Blue Rockfish Arranged by Leng

The youngest spent females were found in a Monterey partyboat sample collected on February 21, 1965. These fish were 4 years old and measured 262 mm and 265 mm. Mature, unfertilized 4-year-old fish were found in Monterey samples collected on December 6, 1964 (232 mm) and on January 8, 1964 (278 mm). Six 4-year-old fish collected during October 1965 at Monterey showed evidence of becoming mature. They ranged in size from 236 mm to 275 mm. Evidence that females may mature by the third year was obtained in the October 16, 1965 sample at Monterey. A 241 mm, 3-year-old fish was collected which had ovaries in the first stages of maturation (Figure 38). Wales (1952) stated that in blue rockfish, maturation probably does not occur before the fish are four years old, and in most cases, not before the fifth year. This nearly agrees with our data.

The oldest fish with immature ovaries was the 340 mm, 10-year-old fish collected December 12, 1965 at Princeton; however, this may have been an aberrent individual. Disregarding the 10-year-old fish, it appears that the maximum age of immature fish is 8 years. Six immature, 8-year-old fish, ranging in size from 247 mm to 320 mm t.l., were found in our February and March samples. The first age at which more than half the females were mature was 6 years (Figure 38).

Males

The smallest spent and youngest mature male, collected January 8, 1965 at Monterey, measured 229 mm and was 3 years old. The smallest male with running ripe testes was collected on December 20, 1964, at Morro Bay and measured 217 mm. The smallest male with maturing testes measured 190 mm and was collected at the Monterey breakwater on November 25, 1965. Since our method of classifying maturing testes was subjective, the 190 mm fish may have been immature.

The largest fish containing what appeared as immature testes were collected on July 2, 1965 at Monterey and measured 285 and 295 mm. The size at which 50 percent of the males had spawned was about 262 mm (Figure 39). As already noted, the age of first maturation was 3 years. Wales (1952) agrees that by 3 years of age, some males are mature, but states that most males probably mature by the fourth year. This statement does not agree with our data. At 6 to 7 years, one-half of the males were mature, and after 8 years of age, all were mature (Figure 40).

Ovary Development

Immature

Ovaries of immature fish are small, elongate, light-colored bodies lying along the dorsal wall of the visceral cavity. Immature ovaries are round in cross section as opposed to the angular cross section common to testes. On small fish, this difference was not always obvious, and it was often necessary to examine the gonads under a microscope for positive identification.

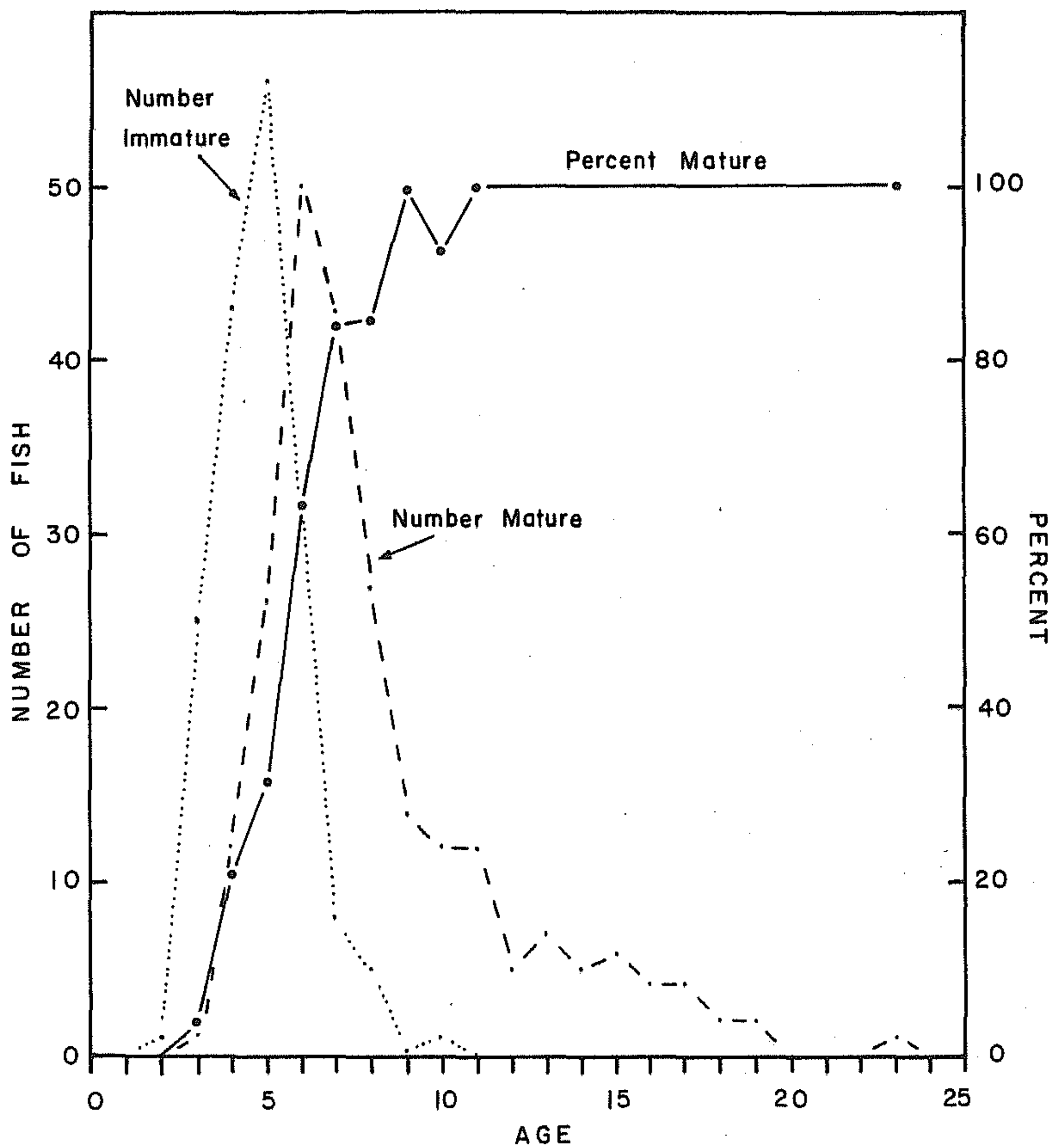


Figure 38. Sexual Maturity (by Age in Years) of 399 Female Blue Rockfish.

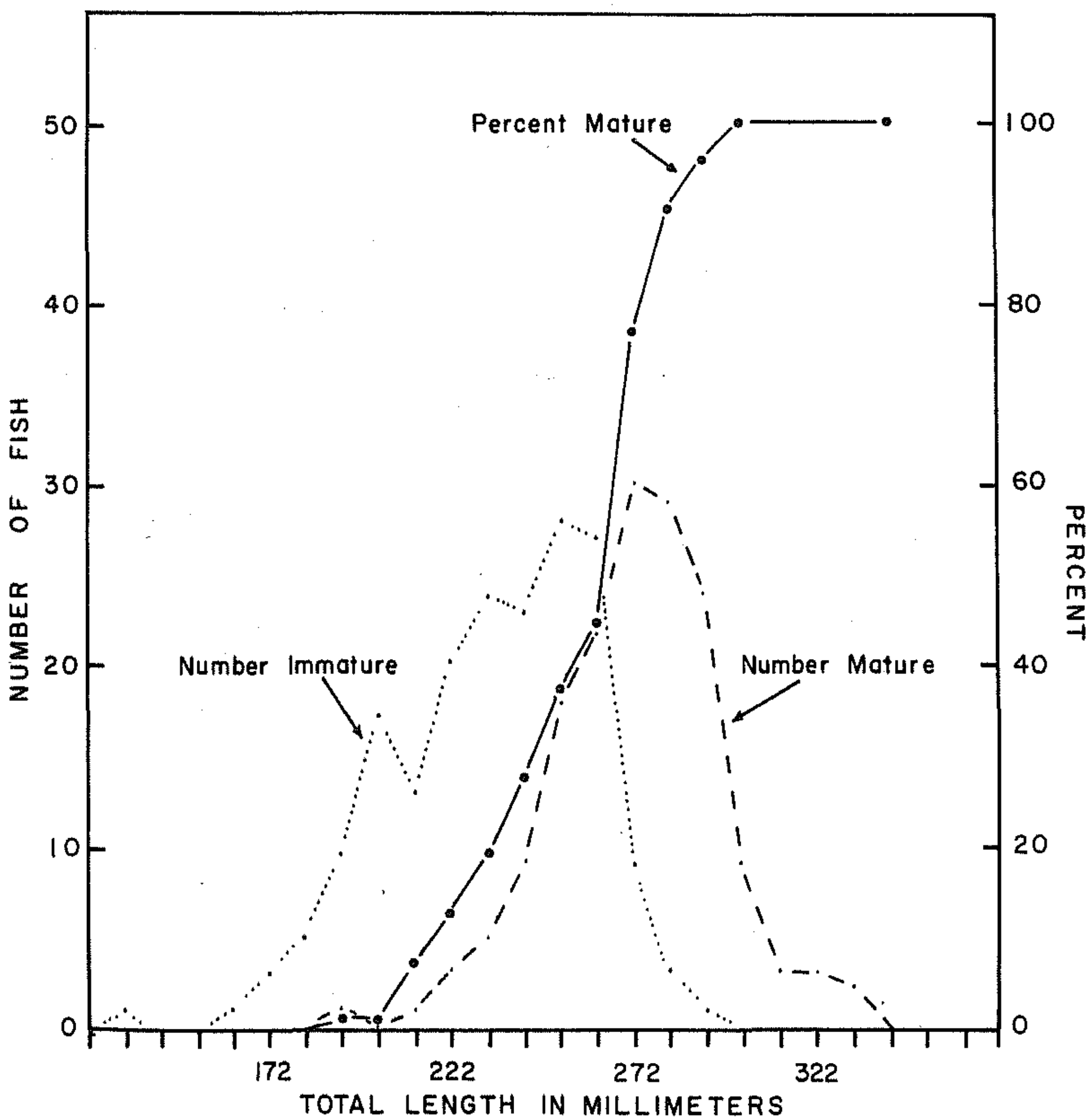


Figure 39. Sexual Maturity of 343 Male Blue Rockfish Arranged by Length.

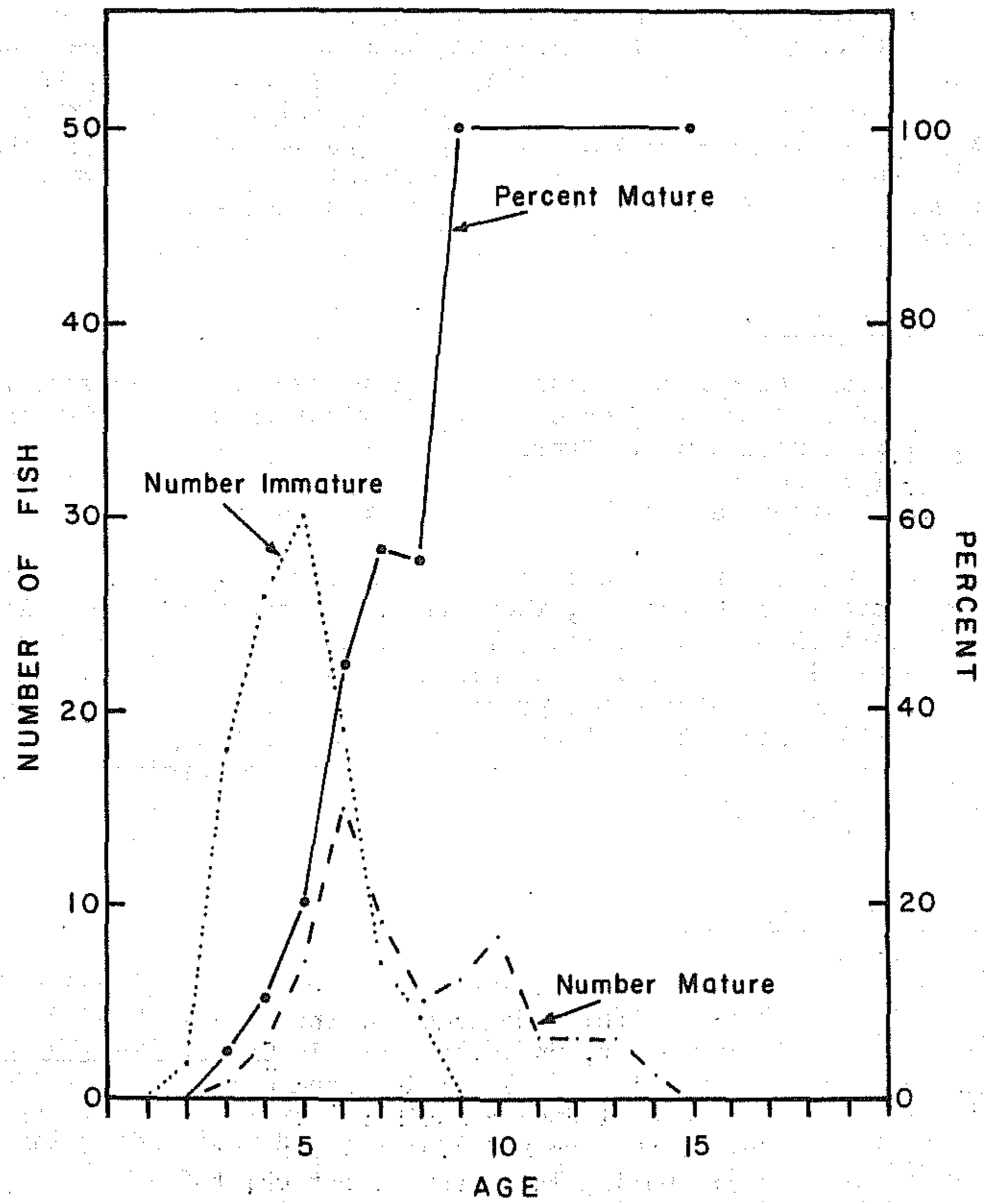


Figure 40. Sexual Maturity (by Age in Years) of 170 Male Blue Rockfish.

Under 60X magnification, immature ovaries appear to be composed almost entirely of tightly packed immature ova. The ova are round and transparent, with diameters ranging up to .270 mm; however, the majority have diameters ranging from .170 to .200 mm (Figure 35). Prior to and during the early pre-spawning period, it was difficult to distinguish ovaries that would mature during the ensuing spawning season from those that would not. From mid-November through to post-spawning, most immature ovaries are readily distinguishable from mature ovaries.

Enlarging (Mature)

The transition from immature to mature ova is rather vague. Ovum diameter of .280 mm and greater was the criterion used in distinguishing mature from immature ova. Ovaries containing enlarging ova, over .280 mm diameter (Figure 35), were considered sexually mature, and capable of producing embryos during the ensuing spawning season.

