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ASSESSMENT OF HERRING (Clupea harengus pallasi) STOCKS IN SOUTHEASTERN CHUKCHI SEA, 1980-1981

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ABSTRACT

A study was conducted by the Alaska Department of Fish and Game from June 1980 to July 1981 to determine abundance, distribution, and spawning run timing of Pacific herring *(Clupea harengus pallasi)* between Cape Prince of Wales and Cape Krusenstern within the Chukchi Sea. Aerial surveys of nearshore waters and variable mesh gillnet and beach seine catches from selected coastal waters were the primary informational gathering techniques. Water turbidity and the occurrence of a variety of schooling fishes did not allow estimates of herring biomass to be made from aerial survey data. Ground crews found the largest herring concentrations in northern Kotzebue Sound, but herring were present in low numbers in most of the areas sampled throughout the study period. The species catch composition for all areas in both years consisted of approximately 65% herring and 21% other pelagic schooling fishes (i.e., smelt, whitefish, cod, and salmon). Herring were primarily caught when water temperatures ranged from 4 to 12° C. Spawning coincided with ice breakup and continued for over a month. Only a few herring spawning areas were found, all were subtidal and located in northern Kotzebue Sound. Since many areas could not be intensely sampled because of the large geographic area involved other spawning areas may exist. The 1977 year class of herring represented 48 and 65% of the total spawning biomass during 1980 (age 3) and 1981 (age 4), respectively. Year class trends for Chukchi Sea herring samples paralleled those of eastern Bering Sea populations suggesting that similar factors may affect year class strength for both areas. However, Chukchi Sea herring were much smaller at age than eastern Bering Sea herring. No seasonal trends in age class composition were evident during the spawning period as was noted in some areas of the eastern Bering Sea where older, larger herring spawned earlier in the season. Existing evidence indicates that Chukchi Sea herring spend their complete life cycle within the region and probably do not mix with Bering Sea stocks. Experimental commercial herring gillnet fishing was conducted during 1980 for both a sac-roe (spring) and food (fall) product. The 1971 year class of herring (age 9) dominated catches, with a high percentage of other fishes captured incidentally. Two major obstacles to development of a commercial fishery exist: high transportation costs for products and large incidental catches of unmarketable fishes. These factors plus the apparent small herring biomass and the relative small size at age suggest that a profitable commercial herring fishery may not develop in the near future.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) conducted a study of Pacific herring *(Clupea harengus pallasi)* in the southeastern Chukchi Sea, from June 1980 to July 1981, in response to growing interest in this area by the commercial fishing industry.

The goal of the study was to assess the distribution and abundance of herring as well as other schooling fishes in selected nearshore areas of the southeastern Chukchi Sea. Specific objective were as follows:

1) Describe the spatial and temporal distribution and abundance of spawning herring;

2) Determine age, sex, size, and relative maturity of herring;

3) Describe types and extent of herring spawning substrates;

4) Estimate herring spawn deposition at selected sites; and

5) Describe the spatial and temporal distribution and abundance of other schooling fishes.

During 1980 field studies were conducted only in Kotzebue Sound; in 1981 field studies were expanded to include Shishmaref Inlet.

Little information is available on herring in the Chukchi Sea. Alverson and Wilimovsky (1966) captured about 1,000 herring in a gillnet set near Cape Thompson in August 1959 while conducting studies for the U.S. Atomic Energy Commission. Although midwater trawls, otter trawls, and beach seines were also fished during their one month sampling cruise, no other significant catches of herring were made. Barton et al. (1977) and Barton (1978, 1980) collected information on herring in southeastern Chukchi Sea for the Bureau of Land Management's (BLM) Outer Continental Shelf Environmental Assessment Program (OCSEAP) in 1976 and 1977 and for the ADF&G in 1979. He concluded that herring occurring in the southern Chukchi Sea composed a separate spawning population from those in Norton Sound and the eastern Bering Sea. Southeastern Chukchi Sea herring grew more slowly and appeared to remain within the Chukchi Sea all year. Wolotira (1977) conducted offshore demersal trawl studies aboard the R/V MILLER FREEMAN during September and October 1976 for OCSEAP. Although the survey was not designed to specifically assess herring, he estimated about 18% of the fish biomass was herring.

Herring is one of many fish species which is an important food source for people living on the Chukchi Sea coast. Herring are caught incidentally in gillnets set for whitefish *(Coregonidae)* and are collected from ice overflows during the winter by people living near Kotzebue Sound. Inhabitants of Shishmaref fish for herring during September and October before freeze-up.

STUDY AREA

The study area included all coastal waters of the southeastern Chukchi Sea from Cape Prince of Wales to Cape Krusenstern, a shoreline distance of approximately 870 km (Figures 1 and 2). Seven aerial survey index units were defined within the study area:

1) Shishmaref (Cape Prince of Wales to Cape Espenberg),

2) Deering (Cape Espenberg to Church Rock),

3) Eschscholtz (Church Rock to Point Garnet),

4) Baldwin (Point Garnet to Kotzebue),

5) Kobuk (Hotham Inlet from Kotzebue to Noatak River),

6) Selawik (Selawik Lake), and

7) Sheshalik (Noatak River to Cape Krusenstern).

Five test fishing study units were defined within the study area:

1) Shishmaref (Coastal and inlet waters near Shishmaref),

2) Deering (Clifford Point east to Kiwalik Lagoon and north to Choris Peninsula),

3) Kotzebue (Cape Blossom north and east to Pipe Spit),

4) Kobuk (all waters of Hotham Inlet east of a line from Pipe Spit to Noatak River mouth and south to Nimiuk Point), and

5) Sheshalik (Noatak River mouth west and north to Cape Krusenstern including Sheshalik and Krusenstern Lagoons).

METHODS

Aerial Surveys

Aerial surveys were flown from June through September 1980 and in June 1981 to document distribution and abundance of herring schools. Survey techniques were similar to those used in previous studies of Bering Sea herring (Barton and Steinhoff 1980). Observers rated visibility conditions during each survey using a range of values from excellent to unacceptable. Size (surface area) and location of each fish school sighted, as well as occurrence of spawning, were recorded on standard charts. To facilitate spatial and temporal comparisons of herring abundance and distribution, observations of fish schools were expressed as relative abundance index (R.A.I.) units. Each R.A.I. unit was

