# Herring Stock Estimates from Diving Surveys of Spawn for Georgia Strait in 1986

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# OF SPAWN FOR GEORGIA STRAIT IN 1986

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# PREFACE

An early draft of this manuscript was presented at the September 1986 Herring Stock Assessment Committee meeting. At that time, spawner biomass estimates were made using a model which predicts egg density from visual observations and spawn sample weights. Since then, eggs in preserved spawn samples have been counted and the results were used in this analysis. Spawner biomass estimates are approximately 39% greater than those presented in September 1986.

# ABSTRACT

Schweigert, J. F. and C. W. Haegele. 1988. Herring stock estimates from diving surveys of spawn for Georgia Strait in 1986. Can. MS Rep. Fish. Aquat. Sci. 1971: 65 p.


Using the results of diving surveys of spawn, we estimated that 60,212 tonnes of herring spawned in Georgia Strait in 1986. In Area 14, 51,092 tonnes were estimated to have spawned on Denman and Hornby islands and along the Vancouver Island shoreline from below Deep Bay to below Little Qualicum River. In Area 15, 1141 tonnes were estimated to have spawned on Harwood and Savary islands. An estimated 7934 tonnes spawned in Area 17: 152 tonnes in Nanoose Bay, 332 tonnes at Icarus Point, 105 tonnes at Sharpe Point and 7344 tonnes along the Vancouver Island shoreline from above Boat Harbour to Coffin Point. Only 46 tonnes were estimated to have spawned in Area 18. All major spawns were surveyed by divers and surface survey results were used to estimate the spawning biomass for the minor spawns.

Estimates of egg density from a predictive model based on sample weight and egg layers were uniformly low in 1986 relative to earlier years. Model predictions have generally been fairly accurate for Georgia Strait spawns and the low estimates for this year appear to result from low estimates of egg layers on the various vegetation substrates.

The spawns were wider and on more gently sloping beaches in Area 14 than in Area 17. Most of the spawn was deposited between 1 m above to 3 m below chart datum. Egg density declined with depth in Area 14 but not Area 17. Sea grasses and the brown algae, _Sargassum muticum_, were the most common vegetation type for egg deposition in Area 17, while rockweed and filamentous red algae were more commonly used in Area 14.

RESUME

Schweigert, J. F. and C. W. Haegele.  1988.  Herring stock estimates from
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        En nous servant des résultats de relevés du frai effectués sous
l'eau, nous avons estimé à 60 212 tonnes le hareng qui a frayé dans le détroit
de Géorgie en 1986.  Dans la zone 14, on a estimé à 51 092 tonnes le hareng
qui a frayé aux îles Denman et Hornby et le long du littoral de l'île
Vancouver d'un point situé au-dessous de la baie Deep jusqu'à un point situé
au-dessous de la rivière Little Qualicum.  Dans la zone 15, on a évalué à 1141
tonnes le hareng qui a frayé aux îles Harwood et Savary.  On estimé que 7934
tonnes de hareng ont frayé dans la zone 17:  152 tonnes dans la baie Nanoose,
332 tonnes a la pointe Icarus, 105 tonnes a la pointe Sharpe et 7344 tonnes le
long du littoral de l'île Vancouver d'un point situé au-dessus de Boat Harbour
jusqu'a a la pointe Coffin.  On a évalué à 46 tonnes seulement le hareng qui a
frayé dans la zone 18.  Des plongeurs ont effectué des relevés des principales
pontes et on s'est servi des résultats des relevés de surface pour estimer la
biomasse des géniteurs pour les petites pontes.

        Les estimations de la densité des oeufs faites à partir d'un modèle
de prédiction basé sur le poids des échantillons et les couches d'oeufs ont
été uniformément basses en 1986 par rapport aux années précédentes.  Les
prédictions selon le modèle ont généralement été assez précises pour les
pontes dans le détroit de Géorgie et les faibles estimations pour cette année
semblent découler des faibles estimations des couches d'oeufs sur les divers
substrats de végétation.

        Les frayères étaient plus larges et sur des plages à pente plus
douce dans la zone 14 que dans la zone 17.  La plus grande partie des oeufs a
été déposée entre 1 m au-dessus et 3 m au-dessous du zéro des cartes.  La
densité des oeufs diminuait avec la profondeur dans la zone 14 mais non dans
la zone 17.  Les zostères et l'algue brune Sargassum muticum constituaient le
type de végétation le plus répandu pour le dépot des oeufs dans la zone 17,
alors que le fucus et les algues rouges filamenteuses e'taient les plantes
marines les plus couramment utilisées dans la zone 14.

# INTRODUCTION

Herring stocks in Georgia Strait appear to have declined over the past several years (Haist et al. 1986). Herring spawns in Georgia Strait were surveyed by divers in 1985 (Schweigert and Haegele 1988) to directly estimate adult spawner biomass, independently from stock assessment models (Haist et al. 1986). Georgia Strait was closed to herring roe fishing in 1986 and a diving survey of spawns was again conducted in 1986 to monitor the rate and magnitude of stock recoveries. The results of the 1986 diving survey of Georgia Strait are presented in this report.

# METHODS

Herring spawns were surveyed either by SCUBA divers or by traditional surface survey techniques. In the surface survey, visual observations were made from the surface. Frequently a viewing box was used to increase the visibility of the bottom. Grapples were used to detect and obtain samples of spawn. From these observations, the length and width of spawn and the layers of eggs were estimated. The proportion of the area of the spawn devoid of eggs or vegetation (bare area) was also estimated. Information on the type of vegetation on which the eggs were deposited was also obtained but not used in this report.

The diving survey followed a two-stage sampling design (Schweigert et al. 1985). Transects perpendicular to the shore were the primary sampling unit and 0.5 sq. m quadrats sampled 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 cover of the vegetation, and the dominant vegetation class were estimated by divers for each quadrat. Samples were weighed and weighed subsamples were preserved in Gilson's fluid for subsequent egg counts. Eggs on the bottom substrate were estimated from diver estimates of layers of eggs and percent of bottom covered by vegetation (Haegele et al. 1979) and added to eggs on vegetation. Depths at sample sites were measured by divers and were corrected to chart datum using water levels observed at applicable tide gauge installations (Tides and Currents, Institute of Ocean Sciences, Sidney, B.C.).

Transects were established at nearly 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 lengths (Schweigert et al. 1985). The inner and outer edge of spawns were determined from measurements along transects. The limits of a spawn beyond the outer transects was determined by exploratory dives. This information was plotted on maps of marine vegetation

at scales of 1:4800 and 1:6000 (Haegele 1978; Haegele and Hamey 1979, 1981), the boundaries of the spawn contoured, and the area of the spawn measured. Spawner biomass (tonnes) was estimated as the product of spawn area, egg density, and 0.00000001, which reflects an assumed 200 eggs per gm female weight (Hay 1985) and a 1:1 sex ratio.

For spawns surveyed only from the surface, the observed length and an adjusted width was used to calculate area. Egg density was estimated from egg layer estimates. The equations and parameter estimates for these adjustments are given by Haist et al. (1986):

(1)  $Width_{adj} = exp [0.375 log_e (Width_{obs}) + 3.401]$

(2)  $Eggs \cdot m^{-2} = 75.861 + 105.321 \cdot Lay_{av}$

To investigate discrepancies in egg density estimates between egg counts and model predictions, we calculated the mean, mode, and 25 and 75 percent quartiles for observed egg layers, sample weight, percent cover of vegetation, observed egg density, and predicted egg density for Area 14 and 17 by vegetation class for all years such data is available.

# RESULTS

## BIOMASS ESTIMATES

It was estimated from spawn surveys that 60,212 tonnes of herring spawned in Georgia Strait in 1986 (Fig. 1). Some spawning occurred in all four Statistical Areas (14, 15, 17, and 18) but 85% occurred in Area 14. We describe the individual spawns in each of these Areas below.

### Area 14

There were three spawnings in Area 14 in 1986. On Denman Island, herring spawned from Longbeak Point at the northern tip (Fig. 2) along the eastern shoreline at Komas Bluff (Fig. 3), Fillongley Park (Fig. 4), and Whalebone Point (Fig. 5) to the southern tip at Boyle Point (Fig. 6) from March 9 to 20. This spawning area was 21.5 km long and covered 375.9 ha (Table 1) at an average egg density of 643,418 eggs per sq. m for a 24,185 tonnes spawner estimate (Table 2). On Hornby Island, herring spawned from March 14 to 21. The spawning was 21.9 km long, covered 222.8 ha (Table 1) and nearly circumscribed the island, occurring from Shingle Spit (Fig. 5) to Collishaw Point (Fig. 7), past Tralee Point to Whaling Station Bay (Fig. 9), missing Tribune Bay, and resuming at Dunlop Point to Norman Point (Fig. 10). Egg density was heavy at 976,221 eggs per sq. m and 21,749 tonnes were

estimated to have spawned on Hornby Island (Table 2). The Qualicum spawning on the Vancouver Island shoreline occurred from March 14 to 23 and began below Deep Bay (Fig. 11), from where it continued past Thames Creek (Fig. 12) to Nile Creek (Fig. 13) and past the Big Qualicum River (Fig 14). Spawn resumed west of the Little Qualicum River (Fig. 15) and continued eastward of the river for about 3 km (Fig. 16). The Qualicum spawning was 16.0 km long and covered 171.5 ha (Table 1). Egg density was lower here (300,715 eggs per sq. m) than on Denman and Hornby islands. We estimated that 5158 tonnes spawned at Qualicum (Table 2).

## Area 15

Herring spawned on Savary and Harwood islands on March 15 and 24, respectively. Neither spawning area was surveyed by divers since surface surveys indicated that both were small and light (Table 1). The Harwood Island spawning was estimated from these reports to have been deposited by 300 tonnes and the Savary Island spawning by 841 tonnes, for an Area 15 total of 1141 tonnes (Table 2).

## Area 17

The major spawning centered at Yellow Point was surveyed by divers while three late spawnings were only surveyed from the surface. Herring spawned at Yellow Point from March 16 to 20, in Nanoose Bay on April 4 and 9, at Icarus Point on April 4 and 5, and at Sharpe Point on April 10. The Yellow Point spawning occurred on Vancouver Island from north of Boat Harbour (Fig. 17), past Yellow Point (Fig. 18) into Kulleet Bay (Fig. 19) and south to Coffin Point (Fig. 20). This spawning area was 17.5 km long, occupied 108.6 ha, and, at an egg density of 676,592 eggs per sq. m, was deposited by 7344 tonnes (Table 1 and 2). The three later spawnings ranged from 0.7 to 2.0 km in length, from 5.8 to 23.9 ha in area, and from 139,000 to 233,000 eggs per sq. m in egg density (Table 1 and 2). The Nanoose Bay spawn was estimated to have been deposited by 152 tonnes, the Icarus Point spawn by 332 tonnes, and the Sharpe Point spawn by 105 tonnes. The total egg deposition in Area 17 was estimated to have been produced by 7933 tonnes of spawners.

## Area 18

The earliest spawning in Georgia Strait occurred in Annette Inlet on Prevost Island on March 6. It was a very light spawning with egg density estimated at 18,222 eggs per sq. m. Because egg counts from samples were not available we used a model modified from that of Schweigert and Fournier (1982) to predict eggs per sq. m from quadrat observations on vegetation type, percent cover of vegetation, egg layers, and sample weight. Although the spawning area was 3.4 km long and occupied 25.3 ha, it was estimated to have been deposited by only 46 tonnes of fish (Table 2).

## MODEL PREDICTIONS

The predictive model referred to earlier underestimated egg density in 1986 for all six vegetation classes (Table 6). In general, the modes for all the variables examined are lower than the means, suggesting non-normal and generally skewed distributions. However, a comparison of means, modes, and 25 and 75 percent quartiles should give a good indication of the range of values for each variable. Stock assessment data indicate that the stock size in Area 14 in 1981 was similar to 1986. Levels for 1983 and 1985 should be lower than for these years. Area 17 assessments indicate that 1986 stock size is larger than for 1985.

The means estimated for egg layers and sample weight reflect this trend for most of the vegetation types. Only for filamentous red algae are the estimates of egg layers in Area 14 higher in 1985 than in 1986. It is clear that the estimates of egg layers for all the vegetation classes is very similar in 1986 to what it had been in 1981 and yet the sample weight and egg count was much greater in 1986 than what it had been in 1981. Observed and predicted egg numbers are most disparate in 1986 for all vegetation classes. Predictions for 1985 appear to be slightly high but we had experienced difficulties in separating eggs and vegetation and many of these eggs were broken in processing resulting in underestimates of egg numbers. Data from Area 17, where available, generally support the results from Area 14.

## SPAWN DISTRIBUTION

The distribution of spawn was determined for the two major Statistical Areas, 14 and 17. Spawn was wider (P < 1%, Student t-test) in Area 14 than Area 17 (Fig. 21). Average transect length was 132 m in Area 14 and the three spawns had similar transect lengths: 147 m at Denman Island, 115 m at Hornby Island, and 124 m at Qualicum. The Yellow Point average transect length was 35 m. Beach slope was the probable cause for this width difference since depths at which spawns were deposited was similar for Area 14 and 17 (Fig. 21). Beach slope in Area 17 was 0.1277, a rise of 12.8 m every 100 m, while beach slope in Area 14 was 0.0506. The average inner edge of spawn was similar in Area 14 and 17 at 1.0 and 0.9 m above chart datum, respectively, while the outer edge of spawn was 2.5 and 2.1 m below chart datum, respectively. Hence spawn was deposited over an approximate average depth range of 3.5 m. The maximum depth to which spawn was deposited was 6.5 m below chart datum.

The type of vegetation on which the eggs were deposited, the mean (Wilcoxon median) percent cover of the vegetation, the mean layers of eggs, the mean egg density, and the mean sample weight were determined by depth interval. Depth intervals chosen were intertidal (above 0 m Chart Datum), upper subtidal (between 0 and 3 m below chart datum), middle subtidal (between 3 m and 6 m below chart datum), and lower subtidal (deeper than 6 m below chart datum). In the intertidal interval, rockweed, other brown algae

(_Sargassum_ muticum) and filamentous red algae were the most common vegetation. Sea grasses, other brown algae, and foliose and filamentous red algae were the most common vegetation in the upper subtidal interval (Fig. 22). In the middle subtidal interval, spawn was mostly on filamentous red algae while there was no spawn in the lower subtidal interval. The vegetation differed significantly between depth intervals only at Denman Island and at Yellow Point (P < 1% for Denman Island and P < 5% for Yellow Point, Chi-square). The vegetation differed significantly between Area 14 and 17 in the upper two depth intervals (P < 1%, Chi-square) with the frequency of sea grasses and other brown algae greater than expected in Area 17 and the frequency of rockweed and filamentous red algae greater than expected in Area 14.