Maturing ova are characterized by the formation of yolk, and when the ova have reached .280 mm, they are opaque and yellow in color. Each ovum is contained within a follicle, and the ova form a tightly packed egg mass within the ovary. The enlarging ovaries become greatly distended, yellow in color, and soon occupy the greater part of the visceral cavity. Wales (1952) inaccurately states that the ova probably break from the follicle when about 0.35 mm in diameter. While enlarging, the ova are visable to the naked eye and reach a diameter of nearly .900 mm prior to fertilization.

Developing (Fertilized)

In all cases observed, the fertilized ova were ovulated (free from the follicle) and free within the lumen of the ovary. Hitz and De Lacy (1965) report finding clear, unovulated ova in Sebastodes caurinus and S. auriculatus with no sign of larval development. In the course of this study, three fish were collected containing ovaries with clear, spherical ova, and in each case, the ova had ovulated and were undergoing gastrulization (Figure 34a). During late gastrulization, the proliferating cells envelop the ova and once again the ova become opaque.

The mean diameters at which ova were first fertilized ranged from .88 to .89 mm, and the largest unfertilized ova averaged .90 mm (Figure 41). As the embryo develops, the ovum enlarges and becomes elongate. The largest developing ova averaged 1.37 mm in diameter and the larvae measured 3.56 mm in total length. As the larvae develop, eye pigment and melanaphores develop, causing the ovary to appear gray (Figure 34b). Fully developed fertilized ovaries nearly fill the visceral cavity and the ova flow easily from the ovary. Hatched larvae (Figure 34c) are often found in ovaries in the advanced stage of development, and quite often the larvae appear to be reabsorbing. Apparently during larval development, some ova are ruptured, releasing the larvae into the lumen of the ovary. Evidently, once outside the ova the larvae die and are reabsorbed.

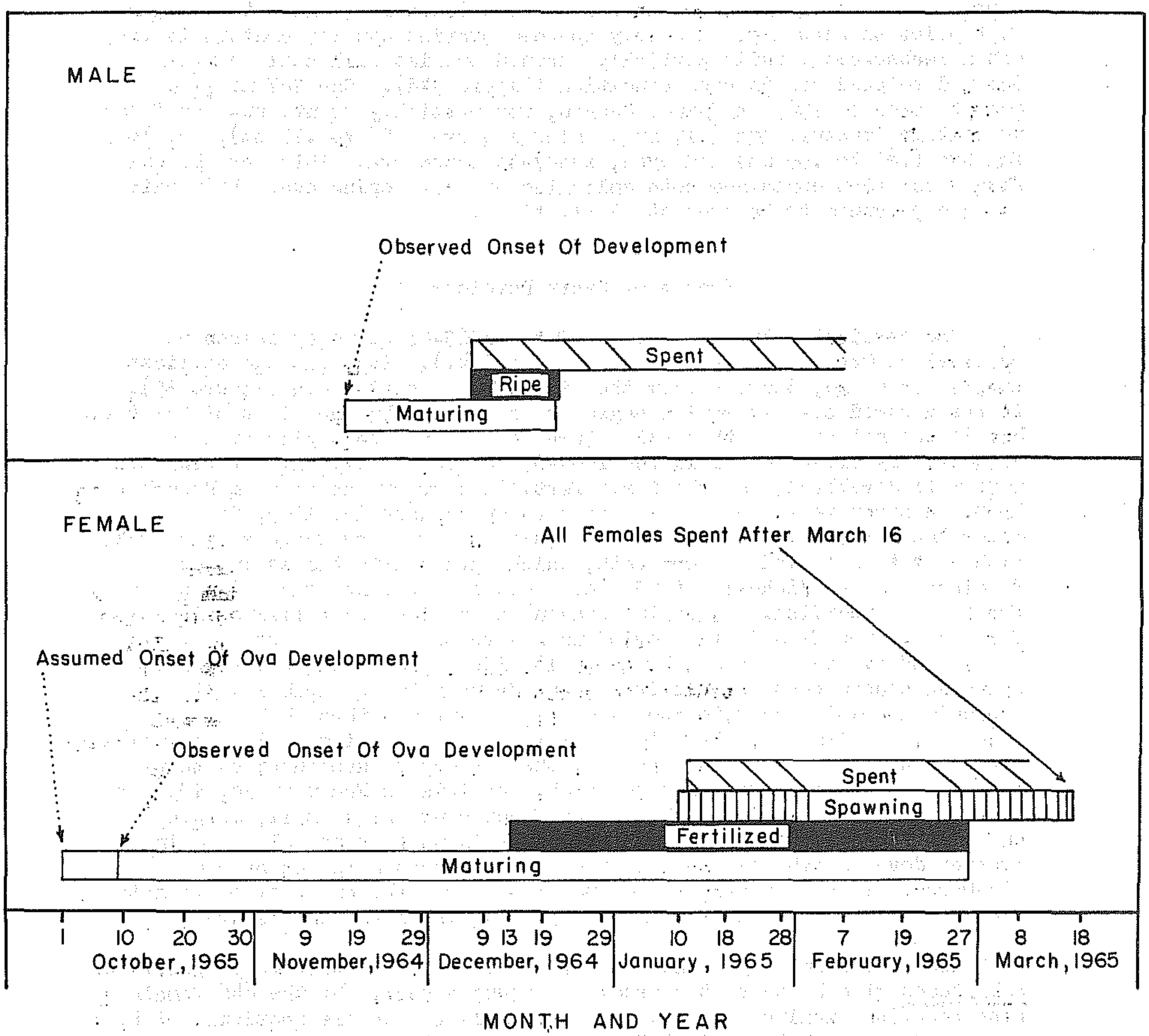


Figure 41. Sexual Development of Mature Male and Female Blue Rockfish by Month from Onset of Gonad Development to Post Spawning.

Spent

Spent ovaries are those that have released or are in the process of releasing ova containing developed embryos. Fully spent ovaries are soft, reddish or gray in color, and are considerably smaller than ovaries just prior to spawning. Recently spawned ovaries usually contain larvae, often reabsorbing, while partially spawned ovaries will still contain fully developed ova in good condition (Figure 34d). One 267 mm fish, caught March 7, 1965 at Carmel Canyon, was partially spent, but was found to contain immature ova (.17 mm), enlarging ova (.58 to .71 mm), developing ova (.81 to .95 mm) and eyed, ready-to-hatch ova. This was the only fish found that contained both enlarging and developing ova. Primordial ova are presumed to be present at all times.

Season of Ovary Development

The earliest maturing ovaries of the 1965-66 spawning season were observed on October 9, 1965 (Figures 35 and 41). This was the earliest sample taken and, judging from the size of some of the ova (Figure 35), it was assumed ova maturation began for some fish by the first of October, but it was not assumed that all mature females had enlarging ovaries in October. By mid-November in the 1964-65 season, nearly all maturing ova were well developed, and the first fertilized ovary was seen on December 13, 1964. A spent female was first observed on January 10, 1965, 28 days after the first fertilized fish was observed. This suggests a blue rockfish gestation period of one month, which agrees with the estimates of Washington State Fisheries (1950) of a one or two month gestation period for Pacific rockfish. "Spawning season" as defined by Phillips (1964) for Pacific rockfish is the period when developed eggs are shed. All developing ova were spawned by March 16, 1965, suggesting a 10-week spawning season that extends from about January 10 to March 16. The "spawning period" according to Wales (1952) extends through November, December, and January. If Wales definition of "spawning period" coincides with our usage of "spawning season", then it may be hypothesized that spawning occurs from November to March. As late as February 28, 1965, an ovary from a 227 mm blue rockfish was found containing small, mature, unfertilized ova (Figure 35). This may indicate that not all maturing ovaries develop embryos, or that the spawning season is not over by mid-March. In all, nearly six months lapse from the onset of ovary maturation in early October to the end of spawning in mid-March (Figure 41).

Recent findings by Mosher (pers. comm.) indicate that many species of Sebastodes give birth to two broods of young a year. Of the 648 female blue rockfish examined for ova maturity, only the before mentioned fish, collected on March 7, 1965 at Carmel Canyon, with ova in all stages of development and partially spent, showed any indication of spawning more than once during a spawning season.

Testes Development

The development of testes was not studied, and all testes were classified subjectively by their appearance. The number of males observed was roughly one-half that of females.

Immature

Immature males possess long, thin, light-colored testes lying along the dorsal wall of the visceral cavity in much the same way as do immature ovaries. Immature testes have a somewhat angular cross-section as do testes in all stages of development.

Maturing

Maturing testes are considerably longer and are white in color. The first maturing testes were observed on November 15, 1964, and by December 20, 1964, nearly all maturing testes had become ripe (Figure 41). One fish, however, had mature testes that were not ripe as late as February 7, 1965.

Ripe

Ripe testes are greatly enlarged, white in color, and the milt is in a running condition. Ripe testes were only observed from December 6, 1964, to December 20, 1964. Wales (1952) reported finding fish with running milt as early as October 1.

Spent

Testes of spent blue rockfish shrink somewhat, become slightly flaccid, and acquire a dark gray mottling. The first spent testes were observed on December 6, 1965, and it appeared that mating activity had ceased before the end of December, as the last ripe fish was seen on December 20, 1965. After December 20, 1965, all mature blue rockfish males observed were spent. It is not known at what time the spent testes return to the resting state.

FISH TRAPPING

The purposes of the fish trapping program were as follows:

1. To obtain samples of juvenile blue rockfish throughout the year for growth studies.

2. To determine if the growth rate of juvenile blue rockfish differs from area to area.

3. To determine relative abundance of juvenile blue rockfish in different areas.

4. To collect length-frequency and relative-abundance data of other juvenile rockfishes and associated species.

Through surface and underwater observations, we found that shallow protected inshore areas, usually those with dense growths of kelp, were excellent nursery grounds.

Starting in the summer of 1963, efforts were made to collect samples of juvenile blue rockfish at the Monterey breakwater and Monterey piers by trapping and by rotenone applied underwater by SCUBA divers. The use of rotenone was partially successful, but was unsatisfactory because of the effect on the total fish population at the breakwater. Mesh-covered traps, 24" x 44", with funnel openings at both small ends, were first used in capturing juvenile blue rockfish but were too large and unwieldy. To capture large numbers of juvenile blue rockfish throughout the year, we needed traps which could easily be fished from a skiff or by a diver working from shore. Many hours were spent underwater observing fish behavior before we decided on the best trap design, bait, and method of fishing the traps.

The final design was a cylindrical trap, 24 inches long and 10-1/2 inches in diameter, covered by 1/4 inch hardware cloth. The entrance funnels at both ends were of clear vinyl plastic, tapering to 1-3/4 inch openings. Cut squid and anchovy were dumped loosely into the traps as bait. The traps were fished on the bottom in areas where juvenile blue rockfish were found to be abundant. Through underwater observations, we found that the fish shy away from anything suspended in the water, but show little fear of a trap resting on the bottom. In most cases, the traps were fished on the bottom from piers, breakwaters, or skiffs. In areas where we could not work from a skiff, the traps were lashed to surf mats and fished by divers (Figure 42). In all cases, it was found that the traps should not be fished for more than 30 minutes at a time, and in some instances, fishing periods of 10 minutes brought best results. Most fish enter the traps within the first 15 minutes, and when left in the water for long periods, many of the fish escape from the traps. Also, the traps attract crabs and starfish if fished for long periods. Freshness of the bait was also important in attracting fish and the bait had to be changed frequently for best results.

Most fish trapping was done at the Monterey breakwater. Other areas fished were: Point Santa Cruz, Capitola Pier, Capitola area reefs, Tanker Buoy Reef, Monterey piers, Cannery Row kelp beds, and Pacific Grove kelp beds. Juvenile blue rockfish were captured in all areas but Capitola. In all, 4,009 fish of nearly 40 species were trapped or rotenoned in these areas (Table 1).

REEF ECOLOGY

Preliminary tag returns indicated that blue rockfish are non-migratory, but left unanswered the question of inter- and intra-reef movements of blue rockfish and associated reef species. Estimates of multi-species

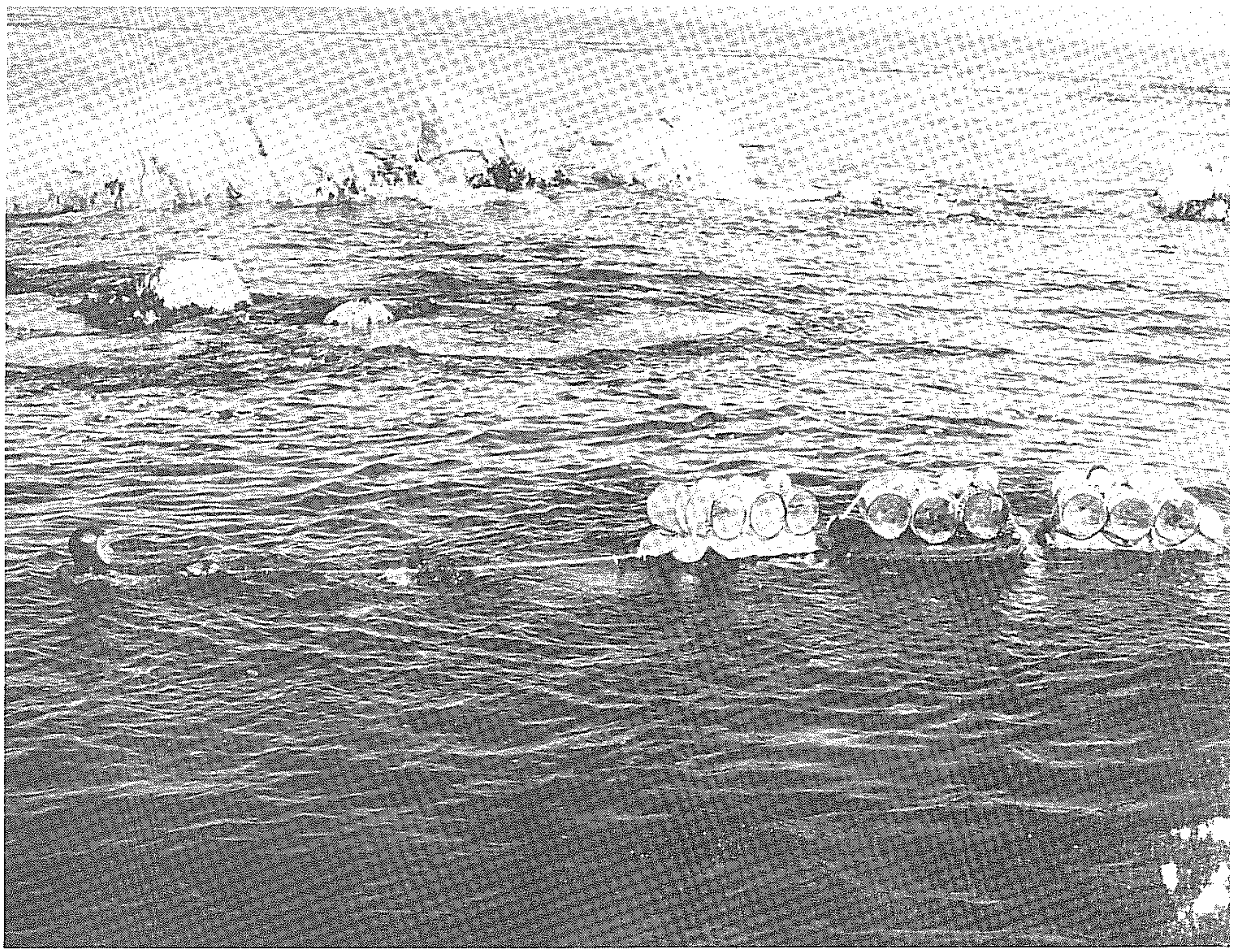


Figure 42. Fish traps on floats being transported by Department diver from shallow, inshore kelp bed along Pacific Grove.
Photo by Al Williams, Jr.

