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Life History Studies on Ten Species of Rockfish (Genus Sebastodes)

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1. ERRATA

CORRECTION

Fish Bulletin 126, page 18 - delete line 30 and substitute the following:

"California, Mexico, appeared in greatly increased numbers as far north"

Correction

2. INTRODUCTION

Life-history information is extremely important in fisheries management, especially details regarding age, fecundity, growth, food habits, and so on. Such knowledge has been lacking for the principal species comprising commercial rockfish catches from California waters. Recent studies have furnished details on annual growth, size and age at maturity, weight-length relationship, season of spawning, fecundity, and feeding habits for 10 species of rockfish (genus Sebastodes) that are commonly taken off California. These are bocaccio, S. paucispinis, chilipepper, S. goodei, yellowtail rockfish, S. flavidus, canary rockfish, S. pinniger, vermilion rockfish, S. miniatus, widow rockfish, S. entomelas, dark-blotched rockfish, S. crameri, splitnose rockfish (rosefish), S. diploproa, stripetail rockfish, S. saxicola, and shortbelly rockfish, S. jordani.

Although 57 varieties of scorpaenids (family Scorpaenidae) exist off the coast of western North America, only two had been studied in any detail prior to this time. Wales (1952) published a partial life history of the blue rockfish, Sebastodes mystinus, and Westrheim (1958), and Alverson and Westrheim (1961) published data on the biology of the Pacific ocean perch, S. alutus. The blue rockfish is a shallow water form, caught mainly by sportfishermen in California. Although poorly represented off California, Pacific ocean perch are abundant in offshore waters of the Pacific Northwest, where they are the primary rockfish sought by otter trawl fishermen.

In California waters, the rockfish family is now represented by 50 species of Sebastodes (rockfish or "rock cod"), 2 species of Sebastolobus (channel rockfish), and 1 of Scorpaena (sculpin). This fish family is one of the most important and colorful in our waters. Most of the species are highly desirable for food and are subjected to both commercial and sportfishing pressure. Only a few are too small to be of direct value for human consumption. Even these are utilized as food by other fishes, often by larger forms of rockfish. Nine of the species in the present study are of considerable commercial value; the tenth, the shortbelly rockfish, is a small form whose greatest value probably is as food for salmon (Merkel, 1957) and similar predators.

As time permits and based upon future catch composition evaluations, other prominent species will be studied in similar detail. The most important of these at present seem to be the shortspine channel rockfish, Sebastolobus alascanus, and flag rockfish, Sebastodes rubrivinctus, in northern California; the speckled rockfish, S. ovalis, in central California; and the bronzespotted rockfish, S. gilli and cow rockfish, S. levis, in southern California.

2.1. Importance of Fishery

As early as 1875, Pacific coast market landings included various forms of rockfish. The catch of these species in California, which in 1900 totaled between 1 and 2 million pounds, reached an all-time high of nearly 18 million pounds in 1958. Subsequently, the annual catch declined to about 10 million pounds in 1962. Previous to 1944, rockfish were caught primarily with hook and line (longlines). About five percent of the annual State poundage was landed by the old-type paranzella and otter trawl boats, which were rigged for capturing flatfish (Clark, 1935). Late in 1943, the introduction of the modified, or "balloon" type, trawl proved so successful that by the end of 1944, the amount of rockfish caught by this type of gear surpassed that landed by longlines (Scofield, 1948).

When longline gear dominated the fishery previous to 1944, the species landed in greatest amount in northern California was the black rockfish, Sebastodes melanops; in central California it was the bocaccio and the chilipepper; and, in southern California it was the vermilion rockfish. After the "balloon" trawl became the dominant gear, the canary rockfish replaced the black rockfish as the species landed in greatest amount in northern California. No change has occurred in the remainder of the State. In the last 2 years, an expansion of the otter trawl fishery at Santa Barbara has resulted in bocaccio and chilipepper becoming the two most important rockfish landed there.

Several other rockfishes are also prominent in commercial catches: dark-blotched rockfish in northern California, splitnose rockfish (rosefish) in both northern and central California, and widow and yellowtail rockfish in central California. The yellowtail rockfish, rarely taken by otter trawlers, is a major component of longline catches.

Although not utilized for human consumption because of their small size, stripetail rockfish and shortbelly rockfish have been included in this study. The former is one of the most important animal-food rockfishes, in which filleted carcasses and unmarketable species are ground and frozen (Best, 1961). As previously mentioned, the shortbelly rockfish is most important as forage for other fishes.

Generally, in northern and central California, the important commercial species differ from the important sport species. This is because most trawling is conducted at a greater distance from shore and at a greater depth than sportsmen usually fish (Heimann and Miller, 1960; Heimann, 1963). In southern California, where there is a greater emphasis on deep-sea fishing, sportfishermen often catch such marketable rockfish as bocaccio, chilipepper, vermilion, canary, and yellowtail. In addition, cow rockfish, which attain weights of 32 pounds, are sought by sportfishermen striving for record size rockfish (J. E. Fitch, pers. comm.).

2.2. Regulations

Commercial setlines and longlines are permitted in all ocean waters of the State except the bays of Humboldt, San Francisco, San Pablo, Morro, and San Diego, and small areas in the northern and southern sections of Monterey Bay. Also, the waters surrounding Santa Catalina Islands are closed to such fishing.

Trawling or drag net operations are not permitted within 3 miles of the mainland anywhere in the State, and the use or possession of these nets in State waters (within the 3-mile limit) is prohibited south of the Santa Barbara-Ventura County line, including the waters around Santa Catalina Island. Minimum size mesh permitted in trawl nets is 4 ½ inches inside stretch measure, except for the strictly regulated shrimp fishery.

No size, bag, or seasonal limits apply to the commercial taking of rockfish in California. Sportfishermen are restricted to 20 rockfish per day to conserve the easily accessible sport species found near rocky inshore areas.

3. MATERIALS AND METHODS

Most data for these life history studies were accumulated during the last several years by sampling selectively at wholesale fish markets at Eureka, Fort Bragg, and Monterey. In addition, collections were made on several cruises with Departmental research vessels operating in southern California waters. Widespread material was collected because all species are not equally abundant along the coast. In the combined sampling over the several-year period, all months are represented. Individual species were examined in at least 9 of the 12 months.

In all, nearly 6,000 fish in the 10 species were processed. Maturity observations were made on all, and weights were taken on 5,600. For any given species, between 422 and 783 specimens were examined. In analyzing age, 1,231 fish were used, or from 92 to 154 per species. However, back-calculations were made to determine the growth attained in previous years, so by including these calculations 8,806 age readings were made, or 450 to 1,285 cases for each species.

In the sampling procedure, each fish was laid flat on a measuring board and its total length recorded in millimeters. Total length was taken from the anterior tip of the jaws, with mouth closed, to the end of the longest caudal ray with the rays brought to the horizontal position. Total length was taken in preference to fork length because not all rockfish have forked tails. Some have caudal fins that are either rounded or truncate posteriorly. All 10 species in the present study have moderately forked tails. The weight of each fish, in the round, was taken with a spring balance scale graduated in tenths of pounds, except that very small fish were weighed on a scale graduated in grams.

The final age determinations for all 10 species were based on identification of annuli on the scales. Both otoliths and scales gave valid readings, but scales were selected because they were obtained with less effort. Species closely associated with a strictly rocky habitat, such as the vermilion rockfish, had a larger proportion of regenerated scales than did those which typically inhabit a relatively smoother ocean bottom.

Scales were examined with a head-band magnifier upon removal from the fish so that abnormal ones could be avoided. Several scales were selected from each fish and placed in a small glass vial containing water

to prevent drying, and labeled for future identification. If the scales were held for several days before mounting, a modicum of phenol in the water forestalled mold. Several scales from each fish were cleaned and placed dry between two glass slides, which were then taped together at the ends and labeled.

By means of a low-power microscope, transmitted light, a 45-degree prism over the ocular, and a mirror facing the prism at a 45-degree angle, scale images were projected downward onto a white surface at magnifications of 30 to 60 diameters, depending upon scale size. For each fish, one scale was selected and the location of its annuli and anterior margin were recorded by marking across a millimeter rule printed along one edge of a 3- by 12-inch card. The card was laid along the anterior mid-longitudinal axis of the magnified scale image with the zero line of the rule at the scale's focus.

Most maturity observations were made during the spawning season so that immaturity could be distinguished with greater certainty. In determining fecundity, ovaries with developing eggs still attached to follicles were excised and hardened in formalin for at least three weeks. Upon removal from formalin, the gross weight of each pair of ovaries was noted, but subtracted from this was the weight of the various enveloping tissues. From the middle of an ovary, a small sample of eggs, usually less than a gram, was removed and weighed on a triple-beam balance calibrated in tenths of grams. The number of eggs counted in the sample served as the basis for calculating the total number of eggs in a paired ovary.

3.1. Scales and Otoliths

Scales and otoliths were examined critically in determining ages, and also in the hopes they could furnish clues for identifying species. Between species, the scales illustrated here (Figures 1 2 3) are not comparable because they were not all taken from the same area of the body. For example, the chilipepper's scale is somewhat rectangular with about 10 radii and a small, triangular, ctenoid zone. Scales from other areas of the chilipepper's body may be nearly round, or elongate, and have as few as six radii, and narrower or broader ctenoid zones.

Otoliths appear to offer a better means of identifying such fishes. Fitch (1957), by means of a large reference collection of otoliths, has been able to identify stomach contents of many fishes, seals, porpoises, and ocean birds. Otoliths unearthed from remains of Indian civilizations have been identified by Fitch (Shumway, Hubbs, and Moriarty, 1961), as well as those in collections at Los Angeles County Museum, representing deposits during the Pleistocene and Pliocene periods. These include several species of rockfish.

The pair of illustrated otoliths (sagittae) (Figure 4) from each species treated in this study are not from the same specimens represented by the scales (Figures 1-3).

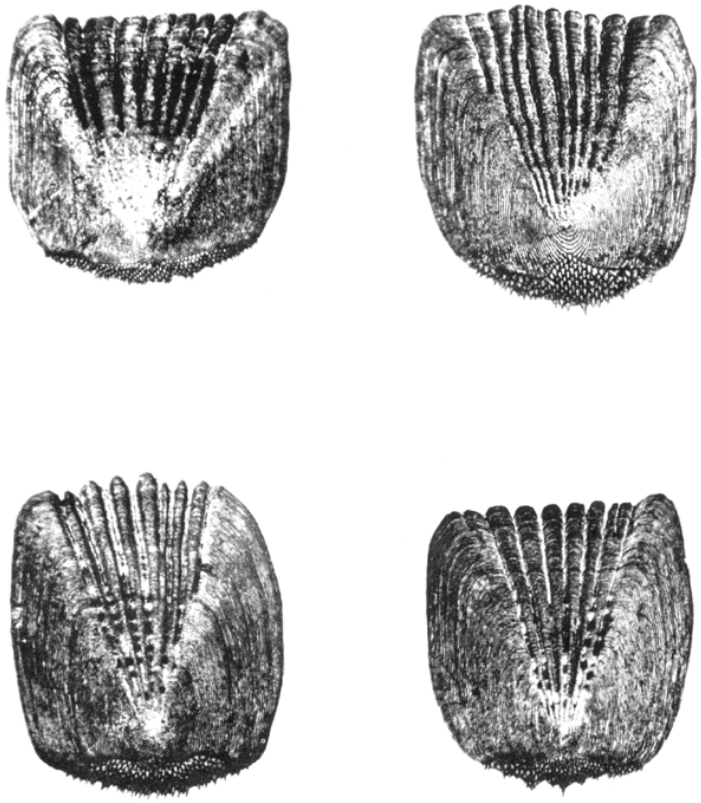

FIGURE 1. Body scales from four species of rockfish (total length and number of annuli noted, L to R). Top row: stripetail rockfish, 287 mm, 13; shortbelly rockfish, 293 mm, 9. Bottom row: dark-blotched rockfish, 285 mm, 5; splitnose rockfish, 295 mm, 10.

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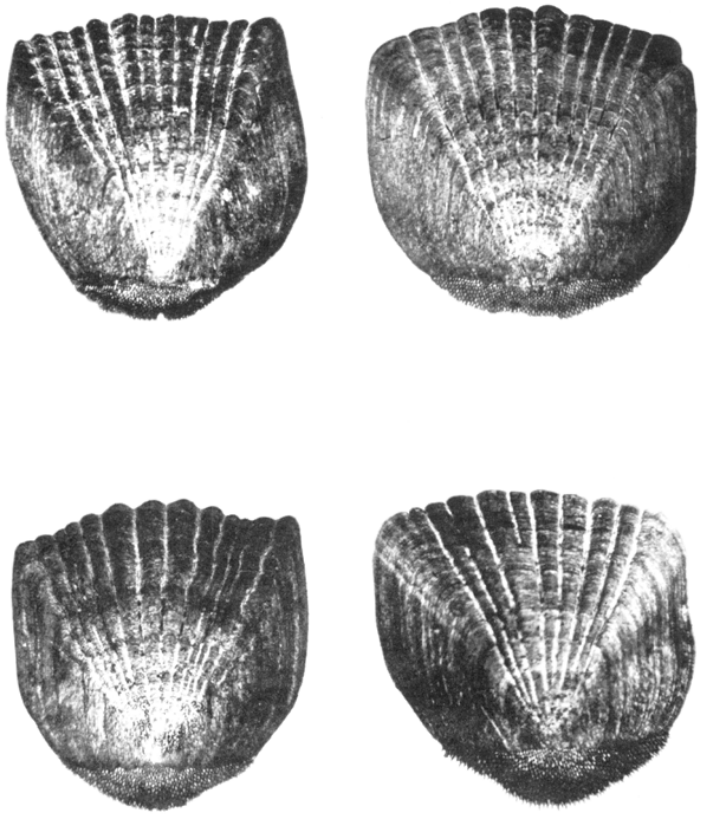

FIGURE 2. Body scales from four species of rockfish (total length and number of annuli noted, L to R). Top row: widow rockfish, 495 mm, 13; yellowtail rockfish, 437 mm, 10. Bottom row: canary rockfish, 397 mm, 7; vermilion rockfish, 463 mm, 11.

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FIGURE 3. Body scales from two species of rockfish (total length and number of annuli noted, L to R): bocaccio, 512 mm, 7; chilipepper, 504 mm, 13.

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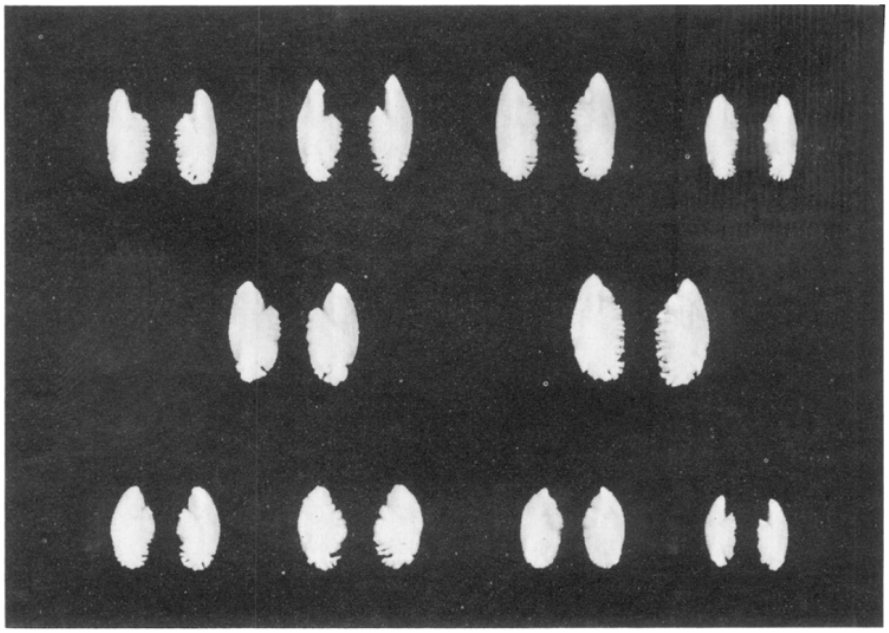


FIGURE 4. Paired otoliths (sagittae) from 10 species of rockfish. Fish total lengths, L to R are: Top row: bocaccio, 687 mm; chilipepper, 515 mm; yellowtail rockfish, 485 mm; widow rockfish, 446 mm. Middle row: canary rockfish, 485 mm; vermilion rockfish, 571 mm. Bottom row: dark-blotched rockfish, 365 mm; splitnose rockfish, 338 mm; stripetail rockfish, 310 mm; shortbelly rockfish, 285 mm.

FIGURE 4. Paired otoliths (sagittae) from 10 species of rockfish. Fish total lengths, L to R are: Top row: bocaccio, 687 mm; chilipepper, 515 mm; yellowtail rockfish, 485 mm; widow rockfish, 446 mm. Middle row: canary rockfish, 485 mm; vermilion rockfish, 571 mm. Bottom row: dark-blotched rockfish, 365 mm; splitnose rockfish, 338 mm; stripetail rockfish, 310 mm; shortbelly rockfish, 285 mm

4. WEIGHT-LENGTH

In determining weight-length relationships, no corrections were made for state of gonad maturity, nor for the amount of food that might be contained in the gut. In some species, the males were slightly heavier than similar-sized females, particularly among the largest specimens, while in others the reverse was true. However, in this study the sexes were combined when determining weight-length (Appendix A; Figures 5, 8, 11, 14, 17, 20, 23, 26, 29, and 32). The total weight of a rockfish increases approximately as the cube of the total length, varying from 2.92 to 3.25 for the different species.

The unclassified, paired lengths and weights were processed on a 7090 electronic computer at Western Data Processing Center, University of California, Los Angeles. The resultant printed summaries not only provided the constants for fitting the curve for each species, and related statistics, but also furnished the computed weight values for successive 5 mm increases in fish length.

The weight-length curves were fitted by the exponential equation $W = aL^b$, expressed in logarithmic form: log W = log + a + b log L where W = weight, L = length, a and b are constants, the latter an exponent. The values of the constants and standard errors for each species are listed in Table 1.

TABLE 1

Constants and Standard Errors for Weight-Length Relationships of 10 Rockfish Species

Rockfish species	log a	b	Standard error of b	Standard error of estimate
Bocaccio	—7.89087	3.0941	0.0093	0.3956
Chilipepper	—8.20340	3.2438	0.0151	0.2148
Yellowtail	—7.60348	3.0402	0.0192	0.1862
Canary	—7.63501	3.0556	0.0141	0.2708
Vermilion	—7.22900	2.9165	0.0152	0.3021
Widow	—8.19271	3.2543	0.0255	0.2352
Dark-blotched	—7.33424	2.9578	0.0149	0.1607
Splitnose	—7.49588	3.0166	0.0140	0.0887
Stripetail	—7.80738	3.1201	0.0201	0.0504
Shortbelly	—8.05202	3.1518	0.0136	0.0302

TABLE 1

Constants and Standard Errors for Weight-Length Relationships of 10 Rockfish Species

The average weights at each 10 mm increase in length are listed in Appendix A. The weights are rounded to .01 pounds, except that the shortbelly rockfish weights have been rounded to .001 pounds. This was necessary because of the small size of this species.

