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Alaska Department of Fish and Game
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Abundance, Age, Sex, and Size Statistics For Pacific Herring In Lower Cook Inlet, 1989

by

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Rance Morrison

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ABSTRACT

Harvests of Pacific herring (*Clupea harengus pallasi*) from the Kamishak and Southern Districts sac roe fishery within the Lower Cook Inlet Management Area of Alaska were sampled for sex, age, weight, and length during April and May 1989. Test fish catches of herring from the Outer District were also sampled for species composition as well during the month of July.

In the Kamishak District the harvest was estimated to be 4365 tonnes (4801 tons) and the spawning biomass at 20,452 tonnes (22,497 tons). In the catch or early-spawning herring samples, there were more males (55%) than females. More than 70% of the samples were represented by only three age groups: age-5 (1984 year class), age-6 (1983 year class), and age-8 (1981 year classes). They were 36.1%, 22.1%, and 13.2% of the samples, respectively. Mean weight and length of the weighted catch samples were 207 g and 242 mm. No age composition samples were collected from the 1,445-tonne (1,590-ton) biomass of late-spawning herring, observed after the fishery was completed. Instead, the age structure of the late-spawning herring was estimated from the regression of late-spawning herring on early-spawning herring and age. Mean weight of the late-spawning biomass was also estimated from a regression of late-spawning mean weights on early-spawning mean weights. The late-spawning biomass was derived from the product of the estimated numbers of fish and its estimated mean weight. The late-spawning biomass was observed between 15 May and 12 June and estimated to be 1,445 tonnes (1,590 tons). Another 9,213 tonnes (10,135 tons) was observed on 12 June, but there is some uncertainty whether these fish were previously counted in the spawning biomass. The calculated late-spawning biomass was in between the two aerial survey estimates.

In the Southern District, the harvest biomass was estimated to be 155.8 tonnes (171.4 tons), while the spawning biomass was estimated to be 1818.2 tonnes (2000.0 tons). Age, sex, and size of the spawning biomass was assumed to be similar to the catch. In the catch samples, 55% were males and 75% were either age-4 (32.0%), -5 (33.3%) or -6 (9.7) fish from the 1985, 1984, and 1983 year classes. Mean weight and length of the combined catch samples were 152 g and 222 mm.

The Outer Districts biomass was estimated to be 29,545 tonnes (35,200 tons) and the Eastern District 30,000 tonnes (33,000 tonnes). Test fish samples were mostly age-1 from the 1988 year class, despite observable differences in body size. Sex composition could not be determined. Some samples in the Outer District were composed entirely of capelin. Mean weight and length of the combined samples were 106 mm and 15 g in the Outer District and 113 mm and 18 g in the Eastern District.

KEY WORDS: Abundance, age, *Clupea harengus pallasi*, Pacific herring, length, Lower Cook Inlet, sex, weight

INTRODUCTION

The Lower Cook Inlet Management Area is comprised of all waters west of the longitude of Cape Fairfield in the Gulf of Alaska, north of the latitude of Cape Douglas in Shelikof Straits, and south of the latitude of Anchor Point in Cook Inlet. The area is subdivided into four management districts: Kamishak, Southern, Outer, and Eastern (Figure 1). Since 1961 catches of Pacific herring (*Clupea harengus pallasi*) have been documented in all districts. Throughout this period the Alaska Department of Fish and Game (ADF&G) maintained a resource monitoring program to collect data from the fishery and the contributing spawning populations. By regulation purse seines have been the only gear allowed in the sac roe fishery. Entry into the sac roe fishery was limited in 1978, at which time 75 permits were issued. Sampling of the herring catch for age, sex, weight, and length data began in 1972 and has been reported annually in the Lower Cook Inlet Annual Management Report Series (e.g. Schroeder and Morrison 1989). Assessment of the spawning biomass began in 1978 with a program of aerial surveys and test fishing for age composition. A total closure of the commercial herring fishery occurred for the 1980-84 period because of low stock abundance. The Kamishak, Eastern, and Outer Districts were reopened in 1985 and the Southern District in 1989.

The timing of the spring sac roe fishery has been from mid-April to early May. Older herring tend to appear on the spawning grounds before the younger herring. Herring movement within the Kamishak District has generally been from south to north. The current management strategy limits the harvest rate to 20% of the estimated biomass by weight for age-6 and older herring and 10% of the biomass by weight of herring age-5 and younger. Age, weight, and length (AWL) data from the purse seine sac roe fishery are used to determine run timing of the younger fish, update the harvest strategy, monitor year class strengths, measure recruitment, and prepare a long-range forecast of abundance.

During 1989 only the Kamishak and Southern Districts were open to the sac roe fishery. The objectives of the 1989 herring sampling program in the Kamishak and Southern District were to (1) estimate the prespawning and early-spawning biomass between mid-April and mid-May, when the commercial fishery was active, (2) estimate the spawning biomass between mid-May and June, the period after the commercial fishery, (3) estimate the age composition of the harvest, (4) calculate the biomass of each age group during the period of the harvest, (5) provide all estimates across time and geographical areas, and (6) provide estimates as soon as possible to support in-season decision making. The objectives in the Outer District were simply to estimate the age composition of the post-spawning biomass.

METHODS

Lower Cook Inlet sac roe herring catches are normally reported separately for the Kamishak, Outer and Eastern Districts (Figure 1). The Kamishak District catches, however, are further subdivided into seven areas (Figure 2). Each of the management districts and seven areas was considered a geographical sampling strata.

The 1989 sac roe and test fishery was not expected to last more than 3 weeks. Furthermore, the younger fish were not expected to appear until the latter half of the fishery. For those reasons each day of actual commercial or test fishing was considered a temporal sampling strata.

Sample sizes were set for each sampling strata such that all of the estimated age class (i) proportions, p_i, from a multinomial population of k age groups were simultaneously within a specified distance, d, of their true population age proportions, Π_i, 95% of the time $(1 - \alpha)$. That is,

$$\Pr \{ \bigcap_{i=1}^{k} | p_i - \pi_i | \leq d \} \geq 1 - \alpha,$$

where d and α, the confidence level, was chosen to be 0.05. Thompson (1987) calculated a maximum sample size of 510 for a worse case scenario when three age classes were present in equal numbers and $d = \alpha = 0.05$. Any deviation in the number of age classes or unequal contributions by age class would require a smaller sample size. Therefore, the numbers of fish initially collected and sent back to Homer for processing was the worse case scenario (510), plus an generous allowance (30%) for unreadable scales. Sample sizes were estimated when about two-thirds (300 fish) of the sample were processed. At that time, the age proportions, p_i, were determined. These were then used as *a priori* estimates to calculate a sample size n such that

$$\sum \alpha_i < \alpha \quad (\alpha = 0.05), \tag{1}$$

where:

$$\alpha_i = 2(1 - \Phi(z_i)), \tag{2}$$

$\Phi(z_i)$ = area under the standard normal distribution, and

$$z_i = d \sqrt{n_i} / \sqrt{(p_i(1-p_i))}. \tag{3}$$

The smallest n that satisfied equations (1)-(3) was then used as estimated to total numbers of fish to process after it was rounded up to the nearest 20 fish (herring scales were mounted on glass slides in groups of 20), increased by the observed unreadable rate, and rounded up again the nearest 20 fish. If, after n fish, it was determined that the *a priori* estimate of sample size was insufficient, additional fish were processed.

Samples were obtained during each fishery opening from randomly selected fishing vessels throughout a management subarea. Ideally, for each fishing period, samples from the catch of a minimum of two boats were collected. These fishing vessels would be waiting for a tender to pump their fish out of their pursed seines when samples were dip-netted from the seine net. Samples were similarly obtained from test fish catches where a purse seiner was contracted to fish at a time and area designated by the department. The samples were packaged in 15-kg (33 lb) boxes and flown to Homer for processing. If there were more Kamishak or Southern District fish than was required for a sampling strata, each 15-kg box was subsampled, simply by dumping the same proportion from all of 15-kg boxes into a sink, processing every fish in the sink, and repeating as necessary. The Outer and Eastern District samples, however, were subsampled in a different manner. Here, the objective was to find fish older than age-1. Therefore, each

sample was first sorted by size. Then the numbers of fish in each size group was determined. Finally, a subsample of each size group proportional to the relative abundance of the size group was made where every fish in the least abundant size group was processed. Multiple scales were also taken from the larger fish to verify that they were only age-1 fish.

Each fish was measured to the nearest millimeter from the tip of the snout to the end of the hyperal plate and weighed to the nearest gram. Sex determined from an inspection of either the gonads or sex products. The scales of up to 20 fish were mounted on a glass slide. One scale was removed, preferably, from the left side of the herring above the pectoral fin, 3 or 4 scales posterior of the operculum. If scales above the pectoral fin were not present on the left side, then they collected from the same area on the right side of the fish. If the herring was from a sample where most of the scales were missing, then any scale available was used. The scales were cleaned, dipped in a 10% mucilage solution and positioned unsculptured side down on a labeled glass slide. Images of scales were magnified 29x by a microfiche reader and the number of annuli per scale was counted to determine age.

Estimates of standard error by age class were derived according the procedures for stratified random sampling described by Snedecor and Cochran (1967).

$$SE = \sqrt{(\Sigma\ C_h^2 * s_h^2 / n_h)},$$

where:

C_h^2 = the herring catch in the *h*th stratum.
s_h^2 = the sample variance in the *h*th stratum.

It was of interest to describe the age composition as it differed through time and by location. Yet, if differences did not exist it was desirable to pool samples adjacent in time and area to minimize sampling. The decision to pool samples was based on a chi-square test of a contingency table for age categories by location. The null hypothesis being tested was that both samples were from the same multinomial population. Samples were pooled only if the null hypothesis was accepted, i.e. no significant difference through time and area, $\alpha > 0.05$.

