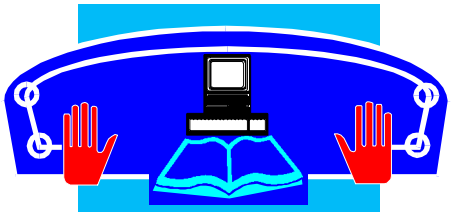

A Diver Survey Of Herring Spawnings In The Fingers Area Of Liverpool Bay, Northwest Territories

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A DIVER SURVEY OF HERRING SPAWNINGS IN THE FINGERS AREA OF LIVERPOOL BAY, NORTHWEST TERRITORIES

by

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ABSTRACT

A diver survey of herring spawns was conducted in the Fingers area of Liverpool Bay, N.W.T. during the summer of 1985 to determine the total number and distribution of deposited herring eggs and to estimate herring biomass. It is estimated that 8.2 tonnes of herring deposited approximately 568 $\times$ 10^6 eggs. Spawning occurred in a protracted pattern from early June to mid-July, and it is not known whether spawning occurred after this date. The estimated incubation period for developing herring eggs in the Fingers Area is 24 days. A number of spawns hatched out prior to being surveyed. A comparison of plankton data to known growth rates and disappearance rates of larval herring in Georgia Strait (B.C.) suggests that no major spawns were missed by the survey team. Eighty percent of deposited eggs were located in Finger 1, Finger 2 and in the approaches to the Kugaluk River. Within all the seven Fingers, most of the spawns were located within 6 km. of the head of the fingers. Major spawning substrates included tundra debris, one species of vascular marine grass (*Zostera*-like) and a leafy red algae (*Callophyllis*-like). Herring spawned on substrate located on shallow sand/mud flats, at depths between 1m and 4.5m. With the exception of the Kugaluk region, these depths corresponded with distinct thermoclines, where surface temperatures ranged between 8 and 12°C. Salinities of these surface waters were between 6 and 16°/oo. Surface temperatures around areas of spawning in the Kugaluk region were colder (5-7°C) and generally more saline (11-170/00). Hypotheses explaining why there may be more herring than the results indicate are presented. Recommendations for future research are suggested.

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INTRODUCTION

Pacific herring, *Clupea harengus pallasi*, occur in the nearshore Beaufort Sea and Liverpool Bay. In 1980 the Department of Fisheries and Oceans (DFO) initiated a study to determine the feasibility of establishing a herring roe fishery in the Beaufort Sea area. This research was initiated in response to a request from the Inuvialuit Development Corporation, who were interested in examining the development of commercial fisheries in the MacKenzie Delta and coastal Beaufort Sea. The herring roe fishery is attractive as it provides high dollar value per unit weight, thus minimizing the impact of transportation costs from the Northwest Territories to the Japanese market.

The goals of the DFO study were to:

1. determine when herring spawn in the Fingers area of Liverpool Bay.
2. determine whether it was possible to capture herring, in quantity, just prior to spawning when the roe are in optimum condition.
3. determine whether the roe can be processed on site or at a facility nearby.
4. determine whether the roe is a market-acceptable product.

To date these objectives have been met (Gillman and Kristofferson, 1984). Both ripe and spent herring have been taken in Tuktoyaktuk Harbour and the Fingers Area of Liverpool Bay in early summer (Figure 1). In late June 1983, approximately 8,600 kg of mature herring were harvested from the lower end of

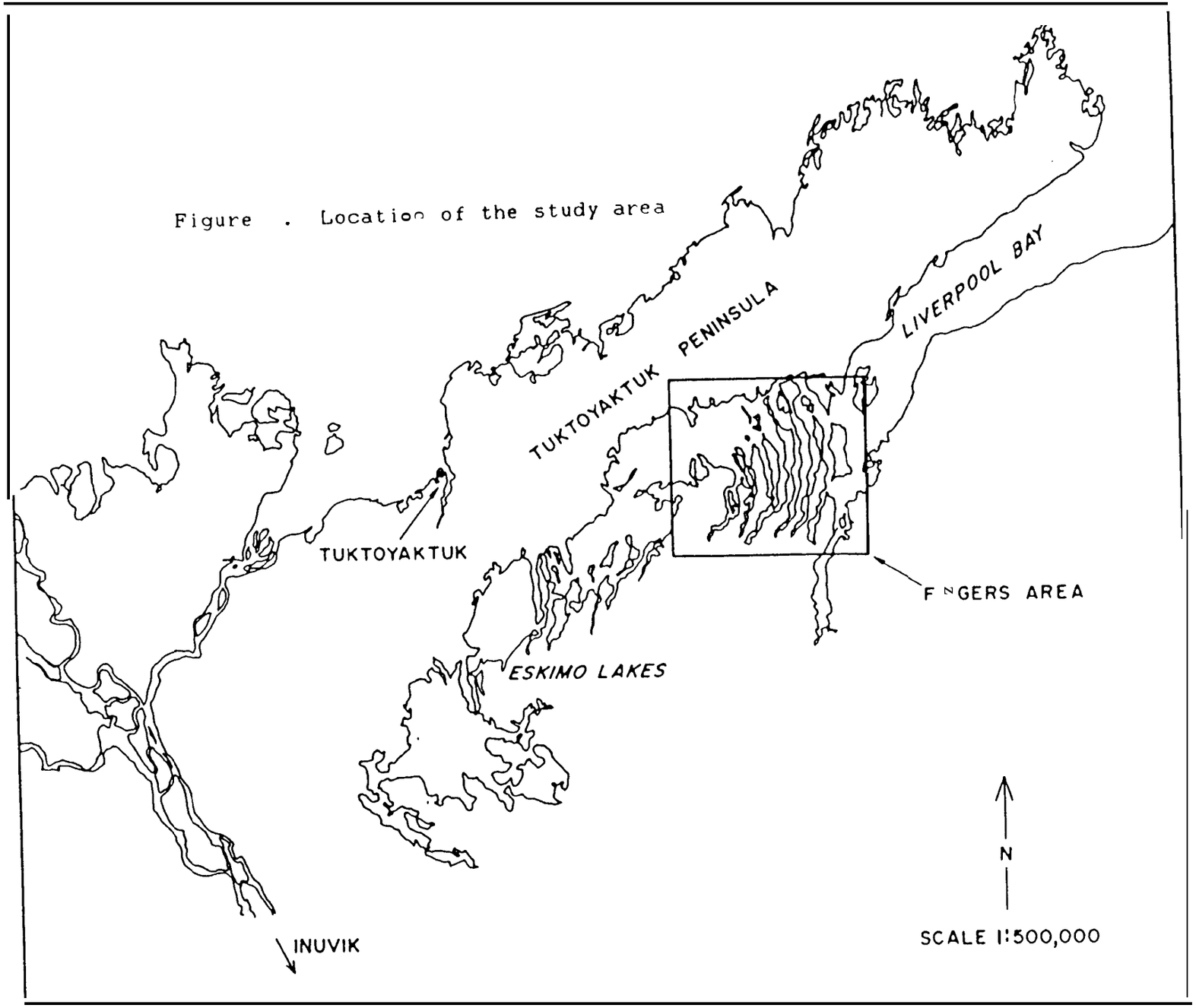


Figure . Location of the study area

Finger One. Approximately 400 kg of roe were extracted from 4,580 kg. of this catch (8.7% roe yield). The roe was shipped to Vancouver for market evaluation and assessed as marketable.

The objective of this project was to determine the size of the herring stock in the area. It is essential to have an estimate of stock size in order to determine harvest quotas and then assess whether the herring stock will allow for an economically viable fishery.

Spawn deposition surveys provide stock estimates by enumeration of eggs in the spawn area. Pacific herring deposit adhesive eggs on a variety of substrates, including marine plants and rock, in the subtidal and intertidal zone. In Liverpool Bay, the spawning period was thought to commence with ice breakup (Gillman and Kristofferson, 1984). In the cold Arctic water it was hypothesized that herring eggs would take 30 to 40 days to hatch (Alderdice, pers. comm.). This anticipated spawning pattern provided the opportunity to conduct a thorough spawn survey of the Fingers Area following ice breakup.

In order to estimate the size of the herring stock in the Finger's Area, the spawn deposition survey method was employed following ice breakup. The results of this survey provide an estimate of the number of eggs deposited in the study area. These data, coupled with information collected by DFO on fecundity (number of eggs per fish), sex ratio and population age composition allow the spawning stock of fish to be calculated. Decisions can then be made as to the potential for a viable herring roe fishery in the Western Arctic.

Synopsis of Herring Spawn Survey Methods

In British Columbia, annual assessments of the status of herring stocks and forecasts of abundance for the next season provide the biological basis for stock management. The spawning escapement (the number of fish which escape a fishery and other sources of mortal ity to spawn) is the single most important component in determining stock status (Haegele et al., 1979). The abundance of the "spawning escapement" is estimated from the number of eggs deposited (Hourston et al. 1972).

With the advent of the west coast roe fishery, the method used to calculate numbers of deposited eggs was based on estimates of length, width and intensity of specific spawnings. Eggs per square yard were determined from these observations. Since 1978, egg intensity has been rated in layers of eggs rather than on an intensity scale and new conversions to eggs per square meter have been implemented. Although these methods are still in use, Haegele and Humphries (1977) demonstrated that spawnings were not accurately assessed by this method and that better results were obtained using direct observations and samples collected by divers. Since 1975 the Herring Investigation Branch of the Pacific Biological Station has been developing and field testing a diver based survey at a variety of spawning habitats that occur on the B.C. coast.

The overall goal of a diver survey of spawn is to estimate the total number of eggs deposited by herring on the spawning grounds. Total egg number is determined from the area of the spawn and the average egg density. The area is estimated by

observing the length of spawn along the shore and measuring spawn width along transect lines placed perpendicular to shore.

These transect lines also serve as a reference grid for specific locations where samples of spawn (egg) density can be collected. A quadrat is placed at predetermined intervals adjacent to the transect line. A series of quadrat observations are made by the divers and all rooted vegetation and attached eggs contained in the quadrat are collected. The samples are sorted into distinct vegetation types and weighed, and subsamples are preserved for subsequent laboratory determination of the total number of eggs in the quadrat. The original quadrat observations, combined with the direct egg counts obtained in the laboratory, are used to calculate the average egg density of a specific spawn. This result, together with the original determination of the spawn area, provides an estimate of the total number of eggs deposited in the surveyed spawns.

Current research at the Pacific Biological Station" (PBS) has focused on developing a predictive model of herring spawn intensities based on diver observations. To construct this model, a set of keys has been developed which relate diver observations to direct counts of eggs per unit area from quadrat samples (Haegele *et al,* 1979). This model has been recently updated by Schweigert *et al.* (1985).

This predictive model is currently being refined by PBS staff in the West Coast field program. In the meantime, egg deposition estimates must still be made from direct egg counts of quadrat samples. Therefore, in the Fingers Area survey,

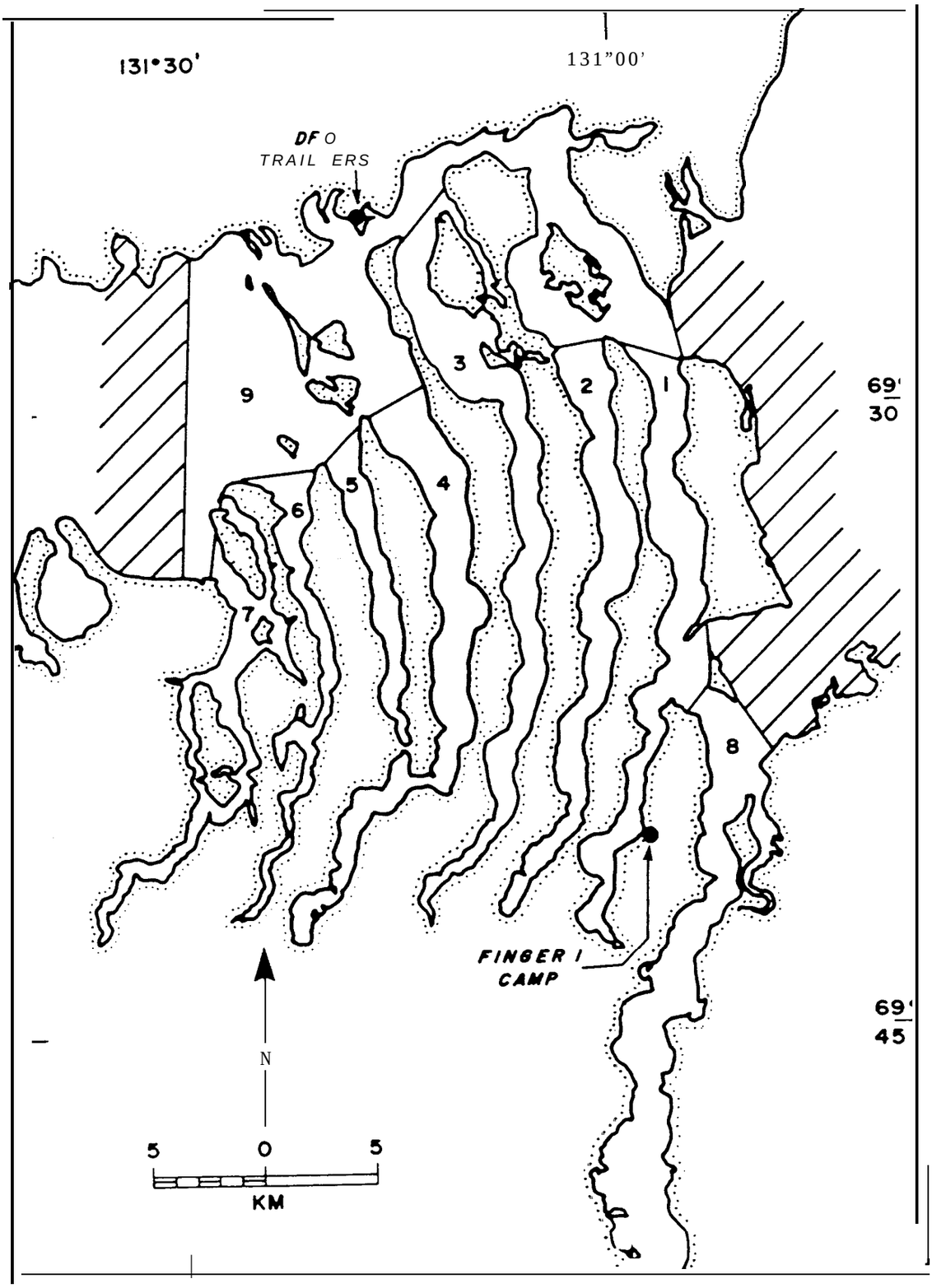
estimates of egg deposition were made from egg counts of samples. However, a series of diver observations were collected in order to facilitate the development of a predictive model for herring spawn deposition in this area in future years. If diver surveys are to be used routinely in the Fingers Area, a predictive model will substantially reduce the costs of the survey program.

MATERIALS AND METHODS

Study Area Description

The Fingers Area forms a 15 to 20 km. wide geographical boundary between Liverpool Bay and the Eskimo Lakes on the south west side of Tuktoyaktuk Peninsula (Figure 1). A series of narrow and convoluted peninsulas, together with a number of small islands, restrict the waterways between Liverpool Bay and Eskimo Lakes to a number of narrow channels. Numbering seven in total, the inlets or 'Fingers" between these peninsulas comprise the main portion of the study area. The remainder of the study area consists of the waterways between the seven fingers and the Tuktoyaktuk Peninsula, along with the approaches to the Kugaluk River estuary. Figure 2 illustrates nine subareas within the main study area.

The diver survey of herring spawnings was conducted between June 25 and July 20, 1985. Six diver/biologists and two local Inuvialuit worked from two base camps, located on the eastern shore of Finger One and the southern shore of the Tuktoyaktuk Peninsula opposite Finger Three (Figure 2). Twin otter and Cessna 206 aircraft equipped with floats were used to transport personnel, equipment and supplies to the camp sites. Three inflatables and one freighter canoe were used to conduct the study. Logistic support was provided by the Polar Continental Shelf Project located in Tuktoyaktuk.



"Figure 2. Location of the nine subregions within the study area.

Sampling Techniques

As little was known about herring spawning patterns in the area, it was necessary to conduct a preliminary survey in order to be sure that we could adequately cover the study area in sufficient detail to find areas of significant spawn. This portion of the program was conducted in Finger One as herring spawn had been previously observed in this inlet, and Finger One was a priority area for the previous DFO program (Gillman, and Kristofferson, 1984).

Three types of dredges were tested at this time by dragging them through known areas of spawning. The accuracy of each dredge, determined by the ability to dredge representative samples of various substrates and herring eggs, was verified by divers. An A-Frame dredge proved to be best suited for sampling the mud and sand bottom types which exist in the study area. The dredge frame was constructed of three 50 cm long 1" x 3" pieces of wood, with nails and two 3 lb. weights attached to -the bottom length. A burlap bag was attached to the frame for the collection of dredge materials, and a rope bridle attached to a 20 m tow line was used to pull the dredge with a boat.

The lower portions of Finger One and Finger Two were surveyed extensively by divers in order to become familiar with the herring spawning patterns in the study area. Based on this preliminary survey, a two phase sampling design suitable for the Fingers Area was developed.

The first phase of the program consisted of a reconnaissance survey to identify areas where spawn was present. The second phase consisted of a follow-up survey to carefully examine each

site where spawn was found. Following the preliminary survey, the dredge was used exclusively during the reconnaissance phase of the survey. Dredging was performed at regular intervals along the shore, usually by two or three boats working in unison. Within 6 km. of the head of each finger, dredge stations were spaced every 500 metres along shore. Spacing elsewhere was 1 km. or occasionally greater. This pattern was based on the known distribution of spawn in Finger 1 and Finger 2.

The dredge was deployed at a depth of 10 metres and towed toward shore to a depth of 1 metre at a speed of approximately one knot. After retrieving the dredge, the boat crew carefully inspected the contents for eggs. Incidence of major plants or animals were recorded for each dredge tow, and eggs were saved. When eggs were found in a sample, the crew marked the shore with flag tape indicating either the specific location or, for large spawns, the start and stop points along the shore. Eggs collected from the dredge sampling were later examined using a dissecting microscope to determine their age. Stages of egg development were determined using the key developed by Outram (1955) for west coast spawnings. The development of eggs from a known spawning date was periodically monitored over the course of the study and compared to Outram's guide. In addition, a number of eggs were kept in the lab and monitored daily until hatching occurred. This information was used to determine the development period of herring eggs, and to examine the synchrony of herring spawns within and between the Fingers.

After completion of the dredge survey in each finger, each

area was redredged to more accurately define the al ong shore limits of the spawn. A dive crew then conducted a detailed spawn survey to determine the width of each spawning so that spawn area could be calculated, as well as estimate the intensity of spawn deposition. The Haegele and Schweigert transect method (Schweigert and Fournier, 1982) was inappropriate for the small size of the spawn area and low concentration of eggs and substrate . Instead, transects to estimate spawn width and quadrat sampling to estimate egg deposition were conducted separately. Divers swam transects perpendicular to shore to measure the distance between the outer and inner edge of spawn. Also measured within this area was the distance with spawning substrate. A target of five width transects per kilometer of spawn was set.