TABLE 14

Numbers and Species of Fish Trapped and Rotenoned at Seven Areas in Monterey Bay

Rockfish	Monterey Breakwater	Monterey Piers	Cannery Row & Pac. Grove	Tanker Buoy Reef	Santa Cruz Point	Capitola Pier	Capitola Kelp Beds	Total
Rockfish								
Blue	1,111	862	311	13	39			2,336
Black-&-Yellow	3							3
Bocaccio	9	13	42					64
Brown		2	1			1	2	6
Canary			1					1
Copper	90	280	193	5			1	569
Gopher	6							6
Kelp	56							56
Olive	1	1	1					3
Widow		1	6					7
Yellowtail	13	18	7					38
Misc. Rockfish	1		9					10
Kelp Greenling	60	80	12	3	1			156
Painted Greenling	13	13	4					30
Rock Greenling			1					1
Cabezon	15	34	11					60
Lingcod	3	1						4
Gibbonsia sp.*	12	7	1					20
Bluespot Goby	11	6	7	3				27
Staghorn Sculpin		3						3
Miscellaneous Cottid	3	2	3					8
Miscellaneous Blenny							2	2
One-Spot Fringehead		14		1			1	16
Speckled Sanddab	1	214	200			16		431
Pacific Sanddab			14	1	1			16
Miscellaneous Sanddab			12					12
Miscellaneous Turbot		1						1
Shiner Perch		23	3				1	27
Rainbow Seaperch	5	4						9
Kelp Perch	4							4
Black Perch		3						3
Striped Seaperch	2							2
Senorita	8	13	42		1			64
Jack Mackerel	2							2
Topsmelt		1						1
Ocean Whitefish		1						1
Wolf-eel	1	6	1					8
Snubnose Sculpin			1					1
Bonehead Sculpin					1			1
TOTALS:	1,430	1,603	883	26	43	17	7	4,009

yield from a rocky reef area were not available.

To answer these problems, we initiated a multi-species tagging program in August 1963, in the Santa Cruz, Capitola, and Monterey areas. Fish were tagged and released on reefs charted with a recording fathometer.

This reef ecology study did not provide much reliable data on short-distance movements of blue rockfish and associated species, or of their interrelationships. This pilot study did, however, reveal methods to obtain such information as well as to point out the value of estimating the yield from rocky reef areas. One of the management considerations in which we are presently involved is the construction of artificial reefs to enhance bottomfishing. Estimates of the potential yield and the proper degree of utilization of present reefs should be attained before expensive artifical reef projects are justifiable.

Artificial fishing reef studies have been underway in southern California for several years (Carlisle, Turner, and Ebert, 1964). These studies have been designed to find the proper materials for artificial reef construction and to follow closely the ecological relationships of organisms, including fish, as they become established on these structures. The approach of this pilot study in Monterey Bay was to determine whether or not a reef area yield could be determined through use of tagging and sport-catch analysis accompanied by underwater ecologically oriented observations.

The most intensive tagging was conducted at the Monterey breakwater where large numbers of juveniles were readily available, and where large blue rockfish could be caught adjacent to the breakwater from our skiff.

Extensive reef mapping was undertaken off of Santa Cruz, Capitola, and Monterey. Using a recording fathometer mounted in a 16-foot skiff, we were able to trace rocky-bottom formations within four miles of each port area. These maps were reproduced and distributed to all skiff launching concessions and public harbor facilities in Monterey Bay. These maps became very popular with skiff fishermen. This resulted in good public relations and excellent cooperation by the fishermen in reporting catches and returning tags. From July through December 1964, it was thus possible to separate the skiff catches into origin by specific reef or sandy-bottom area.

Santa Cruz Reef Areas

Low rockfish populations in the Santa Cruz area resulted in poor catches by our tagging crews; consequently, relatively few fish were tagged. In all, 96 fish of 14 species were released on three reefs (Table 15). The only recovery was a blue rockfish that moved less than a mile in 346 days and had not left the general reef area on which it was released.

From July through December 1964, skiff catches were recorded by reef or sandy areas. Each fishing party was asked to point out on the reef map where their fish were caught. A total of 283 skiffs was sampled--

TABLE 15

Number of Tags Released and Recovered
For 14 Species of Fish Tagged
In Santa Cruz Area from February 1962 to December 1964

	No. Tagged	TL Range in mm	Mean TL in mm	No. Recovered
		Santa Cruz Reef		
Rockfish				
Blue	9	172-263	227	1
Yellowtail	7	175-307	205	0
Gopher	3	232-256	244	0
Black	2	331-329	330	0
Copper	2	210-232	221	0
Canary	3	166-332	233	0
Bocaccio	1	156	156	0
Miscellaneous				
Kelp Bass	2	257-392	334	0
Lingcod	1	524	524	0
Kelp Greenling	1	280	280	0
Sablefish	1	251	251	0
White Croaker	1	285	285	0
		South Rock Reef		
Rockfish				
Blue	28	156-383	213	0
Widow	11	172-221	191	0
Yellowtail	9	149-464	240	0
Canary	2	312-380	346	0
Olive	2	347-366	357	0
Miscellaneous				
Lingcod	3	656-830	747	0
		Whistle Buoy Reef		
Rockfish				
Black	6	335-397	357	0
Gopher	1	257	257	0
Yellowtail	1	244	244	0
TOTAL:	96			1

153 at the Santa Cruz Pier launching site and 130 from Santa Cruz Harbor. Of these skiffs, 212 fished principally on rocky reefs and 71 on sand bottom. The catch was grouped into 9 reef areas shown on the reef map, 2 reef areas north of the map area, and 8 mile square areas for the sandy bottom catches (Figure 43).

About 20 percent of the reef-fishing effort was expended in depths less than 50 feet, and 71 percent was on local reefs in excess of 50-foot depths (Table 16). About 5 percent of the effort was beyond the range of the map, and another 3 percent was classed as "mixed reef" catches wherein the fishermen could not recall on which reef the various fish in their catch were taken.

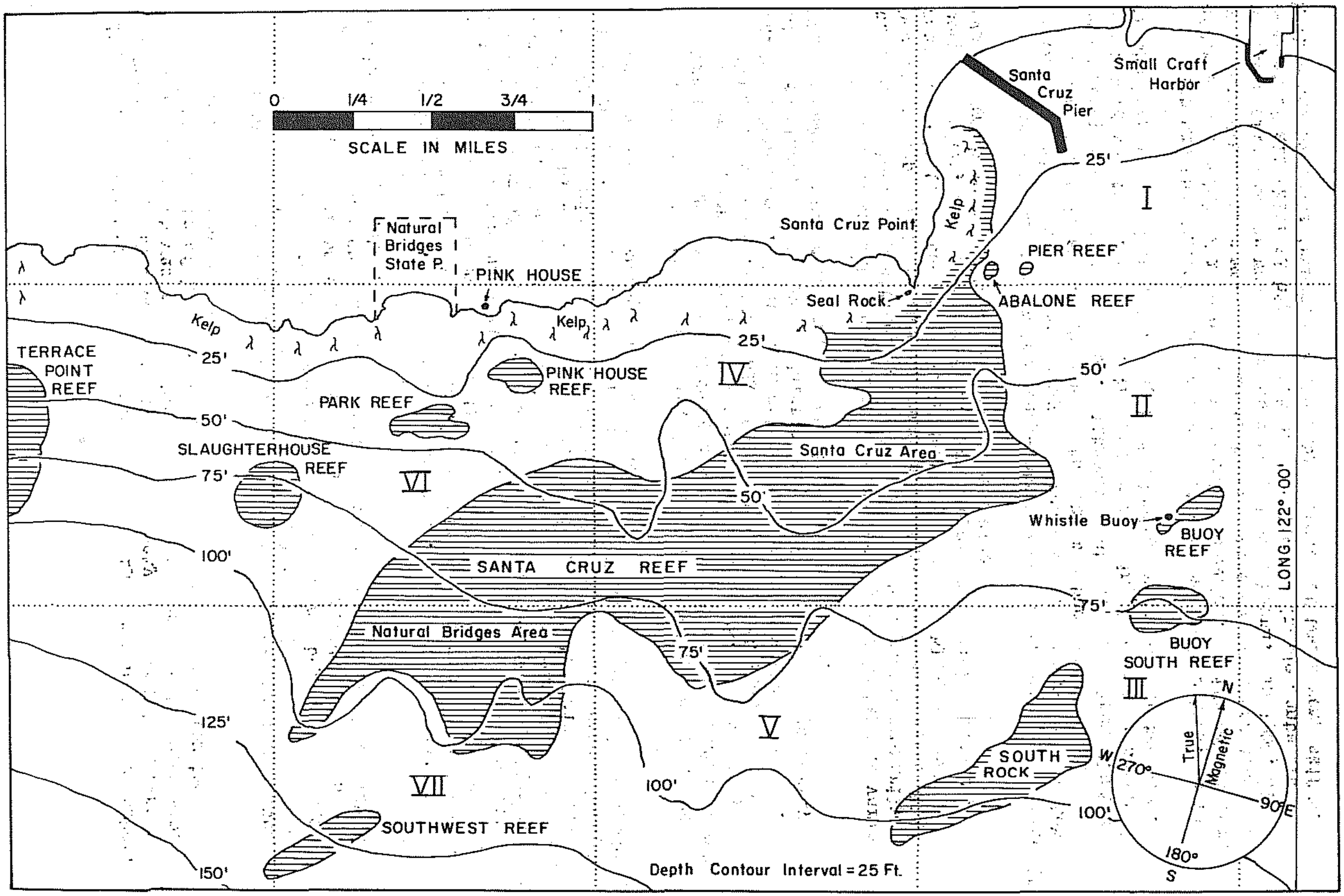
Santa Cruz reef, the largest in the area, received the greatest fishing effort (36.3 percent) and yielded almost 44 percent of all rocky-reef caught fish. Combined with the adjacent kelp bed areas off of Natural Bridges State Beach and around Seal Rock, this large rocky area produced over 60 percent of the rocky-bottom catch and received 56 percent of the total effort. The dominant species on Santa Cruz reef were blue rockfish, black rockfish, white croaker, and jacksmelt (Table 16). White croaker is a typical sandy-bottom form, indicating the presence of "sand islands" within the reef area. It also indicates that fishermen may drift off the outer boundaries of the general reef area.

Of the reefs farther offshore, Buoy Reef received the most effort followed by South Rock. The highest catch-per-skiff of all offshore reefs, a total of 12 fish per day, was recorded at South Rock. Whistle Buoy and South Buoy Reefs yielded only about half the amount recorded per skiff at South Rock. South Rock catches were primarily blue rockfish, black rockfish, and lingcod. Whistle Buoy Reef catches were primarily white croaker, blue rockfish, and chilipepper (Table 16).

Although these data are limited, there does appear to be some variation in species, composition, and yield from adjacent reefs, primarily because of depth and presence of sandy areas within the reef area. The shallow reefs (less than 50 feet in depth) yield more black-and-yellow, copper, gopher, and grass rockfish. The deeper reefs yield schooling type rockfish such as blue, yellowtail, and black rockfish.

Nearly half the effort for sandy-bottom species was expended in Area II around the whistle buoy, and nearly 52 percent of the sandy-bottom catch was taken from this area. The use of the whistle buoy as a prominent reference point is quite obvious. Although most fishermen knew fishing was better at other reef areas, the safety of being in sight or hearing of the buoy resulted in relatively high fishing pressure near the buoy.

Although the following may not be pertinent to reef ecology, it is offered as a point of interest to recreation planning. Skiff effort from the Santa Cruz harbor was recorded as to whether each skiff was launched at the public ramp or was permanently moored at a berth. In 1964, 61 percent of all skiff fishing effort originating from inside Santa Cruz harbor was by boats launched at the public ramp. Of these ramp skiffs,



This chart not intended for use in navigation.

Figure 43. Reef Map of Santa Cruz Area.

TABLE 16

Number of Fish by Species by Reef Origin Landed by Skiff Fishermen at Santa Cruz Pier and Santa Cruz Harbor, 1964.

