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AGE COMPOSITION OF PACIFIC HERRING, Clupea harengus pallasii
(Valenciennes) IN THE TOGIAK DISTRICT OF BRISTOL BAY DURING
THE 1979 AND 1980 SPAWNING SEASONS

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ABSTRACT

Age composition of Pacific herring (*Clupea harengus pallasii*) in the Togiak District of Bristol Bay was examined for the 1979 and 1980 spawning seasons. Samples from both the commercial harvest and catches obtained by test fishing with variable mesh gillnets were examined for both years. This study reports on an analysis of: (1) age composition of the commercial harvests during 1979 and 1980, and (2) age composition estimates of the total spawning migrations calculated from commercial purse seine and test fishing data.

Herring samples from the commercial catch were collected to determine differences in age composition by gear, area, and time period. Age composition estimates for each gear were generally found to be homogeneous for all fishing sections within weekly time periods. Temporal differences in age composition were apparent between weekly time periods during 1979 as the proportion of younger fish in the commercial harvest steadily increased during the later portion of the fishery. The 1973 and 1974 year classes represented approximately 80% of the total commercial harvest during both 1979 and 1980.

Although significant differences were found between age composition estimates from test fishing samples collected from different areas within weekly time periods, no trends were found to explain the variability in these data. It was, therefore, felt appropriate to combine the test fish samples for all areas within weekly time periods as a result of the lack of variation in the commercial harvest estimates. Due to consistent differences in age composition and gonad condition, samples collected from the Nushagak Peninsula area were not included with the rest of the test fishing samples. It was concluded that these data supported the hypothesis that the majority of herring in the Nushagak Peninsula area were spent fish that were exiting the inshore spawning areas. Temporal differences in age composition were apparent in test fishing catches during both 1979 and 1980.

Herring samples collected from commercial purse seine and test fish catches were analyzed as indicators of the age composition of the total spawning migration. Age composition estimates for each weekly time period were weighted by the relative abundance of herring present during that time period as indicated through aerial survey data. Comparisons between age composition estimates calculated from the two gear types were inconclusive as the estimates differed in 1979 but were similar in 1980. All age composition estimates showed the 1973 and 1974 year classes to be dominant and represented approximately 80% of the total spawning migrations during 1979 and 1980.

INTRODUCTION

The objective of this report is to present an analysis of the age composition of Pacific herring (*Clupea harengus pallasii*) in the Togiak District of Bristol Bay during the 1979 and 1980 spawning seasons. This report expands upon a recent summarization of age, weight, length, and sex data of herring samples from eastern Bering Sea spawning sites during 1979 and 1980 (McBride et al. 1980) and corrects a previous report to the North Pacific Fishery Management Council that presented age composition results of the 1979 herring spawning migration (Barton and Steinhoff 1980).

Due to sampling problems associated with this fishery, it is difficult to clearly define the age composition of the total spawning migration. The Alaska Department of Fish and Game has collected herring samples in Bristol Bay from both the commercial harvest (since 1968) and catches obtained by test fishing with variable mesh gillnets (since 1978). The original purpose of these sampling programs was to enable analysis of age, length, weight, sex, and maturity of herring removed by the commercial fishery and present in the "total run". However, no method has yet been found to sample the Bristol Bay herring migration either exclusively before or after exposure to the commercial harvest. Therefore, the test fishing program has sampled herring on the spawning grounds in the midst of the commercial fishery. It is difficult to determine whether these samples adequately represent either the entire herring population (before commercial removal) or only that portion of the herring population which escaped the fishery.

The analyses in this report differentiate between the age compositions of samples collected from both the commercial fishery and through test fishing. A comparison is made between the results of the two sampling methods before final analysis of age composition of the spawning migration.

COMMERCIAL HARVEST

Data Collection and Analysis

In 1979 and 1980, a sampling design for collection of herring samples in the commercial harvest was employed that would provide a statistically valid comparison of age composition by gear, fishing section, and time period. It was determined that a minimum of 150 samples was necessary to allow statistical estimation of age classes which represent at least 10% of the total age composition with an alpha level of 5%. Attempts were made to collect a minimum of 150 samples for both major gear types (purse seine and gillnet) and each of four fishing sections (Figure 1 and Appendix Tables 1 and 2). Since older herring predominate early in the migration (Barton 1979), the total commercial harvest was divided into 7-day time periods. Herring samples were collected randomly throughout each time period by gear type and area.

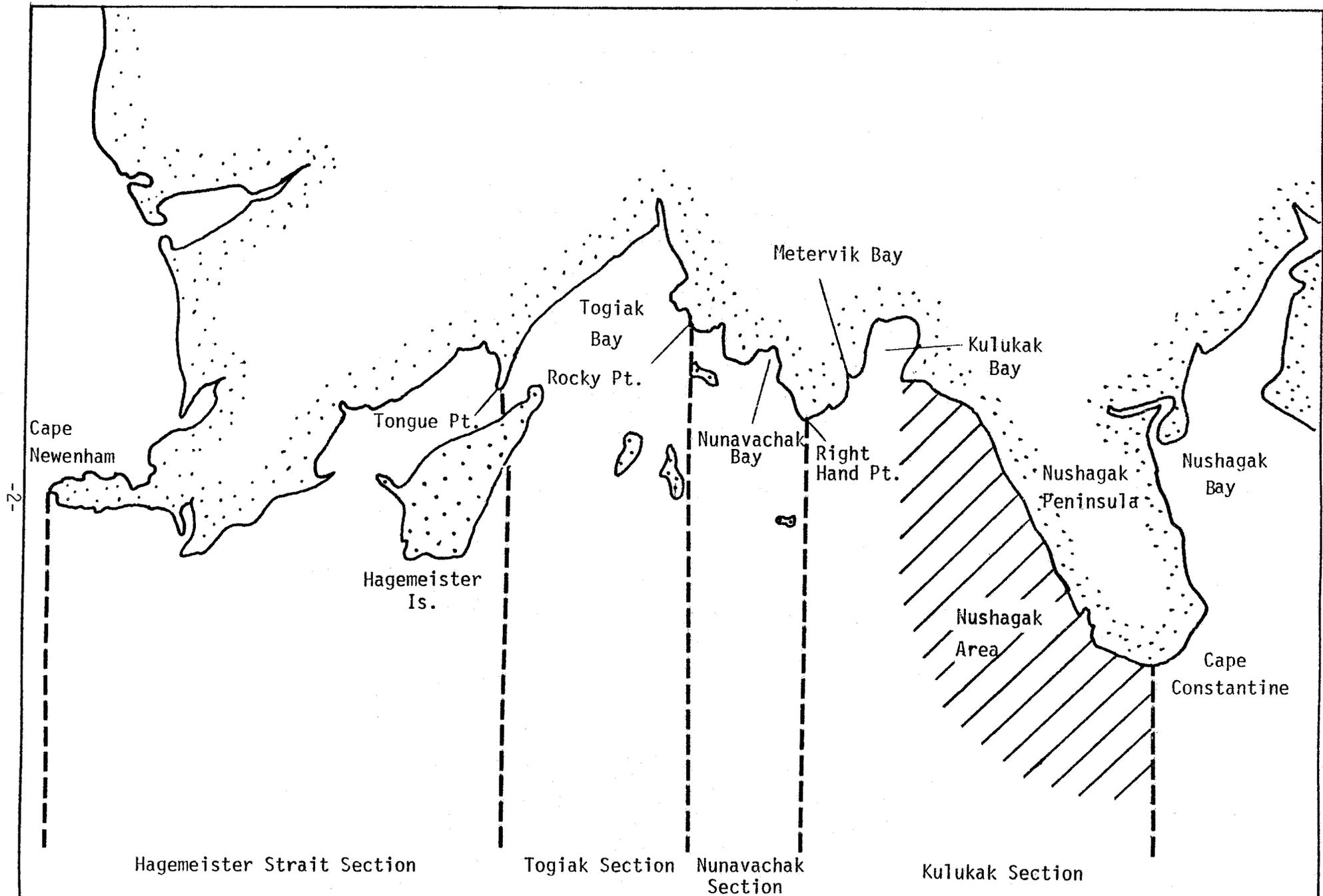


Figure 1. Togiak herring fishing district, Bristol Bay.

