

Size Composition, Age Composition, and Growth of Canary Rockfish, *Sebastes pinniger*, and Splitnose Rockfish, *S. diploproa*, From the 1977 Rockfish Survey

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Introduction

Due in large part to the declining stocks of the Pacific ocean perch, *Sebastes alutus*, commercial interest in the "other rockfish" group has increased. A major goal of the 1977 Rockfish Survey was to provide biological population characteristics of the various species of *Sebastes* composing the "other rockfish" group as a data base for management decisions on regulation of the fishery. Very little infor-

mation is available on the species of the "other rockfish" group. Reports dealing with this fishery at the species level have been few; most notable are those of Alverson et al. (1964) for the Oregon-Washington region and Heimann (1963) for the Monterey Bay (California) area. This report deals with growth, size composition, and age composition within stocks of canary rockfish, *S. pinniger*, and splitnose rockfish, *S. diploproa*.

The canary rockfish is an important component of the sport and commercial fisheries. This species reaches a maximum size of 76 cm; it inhabits a depth range from the surface (juveniles) to 150 fathoms (274 m), and a latitudinal range from Baja California to Alaska (Miller and Lea, 1972), although commercial quantities are present only from central California waters to Dixon Entrance, Alaska. Off California, the principal catch of this species is in the sport and commercial longline catch; it is of minor importance in the trawl fishery (Miller and Gotshall, 1965; Heimann, 1963). Off Oregon, however, it is a dominant species in the trawl catch of the "other rockfish" group in depths less than about 120 fathoms (219 m) (Fraidenburg et al., 1977).

The splitnose rockfish is a smaller species, reaching a maximum size of 46 cm and inhabiting a range from Baja California to Alaska at depths of 100-260 fathoms (183-475 m) (Miller and Lea, 1972). This species enters the

fishery largely as incidental catch (Nittos and Reed, 1965; Alverson et al., 1964), although a directed fishery was present off Monterey in the early 1960's, when this species made up 44 percent of the total fish catch in the "deep water sub-fishery" (130-200 fathoms or 238-366 m) (Heimann, 1963). Although pelagic when young (Boehlert, 1977), fish greater than 50 mm in length are represented in the benthic habitat. This species associates with mud bottoms and does not enter into the longline or sport catch.

Materials and Methods

All hauls were taken with Nor'Eastern¹ trawls. Otoliths and length-frequency measurements were taken as described in Gunderson and Sample (1980). All lengths reported are fork lengths measured to the nearest centimeter. Length-frequencies were weighted by catch per unit effort (numbers of fish) for the final analysis of size composition. Age was determined from whole otoliths examined under a binocular microscope at ten magnifications using methodology similar to that of Westrheim (1973) and Six and Horton (1977). Each complete hyaline-opaque ring pair was assumed to represent 1 year's growth. Although not verified as true annuli for either species, Westrheim (1973) demonstrated annulus formation in young specimens and was able to follow the progression of a dominant year class through the fishery for Pacific ocean perch. The

ABSTRACT—Trawl samples from California to Washington (lat. 34°00'–48°30'N) taken in the 1977 Rockfish Survey were analyzed to provide information on growth, size composition, and age composition of canary rockfish, *Sebastes pinniger*, and splitnose rockfish, *S. diploproa*. Canary rockfish were taken predominantly in the Oregon-Washington region at depths of 50-149 fathoms (91-272 m). This species was considered as a single stock; recruitment to the sampling gear and area was complete at ages of approximately 14-15 years and sizes of 51 cm (males) and 55 cm (females). Splitnose rockfish were taken in all areas, at depths of 50-260 fathoms (91-475 m); it was considered in three latitudinal strata (based on differences in growth) and two depth strata (based on differences in length-frequencies). Recruitment to the sampling gear and area was generally complete at ages 14-17 and sizes of 26 cm (males) and 29 cm (females). Fish in the shallow strata were smaller than in the deep strata. In the deep strata there was a general trend of increasing mean size to the north. The size and age compositions in the northern stratum, when compared with historical data, suggest an impact of fishing pressure. It is suggested that the close ecological association of splitnose rockfish with Pacific ocean perch, *S. alutus*, may have resulted in a concomitant decline in stocks due to incidental catches of the former.

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¹Mention of trade names or commercial products does not imply endorsement by the National Marine Fisheries Service, NOAA.

age-length keys in the current study were applied to weighted length-frequency data to construct age compositions.

