BIOLOGY OF WALLEYE POLLOCK, *THERAGA CHALCOGRAMMA*, IN THE WESTERN GULF OF ALASKA, 1973-75

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ABSTRACT

Data on the stock composition, growth, mortality, and abundance of walleye or Alaska pollock, *Theragra chalcogramma*, in the western Gulf of Alaska were collected during six demersal trawl surveys in 1973-75. Over 102,000 km² of continental shelf and slope were surveyed; most of this area was covered during spring and summer.

Using the area-swept technique and catchability coefficients of 1.0 and 0.5, the exploitable pollock biomass in the survey region was between 610,000 and 1,220,000 metric tons. The percentage of larger and older fish increased to the west. Sexual maturity was reached at age 3. Growth completion rates ranged from 0.2 to 0.4. Natural mortality was estimated (assuming natural mortality equals growth completion rate) at 0.33 for males and 0.30 for females. Variations in growth completion rates within year class and variable recruitment strength indicated a probable east-west separation of pollock spawning populations near Kodiak.

The National Marine Fisheries Service conducted six trawl surveys of walleye or Alaska pollock, *Theragra chalcogramma*, and other groundfish resources in the western Gulf of Alaska from Cape Cleare, Montague Island, west to Unalaska Island during each spring and summer of 1973-75 (Figure 1). These surveys have provided information on the geographic and bathymetric distribution and densities of species within the groundfish commmunity (Hughes and Parks 1975).

An additional goal of these surveys and subject of this report was the collection of pollock life history data for management purposes.

METHODS

Six cruises were completed. Five were conducted from the 28-m NOAA RV *John N. Cobb*, employing 400-mesh Eastern otter trawls with 30-m footropes. During these five surveys, fishing was conducted following a predetermined, stratified random survey pattern (Grosslein[2]). Fishing densities varied from one 30-min trawl/1,370 km² in strata of anticipated low densities (depths of 90 m or less) to one 30-min trawl/515 km² in the remaining depth strata of 91-180 m, 181-270 m, 271-360 m, and 361-450 m. The other cruise was conducted from the 26-m chartered trawler *Anna Marie*, with similar but larger modified Eastern and Norwegian-style otter trawls with about 34-m footropes. Because the purpose of the *Anna Marie* survey was to determine commercial production potentials (Hughes and Parks 1975), fishing was concentrated where fish schools were detected by echo sounding; no predetermined survey pattern was followed. Consequently, the *Anna Marie* data (Sanak-Unalaska, May-June 1974) were not used for pollock density or biomass studies.

Stretch mesh measurements (1 knot included) of all trawls ranged from 10.2- to 14.0-cm mesh in the intermediate and cod end sections. Trawls measured by scuba divers at depths of 15 m indicated vertical heights of 2-3 m and horizontal spread of 11-13 m.

Methods of selecting random samples of pollock for collection of biological data were consistent during all surveys (Hughes 1976a). Length-frequency fork length (FL) measurements to the nearest centimeter by sex were randomly collected from each catch with the desired sample size being 300 pollock. While processing pollock for length-frequency data, stratified subsamples of otoliths (10/sex per cm) and individual fish weights (5/sex per cm) were taken (±5 g). Otoliths were stored in ethanol in plastic boxes (Hughes 1976b) and ages were later determined as described by LaLanne (in press).

Length-frequency distributions determined

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[2]Grosslein, M. D. 1969. Some observations on accuracy of abundance indices derived from research vessel surveys. Unpubl. manuscr. Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

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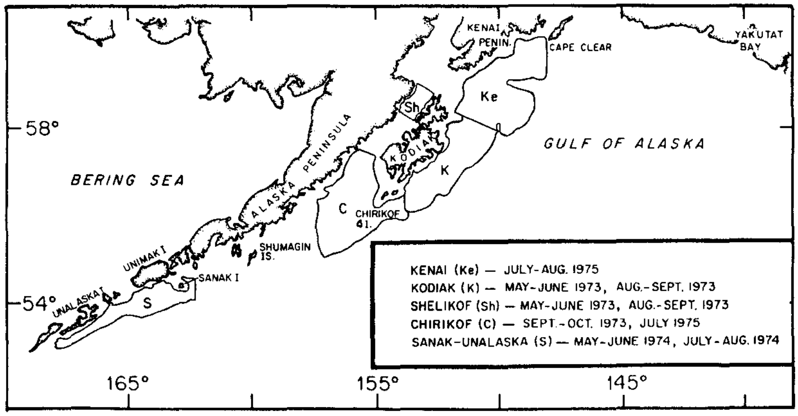

FIGURE 1.—Western Gulf of Alaska regions where trawl surveys were completed, 1973-75.

from the five standard resource assessment surveys were weighted by catch magnitude and area within sampling strata, whereas data collected during the commercial fishing (Sanak-Unalaska, May-June 1974) trials were weighted only by catch magnitudes. Length-age data from the stratified otolith collections of sexed pollock in each survey region (Figure 1) were compiled into age-length keys.

The proportions of observed ages on each length interval above 19 cm were applied to the weighted length frequencies. For this we used a computer program by Allen (1966) modified to exclude extrapolations beyond the aged length range and to include the calculation of mean length at age, as well as numbers at age. Thus numbers and size of pollock in the fishable population were estimated by region, age, and sex.

Resulting analysis provided weighted age composition data and mean length-at-age data for growth studies. Von Bertalanffy growth-in-length parameters and length-weight data were determined for each region.

An area-swept technique (Alverson and Pereyra 1969) was employed to estimate the pollock exploitable biomass, using the relation $\bar{P}w$ = (CPUE) (A)/(c) ($\bar{a}$) where $\bar{P}w$ is equal to the average standing stock, in weight, of the catchable population. A is the total area; $\bar{a}$ is the average bottom area covered by the trawl per standard tow; and c is a coefficient related to the effectiveness of the trawl in capturing pollock.

Whereas earlier studies of Alaskan pollock assumed c = 1.0 (Alverson and Pereyra 1969), pollock were often acoustically detected off the sea bottom and above the trawl's headrope. Estimates of c given for some gadoid species of the northeastern Atlantic Ocean indicated c may not exceed 0.51 (Edwards 1968). In this report, values of both 0.5 and 1.0 provide a conservative range of biomass estimates.