	Shallow Reef Areas (Less than 50 ft.)				Deeper Than 50 Ft	
	West Cliff Drive Kelp	Pink House and Park	Seal Rock	Total Shallow Reef	Whistle Buoy	Buoy Ree
No. Skiffs Sampled	3	8	31	42	34	3
Percent of Sample	1.4	3.8	14.6	19.8	16.0	1.4
Number Fish/Skiff	12.7	5.7	9.9	9.3	7.1	6.0
Species						
Kelp Bass	0	0	4	4	0	0
Cabezon	1	1	9	11	0	0
White Croaker	0	0	9	9	69	2
Starry Flounder	0	0	0	0	2	0
Kelp Greenling	1	1	9	11	0	0
Pacific Hake	0	0	0	0	1	0
Brown Irish Lord	0	0	0	0	0	0
Jacksmelt	0	0	23	23	30	0
Lingcod	0	3	6	9	2	0
Jack Mackerel	0	0	0	0	1	0
Black Rockfish	7	2	48	57	16	6
Black-and-Yellow Rockfish	13	8	27	48	0	0
Blue Rockfish	14	4	64	82	36	3
Bocaccio Rockfish	0	0	2	2	1	0
Brown Rockfish	0	4	7	11	4	1
Canary Rockfish	0	1	8	9	2	1
Chilipepper	0	0	0	0	30	0
China Rockfish	0	0	0	0	0	0
Copper Rockfish	1	10	21	32	4	3
Gopher Rockfish	0	3	23	26	4	0
Grass Rockfish	0	5	19	24	0	0
Greenspotted Rockfish	0	0	0	0	3	0
Greenstriped Rockfish	0	0	0	0	0	0
Kelp Rockfish	0	0	2	2	0	0
Olive Rockfish	0	0	9	9	0	0
Rosy Rockfish	0	1	0	1	0	0
Vermilion Rockfish	0	0	1	1	4	0
Widow Rockfish	0	0	0	0	1	2
Yellowtail Rockfish	0	3	3	6	9	0
Sablefish	0	0	0	0	0	0
Pacific Sanddab	0	0	1	1	15	0
Pacific Staghorn Sculpin	0	0	0	0	0	0
Senorita	0	0	0	0	0	0
Blue Shark	0	0	1	1	0	0
Leopard Shark	1	0	0	1	0	0
Petrale Sole	0	0	0	0	0	0
Soupfin Shark	0	0	1	1	0	0
Rock Sole	0	0	2	2	1	0
Sand Sole	0	0	0	0	0	0
Shiner Perch	0	0	0	0	2	0
Walleye Surfperch	0	0	9	9	3	0
Totals:	38	46	308	392	240	18
Percent of Total:	1.7	2.1	13.8	17.6	10.8	0.8

TABLE 1[illegible] (Con't)

	Reefs Deeper Than 50 Feet in Depth					
	South Rock	Southwest Rock	Slaughterhouse Reef	Terrace Pt. Rock	Santa Cruz Reef	Total Deeper Reef
). Skiffs Sampled	31	1	1	4	77	151
ercent of Sample	14.6	0.5	0.5	1.9	36.3	71.2
umber Fish/Skiff	11.9	21.0	3.0	9.0	12.7	11.0
pecies						
elp Bass	1	0	0	0	6	7
abezon	3	0	0	5	9	17
hite Croaker	20	0	0	0	77	168
tarry Flounder	0	0	0	0	1	3
elp Greenling	3	0	0	0	10	13
acific Hake	0	0	0	0	3	4
rown Irish Lord	1	0	0	0	0	1
acksmelt	13	0	0	0	124	167
ingcod	24	0	1	5	43	75
ack Mackerel	1	0	0	0	1	3
lack Rockfish	26	0	0	2	148	198
lack-and-Yellow Rockfish	7	0	0	3	34	44
lue Rockfish	82	1	0	8	162	292
ocaccio Rockfish	2	0	0	0	4	7
rown Rockfish	19	3	1	1	38	67
anary Rockfish	19	9	0	1	24	56
hilipepper	0	0	0	0	34	64
hina Rockfish	0	0	0	0	1	1
opper Rockfish	22	0	0	1	44	74
opher Rockfish	13	1	1	3	44	66
rass Rockfish	3	0	0	1	10	14
reenspotted Rockfish	0	0	0	0	4	7
reenstriped Rockfish	0	0	0	0	2	2
elp Rockfish	1	0	0	1	4	6
live Rockfish	1	0	0	0	9	10
osy Rockfish	8	0	0	0	18	26
ermilion Rockfish	6	0	0	1	16	27
idow Rockfish	9	0	0	0	3	15
ellowtail Rockfish	55	5	0	3	59	131
ablefish	0	0	0	0	6	6
acific Sanddab	29	1	0	0	27	72
acific Staghorn Sculpin	0	0	0	0	2	2
enorita	0	0	0	0	1	1
lue Shark	0	0	0	0	2	2
eopard Shark	0	0	0	0	0	0
etrale Sole	0	1	0	0	3	4
oupfin Shark	0	0	0	0	0	0
ock Sole	0	0	0	0	1	2
and Sole	0	0	0	1	0	1
hiner Perch	0	0	0	0	0	2
alleye Surfperch	1	0	0	0	2	6
otals:	369	21	3	36	087	1,663
'ercent of Total	16.6	0.9	0.1	1.6	43.8	74.7

TABLE 16 (con't)

	Reef Areas Not on Map			Mixed Reef	Grand Total
	Año Nuevo	Waddell-Davenport	Capitola-Soquel		
No. Skiffs Sampled	3	6	4	6	212
Percent of Sample	1.4	2.8	1.9	2.8	99.9
Number Fish/Skiff	11.0	8.2	3.7	12.3	55.5
Species					
Kelp Bass	0	0	0	0	11
Cabezon	1	2	2	1	34
White Croaker	0	7	2	36	222
Starry Flounder	0	0	0	0	3
Kelp Greenling	0	3	0	1	28
Pacific Hake	0	0	0	0	4
Brown Irish Lord	0	0	0	0	1
Jacksmelt	1	0	0	0	191
Lingcod	5	3	1	14	107
Jack Mackerel	0	0	0	0	3
Black Rockfish	7	13	1	5	281
Black-and-Yellow Rockfish	0	2	1	1	96
Blue Rockfish	11	1	0	2	388
Bocaccio Rockfish	0	0	0	0	9
Brown Rockfish	0	0	3	1	82
Canary Rockfish	0	0	0	3	68
Chilipepper	0	0	0	0	64
China Rockfish	0	0	0	0	1
Copper Rockfish	1	4	2	3	116
Gopher Rockfish	5	4	0	2	103
Grass Rockfish	0	0	3	1	42
Greenspotted Rockfish	0	0	0	0	7
Greenstriped Rockfish	0	0	0	0	2
Kelp Rockfish	0	0	0	0	8
Olive Rockfish	0	0	0	0	19
Rosy Rockfish	0	1	0	0	28
Vermilion Rockfish	0	0	0	0	28
Widow Rockfish	2	0	0	0	17
Yellowtail Rockfish	0	7	0	1	145
Sablefish	0	0	0	0	6
Pacific Sanddab	0	1	0	3	77
Pacific Staghorn Sculpin	0	0	0	0	2
Senorita	0	0	0	0	1
Blue Shark	0	0	0	0	3
Leopard Shark	0	0	0	0	1
Petrale Sole	0	0	0	0	4
Soupfin Shark	0	0	0	0	1
Rock Sole	0	0	0	0	4
Sand Sole	0	0	0	0	1
Shiner Perch	0	0	0	0	2
Walleye Surfperch	0	1	0	0	16
Totals:	33	49	15	74	2,226
Percent of Total:	1.5	2.2	0.7	3.3	100.0

75 percent bottom fished and 25 percent trolled for salmon. Of the skiffs moored in the harbor, 51 percent bottom fished and 49 percent trolled.

Capitola Reef Areas

No fish were tagged in this area, but the skiff catch was recorded by reef and sandy-bottom origin. Here, all but one of the reefs covered by the reef map (Figure 44) were in water less than 50 feet deep. The catch was tallied by five shallow reef areas, one deeper reef, several reefs outside the Capitola area off Santa Cruz, and 7 sandy-bottom areas one mile square. A total of 99 skiffs was sampled--70 fishing primarily on rocky bottom and 29 on sandy bottom.

Over 25 percent of the effort was expended on Capitola Reef followed by Adam's Reef with 14.3 percent (Table 17). Adam's Reef produced the most fish-per-skiff day, yielding 28 fish per day and accounted for 21.1 percent of the total rocky-reef catch. Only two percent of the skiffs operating out of Santa Cruz harbor and from Santa Cruz pier utilized reefs off Capitola. But, about 17 percent of the skiffs launched at Capitola fished off Santa Cruz.

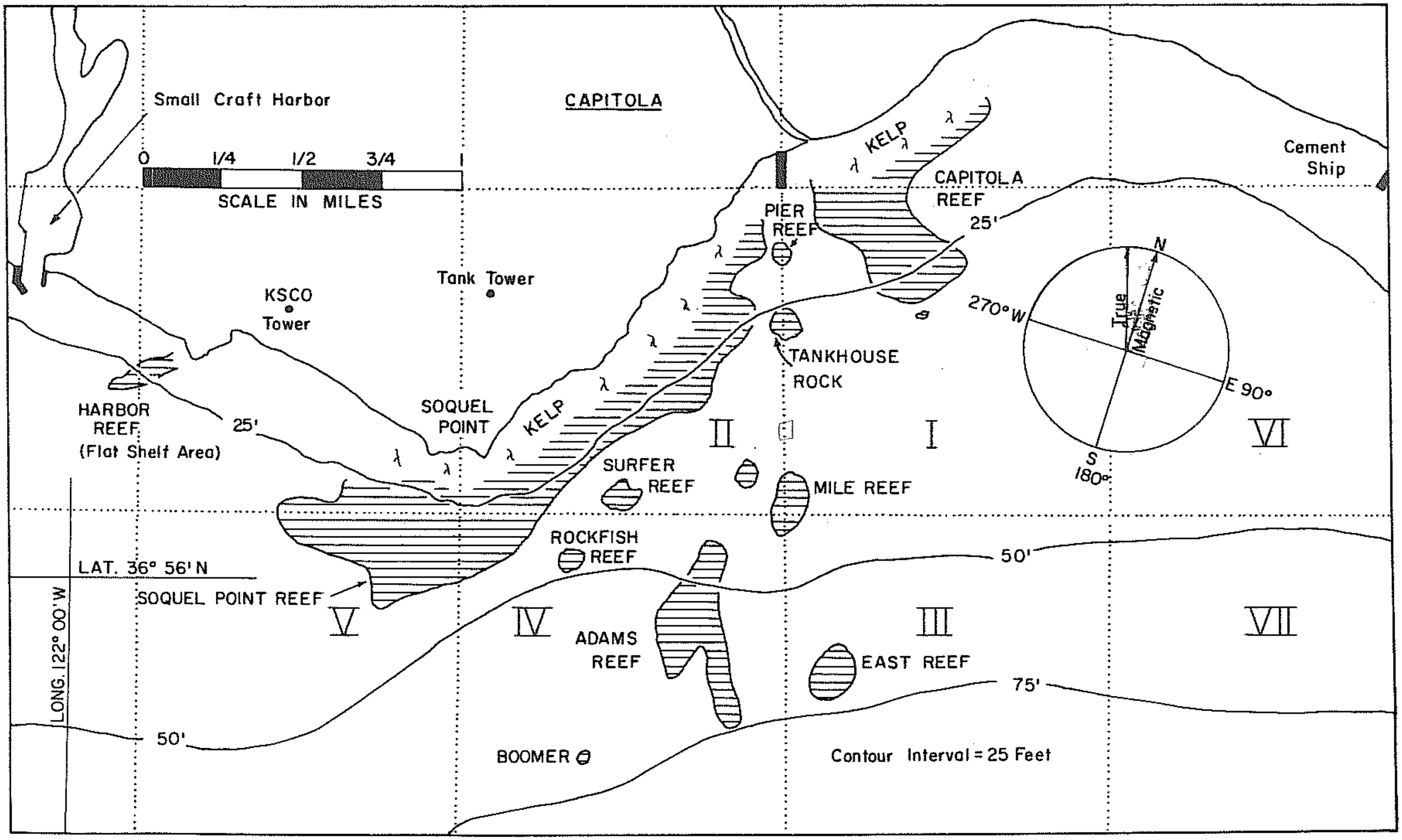
Species composition varied considerably between rocky-reefs off Capitola and was markedly different from Santa Cruz reefs. Brown rockfish was the most frequently landed bottomfish followed by grass rockfish and blue rockfish. About 45 percent of the blue rockfish landed at Capitola were caught on reefs off Santa Cruz. Each reef area catch was dominated by a different species: at Capitola Reef, grass rockfish was first; in the Opal Cliffs area, brown rockfish; at Adam's Reef, black rockfish; and off Soquel Point, blue rockfish.

Sandy-bottom areas yielded large catches of white croaker, the greatest effort and catches in areas I and VI.

Monterey Reef Areas

Reef areas here are more extensive and varied than in the Santa Cruz and Capitola areas. There are 3 reefs and several rocky-shore kelp areas in water less than 50 feet and 5 reef areas deeper than 50 feet in the mapped area (Figure 45). The large reef areas south of Point Piños were not mapped; however, only 8.7 percent of the skiff effort was expended in this southern area. A total of 230 skiffs was sampled, 185 fishing primarily on rocky reefs and 45 on sand bottom.

Pacific sanddabs made up nearly half the reef catch by numbers. Since this is primarily a sand or gravel bottom species, it is obvious our sampling procedure could not always separate the catch as to exact bottom type. Actually, Pacific sanddabs are sometimes taken in rocky areas further complicating recording accuracy. Reef fishermen in quest of rockfish and lingcod seldom anchor and will drift from rocky areas



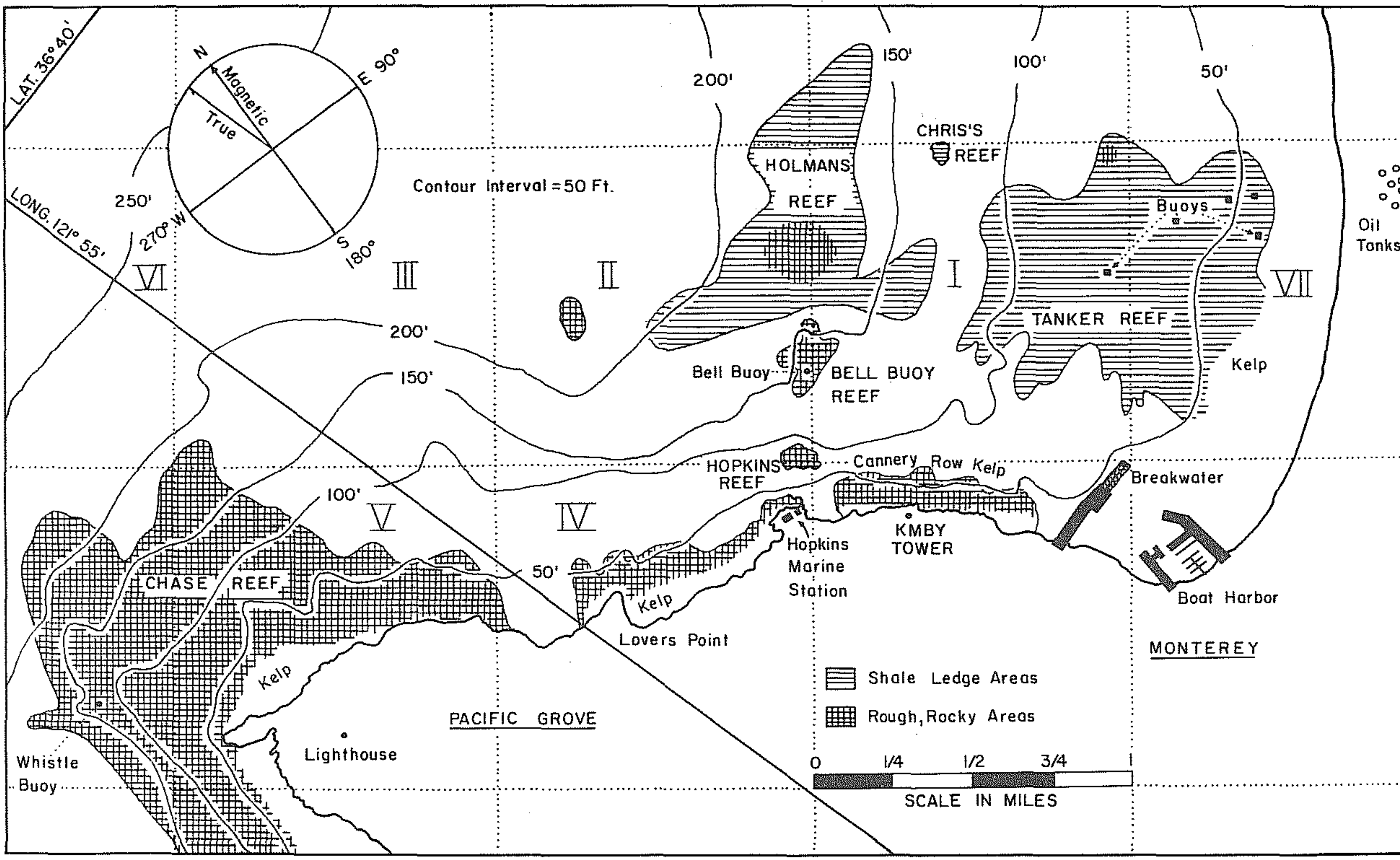
This chart not intended for use in navigation.

