NOAA Technical Memorandum NMFS

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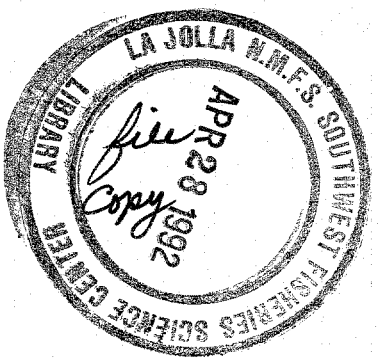

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

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ABSTRACT

Estimated growth parameters for widow rockfish (Sebastes entomelas) differed significantly between sexes and among International North Pacific Fisheries Commission (INPFC) areas and years. Males had greater growth completion rates (K in the von Bertalanffy growth equation) and reached a smaller average maximum length than did females. Widow rockfish were found to have smaller K values and reach larger average maximum lengths with increasing latitude. Significant differences in growth among years were found; however, preliminary examination of these differences did not detect a pattern. For future stock assessments, we suggest that four sets of growth parameters adequately describe the growth of widow rockfish: a set for males and females from the north (Vancouver and Columbia INPFC areas) and a set for males and females from the south (Eureka and Monterey INPFC areas).

INTRODUCTION

Widow rockfish (Sebastes entomelas) is the dominant rockfish species in west coast groundfish landings. Between 1978 and 1988, widow rockfish made up more than 30% of total rockfish landings on the west coast (Pacific Fisheries Management Council [PFMC] 1989). In 1981, widow rockfish accounted for about 50% of all west coast rockfish landings. Since 1982, landings of widow rockfish have declined, primarily due to regulatory measures implemented to protect the stock.

Recent stock assessments of widow rockfish have been based on the stock synthesis model (Methot 1990). That model uses growth data obtained from port sampling to relate landings to estimates of population size. The von Bertalanffy growth parameters currently used were estimated by Lenarz (1987) using ages obtained from whole otoliths. In addition, a single set of growth parameters have been used for the entire coast and for all years. If whole otolith ages produce biased estimates of the growth parameters or if the differences in growth among areas or years are significant, use of these estimates could result in biased projections of population size.

Studies of other species have shown that growth parameters can vary both spatially and temporally. Using ages from whole otoliths, Boehlert (1980) found that splitnose rockfish (S. diploproa) have a greater length-at-age in Washington than in California. The same trend has been observed for yellowtail rockfish (S. flavidus) (Fraidenburg 1980), chilipepper (S.

goodei) and boccacio (S. paucispinus) (Wilkins 1980). However, the trend for increasing length-at-age with latitude is not universal. No significant difference in length-at-age for canary rockfish (S. pinniger) was found between Washington and California (Boehlert 1980).

Latitudinal differences in growth rate, maximum length, and length at age have been found for other genera as well. American shad (Alosa sapidissima) (Leggett and Carscadden 1978), Atlantic menhaden (Brevoortia tyranus) (June and Reintjes 1959), Atlantic croaker (Micropogonias undulatus) (White and Chittenden 1977), and weakfish (Cynoscion regalis) (Shepherd and Grimes 1983) all showed latitudinal differences in maximum length. Conover (1990) found that striped bass (Morone saxatilis), American shad, and mummichog (Fundulus heteroclitus) exhibit faster rates of growth within a growing season with increasing latitude. These differences in growth have been attributed to temperature, food availability, or adaptation. Conover (1990) suggested that rapid within-season growth is a trait which favors those species that experience high levels of size-selective winter mortality. Since winters are longer with increasing latitude, a gradient for selection of faster growing fish could develop. Note, however, this tendency does not necessarily result in a greater length-at-age in more northerly areas, because of the shorter growing seasons associated with increasing latitude.

Temporal variation in growth has not been studied as extensively as spatial variation, partly due to the need for

extended time series of age and length data (Boehlert et al. 1989). In a study of 1929-1980 witch flounder (Glyptocephalus cynoglossus) landings, Bowering (1989) found that L_∞ (the average maximum length parameter in the von Bertalanffy growth equation) increased gradually while K (the rate of growth parameter in the von Bertalanffy growth equation) decreased. He attributed this to density-dependent factors resulting from heavy fishing pressure. Weakfish have also shown an increase in length at age over time, which was attributed to density-dependent factors resulting from fishing (Shepherd and Grimes 1983). Boehlert et al. (1989) found that splitnose and canary rockfish growth differed significantly between years, with increased growth rates since 1970. The conclusion was viewed as preliminary because it was based on measurements of unvalidated annuli in sectioned otoliths (Boehlert et al. 1989). Boehlert et al. (1989) attributed changes in growth rate to density-dependent factors relating to fishing pressure. For Pacific whiting (Merluccius productus), Hollowed et al. (1988) found that K increased and L_∞ decreased for cohorts after 1967. Those changes were attributed to size-selective fishing mortality, such that faster-growing fish became vulnerable to fishing at a younger age, and therefore had a greater chance of being caught.

This study was undertaken to obtain updated estimates of the von Bertalanffy growth parameters using broken and burnt otoliths and to test for differences in size at age among years and areas.

If size at age differs significantly among either years or areas, separate submodels will be needed to assess the status of the widow rockfish stock.

METHODS

California, Oregon, and Washington operate independent port sampling programs. Samplers from all three states collect otoliths, sex, and length data from the commercial fisheries; however, sampling protocols vary among states. Adequate port sampling data on the length, sex, and age of widow rockfish in Washington, Oregon, and California trawl landings were available for the years 1981-89. For consistency with Oregon and Washington, California total length measurements were converted to fork lengths using conversion formulae from Echeverria and Lenarz (1984). California samples were assigned to International North Pacific Fisheries Commission (INPFC) areas (Figure 1) based on the port of landing; Washington and Oregon samples were assigned based on area fished. Data from the Conception INPFC area were excluded from the study due to the small number of fish measured. Also due to inadequate sample sizes, fish older than 20 years or younger than five years were omitted from the study. We further restricted the analysis to those year-sex-area combinations having at least ten age classes comprised of five or more fish (Appendix A).

Ages of fish landed in Washington were determined by the Washington Department of Fisheries, Seattle, Washington. Ages for Oregon and California fish were determined by the National

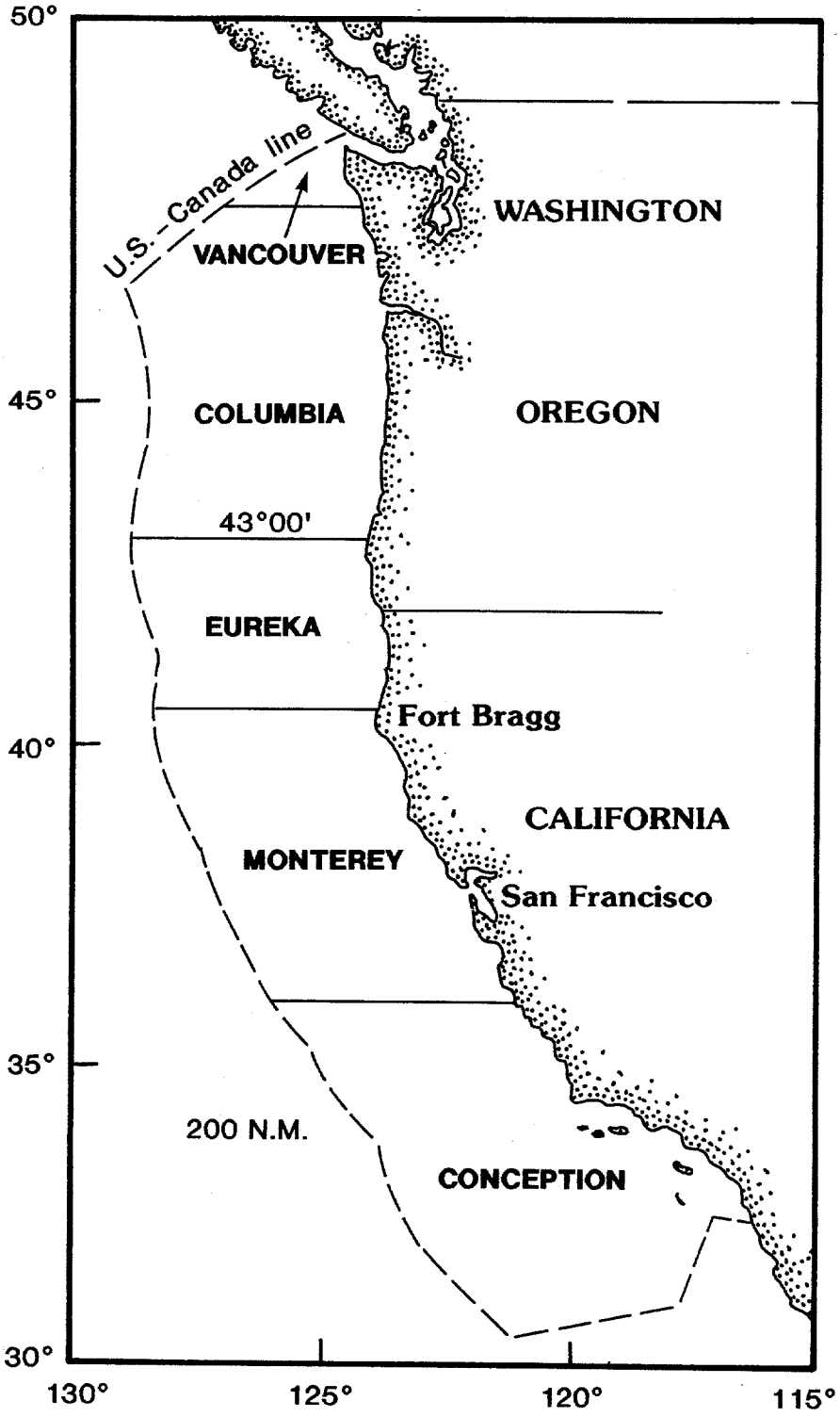


Figure 1. INPFC areas used to test for spatial differences in widow rockfish growth. Data for the Conception area were excluded because of small sample sizes.

Marine Fisheries Service, Tiburon, California. In both agencies, ages were based on examination of the otolith surface until 1984 when the broken and burnt otolith method was adopted. Primary age readers at the Tiburon Laboratory changed in 1985 and again in 1987.

Parameters for the von Bertalanffy growth curve were calculated iteratively using the method described by Schnute (1981). Curves were fitted to mean size at age rather than to individual observations of size at age to avoid giving too much weight to heavily sampled age classes. The results given below are expressed using the traditional form of the von Bertalanffy curve:

$$L_t = L_\infty (1 - e^{-K(t-t_0)})$$

where L_t = length at age t (cm FL)

L_∞ = average maximum length (cm FL)

K = growth completion rate ($years^{-1}$)

t_0 = theoretical age when fish is length 0 (years)

We tested for growth differences among years, areas, and sexes using the Extra Sum of Squares Principle (Draper and Smith 1981, Ratkowsky 1983). To test for differences in growth among years, we compared the error sum of squares from separate growth curves by year, area, and sex to that for growth curves by area and sex but pooled over years. Similar comparisons were made to

