

Maturity of Widow Rockfish *Sebastes entomelas* from the Northeastern Pacific, 1977-82

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ABSTRACT

Gonad development, size, age, calculated weight at maturity, and fecundity for the widow rockfish (*Sebastes entomelas*) are reported. In 1977-82, a total of 3,636 specimens were examined from commercial trawl and partyboat sport catches off Oregon and California. Gonad development was earlier in southern latitudes. The principal months of parturition were February-March off Oregon and January-February off California. Mean size, age, and calculated mean weight at 50% maturity were 33 cm fork length (FL), 4 years of age, and 534 g for Oregon males, compared with 32 cm FL and 5 years for California males. Oregon females were 50% mature at 38 cm FL, 7 years of age, and 937 g, as compared with 33 cm FL and 5 years for California females. Over 99% of the males and 92% of the females randomly sampled from Oregon landings were mature, compared with 93% males and 94% females from California landings. Fecundity increased with increasing length and ranged from 95,000 to 1,113,000 eggs in Oregon samples.

INTRODUCTION

Research on the life history of the rockfishes has focused primarily on commercially important species (Sorokin 1958, 1967; Shiokawa 1962; Moser 1967; Gunderson 1977) or species in a near-shore habitat (Berge and Schultz 1973; Müller and Geibel 1973; Hallacher 1976; Hobson and Chess 1976; Larson 1977). Some life history information on the widow rockfish (*Sebastes entomelas*) occurs incidentally in studies using market samples (DeLacy and Dryfoos 1962; DeLacy et al. 1964; Phillips 1964) and in trawl surveys (Haring et al. 1971; Hitz 1962; Westrheim 1975; Westrheim and Haring 1975). The species has only recently been focused upon, due to a new and rapidly expanding fishery. In 1979 a target fishery began on widow rockfish off Oregon and California by large domestic trawlers using pelagic trawls. Life history information on these populations is being investigated while the fishery is still young.

The reproductive biology of widow rockfish was investigated to determine months of spawning (parturition) and age and size of sexual maturity for each sex. This information provides a baseline for examination of possible changes in the populations, such as sexual maturity at younger ages as fishing reduces the density of fish. Field studies were conducted to determine age, length, and weight at sexual maturity by sex for widow rockfish landed by the commercial fleet in Oregon during 1979-80. Life history information on *Sebastes* spp. was collected from the sport and commercial fleets in California beginning in 1977, and the program was expanded in 1980 to include reproductive biology. This information has been used to examine reproductive biology of widow rockfish and to make comparisons between the Oregon and California populations.

METHODS

Life history and maturity data were acquired by sampling rockfish in the Oregon commercial fishery and in the California commercial and sport fisheries. The Oregon phase of the sampling began in 1979 on commercial trawl catches made from Cape Blanco to the Columbia River. Since 1979, data collected included fork length, sex, otolith and gonad stage, and descriptions of gonads of individual fish. Individual weight to the nearest 10 g was added to the data collected in December 1979. Information on stomach contents was taken frequently in 1980. Sixty-eight ovaries were collected in December 1980 and January 1981 and processed as described by Boehlert et al. (1982). Samples of approximately 30 fish were taken from commercial landings at least once a month when available. In 1979, 14 random samples were taken, comprised of 195 females and 209 males. In 1980, 31 random samples were taken, comprised of 446 females and 475 males. An additional 49 females and 81 males were selectively sampled because they were either very small or large specimens, and they were needed to supplement the random samples. Sampling began in 1977 on sport catches made in California. Data were collected on morphometrics, meristics, sex, gonad stage, and age (otoliths) for all rockfish species and included 42 male and 80 female widow rockfish. California maturity data collection was expanded in March 1980 on catches made from Eureka to Morro Bay. Random samples of the sport and commercial fisheries contained 15-20 fish per sample for all *Sebastes* spp. landed. Data collected included total length, sex, otoliths, gonad stage, interstitial fat, and stomach contents from 832 male and 1,227 female widow rockfish. Total length (TL) was converted to fork length (FL) by the equation $FL = 6.1635 + 0.9341(TL)$ for com-

paring Oregon and California data (Lenarz 1987).

The Oregon maturity criteria used to describe gonad condition were modified from Westheim (1975) and Gunderson (1977) and are shown in Table 1. California maturity stages were determined in the laboratory after the gonads were preserved in 10% formalin. The criteria (Table 2) were similar to those used in Oregon.