The total tonnage of the herring harvest during each period was obtained from harvest receipts (fish tickets) which document each sale by a licensed fishermen. The spawning biomass was obtained from aerial surveys.

A total of 21 aerial surveys were conducted in the Kamishak District between 19 April and 12 June. Many of these were only partial surveys due to weather and water conditions. Surveys were flown as close to an altitude of 610 m (2,000 ft) as possible in a single engine aircraft. The surveys were flown at various tide stages. However, the period between low slack water to approximately 3-4 h into the flood appeared to provide the best water clarity and the most visible schools of herring. The total number of schools were counted, and the volume of individual schools was estimated in tons by experienced observers.

Aerial survey estimates were calibrated in the following manner. The aerial surveyor estimated the tonnage of a school while in the air and then directed a fishing vessel to set its seine around the same school. If the entire school was

encircled by purse seine, the herring biomass in the seine was compared with the aerial surveyor's estimate. On 7 May 1988, there were two sets used for calibration. The combined estimated biomass was 50 tons, while the corresponding landed biomass was 51.3 tons, or 2.6% low. On 4 May 1989 three sets were used for calibration. Altogether, the estimated biomass was 43.6 tonnes (48 tons), while the corresponding landed biomass was 38.6 tonnes (42.5 tons), or the estimate was high by 12.9%.

No age and size composition samples were taken from the 1989 late-spawning biomass. Instead, a log-log regression of late-spawning herring on early-spawning herring and age (r squared = .65, df = 13; Figure 3) was used to estimate the numbers of late-spawning herring. The numbers of fish estimated by this method tended to be on the low side for the younger fish. A log-log regression of late-spawn on early harvest and spawn mean weight (r squared = .99, df = 15; Figure 4) was used to estimate the late-spawn mean weight; late spawners tend to be smaller. Two years of data, 1987 and 1988, were available for the regression models.

RESULTS

The preseason forecast of abundance for the Kamishak District was 35,112 tonnes (38,623 tons) with a sac roe harvest of about 4,811 tonnes (5,292 tons) expected. About 74 seiners participated in the fishery, delivering a total harvest of 4,364.9 tonnes (4801.4 tons). The Kamishak District spawning biomass was estimated to be 20,451.8 tonnes (22,497.0 tons).

There was no preseason forecast prepared for the Southern District. About 13 seiners fished the Southern District. However, only 6 vessels made deliveries for a total harvest of 155.8 tonnes (171.4 tons). The Southern District spawning biomass was estimated to be 1,818.2 tonnes (2,000.0 tons).

There was no sac roe fishery in the Outer and Eastern Districts. The Outer and Eastern District never opened on 20 April due to the presence of oil from the Exxon Valdez oil spill. On July 18, aerial surveyors estimated the biomass to be 29,545 tonnes (35,200 tons) in the Outer District and more than 30,000 tonnes (33,000 tons) in the Eastern District. Herring in July are not considered to be spawning.

Kamishak District Commercial Catch

Within the Kamishak District there were 6 d of fishing in four areas (Tables 1 and 2). The sample sizes of readable scales ranged from 136 to 477 (Table 3). With only one exception, the same three age groups were found to predominate in the samples: age-5 (1984 year class), age-6 (1983 year class), and 8 (1981 year class). The exception was found on 30 April when over 12% of the samples were age-9 (1980 year class). The 4 May sample also had 9.5% of age-9 fish.

On 20 April catches were reported from three management areas: 173.2 tonnes (190.5 tons) from Area #5, 83.5 tonnes (91.8 tons) from Area #7, and 45.0 tonnes (49.5 tons) from Area #9. The corresponding catch samples were 136 readable scales from Nordyke Reef, 215 from Fortification Bluff, and 214 from Iliamna Bay. There were no statistical difference between the age compositions from Nordyke Reef and the other two areas: Fortification Bluff (χ^2 = 10.56, P =0.68, df = 12; Table 4) and Iliamna Bay (χ^2 = 9.32, P = 0.58, df = 12; Table 4). However, there were significant differences between the Fortification Bluff and the Iniskin Bay samples (χ^2 = 26.40, P =0.01, df = 11; Table 4). Essentially, there were twice as many age-5 herring in the Fortification Bluff samples. Nevertheless, all 3 samples were similar in that ages 5, 6, and 8 were dominant. Because the individual sample sizes were small, all three were combined to create the first sample strata (Table 5). In the combined sample mean lengths and weights were 242 mm and 212 g.

On 22 April catches of 601.4 tonnes (661.5 tons) were reported from Area #5 and 227.7 tonnes (250.5 tons) from Area #7. The corresponding catch samples were 477 readable scales from Chenik and 437 from Fortification Bluff (Tables 1 and 2). The age compositions from the two samples were found to be statistically different (χ^2 = 20.81, P =0.04, df = 11; Table 4), but most of it was due to differences among the age-12 fish which accounted for <4% of the total age composition. Without the age-12 fish, however, the two age compositions were statistically similar (χ^2 = 9.41, P =0.49, df = 10). Therefore, the two samples were combined to create the second sample strata (Table 6). The pooled sample had a mean length and weight of 241 mm and 206 g.

The third sampling strata represent a harvest of 2,187.6 tonnes (2406.4 tons) on 25 April from Area #5. A catch sample of 432 readable scales was obtained from Chenik (Tables 1 and 2). Mean lengths and weights were 243 mm and 212 g (Table 7).

The fourth sampling strata represent a harvest of 255.5 tonnes (281.1 tons) on 26 April, again from Area #5. This catch sample of 438 readable scales was also obtained from Chenik. This sample had a mean length and weight of 237 mm and 195 g (Table 8).

The fifth sampling strata represent a harvest of 736.8 tonnes (810.5 tons) on 30 April from Area #9. A catch sample of 409 readable scales was obtained from Iniskin Bay. This sample was exceptional in that, four age groups comprised 10% or more of the total samples: ages 5, 6, 8, and 9 (Table 9). Mean lengths and weights were 242 mm and 195 g.

The last catch sample was taken from a series of aerial survey calibration sets made on 4 May. From a catch of 54.1 tonnes (59.6 tons) in Area #8, Rocky Cove, 432 readable scales were obtained. Mean length and weight were 240 mm and 203 g (Table 10). The proportion of age-9 in this sample was also relatively high, 9.5%.

Throughout the Kamishak District fishing season, ages 5, 6, and 8 were predominant in the catch samples (mean statistics weighted by sample period catches). Estimated mean length and weight of the entire sac roe harvest were 242 mm and 207 g (Table 11).

Kamishak District Spawning Biomass

During the sac roe fishery, 17,464 tonnes (19,210 tons) of herring were estimated to have escaped the fishery and spawned. They are referred to as the early-spawning biomass. After the sac roe fishery, another 1,445 tonnes (1,590 tons) of herring were observed spawning between 15 May and 8 June (Table 12). They were considered the late-spawning biomass. No test fish samples were taken from the late-spawning biomass, and age composition was estimated from the regression of the late to early ratio on age (Figure 3). This produced an estimate of 29,235 million individuals. Their mean weight was estimated from the regression of late mean weight on early mean weight (Figure 4). Together, that led to a biomass estimate of 2,988 tonnes (3,287 tons) which was greater than that from the aerial surveys. However, on 12 June another 9,213 tonnes (10,135 tons) of herring were observed on 12 June. Test fish samples were again not taken due to boats being on charter with the Exxon Valdez oil spill clean up. These fish may or may not have been previously included as part of the spawning biomass. Consequently, the estimated late-spawning biomass was derived from the above regression model which is greater that the 15 May to 8 June estimate but less than the 12 June estimate (Table 13). The combined catch, early and late-spawning biomass estimate of age composition is presented in Table 14.

Southern District Commercial Catch

Within the Southern District, there were 3 d of fishing, one in Mud Bay (west side of Kachemak Bay) and two in Mallard Bay (east side of Kachemak Bay). All of the sac roe harvest and test fish samples were also obtained within Kachemak Bay. A single bycatch sample was obtained from Tutka Bay (Table 15). Although there were significant differences in age composition (Table 16) between the east (Aurora Lagoon and Mallard Bay) and west (Millers Landing and Mud Bay) side of Kachemak bay, and within the east, most of the fish were less than 6-years-old. The sample sizes of readable scales ranged from 95 to 543 (Table 15).

Three samples were collected on the west side of Kachemak Bay. The first was a test fish sample from Millers Landing on 21 April. This sample was too small to be useful by itself. There were only 95 readable scales available. Nevertheless, over 89% of the samples were represented by only two large age classes: ages 4 and 5 (Table 17). Mean lengths and weights were 222 mm and 143 g.

The second sample was from a harvest of 6.7 tonnes (7.4 tons) in Mud Bay on 27 April. There were 457 readable scales collected from this catch. The same two age groups predominated as before: ages 4 and 5 (Table 18). Mean lengths and weights were also similar 222 mm and 151 g.

The final west Kachemak Bay sample was a test fish sample from Mud Bay on 8 May. There were 357 readable scales. This time there were three age classes each greater than 10%: ages 4, 5, and 6 (Table 19). Mean lengths and weights increased to 225 mm and 162 g.

There were 5 samples collected on the east side of Kachemak Bay. The first was from a harvest of 10.9 tonnes (12.0 tons) in Mallard Bay on 29 April. There were 303 readable scales. The two largest age groups (greater than 10%) were ages 5 and 6 (Table 20), a year older than the herring found on 21 and 27 April on the west side of Kachemak Bay. Mean lengths and weights were correspondingly larger at 229 mm and 172 g.