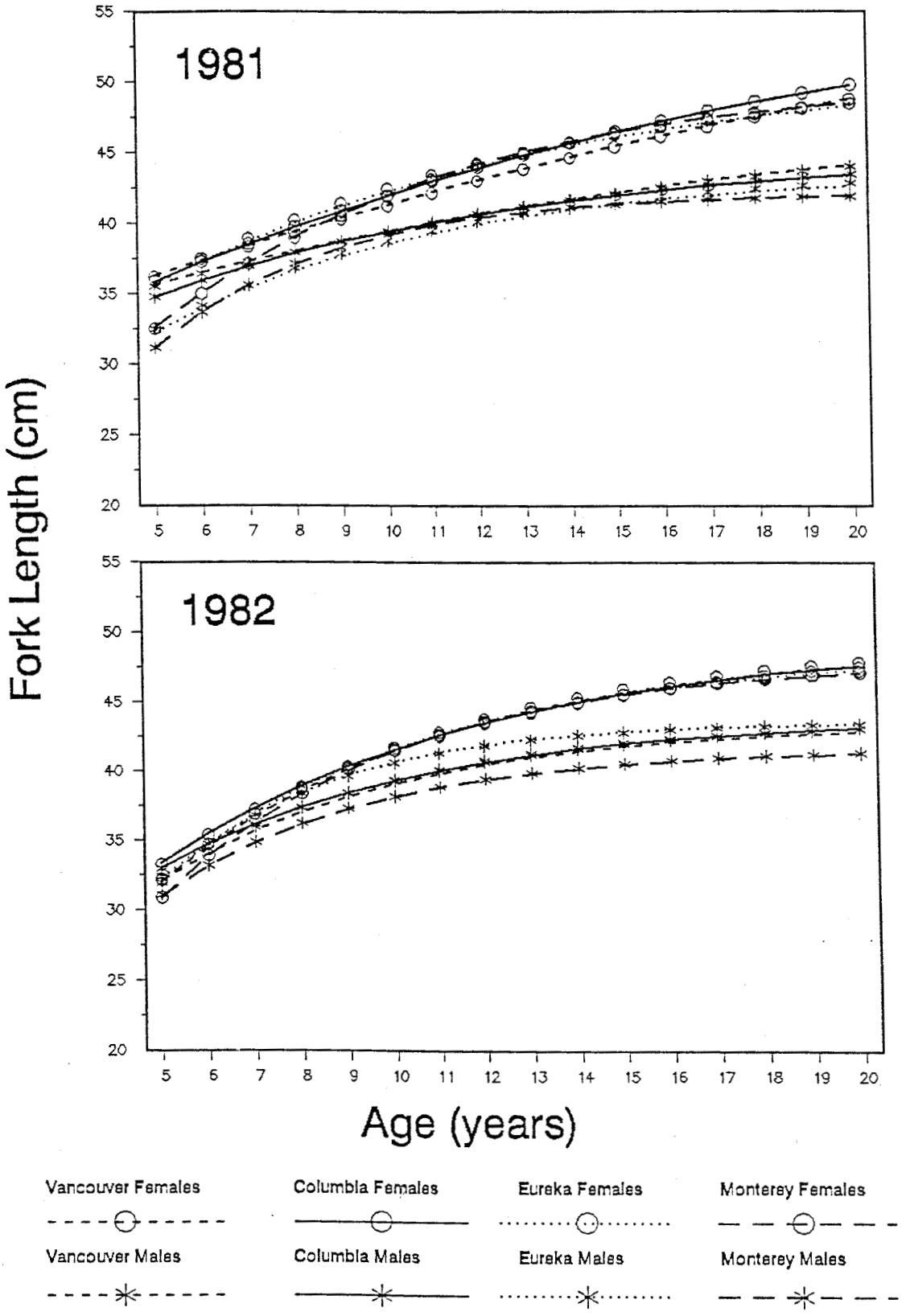
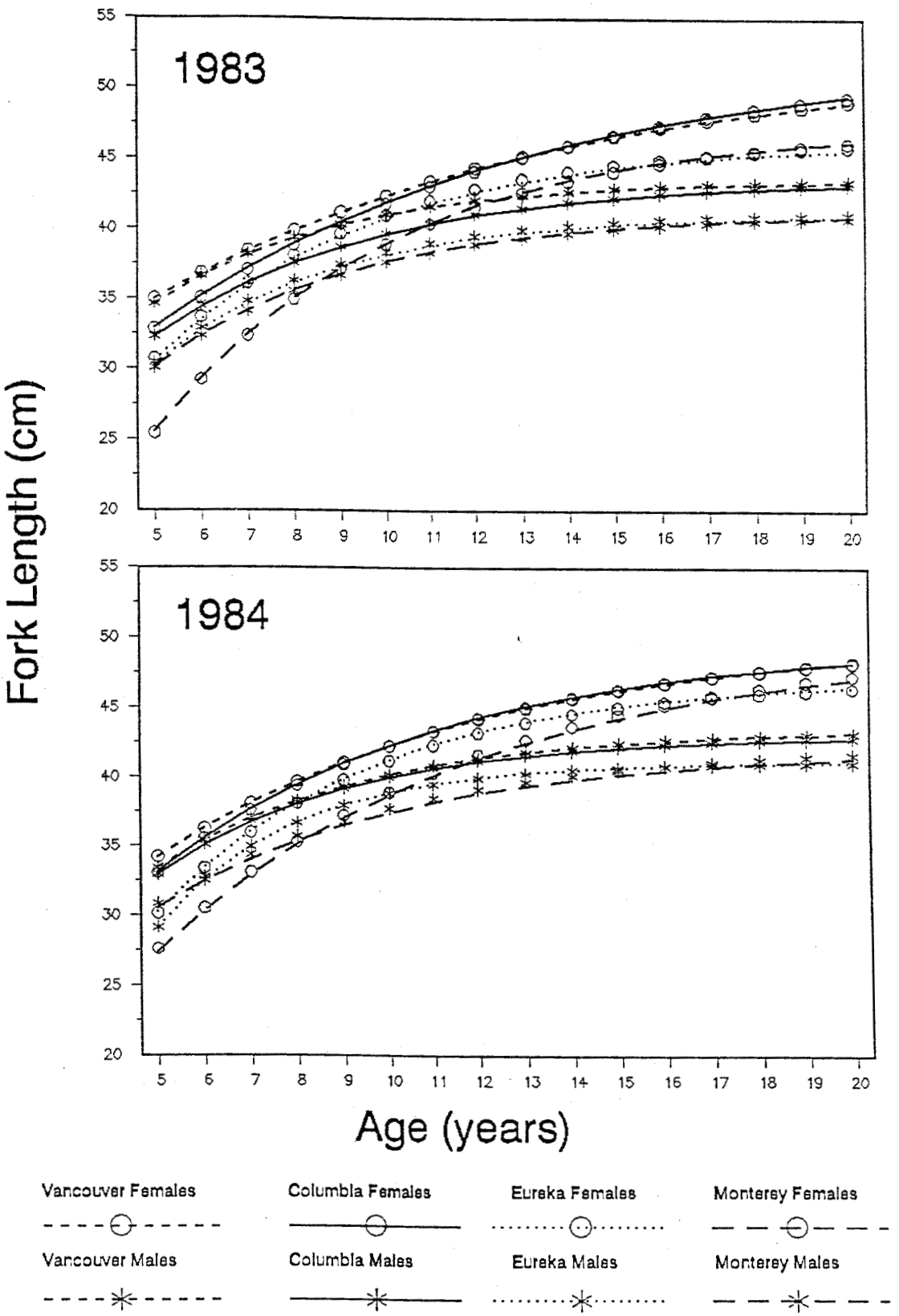


Figure 2. Growth curves by INPFC area and sex for widow rockfish from 1981-1989.



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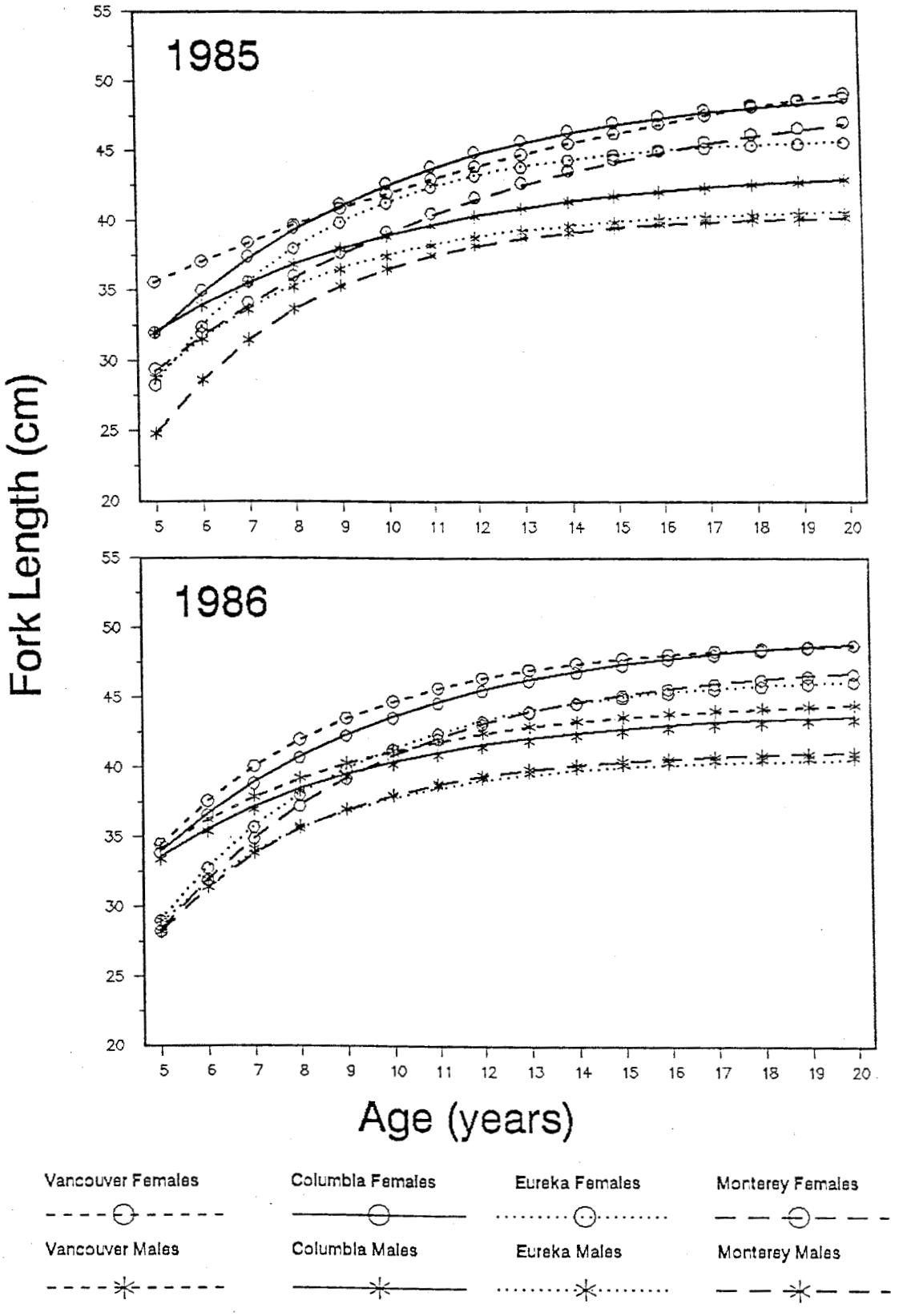

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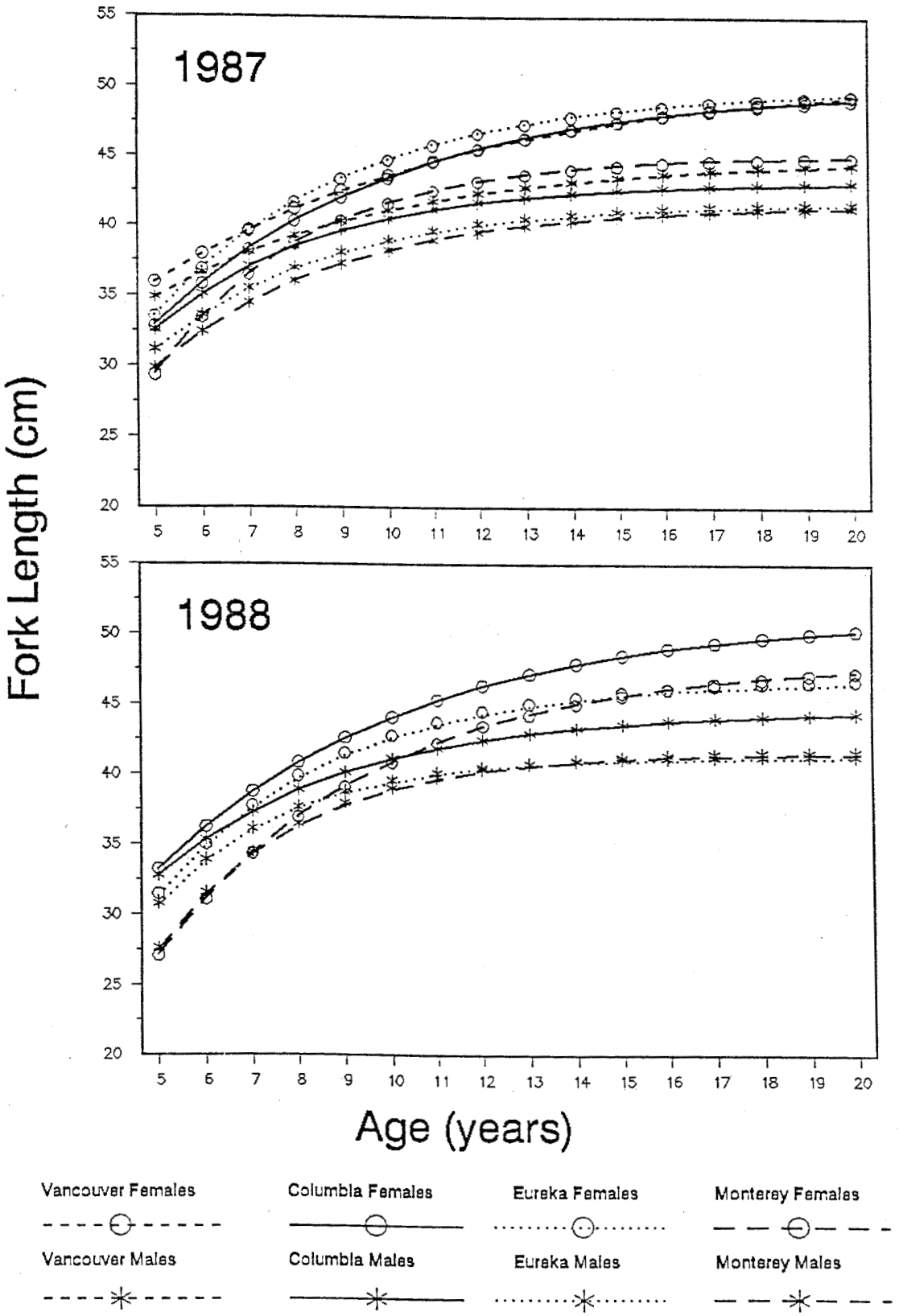

