

SH  
223  
F55  
no. 1795  
c.1

DFO - Library / MPO - Bibliothèque



12021855

# Herring Stock Estimates from Diving Surveys of Spawn for the North Coast of British Columbia in 1982

J. F. Schweigert and C. W. Haegele

Department of Fisheries and Oceans  
Fisheries Research Branch  
Pacific Biological Station  
Nanaimo, British Columbia V9R 5K6



November 1984

**Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1795**



Government of Canada  
Fisheries and Oceans

Gouvernement du Canada  
Pêches et Océans

## **Canadian Manuscript Report of Fisheries and Aquatic Sciences**

These reports contain scientific and technical information that represents an important contribution to existing knowledge but which for some reason may not be appropriate for primary scientific (i.e. *Journal*) publication. They differ from Technical Reports in terms of subject scope and potential audience: Manuscript Reports deal primarily with national or regional problems and distribution is generally restricted to institutions or individuals located in particular regions of Canada. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevant to Canada.

Manuscript Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted by *Aquatic Sciences and Fisheries Abstracts* and will be indexed annually in the Department's index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901-1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426-1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Details on the availability of Manuscript Reports in hard copy may be obtained from the issuing establishment indicated on the front cover.

## **Rapport manuscrit canadien des sciences halieutiques et aquatiques**

Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution importante aux connaissances actuelles mais qui, pour une raison ou pour une autre, ne semblent pas appropriés pour la publication dans un journal scientifique. Ils se distinguent des Rapports techniques par la portée du sujet et le lecteur visé; en effet, ils s'attachent principalement à des problèmes d'ordre national ou régional et la distribution en est généralement limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du Ministère des Pêches et des Océans, notamment gestion des pêches; techniques et développement, sciences océaniques et environnements aquatiques, au Canada.

Les Manuscrits peuvent être considérés comme des publications complètes. Le titre exact paraît au haut du résumé de chaque rapport, qui sera publié dans la revue *Aquatic Sciences and Fisheries Abstracts* et qui figurera dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros de 1 à 900 de cette série ont été publiés à titre de manuscrits (Série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés en tant que manuscrits (Série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros allant de 901 à 1425 ont été publiés à titre de manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 ont été publiés à titre de Rapport manuscrits du Service des pêches et de la mer, Ministère des Pêches et de l'Environnement. Le nom de la série a été changé à partir du rapport numéro 1551.

La page couverture porte le nom de l'établissement auteur où l'on peut se procurer les rapports sous couverture cartonnée.

Canadian Manuscript Report of  
Fisheries and Aquatic Sciences No. 1795

November 1984

HERRING STOCK ESTIMATES FROM DIVING SURVEYS OF SPAWN  
FOR THE NORTH COAST OF BRITISH COLUMBIA IN 1982

by

J. F. Schweigert and C. W. Haegele

Department of Fisheries and Oceans  
Fisheries Research Branch  
Pacific Biological Station  
Nanaimo, British Columbia V9R 5K6

(c) Minister of Supply and Services Canada 1984

Cat. No. Fs 97-4/1795E      ISSN 0706-6473

Correct citation for this publication:

Schweigert, J. F. and C. W. Haegele. 1984. Herring stock estimates from diving surveys of spawn for the North Coast of British Columbia in 1982. Can. MS Rep. Fish. Aquat. Sci. 1795: 43 p.

ABSTRACT

Schweigert, J. F. and C. W. Haegele. 1984. Herring stock estimates from diving surveys of spawn for the North Coast of British Columbia in 1982. Can. MS Rep. Fish. Aquat. Sci. 1795: 43 p.

Divers surveyed and sampled major 1982 herring spawns in Statistical Areas 3 to 5. Spawner biomass was estimated at 5700 tonnes, which agreed closely with prespawning echosounder estimates, but was considerably lower than the 19,500 to 29,000 tonnes estimated with population models. The low estimated spawner biomass supports the decision to close the sac-roe fishery in Chatham Sound from 1979 through 1983 and in Porcher Island from 1982 through 1983.

Key words: Pacific herring, spawn, diver survey, stock assessment

RÉSUMÉ

Schweigert, J. F. and C. W. Haegele. 1984. Herring stock estimates from diving surveys of spawn for the North Coast of British Columbia in 1982. Can. MS Rep. Fish. Aquat. Sci. 1795: 43 p.

Des plongeurs ont étudié et échantillonné les grands frais de hareng de 1982 dans les zones statistiques 3, 4 et 5. La biomasse a été évaluée à 5,700 t, ce qui se rapproche beaucoup des estimations effectuées par écho-sondeur avant la fraie, mais est considérablement inférieure aux 19,500 à 29,000 t déterminées à l'aide de modèles démographiques. La faible biomasse estimative de reproducteurs appuie la décision d'interdire la pêche du hareng plein dans le passage Chatham, de 1979 à 1983, et dans l'île Porcher, de 1982 à 1983.

Mots-clés: hareng du Pacifique, frai, levé en plongée, évaluation du stock

## INTRODUCTION

Stocks of herring (*Clupea harengus pallasii*) on the North Coast (Statistical Areas 3 to 5) of British Columbia supported substantial reduction fisheries from the 1930s to the collapse of the stocks in 1967. Catches from 1946 to 1967 averaged 25,000 tonnes and stocks were estimated to have averaged 70,000 tonnes for the period 1951 to 1970 (Hourston 1981). Between 1967 and 1970 a food and bait fishery continued to operate in Browning Entrance and an average of 1500 tonnes was landed annually. From 1971 to 1981, a sac-roe fishery as well as the Browning Entrance food and bait fishery operated on the North Coast and an average of 5300 tonnes was landed annually.

In 1978, a roe fishery catch of 8200 tonnes was anticipated for the North Coast; however, because of unexpectedly low echosounder estimates on the grounds, only 4400 tonnes were taken (Webb et al. 1980). There was concern by fishery managers and scientists that stock estimates, based primarily on Fishery Officer spawn report data, were unrealistically high for the North Coast, so a diving survey was conducted in 1979 in Chatham Sound (lower Area 3 and upper Area 4) to estimate egg deposition. Estimates from this survey were  $8.0 \times 10^{11}$  eggs (Haegele and Miller 1979), which is approximately equivalent to 8000 tonnes of spawning fish, and this was considered below the minimum desired escapement for Chatham Sound. No sac-roe fishery was permitted in the year of the survey and Chatham Sound remained closed pending further assessment. In 1982, the remainder of the North Coast was also closed to the sac-roe fishery because of apparent low stock abundance and poor recruitment of the 1978 and 1979 year classes (Chalmers 1982). The North Coast remained closed to sac-roe fishing in 1983. To determine whether the closures were justified and to obtain an estimate of stock size that could be compared to other and future assessments, a diving survey of herring spawns was conducted in 1982. This survey is the subject of this report.

## METHODS

Herring spawns were sampled by SCUBA divers using a two-stage sampling design. Transects perpendicular to the shore were the primary sampling unit and  $0.50 \text{ m}^2$  quadrats sampled along the transect were the secondary sampling unit. Samples consisted of the attached or rooted vegetation, and the eggs adhering to it, within the quadrat. These samples, after collection, were separated by vegetation classes into fractions, which were then weighed. A weighed subsample of each fraction was preserved for subsequent egg enumeration. Eggs on the bottom substrate were estimated from diver estimates on layers of eggs and percent of bottom covered by eggs [1 layer of eggs =  $3.4 \times 10^5$  eggs·m<sup>-2</sup> (Haegele et al. 1979)] and added to eggs on vegetation. For each quadrat the layers of eggs on vegetation and the percent cover of vegetation were estimated by divers and the depth at each sample site was recorded and later corrected to Chart Datum from water levels observed at Prince Rupert (Tides and Currents, Institute of Ocean Sciences, Sidney, B.C.).

Transects were established at approximately equal intervals and marked with gillnet leadline. Samples were collected also at equal intervals along transects. Based on preliminary analysis of results from studies in the Strait of Georgia, the optimal level of sampling was a transect density of 2.5 transects·km<sup>-1</sup> and 5 samples per transect. In this survey transect density was 2.4 transects·km<sup>-1</sup> and an average of 6.1 samples (n = 79, S.D. = 3.3) per transect were taken. The mean egg density (eggs·m<sup>-2</sup>) and 95% confidence interval were calculated assuming unequal primary units (transect lengths). This estimator weights the within transect means by the transect length to determine an overall mean for the spawn (Schweigert et al. 1984).

The inner and outer edge of spawns were determined from measurements along transects and the end of spawns beyond the outer transects were determined on exploratory dives. This information and the depth at sample sites were plotted on maps of shoreline vegetation at a scale of 1:6000 (Haegele and Hamey 1982a,b). The boundaries of the spawn and 2 m depth intervals were contoured using this information. The area of spawn between 2 m depth contours was measured on a micro-computer graphics tablet. Spawner biomass (tonnes) was estimated as the product of spawn area, egg density and 10<sup>-8</sup>, which assumes 200 eggs·g<sup>-1</sup> female weight (Hay 1985) and a 1:1 sex ratio. Egg distribution by 2 m depth intervals was estimated as the product of spawn area and mean eggs·m<sup>-2</sup> for quadrat samples obtained within the depth stratum.

Fishery Officers assessed the spawns independently from divers, recording length, average width, and average layers of eggs (Chalmers 1982). An echosounder estimate of herring biomass was made from a charter seine vessel and from Fishery Patrol vessels.

## RESULTS

Ten spawns were surveyed by divers on the North Coast in 1982. Locations of spawns, transect positions and quadrat locations are shown in Figs. 1 to 11. Sampling information, egg density and spawner biomass estimates are given for individual spawns, major geographical areas, and the entire North Coast in Table 1.

### BIOMASS ESTIMATES

#### Chatham Sound

There were four spawns surveyed by divers in Chatham Sound. Spawning progressed from north to south, beginning on March 27 in Port Simpson and ending April 4 in Big Bay. In Port Simpson (Fig. 2) two small patches of spawn were combined for analysis and this spawn was deposited by 77 tonnes of herring. Around the Flat Top Islands (Fig. 3) 220 tonnes spawned. The spawn

in Pearl Harbor was continuous with spawn along Burnt Cliff Island and the small islands adjacent to Burnt Cliff Island (Fig. 3). Together, this spawn was produced by 1553 tonnes. In Big Bay 1503 tonnes spawned between Beletti and Shattock points (Fig. 4). The sum for individual spawns was 3353 tonnes of spawners. Combining the data for all spawns, the estimate was for 3505 tonnes.

#### North Porcher Island

On North Porcher Island, two spawns, deposited between April 4 to 10, were surveyed. The Hunt Inlet spawn (Fig. 6) was deposited by 315 tonnes, the Hunt-West (Fig. 7) spawn by 46 tonnes. The sum of these two estimates was 361 tonnes, the estimates for the combined data was 386 tonnes for North Porcher Island.

#### Kitkatla Inlet

In Kitkatla Inlet there were three waves of spawn. Herring spawned from March 16 to 20 in Dries Inlet, from April 4 to 10 on Ness Islands and in Freeman Passage, and on April 18 on Billy Islands. Dries Inlet spawn (Fig. 8) was deposited by 447 tonnes. Around Ness Islands (Fig. 9) an estimated 271 tonnes spawned. The Freeman Passage spawn (Fig. 10) was the largest in Kitkatla Inlet and was deposited by 823 tonnes. The late spawn on Billy Islands (Fig. 11) was the smallest and was deposited by 156 tonnes. The Kitkatla Inlet spawner biomass was estimated at 1966 tonnes for combined data and the sums of individual spawns produced an estimate of 1697 tonnes.

#### SPAWN DISTRIBUTION

Mean percent cover of vegetation, layers of eggs and egg density (eggs·m<sup>-2</sup>) were highest in the +2 to 0 m depth interval, declining with shallower and deeper depths (Fig. 12). However, only for Chatham Sound were the differences between depth intervals consistently significant. Between locations, only percent cover and layers in the 0 to -2 m depth interval were significantly different.

Spawn in Chatham Sound was deposited quite shallow, 81% of the area of spawn was above Chart Datum and 95% of the eggs were deposited above Chart Datum (Tables 2, 3; Figs. 13, 14). Spawn on the north shore of Porcher Island was deeper, 80% of the area of spawn was below Chart Datum, however due to low egg density in deeper water, 50% of the eggs were deposited above Chart Datum. In Kitkatla Inlet spawn was deposited to the greatest depth, to 10 m below Chart Datum. However, because of the considerable amount of shallow spawn in Dries Inlet, 42% of the area of spawn and 52% of the eggs were above Chart Datum.

## FISHERY OFFICER SPAWN SURVEYS

Fishery Officers located and surveyed most of the spawns surveyed by divers, except spawns on northern Porcher Island. In addition, Fishery Officers located and surveyed spawns in Portland Inlet. Fishery Officers generally reported on longer spawns in several patches. The results of the Fishery Officer spawn survey are compared to results from the diving survey in Table 4. For spawns where dual surveys were conducted, estimates of length were generally similar, estimates of spawn area by Fishery Officers were lower than by divers, and layers of eggs were estimated higher by Fishery Officers.

## DISCUSSION

### SPAWN SURVEY COMPARISON

In Chatham Sound, where 81% of the spawn area was found by divers to be above Chart Datum, Fishery Officer reports were for 71% of the area measured by divers. In Kitkatla Inlet, where 42% of the spawn area was found by divers to be above Chart Datum, Fishery Officers reported 27% of the area measured by divers. The mean tide for Prince Rupert in April 1982 was 3.9 m above Chart Datum. Hence, it would appear that Fishery Officers were unable to successfully determine the presence of spawn that was deeper than about 3 m below mean tide level. The survey techniques available to Fishery Officers, visual inspection from the water surface and grappling, appear not to be suitable for determining the presence of deeper spawn. Estimates of egg layers by Fishery Officers were higher than estimates by divers by 2 and 4 times for Chatham Sound and Kitkatla Inlet, respectively. Egg layer estimates by Fishery Officers were most likely made from samples obtained in the intertidal zone, where egg layers were greatest (Fig. 12).

Along some shorelines, Fishery Officers reported spawn where none was found by divers. Where spawn was found by divers, the length estimates by Fishery Officers were generally lower. Patchiness of spawn deposition was likely the explanation for both. When adjacent diving transects had spawn, it was assumed that spawn was continuous between them. If two successive diving transects had no spawn, then spawn was assumed to have ended. Hence, if spawn was patchy, then the diving survey could miss small spawns and, alternately, bare patches in larger spawns could remain undetected. Fishery Officer survey techniques, where the observer travels parallel to the shore, may be more amenable for detecting such discontinuities. Overall, however, length estimates from dual spawn surveys were similar (27.7 km vs 29.8 km).

## STOCK ESTIMATE COMPARISONS

The stock estimate for areas surveyed on the North Coast was for 5659 tonnes from the diving survey. This did not include Portland Inlet, where Fishery Officers reported 2.3 ha of spawn, which accounted for 3% of the total area of spawn reported by them. Adjusting the diving survey estimate by this factor, 5829 tonnes for the entire North Coast are estimated. The 1982 echosounder estimate was between 5300 and 6200 tonnes (Chalmers 1982). However, Chalmers speculates that early spawning fish in Kitlatla Inlet were not included in the echosounder estimate. He estimates these earlier spawners to have been 1800 to 2200 tonnes, but the early Dries Inlet spawn was found from the diving survey to have been deposited by only 447 tonnes.

Stock assessment models used for B.C. herring produced considerably higher stock estimates than the diving survey (Stocker et al. 1983). Hourston's method estimated 1982 spawner biomass at 19,500 tonnes. This method uses spawn survey data collected by Fishery Officers to calculate egg deposition and, from this, spawner biomass. An "egg survival factor" is used to compensate for under-reporting of spawn (factors of 0.33, 0.67, and 1.00 were used for the North Coast). The high stock estimate by the Hourston method was probably in part due to the high estimate of egg layers. The difference in eggs·m<sup>-2</sup> between 1 layer and 3 layers (diver versus fishery officer estimate) on eelgrass at average (60) percent cover is 2.2 fold (Haegele et al. 1979). The age-structured model estimated the biomass of 3-yr-old and older fish at 29,000 tonnes (variable assumption) and the surplus production model estimated 20,000 tonnes (variable q). Since the estimates from the latter two models include all 3-yr-old and older fish, some of which may not have recruited, these estimates would tend to be higher. Both of these models also use the Fishery Officer spawn survey data (length and intensity) and the long, but narrow, spawns in Portland Inlet and the inflated estimate of egg layers may have contributed to the high stock estimates. Hence, some modification of the stock assessment models may be anticipated to calibrate them more closely with the more accurate escapement estimates that have been obtained by directly censusing egg depositon with diving surveys.