RESULTS

The surveys resulted in 144 fishing days on the grounds and 368 successful trawl hauls. Over 455,000 kg of groundfish were sampled, including 49,912 pollock which were processed for biological data.

Size and Age Composition

In the three regions where spring and summer surveys were conducted during the same year (Shelikof Strait 1973; southeast Kodiak 1973; and Sanak-Unalaska 1974), seasonal variations in size and age composition were attributed to fish measuring <28 cm which represented the 1- and 2-yr-old juvenile segment of the population (Figures 2, 3). However, substantial differences between regions indicate that size and age of adult pollock consistently increased when moving from the southeast Kodiak and Shelikof Strait regions westward through the Chirikof region and into the Sanak-Unalaska region.

The age composition data also indicated that Gulf of Alaska pollock display strong variations in year-class strength. Both 1967 and 1970 year classes showed unusually strong recruitment. Indication of a strong 1967 year class, sampled as 6-yr-olds, was noted during the May-June 1973 surveys of the southeast Kodiak and Shelikof regions. The relative strength of this year class was again noted 3 mo later during the August-September survey of southeast Kodiak and, particularly, of Shelikof Strait. Farther west, in the October 1973 Chirikof

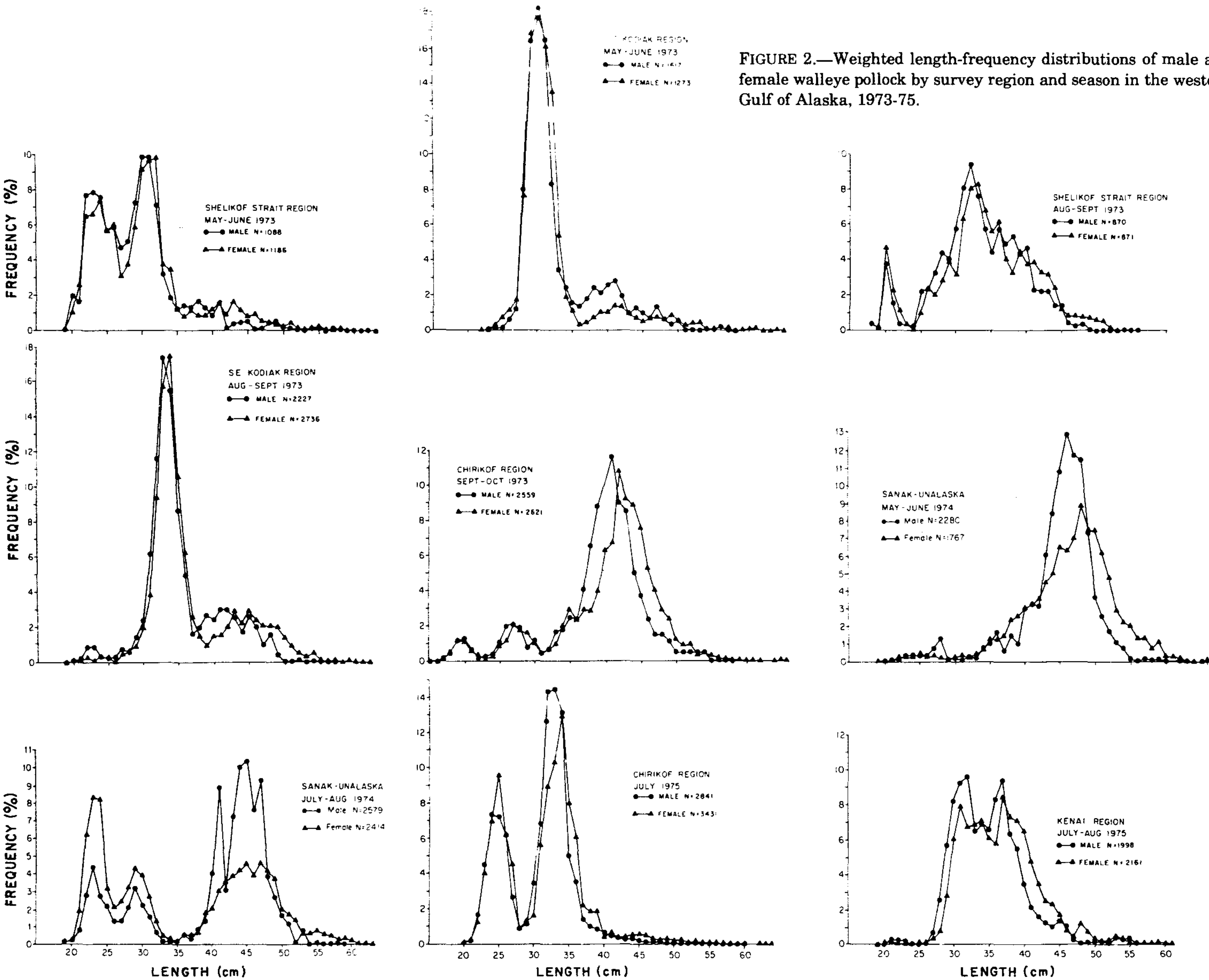

FIGURE 2.—Weighted length-frequency distributions of male and female walleye pollock by survey region and season in the western Gulf of Alaska, 1973-75.