In the second sample there were 408 readable scales from Aurora Lagoon on 3 May. This sample was unusual in that this was the only sample with five age classes greater than 10%: ages 5, 6, 7, 8, and 9 (Table 21). Accordingly, mean lengths and weights were larger at 246 mm and 206 g. This sample was reported to have come from within Aurora Lagoon. However, no fish were seen in the lagoon during the aerials surveys.

In the third sample there were 373 readable scales from a purse seine harvest in Mallard Bay on 10 May. In this sample, there were only two age classes greater than 10%: ages 4 and 5 (Table 22). Mean lengths and weights were 222 mm and 151 g.

In the fourth sample there were 543 readable scales from Mallard Bay on 30 May. This sample was similar to the 10 May sample in that there were only two age classes greater than 10%: ages 4 and 5 (Table 23). Mean lengths and weights were 217 mm and 142 g.

A shrimp trawl herring bycatch sample from Tutka Bay on 16 May (Table 15) was the last east Kachemak Bay sample. The herring bycatch sample were entirely age-2 herring with a mean length of 124 mm and mean weight of 21 g (Table 24). Six days earlier, five boats fished in Tutka Bay but were unsuccessful in seining any fish, despite being able to spot 272.7 tonnes (300 tons) from the air. Apparently, the age and size of the herring in Tutka Bay and their schooling behavior, away from shallow inshore areas, may have been the reason why commercial boats were unable to seine any herring almost a week earlier.
Throughout the Southern District fishing season, two age groups were predominant in the catch samples (mean statistics weighted by sample period catches, includes neither test fish samples nor bycatch samples): ages 4 and 5. Estimated mean length and weight of the entire sac roe harvest were 222 mm and 152 g (Table 25).

Southern District Spawning Biomass

The Southern District spawning biomass was estimated to be 1,818.2 tonnes (2,000 tons). All of the observations were on the east side of Kachemak Bay with 80% between Aurora Lagoon and Mallard Bay and the remainder off Glacier Spit, in Halibut Cove, China Poot Bay, and upper Tutka Bay. The age composition of the spawning biomass was assumed to be the same as the catch (Table 26).

Outer and Eastern District Test Fish Results

The Outer and Eastern Districts were not opened to the sac roe fishing in 1989. Instead eight test fish samples were collected between 24 July and 27 July. Two of the samples, Nuka Bay on 25 July and Thunder Bay on 26 July (both in the Outer District), were entirely capelin (*Mallotus nillosus*). Although there was a deliberate effort to find fish older than age-1, very few could be found even among the larger specimens. The small sample sizes reflect the single age structure of many of the samples (Table 27). Most of the fish were age-1 even though there was an obvious difference in fish length (Tables 28 to 36). There was no geographical pattern to the size differences. Port Dick age-1 herring exhibited the greatest size range, from 75 to 136 mm, as well as having some of the smallest members. Paguna Bay and Cheval Island, on the other hand, had some of the larger age-1 herring, none of which were less than 106 mm. The total biomass for herring observed in the Outer and Eastern Districts on 18 July were conservatively estimated at 29,545 tonnes (32,5000 tons) and 30,000 tonnes (33,000 tons). Estimated mean length and weight in the Outer District were 106 mm and 15 g (Table 33). Estimated mean length and weight in the Eastern District were 113 mm and 18 g (Table 36).

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Table 1. Sac roe herring catch in tonnes (tons) by area and date, Kamishak District, 1989.

Date	Management Areas (south to north)				
	#5 Nordyke Reef & Chenik	#7 Fortification Bluff	#8 Rocky Cove	#9 Iliamna, Cottonwood, & Iniskin Bay	Total
20 April	173.2 (190.5)	83.5 (91.8)		45.0 (49.5)	301.6 (331.8)
21					
22	601.4 (661.5)	227.7 (250.5)			829.1 (912.0)
23					
24					
25	2187.6 (2,406.4)				2187.6 (2,406.4)
26	255.5 (281.1)				255.5 (281.1)
27					
28					
29					
30				736.8 (810.5)	736.8 (810.5)
1 May					
2					
3					
4			54.2 (59.6)		54.2 (59.6)
Total	3217.7 (3,539.5)	311.2 (342.3)	54.2 (59.6)	781.8 (860.0)	4364.9 (4,801.4)

Table 2. Sample sizes of readable herring scales, Kamishak District, 1989.

Date	Management Areas (south to north)				
	#5 Nordyke Reef & Chenik	#7 Fortification Bluff	#8 Rocky Cove	#9 Iliamna, Cottonwood, & Iniskin Bay	Total
20 April	136	215		214	565
21					
22	477	437			914
23					
24					
25	432				432
26	438				438
27					
28					
29					
30				409	409
1 May					
2					
3					
4			342		342
Total	1,483	652	342	623	3,100

Table 3. Probability of age composition being similar from chi-square test of independence by date and area, Kamishak District, 1989.

Area	Date	Nordyke 20 Apr	Fort. Bl. 20 Apr	Iliamna 20 Apr	Chenik 22 Apr	Fort. Bl. 22 Apr	Chenik 25 Apr	Chenik 26 Apr	Iniskin 30 Apr
Fort. Bl.	20 Apr	0.68							
Iliamna	20 Apr	0.58	0.01*						
Chenik	22 Apr	0.77	0.13	0.03*					
Fort. Bl.	22 Apr	0.31	0.02*	0.01*	0.04*				
Chenik	25 Apr	0.74	0.03*	0.05	0.01*	0.02*			
Chenik	26 Apr	0.17	0.01*	0.01*	0.01*	0.88	0.01*		
Iniskin	30 Apr	0.45	0.01*	0.02*	0.01*	0.02*	0.01*	0.01*	
Rocky	4 May	0.04*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.48

* $P < 0.05$

Table 4. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Areas #5, 7, & 9, Nordyke Reef, Fortification Bluff, and Iliamna Bay, Kamishak District, 20 April 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
Nordyke Reef	1														
	2														
	3	1	0	0	1	0.7	86	0.0	1	189	0.0	1			
	4	1	2	0	3	2.2	160	35.5	3	220	12.9	3			
	5	30	19	0	49	36.0	160	18.0	49	224	8.1	49			
	6	18	12	0	30	22.1	205	27.8	30	241	9.8	30			
	7	2	2	0	4	2.9	239	17.7	4	252	6.1	4			
	8	7	8	0	15	11.0	247	27.4	15	255	8.5	15			
	9	6	7	0	13	9.6	253	34.3	13	256	10.8	13			
	10	4	3	0	7	5.1	283	24.5	7	263	7.7	7			
	11	4	1	0	5	3.7	268	17.4	5	258	2.8	5			
	12	4	2	0	6	4.4	278	22.3	6	263	7.5	6			
	13	0	2	0	2	1.5	280	33.9	2	261	0.0	2			
	14	0	1	0	1	0.7	258	0.0	1	244	0.0	1			
	15														
	16														
Sample Total		77	59	0	136	100.0	208	51.8	136	240	17.6	136			
Fortification Bluff	1														
	2														
	3														
	4	1	2	0	3	1.4	151	7.0	3	223	5.9	3			
	5	54	39	0	93	43.3	165	20.3	93	224	9.4	93			
	6	19	15	0	34	15.8	205	27.9	34	239	9.5	34			
	7	6	7	0	13	6.0	226	27.2	13	244	10.7	13			
	8	12	9	0	21	9.8	247	31.5	21	252	9.6	21			
	9	7	8	0	15	7.0	278	23.8	15	257	10.3	15			
	10	7	6	0	13	6.0	274	21.4	13	260	7.4	13			
	11	3	0	0	3	1.4	284	43.3	3	255	5.2	3			
	12	7	6	0	13	6.0	282	27.9	13	264	9.4	13			
	13	3	2	0	5	2.3	298	21.3	5	267	8.5	5			
	14														
	15	1	0	0	1	0.5	274	0.0	1	244	0.0	1			
	16	1	0	0	1	0.5	206	0.0	1	254	0.0	1			
Sample Total		121	94	0	215	100.0	210	53.1	215	239	17.5	215			

- Continued -

Table 4. (page 2 of 2)

	Age	Sex: No. Male	Sex: No. Female	Sex: No. Unknown	Total No.	Percent of Total	Weight: Mean (g)	Weight: SD	Weight: Number Weighed	Length: Mean (mm)	Length: SD	Length: Number Measured	Biomass: No. Fish X 1000	Biomass: Tons	Biomass: Tonnes
	1														
	2														
	3														
	4	1	1	0	2	0.9	148	5.7	2	223	1.4	2			
	5	34	20	0	54	25.2	163	17.5	54	226	8.4	54			
	6	30	18	0	48	22.4	196	23.8	48	243	8.7	48			
	7	6	3	0	9	4.2	221	25.7	9	249	10.1	9			
Iliamna Bay	8	19	15	0	34	15.9	246	30.1	34	255	8.5	34			
	9	10	9	0	19	8.9	263	30.6	19	260	8.5	19			
	10	13	8	0	21	9.8	267	26.0	21	259	9.7	21			
	11	5	6	0	11	5.1	261	13.9	11	262	5.7	11			
	12	6	5	0	11	5.1	265	36.8	11	260	8.8	11			
	13	2	0	0	2	0.9	299	12.7	2	267	11.3	2			
	14	1	1	0	2	0.9	281	38.2	2	264	0.7	2			
	15	0	1	0	1	0.5	292	0.0	1	268	0.0	1			
	16														
Sample Total		127	87	0	214	100.0	218	48.9	214	246	16.1	214			
	1														
	2														
	3	1	0	0	1	0.2	86	0.0	1	189	0.0	1	3	0.2	0.2
	4	3	5	0	8	1.4	154	20.1	8	222	7.7	8	20	3.4	3.1
	5	118	78	0	196	34.7	163	19.0	196	225	8.8	196	491	88.3	80.1
	6	67	45	0	112	19.8	201	26.3	112	241	9.2	112	281	62.2	56.4
	7	14	12	0	26	4.6	226	25.3	26	247	10.1	26	65	16.2	14.7
Areas Combined	8	38	32	0	70	12.4	246	29.6	70	254	8.8	70	176	47.7	43.2
	9	23	24	0	47	8.3	265	30.7	47	258	9.7	47	118	34.4	31.2
	10	24	17	0	41	7.3	272	24.5	41	260	8.6	41	103	30.8	28.0
	11	12	7	0	19	3.4	266	21.3	19	260	5.5	19	48	14.0	12.7
	12	17	13	0	30	5.3	275	30.7	30	262	8.7	30	75	22.8	20.7
	13	5	4	0	9	1.6	294	21.4	9	266	7.7	9	23	7.3	6.6
	14	1	2	0	3	0.5	273	30.1	3	257	11.3	3	8	2.3	2.1
	15	1	1	0	2	0.4	283	12.7	2	256	17.0	2	5	1.6	1.4
	16	1	0	0	1	0.2	206	0.0	1	254	0.0	1	3	0.6	0.5
All Samples Combined		325	240	0	565	100.0	212	51.3	565	242	17.3	565	1417	331.8	301.0
Sex Composition		57.5	42.5												
Unaged		38	27	0	65	100.0	240	61.3	65	250	19.1	65			
Sex Composition		58.5	41.5												

