Length and Age at Maturity For Pacific Ocean Perch (*Sebastes alutus*) Off Oregon

Robert W. Hannah
Steven J. Parker

Oregon Department of Fish and Wildlife
Marine Resources Program
2040 Southeast Marine Science Drive,
Newport, Oregon 97365, U.S.A.

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Introduction

The age and length at maturity for female fish is a critical parameter in many stock assessment models. For example, Clark (1991) and Lunsford (1999) have shown that changes in the age at 50% maturity can have a strong influence on estimated target fishing rates. For a variety of U. S. west coast rockfish species, particularly those found on the upper continental slope, age and length at maturity are not well established (Love et al. 2002). For Pacific ocean perch (*Sebastes alutus*), the best maturity data available have been from samples collected during the National Marine Fisheries Service (NMFS) summer abundance surveys (Hamel et al. 2003). These data cover a broad geographic range and also include a wide size range of fish, unlike some commercial fishery samples which can lack adequate numbers of small, immature fish. However, survey data are based on a simple visual assessment of maturity, so they suffer from a different but serious problem. In summer, maturity status of ovaries from winter spawning species like Pacific ocean perch can be very difficult to determine; ovaries of mature, "resting" fish are macroscopically identical to ovaries of immature fish (Gunderson et al. 1980, Nichol and Pikitch 1994).

Uncertainty in summer data is best addressed by collecting samples from a wide size range of fish during seasonal periods when visual maturity determinations are more accurate. However, even with an optimal sampling period, the possibility remains that visual assessment of female rockfish maturity could be an inaccurate assessment of "functional maturity"; the successful production of larvae. Nichol and Pikitch (1994) evaluated maturity of darkblotched rockfish (*S. crameri*) microscopically and found that some ovaries with evidence of vitellogenesis also showed mass atresia and resorption of oocytes during development. Their findings underscore the importance of using histological evidence of maturity over visual assessment, as the difference between a functionally immature and a functionally mature female can depend on attributes visible only microscopically, even during the active reproductive season.

The primary objective of this study was to collect samples of Pacific ocean perch ovaries from a wide size range of fish, during the active reproductive season and use microscopic evaluation of stained thin-sections to develop functional age and length at maturity curves for use in stock assessment for the U.S. west coast.

Methods

Maturity data for female Pacific ocean perch were collected from two sources; dockside sampling of Oregon's commercial fishery landings and chartered research trawl trips. Each fish was measured (cm fork length). An ovary was removed and assigned a macroscopic maturity stage following the criteria of Westrheim (1975). Only experienced samplers were used to assign macroscopic maturity stages to minimize staging errors. One ovary was then preserved from each female fish for histological examination, except for fish with an unambiguous maturity status, such as those with developed larvae. Otoliths were removed for subsequent age determination. Ages were determined by production aging staff of the NMFS Cooperative Aging Unit with experience aging Pacific ocean perch, using the break and burn technique on sagittal otoliths (Chilton and Beamish, 1982).

Ovaries were preserved in 10% buffered formalin, and later transferred to 70% ethanol for storage. Tissue samples from the midsection of the ovary were then embedded in paraffin, sectioned at 5 μm and stained with Harris's hematoxylin and eosin Y (West, 1990). The diameter (μm) of the five largest, spherical, non-atretic oocytes in the most advanced oocyte stage were measured with an ocular micrometer and used to calculate a mean maximum oocyte diameter (MMOD) for each sectioned ovary (West 1990, Nichol and Pikitch 1994). Only oocytes sectioned through the nucleus were used for this measurement. MMOD was compared for mature and immature fish to determine the appropriate period to evaluate samples to determine maturity. The samples were classified histologically as mature or immature based on the presence or absence of vitellogenin, post-ovulatory follicles, and level of atresia. If the majority of the developing class of oocytes was atretic, the ovary was categorized as showing "major atresia" and the individual fish was considered functionally immature.