Quadrat sample locations were chosen based on available substrate rather than a random process. This method of selective sampling was necessary because of the generally sparse . substrate cover. With each quadrat sample, a series of visual observations were recorded. Included were water depth, bottom type, substrate type, percent of the bottom covered with substrate, and intensity of spawn. After recording these observations, the entire quadrat contents were placed into a numbered burlap bag. A minimum of five quadrat samples were collected for each spawn. The sampling was designed to obtain a sufficient number of each major spawn substrate category.

Sample Processing

Quadrat samples of spawn were transported to the field camp

for processing. The spawn density was determined for each sample in terms of layers of eggs. The samples were weighed to the nearest gram (wet weight) and placed into labelled plastic bags. The samples were then preserved in Gilson's fluid and the bags heat sealed and stored" in 5 gallon plastic buckets. The preserved egg samples were later transported to the Bamfield Marine Station, located in Bamfield, B.C. for further processing.

At the laboratory, egg samples were sprayed with seawater through a 3mm mesh screen size, and subsequently a 602 urn mesh screen to catch the herring eggs. Since the spraying process was not successful in removing all attached eggs from the substrate, the material on both screens had to be examined for eggs.

Material caught on the 3mm mesh screen was examined under a desk-top magnifier and all eggs enumerated. The 602 urn mesh screen collected loose eggs as well as small bits of plant material and invertebrates that were forced through the larger mesh screen during the spraying process. This mixture was placed in a saturated solution of water and table sugar in a large finger bowl. After a few minutes, most of the material except the herring eggs sank and the eggs could be scooped *from* the surface. All the eggs thus recovered from the 602um mesh screen were counted in a small tray under a dissecting microscope .

Temperature/Salinity and Plankton Sampling

Temperature/salinity profiles and plankton tows were conducted throughout the Fingers Area during the course of the

study. Temperature and salinity measurements were recorded at standard depths (0,1,2,3,4,5,7,10 and 15m) using a YSI Model 33 temperature/salinity meter. Plankton tows were performed using a 330um black, 1/2 m2 Scor net equipped with a Narishige meter. Horizontal tows consisted of lowering the net vertically to the prescribed depth, towing at that depth for five minutes at 2-3 knots, and then retrieving the net vertically. For oblique tows the net was equipped with a 2 lb. weight attached to its rim. The net was lowered vertically to 10m depth, then towed for 1 minute at depths of 10, 7.5, 5, 2.5m, again at 1-2 knots. Between depths the net was raised obliquely without reduction in towing speed. At most stations four tows were performed: two horizontal at depths of 1.7m, one at 0.9m and one oblique tow from 10m to the surface. At shallow locations the deeper tows were deleted.

The plankton samples were fixed in 5% formaldehyde and stored in heat-sealed *core* bags. Each sample was screened at two separate occasions for fish larvae on a light table. All larvae found were removed from the samples, counted, identified, measured for length with an ocular micrometer, and assessed for presence of yolk sac.

A set of temperature/salinity and plankton stations within each Finger were made on the same day. In addition, one set of repeat measurements for early and late July were conducted in subareas three and eight.

RESULTS

Spawn. Locations

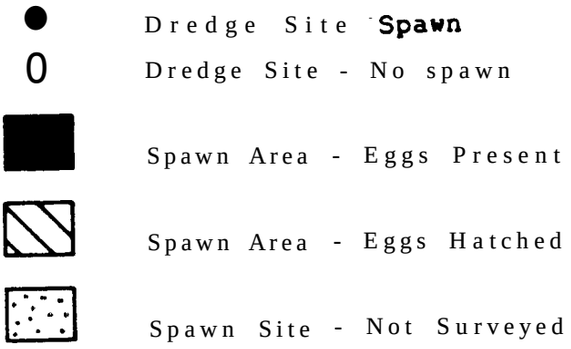
A total of 766 reconnaissance dredges were conducted throughout the study area. Spawn intensities were never greater than trace amounts. A total of 30 spawns were located. Of these, 18 were sampled and 12 were not sampled. In four of the unsampled spawns the eggs were hatched out, but egg cases were still present allowing the measurement of total spawn area. The remaining eight unsurveyed spawns were located by dredging, but subsequent diver surveys did not locate sufficent eggs eggs to sample . Figures 3 through 11 illustrate the dredge sites and the location of herring spawns within each subarea.

Spawning Substrates

The maj or spawn substrates consisted of various forms of eroded tundra and two types of vegetation. The vegetation included a leafy red algae (*Callophyllis*-like) and-a vascular seagrass similar to *Zostera marina*. These spawn substrates were broken down into the following categories:

1. Compact Mat -intact clumps of tundra
2. Course Debris - roots, sticks and small bits of tundra
3. Fine Debris - finely eroded bits of tundra
4. Wood Chips - fragments of wood smaller than 5 mm
5. Leafy Red Algae - *Callophyllis*-like
6. Seagrass - similar to *Zostera marina*

Depth of the herring spawns ranged between 1 m and 4.5 m. Most of these spawns were between 1 m and 3 m in depth, and were located on shallow sloping sand/mud flats. All but one of the spawns were located in the Fingers or the approaches to the



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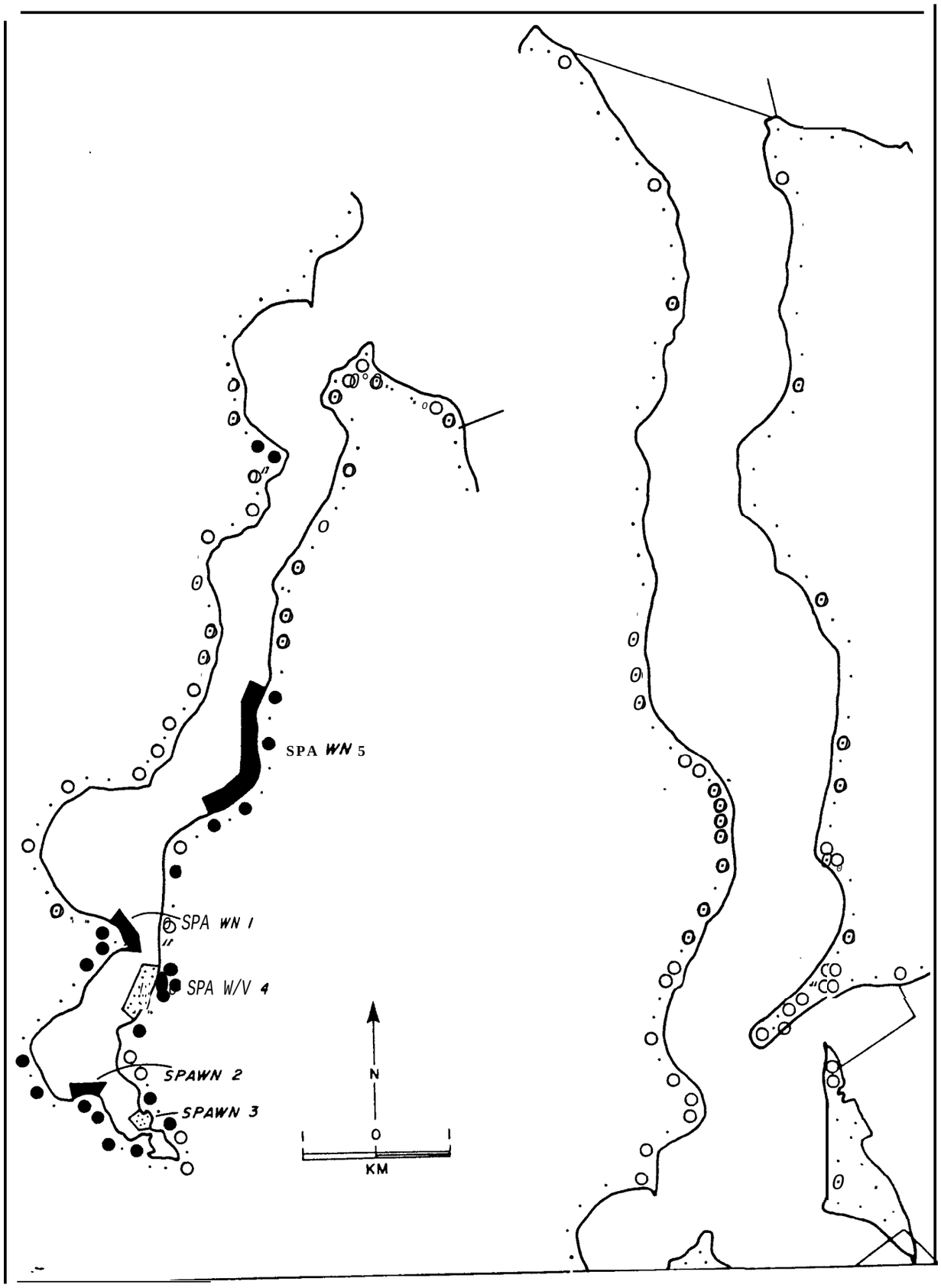
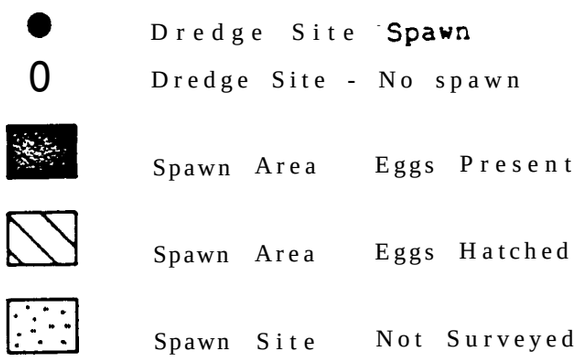


Figure 3. Location Of the reconnaissance sites and herring spawns within Subarea 1 .



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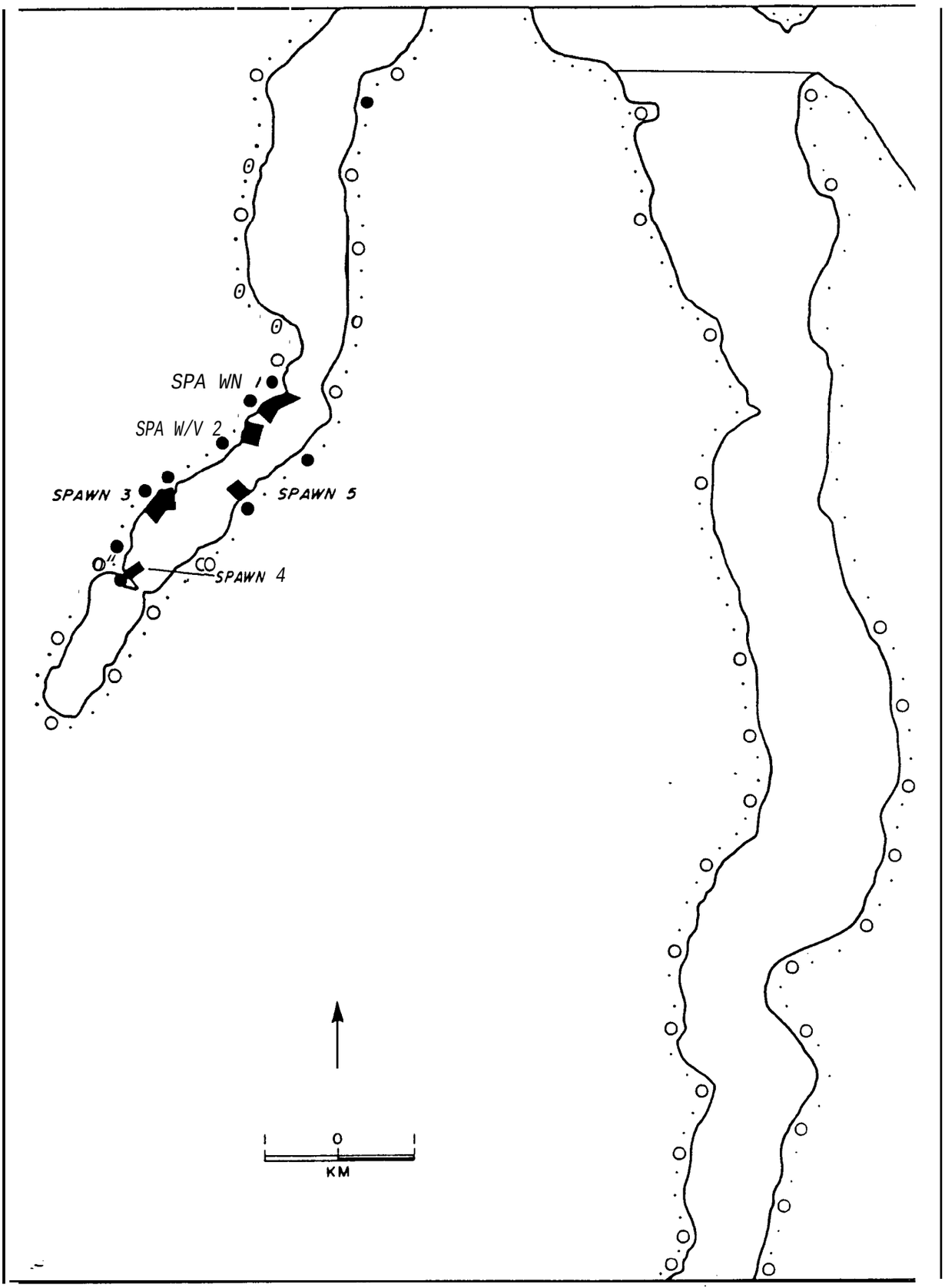

Figure 4. Location of the reconnaissance sites and herring spawns within Subarea 2.

Dredge Site - Spawn

Dredge Site - No spawn

Spawn Area - Eggs Present

Spawn Area - Eggs Hatched

Spawn Site - Not Surveyed

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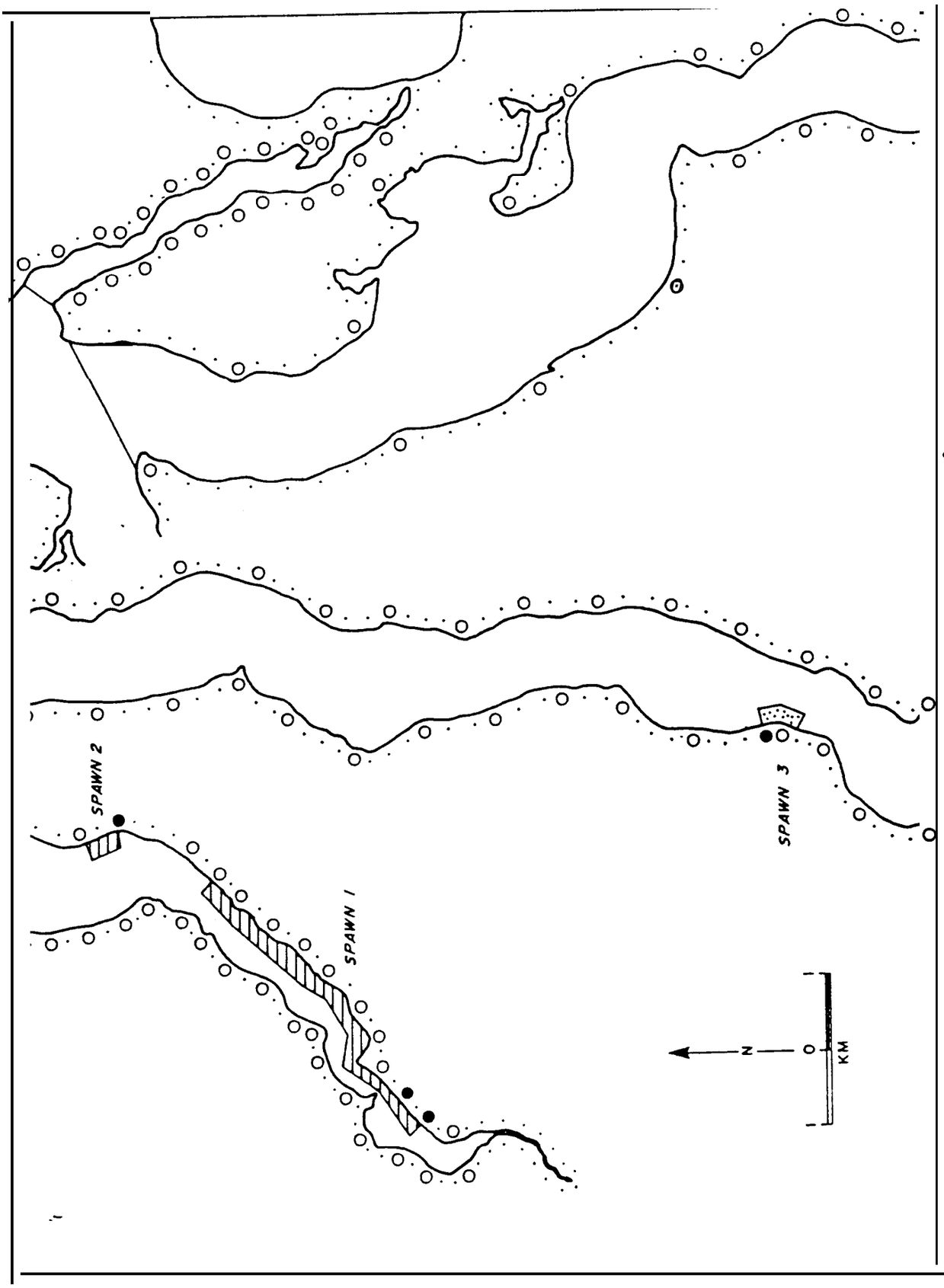
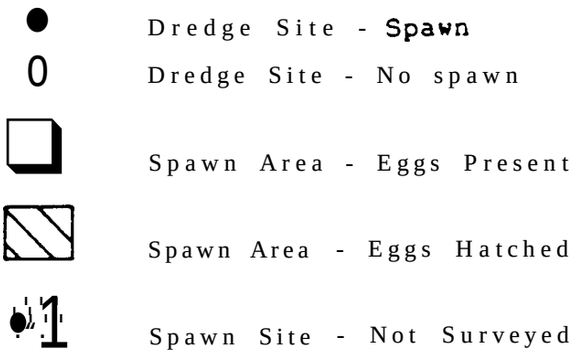


Figure 5. Location of the reconnaissance survey and spawns within Subarea 3.



