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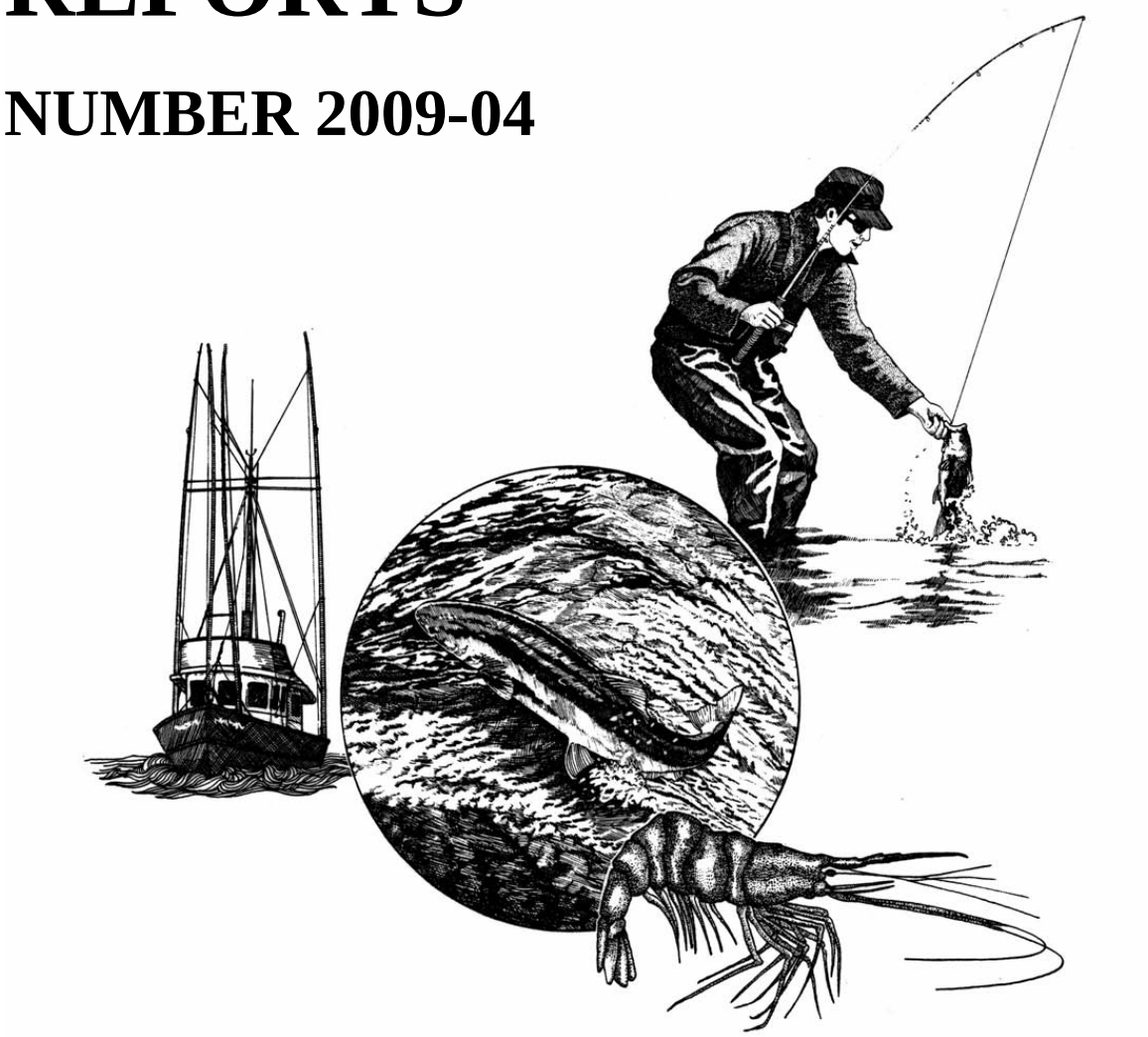

FISH DIVISION
Oregon Department of Fish and Wildlife

Length and age at maturity of female yelloweye rockfish *(Sebastes rubberimus*) and cabezon (*Scorpaenichthys marmoratus*) from Oregon waters based on histological evaluation of maturity

Length and age at maturity of female yelloweye rockfish (*Sebastes rubberimus*) and cabezon (*Scorpaenichthys marmoratus*) from Oregon waters based on histological evaluation of maturity

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Introduction

Accurate estimates of female age or length at maturity are critical for the conservation of exploited fish stocks. Age at maturity is particularly important, as it strongly influences population model estimates of sustainable harvest rates (Clark 1991) and, along with mean body size, is an important predictor of the risk of overexploitation (Reynolds et al. 2005).

For many U.S. west coast groundfish stocks, data on age and length at maturity is of poor quality. The age at maturity curves used in many stock assessments are currently based on macroscopic (visual) assessment of ovary condition. However, there is abundant evidence that histological evaluation of ovarian thin-sections, especially if combined with optimal seasonal sampling, is much more accurate (Gunderson et al. 1980, Wyllie Echeverria 1987, West 1990, Nichol and Pikitch 1994, Hannah and Parker 2007). The age data that have been used to develop curves of age at maturity for some species is also based on outdated ageing methods, such as surface aging of otoliths, as opposed to the more accurate "break and burn" technique (Barss 1989, Wyllie Echeverria 1987, Chilton and Beamish 1982). For other species, such as cabezon (*Scorpaenichthys marmoratus*), accurate age and growth data, based on thin-sectioning of otoliths, have just recently been developed (Grebel and Cailliet 2003). Information on age and length at maturity that is based on histological evaluation of maturity status and modern ageing techniques is therefore needed for many U.S. west coast groundfish species.

Histology-based maturity data has been developed for some U.S. west coast groundfish species. These include darkblotched rockfish (*Sebastes crameri*, Nichol and Pikitch 1994), petrale sole (*Eopsetta jordani*, Hannah et al. 2002), greenstriped rockfish (*Sebastes elongatus*, Shaw and Gunderson 2006), Pacific ocean perch (*Sebastes alutus*, Hannah and Parker 2007) and rosethorn rockfish (*Sebastes helvomaculatus*, Shaw and Gunderson 2008). We report here on the development of similar data for female yelloweye rockfish (*Sebastes rubberimus*) and cabezon.

