

#1984



Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians  
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

DFO - Library / MPO - Bibliothèque

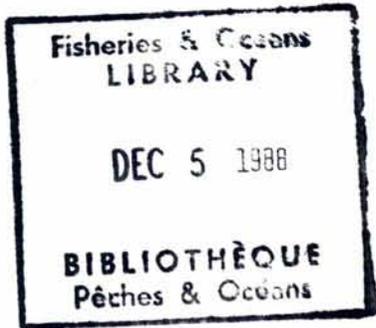


12022208

# Herring Spawning Stock Biomass Estimates from Diving Surveys for the Central Coast in 1986

J. F. Schweigert and C. W. Haegele

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



May 1988

## Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1984

SH  
223  
F55  
#1984  
C.1



Fisheries  
and Oceans

Pêches  
et Océans

Canada

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

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, 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 and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual 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.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

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

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est 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, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 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 comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of  
Fisheries and Aquatic Sciences No. 1984

May 1988

HERRING SPAWNING STOCK BIOMASS ESTIMATES  
FROM DIVING SURVEYS FOR THE CENTRAL COAST  
IN 1986

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 1988

Cat. No. Fs 97-4/1984E

ISSN 0706-6473

Correct citation for this publication:

Schweigert, J. F. and C. W. Haegele. 1988. Herring spawning stock biomass estimates from diving surveys for the central coast in 1986. Can. MS Rep. Fish. Aquat. Sci. 1984: 43 p.

ABSTRACT

Schweigert, J. F. and Haegele, C. W. 1988. Herring spawning stock biomass estimates from diving surveys for the Central Coast in 1986. Can. MS Rep. Fish. Aquat. Sci. 1984: 43 p.

Diving and surface spawn surveys in 1986 indicated that 25,946 tonnes of herring spawned in the Central Coast District (Statistical Areas 6-9). In addition, roe seine fisheries in Area 7 caught 1707 tonnes and the roe gillnet fisheries in Areas 6 and 7 caught 1084 tonnes of herring. The food and bait fisheries in Area 8 caught another 30 tonnes of fish.

Most of the spawning occurred in Area 7. Over half (57%) of the spawn occurred in this area, where 72 km of spawn was deposited by 14,703 tonnes of herring. In Area 6 38.7 km of spawn was deposited by 7168 tonnes (28%) of fish. Area 8 spawn deposition totalled 15.7 km and 2844 tonnes (11%). Finally, the spawn at the head of Rivers Inlet (Area 9) totalled 16.3 km and 1231 tonnes of herring or 5 % of the total Central coast deposition.

The 1986 diving survey was the first conducted in the Central Coast and results indicated that spawn distribution was similar to that in other Districts. Spawn was confined primarily to the intertidal and upper subtidal zone (above 3 m below chart datum). The percent cover of vegetation and the sample weights were also similar to those in other Districts and declined with depth only in the lower subtidal zone (deeper than 3 m below chart datum). Egg layers and egg density followed a similar pattern. However, the slopes of the beaches were much steeper than for other spawn surveyed to date. In addition, the vegetation types utilized for spawning differed from other Districts, consisting primarily of kelps, rockweeds and filamentous red algae.

## RÉSUMÉ

Schweigert, J. F. and Haegele, C. W. 1988. Herring spawning stock biomass estimates from diving surveys for the Central Coast in 1986. Can. MS Rep. Fish. Aquat. Sci. 1984: 43 p.

D'après les relevés sur la fraye effectués par plongée et en surface en 1986, 25 946 tonnes de harengs ont pondu dans le district de la zone centrale de la côte (zones statistiques 6-9). De plus, les prises de hareng rogué à la senne dans la zone 7 se sont élevées à 1 707 tonnes et les prises de hareng rogué aux filets maillants dans les zones 6 et 7, à 1 084 tonnes. Dans la zone 8, on a capturé trente autres tonnes de poissons destinés à la consommation et aux appâts.

La fraye a lieu presque entièrement dans la zone 7. Plus de la moitié des oeufs (57 %) sont déposés dans cette zone: 14 703 tonnes de harengs ont pondu sur une longueur de 72 km. Dans la zone 6, 7 168 tonnes (28 %) de poissons ont déposé des oeufs sur une longueur de 38,7 km. Dans la zone 8, 2 844 tonnes (11 %) de poissons ont pondu sur une longueur de 15,7 km. Finalement, le nombre d'oeufs déposés à l'amont de l'inlet Rivers (zone 9) couvrait une longueur de 16,3 km (1 231 tonnes de harengs) ou 5 % du nombre total d'oeufs déposés dans la zone centrale de la côte.

Le relevé par plongée effectué en 1986 était le premier relevé effectué dans la zone centrale de la côte et les résultats ont montré que la répartition des oeufs était semblable à celle d'autres districts. Le frai était limité à la zone intertidale et à la partie supérieure de la zone infratidale (au-dessus d'une limite de 3 m sous le zéro des cartes). Le pourcentage de couverture végétale et le poids des échantillons étaient également similaires à ceux d'autres districts et diminuaient avec la profondeur seulement dans la partie inférieure de la zone infratidale (au-dessous d'une limite de 3 m sous le zéro des cartes). Les couches d'oeufs et leur densité suivaient un profil identique. Toutefois, les pentes des plages étaient beaucoup plus abruptes que celles d'autres aires de ponte étudiées jusqu'à maintenant. De plus, la végétation des frayères différait de celle d'autres districts, et se composait principalement de laminaires, de fucus et d'algues rouges filamenteuses.

## INTRODUCTION

Herring abundance in the Central Coast District (Areas 6 to 9) has recently shown signs of decline (Haist et al. 1986). A first attempt to survey spawn in this District (with divers) was made in 1986 to accurately assess the status of the spawning stocks. Diving surveys of herring spawn were also made for most of the British Columbia coast, except for the Queen Charlotte Islands, to obtain more accurate spawning stock biomass estimates than are possible with the traditional surface surveys. It was also the intention of these surveys to obtain calibration information from simultaneous diving and surface surveys to adjust surface survey estimates for spawns that were not surveyed by divers. The 1986 Central Coast diving survey is the subject of this report.

## MATERIAL AND METHODS

Herring spawns were surveyed independently with traditional surface survey techniques and by SCUBA divers. Surface survey data were collected using a variety of techniques. Visual observations were made from a boat, frequently using a viewing box to enhance the visibility of the bottom. Grapples were used to determine the presence of and obtain samples of spawn. From these observations the length and width of spawn and the layers of eggs were estimated.

The spawn survey by divers used a two-stage sampling design. Transects perpendicular to the shore were the primary sampling unit and 0.50 m<sup>2</sup> quadrats along the transect were the secondary sampling unit. Samples consisted of all the rooted or attached vegetation, and the eggs adhering to it, within the quadrat. Layers of eggs, percent of the quadrat covered by vegetation, and the dominant vegetation were estimated by divers for each quadrat. Samples were weighed and weighed subsamples were preserved in Gilson's fluid and egg counts obtained. Eggs on the bottom substrate were calculated from diver estimates of the number of egg layers and percent of bottom covered by vegetation (Haegele et al. 1979) and then added to eggs on vegetation.

Transects were established at approximately equal intervals along the length of the spawn and samples were collected at equal intervals along each transect with the spacing determined by the width of the spawn. The mean egg density and 95% confidence interval were calculated for each spawn and transect means were weighted by transect length (Schweigert et al. 1985). In Area 9 the vegetation zone was generally 5 m or less in width so that it was not possible to establish transects. In fact, the vegetation consisted of a narrow rockweed zone attached to small and large boulders or directly to the steep rock face of the cliffs. Consequently, we obtained a random single quadrat sample at each transect location and collected transect samples approximately every 1 km along the length of the spawn.

The boundaries of spawns were determined from measurements along transects and the ends of spawns beyond the outer transects were determined on exploratory dives. This information was plotted on maps of marine vegetation at a scale of 1:6000 (e.g., Haegele and Hamey 1980), the boundaries of the spawn contoured, and the area of the spawn measured using a digitizer. When vegetation maps were not available, marine charts were used. Spawn on Macrocystis sp., a giant kelp, was surveyed separately at one location, using the procedure developed by Haegele and Schweigert (1985). Spawner biomass (tonnes) was estimated as the product of spawn area, egg density, and  $10^{-8}$ , which assumes 200 eggs • gm<sup>-1</sup> female weight (Hay 1985) and a 1:1 sex ratio.

The estimated tonnages for each area were based on the diving survey estimate if one was available. Otherwise the tonnage was estimated from the surface survey by adjusting the width to a diving survey estimate and egg density was approximated from a relationship between diving survey egg densities and surface survey estimates of average egg layers as detailed in Schweigert and Stocker (1988).

## RESULTS

In the Central Coast over half of the spawning occurred in Area 7 with the longest single spawn being recorded in Spiller Channel (Table 1, 2; Fig. 1). A small amount of spawn was also surveyed on the giant kelp, Macrocystis sp. (Table 3). It was estimated that 28,767 tonnes of fish were available to spawn in the Central Coast during 1986 (Table 4). Of this total the seine fishery caught 1707 tonnes in Area 7 while the gillnets took 1084 tonnes in Areas 6 and 7. The food and bait fishery removed another 30 tonnes the previous fall and winter in Area 8. The estimates include three late spawns which occurred in June. Other spawn was deposited between March 3 and April 21.

### AREA 6 - KITASU AND WEETEEAM BAYS

The two major spawnings in Area 6 occurred in Kitasu (Fig. 2, 3) and Weeteem bays. Only the former spawning was covered by the diving survey. The majority of the spawn in Kitasu Bay appeared to be deposited in the Parson's Anchorage and Marvin Island area on Macrocystis sp. with some also being deposited heavily on the stringy red algae in this area. It was estimated that 898 tonnes of fish spawned on understory vegetation, with an additional 88 tonnes spawning on giant kelp (Appendix Table 1, 2). The gillnet fishery took 638 tonnes and an unknown amount was collected as spawn-on-kelp. The total for Kitasu Bay amounts to 1624 tonnes but this figure is probably conservative due to undersampling of Macrocystis because of time constraints and mechanical problems. The egg density was estimated at

256,000 eggs/m<sup>2</sup> at 0.60 layers which reflects the patchiness of the vegetation in the area.

The spawns in Weeteeam Bay were surveyed by the guardian for Area 6 who has done the survey for the past several years. The adjusted area was 43.9 ha with an average egg density estimated at 370,000 eggs/m<sup>2</sup> for 1623 tonnes of spawners.

In addition the total for the Area includes two late spawns which occurred in June at Hawkesbury and Gil islands estimated at 4541 tonnes. This may be an overestimate because the width adjustment which may not be warranted for these locations. Unfortunately, due to the lateness of this spawn, divers could not visit the spawn site to verify the spawn width.

#### AREA 7 - SEAFORTH CHANNEL AND THOMPSON BAY

The major spawnings in this area were all covered by the diving survey (Fig. 4-10), but a number of small scattered late spawnings were sampled only by the surface survey. The majority of the spawn (67%) was contained in three areas: Spiller Channel, Kynumpt Harbour and vicinity, and Thompson Bay.

Another 14 spawns of 200-300 tonnes each occurred in widely scattered areas, primarily Thompson Bay and Kildidt Sound. Egg densities averaged 400,000 eggs/m<sup>2</sup> and ranged from 122,000-3,533,000 eggs/m<sup>2</sup>. The estimate of 1,328,000 eggs/m<sup>2</sup> for Bend Point Cove and 3,553,000 eggs/m<sup>2</sup> for Princess Alice Island seem unrealistically high. The spawn in these two areas was deposited mostly on an unusual accumulation of drift stringy red algae almost 1 m deep. Although the estimate of 218 tonnes for Bend Point Cove is plausible the estimate of 3475 tonnes for Princess Alice Island is too high. Estimates of egg density based on predictions from the estimates of average egg layers and percent cover or sample weight for Princess Alice Island are for 602,000 and 2,027,000 eggs/m<sup>2</sup> equivalent to 589 and 1983 tonnes of spawners. Either of these estimates seem more reasonable than the 3475 tonnes from the egg counts. However, throughout the paper we have based our estimates on the egg counts which means that estimate of total tonnage for the Area and the entire District will be slightly inflated. The seine fishery removed 446 tonnes and the gillnets 1707 tonnes yielding a total prefishery biomass of 16,856 tonnes for all of Area 7.

#### AREA 8 - KWAKSHUA AND KWAKUME

Only one small spawning in Pruth Bay was surveyed by the diving team (Fig. 11). A later spawning in Keith Anchorage and spawns at Kwakume were covered by the surface survey. A total of 57.89 ha of spawn were recorded in the Area with an egg density of 329,000 eggs/m<sup>2</sup> in Kwakshua and 285,000 eggs/m<sup>2</sup> in Keith Anchorage and much heavier deposition of 494,000 eggs/m<sup>2</sup> at Kwakume. In addition, a late spawn occurred in June in Burke Channel. The

total tonnage including food and bait fisheries was 2874 tonnes for Area 8.

#### AREA 9 - RIVERS INLET

An extensive spawning was sampled by the diving survey near the head of Rivers Inlet (Fig 12). The 16.3 km of spawn was deposited on a narrow band of rockweed on the rock faces. The egg deposition averaged 0.66 layers and 493,000 eggs/m<sup>2</sup> which translates into 1231 tonnes of spawning fish.

#### SAMPLING DESIGN

The spawnings in this assessment region were unusual because they were relatively small and generally much narrower than most areas surveyed to date. The estimates of optimal sampling fractions required to achieve a 25% standard error on the mean estimated egg density were much higher than we have estimated previously for other areas (Table 5). On the other hand, the estimates of the optimal number of transects per km were lower than we have found for other areas and the sampling during this survey usually exceeded the optimal level.

#### SPAWN DISTRIBUTION

The distribution of spawn was similar in Areas 6 and 7, and similar in Areas 8 and 9 (Table 6). In the former two areas, most of the spawn was deposited in the intertidal and upper subtidal zone with lesser amounts deeper than 3 m below chart datum. In Areas 8 and 9 virtually all of the spawn occurred shallower than 3 m below chart datum. In fact, in Area 9 all of the spawn was in the intertidal zone because there was no vegetation below the rockweed zone. Egg layers and sample weight also decreased deeper than 3 m below chart datum although there is no clear trend in percent cover (Table 7). The slopes of the spawning areas were similar in Areas 7 and 8 at about 0.30 and more gradual at 0.18 in Area 6 (Table 8). These slopes are steeper than we have found in all other areas of the coast. Similarly, the transects are shorter and begin at greater depths than for most other areas surveyed to date. These results are also reflected in the vegetation substrates utilized for spawn deposition (Table 9). The majority of spawn was deposited on kelp and rockweed in Areas 8 and 9 and kelp and sea grasses in Area 6. Area 7 contained a mixture of these vegetation types plus a majority of spawn on filamentous algae. Although these vegetation types cover a great depth range from the intertidal to more than 6 m below chart datum, most of the eggs were deposited shallower than 3 m below chart datum (Table 6).

## DISCUSSION

Herring spawning stocks in 1986 in the Central Coast were expected to be near 1985 levels (Haist et al. 1986). Since this was the first year of extensive diving surveys in the Central Coast it was difficult to make comparisons of estimates with those from previous years done by surface survey. In addition, a number of problems were noted with the survey methods. The spawns in this area are very different from those in all other areas of the coast. The topography of most of the spawning areas does not lend itself to the two-stage sampling scheme and some form of stratified procedure should be explored. Most of the spawning areas are relatively narrow and drop off to deep depths rapidly. The estimated tonnage for the area is slightly higher than that forecast by the stock assessment models (Haist et al. 1986). This is partly a function of the inclusion of the estimates for the late spawning inlet stocks that are not considered in the assessment of the main migratory bodies of fish. In addition, there is some uncertainty about the accuracy of estimates for two spawns which contained an unusual algal species which appeared to result in unrealistically high estimates of spawning biomass. Overall the survey results indicate that any apparent downturn of stocks in the District may have abated and some improvement may be expected due to an average recruitment in the District comparable to what occurred in the southern management regions. This was also the first year of dual survey coverage for calibration of diver and surface survey data and the results should be extremely useful for updating the calibration equations for the escapement model estimates for the Central Coast stock assessment region.