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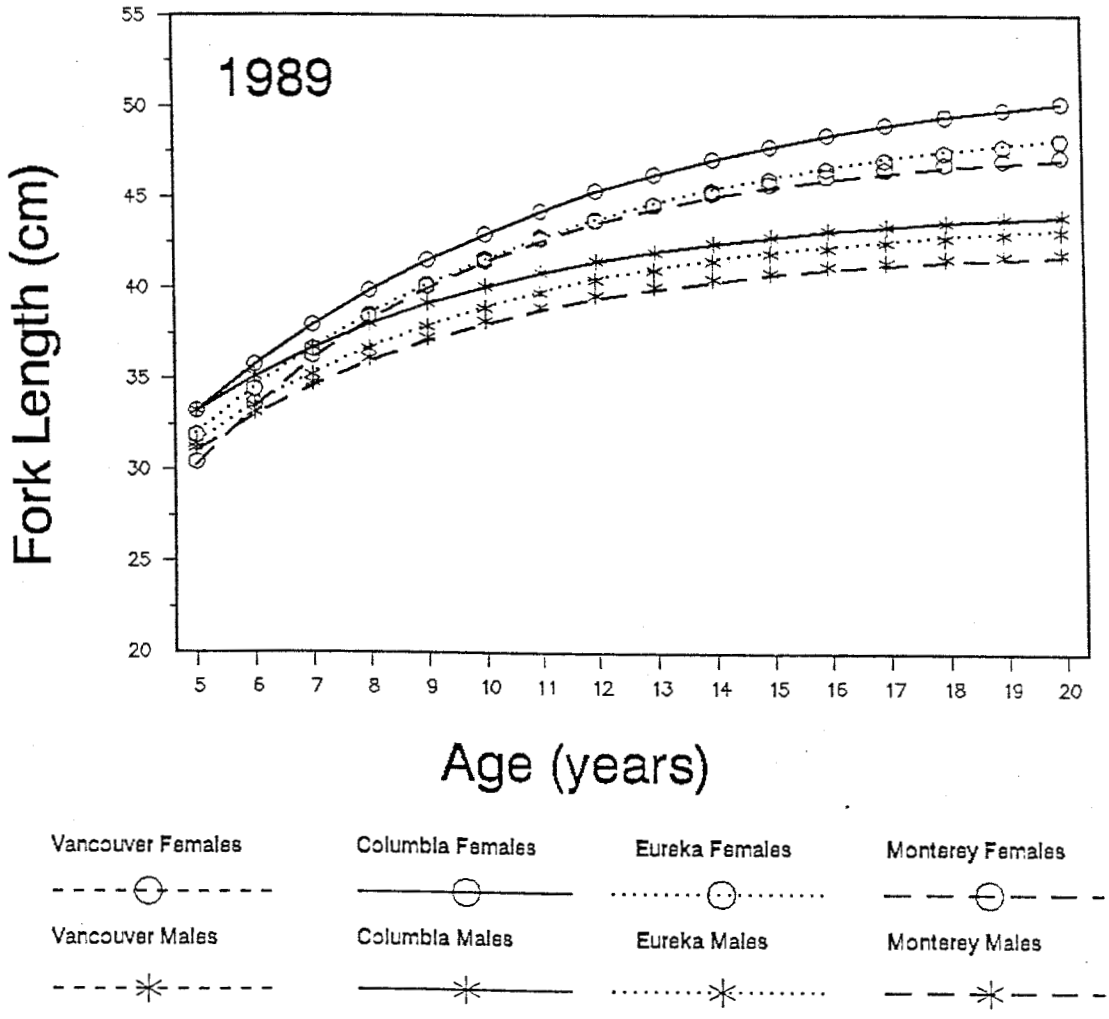

Figure 2. Cont.

test for differences among areas and between sexes. The results should be viewed as preliminary because multiple significance tests were made from the same data set.

RESULTS AND DISCUSSION

Males were found to have a higher growth completion rate (K) and reach a smaller average maximum length (L_∞) than females (Tables 1-2, Figure 2). Growth completion rate (K) varied from 0.07 yr^{-1} (Vancouver 1981) to 0.35 yr^{-1} (Eureka 1988) for males and from 0.04 yr^{-1} (Vancouver 1981) to 0.30 yr^{-1} (Monterey 1987) for females (Table 2).

Table 1. Degrees of freedom (numerator, denominator), Calculated F values, probability > F, and Sum of the Squares for the Extra Sum of the Squares Principle Tests (Draper and Smith 1980, Ratkowsky 1983) for differences in growth among sexes, years, areas (INPFC), and regions (north and south). The reduced model is for the test variable pooled, the expanded model is for the test variable separated. The expanded model is the same for each test.

					SUM OF SQUARES	
TEST	D.F.	F	P	MODEL	RESIDUAL	EXPLAINED
Sex	99, 781	72.06	<0.0001	Reduced	3537.13	1,674,457.00
				Expanded	349.01	1,677,645.10
Year	24, 781	7.38	<0.0001	Reduced	922.48	1,677,071.15
				Expanded	349.01	1,677,645.10
Area	51, 781	18.54	<0.0001	Reduced	1567.18	1,676,426.23
				Expanded	349.01	1,677,645.10
Region	108, 781	3.57	<0.0001	Reduced	497.35	1,677,496.82
				Expanded	349.01	1,677,645.10

L_∞ estimates for males ranged from 40.51 cm FL (Monterey 1985) to 45.53 cm FL (Vancouver 1987) except for an anomalously high value for Vancouver 1981 (48.65 cm FL) (Table 2). Estimates for females ranged from 45.17 cm FL (Monterey 1987) to 54.86 cm FL (Vancouver 1985) except for anomalously high 1981 Vancouver (64.04 cm FL) and Columbia (59.27 cm FL) values (Table 2).

Table 2. von Bertalanffy growth parameters for male and female widow rockfish (Sebastes entomelas) by year and INPFC areas.

		YEAR								
SEX		1981	1982	1983	1984	1985	1986	1987	1988	1989
						VANCOUVER				
Male	t_o	-13.77	-2.06	-1.34	-1.62		-1.84	-2.86		
	L_∞	48.65	43.61	43.57	43.53		44.90	44.98		
	K	0.07	0.19	0.25	0.22		0.21	0.19		
Female	t_o	-15.87	-1.59	-5.05	-3.17	-8.05	-0.04	-3.64		
	L_∞	64.04	49.33	52.31	50.16	54.86	49.10	51.19		
	K	0.04	0.16	0.11	0.14	0.08	0.24	0.14		
						COLUMBIA				
Male	t_o	-7.24	-3.16	-1.42	-1.01	-2.36	-1.83	-0.16	-0.53	-2.55
	L_∞	45.14	44.03	43.47	42.96	43.70	43.98	43.14	44.64	44.72
	K	0.12	0.17	0.21	0.24	0.18	0.21	0.27	0.24	0.18
Female	t_o	-10.51	-2.96	-3.17	-1.86	-0.68	-1.02	-0.61	-0.76	-2.14
	L_∞	59.27	49.66	52.59	49.65	49.80	49.63	50.00	51.46	52.58
	K	0.06	0.14	0.12	0.16	0.18	0.19	0.19	0.18	0.14
						EUREKA				
Male	t_o	-3.43	0.12	-0.14	1.26	0.27	0.60	-0.25	1.11	-2.00
	L_∞	43.79	43.59	41.24	41.13	40.77	40.77	41.77	41.41	44.04
	K	0.16	0.27	0.26	0.33	0.26	0.28	0.26	0.35	0.18
Female	t_o	-4.67	-1.39	-0.15	0.12	1.44	0.92	0.14	0.74	-1.79
	L_∞	51.80	48.56	46.40	47.14	45.87	46.65	46.96	46.93	50.13
	K	0.11	0.17	0.21	0.21	0.27	0.24	0.23	0.26	0.15
						MONTEREY				
Male	t_o	-0.17	-1.21	-0.72	-2.21	1.59	1.90	-0.05	1.72	-1.93
	L_∞	42.17	41.70	41.17	42.27	40.51	40.94	41.62	41.58	42.48
	K	0.26	0.22	0.23	0.18	0.28	0.28	0.25	0.33	0.19
Female	t_o	-1.94	-0.40	0.93	-0.74	-1.85	0.70	1.48	1.05	0.01
	L_∞	50.39	48.13	47.45	49.94	49.81	47.47	45.17	48.25	48.00
	K	0.15	0.19	0.19	0.14	0.13	0.21	0.30	0.21	0.20

Estimates of t_0 fluctuated without pattern among years,

areas and sexes (Table 2). The youngest fish used in fitting the growth curves were five-year-olds, thus t_0 probably was not well estimated.

Growth patterns among areas were significantly different (Table 1). Fish in the north were found to grow slower and reach a higher L_∞ than fish in the more southern INPFC areas (Table 2, Figure 2). This trend was most evident for males.

We also detected significant differences in growth parameters among years (Table 1). However, when mean size at age was compared among years, we found no pattern to the differences which would lead us to conclude that a long-term directional shift in growth patterns was occurring, except that both males and females tended to vary in the same direction most of the time (Figures 3-6). Changes in the growth curves among years did not coincide with a change in ageing methods from surface readings to the break and burn technique in 1984, nor to the period of lower coastwide landings after 1982, nor to changes in primary agers for the Columbia, Eureka, and Monterey INPFC areas (1985 and 1987) (Figure 7 - 10). Interannual variation in the growth curves was not similar among areas. We also found no evidence that the interannual variation was caused by differences among cohorts. The differences among years could be due to changes in the spatial distribution of the stock or the fishery. Such changes could result in catches from subpopulations with different growth characteristics. It is possible that there is a

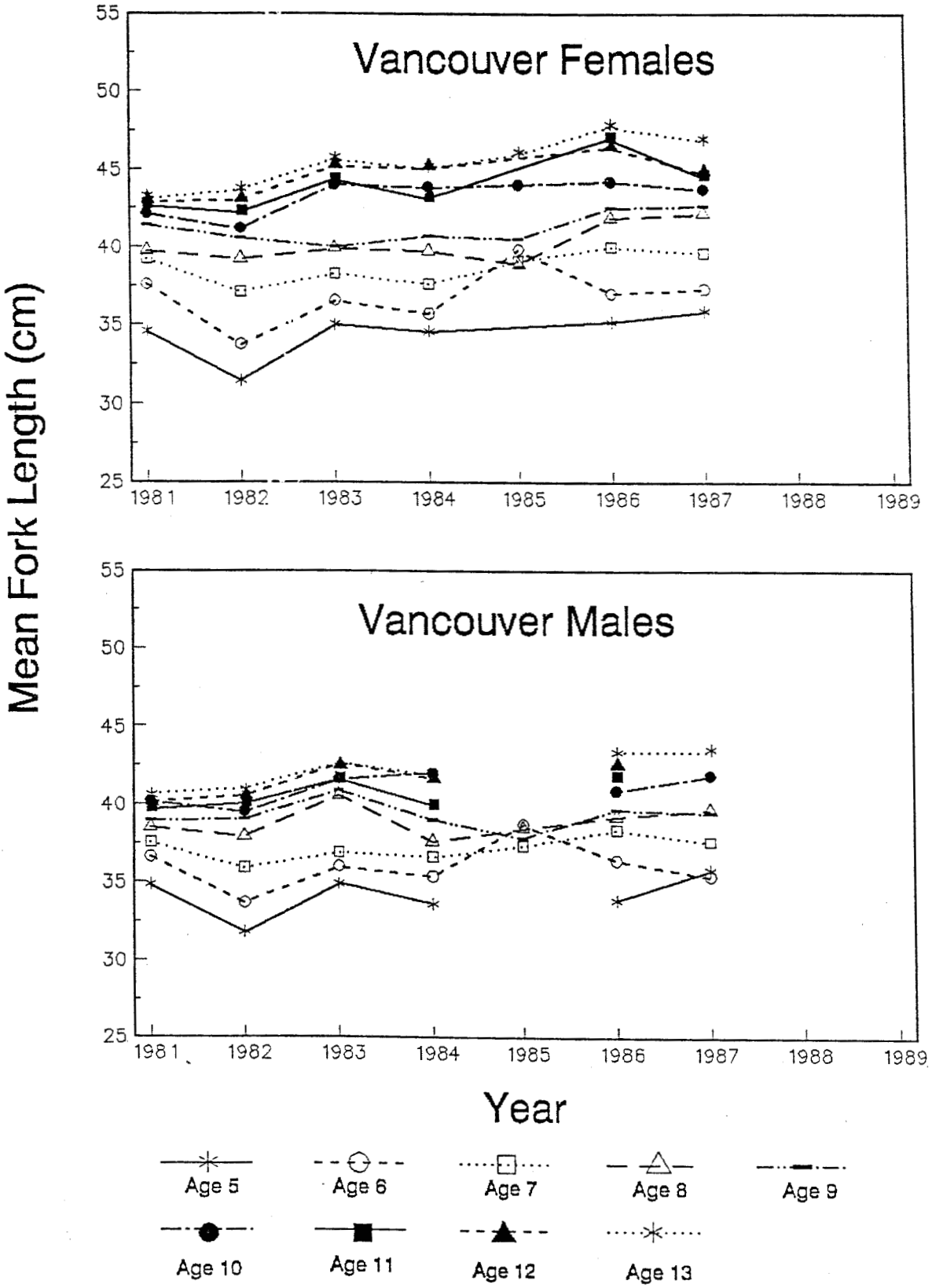

Figure 3. Mean size at age for 1981- 1987 widow rockfish landings in the Vancouver area.