Table 5. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Areas #5 & 7, Chenik and Fortification Bluff, Kamishak District, 22 April 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
Chenik	1														
	2														
	3														
	4	15	4	0	19	4.0	127	25.7	19	209	9.8	19			
	5	98	71	0	169	35.4	160	21.5	169	225	10.8	169			
	6	53	43	0	96	20.1	200	25.4	96	241	10.2	96			
	7	13	11	0	24	5.0	230	19.4	24	252	7.0	24			
	8	32	20	0	52	10.9	247	23.2	52	255	9.3	52			
	9	18	20	0	38	8.0	261	26.6	38	258	8.4	38			
	10	10	9	0	19	4.0	277	28.1	19	260	12.3	19			
	11	13	4	0	17	3.6	284	36.3	17	264	12.9	17			
	12	18	10	0	28	5.9	287	28.5	28	260	9.3	28			
	13	4	1	0	5	1.0	277	24.6	5	265	10.5	5			
	14	3	2	0	5	1.0	300	41.7	5	266	7.3	5			
	15	3	1	0	4	0.8	295	45.7	4	266	8.8	4			
	16	1	0	0	1	0.2	290	0.0	1	254	0.0	1			
Sample Total		281	196	0	477	100.0	208	55.6	477	241	18.8	477			
Fortification Bluff	1														
	2														
	3														
	4	9	3	0	12	2.7	135	18.1	12	216	8.7	12			
	5	110	80	0	190	43.4	161	20.9	190	227	8.7	190			
	6	59	41	0	100	22.8	203	24.2	100	242	7.7	100			
	7	8	9	0	17	3.9	238	8.8	17	256	5.8	17			
	8	25	18	0	43	9.8	249	34.0	43	255	9.6	43			
	9	14	18	0	32	7.3	270	36.7	32	261	9.7	32			
	10	3	13	0	16	3.7	288	28.0	16	265	9.1	16			
	11	10	5	0	15	3.4	291	25.9	15	263	10.3	15			
	12	2	5	0	7	1.6	296	31.2	7	268	10.9	7			
	13	3	1	0	4	0.9	289	35.1	4	273	3.9	4			
	14														
	15	1	0	0	1	0.2	282	0.0	1	266	0.0	1			
	16	1	0	0	1	0.2	334	0.0	1	264	0.0	1			
Sample Total		245	193	0	438	100.0	203	53.5	438	240	17.0	438			

- Continued -

Table 5. (page 2 of 2)

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3														
	4	24	7	0	31	3.4	130	23.1	31	212	9.8	31	136	19.5	17.7
	5	208	151	0	359	39.2	161	21.2	359	226	9.8	359	1578	279.7	253.8
	6	112	84	0	196	21.4	201	24.8	196	242	9.0	196	862	191.4	173.6
	7	21	20	0	41	4.5	233	16.2	41	253	6.7	41	180	46.3	42.0
Areas Combined	8	57	38	0	95	10.4	248	28.4	95	255	9.4	95	418	114.2	103.6
	9	32	38	0	70	7.7	265	31.7	70	259	9.1	70	308	89.9	81.6
	10	13	22	0	35	3.8	282	28.2	35	262	11.0	35	154	47.8	43.4
	11	23	9	0	32	3.5	287	31.6	32	263	11.6	32	141	44.5	40.4
	12	20	15	0	35	3.8	289	28.8	35	262	10.0	35	154	48.9	44.4
	13	7	2	0	9	1.0	282	28.4	9	268	8.8	9	40	12.3	11.2
	14	3	2	0	5	0.5	300	41.7	5	266	7.3	5	22	7.3	6.6
	15	4	1	0	5	0.5	292	39.9	5	266	7.6	5	22	7.1	6.4
	16	2	0	0	2	0.2	312	31.1	2	259	7.1	2	9	3.0	2.7
All Samples Combined		526	389	0	915	100.0	206	54.6	915	241	18.0	915	4023	912.0	827.4
Sex Composition		57.5	42.5												
Unaged		22	23	0	45	100.0	230	53.7	45	248	18.2	45			
Sex Composition		48.9	51.1												

Table 6. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Area #5, Chenik, Kamishak District, 25 April 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3														
	4	1	2	0	3	0.7	136	19.1	3	215	10.8	3	71	10.7	9.7
	5	89	65	0	154	35.6	158	23.2	154	224	10.3	154	3665	638.4	579.2
	6	56	38	0	94	21.8	203	21.0	94	243	7.5	94	2237	500.7	454.2
	7	8	7	0	15	3.5	231	24.7	15	250	4.9	15	357	90.8	82.4
25 April	8	29	32	0	61	14.1	249	27.0	61	257	8.3	61	1452	397.8	360.9
	9	16	12	0	28	6.5	258	26.6	28	259	8.8	28	666	189.5	171.9
	10	17	9	0	26	6.0	269	22.0	26	260	7.6	26	619	183.5	166.4
	11	12	15	0	27	6.3	287	37.3	27	267	7.7	27	643	203.6	184.7
	12	9	5	0	14	3.2	304	28.9	14	270	6.0	14	333	111.5	101.2
	13	5	3	0	8	1.9	303	20.8	8	264	11.9	8	190	63.5	57.6
	14														
	15	1	1	0	2	0.5	312	50.9	2	264	0.7	2	48	16.4	14.8
	16														
Sample Total		243	189	0	432	100.0	212	55.4	432	243	18.5	432	10281	2406.4	2183.1
Sex Composition		56.3	43.8												
Unaged		12	16	0	28	100.0	219	58.9	28	243	19.5	28			
Sex Composition		42.9	57.1												

Table 7. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Area #5, Chenik, Kamishak District, 26 April 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3														
	4	10	6	1	17	3.9	125	17.5	17	211	8.8	17	51	7.0	6.4
	5	100	88	2	190	43.4	159	22.5	190	224	10.1	190	567	99.1	89.9
	6	50	47	1	98	22.4	201	23.6	98	242	7.3	98	292	64.9	58.9
	7	8	8	0	16	3.7	226	32.3	16	251	7.8	16	48	11.9	10.8
26 April	8	31	21	1	53	12.1	234	27.9	53	252	8.3	53	158	40.8	37.0
	9	9	13	0	22	5.0	268	41.0	22	258	9.2	22	66	19.4	17.6
	10	10	10	0	20	4.6	265	32.8	20	260	8.3	20	60	17.4	15.8
	11	5	5	0	10	2.3	289	34.6	10	266	8.8	10	30	9.5	8.6
	12	6	2	0	8	1.8	288	31.8	8	265	9.3	8	24	7.6	6.9
	13	1	2	0	3	0.7	287	11.5	3	265	9.2	3	9	2.8	2.6
	14														
	15														
	16	1	0	0	1	0.2	216	0.0	1	252	0.0	1	3	0.7	0.6
Sample Total		231	202	5	438	100.0	195	50.6	438	237	17.4	438	1307	281.1	255.0
Sex Composition		53.3	46.7												
Unaged		13	8	1	22	100.0	204	58.9	22	241	19.0	22			
Sex Composition		61.9	38.1												

Table 8. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Area #9, Iniskin Bay, Kamishak District, 30 April 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3														
	4	5	5	0	10	2.4	120	13.6	10	213	11.9	10	92	12.2	11.1
	5	59	72	2	133	32.5	152	19.8	133	226	10.0	133	1226	205.2	186.2
	6	51	48	1	100	24.4	186	24.2	100	242	10.8	100	922	189.2	171.6
	7	7	11	0	18	4.4	214	36.4	18	249	14.5	18	166	39.1	35.4
30 April	8	30	28	0	58	14.2	234	29.5	58	256	8.6	58	535	138.0	125.2
	9	27	22	1	50	12.2	240	21.0	50	260	8.5	50	461	122.0	110.6
	10	12	10	0	22	5.4	250	23.0	22	261	8.3	22	203	55.9	50.7
	11	5	3	0	8	2.0	286	38.0	8	270	9.4	8	74	23.2	21.1
	12	4	5	0	9	2.2	246	40.1	9	258	13.5	9	83	22.5	20.4
	13	0	1	0	1	0.2	314	0.0	1	281	0.0	1	9	3.2	2.9
	14														
	15														
	16														
Sample Total		200	205	4	409	100.0	195	47.4	409	242	17.7	409	3769	810.5	735.3
Sex Composition		49.4	50.6												
Unaged		23	27	1	51	100.0	210	50.6	51	247	18.2	51			
Sex Composition		46.0	54.0												