Logistic regression was used to fit sigmoid length-maturity and age-maturity curves. The model fitted had the general form,

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

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

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

Results and Discussion

We collected maturity data from 965 female Pacific ocean perch between May 2000 and March 2003 (Table 1). Collection areas ranged from the southern end of Heceta Bank northwards to just south of the Astoria canyon, in depths ranging from about 275-400 m. Ovarian sections were examined for 324 fish and ages were determined for 465 fish. Visually-determined maturity stages (Figure 1) indicated that reproduction was highly synchronous and that the seasonal period of December to March would be most definitive for estimating age and length at maturity for this species off Oregon. For these months, visual and microscopic maturity determinations were generally very consistent (Figures 1 and 2). Further, examination of stained thin sections in other months suggested that maturity could not be accurately determined outside of the December-March period, even microscopically.

Table 1. Summary of numbers of female Pacific ocean perch sampled for maturity, by month, 2000-2003. The number of ovaries examined using histology and the number of fish for which age determinations were made are also shown by month.

Month	Sampled for Maturity	Examined Histologically	Age Determined
January	103	30	103
February	182	47	163
March	100	6	100
April	0	0	0
May	281	82	0
June	0	0	0
July	0	0	0
August	1	0	0
September	123	65	0
October	76	0	0
November	0	0	0
December	99	94	99
Total	965	324	465