5. AGE

Rockfish scales are ctenoid, characteristic of spiny-rayed fishes. The ctenii, or small teeth, are on the narrowly exposed, posterior margin of the scale. The larger, anterior portion, which grows in a pocket under the top layer of skin, is the section that shows growth marks. The growth marks appear as closely-spaced circuli, or ridges. The circuli are nearly concentric around a common center, the focus or origin of the

scale. Fanning out from the area of the focus to the anterior scale margin are numerous deep grooves, called radii. The radii may serve to adapt a scale to the fish's body contour.

Regenerated scales are recognized by their abnormal pattern. Those lost early in life may have expanded, irregular central areas, devoid of circuli. Those lost later in life will not duplicate annuli previously formed, and the circuli are widely-spaced and misshapen, although growth beyond the regenerated portion might be normal. Such scales were avoided in this study.

Annual growth marks were detected by noting where two or three circuli were closely-spaced, forming a darker zone. In the lateral scale fields, the course of an annulus may transect several circuli. A change in lighting often helps to bring annuli into sharper relief. All normal scales from a given fish should show the same number of annuli, in the same relative positions.

5.1. Calculated Lengths

As previously mentioned, a magnified scale image from each fish was projected onto a ruled card, and the distances of the annuli and the margin from the focus of the scale were marked. From these marked cards, the length the fish had attained when each annulus was formed was computed, assuming a straight-line relationship between scale length and fish length. Calculations were made with a 20-inch slide rule as a problem in simple proportion. The results were posted on the card, along with other pertinent information relating to the fish. These back-calculations are the principal support for the annual growth-in-length presented herein.

Attempts were made to select all scales from the body area adjacent to the tip of the pectoral fin where the largest scales occur. Sometimes these scales showed regeneration and selections had to be made from other body areas where the scales were smaller. The mutual relationship between total fish length and total scale length was evaluated for bocaccio and for chilipeppers by choosing the largest normal scales available for a series of lengths. The paired values were plotted with fish length along the horizontal axis and scale length along the vertical axis. A judged straight line through the scatter of points intersected the horizontal axis at about 40 mm for the bocaccio and 30 mm for the chilipepper. This may indicate approximate sizes at which scales are first discernible in these species. Young fish in this size range were not available to verify this.

5.2. First Year Agreement

To test the agreement between lengths as calculated from scales and actual fish lengths at approximately the end of the first year of growth, samples of young fish for several of the species were examined. These fish were taken during the winter, and otolith examinations disclosed that all were completing their first year. The ayerage fish lengths are close to those determined by back-calculations on scales of older fish (Appendix B):

1. Bocaccio. Twenty-two bocaccio from Monterey Harbor in February 1938 were 129–204 mm long. Their average length was 175

mm, compared to the calculated mean length of 171 mm (fitted curve, 175 mm).

2. Chilipepper. Forty-nine chilipeppers from Monterey Harbor in January 1937, 1938, and 1939 were 95–123 mm long. Their average length was 105 mm, compared to the calculated mean length of 106 mm (fitted curve, 111 mm).

3. Yellowtail rockfish. Ten specimens from Monterey Harbor in February 1938 were 102–114 mm long. Their average length was 106 mm, compared to the calculated mean length of 106 mm (fitted curve, 107 mm).

4. Splitnose rockfish. Thirty-three specimens taken in a small dredge in 80 fathoms of water off Monterey Bay during January and February 1958 and 1959, were 52–77 mm long. Their average length was 65 mm, compared to the calculated mean length of 65 mm (fitted curve, 66 mm).

Shrimp trawling from the research vessel *N. B. Scofield* during August 1959, in 40 to 70 fathoms of water between Pt. Reyes and Fort Bragg, yielded two species of zero-year-old Sebastodes. These were approaching the end of their growth for the year:

1. Dark-blotched rockfish. Fifty-four specimens were 65–91 mm long. Their average length was 79 mm, compared to the calculated mean length of 82 mm, at the end of the first year (fitted curve, 81 mm).

2. Stripetail rockfish. Thirteen specimens were 51–69 mm long. Their average length was 60 mm, compared to the calculated mean length of 66 mm, at the end of the first year (fitted curve, 69 mm).

In addition to furnishing growth information, these samples indicated that 1-year-old splintnose rockfish, dark-blotched rockfish, and stripetail rockfish, whose depth range as adults may extend to 200 fathoms or more, inhabit somewhat deeper water than do young bocaccio, chilipepper, widow rockfish, and shortbelly rockfish, whose depth range as adults is rarely down to 175 fathoms.

5.3. Rate of Growth

In the 10 species studied, the males tended to grow slightly slower than the females. Male bocaccio, chilipepper, and stripetail rockfish grew significantly slower than the females. In the remaining seven the males grew only a little less rapidly than the females, or at practically the same rate. In all cases, the males failed to attain either the lengths or the ages the females did. I have listed the mean lengths attained at the end of each year, sexes combined, in Appendix B, and shown the growth curves as solid lines in Figures 6, 9, 12, 15, 18, 21, 24, 27, 30, and 33.

Subsequently, my unclassified age readings were turned over to Norman J. Abramson, who designed an electronic computer routine for fitting the von Bertalanffy growth equation:

$$l_t = L_\infty \ [1 - \exp \ (- kt + kt_0) \ ].$$

EQUATION

In this equation, l_t = total length at age t; [L8] = maximum expected length; t_0 = fitted length at age zero, extrapolated backward from growth pattern in later life; k = a parameter related to the metabolic rate; exp = exponential function (Abramson, 1963). I have listed the estimates of the parameters for the fitted growth curves in Table 2. The exponential function of $(- kt + kt_0)$, which is to be subtracted from 1, can be found in a table of exponential functions under the column headed, e^{-x}.

The fitted lengths for each year of growth are in Appendix B, and plotted as a dashed line in the 10 figures noted above. The curves for the fitted values have been extrapolated to larger sizes than are represented in the sampling, and maximum ages were estimated from these projections. The dispersal of lengths about a mean was substantially reproduced by taking plus or minus twice the standard error of estimate. In the fitted data (Appendix B), the increment in length between successive ages decreases by a percentage that is constant for each species. Slight differences in the fractional portion of a percentage are due to rounding fish lengths to the closest tenth.

TABLE 2

Estimates of Parameters for von Bertalanffy Growth Curves for 10 Rockfish Species

Rockfish species	Average maximum length $L\infty$	Metabolic rate constant k	Fitted length at age zero t_0
Bocaccio			
Estimates	812.97	0.14784	—0.6439
Standard errors	9.13	0.00371	0.03731
Chilipepper			
Estimates	552.67	0.18204	—0.2283
Standard errors	5.57	0.00458	0.03622
Yellowtail			
Estimates	524.91	0.17249	—0.3219
Standard errors	4.03	0.00351	0.03347
Canary			
Estimates	654.96	0.12235	—0.4021
Standard errors	7.72	0.00298	0.03567
Vermilion			
Estimates	687.98	0.09841	—0.6901
Standard errors	11.14	0.00310	0.04941
Widow			
Estimates	526.88	0.21456	—0.1148
Standard errors	4.61	0.00496	0.03124
Dark-blotched			
Estimates	501.70	0.15653	—0.1184
Standard errors	6.25	0.00417	0.03173
Splitnose			
Estimates	418.12	0.12251	—0.4081
Standard errors	5.58	0.00342	0.04120
Stripetail			
Estimates	327.07	0.14738	—0.6047
Standard errors	4.20	0.00480	0.05403
Shortbelly			
Estimates	315.40	0.27520	—0.2703
Standard errors	4.41	0.01067	0.04516

TABLE 2 Estimates of Parameters for von Bertalanffy Growth Curves for 10 Rockfish Species

The von Bertalanffy curve fits the mean-length curve quite well for all species through age 12 or 13, and in 3 species through ages 15 or 16 (vermilion rockfish, canary rockfish, bocaccio). In the short-lived shortbelly rockfish, the fit was good to the maximum age of 10 years. For most species, the fitted curve beyond age 12 fell below the mean-length curve. Where the mean curve deviates considerably above the fitted curve, it might indicate that at the magnifications used (30 to 60 diameters), annuli close to scale margins were not detected in some of the older fish. Upon re-examining the margins of scales from some of the oldest fish under higher magnification (100 to 120 diameters), questionable annuli could be detected in some cases. Since the observed growths were in good agreement with the fitted data, at least through age 12, reliance can be placed on projecting the fitted curve to represent older fish.

With some large rockfish, desirable scales may be 15 mm in diameter. If back-calculations are desired, and the image of such a scale is projected to 100 diameters with the standard microscope, a card at least 20 inches long would be needed to cover the field. Even so, the field would not include the entire image. However, if the annuli are not marked on a card, the age of a fish can be ascertained by shifting the scale. The "Zoom" microscope was not available when these age determinations were made, but such an instrument should simplify projecting scale images at desired magnifications.

The length frequencies for successive ages, sexes combined, for the 10 species are shown in Figures 7, 10, 13, 16, 19, 22, 25, 28, 31, and 34. The frequencies, by 10 mm groupings, were smoothed once by threes and plotted as percentages. If ages could not be supported by at least 10 readings they have not been included.

As noted previously, the males failed to attain the lengths or grow as old as the females. Consequently, in the data with sexes combined the maximum sizes and ages apply to the dominant females. Similar information was not derived for the males.

6. REPRODUCTION

6.1. Maturity

Pacific rockfish, genus Sebastodes, are ovoviviparous, that is, fertilization and development of the embryo take place in the body of the mother. When embryonic development is complete, the female sheds the eggs and the stimulus resulting from exposure to sea water activates the larvae (Morris, 1956). In most species, the partially developed ovaries are yellow, but may be light gray in a few forms. With the approach of hatching, the ovaries become dusky or dark gray due to melanophores in the embryos. The distribution of melanophores in the newly-hatched bocaccio, chilipepper, stripetail rockfish, and shortbelly rockfish larvae were illustrated by Morris (1956). At hatching, the mean standard length of the larvae of these four species was 3.7 to 5.4 mm.

6.2. Spawning Season

In Sebastodes, "spawning season" denotes the period when the developed eggs are shed. This is in the winter, from about mid-November to mid-March, for bocaccio, chilipepper, yellowtail rockfish, canary rockfish, vermilion rockfish, widow rockfish, dark-blotched rockfish, stripetail rockfish, and shortbelly rockfish. Splitnose rockfish spawn mainly in the spring, from about February through July.

Ahlstrom (1958) and Ahlstrom and Kramer (1957) report that during 1950–1956, rockfish larvae were taken throughout the year, and up to 300 miles from shore, in routine plankton tows off the California coast. Plankton hauls were made from a depth of 140 meters to the surface but rockfish larvae seldom occurred as deep as 100 meters. They were found in association with sardine, Sardinops caeruleus, anchovy, Engraulis mordax, jack mackerel, Trachurus symmetricus, and Pacific mackerel, Scomber diego, eggs and larvae. Obviously some rockfishes spawn during other months of the year. This is not surprising when we consider their wide distribution. The adults of some species are found only around rocky shores and rarely as deep as 30 fathoms. Adults of others are found offshore in waters of increasing depth, some to at least 300 fathoms. Greater quantities of several species have been taken in recent years because of increased fishing in deeper waters.

6.3. Fecundity

During their annual spawning, nine of the species studied will produce a maximum of about 0.2 to 2.0 million eggs. The tenth species, the shortbelly rockfish, which attains a length of only 12 inches, will shed at most about 50,000 developed eggs. I have listed the calculated number of eggs in the paired ovaries of the ten species in Appendix C. Although the general trend is for an increased number of eggs in successively larger fish, the largest fish did not always bear the greatest number of eggs. This irregularity, observed in other fishes also, was not due to a loss of eggs when the ovaries were excised because ovaries with flowing eggs were not selected.

In general, the largest fish of a species tend to ripen and spawn earlier than do subordinate sizes. An occasional precocious female was encountered in some forms.

7. FEEDING HABITS

Since rockfish larvae are taken within the upper 100 meters of water, along with sardine, anchovy, jack mackerel, and Pacific mackerel larvae, I have assumed they are plankton feeders, as are the young of most fishes. In some rockfish, the adults may continue to feed primarily on planktonic organisms, but there may be a shift to larger items, such as euphausiids. The most common and widespread euphausiid along our coast is Euphausia pacifica, which attains a length of at least 1 inch. Adult euphausiids are capable of considerable vertical migration in the sea but are commonly associated with the 100–400 meter (55–219

fathoms) strata, at least in Monterey Bay (Barham, 1957). Therefore, at times euphausiids and other macroplanktonic forms are available to rockfish in deeper waters.

Adult splitnose rockfish, stripetail rockfish, and shortbelly rockfish feed almost exclusively on macroplanktonic organisms, primarily euphausiids. Such rockfishes as chilipepper, yellowtail, canary, vermilion, and dark-blotched feed on euphausiids and other macroplankton at times, but usually they prey upon smaller fishes. The widow rockfish is mainly a macroplankton feeder, with hyperiid amphipods dominating their diet, but small fish are also eaten at times. Bocaccio feed primarily on other fishes, even before they complete their first year of life.

Since amphipods are seldom found in the diets of other macroplankton-feeding rockfish, the widow rockfish might occupy a somewhat different habitat. Trawler catches tend to confirm this. Ordinarily, only a few widow rockfish appear in bocaccio and chilipepper catches, but in specific areas the catches may consist primarily of widow rockfish. According to some otter trawl fishermen at Monterey, widow rockfish concentrate over mud bottoms adjacent to rocks. Obviously, systematic surveys are needed to define more clearly the ecological associations of the various rockfishes.

Sometimes, fish in localized areas are able to profit from swarms of organisms transported there by currents. Starting in 1957 and lasting at least through 1959, a northward redistribution of planktonic forms together with certain tunicates, pelagic red crabs, Pleuroncodes planipes, and sand crabs, Emerita analoga, demonstrated existence of a countercurrent, in addition to warming the environment north of their usual ranges (Radovich, 1961). The galatheid pelagic red crab, whose maximum abundance is normally centered off southern Baja a countercurrent, in addition to warming the environment north of as Monterey Bay. Glynn (1961) reported a mass stranding on the southern shore of Monterey Bay in January 1960, 101 years after a similar mass stranding had been reported for the same general area. During this "warm water" period, pelagic red crabs were frequently found in the stomachs of various fish, including rockfishes taken off southern and central California.

Lanternfishes (Myctophidae) are generally considered deep-sea fishes, but extensive vertical, diurnal migrations are performed by many of the species. One, the blue lanternfish, Tarletonbeania crenularis, is found closer to shore than most of its relatives, and is fortuitously fed upon by some of the rockfishes. Louis Zermatten, a longline fisherman at San Pedro, reported that during the last week of April 1963, while fishing off San Nicolas Island in 65 fathoms of water, he made an excellent catch of large vermilion rockfish. These had gorged themselves on blue lanternfish, many of which were spewed on deck. Depth-indicator recordings revealed a school of small fish

(most likely these lanternfish) above the bottom. On a previous fishing trip to the same area, Zermatten reported that vermilion rockfish had been feeding heavily on large adult anchovies (J. E. Fitch, pers. comm.).

A mass stranding of blue lanternfish occurred on a beach a few miles south of Monterey Bay on October 17, 1952 (Aughtry, 1953). Along 200 yards of beach there were thousands of these fish measuring 2½ to 3 inches long. Their stomachs were stuffed with euphausiids. Mr. C. Loero, General Fish Corporation, Monterey, reported that bocaccio and chilipepper caught during the previous week off Pt. Sur (about 200 miles south of Monterey Bay) were gorged with lanternfish.

8. SYSTEMATIC ACCOUNT

In the following section, summaries for each of the 10 rockfish species occupy four pages. The first page is composed of a photograph of the species, and a classified brief giving the known distribution of the species, greatest depth taken, maximum size, distinguishing characters, size at maturity, fecundity, and feeding habits. The greatest depth taken and maximum size apply only to California. Occupying the second page is a weight-length curve, which shows the mean weight of specimens at different lengths. The third page has an age-length or growth curve, depicting the mean length at successive ages. On the fourth page, appear length frequency curves for each completed year of growth, starting with age 1. If ages could not be supported by at least 10 readings, they are not shown.

8.1. BOCACCIO

Sebastodes paucispinis (Ayres, 1854)

Distribution—Sacramento Reef, Baja California, to Queen Charlotte Sound, British Columbia.

Greatest depth taken and maximum size—175 fathoms; 34 inches.

Distinguishing character:

Color—Pink or olive-brown dorsally and pink on sides. An occasional adult may have a jet-black blotch, or blotches, anywhere on body (melanism). Specimens shorter than 10 inches have small, brown spots on sides.

Top of head, between mid-orbits—Convex (elevated).

Spines on top of head, bordering orbits—Absent (obsolete).

End of maxillary—Reaches to under rear of orbit.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	9 (occas. 8 or 10)
Number of pectoral fin rays	15 (occas. 16)
Number of pores in lateral line	54 – 58
Number of rakers on first gill arch	28 – 31

Size and age at maturity—A few mature when 14 inches long, or 3 years old. Fifty percent are mature when 16¼ inches long, or 4 years old. They attain a a maximum age of about 30 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 20,000 in a fish 15 inches long, to about 2,300,000 in a fish 30½ inches long.

Food—Before completing their first year the young of this fast-growing species start eating the young of other rockfish, surfperch (Embiotocidae), jack mackerel, and various small inshore fishes. Adults, found in deeper water, feed on smaller rockfishes, sablefish, Anoplopoma fimbria, anchovies, lanternfish, and squids, Loligo opalescens.

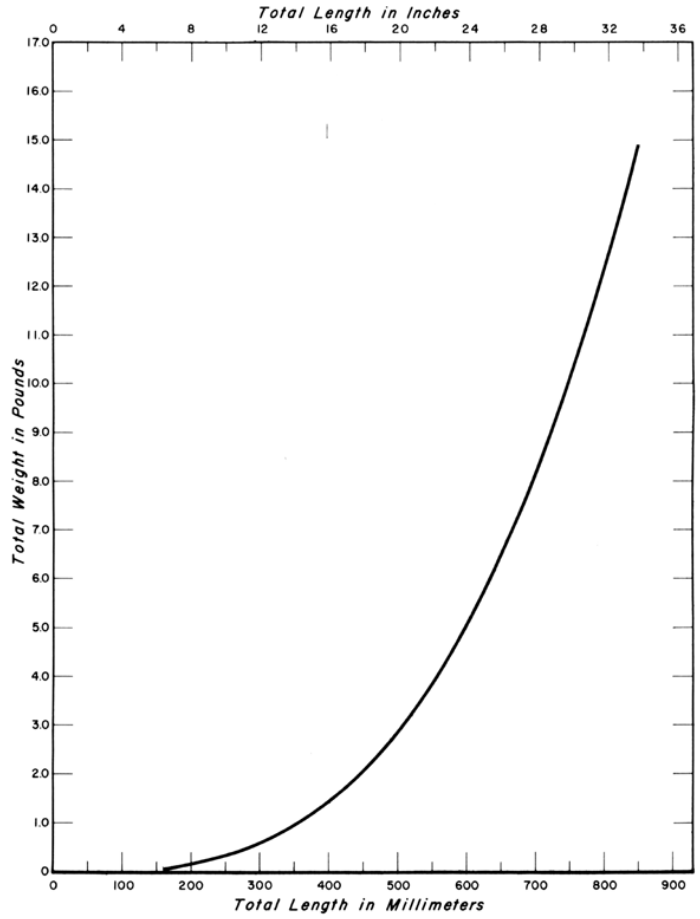


FIGURE 5. Bocaccio weight-length relationship, sexes combined, 711 fish.