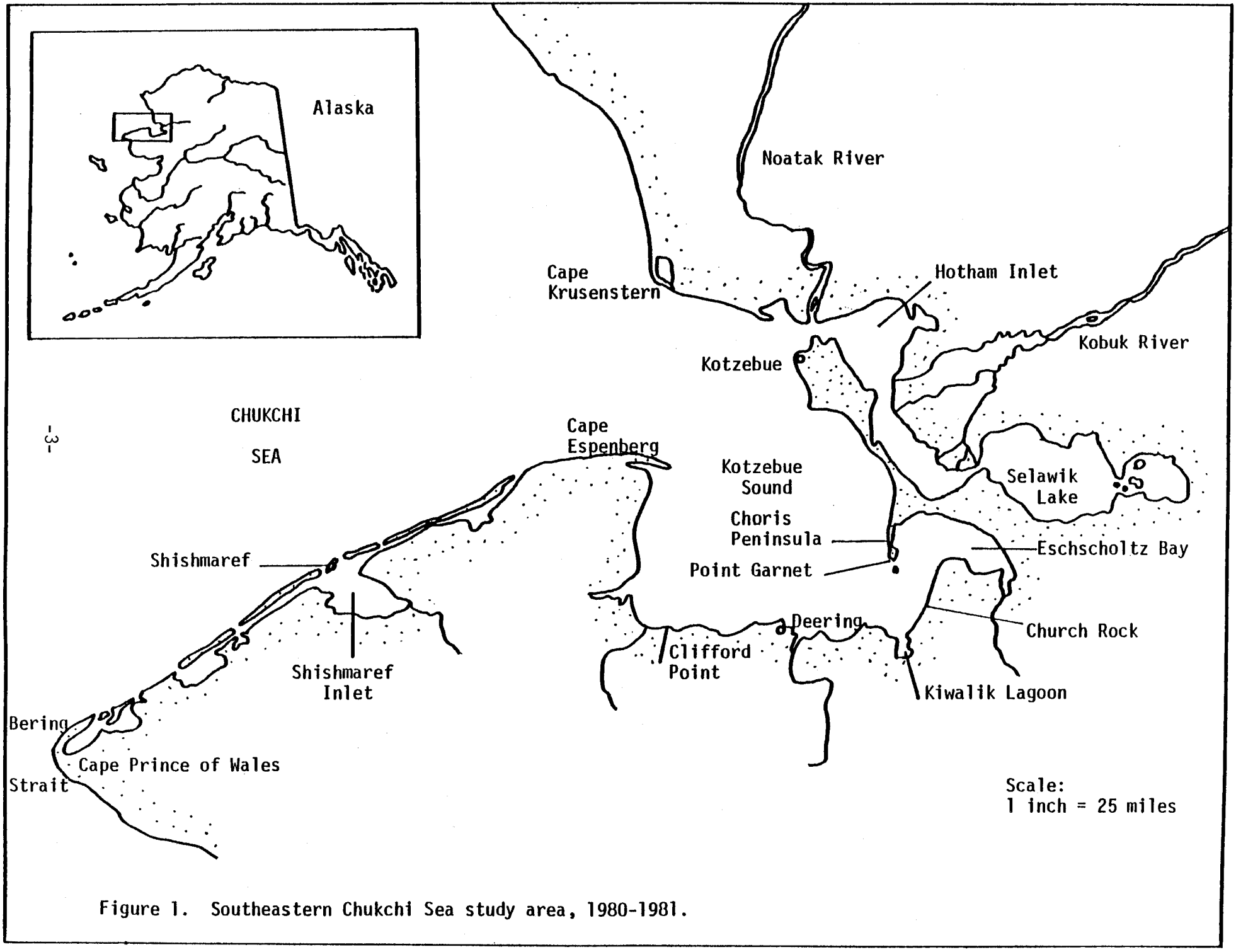

Figure 1. Southeastern Chukchi Sea study area, 1980-1981.

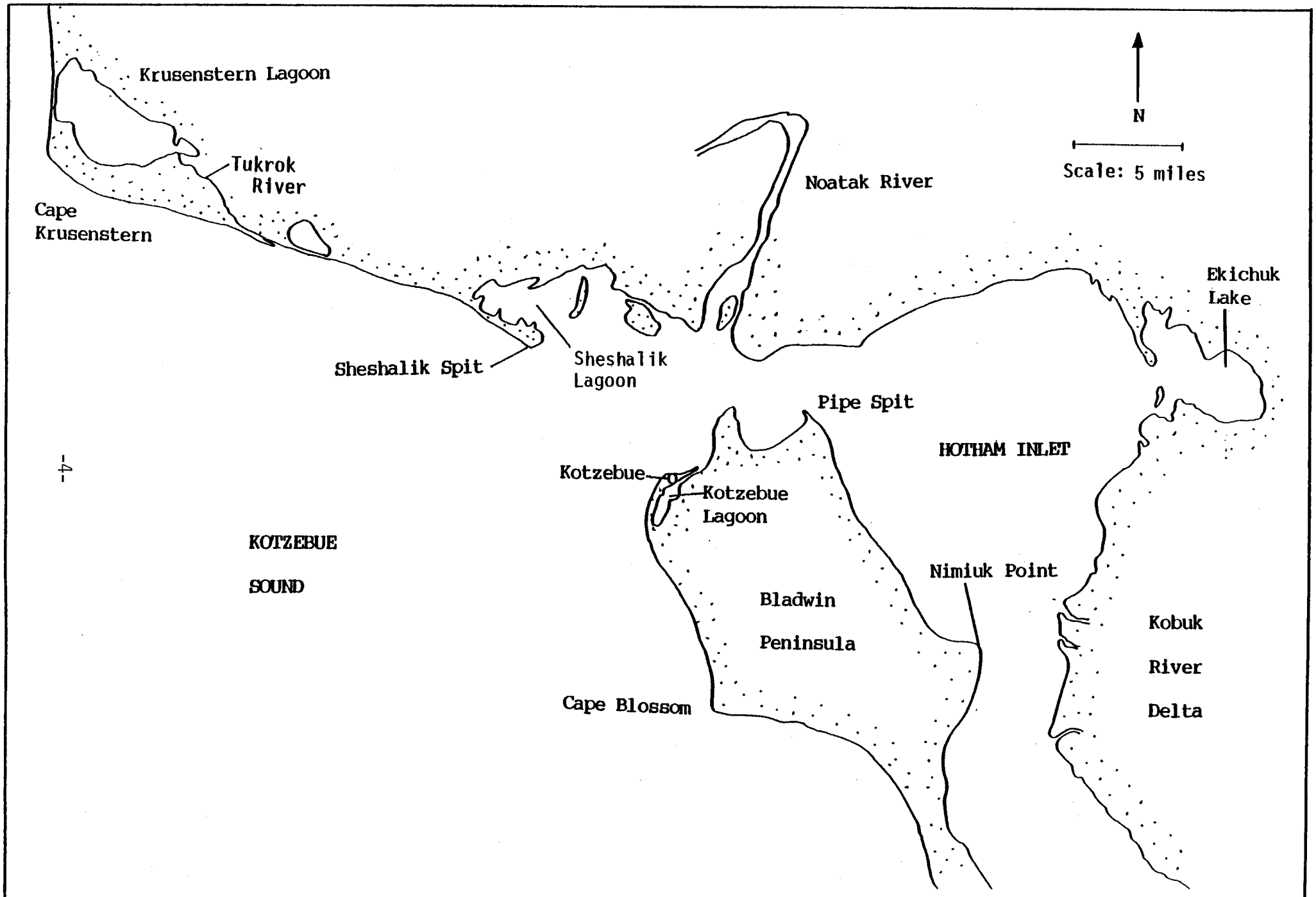

Figure 2. Northern Kotzebue Sound study area, southeastern Chukchi Sea, 1980-1981.

equivalent to one fish school having a surface area of 50 m^2 (e.g., a school with a surface area of 1,000 m^2 was equal to 20 R.A.I. units).

Test Gillnet Fishing

Herring were captured with floating or sinking multifilament gillnets within four test fishing units in 1980 (Deering, 12-17 July and 25 September; Kotzebue, 10 July - 20 September; Kobuk, 14 June - 19 September; and Sheshalik, 7 July - 19 September) and in 1981 (Shishmaref, 15 - 27 June; Kotzebue, 31 May - 7 July; Kobuk, 9 June - 17 July; and Sheshalik 12-30 June). Field personnel set and retrieved gillnets using outboard powered skiffs or rubber rafts. Gillnets were 48 m long, 3 m deep and consisted of six 8 m panels, each with a different stretch mesh size (25, 38, 51, 64, 76, and 102 mm). Similar gillnets have been used by ADF&G to sample herring in eastern Bering Sea spawning areas (Barton 1978; Barton and Steinhoff 1980). Additionally, in 1981 "special" floating gillnets having the same measurements as the standard gillnets but with different panel stretch mesh sizes (25, 38, 44, 51, 57, and 64 mm) were fished in the same areas as standard floating test gillnets to determine whether catches from both nets contained herring of similar size and age. Comparisons were made during two time periods: 13 June and 25-26 June. Chi-square testing procedures were used to compare age composition of catches (Hoel 1971). Some age classes had to be grouped to obtain minimum expected values of 5.0 for each cell. Also, differences between mean length and mean age of herring captured by both types of gillnets were examined using the F-test (Sokal and Rohlf 1969).

Changes in age composition over time during the spawning period have been documented in eastern Bering Sea herring populations (Barton 1979; McBride and Whitmore 1981). Therefore, sampling during the present study was subdivided into 7 day time periods to detect shifts in age class composition. A sample of at least 181 herring was needed from each study unit during each time period to ensure that the 95% confidence limits of the estimated age composition were within ±10% of the estimated mean for each of seven age groups present, i.e., ages 3, 4, ...8, 9+ (Ivan Frohne, ADF&G Div. Comm. Fish., Juneau, AK and David Bernard, ADF&G Div. Comm. Fish., Stock Separation, Anchorage, AK pers. comm.). Attempts were made to collect 200 herring samples per time period to account for regenerated, reabsorbed, or otherwise illegible scales. Large catches were subsampled when necessary by weighting the total catch by the percentage captured in each mesh size. Collecting effort was as evenly distributed throughout each 7 day period as was allowed by weather and logistic limitations.

When herring were abundant gillnets were fished for short periods of time (i.e., less than 1 hour) to avoid net saturation. When herring were scarce gillnets were fished for longer periods of time (e.g., overnight). Initially sets were made at random locations. However, when locations having high herring concentrations were found, they were sampled regularly to obtain information on temporal variations in abundance [reflected as catch per unit effot (CPUE) changes]. Sampling was also continued in areas in which herring were scarce and expanded into areas which had not been previously fished to detect spatial changes in herring abundance patterns.