Commercial harvest data was stratified by fishing section, week, and gear type to test for differences in age composition estimates. To estimate the contribution of each age class to the total harvest, the following equation was used:

$$H_{ijkl} = C_{jkl} A_{ijkl} \bar{W}_{il} / \sum_{i=1}^n A_{ijkl} \bar{W}_{il}$$

where,

H_{ijkl} = commercial harvest (weight) of age i herring by gear type j in fishing section k during week l ,

C_{jkl} = commercial harvest (weight) of all herring age classes by gear type j in fishing section k during week l ,

A_{ijkl} = proportion of age i herring in catch samples from gear type j in fishery section k during week l ,

\bar{W}_{il} = mean weight of age i herring calculated from total catch samples (i.e., all gear types and fishing sections combined) taken during week l , and

n = total number of age classes represented in catch samples.

Differences in age composition estimates among fishing sections were examined through chi-square testing procedures (Sokal and Rohlf 1969).

Estimation of Age Composition

No significant differences in age composition estimates were found among samples collected from different fishing sections except during the period 13-19 May 1979 (Table 1). During this period, Kulukak Section purse seine and gillnet age composition estimates were significantly different from Nunavachak and Togiak estimates. Kulukak gillnet samples had a larger proportion of age 6 and older fish than other sections, while purse seine samples had a lower proportion of age 3 fish than other sections. No significant difference was found between the Nunavachak and Togiak estimates. While the Kulukak age composition estimate during one sampling period differed from the rest of the Togiak District, it was concluded that there was generally no significant difference in age composition estimates between areas within any time period. Therefore, analysis of the age composition of the commercial harvest was based on samples grouped only by gear type and time period.

The relative contribution of individual year classes to the commercial harvest was similar during both years (Tables 2 and 3; Figures 2 and 3). The

Table 1. Variability of commercial catch age composition estimates between fishing sections in the Togiak District as estimated through chi-square analysis.

Gear Type	Time Period	Samples		Chi-Square		Conclusion
		Areas Compared	Sample Size	Calculated	Expected ¹	
-----1979-----						
Purse Seine	5/13-5/19	Kulukak	188	167.3	26.2	Significantly Different
		Nunavachak	199			
		Togiak	159			
	5/20-5/26	Nunavachak	199	7.7	16.8	Not Significantly Different
		Togiak	159			
		Kulukak	189			
Gillnet	4/29-5/05	Nunavachak	163	22.6	26.2	Not Significantly Different
		Togiak	239			
		Kulukak	172			
	5/06-5/12	Nunavachak	223	11.5	26.2	Not Significantly Different
		Togiak	230			
		Kulukak	174			
5/13-5/19	Nunavachak	195	49.3	29.1	Significantly Different	
	Togiak	187				
	Kulukak	170				
5/20-5/26	Nunavachak	195	6.7	18.5	Not Significantly Different	
	Togiak	187				
	Kulukak	175				
Purse Seine	4/29-5/05	Togiak	196	6.2	26.2	Not Significantly Different
		Nunavachak	184			
		Kulukak	175			
	4/29-5/05	Hagemeister	200	21.8	34.8	Not Significantly Different
		Togiak	142			
		Nunavachak	195			
Gillnet	4/29-5/05	Togiak	200	9.9	26.2	Not Significantly Different
		Nunavachak	202			
		Kulukak	181			
	5/06-5/12	Nunavachak	183	18.6	26.2	Not Significantly Different
		Togiak	132			
		Kulukak	112			

¹ $\alpha = .01$

Table 2. Estimated biomass of Pacific herring in the Togiak District commercial catch by age class, 1979.

Sample Period	Age	Mean Weight at Age (gms)	Purse Seine				Gillnet				Total	
			Number Sampled	Percent by Number	Percent by Weight	Commercial Catch (mt)	Number Sampled	Percent by Number	Percent by Weight	Commercial Catch (mt)	Percent	Commercial Catch (mt)
4/29-5/05	1	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	217	-	-	-	-	-	-	-	-	-	-
	4	219	8	3	3	32.2	19	6	5	3.6	3	35.8
	5	240	117	49	47	504.1	180	59	58	42.3	48	546.4
	6	260	95	40	42	450.5	90	30	32	23.3	41	473.8
	7	264	18	8	8	85.8	14	5	5	3.6	8	89.4
	8+	298	-	-	-	-	-	-	-	-	-	-
	9+	288	1	tr	tr	tr	-	-	-	-	-	-
Period Total			239	100	100	1072.6	303	100	100	72.8	100	1145.4
5/06-5/12	1	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	144	15	4	3	92.0	7	1	1	8.9	3	100.9
	4	172	53	13	11	337.3	50	8	7	62.3	10	399.6
	5	202	188	44	42	1,287.7	363	58	55	489.8	45	1,777.5
	6	240	124	29	33	1,011.7	165	26	29	258.4	32	1,270.1
	7	240	39	9	10	306.6	37	6	7	62.3	9	368.9
	8+	284	2	tr	tr	tr	3	1	1	8.9	tr	8.9
	9+	293	4	1	1	30.6	2	tr	tr	tr	1	30.6
Period Total			425	100	100	3,065.9	627	100	100	890.6	100	3,956.5
5/13-5/19	1	-	-	-	-	-	1	tr	tr	tr	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	109	156	29	18	188.3	7	1	1	19.5	7	207.8
	4	149	34	6	5	52.3	35	6	4	78.0	4	130.3
	5	191	232	43	46	481.4	344	63	58	1,131.4	54	1,612.8
	6	250	100	18	25	261.6	122	22	27	526.6	26	788.2
	7	266	22	4	6	62.8	32	6	8	156.1	7	218.9
	8+	205	1	tr	tr	tr	5	1	1	19.5	1	19.5
	9+	299	1	tr	tr	tr	4	1	1	19.5	1	19.5
Period Total			546	100	100	1,046.4	550	100	100	1,950.6	100	2,997.0
5/20-5/26	1	-	-	-	-	-	-	-	-	-	-	-
	2	85	-	-	-	-	-	-	-	-	-	-
	3	107	304	52	40	350.4	16	3	2	20.7	20	371.1
	4	147	66	11	11	96.3	74	13	11	114.0	11	210.3
	5	155	147	25	28	245.2	303	55	47	487.1	38	732.3
	6	246	43	7	12	105.1	116	21	29	300.6	21	405.7
	7	266	28	4	8	70.1	40	7	10	103.6	9	173.7
	8+	126	5	1	1	8.8	6	1	1	10.4	1	19.2
	9+	-	1	tr	tr	tr	-	-	-	-	-	-
Period Total			591	100	100	875.9	555	100	100	1,036.4	100	1,912.3
5/27-6/02	1	18	-	-	-	-	-	-	-	-	-	-
	2	80	-	-	-	-	-	-	-	-	-	-
	3	124	-	-	-	-	11	3	2	2.1	2	2.1
	4	145	-	-	-	-	28	9	7	7.3	7	7.3
	5	179	-	-	-	-	176	55	50	51.8	50	51.8
	6	219	-	-	-	-	61	19	21	21.8	21	21.8
	7	266	-	-	-	-	43	13	18	18.7	18	18.7
	8+	355	-	-	-	-	3	1	2	2.1	2	2.1
	9+	345	-	-	-	-	1	tr	tr	tr	tr	tr
Period Total			-	-	-	-	155	100	100	103.8	100	103.8
Total	1	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	10	630.7	-	-	1	51.2	7	681.9
	4	-	-	-	9	518.1	-	-	7	265.2	8	783.3
	5	-	-	-	41	2,518.4	-	-	54	2,202.4	47	4,720.3
	6	-	-	-	30	1,828.9	-	-	28	1,130.7	29	2,959.6
	7	-	-	-	9	525.3	-	-	9	344.3	9	869.6
	8+	-	-	-	tr	8.8	-	-	1	40.9	tr	49.7
	9+	-	-	-	1	30.6	-	-	tr	19.5	tr	50.1
Total			-	-	-	6,060.3	-	-	100	4,054.2	100	10,115.0

tr = trace

1 Includes samples from commercial catch and test fishing.

2 Average of previous and following periods.

3 Includes 152.3 mt harvested during 5/27-6/02.

Table 3. Estimated biomass of Pacific herring in the Togiak District commercial catch¹ by age class, 1980.