Methods

Yelloweye rockfish

Yelloweye rockfish used for this study came from two sources: samples from Oregon's recreational fishery landings at the ports of Newport and Depoe Bay and samples collected opportunistically in the course of other research projects that were conducted in the vicinity of Newport, Oregon (Hannah and Parker 2007, Hannah et al. 2008). All fish were measured (cm TL) and sexed and otoliths were collected for age determination. Maturity data were collected only for female fish. Each ovary was removed and assigned a maturity stage (Table 1) following the criteria of Westrheim (1975). Whenever possible, a small section of ovary from fish in stages 1, 2, 3, 6 and 7 was collected for histological preparation and microscopic evaluation. These samples were preserved in 10% buffered formalin and later transferred to 70% ethanol for storage.

Table 1. Visual (macroscopic) maturity stages and descriptions for rockfish ovaries from Westrheim (1975).

Stage	Condition	Description
1	Immature	Small, translucent
2	Maturing	Small, yellow, translucent or opaque
3	Mature	Large, yellow, opaque
4	Fertilized	Large, orange-yellow, translucent
5	Ripe	Large, translucent yellow or gray, with black dots (contain embryos or larvae)
6	Spent	Large, flaccid, red. A few larvae may be present
7	Resting	Moderate size, firm, red-gray, some with black blotches

Maturity status of female yelloweye rockfish was determined using a combination of macroscopically-determined maturity stages (Table 1) and microscopic examination of stained ovarian thin-sections. Female rockfish determined macroscopically to be in stages 4-6, were considered unambiguously mature. One difficulty with determining maturity status based solely on macroscopic evaluation of ovaries is that "maturing" and "resting" ovaries cannot be reliably separated (Wallace and Selman 1981, Wyllie Echeverria 1987). These stages appear quite similar but represent fundamentally different maturity states. In some rockfish species, young females have also been shown to undergo abortive maturation, as characterized by mass atresia of the developing class of oocytes, further complicating the macroscopic assessment of maturity (Hannah and Parker 2007). To attain the most accurate maturity classification, we microscopically evaluated all stage 1, 2, 3 and 7 ovaries. A number of stage 6 ovaries were also evaluated microscopically to verify the accuracy of classifying this stage as mature and also to examine the typical structure of post-ovulatory follicles, to inform the microscopic evaluation of stage 7 ovaries.

For microscopic evaluation, ovarian tissue samples were embedded in paraffin, sectioned at 5 µm and stained with Harris's hematoxylin and eosin Y (West 1990), then examined using a binocular microscope at 100x magnification. The stage of the most advanced oocyte observed was recorded, following Bowers (1992). The diameter (µm) of the largest spherical non-atretic oocyte in the most advanced stage from each of five microscope fields was measured using an ocular micrometer and used to calculate a mean maximum oocyte diameter (MMOD) for each ovary (Hannah and Parker 2007). Maturity status was assigned as either mature, immature or unknown. Ovaries with large oocytes showing dark-staining vitellogenin were classified as mature, as were fish with obvious signs of post-release reorganization, such as post-ovulatory follicles (Wyllie Echeverria 1987) or residual larvae or larval eye pigment. Ovaries with non-vitellogenic oocytes that appeared well organized were classified as immature. Ovaries with signs of some late-stage reorganization, but without post-ovulatory follicles or other definitive indicators of maturity, were classified as unknown, because it was not possible to determine if the reorganization was a result of abortive maturation in an immature female or the late stages of post-release reorganization in a mature female. Females classified as unknown were not used for calculating final age or length at maturity curves, but were used in sensitivity analysis. Evidence of abortive maturation, characterized by mass atresia of the developing class of oocytes, usually from an early vitellogenic stage, was also noted at this time (Hannah and Parker 2007). The accuracy of macroscopic staging of ovaries was then evaluated by comparing the maturity status determined from the macroscopic and microscopic evaluations. Ages were determined using the break and burn technique applied to sagittal otoliths (Chilton and Beamish 1982).

Cabezon

The cabezon samples we analyzed were secured from two sources. Female cabezon from waters off Newport and Depoe Bay, Oregon, were sampled as part of an ongoing multi-species study of female fish maturity begun by the Oregon Department of Fish and Wildlife (ODFW) in 2000. These samples were obtained by sampling the recreational fishery and were combined for both ports to provide larger sample sizes. Cabezon from waters off Port Orford were also analyzed. These cabezon were sampled cooperatively with the Port Orford Ocean Resources Team (POORT) and were sampled from commercial fishery landings as well as targeted sampling by cooperating commercial fishers.

All cabezon sampled were measured (cm TL) and sexed. Otoliths were collected for age determination. The ovary was removed, weighed and assigned a maturity stage using the criteria shown in Table 2, which were developed based on the universal female maturity criteria of Nikolsky (1963). For samples collected in Port Orford, all 7 macroscopic stages shown in Table 2 were used. For the Newport and Depoe Bay samples, stage 5 (spawning) was not used. A small section of ovary from fish of all stages was collected whenever possible for histological preparation and microscopic evaluation. These samples were also preserved in 10% buffered formalin and later transferred to 70% ethanol for storage.

Table 2. Visual (macroscopic) maturity stages and descriptions used for cabezon ovaries following the universal female maturity criteria of Nikolsky (1963). Stage 5 (spawning) was not used for staging samples collected in Newport and Depoe Bay, Oregon.

Stage	Condition	Description
1	Immature	Ovary is translucent, thin, usually creamy white or pale pink in color.
2	Maturing	Ovary is small, light pink to deep red colored. Only for fish which have not spawned previously.
3	Ripening	Ovary enlarging, with granular consistency, usually pink to red colored and opaque. Full of developing eggs.
4	Ripe	Ovary large and filled with mix of larger translucent eggs (1-2mm) and small pink to red developing eggs.
5	Spawning	Ovary very large and filled with entirely translucent eggs (1.5-2mm)
6	Spent	Ovary is large (but smaller than stage 4) and flaccid. Deep red to purple in color. Some large eggs present.
7	Resting	Ovary smaller than stage 3, red to purple, no granular tissue present.