FIGURE 5. Bocaccio weight-length relationship, sexes combined, 711 fish

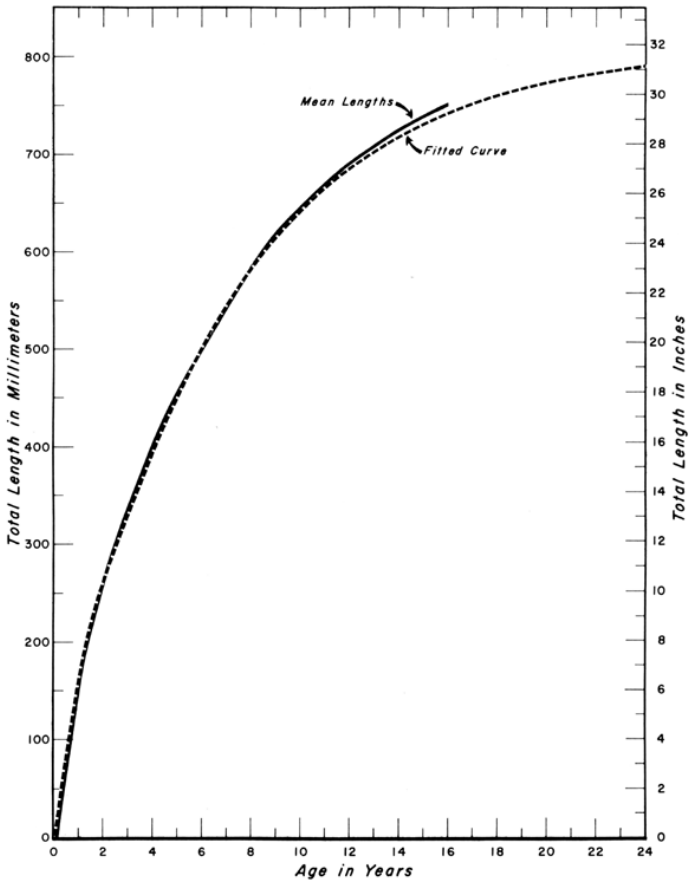


FIGURE 6. Bocaccio age-length relationship, sexes combined, 1,008 items.

FIGURE 6. Bocaccio age-length relationship, sexes combined, 1,008 items

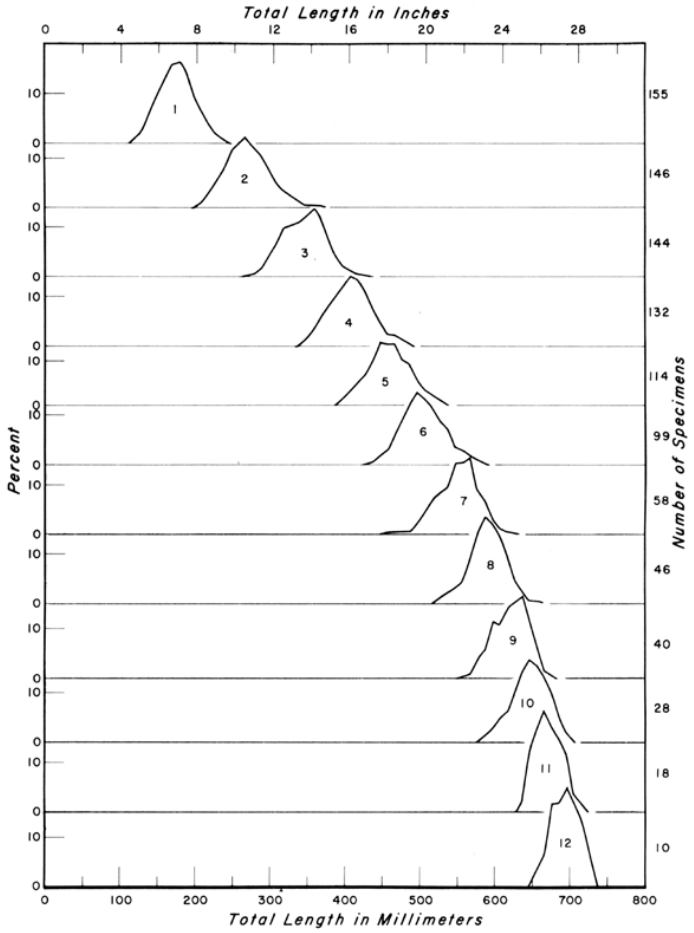
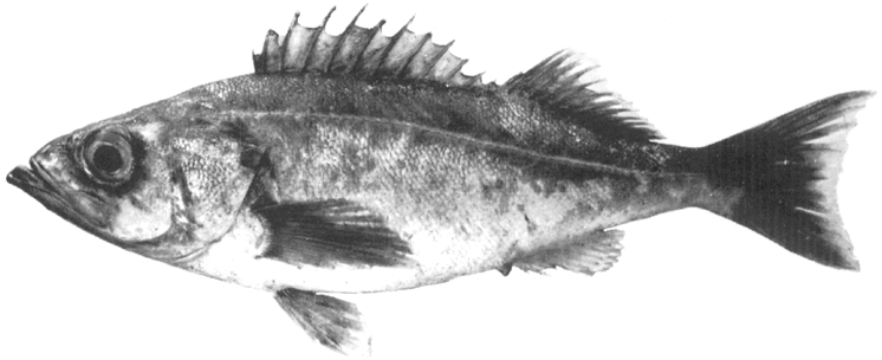


FIGURE 7. Bocaccio length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 7. Bocaccio length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.2. CHILIPEPPER



Sebastodes goodei Eigenmann and Eigemann, 1890

Distribution—Magdalena Bay, Baja California, to Eureka, California.

Greatest depth taken and maximum size—180 fathoms; 22 inches.

Distinguishing characters:

Color—Uniformly light red. Young with light olive on back.

Top of head, between mid-orbits—Convex (elevated).

Spines on top of head, bordering orbits—Absent (obsolete).

End of maxillary—Reaches to under mid-orbit.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	8 (rarely 9)
Number of pectoral fin rays	17 (occas. 16 or 18)
Number of pores in lateral line	50 – 56
Number of rakers on first gill arch	34 – 39

Size and age at maturity—An occasional precocious female may mature when 8¾ inches long, or 2 years old. Fifty percent of the males mature at 11½ inches; 50 percent of the females at 12 inches, or when 4 years old. They attain a maximum age of about 16 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 29,000 in a 12-inch fish, to about 538,000 in 20½- to 22-inch fish.

Food—Adults may feed on euphausiids and small squids, or on small fishes such as anchovies, young hake, Merluccius products, and lanternfish.

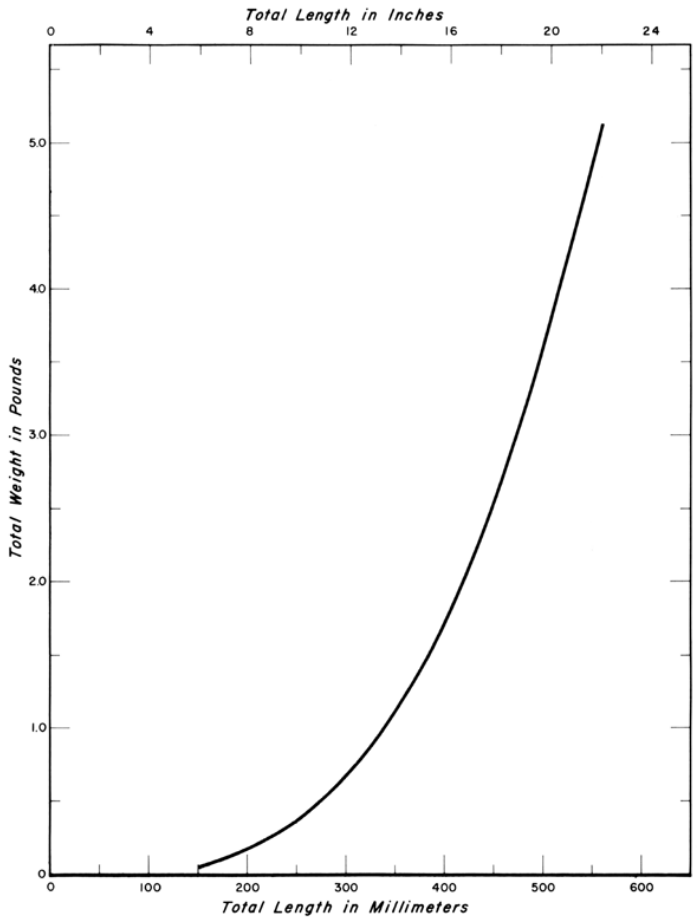


FIGURE 8. Chilipepper weight-length relationship, sexes combined, 783 fish.

FIGURE 8. Chilipepper weight-length relationship, sexes combined, 783 fish

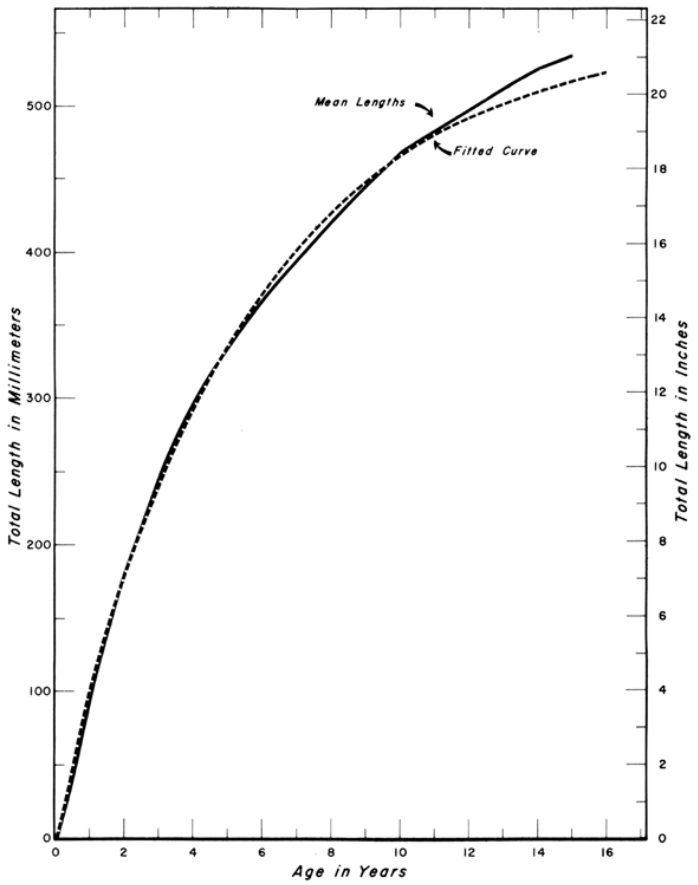


FIGURE 9. Chilipepper age-length relationship, sexes combined, 960 items.

FIGURE 9. Chilipepper age-length relationship, sexes combined, 960 items

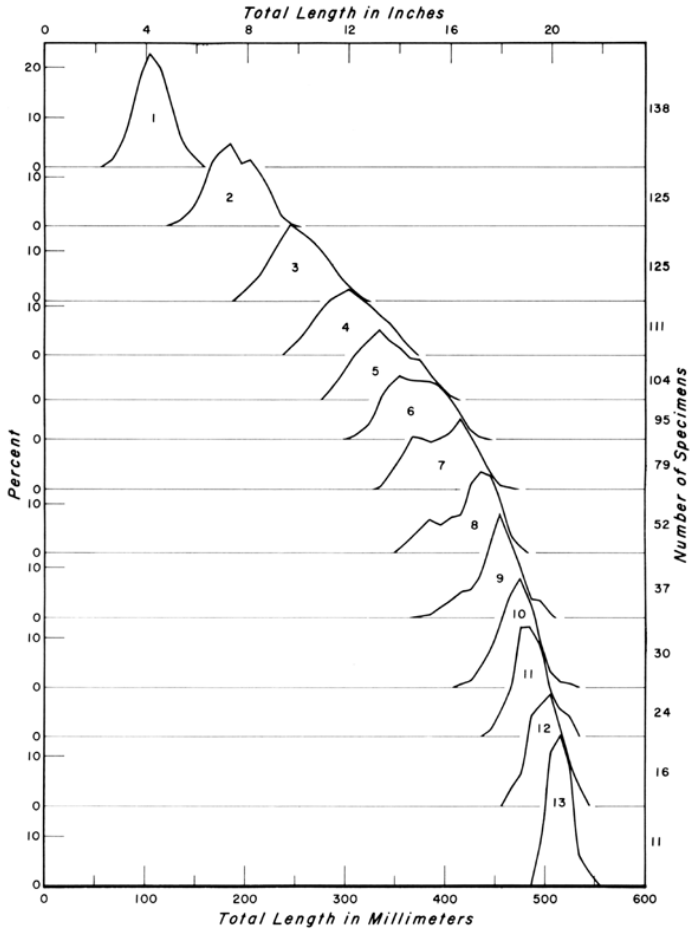
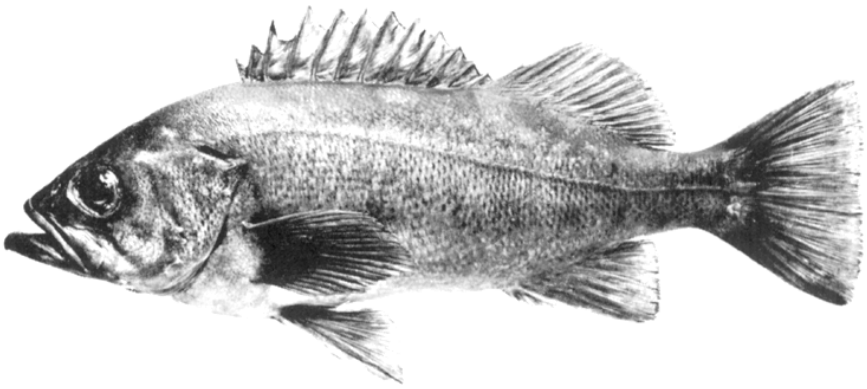


FIGURE 10. Chilipepper length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 10. Chilipepper length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.3. YELLOWTAIL ROCKFISH



Sebastodes flavidus Ayres 1862

Distribution—San Diego, California, to Vancouver Island, British Columbia.

Greatest depth taken and maximum size—100 fathoms; 23 inches.

Distinguishing characters:

Color—Dark gray with brown speckling on scales, sometimes with touches of green; fins dusky-yellow. An occasional adult may have a melanistic blotch, or blotches, anywhere on its body. Individuals shorter than about 12 inches have blackened area on the posterior portion of their spinous dorsal fin.

Top of head, between mid-orbits—Convex.

Spines on top of head, bordering orbits—Absent (obsolete).

End of maxillary—Reaches to under rear of pupil of eye.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	8 (occas. 7 or 9)
Number of pectoral fin rays	18 (occas. 17 or 19)
Number of pores in lateral line	49 – 55
Number of rakers on first gill arch	34 – 39

Size and age at maturity—A few mature when 11 inches long, or 3 years old. Fifty percent are mature when 13 inches long, or 5 years old. They attain an age of about 24 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 50,000 in a fish 12 inches long, to about 633,000 in fish 19 to 21 inches long.

Food—Adults feed on small hake, anchovies, lanternfish and other small fishes, as well as on euphausiids, salps, pyrosomes, and small squids.

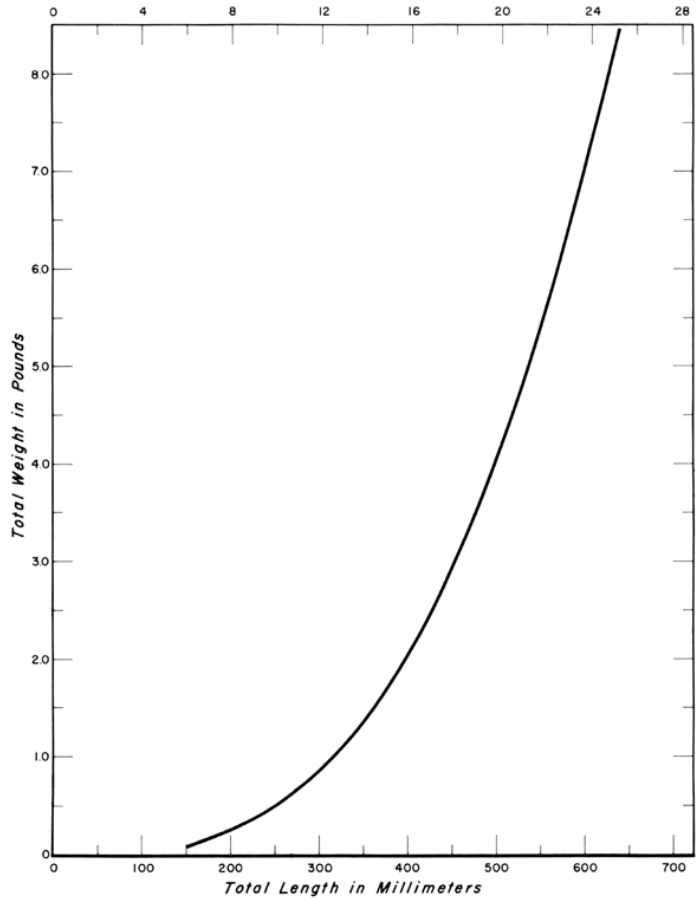


FIGURE 11. Yellowtail rockfish weight-length relationship, sexes combined, 450 fish.