Sample Period	Age	Mean Weight at Age (gm) ²	Purse Seine				Gillnet				Total		
			Number Sampled	Percent By Number	Percent By Weight	Commercial Catch (mt)	Number Sampled	Percent By Number	Percent By Weight	Commercial Catch (mt)	Percent	Commercial Catch (mt)	
4/22-4/28	3	-	0	0	0	0				0	0		
	4	184 ³	0	0	0	0				0	0		
	5	298	2	1	1	4.8				1	4.8		
	6	281	111	44	41	192.2				41	192.2		
	7	312	103	40	41	192.2				41	192.2		
	8 ₊	326	30	12	13	61.0				13	61.0		
	9 ⁺	403	8	3	4	18.7				4	18.7		
	Period Total			254	100	100	468.9				100	468.9	

4/29-5/05	3	172	0	0	0	0	0	0	0	0	0		
	4	184	1	tr	tr	tr	5	1	1	6.9	tr	6.9	
	5	237	2	tr	tr	tr	9	2	2	13.9	tr	13.9	
	6	276	298	43	39	3,111.8	352	60	57	395.5	40	3,507.3	
	7	319	315	45	47	3,750.0	174	30	32	222.0	46	3,972.0	
	8 ₊	336	66	10	11	877.7	41	7	8	55.5	11	933.2	
	9 ⁺	433	14	2	3	239.4	2	tr	tr	tr	3	239.4	
	Period Total			697	100	100	7,978.9	583	100	100	693.8 ⁴	100	8,672.7 ⁴

5/06-5/12	3	117	0	0	0	0	0	0	0	0	0		
	4	204	4	1	1	65.2	5	1	1	19.1	2	84.3	
	5	234	2	tr	tr	tr	8	2	2	38.1	tr	38.1	
	6	271	158	45	40	2,607.4	261	61	58	1,105.2	44	3,712.6	
	7	313	146	41	44	2,868.2	134	31	34	647.9	42	3,516.1	
	8 ₊	318	35	10	11	717.1	16	4	4	76.2	9	793.3	
	9 ⁺	353	9	3	4	260.7	3	1	1	19.1	3	279.8	
	Period Total			354	100	100	6,518.6 ⁵	427	100	100	1,905.6	100	8,424.2 ⁵

5/13-5/19	3	143					1	1	1	2.1	1	2.1	
	4	182					3	3	2	4.2	2	4.2	
	5	216					3	3	2	4.2	2	4.2	
	6	260					75	62	58	120.5	58	120.5	
	7	317					31	26	30	62.3	30	62.3	
	8 ₊	336					4	3	4	8.3	4	8.3	
	9 ⁺	400					2	2	3	6.1	3	6.1	
	Period Total						119	100	100	207.7	100	207.7	

Total	3				0				tr	2.1	tr	2.1	
	4				tr	65.2			1	30.2	1	95.4	
	5				tr	4.8			2	56.2	tr	61.0	
	6				40	5,911.4			58	1,621.2	42	7,532.6	
	7				46	6,810.4			33	932.2	44	7,742.6	
	8 ₊				11	1,655.8			5	140.0	10	1,795.8	
9 ⁺				3	518.8			1	25.2	3	544.0		
Total				100	14,966.4			100	2,807.1	100	17,773.5		

tr = Trace

- 1 Preliminary catch data.
- 2 Includes sample taken from commercial catch and test fishing.
- 3 Data from period 4/29-5/05.
- 4 Includes 6.3 mt harvested during period 4/22-4/28.
- 5 Includes 26.3 mt harvested during period 5/13-5/19.

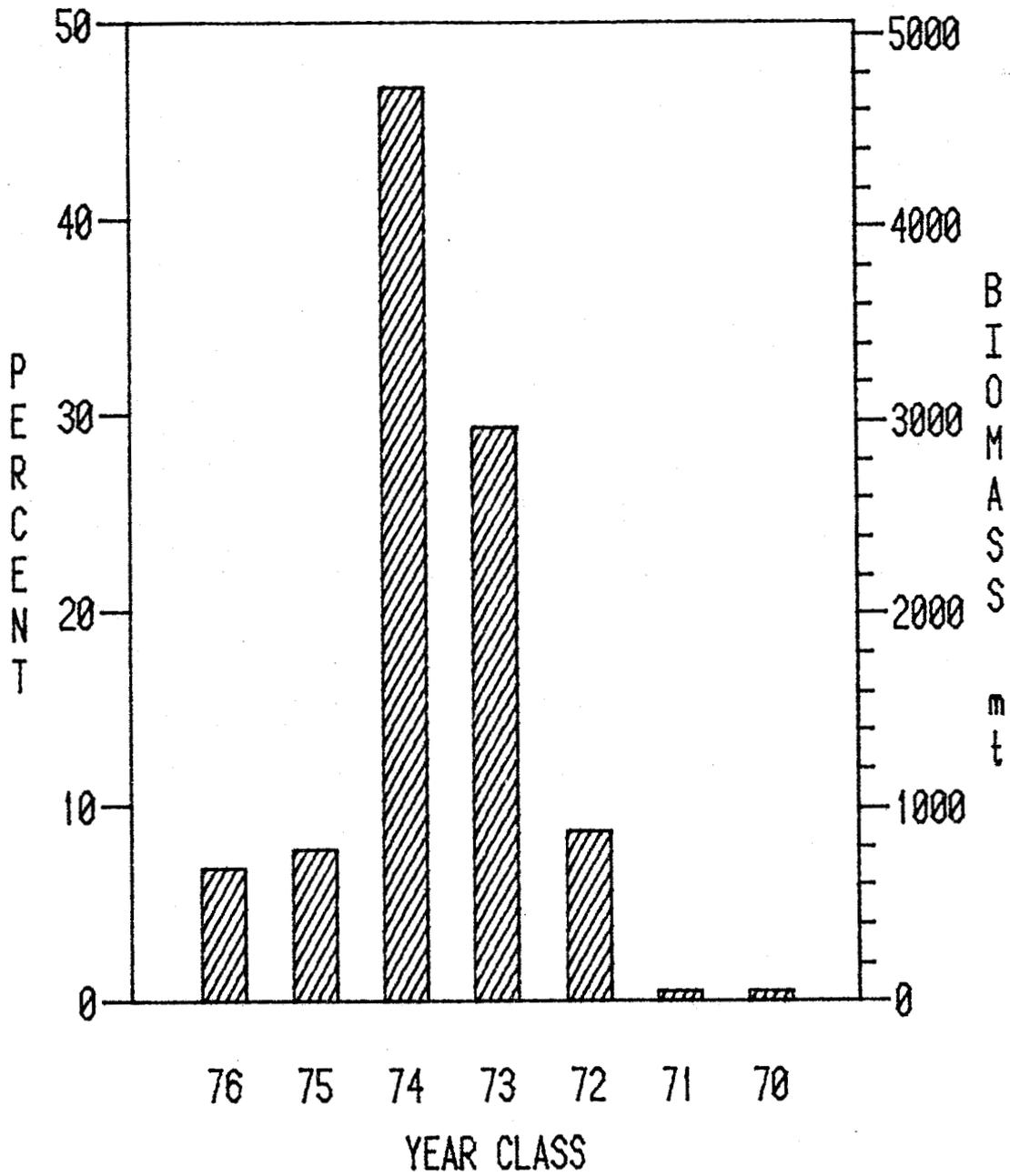


Figure 2. Age composition of Pacific herring in the Togiak District commercial catch, 1979.