All herring sampled were measured (standard length, mm), their age determined from a scale, and their relative sexual maturity rated according to a modified Bergen scale as shown in Table 1 (International Council for the Exploration of the Seas 1962, cited in Jones 1970). Every fifth herring sampled was also weighed (wet weight, nearest 0.1 g). All other fishes were counted, identified to species or species group, and, when time permitted, measured (fork length, mm). Stomach contents of whitefish and northern pike *(Esox lucius)* were examined to detect predation upon herring and spawn. Additional data collected for each gillnet set included surface water temperature (°C), water depth (m), and fishing time (hours). Additionally, in 1981 surface water salinities (0/00) were taken from a site within Hotham Inlet.

The outer edge of each herring scale was counted as an annular check from herring captured during the spawning season which runs from June through mid-July (Rounsefell 1929). The scale edge was not counted as an annular check for most herring captured after mid-July as growth had occurred since spawning (Rumyantsev and Darda 1970). All scales were aged by at least two biologists experienced in interpreting herring scale age.

Age Composition of Spawning Herring

Aerial survey data were inadequate to use as an index of herring abundance. Herring age composition estimates for each year could not be weighted by the RAI unit (McBride and Whitmore 1981). Age composition of spawning herring was estimated from the total variable mesh gillnet catch taken in Kobuk study unit during 14 June to 6 July 1980 and from catches taken in Shishmaref, Kotzebue, Kobuk, and Sheshalik study units during 27 May to 7 July 1981.

Test Commercial Catch Sampling

In 1980 the Alaska Department of Commerce and Economic Development (ADCED) awarded the Alaska Native Foundation (ANF) a contract to examine development of a commercial fishery for Chukchi Sea herring. Field work and data analysis was done by Community Enterprises Development Corporation (CEDC) under a subcontract to ANF (Strombom 1981). During this study herring were captured with gillnets (46 m long, 57 mm stretch mesh) fished near Shishmaref, Deering, and Kotzebue between 6 September and 6 October. A total of 246 herring samples from this study were obtained by the ADF&G. Additional herring samples were also obtained from an actual commercial venture attempted near Kotzebue in June 1980. These herring test commercial catch samples were treated in the same manner as herring test gillnet catch samples.

Beach Seining

A beach seine (61 m long, 2.5 m deep, 5 mm stretched mesh) was used by ADF&G personnel to catch juvenile herring in Kotzebue Sound. Data collected from each seine haul included catch by species, water temperature (°C), salinity (0/00) in 1980 only, beach description, and weather observations. Sampling procedures for captured herring were the same as those used for test gillnet catches.

Table 1. Maturation index and condition of herring gonads based on the Bergen scale.

Condition	Index	Key Characteristics
Virgin	1	Virgin herring. Gonads very small, threadlike, 2-3 mm wide. Ovaries wine red. Testes whitish or gray brown.
	2	Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye, but can be seen with magnifying glass. Ovaries a bright red color, testes reddish gray color.
Green	3	Gonads occupying about half of the ventral cavity. Width of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with the naked eye. Ovaries orange; testes reddish gray or grayish.
	4	Gonads almost as long as body cavity. Eggs larger, varying in size, opaque. Ovaries orange or pale yellow; testes whitish.
Ripe	5	Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish, testes milkwhite. Eggs and sperm do not flow, but sperm can be extruded by pressure.
	6	Ripe gonads; eggs transparent; testes white; eggs and sperm flow freely.
Spent	7	Spent herring. Gonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.
	8	Recovering spents. Ovaries and testes firm and larger than virgin herring in stage 2. Eggs not visible to naked eye. Walls of gonads striated; blood vessels prominent. Gonads wine red color. This stage passes into stage 3.

Spawn Substrate Studies

Attempts were made to locate herring spawning sites and identify aquatic vegetation. Since tidal fluctuations were small, the intertidal area available for plant colonization was negligible. Therefore, efforts were made to sample subtidal areas with an Eckmann grab and bottom drags. Kobuk, Kotzebue, and Sheshalik study areas were sampled both years, Deering was sampled only in 1980, and Shishmaref only in 1981.

RESULTS

Aerial Surveys

In 1980, 1979 fish schools (419 R.A.I. units) were sighted between 7 June and 24 September in nine aerial surveys (Table 2). Fish school sightings occurred only within three study units: Deering (70%), Kotzebue (25%), and Baldwin (5%). No schools were sighted during three surveys flown during 6-29 June 1981, but weather conditions were unsatisfactory. Only two observations of probable spawn (milt) patches were made during the study: one on 22 June 1980 in Hotham Inlet (on the east side of the Baldwin Peninsula) and another on 8 June 1981 in Kotzebue Lagoon. Aerial survey information was inadequate for estimating total herring abundance since poor water clarity and weather conditions limited flight time.

Test Gillnet Catches

A total of 12,829 fishes representing 10 families was captured in 280 gillnet sets during 818 hours of fishing (Tables 3 and 4). Although most of the total fishing effort (88%) occurred during 1980 only 54% of the total catch was made that year. Herring was the most abundant species captured during both years, representing 52 and 81% of the catch during 1980 and 1981, respectively. Whitefish, flounders *(Pleuronectidae)*, and sculpins *(Cottidae)* combined represented 33% and 17% of the catch during 1980 and 1981, respectively. Six species of whitefish were encountered in gillnet catches, but humpback whitefish *(Coregonus pidschian)* and least cisco *(C. sardinella)* were most abundant. Whitefish were caught in all study units, but largest catches occurred in Kobuk study unit (Hotham Inlet). Saffron cod *(Eleginus gracilus)* (locally called tom cod) were caught in Sheshalik and Deering study units in all months of the study, but were caught in Kobuk and Kotzebue study units only in September. Rainbow smelt *(Osmerus mordax)* were present in all study units, but were most abundant in Sheshalik and Deering study units during July.

Northern pike, captured only in Hotham Inlet, were the only observed predator of adult herring. On 22 June 1980, 12 northern pike (mean fork length 664 mm) were captured and their stomach contents were examined. A total of 22 herring was found in the stomach contents, but four stomachs contained no herring and a single stomach contained seven herring. Seven days later an additional 17 pike stomachs were examined; only a single herring was identified.

Weekly mean surface water temperatures ranged from 0 to 16°C during sampling (Table 5). Herring catches were highest between temperatures of 4 to 12°C.

Table 2. Relative size and abundance of fish schools sighted in southeastern Chukchi Sea, 1980-1981.

Index Unit	Survey Date	Rating [1]	Number of Schools sighted [2]					R.A.I.	Remarks
			Sm.	Md. 1	Md. 2	Lg.	Total School		
					1980				
Shishmaref	6/15	U	-	-	-	-	-	-	Ice
	Total		0	0	0	0	0	0	
Deering	6/13 [3]	F	-	-	-	-	-	-	
	6/15 [3]	G	22	11	9	3	45	169	
	6/26 [3]	G-F	-	-	-	-	-	-	
	6/27	G-F	54	8	5	3	70	146	
	7/3 [3]	G	-	-	-	-	-	-	
	9/9	E	8	-	-	-	8	8	
	9/2 [4]	F-P	2	-	-	-	2	2	
	Total		86	19	14	6	125	325	
Eschscholtz	6/26	F-G	-	-	-	-	-	-	
	6/27	G	-	-	-	-	-	-	
	7/3	P-U	-	-	-	-	-	-	
	Total		0	0	0	0	0	0	
Baldwin	6/7	P	-	-	-	-	-	-	
	6/26	F-G	-	-	-	-	-	-	
	6/27	G	-	-	-	-	-	-	
	7/3	F	6	-	1	1	8	38	
	9/9	F	-	-	-	-	-	-	
	9/24	F	-	-	-	-	-	-	
	Total		6	0	1	1	8	38	
Kobuk	6/7 [4]	P	-	-	-	-	-	-	
	6/22	G-F	41	5	-	-	46	56	
	6/29	G	-	-	-	-	-	-	
	Total		41	5	0	0	46	56	
Season Total			133	24	15	7	179	419	
					1981				
Shishmaref	6/8	P	-	-	-	-	-	-	Ice
	6/29	U	-	-	-	-	-	-	Wind
	Total		0	0	0	0	0	0	
Deering	6/8	U	-	-	-	-	-	-	Ice
	Total		0	0	0	0	0	0	
Baldwin	6/8	U	-	-	-	-	-	-	Ice
	6/29 [3]	U	-	-	-	-	-	-	Wind
	Total		0	0	0	0	0	0	
Kobuk	6/8	P	-	-	-	-	-	-	Turbid
	6/23	U	-	-	-	-	-	-	Turbid
	6/29	U	-	-	-	-	-	-	Wind, Turbid
	Total		0	0	0	0	0	0	
Sheshalik	6/8 [3]	P	-	-	-	-	-	-	
	6/23	U	-	-	-	-	-	-	Wind
	Total		0	0	0	0	0	0	
Season Total			0	0	0	0	0	0	

[1] Survey rating index: E-Excellent; G-Good; F-Fair; P-Poor; U-Unacceptable.