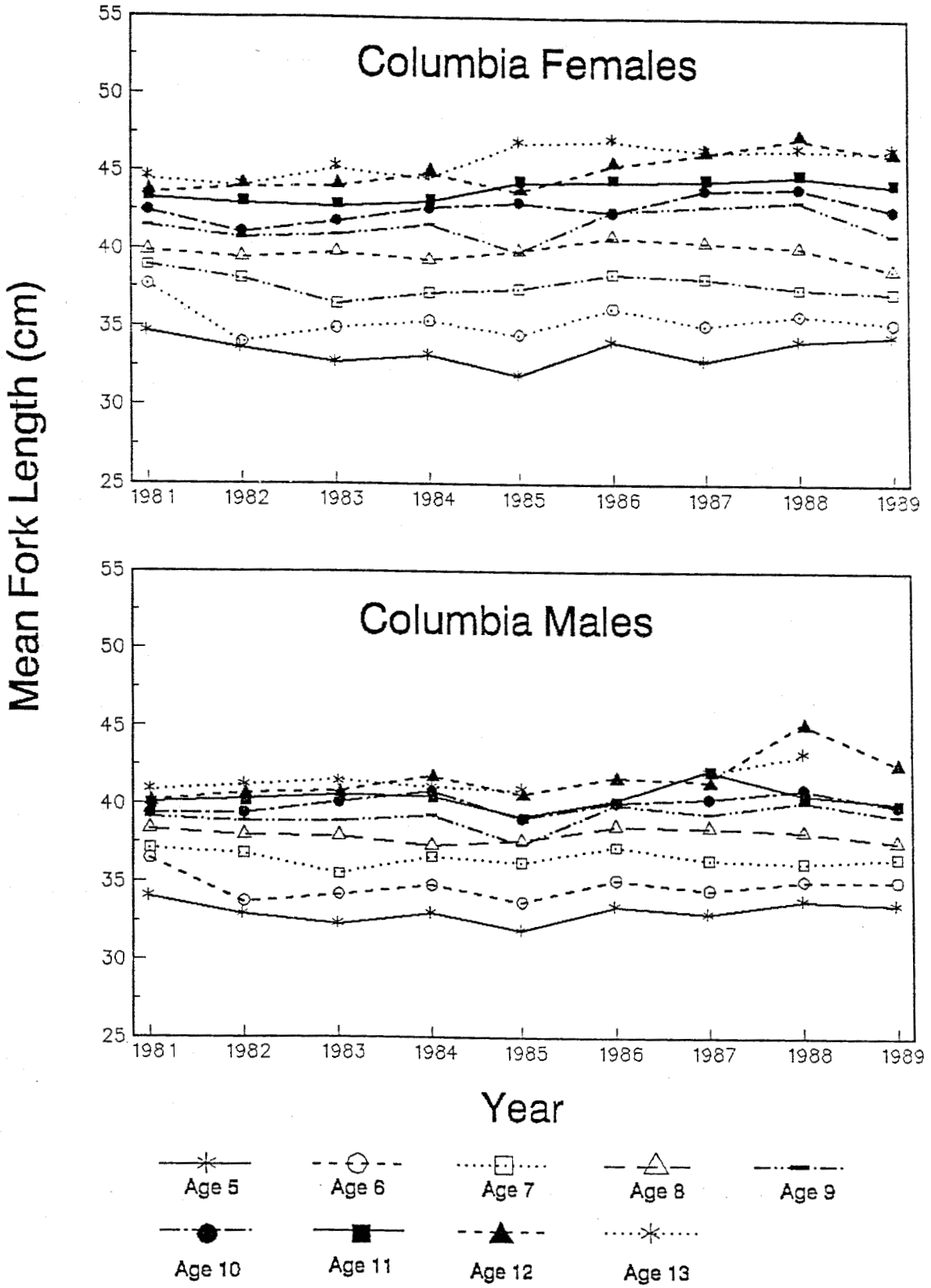

Figure 4. Mean size at age for 1981 - 1989 widow rockfish landings in the Columbia area.

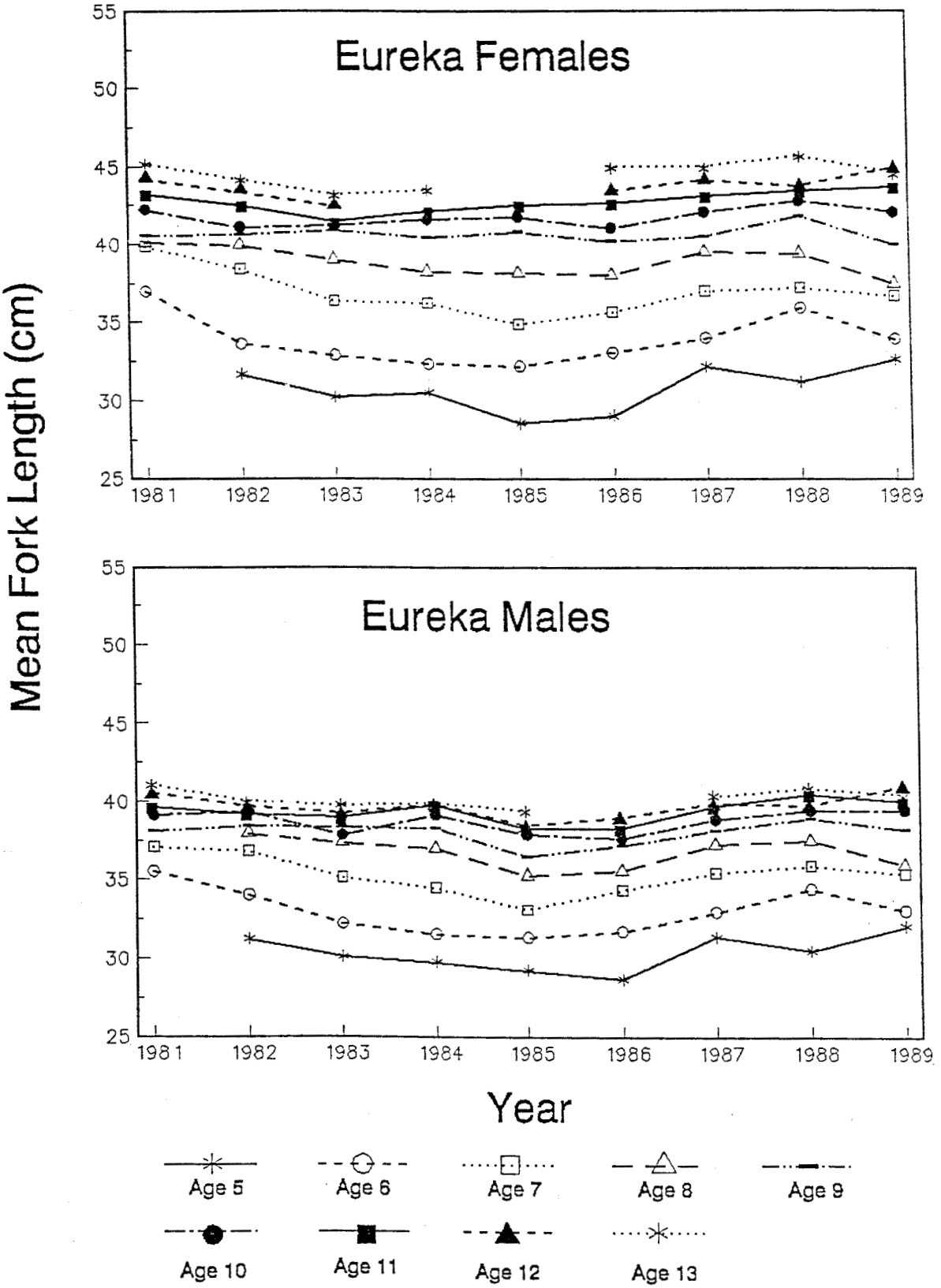

Figure 5. Mean size at age for 1981 - 1989 widow rockfish landings in the Eureka area.

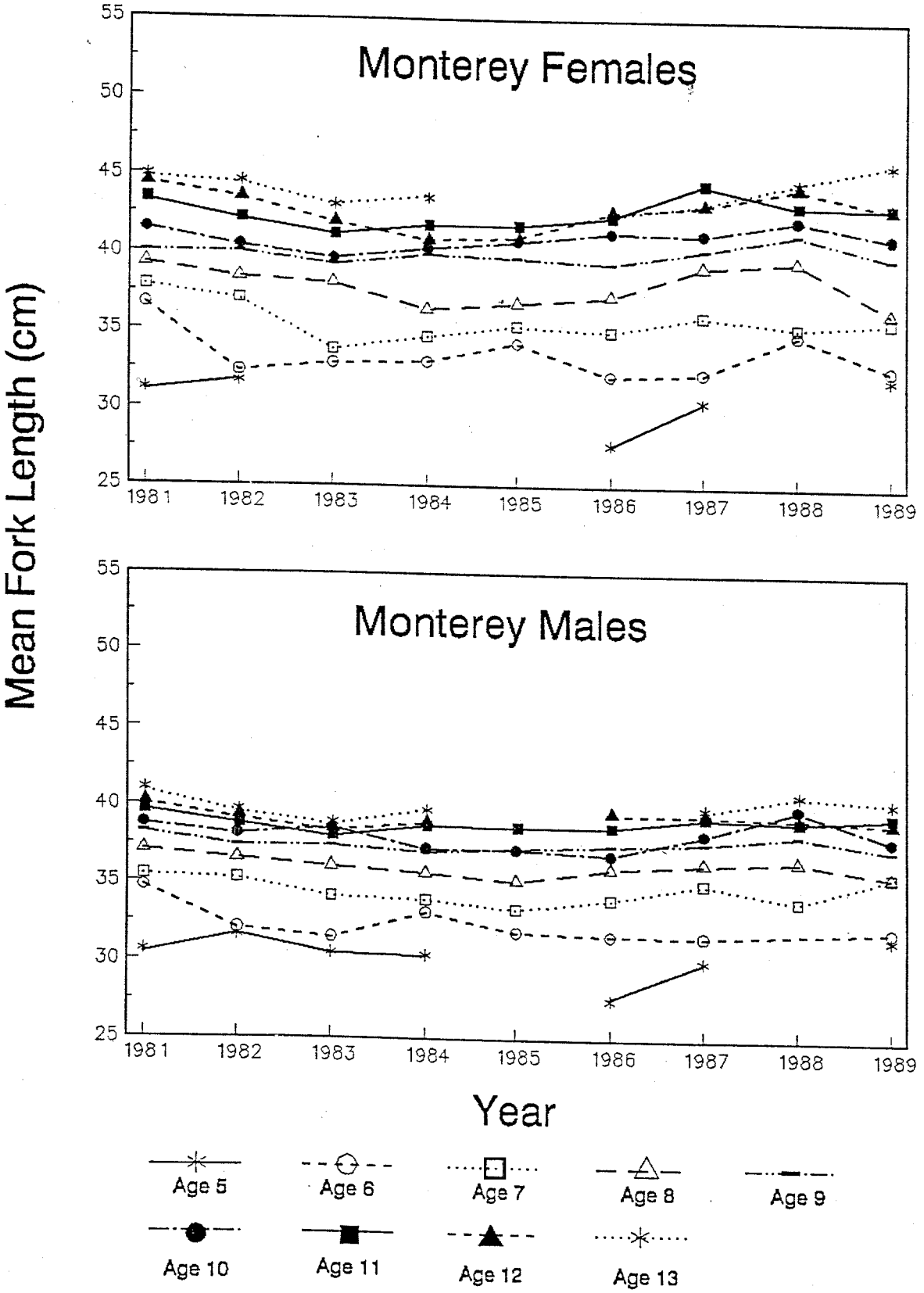

Figure 6. Mean size at age for 1981 - 1989 widow rockfish landings for the Monterey area.