Two criteria were applied to determine the geographic and bathymetric units for the analysis of size and age compositions for the two species. The first separation was based on observed differences in growth (from age-length keys); the second was based on differences in the length-frequency distribution by area. The initial units for comparison were divided geographically into areas corresponding roughly to the 13 biological strata (described in Gunderson and Sample, 1980) in the survey and bathymetrically into four depth strata, 50-99 fathoms (91-181 m); 100-149 fathoms (183-272 m); 150-199 fathoms (274-364 m); and 200-260 fathoms (366-475 m). This resulted in 52 possible areas for initial consideration, but data were lacking for many of them.

Results

Canary Rockfish

Totals of 646 otoliths from male and 449 otoliths from female canary rockfish were taken. The mean length for male otolith specimens was 45.5 cm (range 21-61 cm) and for females 47.5 cm (range 21-64 cm). Otoliths were collected from lat. 40°27'N in the south to lat. 48°01'N in the north. Latitudinal growth differences were not examined, however, because 67 percent of all otoliths were taken between lat. 45°32' and 46°46'N. Age determination from California samples (taken from commercial and recreational catches) shows little latitudinal growth variation for this species (Boehlert²).

Numbers of otoliths at each age, mean lengths at age, and standard deviation of length are presented by sex in Table 1. It is apparent from the table that females grow faster than do males beyond age 8-9 and reach a larger size. This phenomenon is frequently ob-

² Boehlert, G. W. 1978. Latitudinal growth variation in the genus *Sebastes*. Unpubl. manuscr. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. East, Seattle, WA 98112.

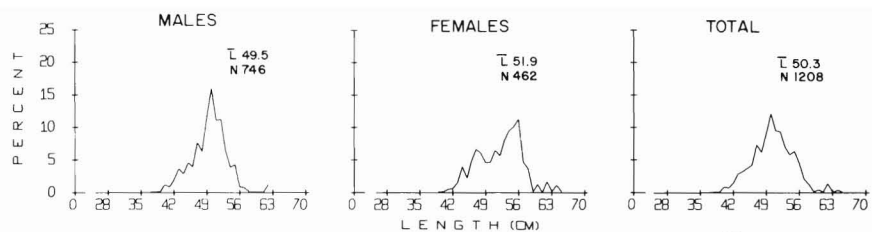


Figure 1.—Size compositions of canary rockfish; mean length (\bar{L}) and number of specimens (N) are indicated.

Table 1.—Numbers of otoliths (N), mean lengths (in cm) at age (L), and standard deviation of mean length at age (s) for male and female canary rockfish¹.

Age	Males			Females		
	N	L	s	N	L	s
1	0	—	—	0	—	—
2	0	—	—	0	—	—
3	3	23.0	1.7	3	22.3	1.2
4	8	28.3	3.8	7	29.4	2.9
5	25	31.0	2.2	14	32.9	3.0
6	45	33.3	2.6	27	33.8	2.5
7	18	36.9	1.6	20	37.3	3.5
8	33	42.8	2.2	20	41.4	2.4
9	96	43.5	2.4	57	44.5	2.7
10	87	45.3	2.3	66	46.7	2.2
11	38	46.3	3.1	46	48.0	3.0
12	42	48.8	2.2	23	51.7	2.6
13	63	49.9	1.9	35	53.2	2.0
14	73	50.8	2.2	46	54.5	2.2
15	41	51.0	2.0	42	55.3	2.3
16	37	52.1	2.3	25	56.6	3.5
17	22	53.0	2.6	11	55.1	2.5
18	12	52.6	2.5	6	57.0	3.9
19	3	53.0	1.0	0	—	—
20	0	—	—	1	62.0	0.0

¹Boehlert, G. W. 1978. Latitudinal growth variation in the genus *Sebastes*. Unpubl. manuscr. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

served in other members of the genus *Sebastes* (Six and Horton, 1977; Kelly and Wolf, 1959; and Miller and Geibel, 1973).