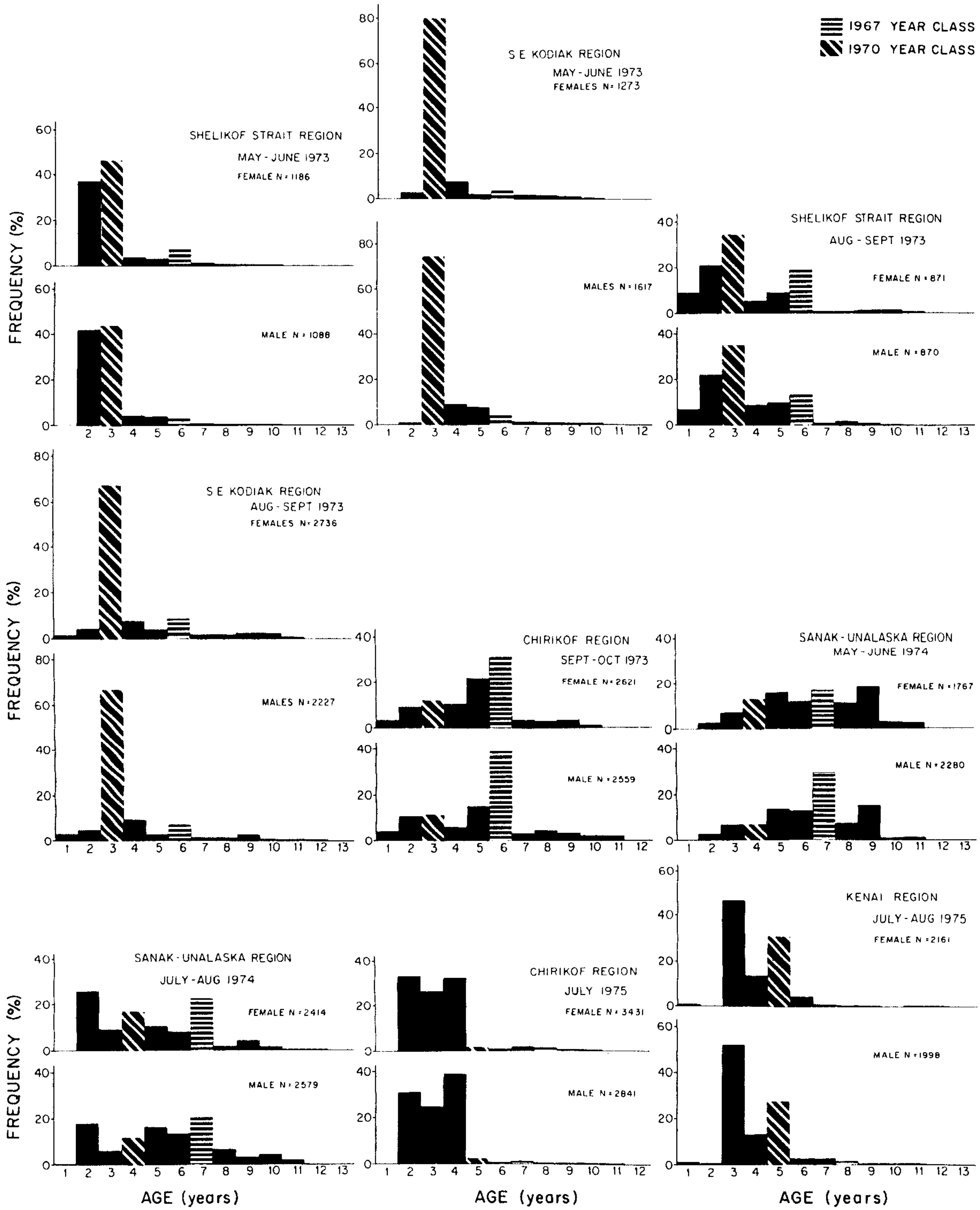

FIGURE 3.—Weighted age-frequency distributions of male and female walleye pollock by survey region and season in the western Gulf of Alaska, 1973-75.

survey, 6-yr-old pollock were dominant. One year later, in the most westward region (Sanak-Unalaska 1974), the prominence of the 1967 year class as 7-yr-olds was apparent during both the May-June and July-August surveys.

During the May-June and August-September 1973 surveys of southeast Kodiak and Shelikof Strait, 3-yr-old pollock (1970 year class) were dominant. The unusual strength of this year class was again noted 2 yr later east of Kodiak as 5-yr-olds during the 1975 Kenai survey. However, recruitment of the 1970 year class was not successful west of Kodiak, as shown by the low relative abundance of 3-yr-olds in the Chirikof region in 1973, of 4-yr-olds in the Sanak-Unalaska region in 1974, and of 5-yr-olds in the Chirikof region in 1975.

Maturity and Sex Composition

Most adult pollock (>85%) had spawned prior to our earliest sampling (May). Based upon a subjective evaluation of gonad condition from pollock collected during May, it appeared that prime spawning periods were March and April. Ripe males and females were obtained as late as August, but these represented <0.1% of samples. Both sexes were fully recruited to the spawning population at age 3. Mature or recently spent age 2 males were encountered but represented <5% of that age-group. Mature or spent age 2 females were not encountered; however, minor gonad enlargement was noted. Means of lengths at first maturity in spring surveys were 29-32 cm for males and 30-35 cm for females.

Our data indicate that sex composition fluctuates around 50% at 20-45 cm FL but that females become progressively more dominant with larger size (Figure 4). As will be shown later, the point of major difference in sex ratio (45 cm) is composed primarily of age 4, 5 females and age 5, 6 males.

Length-Weight

Pollock length-weight data by sex were collected during the May-June and August-September surveys of the southeast Kodiak and Shelikof Strait regions in 1973. Data were also collected during the September-October 1973 survey of the Chirikof region. Length-weight relations were determined for these survey regions and periods (Figure 5) by fitting the logarithmic form of the equation ($W = aL^d$), where W is body weight in grams and L is fork length in centimeters, to the mean weight per centimeter-length interval.

Comparison of these curves indicates that female pollock measuring >33 cm weighed considerably less than males of equal length during the May-June postspawning survey. Female weight gain during summer was more rapid than in males, and differences in weight-at-length in the Shelikof Strait, southeast Kodiak, and Chirikof regions were negligible during the August-October sampling.

Regional differences during spring-summer periods were also noted. Shelikof Strait pollock were heavier than southeast Kodiak pollock of equal length during spring and considerably lighter during summer. This difference may be due to a more rapid weight gain in the southeast Kodiak region or to migration of the most healthy fish out of Shelikof. An additional factor suggesting migration was that samples of male pollock in Shelikof actually showed a weight loss from spring to summer.