Table 9. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Area #8, Rocky Cove, Kamishak District, 4 May 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3														
	4	11	10	1	22	5.1	130	14.7	22	210	7.6	22	14	1.9	1.8
	5	63	50	1	114	26.4	162	23.2	114	225	10.4	114	70	12.5	11.4
	6	63	53	0	116	26.9	192	20.6	116	237	8.5	116	71	15.1	13.7
	7	15	8	0	23	5.3	214	28.5	23	246	8.5	23	14	3.3	3.0
4 May	8	27	37	0	64	14.8	239	31.4	64	252	10.0	64	39	10.4	9.4
	9	21	19	1	41	9.5	250	24.2	41	254	8.3	41	25	6.9	6.3
	10	16	15	0	31	7.2	258	29.8	31	260	11.4	31	19	5.4	4.9
	11	4	8	0	12	2.8	271	32.1	12	263	9.8	12	7	2.2	2.0
	12	3	6	0	9	2.1	284	37.6	9	265	8.9	9	6	1.7	1.6
	13														
	14														
	15														
	16														
Sample Total		223	206	3	432	100.0	203	47.5	432	240	17.3	432	266	59.6	54.1
Sex Composition		52.0	48.0												
Unaged		20	20	0	40	100.0	212	46.3	40	241	14.8	40			
Sex Composition		50.0	50.0												

Table 10. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine, areas and dates combined, Kamishak District, 20 April - 4 May, 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	Male	Female	No. Unknown	No.	No. Total	Total (g)	of SD	Mean Weighed	Number (mm)	SD	Mean Measured	Number X 1000	No. Fish Tons	Tonnes
	1	0	0	0	0	0.0	0	0.0	0	0	0.0	0	0	0.0	0.0
	2	0	0	0	0	0.0	0	0.0	0	0	0.0	0	0	0.0	0.0
	3	1	0	0	1	0.0	86	0.0	1	189	0.0	1	3	0.7	0.7
	4	54	35	2	91	1.8	129	2.8	91	213	1.6	91	384	55.2	50.3
	5	637	504	5	1146	36.1	158	1.0	1146	225	0.4	1146	7597	1323.7	1201.1
	6	399	315	2	716	22.1	199	1.2	716	242	0.4	716	4665	1024.0	928.9
	7	73	66	0	139	3.9	227	3.3	139	250	0.9	139	830	208.1	188.8
	8	212	188	1	401	13.2	245	2.0	401	256	0.6	401	2778	749.4	679.8
	9	128	128	2	258	7.8	255	2.4	258	259	0.8	258	1644	462.6	419.7
	10	92	83	0	175	5.5	267	2.6	175	260	0.9	175	1158	341.3	309.7
	11	61	47	0	108	4.5	286	5.1	108	266	1.1	108	943	297.5	270.0
	12	59	46	0	105	3.2	289	4.4	105	266	1.1	105	675	215.5	195.7
	13	18	12	0	30	1.3	299	5.4	30	265	3.0	30	271	89.6	81.4
	14	4	4	0	8	0.1	293	14.4	8	264	3.0	8	30	10.1	9.2
	15	6	3	0	9	0.4	304	23.6	9	264	1.3	9	75	25.6	23.1
Areas & dates combined		1748	1431	12	3191	100.0	207	1.4	3191	242	0.5	3191	21063	4801.4	4364.9

Table 11. Early and late-spawning herring biomass estimates by area, Kamishak District, 1989.

Area	Tonnes			Tons		
	Early[a]	Late[b]	Total	Early[a]	Late[b]	Total
North of Dry Bay	0	55	55	0	60	60
Oil-Dry Bay	818	264	1,082	900	290	1,190
Iniskin Reef and Bay	3,000	9	3,009	3,300	10	3,310
Cottonwood Bay	68	0	68	75	0	75
Ursus Cove	505	541	1,045	555	595	1,150
Rocky Cove and Fortification Bluff	1,182	209	1,391	1,300	230	1,530
Bruin Bay	1,364	36	1,400	1,500	40	1,540
Contact Point	2,091	36	2,127	2,300	40	2,340
Amakdedori Beach	591	145	736	650	160	810
Chenik-Nordyke-McNeil	2,364	45	2,409	2,600	50	2,650
Kamishak-Douglas Reef	5,364	105	5,468	5,900	115	6,015
Augustine	118	0	118	130	0	130
	17,464	1,445	18,909	19,210	1,590	20,800

[a] Through 14 May.
[b] Between 15 May and 8 June. On 12 June, another 9,213 tonnes (10,135 tons) was observed. The final estimate is 2,988 tonnes (3,287 tons, see text for details).

Table 12. Age composition of early-spawning herring biomass estimated from catch data and late-spawning biomass from regression model, Kamishak District, 1989.

Age (years)	Early					Late					Both Spawning Biomass				
	Percent of Total	Mean Weight (g)	Biomass No. Fish X 1000	Biomass Tons	Biomass Tonnes	Percent of Total	Mean Weight (g)	Biomass No. Fish X 1000	Biomass Tons	Biomass Tonnes	Percent of Total	Mean Weight (g)	Biomass No. Fish X 1000	Biomass Tons	Biomass Tonnes
1	0	0	0	0.0	0.0	0.0	0	0	0	0.0	0.0	0	0	0.0	0.0
2	0	0	0	0.0	0.0	0.0	0	0	0	0.0	0.0	0	0	0.0	0.0
3	0.0	86	0	0.0	0.0	1.5	68	306	22.8	20.7	0.3	68	306	22.8	20.7
4	1.8	129	1519	215.5	195.9	19.1	108	3784	447.5	406.9	5.1	114	5302	663.0	602.7
5	36.2	158	30540	5307.9	4825.4	45.9	136	9101	1357.0	1233.7	38.0	153	39642	6664.9	6059.0
6	22.1	199	18645	4081.3	3710.3	18.5	176	3664	710.9	646.3	21.4	195	22309	4792.2	4356.6
7	3.9	227	3290	821.6	746.9	4.1	205	819	184.8	168.0	3.9	223	4110	1006.4	914.9
8	13.2	245	11136	3001.2	2728.4	5.1	224	1007	247.8	225.2	11.7	243	12143	3249.0	2953.6
9	7.8	255	6581	1845.8	1678.0	2.5	234	499	128.4	116.8	6.8	254	7079	1974.3	1794.8
10	5.5	267	4640	1362.8	1238.9	1.4	247	284	77.2	70.2	4.7	266	4924	1440.0	1309.1
11	4.5	286	3796	1194.4	1085.8	0.9	267	182	53.5	48.6	3.8	285	3979	1247.9	1134.4
12	3.2	289	2700	858.2	780.2	0.6	270	111	33.1	30.1	2.7	288	2811	891.3	810.3
13	1.3	299	1097	360.7	327.9	0.3	281	51	15.8	14.3	1.1	298	1148	376.5	342.3
14	0.1	293	84	27.2	24.7	0.1	274	10	3.0	2.7	0.1	291	94	30.2	27.5
15	0.4	304	337	112.8	102.6	0.1	286	16	5.0	4.6	0.3	303	353	117.9	107.2
Total		207	84365	19210.0	17463.6		151	19835	3286.9	2988.1		196	104200	22476.4	20433.1

Table 13. Age composition of Pacific herring catch and spawn, Kamishak District, 1989.

Age (years)	% of Total	Mean Wt. (g)	Biomass		
			No. Fish (X 1000)	Tons	Tonnes
1	0	0	0	0.0	0.0
2	0	0	0	0.0	0.0
3	0.002	68	309	23.1	21.0
4	0.045	115	5,686	717.5	652.3
5	0.377	154	47,239	7,985.3	7,259.4
6	0.215	196	26,974	5,813.4	5,284.9
7	0.039	223	4,940	1,213.6	1,103.3
8	0.119	244	14,921	3,997.7	3,634.2
9	0.070	254	8,723	2,435.4	2,214.0
10	0.049	266	6,082	1,780.1	1,618.3
11	0.039	285	4,922	1,544.5	1,404.1
12	0.028	288	3,486	1,105.9	1,005.4
13	0.011	298	1,419	465.6	423.3
14	0.001	292	124	39.9	36.3
15	0.003	303	428	143.0	130.0
Total		198	125,253	27,265.0	24,786.3

Table 14. Sample sizes of readable herring scales, Southern District, 1989.

Date	Testfish	Sac Roe Harvest	Shrimp Trawl Bycatch	Total
21 April	95			95
27		457		457
29		303		303
03 May	408			408
08	357			357
10		373		373
16			111	111
30	543			543
Total	1776	760	111	2647

Table 15. Probability of age composition being similar from chi-square test of independence by date and area, Southern District, 1989.

Area	Date	Millers L. 21 Apr	Mud Bay 27 Apr	Mallard B. 29 Apr	Aurora L. 3 May	Mud Bay 8 May	Mallard B. 10 May	Tutka Bay 16 May
Mud Bay	27 Apr	0.37						
Mallard Bay	29 Apr	0.01*	0.01*					
Aurora Lagoon	3 May	0.01*	0.01*	0.01*				
Mud Bay	8 May	0.04*	0.06	0.01*	0.01*			
Mallard Bay	10 May	0.01*	0.01*	0.01*	0.01*	0.01*		
Tutka Bay	16 May	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	
Mallard Bay	30 May	0.01*	0.01*	0.01*	0.01*	0.01*	0.03*	0.01*

* $P < 0.05$

Table 16. Age, sex, and size composition of Pacific herring test fish catch by purse seine in Miller's Landing, Southern District, 21 April 1989.