FIGURE 11. Yellowtail rockfish weight-length relationship, sexes combined, 450 fish

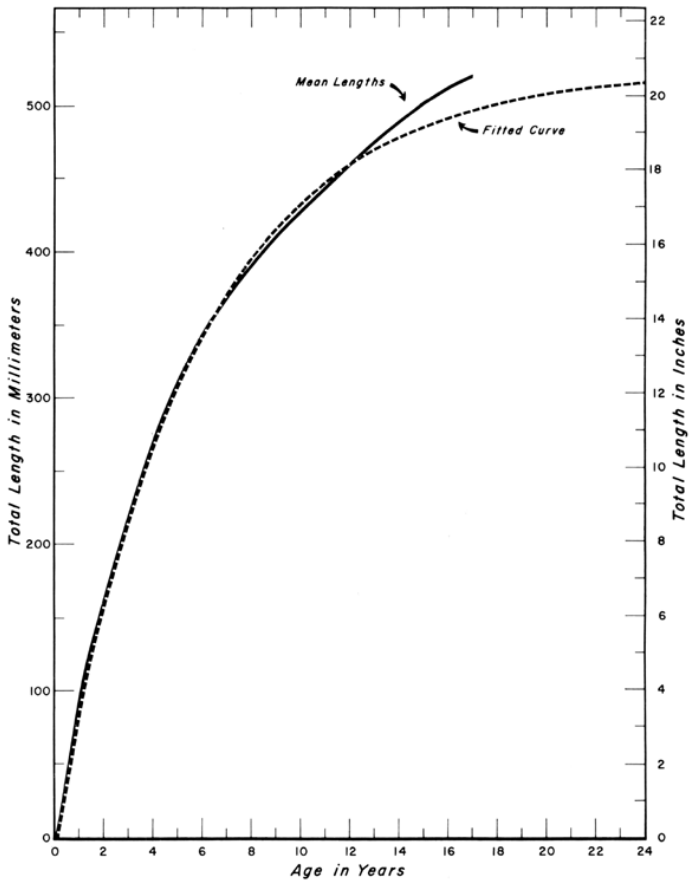


FIGURE 12. Yellowtail rockfish age-length relationship, sexes combined, 1,120 items.

FIGURE 12. Yellowtail rockfish age-length relationship, sexes combined, 1,120 items

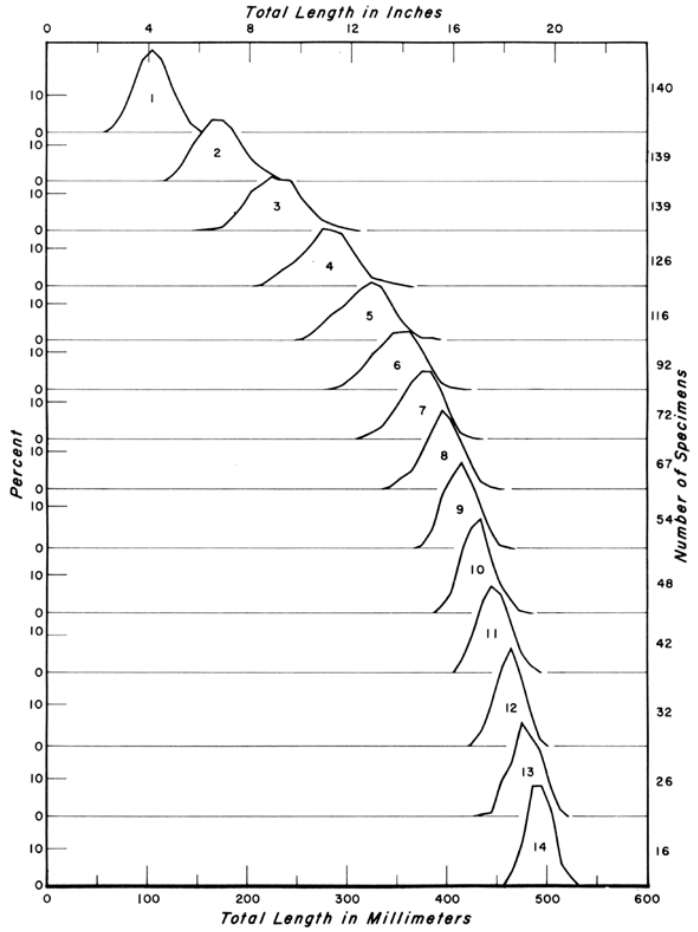
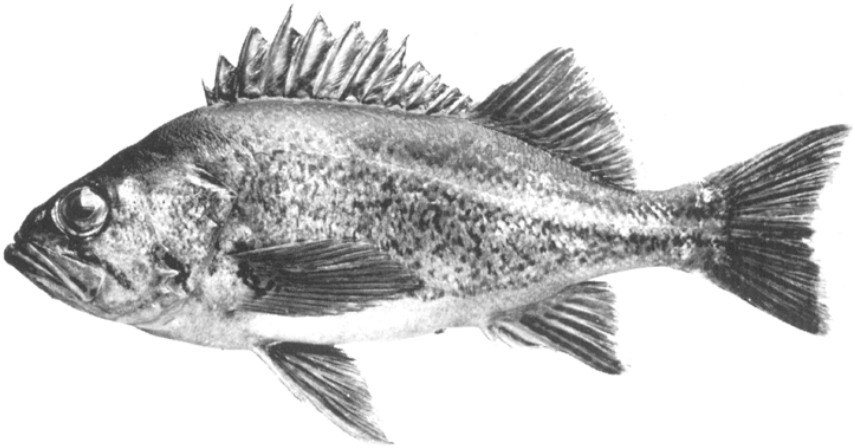


FIGURE 13. Yellowtail rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 13. Yellowtail rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.4. CANARY ROCKFISH



Sebastodes pinniger (Jordan and Gilbert 1880)

Distribution—Cape Colnett, Baja California, to Dixon Entrance, British Columbia.

Greatest depth taken and maximum size—110 fathoms; 26½ inches.

Distinguishing characters:

Color—Gray, mottled with orange; fins orange. An occasional adult may have a jet-black blotch anywhere on body. Specimens shorter than about 12 inches have a black area on the posterior portion of their spinous dorsal fin membrane.

Top of head, between mid-orbits—Convex (elevated).

Spines on top of head, bordering orbits—Four small spines on each side (supraocular spine present).

End of maxillary—Reaches to between rear of pupil and rear of orbit; to mid-orbit in small specimens.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	7
Number of pectoral fin rays	17 (occas. 16 or 18)
Number of pores in lateral line	39 – 44
Number of rakers on first gill arch	40 – 45

Size and age at maturity—An occasional precocious female may mature when 9½ inches long, or 3 years old. Although few small fish were available, 50 percent of the population apparently matures at a length of 14 inches, or when 5 to 6 years old. They attain a maximum age of at least 22 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 260,000 in a fish 19 inches long, to about 1,900,000 in a fish 21 to 26 inches long.

Food—Adults feed on macroplanktonic organisms such as euphausiids, and also on anchovies, sanddabs, Citharichthys spp., and other small fishes.

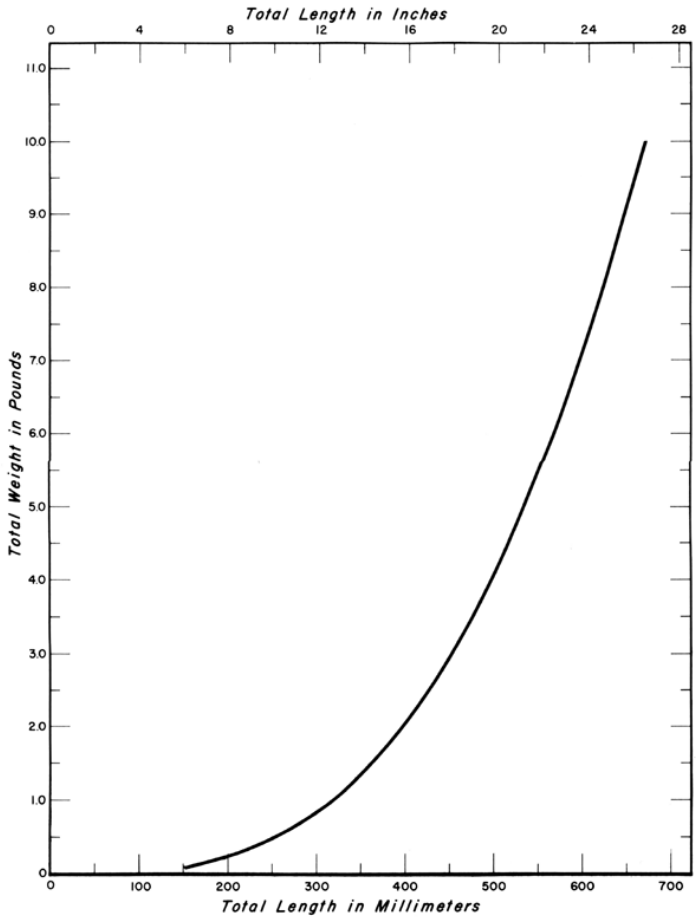


FIGURE 14. Canary rockfish weight-length relationship, sexes combined, 613 fish.

FIGURE 14. Canary rockfish weight-length relationship, sexes combined, 613 fish

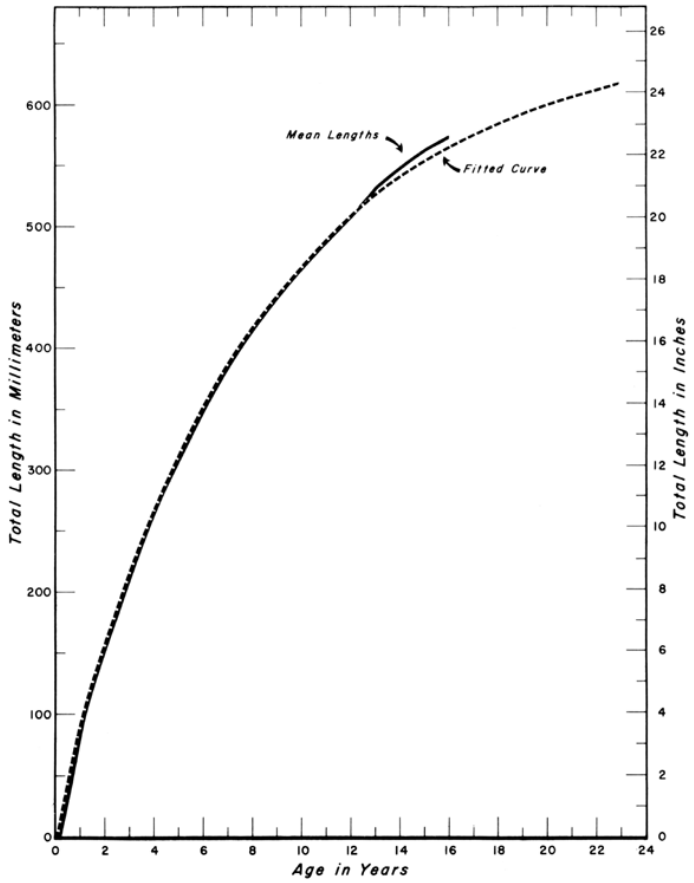


FIGURE 15. Canary rockfish age-length relationship, sexes combined, 1,285 items.

FIGURE 15. Canary rockfish age-length relationship, sexes combined, 1,285 items

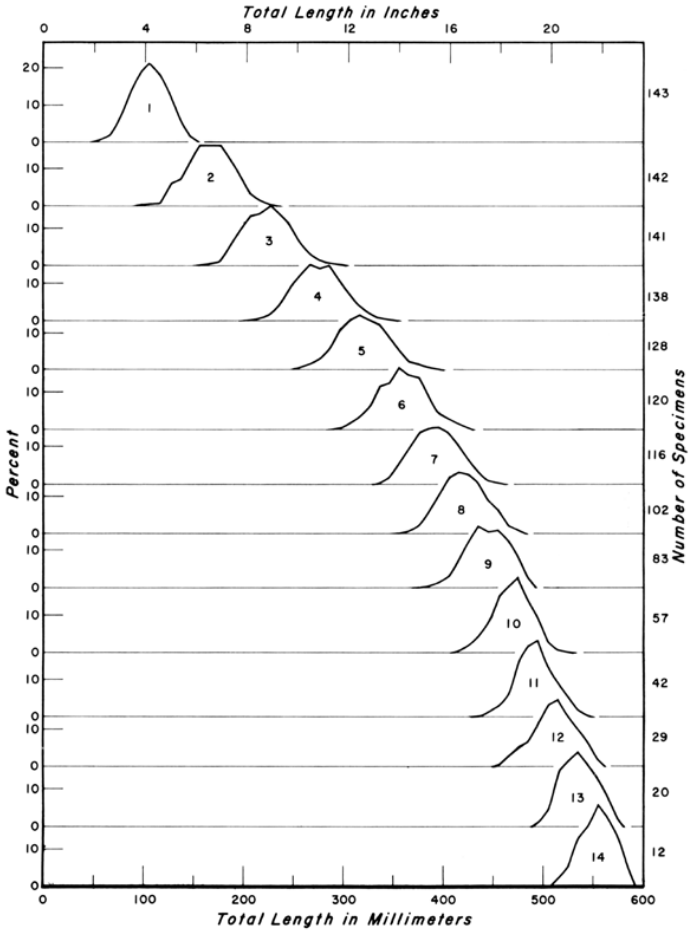
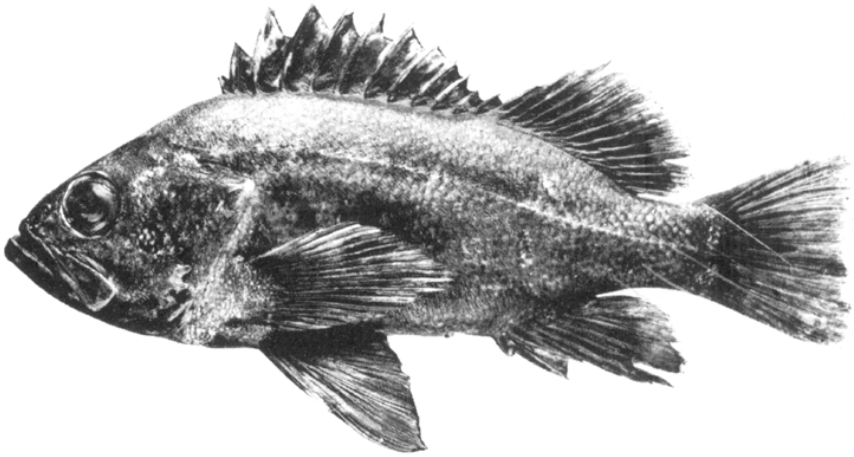


FIGURE 16. Canary rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 16. Canary rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.5. VERMILION ROCKFISH



Sebastodes miniatus (Jordan and Gilbert 1880)

Distribution—San Benito Islands, Baja California, to Vancouver Island, British Columbia.

Greatest depth taken and maximum size—110 fathoms; 25½ inches.

Distinguishing characters:

Color—Dark red mottled with gray and some yellow (offshore), or uniformly dark red (inshore); fins red, edged with black in smaller specimens.

Top of head, between mid-orbits—Convex (elevated).

Spines on top of head, bordering orbits—Four small spines on each side (supraocular spine present).

End of maxillary—Reaches to between rear of pupil and rear of orbit; to mid-orbit in small specimens.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	7 (occas. 6 or 8)
Number of pectoral fin rays	18 (occas. 17)
Number of pores in lateral line	40 – 45
Number of rakers on first gill arch	35 – 42

Size and age at maturity—An occasional precocious female may mature when 9 inches long, or 3 years old. Fifty percent of the population are mature when 13 inches long, or 6 years old. They attain a maximum age of at least 22 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 63,000 in a fish 12½ inches long, to about 1,600,000 in a fish 21½ inches long.

Food—The adults feed on octopi, squids, and small fishes such as anchovies and blue lanternfish. At times, macroplanktonic organisms such as euphausiids, pelagic red crabs, and pyrosomes are found in stomachs.

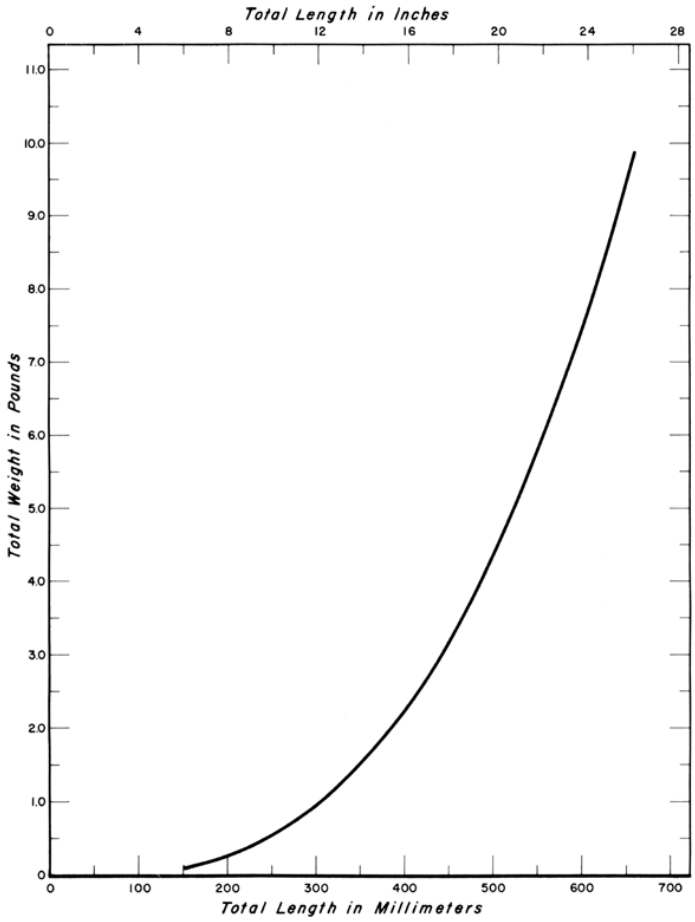


FIGURE 17. Vermilion rockfish weight-length relationship, sexes combined, 617 fish.

FIGURE 17. Vermilion rockfish weight-length relationship, sexes combined, 617 fish

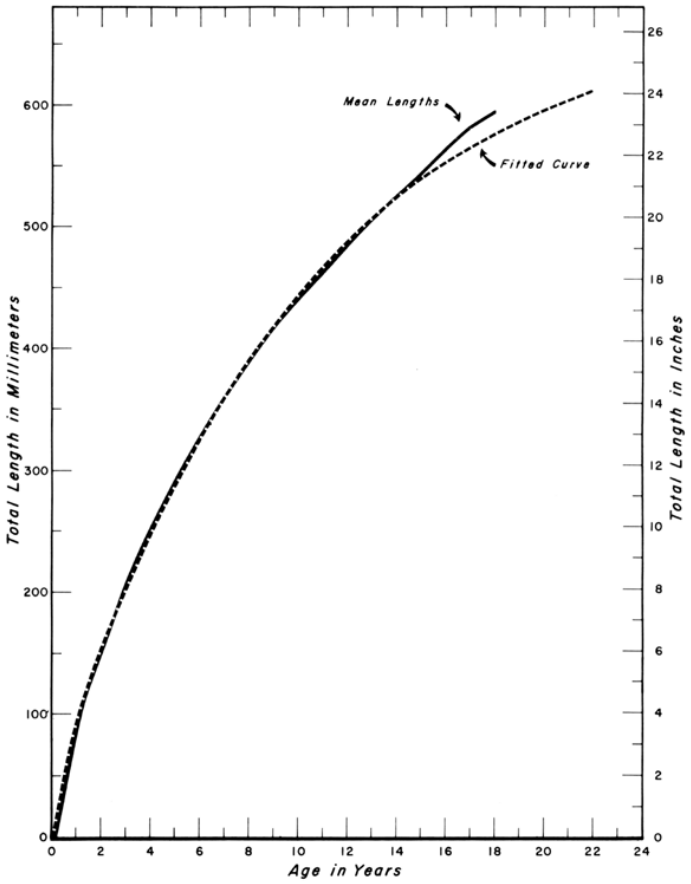


FIGURE 18. Vermilion rockfish age-length relationship, sexes combined, 1,022 items.