The percent cover of the vegetation decreased with depth for all spawns (Fig. 23), but only at Qualicum was the difference significant (P < 1%, Mann-Whitney test). Egg layers, egg density and sample weight decreased with depth for all spawns in Area 14, but not at Yellow Point (Fig. 23). The difference was significant for all three measures at Denman Island between the intertidal and middle subtidal interval and at Hornby Island between the intertidal and upper subtidal interval. Although egg layers were not significantly lower in the subtidal intervals than the intertidal interval at Qualicum, both egg density and sample weight were significantly lower in the upper subtidal interval than in the intertidal interval. This is probably due to the above noted lower percent cover of vegetation in the upper subtidal interval at Qualicum.

In Area 14, 37% of the spawn area was in the intertidal interval and 47% was in the upper subtidal interval (Fig. 24). In Area 17, 33% of the spawn area was in the intertidal interval and 60% of the spawn area in the upper subtidal interval. However, 52% of the eggs in Area 14 were deposited in the intertidal interval, because of the higher egg density there, while only 28% of the eggs were deposited in the intertidal interval in Area 17 because egg density was lower in the intertidal interval than in the upper subtidal interval (Fig. 24).

## DISCUSSION

An important objective of the diver spawn survey research conducted at the Pacific Biological Station over the past decade has been to develop a survey methodology to visually assess herring spawns to estimate stock abundance for management of the resource. For the methodology to be useful it must be possible to develop models that may be used to estimate egg densities from variables that can be readily assessed visually such as layers of eggs and percent cover of vegetation. We have found that although it is possible to do this, these estimates are more variable than those obtained from the weight of spawn samples collected from the quadrats (Schweigert et al. MS). The other important consideration is that these variables be readily standardized so that they can be collected in a routine and unbiased fashion

over time.  Although there is a learning period required, it appears that some of these variables may not be as readily assessed as one would have expected. In particular, it seems that the assessment of egg layers in Georgia Strait during the 1986 survey differed in some manner from what had been done in the past.  If one assumes that there is a consistent positive relationship between egg numbers and sample weight and egg layers, then, as the egg numbers and sample weight increase, so should the estimate of egg layers.  Clearly, this did not occur for the 1985 and 1986 data on sea grasses, other brown algae, and foliose and filamentous red algae.  The sample weights and egg counts increased dramatically relative to 1981 and 1983, while egg layers did not increase significantly enough to reflect these increases.  It appears that some further evaluation of the visual survey methodology is required in dealing with heavy spawns to more accurately reflect actual egg densities.  It also suggests that if the visual survey technique is to be used on an ongoing basis to assess spawns, a small number of samples should be collected for egg counts to ensure accurate calibration of the visual spawn density estimates.

The confidence intervals (95%) for egg densities from egg counts were between 28% (Yellow Point) and 53% (Hornby Island) of the mean for individual spawns (Table 2) and 31% for Area 14 (Table 3).  Sums of spawner biomass for individual spawns were nearly identical to biomass estimates using area means (Table 3).  Hence, despite the occasional high variance, spawner biomass estimates for individual spawns are probably quite reasonable.

The high variance in some of the estimates may be the result of insufficient sampling.  The sampling design for a minimum of 5 samples per transect was approached or exceeded for all spawnings, but the requirement for 4 transects per km was never achieved (Table 4), due mainly to time constraints.  However, the optimal samples per transect (after Schweigert et al. 1985) was exceeded for all spawnings except that at Yellow Point, where the 95% confidence interval was within 28% of the mean.  The optimal transects per km was exceeded for all but the Hornby Island spawning, where the 95% confidence interval was the broadest at 53% of the mean.  Hence, insufficient transects may have been the cause for the high variance.

The distribution of spawn by depth was similar to that documented in diving surveys in the Georgia Strait in 1985 (Schweigert and Haegele 1988). That is, percent cover of vegetation, layers of eggs, and egg density decline with depth.  Most spawn in Georgia Strait is deposited higher than 3 m below chart datum, but most spawn does not extend higher than 1 m above chart datum.  Since low tides never fell below 1 m above chart datum during the egg incubation period in 1986, very little of the spawn became exposed at low tide.  There were some between Area differences in spawn distribution, mostly dictated by beach slope and the attendant vegetation differences.  The beach slope was steeper in Area 17 than in Area 14 and consequently spawnings were narrower in Area 17.

For the two spawnings, Denman Island and Yellow Point, that occurred in the same location and that were of approximately the same length in 1985 and 1986, there were no significant (P < 5%, Student t-test) between year differences in observed beach slope, which is unlikely to change, or in the average inner or outer edge of spawnings.  However, spawn width (i.e. transect

length) was significantly narrower at Yellow Point in 1986 at 35 m, compared
to an average transect length of 67 m in 1985. This is probably the result of
a slightly steeper slope observed in 1986 (0.1277) than in 1985 (0.0958) due
to transect placement and a slightly greater depth range over which eggs were
deposited in 1985. In 1985 the average inner and outer edge of spawn was
1.1 m above and 2.9 m below chart datum, respectively, while in 1985 the range
was from 0.9 m above to 2.9 m below chart datum. The average transect length
at Denman Island did not differ significantly between 1985 and 1986. Egg
density in the intertidal interval was not significantly different between
1985 and 1986 at either Denman Island or Yellow Point (Schweigert and Haegele
1988). However, egg density was significantly higher (P < 1%, Mann-Whitney
test) in 1986 than 1985 at both of these locations in the upper subtidal
zone. The egg density at Denman Island was 752,870 eggs per sq. m in 1986 and
265,200 eggs per sq. m in 1985 in the upper subtidal interval. The egg layers
were similar in the two years, but percent cover of vegetation was
significantly higher in 1986, 62.5 vs. 47.5. The egg density at Yellow Point
was 778,004 eggs per sq. m in 1986 compared to 274,060 eggs per sq. m in 1985
in the upper subtidal zone. Here, the percent cover of the vegetation was
similar between the two years but egg layers were significantly higher in
1986, 2.65 layers vs 1.55 layers. One may argue that this is the result of
limits imposed by available vegetation surface area. In 1986, when stocks
were more abundant, more fish spawned in a given section of beach. At Denman
Island, where the available vegetation, as measured by percent cover, had
remained stable, this resulted in thicker egg deposition, in terms of egg
layers. At Yellow Point, where the vegetation was more abundant (higher
percent cover) in 1986, the same result was achieved without increased egg
thickness.

Herring spawning stocks in Georgia Strait nearly doubled in 1986
over stock sizes estimated in 1985 (Schweigert and Haegele 1988), indicating
good recruitment. The bulk of the increase was in Area 14, where stocks
increased from 23,082 tonnes to 51,092 tonnes (Table 5). Spawn length, area
of spawn, and egg density all increased in Area 14. Specifically, spawn at
Hornby Island increased considerably in both length, area, and egg density;
spawn at Denman Island increased in egg density, and spawn at Qualicum
increased in length and area. In Area 15, there was a 30% decline in spawn,
with no spawn observed along the mainland shore at Atrevida Reef in 1986. In
Area 17, stocks spawning at Yellow Point increased by about 32% and this
increase was due to increased egg density, since both length and area of spawn
declined. There was no spawn observed at Thetis Island in 1986, but there
were several second wave spawns observed that did not occur in 1985. These
amounted to 589 tonnes of spawners, which deposited their eggs in localities
that are traditional spawning grounds, Nanoose Bay and Icarus Point (Haegele
and Fitzpatrick 1983), but were not utilized in 1985. The Area 18 stocks
remained at a very low level and may be on the verge of entirely disappearing.

## ACKNOWLEDGMENTS

## REFERENCES

Haegele, C. W. 1978. Shoreline vegetation on herring spawning grounds between Deep Bay and Dorcas Point, Georgia Strait, B.C. Fish. Mar. Serv. MS Rep. 1485: 49 p.

Haegele, C. W. and L. C. Fitzpatrick. 1983. The distribution of herring spawn and associated roe fisheries in British Columbia (1956-1980). Can. Data Rep. Fish. Aquat. Sci. 407: 245 p.

Haegele, C. W. and M. J. Hamey. 1979. Shoreline vegetation on herring spawning grounds in Stuart Channel, Georgia Strait, B.C. Fish. Mar. Serv. MS Rep. 1534: 29 p.

_____ 1981. Shoreline vegetation on herring spawning grounds for Comox, Denman Island, and Hornby Island. Fish. Mar. Serv. MS Rep. 1617: 41 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.

Haist, V., M. Stocker, and J. F. Schweigert. 1986. Stock assessments for British Columbia herring in 1985 and forecasts of the potential catch in 1986. Can. MS Rep. Fish. Aquat. Sci. 1889: 48 p.

Hay, D. E. 1985. Reproductive biology of Pacific herring (_Clupea harengus pallasi_). Can. J. Fish. Aquat. Sci. 42: 111-126.

Schweigert, J. F. and D. Fournier. 1982. A model for predicting Pacific herring (_Clupea harengus_ pallasi) spawn density from diver observations. Can. J. Fish. Aquat. Sci. 39: 1361-1365.

Schweigert, J. F. and C. W. Haegele. 1988. Herring stock estimates from diving surveys of spawn for Georgia and Johnstone straits in 1985. Can. MS Rep. Fish. Aquat. Sci. (In press)

Schweigert, J. F., C. W. Haegele, and M. Stocker. MS. Synthesis and evaluation of SCUBA surveys to assess Pacific herring spawns. Submitted to Can. J. Fish. Aquat. Sci.

Schweigert, J. F., C. W. Haegele, and M. Stocker. 1985. Optimal sampling design for herring spawn surveys in the Georgia Strait, B.C. Can. J. Fish. Aquat. Sci. 42: 1806-1814.

Table 1. Spawn survey results, from data collected by divers and Fishery Officers, for Georgia Strait in 1986. [Adjusted area = length • width • (100 - % bare)].

| Location | Diving survey | | | | | Surface survey | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of transects | Length (m) | Av. transect length (m) | Area (ha) | Av. egg layers | No. of patches | Length (m) | Av. width (m) | Raw area (ha) | Adjusted area (ha) | Av. egg layers |
| **Area 14** | | | | | | | | | | | |
| Denman I. | 27 | 21500 | 147.35 | 375.891 | 1.75 | 12 | 21030 | 85.57 | 189.760 | 85.626 | 2.18 |
| Hornby I. | 19 | 21850 | 110.74 | 222.793 | 2.06 | 12 | 20050 | 37.82 | 66.025 | 41.469 | 3.16 |
| Qualicum | 14 | 15950 | 124.14 | 171.527 | 1.04 | No survey | | | | | |
| **Area 15** | | | | | | | | | | | |
| Harwood I. | No survey | | | | | 1 | 1800 | 20.00 | 3.600 | 2.160 | 1.00 |
| Savary I. | No survey | | | | | 1 | 800 | 800.00 | 64.000 | 44.800 | 2.00 |
| **Area 17** | | | | | | | | | | | |
| Nanoose B. | No survey | | | | | 2 | 700 | 20.56 | 1.350 | 0.915 | 1.49 |
| Icarus Pt. | No survey | | | | | 2 | 2000 | 40.00 | 8.000 | 5.100 | 0.60 |
| Yellow Pt. | 18 | 17500 | 34.50 | 108.554 | 2.90 | 18 | 16800 | 20.51 | 34.455 | 26.077 | 4.91 |
| Sharpe Pt. | No survey | | | | | 2 | 900 | 7.56 | 0.680 | 0.428 | 1.01 |
| **Area 18** | | | | | | | | | | | |
| Annette In. | 3 | 3400 | 74.33 | 25.300 | 0.28 | No survey | | | | | |

Table 2. Estimates of spawner biomass by individual spawn for Georgia Strait in 1986. (95% confidence intervals are given in brackets.)

| Location | Source (T = transect no.) | Area (ha) | Thousands of eggs per sq. m | Tonnes of Spawners |
|---|---|---|---|---|
| **Area 14** | | | | |
| Denman I. | T 1-7,10-22,31,33,35,37,39,41,44 | 375.891 | 643 (437 to 850) | 24185 (16429 to 31942) |
| Hornby I. | T 2-17,20,21,31,32 | 222.793 | 976 (462 to 1491) | 21749 (10288 to 33211) |
| Qualicum | T 3-8,10-12,18-21,23 | 171.527 | 301 (177 to 424) | 5158 (3045 to 7272) |
| **Area 15** | | | | |
| Harwood I. | Surface survey | 16.570(a) | 181(a) | 300 (-) |
| Savary I. | Surface survey | 29.371(a) | 286(a) | 841 (-) |
| **Area 17** | | | | |
| Nanoose B. | Surface survey | 6.511(a) | 233(a) | 152 (-) |
| Icarus Pt. | Surface survey | 23.876(a) | 139(a) | 332 (-) |
| Yellow Pt. | T 1-8,10,12-20 | 108.554 | 677 (489 to 864) | 7344 (5307 to 9383) |
| Sharpe Pt. | Surface survey | 5.752(a) | 182 | 105 (-) |
| **Area 18** | | | | |
| Annette In. | T 1-3 | 25.300 | 18(b) | 46 (-) |

(a) Area calculated from F.O. observed length and F.O observed width, adjusted using equation (1), and egg density estimated from F.O observed egg layers using equation (2).
(b) Egg density estimated using biomass model (after Schweigert and Fournier 1981).

Table 3.  Summary of spawn length and area, and estimates of spawner biomass using statistical area mean egg densities, for the Strait of Georgia in 1986.  These estimates are compared to estimates derived by summing results for individual spawns from Table 2.

| Statistical Area | Length (m) | Area (ha) | Thousands of eggs per sq. m (95% C.I.) | Tonnes (95% C.I.) | Tonnes (sum) |
|---|---|---|---|---|---|
| 14 | 59300 | 770.211 | 657 (452 to 862) | 50607 (34835 to 66378) | 51092 |
| 15 | 2600 | 45.941 | – | 1141(a) | 1141 |
| 17 | 21100 | 144.693 | 677 (489 to 864) | 9790 (7074 to 12506) | 7933 |
| 18 | 3400 | 25.300 | 18 (–) | 46 (–) | 46 |
| Total | 86400 | 986.145 | | 61584 | 60212 |

(a) From Table 2.