Figure 44. Reef Map of Capitola Area.

TABLE 17

Number of Fish by Species by Reef Origin Landed by Skiff Fishermen at Capitola, 1964.

	Shallow Reefs (Less Than 50' Depth)						Reefs Deeper Than 50 Feet			
	Capitola Reef	Tankhouse Reef	Opal Cliffs Rockfish Reef	Soquel Pt. Reef	Mile Reef	Total Local Shallow Reef	Adams Reef	Santa Cruz Map Area Reefs	Mixed Reef	Total
No. Skiffs Sampled	18	1	6	8	3	36	10	15	9	70
Percent of Sample	25.7	1.4	8.6	11.4	4.3	51.4	14.3	21.4	12.9	100.0
Number Fish/Skiff	9.1	24.0	15.2	13.3	17.7	12.1	27.8	11.7	14.5	14.6
Species:										
Cabezon	5	0	0	0	0	5	1	2	7	15
White Croaker	29	16	12	0	2	59	90	33	25	207
Starry Flounder	1	0	0	0	1	2	1	0	0	3
Kelp Greenling	2	0	3	0	0	5	1	1	1	8
Cottids (unident)	0	0	0	2	0	2	1	0	0	3
Jacksmelt	3	0	21	7	17	48	33	17	2	100
Lingcod	3	0	2	7	2	14	6	19	8	47
Jack Mackerel	0	0	0	0	0	0	1	0	0	1
Black Rockfish	1	3	1	11	7	23	37	4	8	72
Black-and-Yellow R.	9	0	4	6	0	19	7	6	18	50
Blue Rockfish	12	0	2	27	1	42	6	39	0	87
Bocaccio	1	0	0	0	0	1	0	0	0	1
Brown Rockfish	32	3	13	8	12	68	22	11	16	117
Canary Rockfish	0	0	3	1	0	4	1	8	2	15
Copper Rockfish	0	2	12	11	5	30	19	6	18	73
Gopher Rockfish	2	0	1	5	0	8	13	3	1	25
Grass Rockfish	45	0	4	15	0	64	1	2	9	76
Kelp Rockfish	0	0	0	1	0	1	0	0	2	3
Olive Rockfish	0	0	0	1	2	3	3	1	0	7
Rosy Rockfish	0	0	0	0	0	0	0	1	0	1
Vermilion Rockfish	0	0	6	3	0	9	2	6	2	19
Widow Rockfish	0	0	0	0	0	0	0	2	0	2
Yellowtail Rockfish	15	0	1	2	1	19	2	8	4	33
Bat Ray	0	0	2	0	0	2	0	0	0	2
Pacific Sanddab	0	0	0	0	1	1	31	4	0	36
Leopard Shark	0	0	0	0	0	0	0	0	1	1
Spiny Dogfish	0	0	0	0	0	0	0	1	0	1
Smoothhounds	1	0	0	0	0	1	0	0	0	1
Petrale Sole	1	0	0	0	0	1	0	1	0	2
Sand Sole	0	0	0	0	1	1	0	0	0	1
Rainbow Seaperch	0	0	1	0	0	1	0	0	0	1
Shiner Perch	0	0	2	0	0	2	0	0	0	2
Walleye Surfperch	2	0	0	0	1	3	0	0	8	11
Big Skate	0	0	1	0	0	1	0	0	0	1
Totals	164	24	91	107	53	439	278	175	132	1,024
Percent of Total	16.0	2.3	8.9	10.4	5.2	42.9	27.1	17.1	12.9	100.0



This Chart Not Intended For Use In Navigation

Figure 45. Reef Map of Monterey Area.

TABLE 18

Number of Fish by Species by Reef Origin Landed by Skiff Fishermen at Monterey, 1964

	Shallow Reefs (less than 50 ft. Depth)				Deeper Than 50 Ft.	
	Monterey Breakwater	Cannery Row	Lover's Point	Total Shallow Water	Hopkins Reef	Bell Buoy Reef
Number Skiffs Sampled	9	21	23	53	11	23
Percent by Reef	4.9	11.4	12.4	28.7	5.9	12.4
Number Fish/Skiff	11.1	17.6	22.7	18.7	24.2	22.8
Species						
Cabezon	1	2	1	4	1	3
White Croaker	0	0	1	1	14	6
Wolf-eel	0	1	2	3	0	1
Starry Flounder	0	4	1	5	0	1
Kelp Greenling	1	1	2	4	0	1
Pacific Hake	0	0	1	1	0	16
Jacksmelt	0	2	0	2	3	1
Giant Kelpfish	0	0	0	0	0	0
Lingcod	0	4	1	5	2	3
Jack Mackerel	0	5	12	17	18	3
Pacific Mackerel	0	0	0	0	0	0
Mola	0	0	1	1	0	0
Black Rockfish	0	47	9	56	0	1
Black-&-Yellow Rockfish	0	1	1	2	0	0
Blue Rockfish	2	52	32	86	10	48
Bocaccio	9	0	1	10	1	4
Brown Rockfish	0	0	0	0	1	0
Canary Rockfish	0	1	6	7	3	17
Chilipepper	0	0	15	15	0	1
China Rockfish	0	0	0	0	0	0
Copper Rockfish	11	10	12	33	1	6
Gopher Rockfish	9	3	0	12	0	3
Greenspotted Rockfish	0	0	0	0	0	0
Greenstriped Rockfish	0	0	0	0	0	0
Kelp Rockfish	1	1	0	2	0	0
Olive Rockfish	0	1	0	1	0	1
Quillback Rockfish	0	0	0	0	0	0
Rosy Rockfish	0	3	1	4	0	13
Squarespot Rockfish	0	0	0	0	0	0
Swordspine	0	0	0	0	0	0
Starry Rockfish	0	1	0	1	0	0
Stripetail Rockfish	0	0	0	0	0	0
Turkey-Red Rockfish	0	0	0	0	0	0
Vermilion Rockfish	0	0	1	1	1	7
Widow Rockfish	0	0	1	1	0	0
Yellowtail Rockfish	1	1	7	9	1	23
Sablefish	1	31	95	127	104	141
Pacific Sanddab	57	183	245	485	102	216
Senorita	0	0	3	3	0	0
Petrale Sole	1	2	42	45	0	1
Rock Sole	2	4	15	21	4	7
Sand Sole	1	2	0	3	1	0
Barred Surfperch	0	0	0	0	0	0
Black Perch	1	0	0	1	0	0
Pile Perch	0	1	0	1	0	0
Pink Seaperch	0	1	0	1	0	0
Rainbow Seaperch	1	4	0	5	0	1
Sharpnose Seaperch	0	0	9	9	0	0
Shiner Perch	0	0	1	1	0	0
Striped Seaperch	0	0	3	3	0	0
Walleye Surfperch	1	0	0	1	0	0
Diamond Turbot	0	1	0	1	0	0
Ocean Whitefish	0	0	0	0	0	0
Total:	100	369	521	990	267	525
Percent of Total:	2.7	9.8	13.8	26.3	7.1	13.9

TABLE 18 (con't)

	Reefs Deeper Than 50 Ft. in Depth						
	Holman's Reef	Tanker Reef	Chase's Reef	South of Pt. Pinos	Total Reef Over 50'	Mixed Reefs	Grand Total
Number Skiffs Sampled	8	18	49	16	125	7	185
Percent by Reef	4.3	9.7	26.5	8.7	67.5	3.8	100.0
Number Fish/Skiff	10.7	12.5	17.8	26.9	19.2	53.7	20.4
Species							
Cabezon	0	2	8	4	18	0	22
White Croaker	2	28	1	0	51	0	52
Wolf-eel	1	1	0	0	3	0	6
Starry Flounder	1	0	1	1	4	0	9
Kelp Greenling	0	1	8	0	10	0	14
Pacific Hake	2	0	13	0	31	0	32
Jacksmelt	0	0	0	0	4	1	7
Giant Kelpfish	0	0	3	3	6	0	6
Lingcod	1	11	13	10	40	0	45
Jack Mackerel	0	1	18	10	50	6	73
Pacific Mackerel	0	6	0	0	6	1	7
Mola	0	0	0	0	0	0	1
Black Rockfish	0	2	74	44	121	3	180
Black-&-Yellow Rockfish	0	1	3	3	7	0	9
Blue Rockfish	4	11	81	130	284	41	411
Bocaccio	0	1	0	3	9	3	22
Brown Rockfish	0	0	8	0	9	1	10
Canary Rockfish	1	7	15	18	61	1	69
Chilipepper	0	0	3	0	4	0	19
China Rockfish	0	0	1	1	2	0	2
Copper Rockfish	4	7	23	5	46	4	83
Gopher Rockfish	1	1	16	5	26	0	38
Greenspotted Rockfish	0	0	0	12	12	0	12
Greenstriped Rockfish	0	0	0	2	2	0	2
Kelp Rockfish	0	0	1	2	3	0	5
Olive Rockfish	0	0	12	1	14	0	15
Quillback Rockfish	0	0	1	0	1	0	1
Rosy Rockfish	2	5	28	22	70	0	74
Squarespot Rockfish	0	0	0	2	2	0	2
Swordspine	0	0	0	1	1	0	1
Starry Rockfish	1	0	5	8	14	0	15
Stripetail Rockfish	0	0	0	1	1	0	1
Turkey-Red Rockfish	0	0	0	2	2	0	2
Vermilion Rockfish	2	5	7	0	22	1	24
Widow Rockfish	0	1	0	6	7	0	8
Yellowtail Rockfish	3	4	29	25	85	6	100
Sablefish	0	0	52	10	307	144	578
Pacific Sanddab	58	116	408	92	992	152	1,629
Senorita	0	0	0	0	0	0	3
Petrale Sole	0	2	9	0	12	1	58
Rock Sole	2	9	25	6	53	10	84
Sand Sole	0	1	0	0	2	0	5
Barred Surfperch	1	0	0	0	1	0	1
Black Perch	0	0	2	0	2	0	3
Pile Perch	0	0	0	0	0	1	2
Pink Seaperch	0	0	0	0	0	0	1
Rainbow Seaperch	0	0	2	0	3	0	8
Sharpnose Seaperch	0	2	1	0	3	0	12
Shiner Perch	0	0	0	0	0	0	1
Striped Seaperch	0	0	0	1	1	0	4
Walleye Surfperch	0	0	0	0	0	0	1
Diamond Turbot	0	0	0	0	0	0	1
Ocean Whitefish	0	0	1	0	1	0	1
Total:	86	225	872	430	2,405	376	3,771
Percent of Total:	2.3	6.0	23.1	11.4	63.8	10.0	100.1

over sand bottom. As soon as sanddabs or other flatfish are caught, the fishermen will usually move back upwind or upcurrent and drift over the rocks again. As a result, although they were not necessarily sought, flatfish usually appeared in rocky bottom catches at Monterey.

Blue rockfish was the dominant rocky-bottom species at all reefs except for the breakwater area, where the larger copper rockfish were more desired. Even though blue rockfish are by far more numerous than copper rockfish at the breakwater, this is a juvenile blue rockfish nursery area, and relatively few are kept by skiff fishermen.

Black rockfish was second in numbers at all deeper reefs from Chase's Reef southward. Chase's Reef received 26.5 percent of the total effort, the remainder being spread fairly evenly between the other reefs (Table 18). The highest fish-per-skiff averages were recorded on reefs south of Point Piños.

Shallow water areas (less than 50 feet) received 18.5 percent of the fishing effort and yielded 26.3 percent of the skiff catch. Species composition was relatively uniform at all reefs at similar depths. More rosy, yellowtail, widow, and vermilion rockfish were landed at the deeper reefs.

In all, 2,049 fish of 32 species were tagged and released at 8 areas (Tables 19 and 20). The most intensive study area was the Monterey breakwater.

TABLE 19

Number of Blue Rockfish Releases and Recoveries at Monterey Breakwater

Releases			Recoveries			
	No. of Fish	No. of Releases		No. of Fish	No. of Recover.	Percent Recover.
Released once	1,242	1,242	Recovered once	353	353	
Released twice	96	192	Recovered twice	26	52	
Released three times	16	48	Recovered three times	7	21	
Released four times	2	8	Recovered, data lost	22	22	
TOTAL	1,356	1,490	TOTAL	408	448	30.1

Monterey breakwater

The Monterey breakwater was chosen for intensive study for 3 reasons:

1. The great abundance of inshore reef species, especially blue rockfish, at the breakwater.

2. The Monterey breakwater and attached Coast Guard dock were closed to civilian fishing, thus restricting the take of fish from the area.

3. Project personnel could work at the breakwater when inclement weather or other circumstances precluded skiff work outside the harbor.

A total of 1,685 fish of 28 species was tagged and released at Monterey breakwater (Table 20). Blue rockfish was by far the most numerous and available rockfish. Nearly all fish tagged were caught by hook-and-line, and many of the blue rockfish tag recoveries were made by tagging crews. These fish were measured and re-released when uninjured. Many fish re-released were again recovered; some blue rockfish have been recovered 3 times since first released (Table 19). Double releases were recorded for two copper rockfish and one bocaccio (Table 20).