## ACKNOWLEDGMENTS

We would like to thank the divers who collected and processed the samples. They were C. Hand, B. Emmett, and P. Frank from Archipelago Marine Research, D. Miller from P.B.S., K. Bates from Management Biology, Prince Rupert, and Fishery Officers M. Kupr, and S. Beckmann. The diving survey was conducted from the M.V. BASTION CITY operated by R. Littlejohn.

## REFERENCES

- Haegele, C. W. and M. J. Hamey. 1980. Shoreline vegetation on herring spawning grounds in Laredo Sound, British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1580: 23 p.

- Haegele, 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.
- Haegele, C. W. and J. F. Schweigert. 1985. Estimation of egg numbers in Pacific herring spawns on giant kelp. N. Am. J. Fish. Manag. 5: 65-71.
- Haist, V., M. Stocker, and J. F. Schweigert. 1985. Stock assessments for British Columbia herring in 1984 and forecasts of the potential catch in 1985. Can. Tech. Rep. Fish. Aquat. Sci. 1365: 53 p.
- Hay, D. E. 1985. Reproductive biology of Pacific herring (Clupea harengus pallasii). Can. J. Fish. Aquat. Sci. 42: 111-126.
- Schweigert, J. F. and M. Stocker. 1988. A new method for estimating Pacific herring spawning stock biomass from spawn survey data and its management implications. N. Am. J. Fish. Manag. 8: 63-74.
- Schweigert, J. F., C. W. Haegele, and M. Stocker. 1985. Optimal sampling design for herring spawn surveys in the Strait of Georgia, B. C. Can. J. Fish. Aquat. Sci. 42: 1806-1814.

Table 1. Summary of survey information and estimates of spawner biomass for spawns surveyed by divers in the Central Coast in 1986. Confidence intervals (95%) are in brackets.

Location	Transect numbers	No. of quadrats	Length (m)	Average tran. len. (m)	Area (ha)	Average egg layers	Thousands of eggs per sq. m	Tonnes of spawners
<u>Area 6</u>								
Kitasu Bay	7-16,19,25	50	14000	44	35.03	0.6	256 (0-587)	898 (0-2056)
<u>Area 7</u>								
Suzette Bay	5,7,8	20	590	157	2.05	3.1	1062 (0-7225)	218 (0-1481)
Bend Point Cove	1-3	20	450	82	3.46	1.3	1328 (642-2015)	460 (222-697)
Powell Anchorage	1-2,5-9	34	7000	35	20.10	1.2	406 (272-540)	816 (546-1086)
Gale Passage	1-5	18	5000	44	22.00	1.9	389 (0-779)	857 (0-1713)
Spiller Channel	1-34	97	34000	17	56.34	1.9	586 (434-737)	3299 (2447-4152)
Princess Alice I.	1-4	18	900	79	9.78	2.3	3553 (3034-4071)	3475 (2968-3982)
Kynumpt Harbour	1,3,5,7,9,11,13,15, 17,19,20	61	10000	49	65.98	1.0	472 (326-619)	3117 (2151-4082)
Brydon Channel	1-7,10	36	3500	30	14.55	1.0	328 (229-427)	477 (333-621)
<u>Area 8</u>								
Pruth Bay	1-5	14	2000	32	8.21	0.7	329 (6-651)	270 (5-535)
<u>Area 9</u>								
Rivers Inlet	1,2,4,8,10,12,14,16, 18,20,22,24,26,28,30	15	16300	15	24.75	0.7	497 (233-762)	1231 (577-1886)

Table 2. Estimates of spawner biomass for spawns surveyed only from the surface in the Central Coast in 1986.

Locality	No. of patches	Length (m)	Av. width (m)		Area (ha)	Av. egg layers	Thousands of eggs per sq. m	Tonnes
			obs.	adj.				
<u>Area 6</u>								
Hawkesbury Island*	3	14825	9	51	76.08	4.5	529	4028
Gil Island*	2	3890	9	50	19.51	2.0	263	513
Weeteam Bay	21	5970	26	74	43.91	2.8	370	1623
<u>Area 7</u>								
E. Higgins Passage	10	3535	16	64	22.64	2.0	284	644
Joanna Rock	2	600	3	34	2.06	1.2	199	41
St. John Harbour	1	600	150	149	8.92	1.5	234	204
Waskesiu Passage	4	1750	13	60	10.53	1.4	221	233
Joassa Channel	4	1375	11	56	7.70	0.4	122	94
Houghton Islands	7	1050	11	56	5.84	4.2	522	305
McNaughton Group	4	710	13	60	4.23	4.0	501	212
Cultus Sound	1	350	100	128	4.47	2.5	334	149
Spitfire Anchorage	2	550	10	53	2.92	2.6	350	102
<u>Area 8</u>								
Burke Channel*	3	750	9	49	3.68	7.4	880	324
Keith Anchorage	4	1750	6	45	7.83	2.0	285	223
N. of Kwakume Inlet	4	2690	3	36	9.70	4.3	529	513
Kwakume Inlet	8	4090	5	43	17.46	3.2	415	725
Kwakume Point	3	4450	3	33	14.69	4.4	537	789

\*June spawns

Table 3. Estimates of egg deposition on Macrocystis sp. for Kitasu Bay spawns surveyed in 1986. Confidence intervals (95%) are in brackets.

---

Area surveyed (sq. m)	150
No. plants sampled	5
Ave. plant height (m)	4.8 (3.2 - 6.4)
Ave. egg layers	0.8 (0.1 - 1.6)
Area (ha)	8.13
Density (per ha) of	
- plants	2067
- all fronds	15133
- mature fronds	10867
Thousands of eggs per	
- plant	526 (92 - 960)
- frond (all)	72 (40 - 104)
- frond (mature)	120 (13 - 227)
Tonnes estimated from	
- plants	88 (15 - 161)
- fronds (all)	88 (49 - 127)
- fronds (mature)	106 (11 - 201)

---

Table 4. Estimates of total herring spawn and adult herring biomass for the Central Coast in 1986.

	Area 6	Area 7	Area 8	Area 9	Central Coast
<u>Diving survey</u>					
-length (m)	14000	61440	2000	16300	93700
-area (ha)	35.03	194.26	8.21	24.75	262.25
-spawners (t)	1004	12719	270	1231	15224
<u>Surface survey</u>					
-length (m)	24685	10520	13730	0	48935
-area (ha)	139.50	69.31	53.36	0.00	262.17
-spawners (t)	6164	1984	2574	0	10722
<u>Both surveys</u>					
-length (m)	38685	71960	15730	16300	142675
-area (ha)	174.53	263.57	61.57	24.75	524.42
<u>Adult biomass (t)</u>					
-spawners	7168	14703	2844	1231	25946
-catch	638	2153	30	0	2821
-total	7806	16856	2874	1231	28767

Table 5. Estimated optimal sampling design to achieve a SE of 25% of the mean (after Schweigert et al. 1985) and achieved sampling density for 1986 diving surveys of herring spawn in the Central Coast.

Location	Samples per transect	Av. transect length (m)	Achieved sampling fraction	Optimal sampling fraction	Achieved transects per km	Optimal transects per km
Kitasu Bay	4.4	44	0.099	0.120	0.857	7.126
Suzette Bay	6.7	157	0.042	0.029	5.085	499.157
Bend Point Cove	6.7	82	0.081	0.117	6.667	10.996
Powell Anchorage	4.3	35	0.121	0.418	1.143	0.714
Gale Passage	3.6	44	0.082	0.136	1.000	5.792
Spiller Channel	3.2	17	0.190	0.422	0.882	0.313
Princess Alice I.	4.5	79	0.057	0.147	4.444	0.731
Kynumt Harbour	5.1	49	0.104	0.152	1.200	0.798
Brydon Channel	4.5	30	0.150	0.216	2.286	1.351
Pruth Bay	2.8	32	0.088	0.073	2.500	11.447

Table 6. Percent distribution of spawn area and eggs for spawns surveyed by divers in the Central Coast in 1986.

Location		Depth interval [m above (+) or below (-) chart datum]			
		Above 0 m	0 to -3 m	-3 to -6 m	Below -6 m
Area 6	Area	23.3	34.6	30.3	11.8
	Eggs	55.3	32.7	6.5	5.5
Area 7	Area	31.2	40.1	16.4	12.3
	Eggs	37.1	50.3	8.4	4.2
Area 8	Area	86.2	13.8	0.0	0.0
	Eggs	65.9	34.1	0.0	0.0
Area 9	Area	91.8	3.9	0.0	0.0
	Eggs	93.8	3.6	0.0	0.0
Central Coast	Area	37.6	35.1	16.5	10.8
	Eggs	44.4	44.3	7.5	3.8

Table 7. Wilcoxon mean and estimated 95% confidence interval for % cover of vegetation, egg layers, sample weight, and egg density for spawn on bottom vegetation and substrate sampled by divers in the Central Coast in 1986. Samples with less than 0.1 egg layers were excluded.

Location		Depth interval [m above (+) or below (-) chart datum]			
		Above 0 m	0 to -3 m	-3 to -6 m	Below -6 m
Area 6	No. of samples	10	14	10	2
	% cover	80 (48-98)	70 (53-83)	68 (40-100)	-
	egg layers	1.1 (0.6-1.5)	0.6 (0.4-1.0)	0.3 (0.2-0.7)	-
	sample weight (g)	2281 (1028-4130)	1684 (982-2847)	1124 (567-1661)	-
	eggs/sq. m (1000's)	633 (181-1172)	286 (135-563)	81 (16-210)	-
Area 7	No. of samples	98	108	37	16
	% cover	53 (48-60)	64 (60-75)	65 (53-75)	46 (28-63)
	egg layers	1.8 (1.5-2.1)	1.5 (1.3-1.8)	0.9 (0.6-1.3)	1.6 (0.8-2.3)
	sample weight (g)	1978 (1524-2413)	2494 (1845-3467)	1290 (936-1835)	1368 (879-1998)
	eggs/sq. m (1000's)	689 (488-979)	715 (503-1160)	299 (171-467)	231 (96-469)
Area 8	No. of samples	8	5	0	0
	% cover	73 (50-90)	73 (50-100)	-	-
	egg layers	0.8 (0.2-1.7)	1.2 (0.1-4.0)	-	-
	sample weight (g)	1269 (488-3784)	2038 (758-8328)	-	-
	eggs/sq. m (1000's)	264 (49-984)	760 (57-3458)	-	-

Table 7 (cont'd)

Location		Depth interval [m above (+) or below (-) chart datum]			
		Above 0 m	0 to -3 m	-3 to -6 m	Below -6 m
Area 9	No. of samples	15	0	2	0
	% cover	78 (63-88)	-	-	-
	egg layers	0.6 (0.5-0.9)	-	-	-
	sample weight (g)	4350 (2887-5744)	-	-	-
	eggs/sq. m (1000's)	493 (225-835)	-	-	-
Central coast	No. of samples	131	127	49	18
	% cover	58 (53-65)	65 (60-75)	65 (55-75)	50 (33-65)
	egg layers	1.5 (1.3-1.8)	1.4 (1.1-1.6)	0.7 (0.5-1.0)	1.6 (0.6-2.0)
	sample weight (g)	2209 (1813-2660)	2301 (1812-3125)	1236 (958-1594)	1308 (862-1912)
	eggs/sq. m (1000's)	610 (463-821)	633 (457-911)	254 (149-383)	227 (98-415)

Table 8. Description of transect length and beach slope, and outer (OES) and inner edge (IES) of spawn in m above (+) or below (-) chart datum for spawns surveyed by divers in the Central Coast in 1986.

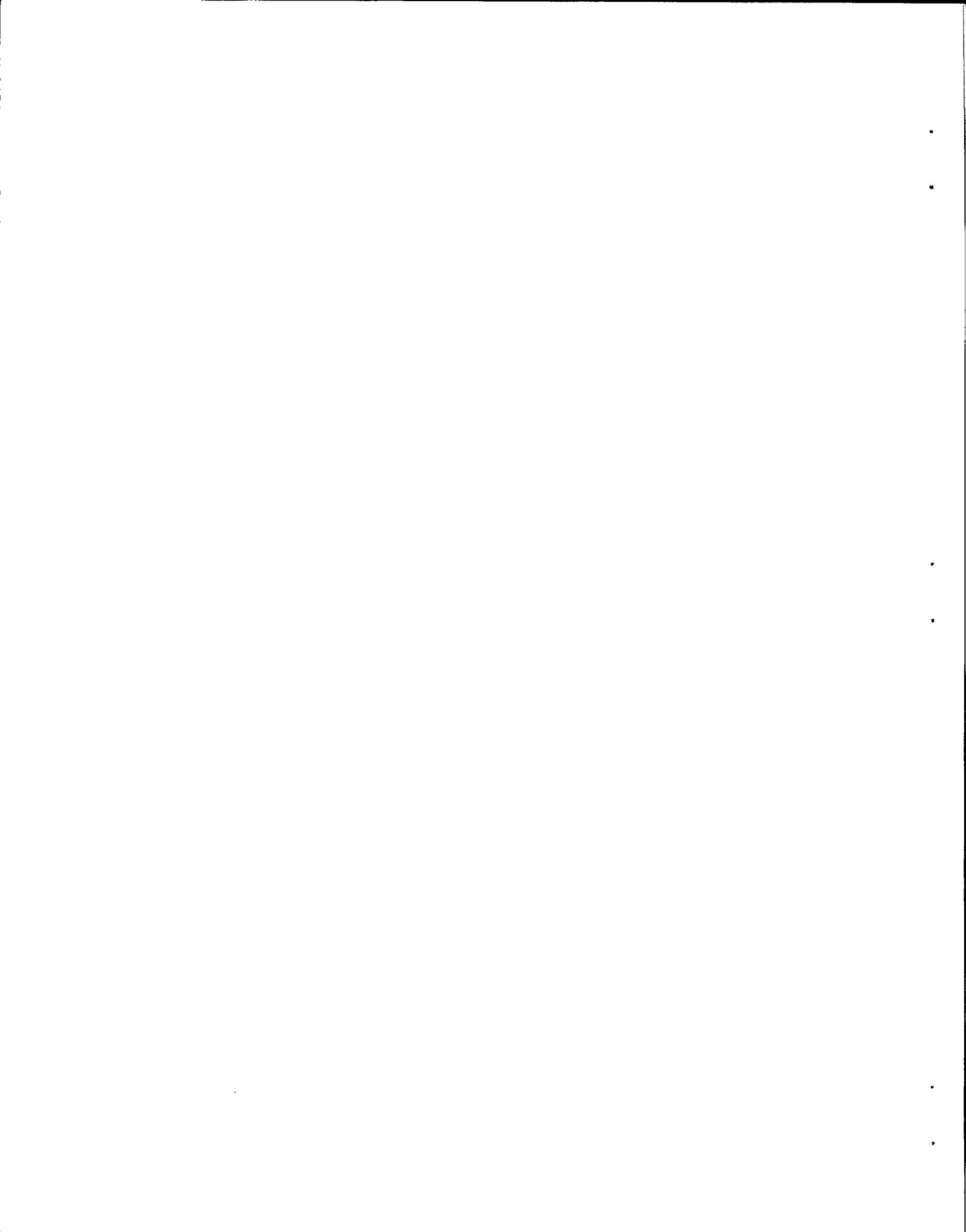
Location		Length (m)	Slope	OES	IES
Area 6	No. of tran.	14	12	12	12
	Average	39	0.184	-4.6	+0.1
	S. D.	46	0.167	3.2	1.7
	95% C. I.	13 to 65	0.077 to 0.290	-6.7 to -2.6	-1.0 to +1.3
	Minimum	5	0.024	0.0	-2.6
	Maximum	167	0.624	-11.3	+3.2
Area 7	No. of tran.	76	72	72	72
	Average	38	0.289	-4.2	+1.8
	S. D.	45	0.244	3.5	1.7
	95% C. I.	28 to 48	0.231 to 0.346	-5.0 to -3.3	+1.4 to +2.2
	Minimum	3	0.014	-16.2	-4.3
	Maximum	303	1.150	+1.6	+3.5
Area 8	No. of tran.	5	5	5	5
	Average	32	0.305	-1.0	+1.4
	S. D.	52	0.331	1.5	1.0
	95% C. I.	0 to 96	0.000 to 0.717	-2.9 to +0.8	+0.2 to +2.6
	Minimum	6	0.007	-2.8	-0.1
	Maximum	124	0.755	+1.0	+2.4
Area 9	No. of tran.	15	2	2	2
	Average	15	-	-	-
	S. D.	23	-	-	-
	95% C. I.	3 to 28	-	-	-
	Minimum	2	-	-	-
	Maximum	78	-	-	-

Table 8 (cont'd)

Location		Length (m)	Slope	OES	IES
Central Coast	No. of tran.	110	91	91	91
	Average	35	0.284	-4.1	+1.6
	S. D.	43	0.245	3.4	1.7
	95% C. I.	27 to 43	0.233 to 0.335	-4.8 to -3.4	+1.2 to +1.9
	Minimum	2	0.007	-16.2	-4.3
	Maximum	303	1.150	+1.6	+3.5

Table 9. Number of samples by dominant vegetation on which herring spawn was deposited for spawns surveyed by divers in the Central Coast in 1986.