Histological preparation of cabezon ovary samples was the same as used for the yelloweye rockfish samples. For Newport and Depoe Bay cabezon samples, we determined the maturity status of individual female cabezon using a combination of macroscopic stages and microscopic evaluations of the histology samples. Females with ovaries in stages 4 or 6 (stage 5 not used at Newport or Depoe Bay, Table 2) were considered unambiguously mature. Samples with microscopic evidence of vitellogenesis or clear signs of post-spawning reorganization, such as post-ovulatory follicles, were also classified as mature. Females with ovaries that appeared well-organized under the microscope and with only smaller oocytes, with no signs of vitellogenesis or post-ovulatory follicles, were classified as immature. A few samples that showed no vitellogenesis or post-ovulatory follicles, but that did not appear well-organized, were classified as "unknown" and were not used for further analysis. For Port Orford samples, the comparison of macroscopic and microscopic maturity classifications revealed some errors in macroscopic staging of females with developing ovaries. Some females that had been staged macroscopically as stage 5 (spawning) or 6 (spent) also had very low gonad

weights and were ultimately determined to be immature based on microscopic examination. Although the number of errors was small, we chose not to use the macroscopic maturity data from Port Orford samples but rather to rely solely on histological determinations of maturity, even though this reduced the total number of samples. Ages were determined for both sets of samples from thin-sections of sagittal otoliths following Grebel and Cailliet (2003). Each thin-section was assigned a read code of 1 to 5, based on the clarity of the structure, with a "1" having the clearest pattern and a "5" having an indiscernible banding pattern, so that no age estimate could be assigned with confidence. All thin-sections which were assigned a read code of "5" were not included in the final analyses. Frequently, these structures had been sectioned incorrectly or were over-sanded during preparation.

Fitting of maturity curves

Logistic regression was used to fit sigmoid curves to the proportion mature by length and age for all species, in the form,

$$p_{x_1} = e^{(b_0+b_1x_1)}/(1+e^{(b_0+b_1x_1)}) \text{ where,}$$

p is the probability that a fish is mature in a given length (cm) or age inteval x_1, and b_0 and b_1 are parameters that define the shape and location of the fitted sigmoid curve. The predicted length or age at 50% maturity was calculated as,

$$L \text{ (or } A)_{50} = -b_0/b_1.$$

To evaluate the sensitivity of our estimates of L_{50} and A_{50} for yelloweye rockfish to errors related to the unknown maturity status of some females, we re-estimated L_{50} and A_{50} assuming all unkown females were mature and then again assuming they were immature.

Results

Yelloweye rockfish

Sample collections resulted in age, length and maturity information for a total of 158 female yelloweye rockfish (Table 3). Availability of samples was limited by a ban on retention of yelloweye rockfish in all fisheries starting in 2004 (PFMC 2004). Of the 158 female yelloweye rockfish sampled, 30 were considered definitively mature based solely on macroscopic inspection of the ovary (stages 4-6, Table 3). The seasonal distribution of these three maturity stages showed that female yelloweye rockfish are not strongly synchronous in their reproductive development (Figure 1). Stage 4-6 ovaries were found from April through October, with stages 4 or 5 noted from April through August (Table 1 and Figure 1).

Table 3. Summary of female yelloweye rockfish sampled for maturity, by month.

Month	Number sampled	Number considered mature based on macroscopic stage only (stages 4-6)	Number of histology samples analyzed
April	4	2	2
May	33	21	12
June	28	1	27
July	24	1	23
August	29	3	26
September	11	1	10
October	29	1	28
Total	158	30	128

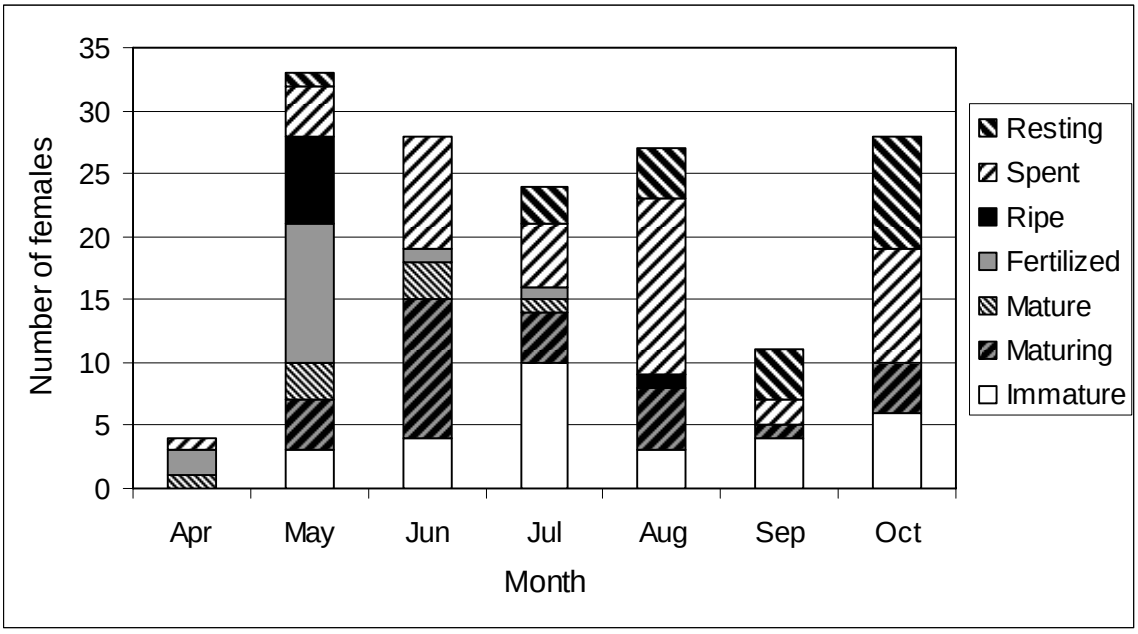


Figure 1. Number of female yelloweye rockfish collected by month and macroscopic maturity stage (Table 1).