## MANAGEMENT IMPLICATIONS

The management strategy for British Columbia herring fisheries prior to 1983 was to allow the harvest of stocks that were surplus to a desired escapement (Hourston 1981). Since 1983 the harvesting strategy has been to harvest 20% of the forecast biomass (Stocker et al. 1983). The following discussion is based on the management strategy in place at the time of the spawn survey.

The spawner requirement for Chatham Sound had been set at 9072 tonnes for 1982 (Hourston 1981). The diving survey estimated 3353 tonnes in 1982. In 1979, a diving survey estimated 8000 tonnes (Haegele and Miller 1979). The 1979 estimate may be high because of the method used to estimate egg density. Rather than actual egg enumeration, as in 1982, egg densities were predicted from diver observations in 1979. Although layers of eggs were significantly higher ( $P = 0.005$ ) in 1979 (1.5 layers) than in 1982 (0.9 layers), they were not sufficiently higher to account for the difference in egg density which was

estimated at  $7.30 \times 10^5$  eggs  $\cdot m^2$  in 1979 and at  $2.10 \times 10^5$  eggs  $\cdot m^2$  in 1982. As well, area of spawn was greater in 1982 than in 1979 (167.2 ha vs 110.3 ha). However, there probably was a moderate decline in stocks from 1979 to 1982 and the 1982 estimate is lower than the desired escapement. Hence, the decision by managers to close the sac-roë fishery in Chatham Sound between 1979 and 1983 appears to have been well justified.

The spawner requirement for Porcher Island, which includes spawns on the north cost of Porcher Island and in Kitkatla Inlet, had been set at 9072 tonnes (Hourston 1981) for 1982. The estimate from the diving survey was for 2352 tonnes. Hence, the 1982 to 1983 sac-roë fishery closure in this area appears to have been the proper management decision.

#### ACKNOWLEDGMENTS

The divers who collected and processed the samples were D. Miller and L. Fitzpatrick from PBS and J. Carolsfeld, C. Hand, H. McElderry, and J. Watson from Archipelago Marine Research. J. Chedyk skippered the charter vessel M.V. LAREDO, from which the survey was conducted. COSEP program summer students J. P. Manhas, D. Cramb, I. Seaton, and T. Morlok enumerated the eggs in the preserved samples. L. Fitzpatrick drafted the figures.

#### REFERENCES

- Chalmers, D. 1982. Review of the 1981-82 British Columbia Herring Fishery and Spawn Abundance. Information Bulletin, D.F.O., F.S.B., Nanaimo: 65 p.
- Haegle, C. W. and M. J. Hamey. 1982a. Shoreline vegetation on herring spawning grounds in Chatham Sound, British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1660: iv + 27 p.
- 1982b. Shoreline vegetation on herring spawning grounds in Kitkatla Channel, British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1664: iv + 29 p.
- Haegle, C. W., A. S. Hourston, R. D. Humphreys, and D. C. Miller. 1979. Eggs per unit area in British Columbia herring spawn depositions. Fish. Mar. Serv. Tech. Rep. 894: 30 p.
- Haegle, C. W. and D. C. Miller. 1979. Assessment of 1979 herring spawnings in Chatham Sound, British Columbia. Fish. Mar. Serv. MS Rep. 1545: 31 p.
- Hay, D. E. 1985. Reproductive biology of Pacific herring (Clupea harengus pallasii). Can. J. Fish. Aquat. Sci.: (in press).

- Hourston, A. S. 1981. Stock assessments for British Columbia herring management units in 1981 and forecasts of the potential catch in 1982. Can. MS Rep. Fish. Aquat. Sci. 1631: iv + 15 p.
- Schweigert, J. F., C. W. Haegele, and M. Stocker. 1984. Optimal sampling design for herring spawn surveys in the Strait of Georgia, B.C. Can. J. Fish. Aquat. Sci.: (submitted).
- Stocker, M., V. Haist, and D. Fournier. 1983. Stock assessments for British Columbia herring in 1982 and forecasts of the potential catch in 1983. Can. Tech. Rep. Fish. Aquat. Sci. 1158: ix + 53 p.
- Webb, L. A. 1979. Review of the 1977-78 British Columbia herring fishery and spawn abundance. Can. Ind. Rep. Fish. Aquat. Sci. 112: 43 p.



Table 1. Length, area, egg density, and spawner biomass estimates for individual spawns, sections and the entire North Coast for spawns surveyed by divers in 1982.

Location	Length (km)	Av. transect length (m)	Area (ha)	No. of transects	No. of samples	Eggs $\text{m}^{-2} \cdot 10^{-3}$ (95% C. I.)	Tonnes of spawners (95% C. I.)
Port Simpson	1.0	36	4.07	5	21	188.7 (8.8-368.6)	77 (4- 150)
Flat Top Islands	1.2	60	6.32	4	19	348.3 (14.4-682.2)	220 (9- 431)
Pearl Harbour	7.5	89	76.62	15	92	202.7 (127.9-277.6)	1553 (980-2127)
Big Bay	4.4	153	80.22	6	52	187.4 (68.6-306.3)	1503 (550-2457)
Chatham Sound	14.1	89	167.23	30	184	209.6 (143.3-276.0)	3505 (2395-4616)
Hunts Inlet	4.0	51	13.57	10	52	231.9 (60.6-403.2)	315 (82- 547)
Hunts West	1.8	34	6.27	5	20	73.7 (-64.2-211.6)	46 (0- 133)
North Porcher	5.8	46	19.84	15	72	194.5 (51.5-337.4)	386 (102- 669)
Dries Inlet	4.0	164	70.53	7	56	63.4 (-9.0-135.9)	447 (0- 959)
Ness Islands	3.0	47	14.87	6	26	182.2 (36.3-328.2)	271 (54- 488)
Freeman Passage	4.8	87	48.80	13	89	168.6 (34.2-303.1)	823 (167-1479)
Billy Islands	1.8	77	8.70	8	55	179.1 (65.8-292.5)	156 (57- 255)
Kitkatla Inlet	13.6	92	142.90	34	226	137.6 (76.6-198.6)	1966 (1095-2838)
North Coast	33.5	82	329.97	79	482	171.5 (127.9-215.0)	5659 (4220-7094)

Table 2. Area of spawn (ha) by depth interval for 1982 North Coast herring spawns surveyed by divers.

Location	Depth interval (m above or below Chart Datum)							
	+4to+2	+2to0	0to-2	-2to-4	-4to-6	-6to-8	-8to-10	+4to-10
Chatham Sound								
Port Simpson	0.49	2.39	1.19					4.07
Flat Top Islands	0.81	4.06	1.45					6.32
Pearl Harbour	17.54	45.17	7.11	3.72	3.08			76.62
Big Bay	26.58	38.72	14.92					80.22
All Chatham	45.42	90.34	24.67	3.72	3.08			167.23
North Porcher								
Hunts Inlet	0.88	2.64	5.29	3.77	0.99			13.57
Hunts-west		0.32	1.37	2.55	2.03			6.27
All Porcher	0.88	2.96	6.66	6.32	3.02			19.84
Kitkatla Inlet								
Dries Inlet	2.82	40.72	19.46	7.53				70.53
Ness Islands	0.50	5.64	8.33	0.40				14.87
Freeman Pass	3.15	6.93	10.60	10.84	10.84	5.44	1.00	48.80
Billy Islands	0.10	0.26	2.01	5.42	0.69	0.22		8.70
All Kitkatla	6.57	53.55	40.40	24.19	11.53	5.66	1.00	142.90
North Coast	52.87	146.85	71.73	34.23	17.63	5.66	1.00	329.97

Table 3. Estimates of egg density and spawner biomass by depth interval for 1982 North Coast herring spawns surveyed by divers.

Location	Depth interval	Area (ha)	Eggs $\cdot 10^{-3} \cdot m^{-2}$ (95% C.I.)	Tonnes of spawners (95% C.I.)
Chatham Sound	+4 to +2	45.42	237 (153 to 321)	1076 (694 to 1458)
	+2 to 0	90.34	252 (188 to 316)	2277 (1698 to 2855)
	0 to -2	24.67	48 (10 to 86)	118 (25 to 212)
	-2 to -4	3.72	115 (9 to 221)	43 (3 to 82)
	-4 to -6	3.08	126 (-38 to 290)	39 (0 to 89)
North Porcher	+4 to +2	0.88	402 (70 to 734)	35 (6 to 65)
	+2 to 0	2.96	385 (13 to 757)	114 (4 to 224)
	0 to -2	6.66	133 (49 to 217)	89 (33 to 145)
	-2 to -4	6.32	97 (21 to 173)	61 (13 to 109)
	-4 to -6	3.02	3 (0 to 6)	1 (0 to 2)
Kitkatla Inlet	+4 to +2	6.57	161 (65 to 257)	106 (43 to 169)
	+2 to 0	53.55	196 (54 to 338)	1050 (289 to 1810)
	0 to -2	40.40	116 (52 to 180)	469 (210 to 727)
	-2 to -4	24.19	65 (33 to 97)	157 (80 to 235)
	-4 to -6	11.53	212 (98 to 326)	244 (113 to 376)
	-6 to -8	5.66	319 (-69 to 707)	181 (0 to 400)
	-8 to -10	1.00	401 (-401 to 1203)	40 (0 to 120)

Table 4. Comparison of diving survey and Fishing Officer spawn survey results for 1982 herring spawns on the North Coast of British Columbia.

Location	Transects	Diver			Fishery Officer			F.O. Div-1		
		Length (m)	Area (ha)	Layers	Length (m)	Area (ha)	Layers <sup>a</sup>	Length	Area	Layers
Portland Inlet Hastings Arm	-	No survey			1000	0.50	0.2	-	-	-
	-	No survey			2500	0.25	0.1	-	-	-
	-	No survey			300	0.03	0.7	-	-	-
	-	No survey			3500	0.35	0.4	-	-	-
	-	No survey			7300	1.13	0.2	-	-	-
Alice Arm	-	No survey			150	0.03	0.1	-	-	-
	-	No survey			300	0.09	0.3	-	-	-
	-	No survey			150	0.08	0.3	-	-	-
	-	No survey			150	0.08	0.2	-	-	-
	-	No survey			25	0.03	0.5	-	-	-
	-	No survey			25	0.01	0.1	-	-	-
	-	No survey			150	0.08	0.3	-	-	-
	-	No survey			30	0.02	0.5	-	-	-
	-	No survey			20	0.01	0.5	-	-	-
	-	No survey			20	0.01	0.5	-	-	-
	-	No survey			80	0.24	0.3	-	-	-
	-	No survey			150	0.08	0.3	-	-	-
	-	No survey			1250	0.76	0.4	-	-	-
Chatham Sound Port Simpson 1	-	-	-	-	100	0.15	1.0	-	-	-
	-	-	-	-	300	0.15	1.4	-	-	-
	-	-	-	-	200	0.40	2.2	-	-	-
	-	-	-	-	50	0.03	2.0	-	-	-
	B1-B3	680	1.90	1.9	650	0.73	1.8	0.96	0.38	0.95
Port Simpson 2	-	-	-	-	300	0.30	2.6	-	-	-
	-	-	-	-	300	0.30	1.0	-	-	-
	-	-	-	-	600	0.60	1.6	-	-	-
	-	-	-	-	600	0.90	0.6	-	-	-
	B4,B5	320	2.17	0.8	1800	2.10	1.2	5.63	0.97	1.50
Flat Top Is.	B1-B4	1200	6.32	1.0	900	1.80	2.7	0.75	0.28	2.70
Pearl Harbour	B1,B2	640	2.55	0.8	1600	4.80	2.1	2.50	1.88	2.63
	B3,B4	700	4.33	0.7	500	1.50	4.0	0.71	0.35	5.71
	B5,B6	850	9.47	0.6	500	2.00	2.9	0.59	0.21	4.83
	(B7)	180	1.32	2.7	250	0.75	3.1	1.39	0.57	1.15
	B7-B9	2100	26.98	1.5	1900	7.60	3.0	0.90	0.28	2.00
	B11 (B11)	250 320	2.02 1.32	1.4 1.4	300 600	0.30 1.20	1.6 2.7	1.20 1.88	0.15 0.91	1.14 1.93

Table 4 (cont'd)

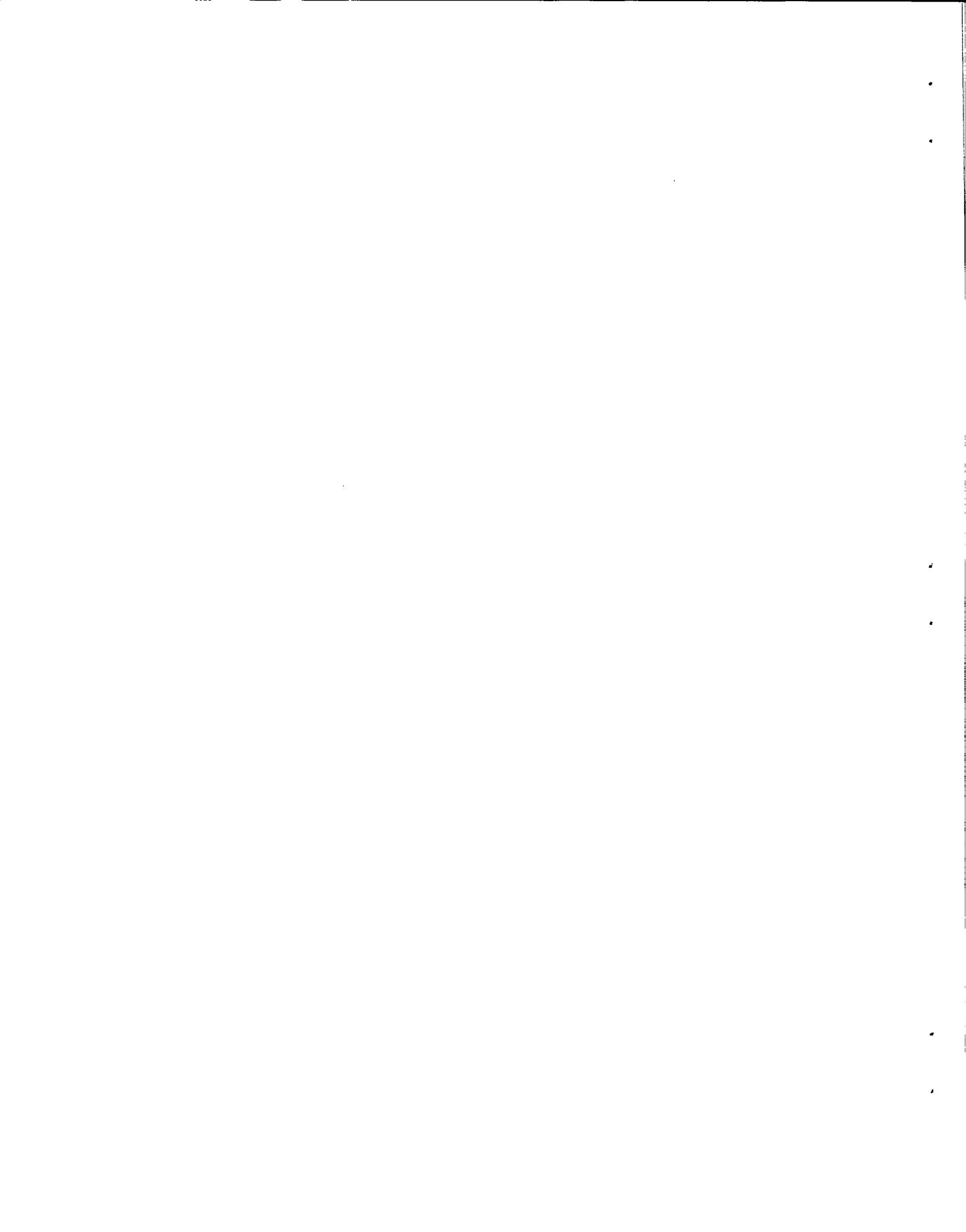
Location	Transects	Diver			Fishery Officer			F.O. Div-1		
		Length (m)	Area (ha)	Layers	Length (m)	Area (ha)	Layers <sup>a</sup>	Length	Area	Layers
Pearl Harbour (cont'd)	B10,B12	600	9.61	0.9	800	2.40	1.8	1.33	0.25	2.00
	B13,B14	800	5.65	1.0	600	3.00	3.4	0.75	0.53	3.40
	(B14)	500	9.32	1.0	500	5.00	3.2	1.00	0.54	3.20
	B15	560	4.05	0.6	800	2.40	2.9	1.43	0.59	4.83
	B1-B15	7500	76.62	1.0	8350	30.95	2.9	1.11	0.40	2.90
Big Bay	B1	320	5.85	0.4	600	12.00	2.4	1.88	2.05	6.00
	(B1)	540	7.65	0.4	1200	4.80	2.7	2.22	0.63	6.75
	B2-B4	1900	49.95	1.4	1600	29.00	3.9	0.84	0.58	2.79
	(B4)	310	9.15	0.7	600	3.60	3.0	1.94	0.39	4.29
	B5	1050	5.88	0.5	1400	3.50	2.9	1.33	0.60	5.80
	B6	280	1.74	1.1	2000	30.00	0.3	7.14	17.24	0.27
	B1-B6	4400	80.22	1.2	7400	82.90	2.2	1.68	1.03	1.83
North Porcher Hunts Inlet	B1-B11	4000	13.57	0.9	No report			-	-	-
Hunts - West	B1-B5	1800	6.27	0.3	No report			-	-	-
Kitkatla Inlet Dries Inlet	B1-B4	1680	36.43	0.7	(2000)	17.54	2.0	(1.19)	0.48	2.86
	B5,6,8	2320	34.10	0.5	137	0.63	3.8	0.06	0.02	7.60
	-		No spawn		91	0.08	4.0	-	-	-
	-		No spawn		549	0.77	4.3	-	-	-
	-		No spawn		366	0.66	4.3	-	-	-
	-		No spawn		366	1.35	2.5	-	-	-
	-		No spawn		640	2.94	3.3	-	-	-
	B1-B6,B8	4000	70.53	0.6	4149	23.97	2.4	1.04	0.34	4.00
Porcher Narrows	-		No survey		110	0.41	1.8	-	-	-
	-		No survey		91	0.25	5.5	-	-	-
	-		No survey		201	0.66	3.2	-	-	-
Ness Is.	B1	430	1.75	1.0	549	0.22	1.0	1.28	0.13	1.00
	B2	240	0.83	0.5	183	0.16	1.0	0.76	0.19	2.00
	B3	650	1.40	0.1	594	0.36	1.0	0.91	0.26	10.00
	B4	600	2.77	0.2	366	0.18	2.1	0.61	0.06	10.50
	B5	680	6.73	0.3	549	1.48	3.8	0.81	0.22	12.67
	B6	400	1.39	0.9	366	0.33	1.3	0.92	0.24	1.44
	B1-B6	3000	14.87	0.5	2607	2.73	2.6	0.87	0.18	5.20