RESULTS

Timing of gonad development

The reproductive biology of the genus *Sebastes* is similar in all species that have been investigated (Eigenmann 1892; Sorokin 1967; Moser 1967; Westheim 1975). *Sebastes entomelas* is ovoviviparous; that is, ova are retained within the ovaries after internal fertilization and contain enough yolk so that no additional nutritive material is supplied to the embryos by the female parent (Hickman 1961; DeLacy et al. 1964; MacGregor 1970). Gestation usually lasts from 1-3 months. Gaseous embryonic wastes are eliminated through the highly vascularized gonad (Moser 1967). While Moser (1967) and MacGregor (1970) reported that some members of the genus have two broods per season, most *Sebastes* species spawn once annually (Westheim 1975). Widow rockfish have a well defined period of egg development and spawn once a year, as shown by our data and by the absence of secondary oocytes as reported by Boehlert et al. (1982).

Samples of Oregon catches indicated that copulation occurred primarily in December. Eggs were fertilized about a month following copulation. Embryos developed at nearly the same rate, and parturition occurred about 1 month following fertilization. Widow rockfish are live bearers, and we observed fish containing large numbers of tiny free larvae.

Gonad development of widow rockfish occurred earlier in southern latitudes as indicated by the principal months of parturition (Table 3). Mature Oregon widow rockfish testes were noticeably swollen in June and contained some noticeable milt in August (Fig. 1). Mature females off Oregon began to display enlarged grey ovaries with opaque white eggs in September. In October as the ovaries enlarged, they become pinky-white in color. By January many females contained colorless, translucent fertilized eggs. Eyed eggs and larvae appeared in February and spawning (parturition) was completed in March.

Gonad development in California fishes begins about a month earlier than in Oregon, with mating during September, fertilized eggs occurring in November, and spawning completed during February (Fig. 1). The trend of later parturition in northern latitudes is confirmed with data from British Columbia where spawning occurs during April (Westheim 1975). There is a time lag of 1 to 2 months between copulation and fertilization. Hence there is the possibility of sperm storage by the female.

Sexual maturity by age, length, and weight

Fifty percent sexual maturity for female widow rockfish occurred at an earlier age and smaller length in southern fishing areas (Table 4). Males appeared to mature sexually at a smaller length and younger age than females off Oregon.

First sexual maturity for males occurred at age 3 yr in Oregon samples (Table 5) and age 3 in California samples (Table 6). Mature females were first seen at age 5 in Oregon samples and age 3 in

Table 1—Gonad condition criteria applied to *Sebastes entomelas* from Oregon landings, 1979-80.

	Code	Condition	Description
Males	1	Immature	String-like, colorless, translucent, very small
	2	Maturing	Slight swelling, translucent, white, small
	3	Mature	Ribbon-like, swollen, brown to white
	4	Developing	Large, swollen, easily broken, milt in sperm duct
	5	Spawning	Swollen, flowing milt when pressure applied to testes
	6	Spent	Swollen, milt in sperm duct
	7	Resting	Ribbon-like, flat, tan or brown
Females	1	Immature	String-like, very small, firm, translucent
	2	Maturing	Small, greyish white, translucent or opaque
	3	Mature	Large, opaque, granular, grey to pinky-white, ova held in follicle
	4	Developing	Fertilized, large, translucent (cleared) eggs with pink cast or colorless, ova usually not held in follicle
	5	Spawning	Eyed eggs and/or larvae, ova not held in follicle, large, contains much fluid
	6	Spent	Flaccid, purple to pink ovary, flattened elliptical in cross section
	7	Resting	Moderate size, firm, red-grey ovary

Table 2—Gonad condition codes applied to *Sebastes entomelas* from California landings.

Code	Males	Code	Females
1	Immature	1	Immature
2	Maturing	2	Maturing
3	Mature	3	Mature
		4	Fertilized (developing)
		5	Eyed larvae (spawning)
		6	Spent
7	Resting	7	Resting

Table 3—Principal months of parturition by area for *Sebastes entomelas*.

Area	Month
California	January-February
Oregon	February-March
British Columbia	April

¹from Westheim (1975)

Table 4—Percent maturity for Oregon, California, and British Columbia *Sebastes entomelas* by age, size, and weight.