One result of this lack of strong synchrony in reproduction was that the accuracy of macroscopic evaluations of maturity was low for yelloweye rockfish, especially for fish classified macroscopically as immature (stages 1 and 2, Table 4). Histology samples frequently revealed post-ovulatory follicles or larval eye pigment indicating these females were actually in the resting stage. For females classified as spent (stage 6), maturity was well determined macroscopically. Of 37 stage 6 ovaries that were also evaluated microscopically, only 1 was determined to be immature and none were classified as "unknown". Microscopic evaluation of yelloweye rockfish ovary samples resulted in reclassification of the maturity determinations in 25 of 128 samples evaluated by both methods (error rate of 21%, Table 4), with 10 samples that could not be confidently classified as mature or immature by either method. Out of the complete sample of 158 females, only 123 (78%) were correctly classified macroscopically (Tables 3 and 4).

Table 4. Comparison of macroscopic and microscopic determinations of maturity in female yelloweye rockfish collected from waters off Newport and Depoe Bay, Oregon, 2000-2008.

	Macroscopic classification		Microscopic classification		
Month	Condition	Number	Confirmed	Reclassified	Unknown
April	Immature	0	0	0	0
	Mature	2	2	0	0
May	Immature	7	4	3	0
	Mature	5	5	0	0
June	Immature	15	2	7	6
	Mature	12	11	1	0
July	Immature	14	10	4	0
	Mature	9	9	0	0
August	Immature	8	5	3	0
	Mature	18	17	1	0
September	Immature	5	2	2	1
	Mature	5	4	0	1
October	Immature	10	6	4	0
	Mature	18	16	0	2
Total		128	93	25	10

Considering only the months of April to August, a time period more closely bracketing the peak of parturition (Figure 1), the rate of successful macroscopic determination of maturity rises to only 79% (93 of 118). This suggests that macroscopic evaluation of maturity in yelloweye rockfish from Oregon waters incorporates a high degree of error that cannot be avoided via a careful selection of sampling season. For yelloweye rockfish, microscopic evaluation of stained ovarian sections is necessary to generate accurate curves of age and length at maturity.

The logistic curves described the proportion of mature female yelloweye rockfish as a function of length and age reasonably well (Figure 2 and Table 5), considering the modest sample sizes obtained in this study, especially of young fish (Table 5). The

acceptable fit is partly due to very few females showing abortive maturation, which can cause asymmetry in the proportion mature by length or age and degrade the fit to the logistic function (Hannah and Parker 2007). We identified only 1 ovary that showed clear evidence of abortive maturation, as indicated by mass atresia of the developing class of oocytes. Yelloweye rockfish were 50% mature at a length of 38.8 cm (Table 6) and 100% mature at about 50 cm (Figure 2). The estimated age at 50% maturity was 11.6 y and 100% maturity was reached at about age 25 (Table 6 and Figure 2). These estimates were not sensitive to the maturity status of the 10 ovaries classified as "unknown". Fitted maturity curves treating these 10 fish as mature or immature created a range in L_{50} of about ± 0.65 cm and in A_{50} of about ± 0.44 y.

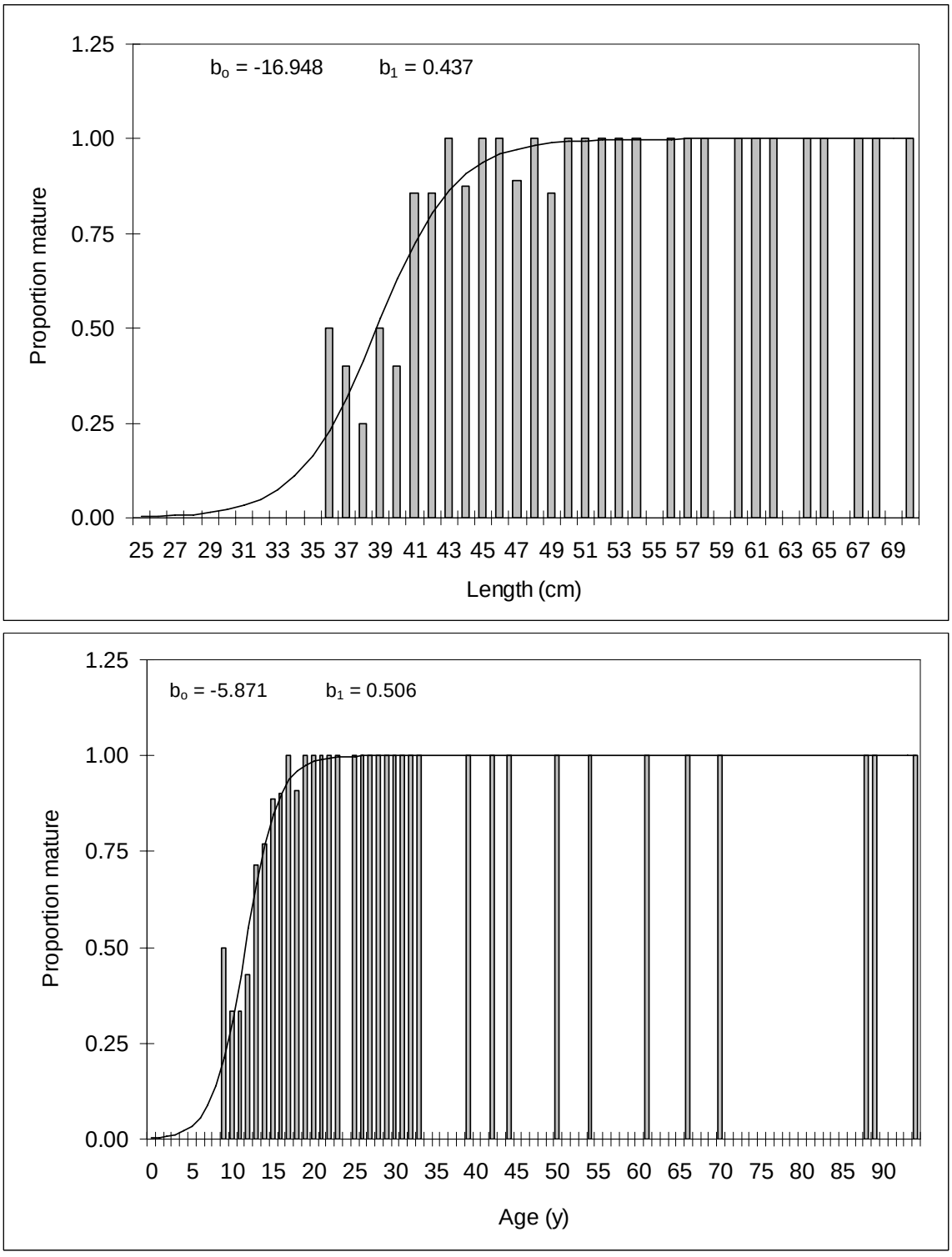


Figure 2. Proportion mature female yelloweye rockfish by length and age, showing fitted logistic curves (Table 5).