Table 4 (cont'd)

Location	Transects	Diver			Fishery Officer			F.O.-Div-1		
		Length (m)	Area (ha)	Layers	Length (m)	Area (ha)	Layers <sup>a</sup>	Length	Area	Layers
Freeman Pass	-	No spawn			183	0.42	8.0	-	-	-
	-	No spawn			46	0.06	3.0	-	-	-
	-	No spawn			91	0.08	3.0	-	-	-
	-	No spawn			69	0.12	8.0	-	-	-
	(B14)	170	1.30	3.8	64	0.12	8.0	0.38	0.09	2.11
	B14	260	1.22	3.8	69	0.10	3.0	0.27	0.08	0.79
	(B14)	210	1.28	3.8	91	0.16	5.0	0.43	0.13	1.32
	B13	330	3.85	0.9	137	0.25	6.0	0.42	0.06	6.67
	B10-B12	800	7.88	0.6	550	6.04	4.1	0.69	0.77	6.83
	B9	270	1.95	6.0	274	0.38	3.0	1.01	0.19	0.50
	B7,B8	710	6.12	0.2	457	0.82	2.8	0.64	0.13	14.00
	B6	110	1.03	0.8	69	0.06	2.8	0.63	0.06	3.50
	(B6)	140	1.24	0.8	137	0.12	1.9	0.98	0.10	2.38
	B5	530	6.23	1.1	219	0.39	1.9	0.41	0.06	1.73
B2-B4	1270	16.70	0.3	No report			-	-	-	
-	No spawn			914	1.65	(4.1)	-	-	-	
B2-B14	4800	48.80	1.0	3370	10.77	4.1	0.70	0.22	4.10	
Billy Is.	B1,B2	460	1.54	0.7	91	0.16	2.0	0.20	0.10	2.86
	B4,B5	170	0.78	1.0	110	0.20	3.0	0.65	0.26	3.00
	B11	380	2.66	0.5	137	0.37	2.0	0.36	0.14	4.00
	B6-B8,B12	790	3.72	0.6	201	0.36	2.0	0.25	0.10	3.33
	B1-B12 (except B3,B9,B10)	1800	8.70	0.7	539	1.09	2.2	0.30	0.13	3.14
<b>Totals</b>										
Portland In.		No survey			8550	1.89	0.3	-	-	-
Chatham Sound		14100	157.23	1.1	19100	118.48	2.4	1.35	0.71	2.18
North Porcher		5800	19.84	0.7	No survey			-	-	-
Kitkatla Inlet		13600	142.90	0.7	10866	39.22	2.9	0.80	0.27	4.14
All dual surveys		27700	310.13	0.9	29765	157.04	2.5	1.07	0.51	2.78
All North Coast		33500	329.97	0.8	38516	159.59	2.5	-	-	-

<sup>a</sup>Layers for totals weighted by reported area.

FIGURES



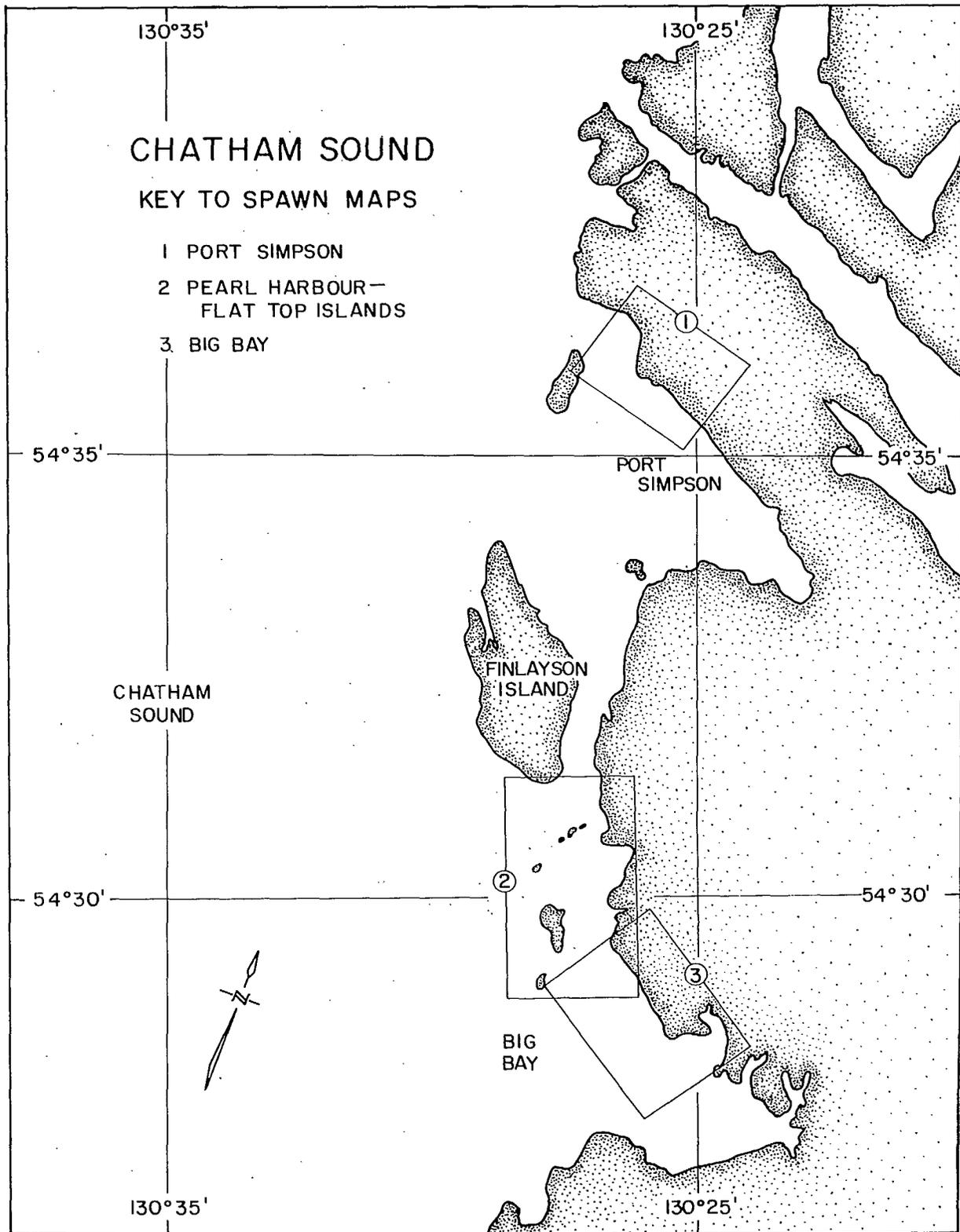


Figure 1. Map of Chatham Sound study area.



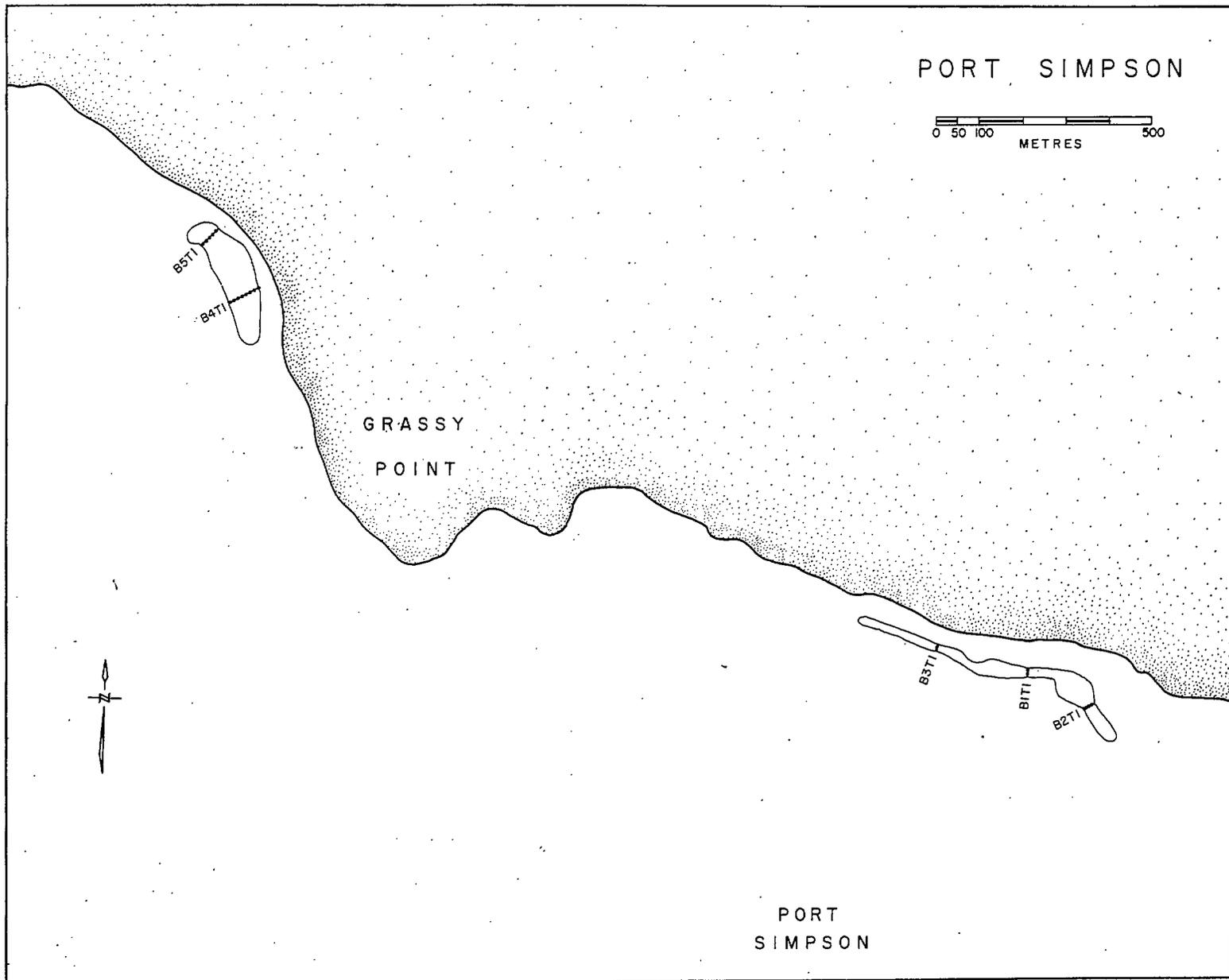
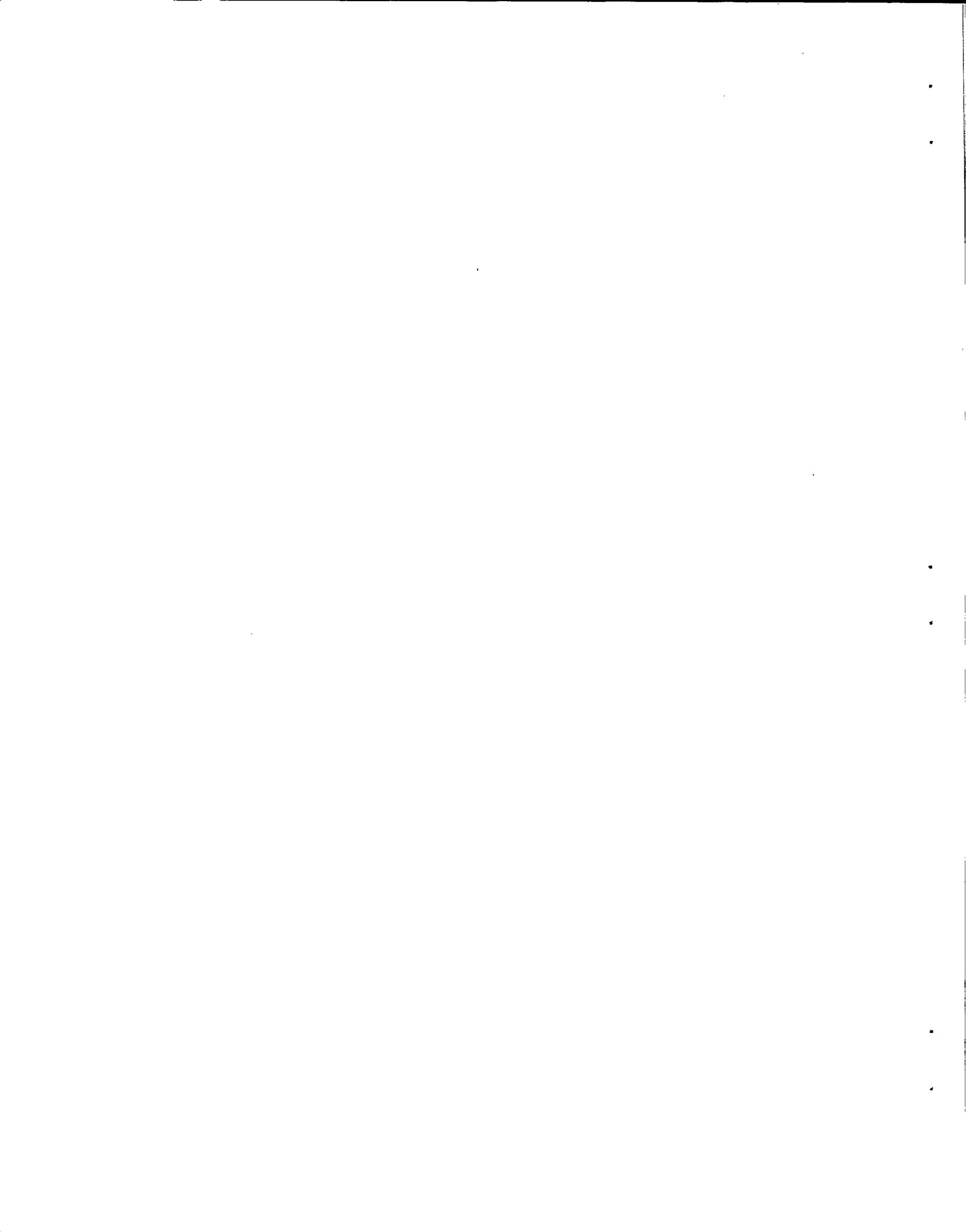
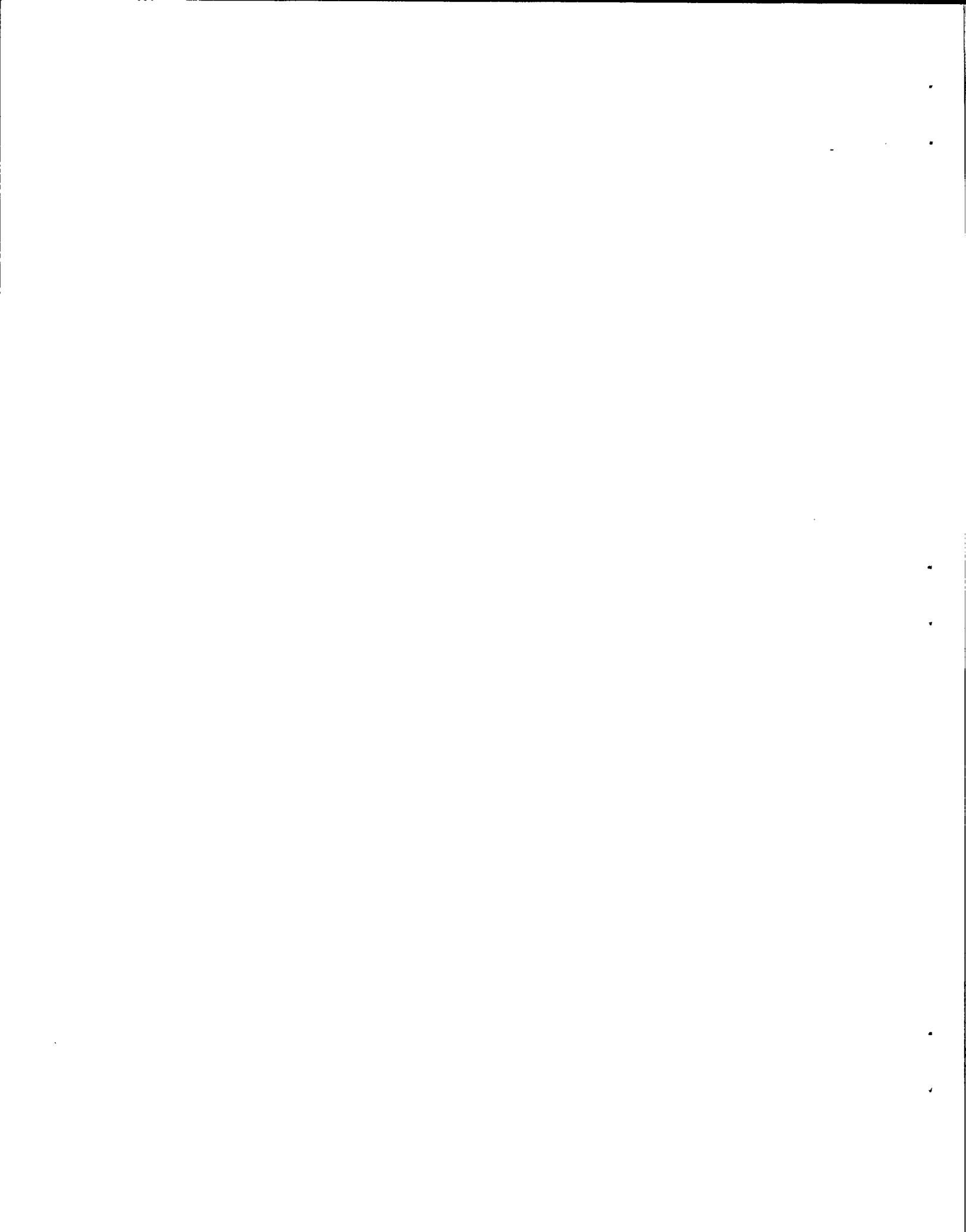


