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Title: Neritic Reef Fishes off Central Oregon: Aspects of Life Histories and the Recreational Fishery

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Howard F. Horton

Recreational angling pressure has recently increased in the neritic reef areas off the central Oregon coast. This study describes weight-length and age-length relationships as well as ages at sexual maturity of the black, blue, canary, yelloweye, and yellowtail rockfish (*Sebastes melanops*, *S. mystinus*, *S. pinniger*, *S. ruberrimus*, and *S. flavidus*, respectively) and the lingcod (*Ophiodon elongatus*). These biological characteristics were examined in relation to the recreational fishery and compared to characteristics reported for the same species from other geographic locations.

Most of the rockfish exhibited characteristics similar to those from other geographic locations. Lingcod characteristics were also similar to those observed from other locations.

Yellowtail rockfish were found to be unique in that males and females appeared to exhibit very similar weight-length relationships and were adequately described by the same weight-length equation. Other rockfish species were best described using separate weight-length equations for each sex.

Lingcod exhibited marked differences between male and female weight-length and length-at-age relationships.

The mean length of black rockfish, yelloweye rockfish, and lingcod sampled has decreased slightly since 1976. This decrease is attributed, in part, to changes in the attitude of anglers towards these species rather than overharvesting. Localized overfishing of yelloweye rockfish may be occurring on some of the smaller, deeper water reefs. However, due to the weather conditions necessary to allow fishing on these reefs, this is not expected to adversely affect the general population of the area under present conditions.

Neritic populations of each species seem to be healthy and not endangered at the present level of exploitation. This conclusion is based on length frequency observations and behavioral characteristics as well as on observations of the recreational fishery.

Present management of this fishery appears to be adequate to protect the neritic reef fishes yet allow an unlimited angling season and generous bag limits.

NERITIC REEF FISHES OFF CENTRAL OREGON: ASPECTS OF LIFE HISTORIES AND THE RECREATIONAL FISHERY

by

Robert Edward McClure

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NERITIC REEF FISHES OFF CENTRAL OREGON: ASPECTS OF LIFE HISTORIES AND THE RECREATIONAL FISHERY

INTRODUCTION

In this thesis I report the results of a study of the age and growth of the black rockfish (*Sebastes melanops*), blue rockfish (*S. mystinus*), canary rockfish (*S. pinniger*), yelloweye rockfish (*S. ruberrimus*), yellowtail rockfish (*S. flavidus*), and the lingcod (*Ophiodon elongatus*). These are some of the most common species of the recreational catch off the central Oregon coast (Coombs 1979).

The specific objectives of my study were:

1. To describe the weight-length relationship for each species.
2. To describe the age-length relationship for each species.
3. To determine the age of sexual maturity for each species of rockfish.
4. To relate the biological data of this study to the recreational fishery.

In Oregon, the recreational fishery for rockfishes is generally conducted close to shore in areas of high bottom relief and < 60 m depth. Typical rod-and-reel, hook-and-line gear is used in this "bottom fishery". Almost all of the angling for rockfish off the central Oregon coast is done from private or charter vessels, with very little angling occurring from the surf or rocky headlands.

Miller and Geibel (1973) reported that nearly 75% of the rockfish landed in the Monterey Bay area were caught by anglers aboard charter boats. Charter boats being vessels on which an angler buys a ticket and fishes with similar anglers, rather than owning and operating a private vessel. Miller and Giebel (ibid) also noted that the species composition of the catch changed at a depth of 73 m (240 ft) from that to be found inshore. The Oregon fishery also occurs to a high degree on charter vessels and the species composition of the neritic reefs is different from that of deeper water of low bottom profile (Gunderson and Sample 1980; Pacific Fishery Management Council 1980).

Coombs (1979) described the recreational fishery, catch composition and movements of the black, blue, yelloweye and canary rockfishes off the central Oregon coast. Steiner (1979) investigated the ecology, feeding habits and species composition of the same species from the same geographical area. Barker (1979) discussed the fishery and population biology of several species of rockfish, including the black and yellowtail rockfishes, from Puget Sound, Washington.

Fraidenberg (1980) described the length-weight, age-length, and other characteristics of trawl caught yellowtail rockfish from the water off Washington, Oregon, and California, but his specimens were from waters deeper and farther offshore than those normally fished by recreational anglers off Oregon. Boehlert (1980) presented similar information for the canary rockfish taken from the same areas using the same types of gear.

Phillips (1964) described the life histories of ten species of commercially important rockfishes from California waters. Of these, only the blue and canary rockfishes are in common with the Oregon recreational catch and of interest to my study.

Lingcod is one of the most abundant and highly prized species taken in the recreational fishery off Oregon (Coombs 1979; Steiner 1979; personal communication, Jerry Butler, Oregon Department of Fish and Wildlife [ODFW], Newport, Oregon). In addition to its abundance and popularity in the recreational fishery, the lingcod is also an important commercial species. Because of its commercial importance, the lingcod has received considerably more attention by researchers than those rockfish species important to only the recreational fishery.

Chatwin (1956) reported age estimates and growth parameters of lingcod from the British Columbia commerical catch. Hart (1967) described the length-weight relationship of lingcod from the commercial catch of the same area. His description of the relationship agreed with that presented by Chatwin (1956).

Phillips (1959) and Miller and Geibel (1973) presented excellent summaries of the life history of the lingcod. These summaries are discussed in the lingcod section of this thesis.

Information gained from the study of commercially available and exploited stocks of rockfishes may not be applicable to neritic reef stocks. The commercial fishery for rockfishes is generally conducted in areas of greater depth and further from shore than the recreational fishery. In addition, the commercial fishery is conducted over areas of relatively low bottom relief whereas the recreational fishery is conducted almost exclusively over high profile reefs which may rise 10-20 m above the surrounding areas. Boehlert (1980) reported an increase in size composition of split-nose rockfish (*S. diploproa*) with increasing lattitude for Pacific coast waters.

The species composition reported for the recreational catch of the neritic reefs (Coombs 1979) is much different than that for trawl catches from deeper waters off Oregon (Gunderson and Sample 1980).

When describing the growth and maturity of a species, age estimates of individuals become an important consideration. Age estimates for rockfishes are commonly based on scale, otolith, and/or vertebral analyses. Wales (1952) used scales for age determination of blue rockfish because he felt that they were the easiest structure to interpret. Miller et al. (1967) also used scales for age estimates of blue rockfish due to the relative ease of back calculation of length-at-age. Six and Horton (1977) examined several structures and determined that for black, yellowtail, and canary rockfish, otolith age estimates proved more consistent than those of other structures.

Other workers have used otoliths for age estimates of canary rockfish (Boehlert 1980, Boehlert and Kappenmann 1980), black rockfish (Barker 1979), and yellowtail rockfish (Kimura et al. 1979, Barker 1979, Fraidenberg 1980). Age-length relationships of 26 species of rockfish from north Pacific waters were presented by Westrheim and Harling (1975) and though some species and age groups are poorly represented, the information is of interest for comparison with species common to this study.

Recently Beamish (1979a,b) suggested that it may be necessary to section otoliths and examine the internal composition in order to more accurately age older individuals. He reasoned that as individual growth slows with age, the annular rings of the otolith become closely spaced at the margin and the central rings often become clouded and difficult, if not impossible, to interpret when viewed from the outside. Sectioning apparently enables these ambiguous areas to be more accurately interpreted.

Until recently estimation of lingcod ages was difficult and unreliable because scales and otoliths, even from large individuals, are small and often difficult to interpret (Chatwin 1954; 1956). Though examination of vertebrae was found to provide reliable estimates of age, the practicality of ageing a large number of individuals is poor because of the time necessary for vertebra preparation (Chatwin 1956). Beamish and Chilton (1977) presented a method of ageing lingcod based on the annual formation of growth rings in dorsal fin rays. Comparison with scale age estimates showed that fin ray estimates were more consistent when read a second time and were also easier to interpret on the initial reading.

An important consideration to fishery management is the age at which individuals of a particular species reach sexual maturity. This information is necessary for development of estimates of the reproductive capacity of the population in question. Many different criteria have been established for determination of various stages of maturity of rockfish. Westrheim (1975), Gunderson (1977), aand Gunderson et al. (1980) all presented indices for determination of various sexual stages of juvenile and mature individuals of each sex. Barker (1979) simply determined if the gonads of an individual were well developed and classified it as mature or immature based on that observation.

STUDY AREA

The area fished by recreational fishermen and research personnel in this study is bounded on the north by Cascade Head, on the south by Otter Rock, and extends out to the 30 fathom (55 m) depth contour (Fig. 1). The rocky reefs of this area are where recreational anglers from Depoe Bay concentrate their bottom fishing effort. These rocky reefs are generally of high bottom relief (Steiner 1979) and may rise abruptly, as much as 20 m above the surrounding area. These reefs may cover a large area or may be as small as a few square meters.

METHODS AND MATERIALS

Recreational and Research Catch

The species composition and angler effort of the recreational fishery was monitored for five to seven days each week from June through September during 1978, 1979, and 1980. This coincides with the period of highest bottom fishing activity. Length, weight, and sex were recorded from a portion of these catches and samples of otoliths, and lingcod dorsal fin rays were collected for age estimation purposes.

Most recreational anglers use similar gear which consists of a rod and reel combination and 14-23 kg (30-50 lb) test monofilament fishing line. A molded lead jig of 113-454 g (4-16 oz) weight, with a size 5/0 barbed hook attached is the primary catching device used. This jig may vary in shape, and is often painted different colors or

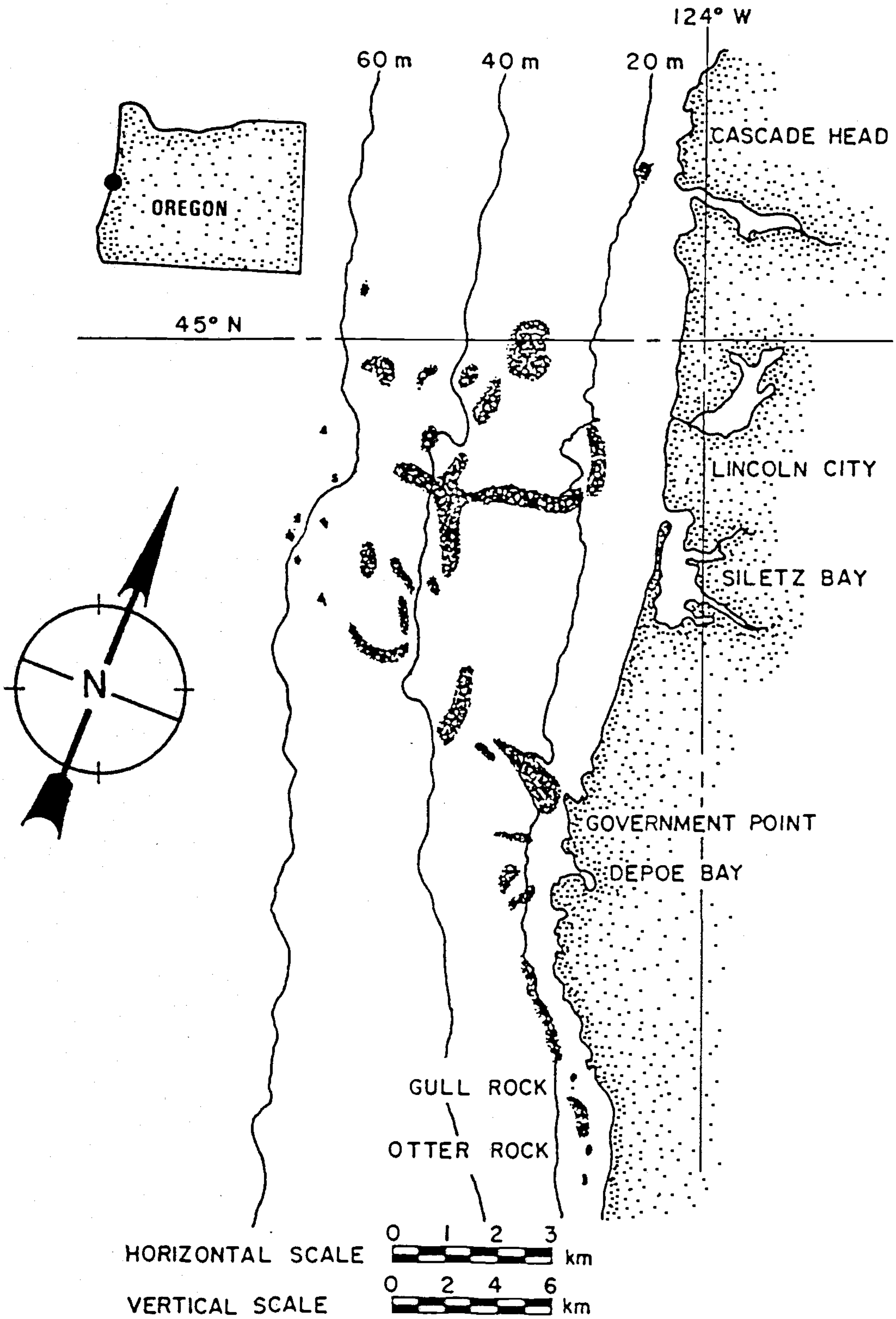

FIGURE 1. Map of the study area. Research and recreational anglers fished the neritic reefs (stippled areas offshore) between Cascade Head and Otter Rock and offshore to the 60 meter contour line. Horizontal scale expanded for clarity.

adorned with various yarn or plastic lures. In recent years some anglers have used additional lures of varying types attached above the lead jig. The jig is then moved up and down to attract the attention of nearby fish. Hooked fish brought to the surface often suffer embolisms or rupture of internal organs due to expansion of the gas bladder caused by rapid decompression. Lingcod have no gas bladder and apparently suffer no ill effects from this rapid decompression.

The recreational catch was sampled at the dock when anglers returned from fishing. The total catch of each boat was recorded and length, weight, and sex data were recorded from a portion of the catch. Otoliths and fin rays were collected with permission of the individual anglers.

The research catch was obtained using gear similar to that used by recreational anglers. Research anglers usually used the terminal jig and at least one additional lure attached to the line above it. Fishing by researchers was conducted aboard the R/V Tooshqua, an 8-meter (26-foot) Newport Dory owned by Oregon State University.

The fishes taken by research workers were measured for fork length and usually taged with a "Floy" T-bar type tag and released as part of an associated tagging study. Those individuals to be sacrificed were weighed and fin ray or otoliths samples were collected.

Biological Data Collection

Individual weight was recorded to the nearest 0.25 kg and fork-length was recorded to the nearest 0.5 cm. Random individuals were selected for gonadal examination to determine size and stage of maturity.

Immature individuals of both sexes were characterized by small gonads which were string-like and clear, pink or light brown in color. Mature males had testes which were enlarged and white or brown in color. The ovaries of mature females were enlarged, granular in appearance, and yellow, orange, or red in color. In the rockfishs, mature ovaries often contained black pigment spots, presumably eye pigment from larvae retained from a previous spawning (MacGregor 1970).

Many rockfish and most lingcod were sexed by external characteristics. These characteristics are illustrated in Figure 2. Occasionally an individual which was externally sexed would be examined internally to verify accuracy of sexing. The technique is accurate for all species examined in this study except the yelloweye rockfish. Large females of this species often possess large genital papilla and are easily mis-identified as males. External characteristics of male and female lingcod made external sexing easy and presumably 100% accurate.

Otoliths were obtained from rockfishes by making a vertical cut through the head, just posterior to the eye sockets, to the level of the upper jaw (Fig. 3). The anterior portion of the head was then rotated forward and down, exposing the cranial cavity and the saggitae. The otoliths were extracted and placed in sample envelopes labeled with length, weight, and other pertinent data. In the laboratory each otolith pair was cleaned of extraneous material, transferred

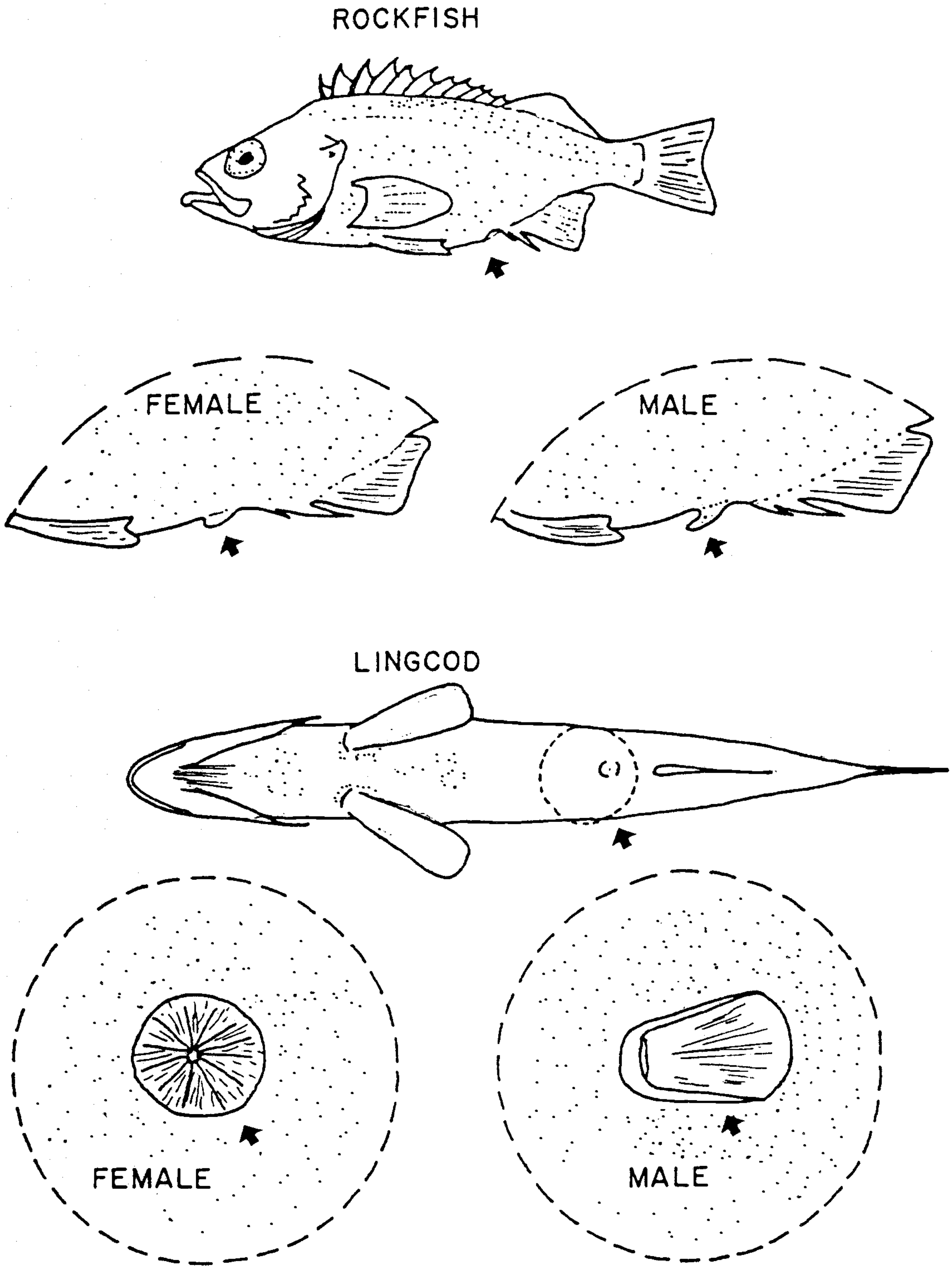

FIGURE 2. External sexing characteristics. The gential papilla of male Sebastes sp. (except S. ruberrimus) is obviously more projected and fingerlike than that of females of the same species. Male lingcod possess a protrusable papilla, triangular in shape. Female lingcod are characterized by a non-protruding sphincter only.

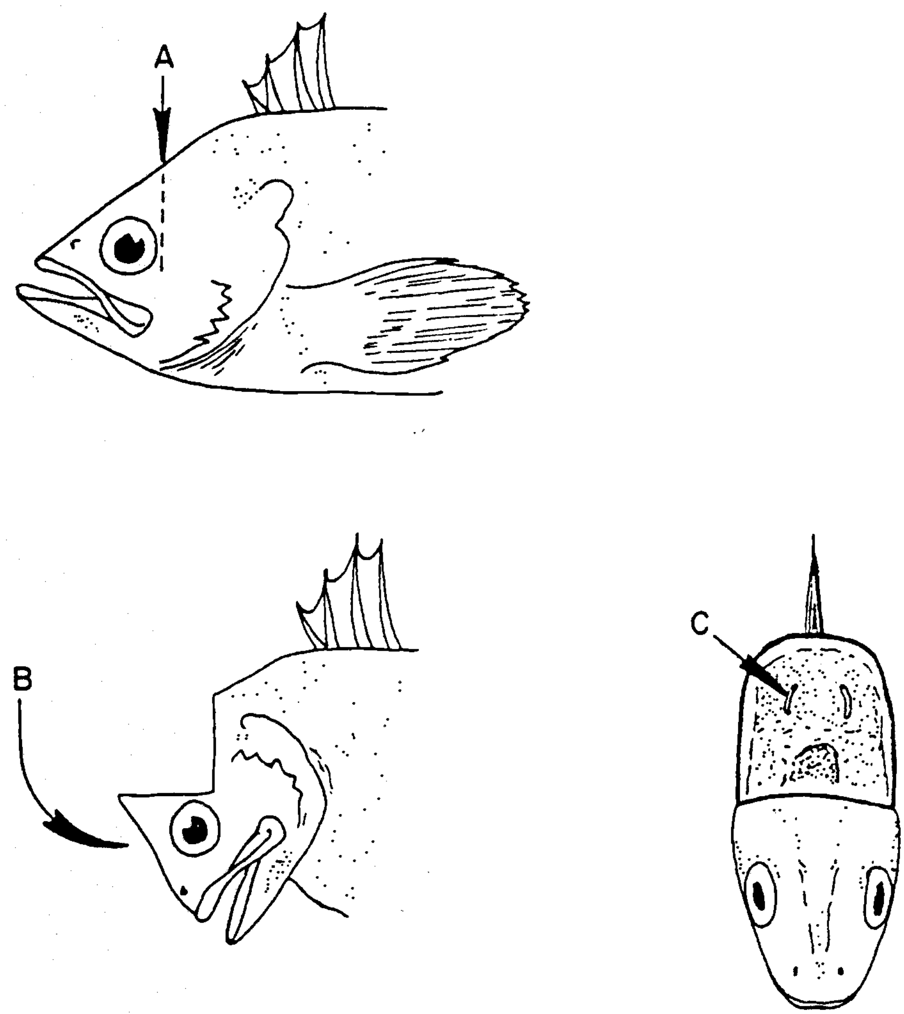

FIGURE 3. Method of removing saggital otoliths from Sebastes sp. A vertical cut is made just behind the eye sockets and to the level of the upper jaw (A). The excised portion of the head is rotated forward and down (B) exposing the cranial cavity and saggitae (C). Otoliths are then removed with forceps.

to a small vial and stored in a 50:50 solution of glycerine and water. Storage in this solution "clears" the otolith, i.e., contrast increases between the opaque and hyaline zones (described below) (Kimura et al. 1979).