Table 5. Number of female yelloweye rockfish sampled and proportion mature, by length (cm) and age (y).

Length (cm)	Number sampled	Proportion mature	Age (y)	Number sampled	Proportion mature
31	1	0.00	6	1	0.00
32	4	0.00	7	0	--
33	2	0.00	8	1	0.00
34	3	0.00	9	4	0.50
35	2	0.00	10	9	0.33
36	4	0.50	11	12	0.33
37	5	0.40	12	7	0.43
38	4	0.25	13	7	0.71
39	4	0.50	14	13	0.77
40	5	0.40	15	9	0.89
41	7	0.86	16	10	0.90
42	7	0.86	17	6	1.00
43	6	1.00	18	11	0.91
44	8	0.88	19	5	1.00
45	5	1.00	20	7	1.00
46	19	1.00	21	5	1.00
47	9	0.89	22	2	1.00
48	9	1.00	23	3	1.00
49	7	0.86	24	0	--
50	3	1.00	25	1	1.00
51	3	1.00	26	3	1.00
52	5	1.00	27	1	1.00
53	5	1.00	28	7	1.00
54	2	1.00	29	1	1.00
55	0	--	30	4	1.00
56	1	1.00	31	3	1.00
57	4	1.00	32	2	1.00
58	2	1.00	33	1	1.00
59	0	--	34	0	--
60	3	1.00	35	0	--
61	2	1.00	36	0	--
62	1	1.00	37	0	--
63	0	--	38	0	--
64	1	1.00	39	1	1.00
65	2	1.00	40	0	--
66	0	--	41	0	--
67	1	1.00	42	3	1.00
68	1	1.00	43	0	--
69	0	--	44	1	1.00
70	1	1.00	45+	8	1.00
Total	148			148	

Table 6. Results of logistic regression analysis of maturity status of yelloweye rockfish versus length (cm) and age.

Independent variable		Coefficients	Standard error	P-value	L_{50} or A_{50}
Length					38.78 cm
	Constant	-16.948	3.234	0.0001	
	Length	0.437	0.080	0.0001	
Age					11.60 yrs
	Constant	-5.871	1.360	0.0001	
	Age	0.506	0.105	0.0001	

Cabezon

Macroscopic maturity data were collected and histology samples analyzed for 725 and 434 female cabezon, respectively, from Newport and Depoe Bay (Table 7). Three females for which histology samples were obtained were ultimately classified as "unknown". Combining females with unambiguous macroscopic maturity stages with those for which definitive assignment of maturity status was made from histology samples yielded a total maturity sample of 525 females. Ages were determined for 299 female cabezon from these two ports (Table 7).

Macroscopic maturity data for female cabezon from Newport and Depoe Bay did not suggest strong synchrony of reproduction but rather suggested nearly year-round spawning, with a broad peak in activity from March through June (Figure 3). Females in ripe or spent condition were encountered from February through November. Microscopic evidence of multiple batches of eggs in a single season was found in many female cabezon, including a bimodal distribution of MMOD for vitellogenic oocytes and the co-occurrence of post-ovulatory follicles with early vitellogenic oocytes.

Table 7. Number of maturity, histology and age samples collected, by month, from female cabezon at Newport and Depoe Bay, Oregon, 2003-2008.

Month	Maturity samples collected	Histology samples analyzed	Number of samples aged
January	7	0	0
February	10	0	0
March	47	1	0
April	65	42	35
May	95	36	50
June	151	81	78
July	188	165	82
August	115	94	49
September	34	9	1
October	10	3	3
November	3	3	1
Total	725	434	299

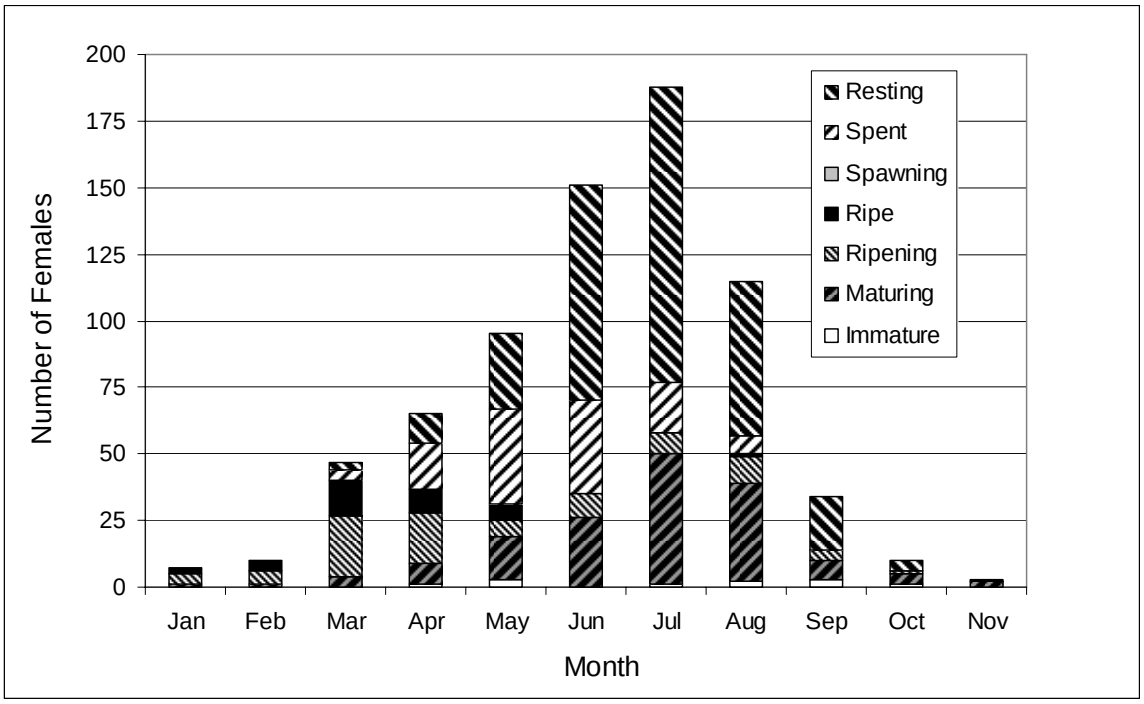


Figure 3. Number of female cabezon collected at Newport and Depoe Bay by month and macroscopic maturity stage (Table 2).