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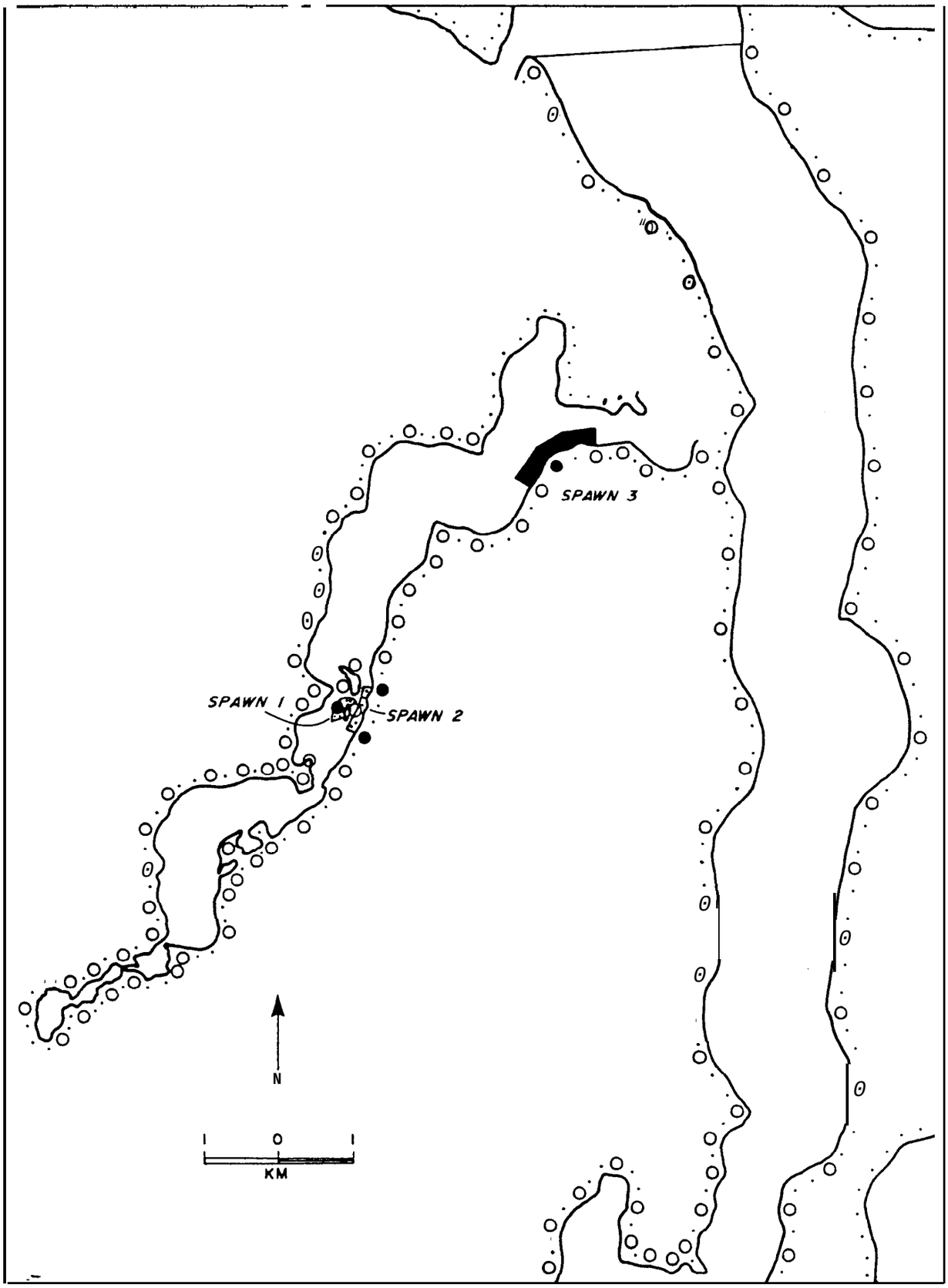
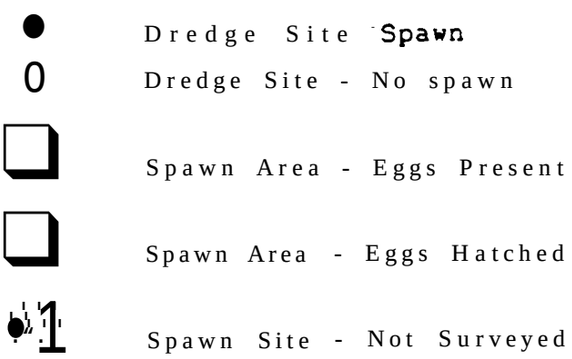


Figure 6. Location of the reconnaissance sites and herring spawns within Subarea 4.



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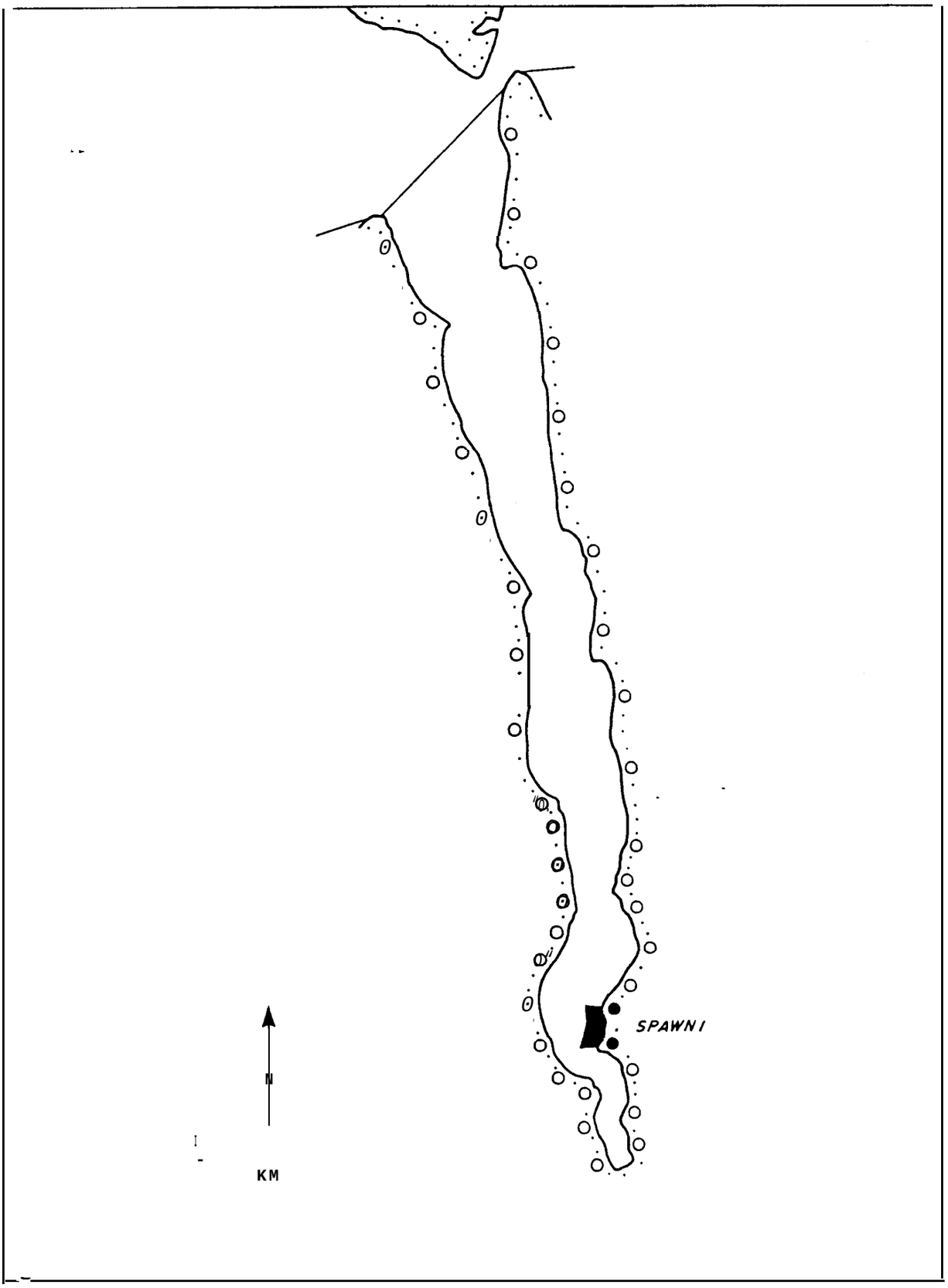
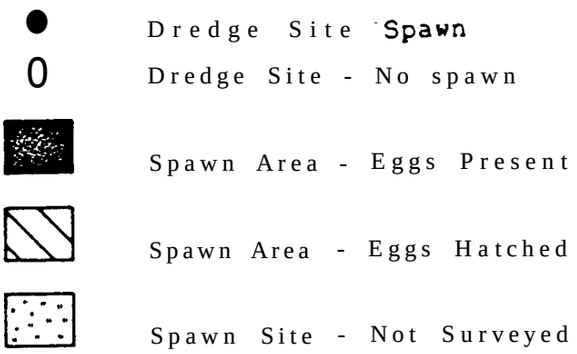


Figure 7. Location of the reconnaissance sites and herring spawns within Subarea 5.



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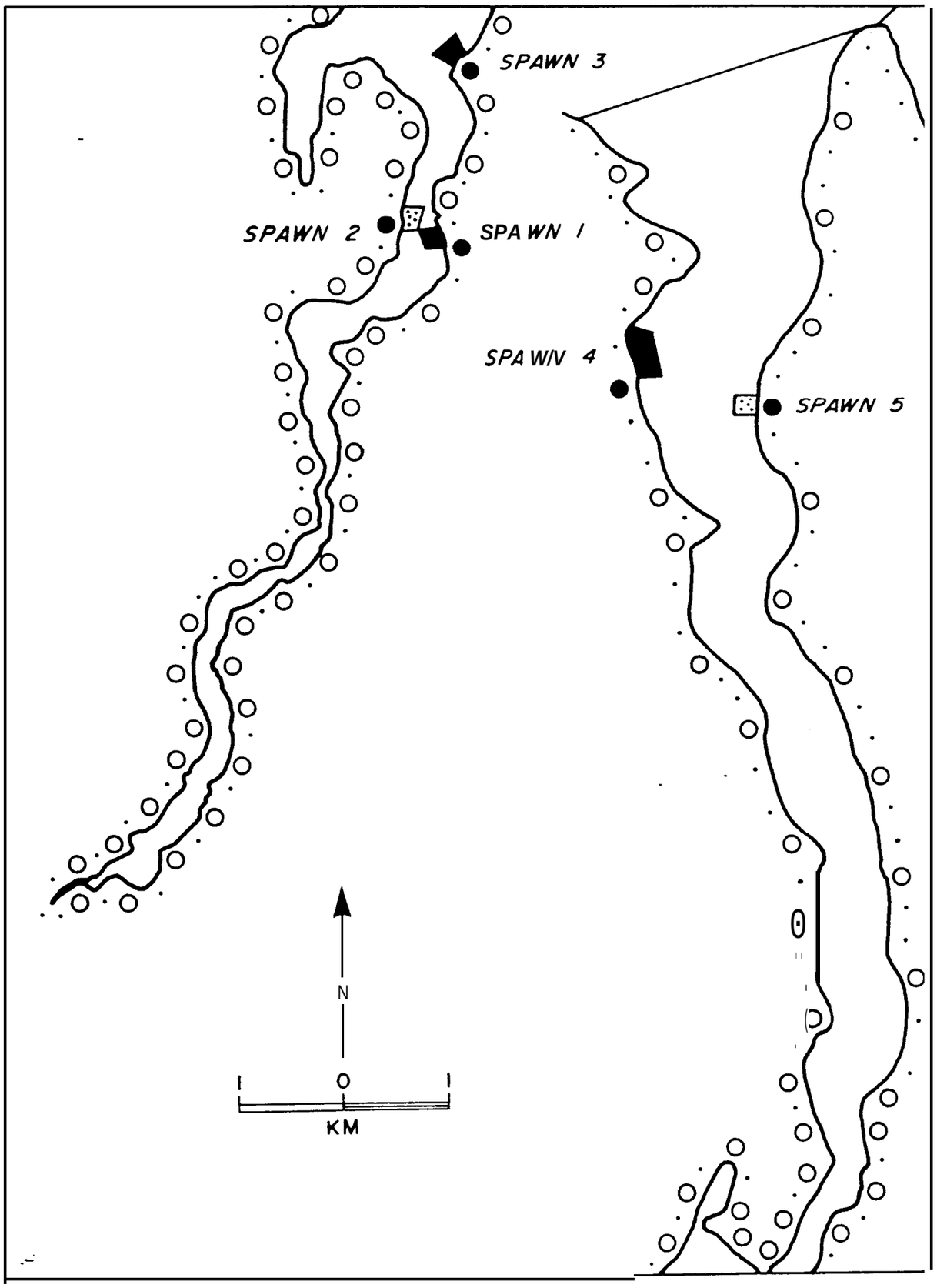

Figure 8. Location of the reconnaissance sites and herring spawns within Subarea 6.

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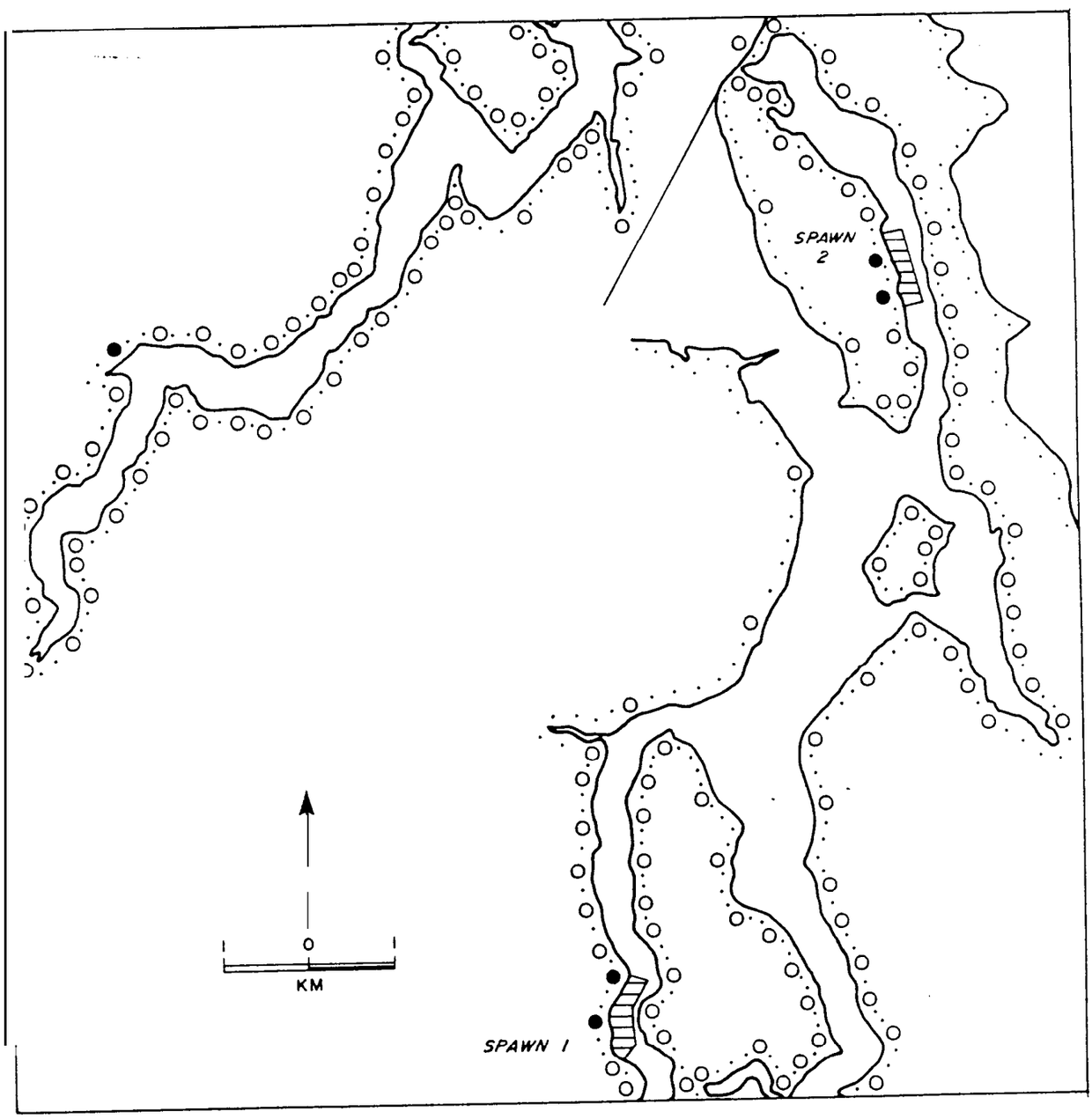
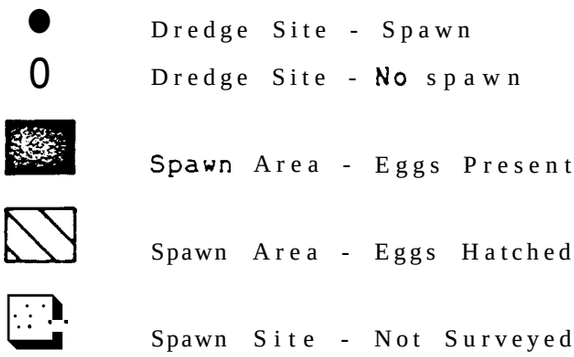


Figure 9. Location of the reconnaissance sites and herring spawns within Subarea 7.



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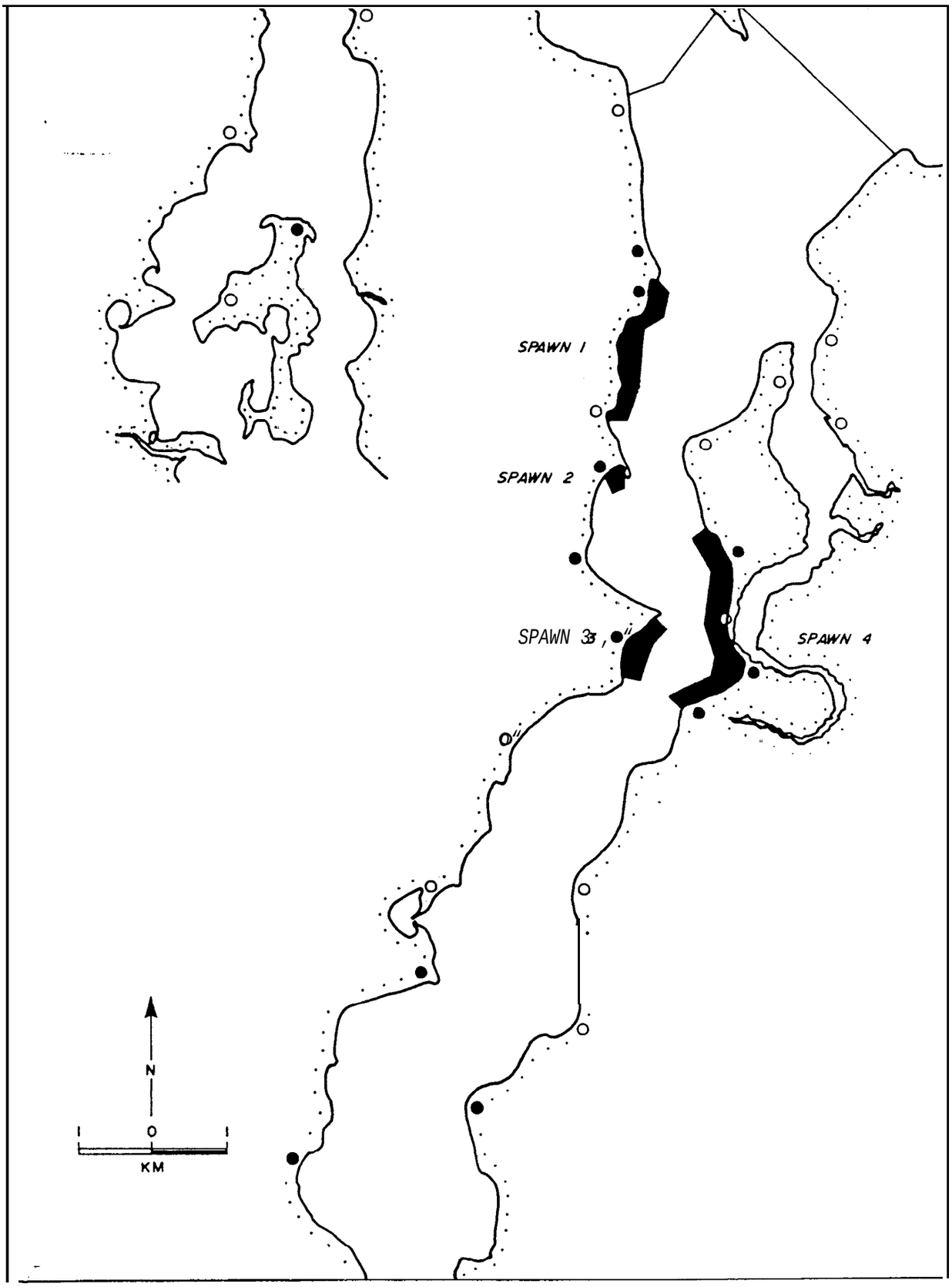
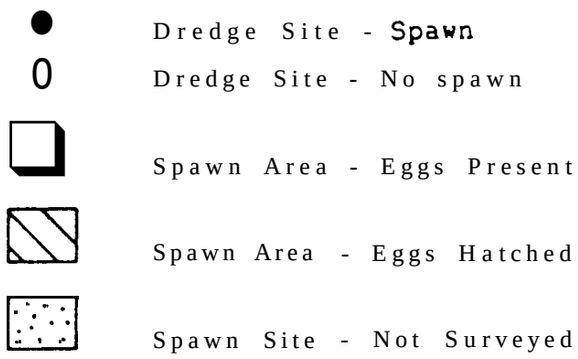


Figure 10. Location of the reconnaissance sites and herring spawns within Subarea 8.