		Sex					Weight			Length		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
21 April	1											
	2											
	3											
	4	12	4	0	16	16.8	108	14.3	16	207	8.8	16
	5	48	21	0	69	72.6	143	15.7	69	222	7.0	69
	6	1	3	0	4	4.2	190	47.6	4	236	18.2	4
	7	0	1	0	1	1.1	152	0.0	1	223	0.0	1
	8	2	0	0	2	2.1	193	35.4	2	245	12.7	2
	9	1	0	0	1	1.1	224	0.0	1	257	0.0	1
	10	1	0	0	1	1.1	212	0.0	1	257	0.0	1
	11											
	12	1	0	0	1	1.1	226	0.0	1	256	0.0	1
	13											
	14											
	15											
Sample Total		66	29	0	95	100.0	143	29.0	95	222	12.5	95
Sex Composition		69.5	30.5									
Unaged		4	4	0	8	8.4	172	22.7	8	230	22.7	8
Sex Composition		50.0	50.0									

Table 17. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Mud Bay, Southern District, 27 April 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2	0	0	3	3	0.7	26	5.1	3	127	6.7	3	0	0.0	0.0
	3	0	3	1	4	0.9	68	21.1	4	175	17.0	4	0	0.0	0.0
	4	37	31	1	69	15.1	111	17.1	69	204	9.3	69	7	0.8	0.7
	5	154	100	8	262	57.3	140	18.6	262	219	8.6	262	25	3.9	3.6
	6	23	19	2	44	9.6	180	27.3	44	236	11.8	44	4	0.8	0.8
	7	8	9	0	17	3.7	202	25.3	17	241	11.2	17	2	0.4	0.3
27 April	8	13	8	0	21	4.6	220	41.7	21	248	11.7	21	2	0.5	0.4
	9	11	4	0	15	3.3	217	29.6	15	247	11.5	15	1	0.3	0.3
	10	7	4	0	11	2.4	232	44.2	11	257	9.9	11	1	0.3	0.2
	11	4	4	0	8	1.8	256	21.3	8	261	4.8	8	1	0.2	0.2
	12	0	2	0	2	0.4	276	7.8	2	269	1.4	2	0	0.1	0.1
	13	1	0	0	1	0.2	242	0.0	1	276	0.0	1	0	0.0	0.0
	14														
	15														
	16														
Sample Total		258	184	15	457	100.0	151	44.2	457	222	19.5	457	44	7.4	6.7
Sex Composition		58.4	41.6												
Unaged		17	4	2	23	100.0	149	42.2	23	224	18.5	23			
Sex Composition		81.0	19.0												

Table 18. Age, sex, and size composition of Pacific herring test fish catch by purse seine in Mud Bay, Southern District, 8 May 1989.

		Sex					Weight			Length		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
8 May	1											
	2											
	3	7	4	0	11	3.1	84	11.1	11	188	8.1	11
	4	27	24	0	51	14.3	105	14.9	51	199	8.6	51
	5	87	98	2	187	52.4	152	26.2	187	222	9.1	187
	6	16	30	0	46	12.9	187	29.0	46	236	11.1	46
	7	7	5	0	12	3.4	195	28.2	12	238	7.4	12
	8	7	3	0	10	2.8	214	29.2	10	248	9.6	10
	9	9	14	0	23	6.4	243	30.7	23	255	7.3	23
	10	2	3	0	5	1.4	270	43.3	5	261	9.0	5
	11	3	7	0	10	2.8	278	41.1	10	264	7.5	10
	12	2	0	0	2	0.6	275	1.4	2	264	2.1	2
	13											
	14											
	15											
	16											
Sample Total		167	188	2	357	100.0	162	51.1	357	225	19.7	357
Sex Composition		47.0	53.0									
Unaged		14	15	0	29	100.0	166	56.9	29	225	21.7	29
Sex Composition		48.3	51.7									

Table 19. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Mallard Bay, Southern District, 29 April 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3	1	0	0	1	0.3	86	0.0	1	195	0.0	1	0	0.0	0.0
	4	20	8	0	28	9.2	111	12.1	28	204	6.9	28	6	0.7	0.6
	5	63	52	2	117	38.6	144	18.5	117	218	9.3	117	24	3.9	3.5
	6	35	31	0	66	21.8	178	24.8	66	233	11.0	66	14	2.7	2.5
	7	11	7	1	19	6.3	193	28.8	19	240	11.2	19	4	0.8	0.8
29 April	8	15	9	0	24	7.9	226	28.7	24	246	9.1	24	5	1.2	1.1
	9	19	10	0	29	9.6	234	27.7	29	251	8.6	29	6	1.6	1.4
	10	6	5	0	11	3.6	238	32.5	11	256	7.0	11	2	0.6	0.5
	11	3	2	0	5	1.7	234	41.5	5	257	10.7	5	1	0.3	0.2
	12	3	0	0	3	1.0	259	48.4	3	263	8.1	3	1	0.2	0.2
	13														
	14														
	15														
	16														
Sample Total		176	124	3	303	100.0	172	46.3	303	229	18.2	303	63	12.0	10.9
Sex Composition		58.7	41.3												
Unaged		14	15	0	29	100.0	192	50.7	29	233	18.4	29			
Sex Composition		48.3	51.7												

Table 20. Age, sex, and size composition of Pacific herring test fish catch by purse seine in Aurora Lagoon, Southern District, 3 May 1989.

		Sex				Percent	Weight			Length		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
	1											
	2											
	3	2	1	0	3	0.7	92	9.2	3	193	3.8	3
	4	8	7	1	16	3.9	117	11.5	16	208	7.8	16
	5	38	22	0	60	14.7	151	21.7	60	225	10.6	60
	6	40	16	0	56	13.7	185	27.7	56	239	9.0	56
	7	28	17	0	45	11.0	215	22.9	45	249	6.5	45
3 May	8	60	18	3	81	19.9	219	28.8	81	253	8.3	81
	9	63	24	0	87	21.3	231	24.5	87	255	8.1	87
	10	21	5	0	26	6.4	239	32.6	26	257	9.7	26
	11	16	3	0	19	4.7	259	32.2	19	262	9.4	19
	12	10	3	0	13	3.2	268	31.4	13	262	8.1	13
	13	0	1	0	1	0.2	248	0.0	1	260	0.0	1
	14											
	15	1	0	0	1	0.2	266	0.0	1	272	0.0	1
	16											
Sample Total		287	117	4	408	100.0	206	45.9	408	246	16.7	408
Sex Composition		71.0	29.0									
Unaged		15	5	0	20	100.0	199	65.2	20	239	22.8	20
Sex Composition		75.0	25.0									

Table 21. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine in Mallard Bay, Southern District, 10 May 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1														
	2														
	3	12	7	0	19	5.1	76	8.9	19	184	8.3	19	47	3.9	3.5
	4	66	62	0	128	34.3	106	15.2	128	204	12.1	128	314	36.7	33.3
	5	54	65	0	119	31.9	150	21.5	119	223	13.1	119	292	48.3	43.8
	6	17	16	0	33	8.8	180	28.7	33	236	12.7	33	81	16.1	14.6
	7	6	8	0	14	3.8	206	22.7	14	247	7.8	14	34	7.8	7.1
10 May	8	10	10	0	20	5.4	232	33.2	20	254	8.2	20	49	12.6	11.4
	9	13	12	0	25	6.7	235	25.9	25	256	8.6	25	61	15.9	14.5
	10	5	3	0	8	2.1	262	45.5	8	261	13.0	8	20	5.7	5.1
	11	1	3	0	4	1.1	262	24.5	4	265	2.2	4	10	2.8	2.6
	12	1	1	0	2	0.5	264	50.9	2	273	5.7	2	5	1.4	1.3
	13	0	1	0	1	0.3	302	0.0	1	275	0.0	1	2	0.8	0.7
	14														
	15														
	16														
Sample Total		185	188	0	373	100.0	151	54.9	373	222	24.0	373	916	152.0	137.9
Sex Composition		49.6	50.4												
Unaged		10	17	0	27	100.0	179	68.4	27	230	25.8	27			
Sex Composition		37.0	63.0												

Table 22. Age, sex, and size composition of Pacific herring test fish catch by purse seine in Mallard Bay, Southern District, 30 May 1989.

		Sex					Weight			Length		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
30 May	1											
	2											
	3	18	15	1	34	6.3	89	23.2	34	189	11.8	34
	4	96	143	11	250	46.0	113	16.9	249	204	11.3	250
	5	64	80	7	151	27.8	149	23.0	151	222	13.3	151
	6	17	15	2	34	6.3	174	23.5	34	234	12.5	34
	7	9	9	0	18	3.3	196	33.3	18	244	14.7	18
	8	5	8	1	14	2.6	239	25.3	14	258	14.0	14
	9	13	6	0	19	3.5	241	30.5	19	254	12.2	19
	10	6	10	0	16	2.9	254	41.2	16	256	14.3	16
	11	1	6	0	7	1.3	314	51.0	7	272	8.8	7
	12											
	13											
	14											
	15											
	16											
Sample Total		229	292	22	543	100.0	142	50.9	542	217	22.3	543
Sex Composition		44.0	56.0									
Unaged		19	18	0	37	100.0	131	39.5	37	214	21.4	37
Sex Composition		51.4	48.6									

Table 23. Age, sex, and size composition of Pacific herring bycatch in shrimp trawl, Tutka Bay, Southern District, 16 May 1959.