The majority of the blue rockfish tag returns came from project personnel fishing. The high return of the blue rockfish tags (30.1 percent) is due to selective underwater spearfishing. Tagged fish were sought by project personnel and sport fishermen. In all, 436 tagged fish of 9 species tagged at the Monterey breakwater were recovered (Table 20).

The most striking find from these recoveries was the lack of movement of breakwater fish (Table 21). Four blue rockfish moved from one side of the breakwater to the other, and the furthest movements recorded were by 5 fish recovered at Monterey Pier No. 2, a distance of approximately 1/4 mile. Also, we received several reports of tagged blue rockfish sightings at both Monterey piers. We suspect that there is some exchange of blue rockfish between the breakwater and some of the nearby reefs, especially the Cannery Row area, but this was not evident by tag returns. The only other recorded movements were by one copper rockfish to Monterey Pier No. 2, and one olive rockfish from the inside of the breakwater to the outside.

The most unusual return was an ocean whitefish. This species is rarely seen in Monterey Bay, and only one was tagged. Also unusual was a single señorita recovered in the same area in which it was tagged over 13 months earlier. Señoritas are not abundant during the winter months, and it was surmised that they seasonally leave the area. If this is true, then it appears that at least some individuals seasonally return to the breakwater.

Monterey Pier No. 1

Four fish were released at Monterey pier, and none was recovered (Table 22).

TABLE 20

Numbers of Tags Released, Tag Recoveries, and Total Lengths in mm for 28 Species of Fish Tagged at Monterey Breakwater from August, 1963, to May, 1965

	No. Tagged	No. Recovered	Percent Recovered	T.L. Range in mm	Mean T.L. in mm
Rockfish					
Blue	1,356	408	30.1	91-293*	154
Copper	111**	15	13.3	85-249	179
Bocaccio	50***	1	2.0	113-323	155
Yellowtail	36		0.0	120-268	175
Black	35	6	17.1	150-320	244
Olive	23	2	8.7	149-435	237
Kelp	11		0.0	165-324	238
Black-and-Yellow	8		0.0	80-248	193
Gopher	4		0.0	180-207	193
Grass	3		0.0	116-285	218
Brown	1		0.0	172	172
Miscellaneous					
Senorita	17	1	5.9	163-215	191
Lingcod	8	1	12.5	415-517	475
Kelp Greenling	3			222-260	246
Painted Greenling	1			154	154
Cabezon	1			302	302
Jack Mackerel	1			144	144
Wolf-eel	1			600	600
Kelp Bass	2			276-317	296
Ocean Whitefish	1	1	100.0	404	404
Kelpfish, Giant	1			198	198
Starry Flounder	1			335	335
Shiner Perch	3			113-130	121
Black Perch	2	1	50.0	260-295	278
White Seaperch	2			240-253	246
Striped Seaperch	1			258	258
Walleye Surfperch	1			186	186
Pile Perch	1			148	148
Total:	1,685	436			

* Includes 140 fish of all sizes not tagged
** Plus 2 re-releases
*** Plus 1 re-release

TABLE 21

Days at Liberty and Movement for Nine Species of Fish Tagged at Monterey Breakwater

Species	Days at Liberty							Movement			
	1-99	100-199	200-299	300-399	400-499	500-599	Total	Inside to Outside	Outside to Inside	to Pier No. 2	No Movement Recorded
Rockfish											
Blue*	299	60	21	12	1	1	394	2	2	5	385
Copper	7	6	2				15			1	14
Bocaccio	1						1				1
Black	4	2					6				6
Olive	2						2	1			1
Miscellaneous											
Lingcod	1						1				1
Ocean whitefish				1			1				1
Senorita				1			1				1
Black perch	1						1				1

* Includes multiple releases, not all releases had complete data.

TABLE 22

Numbers of Tags Released, Tag Recoveries, and Total Lengths in mm for 15 Species of Fish Tagged at Tanker Buoys, Chases Reef, Bell Buoy Reef, Hopkins Reef, and Cannery Row from August, 1963 to May, 1965

	No. Tagged	T.L. Range in mm	Mean Length in mm	No. Recover.	Percent
Tanker Buoys	147			6	
Rockfish					
blue	109	115-273	182	1	0.9
canary	11	155-305	245	4	36.4
vermillion	7	263-380	324		
black	4	280-324	306		
copper	2	187-212	200		
yellowtail	2	190-317	254		
gopher	1	293	293		
Miscellaneous					
Lingcod	10	391-565	550	1	10.0
Kelp greenling	1	359	359		
Chases Reef - Kelp Area	34			0	
Rockfish					
blue	21	122-234	159		
bocaccio	6	145-162	155		
yellowtail	5	160-275	237		
Miscellaneous					
Cabezon	1	106	106		
Jacksmelt	1	366	366		
Chases Reef - Deep	157			3	
Rockfish					
blue	83	148-292	221	3	3.6
black	43	155-339	299		
yellowtail	14	190-316	240		
widow	9	206-233	222		
olive	2	295-388	342		
gopher	2	258-268	263		
canary	1	231	231		
vermilion	1	391	391		
copper	1	354	354		
bocaccio	1	264	264		
Bell Buoy	5			0	0.0
Rockfish					
Blue	4	164-230	195		
copper	1	256	250		
Hopkins Reef	14			0	0.0
Rockfish					
blue	12	155-213	178		
black	2	185-306	246		
Cannery Row	3			0	0.0
Rockfish					
blue	2	147-162	155		
olive	1	157	157		
Monterey Pier No. 1	4			0	0.0
Greenling					
Kelp	3	136-157	150		
Painted	1	157	157		

Tanker Buoys, Cannery Row, Hopkins Reef, Bell Buoy Reef, Chase Reef Kelp Area, and Chase Reef - Deep

Five of these 6 areas are distinct reefs separated by areas of sand or mud (Figure 46). The 2 subdivisions of Chase Reef are not separate reefs, but are different habitats. Chase Reef Kelp Area is more protected, supports luxurient growths of giant and bull kelp, and the maximum water depth is around 60 feet. Chase Reef - Deep is unprotected, and the maximum water depth is around 240 feet.

In all, 360 fish of 14 species were tagged and released in these areas with blue rockfish accounted for 63 percent of the releases. Nine fish in all were recovered (Table 23). Of the 4 blue rockfish recovered, there was only 1 possible movement. A blue rockfish tagged on Chase Reef - Deep was recovered 52 days later by a spear fisherman who, we believe, was fishing at the Monterey breakwater. Four canary rockfish were recovered, which accounted for the highest percent of recoveries (33.3 percent). All recovered canary rockfish were released at the Tanker Buoy Reef. Two of these recoveries exhibited movements to other reefs, one a distance of 1-1/2 miles and one about 1 mile (Figure 46). The greatest movement of all the fish recovered was by a lingcod tagged at Tanker Buoy Reef and recovered 438 days later at Capitola, a distance of 22 miles.

TABLE 23

Days at Liberty and Movement for Eight Fish Tagged at Chase's Reef and the Tanker Buoys

Species	Days at Liberty	Location of Release	Location of Recovery	Movement in Miles
Rockfish				
blue	52	Chase's Reef	Breakwater	3
	359	"	Chase's Reef	None
	414	"	" "	None
	467	Tanker Buoy	No Data	
canary	28	Tanker Buoy	Tanker Buoy	None
	450	" "	Bell Buoy	1-1/2
	477	" "	Tanker Buoy	None
	695	" "	Chris' Reef	~ 1
Lingcod	438	Tanker Buoy	Capitola	22

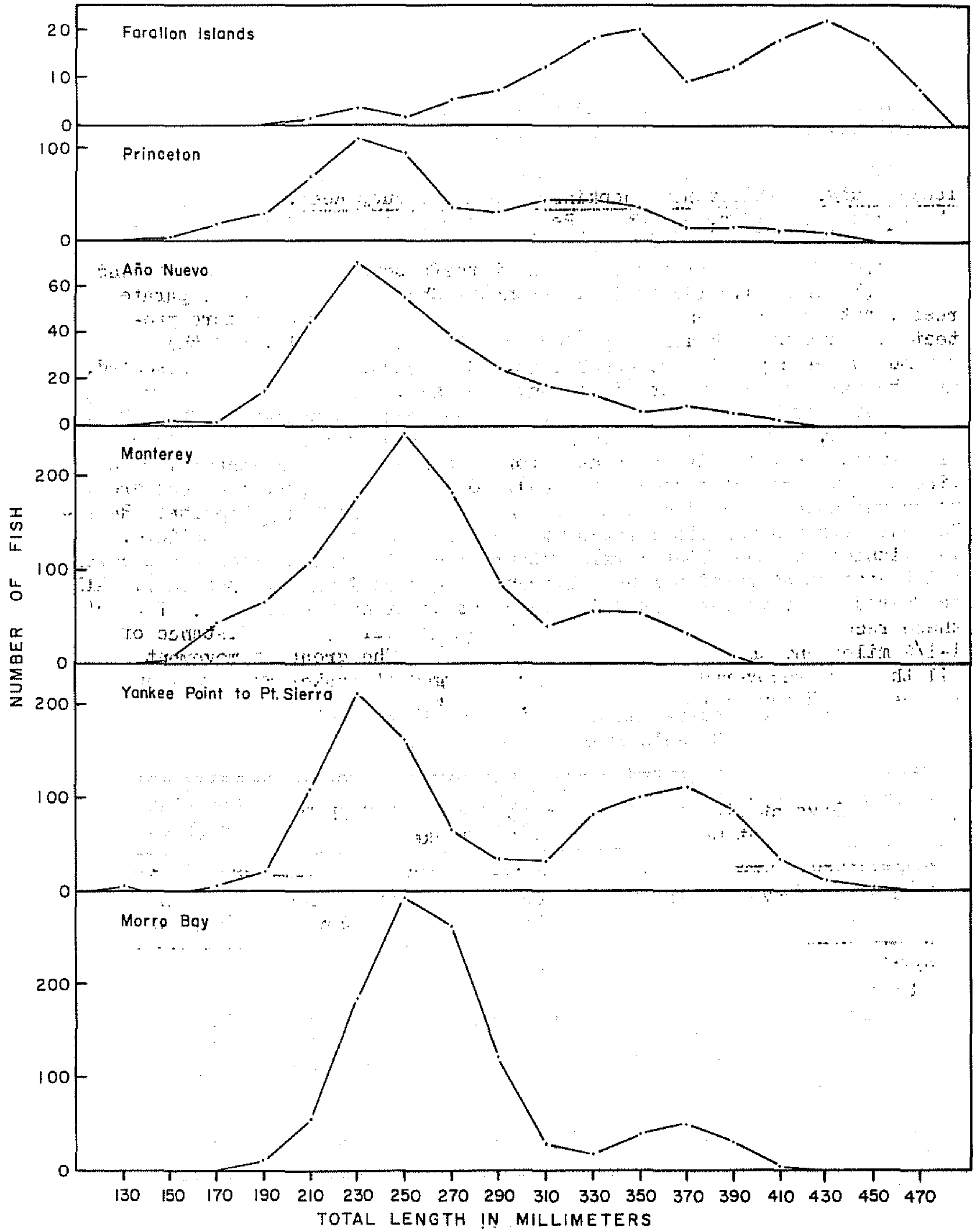


Figure 46. 1962 Frequencies - Tagging Data - N.B. Scofield Plus Partyboat Releases.

MANAGEMENT CONSIDERATIONS

The bottomfish sport fishery off central California has been intensively pursued since the mid-1950's. At that time there was a "backlog" of large adult fish of all species, including blue rockfish. These fish were readily available to the fishing fleets equipped with new recording fathometers, radios for continuous contact between sport boats, and more efficient fishing gear such as multi-hook jigs. Catches increased rapidly from 1954 through 1958. Since 1958, a reversal has taken place and at most ports there has been a continual decline each year. After a period of about 10 years the present level of fishing intensity has resulted in heavily exploited bottomfish populations near all ports south of the Farallones. In areas outside the range of skiffs and partyboats, there are bottomfish stocks that are not utilized. We at least know the blue rockfish in these isolated stocks are non-migratory, and therefore cannot be considered as reservoirs for populations now being fished.

Lacking data to compute yield estimates and mortality rates, we must base our conclusions of overfishing and management suggestions on modal characteristics of catch length frequencies, catch-per-unit of effort values, and pertinent life history information. Annual mean lengths and their standard deviations are of limited value because of the strong bi-modal characteristics of the length frequencies.

Of all the marine bottomfish for which we have life history data along the California coast, the blue rockfish probably has the greatest potential of being overfished. These fish form dense schools over shallow reef areas during most of the year, and are easily taken by hook-and-line by the most novice of fishermen. Reef areas, at least in the Monterey Bay area where we have mapped them, make up a relatively small area of the ocean's bottom, thus further exerting a control on local population levels. Nursery areas must have kelp beds and rocky shorelines with abundant rock weeds for both food and hiding places where juveniles remain for at least three years until they move about. Also, blue rockfish are a highly desired food fish. Thus, it is no wonder that during the peak of the central California bottomfish catch in 1958 and 1959 this species contributed about half the boat catch by numbers, and was first in numbers taken for all hook-and-line species by all fishing methods combined during the 1958-61 ocean fishing assessment survey. This species now contributes only 21 percent of the partyboat catch from Bodega Bay to Avila, and average about 35 mm shorter now than they did during 1958-61 at ports south of the Farallon Islands. In cases where length-frequency polygons have become strongly bi-modal, such as at Santa Cruz, Monterey, Morro Bay, and Avila, the modal group of larger fish has become progressively smaller in relation to the incoming modal group of young fish. Only at Monterey has the younger group supplied enough fish to increase the catch-per-hour values.

Following is a general resumé of the bottomfish fishery conditions with emphasis on blue rockfish from Bodega Bay southward. The Bodega Bay partyboat and skiff fisheries are apparently at such a low level of intensity that no significant trends have occurred in fish size, modal pattern of the length frequencies, or catch-per-hour values. However, even in this region of relatively light fishing intensity there were fluctuations in blue rockfish catch-per-hour values, most likely due to differential preference for other species and shifting of fishing areas by the boat operators. The fact that catch variations may be due to species preference rather than to size of fish or abundance of blue rockfish must be kept in mind when evaluating catch fluctuations in areas where fishing intensity is heavier.

At the Farallon Islands, for example, there appears to be a classic example of poor recruitment in a blue rockfish population that has been fished only about 4 years. The catch-per-hour dropped from 0.60 in 1962 to 0.38 in 1963, but the fish were actually larger in 1963. There were no strong year classes entering the fishing grounds during our sampling from 1961-1964. Likewise, in research tagging efforts we did not find an abundance of young fish around these islands.