Table 4. 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 Georgia Strait.

| Location | Samples per transect | Spawn width (m) (area/length) | Achieved sampling fraction | Optimal sampling fraction | Achieved transects per km | Optimal transects per km |
|----------|---------------------|-------------------------------|---------------------------|---------------------------|---------------------------|--------------------------|
| Denman I. | 6.8 | 174.8 | 0.039 | 0.034 | 0.827 | 0.811 |
| Hornby I. | 5.6 | 102.0 | 0.055 | 0.029 | 1.150 | 1.477 |
| Qualicum | 7.4 | 107.5 | 0.068 | 0.046 | 1.139 | 0.957 |
| Yellow Pt. | 4.7 | 62.0 | 0.075 | 0.113 | 0.972 | 0.522 |
| Area 14 | 6.1 | 111.5 | 0.055 | 0.031 | 0.891 | 0.574 |

Table 5. Comparison of herring spawn and adult herring biomass estimates from diving surveys for the Strait of Georgia in 1985 and 1986.

| Location | Year | Length (m) | Av. tran. len. (m) | Area (ha) | Av. egg layers | Thousands of eggs per sq. m | Spawners (t) | Catch (t) | Adult biomass (t) |
|---|---|---|---|---|---|---|---|---|---|
| **Area 14** | | | | | | | | | |
| Denman I. | 1985 | 20100 | 178 | 338.4 | 0.5 | 403 | 13647 | – | – |
| | 1986 | 21500 | 147 | 375.9 | 1.8 | 643 | 24185 | – | – |
| Hornby I. | 1985 | 6900 | 57 | 34.3 | 0.2 | 69 | 238 | – | – |
| | 1986 | 21850 | 111 | 222.8 | 2.1 | 976 | 21749 | – | – |
| Qualicum | 1985(a) | 6100 | 159 | 96.9 | 1.8 | 272 | 2632 | – | – |
| | 1986 | 15950 | 124 | 171.5 | 1.0 | 301 | 5158 | – | – |
| Sum Area 14 | 1985 | 33100 | – | 469.6 | – | – | 16517 | 6565 | 23082 |
| | 1986 | 59300 | – | 770.2 | – | – | 51092 | 0 | 51092 |
| | | | | | | | | | |
| **Area 15** | | | | | | | | | |
| Harwood I. | 1985 | 3000 | 92 | 38.2 | 0.4 | 164 | 628 | – | – |
| | 1986(a) | 1800 | 92 | 16.6 | 1.0 | 181 | 300 | – | – |
| Savary I. | 1985 | 800 | 82 | 15.7 | 0.3 | 48 | 76 | – | – |
| | 1986(a) | 800 | 367 | 29.4 | 2.0 | 286 | 841 | – | – |
| Atrevida Rf. | 1985 | 7200 | 49 | 47.4 | 0.4 | 192 | 910 | – | – |
| | 1986 | 0 | 0 | 0.0 | 0.0 | 0 | 0 | – | – |
| Sum Area 15 | 1985 | 11000 | – | 101.3 | – | – | 1614 | 0 | 1614 |
| | 1986 | 2600 | – | 45.9 | – | – | 1141 | 0 | 1141 |
| | | | | | | | | | |
| **Area 17** | | | | | | | | | |
| Thetis I. | 1985 | 3200 | 48 | 11.4 | 0.6 | 113 | 128 | – | – |
| | 1986 | 0 | 0 | 0.0 | 0.0 | 0 | 0 | – | – |
| Yellow Pt. | 1985 | 21000 | 67 | 133.1 | 0.5 | 419 | 5579 | – | – |
| | 1986 | 17500 | 35 | 108.6 | 2.9 | 677 | 7344 | – | – |
| Other V.I. | 1985 | 0 | 0 | 0.0 | 0.0 | 0 | 0 | – | – |
| | 1986(a) | 3600 | 100 | 36.1 | 0.8 | 163 | 589 | – | – |
| Sum Area 17 | 1985 | 24200 | – | 144.5 | – | – | 5707 | 0 | 5707 |
| | 1986 | 21100 | – | 144.7 | – | – | 7933 | 0 | 7933 |

Table 5 (cont'd).

| Location | Year | Length (m) | Av. tran. len. (m) | Area (ha) | Av. egg layers | Thousands of eggs per sq. m | Spawners (t) | Catch (t) | Adult biomass (t) |
|---|---|---|---|---|---|---|---|---|---|
| Area 18 | | | | | | | | | |
| Selby Cove | 1985(a) | 550 | 130 | 7.2 | <0.0 | 34 | 25 | – | – |
| | 1986 | 0 | 0 | 0.0 | 0.0 | 0 | 0 | – | – |
| Annette In. | 1985(a) | 2050 | 199 | 40.7 | <0.0 | 34 | 140 | – | – |
| | 1986 | 3400 | 75 | 25.3 | 0.3 | 18 | 46 | – | – |
| Sum Area 18 | 1985 | 2600 | – | 47.9 | – | – | 165 | 0 | 165 |
| | 1986 | 3400 | – | 25.3 | – | – | 46 | 0 | 46 |
| Sum S of G | 1985 | 70900 | – | 763.3 | – | – | 24003 | 6565 | 30568 |
| | 1986 | 86400 | – | 986.1 | – | – | 60212 | 0 | 60212 |

(a) Based partially or entirely on F.O. surface data.

Table 6. Comparison of egg layers, sample weight, percent cover, observed and predicted egg density (in thousands of eggs per sq. m) for Strait of Georgia spawns from 1981-86.

| | | Egg layers | | | | Sample weight (g) | | | | % cover | | Obs. density | | | Pred. density | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Mode | Q1 | Q3 | Mean | Mode | Q1 | Q3 | Mean | Mode | Mean | Q1 | Q3 | Mean | Q1 | Q3 |
| **Sea Grasses** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 135 | 1.73 | 2.00 | 0.80 | 2.00 | 1558 | 57 | 615 | 2163 | 69 | 80 | 262 | 21 | 417 | 293 | 103 | 427 |
| Area 14-1983 | 206 | 1.11 | 0.10 | 0.20 | 2.00 | 977 | 262 | 299 | 1459 | 45 | 25 | 191 | 24 | 266 | 237 | 51 | 359 |
| Area 14-1985 | 30 | 0.90 | 0.10 | 0.18 | 1.50 | 1188 | 66 | 324 | 1850 | 42 | 20 | 270 | 18 | 406 | 204 | 38 | 340 |
| Area 14-1986 | 25 | 1.28 | 0.10 | 0.50 | 2.00 | 1599 | 1230 | 881 | 2199 | 71 | 90 | 434 | 127 | 716 | 284 | 137 | 398 |
| Area 17-1985 | 44 | 0.90 | 0.20 | 0.25 | 1.50 | 1384 | 192 | 475 | 2232 | 67 | 75 | 280 | 17 | 432 | 237 | 62 | 375 |
| Area 17-1986 | 13 | 0.94 | 1.50 | 0.45 | 1.50 | 1658 | 391 | 762 | 2229 | 73 | 90 | 468 | 187 | 381 | 277 | 124 | 390 |
| **Rockweed** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 7 | 0.83 | 0.10 | 0.10 | 1.50 | 713 | 8 | 16 | 1290 | 42 | 5 | 84 | 0 | 190 | 93 | 1 | 156 |
| Area 14-1983 | 18 | 0.59 | 0.10 | 0.10 | 1.00 | 771 | 54 | 109 | 772 | 26 | 5 | 20 | 0 | 29 | 94 | 9 | 91 |
| Area 14-1985 | 8 | 0.62 | 0.10 | 0.10 | 0.87 | 782 | 38 | 160 | 504 | 34 | 5 | 31 | 0 | 27 | 89 | 15 | 44 |
| Area 14-1986 | 23 | 0.94 | 0.30 | 0.30 | 1.50 | 2079 | 328 | 1170 | 2226 | 66 | 50 | 322 | 82 | 287 | 255 | 118 | 255 |
| Area 17-1985 | 16 | 0.86 | 1.00 | 0.75 | 1.00 | 435 | 83 | 153 | 615 | 86 | 100 | 90 | 3 | 158 | 435 | 153 | 615 |
| **Kelp** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 21 | 1.31 | 1.00 | 0.50 | 2.00 | 1329 | 214 | 662 | 1683 | 52 | 50 | 75 | 2 | 81 | 167 | 79 | 198 |
| Area 14-1983 | 31 | 0.34 | 0.10 | 0.10 | 0.50 | 880 | 78 | 389 | 984 | 27 | 30 | 56 | 6 | 42 | 103 | 33 | 121 |
| Area 14-1985 | 12 | 0.71 | 0.25 | 0.25 | 1.37 | 1757 | 110 | 595 | 3534 | 55 | 100 | 78 | 7 | 103 | 198 | 68 | 404 |
| Area 14-1986 | 5 | 1.36 | 1.00 | 0.40 | 2.50 | 2940 | 991 | 1264 | 5261 | 82 | 100 | 626 | 48 | 1470 | 383 | 140 | 737 |
| Area 17-1985 | 9 | 0.84 | 0.20 | 0.45 | 1.22 | 1445 | 292 | 653 | 2261 | 62 | 55 | 43 | 1 | 78 | 171 | 70 | 272 |
| **Other Brown Algae** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 40 | 3.31 | 4.00 | 2.00 | 4.75 | 1860 | 76 | 453 | 2896 | 61 | 60 | 390 | 27 | 657 | 325 | 87 | 490 |
| Area 14-1983 | 93 | 2.48 | 1.50 | 1.00 | 3.50 | 1708 | 357 | 345 | 2631 | 32 | 10 | 214 | 22 | 269 | 325 | 60 | 517 |
| Area 14-1985 | 41 | 2.19 | 0.10 | 0.35 | 3.50 | 3852 | 224 | 825 | 4197 | 46 | 30 | 650 | 23 | 516 | 658 | 98 | 674 |
| Area 14-1986 | 65 | 3.75 | 1.50 | 1.50 | 5.00 | 5045 | 164 | 1367 | 6928 | 51 | 90 | 1540 | 267 | 2357 | 902 | 187 | 1244 |
| Area 17-1985 | 47 | 4.63 | 8.00 | 3.00 | 7.00 | 5790 | 62 | 2094 | 8072 | 58 | 60 | 964 | 96 | 1173 | 1039 | 379 | 1420 |
| Area 17-1986 | 32 | 5.13 | 6.00 | 2.00 | 6.75 | 4011 | 60 | 1015 | 6818 | 61 | 100 | 968 | 73 | 1746 | 760 | 191 | 1325 |

Table 6 (cont'd).

| | N | Egg layers | | | | Sample weight (g) | | | | % cover | | Obs. density | | | Pred. density | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Mode | Q1 | Q3 | Mean | Mode | Q1 | Q3 | Mean | Mode | Mean | Q1 | Q3 | Mean | Q1 | Q3 |
| **Foliose Red Algae** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 55 | 1.24 | 1.00 | 0.50 | 2.00 | 1093 | 306 | 566 | 1502 | 55 | 80 | 138 | 17 | 186 | 150 | 75 | 198 |
| Area 14-1983 | 69 | 0.90 | 1.00 | 0.25 | 1.00 | 948 | 676 | 342 | 1267 | 36 | 25 | 151 | 15 | 241 | 174 | 43 | 221 |
| Area 14-1985 | 32 | 0.94 | 1.00 | 0.25 | 1.00 | 1486 | 16 | 530 | 1626 | 41 | 40 | 194 | 19 | 140 | 205 | 57 | 199 |
| Area 14-1986 | 25 | 1.32 | 0.50 | 0.40 | 2.25 | 1690 | 372 | 640 | 2615 | 58 | 50 | 308 | 77 | 541 | 223 | 85 | 338 |
| Area 17-1985 | 20 | 0.36 | 0.10 | 0.10 | 0.47 | 1076 | 110 | 436 | 1785 | 75 | 100 | 123 | 13 | 202 | 117 | 41 | 198 |
| Area 17-1986 | 3 | 1.02 | 0.25 | 0.25 | 2.00 | 1363 | 362 | 362 | 2092 | 83 | 65 | 356 | 12 | 563 | 185 | 39 | 266 |
| **Filamentous Red Algae** | | | | | | | | | | | | | | | | | |
| Area 14-1981 | 54 | 1.84 | 0.10 | 0.45 | 3.25 | 1585 | 117 | 172 | 1836 | 47 | 30 | 324 | 4 | 259 | 277 | 25 | 305 |
| Area 14-1983 | 117 | 1.17 | 0.10 | 0.20 | 2.00 | 745 | 9 | 155 | 1076 | 30 | 10 | 96 | 5 | 131 | 138 | 24 | 200 |
| Area 14-1985 | 62 | 2.10 | 0.10 | 0.50 | 3.12 | 2943 | 10 | 731 | 4944 | 57 | 100 | 569 | 35 | 986 | 494 | 90 | 855 |
| Area 14-1986 | 139 | 1.94 | 1.00 | 0.80 | 2.30 | 2445 | 812 | 850 | 3302 | 62 | 100 | 668 | 109 | 951 | 404 | 129 | 531 |
| Area 17-1985 | 22 | 1.94 | 0.50 | 0.50 | 2.62 | 2140 | 76 | 937 | 2904 | 63 | 100 | 238 | 13 | 365 | 353 | 141 | 484 |
| Area 17-1986 | 10 | 4.63 | 1.00 | 1.00 | 7.00 | 2152 | 306 | 627 | 2715 | 57 | 50 | 556 | 138 | 753 | 422 | 87 | 558 |
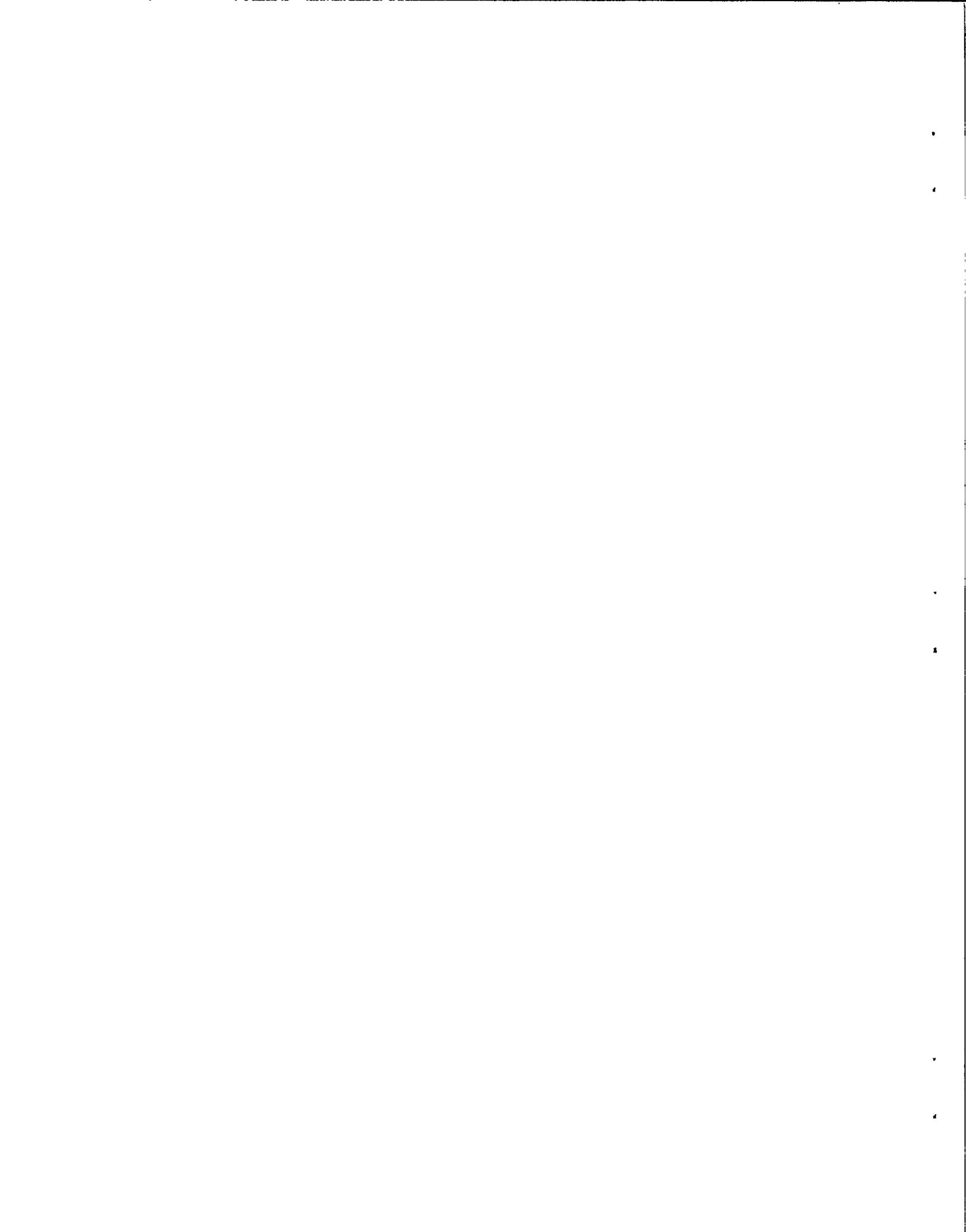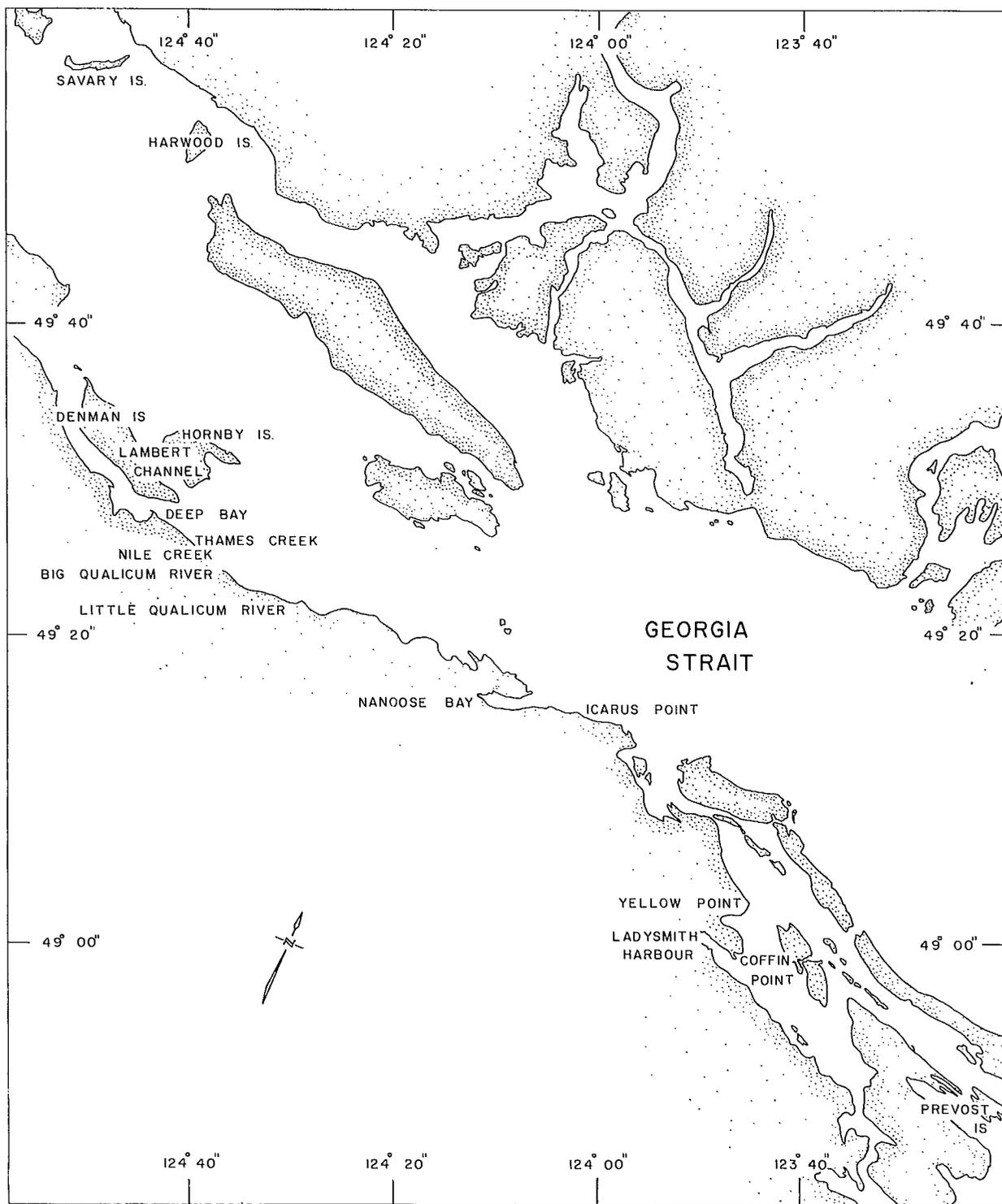
Fig. 1. Strait of Georgia herring spawn study area with major spawning locations identified.