A total of 1,208 length-frequency observations were made on 746 males and 462 females from biological strata 6 to 13. The majority of the observations were made in strata 10 and 11. Of the possible 52 latitudinal and bathymetric areas, length-frequency measurements were made in only 10, representing seven areas in the 50- to 99-fathom (91- to 181-m) range and three areas in the 100- to 149-fathom (183- to 272-m) range. Comparison of the length frequencies from these areas revealed only minor differences in the size compositions, certain of which may have resulted from relatively low sample numbers; consequently, no di-

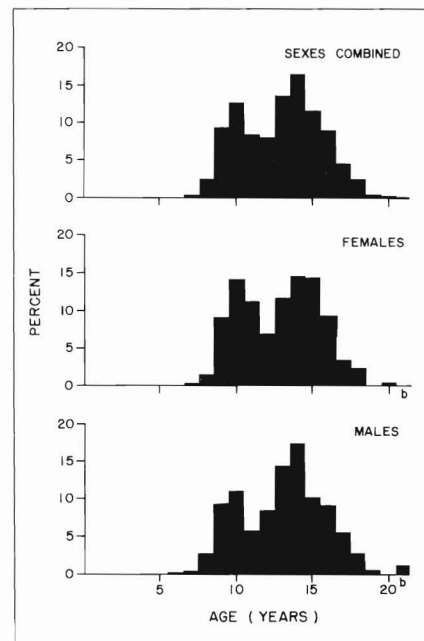


Figure 2.—Age composition of canary rockfish; "b" designates lengths greater than those in the age-length key.

visions were made on the basis of length frequencies and the population was considered as a single unit. Size and age composition for the combined collections of canary rockfish are presented in Figures 1 and 2.

Splitnose Rockfish

A total of 1,075 otoliths from male and 751 otoliths from female splitnose rockfish were taken. Although sampling was insufficient to allow bathymetric comparison of growth rates, the otolith collections were widely spaced throughout the 13 biological strata. Three arbitrary latitudinal strata (based

on the collections of otoliths), corresponding to biological strata 1-3, 4-5, and 6-13, were used to analyze latitudinal growth variation. Numbers of otoliths, mean size, and size range of males and females in the otolith collections are presented in Table 2.

Analysis of growth curves indicated that growth rate varies with latitude, being generally faster in the north (Boehlert, footnote 2). Age-length keys from these three strata are presented in Table 3 for both males and females. Due to the differences in growth rate, these three divisions (lat. 34°00'-37°06', 37°07'-40°25', and 40°26'-48°30'N) were chosen as latitudinal units for analysis of size and age composition.

A total of 19,436 length-frequency observations were made (10,902 males, 7,632 females, and 902 unsexed) from biological strata 1-13. Of the possible 52 biological and depth strata, length-frequency samples were obtained in 31. These were obtained in 2 of the 50- to 99-fathom (91-181-m) strata, 10 of the 100- to 149-fathom (183- to 272-m) strata, 12 of the 150- to 199-fathom (274- to 364-m) strata, and 7 of the 200- to 260-fathom (366- to 475-m) strata. Comparison of the size compositions in these samples indicates a trend of increasing mean size with depth in a given latitudinal area. Although mean lengths in the two samples in the 50- to 99-fathom range were quite small (14.2 and 12.8 cm), the numbers were relatively low and these depths were represented only in biological strata 1 and 2. For this reason, they were combined with the samples in the 100- to 149-fathom range. Mean lengths and distribution of length frequencies were similar in the 150- to 199- and 200- to 260-fathom ranges but generally differed from the lower mean lengths and length frequency distributions in the 100- to 149-fathom range. Consequently, the samples were divided into shallow (50-149 fathoms; 91-272 m) and deep (150-260 fathoms; 274-475 m) categories.

Size compositions for six latitudinal-bathymetric groups of splitnose rockfish are presented in Figure 3. As is the case with canary rockfish, mean

lengths of females are generally greater than those of males. With the exception of the northern stratum (lat. 40°26'-48°30'N), the size compositions in shallow water generally show a broader spread than the more distinct peaks in the deeper water zone. In all three geographic regions, the relative abundance of juveniles (<21 cm) was quite high in the 50- to 149-fathom depth zone, and decreased sharply in the 150- to 260-fathom zone.

Age compositions for splitnose rockfish are presented in Figure 4 (males), Figure 5 (females), and Figure 6 (total). There was insufficient sampling of otoliths in shallow water to

allow use of separate age-length keys for the two depth zones; consequently, three male and three female age-length keys (Table 3), based on latitudinal collections of otoliths, were used. Examination of Table 3 indicated that the only complete sampling of young (ages 1-3) fish for otoliths was undertaken in the southern geographic stratum (lat. 34°00'-37°06'N). Relatively large numbers of small specimens, however, were sampled in the length-frequency measurements from the shallow portions of the middle and northern geographic strata (50-149 fathoms, lat. 37°07'-40°25'N and lat. 40°26'-48°30'N; Fig. 3). The lack of young

Table 2.—Number of otoliths, mean size, and size range of specimens of splitnose rockfish by sex and geographic area.