FIGURE 18. Vermilion rockfish age-length relationship, sexes combined, 1,022 items

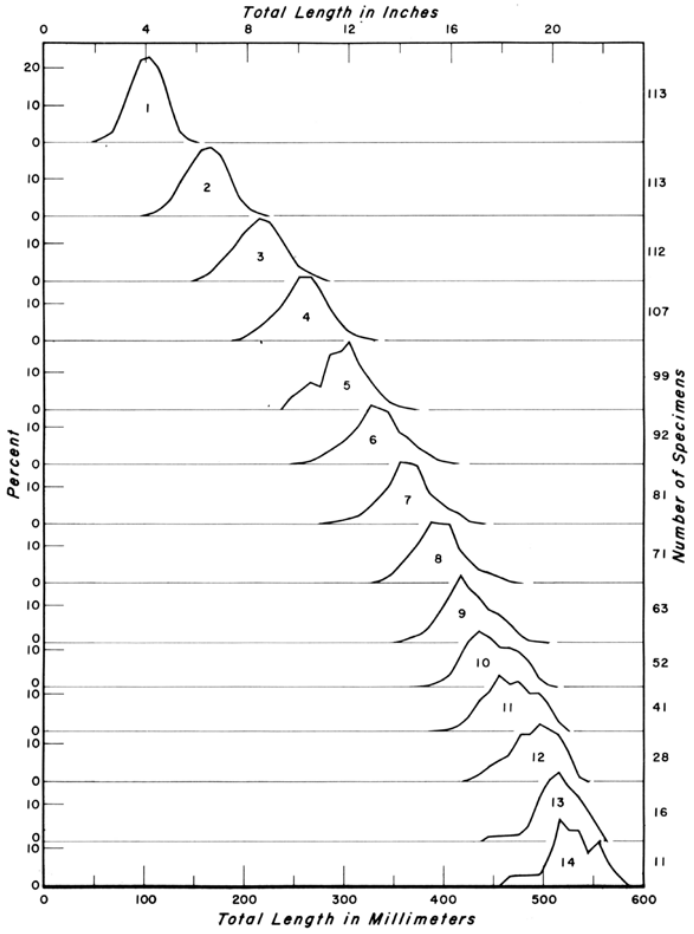
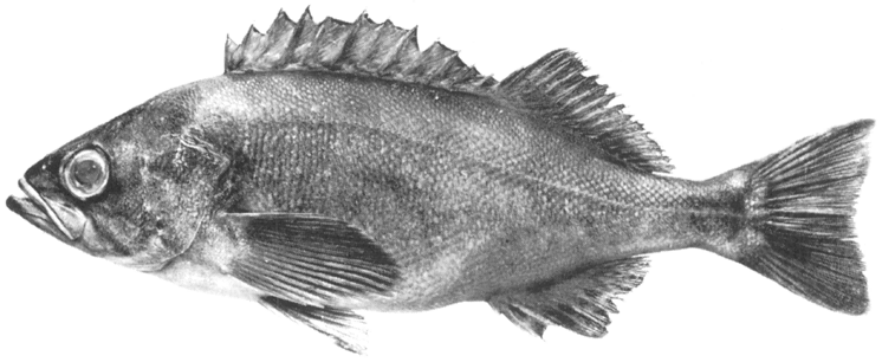


FIGURE 19. Vermilion rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 19. Vermilion rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.6. WIDOW ROCKFISH



Sebastodes entomelas (Jordan and Gilbert 1880)

Distribution—San Diego, California, to southeastern Alaska.

Greatest depth taken and maximum size—175 fathoms; 21 inches.

Distinguishing characters:

Color—Dusky brown with traces of yellow; fins dark. Specimens smaller than about 10 inches are lighter in color and have vague streaks of orange.

Top of head, between mid-orbits—Convex (elevated).

Spines on top of head, bordering orbits—Obsolete in adults; specimens less than about 8 inches long may have three or four short, delicate spines on each side.

End of maxillary—Reaches to under mid-orbit.

Second anal fin spine—Hardly thicker than third; tip of second does not reach tip of third (spines depressed).

Number of anal fin rays	8
Number of pectoral fin rays	17 – 19
Number of pores in lateral line	52 – 54
Number of rakers on first gill arch	35 – 37

Size and age at maturity—A few mature when 12 inches long, or 3 years old. Fifty percent are mature when 12¾ inches long, or 4 years old. They attain a maximum age of about 16 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 55,000 in a fish 12½ inches long, to about 900,000 in a fish 20 inches long.

Food—The adults feed extensively on macroplanktonic organisms, primarily hyperiid amphipods. Occasionally salps, pyrosomes, small squids, and anchovies are eaten.

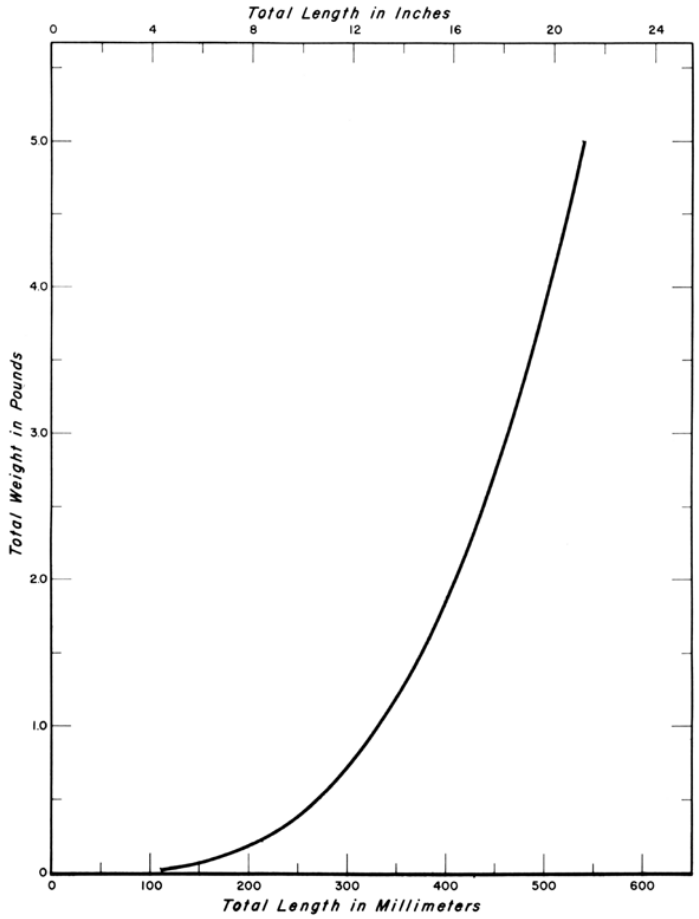


FIGURE 20. Widow rockfish weight-length relationship, sexes combined, 466 fish.

FIGURE 20. Widow rockfish weight-length relationship, sexes combined, 466 fish

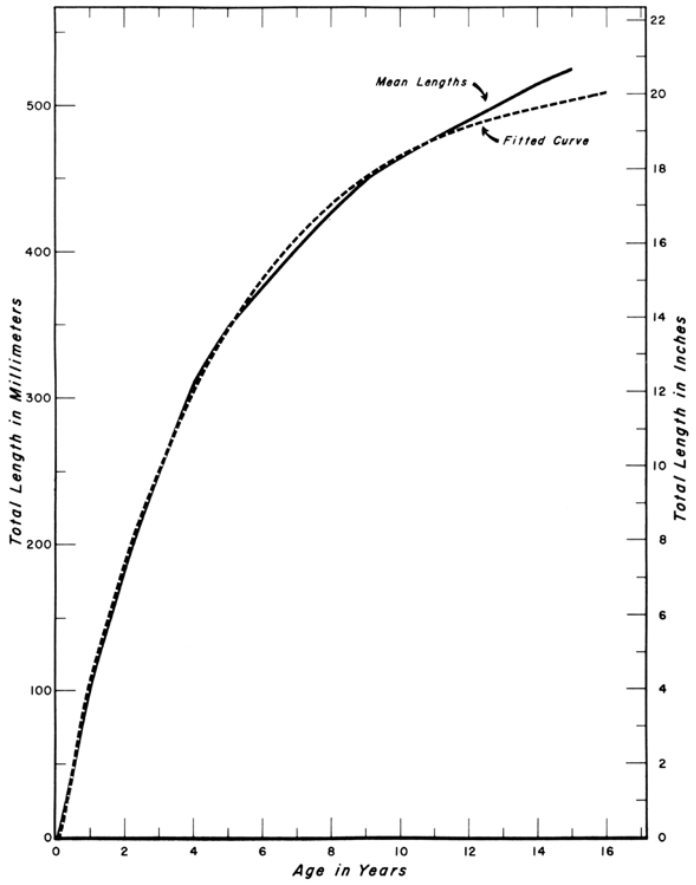


FIGURE 21. Widow rockfish age-length relationship, sexes combined, 921 items.

FIGURE 21. Widow rockfish age-length relationship, sexes combined, 921 items

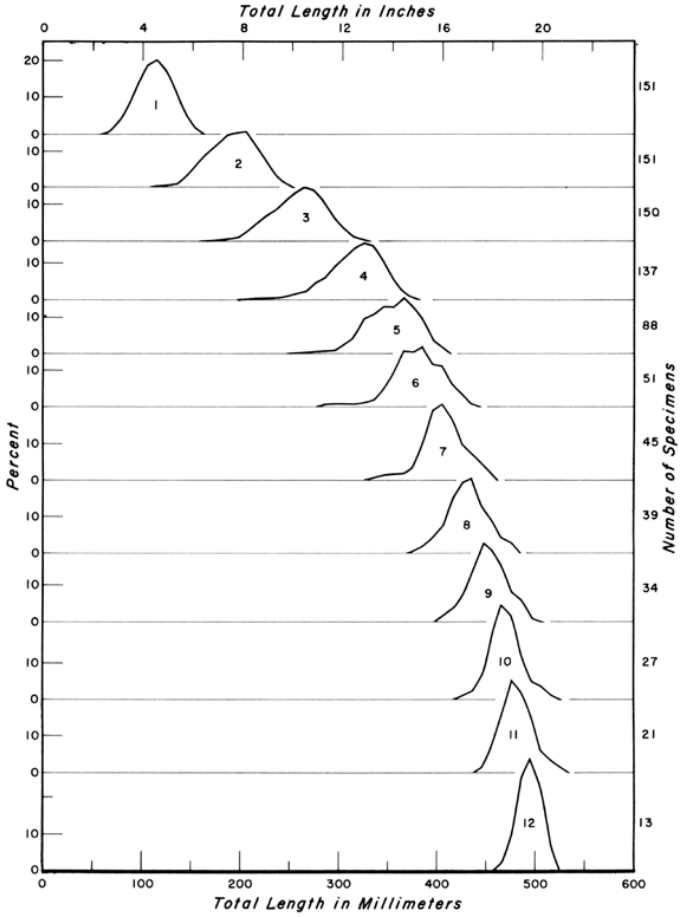
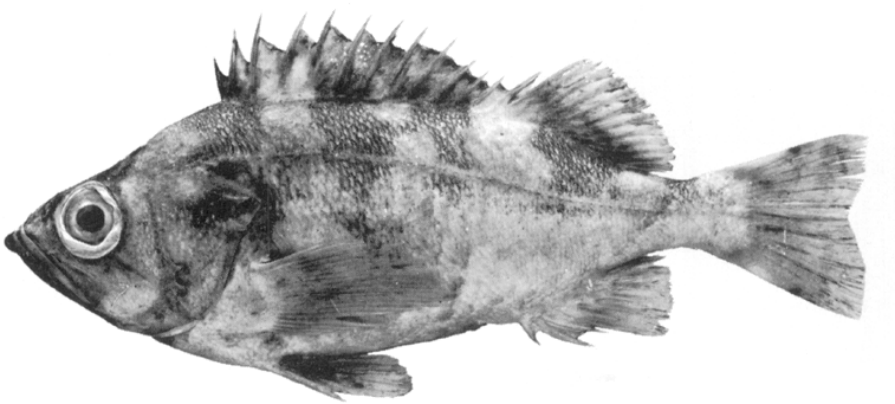


FIGURE 22. Widow rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 22. Widow rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.7. DARK-BLOTCHED ROCKFISH



Sebastodes crameri Jordan 1896

Distribution—Santa Monica Bay, California, to Bering Sea.

Greatest depth taken and maximum size—200 fathoms; 22½ inches.

Distinguishing characters:

Color—Pink, with four dusky patches on back (three under spinous and one under soft dorsal fin), and a small patch on caudal peduncle. An occasional adult may have a jet-black blotch, or blotches, anywhere on body. Young fish may have some light yellow-green on body.

Top of head, between mid-orbits—Slightly to moderately convex.

Spines on top of head, bordering orbits—Four prostrate spines on each side (supraocular spine present).

End of maxillary—Reaches to between rear of pupil and rear of orbit; to midorbit in small specimens.

Second anal fin spine—About twice as thick as third anal spine; tip of second spine does not reach tip of third (spines depressed).

Number of anal fin rays	7 (occas. 6)
Number of pectoral fin rays	18 – 20
Number of pores in lateral line	40 – 50
Number of rakers on first gill arch	29 – 34

Size and age at maturity—A few fish mature when 11 inches long, or 5 years old. Fifty percent are mature when 12 inches long, or 6 years old. They attain a maximum age of at least 30 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 45,000 in a fish 13 inches long, to about 600,000 in a fish 22½ inches long.

Food—Adults feed extensively on macroplanktonic organisms, primarily euphausiids, but occasionally on amphipods, small salps, and small octopi. Infrequently, small fish such as anchovies appear in their diet.

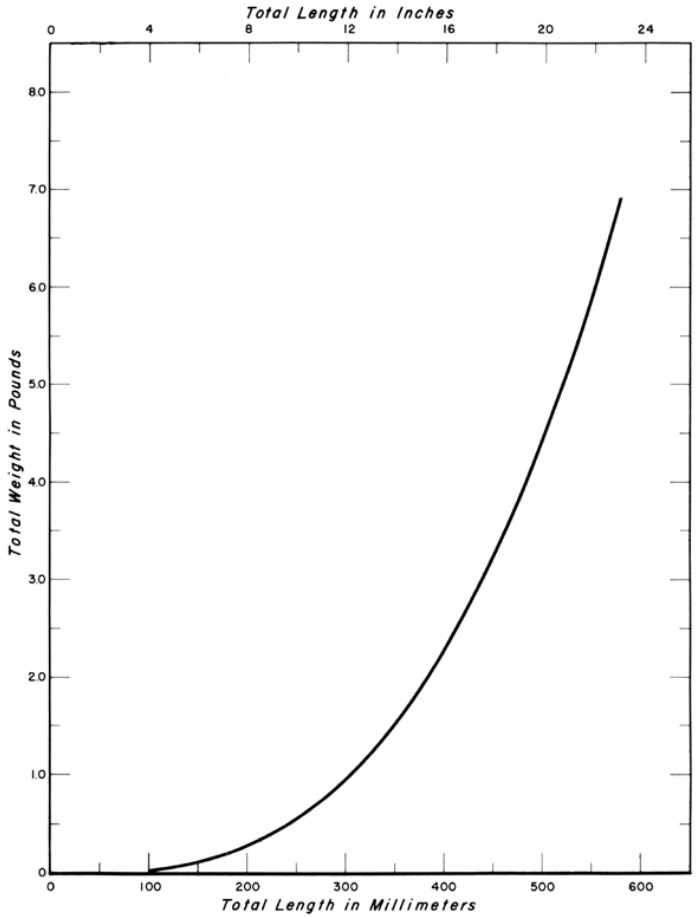


FIGURE 23. Dark-blotched rockfish weight-length relationship, sexes combined, 422 fish.

FIGURE 23. Dark-blotched rockfish weight-length relationship, sexes combined, 422 fish

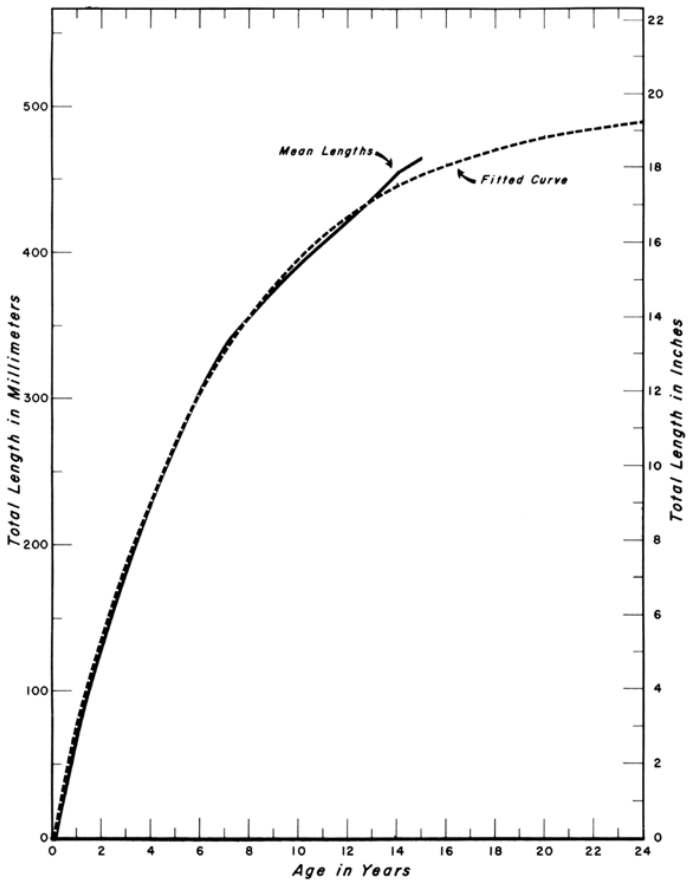


FIGURE 24. Dark-blotched rockfish age-length relationship, sexes combined, 683 items.