[2] Fish school categorization: small - surface area less than 50m
medium 1 - surface area between 50-254m
medium 2 - surface area between 255-450m
large - surface area greater than 450m

[3] Partially surveyed.

[4] Possibly a large school in Ekichuk Lake.

Table 3. Variable mesh gillnet catch composition and catch per unit effort (number/hour) by common name and family in four study units in southeastern Chukchi Sea, 14 June - 30 September 1980.

Common Name (Family)	Catch by Number (C.P.U.E.) Study Unit				Total	Percent Composition
	Kobuk [1]	Kotzebue [2]	Sheshalik [3]	Deering [4]		
Pacific Herring (Clupeidae)	1674 (8.7)	619 (7.7)	908 (4.4)	372 (1.5)	3573 (5.0)	51.9
Capelin (Osmeridae)	0 (0.0)	0 (0.0)	0 (0.0)	4 (tr.)	4 (tr.)	0.1
Rainbow Smelt (Osmeridae)	36 (0.2)	8 (0.1)	117 (0.6)	181 (0.7)	342 (0.5)	5.0
Pond Smelt (Osmeridae)	0 (0.0)	0 (0.0)	0 (0.0)	1 (tr.)	1 (tr.)	tr.
Saffron Cod (Gadidae)	28 (0.1)	169 (2.1)	110 (0.5)	232 (1.0)	539 (0.7)	7.8
Humpback Whitefish (Coregonidae)	326 (1.7)	16 (0.2)	98 (0.5)	1 (tr.)	441 (0.6)	6.4
Broad Whitefish (Coregonidae)	15 (0.1)	0 (0.0)	2 (tr.)	0 (0.0)	17 (tr.)	0.3
Round Whitefish (Coregonidae)	2 (tr.)	0 (0.0)	0 (0.0)	0 (0.0)	2 (tr.)	tr.
Sheefish (Coregonidae)	80 (0.4)	2 (tr.)	19 (0.1)	0 (0.0)	101 (0.1)	1.5
Least Cisco (Coregonidae)	413 (2.2)	11 (0.1)	87 (0.4)	1 (tr.)	512 (0.7)	7.4
Arctic Cisco (Coregonidae)	6 (tr.)	2 (tr.)	10 (tr.)	9 (tr.)	27 (tr.)	0.4
Northern Pike (Esocidae)	71 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	71 (0.1)	1.0
Flounders (Pleuronectidae)	224 (1.2)	65 (0.8)	229 (1.1)	113 (0.5)	631 (0.9)	9.2
Sculpin (Cottidae)	95 (0.5)	264 (3.3)	126 (0.6)	45 (0.2)	530 (0.7)	7.7
Poacher (Agonidae)	0 (0.0)	0 (0.0)	1 (tr.)	3 (tr.)	4 (tr.)	0.1
Greenling (Hexagramidae)	0 (0.0)	0 (0.0)	9 (tr.)	32 (0.1)	41 (0.1)	0.6
Prickleback (Stichaeidae)	0 (0.0)	0 (0.0)	1 (tr.)	0 (0.0)	1 (tr.)	tr.
Arctic Char (Salmonidae)	0 (0.0)	0 (0.0)	2 (tr.)	0 (0.0)	2 (tr.)	tr.
Pink Salmon (Salmonidae)	1 (tr.)	0 (0.0)	7 (tr.)	15 (tr.)	23 (tr.)	0.3
Chum Salmon (Salmonidae)	6 (tr.)	1 (tr.)	14 (0.1)	0 (0.0)	21 (tr.)	0.3
TOTAL	2977 (15.6)	1157 (14.4)	1740 (8.4)	1009 (4.2)	6883 (9.6)	100.0

[1] Majority of fishing effort occurred during 14 June - 1 July with little effort in July, August and September.
[2] Majority of fishing effort during late August and September.
[3] Majority of fishing effort during July and August.
[4] All fishing effort during 10-17 July and 9 September.

Table 4. Variable mesh gillnet catch composition and catch per unit effort (number/hour) by common name and family in four study units in southeastern Chukchi Sea, 30 May - 7 July 1981.

Common Name (family)	Catch by Number (C.P.U.E.) Study Unit				Total	Percent Composition
	Kobuk	Kotzebue	Sheshalik	Shishmaref		
Pacific Herring (Clupeidae)	1673 (102.0)	1743 (118.6)	1132 (115.5)	276 (4.7)	4824 (48.2)	81.2
Rainbow Smelt (Osmeridae)	14 (0.8)	25 (1.7)	5 (0.5)	15 (0.3)	59 (0.6)	1.0
Saffron Cod (Gadidae)	1 (0.1)	4 (0.3)	47 (4.8)	2 (tr.)	54 (0.5)	0.9
Humpback Whitefish (Coregonidae)	169 (10.3)	128 (8.7)	27 (2.8)	0 (0)	324 (3.2)	5.4
Sheefish (Coregonidae)	59 (3.6)	27 (1.8)	11 (1.1)	0 (0)	97 (1.0)	1.6
Least Cisco (Coregonidae)	75 (4.6)	34 (2.3)	35 (3.6)	0 (0)	144 (1.4)	2.4
Arctic Cisco (Coregonidae)	1 (0.1)	3 (.2)	1 (0.1)	7 [1] (0.1)	12 (0.1)	0.2
Northern Pike (Esocidae)	4 (0.2)	0 (0)	0 (0)	0 (0)	4 (tr.)	0.1
Flounders (Pleuronectidae)	128 (7.8)	117 (8.0)	83 (8.5)	41 (0.7)	369 (3.7)	6.2
Sculpin (Cottidae)	0 (0)	0 (0)	41 (4.2)	18 (0.3)	59 (0.6)	1.0
TOTAL	2124 (129.5)	2081 (141.6)	1382 (141.0)	359 (6.1)	5946 (59.4)	100.0

[1] *Coregonidae* thought to be Arctic Cisco but not positively identified beyond family.

Table 5. Weekly mean surface water temperatures (°C) from variable mesh gillnet set locations in five study units in southeastern Chukchi Sea, 1980-1981.

	Study Units							
	1980				1981			
Time Period	Kobuk	Kotzebue	Sheshalik	Deering	Kobuk	Kotzebue	Sheshalik	Shishmaref
5/27-6/2						3		
6/3-6/09					4	5		
6/10-6/16	11				11	13	13	4
6/17-6/23	11				12	12	10	8
6/24-6/30	13				13	12	8	9
7/1-7/7	13		16		11	11		7
7/8-7/14		11	11	11				
7/15-7/21	14	12		12				
7/22-7/28	16		9					
7/29-8/4	16		14					
8/5-8/11	15		13					
8/12-8/18			15					
8/19-8/25								
8/26-9/1	10	9						
9/2-9/8		5						
9/9-9/15	8	6	8					
9/16-9/22		4	6					
9/23-9/29				7				
9/30-10/6		0						

Surface water salinities taken in Hotham Inlet from 9 June to 6 July 1981 ranged from 8.5 to 10.0 0/00.

Test Gillnet Age and Size Composition

The 1977 year class (age 4 in 1981) comprised 48 and 65% of the samples taken during the spawning season in 1980 and 1981, respectively (Figure 3). Except for the 1976 year class which comprised 18% of spawning herring sampled in 1980, no other year class comprised more than 9% of samples taken in either year. Post spawning season age composition estimates (mid-July to September 1980) as compared to the spring were unchanged in the Kobuk study unit, however, 3-year-old herring were more numerous in the Deering study unit and less numerous in the Kotzebue and Sheshalik study units. Herring ages ranged from two to 16 years in 1980 and two to 14 years in 1981.

No significant differences in age composition of spawning herring were found in 1981 ($P > 0.1$) between catches made in the Kobuk and Kotzebue study units. However, lower than expected proportions of younger age herring (ages 2, 3, and 4) occurred in catches from both the Sheshalik and Shishmaref study units. No consistent differences were found between age composition, mean length, or mean age of herring captured in standard gillnets with those captured in "special" gillnets within the two sample periods (chi-square and F-tests, $P = 0.05$). Mean length at age was similar for both gillnet types (Table 6). Most herring were captured in mesh sizes ranging from 38 to 51 mm; 97% of the total catch in standard gillnets occurred in 38 and 51 mm mesh sizes, while 94% of the total catch in "special" gillnets occurred in 38, 44, and 51 mm mesh sizes (Table 7).

Herring captured during this study (Table 8) were smaller at age than any eastern Bering Sea stock (Barton and Steinhoff 1980; McBride et al. 1981; Fried et al. 1981). No latitudinal trends were found within the Chukchi Sea Analysis of length data indicated growth occurred primarily from July through September. Trends in weight gained were not evident because of the limited number of samples obtained and the variability introduced by gonad conditions.