Item	Lat. 34°00' to 37°06'N		Lat. 37°07' to 40°25'N		Lat. 40°26' to 48°30'N	
	Males	Females	Males	Females	Males	Females
No. of otoliths	430	399	339	178	306	174
Mean size (cm)	21.9	23.6	25.4	25.0	27.4	27.6
Size range (cm)	8-32	8-33	14-33	16-36	16-36	16-39

Table 3.—Numbers of otoliths (N), mean lengths at age (L), and standard deviation of mean length (in cm) at age (s) for male and female splitnose rockfish for the three geographic areas¹.

Age	Lat. 34°00' to 37°06'N						Lat. 37°07' to 40°25'N						Lat. 40°26' to 48°30'N					
	Males			Females			Males			Females			Males			Females		
	N	L	s	N	L	s	N	L	s	N	L	s	N	L	s	N	L	s
1	10	8.7	0.7	6	9.3	0.8	0	—	—	0	—	—	0	—	—	0	—	—
2	23	10.8	1.0	26	10.3	1.0	0	—	—	0	—	—	1	16.0	0.0	0	—	—
3	36	12.7	1.1	33	12.9	1.3	2	15.5	2.1	1	16.0	0.0	9	16.2	0.4	9	17.1	0.8
4	19	14.4	1.3	11	13.6	1.3	2	18.0	0.0	6	16.5	0.6	8	18.5	1.5	13	17.8	1.2
5	7	17.3	1.7	5	14.4	1.3	9	18.6	1.5	14	18.9	1.3	17	20.2	1.3	11	20.3	1.4
6	19	17.0	1.9	9	16.7	1.9	18	20.3	1.5	18	19.8	1.2	10	21.0	0.7	10	21.8	1.1
7	15	18.5	2.3	10	19.9	2.8	17	21.4	1.4	15	21.3	0.7	10	21.6	0.8	9	24.1	2.0
8	14	20.8	2.1	9	21.6	1.9	17	22.1	1.9	9	22.1	0.9	4	24.0	0.8	7	24.9	1.3
9	5	22.8	1.5	9	22.3	0.9	18	23.0	1.6	15	24.0	1.1	15	26.1	1.3	5	25.4	1.7
10	17	23.1	1.1	13	22.6	1.1	14	23.4	1.7	14	25.1	1.0	15	26.2	1.2	13	27.1	1.0
11	19	23.1	1.1	15	24.0	1.3	18	24.4	1.0	10	25.4	1.3	10	26.9	1.5	9	27.4	1.5
12	17	24.4	1.3	15	24.7	1.7	21	24.8	1.6	8	26.5	2.0	19	26.6	1.3	5	27.4	1.1
13	33	24.9	1.2	12	25.8	1.7	26	25.7	1.0	6	26.2	1.7	17	27.7	1.4	5	29.8	1.6
14	50	25.1	1.3	26	26.2	1.2	24	26.3	1.5	4	27.8	1.0	20	28.3	1.7	5	30.0	1.6
15	43	26.0	1.4	32	27.2	1.6	35	26.5	1.5	8	28.9	1.6	16	28.4	2.0	13	29.6	1.9
16	28	26.1	1.0	33	27.4	1.5	25	27.1	1.1	7	29.1	1.2	21	29.2	1.7	5	32.0	1.2
17	25	26.7	1.1	45	28.2	1.4	29	27.3	1.4	9	30.0	1.2	29	30.1	1.6	8	32.6	1.3
18	19	26.8	1.4	25	28.4	1.2	18	28.3	1.5	11	29.7	1.1	15	30.2	1.5	7	33.6	3.2
19	12	27.2	2.2	23	29.4	1.5	14	28.6	1.3	6	29.8	1.8	10	30.0	2.0	5	31.4	1.8
20	8	28.0	1.2	18	29.9	1.7	7	29.0	1.6	6	30.0	1.7	15	31.5	2.1	6	34.3	2.2
21	8	27.8	2.1	11	30.6	0.9	6	28.8	1.0	4	31.0	1.2	12	31.5	1.7	8	34.9	2.2
22	2	27.5	2.1	7	30.4	1.0	6	30.3	1.5	2	30.5	2.1	4	32.5	0.6	9	34.3	1.9
23	1	27.0	—	3	30.7	0.6	5	31.4	0.9	2	34.5	2.1	12	31.6	1.2	3	35.3	1.5
24	0	—	—	2	31.0	1.4	3	32.6	0.6	0	—	0.0	5	32.6	1.5	4	34.8	1.0
25	0	—	—	1	33.0	0.0	3	31.0	1.0	2	32.5	0.7	8	31.9	1.2	3	35.0	2.0
26+	0	—	—	0	—	—	2	30.0	1.4	1	35.0	0.0	4	32.5	0.6	2	36.0	2.9