FIGURE 24. Dark-blotched rockfish age-length relationship, sexes combined, 683 items

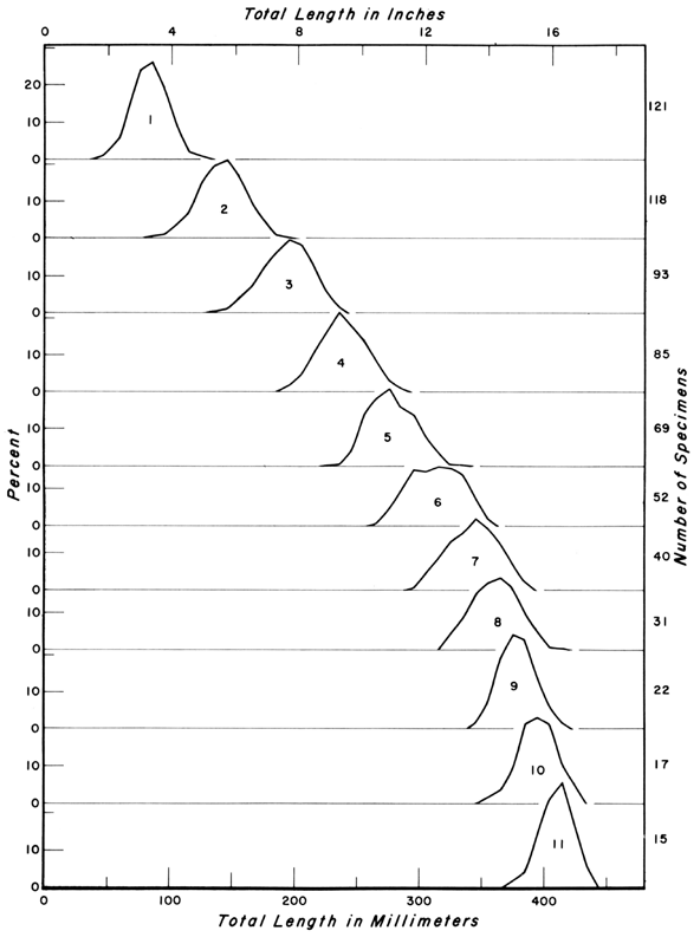
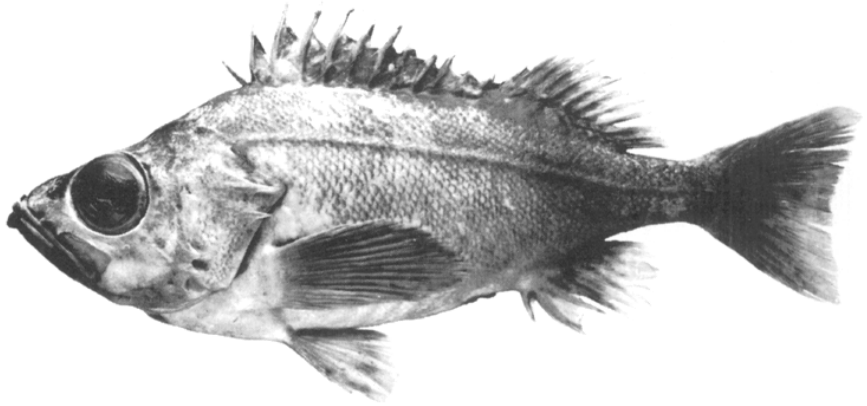


FIGURE 25. Dark-blotched rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 25. Dark-blotched rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.8. SPLITNOSE ROCKFISH (ROSEFISH)



Sebastodes diploproa (Gilbert 1890)

Distribution—Coronado Islands, Baja California, to Vancouver, British Columbia.

Greatest depth taken and maximum size—250 fathoms; 16 inches.

Distinguishing characters:

Color—Uniformly light red.

Top of head between mid-orbits—Flat to slightly concave, with narrow median groove bordered by low ridges.

Spines on top of head, bordering orbits—Three on each side (supraocular spine absent).

End of maxillary—Reaches to under mid-orbit, or rear of pupil.

Note—The dentigerous premaxillaries are prolonged anteriorly.

Second anal fin spine—About twice as thick as third; tip of second reaches almost to, or slightly beyond tip of third (spines depressed).

Number of anal fin rays	6 or 7 (occas. 8)
Number of pectoral fin rays	18 (occas. 17 or 19)
Number of pores in lateral line	33 – 43
Number of rakers on first gill arch	32 – 37

Size and age at maturity—A few fish mature when 7½ inches long, or 4 years old. Fifty percent are mature when 8¼ inches long, or 5 years old. They attain a maximum age of about 18 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 14,000 in a fish 7½ inches long, to about 255,000 in a fish 14½ inches long.

Food—Adults appear to feed exclusively on macroplanktonic organisms, primarily euphausiids. Occasionally, small salps or pteropods are found in their stomachs.

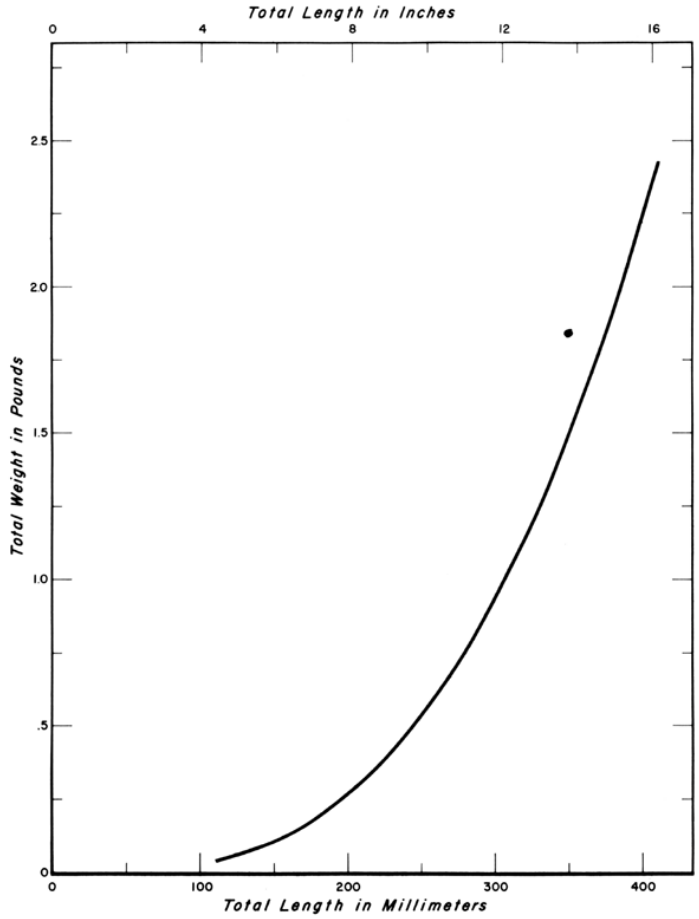


FIGURE 26. Splitnose rockfish weight-length relationship, sexes combined, 635 fish.

FIGURE 26. Splitnose rockfish weight-length relationship, sexes combined, 635 fish

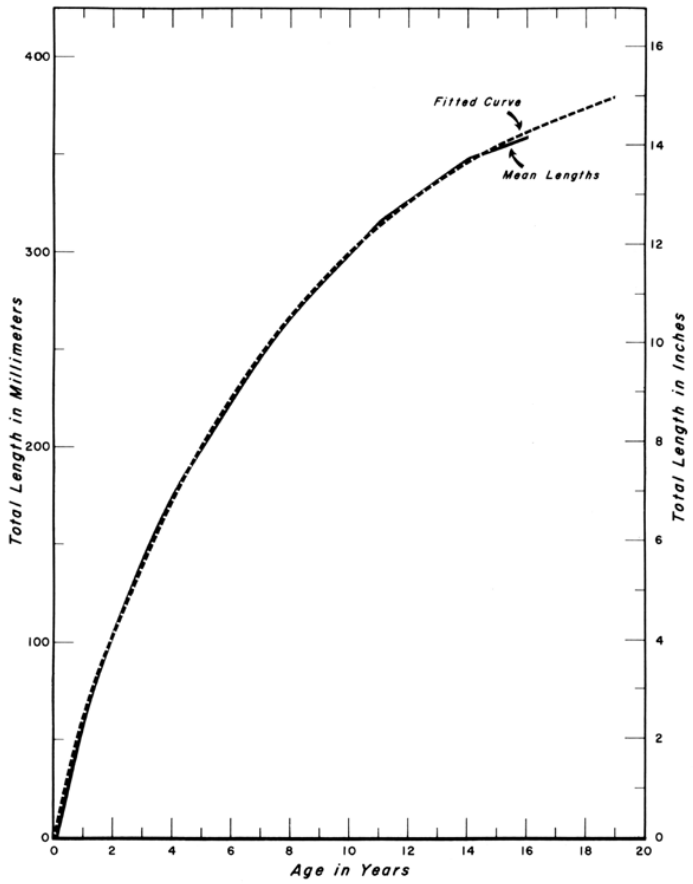


FIGURE 27. Splitnose rockfish age-length relationship, sexes combined, 803 items.

FIGURE 27. Splitnose rockfish age-length relationship, sexes combined, 803 items

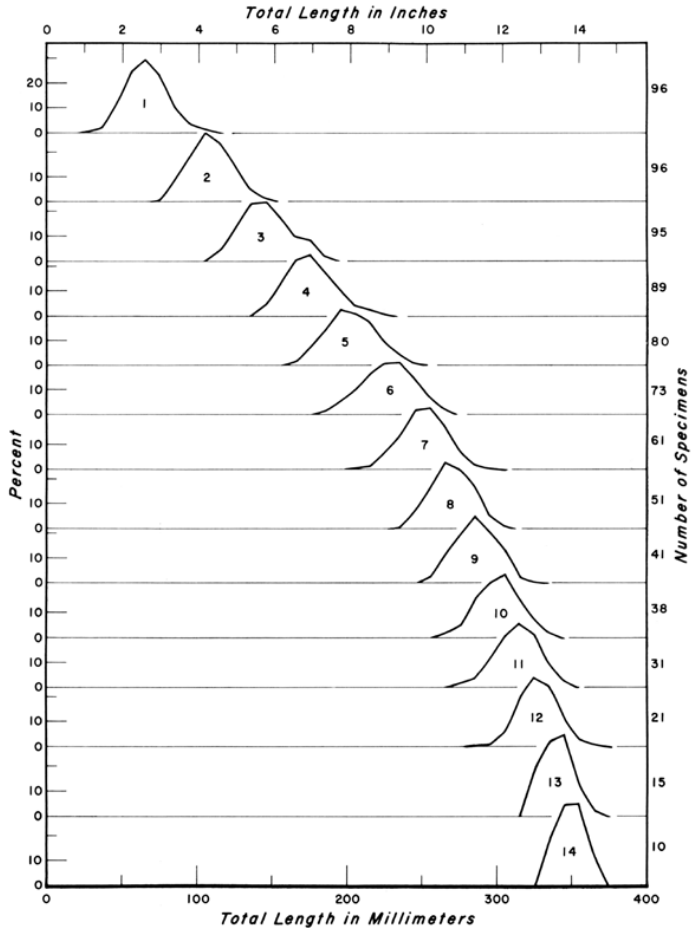
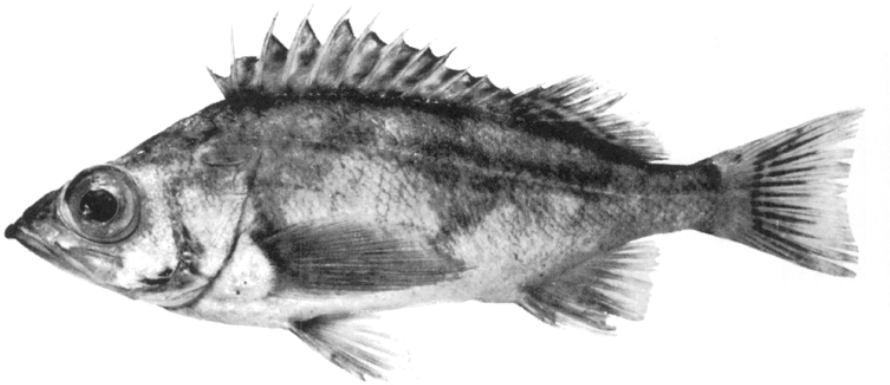


FIGURE 28. Splitnose rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 28. Splitnose rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.9. STRIPETAIL ROCKFISH



Sebastodes saxicola (Gilbert 1890)

Distribution—Sebastian Viscaino Bay, Baja California, to southeastern Alaska.

Greatest depth taken and maximum size—230 fathoms; 13 inches.

Distinguishing characters:

Color—Yellow-pink with some light green; several vague, dusky blotches on back; fins yellow-pink; green streaks on membranes of caudal fin, at least on uppor portion.

Top of head, between mid-orbits—Nearly flat or slightly concave. Usually, with a narrow, median groove.

spines on top of head, bordering orbits—Three on each side (supraocular spine absent).

End of maxillary—Reaches to under mid-orbit, or rear of pupil.

Second anal fin spine—About twice as thick as third; tip of second reaches beyond tip of third (spines depressed).

Number of anal fin rays	7 (occas. 5, 6 or 8)
Number of pectoral fin rays	16 (occas. 15 or 17)
Number of pores in lateral line	36 – 42
Number of rakers on first gill arch	31 – 35

Size and age at maturity—A few mature when 5 inches long, or 2 years old. Fifty percent of the males mature when 5¾ inches long; females when 6¾ inches long, or 4 years old. They attain a maximum age of about 17 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 15,000 in a fish 7 inches long, to about 200,000 in a fish 12½ inches long.

Food—Adults feed exclusively on macroplanktonic organisms, primarily euphausiids.

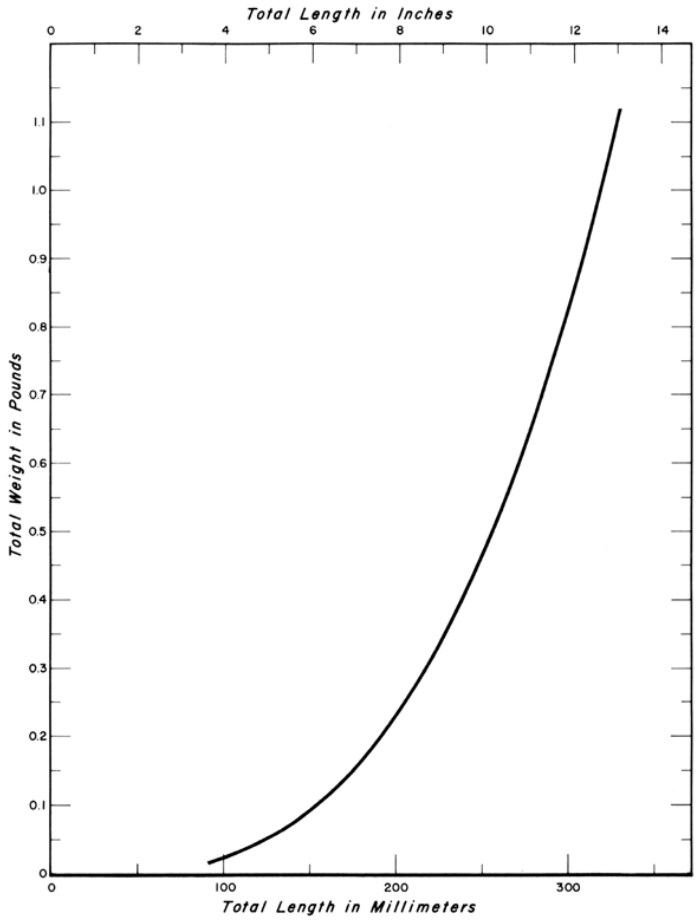


FIGURE 29. Stripetail rockfish weight-length relationship, sexes combined, 429 fish.

FIGURE 29. Stripetail rockfish weight-length relationship, sexes combined, 429 fish

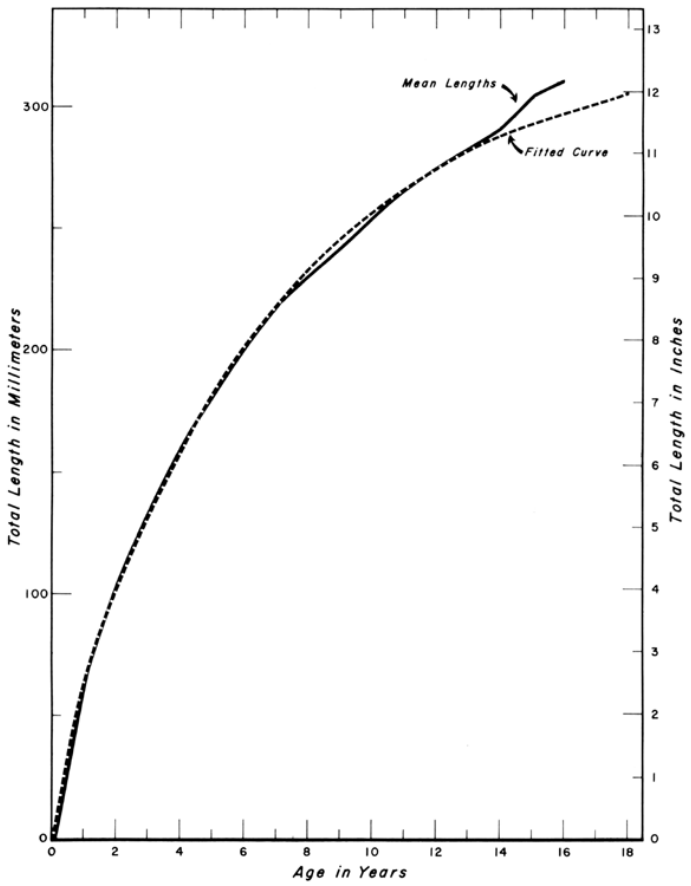


FIGURE 30. Stripetail rockfish age-length relationship, sexes combined, 554 items.