Density Distribution and Estimates of Standing Stock

Pollock were distributed over depth intervals of 50-360 m (Table 1). Highest densities occurred at depths of 91-270 m during spring and summer. Geographically, densities were highest at Sanak-Unalaska (181-270 m), followed by southeast Kodiak (91-180 m). Spring-summer 1973 assessment surveys of Shelikof Strait and southeast Kodiak indicated highest densities during summer.

The summer biomass of pollock exceeding 20 cm FL was estimated as 610,000-1,200,000 metric tons (t) of whole fish (Table 1). Regional biomass estimates were greatest in the Chirikof region, followed by Sanak-Unalaska, southeast Kodiak, Kenai, and Shelikof Strait.

Growth

Length-age data from the nine surveys were fitted by the von Bertalanffy relation $l_t = L_\infty \{1 - \exp k(t - t_0)\}$ following computational procedures by Fabens (1965). Because variation in age range affects comparability of parameters (Hirschhorn 1974), curve fits over original age ranges were supplemented: 1) with fits over a standardized age range of 2-8 yr, 2) with an artificial data point (0,0)

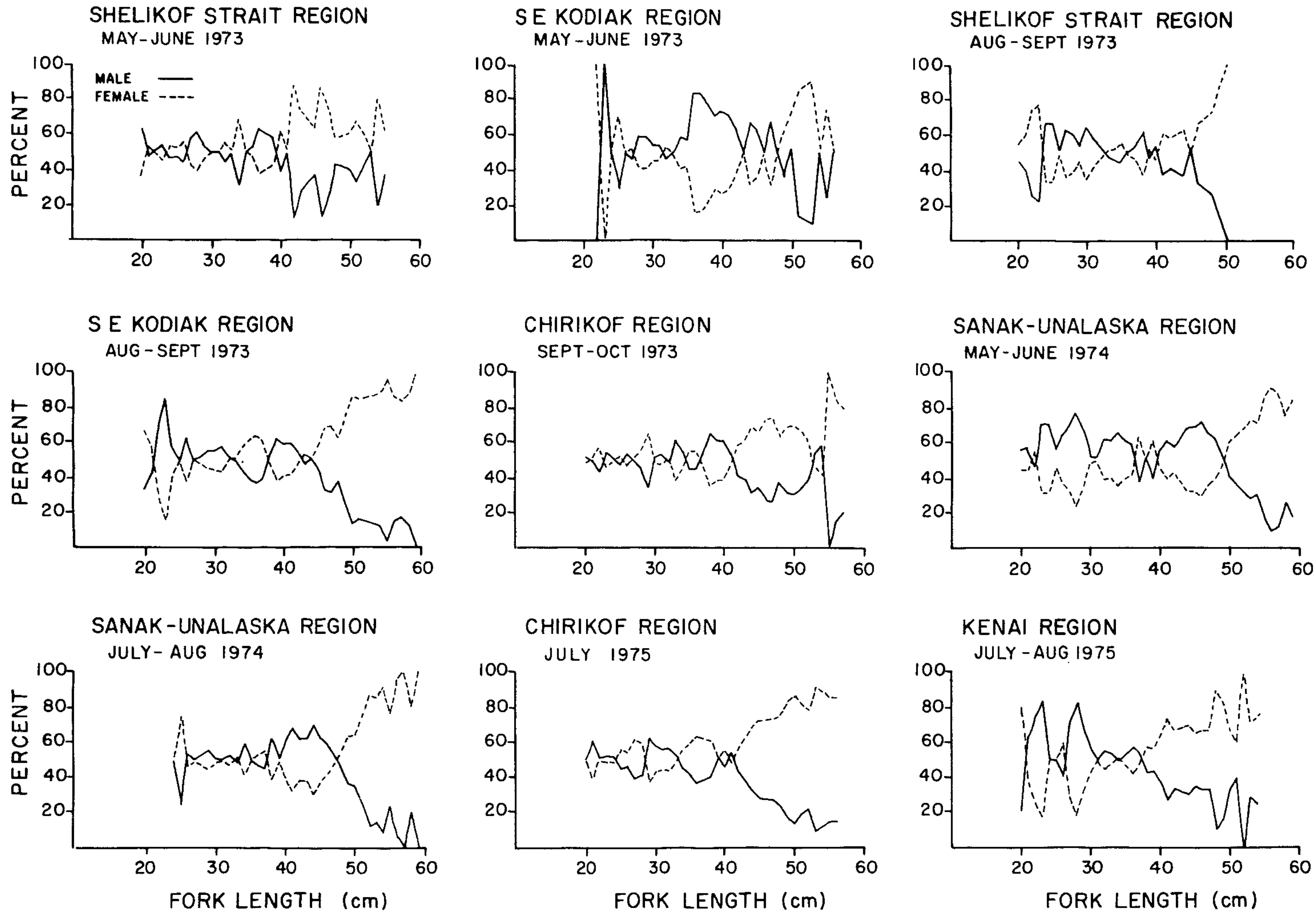

FIGURE 4.—Walleye pollock sex composition plotted as a function of increasing fish length by survey region and season in the western Gulf of Alaska, 1973-75.