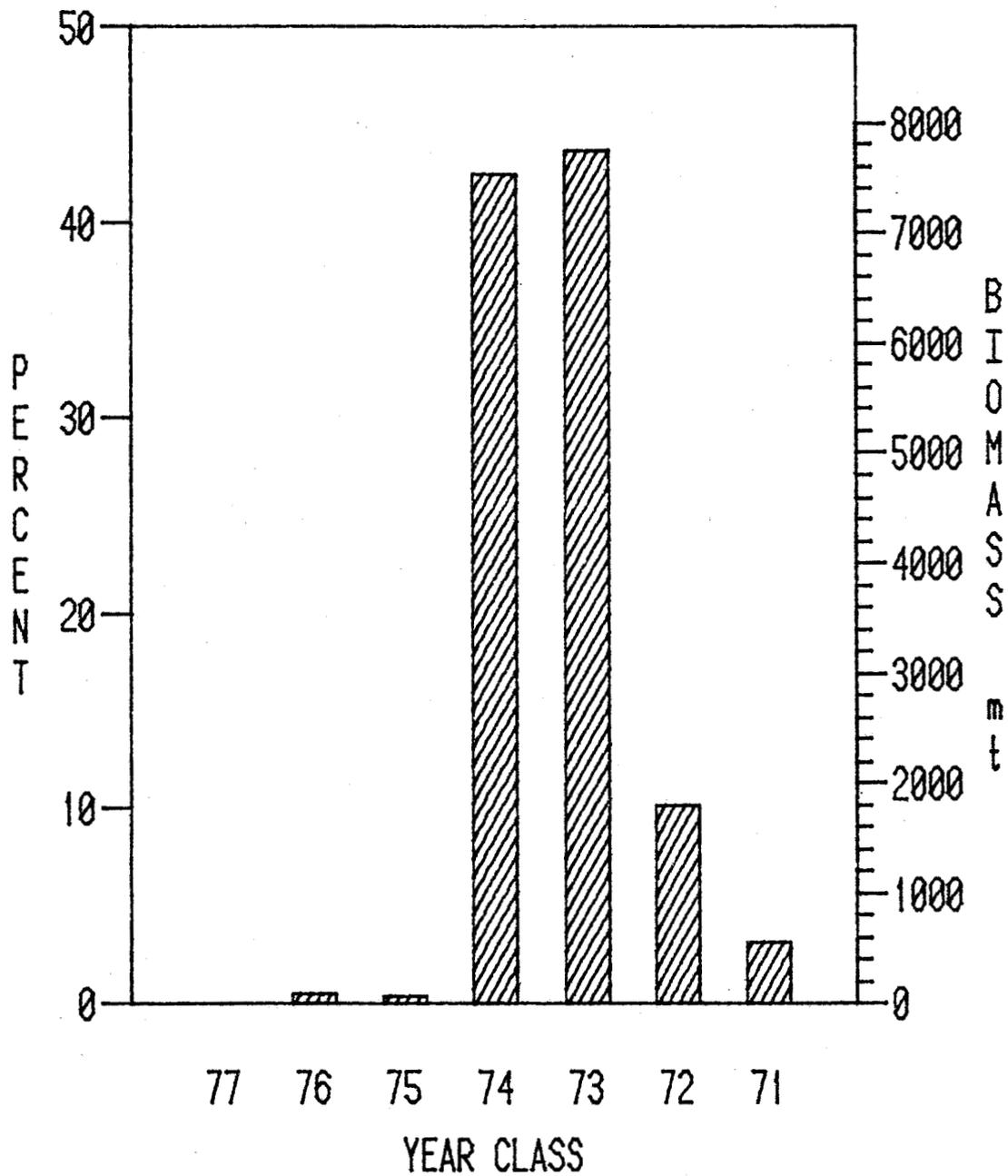


Figure 3. Age composition of Pacific herring in the Togiak District commercial catch, 1980.

1974 and 1973 year classes (ages 5 and 6 in 1979 and ages 6 and 7 in 1980) represented approximately 82% of the 27,888.5 mt of herring harvested during 1979 and 1980. The 1972 year class (age 7 and 8 in 1979 and 1980, respectively) represented approximately 9 and 10% of the total harvest in 1979 and 1980, respectively. All other year classes, particularly more recent ones (1975, 1976, and 1977), contributed little biomass to the total harvest.

Temporal differences in age composition were apparent in the 1979 commercial purse seine samples (Figure 4). These data show an increasing proportion of young fish throughout the duration of the migration. This trend is not apparent in the 1980 commercial catch samples; probably as a result of the short duration of the fishery.

TEST FISHING

Data Collection and Analysis

Sampling design and analysis methods used for test fishing with variable mesh gill nets were virtually the same as those used for the commercial harvest. Herring samples from test fishing catches were grouped by the same time periods and areas as commercial catch samples. Test fishing was done in only two areas in 1979, Kulukak and Hagemeister, and four in 1980, Kulukak, Nunavachak, Togiak, and Nushagak Peninsula (Figure 1 and Appendix Tables 3 and 4). The Nushagak Peninsula area was intensely sampled for the first time in 1980. It was thought that the large number of herring schools sighted in this area might be post-spawning herring that were leaving inshore spawning locations. Therefore, these schools could have a different age composition than herring in other sections. To further examine this hypothesis, the relative maturity of herring from test fishing catches was determined.

Estimation of Age Composition

Significant differences in age composition estimates were found among samples collected from different test fishing sections during both years (Table 4). Both comparisons that included samples collected from the Nushagak Peninsula area were significantly different. Two of 5 comparisons between the remaining areas, excluding the Nushagak Peninsula area, were also significantly different.

The limited data collected from the Nushagak Peninsula area during 1980 supported the hypothesis that herring in this area were primarily post-spawners that were exiting inshore spawning locations. Although only two comparisons of age composition were possible, both showed significant differences between samples collected from the Nushagak area and those from the Kulukak, Nunavachak, and Togiak sections. This hypothesis was further supported by comparison of the sexual maturity of samples collected from the Nushagak area with those from other sections (Table 5). In every comparison between samples collected from the Nushagak Peninsula area and

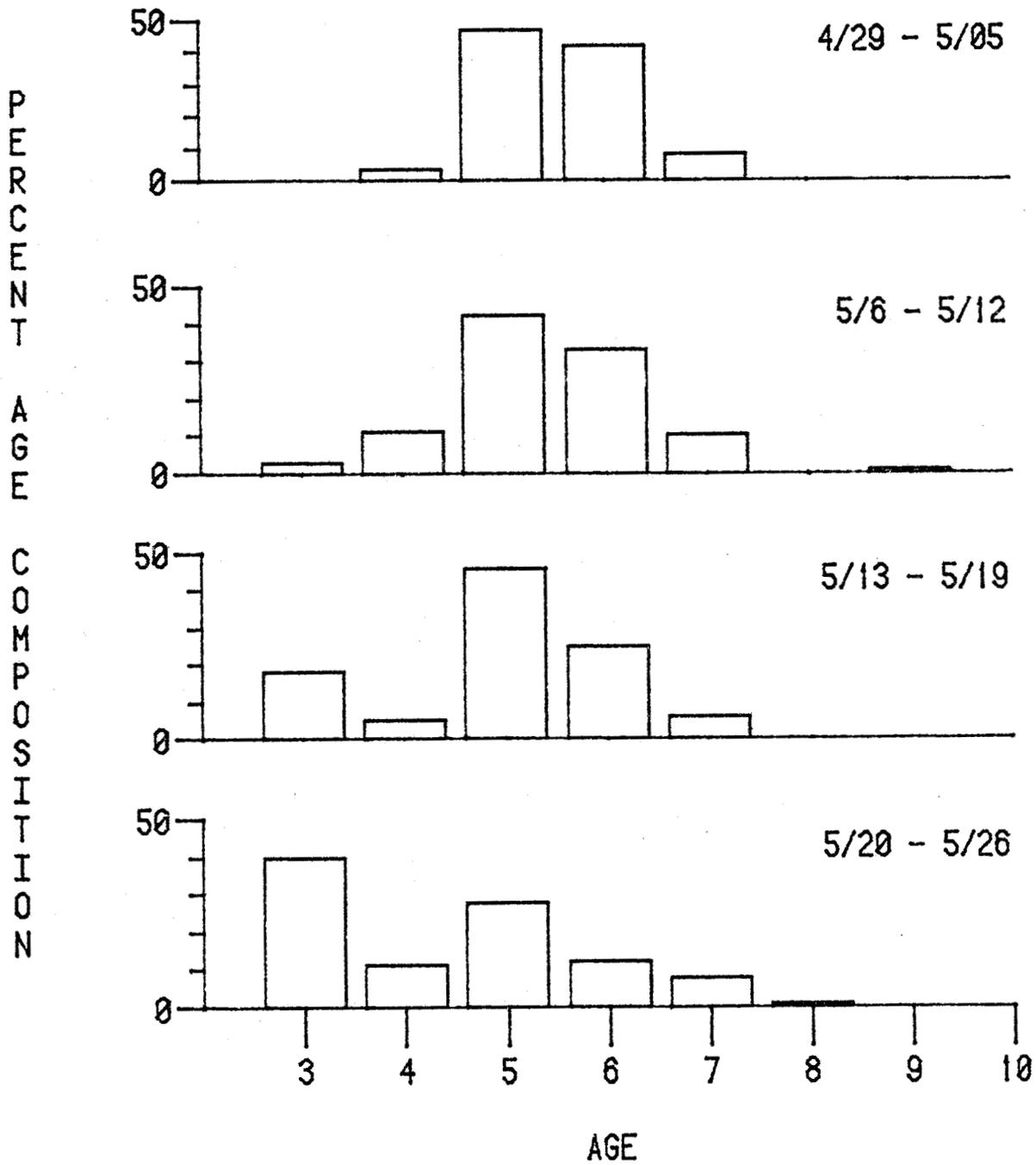


Figure 4. Temporal differences in herring age composition in the Togiak District commercial purse seine catches, 1979.