		Sex					Weight			Length		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
16 May	1											
	2	0	0	111	111	100.0	21	3.3	111	124	6.3	111
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											
	11											
	12											
	13											
	14											
	15											
	16											
Sample Total		0	0	111	111	100.0	21	3.3	111	124	6.3	111

Table 24. Age, sex, and size composition of Pacific herring sac roe harvest by purse seine, areas and dates combined, Southern District, 27 April - 10 May, 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	0	0	0.0	0	0.0	0	0	0.0	0	0	0.5	0.5
	2	0	0	3	3	0.0	26	2.9	3	127	3.9	3	0	0.5	0.5
	3	13	10	1	24	4.7	76	2.0	24	184	1.9	24	48	4.4	4.0
	4	123	101	1	225	32.0	106	1.3	225	204	1.0	225	327	38.7	35.1
	5	271	217	10	498	33.3	149	1.7	498	222	1.0	498	341	56.6	51.4
	6	75	66	2	143	9.7	180	4.1	143	236	1.8	143	99	20.1	18.4
	7	25	24	1	50	3.9	205	5.2	50	246	1.8	50	40	9.5	8.7
	8	38	27	0	65	5.5	231	6.5	65	253	1.6	65	56	14.8	13.4
	9	43	26	0	69	6.6	235	4.7	69	255	1.5	69	68	18.3	16.7
	10	18	12	0	30	2.2	259	14.0	30	260	4.0	30	23	7.1	6.3
	11	8	9	0	17	1.2	259	10.3	17	264	1.0	17	12	3.8	3.5
	12	4	3	0	7	0.6	264	29.5	7	271	3.3	7	6	2.2	2.1
	13	1	1	0	2	0.2	299	0.0	2	275	0.0	2	2	1.3	1.2
	14	0	0	0	0	0.0	0	0.0	0	0	0.0	0	0	0.5	0.5
	15	0	0	0	0	0.0	0	0.0	0	0	0.0	0	0	0.5	0.5
All periods combined		619	496	18	1133	100.0	152	2.6	1133	222	1.1	1133	1023	171.9	156.0

Table 25. Age composition of Pacific herring spawning biomass estimated from catch data, Southern District, 1989.

Age (years)	# Fish X 1000	Biomass Tonnes	Tons
1	0	0.0	0.0
2	0	1.8	2.0
3	1124	85.5	94.0
4	5489	581.8	640.0
5	4063	605.5	666.0
6	980	176.4	194.0
7	346	70.9	78.0
8	433	100.0	110.0
9	511	120.0	132.0
10	154	40.0	44.0
11	84	21.8	24.0
12	0	10.9	12.0
13	0	3.6	4.0
14	0	0.0	0.0
15	0	0.0	0.0
Total	13185	1,818.2	2,000.0

Table 26. Sample sizes of readable herring scales, Outer and Eastern Districts, 1989.

Date	District	Location	Number of Age Classes	Sample Size
24 July	Outer	Port Dick Bay	3	148
25		Moonlight Bay	1	40
26		Paguna Arm	1	40
26		Crater Bay	2	45
27	Eastern	Day Harbor	1	40
27		Cheval Island	1	40
27		Verdant Bay	1	40
Total				393

Table 27. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Port Dick, Outer District, 24 July 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	146	146	98.6	14	4.1	146	105	10.0	146	58	1	1
	2	0	0	1	1	0.7	47	0.0	1	152	0.0	1	0	0	0
	3														
	4	0	0	1	1	0.7	161	0.0	1	217	0.0	1	0	0	0
	5														
	6														
	7														
24 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	148	148	100.0	16	13.0	148	106	14.0	148	58	1	1

Table 28. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Moonlight Bay, Outer District, 25 July 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	40	40	100.0	8	2.7	40	92	8.8	40	119	1	1
	2														
	3														
	4														
	5														
	6														
	7														
25 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	40	40	100.0	8	2.7	40	92	8.8	40	119	1	1

Table 29. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Paguna Arm, Outer District, 26 July 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
26 July	1	0	0	40	40	100.0	22	2.9	40	120	6.9	40	42	1	1
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	40	40	100.0	22	2.9	40	120	6.9	40	42	1	1

Table 30. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Crater Bay, Outer District, 26 July 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	44	44	97.8	14	4.4	44	106	9.1	44	62	1	1
	2	0	0	1	1	2.2	38	0.0	1	145	0.0	1	1	0	0
	3														
	4														
	5														
	6														
	7														
26 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	45	45	100.0	14	5.7	45	107	10.8	45	64	1	1

Table 31. Age, sex, and size composition of Pacific herring test fish harvest by purse seine, areas and dates combined, Outer District, 24-26 July 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	270	270	98.9	14	5.4	270	105	12.1	270	60	.9	.9
	2	0	0	2	2	.7	43	6.4	2	149	4.9	2	0	.0	.0
	3														
	4	0	0	1	1	.4	161	.0	1	217	.0	1	0	.0	.0
	5														
	6														
	7														
24-26 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
All Samples Combined		0	0	273	273	100.0	15	10.6	273	106	14.3	273	60	1.0	.9

Table 32. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Day Harbor, Eastern District, 27 July 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	40	40	100.0	19	3.2	40	117	6.2	40	48	1	1
	2														
	3														
	4														
	5														
	6														
	7														
27 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	40	40	100.0	19	3.2	40	117	6.2	40	48	1	1

Table 33. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Cheval Island, Eastern District, 27 July 1989.

		Sex					Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	Percent of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	40	40	100.0	20	3.3	39	118	6.3	40	44956	1000	907
	2														
	3														
	4														
	5														
	6														
	7														
27 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	40	40	100.0	20	3.3	39	118	6.3	40	44956	1000	907

Table 34. Age, sex, and size composition of Pacific herring test fish harvest by purse seine in Verdant Bay, Eastern District, 27 July 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
	1	0	0	40	40	100.0	13	2.8	39	104	7.9	40	67	1	1
	2														
	3														
	4														
	5														
	6														
	7														
27 July	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
Sample Total		0	0	40	40	100.0	13	2.8	39	104	7.9	40	67	1	1

Table 35. Age, sex, and size composition of Pacific herring test fish harvest by purse seine, areas and dates combined, Eastern District, 27 July 1989.

		Sex				Percent	Weight			Length			Biomass		
	Age	No. Male	No. Female	No. Unknown	Total No.	of Total	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured	No. Fish X 1000	Tons	Tonnes
27 July	1	0	0	120	120	100.0	18	4.2	118	113	9.3	120	52	1.0	.9
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														
All Samples Combined		0	0	120	120	100.0	18	4.2	118	113	9.3	120	52	1.0	.9

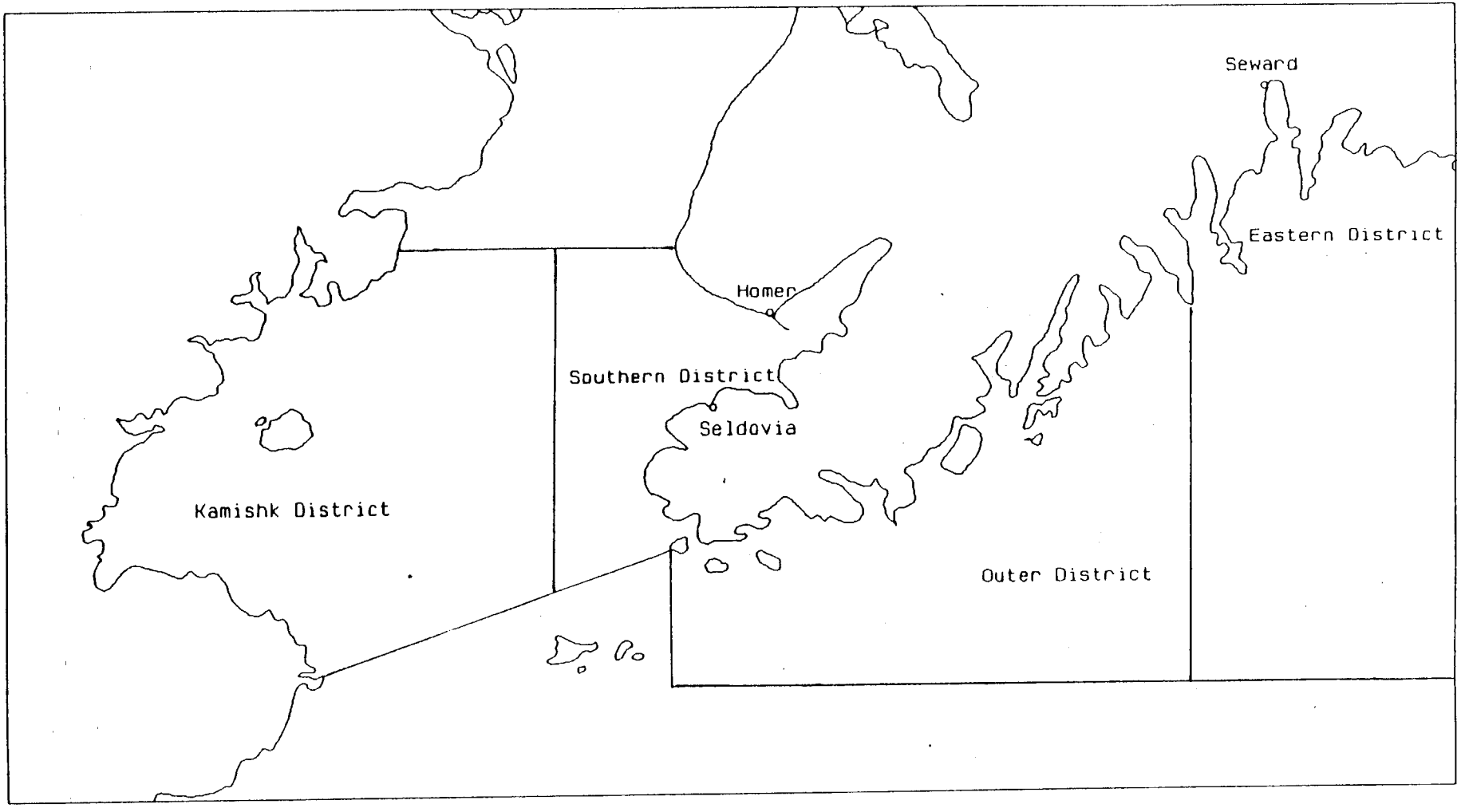

Figure 1. Kamishak, Southern, Outer, and Eastern District of Lower Cook Inlet Management Area