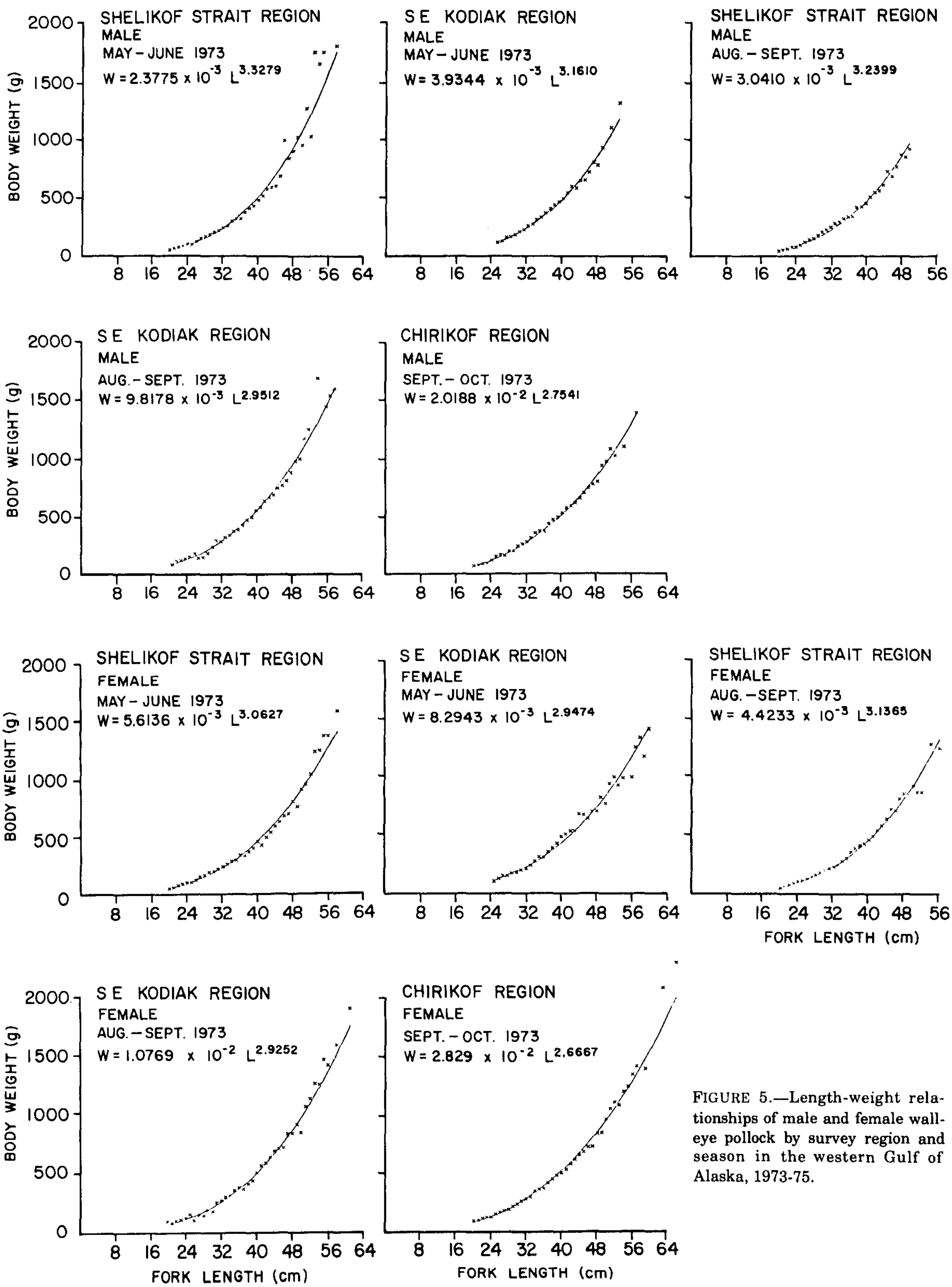

FIGURE 5.—Length-weight relationships of male and female walleye pollock by survey region and season in the western Gulf of Alaska, 1973-75.

TABLE 1.—Summary of exploitable walleye pollock biomass and density by depth strata and survey regions in the western Gulf of Alaska. Catchability coefficients 1.0 and 0.5 are used to produce a range of pollock biomass and density. Biomass estimates were calculated from the summer survey period due to limited spring survey coverage.

Survey region and period	Depth strata (m)	Area surveyed (km²)	Density (t/km²)		Exploitable biomass (t)	
			c = 1.0	c = 0.5	c = 1.0	c = 0.5
Summer:						
Kenai Peninsula	91-180	19,183	4.1	8.2	77,742	155,485
(148°-152°W)	181-270	8,026	2.8	5.6	22,230	44,460
July-Aug 1975	271-360	796	0.2	0.4	186	371
Regional total		28,005			100,158	200,316
SE Kodiak	55-90	7,302	2.2	4.4	16,180	32,360
(152°-154°W)	91-180	6,143	16.1	32.2	99,042	198,085
Aug-Sep 1973	181-270	1,475	9.9	19.8	14,706	29,412
	271-360	737	0	0	0	0
Regional total		15,657			129,928	259,857
Shelikof Strait	55-90	381	0.2	0.4	89	178
(Aug-Sep 1973)	91-180	3,341	5.8	11.6	19,480	38,960
	181-270	2,713	1.0	2.0	2,610	5,221
Regional total		6,435			22,179	44,359
Chirikof	55-90	9,439	1.0	2.0	9,082	18,163
(154°-159°W)	91-180	12,749	13.6	27.2	173,583	347,168
July 1975	181-270	11,661	0.2	0.4	11,220	22,440
Regional total		33,849			193,885	387,771
Sanak-Unalaska	50-90	6,647	2.7	5.4	18,060	36,120
(162°-168°W)	91-180	8,935	13.1	26.2	117,096	234,192
July-Aug 1974	181-270	912	31.8	63.6	29,107	58,214
	271-360	703	0	0	0	0
	361-450	322	0	0	0	0
Regional total		17,519			164,263	328,526
Survey total		101,465			610,413	1,220,826
Spring:						
SE Kodiak	50-90	4,778	0.4	0.8	—	—
(148°-152°W)	91-180	4,496	2.0	4.0	—	—
May-June 1973	181-270	737	0.4	0.8	—	—
Regional total		10,011				
Shelikof Strait	50-90	381	0.2	0.4	—	—
(May-June 1973)	91-180	3,982	0.7	1.4	—	—
	181-270	11,558	0.6	1.2	—	—
	271-360	1,008	0.3	0.6	—	—
Regional total		16,929				
Survey total		26,940				

added on the assumption that at age 0 length is near 0 (Alverson and Carney 1975), and 3) with nominal ages or ring counts incremented by the fraction of a year between middates of spawning and sampling (Δt in Table 2).

Because each growth pattern in Figure 6 represents a synthetic cohort, i.e., a composite of year classes, the departures from the pattern, generated by members of the 1967 and 1970 year classes, were examined in detail. According to the age composition discussed earlier, both year classes were encountered in relatively high abundance at one extreme of the survey range (Figure 3) and in low abundance at the other (the 1967 year class was prominent at Sanak-Unalaska, the 1970 year class at Kenai). To examine the evidence for a growth-density relation, the size differences between the synthetic growth curves and observed mean lengths of the sampled age-groups of these year classes were calculated (lower part of Table 2).