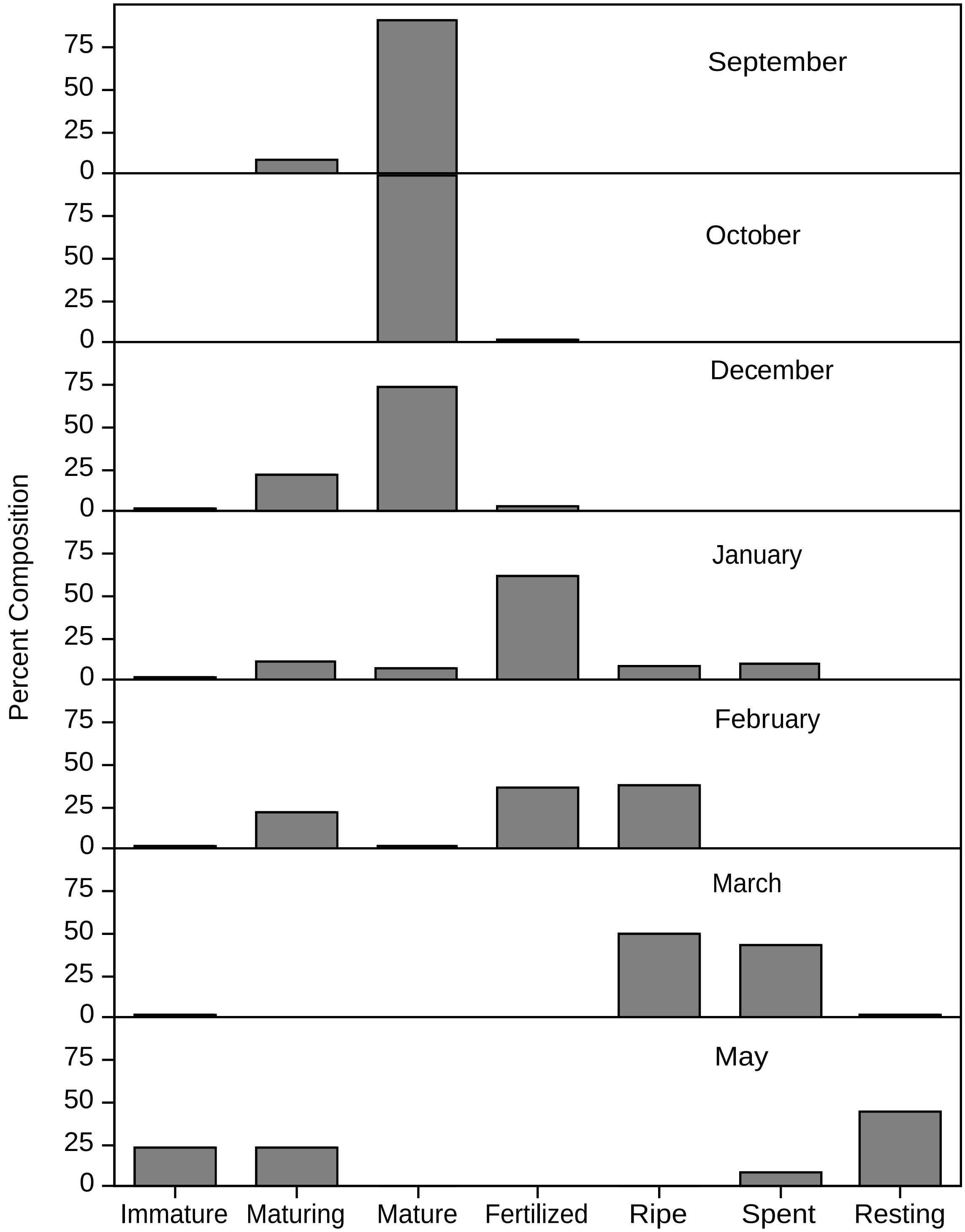


Figure 1. Relative frequency of visual maturity stages for female Pacific ocean perch, by month, 2000-2003.