¹Boehlert, G. W. 1978. Latitudinal growth variation in the genus *Sebastes*. Unpubl. manusc. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

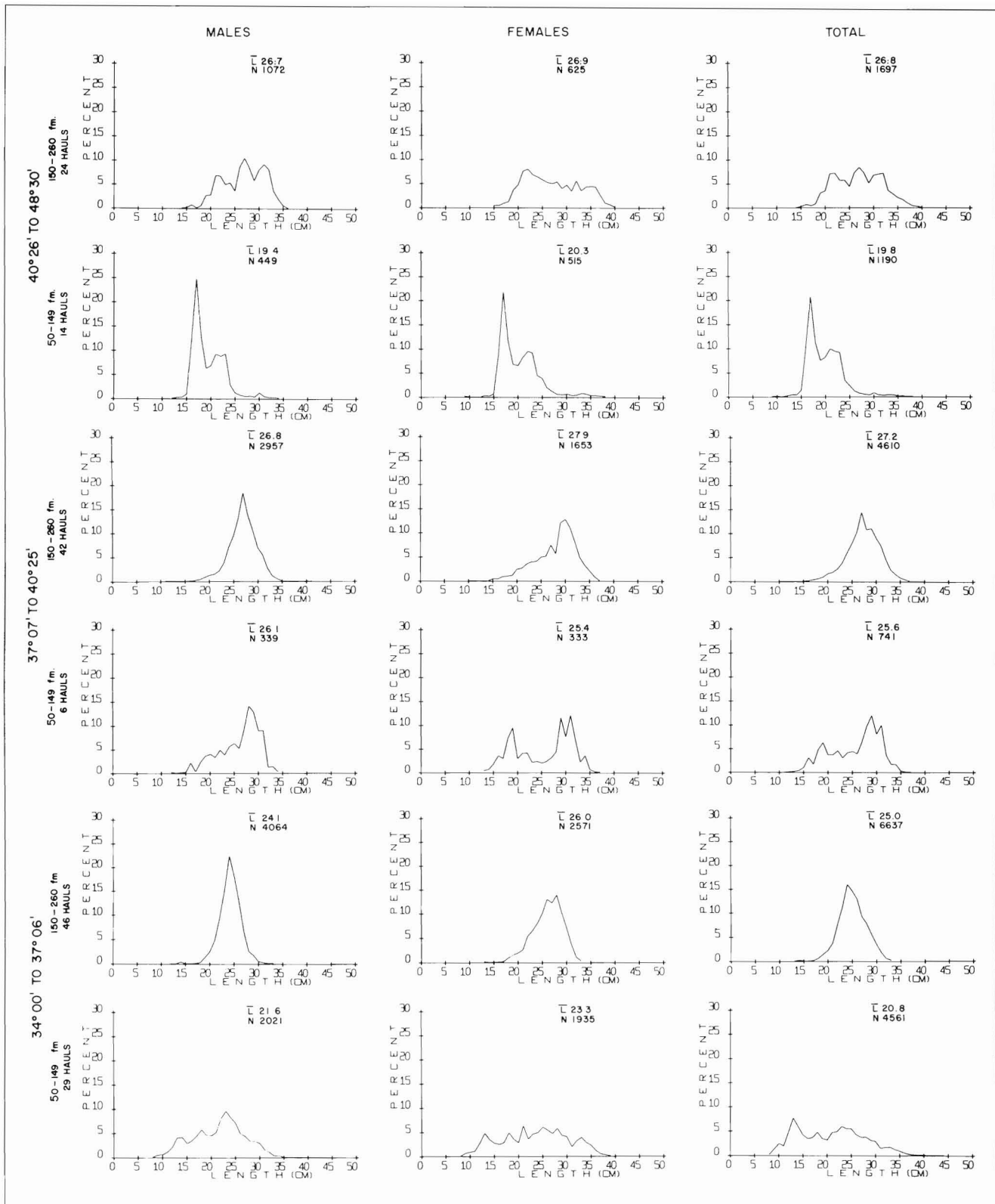


Figure 3.— Size compositions of splitnose rockfish by geographic and bathymetric area. Mean length (\bar{L}) and number of specimens (N) are indicated.

specimens in the age-length keys for these areas would have resulted in large proportions of specimens below the key length in the age composition. For this reason, all fish aged 1-3 years were pooled by sex and included in all age-length keys. The inaccuracy involved in assuming similar growth for the first 3 years was compensated for by the information gained in the age compositions.