Table 4. Variability of test fishing age composition estimates between fishing sections in the Togiak District as estimated through chi-square analysis.

Time Period	Samples		Chi-Square		Conclusion
	Areas Compared	Sample Size	Calculated	Expected ¹	
1979					
5/13-5/19	Kulukak	111	13.4	20.1	Not Significantly Different
	Hagemeister	282			
5/27-6/02	Kulukak	905	52.7	20.1	Significantly Different
	Hagemeister	159			
1980					
5/13-5/19	Nushagak	160	56.5	26.2	Significantly Different
	Kulukak	556			
	Nunavachak	150			
5/20-5/26	Kulukak	556	20.3	16.8	Significantly Different
	Nunavachak	150			
5/20-5/26	Kulukak	283	6.7	16.8	Not Significantly Different
	Togiak	114			
5/27-6/02	Nushagak	181	150.7	26.2	Significantly Different
	Kulukak	178			
	Togiak	191			
5/27-6/02	Kulukak	178	16.3	16.8	Not Significantly Different
	Togiak	191			

¹ $\alpha = .01$

Table 5. Gonad maturity of Pacific herring in the Togiak District test fishing catches, 1980.

Sample Period	Gonad Maturity ¹	Nushagak Area		Kulukak		Nunavachak		Togiak	
		No.	%	No.	%	No.	%	No.	%
4/29-5/5	Virgin								
	Green	14	33	21	11				
	Ripe	16	38	174	88				
	Spent	12	29	3	1				
Period Total		42	100	198	100				

5/6-5/12	Virgin								
	Green	8	57	11	5				
	Ripe			203	90				
	Spent	6	43	11	5				
Period Total		14	100	225	100				

5/13-5/19	Virgin								
	Green	27	15	15	2	20	12		
	Ripe	135	77	611	96	130	81		
	Spent	13	8	9	2	11	7		
Period Total		175	100	635	100	161	100		

5/20-5/26	Virgin								
	Green	3	8	22	7			29	25
	Ripe	15	43	252	80			58	49
	Spent	17	49	39	13			31	26
Period Total		35	100	313	100			118	100

5/27-6/2	Virgin	1	tr.						
	Green	8	4	7	4			31	15
	Ripe	20	10	145	76			83	40
	Spent	171	86	37	20			92	45
		200	100	189	100			206	100

All Periods	Virgin	1	tr.						
	Green	60	13	76	5	20	12	60	19
	Ripe	186	40	1,385	89	130	81	141	43
	Spent	219	47	99	6	11	7	123	38
Period Total		466	100	1,560	100	161	100	324	100

¹ Adapted from the Bergen scale: Virgin: Index 1 and 2
 Green: Index 3 and 4
 Ripe: Index 5 and 6
 Spent: Index 7 and 8

those from the remainder of the Togiak District, the Nushagak samples exhibited a larger relative proportion of spent fish.

Significant variation was observed between some of the Kulukak, Nunavachak, and Hagemeister section age composition estimates. Although results of the chi-square tests indicate significant differences in age composition between fishing sections, it was nevertheless felt appropriate to group weekly samples across all fishing sections (excluding the Nushagak Peninsula area) for the following reasons: (1) No consistent trends were found to explain the variability of age composition estimates between the Kulukak, Nunavachak, and Hagemeister sections; and (2) Little variability was found in the commercial harvest age composition estimates for these sections (Table 1).

It was felt that the lack of significant variation between commercial harvest age composition estimates from different fishing sections strongly indicated that the Togiak District should be treated as a single area. Therefore, test fishing samples were grouped by time period across all areas, excluding the Nushagak Peninsula samples (Tables 6 and 7).

The relative contribution of individual year classes to test fishing catches was similar during both years. The 1974 and 1973 year classes (ages 5 and 6 in 1979 and ages 6 and 7 in 1980) usually represented over 50% of the catches during 1979 (50-82%) and 1980 (47-82%). The 1972 year class (age 7 in 1979 and age 8 in 1980) was the only other year class that generally represented over 10% of the catches during 1979 (5-18%) and 1980 (8-17%). The 1975 year class (age 4 in 1979 and age 5 in 1980) was poorly represented in all catches (1-7% in 1979; 1-2% in 1980). The 1977 and 1976 year classes (ages 2 and 3 in 1979; ages 3 and 4 in 1980) varied greatly in their contribution to catches (0-26% in 1979; 0-41% in 1980).

Temporal differences in age composition were apparent in both the 1979 and 1980 test fishing samples (Figures 5 and 6). The proportion of younger, primarily age 3, herring increased from low levels early in the migration to a maximum of 28% during the later stages of the migration.

TOTAL AGE COMPOSITION

Data Analysis

Age composition data from both purse seine and test fishing catches were used as estimates of age composition of the entire spawning migration. Chi-square tests were used to detect differences between age composition estimates calculated from commercial purse seine and test fishing samples for both 1979 and 1980.

In order to estimate the contribution of each age class to the total herring spawning population, it was necessary to weight age composition estimates for any time period by the relative abundance of herring during that time period. A relative abundance index (RAI) was calculated for each sampling period from

Table 6. Estimated age composition of Pacific herring in the Togiak District test fishing catches, 1979.

Sample Period	Age	Mean Weight at Age (gm) ¹	Number Sampled	Percent by Number	Percent by Weight
4/29-5/05	1	-	0	-	-
	2	-	0	-	-
	3	217	1	tr	tr
	4	219	8	1	1
	5	240	404	59	57
	6	260	146	21	22
	7	264	117	17	18
	8+	298	1	tr	tr
	9+	288	13	2	2
Period Total			690	100	100
5/06-5/12	1	-	0	-	-
	2	-	0	-	-
	3	144	12	15	11
	4	172	2	3	2
	5	202	55	70	72
	6	240	6	8	10
	7	240	3	4	5
	8+	284	0	0	0
	9+	-	0	0	0
Period Total			78	100	100
5/13-5/19	1	-	1	tr	tr
	2	102	11	3	2
	3	109	92	23	14
	4	149	22	5	4
	5	191	168	43	44
	6	250	58	15	20
	7	266	25	7	10
	8+	205 ²	3	1	1
	9+	299	13	3	5
Period Total			393	100	100
5/20-5/26	1	-	1	tr	tr
	2	85	26	7	3
	3	107	51	13	8
	4	147 ²	13	3	3
	5	155	180	46	41
	6	246	71	18	25
	7	266 ²	37	10	15
	8+	126	2	1	1
	9+	322 ²	7	2	4
Period Total			388	100	100
5/27-6/02	1	18	6	1	tr
	2	80	90	8	4
	3	124	306	29	22
	4	145	71	7	6
	5	179	373	35	38
	6	219	102	9	12
	7	266	95	9	14
	8+	355	1	tr	tr
	9+	345	20	2	4
Period Total			1,064	100	100
6/03-6/09	1	-	0	-	-
	2	67	24	4	2
	3	103	170	30	20
	4	143	46	8	7
	5	167	216	39	42
	6	235	52	9	13
	7	232	44	8	12
	8+	355 ²	3	1	2
	9+	345 ²	6	1	2
Period Total			561	100	100

¹ Includes samples taken from commercial catch and test fishing.

² Average of previous and following periods.

Table 7. Estimated age composition of Pacific herring in the Togiak District test fishing catches, 1980.

Sample Period	Age	Mean Weight at Age (gm) ¹	Number Sampled	Percent by Number	Percent by Weight
4/29-5/05	3	172	1	tr	tr
	4	184	3	1	tr
	5	237	4	2	2
	6	276	83	41	37
	7	319	77	38	40
	8+	336	31	15	17
	9+	433	5	3	4
Period Total			204	100	100
5/06-5/12	3	117	1	tr	tr
	4	204	6	3	2
	5	234	4	2	2
	6	271	101	48	45
	7	313	73	34	37
	8+	318	27	13	14
	9+	353	1	tr	tr
Period Total			213	100	100
5/13-5/19	3	143	169	20	11
	4	182	114	13	10
	5	216	14	2	2
	6	260	261	30	31
	7	317	224	26	33
	8+	336	71	8	11
	9+	400	13	1	2
Period Total			866	100	100
5/20-5/26	3	133	177	41	27
	4	171	69	16	14
	5	200	4	1	1
	6	250	98	23	29
	7	293	58	13	19
	8+	310	21	5	8
	9+	427	3	1	2
Period Total			430	100	100
5/27-6/02	3	137	210	38	28
	4	168	61	11	10
	5	200 ²	10	2	2
	6	206	152	28	31
	7	246	68	12	16
	8+	262	39	7	10
	9+	254	10	2	3
Period Total			550	100	100

tr = trace

¹ Includes samples taken from commercial catch and test fishing.