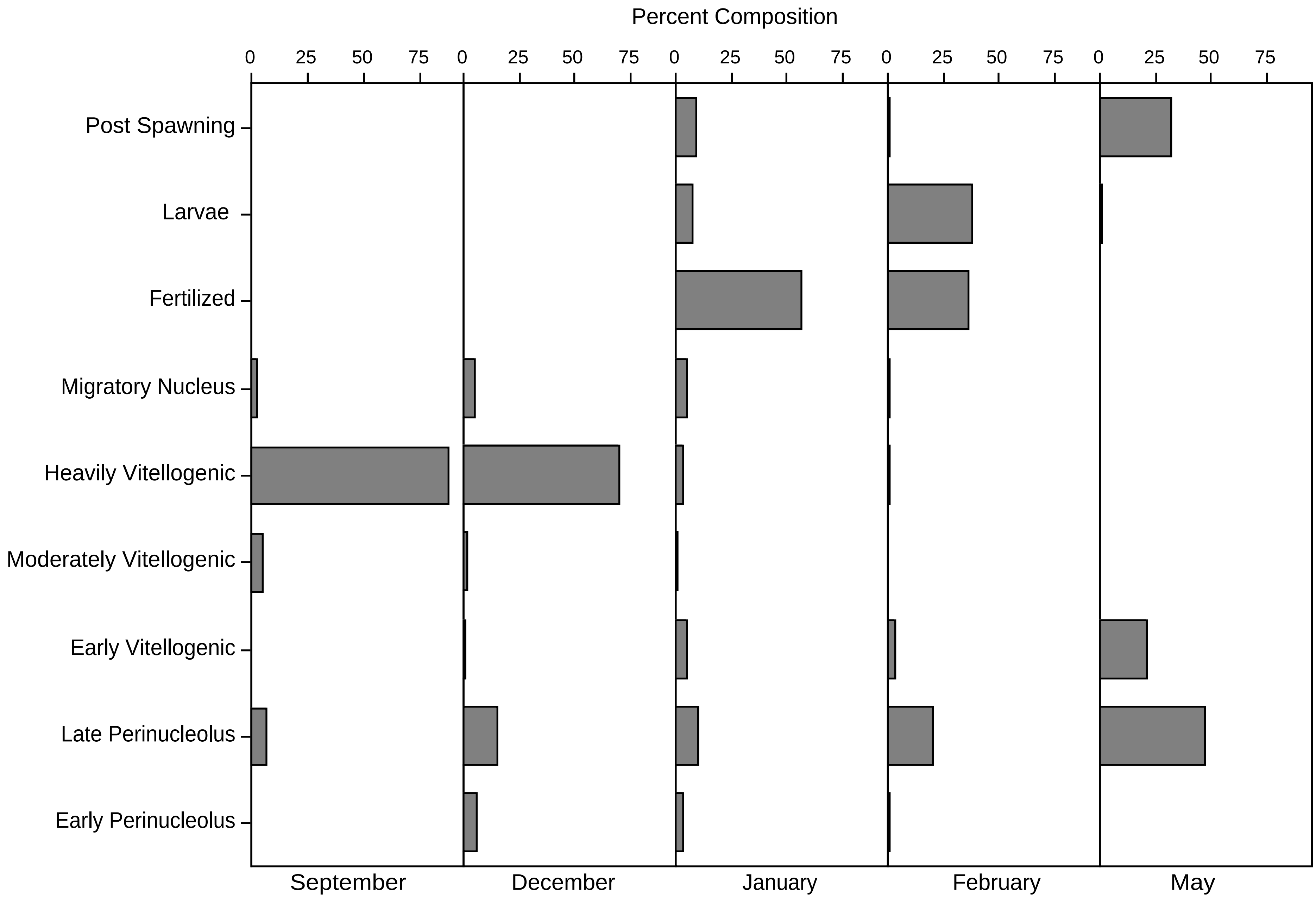


Figure 2. Percent composition of maturity stages by month based on a combination of microscopic evaluation of oocyte development and visual staging of fertilized, ripe and obviously spent ovaries of Pacific ocean perch, 2000-2003.

Microscopic examination of ovarian thin sections revealed significant numbers of female Pacific ocean perch with mass atresia of developing oocytes, indicative of abortive maturation (Figure 3). The frequency of abortive maturation decreased with age, indicating that older female Pacific ocean perch are more competent spawners than younger fish. Abortive maturation has been noted previously for Pacific ocean perch in more northern waters (Leaman 1988). However, this earlier study showed lower levels of abortive maturation and did not look for a relationship with maternal age. The effect of maternal size on the quality of eggs and larvae is well established for some fish species (Trippel et al. 1997) but has not been investigated for most rockfish. Berkeley et al. (2004) have shown that growth and survival of larvae from older black rockfish (*S. melanops*) may be higher than for younger fish; a maternal-age effect on larval quality. Our data suggest another mechanism by which maternal-age may influence reproductive success of Pacific rockfish, through age-modulated levels of abortive oocyte development. This is a different phenomenon than reduced fecundity due to a proportion of the oocytes not completing development. In this instance, the entire developing oocyte class is aborted and the fish does not spawn in that year. Our data did not allow an examination of the interannual variation in levels of abortive maturation, suggesting more study is needed to evaluate this phenomenon at a population level.

The length and age at maturity data collected in this study provided a poor fit to the standard logistic curve (Figure 4). This is most likely due to the effect of abortive maturation of younger fish, a phenomenon that decreased with size and age, making the data set asymmetric and a poor fit to a symmetric logistic function. The logistic curves fitted indicate that off the U.S. west coast, Pacific ocean perch are 50% mature at a length of about 31 cm and age 5. However, inspection of the data suggests that the poor fit of the logistic curve is biasing the estimates of 50% maturity, especially with respect to age, and suggest an age at 50% maturity of 6 is more appropriate (Table 2). This age of 50% maturity is still considerably younger than assumed in the previous stock assessment (age 8, Hamel et al. 2003).

References

Berkeley, S. A. M. A. Hixon, R. J. Larson and M. S. Love. 2004. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. Fisheries 29(8):23-32.

Chilton, D. E. and R. J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. J. Fish. Aquat. Sci. Spec. Publ. 60:2-18.

Clark, W.G. 1991. Groundfish exploitation rates based on life history parameters. Can. J. Fish. Aquat. Sci. 48:734-750.

Hamel, O. S., I. J. Stewart and A. E. Punt. 2003. Status and future prospects for the Pacific ocean perch resource in waters off Washington and Oregon as