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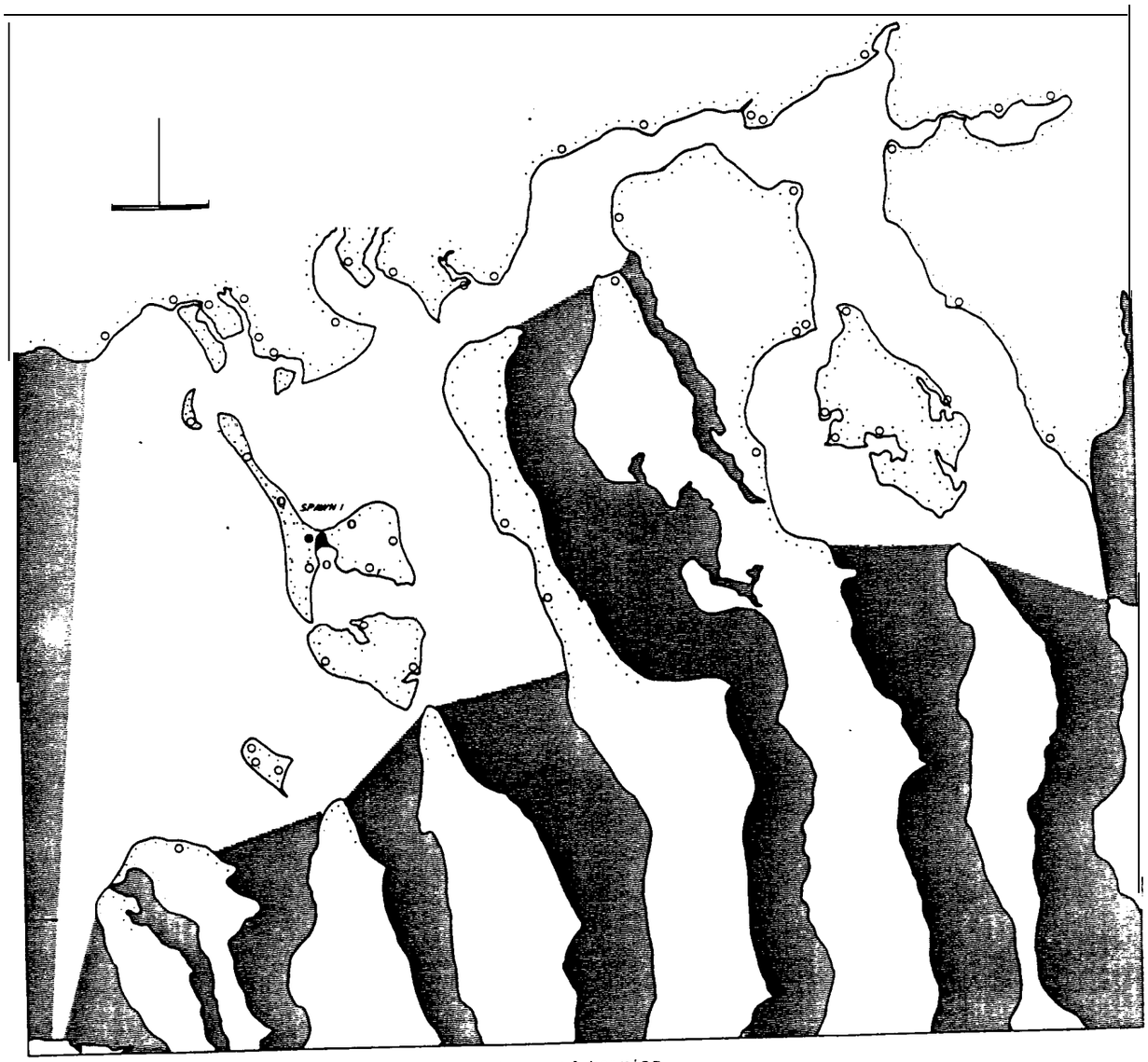


Figure 11. Location of the reconnaissance sites and herring spawns within Subarea 9.

Kugaluk River estuary. Twenty one of the spawns were within 6 km of the head of a finger.

When all of the spawns which were sampled are considered, 80 percent of the deposited eggs were located at the heads of Finger 1 and Finger 2 and within the approaches to the Kugaluk River estuary. Sixteen percent of the eggs were located in Finger 7, and the remaining 4 percent were distributed throughout the rest of the study area.

Number of Herring Eggs

Total number of eggs in the study area was estimated by multiplying the mean density of herring eggs by the area of observed spawn. Mean egg density for each of the six sampled substrate types (total number of quadrats = 130) was used. Except for coarse debris samples, mean egg densities from all quadrats within the study area containing identical substrate types were used to calculate total egg numbers. These five substrate types could not be grouped by subarea because of low sample size. There were a sufficent number of quadrat samples containing course debris to allow calculation of mean egg density for this substrate type by subarea.

Table 1 summarizes mean egg densities of sampled substrate types within the study area. A one-way analysis of variance indicates that mean egg density between the six substrate categories is significantly different throughout the study area ($P < 0.05$; Appendix I).

Table 2 summarizes the mean egg densities of coarse debris samples within the six subareas where coarse debris was found. A

Table 1. Mean egg densities of substrate types sampled throughout the Fingers Area.

Vegetation Type	Mean egg density m^{-2}	±95% C.I.	N
1. grass	237	± 112	24
2. foliose reds	10836	± 5574	17
3. compact mat	2460	± 2766	13
4. coarse debris	11507	± 6370	51
5. fine debris	22130	±24307	9
6. coarse chips	17111	±11158	16

Table 2. Mean egg densities of coarse debris samples.

Subarea	Mean egg density m^{-2}	±95% C.I.	N
1	36577	±23274	12
2	666	± 771	5
5	347	± 4235	2
6	4359	± 4033	9
8	5683	± 3961	14
9	2789	± 1769	9

one way analysis of variance indicates that the mean egg densities of the coarse debris substrate differ significantly between subareas ($P<0.05$; Appendix II).

For each spawn the appropriate mean egg density value for coarse debris (Table 2) and the overall mean egg density for the remaining five substrate types (Table 1) were multiplied by the measured area of each substrate type to calculate total egg

number. Table 3 summarizes the total number of eggs in each subarea calculated in the above manner. It is estimated that 482.93 x106 herring eggs were deposited in the study area (95% confidence interval = $\pm 336.54 \times 10^6$).

Due to the high degree of variance between mean egg values, a second method was used to verify the estimate of total egg numbers. All quadrat samples within a subarea (regardless of substrate type) were grouped together to calculate mean egg densities (Table 4). A one-way analysis of variance indicates that mean egg density also varies significantly between different subareas ($P<0.01$; Appendix III). Mean egg density for each subarea was multiplied by total spawn area within that subarea to calculate a second value for total egg numbers. Using this second method (Table 5), it is estimated that 410.79 $X10^6$ herring eggs were deposited in the study area (95% confidence interval = $\pm 183.25 \times 10^6$).

Both methods of estimating total egg numbers produce similar values. The 95% confidence interval remains wide whether the data are grouped according to subarea or by substrate type. These confidence intervals are likely a result of low sample size and patchiness of herring spawn. The analyses of variance results suggest that these two groupings of variables are valid and successful at reducing total sample variances. Future survey designs could improve on the present method by stratifying spawns in each subarea by spawning substrate and allocating sampling intensity according to the observed variances of each substrate type. The data collected in this study can be used to provide estimates of the sample effort required to achieve a desired

ıble 3. Spawn survey results and estimates of total egg numbers using mean egg densities by substrate type.

ıcations	spawn description: eggs present	eggs hatched	not surveyed	shoreline length (m)	total area (m^2)	substrate type*	estimated area (m^2)	Mean egg density $\cdot m^{-2}$ (95% C.I.)	Total nbr of eggs $\cdot 10^6$ (95% C.I.)
ıbarea 1									
Spawn 1	x			400	2360	4	826	36,577 ±23,274	30.21 ± 19.22
						5	425	22,129 ±24,307	9.40 ± 10.33
						6	1109	17,111 ±11,158	18.98 ± 12.37
Spawn "2	x			400	3120	5	1872	22,129 ±24,307	41.43 ± 45.50
						4	624	36,577 $23,274	22.82 ± 14.52
						6	624	17,111 ±11,158	10.6EI ± 6.96
Spawn 3			x	*400*					
Spawn 4			x	(300					
Spawn 5a			y	2, 000					
Spawn 5b	x		—	2,000	400	4	400	36,577 ±23,274	14.63 ± 9.31
ubtotals	3	0	3		5880				148.15 ±118.21
ubarea 2									
Spawn 1	x			500	2850	6	1283	17,111 ±11,158	21.95 ± 14.32
						2	1567	10,836 ± 5,574	16.98 ± 8.73
Spawn 2	x			400	2400	4	1920	665 ± 771	1.28 ± 1.48
						6	480	17,111 ±11,158	8.21 ± 5.36
Spawn 3	x			500	11,000	2	11,000	10,836 ± 5,574	119.2 ± 61.31
Spawn 4	x			150	2550	2	2550	10,836 ± 5,574	27.63 ± 14.21
Spawn 5	x		—	100	10	4	10	665 ± 721	0.01 + 0.01
ubtotals	5	0	o		18,810				195.26 ±105.41

Table 3. Spawn survey results and estimates of totalegg numbers using mean egg densities by substrate type.
continued . . .

Locations	spawn description: eggs present	eggs hatched	not surveyed	shoreline length (m)	total area (m^2)	substrate type*	estimated area (m2)	Mean egg density $\cdot m^{-2}$ (95% C.I.)	Total nbr of eggs $\cdot 10^6$ (95% C.I.)
Subarea 3									
Spawn 1		x		4500	9900	1	9900	236 ± 112	2.34 ± 1.11
Spawn 2		x		500	1100	1	1100	236 ± 112	0.26 ± 0.12
Spawn 3			x	100					
Subtotals	0	2	1		11,000				2.60 ± 1.23
Subarea 4									
Spawn 1			x	150					
Spawn 2			x	500					
Spawn 3	x			1000	6100	1	5673	236 ± 112	1.34 ± 0.64
						6	427	1711 511,158	7.31 ± 4.76
Subtotals	1	0	2		6100				8.65 ± 5.40
Subarea 5									
Spawn 1	x			500	550	3	330	2459 ± 2766	0.81 ± 0.91
						4	220	346 ± 4235	0.08 ± 0.93
Subtotals	1	0	0		550				0.89 ± 1.84

ts and estimates of total egg numbers us:ng mean egg
rate type.

iption not surveyed	shoreline length (m)	total area (m^2)	substrate type*	stimated area (m^2)	Mean egg density $\cdot m^{-2}$ (95% C.I.)	Total nbr of eggs $\cdot 10^6$ (95% C.I.)
	3∞	420	1	420	236 ± 112	0. ○ ± 0.°5
x	2∞	-				
	3∞	240	4	96	4358 ± 4032	0.42 ± 0.39
			5	144	22129 ± 24307	3.19 ± 3.50
	400	94	4	94	4358 ± 4032	0.41 ± 0.38
x	500	-				
2		754				4.12 ± 4.32
	1000	7400	4	1480	11506 ± 6370	17.03 ± 9.43
			1	4070	236 ± 112	0.96 ± 0.46
			5	1850	22129 ± 24307	40.94 ±44.97
	1200	5400	1	3780	236 ± 112	0.89 ± 0.42
—			4	1620	11506 ± 6370	18.64 ±10.32
0		12,800				78.46 ±65.60

ults and estimates of total egg numbers using mean egg
strate type.

cription		shoreline length (m)	total area (m^2)	vegetation type*	estimated area (m^2)	Mean egg density $\cdot m^{-2}$ (95% C.I.)	Total nbr of eggs $\cdot 10^6$ (95% C.I.)
s hed	not surveyed						
		2100	3570	3	3213	2459 ± 2766	7.90 ± 8.89
				4	357	5682 ± 3961	2.03 ± 1.41
		300	960	4	960	5682 ± 3961	5.45 ± 3.80
		800	3440	4	3440	5682 ± 3961	19.55 ±13.63
		2800	2520	4	1512	5682 ± 3961	8.59 ± 5.99
	—			1	1008	236 ± 112	0.24 ± 0.11
	0		10,490				43.76 ±33.83
		100	380	4	342	2789 ± 1769	0.95 ± 0.60
	—			3	38	2459 ± 2766	0.09 ± 0.10
	0		380				1.04 ± 0.70
	8		66,764				482.93 ± 336.54

fine debris
wood chips

level of sample variance.

Table 4. Mean egg density by subarea.

Subarea	Mean egg density r-n-^{2}	95% C.I.	N
1	33211	±12184	27
2	7074	± 3743	28
4	269	± 144	15
5	187	± 365	5
6	2253	± 1875	20
8	4445	± 1227	25
9	2574	± 1627	10

Corrections for Spawn Lengths and Sample Interval

In areas where spawns were considered to occur (within 6 km. of the heads of the Fingers) the dredges were conducted at 500m intervals along shore. Assuming that the dredge is 100% effective in detecting spawn, this sampling interval would detect all spawns 500m or greater in length, but could miss some spawns less than 500m in length. To evaluate the effect of sampling interval, known spawns less than 500m in length were grouped into 100m intervals as shown in Figure 12. Of these fourteen spawns, five were 100-200m in length and five were 400-500m in length. This observed frequency can be corrected by considering the probability of detecting spawn of given length by using a 500m sampling interval (Table 6). For example, randomly

Table 5. Summary of spawn survey information and estimates of total egg numbers using mean egg densities by subarea

Sub area	Nbr dredges	Nbr transects	total	with eggs	eggs hatched	not surveyed	Spawn area (m^2)	Nbr quadrats	Mean egg density $.m^{-2}$ (95% C.I.)	Total number of eggs $. 10^6$ (95% C.I)
	47	77	6	3	0	3	5,880	27	332[1] (±12,184)	195.28 (±71.64)
2	89	34	5	5	0	0	18,810	28	7074 (±3743)	133.06 ±70.41)
3	103	05	3	0	2	1	11,000	0	236[1] (±112)	2.60 (± 1.23)
4	110	0	3		0	2	6,100	5	269 (±144)	1.58 (± 0.88)
5	42	03	1	1	0	0	550	5	187 (±365)	0.10 (± 0.2)
6	109	25	5	3	0	2	754	20	2253 (±1875)	.70 (± 1.41)
7	153	07	2	0	2	0	12,800	0	2253[2] (±1875)	28.84 (±24.0)
8	63	7	4	4	0	0	10,490	25	4445 (±1226)	46.63 (±12.86)
9	50	04	1	1	0	0	380	10	2574 (±1627)	1.00 (± 0.62)
otals	766	82	30	18	4	8	66,764	130		410.79 ± 83.25

. No quadrats taken. Use overall mean egg density for grass substrates.

2. Spawn substrates similar to those in Subarea 6.

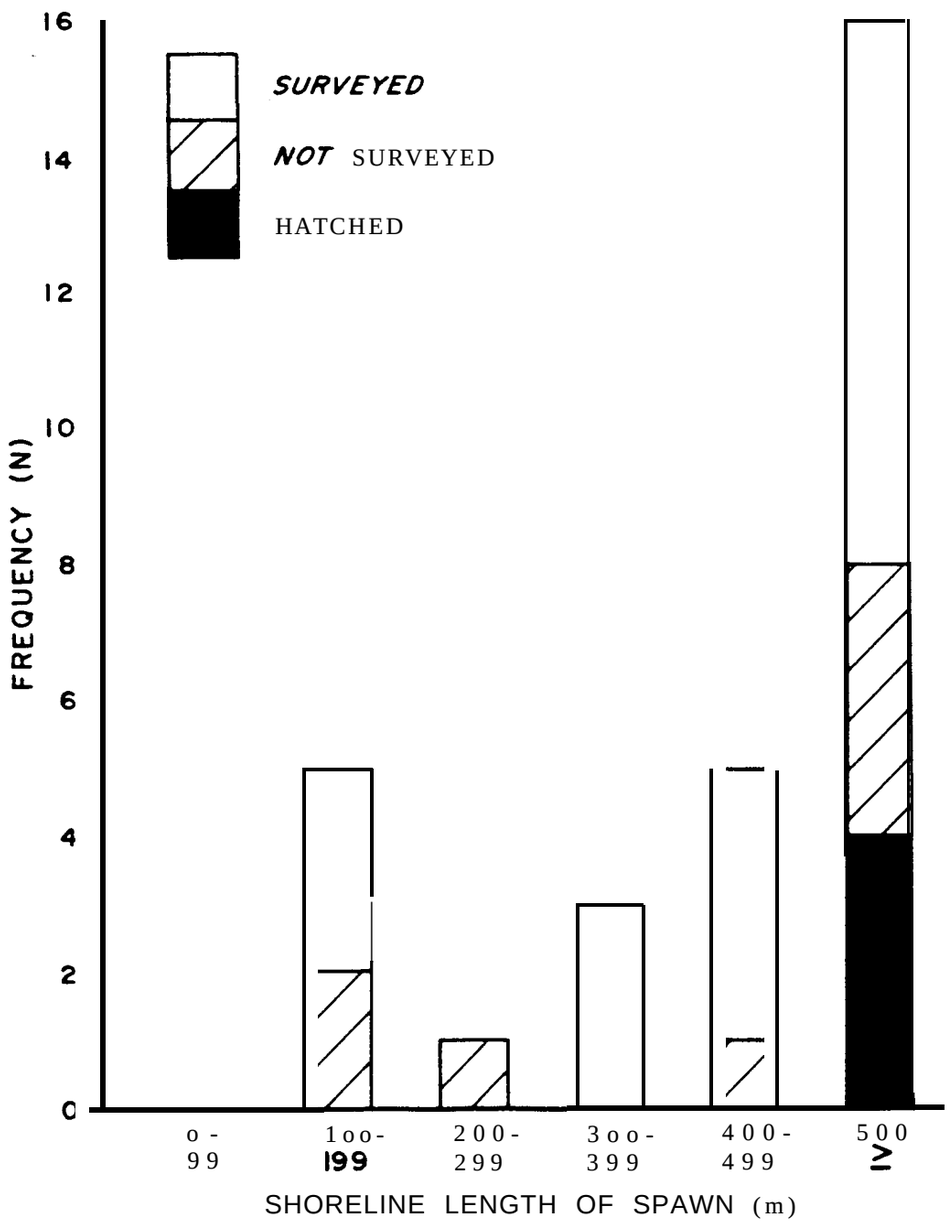


Figure 12. Frequency of spawn lengths in IOOm intervals.

expected frequency is 16.7 (5/0.30). Likewise 90% of the 400-500m spawns were detected giving a total expected frequency of 5.5. A total of 28.5 spawns less than 500m are expected by applying these corrections over all length intervals.