Test Commercial Gillnet Catches

Pacific herring, Saffron cod, sculpin, whitefish, and smelt *(Osmeridae)* were captured during the commercial fishery development feasibility study conducted by CEDC (Strombom 1981). Herring and cod were the only fish species found in sufficient quantities to warrant consideration of potential marketing.

Herring were the most abundant fish species captured near Shishmaref (30/gillnet hour) with significantly lower catches made near Deering (3.5/gillnet hour). Cod catches were greatest near Deering (11/gillnet hour) with lesser catches made near Shishmaref. No results were obtained by CEDC from the Kotzebue area.

Test Commercial Gillnet Age Composition

Approximately 98% of all herring captured in test commercial gillnets during 1980 were ages 5 and older while more than 50% of those captured in test gillnets were ages 3 and 4 (Figure 3). Kotzebue samples were primarily age 9 and

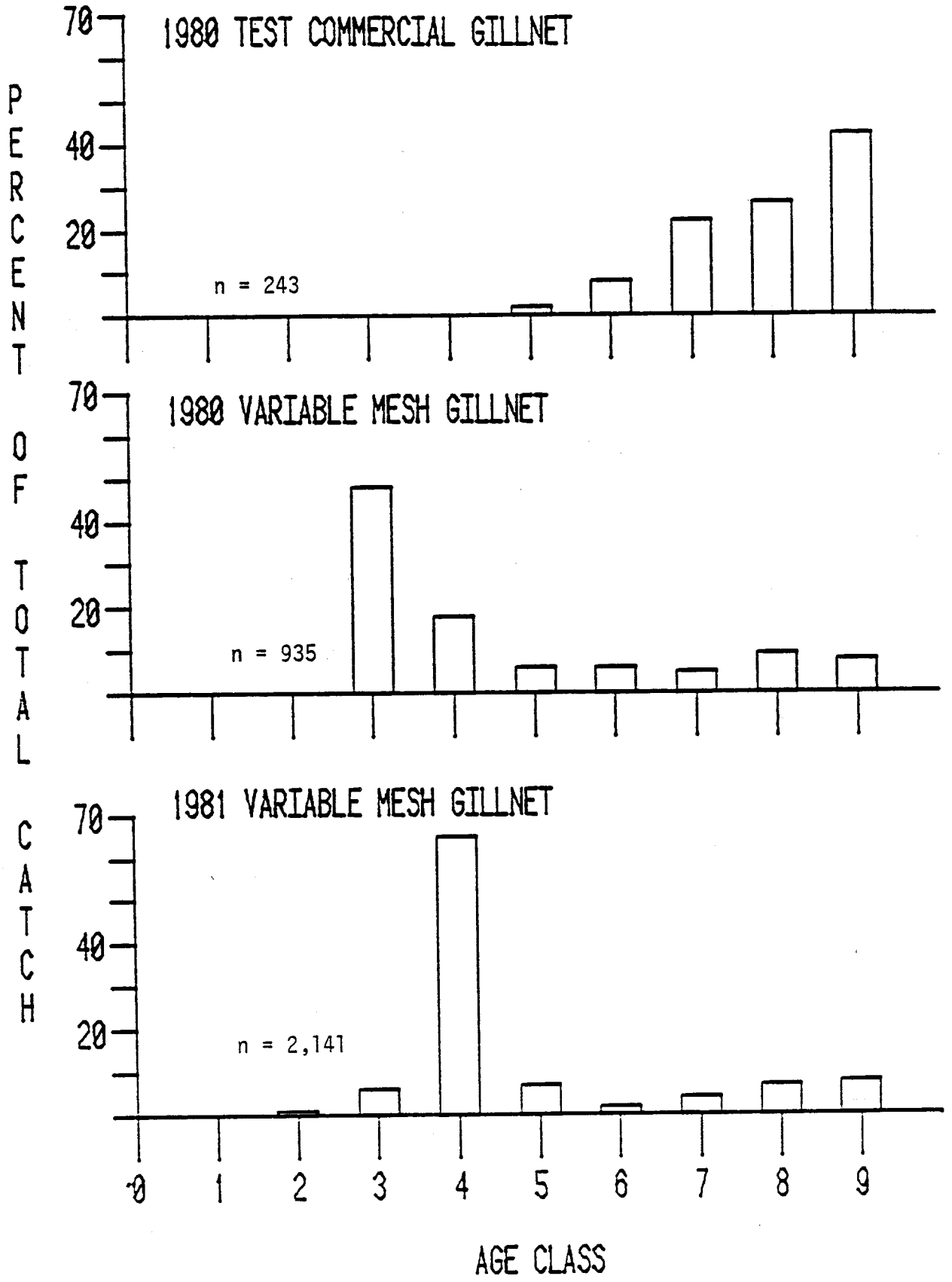

Figure 3. Percent age composition of herring captured in test commercial gillnets and of the spawning herring population captured in variable mesh gillnets in southeastern Chukchi Sea, 1980-1981.

Table 6. Mean standard length at age of herring captured in standard and "special" variable mesh gillnets, southeastern Chukchi Sea, 1981.

Age	Standard Gillnet		Special Gillnet	
	Mean Length (mm)	Number Sampled	Mean Length (mm)	Number Sampled
2	132	4	-	0
3	166	11	160	4
4	175	156	176	129
5	181	14	185	18
6	190	3	194	4
7	203	7	207	14
8	214	12	208	16
9+	217	21	214	38

Table 7. Mean standard length by mesh size of herring captured in standard and "special" variable mesh gillnets, southeastern Chukchi Sea, 1981.

Mesh Size (mm)	Standard Gillnet		Special Gillnet	
	Mean Length (mm)	Number Sampled	Mean Length (mm)	Number Sampled
25	140	5	154	6
38	177	230	176	125
44	N/A	N/A	193	108
51	213	51	217	25
57	N/A	N/A	231	4
64	188	2	217	7
76	210	1	N/A	N/A
102	-	0	N/A	N/A

Table 8. Mean length and mean weight at age of herring samples by study unit from variable mesh and test commercial gillnets, southeastern Chukchi Sea, 1980-1981.

Study Units	Mean Length (mm)									Mean Weight (g)								
	Age Class									Age Class								
	2	3	4	5	6	7	8	9+	Sample Size	2	3	4	5	6	7	8	9+	Sample Size
14 June - 8 July 1980																		
Kobuk	-	164	170	176	198	212	214	225	1069	-	51	58	61	104	106	135	172	169
Sheshalik	-	165	172	197	205	212	217	231	43	-	58	61	-	119	-	121	-	7
TOTAL	-	164	171	177	199	212	214	225	1112	-	51	58	61	107	106	134	172	176
9 July - 5 October 1980																		
Kobuk	159	178	182	197	211	220	224	232	173	-	77	77	86	125	-	152	198	33
Kotzebue	159	176	183	195	200	211	219	231	406	52	77	83	99	106	127	156	180	78
Sheshalik	161	170	181	190	200	219	217	228	418	48	53	76	83	92	152	149	168	81
Deering	162	169	176	197	212	215	217	222	345	57	63	86	111	139	140	-	-	49
Shishmaref	-	-	-	218	205	206	206	220	108	-	-	-	-	-	-	-	-	-
TOTAL	161	172	181	194	206	213	216	228	1450	49	64	77	87	108	136	152	180	241
30 May - 7 July 1981																		
Kobuk	131	162	175	182	191	199	212	218	843	-	42	59	63	-	-	122	114	57
Kotzebue	136	165	176	186	197	205	212	218	840	-	49	64	74	-	-	159	159	41
Sheshalik	143	173	179	186	193	203	215	226	292	-	72	64	64	-	94	-	126	38
Shishmaref	-	-	183	188	194	196	202	210	166	-	47	80	81	87	84	100	88	40
TOTAL	134	164	176	184	195	200	209	220	2141	-	47	64	69	87	85	109	121	176

older (74%) while age 7 and 8 herring were dominant in Deering (59%) and Shishmaref (73%) samples.

Gonad Maturity

Most herring examined in June 1980 were ripe in both the Kotzebue (88%) and Kobuk (78%) study units (Table 9). Thereafter, the frequency of ripe herring decreased until September when no ripe herring were present in samples. The male to female ratio during 1980 was 1:1.1 for all test gillnet samples combined.