Macroscopic staging was mostly accurate for cabezon collected from Newport and Depoe Bay, with a combined error rate of 14.3% (Table 8). The most common type of error was a female classified macroscopically as stage 2 (maturing) that showed microscopic evidence of vitellogenesis and therefore was reclassified from immature to mature, under the assumption that it would have spawned that year. This error was most prevalent in July and August in Newport and Depoe Bay samples.

Female cabezon from Newport and Depoe Bay samples were 50% mature at a length of 43.8 cm and at an age of 4.0 y and were fully mature at about 53 cm and an age of 8 y (Table 9 and Figure 4). The logistic curve fit the proportion mature by age and length well despite relatively low numbers of immature fish and fish below 42 cm in size (Tables 10 and Figure 4).

Histology samples were analyzed for 156 female cabezon from Port Orford (Table11). All histology samples from Port Orford were successfully classified as mature or immature, none were classified as "unknown". Ages were determined for 132 female cabezon (Table 11). Female cabezon collected from waters off Port Orford were 50% mature at a length of 40.3 cm and at an age of 3.1 y (Table 12 and Figure 5).

Discussion

Yelloweye rockfish

The lack of synchrony in reproductive development of yelloweye rockfish made interpretation of maturity status more difficult, as fish that appeared immature were

Table 8. Comparison of macroscopic and microscopic determinations of maturity in female cabezon collected from waters off Newport and Depoe Bay, Oregon, 2003-2007.

Month	Macroscopic classification		Microscopic classification		
	Condition	Number	Confirmed	Reclassified	Unknown
March	Immature	0	0	0	0
	Mature	1	1	0	0
April	Immature	5	4	1	0
	Mature	37	36	1	0
May	Immature	5	1	3	1
	Mature	31	31	0	0
June	Immature	17	14	3	0
	Mature	64	61	3	0
July	Immature	43	25	18	0
	Mature	122	116	4	2
August	Immature	30	14	16	0
	Mature	64	61	3	0
September	Immature	2	0	2	0
	Mature	7	7	0	0
October	Immature	0	0	0	0
	Mature	3	3	0	0
November	Immature	2	0	2	0
	Mature	1	1	0	0
Total		434	375	62	3

Table 9. Number of female cabezon sampled and proportion mature, by length (cm) and age (y) at Newport and Depoe Bay, 2003-2008.

Length (cm)	Number sampled	Proportion mature	Age (y)	Number sampled	Proportion mature
39	2	0.00	3	6	0.17
40	5	0.00	4	49	0.53
41	6	0.17	5	71	0.72
42	16	0.38	6	58	0.90
43	17	0.59	7	36	0.97
44	16	0.50	8	35	1.00
45	13	0.77	9	20	1.00
46	17	0.65	10	12	1.00
47	20	0.65	11	7	1.00
48	20	0.60	12	1	1.00
49	19	0.95	13	2	1.00
50	15	1.00	14	1	1.00
51	29	0.90	15	--	--
52	31	0.84	16	--	--
53	30	1.00	17	--	--
54	25	0.96	18	--	--
55	20	1.00	19	1	1.00
56	34	1.00			
57	25	1.00			
58	19	1.00			
59	22	1.00			
60	21	1.00			
61	22	1.00			
62	13	1.00			
63	17	1.00			
64	9	1.00			
65	6	1.00			
66	8	1.00			
67	8	1.00			
68	7	1.00			
69	4	1.00			
70	3	1.00			
71	3	1.00			
72	--	--			
73	--	--			
74	2	1.00			
75	--				
76	--				
77	1	1.00			

Table 9 (continued).

Total	525	0.86		299	0.82

Table 10. Results of logistic regression analysis of maturity status of cabezon versus length (cm) and age, by port.

Independent Variable		Coefficients	Standard error	P-value	L_{50} or A_{50}
Newport-Depoe Bay					
Length					43.82 cm
	Constant	-15.205	1.845	0.0001	
	Length	0.347	0.039	0.0001	
Age					4.02 y
	Constant	-4.643	0.910	0.0001	
	Age	1.156	0.185	0.0001	
Port Orford					
Length					40.29 cm
	Constant	-8.582	2.121	0.0001	
	Length	0.213	0.045	0.0001	
Age					3.13 y
	Constant	-3.138	1.234	0.0110	
	Age	1.001	0.263	0.0001	