Location		Depth interval [m above (+) or below (-) chart datum]				
		Above 0 m	0 to -3 m	-3 to -6 m	Below -6 m	All depths
Area 6	Sea grasses	6	7	2	0	15
	Rockweed	1	0	0	0	1
	Kelp	1	6	8	2	17
	Foliose algae	0	0	0	0	0
	Filamentous algae	2	1	0	0	3
Area 7	Sea grasses	15	24	2	0	41
	Rockweed	42	4	0	0	46
	Kelp	5	33	30	15	83
	Foliose algae	2	3	0	0	5
	Filamentous algae	34	44	5	1	84
Area 8	Sea grasses	6	1	0	0	7
	Rockweed	0	0	0	0	0
	Kelp	0	2	0	0	2
	Foliose algae	0	0	0	0	0
	Filamentous algae	2	2	0	0	4
Area 9	Sea grasses	0	0	0	0	0
	Rockweed	15	0	0	0	15
	Kelp	0	0	2	0	2
	Foliose algae	0	0	0	0	0
	Filamentous algae	0	0	0	0	0
Central Coast	Sea grasses	27	32	4	0	63
	Rockweed	58	4	0	0	62
	Kelp	6	41	40	17	104
	Foliose algae	2	3	0	0	5
	Filamentous algae	38	47	5	1	91



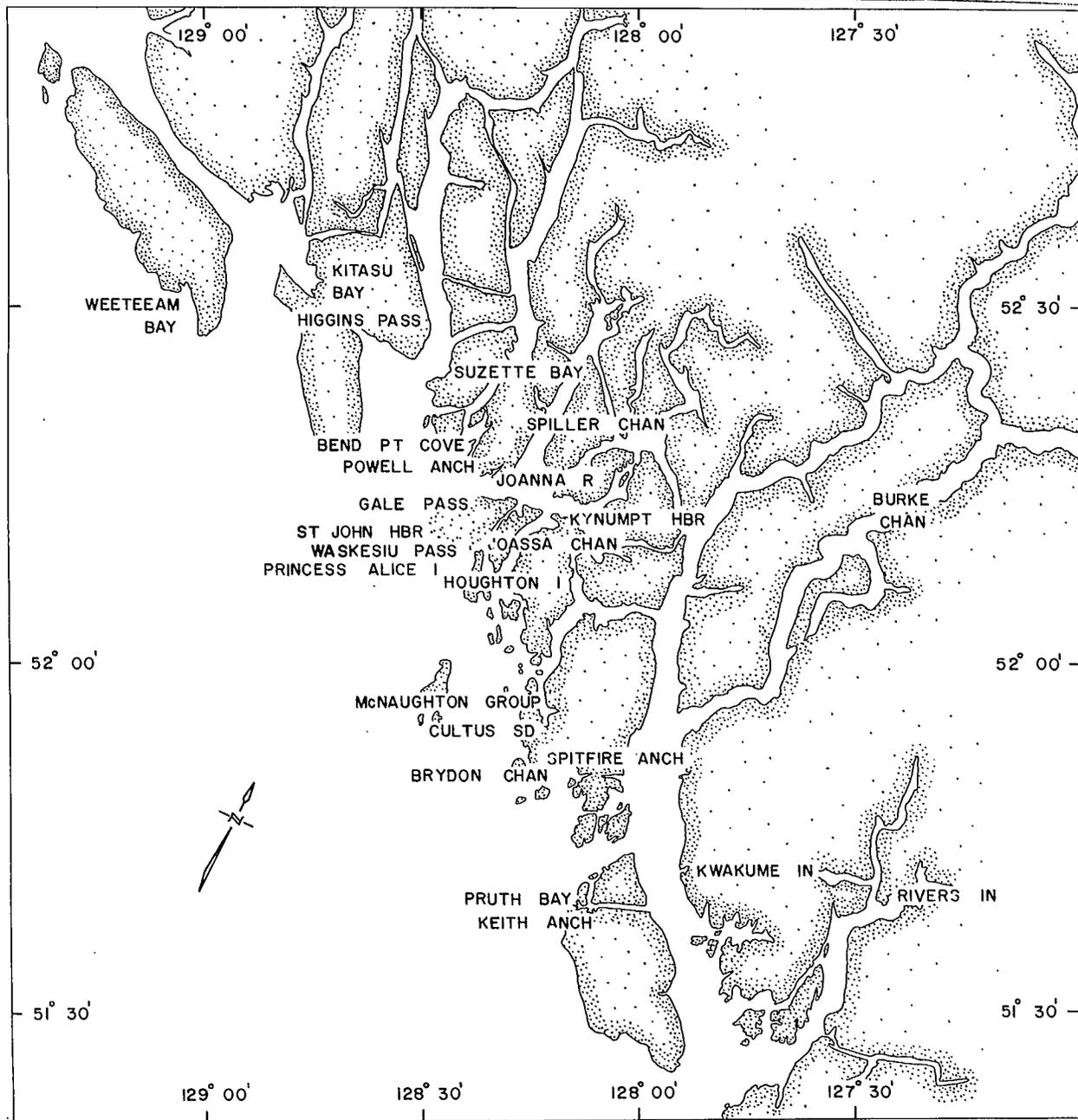
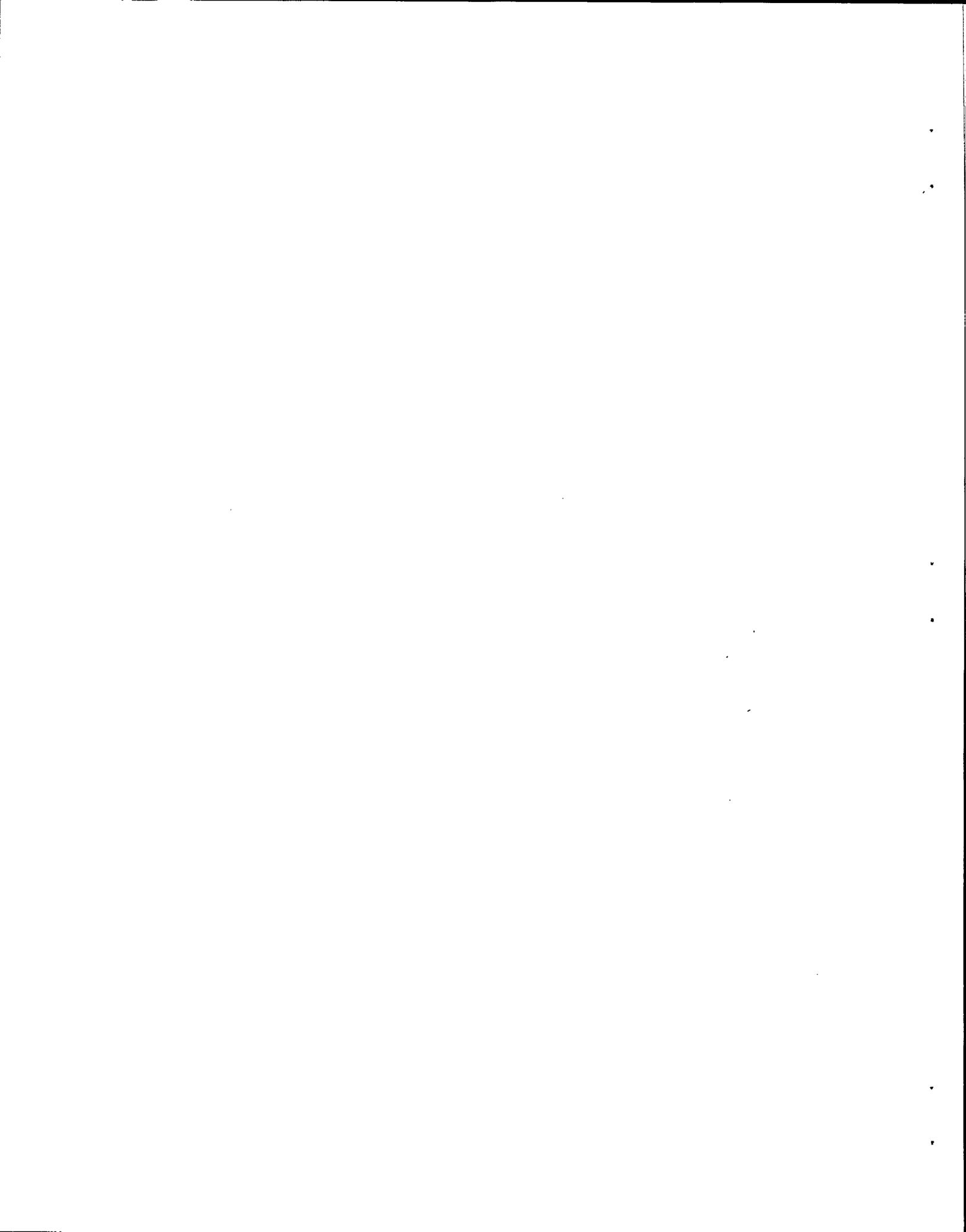


Fig. 1. Chart showing the locations of the areas surveyed in the Central coast during 1986 by divers.



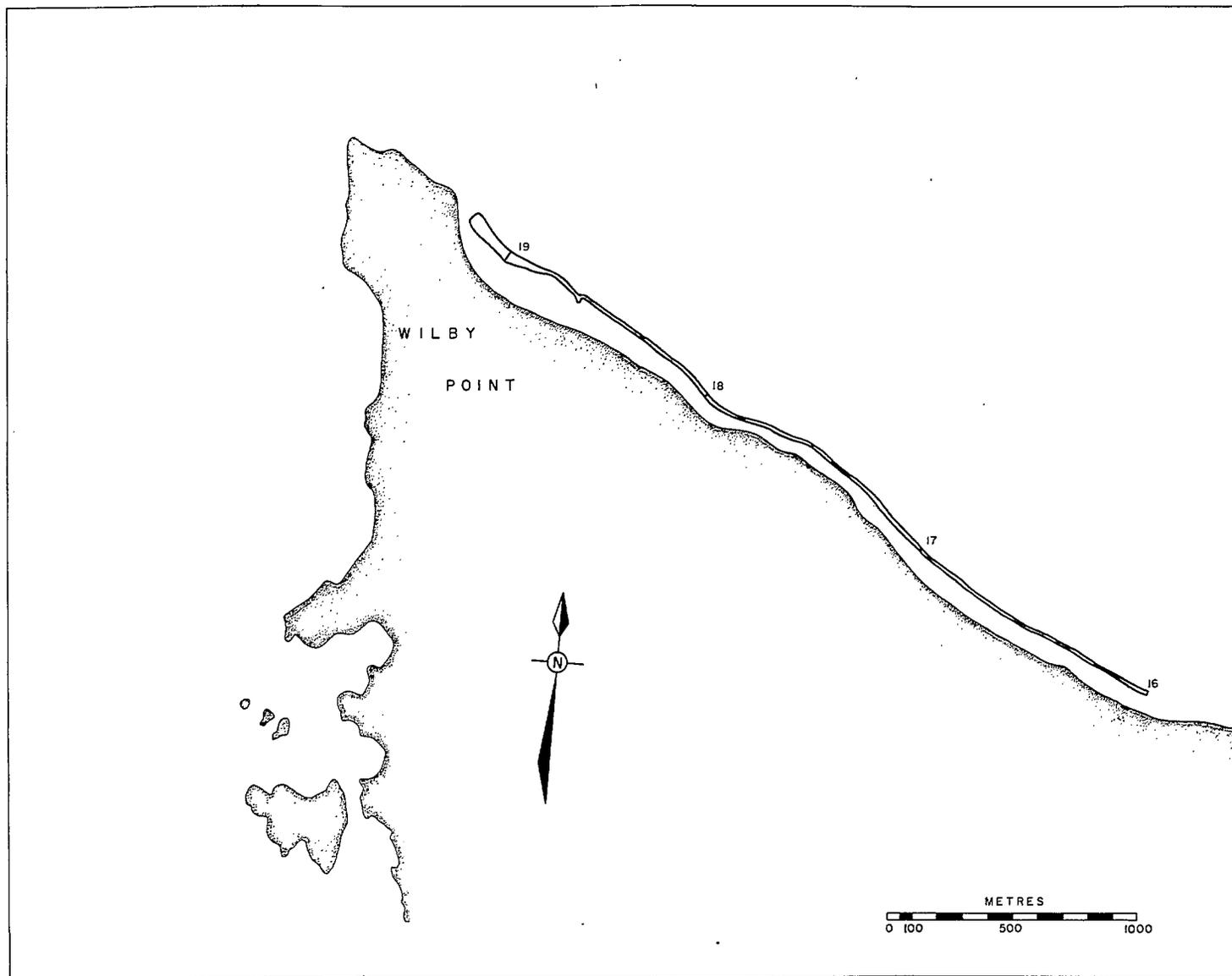
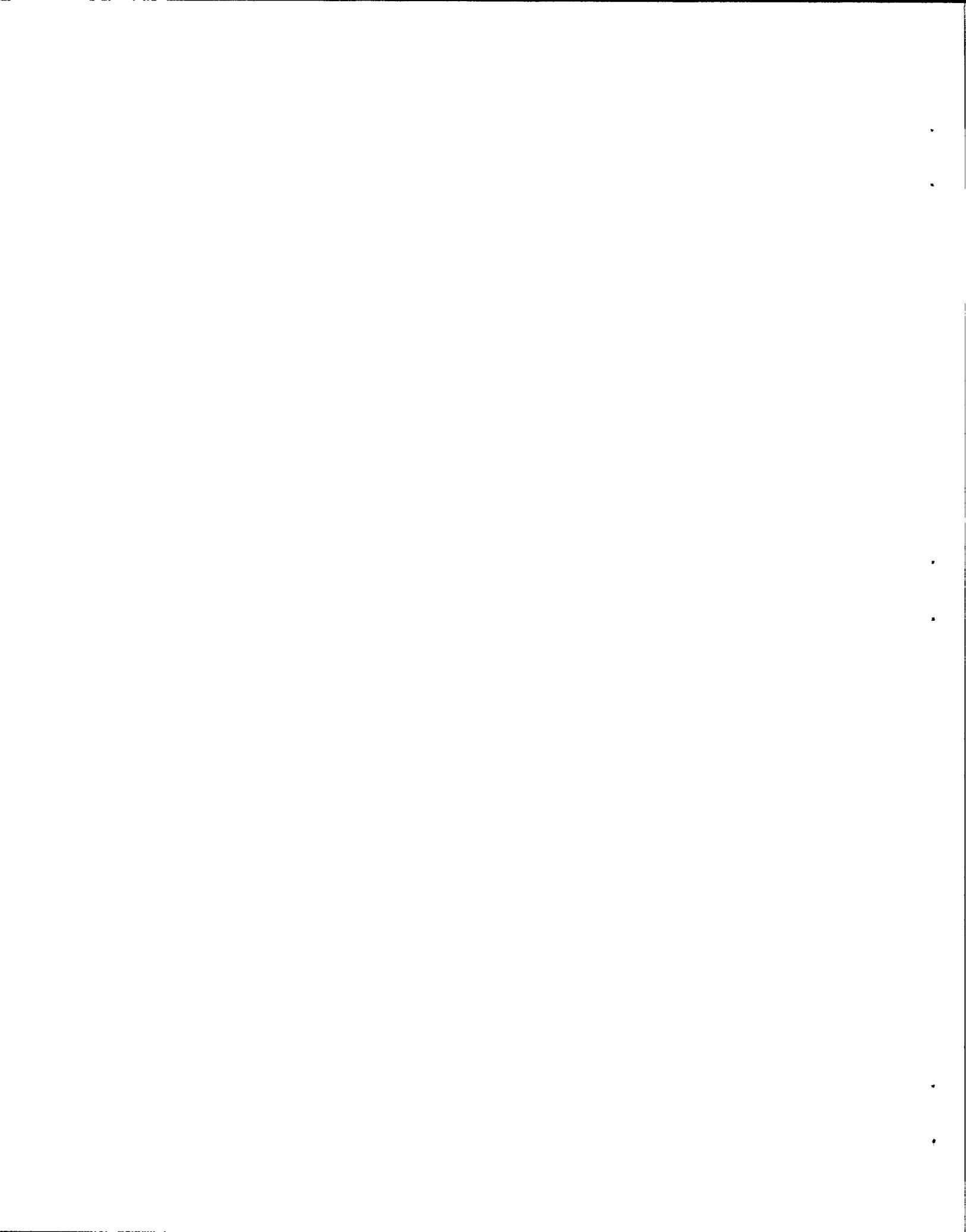


Fig. 2. Herring spawn at Wilby Point in Kitsu Bay in Area 6, surveyed by divers in 1986, with transect locations shown.