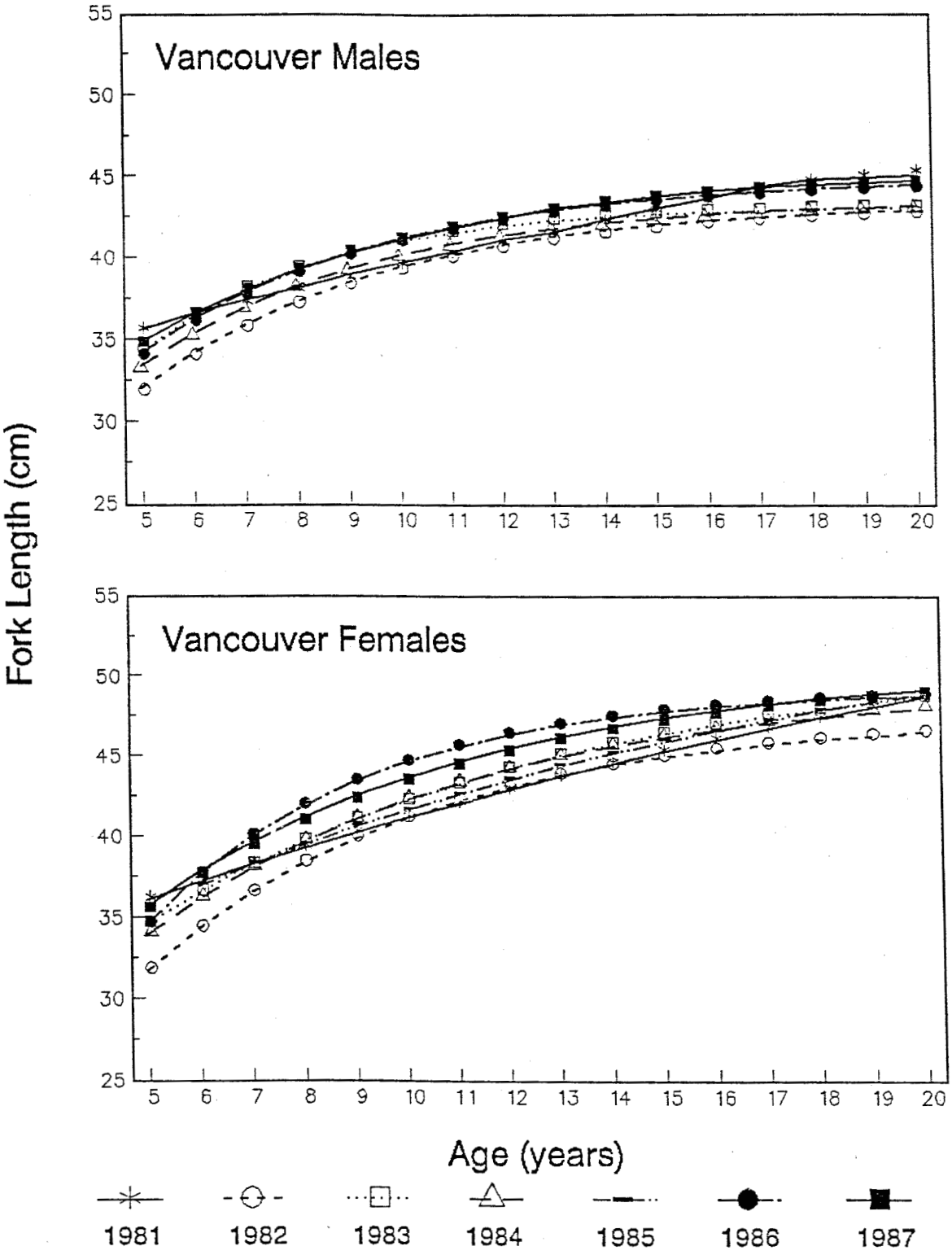

Figure 7. Predicted growth curves for male and female widow rockfish from the Vancouver area for 1981 - 1987. Males in 1985 were excluded due to a lack of data.

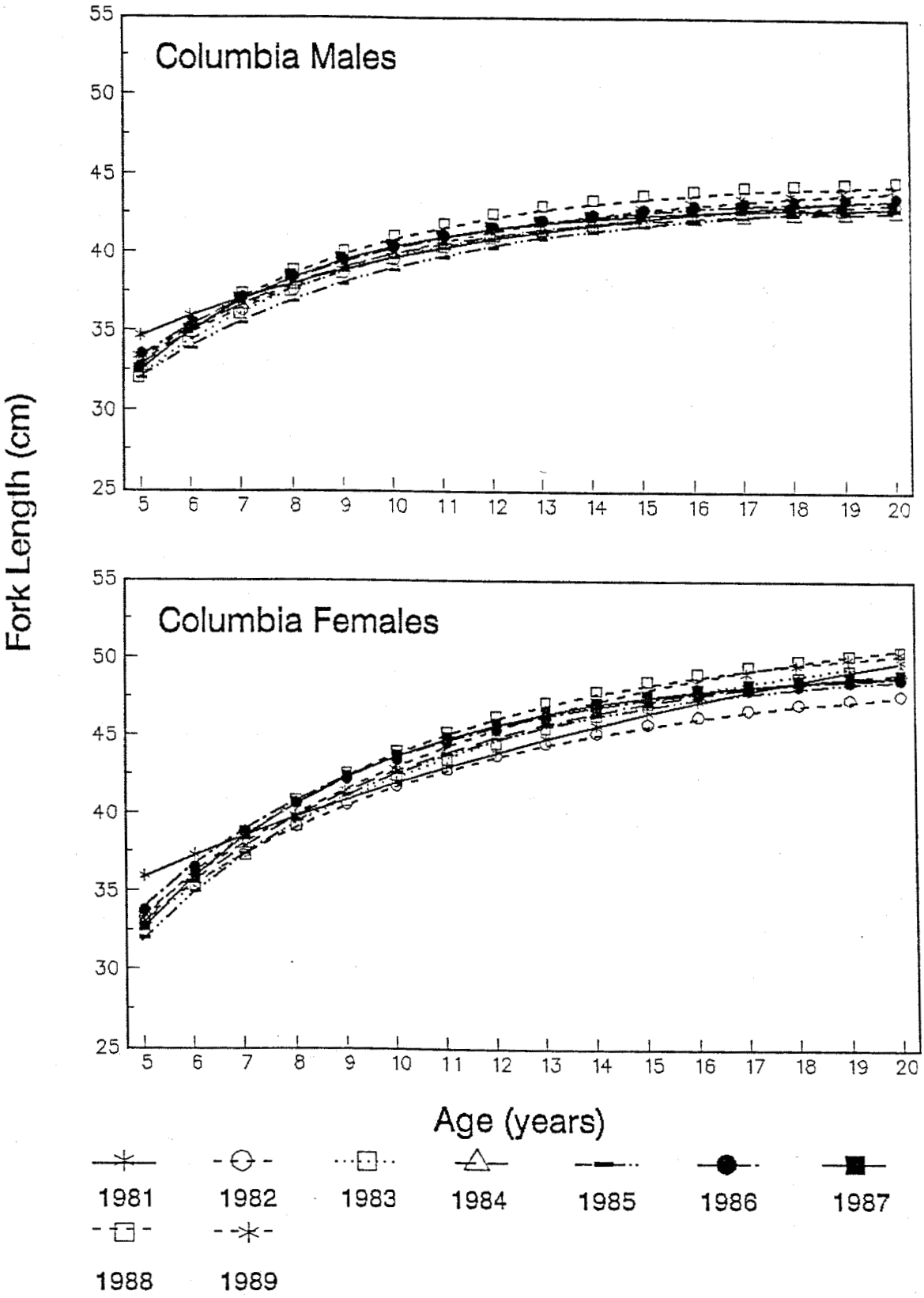

Figure 8. Predicted growth curves for male and female widow rockfish from the Columbia area for 1981 - 1989.

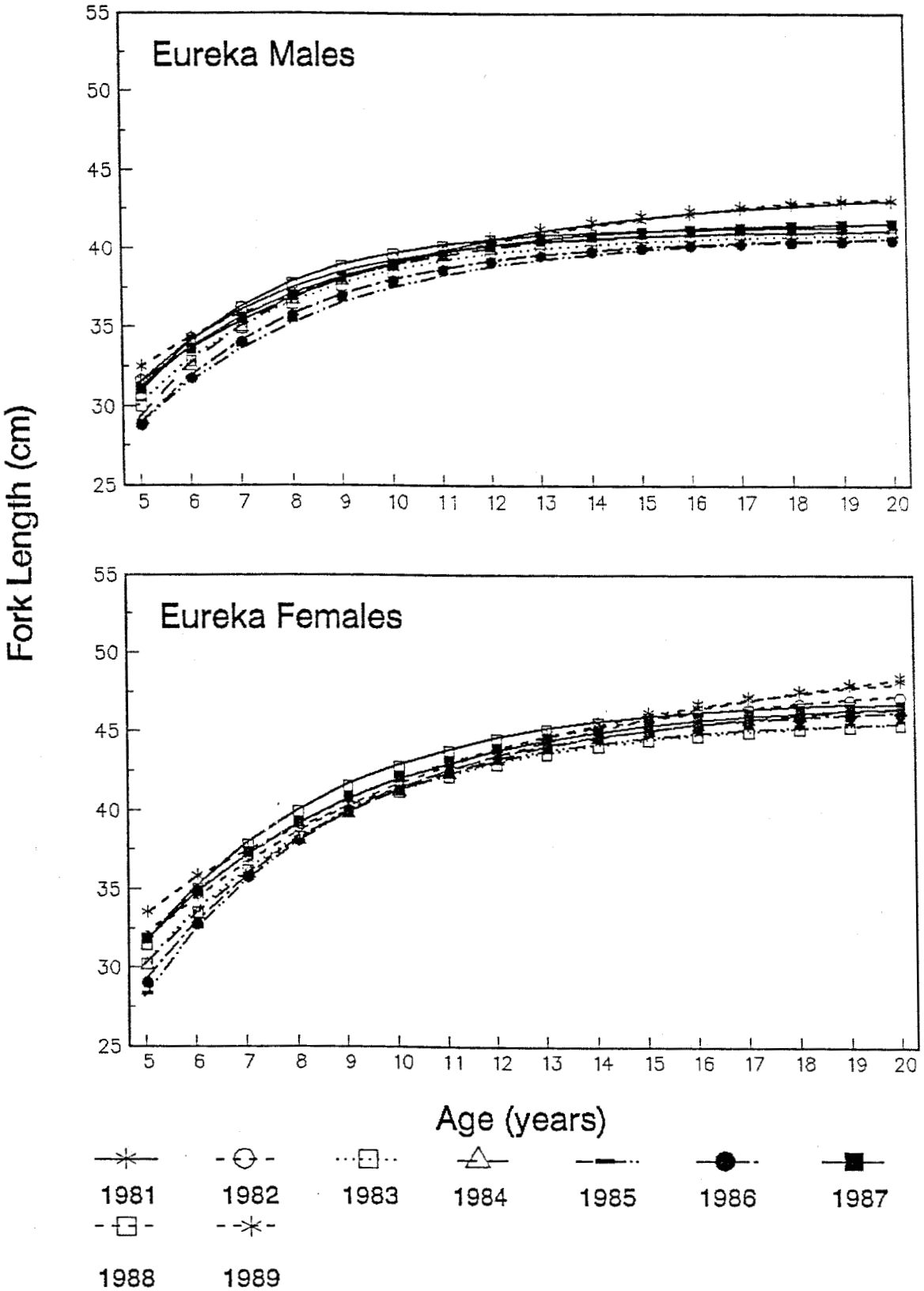

Figure 9. Predicted growth curves for male and female widow rockfish from the Eureka area for 1981 - 1989.

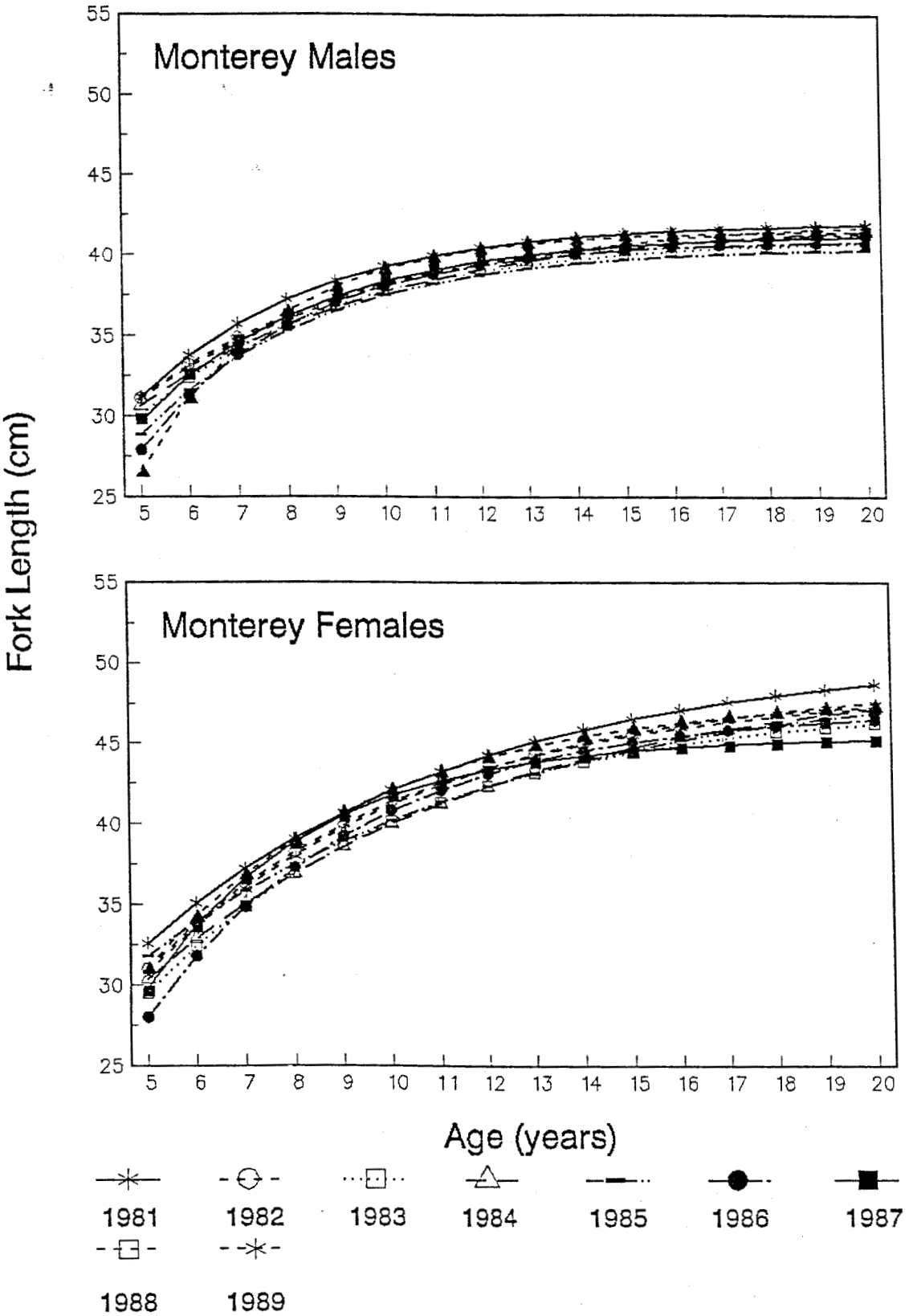

Figure 10. Predicted growth curves for male and female widow rockfish from the Monterey area for 1981 - 1989.

pattern to the differences which was not detected and which has biological significance.