From Princeton southward there is more fishing effort and a pattern of decreasing catch-per-hour and fewer older, large fish is evident.

The formation of strongly bi-modal length-frequency polygons in 1961 and 1962 necessitates careful analysis. The fish tagging cruise of 1962 gave us blue rockfish length-composition data from fished and unfished areas (Figure 46). The frequencies in the Yankee Point to Point Sierra area were bi-modal with the incoming group of young fish about 20-25 mm (about one year old) smaller than the mode of smaller fish at Monterey and Morro Bay. The mode of older fish (over 300 mm) contributed to more of the total frequency than comparable modes at Monterey and Morro Bay.

We assume that these strongly bi-modal length frequencies are due to natural causes, either poor year-class strength for several years from about 1954 through 1956 and/or strong year classes from 1948 through 1953 (the older fish mode), and 1957 through 1962 (the younger fish mode). These year-class dates are mere assumptions using 1964 scale and growth increment data to estimate approximate ages of fish of a certain size group. Evidence from sport-catch length frequencies indicates there was poor year-class strength during 1953-1955 rather than exceptionally strong year classes in later periods because of the continuing decline of blue rockfish. It is difficult to determine the relative strength of the year classes comprising the older-fish modes. It is possible these year classes (approximately from 1948-1953) may have been relatively strong, creating a large fishable population available at a time when the demand for bottomfish increased due to the salmon scarcity and to expanding recreational needs in general. Unfortunately, there are no catch data prior to 1958 to determine just how "normal" the conditions were in 1958 during the peak blue rockfish catches. Continued surveillance of the bottomfish fishery is needed to better determine the "normality" of blue rockfish abundance and year-class strength variations.

We do know that younger fish have increased the bottomfish catches in recent years at Monterey, yet older fish in the catch continue to decline in numbers each year. At Bodega Bay and the Farallones, fishing does not seem to be affecting the size composition of the catch. Possibly, fishing intensity is not great enough so natural trends or changes can be detected by the sport catch.

The Santa Cruz reef areas give us one of the better examples of possible blue rockfish decline, continued scarcity, and small size due to fishing pressure. Partyboat sampling was conducted in 1960; however, during 1957, 1958, and 1959, pier and skiff sampling was conducted, and partyboat and skiff bottomfish catches were observed throughout that period. Also, some boat trips were made in 1958 and 1959 to establish sampling procedures for 1960. During this 1957-59 period, blue rockfish contributed 60-70 percent of the partyboat catch and about a third of the skiff catch by numbers. Interviews with partyboat operators revealed that most of these fish were taken at South Rock, Southwest Reef, and around the whistle buoy. Most partyboat blue rockfish catches in 1964 were made off Davenport because the reefs mentioned above were not producing sufficient fish for partyboat use. In 1964, blue rockfish made up but 4 percent of the partyboat and 10 percent of the skiff catch. Increased skiff effort at Santa Cruz harbor and from Capitola and Santa Cruz piers has resulted in heavier fishing intensity since 1962. It will be interesting to see if the present fishing intensity will inhibit a buildup of larger blue rockfish without placing some limitation on the take of small fish. Continued surveillance of the skiff fishery here is essential.

Considering the slow growth rate of blue rockfish, a strong group of fish now around 200-230 mm would take about 3 to 4 years to build up a population of large, desirable fish. If a population is now at a seriously low level and strong year classes as yet not spawned are needed, then the time span for the return of a fishable population would be around 7 or 8 years.

A good example of how a sportfishery for species frequenting rocky bottom kelp areas can be managed is the kelp bass program in southern California (Young, 1963). Size limits were imposed starting at 10-1/2 inches, increasing yearly by 1/2 inch until the optimum minimum size of 12 inches was reached. A daily bag limit of ten fish is also in effect.

The only restriction on blue rockfish is the daily limit of twenty fish per rockfish aggregate. Possible catch control programs are: an annual bag limit of the total sportfish catch, closed seasons, change in the present daily bag limit, gear restrictions, area closures, and minimum size limits. Of these, only a minimum size limit is biologically sound.

Length-frequency data from 1959-1964 were used to determine the number of sport caught blue rockfish measuring less than 8, 9, and 10 inches total length (Tables 24, 25, and 26). These data were totaled for each port, and all ports combined for the partyboat and skiff fisheries from Bodega Bay to Avila. In the partyboat catch, only 2 to 5 percent of the blue rockfish and 1 percent of the total catch were blue rockfish 8 inches and less in length (Table 24). For blue rockfish 9 inches and less, the lowest number was in 1960 with 4 percent of the blue rockfish and 1 percent of the total catch. The largest number of blue rockfish 9 inches and less in the partyboat catch was in 1964 with 17 percent and 4 percent of the blue rockfish and total catch, respectively. For fish 10 inches and less, the percentage increased from 10 percent of the blue rockfish and 3 percent of the total catch in 1960 to 34 percent of the blue rockfish and 7 percent of the total catch in 1964.

Skiff catches consisted of smaller blue rockfish on the average than partyboat catches, and had higher percentages of fish less than 8, 9, and 10 inches long (Table 25). Only in 1959 are there complete skiff catch data for all ports. In 1963 and 1964 there are complete data for the Santa Cruz, Capitola, and Monterey skiff fisheries. For several ports in some years, length-frequency and catch-per-hour data only were tabulated. These length-frequency data were included to demonstrate trends and fluctuations in numbers of small fish.

The 1959-1960, 1963, and 1964 data for skiff and partyboat catches at Santa Cruz, Capitola, and Monterey were grouped for direct comparison of these two fisheries and to compute total numbers of fish and percentages below the three length categories (Table 26). Unfortunately we had to combine 1959 skiff data with 1960 partyboat data in the comparison.

In the Monterey Bay area small fish were more prevalent in 1964 when 61 percent of the blue rockfish skiff catch and 46 percent of the partyboat blue rockfish catch were fish 10 inches or less. Of the total catch of all species, blue rockfish 10 inches and less made up 5 percent and 13 percent of the skiff and partyboat catches, respectively. In the combined skiff and partyboat catches, blue rockfish 10 inches and less numbered around 30,000 per year in the Monterey Bay area from 1959-1964. In this same period, blue rockfish 8 inches and less numbered around 6,000, and blue rockfish 9 inches and less about 14,000.

Blue rockfish 8 and 9 inches in total length are around 3 to 5 years of age on the average, and those 10 inches are around 4 to 7 years of age. No females and 2 percent of the males spawn by 8 inches. Five percent of the females and 10 percent of the males spawn at 9 inches, and 25 percent of the females and around 30 percent of the males spawn at 10 inches. When 11 inches in length about 60 percent and 90 percent of the females and males, respectively, have spawned at least once.

Growth curves do not show a sharp change in growth at the approximate ages of sexual maturity. This is most likely due to the extended length and age span of first maturity. However, there is a discernable change in the growth curve slope at around 7 to 9 years of age, at which time fish are around 10 to 11 inches long.

TABLE 24

Number and Percentage of Blue Rockfish Less than 8, 9, and 10 Inches Total Length in the Partyboat Catches from Bodega Bay to Avila, 1960-1964

	Eight Inch (203 mm)			Nine Inch (229 mm)			Ten Inch (254 mm)			Number Blue Rockfish	Total Catch
	No. of Fish	% of Blue Rockfish	% of Total Catch	No. of Fish	% of Blue Rockfish	% of Total Catch	No. of Fish	% of Blue Rockfish	% of Total Catch		
Bodega Bay											
1960	0	0	0	108	1	0	325	3	1	10,849	33,277
1961	168	11	1	198	13	1	244	16	1	1,526	23,035
1962	0	0	0	48	1	0	287	6	1	4,786	20,428
1963	0	0	0	54	1	0	216	4	1	5,398	28,586
Farallon Islands											
1961	0	0	0	0	0	0	196	3	0	6,528	33,131
1962	0	0	0	181	2	0	272	3	0	9,056	36,430
1963	0	0	0	0	0	0	0	0	0	4,700	34,380
1964	0	0	0	0	0	0	0	0	0	425	15,607
Princeton											
1960	538	1	0	1,076	2	1	2,689	5	2	53,776	126,213
1961	0	0	0	150	1	0	450	3	1	14,991	60,478
1962	745	3	1	4,716	19	8	6,950	28	12	24,822	58,213
1963	381	2	0	762	4	1	2,285	12	3	19,041	89,733
1964	580	9	1	1,289	20	2	1,868	29	4	6,443	53,146
Año Nuevo											
1960	76	1	0	379	5	3	1,665	22	14	7,570	12,249
1961	118	2	1	178	3	1	415	7	3	5,922	12,606
1962	351	4	2	1,316	15	7	2,894	33	16	8,770	18,147
1963	115	2	1	573	10	4	1,547	27	11	5,731	13,760
1964	429	11	4	779	20	8	1,286	33	13	3,897	9,789

TABLE 24 (con't)

	Eight Inch (203 mm)			Nine Inch (229 mm)			Ten Inch (254 mm)			Number Blue Rockfish	Total Catch
	No. of Fish	% of Blue Rockfish	% of Total Catch	No. of Fish	% of Blue Rockfish	% of Total Catch	No. of Fish	% of Blue Rockfish	% of Total Catch		
Santa Cruz											
1960	757	6	1	1,640	13	1	2,522	20	2	12,612	100,458
1961	404	6	1	1,550	23	3	2,964	44	5	6,737	57,415
1962	249	5	0	1,047	21	2	2,094	42	3	4,986	69,010
1963	250	5	1	651	13	2	1,652	33	6	5,005	26,255
1964	434	12	1	1,158	32	1	1,809	50	2	3,618	86,024
Monterey											
1960	1,600	2	1	4,000	5	2	9,600	12	6	79,995	158,026
1961	1,895	8	1	4,264	18	4	6,633	28	6	23,688	103,398
1962	951	5	0	3,044	16	2	7,610	40	6	19,024	126,100
1963	4,010	5	2	9,625	12	6	21,656	27	18	80,206	160,740
1964	2,824	6	3	10,535	22	11	21,648	46	24	47,061	90,579
Morro Bay											
1960	392	1	0	1,566	4	1	3,132	8	1	39,152	221,095
1961	219	1	0	1,970	9	1	4,597	21	3	21,890	171,610
1962	0	0	0	1,980	3	1	12,540	19	3	66,003	244,468
1963	609	1	0	3,044	5	1	14,002	23	5	60,880	251,042
1964	712	2	0	2,494	7	1	6,414	18	3	35,631	198,556
Avila											
1960	182	2	0	546	6	1	728	8	1	9,103	52,995
1962	119	1	0	347	3	1	2,969	25	7	11,875	44,059
1963	65	1	0	129	2	0	771	12	2	6,429	41,672
1964	86	1	0	1,203	14	3	2,664	31	8	8,592	35,095
Totals											
1960	3,545	2	1	9,315	4	1	20,661	10	3	213,057	704,313
1961	2,804	4	1	8,310	11	2	15,499	21	3	74,545	461,673
1962	2,415	2	0	12,679	8	2	35,616	24	6	149,322	616,855
1963	5,430	3	1	14,838	8	2	42,129	22	6	187,390	646,168
1964	5,065	5	1	17,458	17	4	35,689	34	7	105,667	488,795

Number and Percentage of Blue Rockfish Less than 8, 9, and 10 Inches Total Length in the Skiff Catches from Bodega Bay to Avila, 1959-1964

	Eight Inch (203 mm)			Nine Inch (229 mm)			Ten Inch (254 mm)			Total Blue Rockfish	Total Catch
	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch		
Bodega Bay											
1959	46	2	0	115	5	0	300	13	1	2,309	20,980
Pedro Pt.											
1959	352	30	5	469	40	7	587	50	10	1,173	6,078
Princeton											
1959	837	14	5	1,375	23	9	2,571	43	17	5,980	15,496
1962	--	11	--	--	36	--	--	65	--	--	--
Santa Cruz											
1959	429	6	1	1,143	16	4	2,430	34	8	7,146	31,419
1961	--	18	--	--	40	--	--	57	--	--	--
1962	--	15	--	--	31	--	--	44	--	--	--
1963	363	15	2	1,114	46	7	1,671	69	11	2,422	14,948
1964	918	34	4	1,431	53	5	1,783	66	7	2,701	26,540
Capitola											
1959	153	17	0	207	23	1	289	32	1	902	40,318
1961	--	10	--	--	16	--	--	22	--	--	--
1962	--	49	--	--	70	--	--	85	--	--	--
1963	248	43	1	351	61	2	380	66	2	576	20,114
1964	486	36	1	635	47	1	973	72	2	1,351	42,354
Monterey											
1959	2,657	6	3	4,872	11	6	7,972	18	10	44,291	76,462
1961	--	38	--	--	59	--	--	73	--	--	--

TABLE 25 (con't)

	Eight Inch (203 mm)			Nine Inch (229 mm)			Ten Inch (254 mm)				
	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch	Total Blue Rockfish	Total Catch
Monterey (con't)											
1962	--	28	--	--	47	--	--	68	--	--	--
1963	1,719	17	7	3,236	32	13	5,258	52	20	10,112	25,879
1964	1,412	24	3	2,294	39	5	3,353	57	8	5,883	42,944
Cayucos											
1959	27	1	0	82	3	1	301	11	3	2,733	10,670
Morro Bay											
1959	24	1	0	96	4	1	168	7	2	2,406	9,415
1963	--	5	--	--	14	--	--	38	--	--	--
1964	--	17	--	--	36	--	--	43	--	--	--
Avila											
1959	97	4	1	121	5	1	194	8	1	2,422	15,785
1964	--	4	--	--	15	--	--	27	--	--	--
Total: (1959) only	4,622	7	2	8,480	12	4	14,812	21	7	69,362	226,627

Number and Percentage of Blue Rockfish Less than 8, 9, and 10 Inches Total Length in the Combined Skiff and Partyboat Catch Landed at Santa Cruz, Capitola, and Monterey, 1959-1964

	Eight Inch (203 mm)			Nine Inch (229 mm)			Ten Inch (254 mm)			Total Blue Rockfish	Total Catch
	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch	Number	% of Blue Rockfish	% of Total Catch		
Skiff											
1959	3,239	6	2	6,222	12	4	10,691	20	7	52,339	148,199
1963	2,330	18	4	4,701	36	8	7,309	56	12	13,110	60,941
1964	2,816	29	3	4,360	44	4	6,109	61	5	9,935	111,838
Party Boat											
1960	2,357	3	1	5,640	6	2	12,122	13	5	92,607	258,484
1963	4,260	5	2	10,276	12	5	23,308	27	12	85,211	186,995
1964	3,258	6	2	11,693	23	7	23,457	46	13	50,679	176,603
Total (Skiff and Party boat)											
1959-1960	5,596	4	1	11,862	8	3	22,813	16	6	144,946	406,683
1963	6,590	7	3	14,977	15	6	30,617	31	12	98,320	247,936
1964	6,074	10	2	16,053	26	6	29,566	49	10	60,614	288,241

Thus, considering the few numbers of fish which would be returned to the fishery at either 8 or 9 inches, the age of first maturity, and continued rapid growth to about 11 inches, the minimum blue rockfish size limit should be at 10 inches total length. In 1964, such a size limit would have returned about half the partyboat and skiff blue rockfish catch, and about 10 percent of the total catch.