Lingcod fin rays were collected as suggested by Beamish and Chilton (1977). One ray (of the fourth through the eighth rays of the second dorsal fin) was cut from the fin as close to the base as possible. The fin ray was then cleaned of extraneous tissue, and placed in an appropriately labeled sample envelope. In the laboratory each fin ray was allowed to air-dry and then embedded in a block of polyester resin. Once the resin had cured (hardened), the fin ray was sectioned using a Gillings-Hamco Thin Sectioning Machine equipped with a water cooled/lubricated, diamond impregnated lapidary saw blade. Section thickness ranged from 0.3 to 0.5 mm. Fin ray sections were laminated to a plastic card (Appendix A) to facilitate examination in a microfiche reader.

Age Estimation Using Otoliths

Whole otoliths which had been stored in glycerine solution were examined at six to ten magnifications using a stereo dissecting microscope. The otoliths were placed in a black watch glass, immersed in alcohol, and illuminated by reflected light. Alcohol was chosen as the immersion media in preference to glycerine or glycerine/water (Six 1976) to avoid the visual distortion created by incomplete mixing and the viscosity of glycerine. Thymol was added to the glycerine solution to inhibit fungal growth (Beamish 1979a).

Age estimates were made by enumerating the hyaline, slow growth zones as described by Westrheim (1973), Pannella (1974), and Six and Horton (1977). The general structure of an idealized otolith is presented in Figure 4.

The central, opaque portion of the otolith was assumed to represent the initial growth which occurred prior to the first winter slow growth period of the individual fish. The formation of the surrounding hyaline ring was considered to represent this slow, winter-growth period. The combination of one opaque and one surrounding hyaline zone was thus considered to represent one year of growth in the life of the fish being examined. This corresponds to the methods of Westrheim (1973), Six and Horton (1977), and Kimura et al. (1979).

Otolith samples were subjected to a second reading where the entire sample, or a subsample, was read and assigned a second age without reference to the first reading. Comparison of the two estimates allowed determination of the consistency of estimated ages from otolith to otolith based on agreement between the first and second readings of the same otolith.

Age Estimation Using Fin Ray Sections

The laminated fin ray sections (Appendix A) were viewed at magnifications of 24 and 42x on a 3M Corporation Model 800 Microfiche Reader-Printer. As described by Beamish and Chilton (1977), the alternate translucent and clear zone pairs were assumed to represent

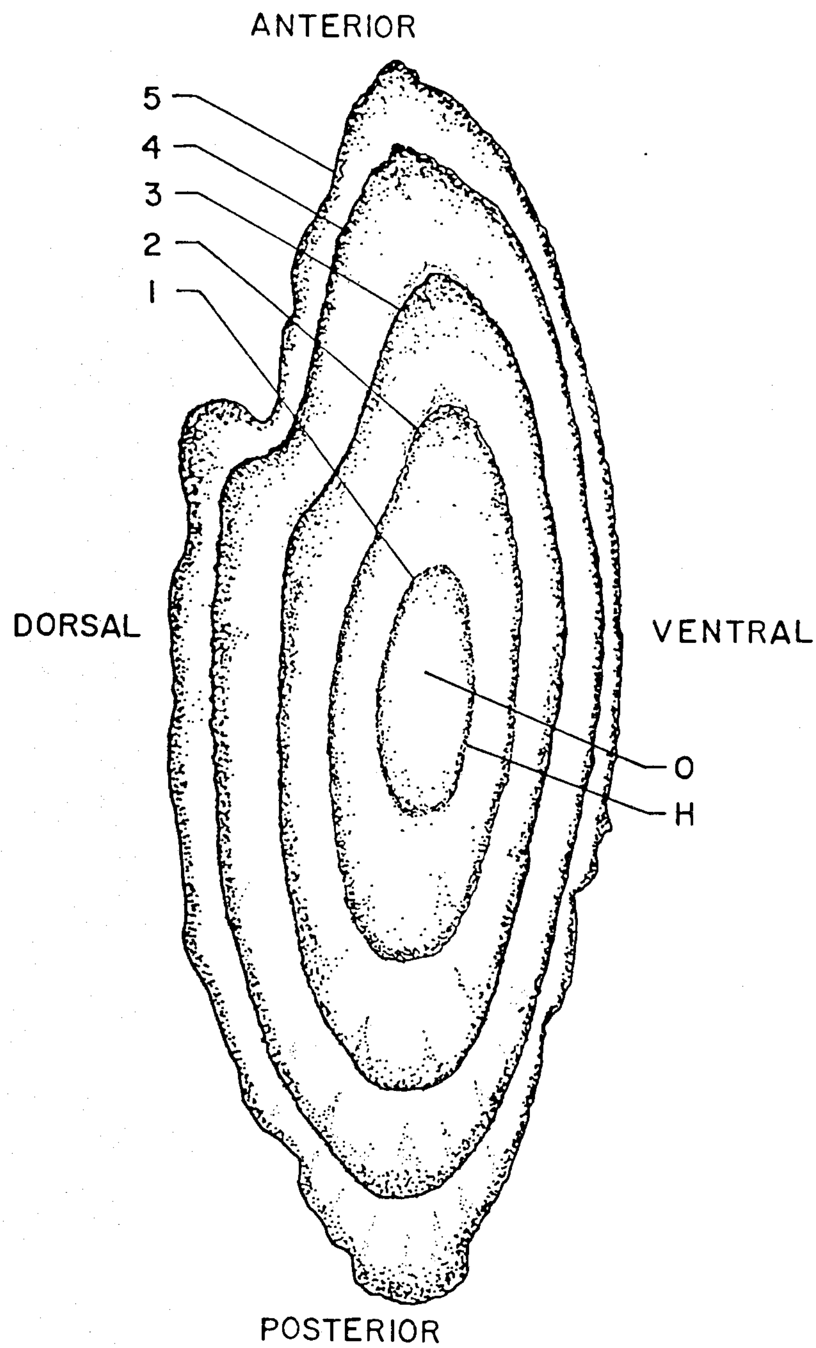

FIGURE 4. Generalized otolith structure, as viewed by reflected light against a dark background. Opaque (O) and hyaline (H) zone pairs are assumed to represent one annual growth period (see text). This example would be assigned an estimated age of 5 years (as indicated by enumeration of hyaline zones).

one year of growth of the individual. Figure 5 illustrates the structure of a lingcod fin ray section and the characteristics of the translucent and clear zones used for age determination.

Weight-Length Relationship

Measured weights and lengths were used to determine the characteristics of the exponential model used to describe the generalized weight-length relationship for each species and sex. The exponential model of the form $w = a\ell^b$ was used (Ricker 1975), where:

w = the weight of the individual

ℓ = the length of the individual

a and b = constants determined for each species and/or sex.

Age-Length Relationship

The age-length relationships for each species and sex (except canary and yellowtail rockfish) were described by the von Bertalanffy equation using the computer program BGC2 (Abramson 1971). This program weights each age group based on sample size and provides the von Bertalanffy estimates of length at age as well as the constants for the equation.

The age-length relationships for canary and yellowtail rockfish could not be described using this program due to high variation in observed length-at-age and/or small and incomplete age samples. Instead, these species were described by the exponential equation $L = cA^b$ where:

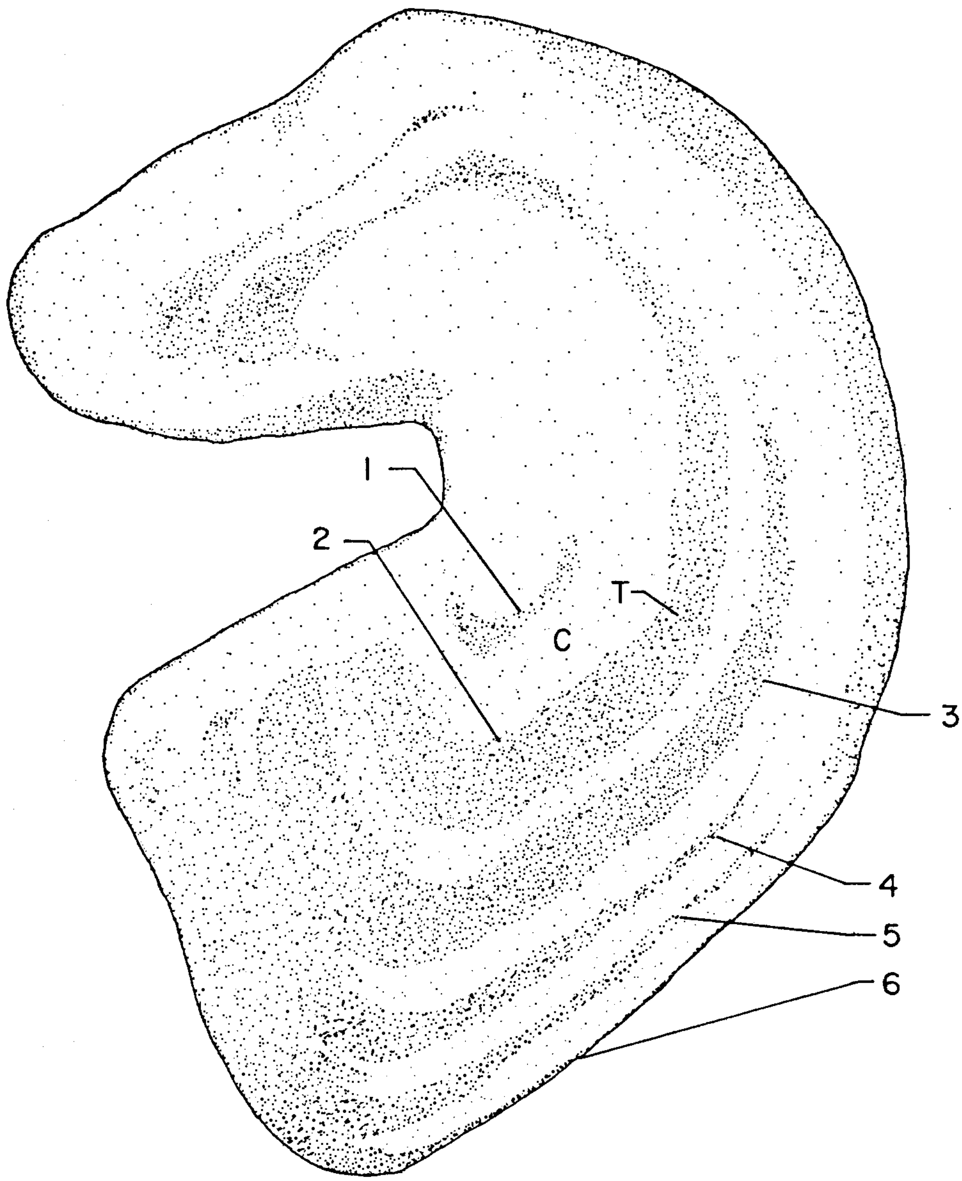

FIGURE 5. Generalized lingcod fin ray section, as viewed by transmitted light. Age is estimated by enumeration of translucent (T) and, clear (C) zones, representing one year of growth (Beamish and Chilton 1977). This example would be assigned an age of 6 years.

L = fork length

A = age of the individual

c and b = constants determined for each species or sex and calculated from the measured length and weight data.

The calculated lengths at age and their resultant curves were not extended beyond lengths or ages actually observed as the calculated relationship may not apply beyond the observed ranges.

Survival and Mortality

Survival estimates were made by the Robson-Chapman method (Ricker 1975) and were determined for individuals of the age of full recruitment and older. Total mortality was estimated based on catch curve analysis (Ricker 1975), again using only those individuals of recruitment age or older.

RESULTS AND DISCUSSION

Black Rockfish

Results:

A total of 5,958 fork lengths and 995 whole weights were recorded from black rockfish caught by recreational and research anglers. Weight-length relationships for each sex, as well as both sexes combined, are presented in Table 1. The individual sex and combined sex models were tested to determine if there was a signficant difference between them. The method used to test for differences between the individual male and female models and the combined sexes model utilized

TABLE 1. Weight-length relationships for black, blue, canary, yelloweye, and yellowtail rockfish, and lingcod. Calculated by geometric mean regression of the log transformed length and weight of individuals. Males, females and combined sexes (all individuals including those of undetermined sex) are presented. The model, $w=c\ell^b$ was used (Ricker 1975) where: w = weight; ℓ = length; and c and b are constants determined from the weight-length regression for each species and/or sex.

Species	Sex group	Calculated weight-length model	Number of individuals
Black rockfish	Combined	$w=0.0000184\ell^{3.000}$	N = 995
	Male	$w=0.0000250\ell^{2.922}$	N = 553
	Female	$w=0.0000117\ell^{3.126}$	N = 442
Blue rockfish	Combined	$w=0.0000494\ell^{2.752}$	N = 164
	Male	$w=0.0000533\ell^{2.709}$	N = 55
	Female	$w=0.0000943\ell^{2.586}$	N = 109
Canary rockfish	Combined	$w=0.0000127\ell^{3.120}$	N = 334
	Male	$w=0.0000564\ell^{2.707}$	N = 138
	Female	$w=0.0000222\ell^{2.958}$	N = 196
Yelloweye rockfish	Combined	$w=0.0000127\ell^{3.120}$	N = 325
	Male	$w=0.0000211\ell^{2.994}$	N = 162
	Female	$w=0.0000086\ell^{3.223}$	N = 163
Yellowtail rockfish	Combined	$w=0.0000520\ell^{2.646}$	N = 110
	Male	$w=0.0000232\ell^{2.911}$	N = 17
	Female	$w=0.0000161\ell^{3.000}$	N = 40
Lingcod	Male	$w=0.0000185\ell^{3.404}$	N = 357
	Female	$w=0.0000237\ell^{3.301}$	N = 121

the differences between the squared errors of each model as described by Netter and Wasserman (1974).

The results of this test (Table 2) suggest that male and female weight-length relationships are not adequately described by the combined sex model. The calculated weight-length curves for each sex are presented in Figure 6. Examination of these curves indicates that females < 35 cm in length weigh less than males of equal length. At lengths > 43 cm, females are heavier than males and this difference increases with increasing length throughout the remainder of observed lengths.

Comparison of the combined sex model from this study with that presented by Barker (1979) for black rockfish from Puget Sound indicates similar weight-length relationships for fish from both areas, though the Puget Sound fish appear to be slightly heavier than fish from this study at any given length (Table 3).

Otolith age estimates were made for 351 individuals. Each otolith sample was read a second time to determine the consistency of assigned age estimates. Assigned ages agreed in 40% of the cases and were within one year ($^{+}$1 year) in 94% of the cases. Only those indiviuduals with estimated ages agreeing within one year were used for further age analysis.

Mean observed length-at-age values and calculated length-at-age values are presented in Table 4. The calculated length-at-age curve and the mean lengths at estimated ages are presented in Figure 7. Individuals of age 4 have a calculated length of < 30 cm with males

TABLE 2. Results of hypothesis test for differences in calculated weight-length relationships of male and female rockfish and lingcod. The error values of the combined sex regression and the error values of the individual sex regressions were compared to determine if there was a significant difference ($p \leq 0.05$) between the combined and individual weight-length relationships described.

Hypothesis	Species	F Table value	Calculated F value	Decision
C_1: Assume that there is no significant difference between male and female weight-length relationships. The weight-length relationship of both sexes is adequately described by a single equation	Black rockfish (*Sebastes melanops*)	F(.95;2,941)=3.00	F = 644.50	Reject C_1
	Blue rockfish (*S. mystinus*)	F(.95;2,172)=3.00	F = 19.50	Reject C_1
	Canary rockfish (*S. pinniger*)	F(.95;2,359)=3.00	F = 180.47	Reject C_1
C_2: Assume that there is a significant difference betwen the male and female weight/length relationships. A single equation does not adequately describe the relationship for each sex.	Yelloweye rockfish (*S. ruberriums*)	F(.95;2,319)=3.00	F = 131.60	Reject C_1
	Yellowtail rockfish (*S. flavidus*)	F(.95;2,116)=3.00	F = 2.98	Accept C_1
	Lingcod (*Ophiodon elongatus*)	F(.95;2,495)=3.00	F = 92.9	Reject C_1

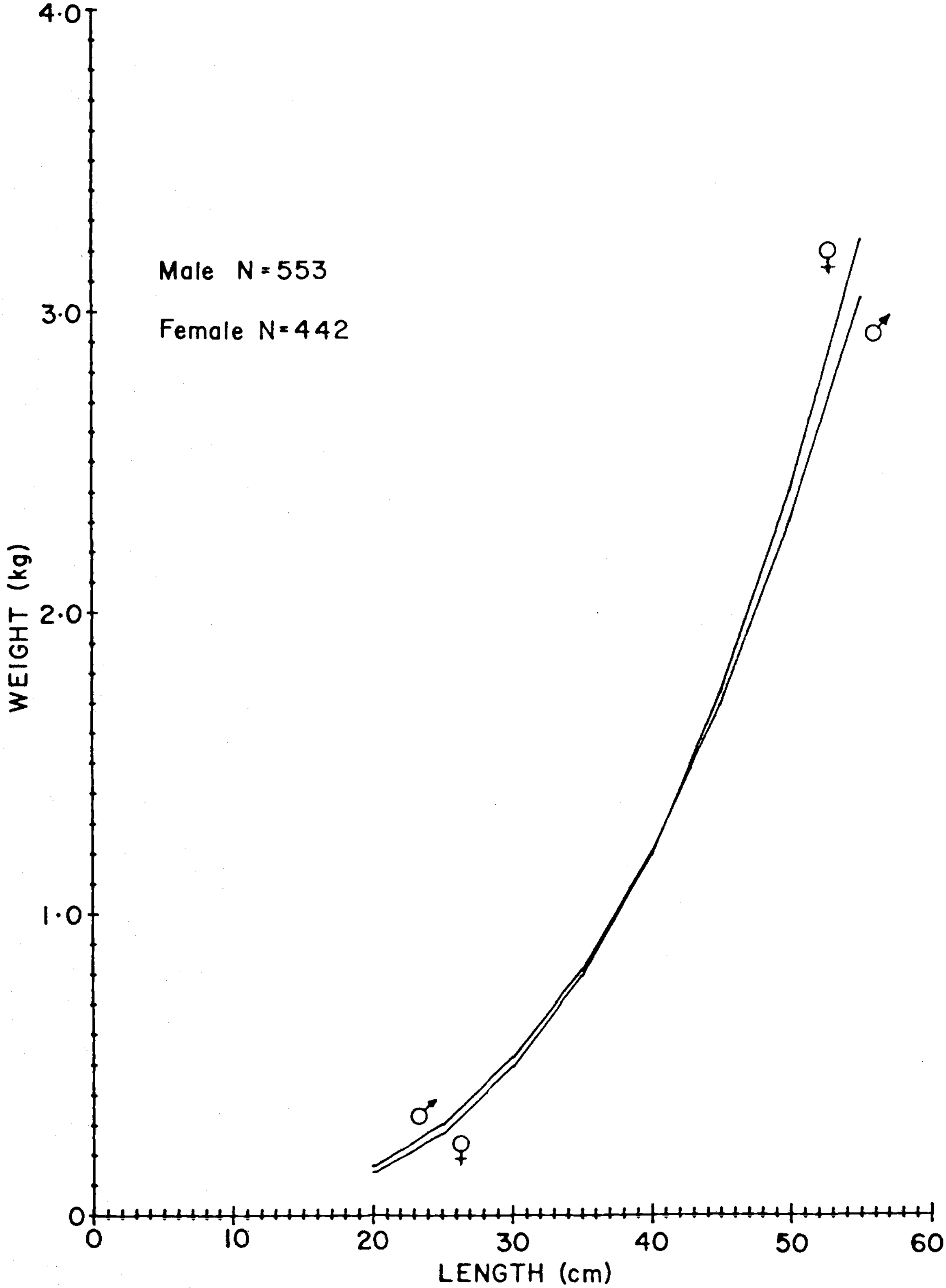

FIGURE 6. Calculated weight-length relationships of male and female black rockfish (Sebastes melanops) taken by hook-and-line off Depoe Bay, Oregon, during 1976-80.

TABLE 3. Comparison of biological statistics of black rockfish (*Sebastes melanops*) from neritic reefs off Depoe Bay, Oregon, with those from other studies and areas.

Statistic	Area (author)		
	Depoe Bay (this study)	Central Oregon (Six 1976)	Puget Sound (Barker 1979)
Model describing the weight-length relationship of combined sexes.	$\omega = 0.0000184\ \ell^{3.00}$ $(\log \omega = -4.73424 + 2.99978 (\log \ell)$	Not determined	$\log\omega = -4.8618 + 3.02679 (\log\ell)$ [a]
Sex ratio of catch	Male: 61.4% (N = 243) Female: 38.6% (N = 153)	Not determined	Male: N = 57 [67.9%] Female: N = 27 [32.1%]
Calculated length (cm) at selected ages (years).	Age / Male / Female 4 / 29.8 / 28.8 8 / 42.0 / 42.9 12 / 46.7 / 48.5	Age / Male / Female 4 / 32.5 / 32.3 8 / 43.7 / 44.3 12 / 48.2 / 51.8	Age / Male / Female 4 / 29.2 / 31.8 8 / 42.1 / 43.6 12 / 49.7 / 52.2
Age at which 100% of fish are mature.	Male: 8 years Female: 9 years	Not determined	Male: 4 years Female: 3 years
Age of full recruitment to the fishery.	Both sexes: 7 years (N = 351) Male: 7 years Female: 7 years	Both sexes: 9-11 years [a,b]	Both sexes: 5 years (N = 43) Males: 5 years [a] Female: 7 years
Estimated survival (S) and/or total mortality (Z)	S: 0.758 Z: 0.276 ages 7-14	S: 0.58 - 0.67 Z: -- ages 12-17	S: 0.7203 Z: 0.3281 ages 5-14

[a] Information converted from authors data.

[b] Recruitment to commercial gear.

[c] Average of two estimates presented.