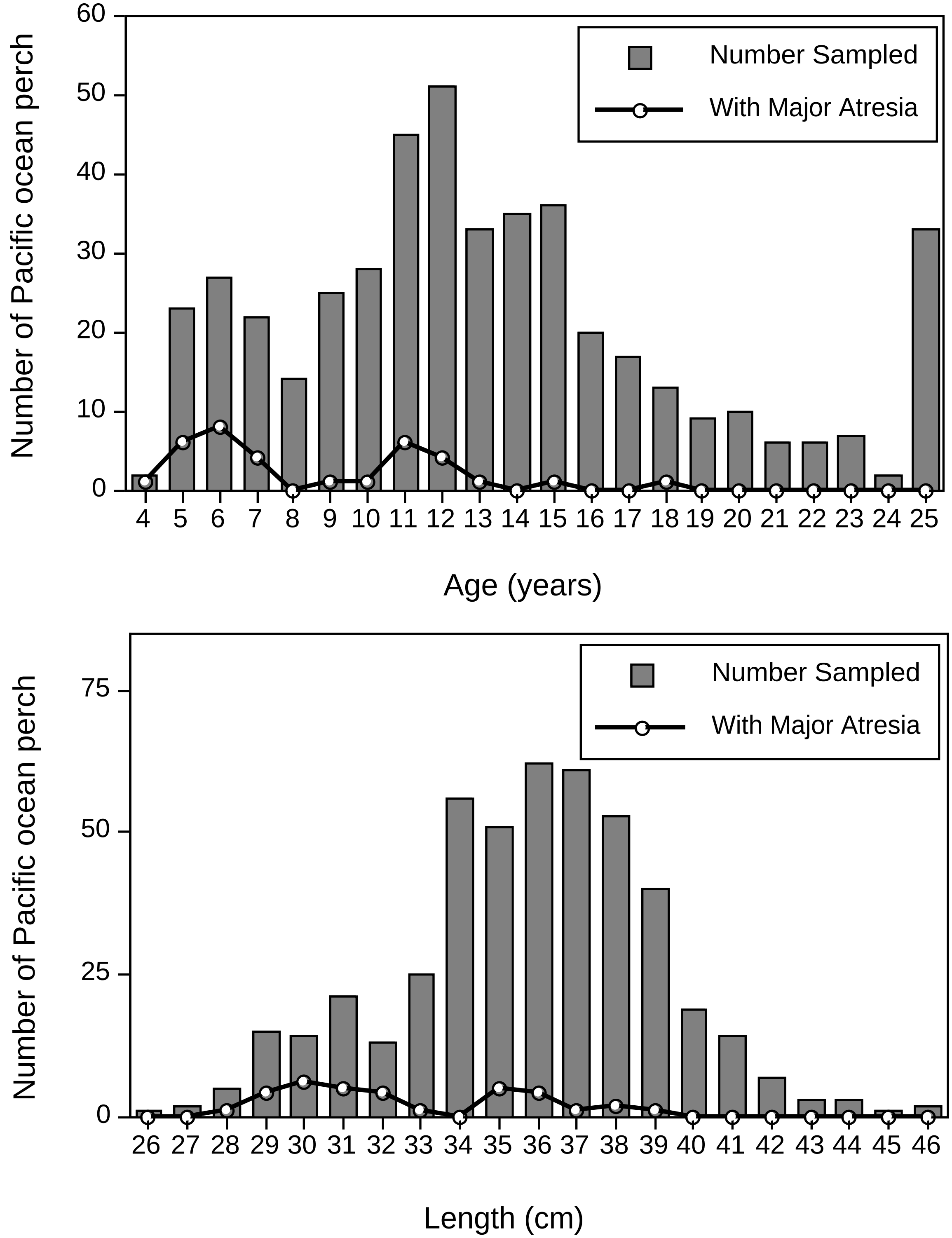