LONGBEAK POINT

20

18

17

16

N

METRES

0        500
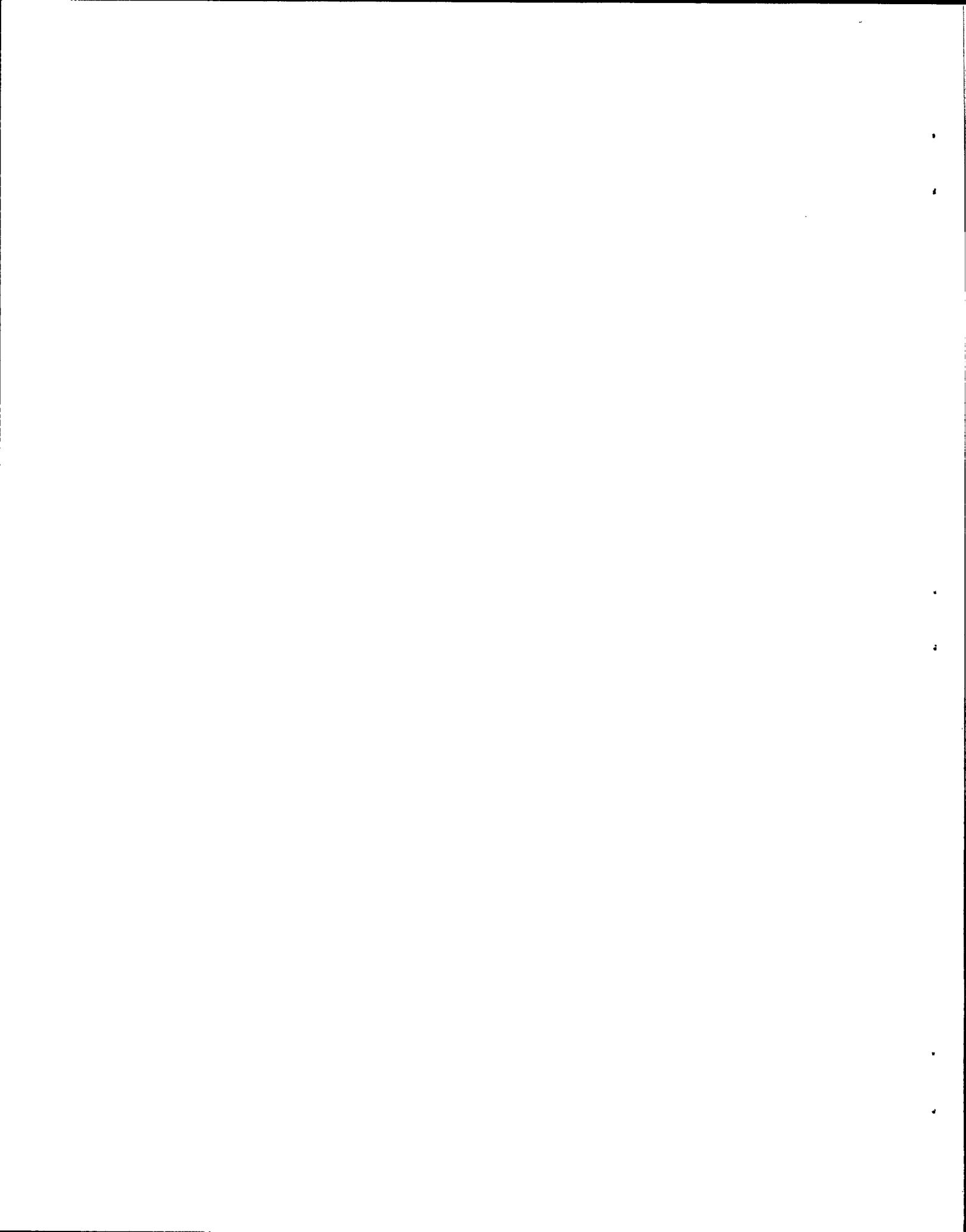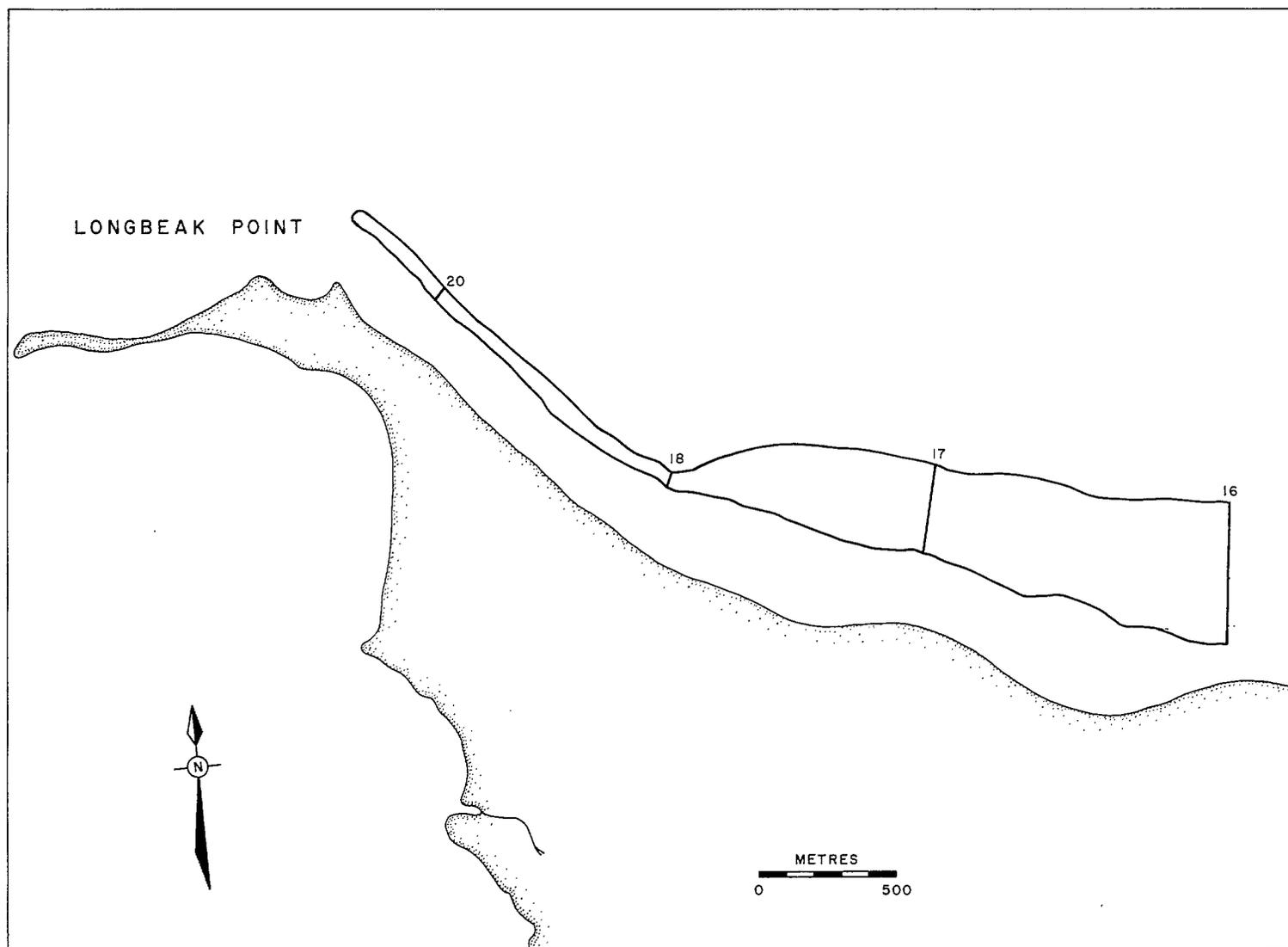
Fig. 2. Herring spawn at Longbeak Point on Denman Island, surveyed by divers in 1986, with transect locations shown.