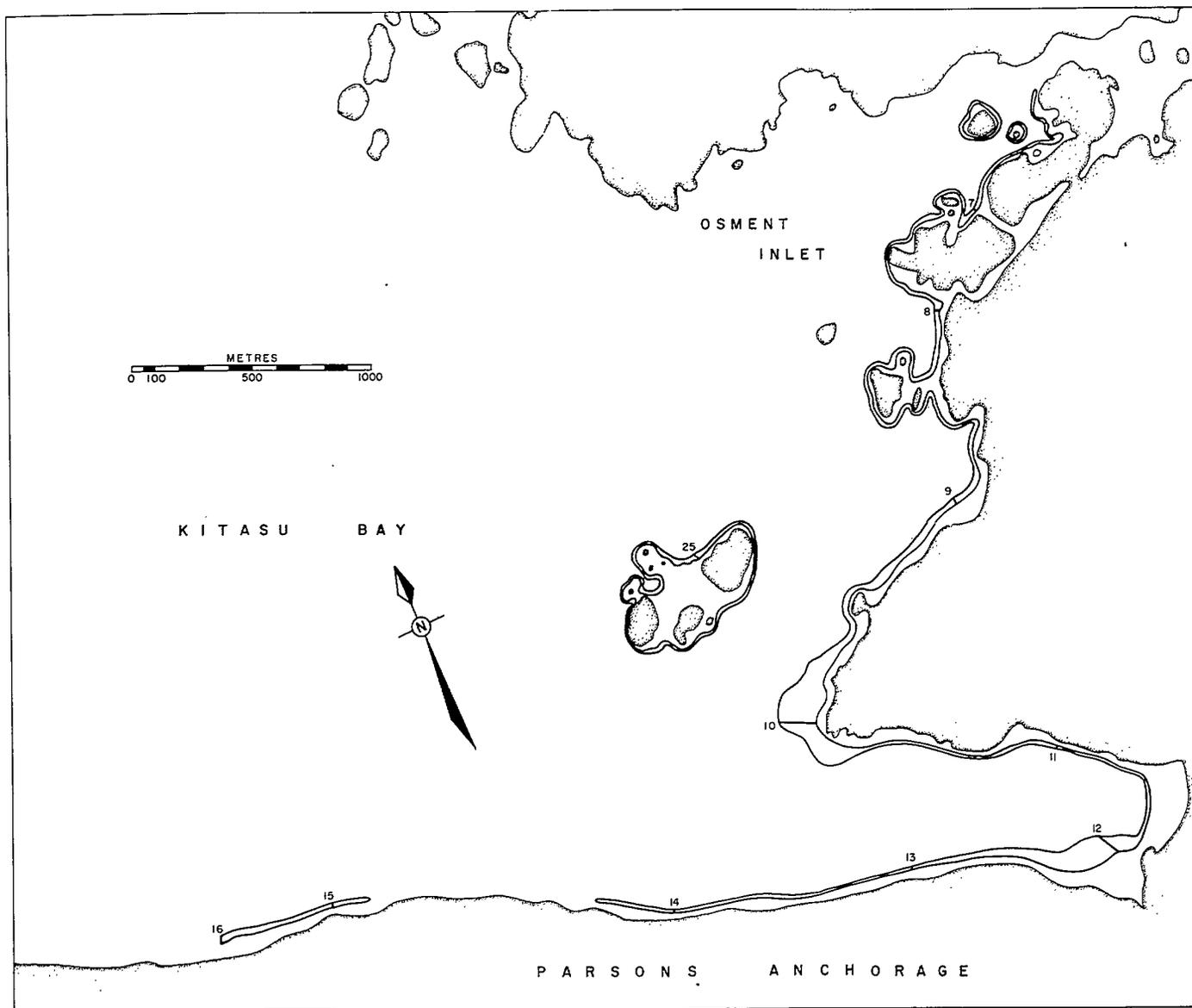
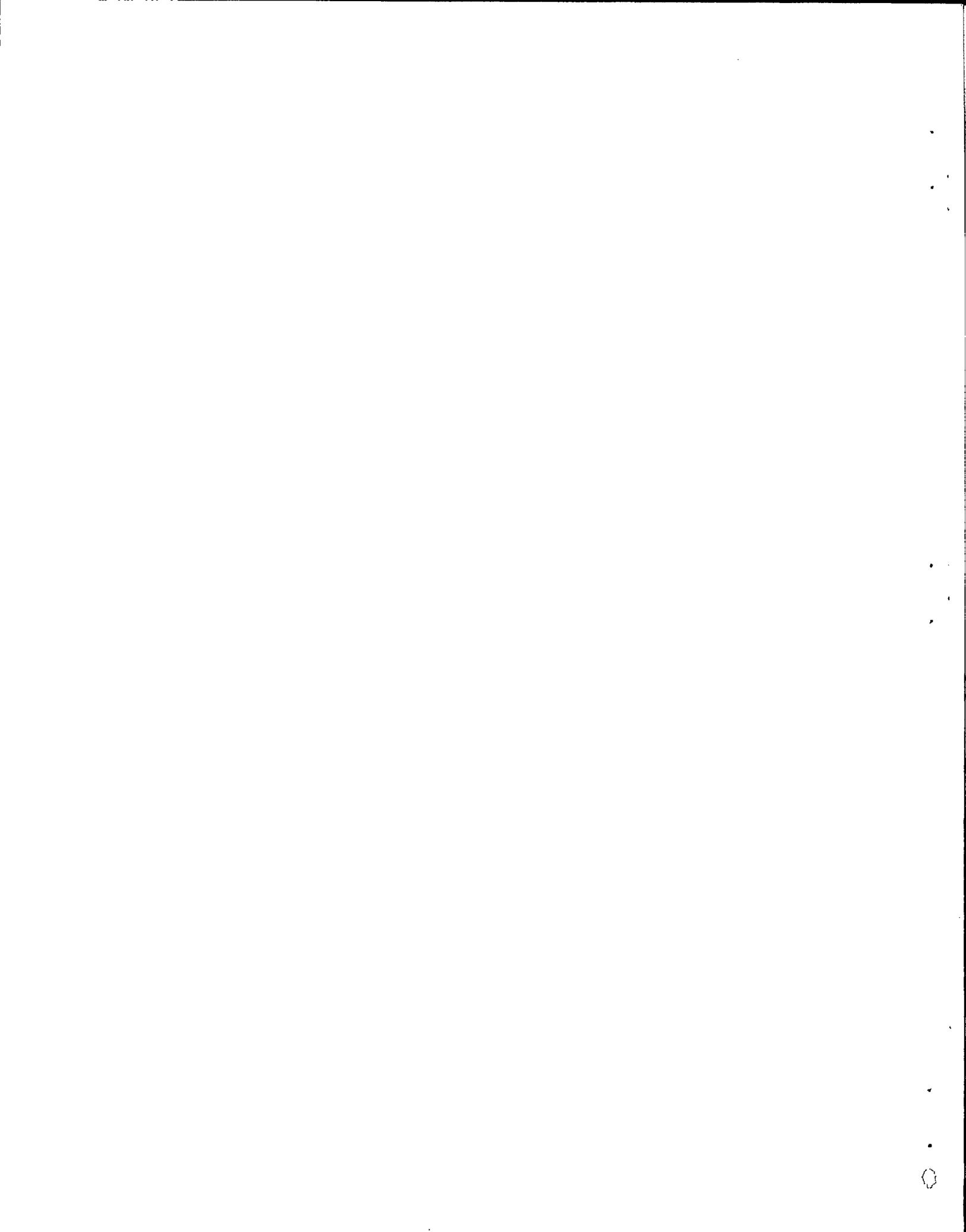


Fig. 3. Herring spawn at the head of Kitasu Bay in Area 6, surveyed by divers in 1986, with transect locations shown.



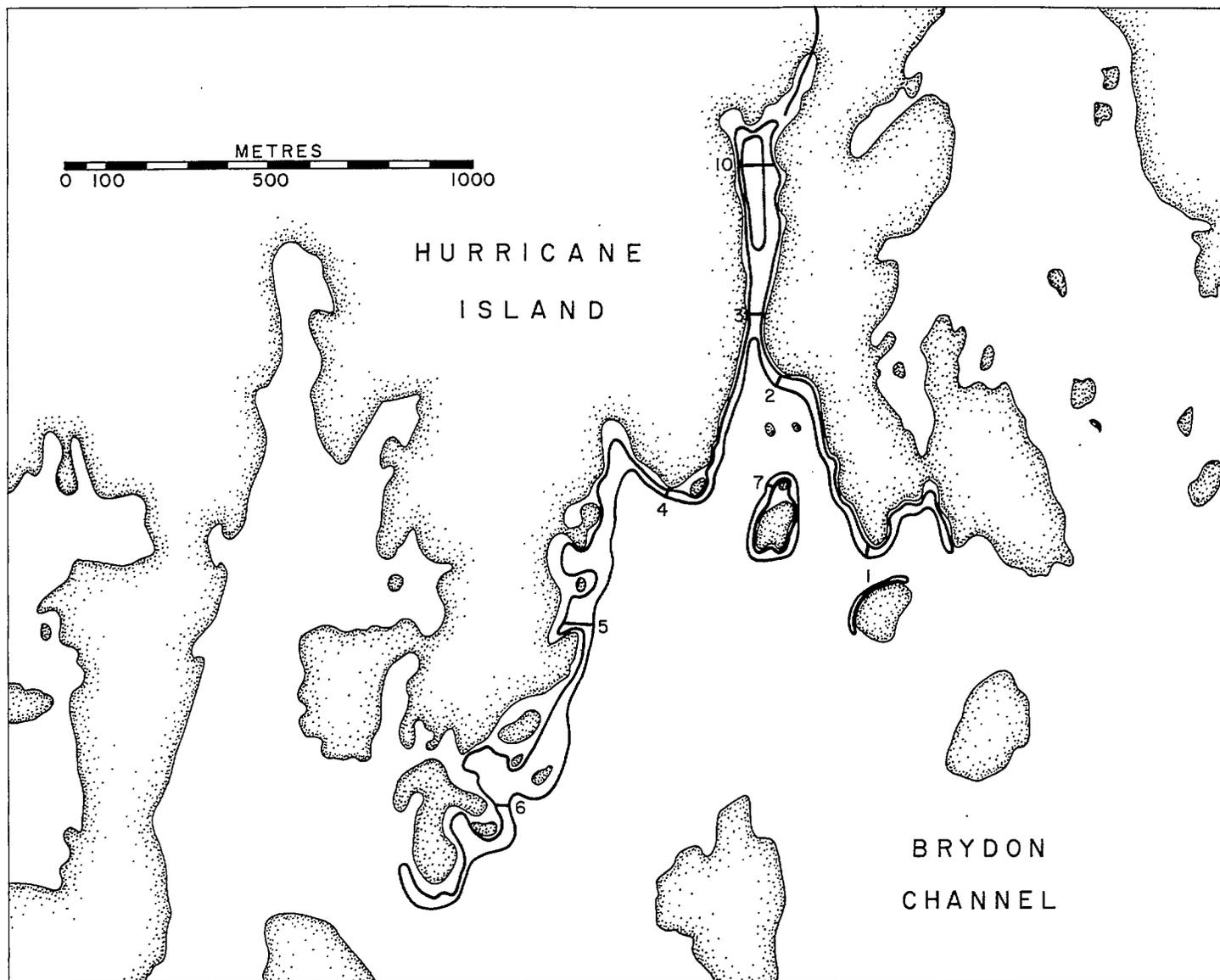
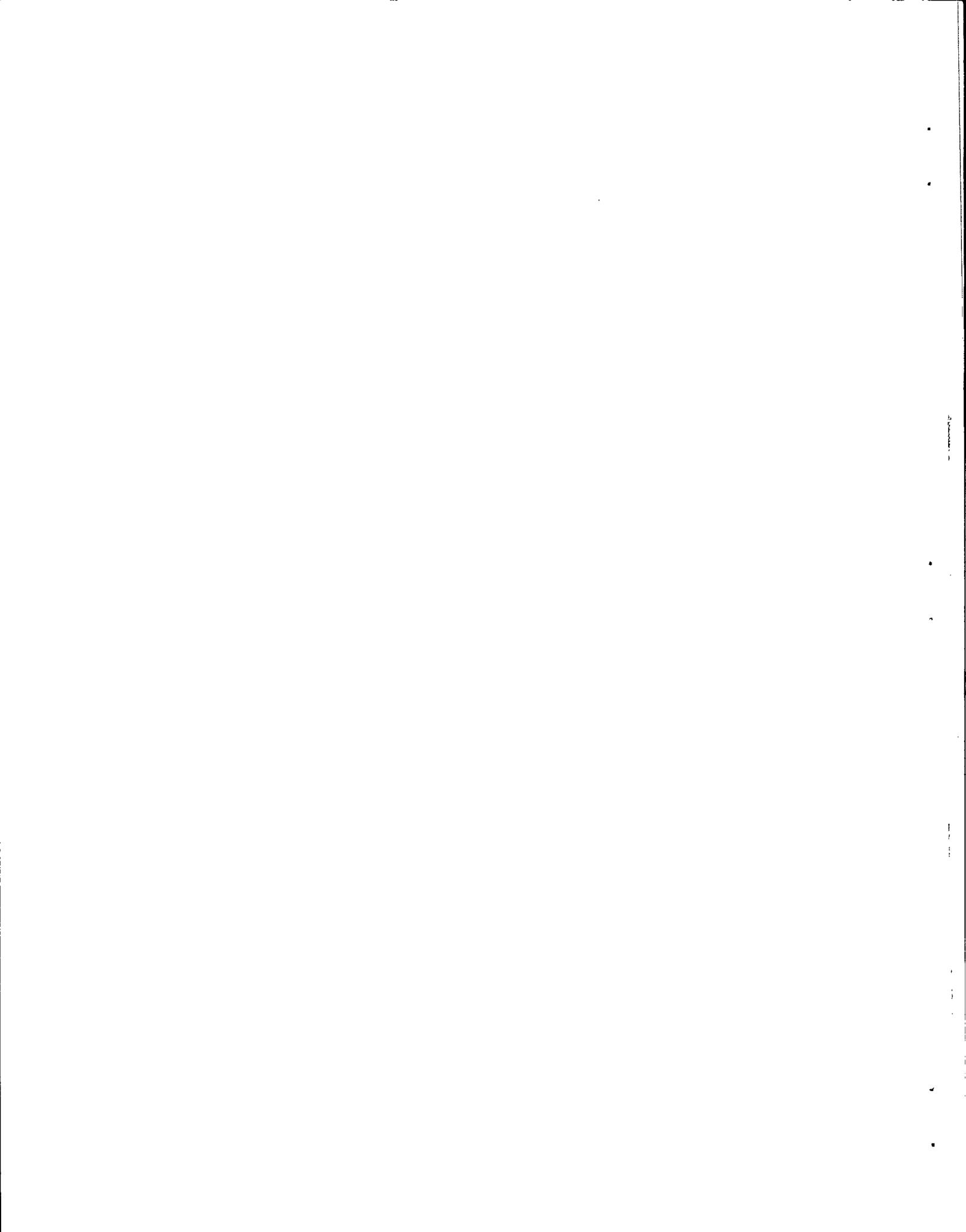


Fig. 4. Herring spawn in Brydon Channel in Area 7, surveyed by divers in 1986, with transect locations shown.