FIGURE 30. Stripetail rockfish age-length relationship, sexes combined, 554 items

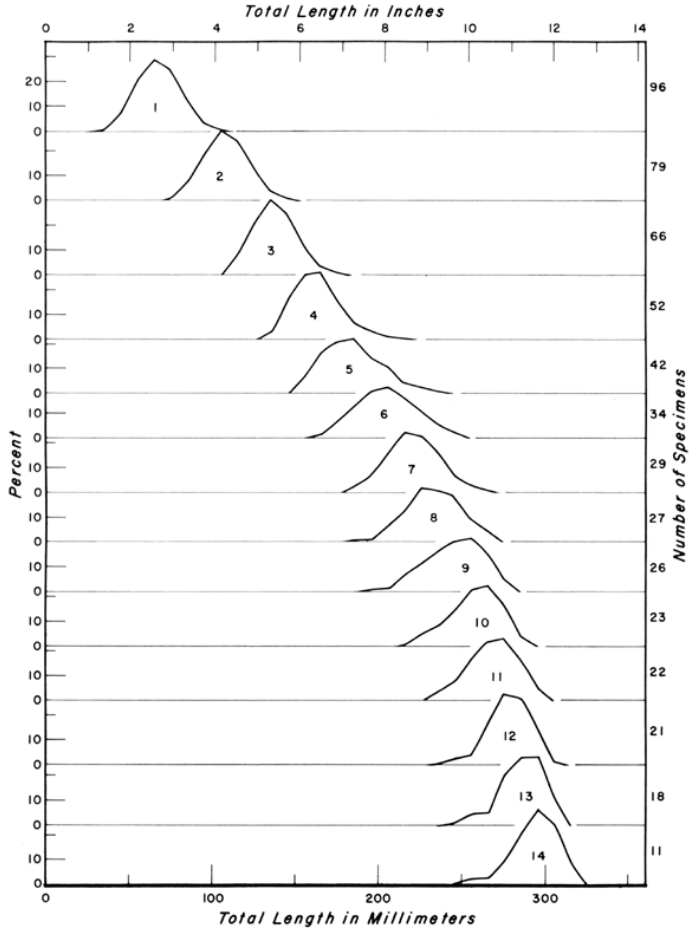
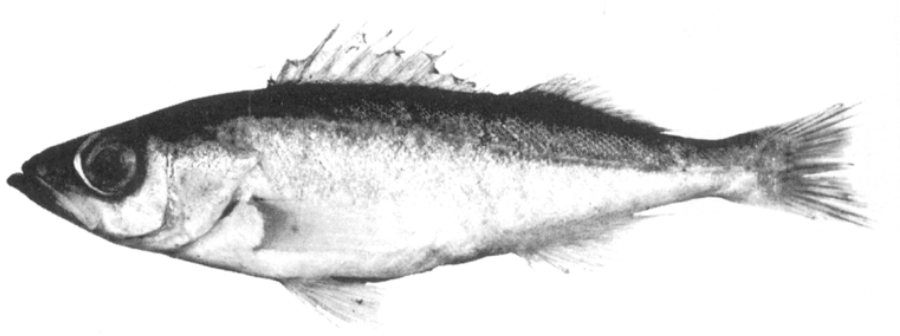


FIGURE 31. Stripetail rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 31. Stripetail rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

8.10. SHORTBELLY ROCKFISH



Sebastodes jordani Gilbert 1893

Distribution—Ensenada, Baja California, to State of Washington.

Greatest depth taken and maximum size—155 fathoms; 12 inches.

Distinguishing characters:

Color—Olive-pink dorsally becoming light pink on sides; fins same color as adjacent body parts.

Top of head between mid-orbits—Moderately convex.

Spines on top of head, bordering orbits—Small, weak, and in some cases, obsolete. If present, no more than three on each side (supraocular spine absent).

End of maxillary—Reaches barely to mid-orbit.

Second anal fin spine—Hardly thicker than third; tip of second does not reach beyond tip of third (spines depressed).

Note—This is the only rockfish with anus notably anterior to anal fin.

Number of anal fin rays	9 or 10 (occas. 8 or 11)
Number of pectoral fin rays	20 or 21 (occas. 19 or 22)
Number of pores in lateral line	52 – 59
Number of rakers on first gill arch	42 – 47

Size and age at maturity—A few mature when 6 inches long, or 2 years old. Fifty percent are mature when 6½ inches long, or 3 year old. They attain a maximum age of 10 years.

Fecundity—The number of developing eggs in the paired ovaries increases from 6,000 in fish 7 inches long, to about 50,000 in fish 12 inches long.

Food—Adults feed exclusively on macroplanktonic organisms, primarily euphausiids.

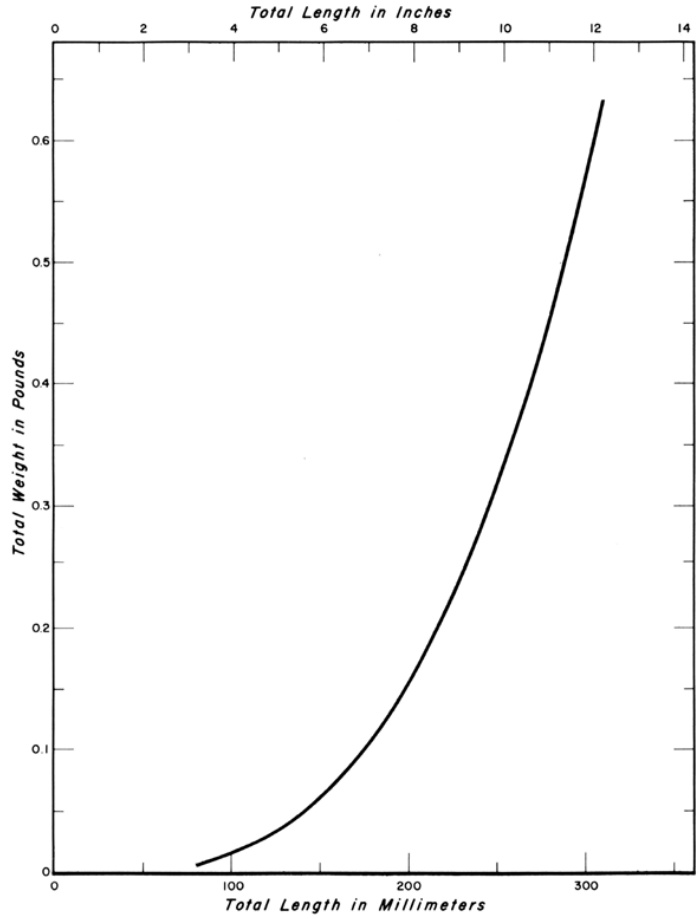


FIGURE 32. Shortbelly rockfish weight-length relationship, sexes combined, 474 fish.

FIGURE 32. Shortbelly rockfish weight-length relationship, sexes combined, 474 fish

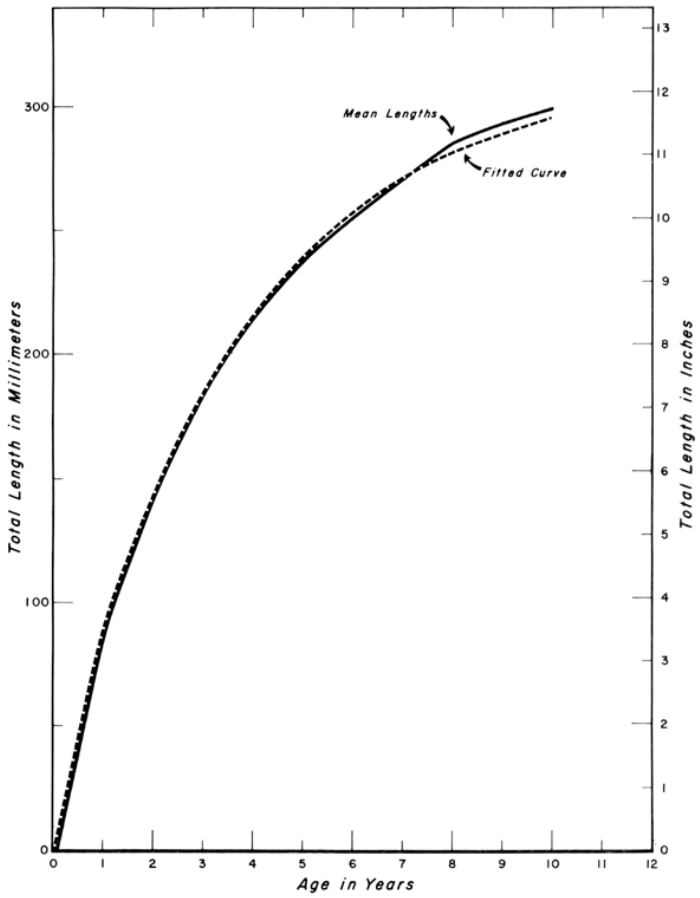


FIGURE 33. Shortbelly rockfish age-length relationship, sexes combined, 450 items.

FIGURE 33. Shortbelly rockfish age-length relationship, sexes combined, 450 items

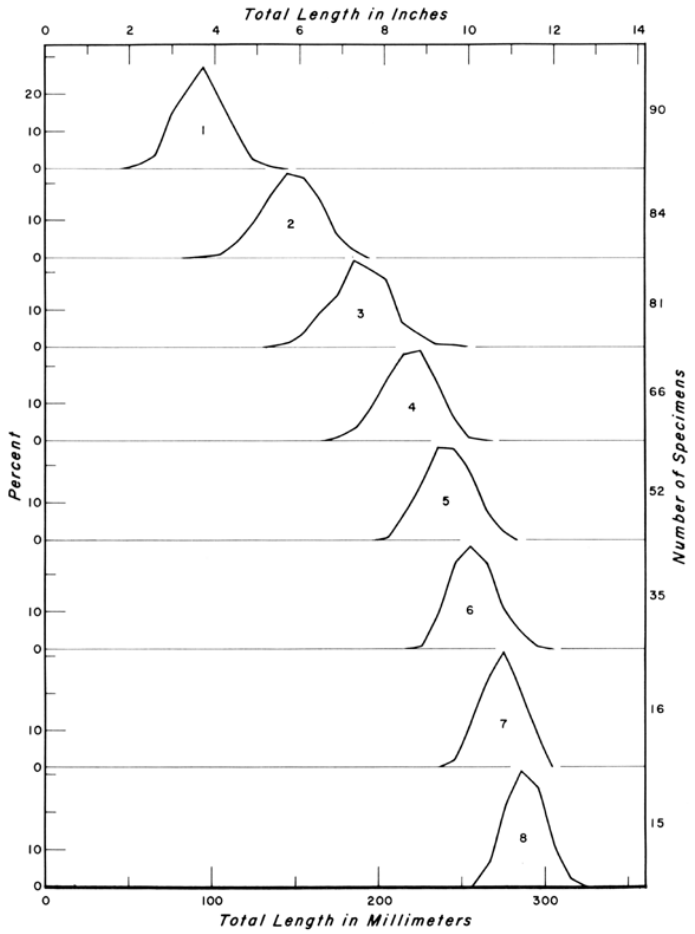


FIGURE 34. Shortbelly rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted.

FIGURE 34. Shortbelly rockfish length frequency distributions by age. Where fewer than 10 readings were available for a given age, that age was not plotted

9. RACIAL STUDIES

Racial studies, which usually involve meristic counts, tagging, and serology were not undertaken.

Among meristic characters, vertebral counts are unproductive because the number of these elements is identical in all species in the genus Sebastodes (Jordan and Evermann, 1898). Fin ray, gill raker, and lateral line pore counts for a species exhibit some variation (Phillips, 1957), and may offer a basis for comparing stocks occurring in different latitudes. However, even if such comparisons were made and found to lack statistical significance, this would not preclude the possibility that separate stocks exist.

Evidence for assuming the stocks of at least some species do not intermingle over a wide area became apparent in this study. In both the bocaccio and chilipepper, ripe females with eggs ready to hatch were noted within the same 3-week period at such widely separated ports as Monterey, Fort Bragg, and Eureka. Since Eureka is about 300 miles northward of Monterey, localized spawning rather than a common spawning area is indicated. Other species may exhibit similar spawning patterns. Although concurrent spawning in widely separated regions may indicate restricted coastwide movements for a species, direct proof of such is still lacking for practically all rockfish.

An assured way of discovering fish movement is through a tagging program. However, rockfish tagging poses a problem because these forms are sensitive to sharp pressure changes. Rockfish brought steadily to the surface from deep water have their air bladders distended and their eyes popped. In some individuals, the inflated air bladder may project into the mouth through a slit in the throat. In others, the stomach may be inverted in the throat. The chances of survival are dubious in such cases.

As part of a life history study, a tagging project is being conducted on blue rockfish, Sebastodes mystinus, which occur in relatively shallow water (Blue rockfish management study, Dingell-Johnson F-19-R). Recoveries of individuals at liberty for a year have revealed little movement away from the locality of release (Dan Miller, pers. comm.). Even this shallow-water form when brought to the surface, usually exhibits inflation of the air bladder due to lessened pressure. Deflation is accomplished by inserting a hypodermic needle through the body wall at the proper place, while a fish is immersed in a bath containing an anesthetic. Most fish treated in this manner survive. Currently, aquarium tests are being conducted on blue rockfish from deeper water to ascertain if replacing an inverted stomach, and deflating and replacing protruding eyes have any long-term effects (Gotshall, 1963).

One solution to the complex problem of tagging commercial forms from deep water might be to seek sub-adults in shallower water than is occupied by adults, and to apply tagging techniques developed for blue rockfish. Also, trapped fish might be allowed to adjust to lessening pressure by hoisting them to the surface in leisurely steps. However,

this method may be impractical if an exorbitant amount of time is required.

If just the information on movements of fish stocks is needed, tagged, detachable hooks might be considered. Recently, a 13-inch kelp bass, Paralabrax clathratus, was caught near where it had tagged itself when it took such a baited hook 2¼ years previously. About 100 of these labeled hooks had been experimentally fished by the author off southern California in February 1961, but no other recoveries have been reported. Since this trial was made with tinned hooks, attached to fishing line by sewing thread, further trials might be made with rust-proof, stainless steel hooks, using tested monofilament for the weak-link.

Several fisheries agencies have made considerable progress in serological differentiation of fish bloods. Studies on the Atlantic redfish, Sebastes marinus, which is related to Pacific coast rockfishes, have revealed individual differences in red blood antigens (Sindermann, 1961). As such techniques improve they might be applied to Pacific coast forms. If subsequent serological studies demonstrate genetically distinct stocks for various species, future life history studies might profitably include comparisons between such stocks.

10. SUMMARY

Details regarding weight-length relationships, annual growth, size and age at maturity, spawning season, fecundity, and feeding habits are presented for 10 rockfishes: bocaccio, chilipepper, yellowtail, canary, vermilion, widow, dark-blotched, splitnose, stripetail, and shortbelly. These forms are prominent in the commercial rockfish catch from California waters.

Ages were determined from body scales, and back-calculations were made to determine the growth attained when previous annuli were formed.

Calculated mean lengths agreed quite well with exponentially-fitted curves at least through ages 12 for all species, except the shortbelly rockfish whose maximum age is 10.

The fitted curves were extrapolated to larger sizes than those selected for age determinations, and in most cases the maximum age for a species in California was estimated from these projections.

All but the shortbelly rockfish attain maximum ages that are calculated to be between 16 and 30 years.

Maximum weights vary from 0.6 pounds in the shortbelly rockfish to at least 15.0 pounds in the bocaccio. The largest of the rockfishes, the cow, attains a weight of at least 32 pounds. It was not included in the present study, although it is well-known to southern California deep-sea fishermen.

Since all Sebastodes are ovoviviparous, the term "spawning" is synonymous with "hatching period." Spawning for nine of the species occurs during the winter, from about mid-November to mid-March. The splitnose rockfish spawns during the spring, from about February through July.

In the shortbelly rockfish, 50 percent of the 3-year-olds are mature. In the nine remaining forms, ages of 4 to 6 years had to be attained before 50 percent of the population of a given species were mature.

The number of eggs the larger females will spawn in a season varies from about 50,000 in the shortbelly rockfish to over 2 million in the bocaccio.

Stomach examinations revealed that the splitnose, stripetail, and shortbelly rockfish are essentially plankton feeders throughout life, but as adults they switch to larger planktonic organisms (macroplankton), such as euphausiids. The bocaccio feeds almost exclusively on other fishes, changing from a plankton diet before they become a year old. The remaining species feed adventitiously on macroplanktonic organisms and on small fishes.

11. ACKNOWLEDGMENTS

Phil M. Roedel and Harold G. Orcutt, Marine Resources Operations, gave support and counsel to this study. E. A. Best provided information on some dark-blotched rockfish taken at Eureka. Captain Richard Mitchell and the crew of the Department's research vessel N. B. Scofield, and Marco Mazarovich and Andrew Felando, who operated our research vessel Nautilus were very helpful on cruises in southern California waters. John E. Fitch and Carl L. Hubbs furnished some new information on maximum sizes and ranges of species. Fitch also contributed notes on feeding habits, and made many helpful suggestions in reviewing the manuscript for publication. Norman J. Abramson designed computer programs for handling the original weight-length and the age-length data, and also furnished the resulting statistical summaries for fitting and evaluating the curves. I am indebted to Western Data Processing Center, University of California, Los Angeles, for use of their 7090 electronic computer to obtain the statistical summaries.

Thanks are due the friendly personnel of the six markets where rockfish were sampled: Eureka Fisheries, Inc., and Tom Lazio Fish Company, Eureka; A. Paladini, Inc., Fort Bragg; and General Fish Company, Regal Seafood Company, and Mission Fisheries, Monterey.

The photographs were taken by the author, and the line drawings were reproduced by C. T. Murray.