The results are shown along a schematic east-west axis in Figure 7. In the easternmost region (Kenai), the strong 1970 year class indicates negative departures from expectation (at age 5), whereas corresponding departures are positive for the relatively weak year class of 1967 (at age 8). In the westernmost region, the relative strengths of these year classes seemed to be reversed, and the direction of departures of their mean lengths at ages 4 and 7 also reversed. By this criterion, the segregation of the two components of each year class was most pronounced at the extremes and least so in the intermediate Kodiak-Shelikof region where the lines cross.

Age-specific observed lengths of the 1970 and 1967 year classes were also compared directly with those of others, apparently weaker year class-

TABLE 2.—Mean length (centimeters) at age of western Gulf of Alaska *Theraga chalcogramma* by survey and sex; growth parameters (L_∞, K, t_0) for original and "selected" data sets, with standard deviation (σ) of departures from fit; departures of 1967 and 1970 year class mean lengths at age, from fit (Δ67YC, Δ70YC).

		Sanak				Chirikof				Kodiak			
		May-June 74		July-Aug. 74		July 1975		Sept.-Oct. 73		May-June 73		Aug.-Sept. 73	
		M	F	M	F	M	F	M	F	M	F	M	F
Item		(0.17)[1]		(0.42)		(0.25)		(0.50)		(0.17)		(0.42)	
Years of age (t)	1	—	—	20.00	—	—		19.49	20.02	—	—	23.07	23.09
	2	25.52	24.36	29.55	29.75	24.70	24.99	27.15	27.99	25.24	26.21	29.51	29.50
	3	35.19	35.20	38.51	36.04	31.54	32.18	35.01	35.74	30.24	30.38	33.44	33.85
	4	39.59	40.17	41.16	42.14	33.88	34.98	39.32	40.58	38.77	38.44	40.37	41.48
	5	43.68	44.63	44.07	45.18	38.41	40.07	40.18	42.63	40.30	43.55	41.70	44.32
	6	45.16	46.81	45.01	47.05	42.10	43.05	41.36	43.82	43.26	45.15	43.37	45.91
	7	47.02	48.70	44.69	47.02	42.59	44.98	43.84	48.44	47.66	50.62	46.47	48.73
	8	47.50	51.01	47.27	51.65	44.67	48.02	47.37	48.37	48.04	53.04	46.97	50.16
	9	48.27	50.74	48.34	53.51	49.84	52.86	46.85	49.39	46.67	51.62	46.41	50.77
	10	53.16	55.25	47.74	52.05	50.86	54.21	46.04	52.73	46.03	57.03	48.00	49.52
	11	50.11	55.56	48.13	46.79	50.57	53.85	—	—	—	—	54.10	54.00
	12	—	—	—	57.00	—	54.00	—	—	—	—	55.07	—
Parameter sets for original data	L_∞	50.06	55.22	48.14	53.03	52.36	58.40	47.26	54.37	48.21	66.25	58.69	56.34
	K	−0.47	−0.37	−0.47	−0.42	−0.25	−0.21	−0.38	−0.28	−0.38	−0.18	−0.19	−0.24
	t_0	0.68	0.63	0.29	0.61	−0.30	0.42	0.10	−0.09	0.26	−0.61	−1.18	−0.75
	σ	1.63	1.58	0.94	2.94	2.52	1.45	1.32	1.31	1.87	1.70	2.30	1.40
Parameter sets for ages 0, 2-8	L_∞	51.649	57.855	48.948	54.288	47.651	52.515	49.848	51.970	52.271	59.788	48.496	53.118
	K	−0.328	−0.265	−0.396	−0.328	−0.323	−0.284	−0.319	−0.315	−0.302	−0.256	−0.383	−0.331
	t_0	−0.036	−0.052	−0.019	0.012	0.011	0.023	−0.004	−0.015	0.021	0.062	0.018	0.021
	σ	1.228	1.429	1.349	1.246	0.940	1.013	1.603	1.132	1.363	1.686	1.157	1.074
	Δ70 YC	+0.96	+1.25	+0.65	+0.66	−0.49	−0.53	+1.46	+0.91	−1.85	−2.47	−1.88	−2.02
	Δ67 YC	+0.24	−0.59	−1.69	−2.48	+0.34	+0.59	−2.23	−1.50	−0.86	−2.16	−0.95	−0.82

		Shelikof				Kenai	
		May-June 73		Aug.-Sept. 73		July-Aug. 75	
		M	F	M	F	M	F
Item		(0.17)		(0.42)		(0.33)	
Years of age (t)	1	—	—	20.71	20.74	21.92	21.23
	2	23.95	24.04	28.30	29.38	26.47	29.00
	3	30.37	30.64	32.71	33.52	31.84	32.58
	4	35.75	36.37	36.86	37.48	36.43	38.13
	5	38.86	40.34	38.71	39.20	37.94	39.65
	6	41.42	44.18	40.06	42.09	43.04	45.65
	7	49.01	46.50	45.32	47.51	[2]43.33	50.37
	8	49.41	49.29	43.94	46.52	51.06	51.32
	9	46.49	47.82	45.21	47.77	51.72	54.10
	10	47.00	49.85	45.60	48.39	53.00	—
	11	—	—	—	44.00	53.45	53.22
	12	—	—	—	—	—	55.44
Parameter sets for original data	L_∞	49.48	52.92	46.62	46.50	62.63	57.60
	K	−0.34	−0.28	−0.33	−0.39	−0.10	−0.22
	t_0	0.26	0.05	−0.31	−0.06	−1.50	−0.71
	σ	2.42	0.90	1.16	2.29	1.72	1.88
Parameter sets for ages 0, 2-8	L_∞	55.974	56.041	45.010	47.592	54.591	54.274
	K	−0.253	−0.255	−0.405	−0.386	−0.274	−0.312
	t_0	0.042	0.019	0.018	0.031	0.089	0.069
	σ	1.846	0.466	1.561	2.002	2.832	2.579
	Δ70 YC	−0.23	−0.31	−0.94	−1.21	−3.66	−4.11
	Δ67 YC	−2.68	−0.18	−1.57	−1.46	+2.18	+1.17

[1]Age, increment (ΔT) for sample date.
[2]Extreme frequencies eliminated in computing mean length at age 7.

es to see whether differences agree, in direction, with those generated by use of synthetic cohort growth curves. In this comparison, only early season samples were considered. Both year classes indicated lower mean lengths than other year classes sampled at like ages.