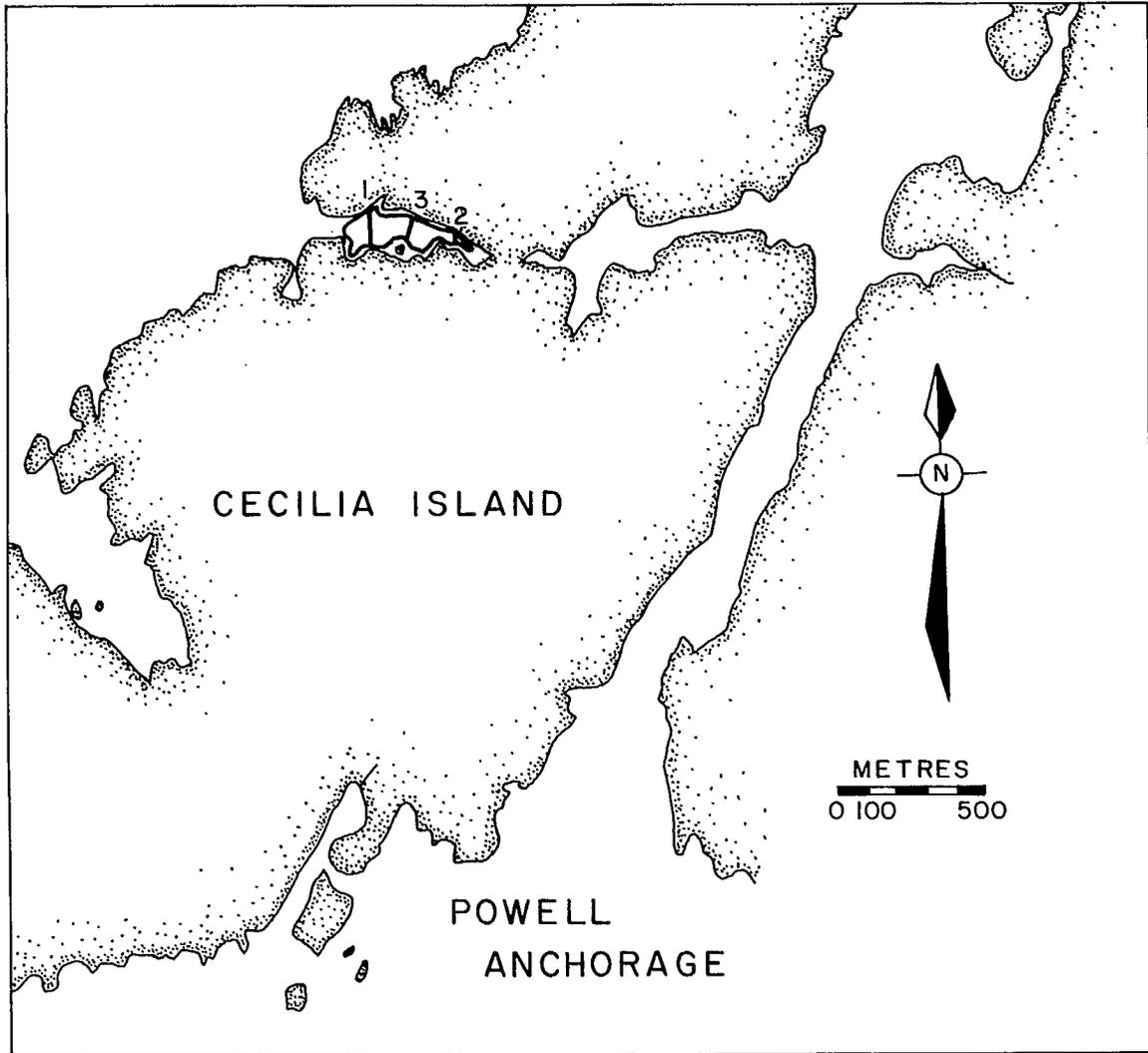
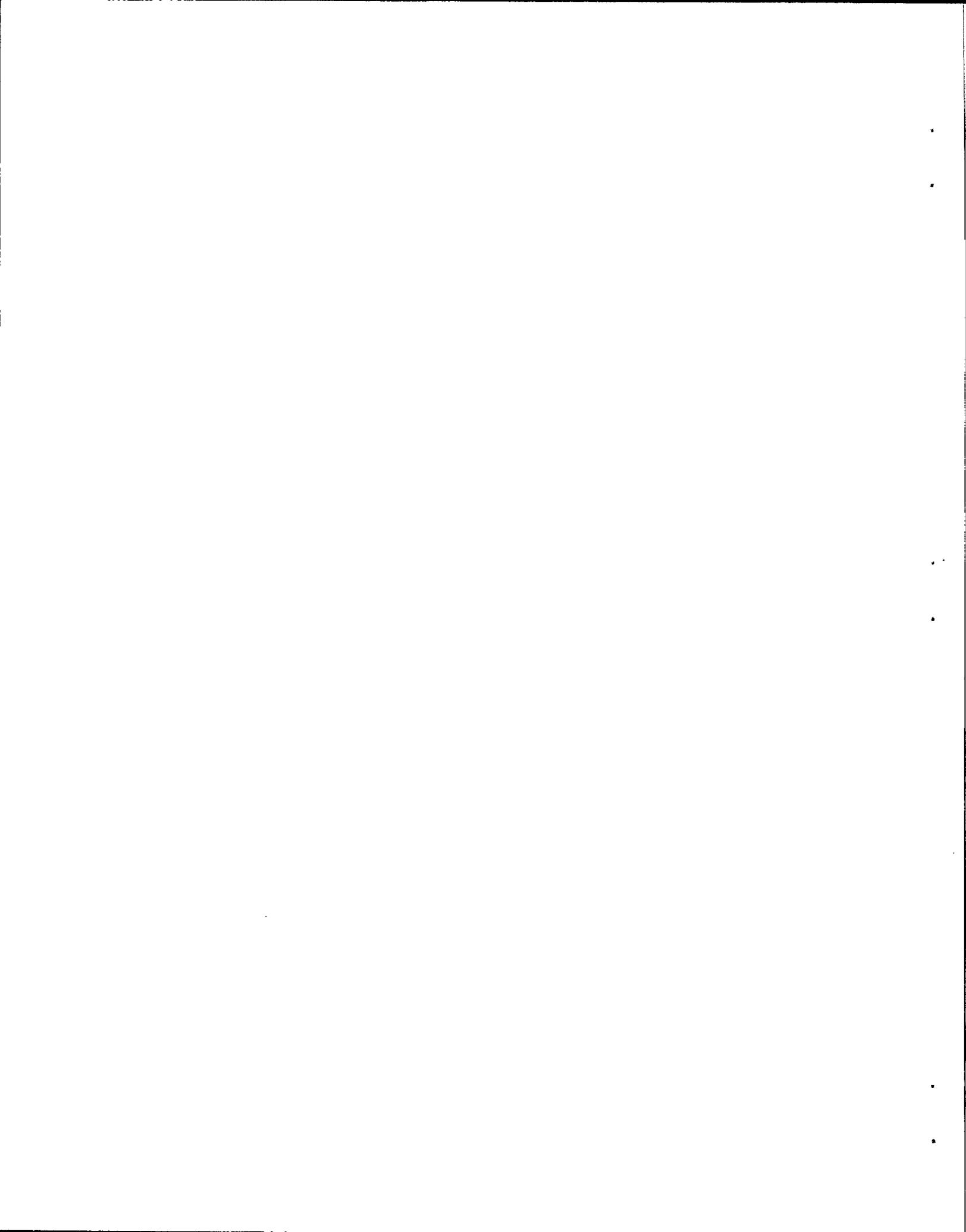


Fig. 5. Herring spawn in Bend Point Cove on Cecilia Island in Area 7, surveyed by divers in 1986, with transect locations shown.



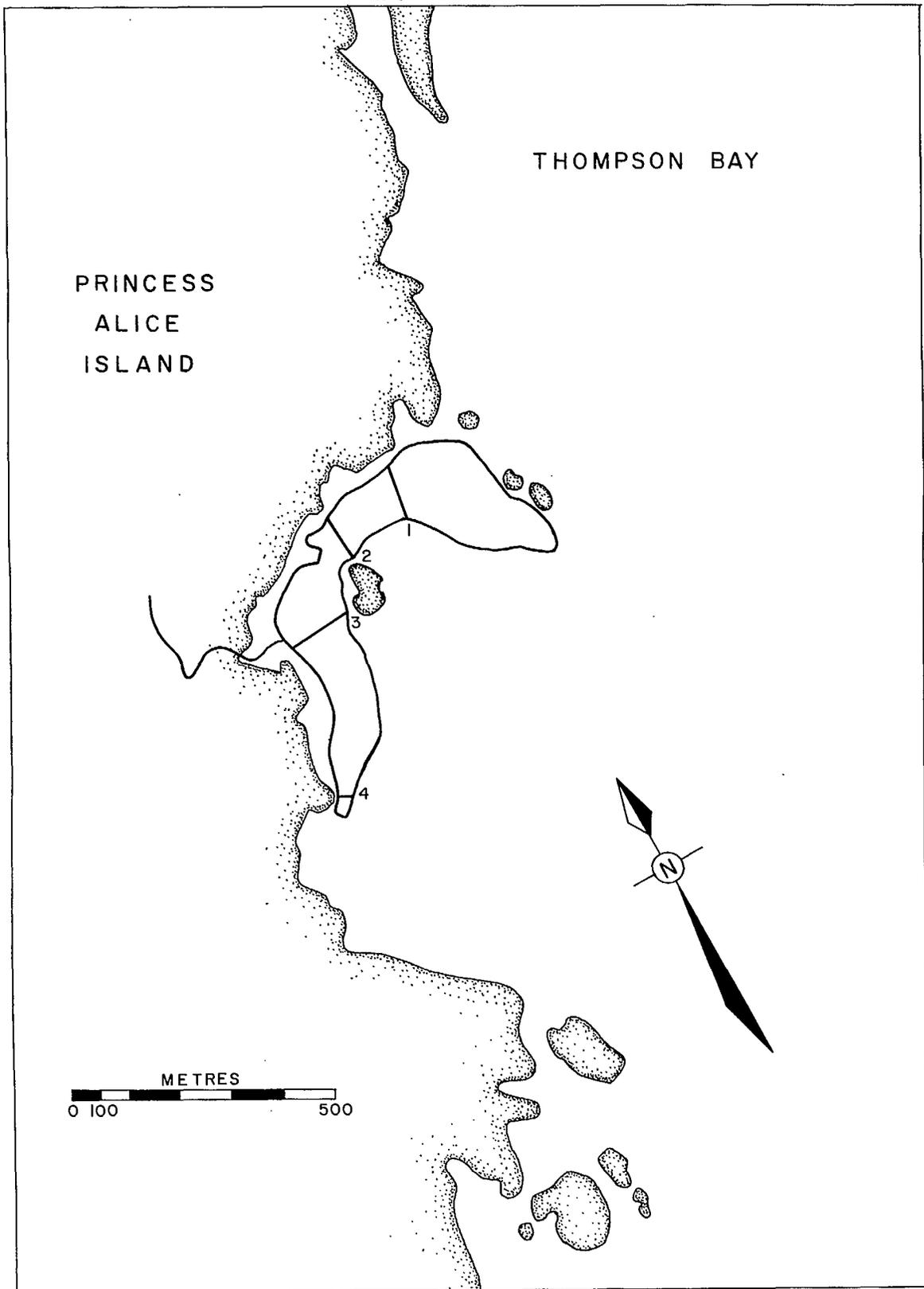
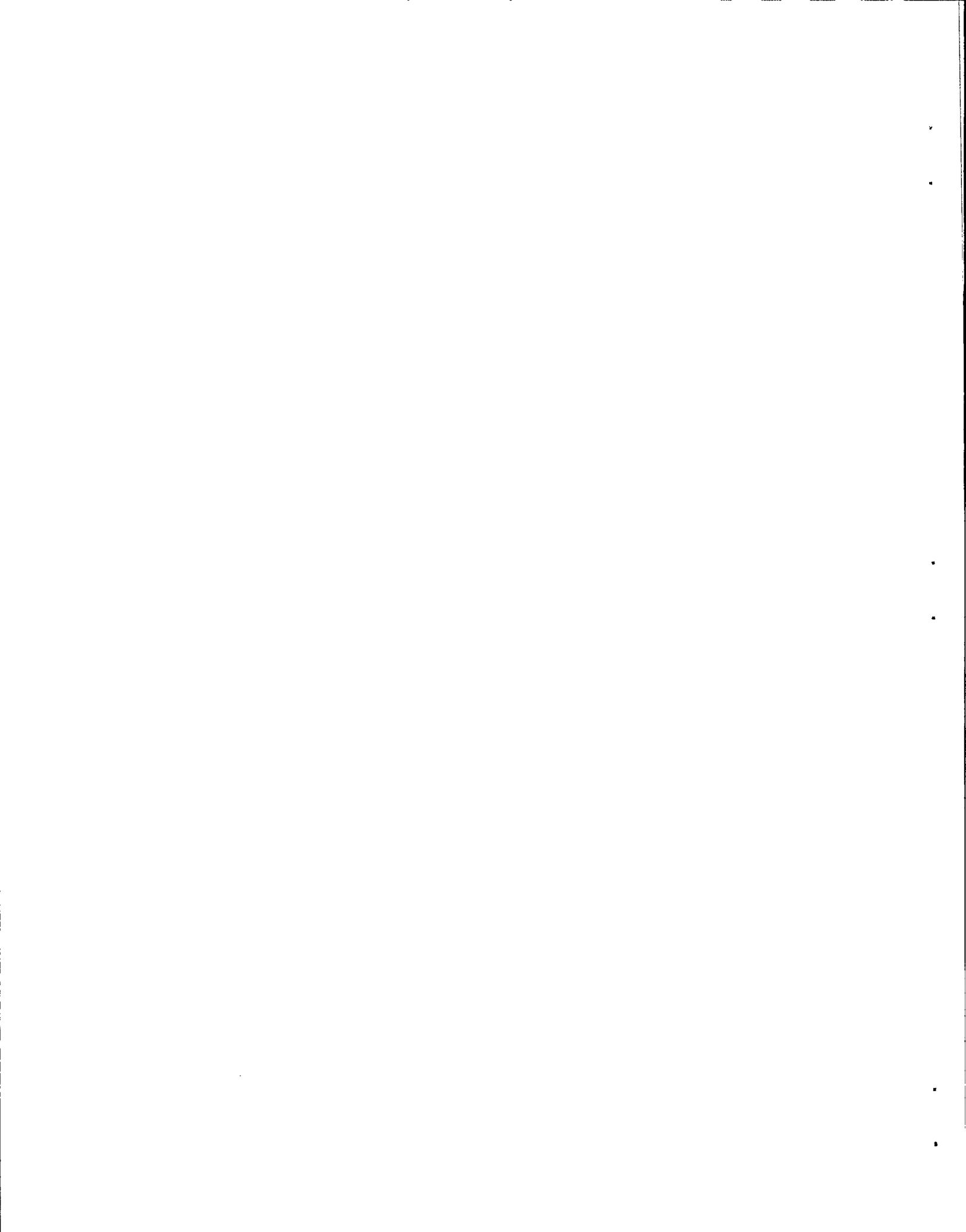


Fig. 6. Herring spawn near Princess Alice Island in Thompson Bay in Area 7, surveyed by divers in 1986, with transect locations shown.