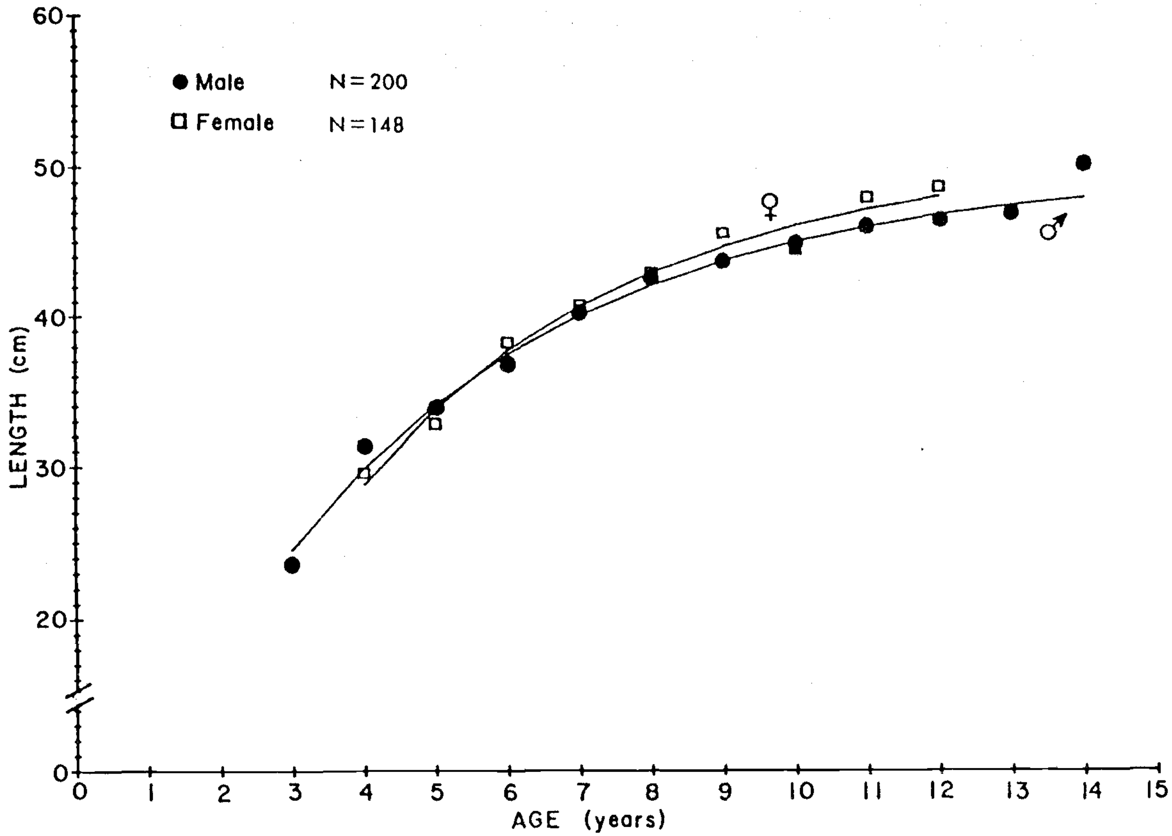

FIGURE 7. Calculated length-at-age curves and mean observed length-at-age of black rockfish (*Sebastes melanops*) taken by hook-and-line off Depoe Bay, Oregon 1978-80.

TABLE 4. Mean observed length-at-age and fitted von Bertalanffy estimates of length-at-age determined for black rockfish (Sebastes melanops) aged by otolith examination and captured by hook-and-line from neritic reefs off Depoe Bay, Oregon; 1978-80. Asterisk (*) denotes ages not used in calculation of von Bertalanffy parameters due to small sample size.

Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
1	0	--	--	--	1	0	--	--	--
2	0	--	--	--	2	0	--	--	--
3	3	23.5	24.5	1.6	3	0	--	--	--
4	6	31.3	29.8	1.8	4	8	29.5	28.8	1.3
5	13	33.8	34.0	1.1	5	18	32.8	33.8	0.9
6	24	36.7	37.6	0.6	6	22	38.2	37.6	1.0
7	29	40.2	39.9	0.7	7	25	40.6	40.6	0.6
8	21	42.7	42.0	0.8	8	19	42.8	42.9	1.2
9	30	43.5	43.6	0.6	9	23	45.5	44.7	0.9
10	32	44.8	44.9	0.5	10	17	44.3	46.3	1.7
11	23	45.9	45.9	0.7	11	11	47.9	47.1	0.9
12	11	46.3	46.7	1.3	12	5	48.5	47.9	1.0
13	5	46.8	47.3	0.5	13	0	--	--	--
14	3	50.0	47.8	2.5	*14	2	52.5	--	--
15	0	--	--	--	*15	1	56.0	--	--

von Bertalanffy Length-at-age Parameters (and standard error)

Male		Female	
L_∞ = 49.7 cm	(1.5 cm)	L_∞ = 50.6 cm	(2.7 cm)
k = 0.2373	(0.0396)	k = 0.2595	(0.0724)
t_o = 0.1390	(0.5813)	t_o = 0.7690	(0.8312)

being slightly longer than females. However, by age 6 both calculated and mean lengths indicate that females are longer than males and remain so throughout the observed range. These curves again illustrate the increasing difference in length between males and females with increasing age.

The length frequencies of black rockfish captured by hook-and-line off Depoe Bay, and estimated age projected at mean observed length for each age (for combined sexes) are presented in Figure 8. By age 7 black rockfish are fully recruited to the fishery (mean length 40 cm). Barker (1979) reported full recruitment to the Puget Sound fishery (hook-and-line and spearfishing) by age 5 (Table 3). From Figure 8 it is also apparent that few fish younger than age 4 (mean length 30.5 cm) or older than age 11 (mean length 46.6 cm) appeared in the Depoe Bay catch.

Examination of the annual length frequencies for the years 1976 through 1980 (Fig. 9) indicates that the mean length of the catch has decreased from 42.8 cm in 1978 to 40.7 cm in 1980. This reduced length may be indicative of overexploitation of large individuals or may be caused by changes in the fishery (these changes will be discussed later).

Maturity estimates based on examination of gonads, and related to age and length, are presented in Table 5. Over 50% of the males that I examined were mature by age 5 and all had matured by age 8. Over 50% of the females I examined were mature by age 6 and all had enlarged, mature ovaries by age 9. These estimates suggest that

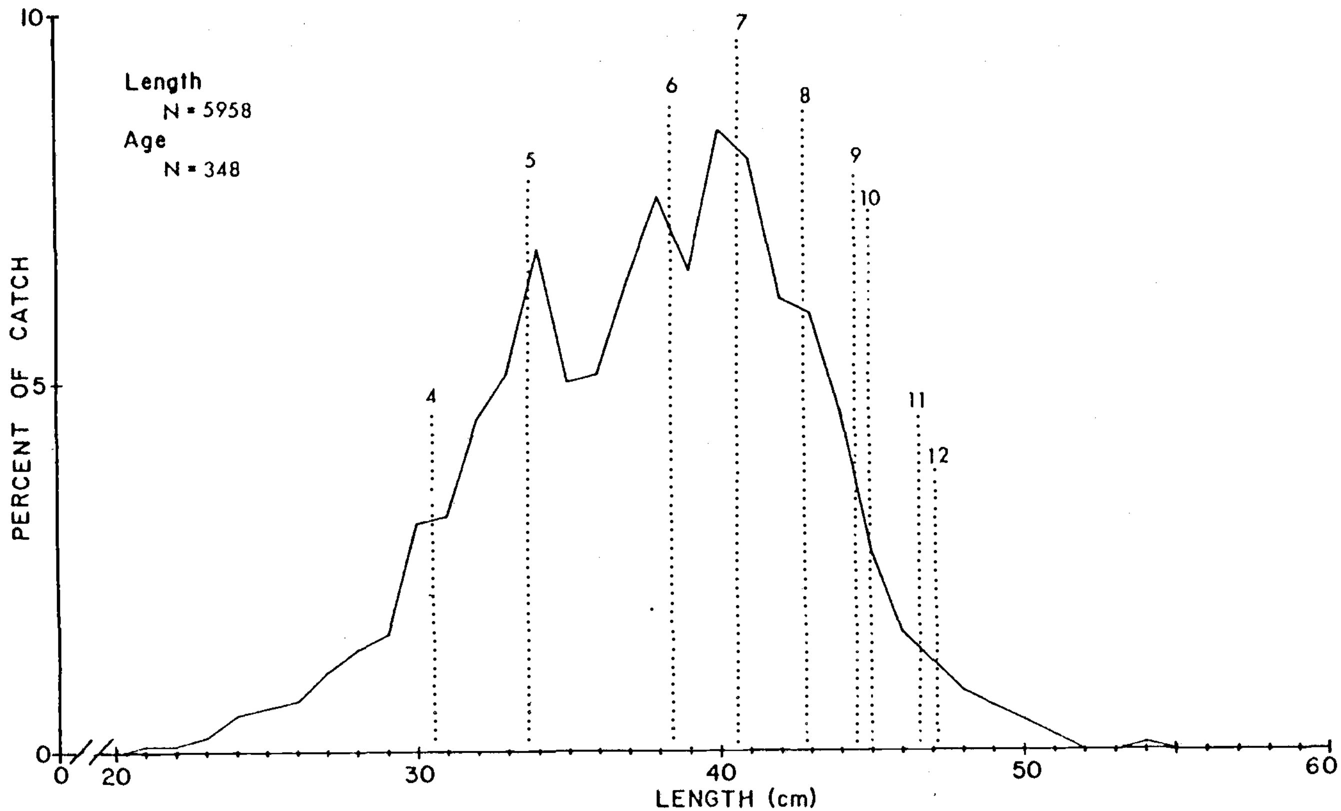

FIGURE 8. Length frequency of all black rockfish (Sebastes melanops) sampled from the hook-and-line catch taken off Depoe Bay, Oregon, during 1976-80. Estimated ages are projected at mean observed length-at-age for the combined sexes.

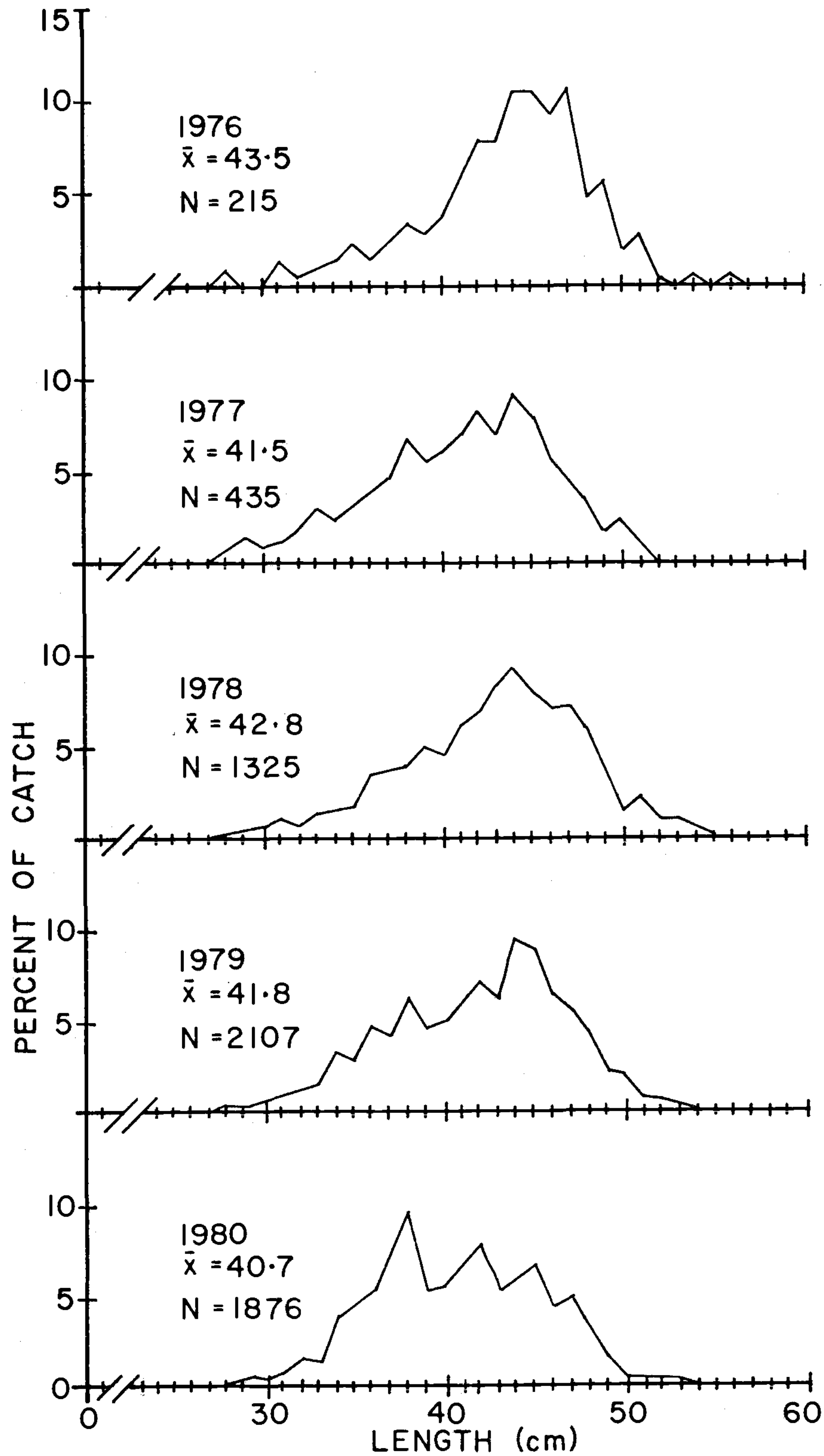

FIGURE 9. Annual length frequencies of black rockfish (Sebastes melanops) taken by hook-and-line off Depoe Bay, Oregon, from 1976-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

TABLE 5. Percentage of sexually mature black rockfish (*Sebastes melanops*) by age, based on gonadal examination. Fish captured by hook-and-line from the neritic reefs off Depoe Bay, Oregon, from 1978-80.

	Male		Female	
Age	Number sampled	% sexually mature	Number sampled	% sexually mature
3	2	0	0	0
4	10	20	7	14
5	14	78	8	40
6	19	63	16	75
7	20	85	20	85
8	18	100	11	82
9+	30	100	38	100
TOTAL	113		100	

black rockfish from this area mature at older ages than those found by Barker (1979) for black rockfish from Puget Sound (Table 3). These differences may be a result of actual biological differences or may be due to the small sample size used by Barker (1979).

Total mortality (Z), estimated from catch curve analysis for fish beyond the age of full recruitment, was 0.276. Survival was determined for the portion of the catch beyond the age of full recruitment, based on the method of Robson and Chapman as described by Ricker (1975). Survival (S) was estimated at 0.758. The estimates of survival and mortality from this study are similar to those of Barker (1979). Six and Horton (1977) estimated lower survival, but for older aged fish than used here (Table 3).

Discussion:

Black rockfish are the most numerous species captured by anglers in the recreational fishery from the area off Depoe Bay. They exhibit similar age, growth, maturity and recruitment characteristics to the same species from Puget Sound (Barker 1979) and are similar in length-at-age to those taken in the trawl fishery off central Oregon (Six and Horton 1977).

Full recruitment of the combined sexes occurs at age 7 (~ 41 cm fork-length). This is well after 50% of both sexes are mature and allows the assumption that beyond initial maturity many of the mature individuals will survive through at least one spawning season. The drastic differences between my age at maturity estimates and those of

Barker (1979) are probably due to his small sample size (often a single individual for each age).

The mean length of the catch has dropped since 1976 (Fig. 9) and I believe that this can be attributed, in part, to a change in fishing habits rather than a reduction in the number of larger individuals in the population. Until recently, black rockfish were poorly accepted by most anglers and all but the largest individuals caught were returned to the sea. As such, the smaller individuals were not recorded and the average size of the catch was thus biased towards larger individuals. While aboard charter vessels in the 1979 and 1980 seasons, I noticed a much greater acceptance of black rockfish as a desirable species and that very few black rockfish were thrown back, even small ones. I feel that it is this greater acceptance, and the retention of a more representative sample of the actual catch which may explain the apparent reduction in the average size of black rockfish. The 1980 mean length is only slighly shorter than the 1977 mean length (Fig. 9) and the 1980 mean length may be a result of natural fluctuation.

The black rockfish is often found in dense schools which also cover extensive areas. As such, the anglers on private or charter vessels find it very easy to catch a large number of individuals from a school in a short period of time. Recently I have observed charter boats return from a 4-hour bottom trip with over 100 fish, over 90% of which were black rockfish. Though such catches may seem high, I believe that the recreational fishery has had very little adverse impact on the black rockfish population of the neritic reef areas. I base this on the availability of this species to the anglers as well as personal observations of conditions which enable research anglers to experience catches in excess of 30 black rockfish per hour during tagging operations.

Blue Rockfish

Results:

A total of 699 fork-lengths and 164 whole weights were recorded from blue rockfish caught by hook-and-line. Weight-length relationships for males, females and all individuals (sexed and unsexed) are presented in Table 1. Individual and combined sex models were tested to determine if a signficant difference existed between the models. Results suggest that individual sex models best describe the blue rockfish weight-length relationship (Table 2). The calculated weight-length curves for both sexes are presented in Figure 10. Examination of these curves reveals that throughout the observed length range females are heavier than males of equal length. This weight difference increases with increasing length throughout the observed range.

The overall sex ratio of the sampled individuals was 40% male and 60% female. However, if only those individual > 37 cm in length are considered (ages 5-6 for females and 7-8 for males), the ratio shifts to 18% males and 82% females. Though the number of individuals > 37 cm in length is small, this observation supports the

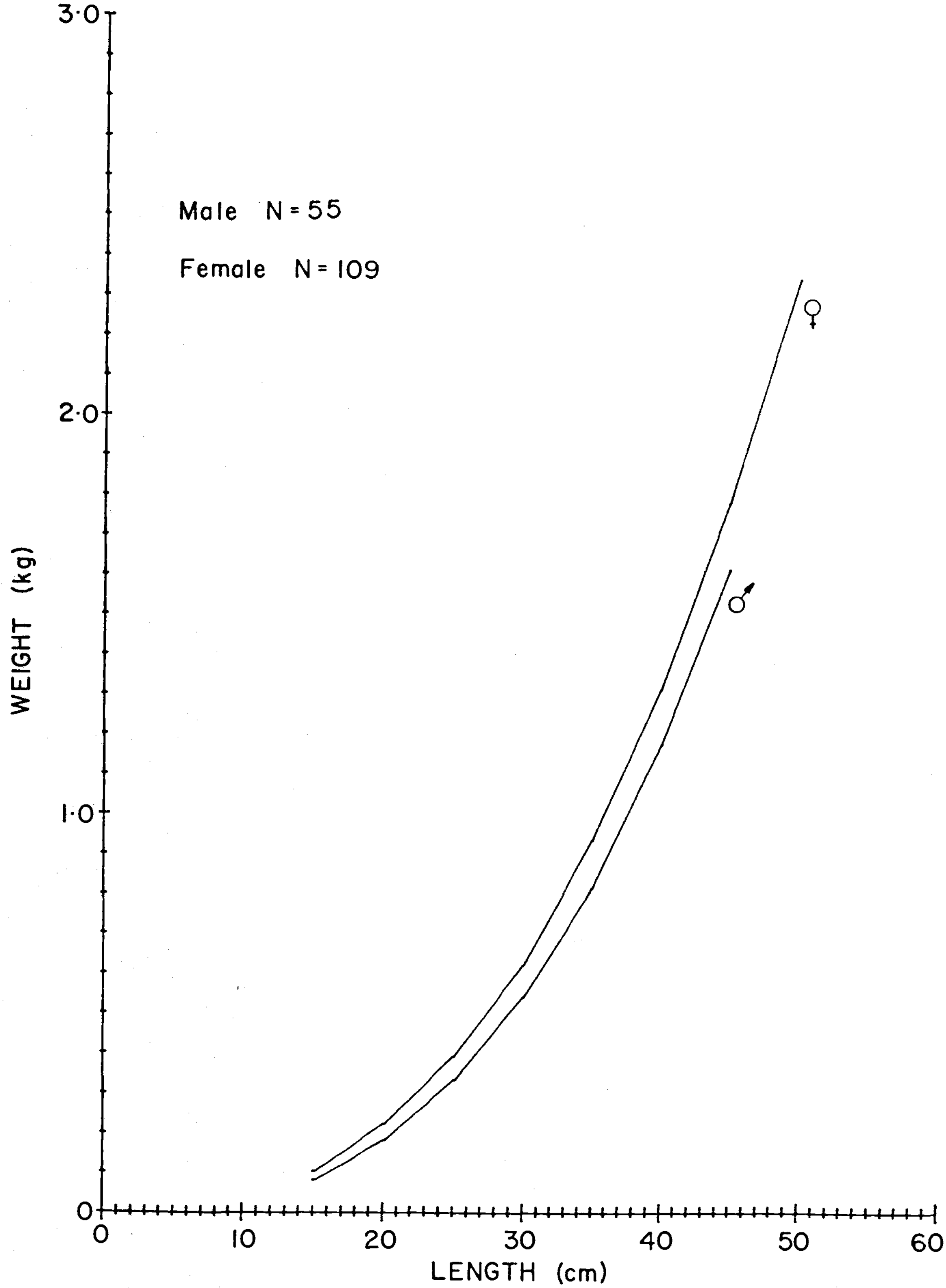

FIGURE 10. Calculated weight-length relationships of male and female blue rockfish (Sebastes mystinus) taken by hook-and-line off Depoe Bay, Oregon, during 1976-80.

belief of this and other studies that females of many of the species in the genus Sebastes attain a larger size, and probably an older age, than males of the same species (Miller and Geibel 1973; Fraidenberg 1980). Miller et al. (1967) reported weight-length relationships for blue rockfish which indicate that fish from the Monterey area were lighter in weight at a given length than those from off Depoe Bay (Table 6).

Age estimates were made based on readings of otoliths from 105 individuals. Eighty percent (N = 88) were read a second time to determine consistency of estimated ages. Second readings agreed exactly with initial readings in 35% of the cases and within one year (±1 year) in 75% of the cases. The calculated length-at-age as well as observed mean length-at-age are presented in Table 7. The graphs depicting these relationships are presented in Figure 11. From these data it is apparent that females of age 3 and older (fork length > 25 cm) are longer and heavier than males of equal age. Also the growth rate of females is greater than that of males, resulting in increased length differences with increased age.

Few blue rockfish younger than age 2 (18-20 cm) appeared in the recreational catch. Overall catch length frequency data indicate that full recruitment to the fishery occurs by age 5 (> 30 cm fork length), (Fig. 12). Age of recruitment estimates are similar to those of Wales (1952) and Miller and Geibel (1973) for blue rockfish from the Monterey Bay region. Miller et al. (1967) suggest that recruitment in

TABLE 6. Comparison of biological statistics of blue rockfish (<u>Sebastes</u> <u>mystinus</u>) sampled from neritic reefs off Depoe Bay, Oregon, with those from other studies and areas.

Statistics	Area (author)		
	Depoe Bay (this study)	Central California (Miller et al. 1967)	Monterey Bay, California (Miller and Geibel 1973)
Equation describing the weight-length relationship.	Both sexes: $\omega=0.0000494\ell^{2.752}$ $\log\omega = -4.30625+2.75172(\log \ell)$ Male: $\omega=0.0000533\ell^{2.709}$ $\log\omega = -4.27921+2.70904(\log\ell)$ Female: $\omega=0.0000943\ell^{2.586}$ $\log\omega = -4.0253+2.58607(\log\ell)$ (cm:length and kg:weight)	Both sexes: $\log\omega = -6.31686+2.53589(\log\ell)$ Male: $\log\omega = -7.47782+2.98849(\log\ell)$ (mm:length and pounds:weight) Female: $\log\omega = -6.99302+2.80779(\log\ell)$	(data from Miller et al. (1967) presented)
Age at maturity	Male: 50%+ 3 years 100% 4 years Female: 50%+ 4 years 100% 8 years	Male: 50%+ 6-7 years 100% 9 years Female: 50% 6 years 100% 9 years	Males: 50% 7 years[a] 100% 9 years Female: 80% 6 years[a] 100% 10 years
Age of full recruitment to the fishery.	Both sexes: 5 years Male: 4 years Female: 6 years	Both sexes: 3-4 years	Both sexes: 5-6 years[a]
Calculated length at selected ages.	Age / Male / Female	Age / Both Sexes	Age / Both-Sexes / (Monterey)
	3 / 23.6 / 25.1	3-4 / 22.6	3 / 17.5 / 18.0
	4 / 27.7 / 30.9	4-5 / 26.1	4 / 21.0 / 22.0
	5 / 31.0 / 35.2	5-6 / 28.2	5 / 24.0 / 25.0
	6 / 33.7 / 38.4	6-7 / 29.8	6 / 26.0 / 28.5
	7 / 35.8 / 40.7		7 / 28.0 / 30.0

[a]Converted from authors data.