	Maturity %	Males			Females		
		Age (yr)	Length (cm)	Weight (g)	Age (yr)	Length (cm)	Weight (g)
Oregon	>0	3	31	444	5	35	662
	50	4	33	534	7	38	937
	100	3	38	370	9	43	1150
California	>0	4	25	—	4	25	—
	50	5	32	—	5	33	—
	100	3	46	—	3	46	—
British Columbia ¹	50	—	37	—	—	38	—

¹from Westheim (1975)

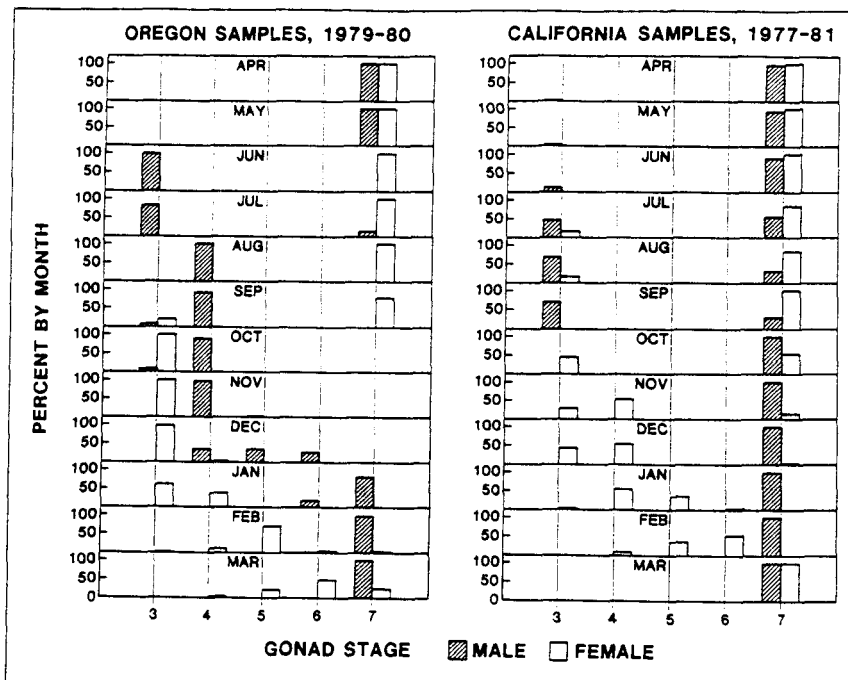


Figure 1—Gonad condition of *Sebastes entomelas* by month from Oregon samples, 1979-80, and from California samples, 1977-81. See Appendix for actual percent distribution of Oregon random samples.

Table 5—Maturity by age and sex for *Sebastes entomelas* for Oregon samples, 1979-80 (includes random and nonrandom age samples).

Age (yr)	Number				%	
	Immature		Mature		Mature	
	M	F	M	F	M	F
3	0	—	1	—	100	—
4	6	4	5	0	46	0
5	10	23	29	4	74	15
6	1	10	21	2	96	17
7	2	3	16	—	89	70
8	0	6	59	23	100	79
9	2	8	196	150	99	95
10	0	6	187	217	100	97
11	0	2	74	73	100	97
12	0	0	41	36	100	100
13	0	0	15	19	100	100
14	0	0	7	15	100	100
15	0	0	8	10	100	100
16	0	0	4	8	100	100
17	0	0	3	3	100	100
18	0	0	1	4	100	100
19	—	0	—	4	—	100
20	—	0	—	4	—	100
21	—	0	—	1	—	100
22	—	0	—	2	—	100
23	—	0	—	2	—	100
Total no.	21	62	667	584		

Table 6—Maturity by age and sex for *Sebastes entomelas* from samples off California, 1977-82.

Age (yr)	Number				%	
	Immature		Mature		Mature	
	M	F	M	F	M	F
2	1	1	—	—	—	—
3	9	13	3	2	25	13
4	17	23	4	6	19	21
5	9	14	24	25	73	64
6	9	5	36	44	80	90
7	5	5	40	45	90	90
8	1	—	38	41	97	100
9	—	1	55	62	100	98
10	4	—	96	124	96	100
11	2	2	139	160	99	99
12	2	3	120	152	98	98
13	—	4	65	122	100	97
14	—	—	54	97	100	100
15	—	1	28	78	100	99
16	—	—	37	73	100	100
17	—	—	17	46	100	100
18	—	—	10	41	100	100
19	—	—	8	19	100	100
20	—	—	6	10	100	100
21	—	—	2	8	100	100
22	—	—	1	10	100	100
Total no.	59	72	783	1165		

California samples. Males from Oregon samples were 50% mature at about age 4 and 100% mature at age 8. California males were 50% and 100% mature at about age 5 and 8, respectively. Oregon female widow rockfish were 50% and 100% sexually mature at about age 7 and 9, respectively. Off California, females reached 50% and 100% sexual maturity at about age 5 and 8, respectively.