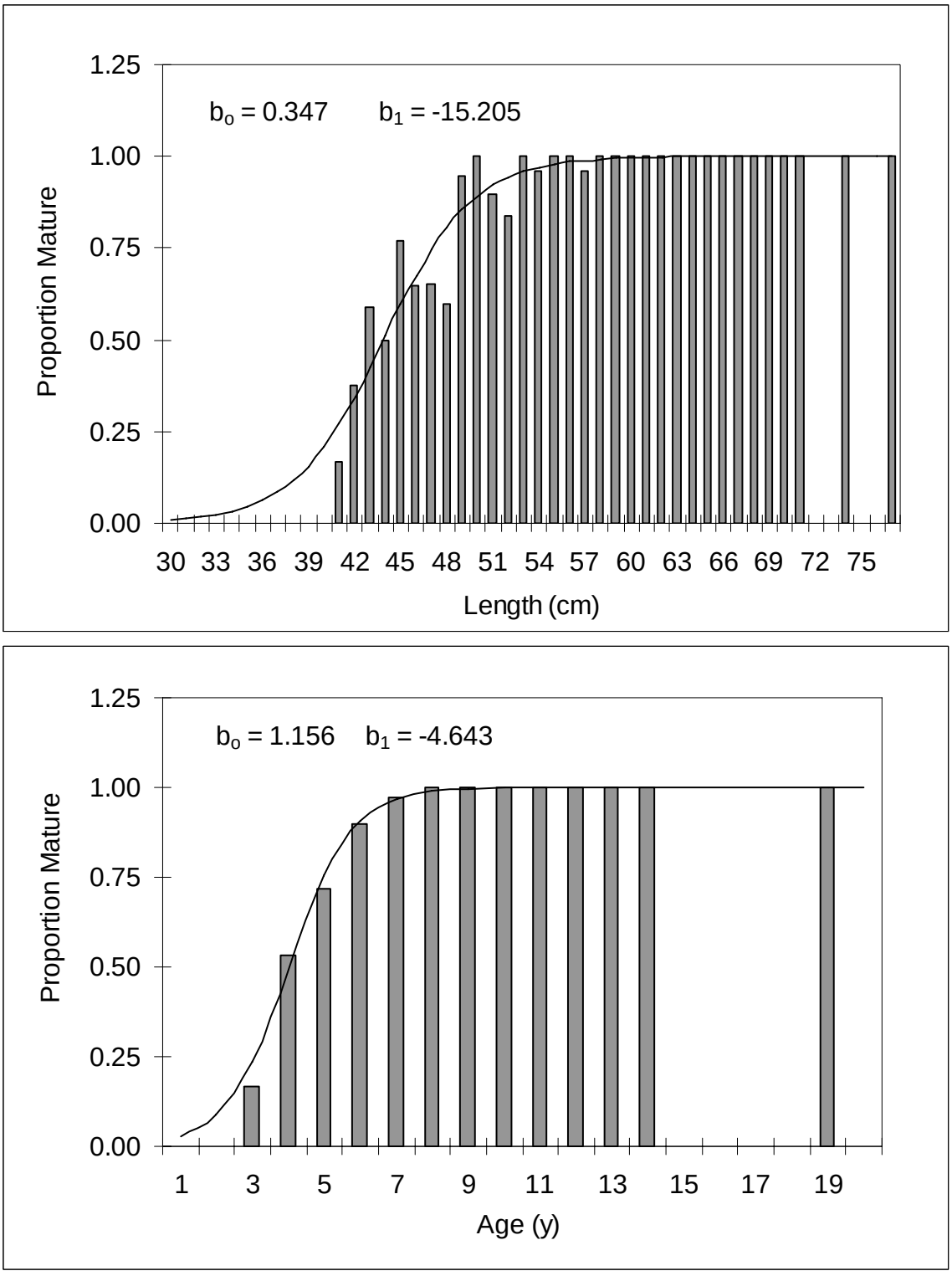
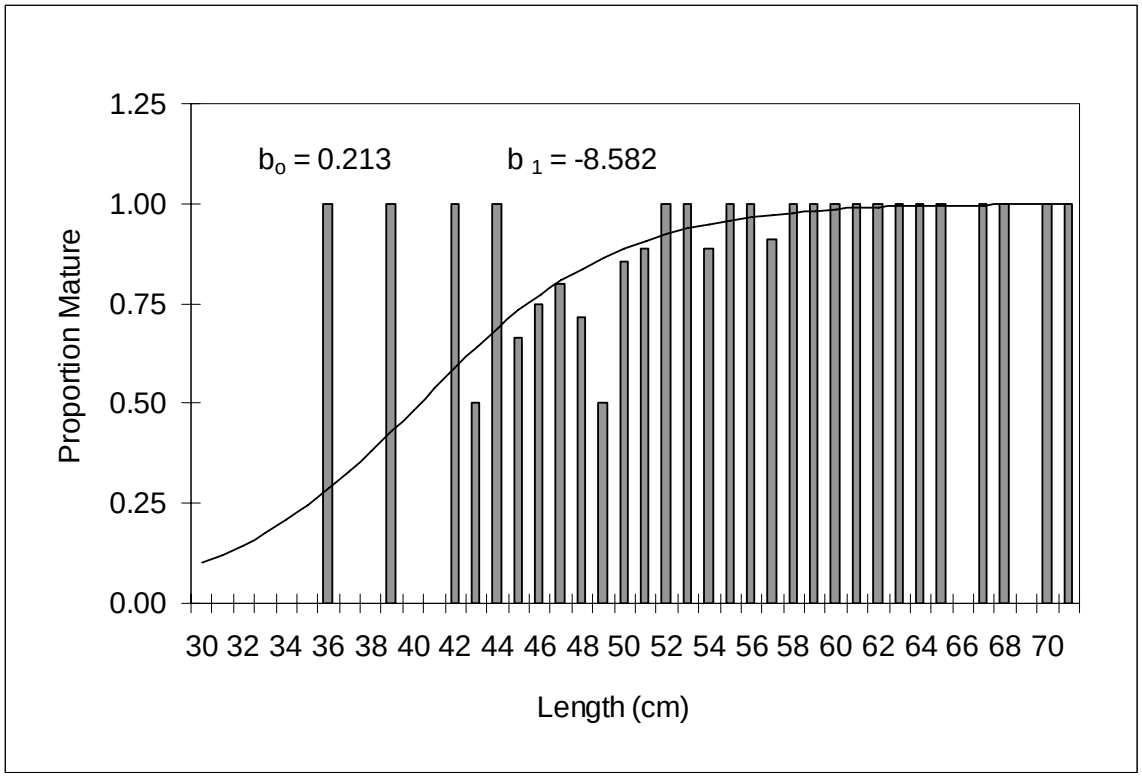


Figure 4. Proportion mature female cabezon by length and age at Newport and Depoe Bay, 2003-2007, showing fitted logistic curves.

Table 11. Number of histology and age samples collected, by month, from female cabezon at Port Orford, Oregon, 2002-2004.