Table 6. Actual and expected number of spawns by spawn length interval, correcting for probability of *error* using a 500m sample interval.

Spawn Length (m)	Probability of Detection	Observed Number	Expected Number	Ave. Eggs/ Spawn x106 (±95% C.I.)	Corr. Nbr. Total Eggs x10^6 (±95% C.I.)
o-99	0.1	0	0	0	0
100-199	0.3	5	16.7	5.74(±2.98)	95.86(±49.77)
200-299	0.5	1	2.0	0	0
300-399	0.7	3	4.3	3.05(±2.58)	13.12(±11.09)
400-499	0.9	5	5.5	28.68(±23.22)	157.74(±127.7)
SUBTOTALS		14	28.5		266.72(±188.57)
>500	1.0	16	16		301.67(±197.77)
		GRAND TOTAL (Corrected)			568.39(±386.34)

The se results suggest that a considerable number of spawns measuring less that 500m were overlooked using a 500m sampling interval. While a shorter interval would have reduced this problem, there would not have been enough time to cover the entire study area. Future surveys could incorporate a 200m sample interval by using prior information from this study and preliminary aerial surveys to exclude the large areas devoid of substrate where spawning is not likely to occur.

Carrying the calculations in Table 6 one step further the amount of undetected spawn can be roughly estimated. For each spawn length interval the mean number of eggs per spawn is given.

Correcting for the expected number of spawns in each interval provides a corrected estimate of total spawn. It is estimated that 14.5 spawns measuring less than 500m in length were missed by the 500m sampling interval. Approximately 85.4 x 106 eggs (95% C.I. = $\pm$49.79 x 10^6) were deposited in these spawns. When added to the number of eggs calculated from grouping spawn samples by substrate type (method 1), the corrected number of total eggs in the Fingers Area is estimated to be 568.39 $\times 10^6$ eggs (95% C.I. = $\pm$386.34 x 106).

Spawner Biomass

The number of eggs per gram of total female body weight is a useful measure of relative fecundity, particularly for spawn surveys used to estimate total biomass of spawning fish (Hay, 1985). Two advantages of the eggs per gram estimate in Pacific herring is its relative uniformity over fish size and geographical regions. As a rule of thumb for British Columbia herring, an estimate of 200 eggs/female gram is used to convert egg numbers to tonnes of spawners (Hay 1985). This represents a total of 108 eggs deposited per tonne of spawning herring of both sexes.

Based on fecundity measurements of prespawning herring collected in the Fingers Area during June 1985, there was an average of 138 eggs per gram of female herring (R. Tanasichuk, pers. comm.). Respective fecundities of herring collected in Subareas 1,2,4 and 5 are 116, 150, 151 and 136 eggs per gram of total female weight (R. Tanasichuk, pers. comm.). Although the fecundities were statistically different between subareas, the

mean value can be used to roughly estimate spawner biomass for all of the spawns within the study area. This amounts to approximately 6.9 X 10^7 eggs per tonne of both sexes, assuming a 1:1 sex ratio. Using this conversion factor, it is estimated that 8.24 tonnes of herring spawned in the Fingers Area (95% C.I.= ±5.6 tonnes). Estimates of spawner biomass for the nine subareas along with 95% confidence intervals are presented in Table 7.

Table 7. Estimates of spawner biomass in the Fingers Area.

Subarea	Egg Nbr. x10^6 (±95% C.I.)	Tonnes of Spawners (95% C.I.)
1	148.15 (±118.21)	2.15 (0.44 - 4.21)
2	195.26 (±105.41)	2.83 (1.30 - 4.36)
3	2.6 (± 1.23)	0.04 (0.02 - 0.06)
4	8.65 (± 5.4)	0.13 (0.05 - 0.21)
5	0.89 (± 1.84)	0.01 (-0.02- 0.04)
6	4.12 (± 4.32)	0.06 (O - 0.12)
7	78.46 (± 65.6)	1.14 (0.1-9 - 2.09)
8	43.76 (± 33.83)	0.63 (0.14 - 1.12)
9	1.04 (± 0.70)	0.02 (-0.01- 0.03)
Undetected Spawns	85.46 (+ 49.79)	1.24 (0.52 - 1.96)
TOTAL	568.39 (±384.33)	8.24 (2.67 -13.81)

Spawning Dates

The development of herring eggs from known spawning dates were periodically monitored over the course of the study as well as monitored daily in the lab until hatching occurred. This information was used to estimate the incubation period for herring eggs in the study area, and to calculate a conversion

factor for egg age at a particular embryonic stage in Outram's (1955) key. It is estimated that the incubation period for herring' eggs in the Fingers Area is 24 days in contrast to 15 days in British Columbia waters. Egg ages described in Outram's guide were corrected by a factor of 1.6 to determine the age of herring eggs in the Fingers Area.

Table 8 summarizes the estimated spawning dates for all the spawns in the study area based on egg aging data. The earliest observed spawning date was June 12 in Finger 2. The latest spawning date was July 16 in Finger 1 and the approaches to the Kugaluk River. Within fingers 2 through 7, the timing of first spawnings seems to follow an east-west pattern. This pattern seems to parallel the process of ice breakup and subsequent warming of surface waters in these areas. With the exception of Finger 3, spawning within all the subareas was protracted over the duration of the study.

Plankton Surveys

To determine if major spawns had hatched prior to the surveys in each subarea, plankton tows were conducted concurrently with the spawn surveys. A total of 167 plankton tows were made at 48 stations during the course of the study.

Ratynski (1983) demonstrated that, during the summer months (July-August, 1982) in Tuktoyaktuk harbour, herring larvae were most abundant in the surface waters. Therefore only data from the replicate surface tows were considered for this report. If herring larvae were present in tows at a given station but were absent from the surface tows, an estimate of larval density was

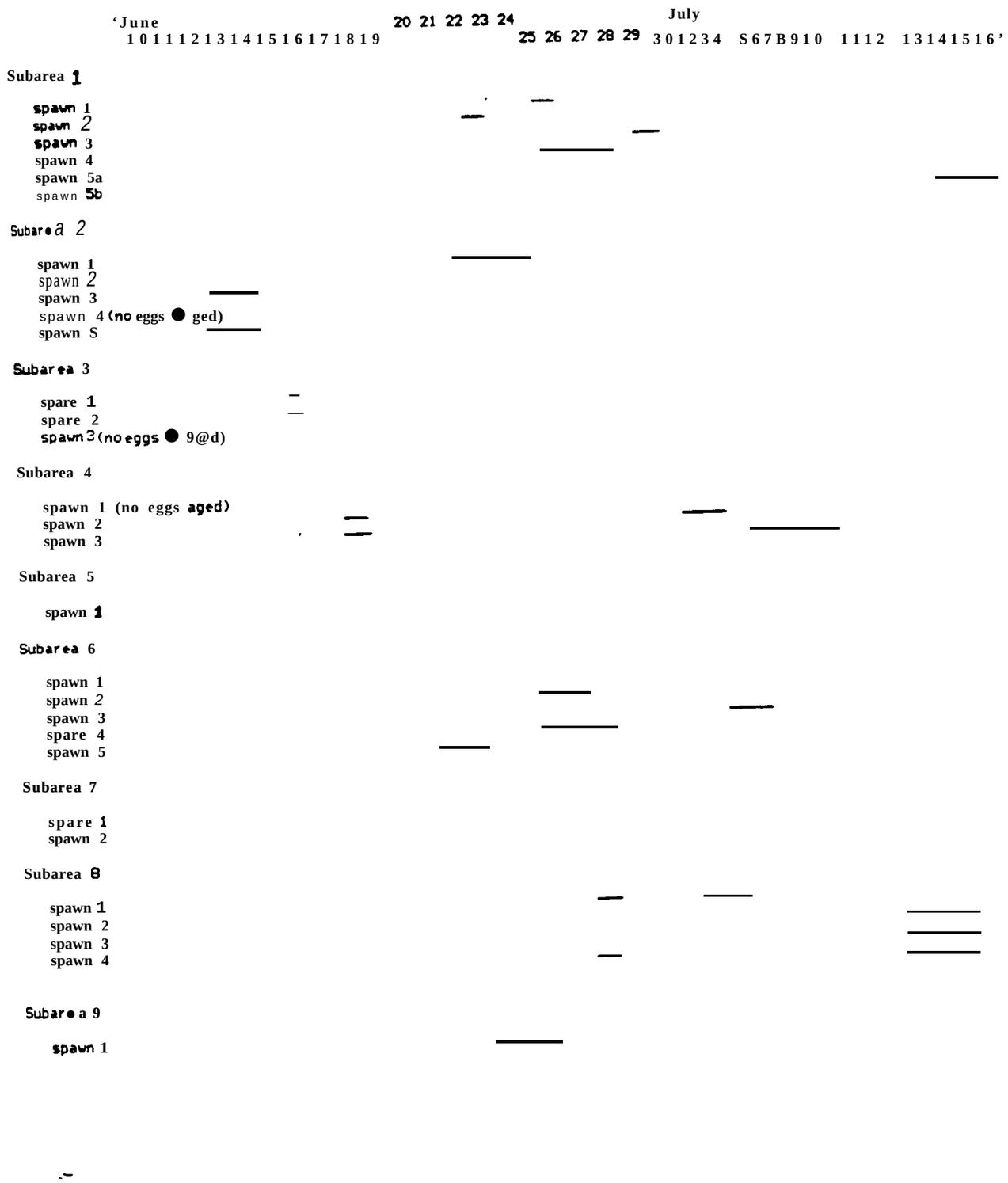


Table 8. **Summary** o'f estimated spawning dates for spawns located in the study area.

made from the tow containing the larvae. This occurred only at one station. To calculate larval density a mean value from the replicate tows was used. The volume of water filtered was taken to be an average of that indicated by the meter (calibrated in a pool after the trip) for the particular type of tow. This was done to compensate for the times the meter malfunctioned in the field. Erroneous readings were not used in estimating the mean volume.

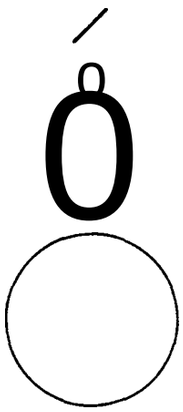
A summary of the plankton information is presented in Appendix IV. Figure 13 illustrates the developmental stage and size class, relative abundance and location of herring larvae in the study area.

Herring larvae were located at the heads of Fingers 2,4,5,6 and 7; and in the approaches to the Kugaluk River. Larvae were also found within a lagoon located in the northeastern portion of the study area. With the exception of the latter location, herring larvae were found near identified spawns. Larval concentrations were grouped into the following density categories: ≤ 0.01 larvae $/m^3$; 0.05 larvae /m3 and 0.40 larvae $/m^3$.

Developmental stages and size classes of the larvae were also grouped into three categories. These were: 0-7mm, yolk sac present; 7.0 $\leq$12mm, no yolk sac present; and >12mm, no yolk sac present. This data can be roughly compared to information regarding ages and concentrations of Pacific herring larvae in British Columbia waters in order to determine the magnitude of spawnings that may have been missed.

Alderdice and Velsen (1971) suggested that herring larvae in

Larval Density at 1m Depth*



larvae not present

< 0.01 larvae/m^3

0.05 larvae/m^3

0.4 larvae/m^3

Larval Stage

yolk sac present
0 - 7.0mm

7.0 < 12.0mm
no yolk sac present

>12.0mm
no yolk sac present

* Mean of 2 replicate horizontal tows. Presence or absence corroborated by horizontal tows at 0m and 2m tows, and an oblique tow from 5m - 0m.

Legend for Figure 13

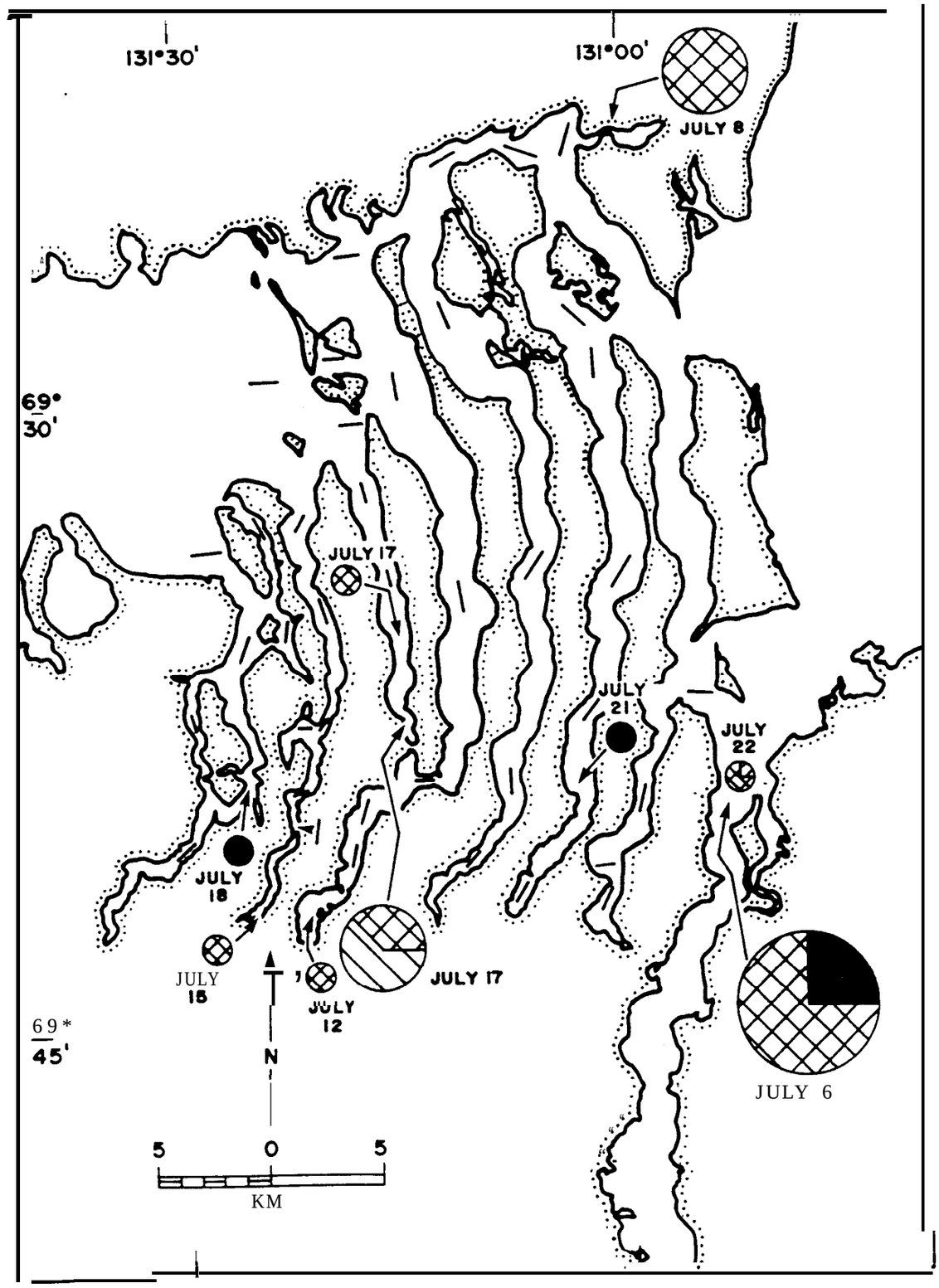


Figure 13. Summary of developmental stage, relative abundance and location of herring larvae within the study area.

the Strait of Georgia which had vestiges of yolk remaining were less than seven days old, and that larvae grew at a rate of 0.48 - 0.52mm/day at temperatures of 8.8 - 9.1°C. Von Westernhagen and Rosenthal (1979) estimated that larvae (approximately 14mm) of the same presumed age collected in the same area grow at a rate of about 0.46mm/day at temperatures of 10.1 - 11.5°C.

Arai and Hay (1982) estimated that the rate of disappearance of herring larvae from the inshore waters of Baynes Sound (Strait of Georgia) was 45 percent per week. In addition Arai and Hay (1982) estimated larval densities for inshore waters of Georgia Strait during the hatching period. In one region, they found densities of Pacific herring larvae (1981, Baynes Sound) in the upper 5m ranged from 1200/10 m 3 at the time of maximum larval density, reducing to 150/10m^3 seven days later, and 30/10m^3 fourteen days later.

Although it would be erroneous to assume similar growth and disappearance rates for herring larvae in the Arctic, a comparison to estimate approximate hatching dates and relative intensities of missed spawns would be useful. As seen in Figure 13 very few larvae were collected during the study. In most areas where larvae *were* found, the concentrations were 0.05 larvae/m^3 or less. It is therefore assumed that no major spawns hatched out prior to being surveyed.

Two size classes of herring larvae, at concentrations of 0.4 larvae/m^3 were found in Subarea 8 on July 6. If a growth rate of 0.46mm/day is assumed for the two size classes of larvae that were sampled, their approximate ages would be 15 to 26 days and greater than 26 days. If a disappearance rate of 45 percent per

week is assumed over four weeks, the maximum concentration of larvae at the time of hatching would be 4.4 larvae/m^3 (based on the largest size category). Compared to maximum larval densities in Georgia Strait, it would appear that spawns in Subarea 8 which hatched prior to being surveyed were not very significant. The spotty distribution and relatively low concentration of herring larvae throughout the study area indicates that no large spawns within the study area were missed by the survey.

Water Temperature and Salinity

Locations of all the temperature/salinity stations are illustrated in Figure 14. Sampling dates along with recorded temperatures and salinities for each station are presented in Appendix V. Figure 15 illustrates the temperature and salinity profile at three stations within Finger 3 on July 10 and July 20. The temperature of the upper 3m of water at the head of Fingers 3 was 12.5°C (July 10) and the salinity of this water was between 10 and 12°/oo. Water temperatures remained above 10°C and salinities remained below 13°/oo to a depth of 5m at both Station 1 and Station 2. Below 5m, temperatures dropped to 5-6°C and salinities increased to 16-19°/oo. Water temperatures at the mouth of the Finger (July 10) were between 7 and 10°C, and salinities were between 14 and 15°/oo to a depth of 3m. Below 3m water temperature dropped to 4.5°C and salinity increased to 16°/oo.