KOMAS BLUFF

METRES

0          500
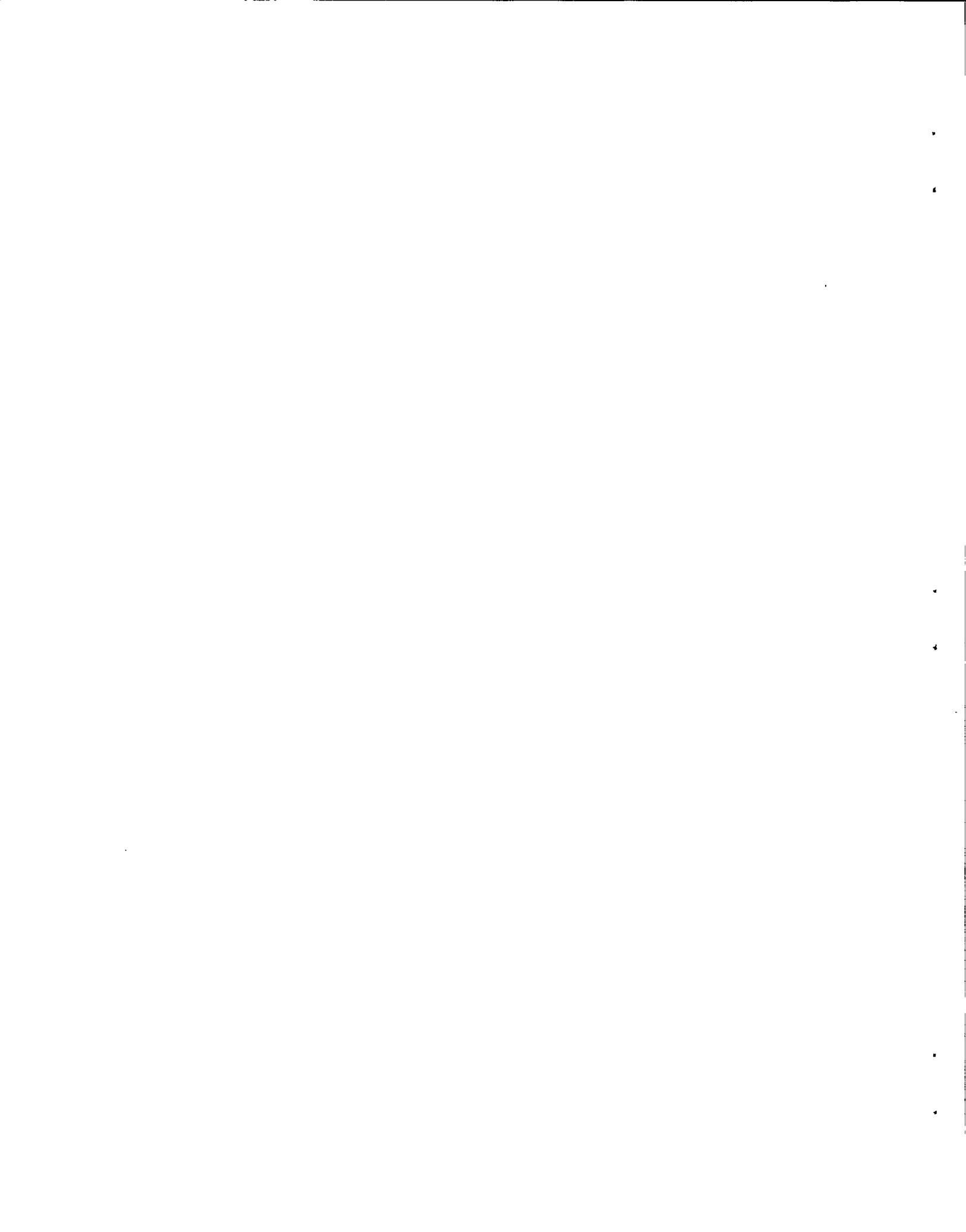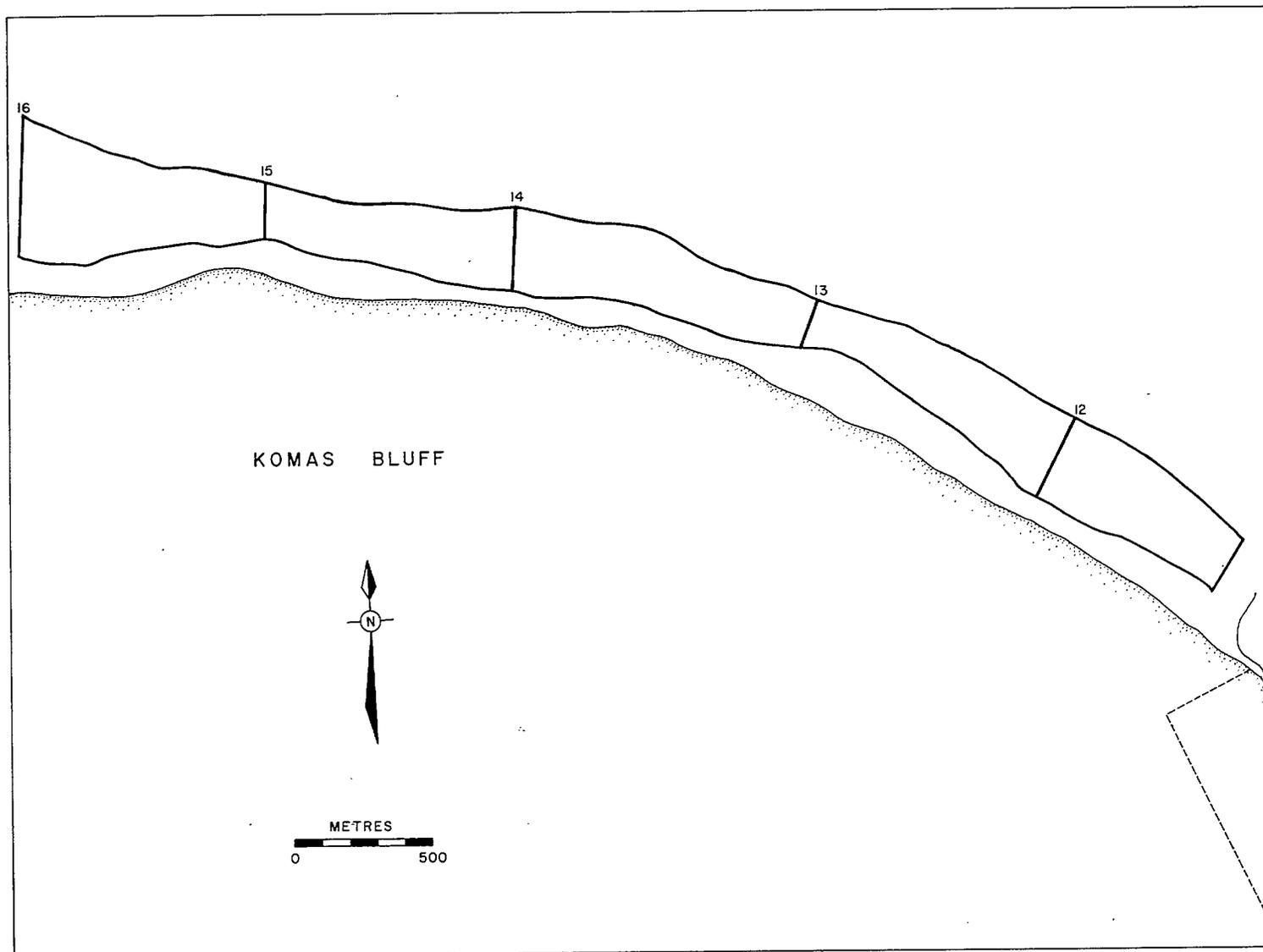
Fig. 3.  Herring spawn at Komas Bluff on Denman Island, surveyed by divers
in 1986, with transect locations shown.
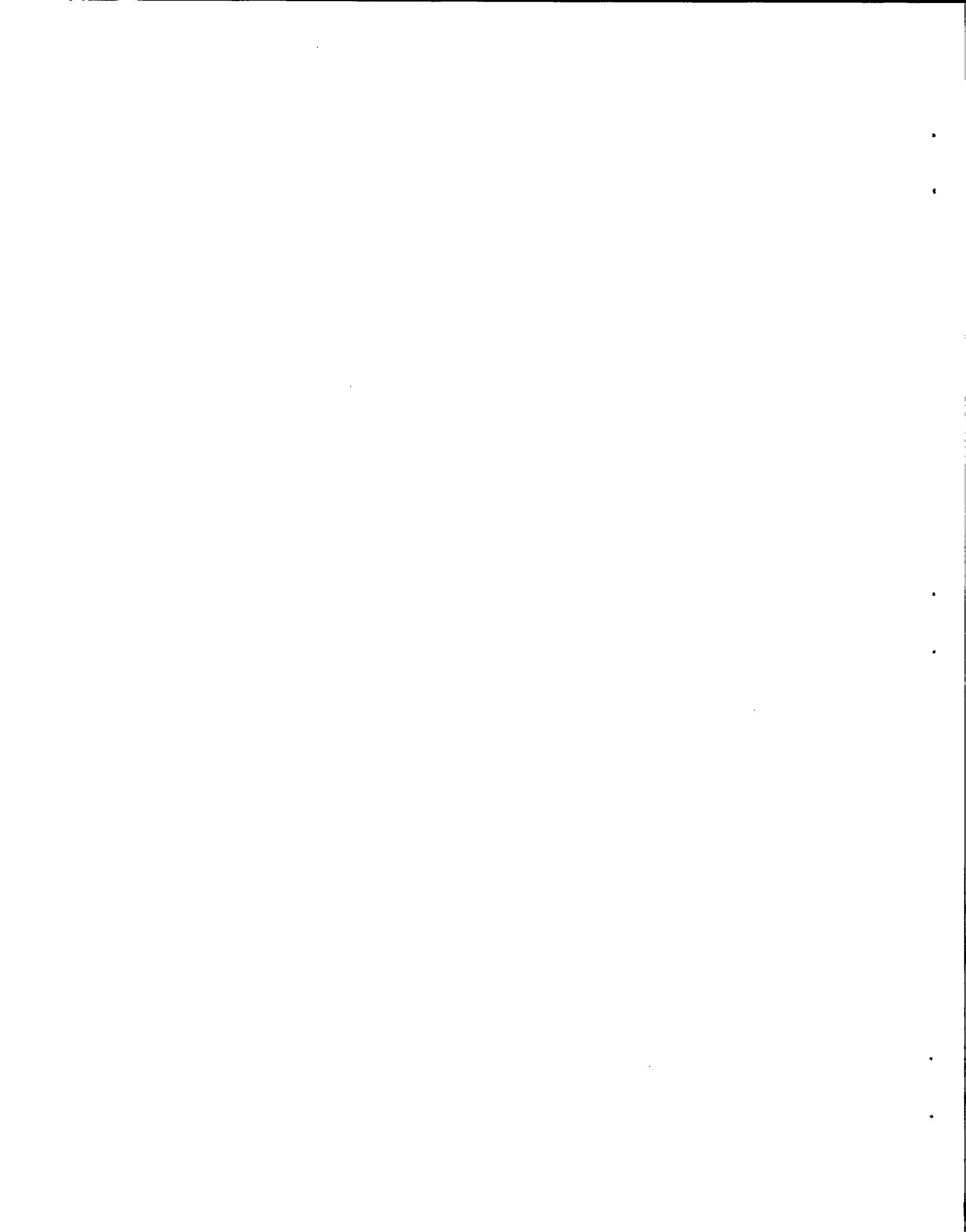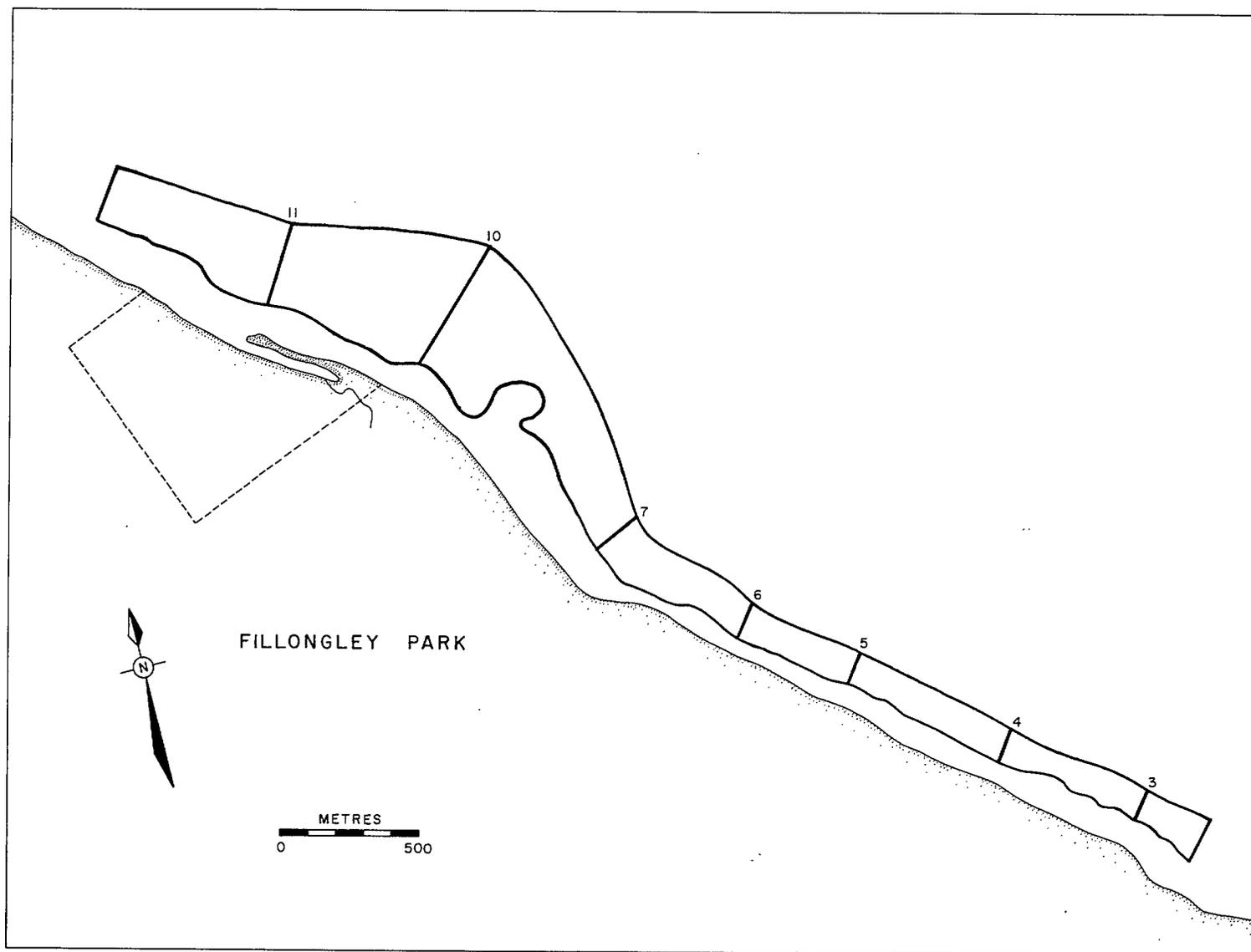
Fig. 4. Herring spawn at Fillongley Park on Denman Island, surveyed by divers in 1986, with transect locations shown.