Figure 2. Herring spawn in 1982 in Port Simpson, with transects and quadrat sample sites indicated.







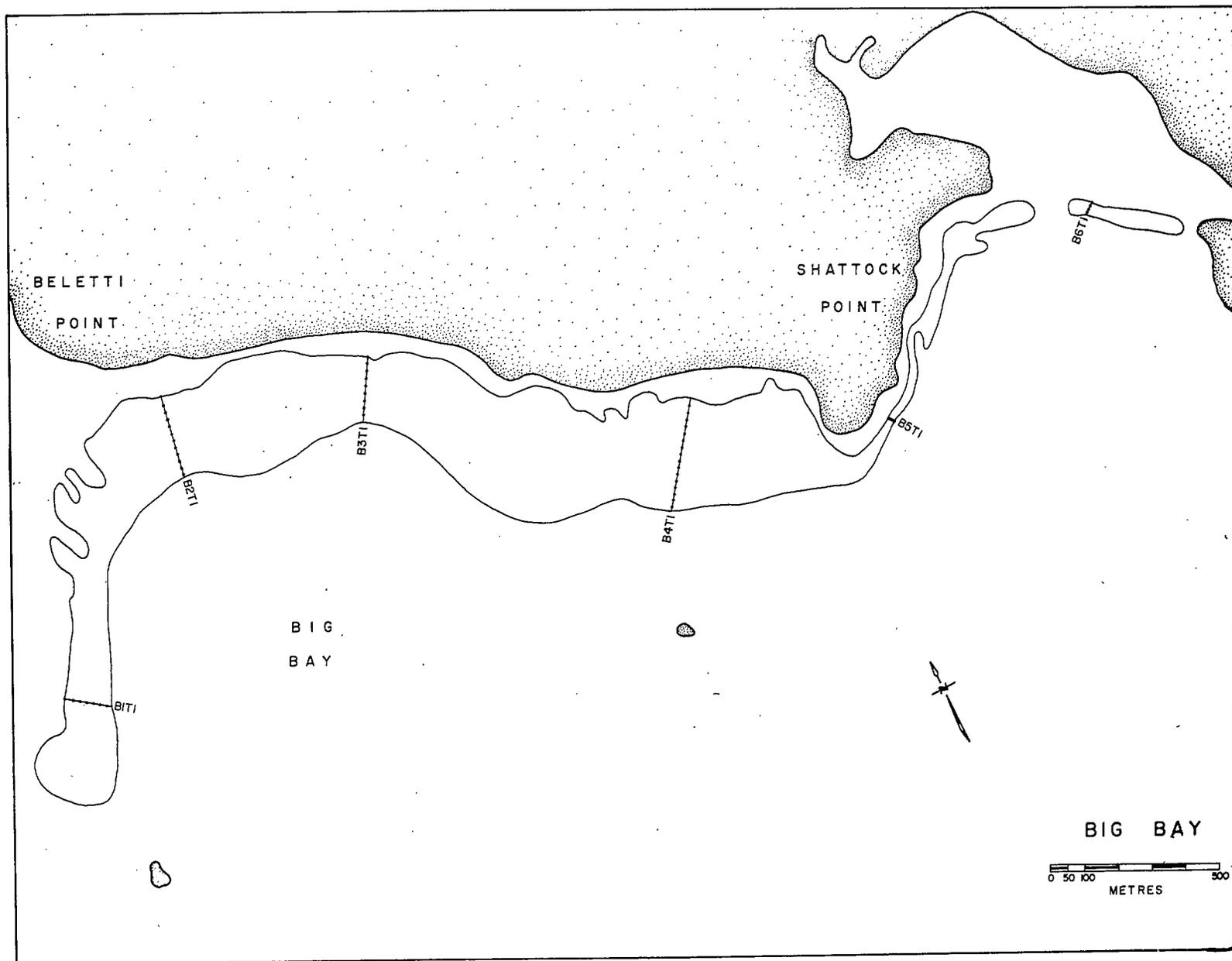
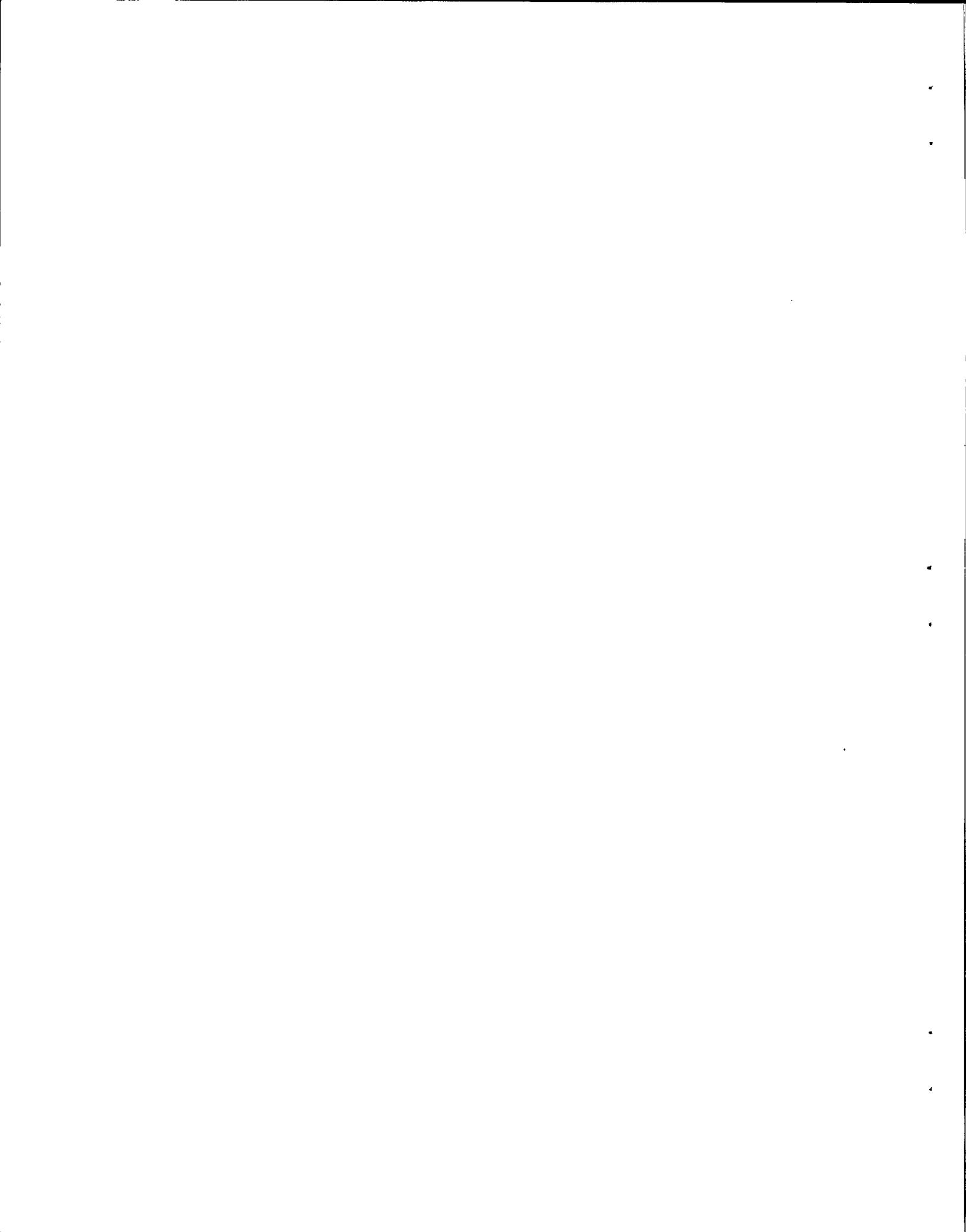


Figure 4. Herring spawn in 1982 in Big Bay, with transects and quadrat sample sites indicated.



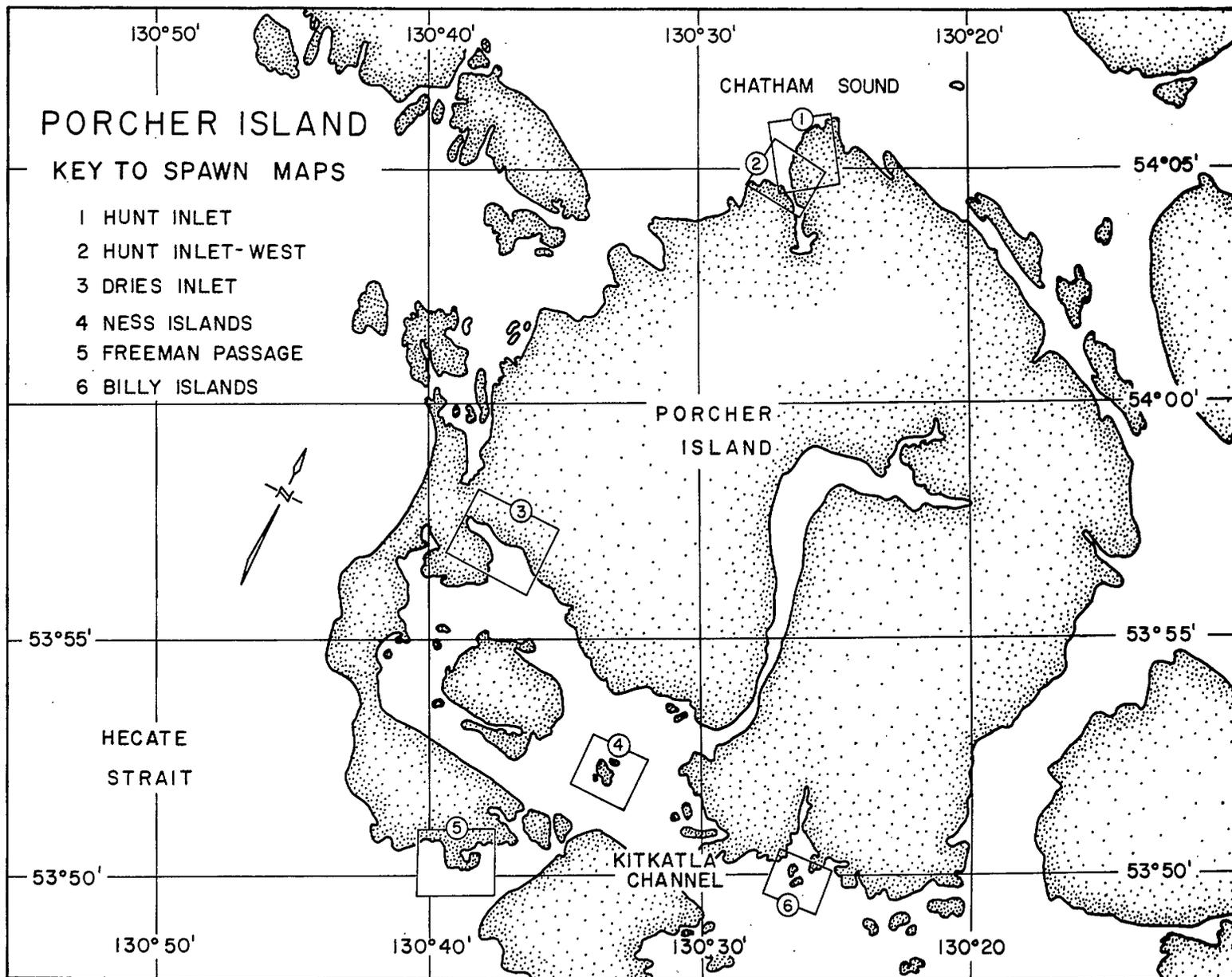
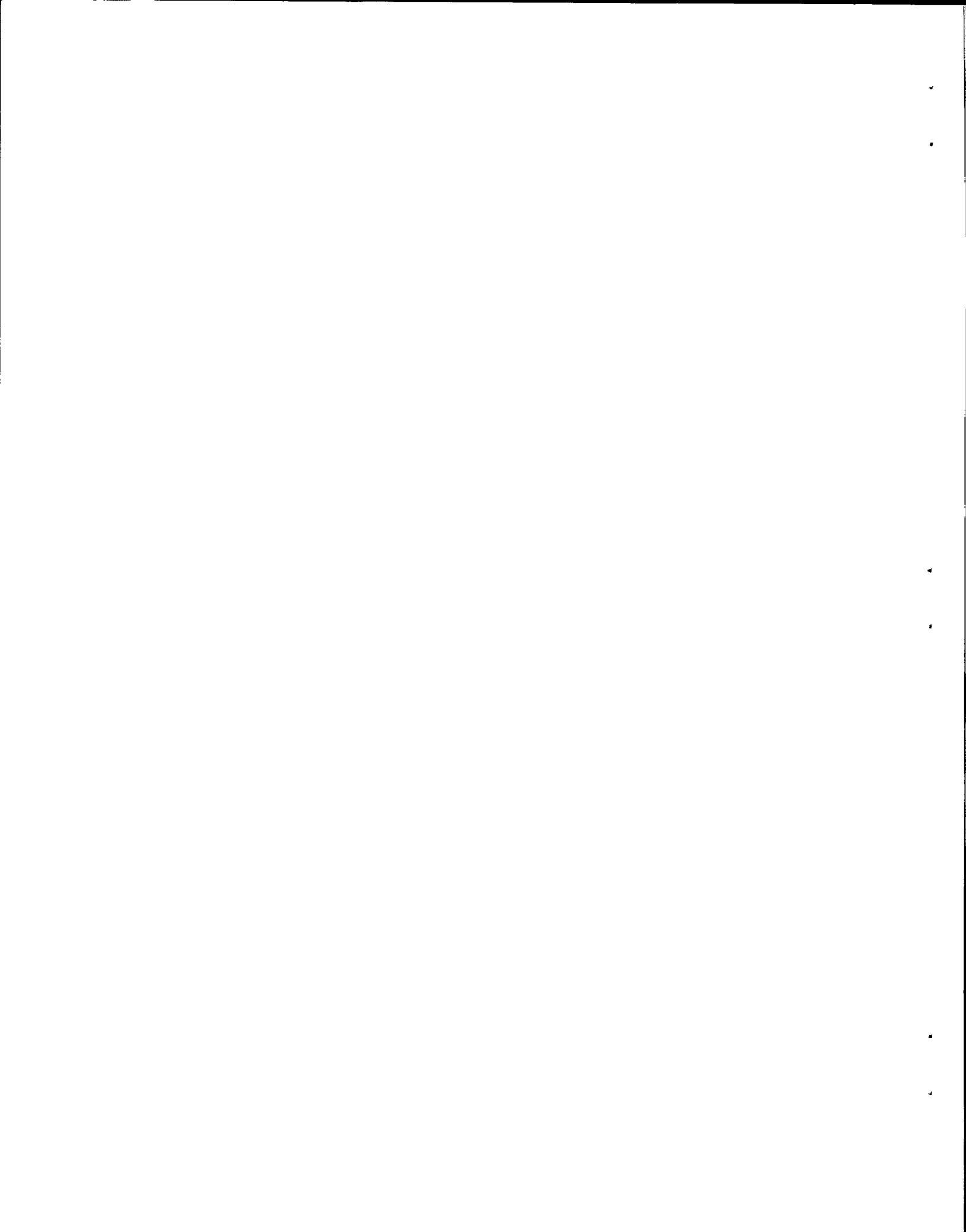