Off Oregon, males began to mature sexually at about 31 cm FL, with 50% mature at 33 cm, most mature at 36 cm, and all mature at 38 cm (Table 7). Females began to mature at 35 cm, and were 50% mature at about 38 cm and almost 100% mature at 42 cm.

Widow rockfish sexual maturity off California began at about 25 cm for males and 26 cm for females (Table 8). Most males and females were mature at 38 cm, but all fish may not have been mature until they were about 46 cm.

Westrheim (1975) reported that length at 50% maturity in the area of West Vancouver Island was 37 cm for males and 38 cm for females.

Calculated mean weight at first sexual maturity was 444 g for males and 662 g for females from Oregon samples (Table 4). Respective weights at 50% and 100% maturity were calculated at 534 g and 870 g for males and 937 g and 1,150 g for females.

Maturity of fish taken by Oregon trawl fishery

Most widow rockfish were sexually mature in the random samples from Oregon commercial trawl landings in 1979-80. By number, about 99% of the males and over 92% of the females were mature (Table 9).

Fecundity

Boehlert et al. (1982) reported on the fecundity of widow rockfish from Oregon samples taken in December 1980 and January 1981. Fecundity increased with increasing length, weight, and usually age. Estimates of fecundity ranged from 95,375 oocytes at 33 cm FL to 1,113,000 oocytes at 52 cm FL. The fecundity-length and fecundity-weight relationships were as follows.

$$\text{Length } F = 59,182.4 L - 1,999,200; r^2 = 0.90; N = 64$$

$$\text{Weight } F = 605.71 W - 261,830.7; r^2 = 0.91; N = 64$$

where F = fecundity, L = fork length (cm); W = weight (gm), r^2 = coefficient of determination, and N = number of specimens.

Table 7—Maturity by fork length and sex for *Sebastes entomelas* from Oregon trawl catches, 1979-80. Selected fish included.

Length (cm)	Number				% Mature	
	Immature		Mature		M	F
	M	F	M	F		
29	—	1	—	0	—	0
30	—	—	—	—	—	—
31	0	—	2	—	100	—
32	3	1	1	0	25	0
33	6	6	6	0	50	0
34	3	10	6	0	67	0
35	5	14	26	1	84	7
36	2	11	51	1	96	9
37	2	14	56	8	97	36
38	0	6	87	15	100	71
39	0	3	123	26	100	90
40	1	4	119	52	99	93
41	0	5	100	83	100	94
42	0	1	65	83	100	99
43	0	0	39	101	100	100
44	0	0	18	70	100	100
45	0	0	10	61	100	100
46	0	0	6	32	100	100
47	0	0	1	21	100	100
48	0	0	1	16	100	100
49	—	0	—	17	—	100
50	—	0	—	12	—	100
51	0	0	1	7	100	100
52	—	0	—	3	—	100
53	—	0	—	1	—	100
54	—	0	—	1	—	100
Total no.	22	76	718	611		

Table 8—Maturity by fork length and sex for *Sebastes entomelas* from California, 1977-82.

Length (cm)	Number				% Mature	
	Immature		Mature		M	F
	M	F	M	F		
22	2	1	—	—	0	0
24	1	—	—	—	0	0
25	1	1	1	—	50	0
26	1	1	4	1	80	50
27	2	4	1	3	33	43
28	6	7	1	1	14	13
29	3	7	1	—	25	0
30	5	8	4	3	44	27
31	6	9	2	4	25	33
32	4	3	5	2	56	40
33	1	4	3	6	75	60
34	2	2	6	6	75	75
35	5	1	6	7	55	88
36	3	6	13	9	81	60
37	6	4	10	16	63	80
38	2	2	23	10	92	83
39	4	1	35	19	90	90
40	2	—	59	21	97	100
41	2	1	31	28	98	97
42	1	1	121	35	99	97
43	5	2	158	47	97	96
44	1	2	122	75	99	97
45	2	1	87	133	98	99
46	—	—	40	145	100	100
47	—	—	19	137	100	100
48	—	—	3	140	100	100
49	—	—	2	164	100	100
50	—	—	—	116	—	100
51	—	—	—	67	—	100
52	—	—	—	28	—	100
53	—	—	—	10	—	100
54	—	—	—	2	—	100
Total no.	67	67	807	1235		

Table 9—Sexual maturity by number in random samples of *Sebastes entomelas* from Oregon trawl landings, 1979-80.