² Average of previous and following periods.

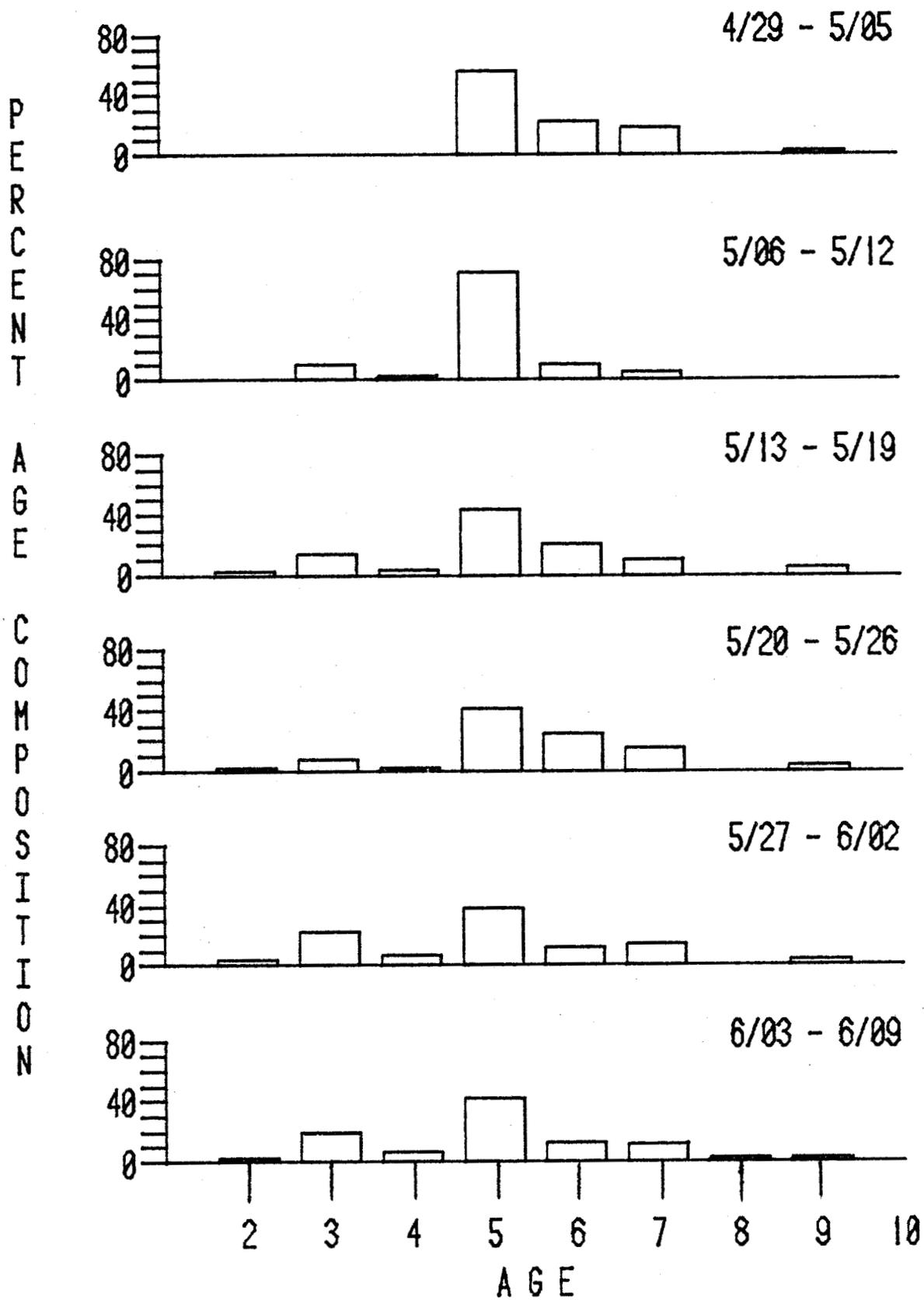


Figure 5. Temporal differences in herring age composition in the Togiak District test fishing catches, 1979.

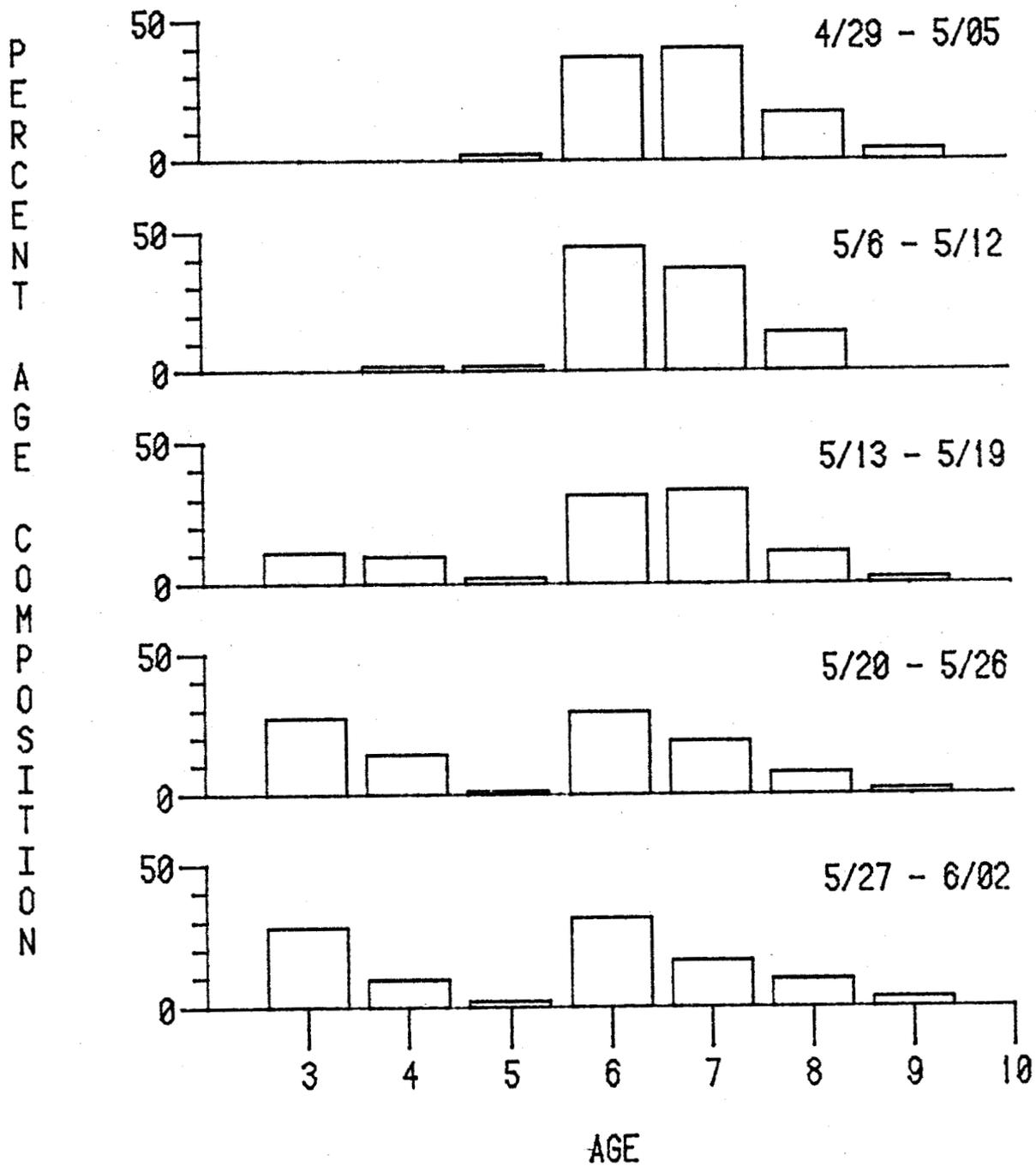


Figure 6. Temporal differences in herring age composition in Togiak District test fishing catches, 1980.

aerial survey data (Kingsbury 1980). The total surface area of all herring schools observed in the Kulukak (excluding the Nushagak area), Nunavachak, Togiak, and Hagemeister sections were standardized in relation to the number of "50 m² small school units" represented (i.e., RAI = total estimated surface area schools observed/50 m²). The largest RAI for each time period was used as a weighting factor for the age composition estimate during that time period. Weighted age composition estimates were summed over all time periods to yield a final age composition estimate for each year.