Figure 5. Map of Porcher Island study areas.



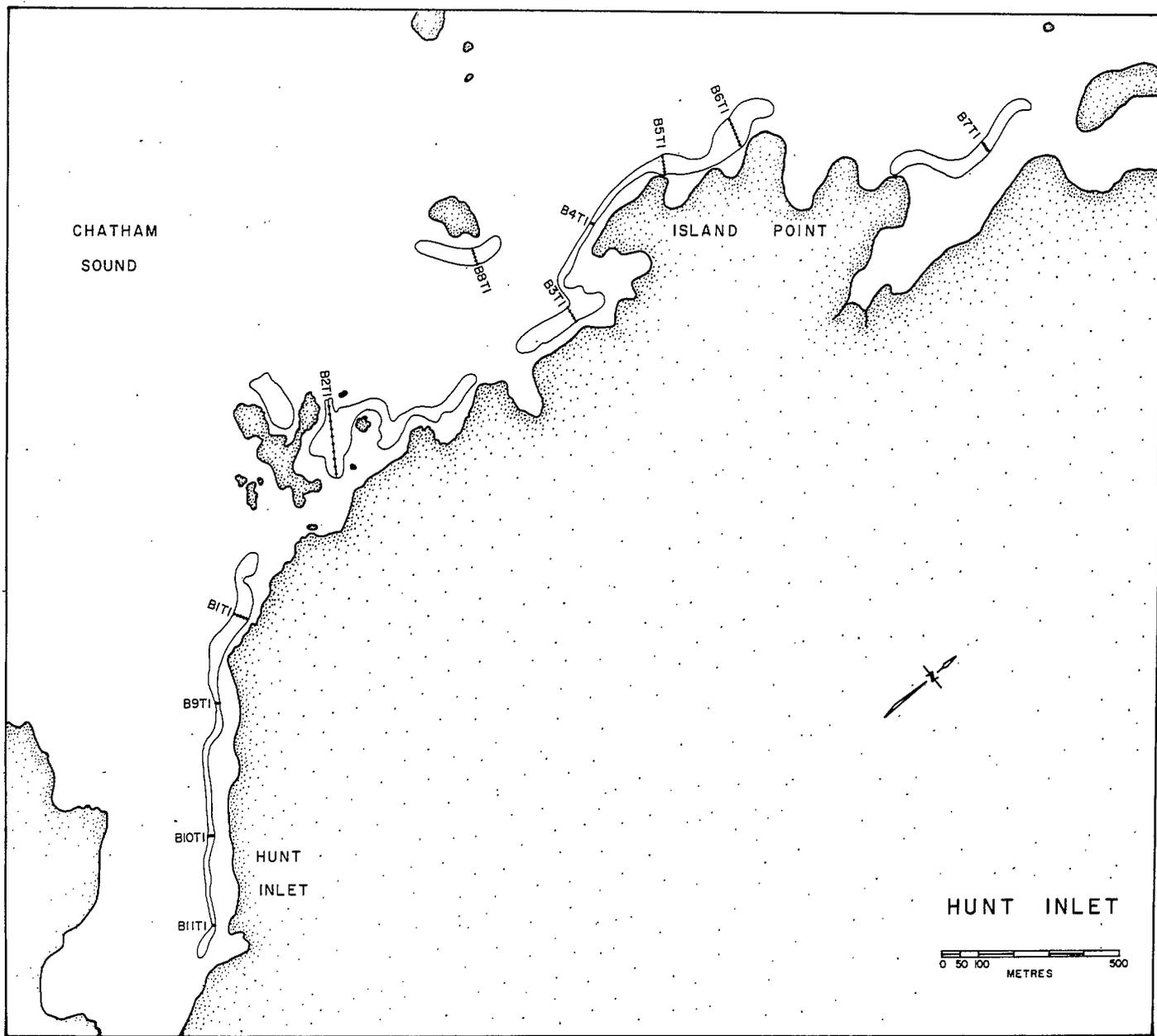
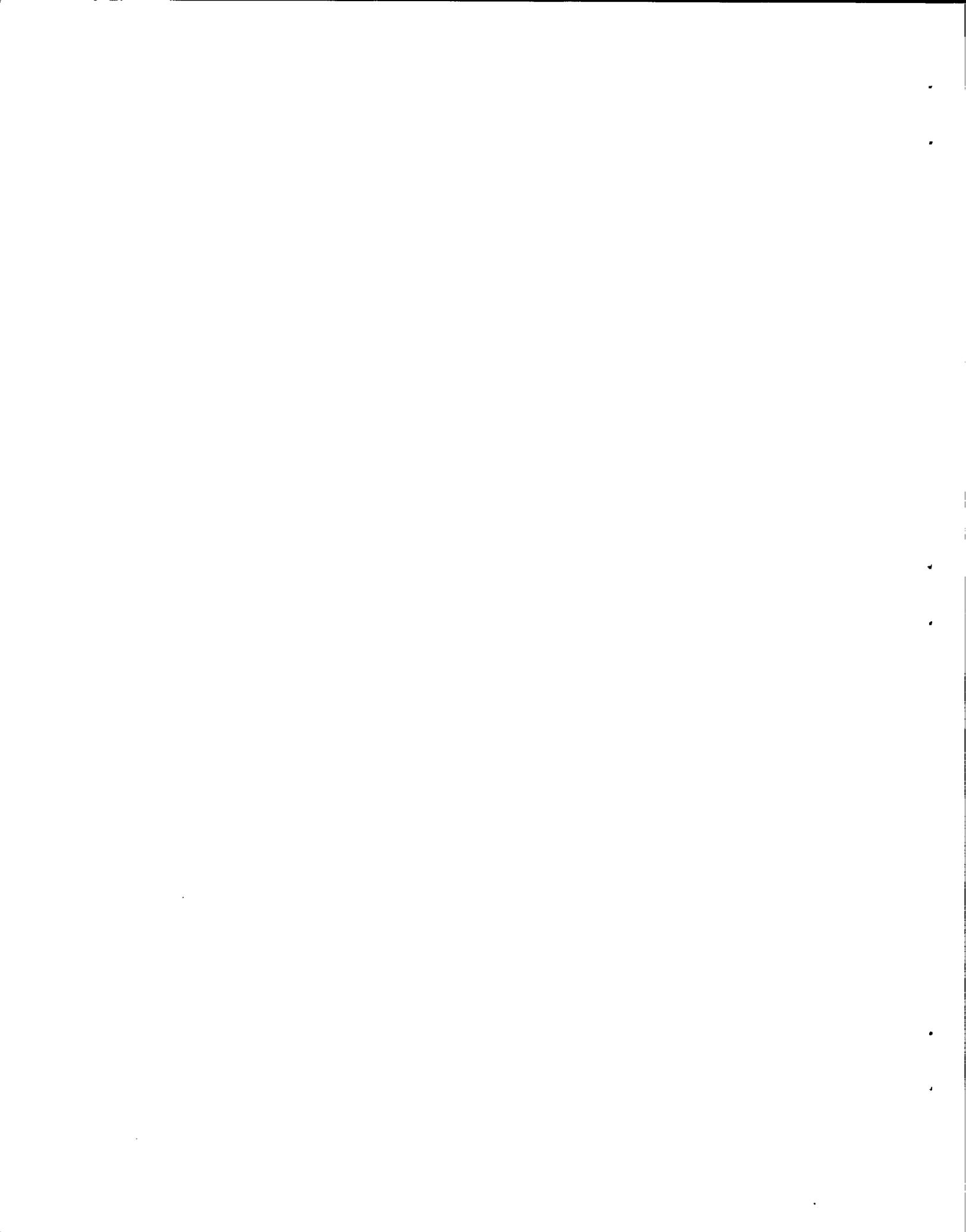


Figure 6. Herring spawn in 1982 in Hunt Inlet, with transects and quadrat sample sites indicated.



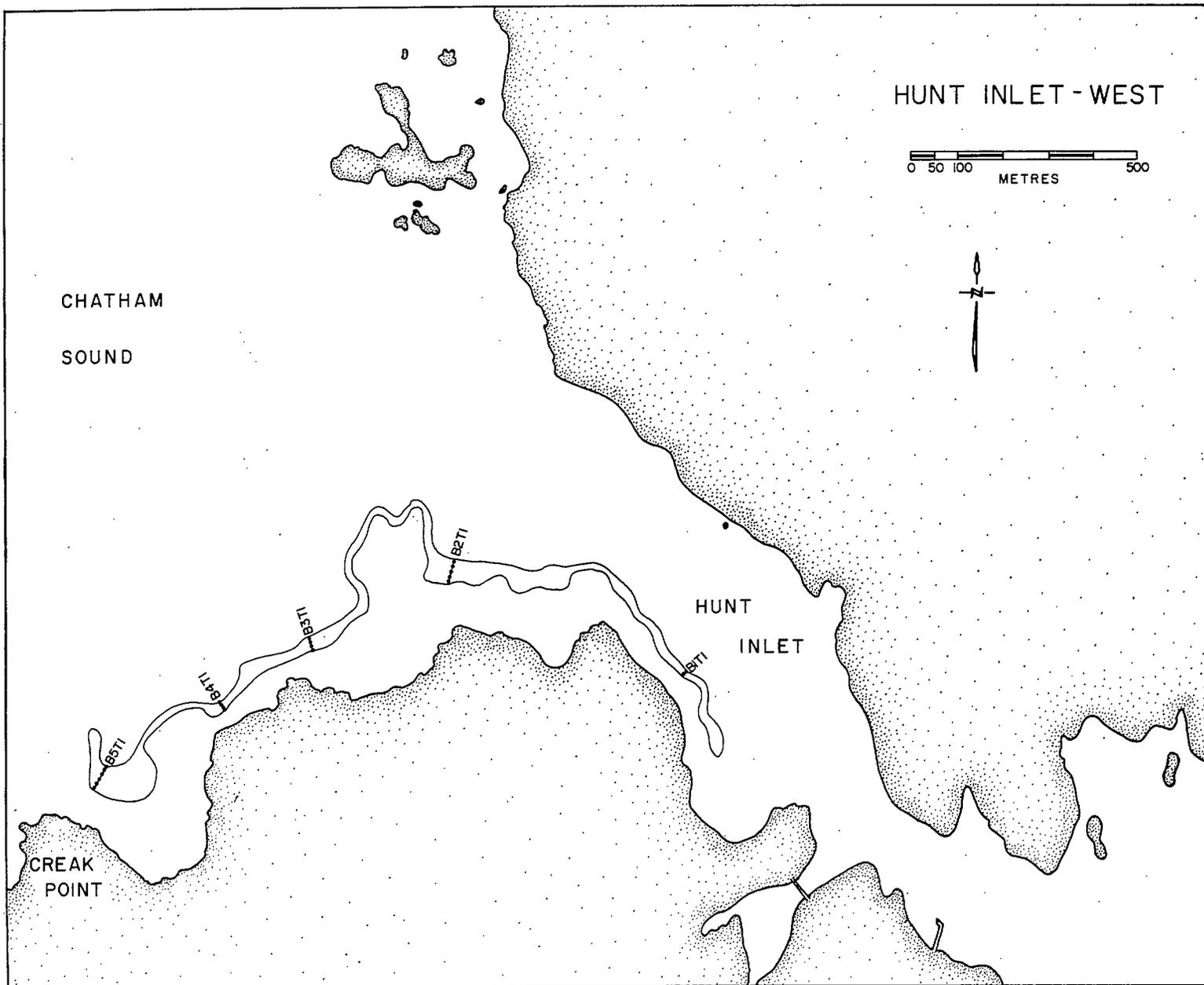
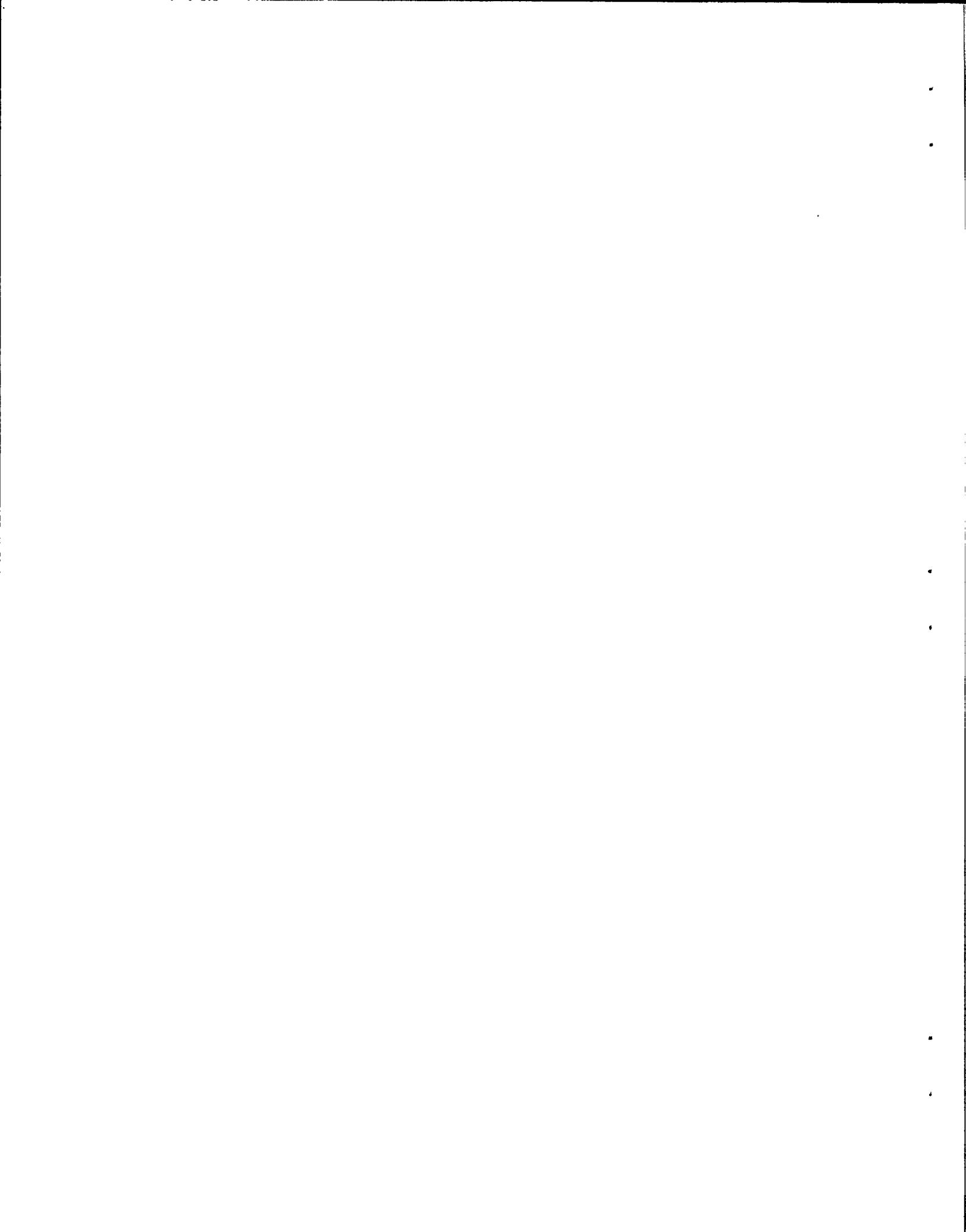