TABLE 7. Mean observed length-at-age and fitted von Bertalanffy estimates of length-at-age determined for blue rockfish (Sebastes mystinus) aged by otolith examination and captured by hook-and-line from neritic reefs off Depoe Bay, Oregon; 1978-80. Asterisk (*) denotes ages not used in calculation of von Bertalanffy parameters due to small sample size.

Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
1	0	--	--	--	1	0	--	--	--
2	3	18.2	18.5	0.2	2	4	18.3	17.2	0.8
3	3	23.3	23.6	0.3	3	2	25.3	25.1	0.3
4	8	27.9	27.7	0.9	4	4	27.7	30.9	0.9
5	6	33.5	31.0	1.9	5	4	35.9	35.2	0.7
6	5	29.6	33.7	0.4	6	11	37.9	38.4	1.2
7	7	36.0	35.8	1.8	7	9	42.1	40.7	1.2
8	6	37.9	37.5	2.2	8	8	43.2	42.4	0.7
9	2	39.8	38.8	2.3	9	6	45.4	43.7	1.3
*10	0	--	--	--	10	4	43.8	44.6	1.2
*11	0	--	-	--	11	2	45.5	45.3	0.5
*12	1	42.0	--	--	12	6	44.2	45.8	0.9
*13	0	--	--	--	*13	2	45.2	46.2	0.0
*14	0	--	--	--	*14	0	--	--	--
*15	0	--	--	--	*15	1	44.0	--	--
*16	0	--	--	--	*16	1	46.0	--	--

von Bertalanffy Length-at-age Parameters (and standard error)

Male			Female		
L_∞ =	48.4	(2.2)	L_∞ =	47.2	(1.2)
k =	0.2296	(0.0391)	k =	0.3072	(0.0387)
t_o =	-0.0301	(0.3876)	t_o =	0.5239	(0.2592)

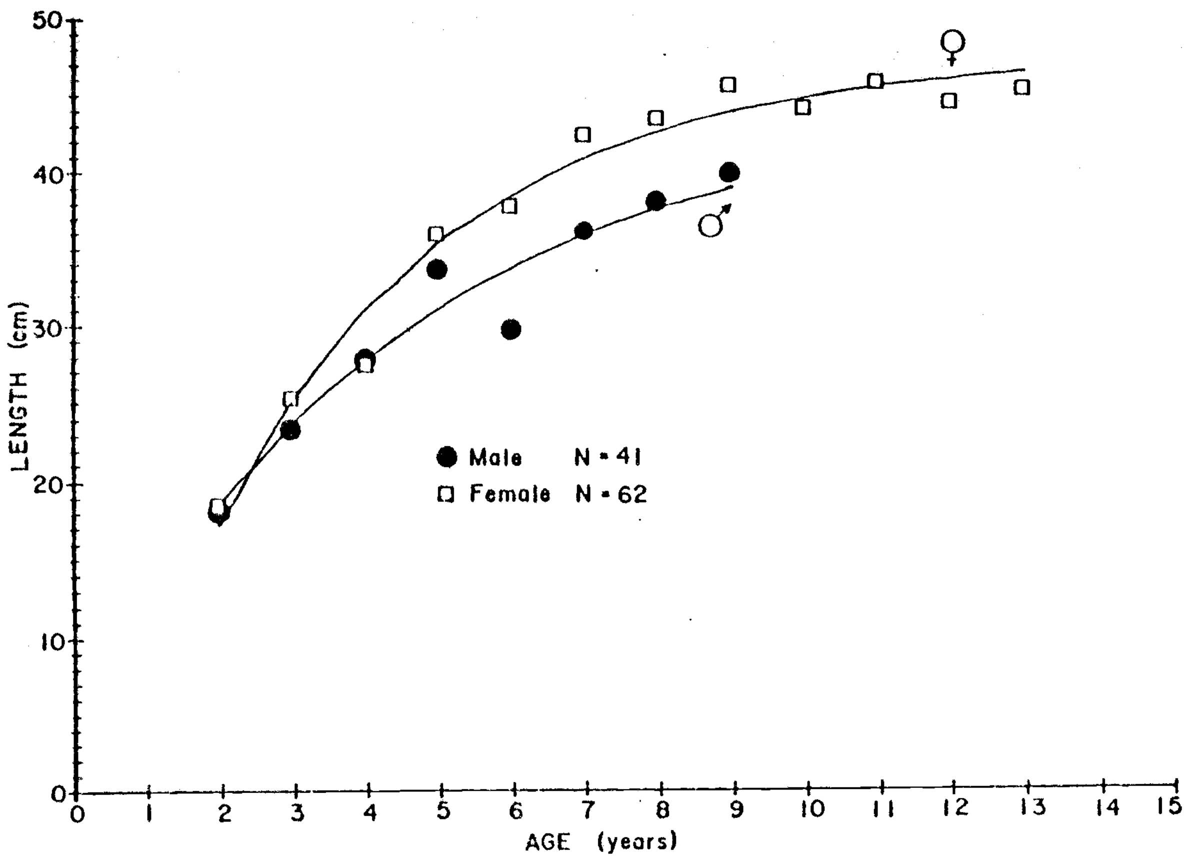

FIGURE 11. Calculated length-at-age curves and mean observed length-at-age of blue rockfish (Sebastes mystinus) taken by hook-and-line off Depoe Bay, Oregon, 1978-80.

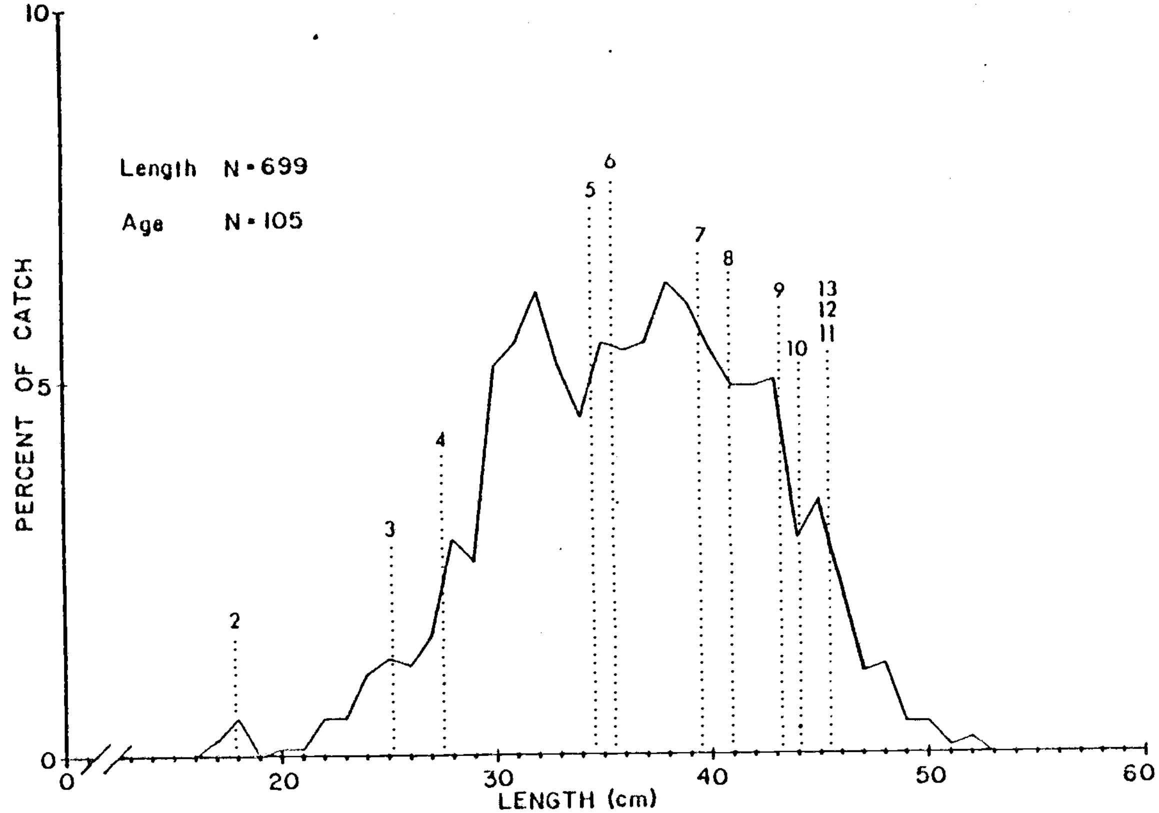

FIGURE 12. Length frequency of all blue rockfish (Sebastes mystinus) sampled from the hook-and-line catch off Depoe Bay, Oregon, during 1976-80. Estimated ages are projected at mean observed length-at-age for the combined sexes.

the Monterey Bay region occurs at a slighly younger age than found off Oregon (Table 6).

Annual length frequency of the catch indicates that a decreasing percentage of small individuals (< 30 cm fork length) have been taken in recent years (Fig. 13). The mean length of the catch has remained fairly constant since 1976, but in 1980 it increased by 3.3 cm over the previous 4-year average (Fig. 13). The reasons for this may be biological, but I believe they are, in part, a result of changes in the fishery, as mentioned previously for black rockfish.

Estimates of age at maturity based on gonadal examination are presented in Table 8. My observations indicate that males first mature at age 3, at which time over 50% of the individuals are mature. All males examined of age 4 and older were found to be sexually mature. One female, age 2, was found to be mature. By the age of 4, over 50% of the females examined were mature and all were mature by age 8. These observations agree with those of Wales (1952) though the observations presented by Miller et al. (1967) and Miller and Geibel (1973) indicate that 100% maturity did not occur until age 9 for males and between ages 9 and 10 for females (Table 6). The differences here may be biological or due to differences in ageing methods used.

Survival and total mortality were estimated at S = 0.771 and Z = 0.260 respectively for fish older than 5 years of age.

Discussion:

Biological data from this study reveal a slightly different perspective on blue rockfish from this area than do those from the

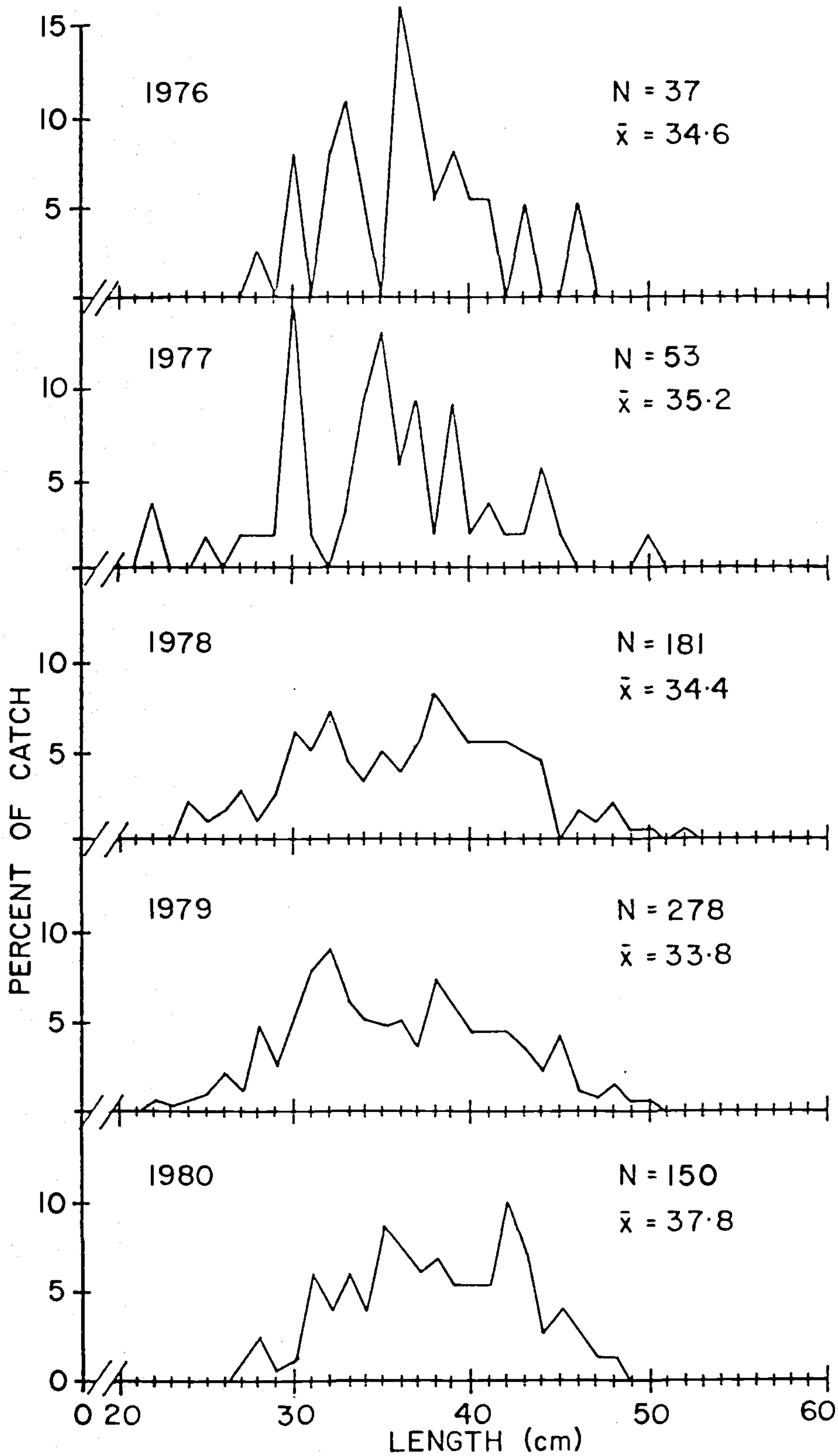

FIGURE 13. Annual length frequencies of blue rockfish (Sebastes mystinus) taken by hook-and-line off Depoe Bay, Oregon, from 1976-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

TABLE 8. Percentage of sexually mature blue rockfish (*Sebastes mystinus*) by age, based on gonadal examination. Fish captured by hook-and-line from the neritic reefs off Depoe Bay, Oregon, from 1978-80.

Male			Female		
Age	Number sampled	% sexually mature	Age	Number sampled	% sexually mature
2	2	0	2	3	33
3	4	75	3	1	0
4	2	100	4	5	60
5	14	100	5	5	60
6+	6	100	6	9	60
			7	7	90
			8	6	100
			9+	17	100
TOTAL	28			53	

Monterey Bay area presented by Wales (1952), Miller et al. (1967) and Miller and Geibel (1973). The fish from the neritic reefs off Depoe Bay appear to grow at a faster rate and reach a larger size than do those from the Monterey area. This corresponds to findings of Boehlert and Kappenman (1980) that at least one species of rockfish (S. diploproa) tend towards larger sizes at age with increasing latitude. Miller and Geibel (1973) reported wide variation in blue rockfish age-length relationships between ecologically different areas off central California. This wide variation in age-length relationships suggests that blue rockfish, though widely distributed (Baja California to Bering Sea [Hart 1973]), are sensitive to the environment of specific geographic locations and this is reflected in different growth characteristics for each area.

The blue rockfish, as with the black rockfish, has become more acceptable to recreational anglers in recent years. This acceptance has resulted in fewer of the larger fish being returned to the sea, and increased targeting on this species has led to increased catches and increased numbers of large fish taken from newly fished areas. The recent decrease in numbers of small individuals in the catch is probably due, in part, to the non-retention of small individuals (blue rockfish are generally smaller than black rockfish) in preference to larger ones as well as the increased availability of large individuals in newly fished areas.

Canary Rockfish

Results:

A total of 634 fork lengths and 334 whole weights were recorded from hook-and-line caught canary rockfish. Weight-length relationships for males, females and combined sexes are presented in Table 1. The combined sex and individual sex models were tested to determine if there were significant differences between the models. The results suggest that the individual sex models best describe the observed relationships (Table 2). Examination of the individual weight-length curves (Fig. 14) reveals that individuals of both sexes have similar weights at fork lengths $\leq$ 45 cm. Above 45 cm females become increasingly heavier than males of equal length.

Age estimates were made based on examination of otoliths from 270 canary rockfish. All otoliths were subjected to a second reading and agreed with initial estimates in 28% of the cases and within one year (±1 year) in 72% of the cases.

I found that older individuals were more difficult to age and that agreement between age estimates was low for males older than 15 years and females older than 14 years of age. Since these "older" individuals were difficult to age and agreement between readings of the same otolith was low, I excluded these individuals from further age calculations. I believe that this exclusion was justified because of the uncertainty of these older ages, though biasing of upper age and size estimates undoubtedly resulted.

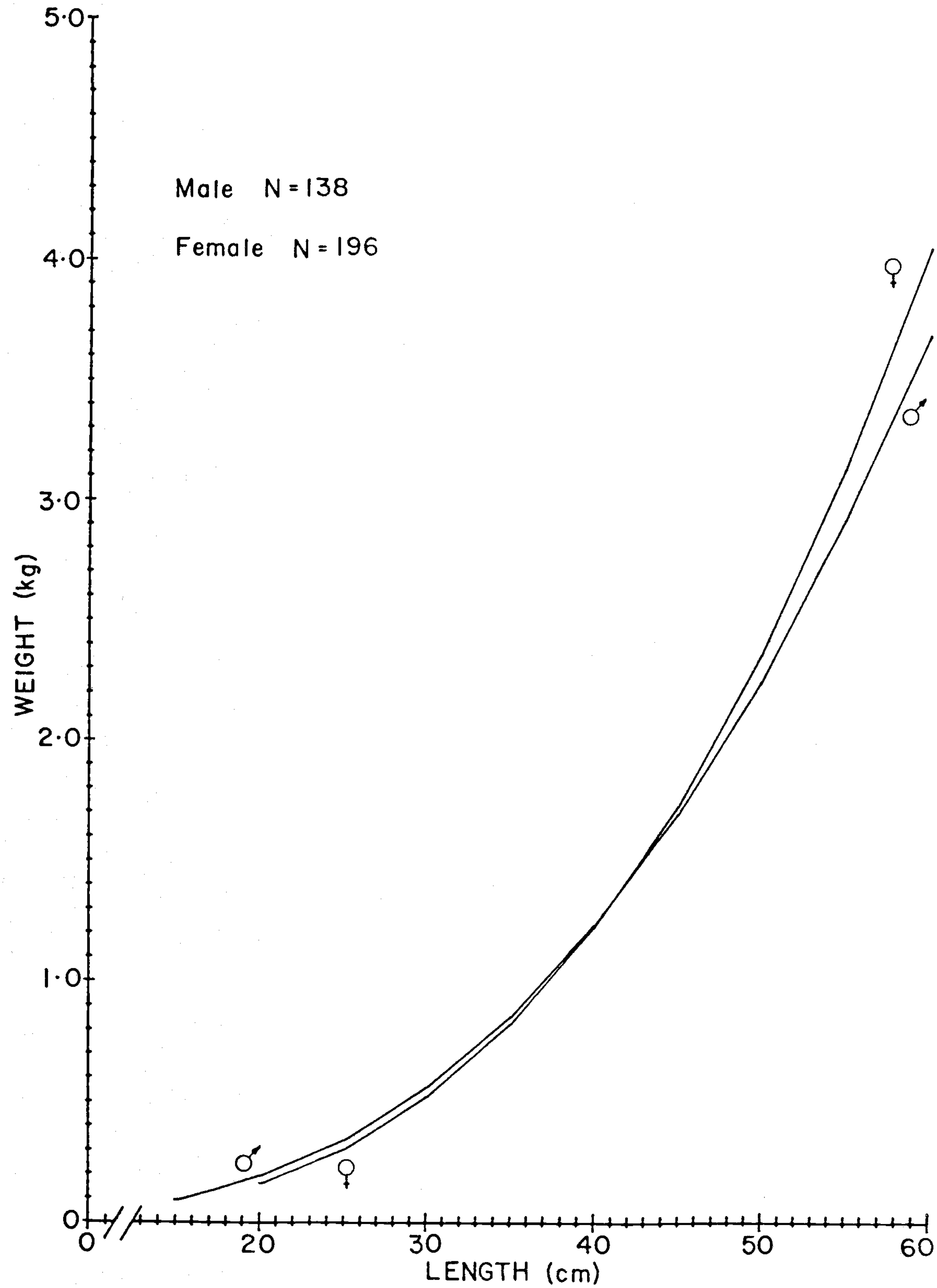

FIGURE 14. Calculated weight-length relationships of male and female canary rockfish (Sebastes pinniger) taken by hook-and-line off Depoe Bay, Oregon, during 1978-80.

An attempt to describe the age-length relationship with the von Bertalanffy equation was unsuccessful, probably due to the wide variation in observed lengths at age and the lack of young individuals in the sample. Alternatively, the relationship was described by the exponential equation $w = a\ell^{b}$. The resulting models, calculated lengths-at-age, and mean observed lengths-at-age, are presented in Table 9. The length-at-age curves and the mean observed lengths-at-age are presented in Figure 15. The mean length-at-age data show high variance from the calculated curves at several points, particularly at age 8 for both sexes and ages 9, 11, and 13 for females.

From the calculated curves (Fig. 15) it is apparent that the growth rate of males is lower than that of females throughout the observed age range (6-15 years). Male canary rockfish appear to be longer at a given age than females, prior to age 7.

Comparison to length-at-age estimates from other studies (Table 10) indicates that lengths estimated for young fish (age 6) from this study are similar to those of Barker (1979), Six and Horton (1977), and Boehlert (1980), but are slightly longer than those of Westrheim and Harling (1975). However, by age 12 the estimated lengths from this study are considerably shorter than those presented in the previously mentioned studies. The reasons for the descrepancies are unknown, but possible explanations will be discussed below.

The presence of individuals which are substantially larger than those included in the length-at-age calculations suggests that canary rockfish may reach relatively old ages. This is supported by the

TABLE 9. Fitted length-at-age and mean observed length-at-age of yellowtail rockfish (*Sebastes pinniger*) and the length-at-age equation determined from individuals aged by otoliths and collected from Depoe Bay, Oregon, from 1978-80. Asterisk (*) indicates ages not used in determination of length-at-age equation due to small sample size.

Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
*4	0	--	--	--	*4	2	33.3	--	0.3
*5	2	33.2	--	5.7	5	9	33.3	30.1	2.4
6	8	32.6	34.1	1.1	6	7	33.3	32.4	1.8
7	10	35.8	35.0	1.2	7	19	34.6	34.4	1.0
8	20	38.1	35.9	1.1	8	16	37.3	36.3	1.0
9	16	36.5	36.6	1.2	9	20	35.5	38.1	1.0
10	15	36.5	37.3	0.9	10	16	39.9	39.8	1.7
11	10	37.5	37.9	2.3	11	6	38.8	41.3	1.6
12	14	39.0	38.5	1.4	12	8	42.6	42.8	0.9
13	14	38.7	39.0	1.3	13	5	46.8	44.2	3.3
14	17	38.1	39.5	0.7	14	8	46.3	45.5	3.1
15	7	41.0	40.0	0.9	*15	5	44.7	--	1.2
*16	5	47.7	--	4.0	*16	3	42.6	--	1.4
*17	0	--	--	--	*18	1	44.0	--	--
*18	2	49.8	--	1.8	*20	1	52.2	--	--
					*29	2	56.0	--	0.0

Length-at-age equation

$\ell = 25.02\ A^{0.1729}$ $\qquad$ $\ell = 15.76\ A^{0.4017}$

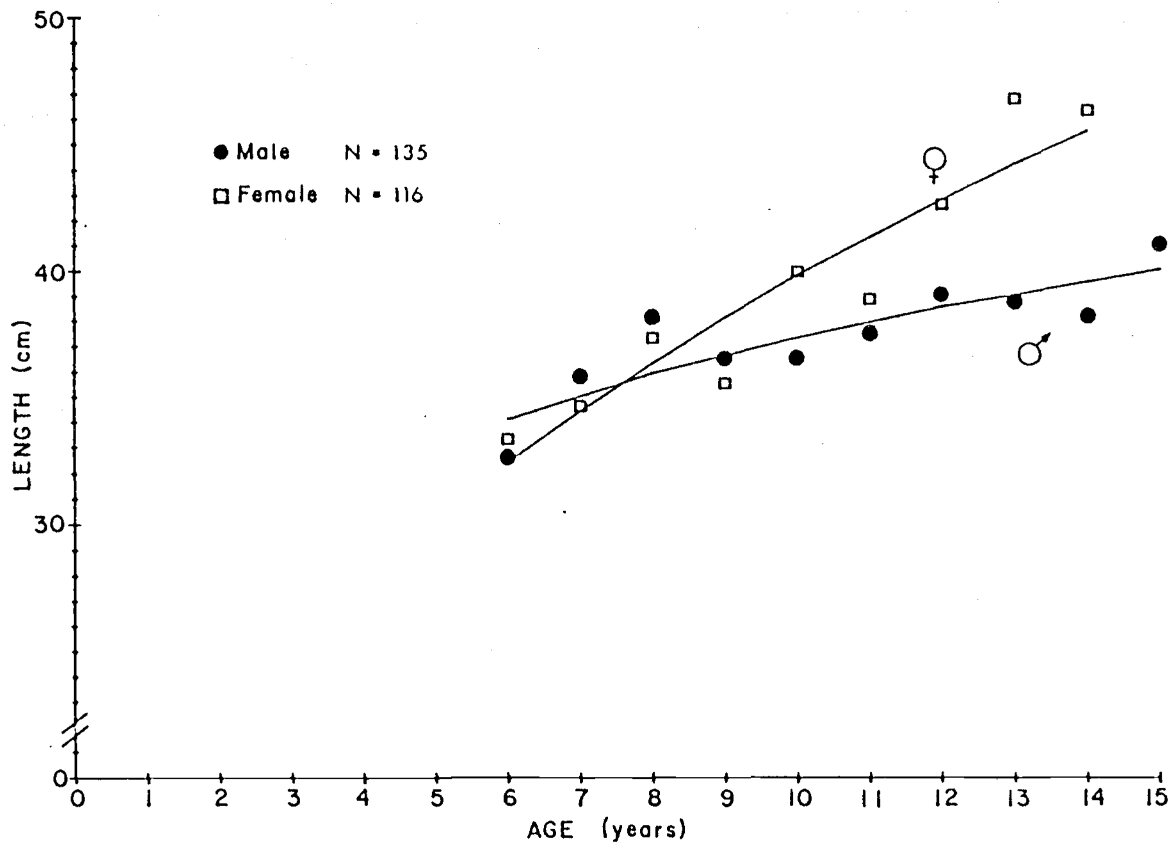

FIGURE 15. Calculated length-at-age curves and mean observed length-at-age of canary rockfish (Sebastes pinniger) taken by hook-and-line off Depoe Bay, Oregon, 1978-80.

TABLE 10. Comparison of biological statistics of canary rockfish (*Sebastes pinniger*) sampled from neritic reefs off Depoe Bay, Oregon, with those from other studies and areas.

Statistic	Depoe Bay (this study)	California (Phillips 1964)	Oregon (Six and Horton 1977)	Oregon, Washington, California (Boehlert 1980)	Northeast Pacific (Westrheim and Harling 1975)
			Area (author)		
Maximum observed age (years).	Male: 18 Female: 29	Combined: 18	Male: 20 Female: 21	Male: 20 Female: 20	Male: 26 Female: 26
Calculated length (cm) at selected ages (years).	Age / Male / Female	Age / Combined Sexes	Age / Male[a] / Female[a]	Age / Male / Female	Age / Male / Female
	6 / 34.1 / 32.4	6 / 35.6	6 / 33.7 / 33.9	6 / 34.4 / 34.5	6 / 30.3 / 30.4
	9 / 36.6 / 38.1	9 / 44.8	9 / 42.2 / 43.5	9 / 43.2 / 43.9	9 / 38.5 / 40.0
	12 / 38.5 / 42.8	12 / 51.5	12 / 46.9 / 49.5	12 / 48.4 / 50.5	12 / 43.6 / 46.1
Age and size at maturity.	Male / Female 50%: 12 yr. / 10 yr. 39.0 cm / 42.6 cm 100%: 12 yr. / 12 yr 39.0 cm / 42.6 cm	Combined Sexes 50% 5-6 years 14 inches [35.6 cm]	Not determined	Not determined	Not determined
Estimated survival (S) and/or total mortality (Z)	S: 0.769 Z: 0.262 ages 8-18	Not determined	S: 0.669-0.740 ages 15-23	Not determined	Not determined

[a] Average of two lengths presented for each age.

presence of two females of 56.0 cm fork length which were assigned estimated ages of 29 years. Boehlert (1980) and Six and Horton (1977) both reported fish older than 20 years of age from deeper waters off the Pacific coast.

Few canary rockfish of < 30 cm fork length were present in the recreational catch (Fig. 16). Full recruitment appears to occur when fish are > 32-38 cm in length (corresponding with ages 6-9). No estimates of recruitment to other fisheries were available for comparison. Few individuals > 60 cm were captured during this study. Boehlert (1980) and Six and Horton (1977) also reported individuals > 55 cm fork length, suggesting that fish of this size are not uncommon.

Annual length frequency was available only for the years 1978 through 1980 (Fig. 17). During this period it appears that a trend towards fewer small fish (< 30 cm fork length) in the catch has occurred. This trend could indicate changes in the length frequency of the population or changes in the fishery for this species. These possibilities will be discussed below.

Gonadal examination of 88 individuals indicated that all individuals, of both sexes, are mature by age 12 (Table 11). The youngest mature males observed were 11 years old, the youngest mature females were 9 years old. Phillips (1964) found that 50% of the individuals were mature at ages 5-6 (36 cm total length) which is slightly shorter than mature individuals in this study (Table 10). No other maturity estimates were available for comparison.

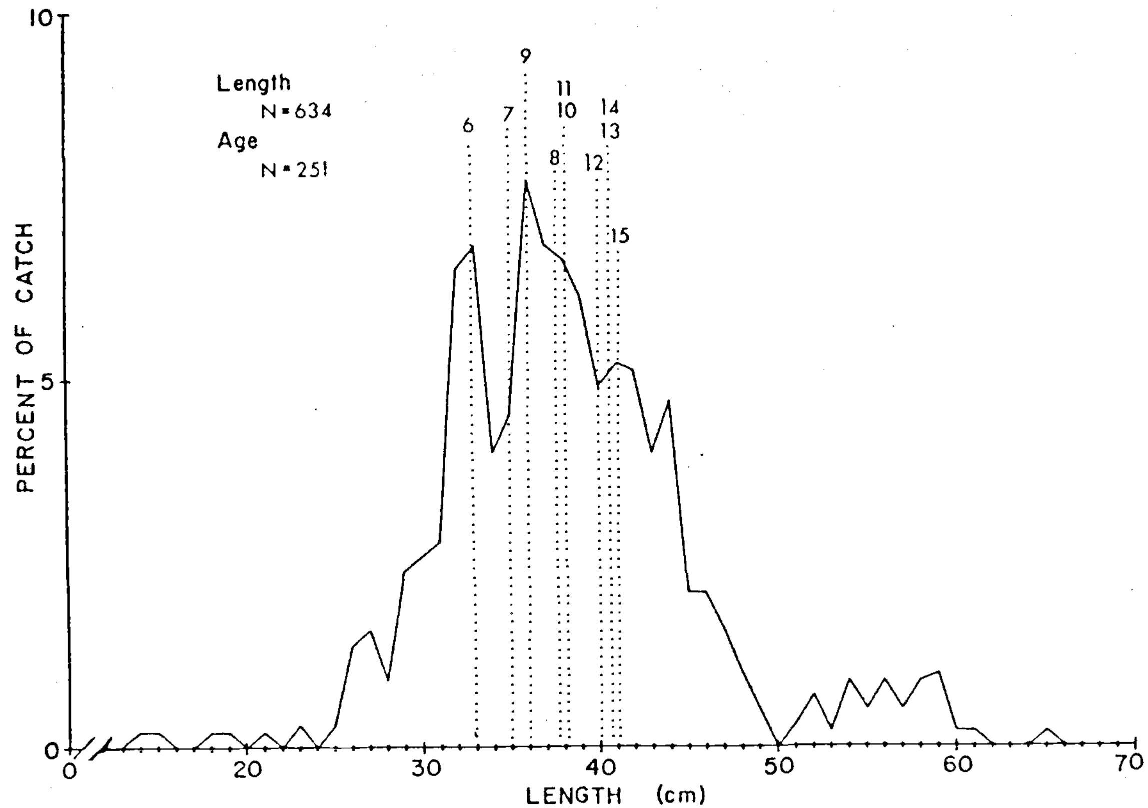

FIGURE 16. Length frequency of all canary rockfish (Sebastes piniger) sampled from the hook-and-line catch taken off Depoe Bay, Oregon, during 1978-80. Estimated ages are projected at mean observed length-at-age for the combined sexes.

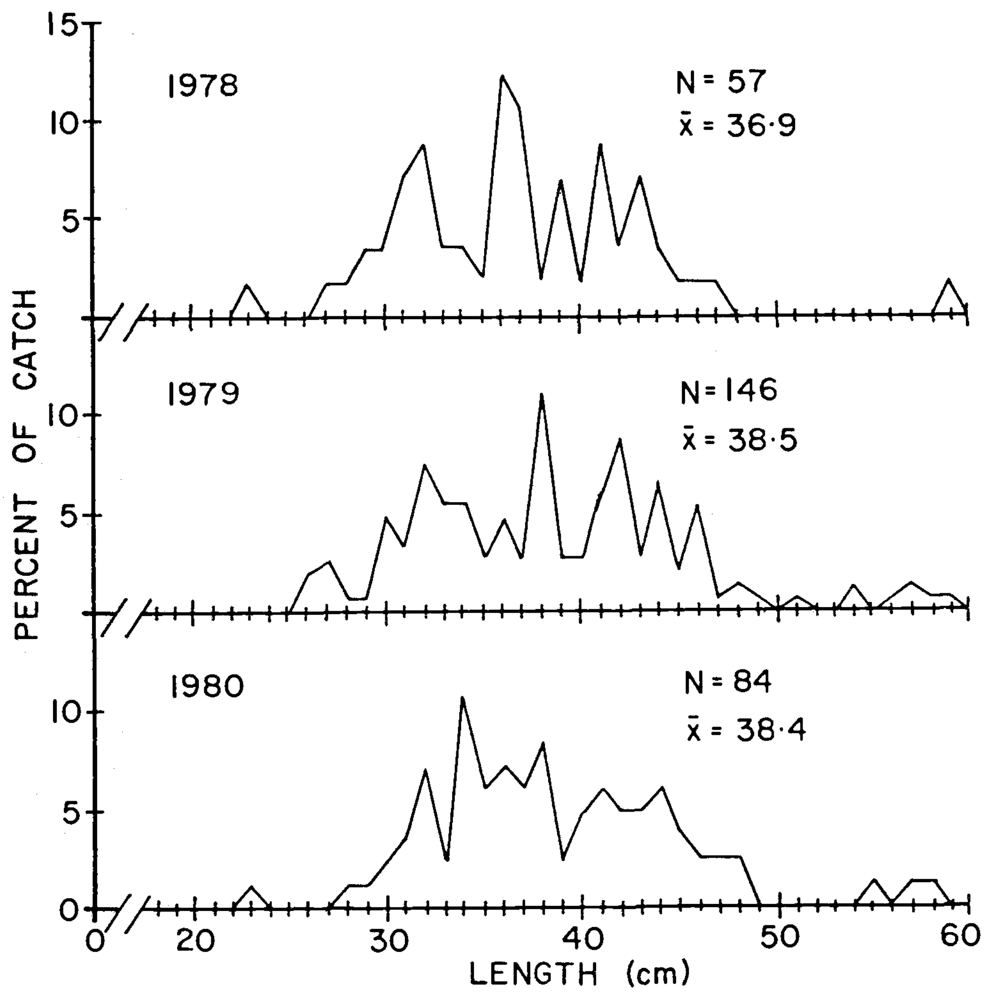

FIGURE 17. Annual length frequencies of canary rockfish (Sebastes pinniger) taken by hook-and-line off Depoe Bay, Oregon, from 1978-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

TABLE 11. Percentage of sexually mature canary rockfish (*Sebastes pinniger*) by age, based on gonadal examination. Fish taken by hook-and-line from the neritic reefs off Depoe Bay, Oregon, from 1978-80.

Age	Male		Female	
	Number sampled	% sexually mature	Number sampled	% sexually mature
6	2	0	1	0
7	2	0	5	0
8	4	0	4	0
9	6	0	5	20
10	1	0	2	50
11	3	33	8	88
12	4	100	6	100
13+	12	100	24	100
TOTAL	34		55	

Survival is estimated at S = 0.769 for ages 8 and above, and total mortality was estimated for the same age group at Z = 0.262.

Discussion:

Canary rockfish constitute an important portion of the recreational catch (fourth in numbers caught by recreational anglers [Coombs 1979]). In addition, canary rockfish are an important component of the commercial "red snapper" complex of the trawl catch. Data available for comparison with this study were collected from commercial or research trawl catches in waters offshore from the neritic reef areas (Phillips 1964; Six and Horton 1977; Boehlert 1980; Westrheim and Harling 1975).

Boehlert and Kappenmann (1980) observed differences in growth of rockfish related to lattitude. They also suggested that unknown, but important, relationships may exist between nearshore and offshore populations of canary rockfish. Interactions of offshore and nearshore populations as well as different growth characteristics in these different areas could cause a great deal of variation in the observed age-length relationships of canary rockfish from the neritic reef areas. The variation evident in the canary rockfish observed here may be the result of mixing of nearshore and offshore populations, a possibility supported by tag returns from canary rockfish which were tagged on neritic reefs and returned from commercial catches made offshore in deeper water (personal communication, Glenn DeMott, Oregon State University, Department of Fisheries and Wildlife).

Comparing the data presented here with data from offshore commercial catches, it appears that growth of individuals inhabiting the neritic reefs may be slower than that of individuals living offshore (Table 10) which are vulnerable to commercial harvest.

Further tagging studies of both offshore and onshore populations should aid in establishing the degree of interaction between these areas and the importance of each. Direct comparisons of length frequencies and biochemical analysis may also be useful in determinng the degree of biological interaction between these areas.

Yelloweye Rockfish

Results:

A total of 500 yellowtail rockfish were measured for fork length, whole weights of 325 of these individuals were also recorded. The weight-length relationships for males, females, and combined sexes (including unsexed individuals) are presented in Table 1. Testing for significant differences between the individual and combined sex models suggested that the seperate sex models best described the individual relationships (Table 2). The resultant weight-length curves are presented in Figure 18. These calculated curves indicate that there is little difference between the weights of males and females at lengths < 60 cm. However, at lengths > 60 cm females become increasingly heavier than males of equal length. The largest male observed during this study was 78.5 cm long and weighted 9.1 kg. The largest female was 71.0 cm long and weighed 9.1 kg also. This supports the idea that

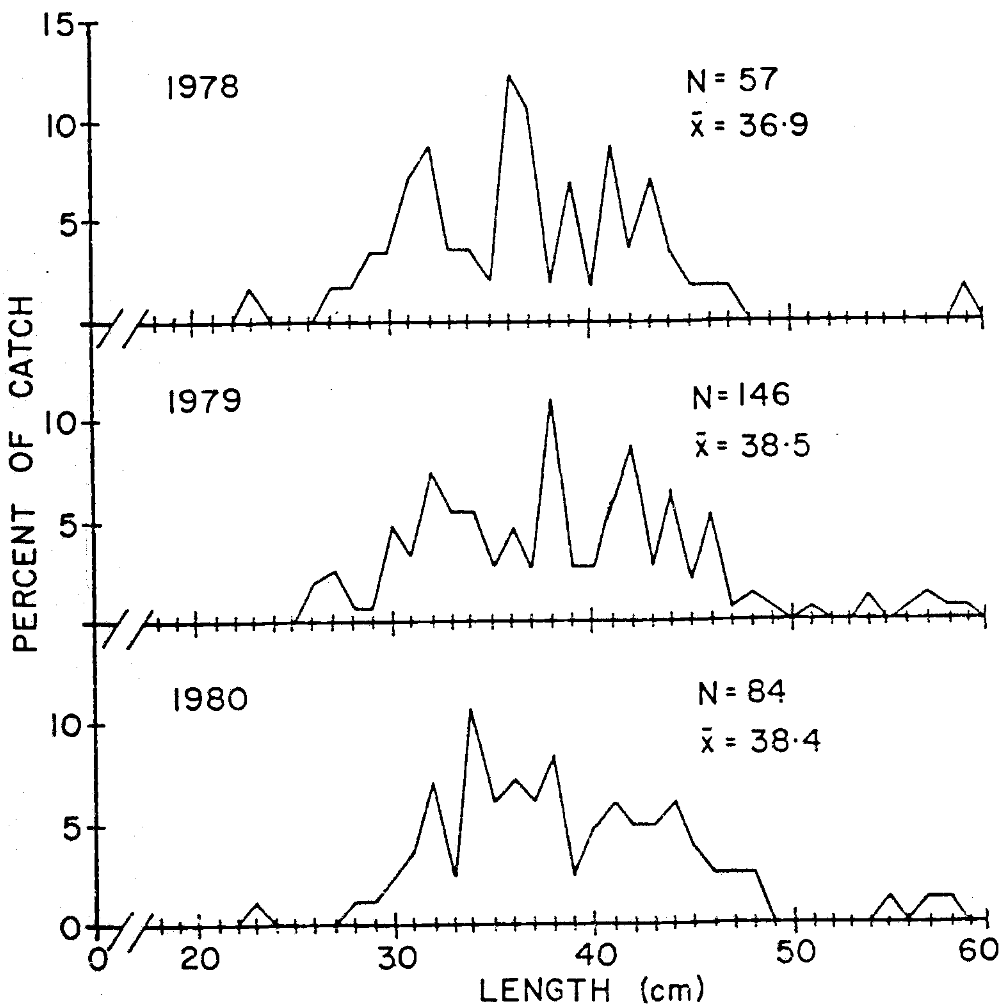

FIGURE 18. Annual length frequencies of canary rockfish (*Sebastes pinniger*) taken by hook-and-line off Depoe Bay, Oregon, from 1978-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

large females tend to be heavier than males of equal length. No other reports of weight-length relationships were available for comparison.

Age estimates were based on readings of otoliths from 223 yelloweye rockfish. All otoliths were read a second time to determine the consistancy of age estimates. Agreement was realized in 33% of the second readings while 60% of the cases were within one year (±1 year) of the original estimate. Otoliths from individuals aged 15 years and older were often difficult to interpret and agreement between the two readings was not as close as for younger aged fish. If agreement between readings for fish younger than 15 years was restricted to one year (±1 year) and older individuals was relaxed to two years (±2 years), 79% of the individuals were then within these limits. The variance of errors of the second reading was not evenly distributed (higher and lower) about the first estimates. The tendency was towards older ages by the second reading for fish which were aged at over 15 years old by the first estimate.

Assigned ages and observed lengths were analyzed and fitted to the von Bertalanffy equation. The resulting von Bertalanffy parameters, estimated lengths, and mean observed lengths-at-age are presented in Table 12. The computed curves describing the length-at-age relationship are presented in Figure 19. These curves, though much different than observed lengths-at-age for some ages, appear to provide a reasonable description of the relationship. From these curves it appears that males grow more rapidly (in length) than females through ages 12-14, then male growth slows markedly and beyond age 19

TABLE 12. Mean observed length-at-age and fitted von Bertalanffy estimates of length-at-age determined for yelloweye rockfish (Sebastes ruberrimus) aged by otolith examination and captured by hook-and-line from neritic reefs off Depoe Bay, Oregon; 1978-80. Asterisk (*) denotes ages not used in calculation of von Bertalanffy parameters due to small sample size.

Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
7	0	--	--	--	7	2	47.5	33.1	10.8
8	8	37.1	37.3	1.8	8	4	35.0	37.7	0.7
9	6	44.9	43.9	3.6	9	10	37.4	41.8	0.9
10	2	48.0	48.9	5.5	10	7	45.5	45.4	4.1
11	8	52.4	52.7	3.5	11	11	48.2	48.5	1.5
12	4	53.8	55.6	4.9	12	5	50.4	51.2	2.7
13	9	57.7	58.0	3.9	13	12	56.9	53.5	2.6
14	16	59.2	59.5	1.4	14	7	57.1	55.6	3.3
15	7	61.3	60.7	2.8	15	12	54.9	57.4	2.0
16	13	61.7	61.7	2.0	16	11	62.1	58.9	2.1
17	7	66.7	62.4	2.2	17	5	60.3	60.3	2.8
18	6	61.3	63.0	2.3	18	5	60.0	61.4	3.0
19	5	58.3	63.4	2.8	19	5	62.5	62.5	2.4
20	7	65.9	63.7	2.0	20	6	61.9	63.4	1.9
21	2	61.3	63.9	5.3	21	5	61.9	64.2	1.8
*22	0	--	--	--	22	2	66.5	64.8	3.5
*23	1	63.0	--	--	23	3	66.3	65.4	2.0
					*24	2	71.5	--	0.7
					*25	2	67.0	--	4.4
					*26	0	--	--	--
					*27	1	66.5	--	--

von Bertalanffy Length-at-age Parameters (and standard error)

Male		Female	
L_∞ = 64.7 cm	(2.2 cm)	L_∞ = 69.5 cm	(4.8 cm)
k = 0.275	(0.071)	k = 0.138	(0.044)
t_o = 4.870	(0.862)	t_o = 2.295	(1.572)

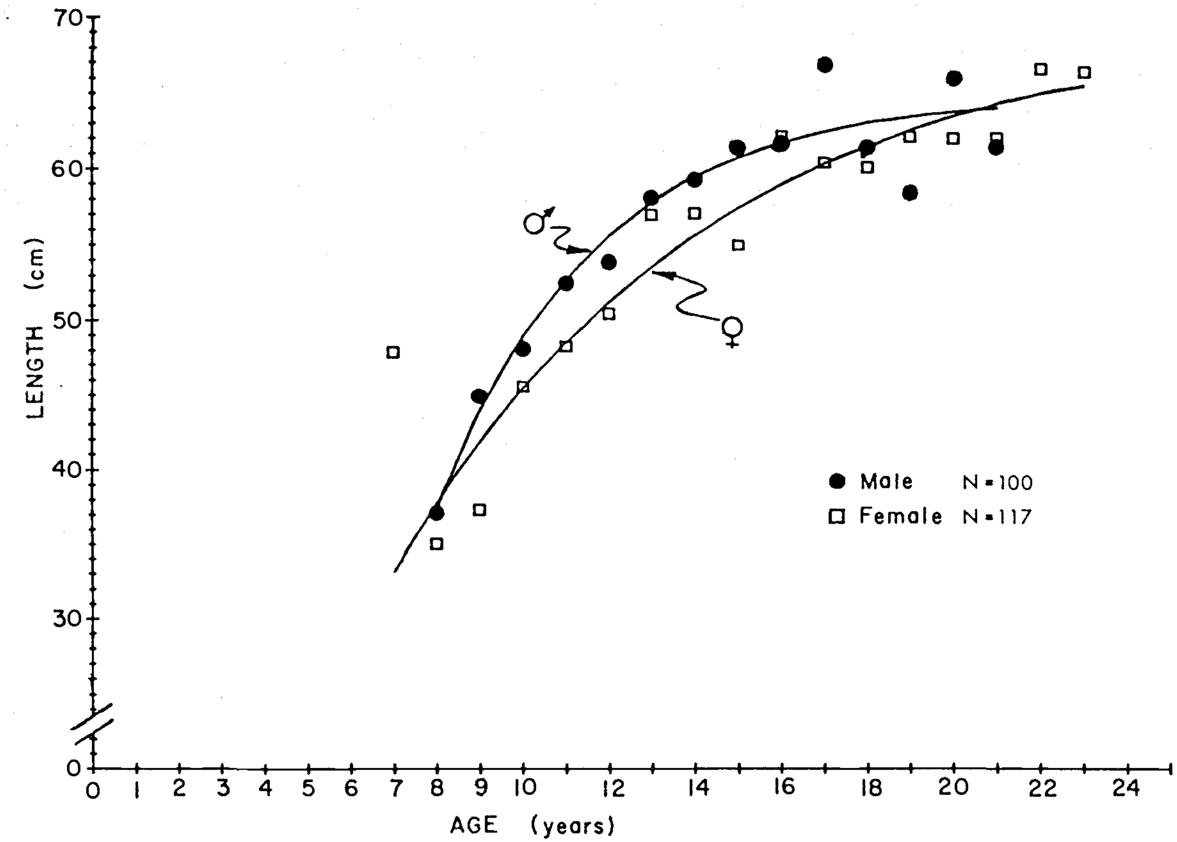

FIGURE 19. Calculated length-at-age curves and mean observed length-at-age of yelloweye rockfish (Sebastes ruberrimus) taken by hook-and-line off Depoe Bay, Oregon, 1978-80.

appears to almost stop. It also appears that between the ages of 8 and 20 years, males are generally longer (though equal to or lighter in weight) than females of equal age. Females maintain a more constant rate of growth and by age 20 are usually longer than males of equal age. Westrheim and Harling (1975) presented observed length-at-age data for yelloweye rockfish based on otolith age estimates of 23 individuals. These estimates and mean observed length-at-age are compared with selected ages from this study in Table 13. Length-at-age estimates for the two studies show little correlation except for males 23 to 25 years of age. Comparison indicates older ages for smaller individuals from Westrheim and Harling (1975) than for individuals from this study in all cases except for one individual estimated to be 27 years old. That individual was extraordinarily long in comparison to younger aged individuals from their study. I feel that a difference in ageing techniques, between their study and this one, and their small sample size may be the reasons for such a large discrepancy in estimated ages. No other studies of yelloweye rockfish were available for comparison.

The majority of yelloweye rockfish appearing in the recreational catch are > 50 cm in length (approximately 11-12 years of age) with very few fish < 35 cm taken (Fig. 20). Annual length frequency of the catches for the years 1978-80 indicate a decline of 5-6 cm in the mean length of fish caught in 1980 (Fig. 21). Also indicated is an increase in the percentage of smaller fish (< 50 cm in length) appearing in the catch. This could be a result of increased abundance

TABLE 13. Comparison of mean observed lengths of yelloweye rockfish (*Sebastes ruberrimus*) sampled from neritic reefs off Depoe Bay, Oregon, and from the Northeast Pacific (Westrheim and Harling 1975).

Depoe Bay (present study)					Northeast Pacific (Westrheim and Harling 1975)				
	Length (cm)					Length (cm)			
Age	Male	(N)	Female	(N)	Age	Male	(N)	Female	(N)
13	57.7	(9)	50.4	(5)	13	--		39.5	(1)
16	61.7	(13)	62.1	(11)	16	49.5		--	
17	66.7	(7)	60.3	(5)	17	--		53.3	(1)
18	61.3	(6)	60.0	(5)	18	51.0	(2)	55.5	(1)
21	61.3	(2)	61.9	(5)	21	--		53.5	(1)
22	--		66.5	(2)	22	--		48.5	(1)
23	63.0	(1)	66.3	(3)	23	--		60.0	(2)
25	--		58.5	(1)	25	63.5	(2)	61.5	(2)
27	--		66.5	(1)	27	--		71.5	(1)

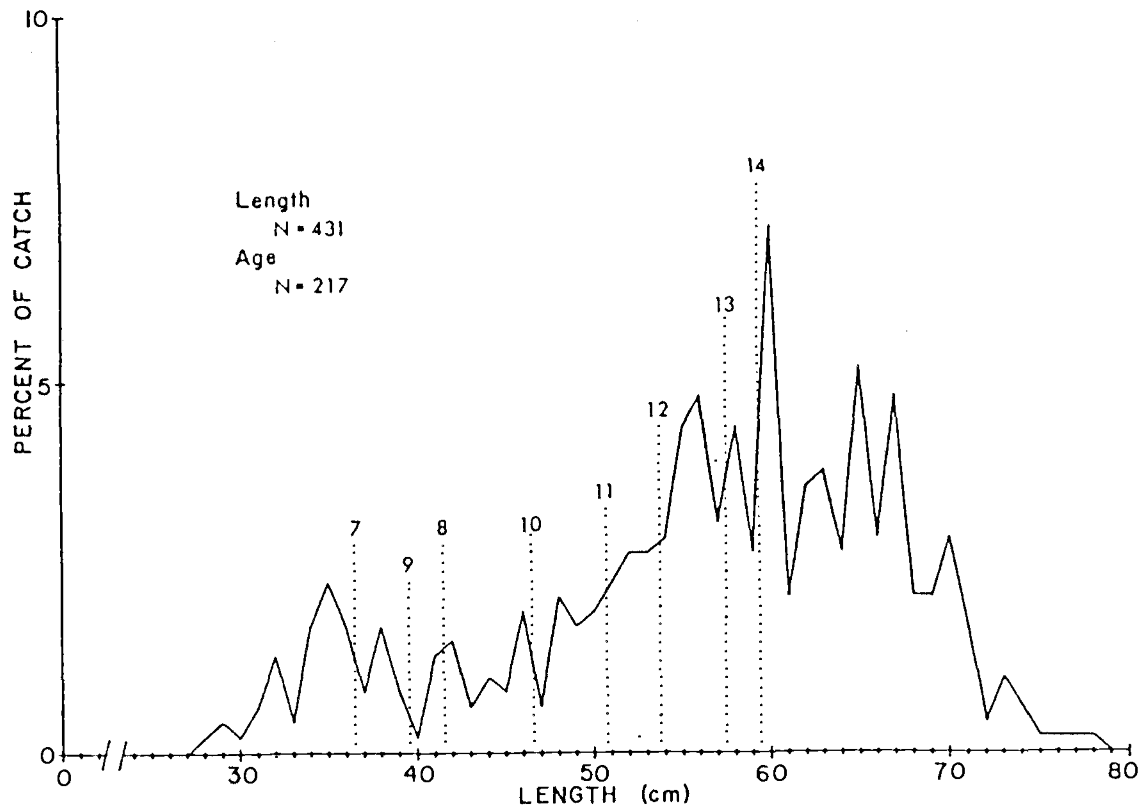

FIGURE 20. Length frequency of all yelloweye rockfish (*Sebastes ruberrimus*) sampled from the hook-and-line catch taken off Depoe Bay, Oregon, during 1978-80. Estimated ages are projected at mean observed length-at-age for the combined sexes.

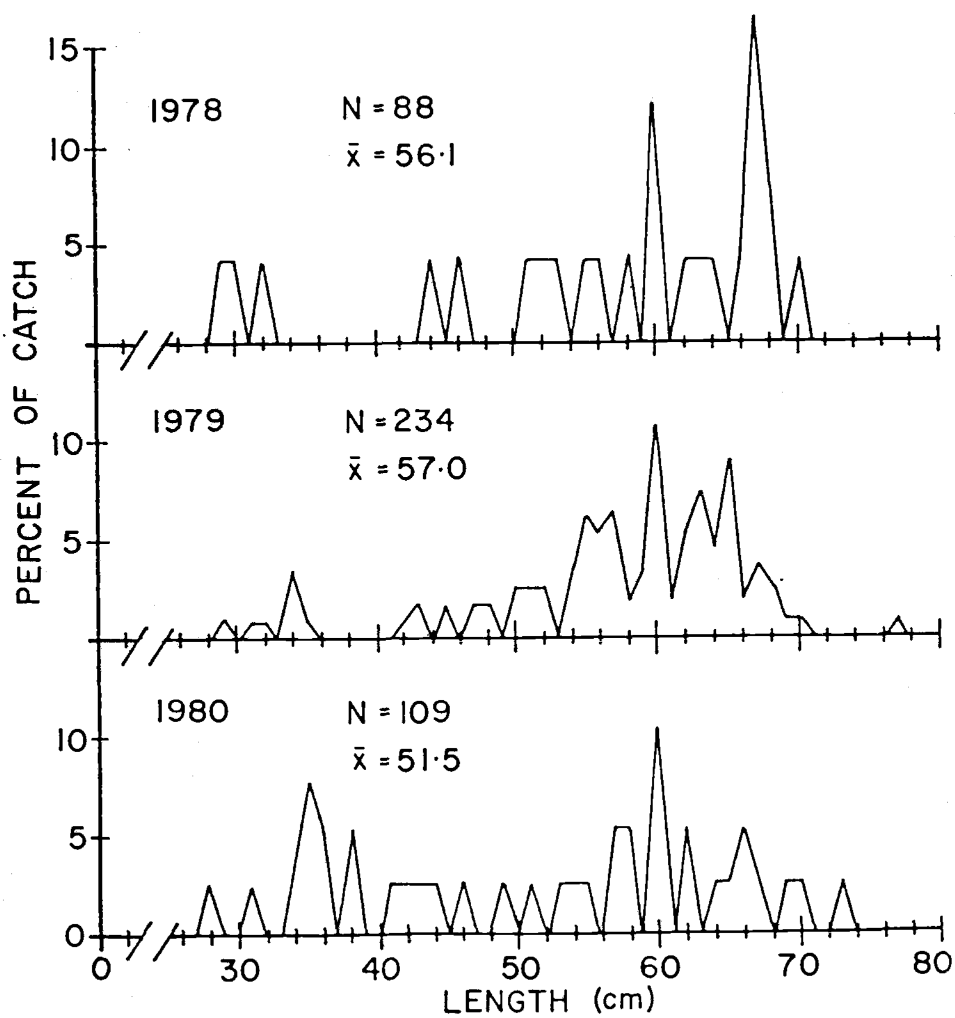

FIGURE 21. Annual length frequencies of yelloweye rockfish (Sebastes ruberrimus) taken by hook-and-line off Depoe Bay, Oregon, from 1978-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

of smaller individuals or changes in the fishery. These possibilities will be discussed below.

Gonadal examination indicated that sexually mature males first appear at age 9, and all are mature by age 12 (Table 14). The first mature females appear at age 10 and all appear to be sexually mature by age 11.

Survival, based on the individuals of full recruitment age (14 years) and older was estimated at S = 0.719. Total mortality for the same age group was estimated at Z = 0.330.

Discussion:

The recent increase in the percentage of smaller fish (< 50 cm fork length) in the catch in 1980 (Fig. 21) is probably a result of several "perfect" days for fishing specifically for yelloweye rockfish. These were days when there was no wind, no current, and the surface was "flat". Once a deep reef (> 50 m) was located and found to be inhabited by yelloweye rockfish, it was possible to remain above the reef for extended periods of time and make large catches of this species. During this extended period of good conditions, catches of 2-3 large yelloweye per angler were not uncommon, and there was also an abundance of smaller individuals in the catch.

Such intense pressure on small reefs could seriously deplete local stocks of yelloweye rockfish. It appears that individuals do not range from their home reef area (Coombs 1979), and as such may not migrate to nearby, recently fished-out reefs. As such extended

TABLE 14. Percentage of sexually mature yelloweye rockfish (*Sebastes ruberrimus*) by age, based on gonadal examination. Fish taken by hook-and-line from the neritic reefs off Depoe Bay, Oregon, from 1978-80.

	Male		Female	
Age	Number sampled	% sexually mature	Number sampled	% sexually mature
7	0	0	2	0
8	6	0	4	0
9	4	25	4	0
10	4	0	3	67
11	4	25	1	100
12	2	100	5	100
13	2	100	6	100
14+	10	100	39	100
TOTAL	32		64	

periods of good weather are not common it is doubtful that such heavy pressure on a single reef is common. Locating the smaller reefs, in deeper water, where this species appears to be most common is also difficult, aiding in protection from overfishing. Under present conditions I feel that the apparently endemic populations of yelloweye rockfish on each reef are relatively safe from over exploitation, though occasionally individual reefs may be fished heavily.

The majority of fish taken in the fishery are mature, and the fishery probably does not adversely affect the general breeding population of the neritic reef area.

Yellowtail Rockfish

Results:

A total of 388 fork lengths and 110 whole weights were recorded from hook-and-line caught yellowtail rockfish. Models describing the male and female weight-length relationships as well as the combined sexes (including unsexed individuals) relationship are presented in Table 1. The calculated curves representing the weight-length relationships for males and females are presented in Figure 22. Comparison of the combined and individual sex models indicates that no significant difference ($p < 0.05$) exists between the curves described by the models (Table 2). Therefore I assumed that the model for the combined sexes adequately describes the weight-length relationships of each sex. Examination of the individual sex curves (Fig. 22) supports this assumption by illustrating the similarity of the weight-length

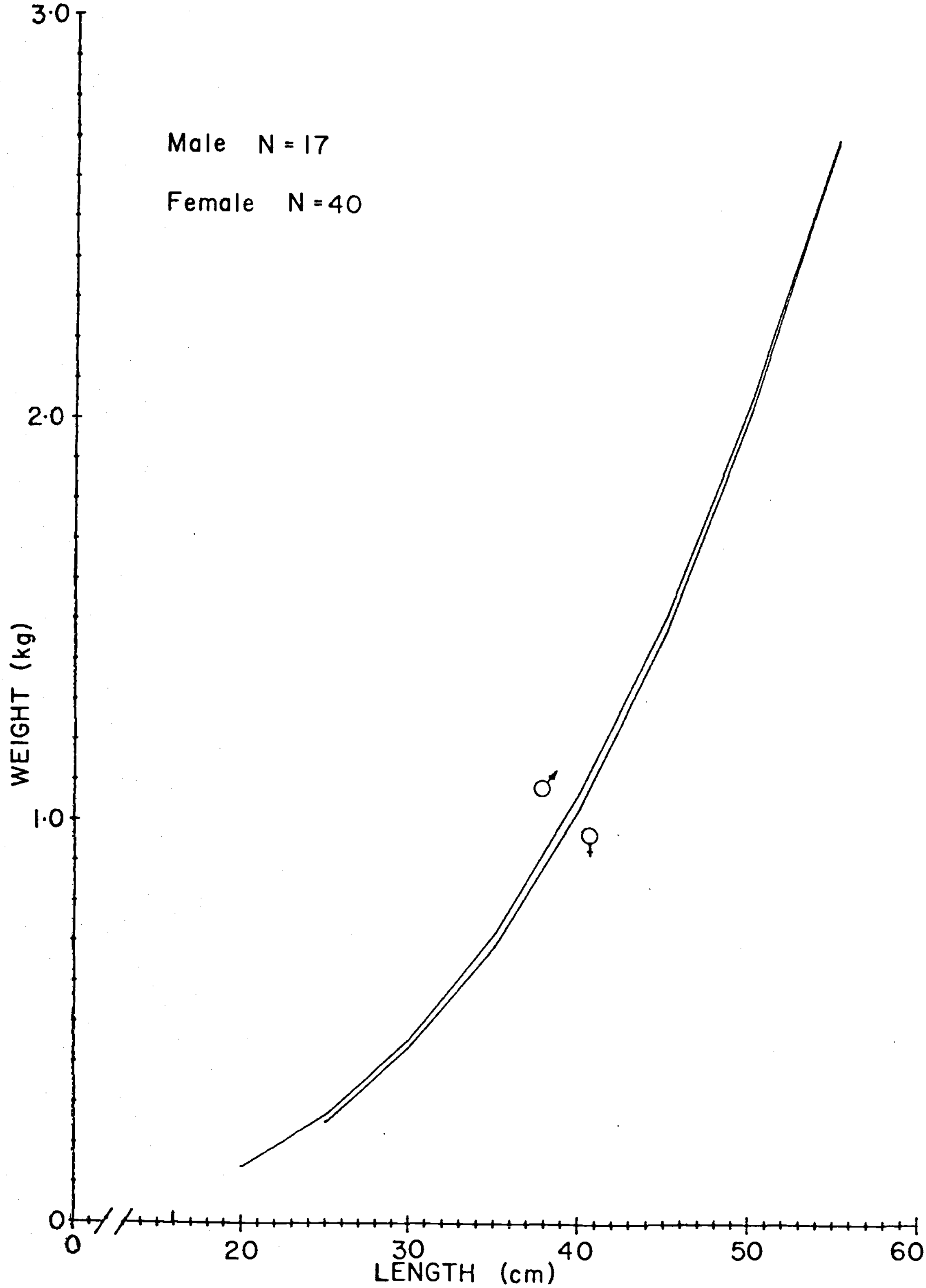

FIGURE 22. Calculated weight-length relationships of male and female yellowtail rockfish (Sebastes flavidus) taken by hook-and-line off Depoe Bay, Oregon, during 1978-80.

relationships of both sexes. This is the only species of rockfish encountered in this study which could be adequately described by a single weight-length model. However, differences between the sexes here may be masked by the relatively small number of males sampled (N = 17).

Comparison of weight-length relationships with other studies (Table 15) indicated relatively close agreement with the findings of Fraidenberg (1980) and Phillips (1964) for fish from the Oregon/Washington area and off central California respectively. Barker (1979) suggests weights which are much lower for fish from Puget Sound at comparable lengths to those reported here.

Age estimates were based on readings of otoliths from 77 individuals (12 male, 31 female, and 34 unsexed). All otoliths were read a second time and agreement was recorded in 80% of the cases while 93% were within one year (± 1 year) of the first estimate.

Age-length relationships could not be adequately described using the computer program BGC2 to fit the von Bertalaffy equation. This was due to the small sample size and the missing ages in the samples. Alternatively, the exponential equation $\ell = cA^b$, was used to describe the relationships. The models describing the female and combined sex relationships are presented in Table 16. No description of the male relationship is presented due to the small and incomplete sample of ages.

The calculated curves describing age-length and the observed mean length-at-ages are presented in Figure 23. Comparison of calculated

TABLE 15. Comparison of biological statistics of yellowtail rockfish (<u>Sebastes flavidus</u>) sampled from neritic reefs off Depoe Bay, Oregon, with those from other studies and areas.

Statistic	Depoe Bay (This study)	N. California–British Columbia (Fraidenberg 1980)	Puget Sound (Barker 1979)
Equation describing weight-length relationship.	Combined sex: ω=0.0000510$\ell^{2.646}$ logω = (-4.29268 + 2.646(logℓ)) Male: ω=0.0000232$\ell^{2.911}$ logω = (-4.63424 + 2.911(logℓ)) Female: ω=0.0001161$\ell^{3.00}$ logω = (-4.79406 + 3.00 (logℓ)	Combined sex: Male: ω=0.0000173$\ell^{2.97}$ Female: ω=0.0000092$\ell^{3.14}$	Combined sex: logω=05.35961+3.20728(logℓ) Male: no data Female: no data
Equation describing age-length relationship.	Exponential $L_t = cA^b$ Combined sex: L_t=13.7965$A^{0.52966}$ Male: Not calculated Female: L=17.675$A^{0.37655}$	von Bertalanffy L_t=L_∞(1-$e^{-k(t-t_o)}$) Combined sex: Not presented Male: L_∞ = 49.04 cm k = 0.209 t_o = 0.185 Female: L_∞ = 55.54 k = 0.163 t_o = 0.250	von Bertalanffy L_t=L_∞(1-$e^{-k(t-t_o)}$) Combined sex: L_∞ = 410 mm k = 0.36 t_o = 0.55 Male: L_∞ = 420 mm k = 0.35 t_o = 0.40 Female: L_∞ = 510 mm k = 0.18 t_o = 0.89
Calculated lengths at selected ages.	Age / Combined sex / Female 4 / 28.8 cm / 29.8 cm 6 / 35.6 / 34.7 8 / 41.5 / --	Age / Male / Female 4 / -- / -- 6 / 35.58 cm / 35.49 cm 8 / 40.18 / 41.07	Age / Combined sex / Male / Female 4 / 291.6 cm / 300.9 mm / 298.5 mm 6 / 352.4 / 360.8 / 362.4 8 / -- / -- / --
Age (size) at maturity.	Male: -- Female 100% 9 years		Male: none found to age 7 Female: none found to age 7

[a]Six used two readings of otoliths and calculated parameters for each reading individually. Calculated length presented here is average of two estimates.