Based on the lack of pattern in the differences among years, we judge the statistical significance to be due to the high power of the test, rather than to important trends in growth. For possible use in future assessments, we present simpler models obtained by combining over years and areas (Table 3). Based on Figure 2, we feel that pooling over years and the Vancouver-Columbia versus the Monterey-Eureka areas is a reasonable

Table 3. Estimated von Bertalanffy growth parameters based on pooled 1981-1989 by INPFC area and for the north (Vancouver and Columbia areas combined) and south (Eureka and Monterey areas combined).

AREA		MALES	FEMALES
Vancouver	t_o	-4.24	-5.41
	L_∞	44.41	51.59
	K	0.16	0.11
Columbia	t_o	-1.70	-2.26
	L_∞	43.47	50.35
	K	0.21	0.15
Eureka	t_o	0.15	0.25
	L_∞	41.45	47.15
	K	0.27	0.22
Monterey	t_o	-0.08	-0.37
	L_∞	41.26	47.92
	K	0.26	0.19
North	t_o	-2.81	-2.68
	L_∞	44.00	50.54
	K	0.18	0.14
South	t_o	-0.28	-0.17
	L_∞	41.50	47.55
	K	0.25	0.20

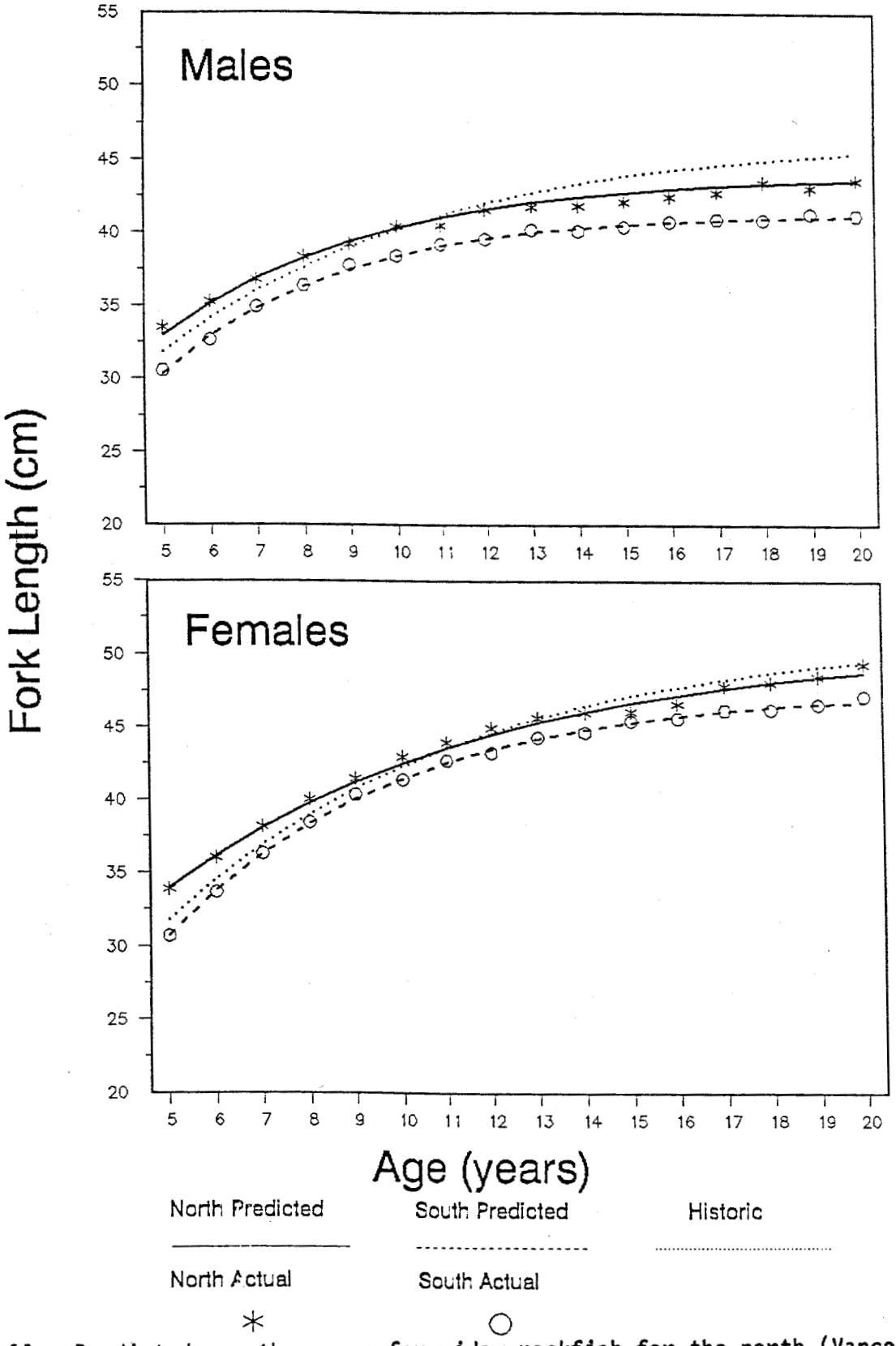

Figure 11. Predicted growth curves for widow rockfish for the north (Vancouver and Columbia) and the south (Eureka and Monterey). Markers show individual yearly mean length at age for each of the areas. Historic growth curves from Lenarz (1987) are shown for reference.

approach for future assessments. That grouping of INPFC areas is consistent with the two areas treated as fisheries within the 1990 assessment (Hightower and Lenarz 1990). The increase in error sum of squares due to pooling (Table 1) seems justifiable to achieve a more practical growth model for use in stock assessment. The estimated parameters (Table 3) and the predicted curves (Figure 11) for these two regions of the coast appear to be sufficiently different to argue against further pooling. The growth curves are also sufficiently different from the historical estimates (Figure 11) to suggest that separate submodels could alter the results of future stock assessment using the stock synthesis model (Methot 1990). We recommend that future assessments be conducted using these revised northern and southern region growth curves.

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SEX	INPFC AREA	YEAR	AGE 5 N	AGE 5 MEAN	AGE 5 CV	AGE 6 N	AGE 6 MEAN	AGE 6 CV	AGE 7 N	AGE 7 MEAN	AGE 7 CV
Male	Vancouver	1981	40	34.88	6.94	68	36.63	3.89	44	37.55	5.09
		1982	34	31.82	6.85	108	33.69	5.08	30	35.93	6.02
		1983	56	34.89	6.71	46	36.02	5.81	10	36.90	6.19
		1984	17	33.65	10.87	141	35.40	5.85	84	36.63	5.76
		1985				7	38.71	6.28	27	37.37	3.87
		1986	31	33.90	6.57	80	36.44	7.20	64	38.39	5.58
		1987	11	35.82	5.12	77	35.43	9.86	147	37.63	8.69
		1988									
		1989									
	Columbia	1981	52	34.04	6.78	190	36.51	4.59	134	37.14	4.34
		1982	329	32.92	7.48	311	33.74	7.56	237	36.80	7.00
		1983	588	32.30	6.51	409	34.18	7.60	93	35.49	6.96
		1984	125	33.00	6.43	418	34.78	5.54	251	36.59	4.74
		1985	235	31.87	6.38	260	33.70	6.96	583	36.21	5.23
		1986	115	33.45	6.63	527	35.13	6.04	298	37.24	5.05
		1987	59	32.97	6.92	392	34.49	7.27	715	36.43	5.82
		1988	32	33.84	8.09	160	35.09	6.67	452	36.22	6.42
		1989	74	33.58	5.98	200	35.07	6.58	345	36.55	6.19
	Eureka	1981				15	35.53	3.82	10	37.10	5.15
		1982	105	31.23	4.99	21	34.05	6.60	56	36.84	4.39
		1983	21	30.10	5.94	180	32.21	6.33	42	35.17	5.18
		1984	77	29.75	5.54	299	31.55	4.90	243	34.53	5.66
		1985	21	29.24	6.83	108	31.34	5.87	255	33.12	4.30
		1986	37	28.68	5.82	53	31.74	5.53	170	34.37	5.89
		1987	38	31.37	5.76	78	32.97	5.42	77	35.48	6.36
		1988	8	30.50	10.07	53	34.45	6.91	85	35.92	6.64
		1989	125	32.08	6.68	38	33.08	6.79	100	35.42	6.36
	Monterey	1981	5	30.60	10.49	35	34.74	6.52	43	35.47	6.72
		1982	118	31.58	5.62	17	32.06	4.34	78	35.26	5.72
		1983	11	30.45	6.94	120	31.48	6.79	25	34.12	8.17
		1984	6	30.33	9.01	11	33.09	10.51	85	33.91	9.04
		1985				13	31.85	6.52	35	33.34	6.70
		1986	28	27.54	6.37	22	31.64	6.66	34	34.00	7.17
		1987	10	30.00	8.75	30	31.60	5.61	39	35.00	6.04
		1988							21	33.90	8.99
		1989	86	31.49	6.10	34	32.03	4.64	23	35.61	8.24

Appendix A. Sample size, mean, and coefficient of variation for widow rockfish fork length (cm) by age, sex, INPFC area, and year of capture.

SEX	INPFC AREA	YEAR	AGE 8 N	AGE 8 MEAN	AGE 8 CV	AGE 9 N	AGE 9 MEAN	AGE 9 CV	AGE 10 N	AGE 10 MEAN	AGE 10 CV
Male	Vancouver	1981	27	38.48	4.41	44	38.95	4.46	79	40.18	3.90
		1982	56	37.91	5.42	21	39.05	7.22	34	39.53	4.28
		1983	7	40.57	5.67	8	40.88	5.46	11	41.64	4.33
		1984	32	37.63	7.33	20	39.00	7.20	5	42.00	2.92
		1985	17	38.47	5.82	6	37.83	3.51			
		1986	37	39.22	4.85	9	39.67	4.37	11	40.91	5.83
		1987	33	39.67	6.45	14	39.50	7.80	9	41.89	4.04
		1988									
		1989									
	Columbia	1981	68	38.38	4.03	154	39.14	4.10	357	39.40	3.90
		1982	201	37.98	5.97	97	38.89	5.14	76	39.39	4.91
		1983	74	37.92	6.70	39	38.87	5.88	28	40.11	5.81
		1984	60	37.30	6.76	49	39.29	4.93	16	40.81	4.92
		1985	219	37.63	5.52	44	37.41	6.97	26	39.08	6.31
		1986	508	38.56	4.07	196	39.98	4.73	18	40.11	6.89
		1987	249	38.50	5.54	129	39.38	4.19	65	40.35	4.98
		1988	316	38.22	6.30	85	40.15	5.41	46	40.98	5.28
		1989	624	37.59	5.90	254	39.30	5.71	66	39.91	6.15
	Eureka	1981				9	38.11	8.55	46	39.13	3.48
		1982	20	37.95	2.63	18	38.44	4.66	9	39.33	3.36
		1983	64	37.38	3.49	15	38.40	2.16	8	37.88	4.77
		1984	50	37.00	3.50	72	38.32	3.58	25	39.16	3.88
		1985	249	35.28	4.58	26	36.50	4.33	47	37.91	3.92
		1986	232	35.58	5.13	212	37.24	4.80	14	37.64	4.25
		1987	127	37.25	5.84	117	38.17	4.59	121	38.89	4.18
		1988	70	37.53	5.07	70	38.94	5.60	47	39.47	4.81
		1989	207	35.98	6.90	122	38.26	6.28	71	39.48	4.59
	Monterey	1981	32	37.06	7.41	33	38.27	3.59	71	38.77	4.53
		1982	76	36.54	5.35	64	37.42	5.32	35	38.14	3.93
		1983	42	36.07	7.10	34	37.41	5.10	20	38.55	4.41
		1984	31	35.65	5.86	36	37.00	6.99	22	37.23	5.74
		1985	115	35.17	6.87	18	37.28	4.30	25	37.20	5.26
		1986	60	35.97	4.96	124	37.45	4.47	9	36.89	5.82
		1987	80	36.34	5.73	86	37.67	4.70	186	38.20	4.51
		1988	26	36.50	5.10	35	38.20	4.66	26	39.88	4.09
		1989	53	35.58	6.10	33	37.27	7.36	20	37.90	6.95