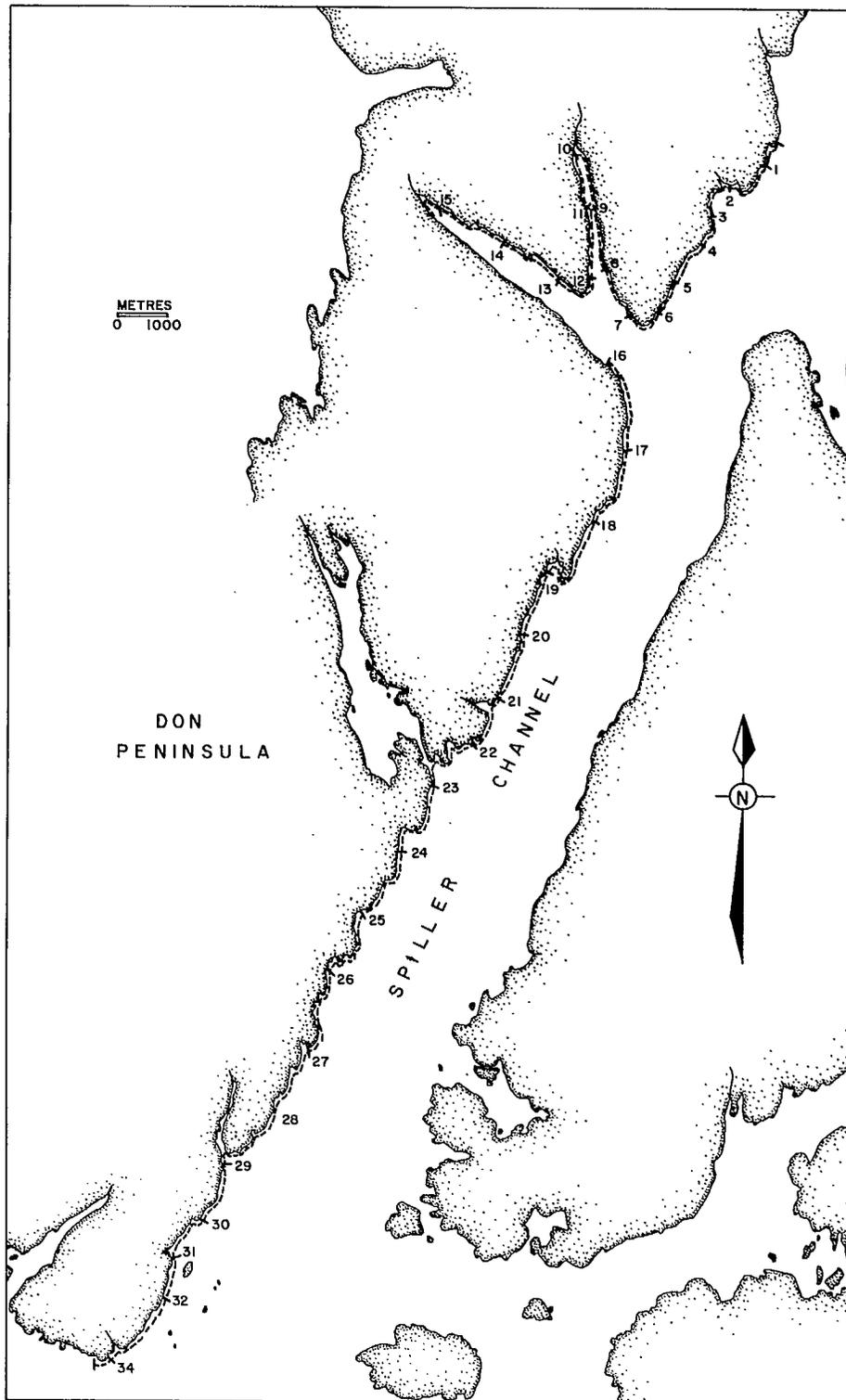
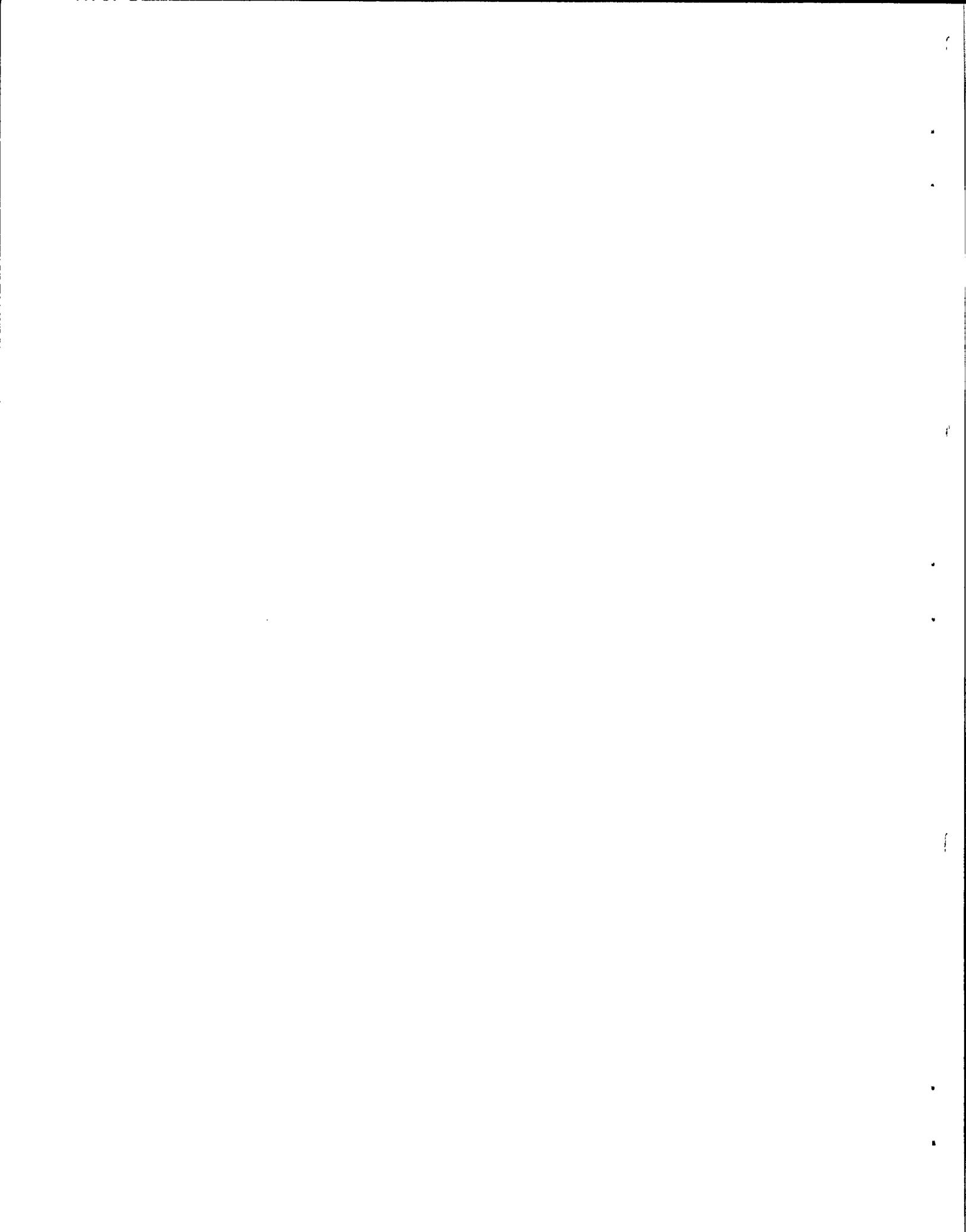


Fig. 7. Herring spawn in Spiller Channel in Area 7, surveyed by divers in 1986, with transect locations shown.



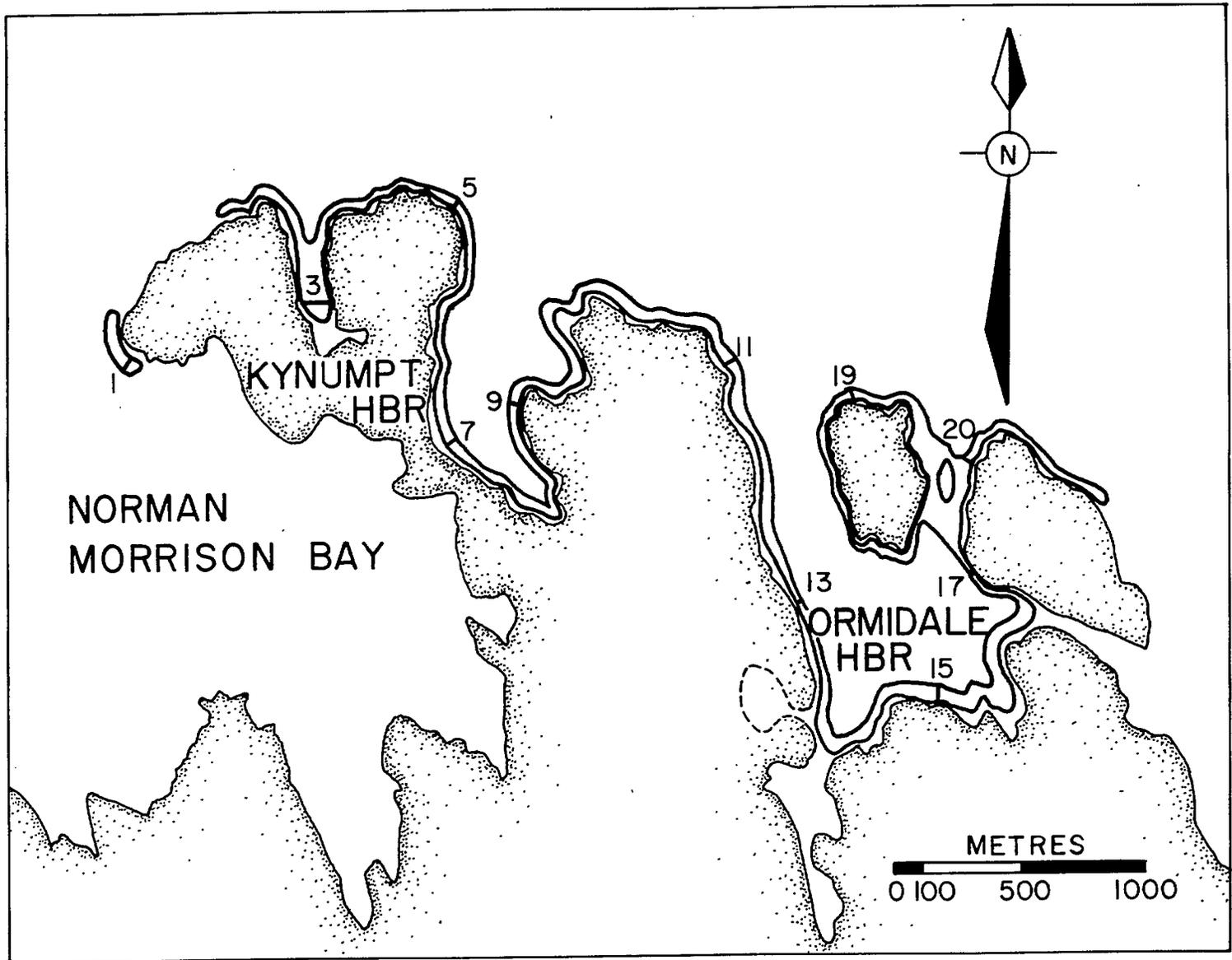
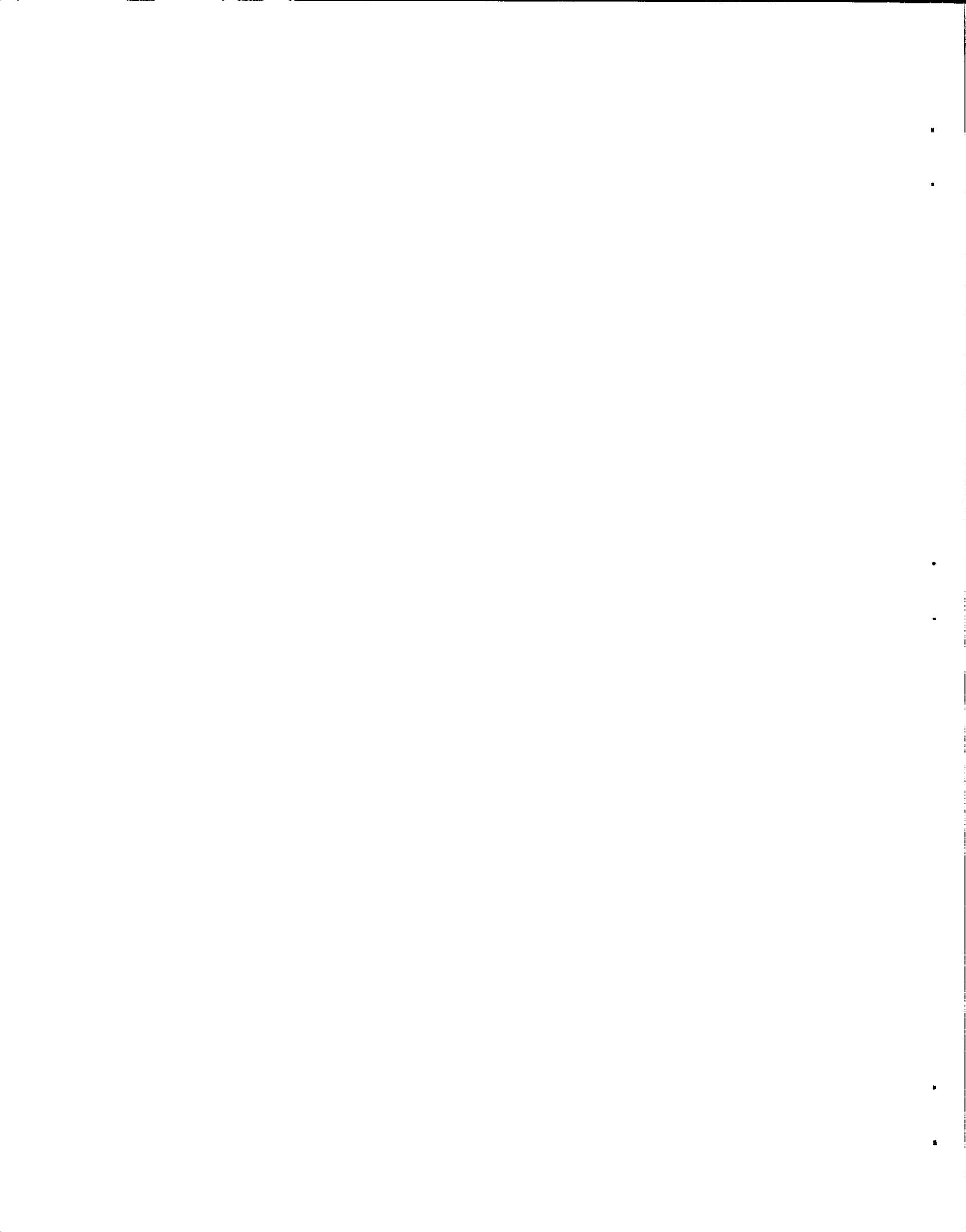


Fig. 8. Herring spawn in Kynumpt and Ormidale Harbours in Area 7, surveyed by divers in 1986, with transect locations shown.