Figure 7. Herring spawn in 1982 in Hunt Inlet-West, with transects and quadrats sample sites indicated.



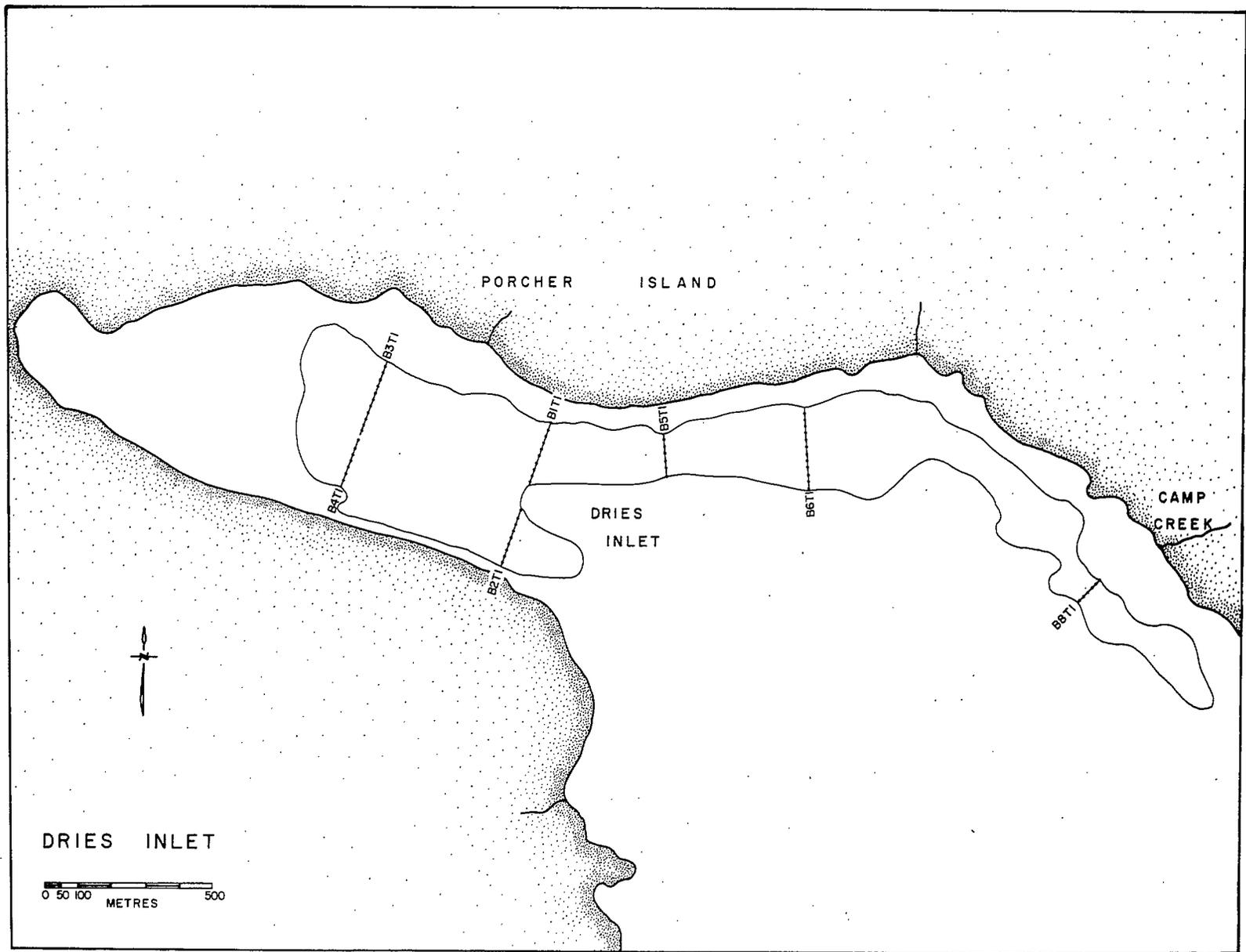
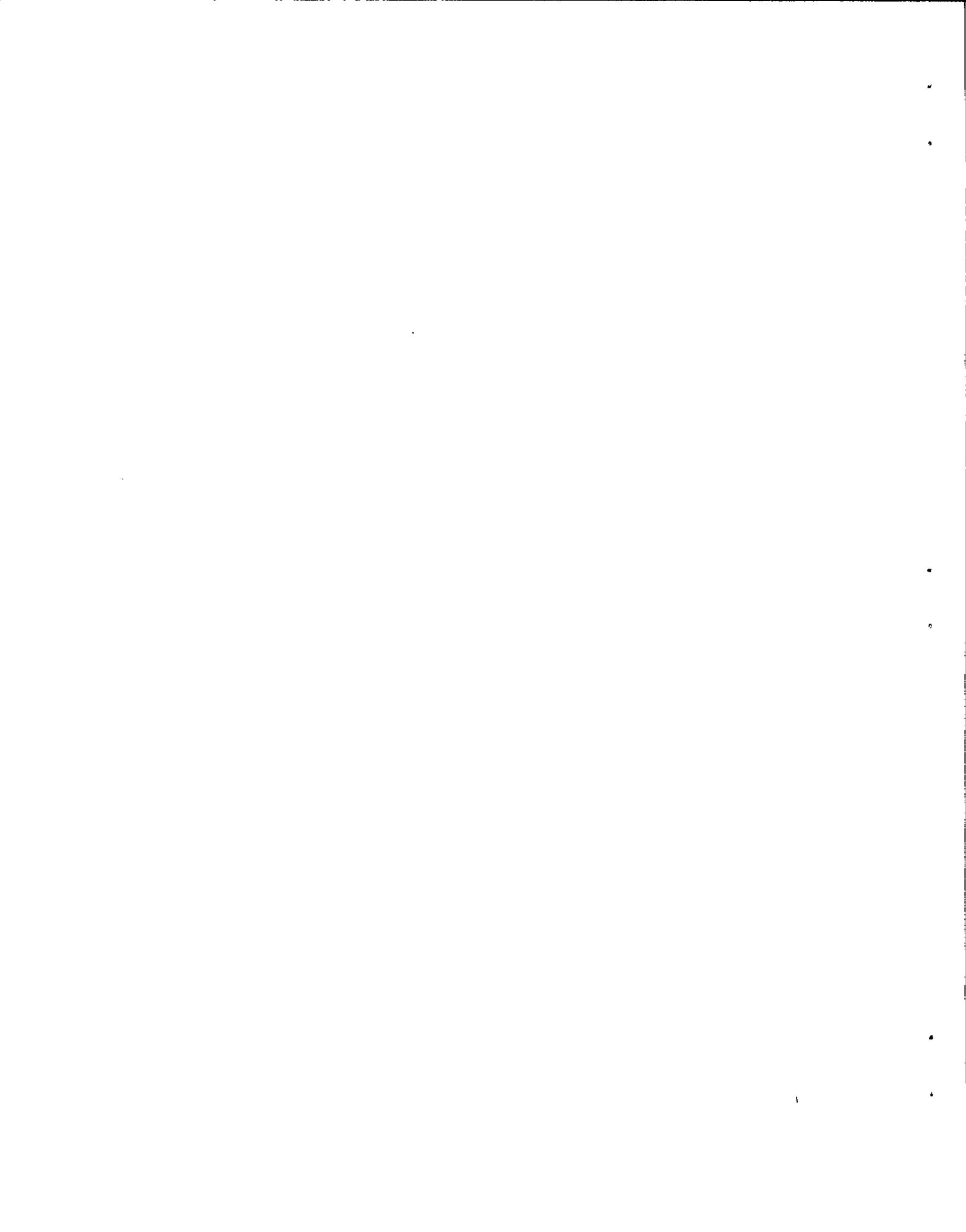


Figure 8. Herring spawn in 1982 in Dries Inlet, with transects and quadrat samples sites indicated.



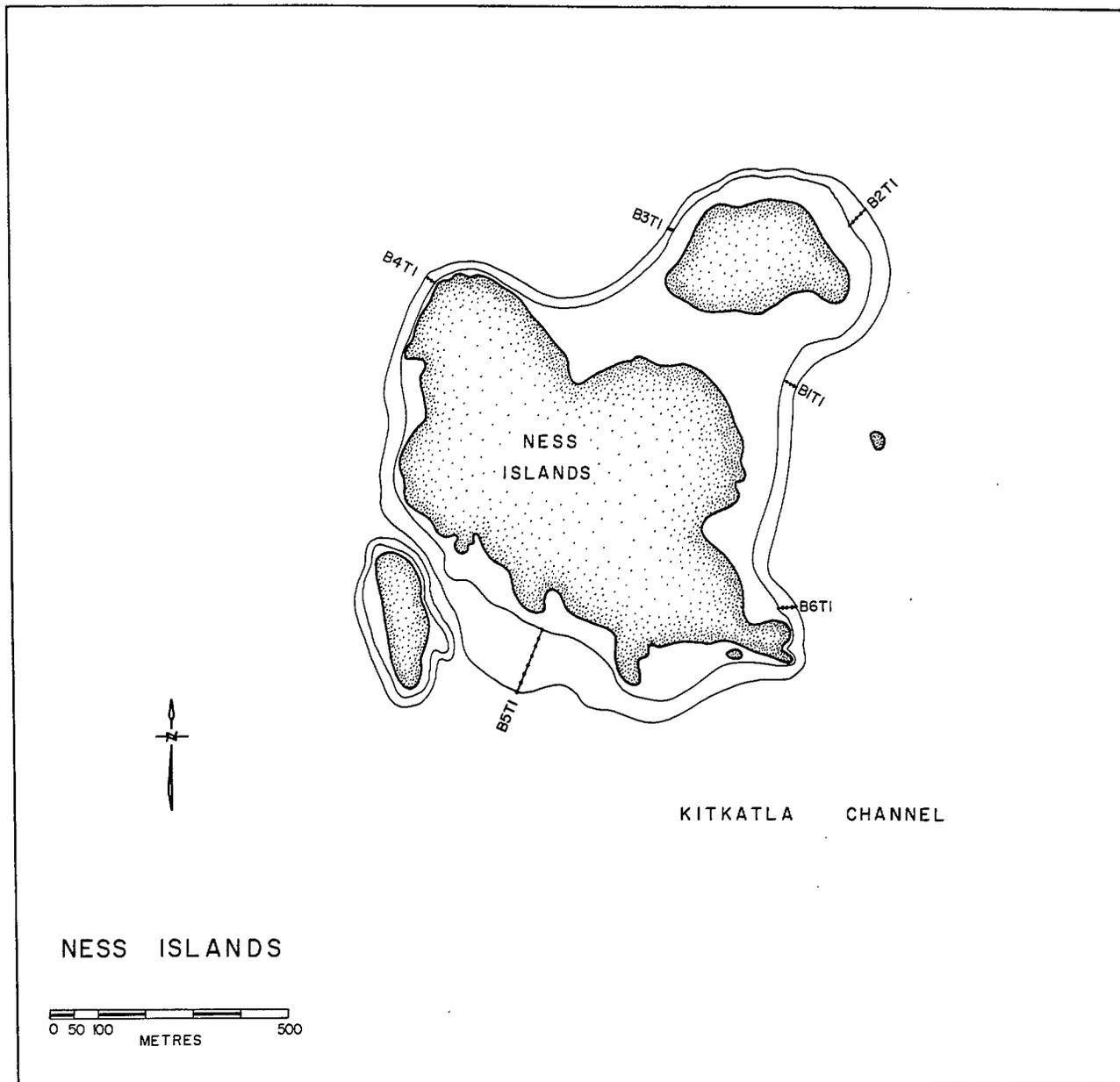
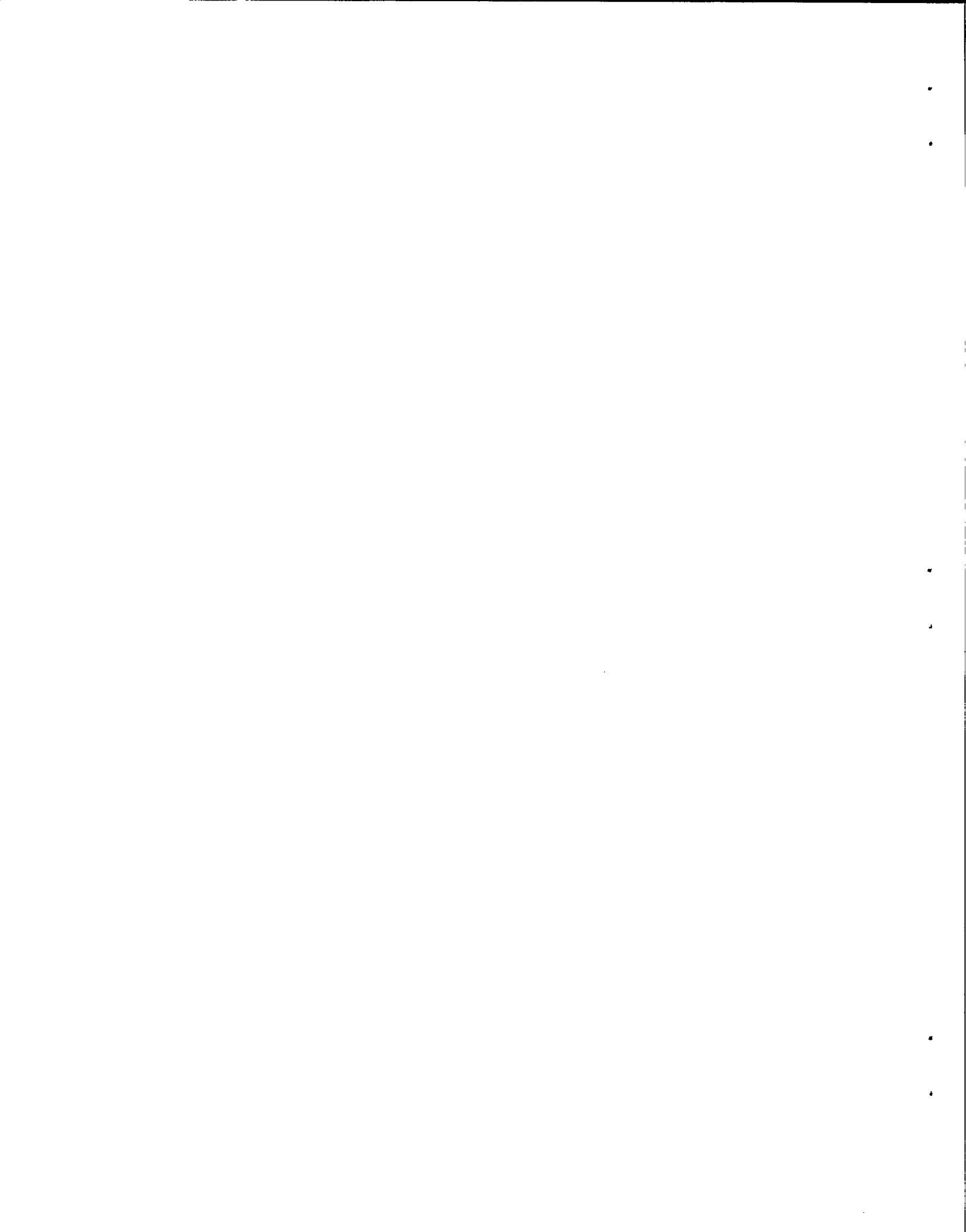


Figure 9. Herring spawn in 1982 around Ness Islands, with transects and quadrat sample sites indicated.