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 11 N	AGE 11 MEAN	AGE 11 CV	AGE 12 N	AGE 12 MEAN	AGE 12 CV	AGE 13 N	AGE 13 MEAN	AGE 13 CV
Male	Vancouver	1981	75	39.81	4.16	56	40.09	5.04	32	40.59	4.37
		1982	57	40.12	2.98	120	40.57	4.38	79	40.90	3.20
		1983	10	41.70	5.77	12	42.50	3.95	22	41.91	2.65
		1984	10	40.00	2.89	15	41.67	2.82	14	41.79	2.99
		1985									
		1986	7	41.86	3.50	10	42.60	4.31	10	43.40	4.37
		1987							7	43.57	3.21
		1988									
		1989									
	Columbia	1981	265	40.06	3.62	122	40.13	5.17	63	40.95	5.76
		1982	149	40.24	4.28	293	40.64	3.85	120	41.24	4.51
		1983	21	40.52	3.79	52	40.75	3.43	44	41.48	3.14
		1984	11	40.45	4.19	12	41.75	3.09	35	41.09	4.70
		1985	18	39.17	6.51	5	40.60	10.24	8	41.00	5.38
		1986	36	40.19	6.12	18	41.67	4.03			
		1987	12	42.17	4.39	17	41.41	8.19	16	42.13	7.25
		1988	19	40.58	6.38	7	45.14	8.52	6	43.33	10.99
		1989	35	40.06	10.09	14	42.57	4.58			
	Eureka	1981	54	39.70	3.16	39	40.56	3.48	25	41.16	2.50
		1982	51	39.24	4.82	83	39.72	3.20	38	40.05	5.89
		1983	10	39.00	3.82	17	39.29	3.34	36	39.92	3.41
		1984	17	39.82	3.47	7	39.86	6.05	21	39.86	4.65
		1985	19	38.32	5.44	8	38.50	3.40	6	39.50	5.94
		1986	43	38.33	4.62	23	39.04	2.62			
		1987	14	39.71	3.75	43	39.93	2.53	19	40.53	1.91
		1988	35	40.51	4.91	17	39.82	6.29	12	41.00	5.50
		1989	35	40.09	4.03	19	41.05	3.39	12	40.50	3.57
	Monterey	1981	75	39.75	3.41	40	40.25	4.31	26	41.08	3.37
		1982	81	38.90	3.32	149	39.40	3.36	76	39.72	3.28
		1983	9	38.11	3.81	21	38.57	3.63	56	38.95	3.81
		1984	13	38.77	6.24	10	39.00	4.68	13	39.77	5.15
		1985	21	38.71	8.69						
		1986	29	38.72	3.15	32	39.63	4.09			
		1987	8	39.38	2.69	40	39.55	3.92	24	39.96	2.15
		1988	40	39.15	3.90	12	39.25	3.78	15	40.87	4.52
		1989	12	39.50	3.50	13	39.08	2.44	18	40.39	3.30

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 14 N	AGE 14 MEAN	AGE 14 CV	AGE 15 N	AGE 15 MEAN	AGE 15 CV	AGE 16 N	AGE 16 MEAN	AGE 16 CV
Male	Vancouver	1981	28	40.82	4.57	14	41.64	3.72	8	43.00	1.76
		1982	58	41.05	3.88	66	41.02	4.00	39	41.26	3.55
		1983	15	41.93	5.06	17	42.18	4.04	8	42.25	2.76
		1984	25	42.40	4.03	20	41.75	3.63	17	42.47	4.49
		1985	5	42.20	1.98	5	43.20	9.32			
		1986	8	43.00	3.04	10	43.40	3.29	15	43.93	4.08
		1987	10	43.00	3.10	8	43.25	3.44	9	43.33	3.83
		1988									
		1989									
	Columbia	1981	38	41.24	5.15	27	41.81	4.45	13	43.54	5.67
		1982	86	41.52	4.81	60	41.18	5.03	35	41.54	4.38
		1983	23	41.39	4.59	21	42.14	4.06	19	42.16	3.73
		1984	52	41.42	3.39	29	41.52	2.70	33	41.91	5.28
		1985	19	41.21	6.19	41	42.15	4.30	5	41.20	6.51
		1986				12	42.83	3.83	53	42.94	4.55
		1987							15	43.07	6.94
		1988									
		1989	9	42.56	4.09						
	Eureka	1981	16	41.50	3.17	11	41.64	2.22	13	42.23	3.37
		1982	28	40.75	3.11	32	40.81	3.14	27	40.56	3.58
		1983	17	39.71	3.05	22	39.59	2.98	18	40.83	3.59
		1984	85	40.36	3.54	10	40.40	3.13	8	40.25	10.93
		1985	24	39.67	3.12	51	39.80	2.30			
		1986				12	40.08	3.09	43	40.53	3.74
		1987							16	41.25	3.49
		1988									
		1989									
	Monterey	1981	19	41.16	3.37	7	41.71	2.28	9	41.22	2.65
		1982	72	40.35	3.41	53	40.62	3.52	34	40.44	2.87
		1983	24	39.42	5.34	18	40.17	3.55	17	40.24	4.35
		1984	36	39.83	3.31	20	39.40	4.69	12	41.08	4.81
		1985	14	38.64	5.88	44	39.50	4.58	6	40.17	5.08
		1986				7	40.57	2.79	41	40.02	3.08
		1987	6	40.17	3.66				20	40.30	3.70
		1988	20	40.45	3.97	5	40.80	4.03	8	41.63	4.96
		1989	12	40.00	5.54	11	40.73	5.28			

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 17 N	AGE 17 MEAN	AGE 17 CV	AGE 18 N	AGE 18 MEAN	AGE 18 CV	AGE 19 N	AGE 19 MEAN	AGE 19 CV
Male	Vancouver	1981	7	43.14	3.65	7	44.71	6.55			
		1982	27	42.44	5.36	17	42.82	3.98	9	43.00	4.50
		1983	5	43.20	1.94	8	43.63	5.74	7	42.57	2.99
		1984	15	42.67	2.89	16	43.38	3.46	16	43.19	2.96
		1985									
		1986	12	44.17	5.86	10	43.90	4.08	9	43.67	3.97
		1987	7	43.00	3.80	8	45.00	3.94			
		1988									
		1989									
	Columbia	1981	10	42.70	3.50	6	43.00	5.30	6	43.00	7.05
		1982	33	42.42	4.00	17	43.06	4.30	15	43.27	2.96
		1983	15	41.27	3.36	7	44.14	4.61	6	42.83	2.30
		1984	12	42.42	3.40	8	43.00	7.03	7	42.71	2.93
		1985	13	42.54	2.98	6	43.33	2.38			
		1986	14	43.21	3.87	7	42.57	3.80	6	43.83	7.27
		1987	16	42.06	8.17	5	42.20	11.29			
		1988	7	44.00	4.91	9	43.56	3.06			
		1989				5	43.80	4.39	14	43.57	5.88
	Eureka	1981	7	42.00	4.12	6	42.33	2.86			
		1982	18	40.94	3.60	20	41.30	3.43	21	41.67	4.32
		1983	13	40.23	3.07	17	41.18	3.67	14	40.43	4.31
		1984	14	41.50	5.33	15	40.93	2.69	12	41.00	2.33
		1985	15	40.80	2.65	12	39.92	3.77	8	40.88	3.32
		1986	11	40.45	3.20	5	39.60	1.38			
		1987	32	40.97	5.49	20	41.05	3.58	7	41.86	3.21
		1988	8	40.75	3.15	10	41.40	3.26	10	41.60	3.24
		1989							6	42.67	3.2
	Monterey	1981									
		1982	25	41.40	3.34	17	41.00	3.11	16	41.38	2.63
		1983	18	40.83	2.94	13	40.38	3.28	14	40.57	3.01
		1984	14	40.79	2.91	9	40.89	3.55			
		1985	11	41.00	3.27						
		1986	11	40.18	3.11	6	40.33	3.00	6	41.17	3.58
		1987	25	40.84	3.58	17	40.94	4.53	10	42.00	2.75
		1988	12	41.67	5.35	26	41.46	3.49	9	41.22	5.53
		1989							12	41.75	2.53

Appendix A cont.

SEX	INPFC AREA	YEAR	N	AGE 20 MEAN	CV
Male	Vancouver	1981			
		1982	10	43.90	4.36
		1983	5	44.40	4.09
		1984	12	43.00	6.35
		1985			
		1986	10	45.10	4.73
		1987			
		1988			
		1989			
	Columbia	1981			
		1982	8	43.63	4.74
		1983			
		1984	20	42.60	4.47
		1985	6	42.67	3.53
		1986	5	43.60	5.03
		1987	8	43.25	10.61
		1988	6	44.17	2.65
		1989	8	43.88	2.84
	Eureka	1981			
		1982	13	41.69	3.30
		1983	6	42.00	6.39
		1984	22	41.14	4.39
		1985	7	40.43	1.95
		1986	13	40.92	4.17
		1987	14	41.64	2.60
		1988			
		1989			
	Monterey	1981			
		1982	10	41.10	3.13
		1983	5	41.00	2.99
		1984	5	42.00	6.07
		1985	10	39.90	3.43
		1986	6	41.50	2.53
		1987			
		1988	6	41.50	2.53
		1989			

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 5 N	AGE 5 MEAN	AGE 5 CV	AGE 6 N	AGE 6 MEAN	AGE 6 CV	AGE 7 N	AGE 7 MEAN	AGE 7 CV
Female	Vancouver	1981	26	34.58	7.19	53	37.58	4.32	45	39.24	3.69
		1982	15	31.47	6.34	65	33.75	5.49	33	37.12	6.66
		1983	68	35.01	6.33	45	36.53	8.82	16	38.25	6.44
		1984	12	34.58	9.01	112	35.72	6.66	58	37.64	7.59
		1985				6	39.83	3.70	53	39.11	4.56
		1986	25	35.20	10.44	93	37.01	8.17	76	40.00	6.14
		1987	9	35.89	14.57	72	37.29	12.18	149	39.63	8.94
		1988									
		1989									
	Columbia	1981	44	34.66	7.59	156	37.69	5.50	134	38.91	4.26
		1982	269	33.64	8.89	249	34.01	7.62	206	38.12	8.01
		1983	524	32.75	7.14	400	34.93	7.99	119	36.50	9.78
		1984	111	33.20	6.41	397	35.40	6.04	389	37.20	6.00
		1985	223	31.91	6.95	260	34.50	6.89	607	37.48	5.83
		1986	110	34.05	7.22	556	36.23	6.79	339	38.45	6.23
		1987	47	32.85	6.35	350	35.15	7.49	692	38.16	7.01
		1988	27	34.15	9.21	169	35.82	7.88	394	37.49	7.39
		1989	77	34.45	6.20	152	35.29	6.55	254	37.28	7.36
	Eureka	1981				11	37.00	3.82	14	39.86	3.79
		1982	75	31.68	7.00	17	33.65	9.16	79	38.43	4.96
		1983	36	30.22	5.49	199	32.90	7.29	47	36.40	6.00
		1984	83	30.51	6.26	245	32.36	6.13	216	36.28	6.71
		1985	25	28.56	6.56	115	32.20	6.57	230	34.89	5.50
		1986	30	29.03	7.86	52	33.08	8.53	143	35.70	5.97
		1987	22	32.18	8.93	50	34.02	6.33	55	37.04	5.99
		1988	11	31.18	8.58	49	35.92	8.60	96	37.20	6.25
		1989	93	32.63	6.51	46	33.96	7.58	63	36.73	7.59
	Monterey	1981	6	31.17	5.53	25	36.72	6.65	39	37.87	6.91
		1982	95	31.71	5.65	21	32.38	9.84	85	37.06	6.69
		1983				112	32.88	6.74	17	33.82	9.71
		1984				14	33.00	8.73	81	34.65	8.85
		1985				9	34.22	10.10	30	35.33	6.78
		1986	30	27.67	5.64	28	32.14	5.13	29	35.03	7.98
		1987	12	30.50	7.20	36	32.33	5.28	24	36.04	6.31
		1988				6	34.83	8.79	21	35.33	5.47
		1989	87	32.01	5.79	56	32.64	6.22	22	35.73	7.64