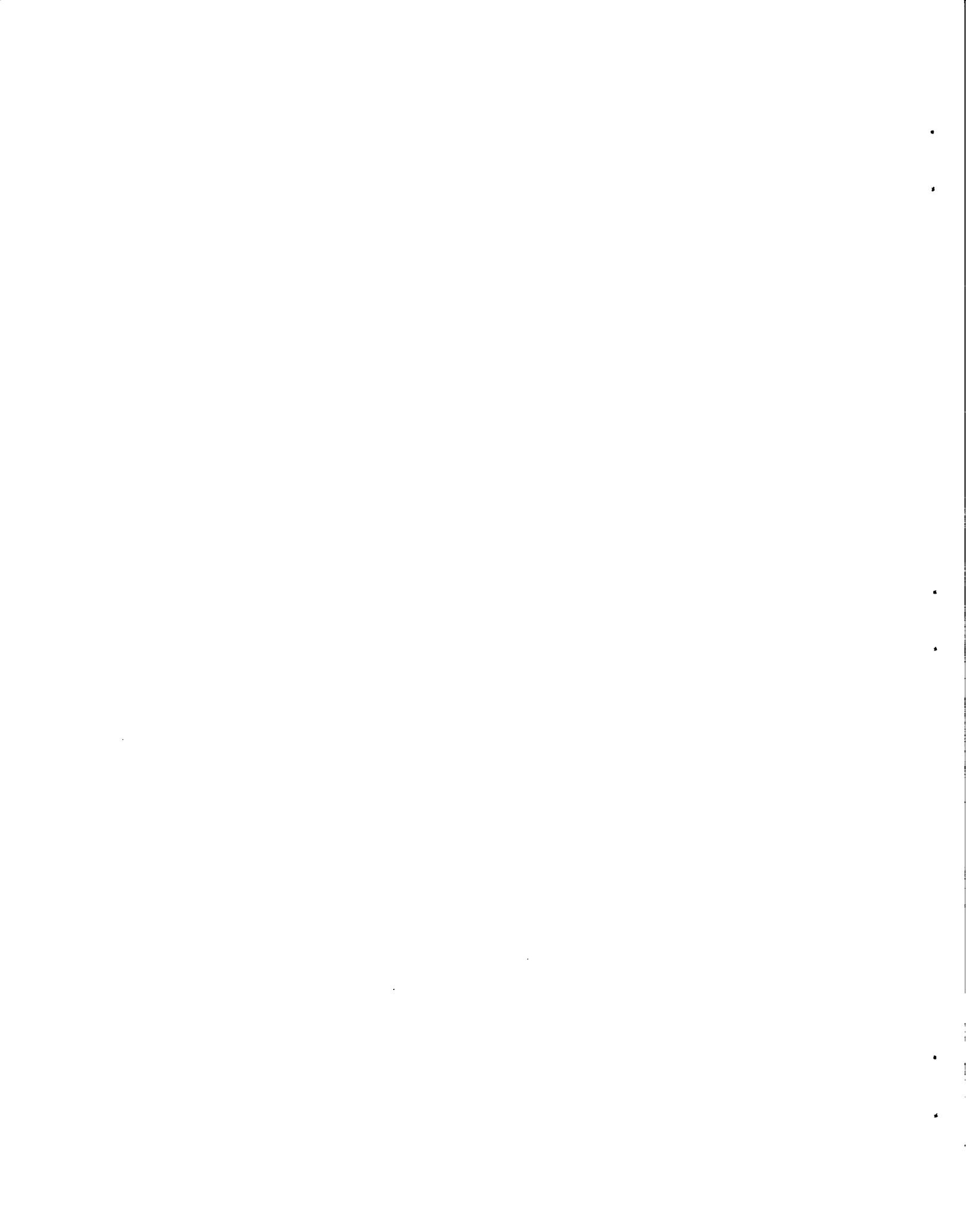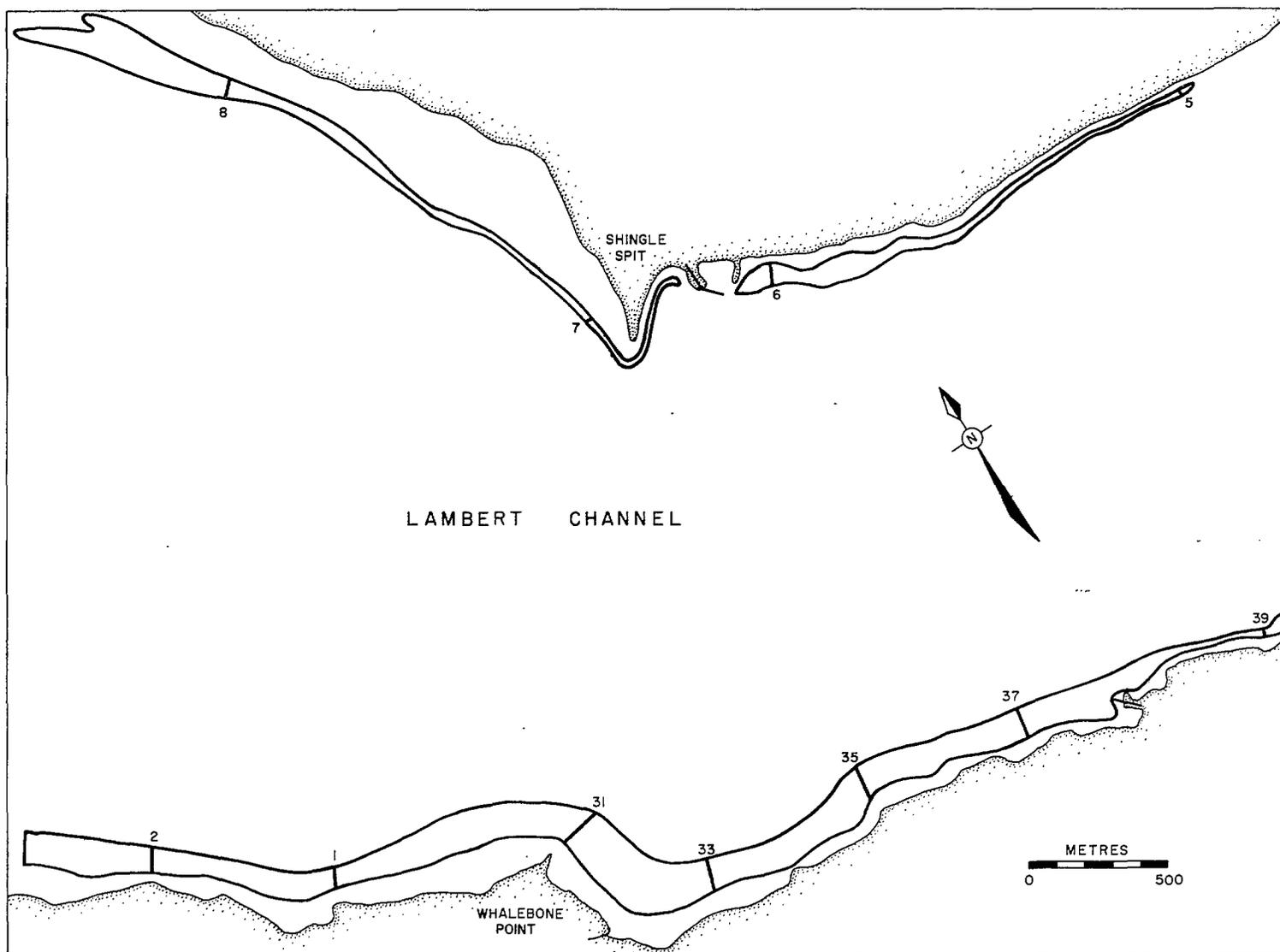
Fig. 5. Herring spawn in Lambert Channel including the spawn on both Denman and Hornby islands, surveyed by divers in 1986, with transect locations shown.
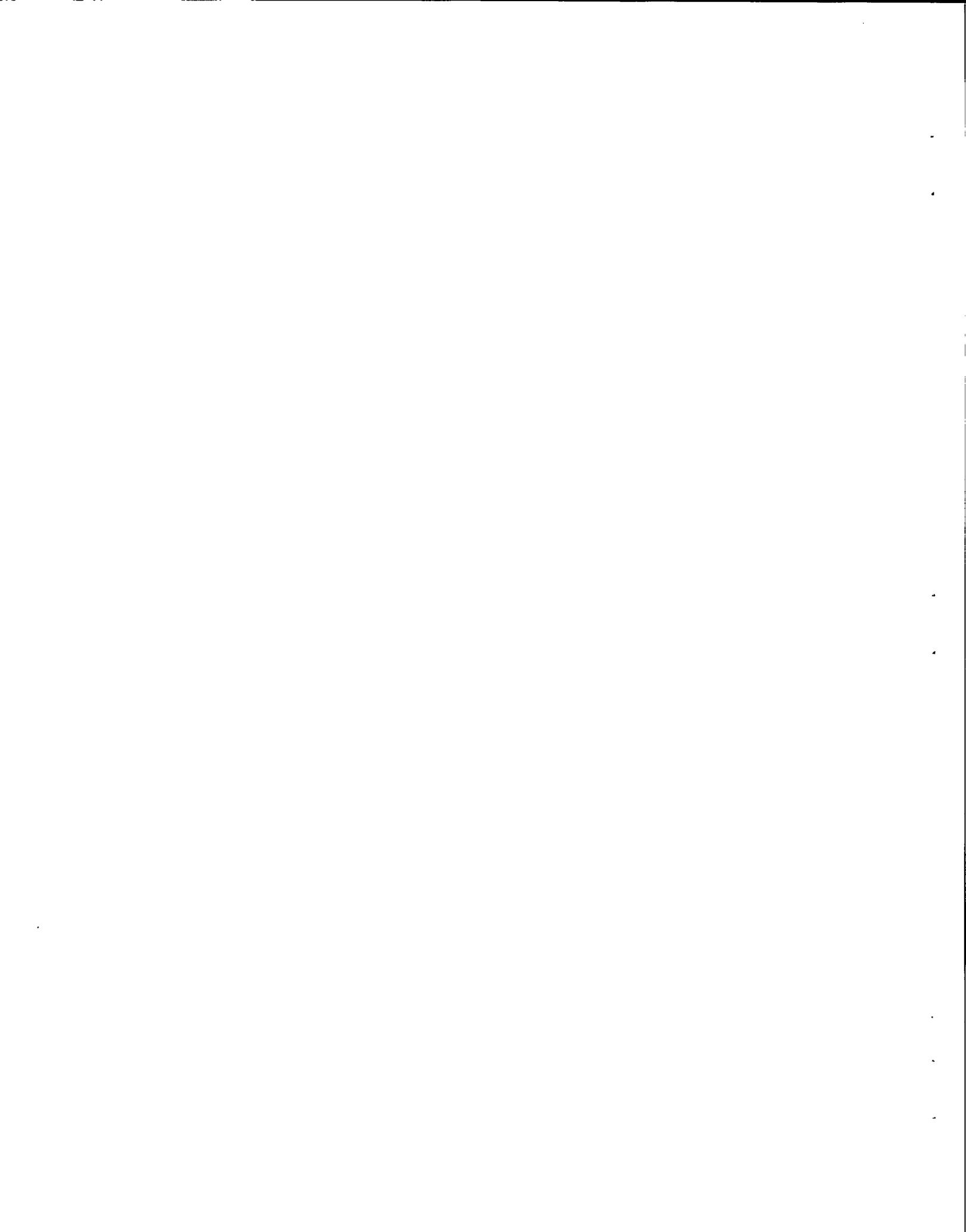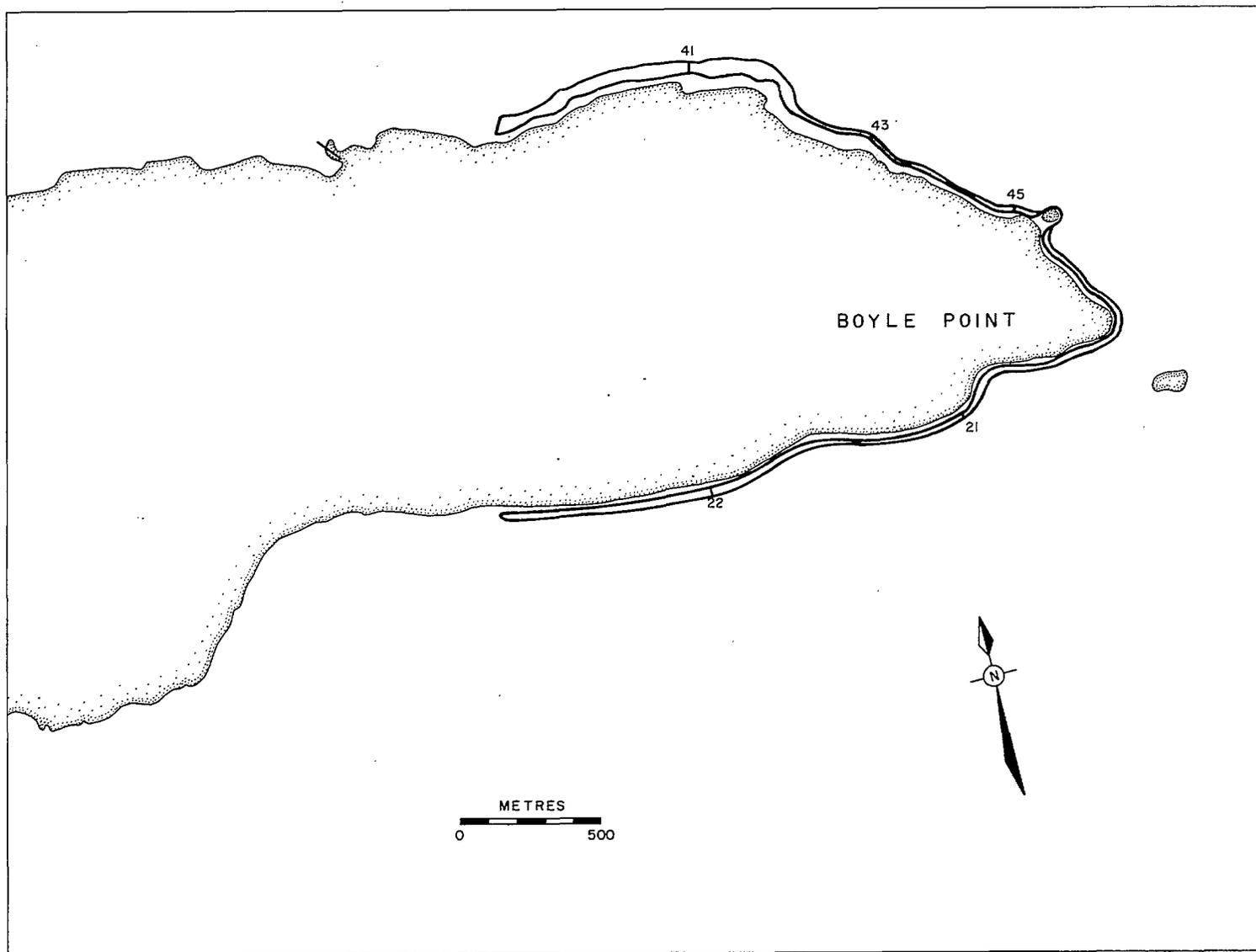
Fig. 6. Herring spawn at Boyle Point on Denman Island, surveyed by divers in 1986, with transect locations shown.