Age Composition of the 1979 and 1980 Spawning Migrations

In 1979, all three comparisons of age composition estimates between purse seine and test fishing samples were significantly different while in 1980, only one of four comparisons was different (Table 8). No observable trend was found in the different comparisons (e.g., one gear type consistently underestimating a certain age class) to explain the variability. Due to the differences in age composition estimates during 1979, results in age composition from both the commercial purse seine and test fishing samples from that year will be discussed in terms of total age composition. As a result of the short duration of the harvest in 1980, age composition estimates of the 1980 spawning population were calculated using only data from test fishing samples.

Age composition estimates from both commercial purse seine and test fish catches for the 1979 spawning migration showed the 1974 and 1973 year classes (age 5 and 6) to be dominant (Table 9). However, the relative contribution of these year classes differed between these gear types (43 and 35%, respectively, in the purse seine estimate; 67 and 13%, respectively, in the test fishing estimate). Both estimates showed the 1977-1975 and 1972-1970 year classes (ages 2,3,4,7,8, and 9) to cumulatively represent approximately 20% of the total spawning population.

The age composition estimate from test fish sampling of the 1980 spawning migration again showed the 1974 and 1973 year classes (ages 6 and 7) to be dominant at 39 and 37%, respectively (Table 9). The remaining year classes again cumulatively represented approximately 20% of the total spawning migration.

The findings in this report differ with those of Barton and Steinhoff (1980) primarily in estimation of the younger (ages 1, 2, and 3) age classes during 1979. The analyses reported here show only trace amounts of age 1 and 2 herring, and a range of 3-8% of age 3 herring (Table 9). Barton and Steinhoff report a trace amount of age 1 herring, but 4% age 2, and 22% age 3 herring. The larger proportion of younger age classes reported by Barton and Steinhoff is a result of their grouping all samples over the duration of the herring migration and, therefore, not accounting for temporal differences in both age composition and relative abundance. The large number of age 3 herring sampled during the later stages of the herring migration represent only a small portion of the overall biomass present during 1979. Both analyses found the 1974 year class (age 5 in 1979) to be very strong.

Table 8. Variability of commercial purse seine and test fishing age composition estimates in the Togiak District as estimated through chi-square analysis.

Time Period	Gear Type	Samples		Chi-square		Conclusions
		Areas Compared	Sample Size	Calculated	Expected ¹	

1979						

5/13-5/19	Purse Seine Var. Gillnet	Kulukak Kulukak	188 111	73.1	18.5	Significantly Different
4/29-5/05	Purse Seine Var. Gillnet	All Sections All Sections	239 690	45.7	16.8	Significantly Different
5/13-5/19	Purse Seine Var. Gillnet	All Sections All Sections	546 393	39.9	20.1	Significantly Different

1980						

5/06-5/12	Purse Seine Var. Gillnet	Kulukak Kulukak	164 160	8.7	16.8	Not Significantly Different
	Purse Seine Var. Gillnet	All Sections All Sections	697 204	17.4	16.8	Significantly Different
5/13-5/19	Purse Seine Var. Gillnet	All Sections All Sections	354 213	11.8	16.8	Not Significantly Different
5/27-6/02	Purse Seine Var. Gillnet	Togiak ² Togiak	113 114	5.3	16.8	Not Significantly Different

¹ = .05

² Samples from purse seine test fishing.

Table 9. Estimated age composition of Pacific herring in the Togiak District during the 1979 and 1980 spawning migrations.

Percent Age Composition and Relative Abundance of Herring During Time Period:											Age Composition
Age	4/29-5/05		5/06-5/12		5/13-5/19		5/20-5/26		5/27-6/02		
	Percent	Weighting Factor ¹									
----- Percent Age Composition During 1979 as Estimated from Commercial Purse Seine Samples -----											
3	-	30,403	3	90,140	18	2,582	40	2,840			3
4	3		11		5		11				9
5	47		42		46		28				43
6	42		33		25		12				35
7	8		10		6		8				9
8 ₊	-		tr		tr		1				tr
9 ⁺	tr		1		tr		tr				1
	100		100		100		100				100
----- Percent Age Composition During 1979 as Estimated from Variable Mesh Gillnet Data -----											
1	-	30,403	-	90,140	tr	2,582	tr	2,840			tr
2	-		-		2		3				tr
3	tr		11		14		8				8
4	1		2		4		3				2
5	57		72		44		41				67
6	22		10		20		25				13
7	18		5		10		15				9
8 ₊	tr		-		1		1				tr
9 ⁺	2		-		5		4				1
	100		100		100		100				100
----- Percent Age Composition During 1980 as Estimated from Variable Mesh Gillnet Data -----											
3	tr	12,122	tr	9,806	11	1,757	27	1,014	28	1,007	3
4	tr		2		10		14		10		2
5	2		2		2		1		2		2
6	37		45		31		29		31		39
7	40		37		33		19		16		37
8 ₊	17		14		11		8		10		15
9 ⁺	4		tr		2		2		3		2
	100		100		100		100		100		100

tr = trace
1 Peak RAI.

SUMMARY

- 1) Temporal differences in age composition were documented during both 1979 and 1980. The spawning migrations were characterized by older fish migrating inshore during the early and middle portions of the run and younger fish returning during the latter portion.
- 2) Little difference in commercial harvest age composition estimates were found among samples collected from different fishing sections within individual time periods during 1979 and 1980. Analysis of age composition was based on samples from all fishing sections grouped by gear type and time period.
- 3) Significant differences in age composition estimates from test fishing catches were found among samples collected from different fishing sections within individual time periods during 1979 and 1980. However, it was felt appropriate to combine test fish samples from all areas within individual time periods as a result of the lack of significant variation between commercial harvest age composition estimates. Due to consistent differences in age composition and gonad condition, samples from the Nushagak Peninsula area were not included in these groupings.
- 4) Comparisons between age composition estimates calculated from commercial purse seine and test fishing data were inconclusive as the estimates significantly differed in 1979, but were similar in 1980.
- 5) All age composition estimates showed the 1973 and 1974 year classes to be dominant and represented approximately 80% of the total spawning migrations during 1979 and 1980. The 1970-1972 and 1975-1977 year classes were relatively much weaker and cumulatively represented approximately 20% of the total spawning biomass.

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APPENDIX

Appendix Table 1. Age class composition by number of commercially caught Pacific herring by gear type, Togiak District, 1979.

Sample Period	Age	Kulukak				Nunavachak				Togiak				Hagemeister				
		Gillnet		Purse Seine		Gillnet		Purse Seine		Gillnet		Purse Seine		Gillnet		Purse Seine		
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
4/29-5/05	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	4	12	7	4	7	7	5	2	1	-	-	2	6	-	-	-	-	
	5	102	59	25	42	78	60	83	57	-	-	9	26	-	-	-	-	
	6	51	30	25	42	39	30	52	36	-	-	18	53	-	-	-	-	
	7	7	4	5	9	7	5	8	5	-	-	5	15	-	-	-	-	
	8+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9+	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
Period Total		172	100	59	100	131	100	146	100	0	34	100	0	0				

5/06-5/12	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	3	2	1	-	-	1	tr	3	3	4	2	12	5	-	-	-	-	
	4	10	6	7	21	19	9	11	11	21	9	32	15	-	-	3	3	
	5	102	59	14	43	123	55	36	36	138	60	124	56	-	-	32	36	
	6	44	25	8	24	67	30	38	39	54	24	43	19	-	-	35	39	
	7	15	9	4	12	10	5	10	10	12	5	6	3	-	-	19	21	
	8+	1	tr	-	-	2	1	1	1	-	-	2	1	-	-	1	1	
	9+	-	-	-	-	1	tr	-	-	1	tr	1	1	-	-	-	-	
Period Total		174	100	33	100	223	100	99	100	230	100	220	100	0	90	100		