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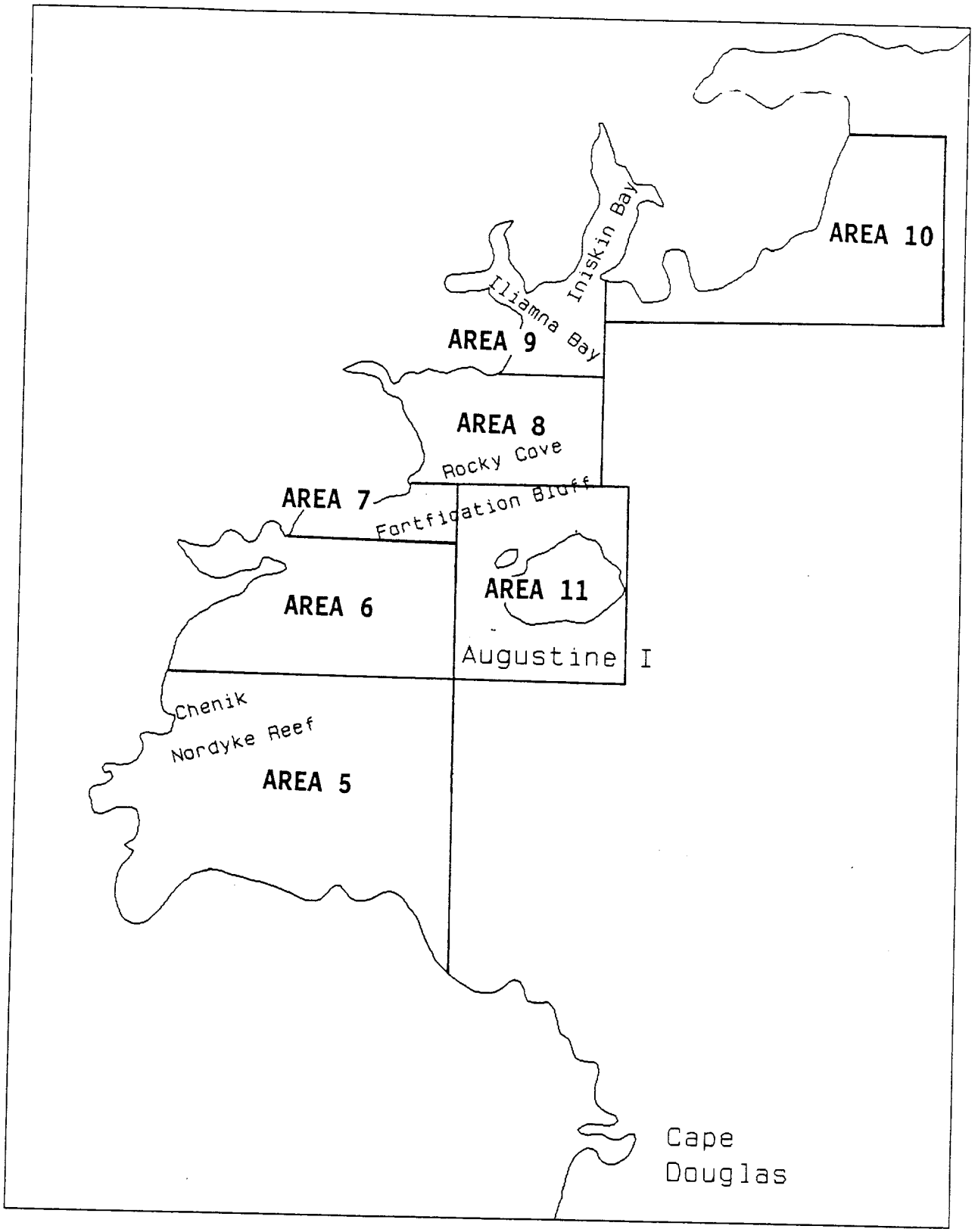

Figure 2. 1989 Kamishak District herring sac roe management areas.

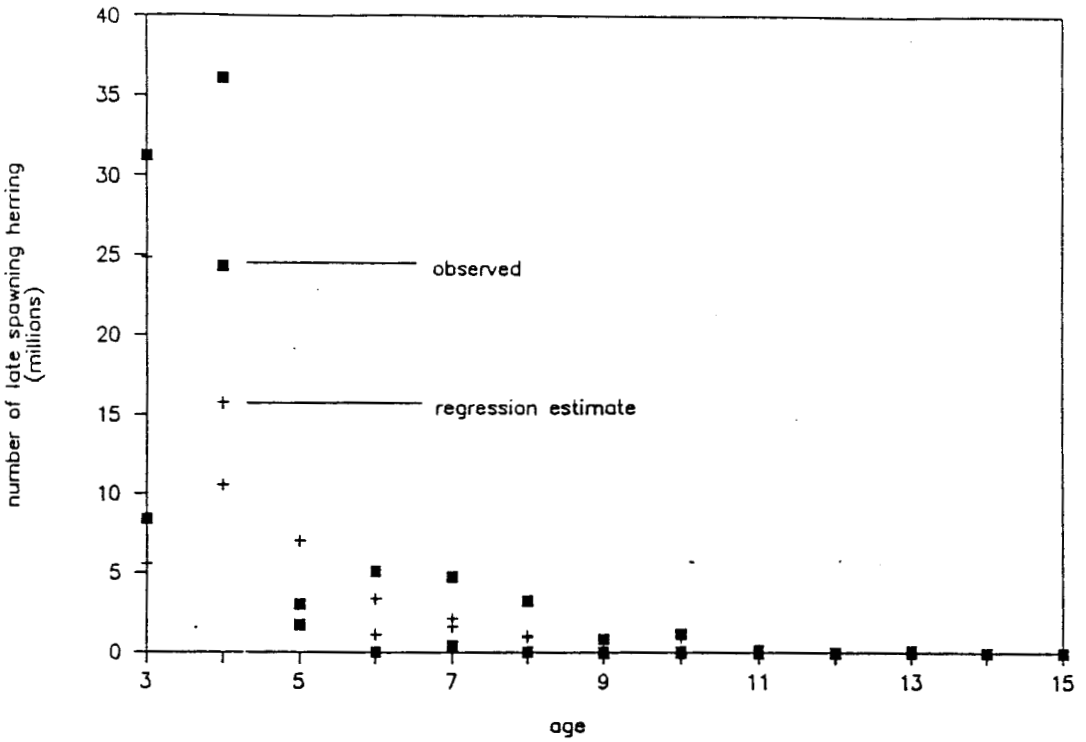

Figure 3. Regression of late on early-spawning herring.

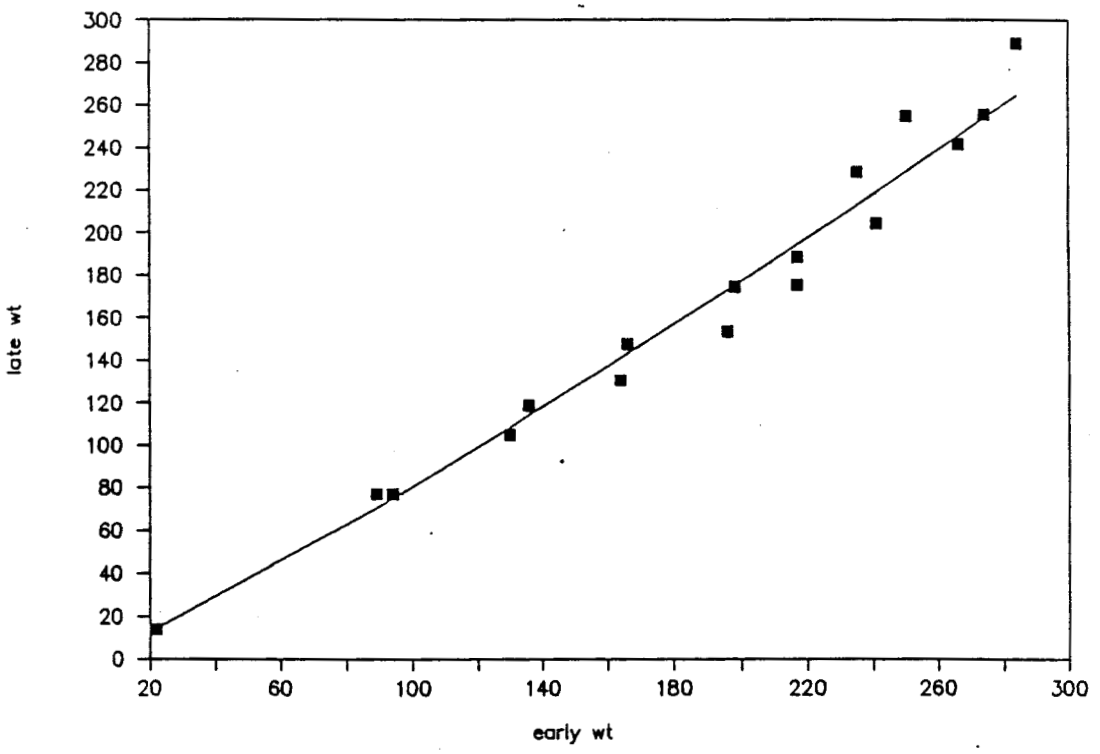

Figure 4. Regression of late on early-spawning herring mean weight.