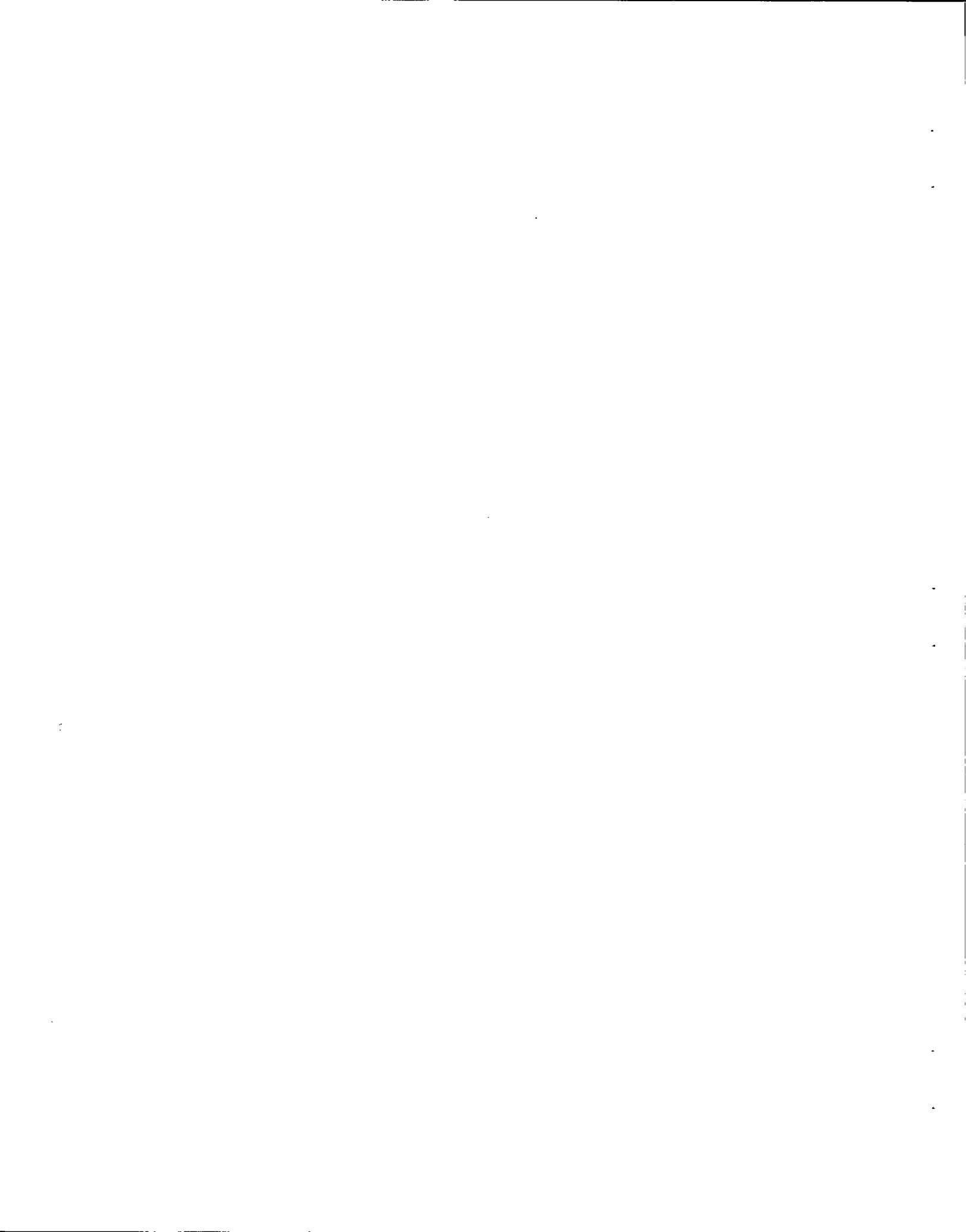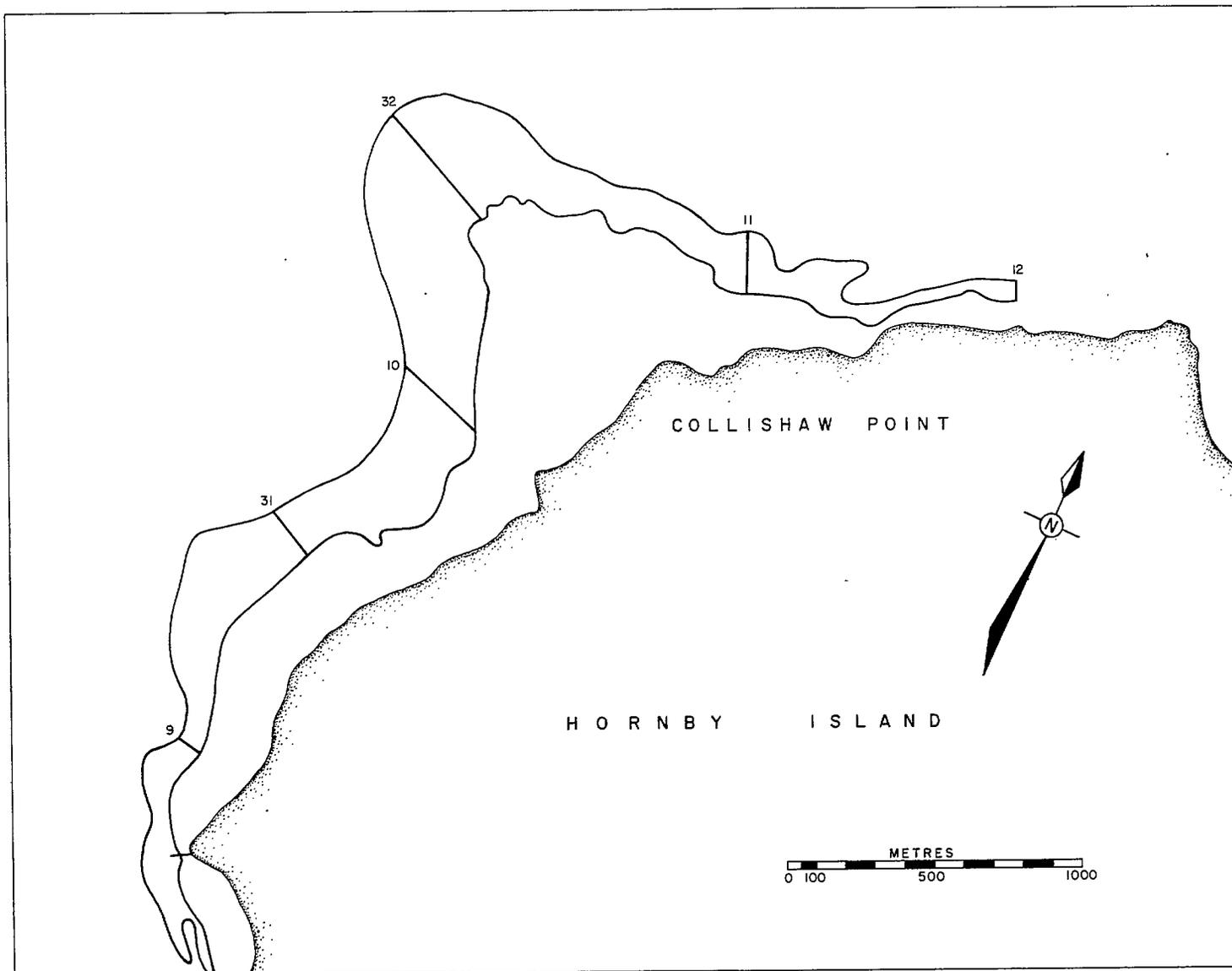
Fig. 7.  Herring spawn at Collishaw Point on Hornby Island, surveyed by divers in 1986, with transect locations shown.
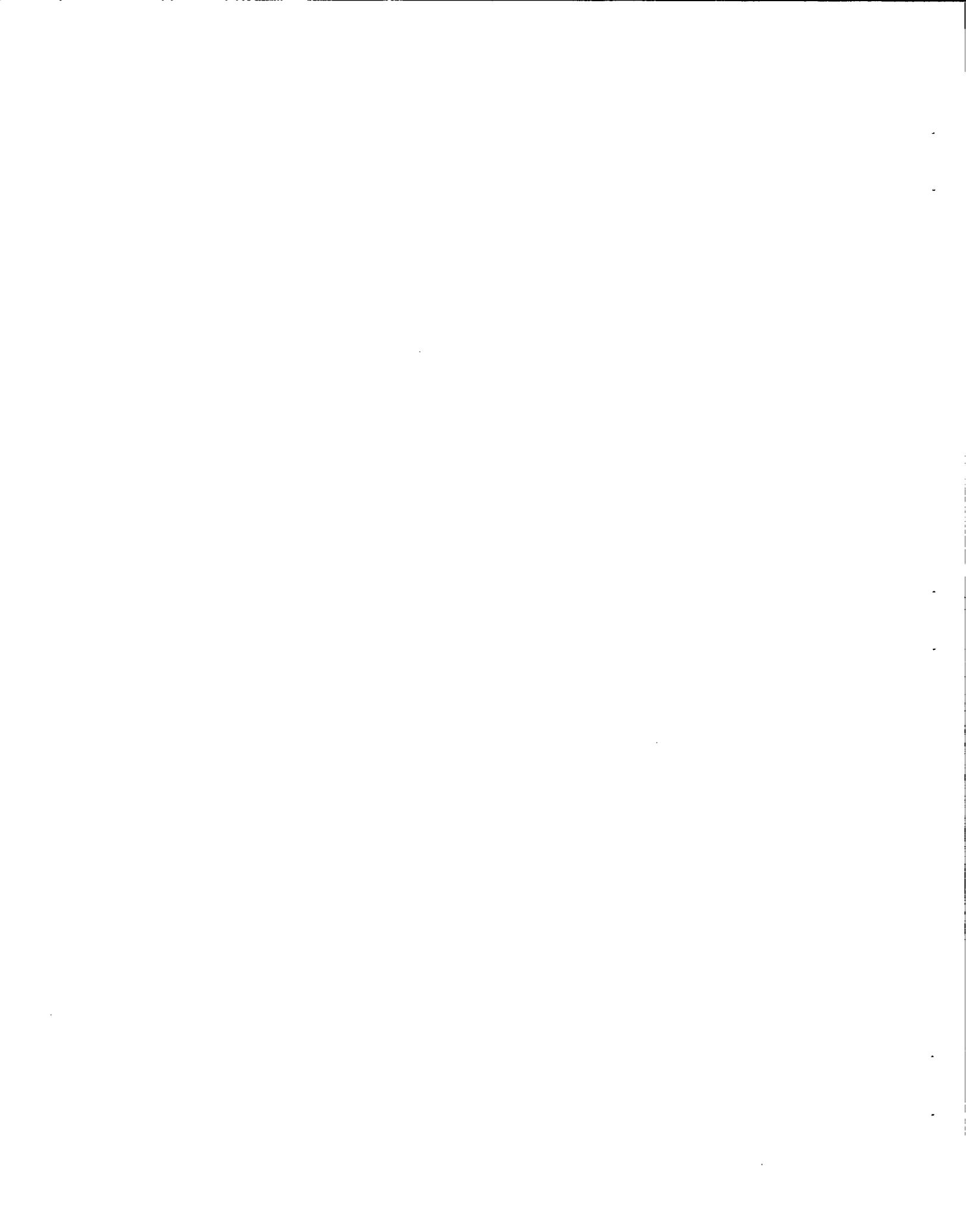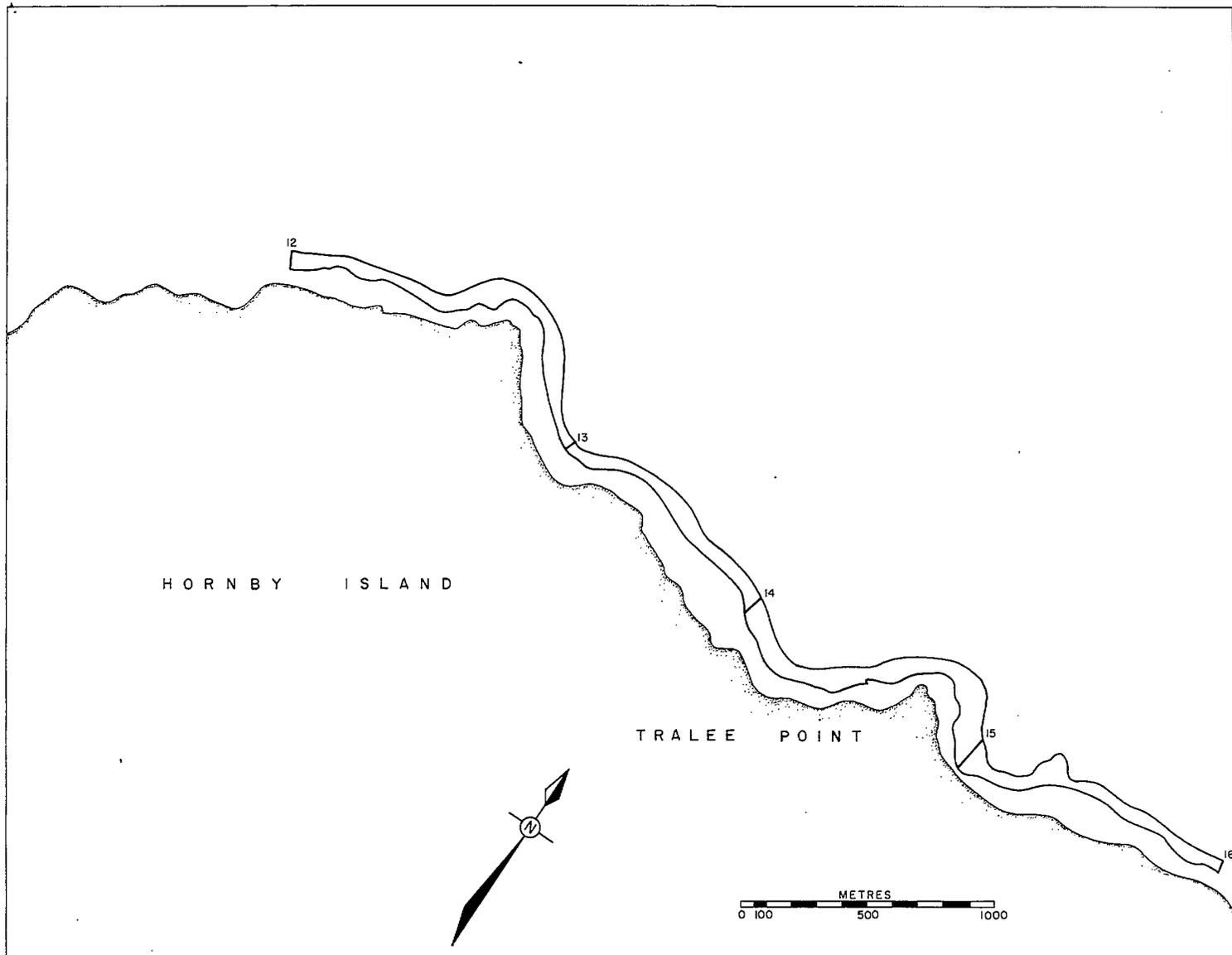
Fig. 8. Herring spawn at Tralee Point on Hornby Island, surveyed by divers in 1986, with transect locations shown.