Growth completion rates (K) were 0.34 in males and 0.28 in females, from surveys indicating prominence of the 1967 or 1970 year classes (Figure 3). A similar averaging of length-at-age in all remaining data gave higher K-values (0.40 and 0.35, respectively), possibly reflecting lower relative year class strengths. We also ranked relative percent frequency at each age within range 2-8 yr, then fitting lengths of ages within ranks, thus replacing the original time-area classifications. Extreme K-values (males 0.25, 0.38; females 0.24, 0.40) were associated with extreme ranks; however, at intermediate ranks fluctuations were considerable. The K-ranges from this rearrangement of the data are similar to those shown in Table 2 for the original data configurations by survey (males,

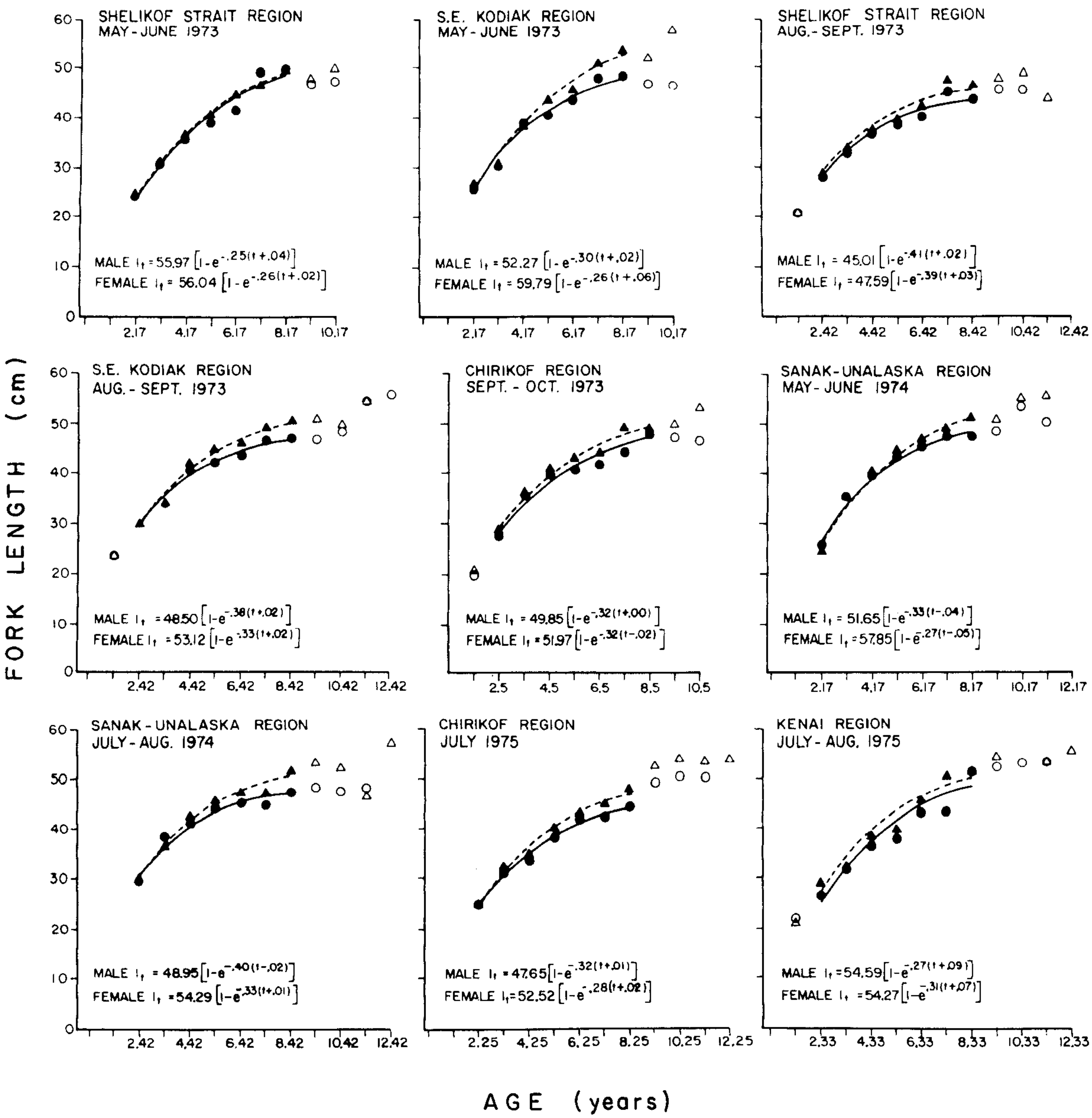

FIGURE 6.—Growth curves of male and female walleye pollock by survey region and season in the western Gulf of Alaska, 1973-75.

0.25, 0.41; females, 0.26, 0.39). The arithmetic means of K in Table 2 (ages 2-8) are 0.33 and 0.30 and the geometric means of L_∞, 50.39 and 54.06 cm for males and females, respectively. Significant negative correlation between ln L_∞ and $|K|$ was found in both sexes. The highest observed ages in each survey lie, on the average, between those ages when growth is theoretically between 95 and 97.5% complete, according to the growth parameters for ages 2-8 in Table 2. Similarity in this regard is considered essential in estimating average natural mortality rates from empirical data (Alverson and Carney 1975).