Table 15. Continued

Statistic	Oregon (Six 1976)[a]	California (Phillips 1964)	Northeast Pacific (Westrheim and Harling 1975)
Equation describing weight-length relationship.	No data No data	Combined sex: $\log\omega = -7.60384 + 3.0402 \log \ell$ L : mm ω : pounds	No Data
Equation describing age-length relationship.	Exponential $L_t = cA^b$ Male: $L_t = 27.9962A^{0.18068}$ $L_t = 28.4118A^{0.17206}$ Female: $L_t = 25.0841A^{0.26386}$ $L_t = 23.6646A^{0.28150}$	von Bertalanffy $L_t = L_\infty (1-e^{-k(t-t_o)})$ Combined sex: L_∞ = 524.91 mm k = 0.17249 t_o = -0.3219	Combined sex: L_∞ = 51.2 cm k = 0.16 t_o = -0.2 Male: L_∞ = 48.5 k = 0.21 t_o = 1.0 Female: L_∞ = 53.0 k = 0.20 t_o = 1.4
Calculated lengths at selected ages.	Age / Male / Female 4 / -- / -- 6 / 38.7 cm / 39.8 cm 8 / 40.7 / 43.0	Age / Combined Sex 4 / 275.8 mm 6 / 348.5 8 / 400.0	Age / Male / Female / Combined Sex 4 / 22.7 / 21.5 / 25.1 6 / 31.5 / 31.9 / 32.2 8 / 37.3 / 38.8 / 37.4
Age (size) at maturity.	-- --	Both (sexes):13 inches (33.0 cm) 50% = 5 years	

[a]Six used two readings of otoliths and calculated parameters for each reading individually. Calculated length presented here is average of two estimates.

TABLE 16. Fitted length-at-age and mean observed length-at-age of yellowtail rockfish (Sebastes flavidus) and the length-at-age equation determined from individuals aged by otoliths and collected from Depoe Bay, Oregon, from 1978-80. Asterisk (*) indicates ages not used in determination of length-at-age equation due to small sample size.

Both Sexes					Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
3	13	25.7	24.7	3.4	*3	1	28.0	--	--	3	5	27.2	26.7	0.9
4	27	28.3	28.8	2.7	*4	5	28.0	--	1.1	4	11	29.5	29.8	0.9
5	15	30.6	32.4	2.7	*5	1	35.5	--	--	5	9	31.0	32.4	0.9
6	7	34.9	35.6	4.7	*6	0	--	--	--	6	2	36.0	34.7	1.0
7	3	39.8	38.7	10.6	*7	1	42.0	--	--	*7	1	30.0	--	--
8	6	42.5	43.5	2.4	*8	3	37.3	--	1.4	*8	1	30.5	--	--
*9	4	35.3	--	--	*9	0	--	--	--	*9	1	47.5	-	--
*10	0	--	--	--	*10	0	--	--	--	*10	0	--	--	--
*11	1	47.0	-	--	*11	0	--	--	--	*11	1	47.0	--	--
*12	0	--	--	--	*12	0	--	--	--	*12	0	--	--	--
*13	0	--	--	--	*13	0	-	--	--	*13	0	--	--	--
*14	1	45.0	--	--	*14	1	45.0	--	--	*14	0	--	--	--

Both Sexes	Male	Female
Length-at-age equation	Length-at-age equation	Length-at-age equation
$\ell = 13.7965\ A^{0.52966}$	Not calculated	$\ell = 17.675\ A^{0.37655}$

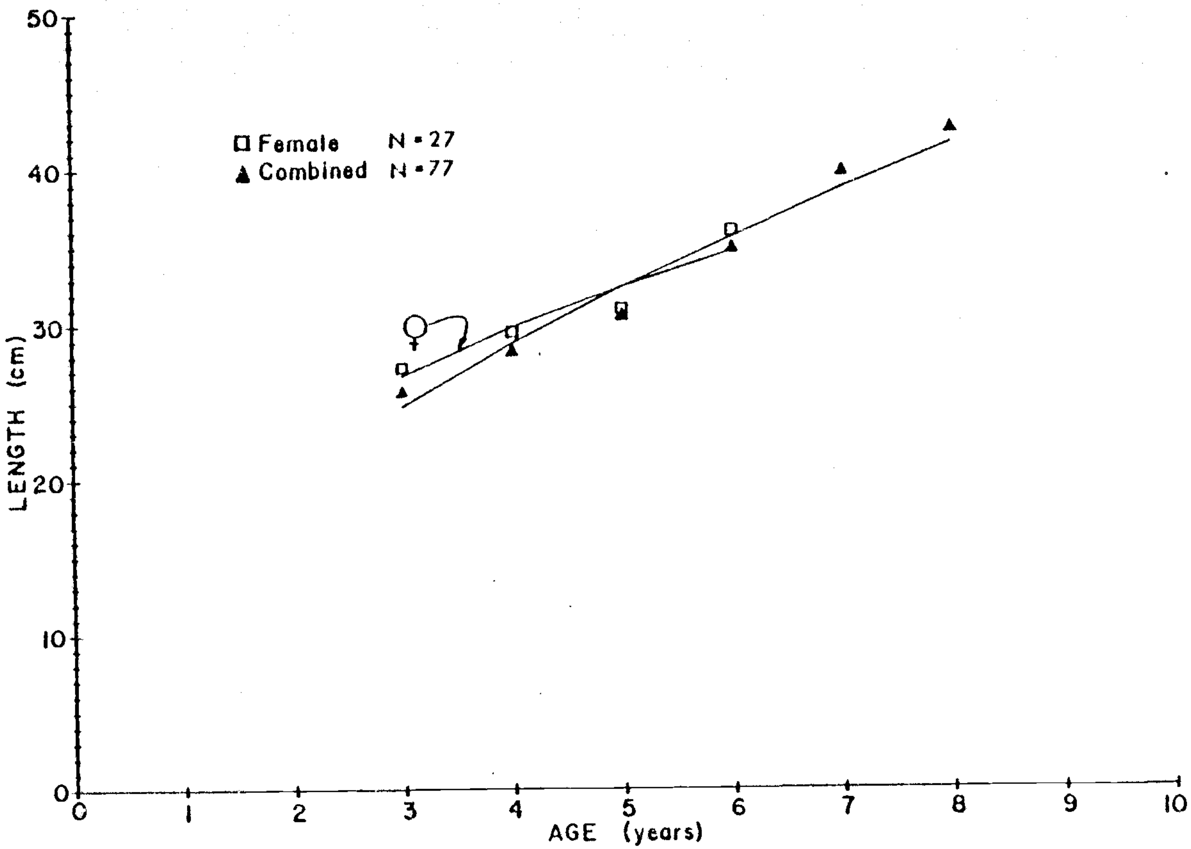

FIGURE 23. Calculated length-at-age curves and mean observed length-at-age of yellowtail rockfish (*Sebastes flavidus*) taken by hook-and-line off Depoe Bay, Oregon, 1978-80.

length-at-age with those reported by other workers reveals similar findings from this study and those based on commercial catches (Fraidenberg 1980; Six and Horton 1977; Phillips 1964; and Westrheim and Harling 1975) which are presented in Table 15.

Yellowtail rockfish first become abundant in the fishery at age 3 (~ 25 cm fork length), and are fully recruited to the fishery by age 5 (~ 32.5 cm fork length) as indicated by length frequency of the total catch examined from 1978-80 (Fig. 24).

Examination of the annual length frequencies of the catch (Fig. 25) indicates that over the period 1978-80, mean length of the catch increased from 30.5 cm (1978) to 32.6 cm (1979) and 39.8 cm (1980). This corresponds closely to the progression of lengths at ages 5 (mean length 30.6 cm), 6 (mean length 34.9 cm), and 7 (mean length 39.8 cm). Such a progression of length frequency could indicate the presence of a strong 1972 year class supporting the catches of this species in the fishery. Without complete catch data it is difficult to determine the condition or strength of the yellowtail rockfish population being fished.

Estimates of age at sexual maturity (Table 17) were difficult to project due to the small sample size. However, comparison of maturity estimates from other studies (Table 15) helps provide estimates of maturity. I found no mature females in my samples of age 5 or younger. I found one mature individual of age 9. Phillips (1964) suggests that 50% of the individuals from his samples were mature by age 5 (33.0 cm fork length). Barker (1979) found no mature females

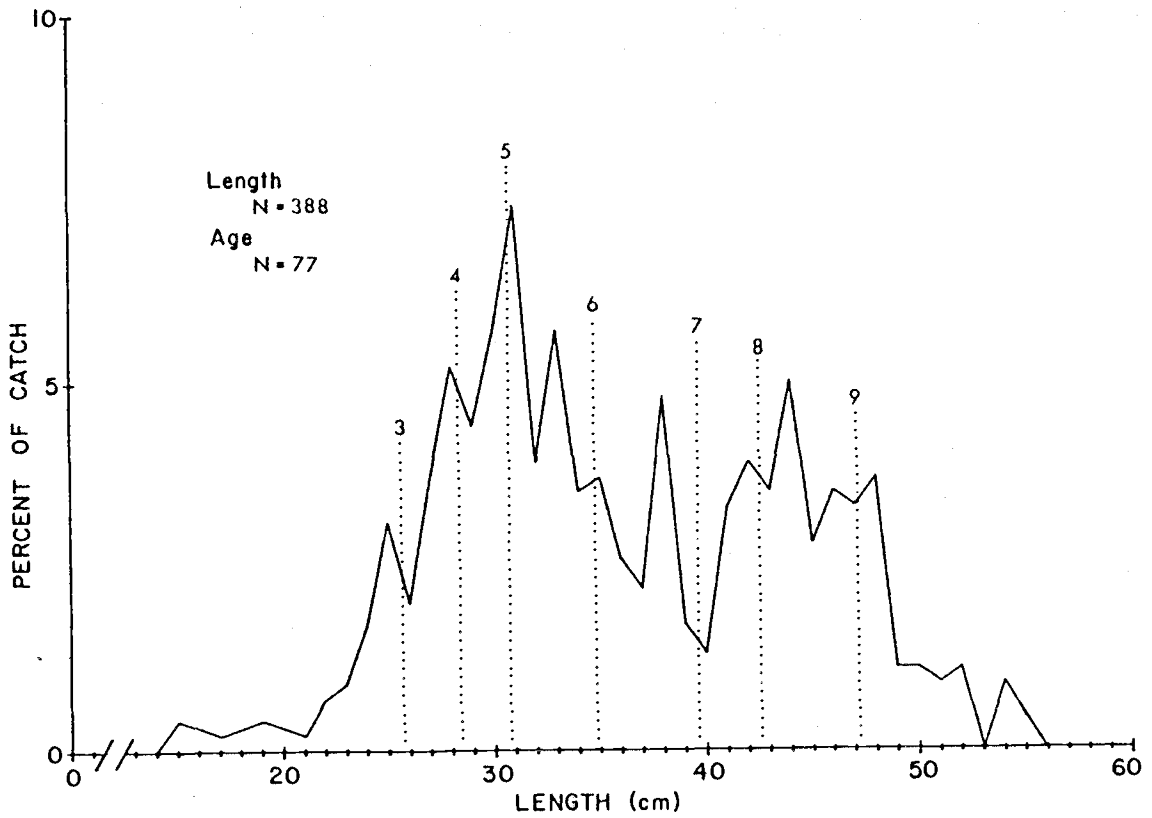

FIGURE 24. Length frequency of all yellowtail rockfish (Sebastes flavidus) sampled from the hook-and-line catch taken off Depoe Bay, Oregon, during 1978-80. Estimated ages are projected at mean observed length-at-age for the combined sexes.

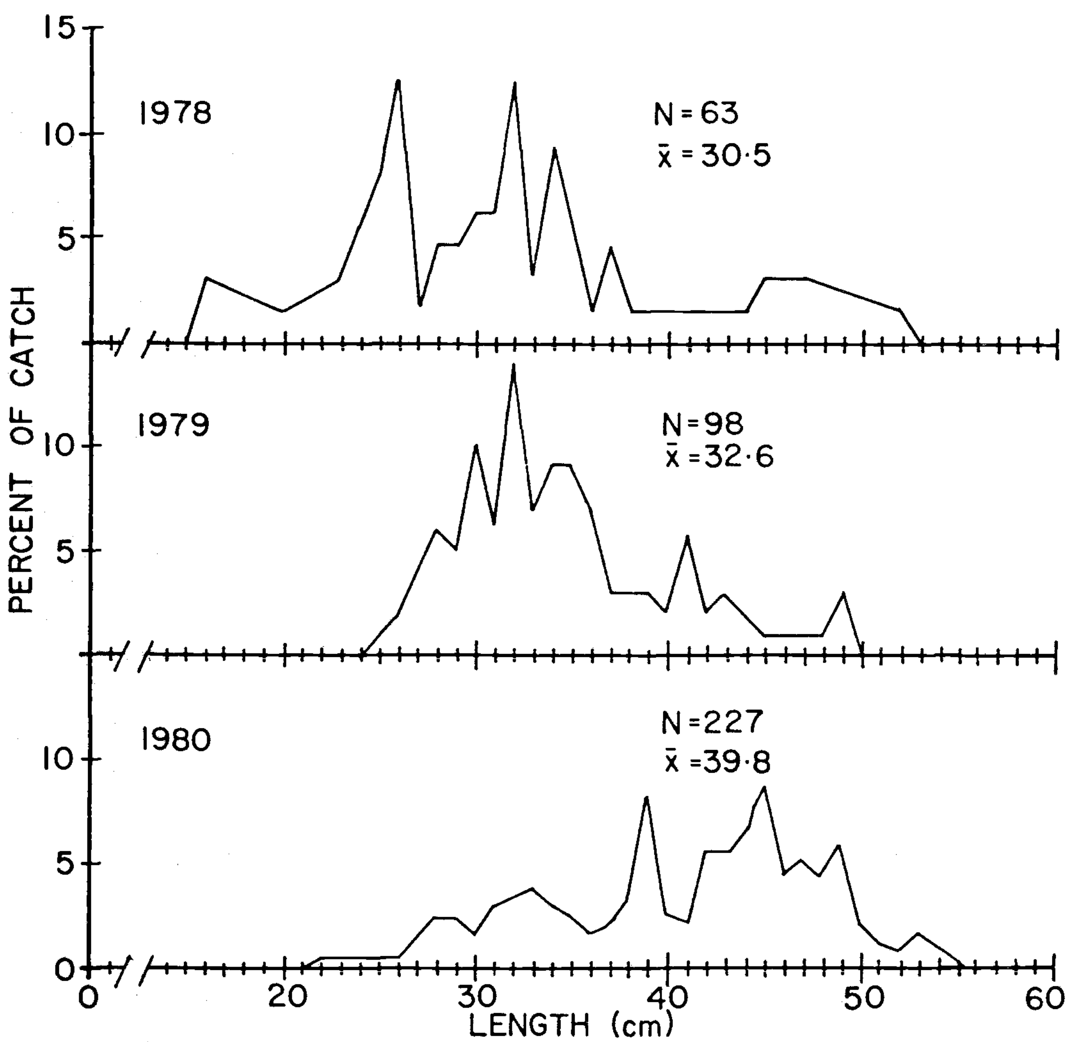

FIGURE 25. Annual length frequencies of yellowtail rockfish (*Sebastes flavidus*) taken by hook-and-line off Depoe Bay, Oregon from 1978-80. Number of fish sampled (N) and mean length of all fish sampled (x) are also presented.

TABLE 17. Percentage of sexually mature yellowtail rockfish (*Sebastes flavidus*) by age, based on gonadal examination. Fish captured by hook-and-line from the neritic reefs off Depoe Bay, Oregon, from 1978-80. No samples were available for males aged 9-13 years, or females aged 10-15 years.

	Male		Female	
Age	Number sampled	% sexually mature	Number sampled	% sexually mature
2	1	0	0	-
3	1	0	4	0
4	5	0	6	0
5	0	-	4	0
6	0	-	0	-
7	0	-	0	-
8	1	0	0	-
9	0	-	1	100

14	1	100	0	-
15	1	100	4	100
16+	2	100	4	100

through age 7. From these observations it may be estimated that female yellowtail rockfish mature sometime between the ages of 5 and 9. I found no mature males of age 4 or younger. I found one immature individual of age 8, and 4 individuals aged 14 and older that were mature. Barker (1979) found no mature individuals at age 7 or younger. From these observations it would appear that males do not mature prior to age 7 or 8.

Survival was estimated for fish of 5 and older at S = 0.578 and total mortality for the same ages was estimated at Z = 0.548. However, these estimates are of questionable value and accuracy due to the small sample size (N = 58.)

Discussion:

Yellowtail rockfish, though not consistently common in the recreational catch, do contribute heavily to the catch at times. The number of fish available for analysis here was limited and as such my data may be biased. This species was often absent from catches for several weeks and when they were present a single individual or large numbers could be taken, suggesting movement into and out of the neritic reef areas.

As this species is important commerically it has recently received much attention and various aspects of the fishery and life history of the yellowtail rockfish have been addressed (Fraidenberg 1980; Barker 1979; Phillips 1964; Westrheim and Harling 1975; Six and Horton 1977). These authors, except Barker (1979), relied upon trawl caught samples for their data. As a consequence, these data may not be directly applicable to the populations caught by recreational anglers on neritic reefs.

This study suggests that both sexes found in the neritic reef areas have similar weight-length relationships, an unusual condition for the Sebastes studied. However, this similarity is probably a result of the small sample size of this study. Fraidenberg (1980) did not feel that the sexes were adequately described by a single equation for trawl caught fish. The models he presented suggest that at lengths > 32 cm the fish were heavier than the fish from my study. This could be an expression of growth differences between nearshore and offshore populations if such seperate populations do exist.

Lingcod

Results:

Fork lengths were recorded from 1,281 lingcod and whole weights were also recorded from 478 of these individuals. The weight-length relationship was determined seperately for each sex because of the obvious size differences between sexes. The exponential models describing the weight-length relationship of each sex is presented in Table 1. The calculated weight-length curves are presented in Figure 26.

Examination of the weight-length curves illustrates that the relationship of both sexes is similar, up to a length of ~ 70 cm. At lengths of 70 to 89 cm males are slightly heavier than females of equal length. No males > 89 cm were observed in this study, but

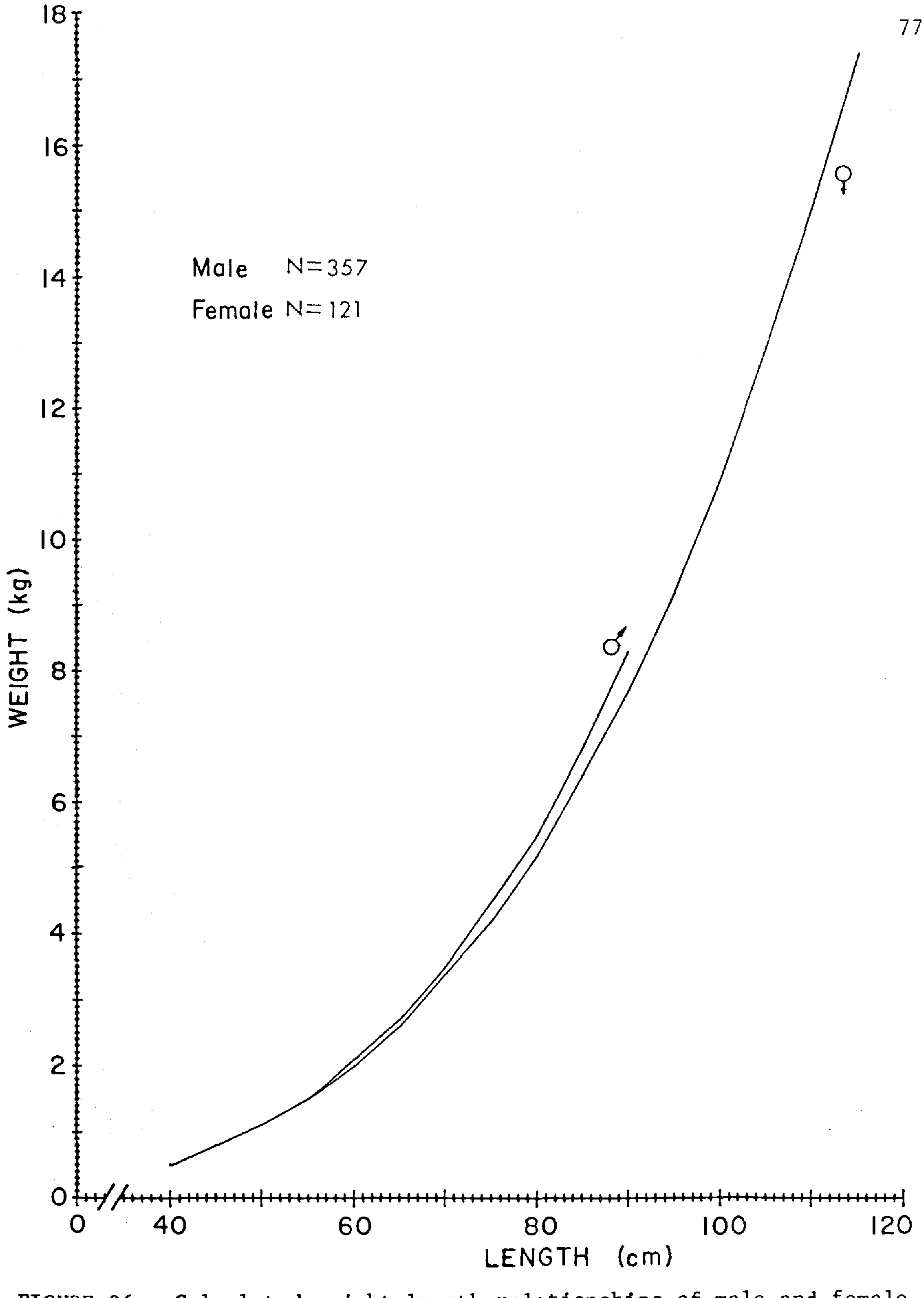

FIGURE 26. Calculated weight length relationships of male and female lingcod (Ophiodon elongatus) taken by hook-and-line off Depoe Bay, Oregon, during 1976-80.

females > 100 cm were not uncommon in the catch. The largest male recorded in this study was 89.0 cm long and weighed 7.7 kg. The largest female recorded was 120.0 cm long and the weight, though not measured, was estimated to be in excess of 18 kg (based on weights of other females of 115 cm fork length).

The method used for sectioning fin rays for age estimation proved to be unsatisfactory in nearly 50% of the cases. The lubricating water, apparently under pressure between the saw blade and the section being cut, often forced the center of the fin ray out of the section, rendering it useless. As a result, fewer than half of the 300 sections cut were useful for age determination (N = 144).

All fin ray sections were subjected to two independent age estimates in order to establish the degree of consistency between readings. Agreement between assigned ages occurred in 53% of the cases while 70% agreed within one year ($\pm$ 1 year).

Age estimates and measured lengths were fitted to the von Bertalanffy equation using the computer program BGC2. The models describing the age-length relationships are presented in Table 18. Comparison of the resulting models with those presented by Beamish and Chilton (1977) show close agreement for lengths of females, and for males through age 4 (Table 19). Beyond age 4 the males from that study appear to be longer than those from this study. Estimated lengths presented by Chatwin (1956) for lingcod from British Columbia show smaller fish at age 2, similar lengths at age 4, longer males and shorter females at age 6; and longer fish of both sexes at age 8.

TABLE 18. Mean observed length-at-age and fitted von Bertalanffy estimates of length-at-age determined for lingcod (Ophiodon elongatus) aged by examination of fin ray sections and captured by hook-and-line from neritic reefs off Depoe Bay, Oregon; 1978-80. Asterisk (*) denotes ages not used in calculation of von Bertalanffy parameters due to small sample size.