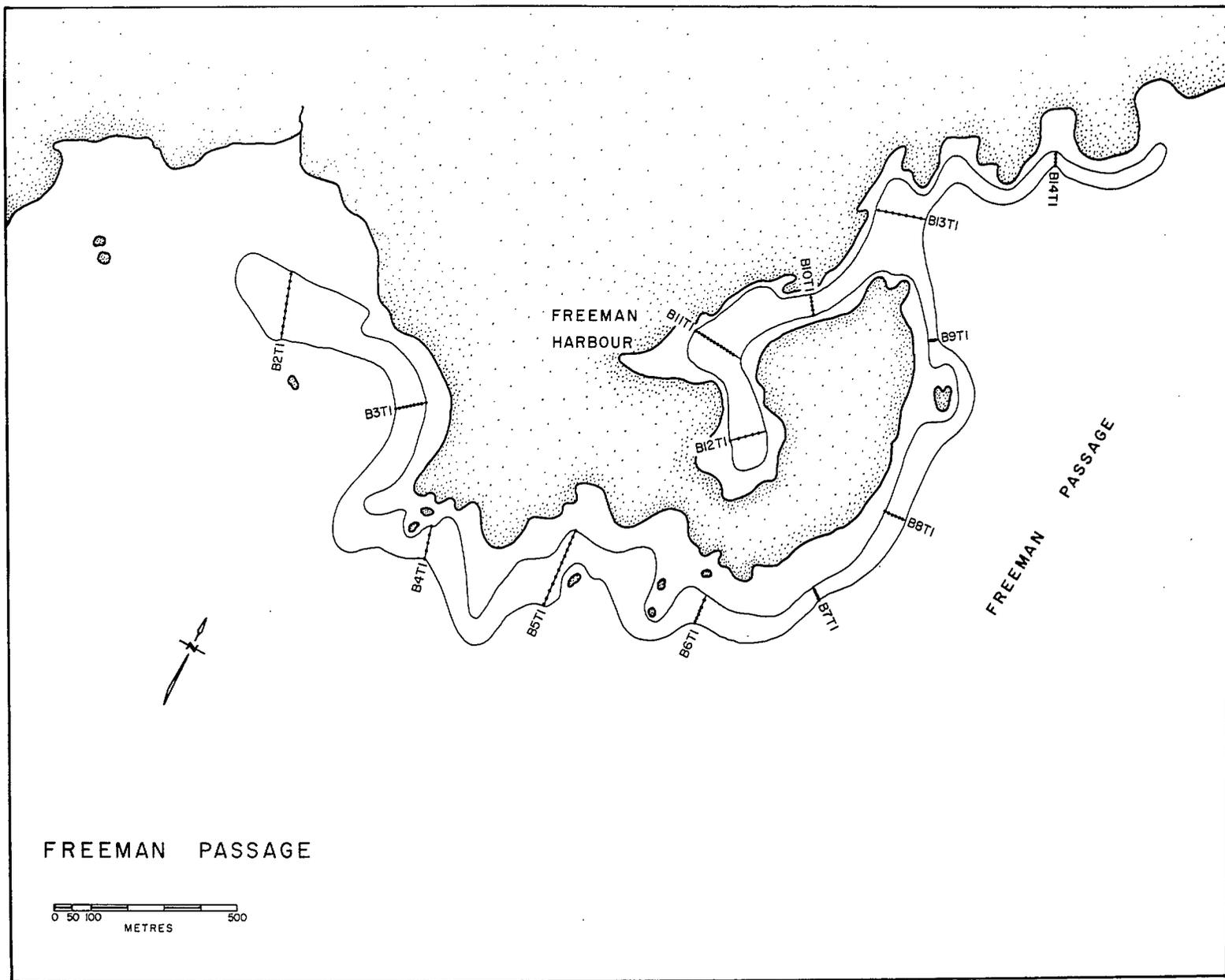
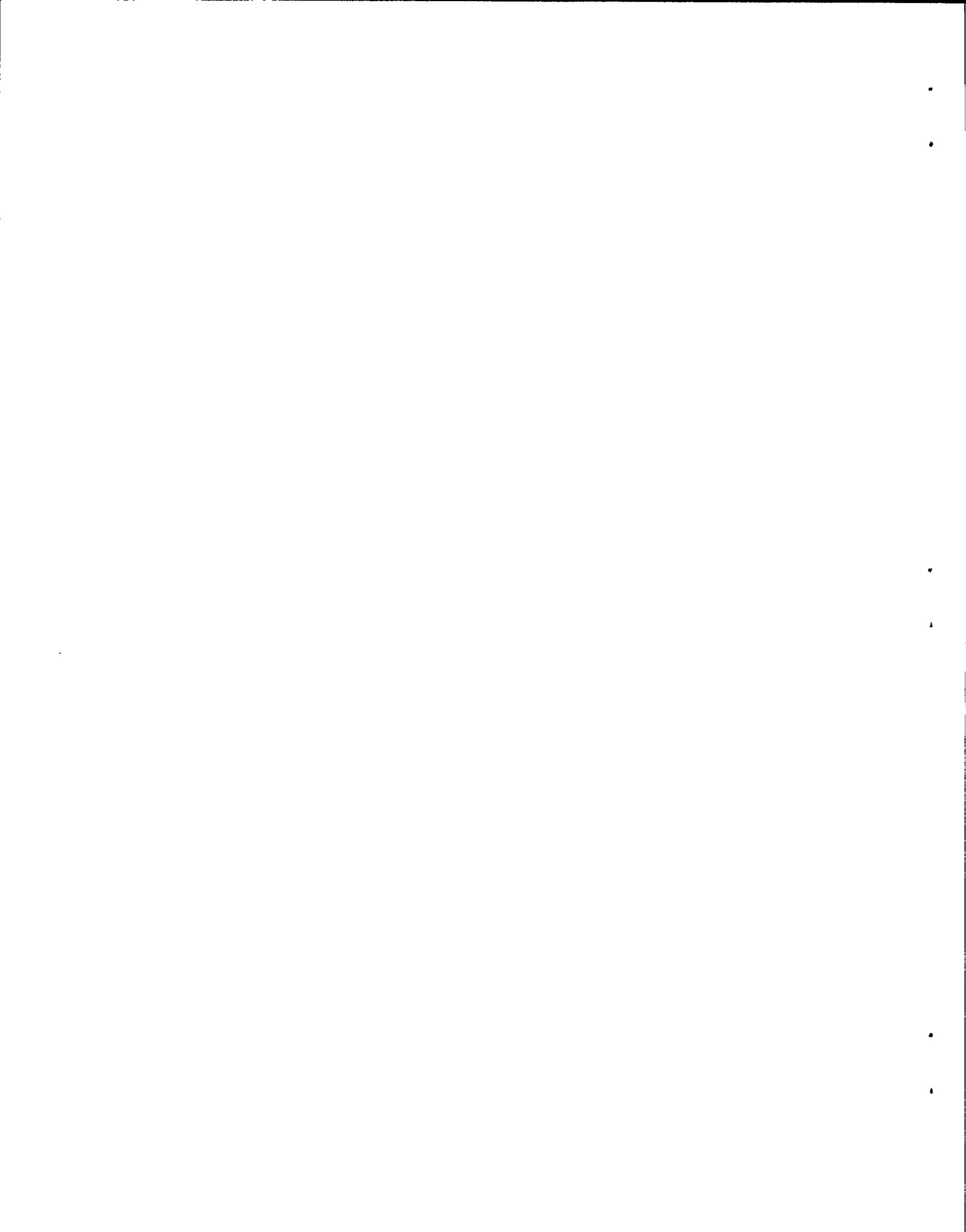


Figure 10. Herring spawn in 1982 in Freeman Passage, with transects and quadrat sample sites indicated.



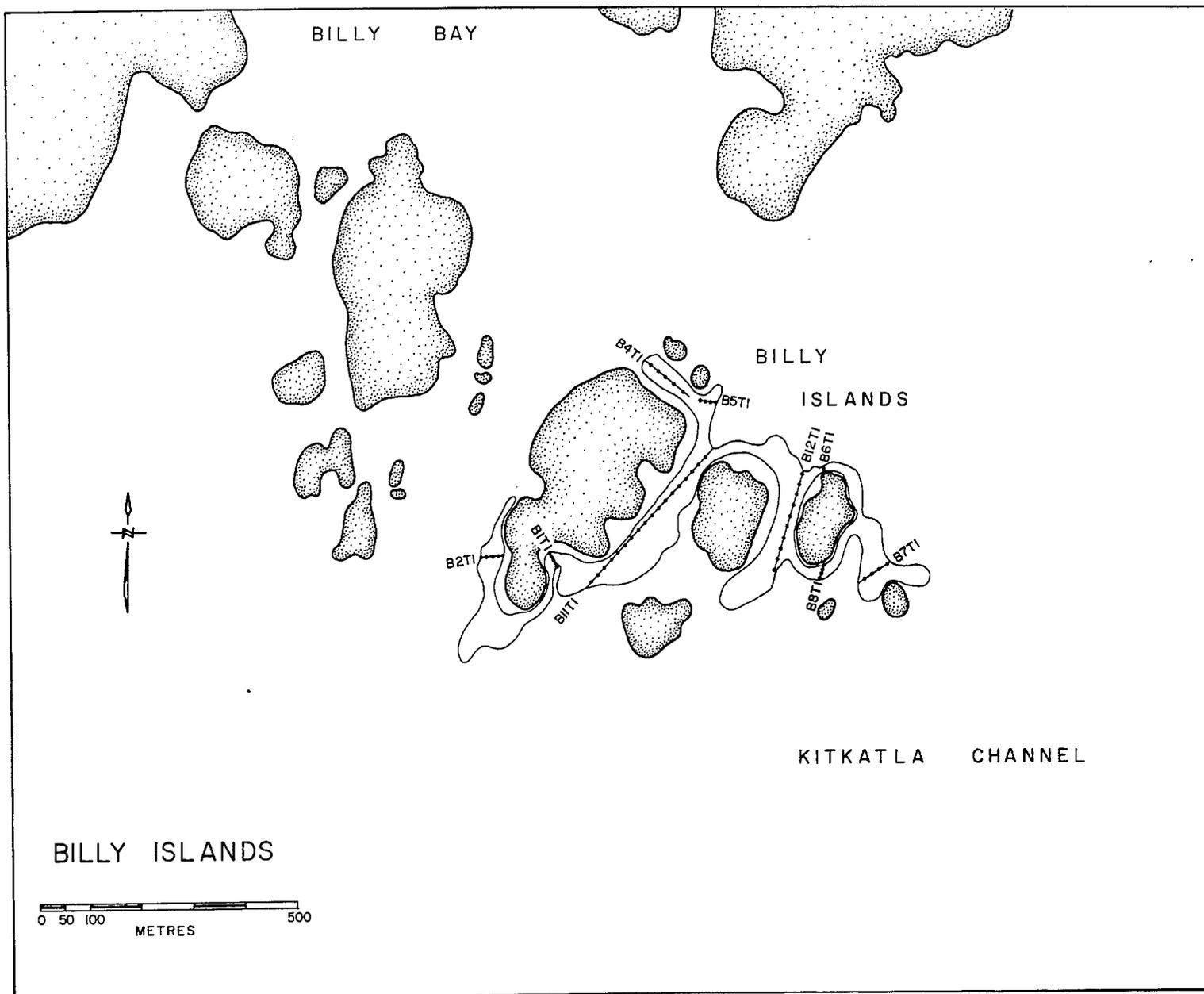
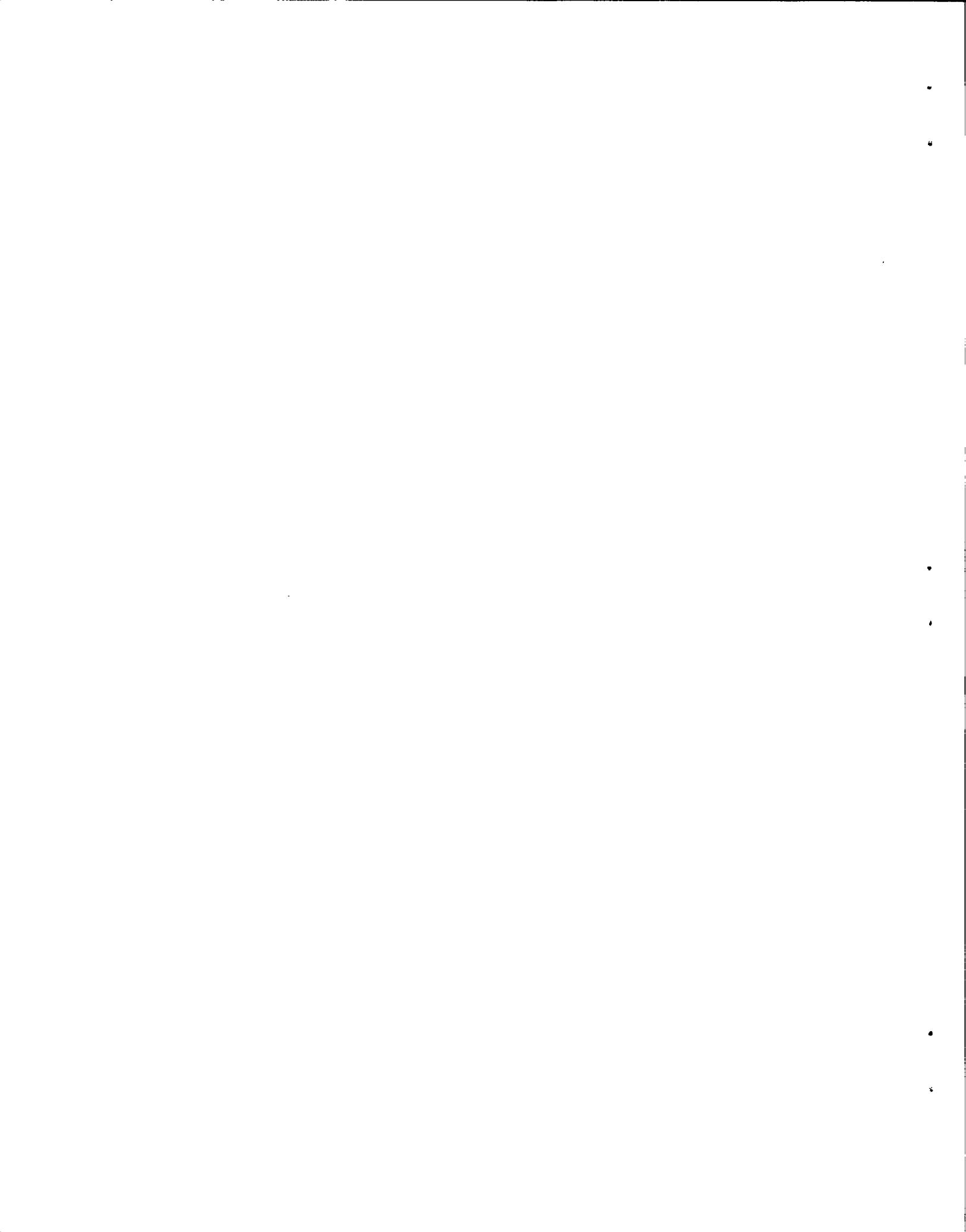


Figure 11. Herring spawn in 1982 around Billy Islands, with transects and quadrat sample sites indicated.