In 1981, few spawned out herring were captured during the first 7-day sample period (Table 10). In the Kobuk study unit, the incidence of spent herring was greatest during the first week of July, although ripe herring occurred throughout all sample periods. In the Kotzebue study unit the incidence of spent herring increased sharply after mid-June. No trends in gonad maturity was noted in herring samples from the Sheshalik study unit, although the highest percentage of ripe herring (36%) occurred during 10-16 June. Eighty-six percent of the herring sampled from Shishmaref in 1981 were either recovering spents or fully recovered spents which looked similar to green herring. In addition, 5% of the Shishmaref samples were virgin herring. The male to female ratio during 1981 for all study units was 1.0:0.8.

Beach Seine Catches

A total of 36 beach seine hauls was made during the study (29 in 1980, 7 in 1981), but only 11 herring were captured (Table 11). The most abundant fishes caught were smelts in 1980, and flounders in 1981. All herring were caught at three locations within Sheshalik study unit: Tukrok River, Krusenstern Lagoon, and Sheshalik Lagoon (Figure 2). Herring ages ranged from 1 to 4 years (1980: Age 1=5, Age 2=1, Age 3=1, Age 4=4). All 4-year-old herring were sexually mature; the rest were immature.

Spawn Substrate

All study units in northern Kotzebue Sound had mud, sand, or silt beach and bottom sediments. Some areas were covered with large amounts of detrital material. Since tidal range was small, an intertidal plant community was absent. Bottom sampling surveys indicated subtidal vegetation was limited. Green algae was the most abundant vegetation type, particularly in inlets and lagoons. Aquatic grasses occurred in scattered locations and were often covered by green algae.

The Deering study unit was characterized by rocky headlands and sandy beaches. Bottom substrates consisted mainly of sand and rocks ranging in size from pebbles to boulders. Silt and mud sediments occurred in Kiwalik and Kugruk Lagoons. Rockweed (*Fucus* sp) was the most abundant vegetation in coastal areas. Although some rockweed occurred intertidally (daily tidal range was about 1-2 m) most was subtidal. Green algae and grasses were the only vegetation found in the lagoons.

The Shishmaref study unit was composed of a series of inlets and embayments. Shallow water dominated the area and the bottom substrate was made up of dark

Table 9. Gonad maturity condition of Pacific herring captured in variable mesh and test commercial gillnets by study unit, southeastern Chukchi Sea, 1980.

Sample Period	Gonad Maturity [1]	Kobuk		Kotzebue [2]		Sheshalik		Deering		Kotzebue Sound Total		Shishmaref	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
6/14-7/6	Virgin	3	tr.	-	-					3	tr.		
	Green	126	14	8	6					134	13		
	Ripe	728	78	119	88					847	79		
	Spent	78	8	8	6					86	8		
Period Total		935	100	135	100					1070	100		
7/7-7/31	Virgin					3	1	1	tr.	4	1		
	Green					180	76	159	58	339	66		
	Ripe					9	4	-	-	9	2		
	Spent					46	19	114	42	160	31		
Period Total						238	100	274	100	512	100		
8/1-8/25	Virgin					6	10			6	10		
	Green					52	81			52	81		
	Ripe					4	6			4	6		
	Spent					2	3			2	3		
Period Total						64	100			64	100		
8/26-9/30	Virgin	3	2	2	tr.	1	1	-	-	6	1		
	Green	171	98	413	100	173	99	80	100	837	99		
	Ripe	-	-	-	-	-	-	-	-	-	-		
	Spent	-	-	-	-	-	-	-	-	-	-		
Period Total		174	100	415	100	174	100	80	100	843	100		
10/5	Virgin											-	-
	Green											64	100
	Ripe											-	-
	Spent											-	-
Period Total												64	100
All Periods:	Virgin	6	tr.	2	tr.	10	2	1	tr.	19	1	-	-
	Green	297	27	421	76	405	85	239	68	1362	55	64	100
	Ripe	728	66	119	22	13	3	-	-	860	34	-	-
	Spent	78	7	8	2	48	10	114	32	248	10	-	-
		1109	100	550	100	476	100	354	100	2489	100	64	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

[2] May contain some test commercial samples during the 6/14-7/6 sample period from Kobuk study unit.

Table 10. Gonad maturity condition of Pacific herring captured in variable mesh and test commercial gillnets by study unit, southeastern Chukchi Sea, 1981.

Sample Period	Gonad Maturity [1]	Kobuk		Kotzebue		Sheshalik		Kotzebue Sound Total		Shishmaref [2]	
		No.	%	No.	%	No.	%	No.	%	No.	%
5/27-6/2	Virgin			4	3			4	3		
	Green			49	40			49	40		
	Ripe			68	56			68	56		
	Spent			1	1			1	1		
Period Total				122	100			122	100		
6/3-6/9	Virgin	-	-	3	2			3	1		
	Green	3	4	9	6			12	5		
	Ripe	73	92	120	73			193	80		
	Spent	3	4	32	19			35	14		
Period Total		79	100	164	100			243	100		
6/10-6/16	Virgin	-	-	1	tr.	-	-	1	tr.		
	Green	1	tr.	1	tr.	1	1	3	tr.		
	Ripe	166	98	238	82	58	36	462	75		
	Spent	3	2	51	18	100	63	154	25		
Period Total		170	100	291	100	159	100	620	100		
6/17-6/23	Virgin	-	-	-	-	-	-	-	-	8	5
	Green	-	-	4	2	53	40	57	12	73	44
	Ripe	167	97	37	22	4	3	208	44	15	9
	Spent	5	3	126	76	75	57	206	44	70	42
Period Total		172	100	167	100	132	100	471	100	166	100
6/24-6/30	Virgin	5	2	1	1	-	-	6	1		
	Green	2	1	33	35	5	56	40	11		
	Ripe	242	93	6	6	2	22	250	69		
	Spent	11	4	55	58	2	22	68	19		
Period Total		260	100	95	100	9	100	364	100		
7/1-7/7	Virgin	3	2	1	3			4	2		
	Green	3	2	5	13			8	4		
	Ripe	112	62	13	33			125	57		
	Spent	62	34	20	51			82	37		
Period Total		180	100	39	100			219	100		
All Periods:											
	Virgin	8	1	10	1	-	-	18	1	8	5
	Green	9	1	101	12	59	20	169	8	73	44
	Ripe	760	88	482	55	64	21	1306	64	15	9
	Spent	84	10	285	32	177	59	546	27	70	42
Season Totals		861	100	878	100	300	100	2039	100	166	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

[2] Sample period 6/15-6/27

Table 11. Beach seine catch composition by study unit with surface water temperature and salinity, southeastern Chukchi Sea, 1980-1981.

Study Unit	Date	Salinity (0/00)	Water Temp. (C)	Catch Composition by Number											
				Herring	Smelt	Saffron Cod	Whitefish	Sandlance	Salmon	Arctic Char	Sculpin	Flounder	Poacher	Prickleback	Stickleback
1980															
	7/10 1/	24	11	-	19,000 [1]	5	33	-	-	-	-	10	-	-	-
	7/12	8	12	-	3	2	-	-	-	-	3	21	-	-	-
	7/12	23	12	-	1	-	-	-	-	-	3	1	-	-	-
	7/12	9	14	-	50	-	-	-	-	-	2	2	-	-	6
	7/12	23	12	-	-	2	3	-	5	-	4	11	-	-	-
	7/13	22	11	-	11	-	-	12	-	-	2	5	11	1	-
	7/13	20	10	-	4	6	1	-	3	-	-	18	1	-	-
Deering	7/13	16	11	-	71	5	-	-	-	-	-	4	-	-	-
	7/14	24	11	-	8	-	-	-	-	-	-	-	-	-	1
	7/14	24	11	-	8	-	-	-	-	-	-	1	-	-	-
	7/14	-	11	-	-	-	9	-	-	-	-	-	-	-	-
	7/15	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	7/16	9	14	-	219	1	-	-	-	-	4	16	15	-	-
	7/16	2	13	-	204	-	-	-	-	1	6	11	-	-	-
	7/16	11	13	-	-	-	-	1	-	-	-	6	-	-	-
Area Total				0	19,579	21	48	13	8	1	24	106	27	1	7
	7/29	-	16	-	-	-	149	-	-	-	-	5	-	-	-
	8/4	-	13	-	-	-	1	-	-	-	-	-	-	-	-
Kobuk	8/26	-	10	-	-	-	15	-	-	-	3	20	-	-	-
	9/4	8	8	-	-	-	36	-	-	-	-	9	-	-	-
Area Total				0	0	0	201	0	0	0	3	34	0	0	0
	7/7	6	16	1	350	3	138	-	-	-	6	10	-	-	-
	7/7	6	16	-	100	3	55	-	6	-	-	17	-	-	-
	7/8	8	13	-	200	1	7	-	-	-	1	35	-	-	-
	7/8	22	10	-	327	11	-	-	-	-	2	51	2	4	-
	7/8	2	15	2	12	-	3	-	-	-	-	2	-	-	-
Sheshalik	7/8	2	15	-	52	-	3	-	-	-	2	6	-	-	8
	8/7	-	14	-	-	-	-	-	-	-	-	14	-	-	300
	8/7	-	13	-	200	-	20	-	-	-	-	-	-	-	50
	8/12	-	18	3	80	-	12	-	-	-	-	-	-	-	500
	8/12	-	18	-	100	-	14	-	-	-	-	-	-	-	200
	8/26	-	7	-	12	11	-	-	-	-	-	1	3	-	-
Area Total				6	1,433	29	252	0	6	0	11	136	5	4	1,058
Season Total				6	21,012	50	501	13	14	1	38	276	32	5	1,065
1981															
	6/11	-	14	-	-	-	30	-	-	-	-	-	-	-	-
	6/15	-	13	-	-	-	2	-	1	1	-	114	-	-	3
	6/15	-	-	-	200	-	12	-	-	-	-	-	-	-	100
Sheshalik	6/16	-	13	-	-	1	-	-	-	-	13	87	-	-	-
	6/19	-	13	5	-	-	50	-	-	-	3	49	-	-	-
	6/22	-	14	-	-	-	55	-	-	1	1	25	-	-	-
Area Total				5	200	1	149	0	1	2	17	275	0	0	103