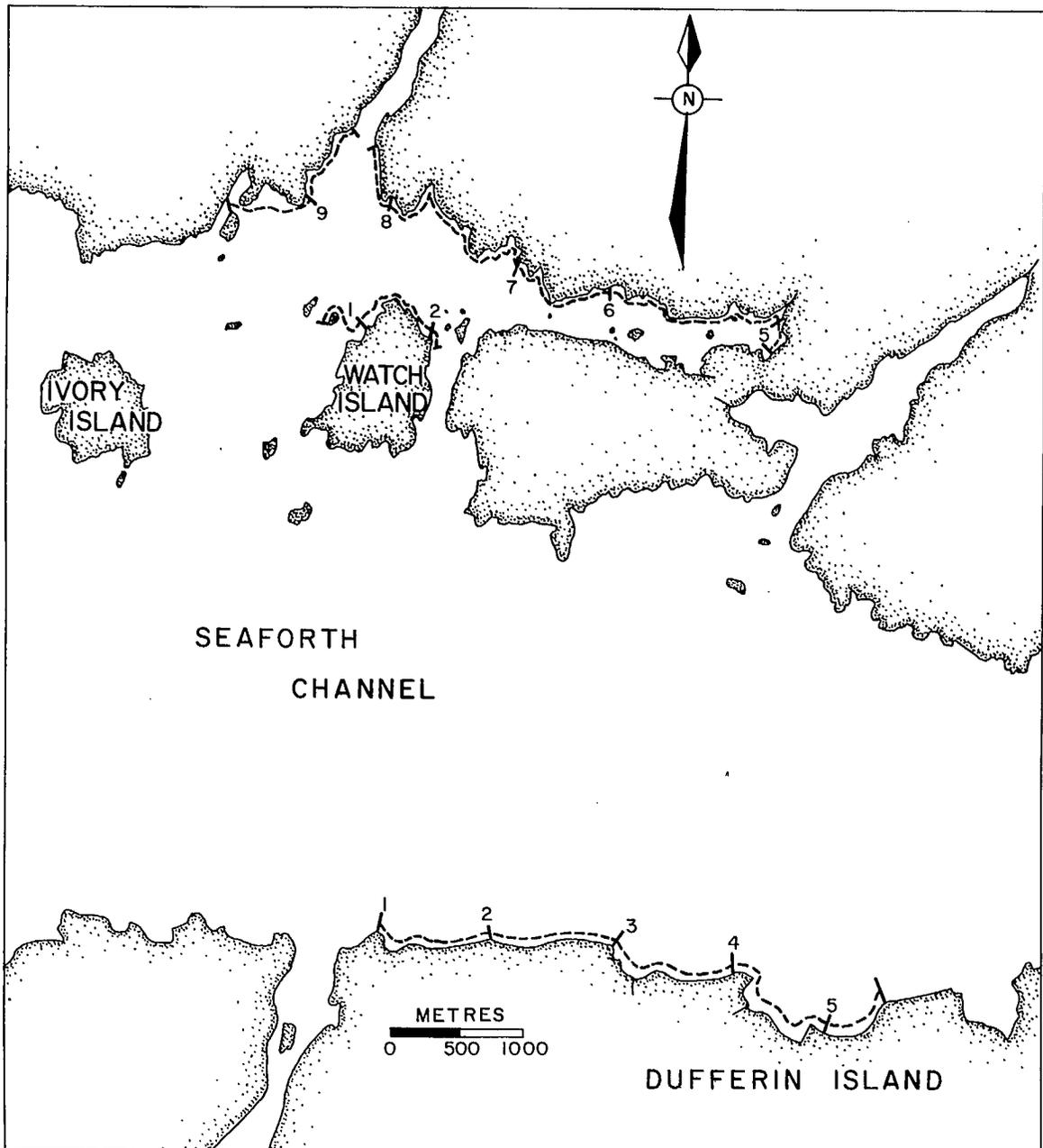
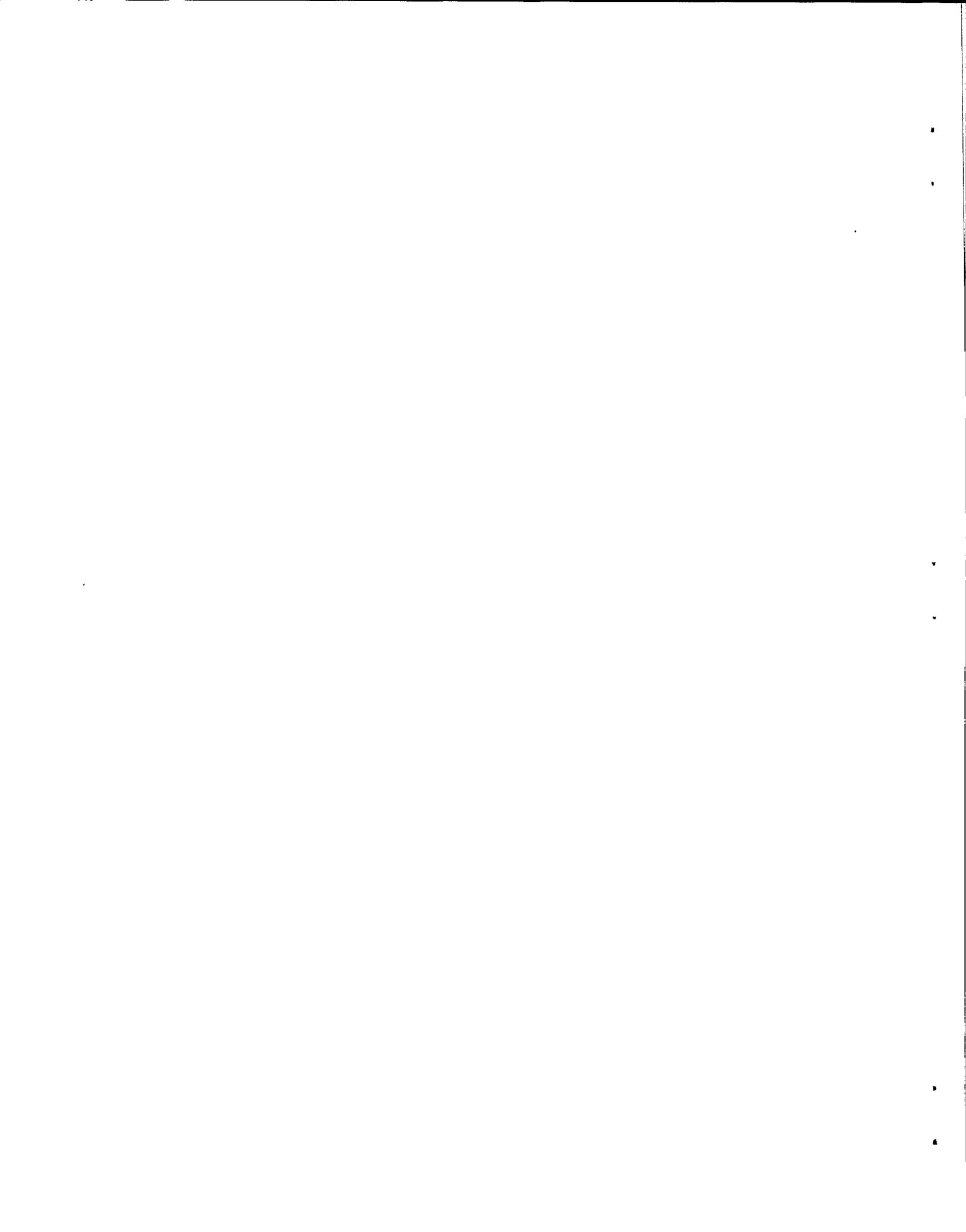


Fig. 9. Herring spawn in Powell Anchorage and Watch Island and in Seaforth Channel near Gale Passage in Area 7, surveyed by divers in 1986, with transect locations shown.



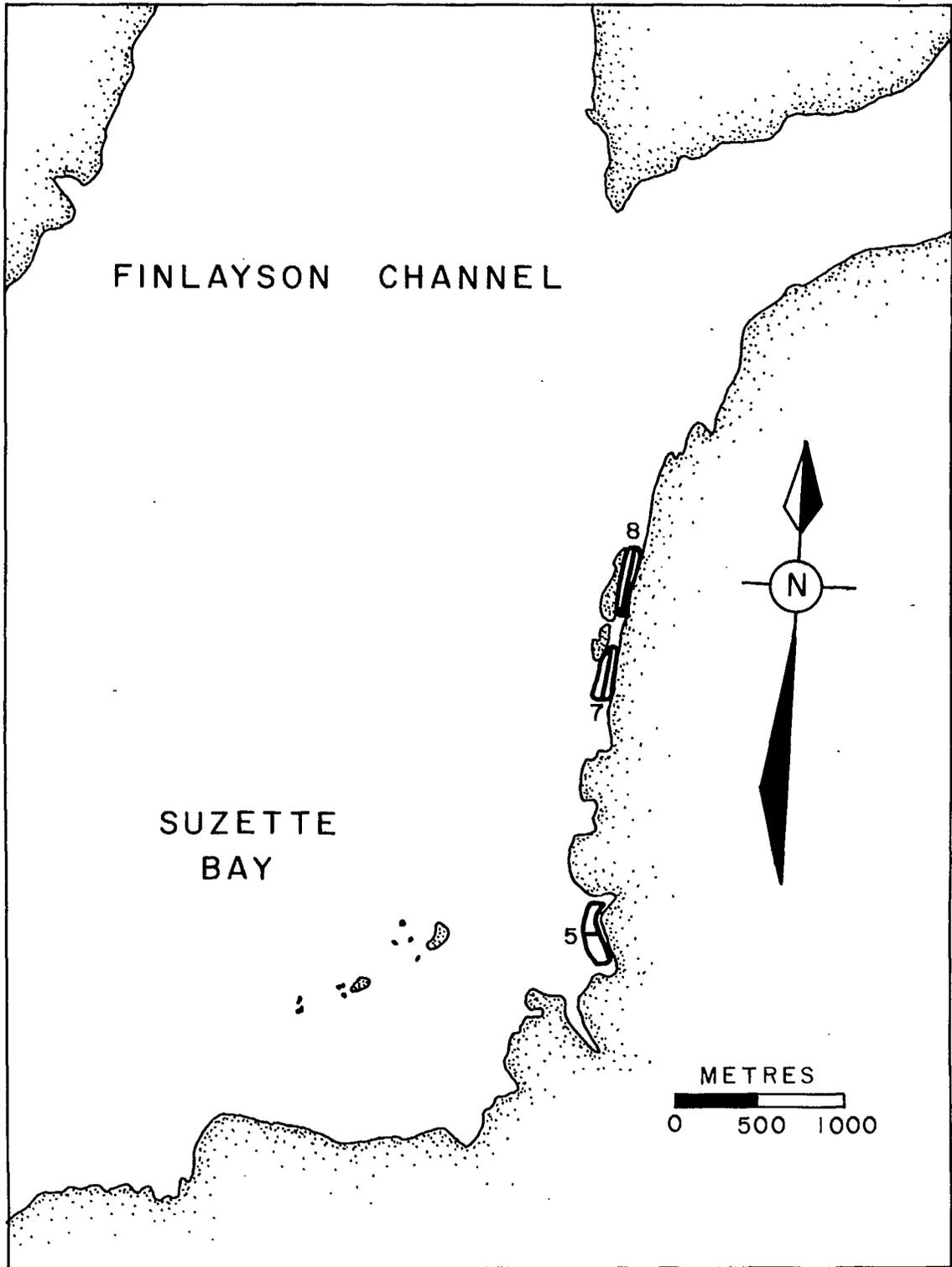
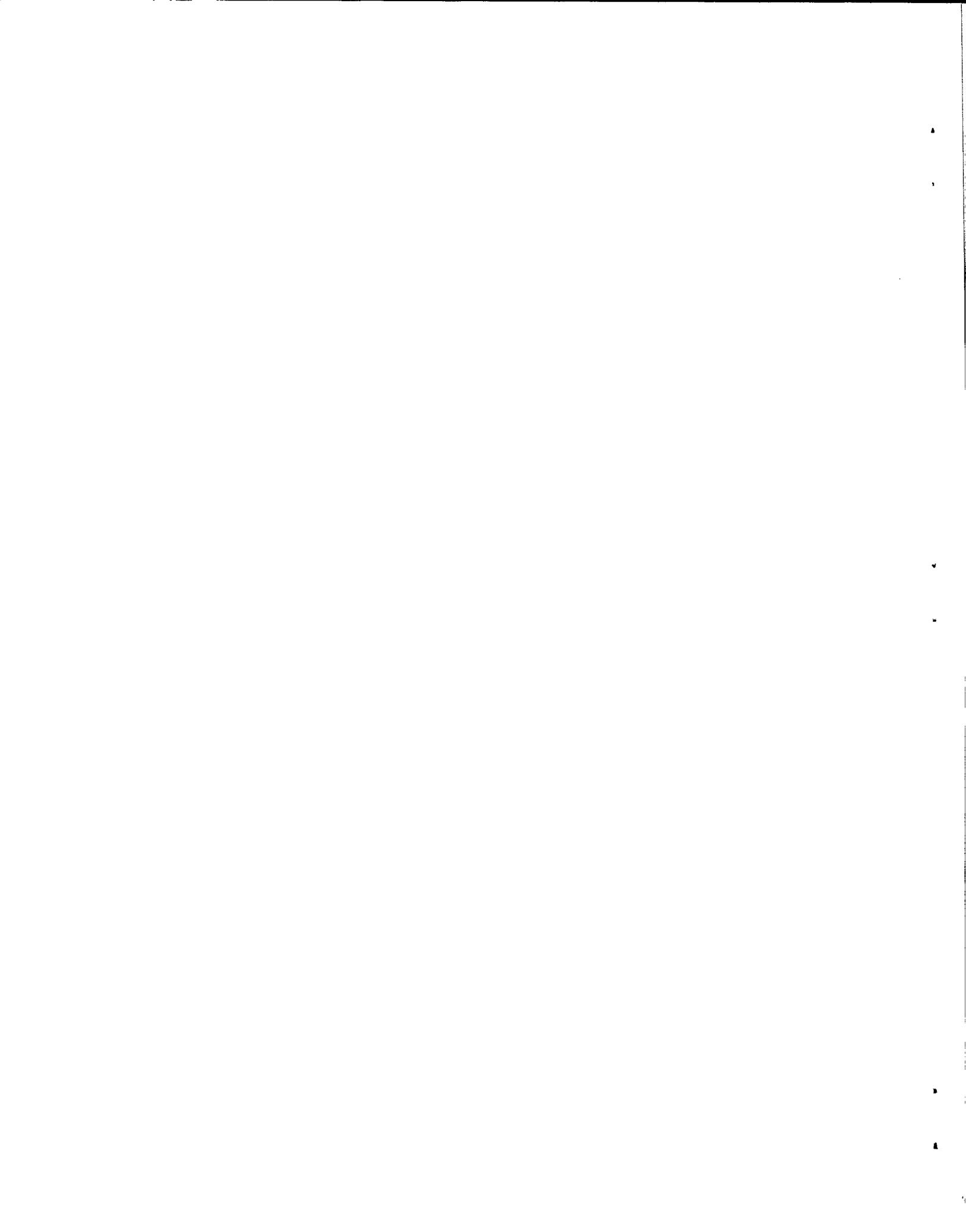


Fig. 10. Herring spawn in Suzette Bay in Area 7, surveyed by divers in 1986, with transect locations shown.