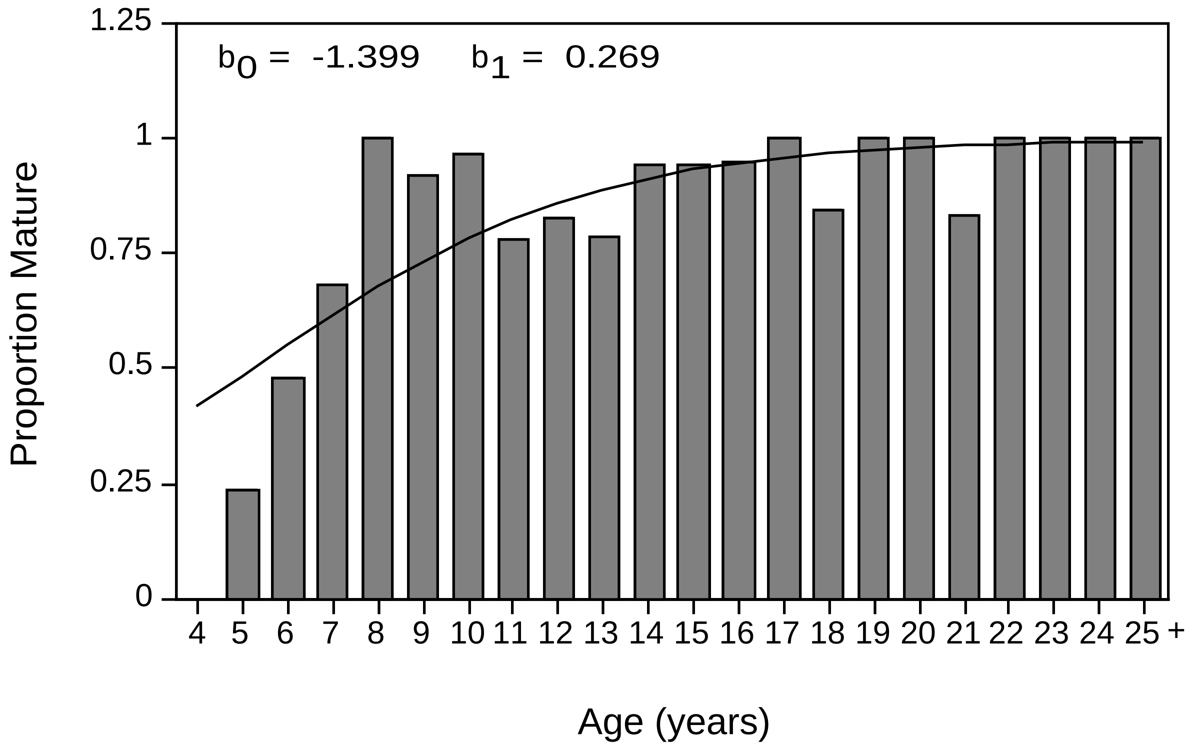