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APPENDICES

APPENDIX A

Mean Weights at Total Length, by 10 mm Groupings, for 10 Species of Rockfish (Sexes Combined)

Total length mm	Bocaccio		Chilipepper		Yellowtail rockfish		Canary rockfish		Vermilion rockfish		Widow rockfish		Dark-blotched rockfish		Splitnose rockfish		Stripetail rockfish		Shortbelly rockfish	
	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish	Mean weight pounds	Number of fish
80																	0.01	2	0.009	4
90																	0.02	7	0.013	22
100	0.02		0.02		0.03		0.03		0.04		0.02		0.04		0.03		0.03	12	0.018	1
110	0.03		0.03		0.04		0.04		0.05		0.03		0.05		0.05		0.04	3	0.024	
120	0.03		0.03		0.05		0.05		0.07		0.04		0.07		0.06	18	0.05	3	0.032	2
130	0.04		0.05		0.07		0.07		0.09		0.05		0.08	1	0.08	22	0.06	12	0.041	8
140	0.06		0.06		0.08		0.08		0.11		0.06		0.10	2	0.10	10	0.08	9	0.052	26
150	0.07		0.07	1	0.10		0.10		0.13		0.08		0.13	11	0.12	13	0.10	23	0.064	30
160	0.08		0.09	1	0.13		0.13		0.16		0.10		0.15	5	0.14	16	0.12	35	0.079	21
170	0.10	8	0.11	2	0.15		0.15		0.19		0.12		0.18	6	0.17	13	0.14	23	0.095	8
180	0.12	16	0.13	1	0.18		0.18	1	0.22	1	0.14		0.22	3	0.20	9	0.17	17	0.114	4
190	0.14	19	0.15		0.21		0.21	1	0.26		0.17		0.25	3	0.24	14	0.20	15	0.135	16
200	0.17	17	0.18	1	0.25		0.25		0.30		0.20		0.30	2	0.28	28	0.24	25	0.159	26
210	0.20	14	0.21	8	0.29		0.29	4	0.35	1	0.23		0.34	10	0.32	20	0.27	21	0.185	22
220	0.23	4	0.25	15	0.33		0.33	3	0.40	2	0.27		0.39	6	0.37	32	0.32	19	0.214	38
230	0.26	2	0.29	13	0.38	1	0.38	1	0.46	2	0.31		0.45	2	0.43	29	0.36	20	0.246	39
240	0.30	1	0.33	13	0.43		0.43	11	0.52	2	0.36		0.51	5	0.48	20	0.42	11	0.282	30
250	0.34		0.38	21	0.49	1	0.49	7	0.58	2	0.41		0.57	3	0.55	21	0.47	18	0.320	31
260	0.38		0.43	13	0.55	7	0.55	2	0.65	6	0.46	2	0.64	7	0.62	26	0.53	19	0.363	28
270	0.43		0.48	8	0.61	8	0.62	3	0.73	3	0.52	2	0.72	7	0.69	26	0.60	39	0.408	37
280	0.48		0.54	6	0.69	8	0.70	4	0.81	1	0.59	5	0.80	12	0.77	25	0.67	40	0.458	32
290	0.53	2	0.61	18	0.76	10	0.77	3	0.90	8	0.66	5	0.89	4	0.86	20	0.75	24	0.512	31
300	0.59		0.68	11	0.85	8	0.86	2	0.99	2	0.74	5	0.98	12	0.95	26	0.83	18	0.569	14
310	0.66	1	0.76	13	0.93	10	0.95	3	1.09	5	0.82	7	1.08	11	1.05	41	0.92	10	0.631	4
320	0.73	3	0.84	18	1.03	12	1.05	1	1.19	4	0.91	13	1.19	10	1.15	38	1.02	3		
330	0.80	1	0.93	21	1.13	23	1.15	4	1.31	6	1.01	23	1.30	15	1.26	36	1.12	1		
340	0.87	3	1.02	33	1.24	24	1.26		1.43	5	1.11	16	1.42	16	1.38	36				
350	0.96	9	1.12	49	1.35	18	1.38	3	1.55	9	1.22	16	1.55	18	1.51	25				
360	1.04	11	1.23	62	1.47	21	1.50	3	1.68	7	1.34	22	1.69	23	1.64	39				
370	1.14	16	1.34	52	1.60	13	1.63	2	1.82	8	1.46	15	1.83	28	1.78	18				
380	1.23	13	1.46	32	1.74	19	1.77	3	1.97	6	1.59	13	1.98	43	1.93	11				
390	1.34	9	1.59	27	1.88	10	1.92	3	2.13	11	1.74	22	2.14	29	2.09	2				

APPENDIX A Mean Weights at Total Length, by 10 mm Groupings, for 10 Species of Rockfish (Sexes Combined)

400	1.45	7	1.73	23	2.03	21	2.07	9	2.29	5	1.88	15	2.30	16	2.26	1						
410	1.56	6	1.87	32	2.19	29	2.23	17	2.46	6	2.04	21	2.48	25	2.43							
420	1.68	4	2.02	20	2.35	19	2.40	19	2.64	8	2.21	28	2.66	20								
430	1.81	4	2.18	16	2.53	13	2.58	28	2.83	35	2.38	33	2.85	14								
440	1.94	11	2.35	18	2.71	24	2.77	30	3.02	28	2.57	28	3.05	15								
450	2.08	11	2.53	21	2.90	24	2.97	32	3.23	39	2.76	24	3.26	17								
460	2.23	18	2.72	23	3.10	16	3.17	37	3.44	35	2.97	20	3.48	8								
470	2.38	22	2.91	28	3.31	24	3.39	34	3.67	44	3.18	19	3.71	5								
480	2.54	28	3.12	27	3.53	20	3.61	36	3.90	45	3.41	22	3.95	5								
490	2.71	30	3.34	32	3.76	12	3.85	38	4.14	30	3.65	25	4.20	1								
500	2.88	20	3.56	26	4.00	9	4.09	31	4.39	30	3.89	33	4.45	1								
510	3.07	24	3.80	27	4.25	13	4.35	25	4.65	26	4.15	18	4.72	1								
520	3.26	19	4.04	17	4.51	14	4.61	23	4.92	36	4.43	6	5.00									
530	3.45	20	4.30	20	4.77	10	4.89	35	5.20	23	4.71	8	5.29									
540	3.66	29	4.57	9	5.05	7	5.18	27	5.50	27	5.00		5.59									
550	3.87	30	4.85	4	5.34	2	5.48	24	5.80	17			5.90									
560	4.10	23	5.14	1	5.64		5.79	29	6.11	20			6.23									
570	4.33	24			5.96		6.11	26	6.43	27												
580	4.57	23			6.28		6.44	12	6.77	12												
590	4.81	19			6.61		6.79	13	7.12	15												
600	5.07	26			6.96		7.14	10	7.47	11												
610	5.34	9			7.32		7.51	6	7.84	4												
620	5.61	19			7.69		7.90	3	8.22	2												
630	5.90	17			8.07		8.29	2	8.62	1												
640	6.19	18			8.47		8.70	2	9.02													
650	6.50	15			8.88		9.12		9.44													
660	6.81	9			9.30		9.56	1	9.87													
670	7.13	15					10.01		10.31													
680	7.47	8					10.47		10.77													
690	7.81	17					10.95		11.23													
700	8.17	9					11.44		11.71													
710	8.54	5					11.95		12.21													
720	8.91	3					12.47		12.72													
730	9.30	4					13.01		13.24													
740	9.70	6					13.56		13.78													
750	10.11	4					14.13		14.33													
760	10.54	1					14.71		14.89													
770	10.97	3																				
780	11.42	2																				
790	11.88																					
800	12.35																					
810	12.83																					
820	13.33																					
830	13.84																					
840	14.36																					
850	14.90																					

APPENDIX A—Cont'd.

APPENDIX B

Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

Age at end of year	Size range (mm)		Mean total length (mm)	Number of fish (sample size)	Standard error of sample means	Lengths for fitted growth curve (mm)
	Minimum	Maximum				
Bocaccio						
1	129	227	171	155	1.79	175.4
2	200	350	267	146	2.30	263.0
3	276	425	343	144	2.36	338.6
4	342	473	405	132	2.35	403.8
5	396	535	457	114	2.63	460.0
6	431	578	502	99	2.79	508.5
7	460	616	548	58	3.64	550.4
8	531	646	587	46	3.42	586.5
9	561	650	620	40	3.54	617.6
10	590	689	645	28	4.24	644.5
11	642	700	670	18	3.89	667.6
12	665	713	692	10	5.18	687.6
13	690	730	708	8	4.96	704.8
14	712	743	726	5	4.98	719.7
15	728	747	738	2	9.50	732.5
16	740	762	751	2	11.00	743.6
17	---	---	771	1	----	-----
			(Standard Error of Estimate 26.16)			
Chilipepper						
1	71	142	106	138	1.27	110.7
2	138	235	187	125	1.90	184.3
3	205	306	252	125	2.15	245.6
4	253	357	302	111	2.51	296.7
5	290	398	339	104	2.55	339.3
6	316	421	369	95	2.61	374.8
7	341	451	396	79	3.04	404.4
8	366	468	422	52	3.76	429.1
9	384	485	448	37	3.92	449.7
10	429	513	469	30	3.19	466.8
11	455	518	485	24	3.23	481.1
12	473	522	499	16	3.35	493.0
13	500	531	514	11	2.84	502.9
14	519	539	528	7	2.64	511.2
15	530	546	537	5	3.06	518.1
16	---	---	551	1	----	-----
			(Standard Error of Estimate 23.54)			
Yellowtail rockfish						
1	66	134	106	140	1.23	107.0
2	118	229	172	139	1.83	173.2
3	164	294	230	139	2.11	229.0
4	212	341	279	126	2.18	275.8
5	264	370	319	116	2.15	315.3
6	303	400	349	92	2.26	348.5
7	328	410	373	72	2.17	376.5
8	350	439	396	67	2.19	400.0
9	385	455	414	54	2.00	419.8
10	407	462	430	48	1.79	436.4
11	421	474	446	42	2.03	450.5
12	433	490	463	32	2.27	462.2
13	443	503	478	26	2.54	472.2
14	476	515	492	16	2.60	480.5
15	492	510	504	6	3.15	487.6
16	509	526	517	3	4.93	493.5
17	517	526	522	2	4.50	498.5
			(Standard Error of Estimate 20.24)			
Dark-blotched rockfish						
1	55	109	82	121	1.15	80.6
2	95	173	140	118	1.45	141.6
3	141	222	192	93	1.83	193.8
4	201	272	238	85	1.81	238.4
5	235	325	277	69	2.13	276.5
6	284	347	312	52	2.62	309.2
7	313	377	342	40	2.98	337.1
8	330	400	361	31	3.10	360.9
9	360	403	378	22	2.69	381.3
10	376	415	394	17	3.00	398.8
11	382	422	409	15	2.75	413.7
12	403	433	424	8	3.67	426.4
13	418	449	437	6	5.09	437.3
14	447	464	456	3	4.98	446.7
15	459	469	464	2	5.00	454.6
16	---	---	470	1	----	-----
			(Standard Error of Estimate 16.07)			

APPENDIX B Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

APPENDIX B—Continued

Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

Age at end of year	Size range (mm)		Mean total length (mm)	Number of fish (sample size)	Standard error of sample means	Lengths for fitted growth curve (mm)
	Minimum	Maximum				
Splitnose rockfish						
1	43	96	65	96	1.06	66.0
2	90	134	108	96	1.10	106.6
3	121	175	144	95	1.35	142.5
4	150	210	174	89	1.52	174.3
5	173	228	201	80	1.68	202.4
6	195	255	227	73	1.81	227.3
7	210	281	250	61	1.69	249.3
8	250	298	269	51	1.63	268.7
9	264	317	285	41	1.83	286.0
10	274	323	300	38	1.99	301.2
11	280	339	316	31	3.08	314.7
12	290	350	327	21	2.54	326.6
13	330	350	338	15	1.53	337.2
14	341	358	348	10	1.89	346.5
15	350	360	353	4	2.48	354.8
16	358	360	359	2	1.00	362.1
			(Standard Error of Estimate 12.85)			
Canary rockfish						
1	60	137	103	143	1.29	103.3
2	102	208	165	142	1.71	166.8
3	173	292	223	141	1.94	223.0
4	212	353	275	138	2.12	272.8
5	261	381	319	128	2.22	316.8
6	311	415	357	120	2.12	355.7
7	360	447	391	116	1.96	390.2
8	365	475	419	102	2.08	420.7
9	388	479	443	83	2.26	447.7
10	422	510	468	57	2.46	471.5
11	448	525	491	42	2.88	492.7
12	466	543	510	29	3.77	511.4
13	507	563	535	20	3.37	527.9
14	523	578	552	12	4.73	542.5
15	538	588	565	7	5.89	555.5
16	550	596	574	3	13.35	566.9
17	---	---	588	1	-----	-----
18	---	---	599	1	-----	-----
			(Standard Error of Estimate 21.43)			
Vermilion rockfish						
1	73	128	101	113	1.30	105.4
2	120	196	161	113	1.68	160.0
3	161	265	214	112	2.09	209.5
4	206	310	257	107	2.14	254.4
5	252	358	298	99	2.46	295.0
6	282	391	331	92	2.65	331.8
7	295	420	362	81	2.73	365.2
8	342	458	394	71	2.85	395.5
9	367	484	422	63	3.06	422.9
10	409	498	445	52	3.25	447.7
11	407	506	465	41	3.83	470.2
12	432	517	488	28	4.71	490.7
13	456	540	512	16	5.57	509.2
14	470	561	526	11	7.50	525.9
15	526	579	546	9	6.35	541.1
16	542	592	569	6	6.85	554.9
17	580	595	587	4	3.20	567.3
18	594	600	597	3	1.76	578.7
19	---	---	607	1	----	-----
			(Standard Error of Estimate 22.28)			

APPENDIX B Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

APPENDIX B—Continued

Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

Age at end of year	Size range (mm)		Mean total length (mm)	Number of fish (sample size)	Standard error of sample means	Lengths for fitted growth curve (mm)
	Minimum	Maximum				
Widow rockfish						
1	76	153	112	151	1.34	112.1
2	127	243	191	151	1.83	192.2
3	171	311	257	150	2.16	256.8
4	218	359	315	137	2.25	309.0
5	258	396	351	88	2.76	351.1
6	327	423	378	51	3.35	385.0
7	343	445	406	45	3.13	412.4
8	383	467	430	39	2.99	434.5
9	415	481	451	34	2.87	452.4
10	438	500	467	27	2.74	466.7
11	458	518	481	21	3.05	478.4
12	479	506	494	13	2.20	487.7
13	493	518	504	8	3.41	495.3
14	508	528	519	3	5.86	501.4
15	521	533	527	2	6.00	506.3
16	---	---	530	1	----	-----
			(Standard Error of Estimate 22.59)			
Stripetail rockfish						
1	45	91	66	96	0.96	68.9
2	80	127	107	79	1.22	104.3
3	121	169	137	66	1.17	134.8
4	146	209	163	52	1.70	161.1
5	160	225	183	42	2.30	183.9
6	175	239	203	34	2.75	203.5
7	190	250	220	29	2.80	220.4
8	198	259	232	27	3.02	235.1
9	205	268	243	26	3.20	247.7
10	228	275	256	23	2.88	258.5
11	240	283	267	22	2.67	267.9
12	247	290	276	21	2.55	276.0
13	254	296	284	18	2.64	283.0
14	260	304	292	11	3.73	289.1
15	294	311	306	5	3.25	294.3
16	300	323	311	3	6.66	298.8
			(Standard Error of Estimate 12.51)			
Shortbelly rockfish						
1	67	122	93	90	1.23	93.1
2	108	179	147	84	1.57	146.5
3	146	231	188	81	1.74	187.2
4	184	242	218	66	1.57	218.0
5	219	264	240	52	1.63	241.4
6	239	277	257	35	1.83	259.2
7	261	287	272	16	2.03	272.8
8	275	300	286	15	2.05	283.0
9	286	303	294	7	2.38	290.8
10	295	306	300	4	2.33	296.7
			(Standard Error of Estimate 12.81)			

APPENDIX B Lengths at Various Ages for 10 Species of Rockfish, Sexes Combined

APPENDIX C

Calculated Number of Developing Eggs in the Paired Ovaries of 10 Species of Rockfish

Species	Total length of fish (mm)	Date		Number of eggs
		Yr.	Mo.	
Yellowtail rockfish	297	58	12	66,100
	330	59	10	48,400
	345	58	12	80,800
	381	58	12	242,600
	430	58	12	295,400
	433	58	12	591,700
	440	58	12	266,000
	445	61	1	621,200
	455	58	12	611,900
	475	61	1	632,800
	478	58	12	394,400
	484	59	10	578,600
	487	58	12	579,000
	514	58	12	472,200
	535	58	12	575,000
Dark-blotched rockfish	335	59	10	52,500
	352	60	10	36,600
	392	60	10	169,600
	420	60	10	173,600
	425	60	10	190,100
	440	60	10	313,800
	473	60	10	331,700
	475	60	10	251,600
	483	60	10	384,200
	500	60	10	478,900
	513	60	10	347,200
	575	59	10	609,800
Bocaccio	380	59	2	20,000
	420	58	12	143,700
	423	59	12	300,000
	445	59	2	105,000
	455	58	12	255,200
	485	59	11	343,800
	525	58	12	432,400
	525	59	10	434,100
	550	58	12	316,400
	574	59	11	618,300
	586	59	10	549,800
	628	58	12	596,400
	648	58	11	1,371,200
	650	59	2	1,057,000
	650	58	11	1,266,600
	660	59	1	839,100
	666	59	10	888,700
	678	58	11	1,306,600
	690	58	12	1,138,000
	695	59	12	1,271,600
	720	59	2	2,107,900
	745	60	12	1,196,000
	747	60	12	1,629,400
	771	59	10	2,297,900
Widow rockfish	324	58	12	55,600
	349	59	10	66,000
	350	58	12	135,100
	353	58	12	91,800
	387	57	10	165,000
	395	59	10	274,900
	404	59	10	247,800
	410	59	10	248,300
	428	58	11	282,300
	434	58	12	234,700
	448	58	11	495,600
	470	58	12	239,200
	475	58	12	250,000
	476	58	11	845,800
	478	58	11	915,200
	495	59	10	470,700
	496	59	10	659,200
	503	59	10	739,500
	525	59	10	802,800
	533	59	10	386,300
Splitnose rockfish	195	60	4	14,400
	249	59	12	50,500
	265	59	4	56,000
	265	59	4	63,800
	270	59	12	83,200
	295	59	12	145,800
	307	59	10	232,500
	320	61	1	189,100
	325	59	10	238,500
	335	59	10	184,200
	345	59	10	218,900
	346	59	10	303,700
	355	59	10	225,700
	365	59	10	234,500
	365	59	10	256,500
Shortbelly rockfish	173	58	2	6,200
	258	59	3	13,300
	268	60	11	19,000
	271	61	1	32,400
	282	60	11	22,500
	293	60	11	34,500
	297	60	11	33,900
	300	60	11	35,100
	301	60	11	29,700
	306	60	11	50,100
Chilipepper	311	60	12	29,200
	320	60	12	35,700
	325	60	12	51,800
	340	58	12	32,700
	360	60	12	71,800
	387	59	12	95,000
	395	58	12	97,600
	405	58	12	114,200
	450	60	12	137,900
	455	58	11	198,000
	460	58	12	138,000
	490	59	10	271,600
	506	59	10	344,900
	514	59	10	236,900
	516	58	11	352,600
	525	59	10	538,600
	530	58	11	302,400
	530	58	11	336,200
	530	58	11	340,000
	533	59	10	318,700
	544	58	11	337,300
	550	59	10	450,300
	573	58	11	336,600
Stripetail rockfish	176	59	10	39,100
	180	59	10	13,500
	185	59	3	17,900
	201	59	10	101,500
	294	58	11	175,700
	295	60	11	153,800
	300	58	12	79,300
	300	59	10	178,600
	302	58	12	65,300
	308	60	11	191,600
	311	59	10	185,600
	324	59	10	166,200
	326	59	10	230,000

APPENDIX C Calculated Number of Developing Eggs in the Paired Ovaries of 10 Species of Rockfish

APPENDIX C—Continued

Calculated Number of Developing Eggs in the Paired Ovaries of 10 Species of Rockfish

Species	Total length of fish (mm)	Date		Number of eggs	Species	Total length of fish (mm)	Date		Number of eggs
		Yr.	Mo.				Yr.	Mo.	
Canary rockfish	478	58	11	260,600	**Vermilion rockfish**	315	59	11	63,300
	490	59	10	946,700		358	59	11	129,300
	498	58	12	827,400		388	59	11	158,800
	515	59	10	815,300		440	59	11	383,600
	528	59	10	655,500		466	60	11	527,300
	535	58	12	1,353,100		476	59	12	226,500
	535	58	12	1,897,600		500	58	12	1,070,700
	548	58	12	1,366,900		512	59	11	501,700
	575	59	10	1,515,000		520	59	11	1,189,500
	665	60	10	1,599,000		528	59	12	1,048,800
						530	59	11	1,388,400
						550	59	11	1,625,600

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APPENDIX C Calculated Number of Developing Eggs in the Paired Ovaries of 10 Species of Rockfish