Discussion

Canary Rockfish

Length frequencies for male canary rockfish showed a dominant mode at 50 cm, whereas those for females were less clear, with a smaller peak at 46-48 cm and a larger peak at 54-56 cm (Fig. 1). Translated to age composition (Fig. 2), there is difficulty in interpreting the point at which recruitment to the sampling gear and area is complete owing in part to the presence of a dominant 1967 year class. The males appear to reach full vulnerability at age 14 (mean length 51 cm), whereas the females reach this stage at age 15 (mean length 55 cm).

Little information exists on the life history and habitat preference of this species. In the southern part of its range, it appears to be primarily a reef-associated species. It composed only 0.2 percent of the rockfish trawl catch off Monterey (Heimann, 1963) but was relatively important in the same area in the partyboat and commercial longline catch over areas generally unsuitable for trawling (Miller and Gotshall, 1965; Miller and Geibel, 1973). In the Columbia region trawl fishery, however, the canary rockfish composes up to 59 percent of the "other rockfish" category at depths from 60 to 90 fathoms (110 to 165 m) (Fraidenburg et al., 1977). Thus, in terms of the fishery, there may be two populations of canary rockfish. At sizes below 50 mm, this species is probably pelagic (Partlo, 1950); subsequent recruitment is probably to the inshore reef population, since juveniles are common in the sport catch (Miller and Gotshall, 1965) and the youngest age classes in the rockfish survey were about 6-7 years (Fig. 2).

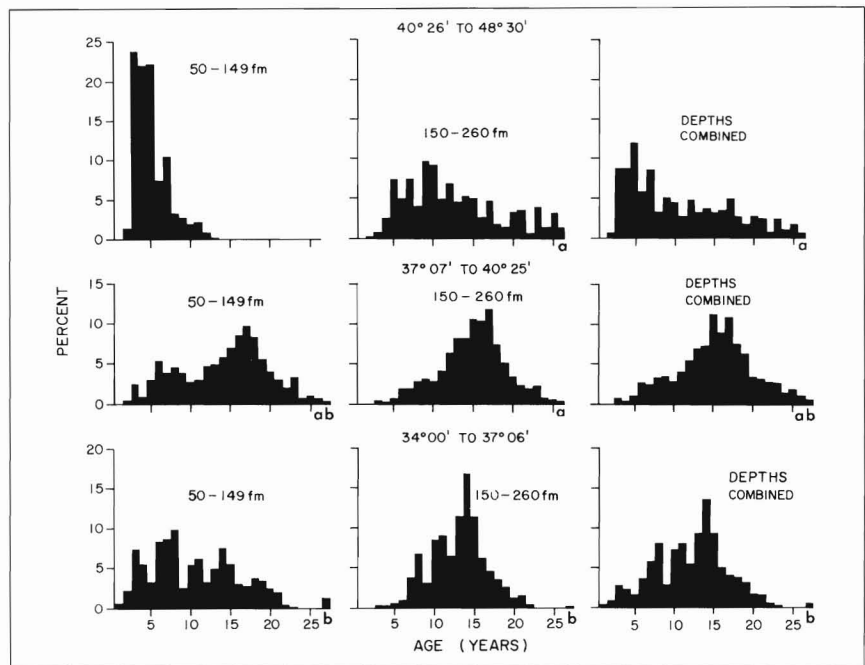


Figure 4.—Age compositions of male splitnose rockfish by area: "a" designates ages greater than 25 years; "b" designates lengths greater than those in the age-length key.