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 8 N	AGE 8 MEAN	AGE 8 CV	AGE 9 N	AGE 9 MEAN	AGE 9 CV	AGE 10 N	AGE 10 MEAN	AGE 10 CV
Female	Vancouver	1981	21	39.76	4.42	24	41.42	5.08	73	42.15	4.34
		1982	49	39.22	4.78	25	40.60	3.26	21	41.19	5.30
		1983	10	39.90	9.70	6	40.00	7.75	12	44.00	7.32
		1984	17	39.76	4.75	11	40.73	7.04	6	43.83	1.72
		1985	17	38.88	4.44	10	40.50	6.71	6	44.00	3.21
		1986	63	41.84	6.01	29	42.52	5.43	16	44.19	5.18
		1987	38	42.16	7.01	43	42.67	5.26	21	43.71	3.48
		1988									
		1989									
	Columbia	1981	68	39.85	5.61	74	41.49	4.15	359	42.46	4.27
		1982	198	39.48	5.69	91	40.73	4.83	63	41.11	6.42
		1983	64	39.81	7.55	25	40.96	5.53	27	41.81	8.97
		1984	78	39.31	7.46	87	41.61	4.87	25	42.68	4.37
		1985	287	39.92	5.47	61	39.85	8.98	43	43.05	6.63
		1986	521	40.85	4.47	220	42.50	4.23	33	42.42	5.56
		1987	266	40.48	6.08	160	42.83	5.47	108	43.88	6.31
		1988	317	40.15	7.62	114	43.14	6.73	62	44.00	6.36
		1989	615	38.74	6.97	327	41.03	6.85	94	42.62	7.82
	Eureka	1981	7	40.14	4.42	5	40.60	2.81	36	42.22	2.84
		1982	32	39.97	4.43	21	40.67	5.57	9	41.11	2.84
		1983	70	39.04	5.07	26	40.88	3.04	10	41.20	3.93
		1984	61	38.26	6.03	65	40.48	4.10	31	41.58	3.33
		1985	223	38.17	4.76	26	40.81	3.67	50	41.76	2.88
		1986	176	38.03	5.00	224	40.23	4.18	22	41.05	5.07
		1987	122	39.53	4.85	104	40.53	3.81	137	42.06	4.28
		1988	70	39.41	5.28	66	41.82	3.43	63	42.78	2.98
		1989	199	37.50	7.83	132	40.00	6.98	67	42.03	6.68
	Monterey	1981	21	39.29	5.23	18	40.06	5.45	53	41.53	4.37
		1982	84	38.44	5.76	60	40.08	4.41	21	40.48	5.67
		1983	55	38.09	5.94	30	39.27	5.13	41	39.66	5.34
		1984	31	36.42	8.53	39	39.95	5.68	16	40.31	7.06
		1985	144	36.84	8.66	18	39.72	5.65	39	40.79	6.09
		1986	32	37.31	5.79	68	39.43	5.10	5	41.40	3.66
		1987	61	39.23	5.13	68	40.31	5.34	111	41.32	5.54
		1988	17	39.59	4.81	29	41.34	4.89	23	42.26	4.23
		1989	59	36.37	7.47	28	39.86	5.49	22	41.18	7.06

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 11 N	AGE 11 MEAN	AGE 11 CV	AGE 12 N	AGE 12 MEAN	AGE 12 CV	AGE 13 N	AGE 13 MEAN	AGE 13 CV
Female	Vancouver	1981	79	42.67	4.27	84	42.93	4.67	67	43.16	4.18
		1982	24	42.21	3.95	83	42.99	4.88	66	43.65	6.10
		1983	13	44.31	6.00	15	45.20	5.68	25	45.64	3.09
		1984	8	43.13	4.19	11	45.09	2.88	19	45.05	5.99
		1985							7	46.00	2.81
		1986	6	47.00	3.81	10	46.40	4.45	14	47.79	5.07
		1987	9	44.56	4.22	9	44.78	3.99	7	46.86	3.78
		1988									
		1989									
	Columbia	1981	420	43.36	4.87	197	43.68	5.33	102	44.60	4.99
		1982	137	43.02	3.72	305	44.10	5.62	136	44.13	5.75
		1983	24	42.88	7.16	38	44.13	4.51	94	45.32	4.03
		1984	14	43.14	4.62	23	45.00	4.02	57	44.68	3.44
		1985	33	44.39	5.00	5	43.80	7.29	10	46.90	2.35
		1986	39	44.49	5.08	36	45.53	5.72	10	47.10	3.93
		1987	17	44.53	5.79	22	46.27	3.72	9	46.44	5.29
		1988	38	44.87	5.39	27	47.33	4.35	17	46.53	6.59
		1989	66	44.29	7.84	24	46.21	5.34	18	46.50	4.38
	Eureka	1981	110	43.21	3.06	54	44.26	3.11	49	45.27	4.03
		1982	38	42.50	3.49	157	43.50	3.15	57	44.21	4.42
		1983	9	41.44	3.64	27	42.48	3.22	67	43.22	3.06
		1984	16	42.13	2.86				31	43.55	3.01
		1985	17	42.53	3.73						
		1986	56	42.66	5.10	32	43.41	3.20	5	45.00	2.72
		1987	13	43.08	3.35	41	44.12	4.06	22	44.95	4.42
		1988	62	43.42	4.08	19	43.68	4.25	18	45.72	2.47
		1989	42	43.69	4.78	38	44.82	3.28	11	44.55	5.06
	Monterey	1981	93	43.37	3.31	50	44.40	2.81	31	44.87	4.63
		1982	64	42.19	4.18	191	43.49	3.23	119	44.53	3.36
		1983	14	41.21	2.55	37	41.97	3.99	56	43.04	3.37
		1984	14	41.79	6.17	7	40.86	3.58	29	43.52	5.75
		1985	23	41.78	7.36	11	41.00	7.64			
		1986	27	42.33	4.99	16	42.69	3.28	5	42.40	6.37
		1987	10	44.50	3.55	42	43.17	4.66	15	43.13	4.87
		1988	45	43.16	3.04	10	44.30	6.12	15	44.60	6.22
		1989	22	43.09	3.57	20	43.00	4.71	11	45.82	6.75

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 14 N	AGE 14 MEAN	AGE 14 CV	AGE 15 N	AGE 15 MEAN	AGE 15 CV	AGE 16 N	AGE 16 MEAN	AGE 16 CV
Female	Vancouver	1981	42	43.69	5.46	18	43.17	5.74	13	45.38	6.07
		1982	65	43.77	3.74	52	44.02	4.35	55	44.71	4.21
		1983	24	45.04	5.50	24	46.00	4.49	14	45.57	6.13
		1984	24	46.21	4.69	28	45.68	4.50	27	45.56	5.32
		1985	5	46.80	1.79	12	46.08	2.99	9	47.33	3.34
		1986	12	47.00	4.97	28	47.96	3.47	32	48.16	3.30
		1987	7	46.43	3.90	17	47.82	6.33	26	47.69	3.39
		1988									
		1989									
	Columbia	1981	71	44.86	5.49	53	45.51	6.81	32	46.78	5.74
		1982	127	44.72	4.82	96	45.27	5.71	75	45.51	6.08
		1983	40	45.60	5.64	26	46.12	5.63	21	46.62	5.77
		1984	131	44.96	3.91	64	46.59	3.35	50	46.08	3.61
		1985	40	46.18	4.16	96	46.43	6.15	22	46.68	3.99
		1986	9	47.22	3.78	22	46.68	4.40	97	47.44	3.41
		1987	9	47.00	10.53	8	45.63	11.77	17	47.00	6.47
		1988	8	48.88	4.82	5	47.60	7.94			
		1989	16	46.94	6.85				5	48.40	2.36
	Eureka	1981	36	45.94	2.20	33	46.39	2.28	39	46.59	2.73
		1982	52	44.96	3.35	51	45.43	2.65	60	46.03	3.90
		1983	29	43.55	3.45	23	43.78	4.24	32	44.75	4.40
		1984	97	44.26	3.12	9	44.56	2.99	12	45.33	2.87
		1985	16	43.44	4.52	49	43.98	3.58	9	45.00	2.22
		1986				11	44.73	4.48	68	45.16	4.02
		1987	10	45.20	3.26				22	45.18	3.39
		1988	8	45.75	2.55	7	46.29	3.46	5	45.80	3.59
		1989	8	45.63	3.30	5	46.00	4.35			
	Monterey	1981	33	45.42	3.30	22	46.18	3.04	18	46.94	4.82
		1982	61	45.20	3.20	79	45.59	3.62	60	45.92	2.93
		1983	42	44.29	3.81	27	45.44	4.58	30	45.43	3.95
		1984	50	43.44	5.56	16	45.50	4.25	15	45.13	3.92
		1985	19	43.63	4.40	51	44.78	5.25	6	44.33	8.87
		1986				7	46.14	3.41	30	45.13	7.47
		1987	5	43.20	4.74				14	45.64	3.90
		1988	11	45.27	5.14						
		1989				5	46.20	3.21	7	47.00	6.02

Appendix A cont.

SEX	INPFC AREA	YEAR	AGE 17 N	AGE 17 MEAN	AGE 17 CV	AGE 18 N	AGE 18 MEAN	AGE 18 CV	AGE 19 N	AGE 19 MEAN	AGE 19 CV
Female	Vancouver	1981	11	48.00	4.27	16	48.06	3.98	15	48.00	7.00
		1982	30	45.13	5.00	28	46.21	4.69	9	47.67	4.81
		1983	13	47.54	4.26	7	48.71	1.95	5	48.00	5.71
		1984	12	46.92	2.80	13	47.46	1.64	13	47.31	2.91
		1985	10	47.00	3.33	9	47.67	3.15	7	48.00	2.41
		1986	28	48.32	3.43	33	48.03	4.78	17	48.53	3.50
		1987	20	47.40	6.65	20	49.05	4.10	16	49.00	3.65
		1988									
		1989									
	Columbia	1981	19	48.58	4.87	14	47.71	8.95	15	49.47	4.51
		1982	53	46.34	6.43	41	47.02	5.18	26	48.08	5.49
		1983	9	49.22	3.63	13	47.38	5.55	12	49.67	3.87
		1984	43	47.70	4.56	44	47.68	3.53	58	48.09	3.47
		1985	17	47.24	3.78	12	48.50	5.16	10	48.00	2.20
		1986	23	47.78	3.73	26	47.77	3.57	16	48.00	7.80
		1987	25	48.68	3.29	22	48.00	6.74	12	49.92	4.31
		1988	12	49.33	2.64	24	50.00	2.70	10	49.10	4.45
		1989	5	49.80	1.68	6	49.17	3.50	11	48.73	7.17
	Eureka	1981	14	47.00	3.12	14	47.64	2.55	7	47.00	2.13
		1982	36	46.19	2.53	40	46.33	4.16	32	47.34	2.19
		1983	26	45.00	4.31	25	45.28	3.85	26	45.50	3.00
		1984	22	46.23	3.20	24	46.17	2.61	5	46.20	5.81
		1985	19	45.63	3.12	13	45.69	3.93	16	45.25	5.90
		1986	11	45.36	3.16	15	45.67	3.17	7	45.86	3.43
		1987	34	45.82	3.93	18	46.78	3.99	21	45.19	6.66
		1988	11	46.45	4.65	29	46.41	2.91	12	46.17	2.90
		1989									
	Monterey	1981	13	47.69	3.77	5	48.40	5.19	5	48.60	4.27
		1982	49	46.84	3.39	50	46.92	3.36	32	47.25	3.80
		1983	20	45.00	3.60	24	45.79	3.92	25	45.56	5.03
		1984	19	46.00	6.32	11	46.45	3.52	22	46.91	3.35
		1985	12	46.83	5.53	14	46.43	6.25	9	46.33	6.56
		1986	12	46.00	4.82	16	45.81	4.59	7	45.29	3.97
		1987	18	46.28	2.95	8	43.13	8.98			
		1988	12	46.17	2.03	16	47.13	2.43	7	46.86	3.98
		1989				5	46.60	8.66	5	45.60	5.05

Appendix A cont.

SEX	INPFC AREA	YEAR	N	AGE 20 MEAN	CV
Female	Vancouver	1981	16	49.50	3.97
		1982	22	47.18	5.84
		1983	8	50.13	3.10
		1984	6	49.50	2.78
		1985	10	49.80	2.81
		1986	18	48.67	4.68
		1987	17	49.76	1.95
		1988			
		1989			
	Columbia	1981	10	50.40	1.92
		1982	20	47.70	5.45
		1983			
		1984	48	48.13	3.20
		1985	6	49.17	5.05
		1986	11	49.55	4.63
		1987	7	49.14	12.51
		1988	6	50.67	2.04
		1989	9	50.56	3.84
	Eureka	1981	5	49.20	2.23
		1982	27	47.85	3.96
		1983	17	46.53	3.49
		1984	30	46.47	3.47
		1985	19	45.68	4.90
		1986	24	46.75	4.15
		1987	12	47.17	1.99
		1988			
		1989	7	47.71	4.64
	Monterey	1981			
		1982	20	46.25	5.15
		1983	21	46.19	4.42
		1984	17	47.24	3.93
		1985	12	46.67	6.29
		1986	7	48.00	3.80
		1987			
		1988	7	47.86	3.70
		1989			
		1989			

Appendix A cont.