Male					Female				
Age	N	Observed length (cm)	Fitted length (cm)	Standard error	Age	N	Observed length (cm)	Fitted length (cm)	Standard error
1	0	--	--	--	1	0	--	--	--
2	13	52.9	54.1	2.3	2	3	50.7	52.2	1.5
3	19	60.0	58.9	2.1	3	3	60.0	60.6	6.2
4	29	63.8	62.8	1.2	4	8	70.3	67.9	2.0
5	31	65.4	66.0	1.3	5	3	76.0	74.3	7.6
6	9	64.1	68.5	3.2	6	3	74.8	79.8	4.6
7	10	71.4	70.5	3.1	7	4	83.5	84.6	2.7
8	4	76.3	72.2	2.2	8	2	94.6	88.7	14.6
9	0	--	--	--	9	0	--	--	--
*10	1	81.2	--	0	*10	2	107.5	--	10.6

von Bertalanffy Length-at-age Parameters (and standard error)

Male		Female	
L_∞ = 79.0 cm	(12.37)	L_∞ = 115.8 cm	(55.19)
k = 0.216	(0.174)	k = 0.142	(0.181)
t_o = 3.3401	(3.0452)	t_o = -2.2182	(3.0520)

TABLE 19. Comparison of biological statistics of lingcod (*Ophiodon elongatus*) sampled from neritic reefs off Depoe Bay, Oregon, with those from other studies and areas.

Statistic	Depoe Bay (this study)	British Columbia (Chatwin 1956)	British Columbia (Beamish & Chilton 1977[a,c])
Equation decribing length-age relationship.	von Bertalanffy $L_t = L_\infty (1-e^{-k(t-t_o)})$ Male: L_∞ = 79.02 k = 0.21594 t_o = 3.34 Female: L_∞ = 115.83 k = 0.14202 t_o = 2.22	No data	von Bertalanffy $L_t = L_\infty (1-e^{-k(t-t_o)})$ Male: (scale) L_∞=143.6; k = 0.042; t_o = 10.77 / (fin ray) L_∞=106.2; k = 0.079; t_o = -8.06 Female: (scale) L_∞ = 109.6; k = 0.192; t_o = -1.94 / (fin ray) L_∞ = 117.1; k = 0.149; t_o = -2.15

Statistic	Age	Male	Female	Age	Male[b]	Female[b]	Age[c]		Male	Female
Calculated lengths at selected ages.	2	54.1	52.2	2	48.2	47.9	2	(1)	--	--
								(2)	49.0	--
	4	62.8	67.9	4	62.9	66.3	4	(1)	64.4	69.9
								(2)	64.5	68.0
	6	68.5	79.8	6	73.4	75.6	6	(1)	77.2	80.1
								(2)	71.0	83.5
	8	72.2	88.7	8	84.0	94.1	8	(1)	78.5	85.8
								(2)	81.0	97.0

[a] Beamish and Chilton present estimates from aging by scales (1) and by fin-ray sections (2).

[b] Lengths estimated from Figure 1, Chatwin (1956); as presented by Beamish and Chilton (1977).

[c] Estimated length from Strait of Georgia (1) and Queen Charlotte Sound (2) samples, fin-ray ages.

Such variation between young and old ages may suggest a difference in ageing techniques or actual biological differences betweeen the two areas.

The calculated age-length curves from this study are presented in Figure 27. Examination of these curves indicates that at ages greater than 2 years, females are substantially longer than males of equal age.

Examination of the length frequency of the catch for the years 1976-80 (Fig. 28) indicates that few lingcod of < 45 cm length were taken in the catch. Most of the catch was composed of fish of 55 to and 95 cm, with few individuals > 105 cm taken. Also evident is that more of the individuals < 80 cm long are male than are female. The length frequency for each year (1976 to 1980) indicates that the mean length of the 1980 catch was slightly shorter than the mean length of the previous years combined (69.6 cm) (Fig. 29). The cause for this decrease may be the slight decrease in the number of large (> 90 cm) individuals included in the catch. This decrease may indicate that the fishery is suffering from excessive pressure, resulting in fewer large individuals remaining in the population. However, based on my observations of the fishery I believe that the decrease lies, at least in part, with the prevailing attitude of anglers towards large lingcod. This theory will be discussed below.

Lingcod were not examined for maturity, but other studies have presented maturity estimates (Miller and Geibel 1973).

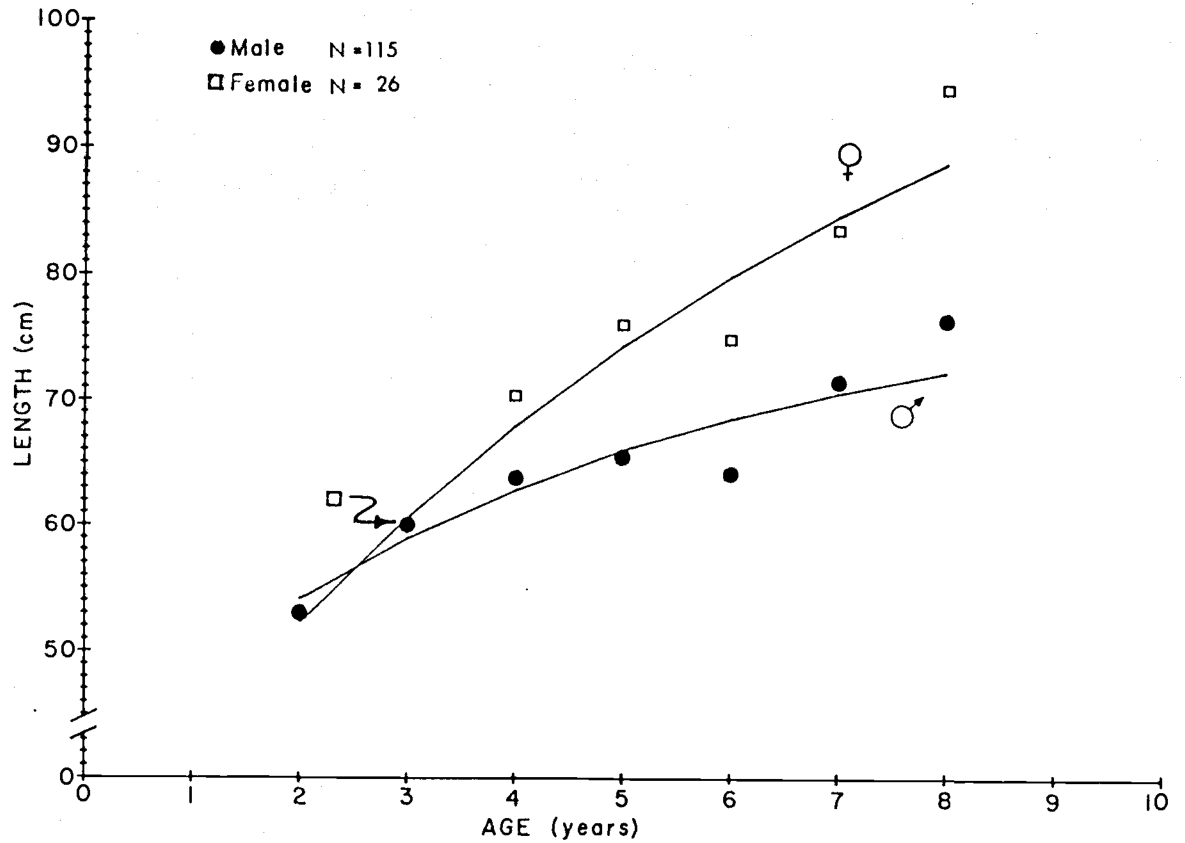

FIGURE 27. Calculated length-at-age curves and mean observed length-at-age of lingcod (*Ophiodon elongatus*) taken by hook-and-line off Depoe Bay, Oregon, 1978-80.

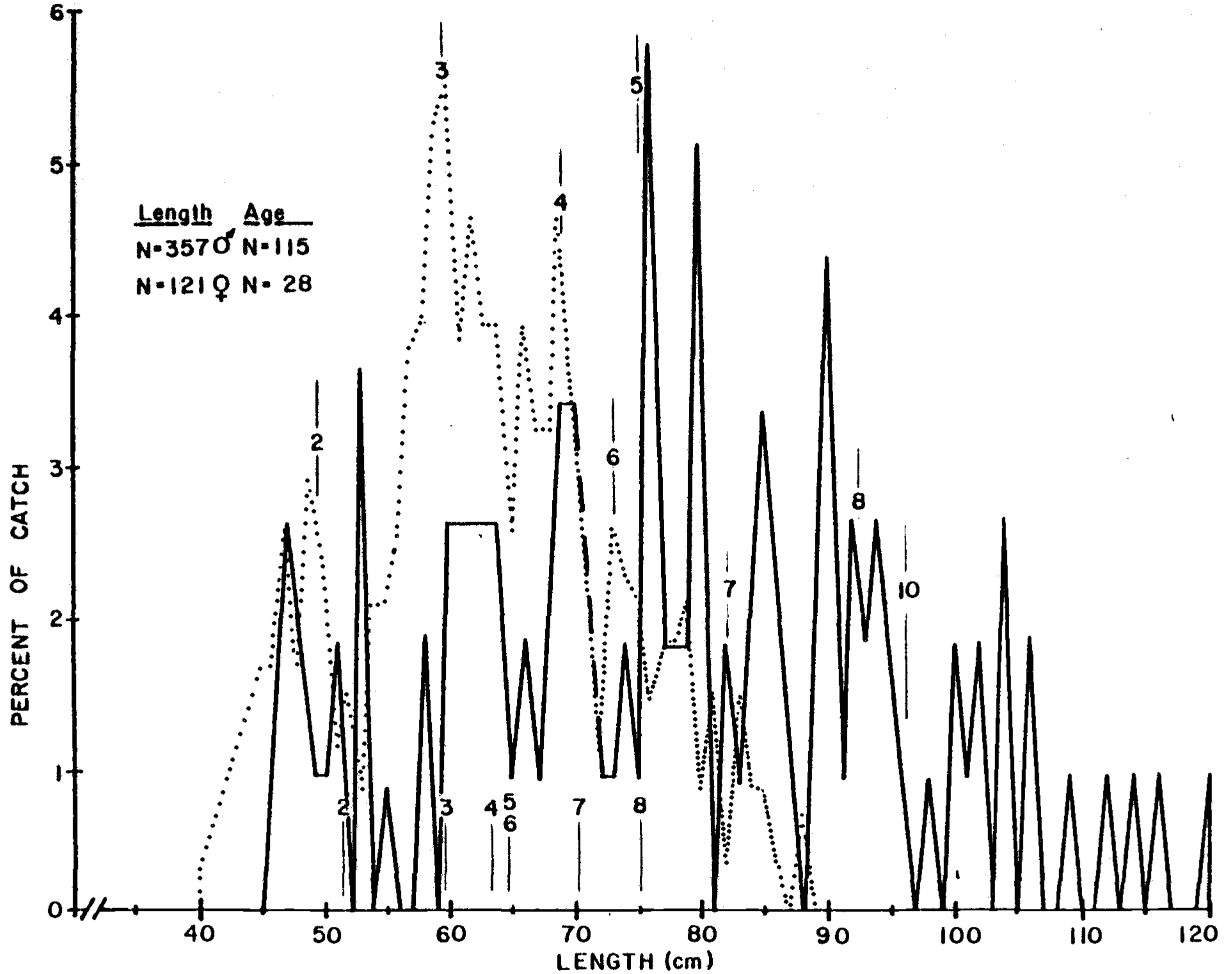

FIGURE 28. Length frequency of all lingcod (Ophiodon elongatus) sampled from the hook-and-line catch taken off Depoe Bay, Oregon, during 1976-80. Estimated ages are projected at mean observed length-at-age for males (lower age set and dotted lines) and females (upper age set and solid lines).

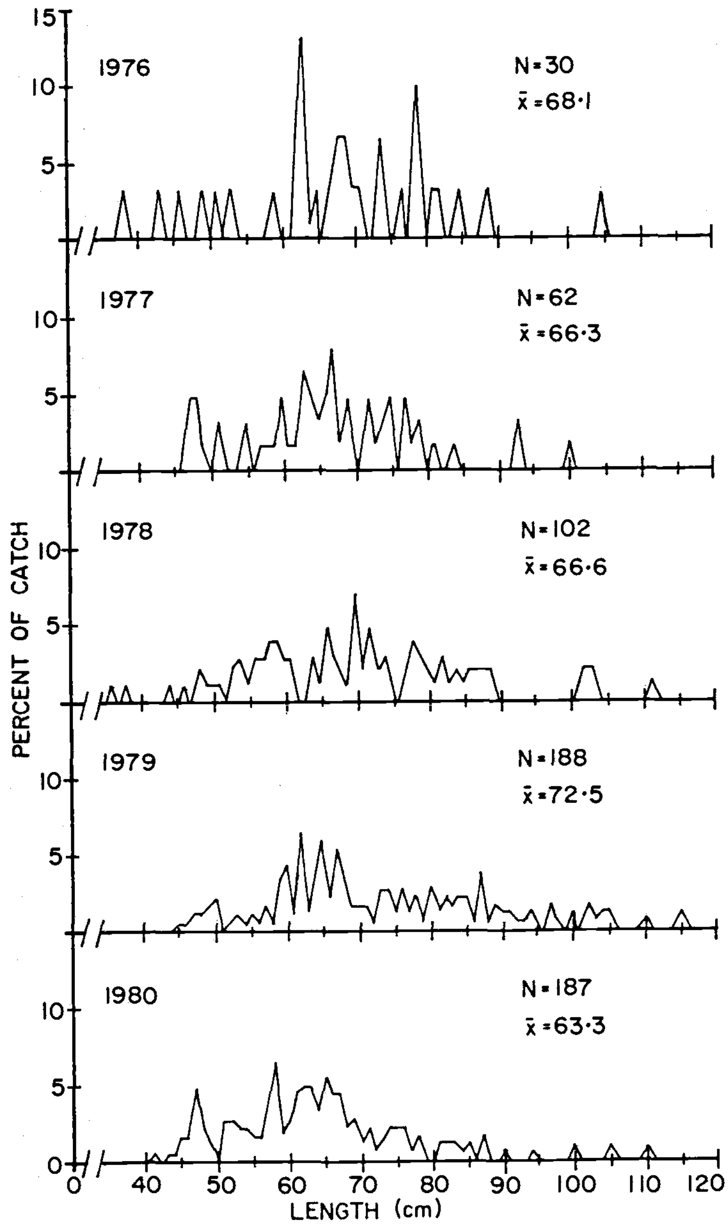

FIGURE 29. Annual length frequencies of lingcod (Ophiodon elongatus) taken by hook-and-line off Depoe Bay, Oregon, from 1976-80. Number sampled (N) and mean length (x) are also presented.

The superimposed ages on the total length frequency graph (Fig. 28) indicate that lingcod of both sexes first enter the fishery before age 2 (~50 cm fork length). It may also be seen that although a large number of immature fish are taken by the fishery, the majority are mature (Miller and Giebel [1973] found most females > 60.0 cm and most males > 50.0 cm to be mature) and have probably been mature for at least one spawning season.

Discussion:

The lingcod is one of the most highly prized sport fishes of the central Oregon coast. In addition, it is a highly popular market species and is fished commercially. As such it is subject to relatively heavy fishing pressure in both nearshore (recreational) and offshore (commercial) areas.

Traditionally the recreational angler has prized a large (> 100 cm length and > 12 kg weight) lingcod over a small one. As apparent from data here (Fig. 26) Miller and Geibel (1973), and stated by Low and Beamish (1978), the majority of lingcod > 90 cm in length are females. The result being that anglers exhibited an indirect preference for female lingcod.

Since the inception of this project in 1976 the anglers of Depoe Bay have exhibited great interest and cooperation. Once they learned that most of the large lingcod were female, many began a voluntary practice of returning all large (> 90 cm) lingcod to the sea unharmed. This was done with the belief that such a practice will result in increased spawning in the immediate area and subsequently better catches of lingcod in the future. Many charter boat captains have also adopted this philosophy aboard their vessels and enforce it (explain, and strongly suggest) among their charter anglers.

Though this release of large "spawners" may indeed increase the number of egg masses (nests), studies indicate that unless a sufficient number of males are present to guard the nests, survival will not be increased (Jewell 1968; Low and Beamish 1978). Until estimates of the population size of the area are made, the effect of this practice will not be known. I believe that this returning of "spawners" rather than a decrease in the numbers of large (female) individuals is at least partially responsible for the observed reduction in the percentage of large individuals in the catch observed at the docks.

SUMMARY AND CONCLUSIONS

I have presented age, length, weight, and length frequency of rockfishs and lingcod taken by recreational anglers, and by researchers using recreational fishing gear, from 1978 through 1980.

The weight-length, and length-at-age relationships were determined for each species and compared to other sutides, where available. Differences in the size and age statistics are probably due to geographic variation or ecological differences between study areas. Such differences have been demonstrated for split-nose rockfish (Boehlert and Kappenmann 1980) and suggested for blue rockfish (Miller and Geibel 1973). Differences in growth (length or weight at age) between geographically and/or ecologically different areas have received little attention. Data presented here suggests that mixing of individuals from different areas (e.g., nearshore/offshore) may be occuring in these neritic areas. In order to better understand and manage these resources, it will be necessary to better understand this mixing.

Recent changes in the attitude of anglers toward rockfish and large lingcod have demonstrated their concern about the condition of the resource, and may be responsible for recently observed changes in length composition of the recreational catch.

All species examined appear to support sizeable populations within the study area, or are apparently supported by movements of fish into the area (i.e., yellowtail rockfish). The recreational fishery appears to have no deleterious effect on the neritic reef populations, though over-fishing of yelloweye rockfish on small, deeper reefs may occur at times.

Further study to establish the size of neritic populations and the possible interactions between nearshore and offshore populations will provide a much more sound understanding of these species and enable managers to establish regulations based on more biologically sound information. In their present state the regulations now in effect appear to be adequate to prevent overfishing, yet allow sufficient catches to satisfy most anglers.

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APPENDIX

Appendix A.

Fin Ray Lamination Process

Many workers now utilize transverse sections of dorsal or pectoral fin rays for determination of age and growth characteristics (Beamish and Chilton 1977; Freeze 1977). In this study I utilized sections of the dorsal fin ray of lingcod (*Ophiodon elongatus*) in preference to scales or otoliths.

Mounting of these sections on glass slides using liquid mounting media proved to be time consuming and cumbersome. The need for microscope slides, storage boxes, and identification labels proved to be expensive, required a large amount of space (drying of several mountings at once), and invariably one or more slides would be broken during mounting or reading. Alternatively, I developed the simple method described here. This method provides for mounting several sections (from several fin rays) on a single, unbreakable card and can be easily read using compound or dissecting microscopes or standard microfiche readers.

The materials required for this method of mounting are:

1. Clear acetate sheeting (0.5 mm thick) cut into 3- x 5-inch cards.

2. Clear or frosted (no pattern), adhesive backed vinyl shelf paper; cut into 3- x 5-inch sheets.

3. Permanent ink, felt-tipped markers (Sharpie-type); black or blue color.

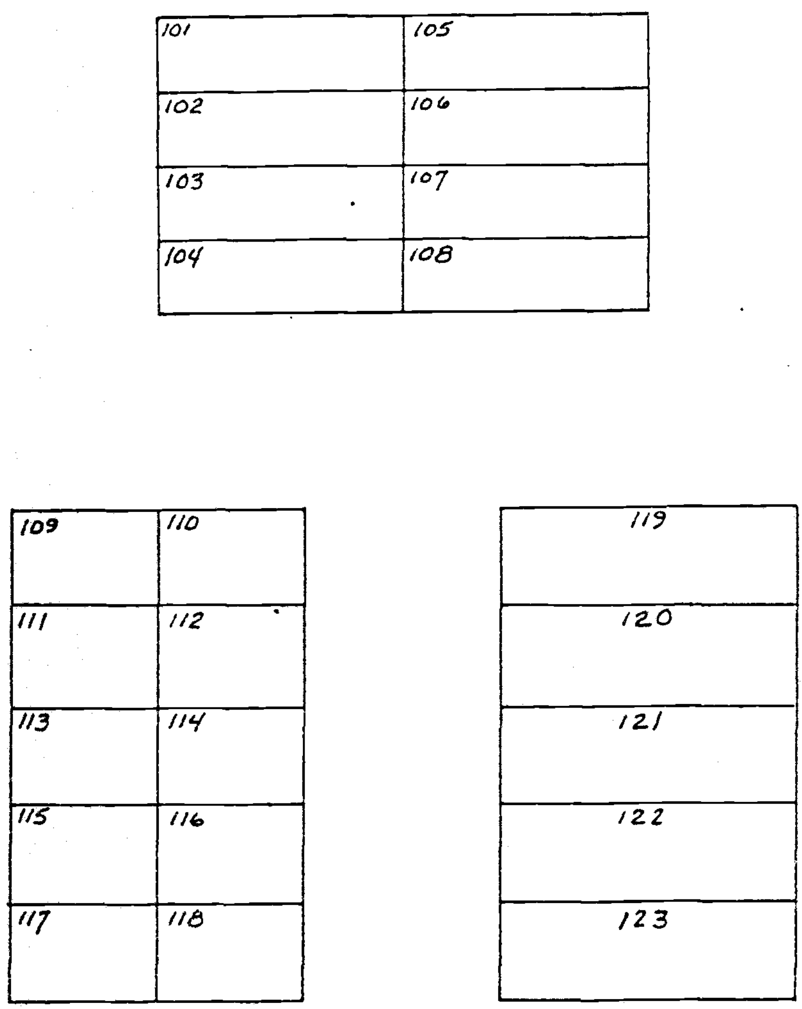
4. Artists brayer or printers roller (rubber surfaced hand roller) 3-6 inches wide.

The acetate cards are marked in appropriate manner for positioning and identifying the samples to be mounted. The marking pattern will vary with the size and numbers of sections to be mounted on each card. Three examples of patterns I used are presented in Figure 1 in their final form. Sample numbers may be marked on prior to mounting or during the mounting process.

To mount the samples an acetate card is placed on the work surface and a vinyl sheet (backing removed) is placed on top of it, adhesive side up, away from the vinyl card. This allows the markings on the card to be viewed through the vinyl sheet without adhering to the card. The sections are then carefully placed on the adhesive surface, over the appropriately marked spaces indicated on the underlying acetate card. Once all samples have been positioned on the vinyl sheet, the acetate card is slid from underneath and placed over the mounted sections. Care should be taken to properly position the card to avoid misalignment. Should misalignment occur, the vinyl sheet may be carefully peeled off the acetate and repositioned.

Once properly aligned the card is placed acetate side down on a hard, smooth surface and the brayer (or roller) is rolled across the vinyl surface several times. This stretches the vinyl around the samples and seals the vinyl to the acetate, completing the lamination. The result is a permanent, unbreakable, easily stored and retrievable sample.

The completed lamination may now be viewed under magnification using various microscopes and projecting devices. I prefer to use a standard microfiche viewer/printer. This provides a large image which is easily and comfortably viewed (by one or more persons) and measured. It also provides the option of quick copies of the image using the printer mode of the machine.



Appendix
FIGURE 1. Three examples of marking patterns used for multiple sample, fin ray section cards. Patterns will vary with user preference and sample type.