[1] Captured 12 miles north of study unit boundary.

mud and muddy sand. Brown algae was abundant. No attached eel grass was found, however, sparsely scattered strands (mostly dead) were found above the tideline. Additionally, at the head of Shishmaref Inlet and near the Serpentine River mouth scattered finely bladed marine grass (100 - 180 mm in length) was found.

Spawn Deposition

Herring spawn was found only within Kobuk study unit at three locations (Figure 2): the northeast corner of Hotham Inlet, the northeast corner of the Baldwin Peninsula, and near Nimiuk Point. Spawn coverage in all areas was very light (1-5% plant coverage). Most spawn occurred on aquatic grasses, but spawn was also deposited on algae and detrital material. Although no herring spawn was seen in Kotzebue study unit, 55% of all humpback whitefish stomachs (n = 56) collected from both Kobuk and Kotzebue study units during 10-23 June contained herring eggs. Therefore, herring must have spawned in Kotzebue study area as well as Kobuk. Forty percent of humpback whitefish stomachs (n = 34) collected from Kobuk during 24 to 30 June still contained herring eggs.

DISCUSSION

Spawn Timing and Distribution

Initiation of spawning in northern Kotzebue Sound coincided with ice breakup in late May during 1980 and 1981. Herring continued to spawn into July. Herring spawning in eastern Bering Sea coastal areas also appears to begin soon after the ice departs (Barton et al. 1977; Barton 1978). Since Chukchi Sea spawning areas may retain their ice cover into July (Barton 1978), herring spawning could be delayed until August in some years.

Most herring spawning activity was observed within Hotham Inlet, and no observations of spawn were made in southern Kotzebue Sound or the Shishmaref area during the present study. Although herring spawning activity was reported in the vicinity of Deering in southern Kotzebue Sound during August 1977 aerial surveys (Barton 1978), only spawned-out herring were captured there during mid-July 1980. Quantitative surveys of spawn deposition in this area would be difficult to conduct since most vegetation suitable for spawning substrate is subtidal and spread out over a large area.

The presence of herring recovering from spawning and the absence of suitable spawn substrate in the Shishmaref area suggests that the Shishmaref Lagoon system may predominantly be a feeding area. Barton and Steinhoff (1980) found that nearly 22% of the herring stomachs examined from the Shishmaref area (29 June - 2 July 1979) had distended stomachs because of ingested material. Port Clarence may be the closest spawning area for these herring. Scale pattern analysis has indicated that two discrete groups of herring occur in Port Clarence during spring, one with a length frequency comparable to the Shishmaref samples (Rowell 1981).

Herring Abundance and Distribution

As in past studies (Barton 1978), aerial survey coverage was insufficient and visibility was too poor to allow an estimate of herring biomass to be made. A demersal trawl survey by the National Marine Fisheries Service within the southeastern Chukchi Sea during September and October 1976, yielded a herring biomass estimate of 1,958 mt (Wolotira 1977). However, the trawl survey was not designed to specifically target on herring, and Wolotira (1977) noted that a substantial portion of the population probably occupied the water column above the area swept by the sampling gear. Additionally, he assumed that the populations sampled were static (i.e., there were no shifts in abundance within the survey area, as well as no movements of animals in or out of the survey area). All trawling effort was made in water depths greater than 9 m. Since neither spatial or seasonal distribution patterns have been described within the Chukchi Sea, the portion of the total Chukchi Sea herrring biomass present in the trawl sampling area cannot be determined.

Test fishing with variable mesh gillnets in nearshore areas indicated herring were most abundant in northern Kotzebue Sound where peak catches were made during June in both years. Herring captured in southern Kotzebue Sound near Derring during July 1960 indicated low abundance levels. If sampling effort had been conducted in southern Kotzebue Sound earlier in the season abundance levels may have been higher. Herring were least abundant in the Shishmaref area. Since sampling near Shishmaref began 15 June in 1981 when ice was still prevalent, it is unlikely that the peak abundance occurred prior to the study. Herring abundance may increase in the fall in this area, since village residents usually harvest herring at that time for personal consumption.

Surface water temperatures increased during July and August and reached 16°C in Hotham Inlet during 21 July 1980. Flemming and Haggarty (1966) found nearshore water temperatures ranging from 10-15°C at all depths of Kotzebue Sound during August. They attributed the warm temperatures primarily to the current system and overall shallowness of the region. Catch per unit of effort during the present study were greatest for herring at water temperatures from 4-12° C. However, adult herring were caught in water temperatures ranging from 2-14°C, and juvenile herring were caught in water temperatures as high as 18.3°C in Krusenstern Lagoon during mid-August 1980. Chukchi Sea herring can also tolerate a wide range of salinities (Barton 1978). Flemming and Haggarty (1966) found surface water salinities dilute (< 31 0/00) to all depths adjacent to the coast during August. During the present study surface salinities of nearshore waters ranged from 2 to 23 0/00.

Existing evidence indicates that herring remain within the Chukchi Sea throughout the year and so comprise a separate stock from those occurring within the Bering Sea. Trawl surveys have shown herring to be present in offshore waters during September and October. Herring have been caught through the ice by local residents jigging for cod in both northern and southern Kotzebue Sound as well as near Shishmaref (Wigutoff and Carlson 1950; Barton 1978). Herring have been found to comprise the major food item in sheefish stomachs in northern Kotzebue Sound in November (Alt 1963, ADF&G files, cited from Barton 1978) and to comprise a portion of the food content in seal stomachs in southern Kotzebue Sound in winter (ADF&G unpublished data). Local residents in Kotzebue

Sound report that large numbers of herring occasionally become trapped in ice overflows. A sample of herring from such an occurrence was obtained from a subsistence fisherman who collected them during January 1981.

Herring Age and Size Composition

Herring samples from variable mesh gillnet catches appear to accurately represent relative abundance trends among different year classes of herring in the eastern Bering Sea (McBride and Whitmore 1981; McBride et al. 1981). Interestingly, year class trends for Chukchi Sea herring samples parallel those of eastern Bering Sea herring, i.e., 1977 year class abundant; and 1975 year class weak (Fried et al. 1981). This indicates that either similar factors affect year class strength of both eastern Bering and Chukchi Sea herring, or that substantial interchange may occur between stocks from both areas. The decrease in length at age of herring samples taken from south to north along the Bering-Chukchi Sea coast (Barton and Steinhoff 1980) lends support to the hypothesis that spawning stocks are separate (Figure 4), but factors affecting year class strength have been widespread and common to all stocks.

Commercial Fishery Development

Although a guideline harvest of 150 mt of herring has been set for Kotzebue Sound by the Alaska Board of Fisheries, and commercial development feasibility studies have been done (Barlindhaug 1980; Strombom 1981), no market has been established for Chukchi Sea herring. Two major obstacles to development of a commercial fishery are high transportation costs for products and large incidental catches of other unmarketable fishes. If a commercial fishery does develop further assessment work will be needed to better estimate available biomass. Also, changes in gillnet mesh size regulations may be warranted. Presently, stretched mesh size must be less than 2-1/8 in. (53 mm) nor more than 3 in. (76 mm). Findings from the present study indicate that a smaller minimum mesh size (1-1/2 - 1-3/4 in. [38-44 mm]) may be warranted, since Kotzebue herring are smaller in size than more southerly stocks.