This same pattern is observed in fingers 4,5,6 and 7 during the first 2 weeks of July. Surface water at the heads of these

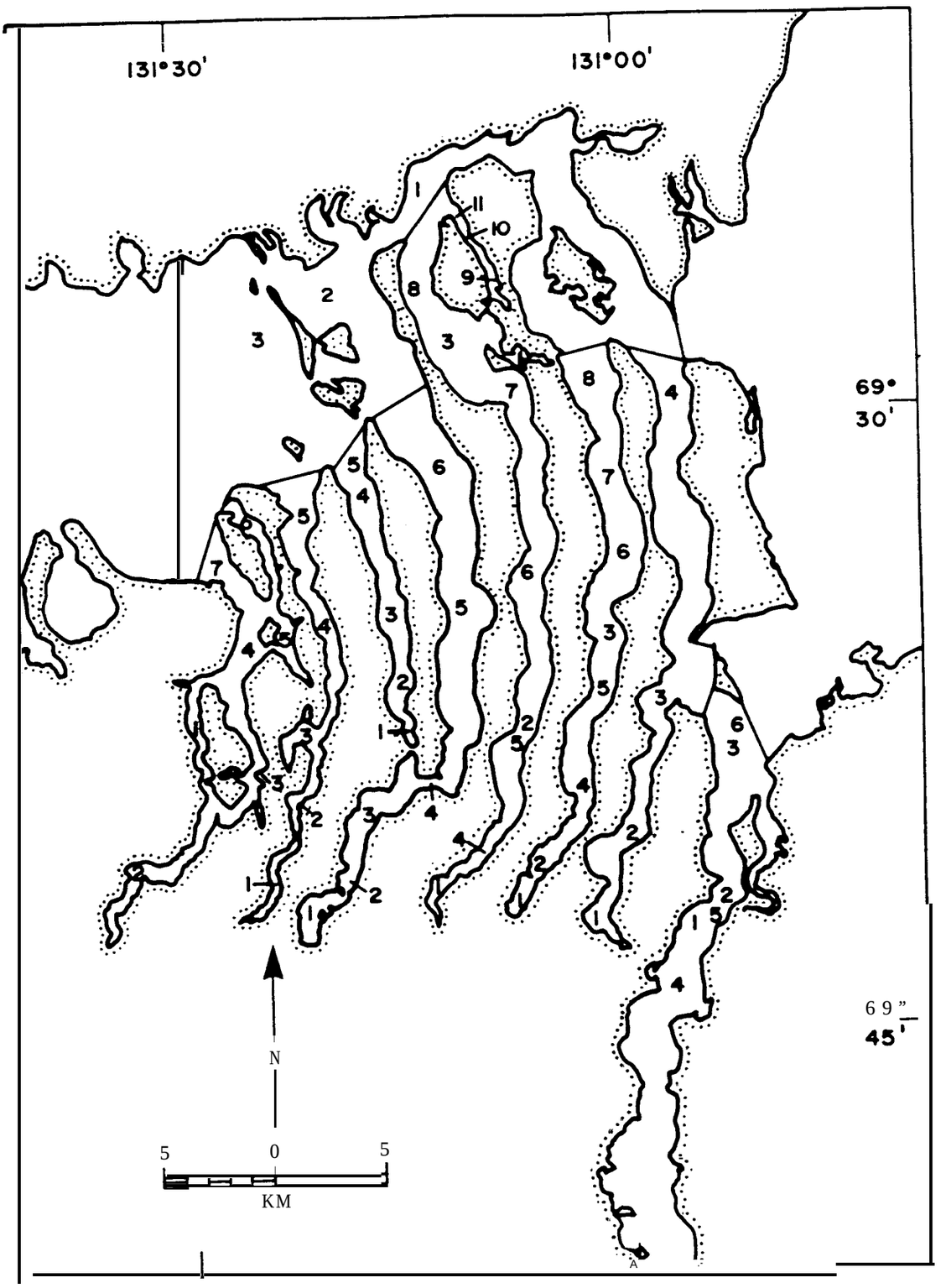
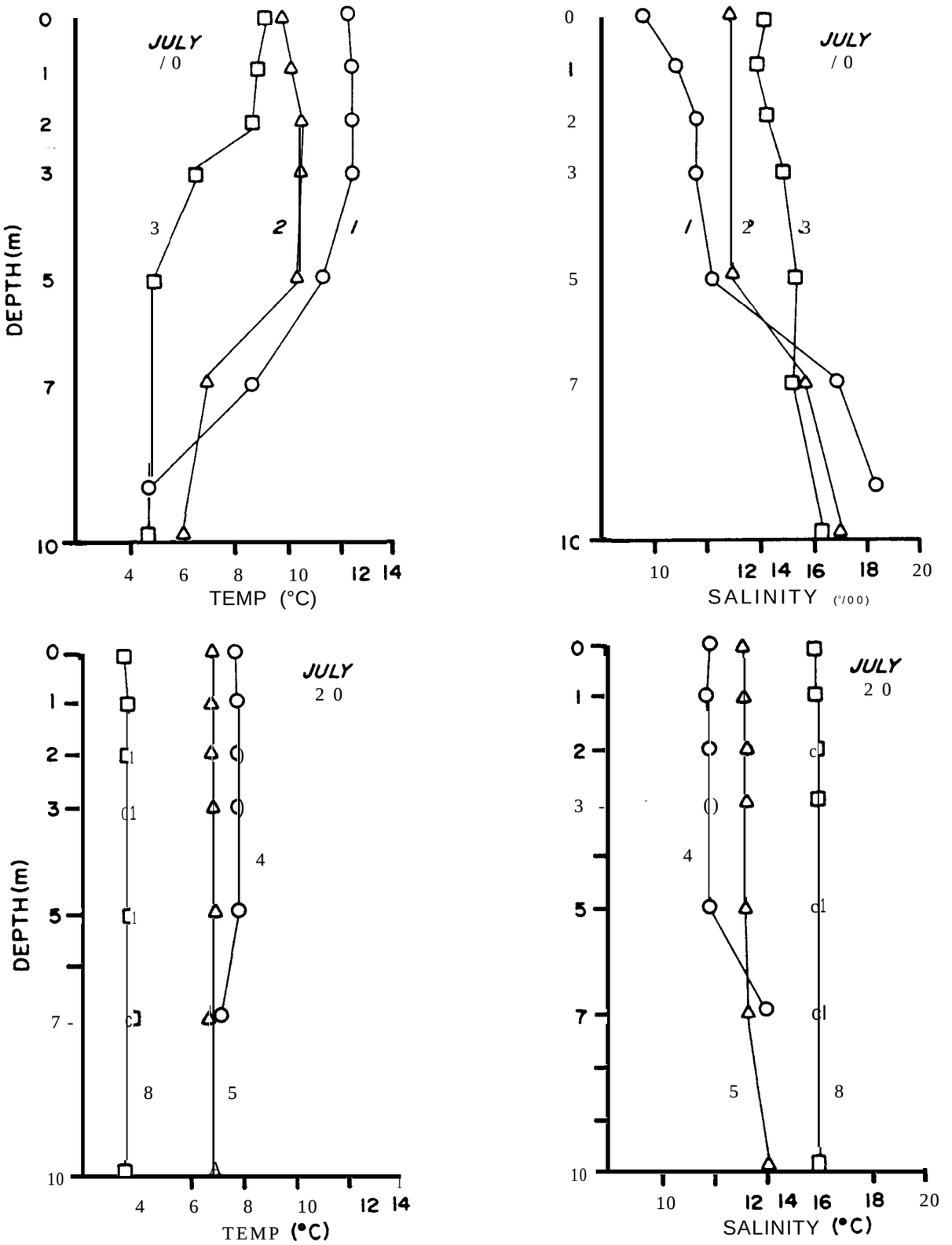


Figure 14. Locations of temperature and salinity stations within the study area.



"Figure 15. Temperature and salinity Profiles at three stations in Subarea 3 on July 10 and July 20. = head of subarea; A = middle of subarea; 0 °: mouth of subarea; # = station number.

inlets was warmer and less saline than water at the mouth of the Fingers. Within 5-6km from the heads of these Finger, a thermocline generally existed between 3 and 5m, above which temperatures ranged between 10 and 120C . Salinities of this surface water remained between 9 and 14°/oo. All of the spawns in these Fingers were located at depths within this warmer and less saline surface water.

The temperature and salinity profiles for the water within Finger 3 on July 20 indicate a mixing of the water column. Although the general pattern of warmer temperatures and lower salinities (as one proceeds south) is still evident, there is no layering of warmer, less saline surface water towards the head of the inlet. Mixing of the water column was most likely caused by increased surface water circulation following ice breakup, combined with high winds. There *is no* comparable data for other inlets.

Hydrographic conditions of the water within the Kugaluk approaches, Finger 1, and Finger 2 was different than those described for Fingers 4 - 7. This is likely due to the influence of Liverpool Bay and freshwater runoff from the Kugaluk River. Figure 16 illustrates temperature and salinity profiles in Finger 2 (July 3) and in the approaches to the Kugaluk River (July 7). In Finger 2 the thermocline was much shallower (approximately 2m). Towards the head of the Finger, surface water temperatures were still between 8 and 120C and salinities ranged between 6 and 16°/oo.

Temperatures and salinities of the water at stations in Subarea 8 indicate that the fresh water from the Kugaluk River

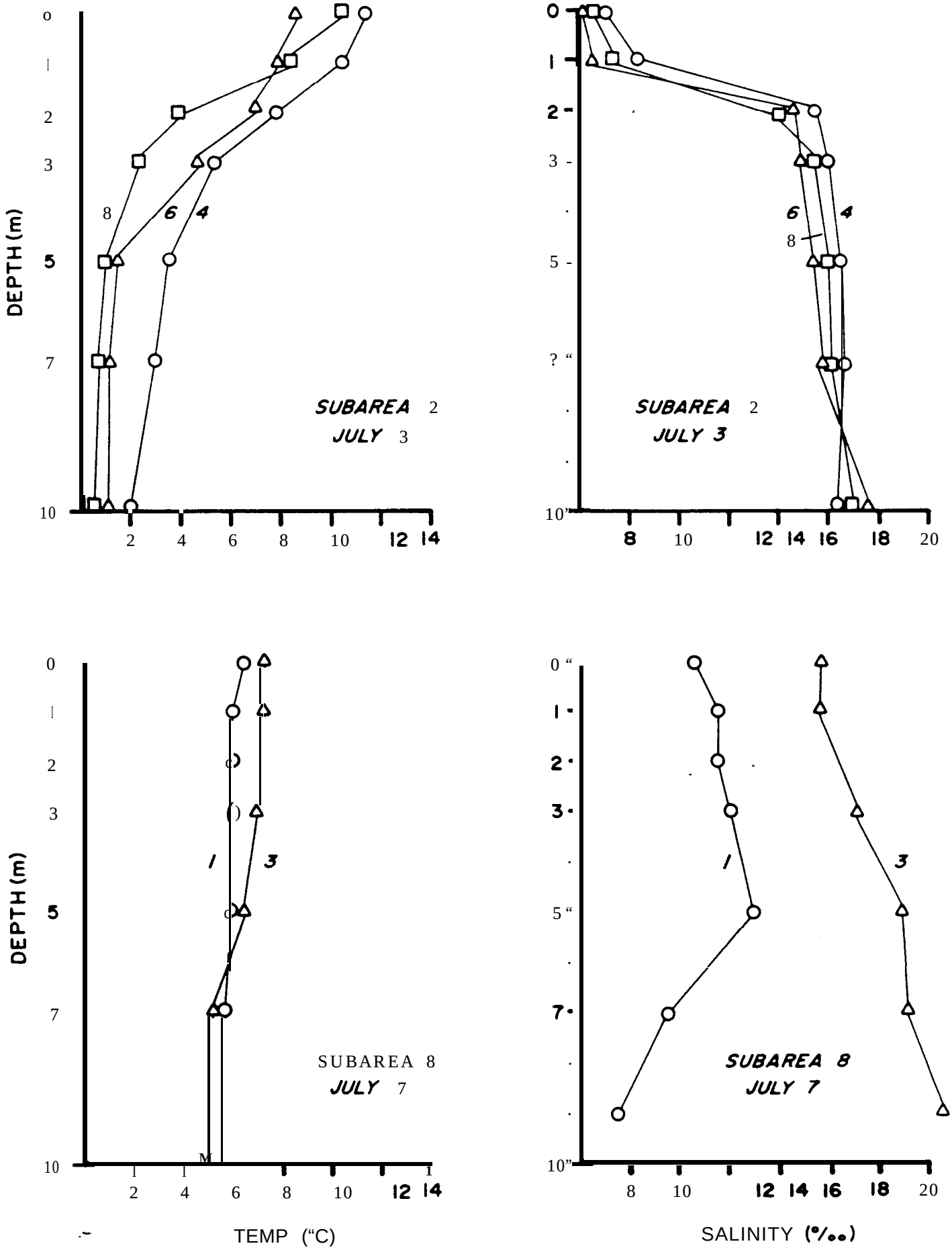


Figure 16. Temperature and salinity profiles in Subarea 2 and Subarea 8. O = head of subarea; Δ = middle of subarea; □ = mouth of subarea; # = station number.

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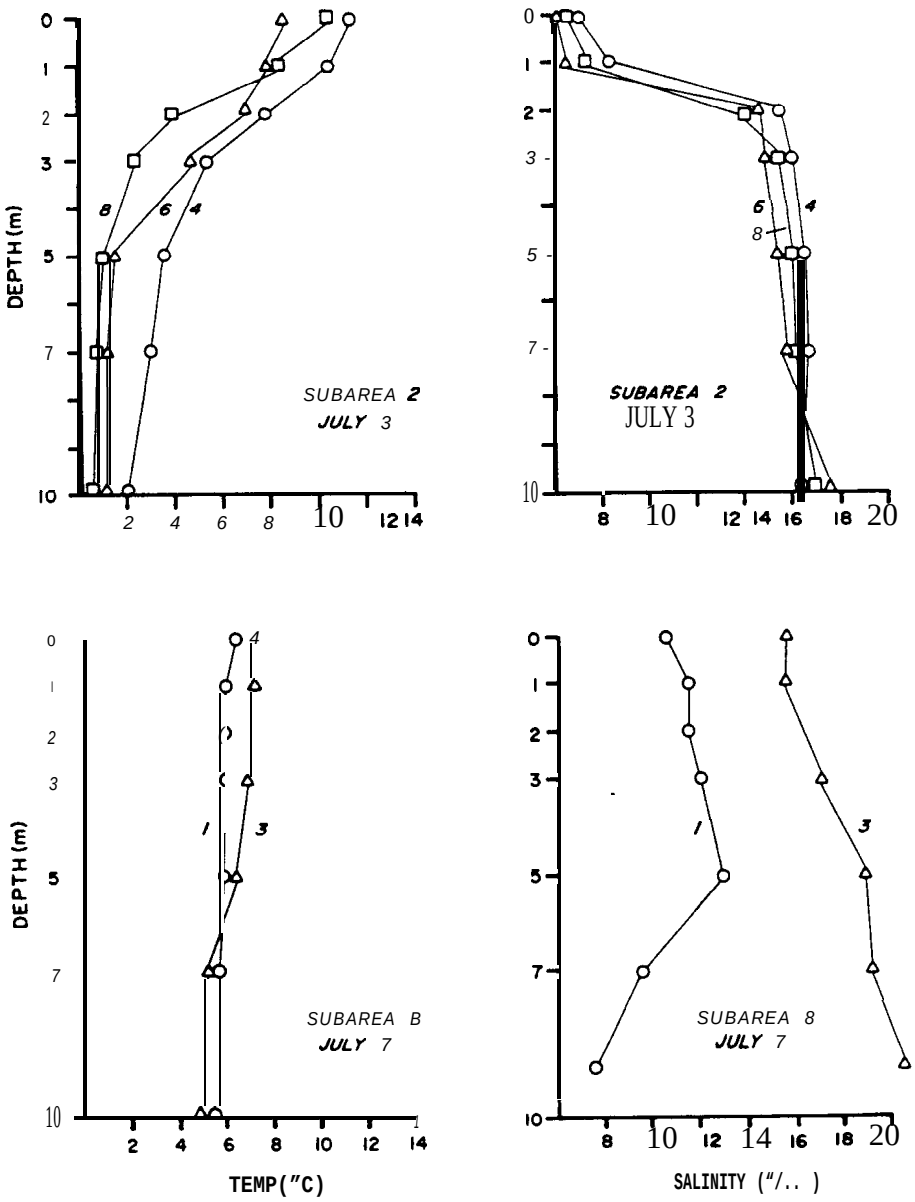

Figure 16. Temperature and salinity profiles in Subarea 2 and Subarea 8. O = head of subarea; A = middle of subarea; □ . moth of subarea; # ' station number.

was well mixed with the Liverpool Bay water mass. Water temperatures at two stations ranged between 5 and 7°C. Salinities at Station 3 ranged between 16 and 21°/00. Salinities at Station 1 increased from 10.5°/oo at the surface to 13°/oo at 5m. Below this depth salinity dropped to 6°/oo, resulting in a density inversion.

Benthic Community Composition

Appendix VI describes the flora and fauna of the nine subareas. The shoreline of the Fingers consisted of shallow sand/mud shelves which gradually sloped to a lower plateau. The shelves in more exposed areas (those towards the mouth of inlets or those which protruded offshore) were predominantly formed of sand. Both these shelf areas were generally featureless with occasional scattered debris. The debris was concentrated in a narrow band immediately above the slope and served as the major spawning substrate. Some areas of the shelves, particularly those on the lee side of protruding sand spits, collected large concentrations of eroded tundra, wood chips and 'organic debris.

The slope started at a depth of 1.5 to 3m, consisted of mud, and was typified by *Tubularia sp.* and *Mytilus edulis.* Half way down the slope finger sponges (*Haliclona sp.*) were prolific. *Tubularia sp.* was less common but present on the lower plateau. Amphipods were quite common. Sponges and mussels extended across the lower plateau, often down to 15m. The tunicate *Globeringia Sp.* was occasionally found on the slope and the lower plateau. Towards the head of each finger, heavy siltation covered all flora and fauna inhabiting the slopes and lower plateaus.

A *Callophyll is*-like foliose red algae was found in varied locations throughout the study area. Identification of this algae was not possible due to the lack of reproductive tissue. This plant provided settling substrate for mussels and sponges. In several places these red algae beds were extensive, extending for 2km along the shore to depths of 15m. Mats of *Chaetomorpha sp* "*were* often found amongst the red algae.