There are other factors to consider in imposing a minimum size limit. When blue rockfish are brought up from certain depths there is a heavy mortality due to gas bladder expansion. In 1964, fishing trips were made in the project's skiff and on partyboats to measure this mortality by depth of capture and size of fish. Fish caught by project personnel were taken with the same gear and handled in the same manner as that employed by sport fishermen. In all, 421 fish were caught and released. Notes were made on the size of fish, condition of gas bladder, evidence of bleeding, and shock. Those swimming downward and remaining down were considered survivors. Even though a fish was only temporarily stunned and may have revived, but was eaten by a gull before it could descend, it was classified as dead.

Sizes of fish ranged from 100 mm to 430 mm and depth of capture from 10 feet to over 200 feet. The depth of capture, which was determined by marked fishing line, was the depth at which the fish was caught and not necessarily the depth of the bottom.

A little over 11 percent of all fish caught died of air bladder expansion (Table 27). None died from this cause when caught at depths less than 50 feet, but 2 did die from shock. From 0-75 feet 1 percent died, and from 0-100 feet, 3 percent died from air bladder expansion. In depths from 125 to over 200 feet, over 60 percent died. Of those in which the stomach was protruding outside of the mouth cavity, only 7 percent could swim downward and stay down.

By size, 7.4 percent, 7.5 percent, and 5.9 percent of all fish 8, 9, and 10 inches and less, respectively, died upon capture and release. There was a strong relationship between size of fish and depth of schooling. No fish smaller than 205 mm was taken at depths greater than 125 feet. Also, fish under 10 inches did not suffer a high mortality because few of them were found in depths in excess of 125 feet.

A 10 inch minimum size limit would result in a mortality of about 6 percent of those returned. Of the 30,000 fish under 10 inches caught in the Monterey Bay area in 1964, around 1,800 would have died had they been returned to the water.

Another problem of setting a size limit involves the use of small (usually under 200 mm) blue rockfish as live bait for lingcod. Should a size limit be imposed, some provision for live bait should be allowed as the number of fish utilized in this manner is small.

There is a small number of blue rockfish taken annually from piers

TABLE 27

Mortality of Blue Rockfish Taken by Hook-and-Line, Monterey, 1964

Size in mm	0-24 Lived	0-24 Died	25-49 Lived	25-49 Died	50-74 Lived	50-74 Died	75-99 Lived	75-99 Died	100-124 Lived	100-124 Died	125-149 Lived	125-149 Died	150-174 Lived	150-174 Died	175-199 Lived	175-199 Died	200+ Lived	200+ Died	Totals Lived	Totals Died
96-105									1	3									1	3
106-115							2												2	
116-125							3		1										4	
126-135	1																		1	
136-145			1				2		1										4	
146-155	1				1		1												3	
156-165	1		4		1		1		2										9	
166-175	1		9		2	1*	1	1	1										14	2
176-185			9	1*			4												13	1
186-195	5		10		4		4	1	3										26	1
196-205	4		15		8		3		1										21	
206-215	8		10	1*	16	1	3	2	1					1					38	5
216-225	9		5		10		3	1			1								28	1
226-235	3		13		15		2		4		1								38	
236-245	2		6		21		7		1		1	1	1	1					39	2
246-255	3		5		12		8				2	1	1						31	1
256-265	1		6		12		9	1	1	1	2		1	1					32	3
266-275	2		3		6		1	1	1	2		2		1		1			13	7
276-285					6		3				2	1		1					11	2
286-295	1		1		5		1		1		1	1	1	3		1			11	5
296-305					4		4			1		1		2					8	4
306-315					9		2				1			1					12	1
316-325					5		1				1					1			7	1
326-335					2		1												3	
336-345			1		3		2		1										7	
346-355					3		1			1									4	1
356-365			1		4														5	
366-375					2		2						1						5	
376-385			1		1		2												4	
386-395					1		3												4	
396-405																				
406-415					1						1								2	
416-425																				
426-436							1												1	
100-199							1	1		1									1	2
200-299					4		2									2	3	7	9	9
300+																2				2
Totals	42	0	100	2	158	2	80	8	20	9	13	7	5	11	0	7	3	7	411	53

* Died from shock; all others died from air bladder expansion.

Total Mortality: 11.2%

Mortality less than 8 inches, 7.4%; less than 9 inches, 7.5%; less than 10 inches, 5.9%.

Mortality by depths: 0-50 ft., 1.4%; 0-75 ft., 1.3%; 0-100 ft., 3.1%; 0-125 ft., 5.0%.

and by shore fishermen. During 1959-60, approximately 14,300 blue rockfish were landed annually by shore fishermen and 600 by pier fishermen. Most of the shore caught fish were taken along the Mendocino coastline and from Monterey to Pt. Sur. Of the 170 shore caught blue rockfish measured in the Monterey area, 75 percent were less than 10 inches total length.

About 3,100 blue rockfish were taken by skindivers in 1960. Nearly all these were greater than 10 inches total length.

One of the more difficult problems of a rockfish size limit is in species identification. Black rockfish and often young olive rockfish and widow rockfish appear similar to blue rockfish. The differences between black rockfish and blue rockfish are recognized only by very experienced fishermen. However, differences between blue, olive, and widow rockfish can be easily pointed out. Thus, black rockfish would have to be included in a minimum size limit with blue rockfish. A 10 inch minimum size would not cause a hardship on sport fishermen because black rockfish catches average larger than blue rockfish. For instance, in the partyboat catch from Bodega Bay to Avila in 1960, 17 of the 2,772 black rockfish measured (less than 1 percent) were 10 inches or less. In the 1959 skiff catch from Fort Bragg to Avila, 178 out of 2,217 black rockfish measured (8 percent) were 10 inches or less.

Even though a 10-inch minimum size limit for blue and black rockfish may result in an improved fishery in future years, such a restriction is not recommended at this time. Identification problems, enforcement demands on both the fisherman and the enforcement officer, and the problem of using these fish as live bait would take some of the fun and relaxation out of the fishing day. Considering that the blue rockfish stocks are not in apparent serious condition (except possibly at Santa Cruz), there is not a case of urgency in regulating the fishery. Continued sampling of the bottomfish catch during the 1966 assessment survey (Dingell-Johnson project F12R-8) from San Francisco to Yankee Point will add further information about this fishery.

An attempt should be made to ask fishermen to voluntarily release all blue rockfish less than 10 inches. By contacting all partyboat operators and organized sport clubs in coastal areas, by placing posters at skiff launching sites and concessions, releasing articles for the press, and general word of mouth contact by patrol officers and field personnel, we should see how fishermen will cooperate voluntarily.

SUMMARY

1. From 1958-1961 blue rockfish was found to be one of the more important sport species of central California, and stocks were in evidence of decline at most ports.

2. Analysis of partyboat and skiff catches demonstrated that a blue rockfish catch analysis could be accomplished only by a multi-species

inshore aggregate sampling program. Troll catch and effort data were not considered in the analysis. The principal catch parameters used in this survey were: length frequency, catch-per-hour, species composition, and total catch and effort. Mortality rates and yield estimates were not computed.

3. In general, blue rockfish stocks were shown to be under-utilized at Bodega Bay, the Farallon Islands, the area between Yankee Point and Point Sierra, and possibly around the Channel Islands of southern California. The most serious apparent decline in blue rockfish stocks has occurred in the Santa Cruz area.

4. Blue rockfish were aged by use of scales and otoliths. Data from scale reading were utilized entirely in computing age composition. Age compositions were computed only for the Monterey partyboat and skiff catch. Scales were collected at Morro Bay and Princeton for growth and maturity studies.

In 1963 and 1964, three and four year old fish were of primary importance in the sport catch. The range in age extended from 2 to 23 years. The 1962 year class appears to be relatively strong at Monterey, making up nearly 25 percent of the skiff and 17 percent of the partyboat blue rockfish catches.

5. Growth studies indicate considerable variation not only between individual fish, but between males and females and between areas of capture. Fish at Monterey breakwater are smaller in size for the same age as fish taken in the Monterey sport catch. Also, fish in the Monterey sport catch were smaller by age than in the Morro Bay and Princeton sport catches. A single growth curve was not computed. Females grew faster and lived longer than males.

6. There was considerable difference between age-length curves computed from calculated lengths from scales and observed lengths. Observed age-length data were comparable to those indicated by tagging as well as trapping growth increment data.

7. Negative growth increments were disclosed by tagging during the winter period. This lack of growth or possibly even shrinkage in total length during this period correlated with the high percentage of empty stomachs during the winter months.

8. Growth rates from modal progressions of young fish from year to year in the sport catch are comparable to those of observed age-length data from scales, tagging returns, and growth increment computed from trapping length frequencies. Most striking was the slower growth exhibited by blue rockfish at Monterey compared to those at Morro Bay and Princeton. Scale aging data disclosed these same differences, the causes of which we do not know.

These modal groups were not of one strong year class, but were made up of one or two dominant year classes with several other year classes represented.

Miller, Daniel J., and Daniel W. Gotshall
1965. Ocean sportfish catch and effort from Oregon to Point Arguello, California, July 1, 1957-June 30, 1961. Fish Bull., Calif. Dept. Fish and Game, (130):135 pp., 16 figs.

Morrell, Michael R.
Unpublished data. Calif. Dept. Fish and Game.

Morris, Robert W.
1956. Early larvae of four species of rockfish, Sebastodes. Calif. Fish and Game, 42 (2):149-153.

Phillips, Julius B.
1964. Life history studies on ten species of rockfish (Genus Sebastodes). Fish Bull., Calif. Dept. Fish and Game, (125):7 opp., 34 figs.

Roedel, Phil M.
1962. The names of certain marine fishes of California. Calif. Fish and Game, 48 (1):19-34.

Skogsberg, Tage
1936. Hydrography of Monterey Bay, California. Thermal conditions, 1929-1933. Trans., Amer. Phil. Soc., 29:1-152.

Sorokin, V. P.
1961. The redfish, gametogenesis and migrations of the Sebastes marinus L. and Sebastes mentella Travin. In:ICES/ICNAF Int. Redfish Symposium, Rapp. Proc-Verb Int. Explor. Mer. 150:245-250. (Also in special publication No. 3 of the Int. Comm. N. W. Atl. Fish.) Source: Fish. Res. Bap. Wash. Dept. Fish., 2 (3):67 p.

Wales, Joseph H.
1952. Life history of the blue rockfish, Sebastodes mystinus. Calif. Fish and Game, 38 (4):485-498.

Washington Department of Fisheries.
1950. Trawl fishery research. Ann. Rep. Wash. Fish. 1950:49.

Young, Parke H.
1963. The kelp bass (Paralabrax clathratus) and its fishery, 1947-1958. Fish Bull., Calif. Dept. Fish and Game, (122): 67 pp., 33 figs.

Appendix

Common and Scientific Names

Bass, kelp	*Paralabrax clathratus*
, striped	*Roccus saxatilis*
Cabezon	*Scorpaenichthys marmoratus*
Croaker, white	*Genyonemus lineatus*
Dogfish, spiny	*Squalus acanthias*
Eel, wolf-	*Anarrhichthys ocellatus*
Flounder, starry	*Platichthys stellatus*
Fringehead, onespot	*Neoclinus uninotatus*
Goby, bluespot	*Coryphopterus nicholsi*
Greenling, kelp	*Hexagrammos decagrammus*
, painted	*Oxylebius pictus*
, rock	*Hexagrammos superciliosus*
Hake, Pacific	*Merluccius productus*
Irish Lord, brown	*Hemilipidotus spinosus*
Jacksmelt	*Atherinops californiensis*
Kelpfish, giant	*Heterostichus rostratus*
Lingcod	*Ophiodon elongatus*
Mackerel, jack	*Trachurus symmetricus*
, Pacific	*Scomber diego*
Mola	*Mola mola*
Ray, bat	*Myliobatis californicus*
Rockfish, black	*Sebastodes melanops*
, black-and-yellow	" *chrysomelas*
, blue	" *mystinus*
, bocaccio	" *paucispinis*
, brown	" *auriculatus*
, canary	" *pinniger*
, chilipepper	" *goodei*
, china	" *nebulosus*
, copper	" *caurinus*
, gopher	" *carnatus*
, grass	" *rastrelliger*
, greenspotted	" *chlorostictus*
, greenstriped	" *elongatus*
, kelp	" *atrovirens*
, olive	" *serranoides*
, quillback	" *maliger*
, rosy	" *rosaceus*
, squarespot	" *hopkinsi*
, starry	" *constellatus*
, stripetail	" *saxicola*
, swordspine	" *rhodochloris*
, turkey-red	" *ruberrimus*
, vermilion	" *miniatus*
, widow	" *entomelas*
, yellowtail	" *flavidus*
Sablefish	*Anoplopoma fimbria*
Salmon, king	*Oncorhynchus tshawytscha*
, silver	" *kisutch*

Sanddab, Pacific	Citharichthys sordidus
, speckled	" stigmaeus
Sculpin, bonehead	Artedius notospilotus
, Pacific staghorn	Leptocottus armatus
, snubnose	Orthonopias triacis
Senorita	Oxyjulis californica
Shark, blue	Prionace glauca
, leopard	Triakis semifasciata
, soupfin	Galeorhinus zyopterus
Skate, big	Raja binoculata
Sole, petrale	Eopsetta jordani
, rock	Lepidopsetta bilineata
, sand	Psettichthys melanostictus
Surfperches	
barred surfperch	Amphistichus argenteus
Black perch	Embiotoca jacksoni
pile perch	Rhacochilus vaca
pink seaperch	Zalembius rosaceus
rainbow seaperch	Hypsurus caryi
sharpnose seaperch	Phanerodon atripes
shiner perch	Cymatogaster aggregata
striped seaperch	Embiotoca lateralis
walleye surfperch	Hyperprosopon argenteum
white seaperch	Phanerodon furcatus
Topsmelt	Atherinops affinis
Turbot, diamond	Hypsopsetta guttulata
Whitefish, ocean	Caulolatilus princeps