Figure 3. Length (cm) and age (years) frequency of female Pacific ocean perch sampled and numbers of ovaries with major atresia by size and age, 2000-2003.



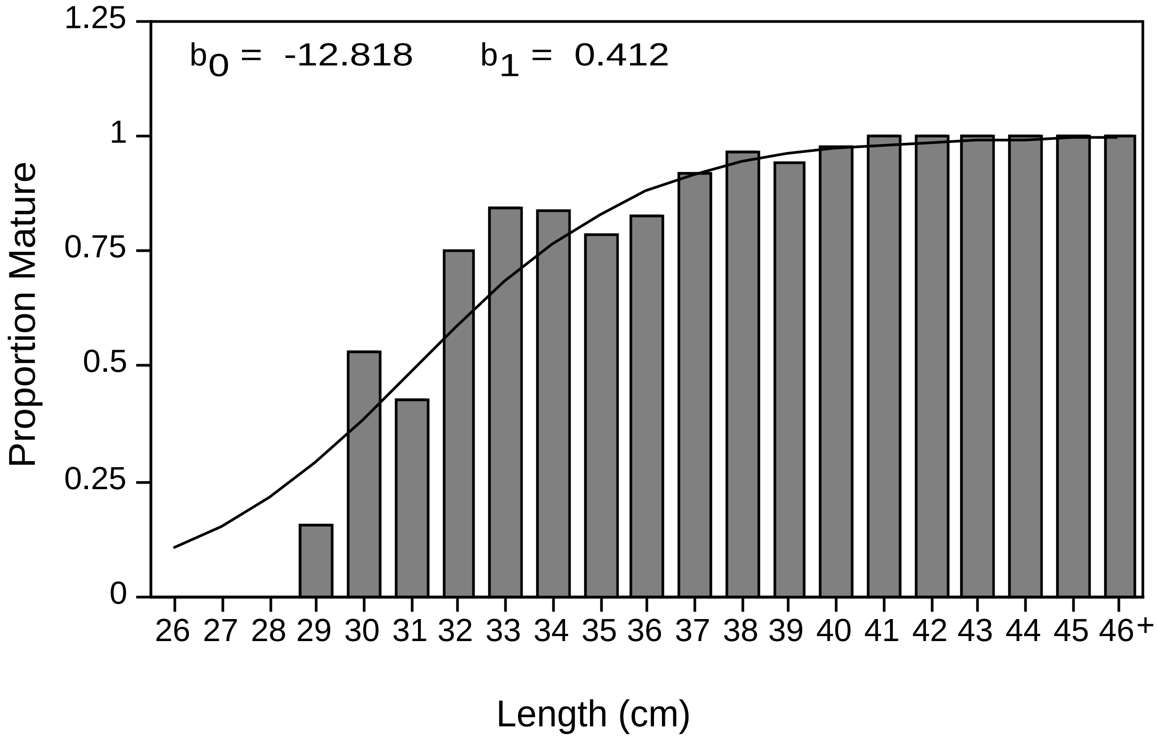


Figure 4. Proportion of mature Pacific ocean perch, by age (years) and length (cm), with fitted logistic curves.

Table 2. Summary of proportion mature by length (cm) and age (y) for Pacific ocean perch collected off Oregon in the months of December to March, 2000-2003.

Length (cm)	Number Sampled	Number Mature	Proportion Mature	Age (y)	Number Sampled	Number Mature	Proportion Mature
26	1	0	0.000	4	2	0	0.000
27	2	0	0.000	5	21	5	0.239
28	5	0	0.000	6	27	13	0.481
29	13	2	0.154	7	22	15	0.682
30	15	8	0.533	8	13	13	1.000
31	14	6	0.429	9	25	23	0.920
32	20	15	0.750	10	28	27	0.964
33	13	11	0.846	11	45	35	0.778
34	25	21	0.840	12	51	42	0.824
35	56	44	0.786	13	33	26	0.788
36	51	42	0.824	14	35	33	0.943
37	62	57	0.919	15	36	34	0.944
38	61	59	0.967	16	20	19	0.950
39	53	50	0.943	17	17	17	1.000
40	40	39	0.975	18	13	11	0.846
41	19	19	1.000	19	9	9	1.000
42	14	14	1.000	20	10	10	1.000
43	7	7	1.000	21	6	5	0.833
44	3	3	1.000	22	6	6	1.000
45	3	3	1.000	23	7	7	1.000
46+	3	3	1.000	24	2	2	1.000
				25+	33	33	1.000
Total	480	403			461	385	

assessed in 2003. *In*: Status of the Pacific Coast Groundfish Fishery Through 2003: Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384.

Gunderson, D., R. P. Callahan and B. Goiney. 1980. Maturation and fecundity of four species of *Sebastes*. Mar. Fish. Rev. 42(3-4)74-79.

Leaman, B. L. 1988. Reproductive and population biology of Pacific ocean perch (*Sebastes alutus* (Gilbert)). Ph.D. Thesis. Univ. of British Col., Vancouver, Canada. 198 p.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley, California.

Lunsford, C. R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska. M.S. Thesis. University of Alaska Fairbanks. 154 p.

Nichol, D. G. and E. K. Pikitch. 1994. Reproduction of darkblotched rockfish off the Oregon coast. Trans. Amer. Fish. Soc. 123:469-481.

Trippel, E. A., O. S. Kjesbu and P. Solemdal. 1997. Effects of adult age and size structure on reproductive output in marine fishes. Pages 31-62 *in* R. C. Chambers and E. A. Trippel, eds. Early life history and recruitment in fish populations. Chapman and Hall, New York.

West, G. 1990. Methods of assessing ovarian development in fishes: a review. Aust. J. Freshwater Res. 41:199-222.

Westrheim, S. J. 1975. Reproduction, maturation and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific ocean. J. Fish. Res. Bd. Can. 32(12):2399-2411.