Yield Relations

For management purposes natural mortality (M) as well as growth rate is needed for recogni-

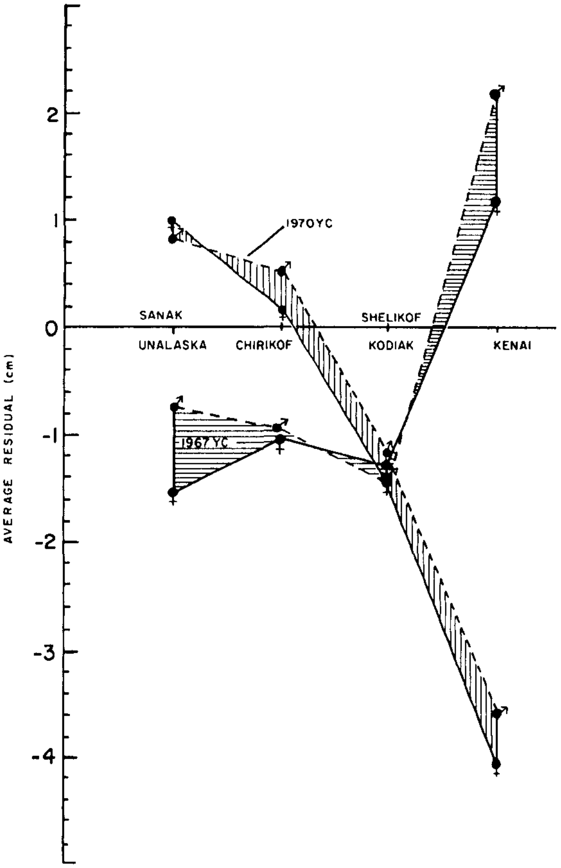

FIGURE 7.—Average of residuals from fit of observed mean length-at-age, taken over all age-groups of the 1967 and 1970 year classes of walleye pollock sampled in the western Gulf of Alaska by region and sex, 1973-75.

tion of optimality in biomass relations. Since no independent estimates of M are available for Gulf of Alaska pollock, we shall assume $M = K$. Yield relations based on this assumption have been examined in detail by Alverson and Carney (1975) for cases where the third Bertalanffy parameter (t_0) is close to zero. In the preceding section and Table 2, such growth estimates were provided.

As indicated earlier, means of observed female lengths at first maturity ranged from 30 to 35 cm, comparable to 32-37 cm when length at this stage is considered as two-thirds of the final length (L_∞) associated with the extreme growth completion rates for females in Table 2 (0.386, 0.255). Use of this constant was discussed and examined by Holt (1962). Corresponding ages at first maturity (T_{mat}) ranged from 2.84 to 4.30 yr, and ages of maximum (unfished) biomass per unit input (T_{mb}) ranged from 3.60 to 5.45 yr, according to equation 5 of Alverson and Carney (1975). The differences ($T_{mb} - T_{mat}$) at each extreme imply two annual pre-T_{mb} spawnings in the low-K cohort compared to one in the high-K cohort. The maximum production per unit input from the low-K (0.255, $L_\infty = 56.04$) cohort exceeds that for the high-K (0.386, $L_\infty = 47.59$) cohort by 64% assuming a cubic length-weight relation. Under the assumption $M = K$, any environmental or fishing conditions tending to reduce growth completion rate (and increase L_∞) would be expected to increase cohort productivity as well as delay the achievement of maximum biomass per unit input. Such a delay also implies an increased number of spawning opportunities for females prior to the age at maximum biomass.

DISCUSSION

Pollock size and age composition, size and age at first maturity, sex composition, length-weight relationship, density distribution by depth and area, estimate of exploitable biomass, in addition to growth and yield relationships in the western Gulf of Alaska have been described. The survey area, Cape Cleare to the western end of Unalaska Island, carries an exploitable pollock biomass that we have calculated at 0.6-1.2 million t. Compared with the 54,000 t of exploitable pollock in the central and eastern portions of the Gulf of Alaska (Ronholt et al.[3]), the resource described in this report represents over 90% of pollock in the Gulf of Alaska.

Agreeability of size, age, and growth data between surveys over the 3-yr study period indicated that assessment techniques were reliable. Weighting size and age composition data by catch rate and square miles within each depth sampling stratum is regarded as desirable when dealing with a species which displays bathymetric preference. Such weighting procedures coupled with the collection of otoliths over all depths and areas appear to provide accurate descriptive information for a large region. It is possible that pollock display bathymetric variations in growth rate as Westrheim (1973) has shown for Pacific ocean perch. However, our data did not allow such de-

[3]Ronholt, L. L., H. H. Shippen, and E. S. Brown. 1976. An assessment of demersal fish and invertebrate resources of the northeastern Gulf of Alaska, Yakutat Bay to Cape Cleare, May-August 1975: NEGOA Annual Report. Unpubl. manuscr., 184 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Seattle, WA 98112.

tailed examination, and the above sampling and analytical procedures would average this phenomenon if it does occur.

Data presented indicate that at least 87% of the pollock resource resides at depths 91-270 m during the summer with greater bathymetric dispersement during the spring. Densities were lowest in the Kenai region (eastern extreme) and highest in the Sanak-Unalaska region (western extreme). Except for the Kenai and Shelikof regions, where densities were notably low relative to other regions, regional biomass estimates are a function of both pollock density and available shelf or slope area at depths of 91-270 m.

Age and size composition data indicated that strong variations in year-class strength occur and recruitment of year classes is not uniform over the western Gulf. Whereas such geographic variations in year-class strength could be caused by environmental conditions, neither of two prominent year classes (1967 and 1970) indicated similar relative abundance over the entire east-west range of these surveys. Rather, the 1967 year class appeared in high density only west of southeast Kodiak and the 1970 year class, only at southeast Kodiak and eastward. These geographic density differences were accompanied by observed growth differences (size at age) and by negative departures of observed size at age in these year classes from expected size based on growth curve fits (Figure 7).

Analysis of all the growth information from these surveys indicated an inverse relation of growth completion rate (K) to relative year-class strength as well as to final estimated fish length (L_∞). From the differences in K values obtained and assuming $M = K$, it is inferred that optimally timed harvests per unit input would be larger in low-K cohorts than in high-K cohorts. Optimal timing from the yield standpoint also implies enhancement of the reproductive potential of low-K cohorts.

In conclusion, the western Gulf of Alaska pollock stock has been described and biological parameters reported for management. It is suggested that an east-west separation of spawning stocks may occur near Kodiak and that management should be applied accordingly.

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