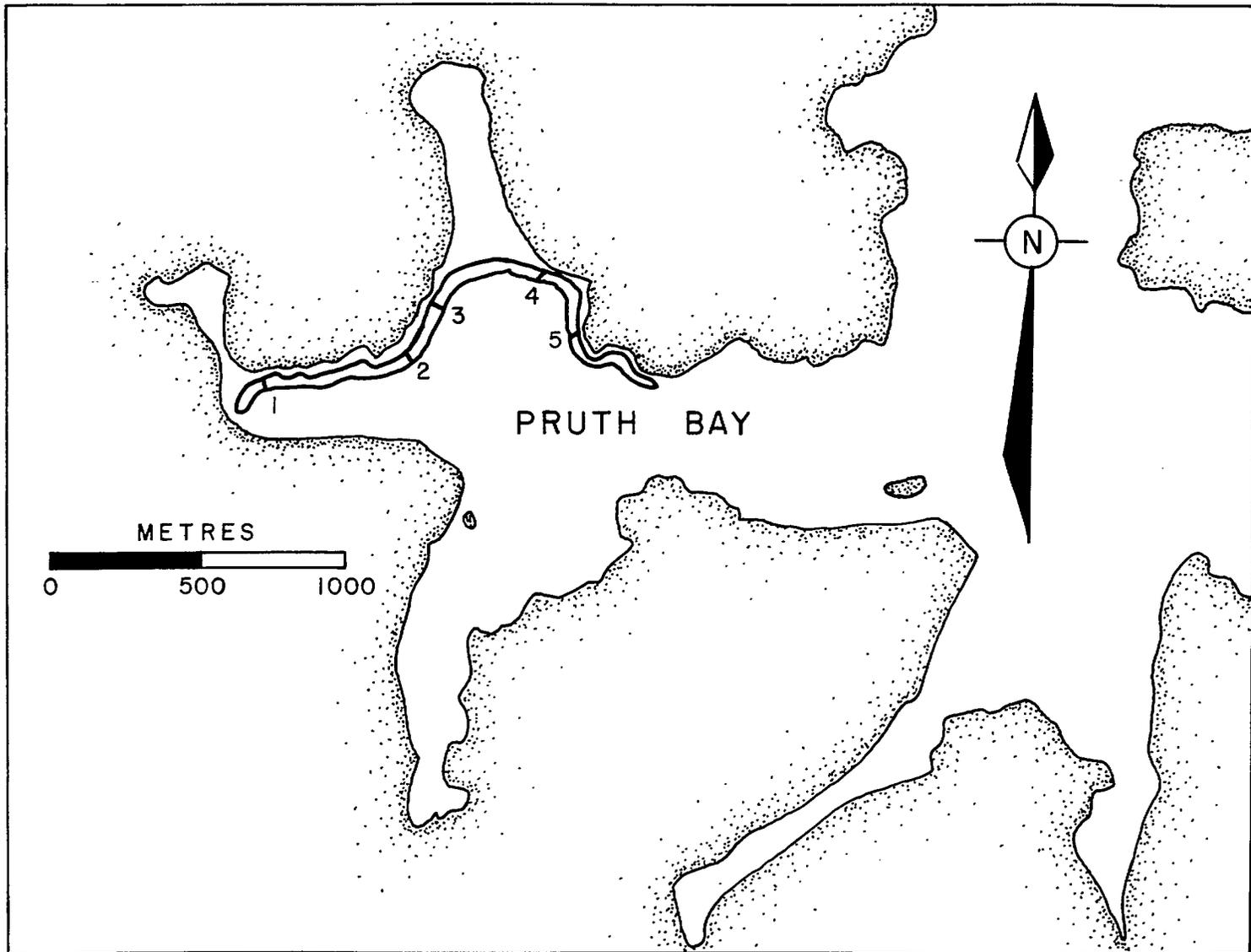
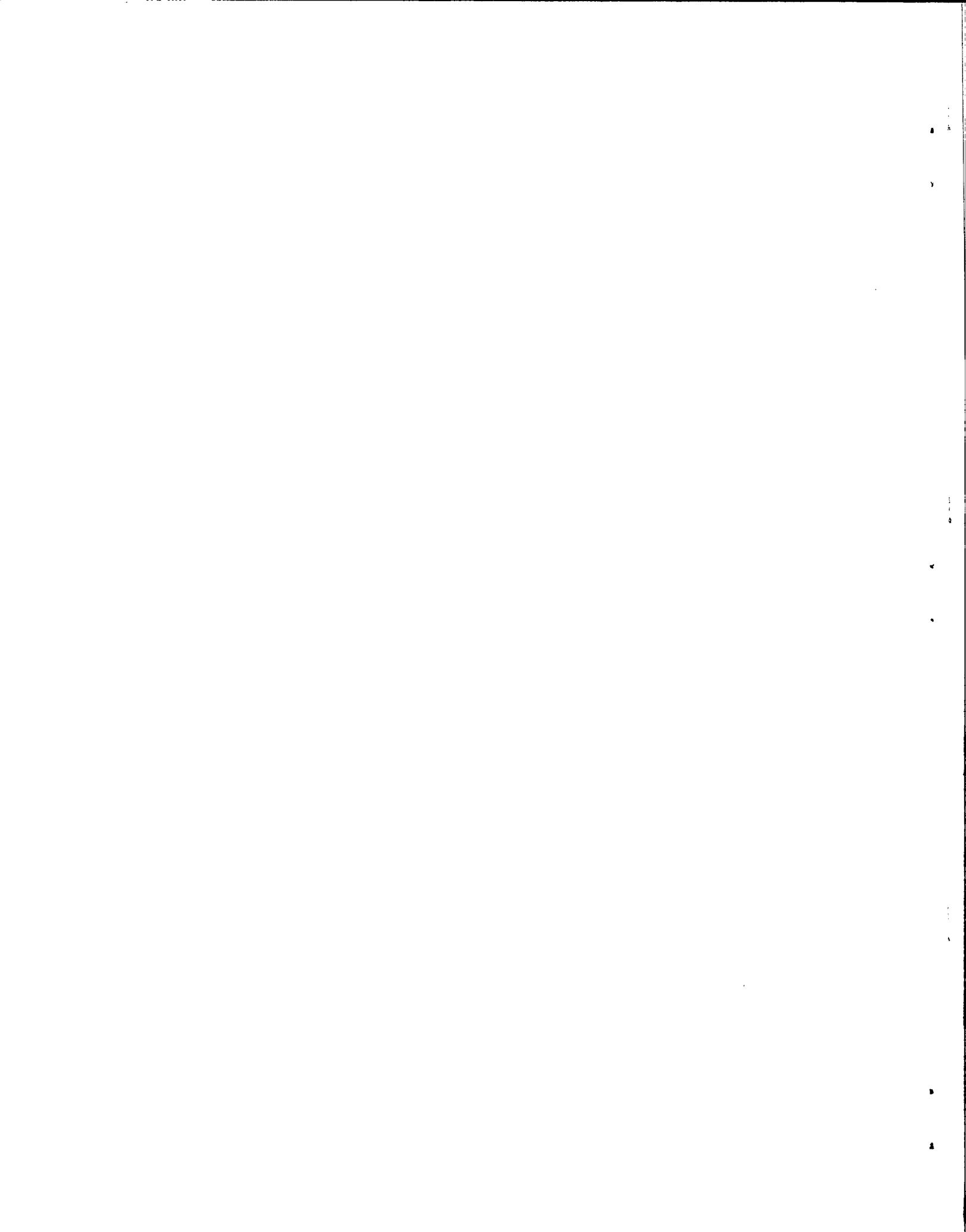


Fig. 11. Herring spawn in Pruth Bay at the head of Kwakshua Channel in Area 8, surveyed by divers in 1986, with transect locations shown.



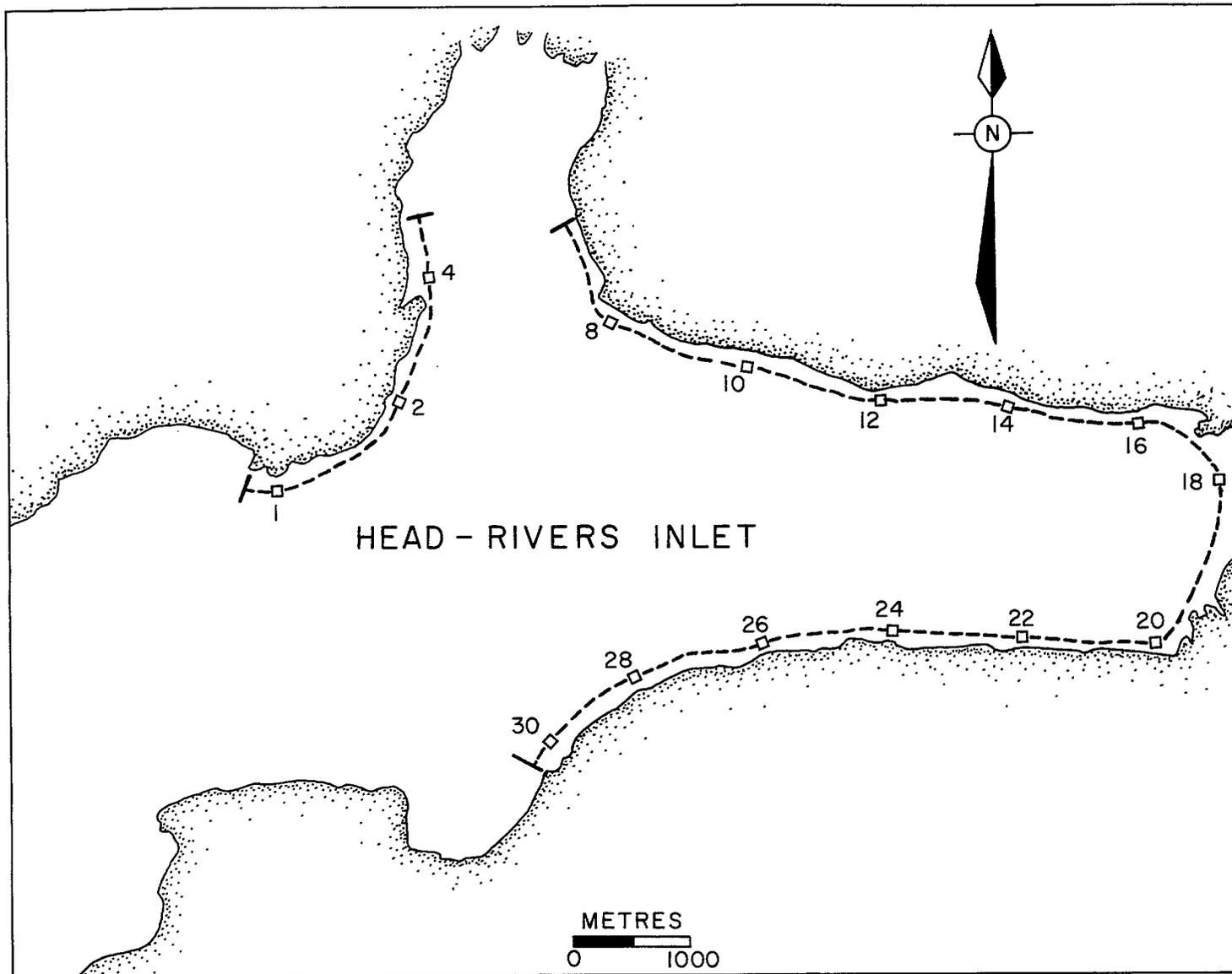
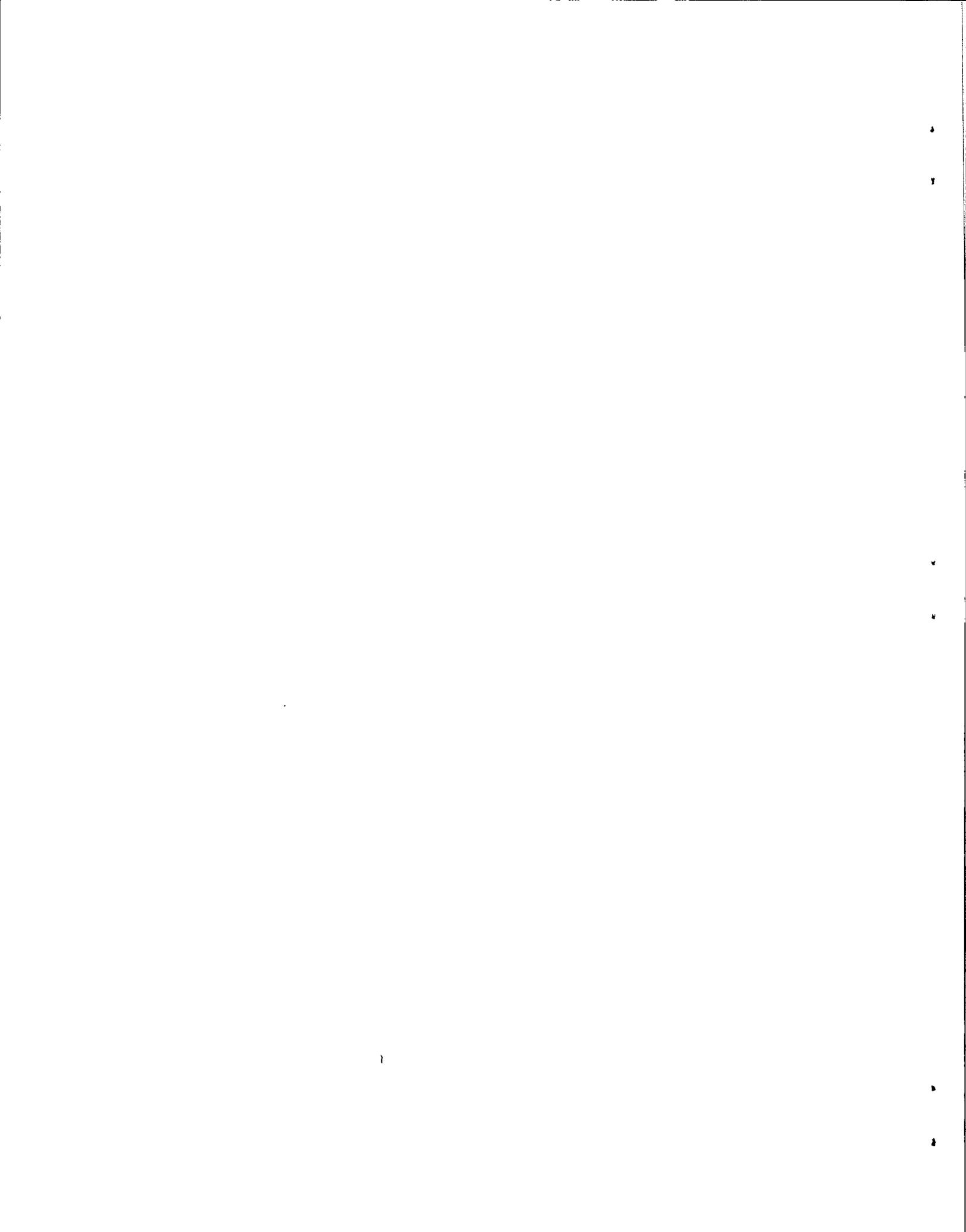


Fig. 12. Herring spawn at head of River's Inlet in Area 9, surveyed by divers in 1986, with transect locations shown.



Appendix Table 1. Macrocystis sp. transect information for spawns surveyed by divers in Kitasu Bay in 1986. (MP = mature plants, IP = immature plants, MF = mature fronds, IF = immature fronds, AF = all fronds.)

Transect no.	Transect length (m)	Surveyed area (sq. m)	No. of plants		No. of MP fronds			No. of IP-IF
			MP	IP	MF	IF	AF	
10	5	10	1	0	12	2	14	0
13	20	40	15	0	43	40	83	0
14	30	60	7	0	33	7	40	0
15	10	20	2	0	47	11	58	0
16	5	10	5	1	21	4	25	2
17	5	10	1	0	7	0	7	0
Total		150	31	1	163	64	227	2

Appendix Table 2. Results for harvested Macrocystis sp. plants collected in Kitasu Bay in 1986. (MP = mature plant, MF = mature fronds, AF = all fronds.)

Transect no.	Height (m)	Egg layers	No. fronds		Thousands of eggs per			Plant weight (g)
			MF	AF	MP	MF	AF	
10	4	1.0	17	25	939	55	38	6630
13	3	0.5	1	3	271	271	90	1102
14	5	1.8	1	1	99	99	99	1141
15	6	0.6	8	10	791	99	79	3034
16	6	0.2	7	10	532	76	53	7110