Month	Number of histology samples analyzed	Number of samples aged
February	0	0
March	0	0
April	0	0
May	11	10
June	20	16
July	18	14
August	0	0
September	62	49
October	41	39
November	4	4
Total	156	132



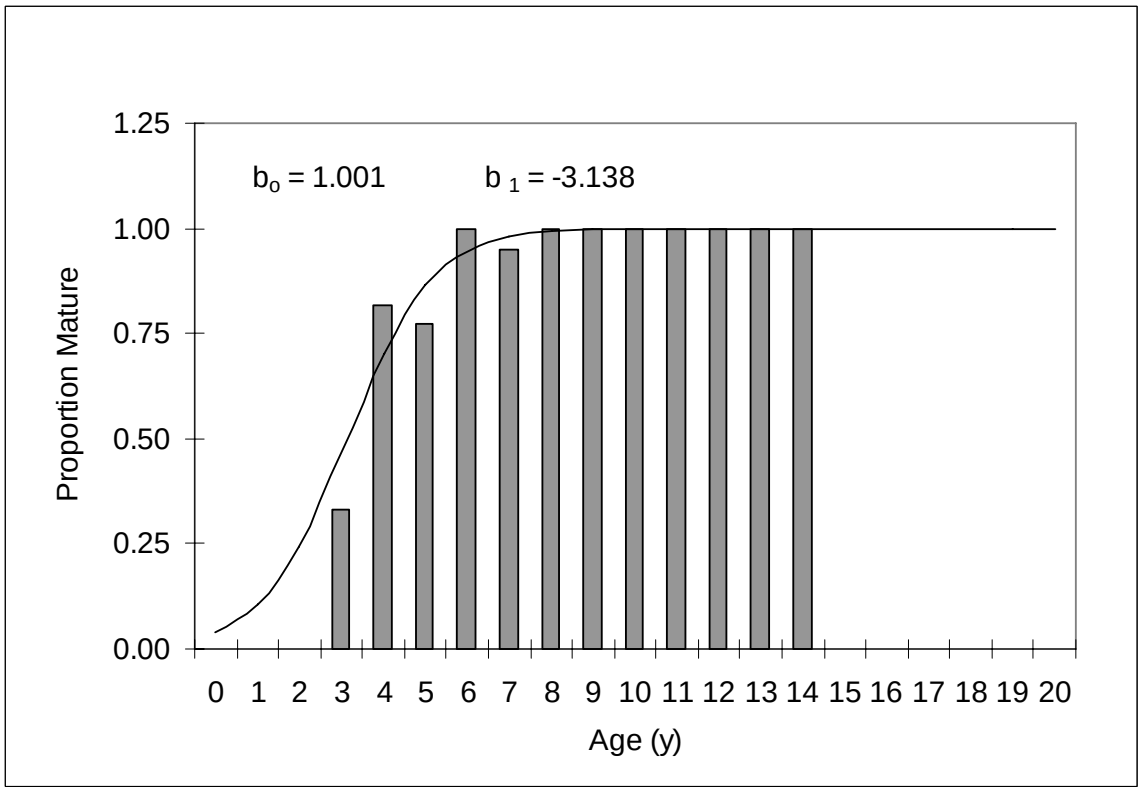


Figure 5. Proportion mature female cabezon by length and age at Port Orford, 2002-2004, showing fitted logistic curves.

Table 12. Number of female cabezon sampled at Port Orford, Oregon and proportion mature by length (cm) and age (y).

Length (cm)	Number sampled	Proportion mature	Age (y)	Number sampled	Proportion mature
33	1	0.00	2	1	0.00
34	--	--	3	6	0.33
35	1	0.00	4	22	0.82
36	2	1.00	5	22	0.77
37	2	0.00	6	39	1.00
38	1	0.00	7	20	0.95
39	1	1.00	8	9	1.00
40	--	--	9	3	1.00
41	3	0.00	10	6	1.00
42	4	1.00	11	1	1.00
43	2	0.50	12	1	1.00
44	3	1.00	13	1	1.00
45	3	0.67	14	1	1.00
46	4	0.75			
47	5	0.80			
48	7	0.71			
49	2	0.50			
50	7	0.86			
51	9	0.89			
52	10	1.00			
53	7	1.00			
54	9	0.89			
55	4	1.00			
56	11	1.00			
57	11	0.91			
58	6	1.00			
59	5	1.00			
60	9	1.00			
61	8	1.00			
62	6	1.00			
63	5	1.00			
64	3	1.00			
65	1	1.00			
66	--	--			
67	1	1.00			
68	1	1.00			
69	--	--			
70	1	1.00			
71	1	1.00			
Total	156	0.88		132	0.88

frequently found microscopically to be mature. Microscopic evaluation of thin sections helped with this problem, but still did not allow definitive assignment of maturity to all samples. Ovary samples classified as "unknown" showed some degree of reorganization that may have been an indication of recent parturition, but lacked definitive features such as post-ovulatory follicles, residual larvae or larval eye pigment. It wasn't possible to rule out late-stage mass atresia for these samples, so a definitive classification of maturity could not be made.

Yelloweye rockfish off central Oregon reached 50% maturity at 39 cm and about 12 years of age. This is 3 cm smaller than the length at 50% maturity of 42 cm used in the most recent coastwide (California, Oregon, Washington) stock assessment (Wallace et al. 2006). It is also less than the 41 cm length at 50% maturity reported for Oregon waters by Barss (1989).

Cabezon

Both sets of cabezon samples considered here included low numbers of immature females. The number of small fish was also very modest (Tables 9 and 12). The low number of immature and small cabezon in the Newport and Depoe Bay samples is partly due to the minimum size limit of 40.6 cm imposed on the recreational fishery in 2003. Despite these problems, the maturity data fit the logistic curves reasonably well (Figures 4 and 5). The latitudinal variation in length and age at 50% maturity is approximately as expected, with larger and older values for more northern Oregon waters (Table 10). The estimates of length and age at 50% maturity developed here for Oregon waters are

considerably larger and older than reported for cabezon collected off California, also consistent with the expected latitudinal variation. Grebel and Caillet (2003) report length and age at 50% maturity of 33.7 cm and 2.3 y, respectively, for female cabezon from California waters, but used only macroscopic evaluation of ovaries. The timing of female spawning for Newport and Depoe Bay samples agrees more closely with the nearly year-round spawning, with a peak in March-April, reported by Lauth (1988) for Puget Sound, Washington, than with the January-February spawning peak reported for cabezon from California waters by O'Connell (1953).

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