Marine grasses (*Zostera*-like) were found at depths of 1-4m in sheltered bays and the heads of Fingers 3 - 7. Initially these grasses were not found in Fingers 1 and 2, but later surveys revealed smal 1 shoots of grass growing out of the sediment in these areas. Herring eggs were found on this grass in several locations. An unidentified vascular aquatic plant was commonly found at the heads of Fingers 5-7. The shoreline of the approaches to the Kugaluk River (subarea 8) consisted of shallow shelves similar to those described in the Fingers. The bottom substrate was a fine, silty sand. Tundra debris, mostly in the form of large clumps, was sparsely scattered over the bottom. Some *Zostera*-like grass was found in the shallows. Water in this area was extremely turbid, and no animals or algae were observed by divers or by dredging.

The northern shoreline of the study area (subarea 9) consisted primarily of sand except in exposed *o r* high current areas where the bottom consisted of a sand/cobble mixture. *Callophyllis*-like red algae, kelp (*Puntaria sp.*), mussels, sponges (*Haliclona Sp.*) and *Tubularia sp. were* all found in subarea 9. No herring spawn was observed in the high current areas. There were a number of sheltered bays in Subarea 9

which consisted of fine mud. These areas tended to collect tundra debris and sticks. A small herring spawn was located in one of these bays.

The lagoon in the northeast portion of subarea 9 was very different from other areas observed. It appeared to be a high current, high productivity region. The lagoon, which is deep in the middle with a narrow shelf around the perimeter, was very muddy. The lagoon contained vast quantities of the *Callophyllis*-like red algae, bottom types of the *Tubularia Sp.*, *Mytilus edulis*, *Haliclona SP.*, *and some Chaetomorpha sp.* There also were large quantities of organic debris.

DISCUSSION

Results of the spawn survey indicate that approximately 8.2 tonnes of herring are estimated to have spawned in the Fingers Area between June 10 and July 22, 1985. This estimate includes corrections for the probability of missed spawns measuring less than 500m in length.

In June, 1983 a test gillnetting survey by the Department of Fisheries & Oceans caught approximately 8.6 tonnes of herring from the lower portion of Finger 1 during eight fishing days (Gillman and Kristofferson 1984). Based on these results, the occurrence of major spawns was anticipated during the 1985 survey. Over '70% of the deposited herring eggs in the study area were located in the lower portions of Finger 1 and Finger 2, where major spawnings were expected based on the test fishing results. However spawn "intensities were never above trace levels.

Because spawning intensities were so low, . it does not seem that the herring were substrate limited. In comparison with British Columbia conditions the amount of available spawning substrate was sparse . There was never more than 0.1 layers of eggs deposited. This indicates that sufficient substrate was available to all spawning herring.

Stock size estimates calculated from the results of this study may be conservative for several reasons. First Pacific herring have evolved a system of spawning-ground selection that appears to maximize the potential for egg and larval survival (Alderdice and Hourston, 1985). There is a tendency for areas of

herring spawn deposition to vary from year to year within the spawning range of individual stocks. This suggests that essential ingredients for spawning success, such as a suitable temperature-salinity regime or other environmental requirements, are local and dynamic. Alderdice and Hourston (1985) suggest that the locations where herring spawn perhaps involve interactions between characteristics of the immediate environment as well as behavioral traits and state of maturation of the adults. It is conceivable that the major portion of herring in Liverpool Bay spawned somewhere other than in the study area or that the major centres of spawn deposition in Liverpool Bay may change from year to year.

Based on egg aging and larval development and distribution, a general pattern of the timing of herring spawns in the Fingers Area can be described. Herring spawned in the approaches to the Kugaluk River during the first week in June, then continued to spawn in a westerly direction primarily in the heads of Fingers 2 through 7. This pattern may parallel the process of ice breakup and subsequent warming of surface waters in these inlets. Herring continued to spawn throughout the area until July 16. It is not known herring spawned after this date. Given the observed pattern of protracted spawning, and the likelihood that herring continued to spawn through August, it is possible that the spawn survey enumerated only a portion of the total eggs deposited in the Fingers Area during the summer of 1985. This second alternative could also explain the low stock estimate.

A third consideration is that Arctic herring may spawn only

in alternate years. Very little is known about migration patterns or reproductive biology of Pacific herring in the Beaufort Sea region. The reproductive biology and migrations of fish species inhabiting the coastal waters of the southeastern Beaufort Sea has been studied in response to the MacKenzie Valley gas pipeline and to offshore drilling in the Beaufort Sea. These studies indicate that many fish species in the Delta Region are alternate year spawners. Inconnu (*Stenodus leucichthys*), least cisco (*Coregonus sardinaella*), Arctic cisco (C. *autumnalis*), broad whitefish (C. *nasus*) and Arctic char (*Salvelinus alpinus*) spawn only in alternate years or at even larger intervals (Marten *et al.*, 1984). If Pacific herring also spawn in alternate years, then only a portion of the total herring stock which spawns in the Fingers Area have been accounted for.

Within the Fingers region, herring began spawning immediately prior to ice breakup (first week in June). Most spawning was restricted to within 6 km of the Finger heads and the approaches to the Kugaluk River. Spawning herring selected shallow (1-4.5m) nearshore sand or mud flats, and spawned on various forms of tundra debris and to some extent marine vegetation. These areas seem to offer optimal conditions for developing eggs. From late June to mid-July surface water temperatures in lower poriton of Fingers 1 - 7 were between 8 and 12°C while salinities ranged between 6 and 16°/oo. Surface temperatures in approaches to the Kugaluk where eggs were found were colder (5-7°C) and salinities were high (11-170/00). Under these conditions, the incubation period of developing herring eggs is approximately 24 days.

SUMMARY

A. From June 12 to July 16, 1985, an estimated 568 $X10^6$ (95% C.I.=$\pm$386x10^6) herring eggs were deposited *in* the Fingers Area of Liverpool Bay. Fecundity data from fish collected in June, 1985 indicates that approximately 6.9 x 10^7 eggs are deposited by 1 tonne of spawning herring. Using this conversion factor an estimated 8.2 tonnes (95% C.I.=$\pm$5.6 tonnes) of herring spawned in the study area.

B. Egg aging and planktonic larval development were used to estimate spawning dates. Spawning occurred in a protracted pattern from early June to July 16, 1985. It is not known if herring continued to spawn after this date. The incubation period for developing herrring eggs in the Fingers Area is estimated to be 24 days.

c. A number of spawns hatched out prior to being surveyed. Although little is known of the ecology of larval herring in Arctic waters, a comparison of plankton data collected in this study with growth and disappearance rates of larval herring in Georgia Strait (B.C.) indicates that no major spawns were missed.

D. Eighty percent of deposited eggs were located in Finger 1, Finger 2 and in the approaches to the Kugaluk River. Within all seven Fingers, most spawns were located within 6 km of the Finger heads.

E. Major spawning substrates included tundra debris, one species of marine grass (*Zostera*-like) and a foliose red algae (*Callophyllis*-like).

F. Herring spawned on substrate located on shallow sand/mud flats, at depths between 1m and 4.5m. Within the seven Fingers, these depths were above distinct thermoclines and surface temperatures ranged between 8 and 12°C. Salinities of these surface waters were between 6 and 16°/oo. Surface water in the approaches to the Kugaluk River, where spawning also occurred, was colder (5-7°C) and generally more saline (11-17 °/oo).

G. There are several reasons that the stock size estimates calculated from the results of this survey may be conservative:

1. It is possible that the major centres of spawn deposition *in* Liverpool Bay change from year to year, depending on such factors as characteristics of the immediate environment, behavioral traits of the herring and maturation stage of adult fish. Herring may have spawned somewhere other than in the study area in 1985.

2. Given the observed pattern of protacted spawning and the possibility that herring continued to spawn through August, it is possible that 'the spawn survey enumerated only a portion of the total eggs deposited in the Fingers Area during the summer of 1985.

3. Very little is known about migration patterns or reproductive biology of Pacific herring in the Beaufort Sea region. It is conceivable that herring in this area spawn only in alternate years or at even longer intervals. If this is the case, then only a portion of the total biomass of spawning herring has been accounted for.

This report presents baseline data' regarding herring spawning patterns, local environmental conditions where spawning occurs and other pertinent information that can be used to -further investigate Pacific herring stocks in the Liverpool Bay -area. With proper modifications, another diver survey of herring spawn would prove valuable. Aerial surveys of the shoreline to locate suitable spawning substrates within specified areas would greatly expediate the diver survey method. Transportation of the survey teams during the early stages of the study (until mid July) should be by aircraft as shifting ice often restricts boat travel . In high piority areas the dredge interval should be reduced to 200m from 500m to locate spawns measuring less than 500m in length. Because most herring eggs were found in the eastern portion of the study area, future investigations should begin at Fingers 1 and 2 and continue east along the southern shore of Liverpool Bay, perhaps as far as Turnabout Point. The Kugaluk, Moose and Smoke Rivers estuaries should also be priority areas .

To determine if Pacific herring are alternate year spawners, scales and otoliths from herring collected in the Fingers Area could be examined for spawning checks. The spawning pattern could be determined by comparing scales and otoliths similar age class fish from Arctic and Pacific coast.

Finally, it may be worthwhile to conduct a hydroacoustic survey of herring in Liverpool Bay in the early fall . Lawrence *et al.* (1984) conducted a fisheries survey of the coastal

freshwater and estuarine environments in the vicinity of the MacKenzie Delta during the open-water season from 1978-1980. Investigations were conducted during three survey periods (June/July, August and September). Pacific herring were most abundant during the fall survey. Herring may also be abundant in Liverpool Bay in September. A hydroacoustic survey at this time might provide an estimate of the size of herring stocks in the region.

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Appendix I. Summary of analysis of variance test comparing mean egg density of sampled substrate types within the study area.

Variable : Mean Egg Density $\cdot m^{-2}$

Source of variation	Ss	DF	Ms
Total	47631618035.312	129	
Groups	5285054820.912	5	1057010964.182
Error	42346563214.400	124	341504542.052

F Statistic = Groups MS/Error MS = 3.095; $P<0.05$

Summary of Group Parameters

	M		N
1. grass	236.862	266.119	24
2. foliose reds	10836.070	10839.785	17
3. compact mat	2459.863	4577.491	13
4. coarse debris	11506.734	22642.166	51
5. fine debris	22129.535	31622.638	9
6. wood chips	17111.146	20944.631	16

Appendix II. Summary of analysis of variance test comparing mean egg density of coarse debris samples between subareas.

Variable: Mean Egg Density ● UI-2

Source of Variation	Ss	DF	MS
Total	25633385017.354	50	
Groups	9997712916.267	5	1999542583.253
Error	15635672101.087	45	347459380.024

F Statistic = Groups MS/Error MS = 5.755; P<0.01

Summary of Group Parameters

Subarea	Mean	Std. Dev.	N
1	36577.250	36629.971	12
2	665.511	620.731	5
5	346.667	471.405	2
6	4358.889	5246.153	9
8	5682.950	6861.573	14
9	2789.362	2301.458	9

Appendix III. Summary of analysis of variance test comparing mean egg density of all sampled substrate types between subareas.

Variable: Mean Egg Density ● 1R-2

Source of Variation	Ss	DF	MS
Total	47631618035.313	129	
Groups	19208697826.589	6	3201449637.765
Error	28422920208.724	123	231080652.103

F Statistic = Groups MS/Error MS = 13.854; P<0.01

Summary of Group Parameters

Subarea	Mean	Std. Dev.	N
1	33211.233	30793.342	27
2	7073.503	9653.080	28
4	269.475	259.611	15
5	186.667	294.090	5
6	2253.487	4007.029	20
8	4444.781	6124.109	25
9	2573.759	2274.430	10

APPENDIX IV

Summary of Plankton Survey Data

Appendix IV Summary of plankton survey information

Location	Sample Nbr	Date	Depth, (m)	Nbr Larvae	Dats of Spawn Survey
Subarea 1					
Station 1		July 6			July 4, 22
	1		10-2	0	
	2		10-2	0	
	3		10-2	0	
	4		10-2	0	
Station 2	5		3	0	
	6		2	0	
Station 3	7		2	0	
Subarea 2					
Station 1	102	July 21	1	0	July 2
	103		2	0	
	104		2	0	
	105		10-2.5	0	
Station 2	106		1	1	
	107		2	0	
	108		2	0	
	109		10-2.5	0	
Station 3	110		1	0	
	111		2	0	
	112		2	0	
	113		10-2.5	0	
Station 4	114		1	0	
	115		2	0	
	116		2	0	
	117		10-2.5	0	
Station 5	118		1	0	
	119		2	0	
	120		2	0	
	121		10-2.5	0	
Station 6	12	July 8	2	0	
	13		3	0	
Subarea 3					
Station 1	156	July 11	5	0	July 11
Station 2	16		2	0	
	17		8	0	
Station 3	28	July 13	2	0	
	29		2	0	
	30		2	0	
	31		2	0	
	32		2	0	
Station 4	33		3	0	

Appendix IV (cont.)

Location	Sample Nbr	Date	Depth (m)	Nbr Larvae	Dates of Spawn Survey
Subarea 3 (cont.)					
(Fingers 2.5)					
Station 5	144	July 23	1	0	
	145		2	0	
	146		2	0	
	147		10-2.5	0	
Station 6	148		1	0	
	149		2	0	
	150		2	0	
	151		10-2.5	0	
Station 7	152		1	0	
	153		2	0	
	154		2	0	
	155		10-2.5	0	
Subarea 4					
Station 1	18	July 12	5	0	July 12
	19		3	1	
Station 2	20		3	0	
Station 3	21		3	0	
	22		5	0	
Station 4	23		3	0	
Station 5	24		2	0	
	25		7-2	0	
Station 6	26		2	0	
	27		2	0	
Subarea 5					
Station 1	65	July 17	10-2.5	0	July 17
	64		1	5	
	63		2	2	
	62		2	3	
Station 2	61		10-2.5	0	
	60		1	0	
	59		2	0	
	58		2	1	
Station 3	57		10-2.5	0	
	56		1	0	
	55		2	0	
	54		2	0	
Station 4	53		10-2.5	0	
	52		1	0	
	51		2	0	
	50		2	0	

Appendix IV (cont.)

Location	Sample Nbr	Date	Depth, (m)	Nbr Larvae	Dates of Spawn Survey
Subarea 6					
Station 1	34	July 15	2	0	July 15, 17
	35		2	0	
	36		10-2.5	0	
Station 2	37		2	0	
	38		2	0	
	39		10-2.5	0	
Station 3	40		2	0	
	41		2	0	
Station 4	42		10	0	
	43		1	0	
Station 5	44		2	0	
	45		2	0	
	46		10	0	
Station 6	47		2	0	
	48		2	1	
Station 7	49		surface	0	
Subarea 7					
Station 1	66	July 18	1	0	July 18
	67		2	0	
	68		2	0	
	69		10-2.5	0	
	70		2	0	
Station 2	71		1	0	
	72		2	0 -	
	73		10-2.5	0	
	74		2	0	
	75		2	0	
	76		2	0	
Station 3	77		1	0	
	78		2	1	
	79		2	0	
	80		10-2.5	0	
Station 4	81		1	0	
	82		2	0	
	83		2	0	
	84		10-2.5	0	
Station 5	85		1	0	
	86		2	0	
	87		2	0	
	88		10-2.5	0	
	89		2	0	
Station 6	90		1	0	
	91		2	0	
	92		2	0	

	93		10-2.5	0	

Appendix IV (cont.)

Location	Sample Nbr	Date	Depth (m)	Nbr Larvae	Dates of Spawn Survey
Subarea 7 continued					
	94		2	0	
	95		2	0	
	96		1	0	
Station 7	97		10-2.5	0	
Subarea 8					
Station 1	8	July 6	3	9	July 22
	9		2	2	
	10		2	5	
	11		5	29	
Station 2	130	July 22	2	1	
	131		2	2	
	132		1	2	
	133		10-2.5	6	
Subarea 9					
Station 1	98	July 19	1	0	July 19
	99		2	0	
	100		2	0	
	101		10-2.5	0	
Station 2	122	July 21	1	0	
	123		2	0	
	124		2	0	
	125		10-2.5	0	
Station 3	14	July 8	surface	0	
Station 4	126	July 21	1	0	
	127		2	0	
	128		2	0	
	129		10-2.5	0	
Station 5	15a	July 8	2	0	
Station 6	156	July 23	1	0	
	157		2	0	
	158		2	0	
	159		10-2.5	0	
	160		1	0	
	161		2	0	
	162		2	0	
	163		10-2.5	0	
	164		1	0	
	165		2	0	
	166		2	0	
	167		10-2.5	0	

APPENDIX V

Temperature and Salinity Profiles

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
JUly 22	Subarea 1			
		0	7.6	14.0
		1	6.5	14.5
		2	7.0	14.0
		3	7.0	14.0
		4	7.0	14.0
		5	7.0	14.0
		7	4.0	15.5
		9	1.9	17.1
		11	0.1	18.0
		15	-0.1	18.2
		20	-0.1	18.2
	Station 2			
		0	6.1	15
		1	6.2	15
		2	6.2	15
		3	6.5	15
		4	6.5	15
		5	6.5	15
		7	6.0	15.2
		9	1.5	17.0
		11	0.5	18
		15	0	20.7
		20	0	20.8
	Station 3			
		0	6.0	15.1
		1	5.1	15.5
		2	5.1	15.5
		3	5.0	15.7
		4	5.0	15.7
		5	5.0	15.7
	Station 4			
July 3		0	4.5	15.0
		1	3.0	15.0
		2	2.5	15.0
		3	2.0	15.5
		4	2.0	15.5
		5	2.0	15.5
		7	.2.0	15.5
		9	1.5	16.0
		11	1.5	16.0
		15	1.5	16.0

Appendix V. cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
July	Subarea 2			
	Station	o	7.1	6.2
		1	7.0	7.4
		2	7.5	7.3
		3	7.0	14.2
	Station 2			
		0	9.1	8.7
		1	9.5	8.7
		3	6.0	15.8
		5	7.5	17.0
	station 3			
		0	4.3	6.0
		1	3.5	6.7
		3	3.5	16.2
		5	1.3	16.5
		7	0.5	17.0
		10	0.5	17.6
July 3	Station 4	0	11.5	7.0
		1	10.5	8.5
		2	8.0	15.5
		3	5.5	16.0
		4	4.0	16.5
		5	3.5	16.5
		7	3.0	16.5
		9	2.5	16.5
		11	1.5	'16.5
	Station 5	0	10.5	6.5
		1	9.5	7.5
		2	7.0	15.0
		3	4.0	15.0
		4	2.0	16.0
		5	1.5	16.5
		7	1.5	16.5
		9	1.0	17.0
		11	1.0	17.0
		15	0.75	18.0
	Station 6	0	8.5	6.0
		1	8.0	6.5
		2	7.0	14.5
		3	3.5	15.0
		4	2.0	15.5
		5	2.0	15.5
		7	1.5	15.5

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		9	1.0	16.0
		11	0.8	16.8
		15	0.5	17.2
	Station 7	0	8.0	7.5
		1	7.5	8.0
		2	7.5	14.0
		3	4.0	14.5
		4	3.0	15.5
		5	2.0	16.0
		7	1.5	16.0
		9	1.0	16.5
		11	1.0	16.5
		15	0.5	17.5
	Station 8	0	10.5	6.5
		1	8.0	7.2
		2	4.0	14.5
		3	2.5	15.5
		4	2.0	16.0
		5	2.0	16.0
		7	1.5	16.0
		9	1.0	16.0
		11	1.0	16.5
		15	0.5	17.0
July 10	Subarea 3			
	Station 1	0	12.5	9.8
		1	12.5	11.0
		2	12.5	11.8
		3	12.5	11.8
		5	11.5	12.1
		7	8.7	17.0
		9	4.9	18.3
	Station 2	0	10.0	13.0
		1	10.3	13.0
		2	10.8	12.9
		3	10.5	13.0
		4	10.8	13.0
		5	10.3	13.0
		7	7.0	15.9
		9	6.0	16.3
		10	6.0	16.5
		15	6.0	16.5
	Station 3	0	9.5	14.3
		1	9.0	14.0
		2	8.9	14.2