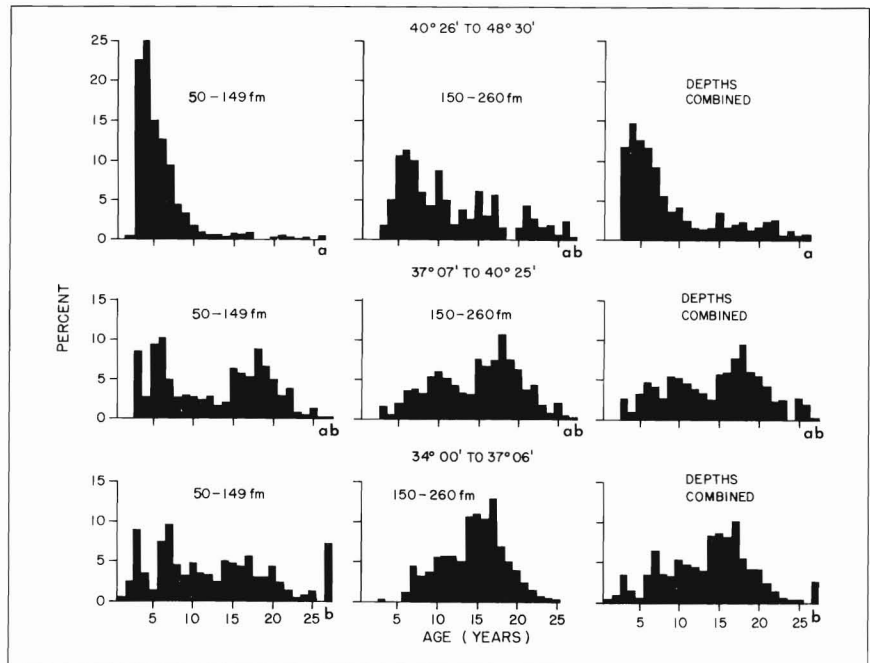


Figure 5.—Age compositions of female splitnose rockfish by area: "a" designates ages greater than 25 years; "b" designates lengths greater than those in the age-length key.

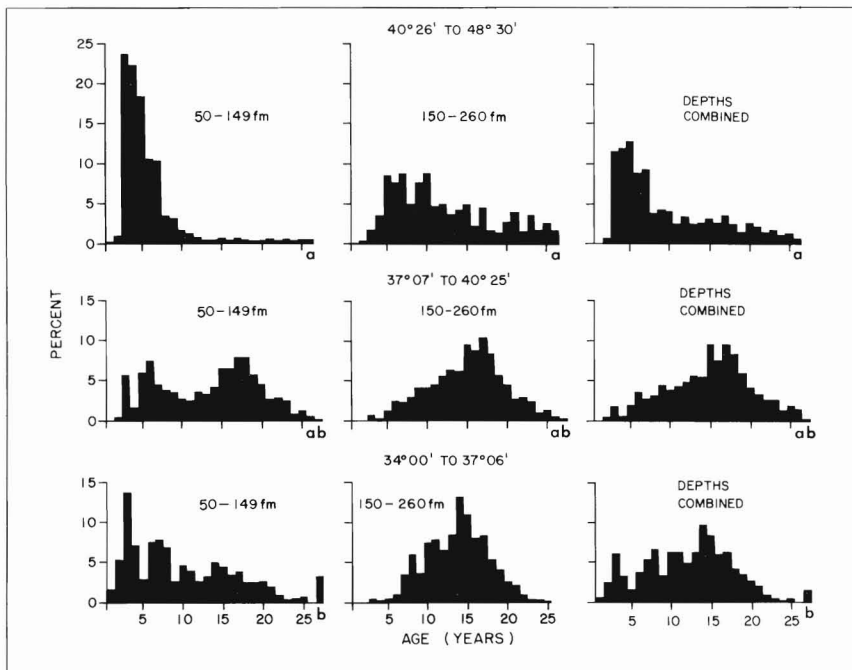


Figure 6.—Age compositions (males, females, and unsexed specimens combined) of splitnose rockfish by area: “a” designates ages greater than 25 years; “b” designates lengths greater than those in the age-length key.

More information is necessary on the relationship between the reef and offshore populations of this species, especially comparison between the southern and central parts of its range.

Splitnose Rockfish

Size compositions for splitnose rockfish (Fig. 3) show a definite trend of smaller fish in the shallow (50- to 149-fathom; 91- to 272-m) strata as compared with the deep (150- to 260-fathom; 274- to 475-m) strata. This is a common phenomenon in the genus *Sebastes* (Moser, 1967; Carlson and Haight, 1976; Boehlert, 1977). Inspection of the southern and central geographical strata (lat. 34°00'-37°06' N and lat. 37°07'-40°25' N) suggests a trend of increasing size to the north at a given depth, but in other respects, the size compositions are similar; the 50- to 149-fathom zones have a wide range of lengths and relatively low mean length, whereas the 150- to 260-fathom strata show well-defined peaks with few specimens in the smaller size

categories. The northernmost geographical area (lat. 40°26'-48°30' N) is anomalous as compared with the other two; the 50- to 149-fathom stratum shows a very large peak at sizes of 16-18 cm and a smaller, less distinct peak at 21-23 cm. The larger sizes (to 35 cm) present in the 50- to 149-fathom zones in the two geographic areas to the south are not represented. Furthermore, in the 150- to 260-fathom zone, there is no distinct mode as in the two southern strata, but rather a combination of peaks, the first of which corresponds to the smaller peak (21-23 cm) in the 50- to 149-fathom range.