5/13-5/19	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	3	5	3	4	2	3	tr	84	42	1	1	68	43	-	-	-	-	
	4	5	3	10	5	16	8	10	5	14	7	14	9	-	-	-	-	
	5	86	50	87	46	136	71	84	42	122	65	61	38	-	-	-	-	
	6	51	30	72	38	32	17	19	10	39	21	9	6	-	-	-	-	
	7	21	12	13	7	3	2	2	1	8	4	7	4	-	-	-	-	
	8+	-	-	1	1	4	2	-	-	1	1	-	-	-	-	-	-	
	9+	1	1	1	1	1	tr	-	-	2	1	-	-	-	-	-	-	
Period Total		170	100	188	100	195	100	199	100	187	100	159	100	0	0			

5/20-5/26	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	3	6	4	109	58	4	2	70	43	6	3	125	52	-	-	-	-	
	4	30	17	14	7	22	11	19	12	22	12	33	14	-	-	-	-	
	5	88	50	48	25	116	59	46	28	99	54	53	22	-	-	-	-	
	6	35	20	13	7	41	21	18	11	40	22	12	5	-	-	-	-	
	7	14	8	4	2	11	6	9	5	15	8	12	5	-	-	-	-	
	8+	2	1	1	1	2	1	-	-	2	1	4	2	-	-	-	-	
	9+	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	
Period Total		175	100	189	100	196	100	163	100	184	100	239	100	0	0			

5/27-6/02	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	3	-	-	-	-	6	6	-	-	5	2	46	64	-	-	-	-	
	4	-	-	-	-	19	18	-	-	9	4	9	13	-	-	-	-	
	5	-	-	-	-	56	55	-	-	120	54	16	22	-	-	-	-	
	6	-	-	-	-	18	18	-	-	43	20	-	-	-	-	-	-	
	7	-	-	-	-	3	3	-	-	40	18	-	-	-	-	-	-	
	8+	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	
	9+	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	
Period Total		0	0	0	0	102	100	0	0	221	100	72	100	0	0			

tr = trace

Appendix Table 2. Age class composition by number of commercially caught Pacific herring by gear type, Togiak District, 1980.

Sample Period	Age	Kulukak				Nunavachak				Togiak				Hagemeister			
		Gillnet		Purse Seine		Gillnet		Purse Seine		Gillnet		Purse Seine		Gillnet		Purse Seine	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
4/22-4/28	1			-	-			-	-			-	-			-	-
	2			-	-			-	-			-	-			-	-
	3			-	-			-	-			-	-			-	-
	4			-	-			-	-			-	-			-	-
	5			-	-			1	2			1	2			-	-
	6			63	45			19	37			29	47			-	-
	7			57	41			23	44			23	37			-	-
	8 ⁺			16	11			8	15			6	10			-	-
	9 ⁺			4	3			1	2			3	4			-	-
Period Total			0	140	100	0	52	100	0	62	100	0	0				
4/29-5/05	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	3	2	-	-	-	-	-	-	2	1	-	-	-	-	1	1
	5	1	1	-	-	5	3	-	-	3	1	1	1	-	-	1	1
	6	116	64	68	43	118	58	71	37	118	59	71	50	-	-	89	44
	7	51	28	72	45	63	31	106	54	60	30	59	41	-	-	78	39
	8 ⁺	10	5	15	9	16	8	14	7	15	8	10	7	-	-	27	13
	9 ⁺	-	-	5	3	-	-	4	2	2	1	1	1	-	-	4	2
Period Total	181	100	160	100	202	100	195	100	200	100	142	100	0	200	100		
5/06-5/12	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	2	2	2	2	1	1	1	2	2	1	-	-	-	-	-	-
	5	2	2	2	2	2	1	-	-	4	3	-	-	-	-	-	-
	6	69	62	26	32	116	63	35	57	76	58	22	40	-	-	-	-
	7	30	27	42	52	62	34	21	34	42	32	25	45	-	-	-	-
	8 ⁺	6	5	8	10	2	1	2	3	8	6	7	13	-	-	-	-
	9 ⁺	3	2	2	2	-	-	3	4	-	-	1	2	-	-	-	-
Period Total	112	100	82	100	183	100	62	100	132	100	55	100	0	0			
5/13-5/19	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-
	4	2	2	-	-	1	4	-	-	-	-	-	-	-	-	-	-
	5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	60	63	-	-	15	66	-	-	-	-	-	-	-	-	-	-
	7	25	26	-	-	6	26	-	-	-	-	-	-	-	-	-	-
	8 ⁺	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9 ⁺	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	96	100	0		23	100	0		0	0	0		0	0			

Appendix Table 3. Age class composition by number of Pacific herring in test fishing catches, Togiak District, 1979.

Sample Period	Age	Kulukak		Hagemeister	
		No.	%	No.	%
4/29-5/05	1	-	-		
	2	-	-		
	3	1	tr		
	4	8	1		
	5	404	59		
	6	146	21		
	7	117	17		
	8+	1	tr		
	9+	13	2		
Period Total		690	100	0	
5/06-5/12	1	-	-		
	2	-	-		
	3	12	15		
	4	2	3		
	5	55	70		
	6	6	8		
	7	3	4		
	8+	-	-		
	9+	-	-		
Period Total		78	100	0	
5/13-5/19	1	-	-	1	tr
	2	1	1	10	4
	3	26	23	66	23
	4	10	9	12	4
	5	53	48	115	41
	6	12	11	46	16
	7	2	6	18	7
	8+	-	-	3	1
	9+	2	2	11	4
Period Total		111	100	282	100
5/20-5/26	1	-	-	1	tr
	2	3	4	23	8
	3	30	36	21	7
	4	3	4	10	3
	5	30	36	150	49
	6	10	12	61	20
	7	5	6	32	11
	8+	1	1	1	tr
	9+	1	1	6	2
Period Total		83	100	305	100
5/27-6/02	1	1	tr	5	3
	2	70	8	20	13
	3	287	32	19	12
	4	64	7	7	4
	5	305	33	68	43
	6	87	10	15	9
	7	71	8	24	15
	8+	1	tr	-	-
	9+	19	2	1	1
Period Total		905	100	159	100
6/03-6/09	1	-	-	-	-
	2	24	4	-	-
	3	167	30	3	43
	4	46	8	-	-
	5	215	39	1	14
	6	52	10	-	-
	7	41	7	3	43
	8+	3	1	-	-
	9+	6	1	-	-
Period Total		554	100	7	100

tr = trace

Appendix Table 4. Age class composition by number of Pacific herring on test fishing catches, Togiak District, 1980.

Sample Period	Age	Nushagak		Kulukak		Nunavachak		Togiak	
		No.	%	No.	%	No.	%	No.	%
4/29-5/05	1	-	-	-	-				
	2	-	-	-	-				
	3	-	-	1	1				
	4	1	3	2	1				
	5	3	8	1	1				
	6	18	45	65	39				
	7	15	37	62	38				
	8+	3	8	28	17				
	9+	-	-	5	3				
Period Total		40	100	164	100	0		0	
5/06-5/12	1	-	-	-	-				
	2	-	-	-	-				
	3	-	-	1	tr				
	4	1	8	5	3				
	5	-	-	4	2				
	6	5	38	96	48				
	7	5	38	68	34				
	8+	2	16	25	13				
	9+	-	-	1	tr				
Period Total		13	100	200	100	0		0	
5/13-5/19	1	-	-	-	-	-	-		
	2	-	-	-	-	-	-		
	3	36	22	96	17	37	25		
	4	41	26	55	10	18	12		
	5	4	2	5	1	5	3		
	6	44	28	164	29	53	35		
	7	24	15	172	31	28	19		
	8+	10	6	54	10	7	5		
	9+	1	1	10	2	2	1		
Period Total		160	100	556	100	150	100	0	
5/20-5/26	1	-	-	-	-			-	-
	2	-	-	-	-			-	-
	3	8	24	126	45			43	38
	4	2	6	49	17			18	16
	5	-	-	2	1			2	2
	6	9	28	64	23			25	22
	7	10	30	29	10			19	16
	8+	4	12	12	4			5	4
	9+	-	-	1	tr			2	2
Period Total		33	100	283	100	0		114	100
5/27-6/02	1	-	-	-	-			-	-
	2	-	-	-	-			-	-
	3	19	10	95	53			96	50
	4	7	4	37	21			17	9
	5	5	3	1	1			4	2
	6	83	46	25	14			44	23
	7	39	22	11	6			18	9
	8+	24	13	6	3			9	5
	9+	4	2	3	2			3	2
Period Total		181	100	178	100	0		191	100

tr = trace

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