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		3	6.8	15.0
		4	4.9	15.7
		5	5.0	15.5
		7	4.9	15.5
		9	4.5	16.5
		10	4.5	16.5
		15	4.5	16.3
July 20	Station 4	0	8.0	12.0
		1	8.0	12.0
		2	8.0	12.0
		3	8.0	12.0
		4	8.0	12.0
		5	8.0	12.0
		6.5	7.0	14.0
	Station 5	0	7.0	13.2
		1	7.0	13.2
		2	7.0	13.2
		3	7.0	13.2
		4	7.0	13.2
		5	7.0	13.2
		7	7.0	13.2
		10	7.0	14.0
		15	5.0	15.5
	Station 6			
		0	6.0	14.8
		1	6.0	14.8
		2	6.0	14.8
		3	6.0	14.8
		4	6.0	14.8
		5	6.0	14.8
		7	6.0	14.8
		10	6.0	14.8
		15	5.0	15.2
	Station 7			
		0	4.0	16.5
		1	4.2	16.5
		2	4.5	17.0
		3	4.5	16.5
		4	4.5	16.5
		5	4.5	16.5
		7	4.5	16.5
		10	4.0	16.8
		15	4.0	16.5

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
	Station 8			
		0	3.8	16.0
		1	3.8	16.0
		2	3.8	16.0
		3	3.8	16.0
		4	3.8	16.0
		5	3.8	16.0
		7	3.8	16.0
		10	3.5	16.0
		15	3.5	16.0
July 20	Station 9			
		0	9.0	15.0
		1	8.0	15.0
		2	7.0	15.0
		3	6.5	15.0
		4	6.0	15.0
		5	5.5	15.5
		7	5.0	15.5
		10	2.0	17.0
		15	0.5	17.0
	Station 10			
		0	8.0	15.0
		1	8.0	15.0
		2	7.0	15.5
		3	7.0	15.5
		4	6.5	15.5
		5	6.0	15.5
		7	5.0	16.0
		10	2.0	17.0
		15	1.0	17.0
	Station 11			
		0	7.5	15.5
		1	5.5	15.5
		2	5.0	15.5
		3	5.0	15.0
		4	4.5	15.0
		5	4.0	15.5
		7	4.0	15.5
		10	4.5	15.5
		15	3.5	16.0
July 12	Subarea 4			
	Station 1	0	10.0	12.1
		1	11.2	12.1
		2	11.5	12.1

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		3	11.0	13.1
		4	10.0	14.8
		5	8.0	15.8
		7	6.0	16.3
		12	5.0	16.3
	Station 2	0	10.0	14.1
		1	11.0	12.8
		2	11.0	12.8
		3	11.0	12.8
		4	11.0	12.8
		5	11.0	12.8
		7	7.0	15.3
		10	5.0	16.2
		12	4.0	19.5
	Station 3	0	9.5	13.0
		1	10.0	12.8
		2	10.1	12.8
		3	10.1	12.8
		4	10.1	12.8
		5	10.3	12.8
		7	7.7	15.1
		10	4.8	15.8
		12	2.8	16.3
	Station 4	0	9.8	13.0
		1	10.0	13.0
		2	10.1	"13.0
		3	10.1	13.0
		4	10.1	13.0
		5	10.1	13.0
		7	6.7	15.5
		10	4.8	15.9
	Station 5	0	7.0	14.5
		1	7.0	14.5
		2	7.0	14.5
		3	7.0	14.5
		4	7.5	14.5
		5	6.1	15.0
		7	5.0	15.3
		10	3.5	15.7
		15	3.1	16.0
	Station 6	0	5.5	15.0
		1	5.5	15.0

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		2	5.5	14.8
		3	5.7	15.2
		4	5.5	15.2
		5	5.0	15.0
		7	4.5	15.0
		10	4.0	15.0
		15	4.0	15.5
	Subarea 5			
July 17	Station 1	0	8.0	13.0
		1	8.0	13.0
		2	8.5	13.0
		3	8.5	13.0
		4	8.5	13.0
		5	8.5	13.0
		7	8.5	13.0
		9	8.5	13.0
		11	6.0	14.0
		15	4.0	15.5
	Station 2	0	7.0	13.75
		1	7.0	13.75
		2	7.0	13.75
		3	7.0	13.75
		4	7.0	13.75
		5	7.0	13.75
		7	6.5	14.0
		9	6.0	-14.0
		11	6.0	14.0
		15	4.0	15.0
	Station 3	0	5.0	14.25
		1	5.0	14.25
		2	5.0	14.25
		3	5.0	14.25
		4	5.0	14.25
		5	5.0	14.25
		7	5.0	14.25
		9	5.0	14.25
		11	5.0	14.25
		15	4.5	14.25
		20	3.5	14.25
	Station 4	0	4.5	14.0
		1	4.5	14.5
		2	4.5	14.5
		3	4.5	14.5
		4	4.5	14.5

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		5	4.5	14.5
		7	4.5	14.5
		9	4.5	14.5
		11	4.0	14.5
		15	4.0	14.5
		20	3.0	15.0
		23	2.0	15.5
	Station 5	0	4.0	15.0
		1	4.0	15.0
		2	4.0	15.0
		3	4.0	15.0
		4	4.0	15.0
		5	4.0	15.0
July 15	~~Subarea 6~~			
	Station 1	0	9.0	8.5
		1	9.5	7.5
		2	10.0	9.0
		3	10.0	10.0
		4	6.5	15.5
		5	4.0	16.8
		7	2.5	16.5
	Station 2	0	10.8	10.0
		1	10.5	10.0
		2	9.8	10.2
		3	9.5	-10.2
		4	9.2	11.8
		5	7.5	14.8
		7	5.0	15.2
		10	2.0	16.2
		15	0.0	17.0
	Station 3	0	8.9	11.0
		1	9.0	11.O
		2	8.5	11.0
		3	8.5	11.0
		4	8.0	12.5
		5	6.5	14.2
		7	5.0	15.0
		10	2.0	16.0
		15	1.0	16.2
	Station 4	0	8.0	11.8
		1	8.0	11.5
		2	7.5	12.0

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		4	5.8	13.2
		5	5.0	14.0
		7	5.0	14.0
		10	4.0	15.0
		15	1.0	16.4
	Station 5	0	5.8	14.0
		1	5.8	14.0
		2	5.0	14.8
		3	5.0	14.9
		4	4.9	15.0
		5	4.9	14.9
		7	4.2	15.0
		10	4.0	15.2
		15	1.0	17.0
July 18	Subarea 7			
	Station 1	0	9.0	9.75
		1	9.0	9.75
		2	9.0	10.0
		3	9.0	10.75
		4	8.0	14.0
		5	5.0	14.75
		7	2.0	16.25
		9	1.5	16.0
		11	1.0	16.0
	Station 2	0	9.0	10.0
		1	9.0	10.0
		2	9.0	10.0
		3	9.0	10.0
		4	9.0	10.0
		5	8.0	13.0
		7	4.0	15.0
		9	3.0	15.0
		11	3.0	16.5
		15	1.5	16.5
	Station 3	0	8.0	11.25
		1	8.0	11.25
		2	8.0	11.25
		3	8.0	11.25
		4	8.0	11.5
		5	7.3	12.25
		7	3.5	16.75
		9	2.0	17.25

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
	Station 4	0	6.0	15.0
		1	5.5	15.5
		2	5.0	16.0
		3	5.0	16.5
		4	5.0	16.5
		5	4.5	17.0
		7	2.5	19.0
		9	1.0	19.0
		11	-0.5	20.0
		15	-1.0	19.5
	Station 5	0	5.0	16.0
		1	4.75	16.0
		2	4.25	16.5
		3	4.0	18.0
		4	4.0	18.0
		5	3.75	19.0
		7	0.0	23.0
		9	-1.0	23.0
		11	-1.5	23.0
		14	-1.5	23.0
	Station 6	0	4.0	19.0
		1	8.0	14.0
		2	8.0	18.0
		3	4.0	20.0
		4	3.0	20.0
		5	3.0	21.0
		7	0.0	23.0
		9	-1.0	23.0
		11	-1.25	23.0
		13	-1.75	23.5
	Station 7	0	6.0	17.0
		1	6.0	17.25'
		2	6.0	17.5
		3	5.0	17.5
		4	5.0	17.5
		5	5.0	17.5
		7	5.0	18.0
		9	5.0	18.0

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
July 7	Subarea 8			
	Station 1	0	6.5	10.5
		1	6.0	11.5
		2	6.0	11.5
		3	6.0	12.0
		4	6.0	13.5
		5	6.0	13.0
		7	5.5	9.5
		9	5.5	7.5
		11	5.5	6.5
		15	5.5	6.0
	Station 2	0	3.5	18.0
		1	5.0	17.5
		2	5.0	18.0
		3	5.0	18.0
		4	5.0	18.5
		5	5.0	19.0
		7	5.0	18.5
		9	5.0	19.0
		11	5.0	19.0
		15	5.0	19.5
	Station 3	0	7.1	15.8
		1	7.1	.15.0
		3	6.9	17.0
		5	6.0	18.9
		7	5.5	19.0
		9	4.9	21.2
July 22				
	Station 4	0	8.0	10.0
		1	7.9	11.0
		2	7.5	11.2
		3	7.0	12.0
		4	7.9	11.9
		5	6.9	12.1
		7	6.7	12.2
		9	6.7	12.2
	Station 5	0	*8.0*	11.1
		1	*7.1*	11.6
		2	7.0	11.1
		3	7.0	11.9
		4	7.0	11.9

		5	7.0	12.0

Appendix V (cont.)

Date	Location	Depth (m)	Temperature (°C)	Salinity °/oo
		7	6.0	12.9
		9	6.5	12.5
		11	6.5	12.5
		15	6.5	12.5
	Station 6	0	7.0	14.0
		1	6.5	14.1
		2	6.0	14.1
		3	6.0	14.5
		4	6.0	14.5
		5	5.5	14.9
		7	5.5	14.9
		9	5.5	14.5
July 20	Subarea 9			
	Station 1	0	5.0	15.5
		1	5.0	15.5
		2	4.0	16.0
		3	4.0	16.0
		4	4.0	16.0
		5	4.0	16.0
		7	4.0	16.0
		10	4.0	16.0
		15	4.0	16.0
	Station 2	0	6.5	14.0
		1	5.5	-14.0
		2	5.0	14.5
		3	5.0	14.5
		4	4.5	14.5
		5	4.5	14.5
		7	4.5	15.0
		10	4.0	15.0
		15	4.0	15.0
	Station 3	0	6.0	14.0
		1	6.0	14.0
		2	5.5	14.0
		3	5.0	14.0
		4	5.0	14.0
		5	5.0	14.5
		7	5.0	14.5
		10	4.5	15.0
		15	4.0	15.0

APPENDIX VI

Benthic Community Descriptions in the Nine Subareas of the Fingers Region.

Appendix VI. Benthic community descriptions in the nine subareas of the Fingers Region.

Subarea 1 and Subarea 2

General

Similar plant and animal communities were present in Subarea 1 and Subarea 2.

Vegetation

Rhodophyta *Callophyllis*-like.	Large beds of this foliose red algae were encountered at the heads of both fingers.
Chlorophyta *Chaetomorpha sp.*	Found in large mats.
Phaeophyta:	**None observed.**
Vascualar plants.	**Some** new grass was observed at Spawn 1 on July 22.

Animals

Coelenterata *Tubualria sp A.*	Common on slopes throughout the Fingers.
Mollusca *Mytilus edulis* *Macoma baltica*	Commonly associated with red algae beds.
Annelida *Polychaeta sp.*	Numerous **polychaetes** were **observed.**
Crustacea	Assorted species of amphipods were observed.
Chordata *Globeringia sp.*	Common solitary **tunicate** observed.
Porifera *Haliclona sp.*	Common finger sponge observed on slope and deeper. Usually in association with red **algae** beds.

Subarea 3

Vegetation

Rhodophyta	
Callophyllis-like	Not very common, some large beds located at the head region in some cases up to six inches deep.
Chlorophyta	
Chaetomorpha sp.	Found throughout inlet, often in large mats.
Vascualar Plants	A marine grass was found throughout the inlet - just starting to sprout.

Animals

similar to Subarea 1 and Subarea 2

Porifera	
Haliclona sp	Found on the slope. New sponges growing on *Callophyll* is-like algae.
Coelenterata	
Tubularia sp. A	Common on slope
Leucartia sp.	**Common hydromedusae.**
Mollusca	
Mytilus edulis	Most common **mollusc.** Heavy settlement on *Callophyllis*-like algae.
Macoma baltica	Common in all dredge **samples** of mud bottoms. Strong association with with diatoms.
Chordata	
Globeringia sp	
Fish eggs	Many non-herring eggs were located throughout the inlet. Associated with tundra debris.
Annelida	
Assorted polychaetes	The most obvious was a **polynoid** (scale worm).
Crustacea	
Lots of **amphipods**	Many species. Always associated with organic matter.
Decopoda	Small clear shrimps or **Mysids** along the bottom

Appendix VI (cont.)

Summary

Animal and plant life was abundant and varied. Large quantities of diatoms and *chaetomorpha sp.* mat. Finger 3 did not seem to have the tundra clumps as encountered in Subarea 2 and Subarea 1. Birds which were abundant in the lower regions of Subarea 3 included White Winged and Surf Scooters, Glaucous and Herring Gulls, Arctic Terns, Old Squaw ducks and Arctic Loons.

Subarea 4

Vegetation

Higher diversity than found in any other Finger several different species easily identified.

Rhodophyta	
Callophyllis-like	More common than in Fingers 1 -3
Chlorophyta	
Chaetomorpha sp.	Found in large mats.
Spongomorpha sp.	Found in top (opening) half of the Finger.
Enteromorpha prolifera	Found at the head of the Finger, only in dredge samples.
Phaeophyta	
Acrothrix sp.	Common, hatched out eggs were found on this algae
Vascular Plants	One marine grass was found at the head of Finger 4. This occurred in great mats which completely filled the dredges.

Animals

Molluscs	Several species of mollusc were found in the dredges.
Mytilus edulis	Usually associated with red algae
Macoma baltica	The most ubiquitous species of clam. Found in all mud dredges.
Yodiella sp.	Found occasionally in mud/sand
Gastropoda	*(x3)* Found occasionally.
Crustacea	
Amphipoda	Numerous species, associated with large quantities of organic matter.
Isopods	Two species found occasionally.

Appendix VI (cont.)

Chordata	
Globeringia sp.	Common solitary tunicate. Outer tunic is covered by granules of sand.
Hemichordata	One hemichordate was found in mud containing coarse organic matter.
Annelida	
Polychaeta	Numerous polychaetes. About 5 species. Most common was a Polynoid (scale worm)
Coelenterata	
Tubularia sp. A	Common on slope faces. Occurred in almost all dredge samples.
Leucarta sp.	Very common Hydromedusa, throughout water column.
Porifera	
Haliclona spp.	Common - usually fairly deep - on slope face and deeper. Two apparent species.

Summary

Subarea 4 was a diverse Finger with at least three separate regions.

A. Head - typified by a vascular grass, a brown algae *Acrothrix sp*, and a green algae *Chaetomorpha sp* and large quantities of loose tundra. Mud with diatom cover suggested a fairly stable substrate

B. **Central region**
Red algae, mud, diatoms and large quantities of organic material. The red algae, mussels, sponge and *Tubularia were* common.

c. Outer region
Less algae and organic material. Small amounts of red algae and *Chaetomorpha.* Dredges did not collect as much organic material. Very sandy substrate.

Subarea 5

Vegetation

Rhodophyta	
Callophyllis-like	Found intermittently on the west shore near the Finger. Uncommon.

Chlorophyta	
Chaetomorpha sp	Found throughout the inlet.
Vascular Plants	Grass was found at the Finger head.

Animals

Coelenterata	
Tubularia sp. A	Found on shallow slope.
Levcartia sp.	Hydromedusa.
Crustacea	
Amphipoda sp	
Porifera	
Haliclona sp.	Near the mouth.
Fish **Eggs**	A patch about 10m x 10m of small opaque 'mystery' eggs. A sample was collected.

Summary

The mouth of Subarea 5 had a sandy/rocky shores. The dive done in Finger 5 revealed a sandy substrate with a steep slope. The slope had scattered debris. This was representative of the east shore. The west shore was composed of a fine muddy sediment. Many dredges came up empty. The head of the inlet seemed **muddy with more** *Callophyllis* type algae, **diatomaceous** mats, and *Chaetomorpha sp.*. Some grass was found, but less than in Subareas 4,6, or 7.

Subareas 6 and 7

General

Similar algae and animal communities as those described for Subarea 5. Grass communities were much more dominant at the heads of the fingers. Much of the grass was just starting to grow, particularly in the shallows.

Vascular Plants	**An aquatic plant extended in fairly wide bands to depths** of 1-3m. Diatoms were frequently observed growing on this plant.
Sea Grasses	Marine grass communities, similar *to* ***Zostera*** *sp, were* observed in Fingers 6 and 7. These sea grass communities appeared to be very stable, and were located in areas of low water movement.

Subarea 8

General

The approaches to the Kugaluk River were typical of a river estuary. The bottom substrate was a fine silty sand. Sparse amounts of tundra debris, mostly larger clumps, were scattered over the bottom. The water was very turbid. Dredges found very few algae or invertebrate fauna.

Vegetation

Algae	
Chaetomorpha sp.	Very sparse, usually associated with diatomaceous mat. Some observed at Spawn 4.
Vascular Plants	

Animals

Crustacea	Some amphipods
Annelida	Some assorted polychaetes
Fish	More than 100 Arctic flounder (*Liopsetta glacialis*) were caught in a gillnet which was set from shore in early July.

Subarea 9

General

This was a varied section of coast. In shallow areas, dredges brought up fine mud and diatomaceous material with very little debris.

Vegetation

Phaeophyta	
Punctaria sp	This large kelp was observed by divers near the trailer camp and picked up by dredges off the mouth of Finger 2.
Chlorophyta	
Chaetomorpha sp	Found in large mats
Rhodophyta	
Callophyllis-like	Large quantities found throughout Subarea 9, especially inside the lagoon in the northeastern portion.
Vascular Plants	None observed.

Appendix VI (cont.)

Animals

Coelenterata	
Tubularia sp A	Found at one site (Spawn 1).
Tubularia sp B	Found in high current areas.
Leucartia sp.	Hydromedusa.
Cyanea *sp.*	Scyphomedusa.
Mollusca	
Mytilus edulis	
Annelida	Tube dwelling **polychaetes** were seen in fine mud at one location (Spawn 1).
Crustacea	Assorted species of **amphipods** were observed.