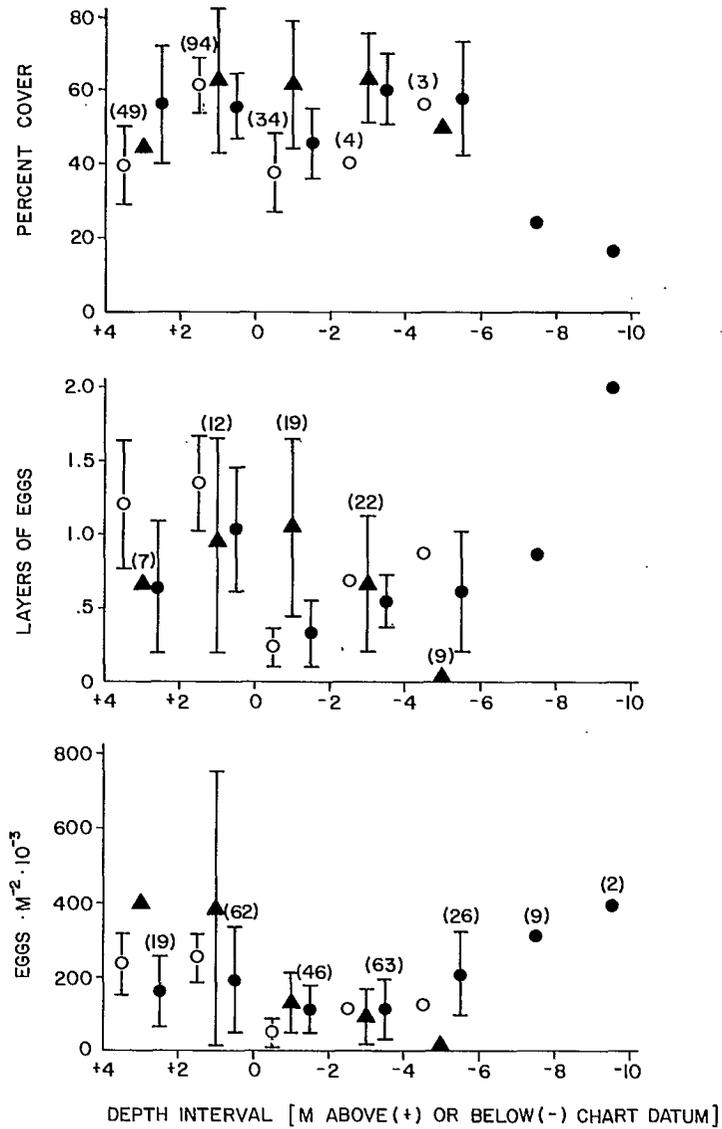
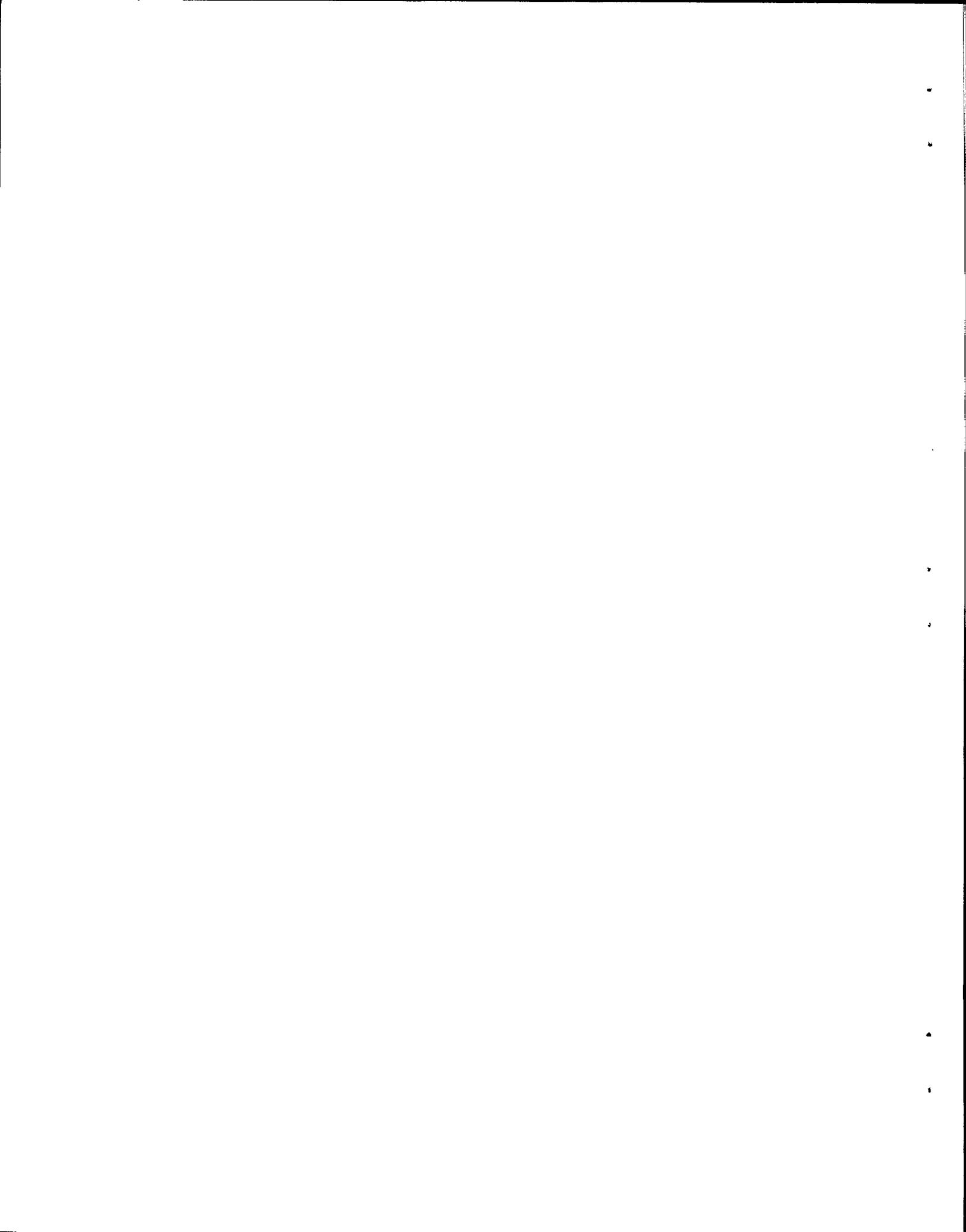


Figure 12. Average percent cover of vegetation, layers of eggs, and egg density ( $\pm 2SE$ ) by 2 m depth interval for Chatham Sound (open circles), North Porcher Island (triangles) and Kitkatla Inlet (closed circles) spawns.



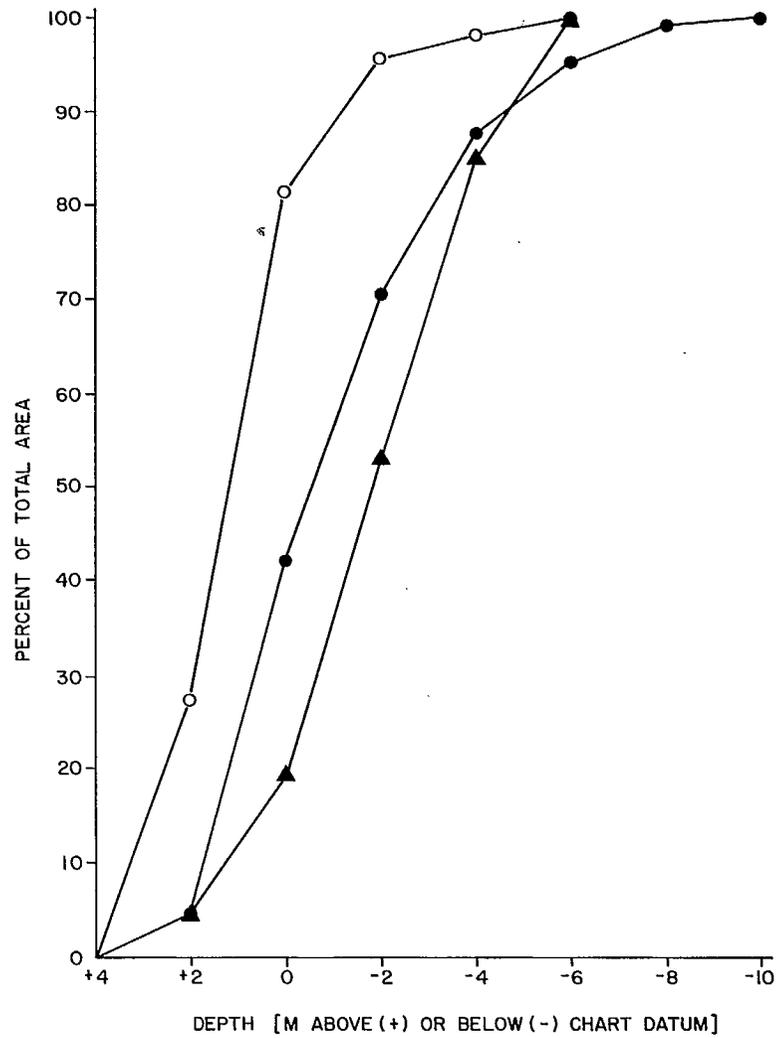
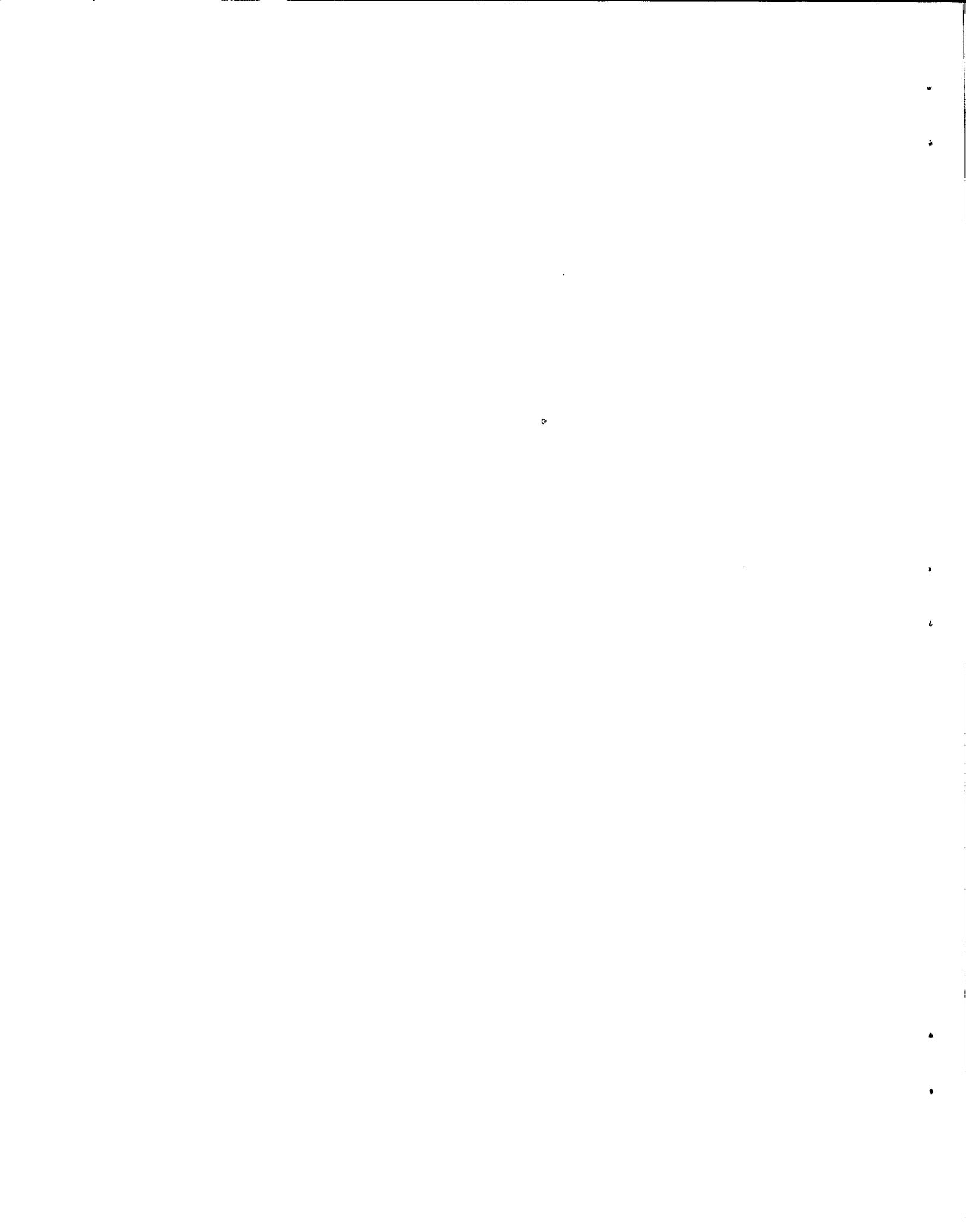


Figure 13. Distribution of spawn area by depth for Chatham Sound (open circles), North Porcher Island (triangles), and Kitkatla Inlet (closed circles).



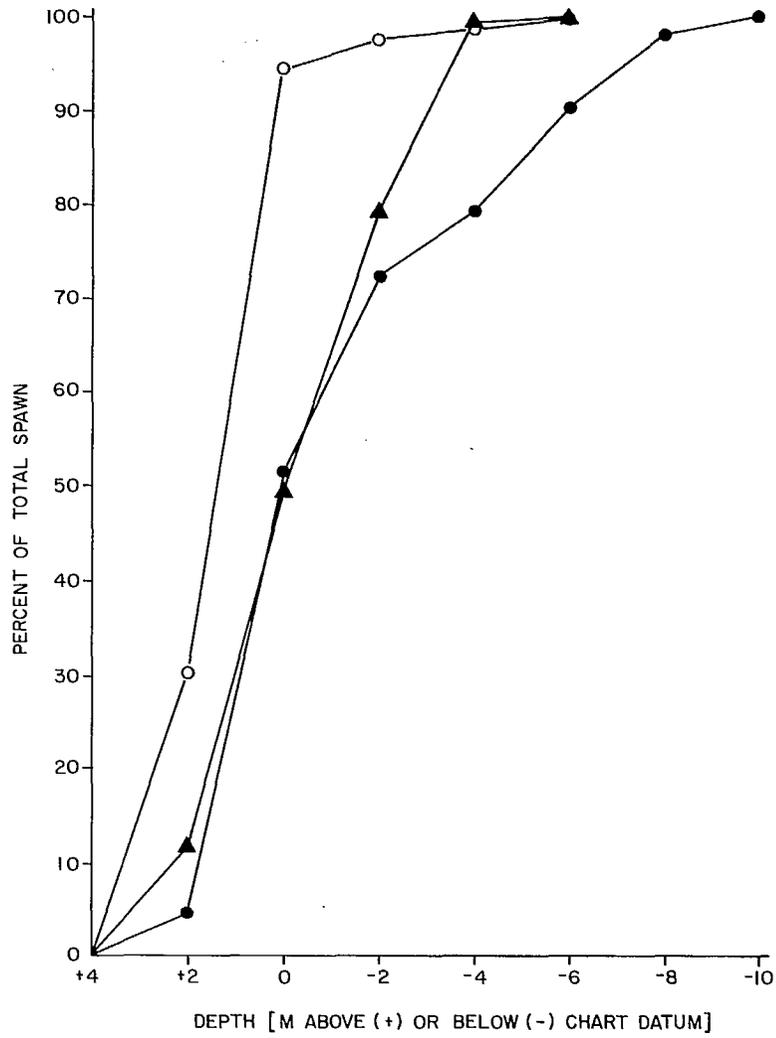


Figure 14. Distribution of eggs by depth for Chatham Sound (open circles), North Porcher Island (triangles), and Kitkatla Inlet (closed circles).