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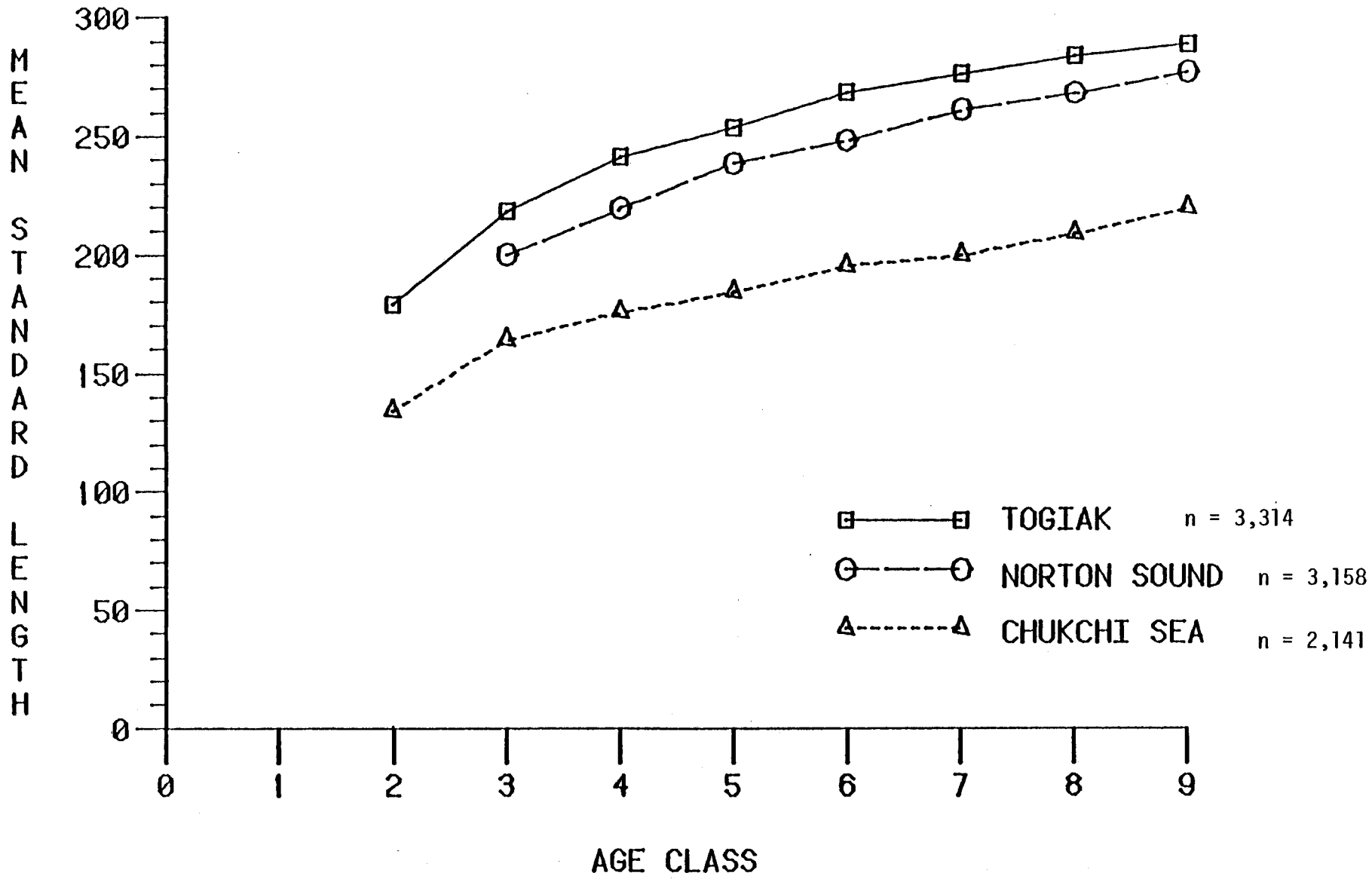

Figure 4. Mean standard length (mm) at age (years) of herring captured at selected coastal areas in the eastern Bering and southeastern Chukchi Seas, 1981.

LITERATURE CITED

Alverson, D.L. and N.J. Wilimovsky. 1966. Fishery investigations of the southeastern Chukchi Sea. Pages 843-860 in N.J. Wilimovsky and J.N. Wolfe, eds. Environment of Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Div. Information. Oak Ridge, Tennessee.

Barlindhaug, J.P. 1980. An analyses of establishing a commercial fishery in northern Bering Sea based on herring and tomcod. Final Report to the Alaska Native Foundation. December 1980, Barlindhaug A/S, Consulting Engineers. Tromso, Norway. 56 pp.

Barton, L.H., I.M. Warner, and P. Shafford. 1977. Herring spawning surveys in the southern Bering Sea. Outer Continental Shelf Environmental Assessment Program, Project Rep. (May 1975 - September 1976). 104 pp.

_____. 1978. Finfish resource surveys in Norton Sound and Kotzebue Sound. Outer Continental Shelf Environmental Assessment Program, Final Rep. (March 1975 - September 1978), ADF&G, Commercial Fisheries Division, Anchorage. 202 pp.

_____. 1979. Assessment of spawning herring and capelin stocks at selected coastal areas in the eastern Bering Sea. Third Progress Rep. North Pacific Fishery Management Council Contract 78-5. 44 pp.

_____ and D.L. Steinhoff. 1980. Assessment of spawning herring *(Clupea harengus pallasi)* stocks at selected coastal areas in the eastern Bering Sea. ADF&G Informational Leaflet No. 187. 60 pp.

Flemming, R.H. and D. Haggarty. 1966. Oceanography of the southeastern Chukchi Sea. Pages 697-754 in N.H. Wilimovsky and J.N. Wolfe, eds. Environment of Cape Thompson Region, Alaska. U.S. Atomic Engery Commission, Div. Tech. Information. Oak Ridge, Tennessee.

Fried, S.M., C. Whitmore, and D. Bergstrom. 1981. Pacific herring stocks and fisheries in the eastern Bering Sea, Alaska, 1981. A report to the Alaska Board of Fisheries. December 1981, ADF&G, Div. of Comm. Fish., Anchorage, Alaska. 21 pp.

Hoel, P.G. 1971. Introduction to Mathematical Statistics, 4th ed. Wiley and Sons, Inc., New York. 409 pp.

Jones, F.R. 1970. Fish migration, 2nd ed. Camelot Press Ltd., London and Southhampton. 325 pp.

McBride, D.N., C. Whitemore, and D. Bergstrom. 1981. Age, sex, and size composition of Pacific herring, *Clupea harengus pallasi* (Vallenciennes) 1979-1980. ADF&G Tech. Data Rep. No. 61. 57 pp.

_____ and C. Whitmore. 1981. Age composition of Pacific herring, *Clupea harengus pallasi* (Valenciennes) in the Togiak District of Bristol Bay during the 1979 and 1980 spawning seasons. ADF&G Informational Leaflet No. 191. 27 pp.

Prokhorov, V.G. 1968. Winter period of life of herring in the Bering Sea, Proceedings of the Pacific Scientific Research Institute of Fisheries and Oceanography. 64:329-338. (In Russian transl. 1970, Fish. Res. Board. Can., Transl. Ser. 1433).

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fish. Res. Board Can. Bull. 191. 382 pp.

Rounsefell, G.A. 1930. Contribution to the biology of the Pacific herring *Clupea pallasi*, and the condition of the fishery in Alaska. Bull. U.S. Bur. Fish. 45:227-320.

Rowell, K.A. 1981. Feasibility of scale pattern analysis techniques for stock identification of eastern Bering Sea Pacific herring. M.S. Thesis. Draft. 59 pp.

Rumyantsev, A.I. and M.A. Darda. 1970. Summer herring in the eastern Bering Sea. Part V: 409-441 in P.A. Moiseev. ed. Soviet fisheries investigations in the northeastern Pacific. (In Russian transl. 1972, Israel Program Sci. Transl. avail. U.S. Dept. Commerce, Natl. Tech. Information Serv., Springfield, VA).

Strombom, D. 1981. The potential for a fall food herring fishery in the villages of Kotzebue, Deering, Shishmaref, and Teller/Brevig Mission. Unpublished. 15 pp.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. The principles and practices of statistics in biological research. W.H. Freeman and Co., San Francisco. 776 pp.

Wigutoff, N.B. and C.J. Carlson. 1950. A survey of the commercial fishery possibilities of Seward Peninsula area, Kotzebue Sound, and certain inland rivers and lakes in Alaska. U.S. Dept. Interior, Fish Leaflet No. 375. 23 pp.

Wolotira, R.J., T.M. Sample, and M. Morin. 1977. Baseline studies of fish and shellfish resources of Norton Sound and the southeastern Chukchi Sea. Final Rep. Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent. Seattle, WA. 292 pp.