Based on examination of age composition in all strata, complete recruitment to the sampling gear and area appears to occur at about age 14 for males (mean length 26 cm) and about age 17 for females (mean length 29 cm). There are definite differences in relative abundance of adjacent year classes between males and females, probably due to sampling errors and the use of age-length keys. For most strata, however, the general form of the age frequency

distribution was quite comparable between sexes (Fig. 4, 5).

In the southernmost geographic stratum, the 50- to 149-fathom (91- to 272-m) zone has a large proportion of fish aged 10 or less, but considerable numbers of older individuals are also present. In the central geographic stratum, fish aged 15-18 make up a major part of the population in both depth zones. In both of these areas, the 150- to 260-fathom (274- to 475-m) zone is dominated by older fish. As with size composition, age composition in the northern geographic stratum is considerably different from the central and southern strata. In the 50- to 149-fathom zone, fish beyond age 12 are rare, and age composition in the 150- to 260-fathom zone is similar to the shallow zone in the southernmost geographic stratum (Fig. 4-6).

I interpret the size and age composition in the northern geographic area (lat. 40°26'-48°30' N) to be the result of fishing pressure. Unfortunately, historical fishing information on members of the “other rockfish” group is relatively scanty. The best data available on the size composition of splitnose rockfish prior to the present study are those of Alverson et al. (1964). Length-frequencies of 672 specimens from the Washington-Oregon region (taken in 1961-62) are plotted in Figure 7 against those from lat. 40°26'-48°30' N (depths combined) in the 1977 rockfish survey. The data from the previous study show a continuation of the trend which would be expected in deep water—i.e., a distinct peak in the size composition similar to the deep southern samples and an increase in the mean length. The current data show a shift to smaller sizes than would be expected, as is evident in both the size and age composition.

The splitnose rockfish commands a relatively low market price and is only partially vulnerable to commercial trawling off Oregon-California where cod end mesh size must be 4.5 inches (11.4 cm) or greater; consequently, there has generally been no directed fishery for this species except in certain areas of very high abundance (Heimann, 1963). Off California, it was an important component of the

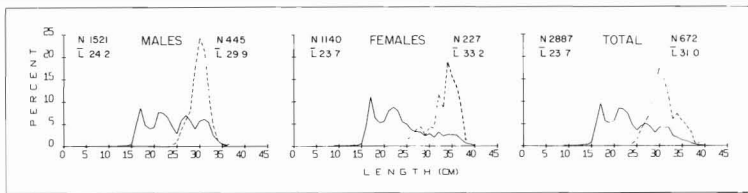


Figure 7.—Comparison of size composition of splitnose rockfish from the present study with that from Alverson et al. (1964). Data from the present study are from all depths in the northern area (lat. 40°26' to 48°30'N), represented by the solid line; data from Alverson et al. (1964) are represented by the dashed line. Mean length (L) and number of specimens (N) are indicated; values on the left are from the present study.

animal food fishery in the early 1960's (Nitsos and Reed, 1965). In the north, however, the species is most closely associated with catches of Pacific ocean perch (Alverson and Westrheim, 1961); the remarkable decline of the Pacific ocean perch stocks in the Oregon-Washington region has been well documented (Gunderson, 1977; Gunderson et al., 1977). Although no data on the incidental catch of splitnose rockfish in the foreign and domestic catch of Pacific ocean perch are available, it is likely that the close ecological association of these two species may have resulted in a concomitant decline in the northern stocks of splitnose rockfish, a slow-growing, long-lived species which is probably unable to withstand intensive fishing pressure.

Acknowledgments

This research was accomplished while the author held a Resident Research Associateship from the National

Research Council. I thank T. Wyatt of the Ageing Unit, Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, Wash., for reading the *S. pinniger* otoliths. D. R. Gunderson and W. H. Lenarz critically read the manuscript.

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