	1979		1980	
	Male	Female	Male	Female
No immature	1	14	4	25
No mature	208	181	475	421
% mature	99.5	92.8	99.2	94.4

The length-fecundity and weight-fecundity relationships described by Boehlert et al. (1982) differed significantly from data presented by Phillips (1964) on California widow rockfish. Fecundity of California fish was generally lower with respect to length and weight. The smallest number of developing eggs that Phillips found in the 1957-59 samples was 55,600 in a 324 mm TL fish (~30.5 cm FL). The largest number of developing eggs (915,200) was found in a 478 mm TL (~45 cm FL) female.

DISCUSSION

Geographical variation in age at maturity

Size at 50% maturity is apparently smaller in southern latitudes (Table 4); however, this may be due to factors other than geographic variation. Oregon and California fish differ only slightly in size after age 8 (Table 10) and the divergence in the growth rate only in younger fish is suspicious. Many fish sampled in California, especially the smaller fish, were sampled from the hook-and-line sport fishery, with 43 of the 134 immature fish landed commercially. The age-length discrepancy may be due to geographical variation, but possibly the larger of the immature fish move offshore where they are available to trawlers, the only catches sampled in Oregon. This possible movement of fish could cause the apparent increase in size at 50% maturity observed in Oregon.

Management implications (biological) based on maturity

The Oregon commercial fishery on widow rockfish in 1979-80 was almost entirely on mature fish. Therefore, the management question is how to best utilize mature fish. During this time there was no biological problem related to the catch of juvenile widow rockfish.

As long as there is not a fishery on juveniles, and as long as juveniles and adult stocks are separate, as apparently they are now, restrictions on size retained would seem to be inappropriate. Oregon female widow rockfish are 50% sexually mature at 38 cm FL, which could be used as a biological point of concern for Oregon fish. With the same reasoning, 33 cm could be the point of concern for California fish. However, since fecundity of small but mature females appears to be relatively low, a larger size may be more appropriate.

Table 10—Mean fork length and weight by sex at age for *Sebastes entomelas* from catches off Oregon and California.

Age (yr)	Mean length (cm)				Mean weight (g)	
	Male		Female		Male	Female
	Ore.	Cal.	Ore.	Cal.	Ore.	
3	31.0	25.3	29.0	24.7	444	350
4	32.0	29.1	33.3	28.7	534	549
5	35.0	32.0	35.2	33.2	642	662
6	36.4	34.6	37.0	34.9	727	780
7	37.6	36.6	39.1	37.3	800	936
8	38.6	38.2	40.2	39.3	870	1,025
9	39.5	39.5	41.6	41.0	932	1,150
10	39.8	40.5	42.8	42.5	958	1,255
11	41.0	41.4	44.2	43.7	1,050	1,400
12	42.2	42.1	45.4	44.8	1,141	1,427
13	43.6	42.6	46.0	45.6	1,261	1,596
14	43.3	43.1	47.7	46.4	1,233	1,798
15	44.2	43.4	48.5	47.0	1,316	1,899
16	46.7	43.7	49.0	47.6	1,558	1,965
17	44.7	44.0	49.0	48.0	1,362	1,965
18	45.0	44.1	49.3	48.4	1,393	2,008
19	46.0	44.3	50.0	48.7	1,490	2,099
20	46.0	44.4	49.5	49.0	1,490	2,031
21	—	—	54.0	49.2	—	2,704
22	—	—	51.4	49.4	—	2,299
23	—	—	52.0	—	—	2,388

Calculated mean weight, $w = aL^b$
 Female: $a = 0.00545$; $b = 3.28781$; $r^2 = 0.99384$
 Male: $a = 0.01188$; $b = 3.06631$; $r^2 = 0.99599$

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Appendix

Distribution (%) of mature widow rockfish by gonad condition and month in Oregon random market samples, 1979-80.

Month	Gonad Stage									
	Male					Female				
	3	4	5	6	7	3	4	5	6	7
January	0	0	0	0	91	61	39	0	0	0
February	0	0	0	2	98	1	11	70	5	3
March	0	0	0	0	100	0	3	22	48	27
April	0	0	0	0	100	0	0	0	0	100
May	0	0	0	0	100	0	0	0	0	100
June	100	0	0	0	0	0	0	0	0	100
July	83	0	0	0	17	0	0	0	0	100
August	0	100	0	0	0	0	0	0	0	100
September	4	91	0	0	0	21	0	0	0	79
October	10	90	0	0	0	100	0	0	0	0
November	0	98	2	0	0	100	0	0	0	0
December	0	36	37	27	0	98	2	0	0	0