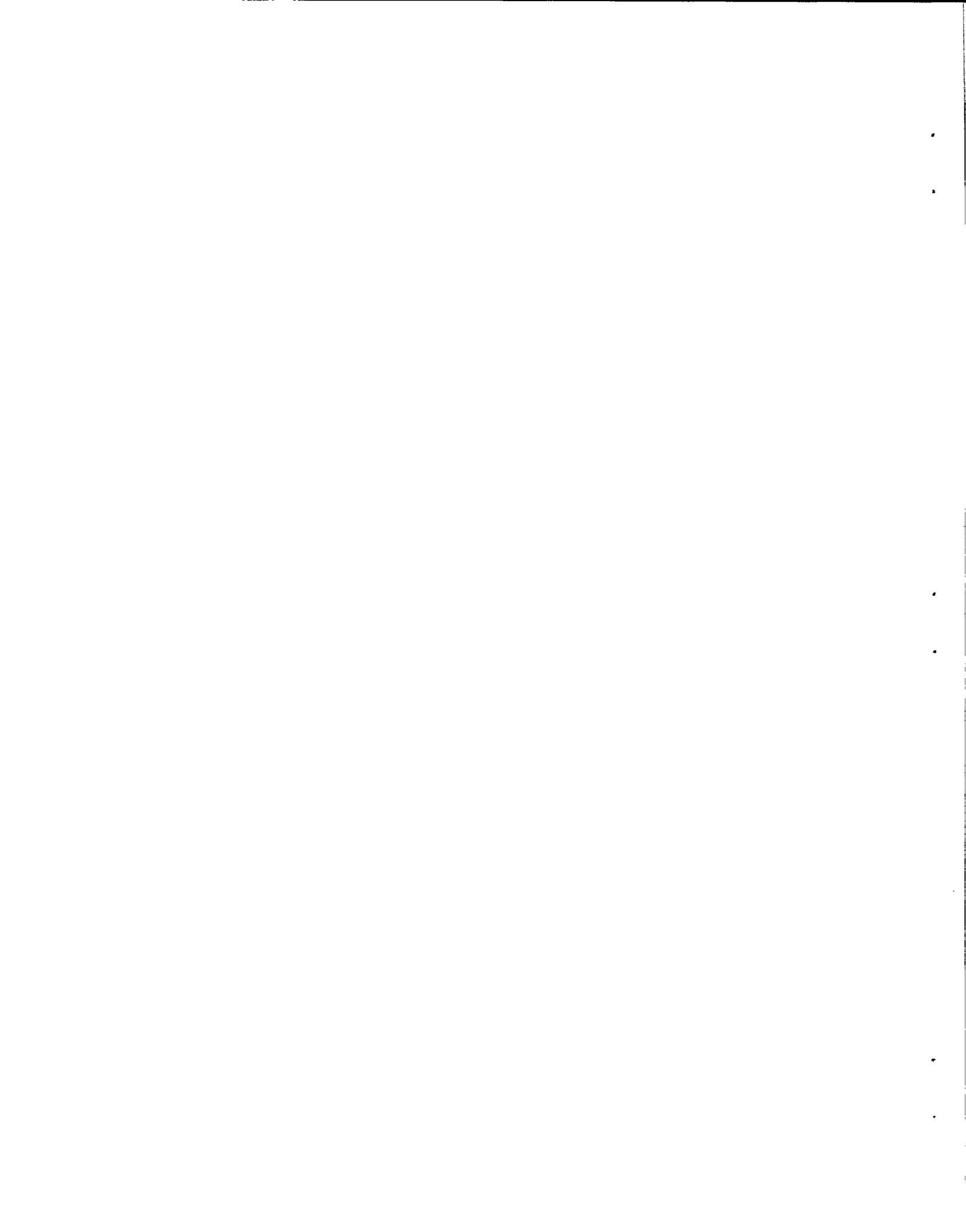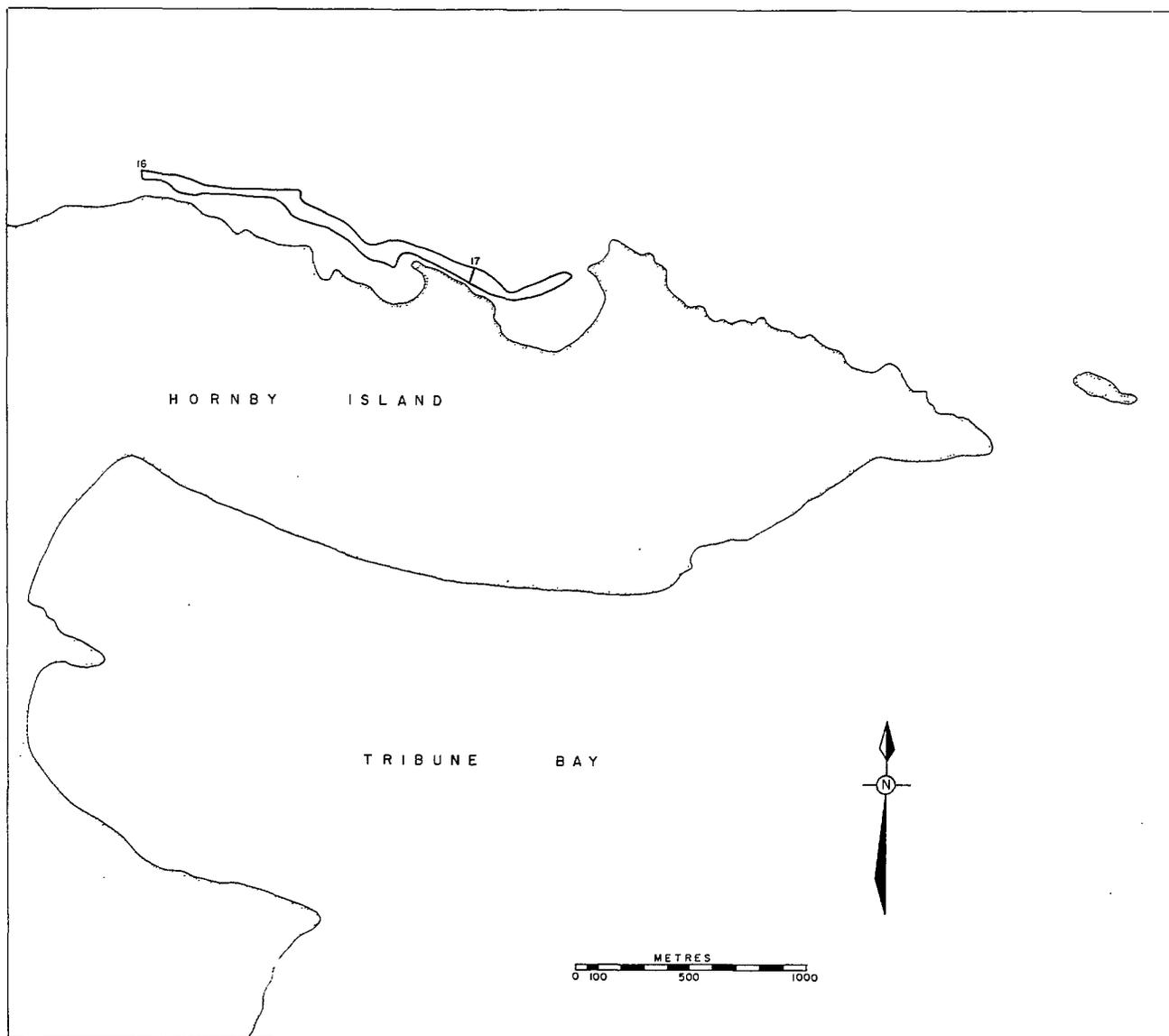
Fig. 9. Herring spawn at Whaling Station Bay on Hornby Island, surveyed by divers in 1986, with transect locations shown.
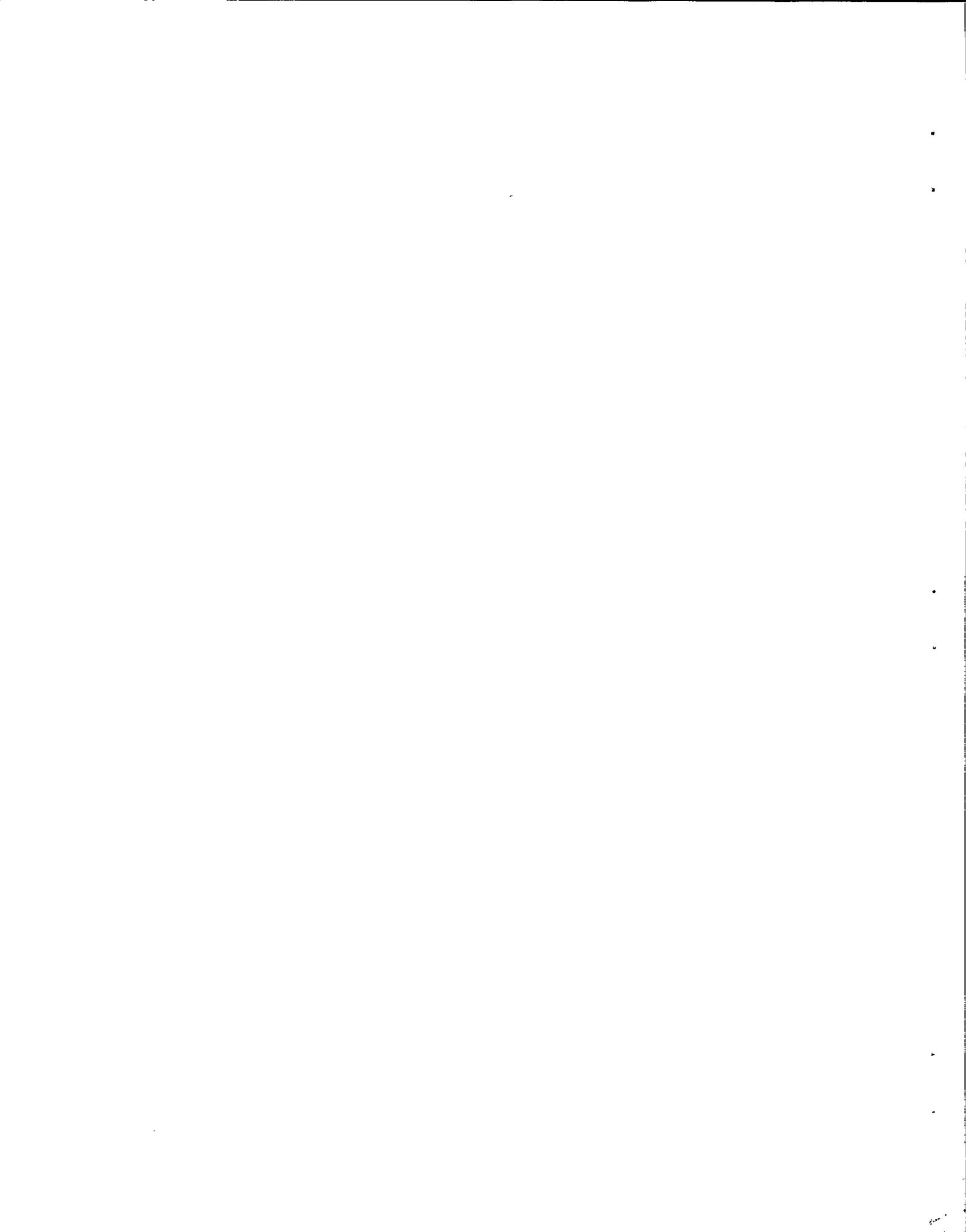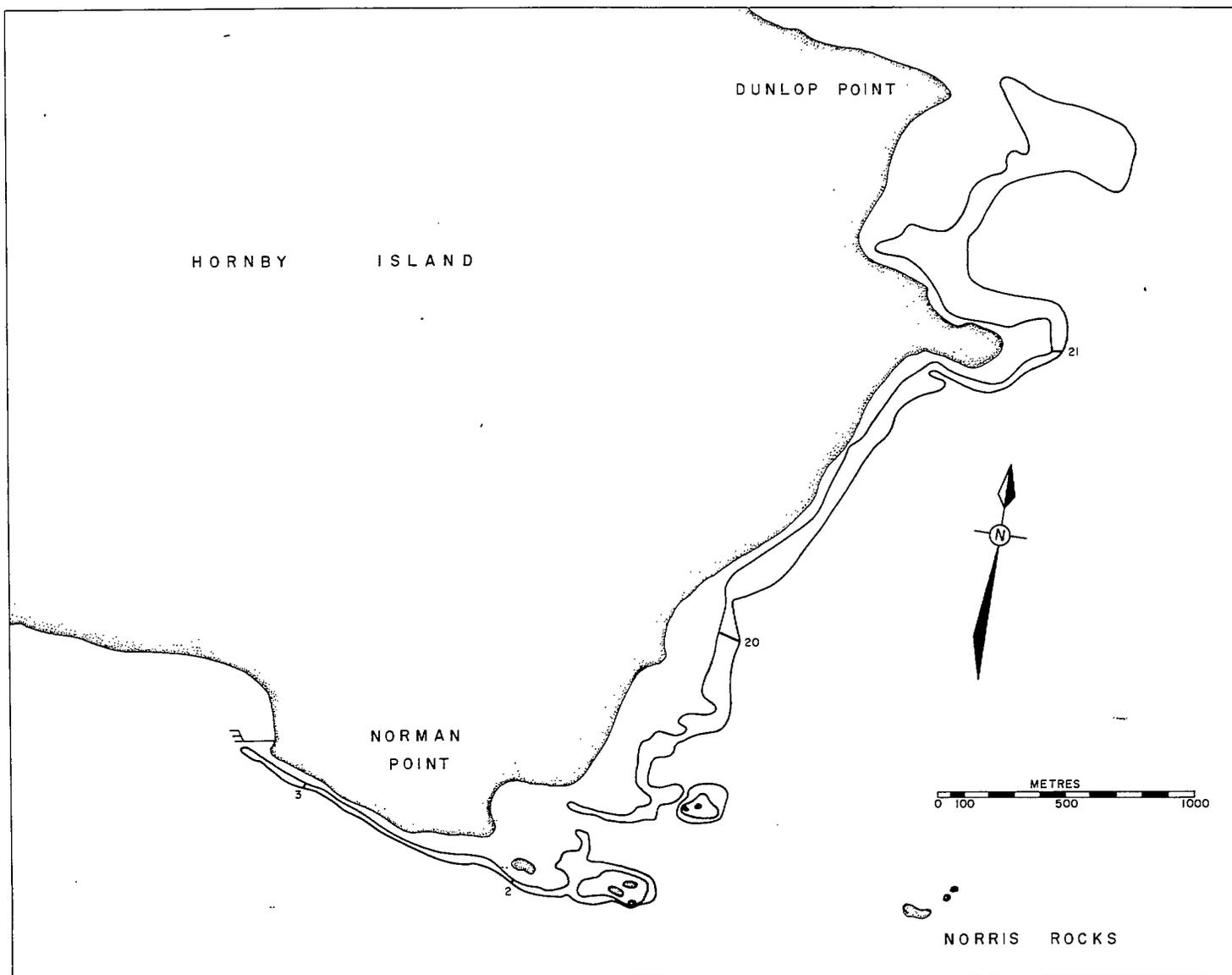
Fig. 10. Herring spawn from Norman Point to Dunlop Point on Hornby Island, surveyed by divers in 1986, with transect locations shown.
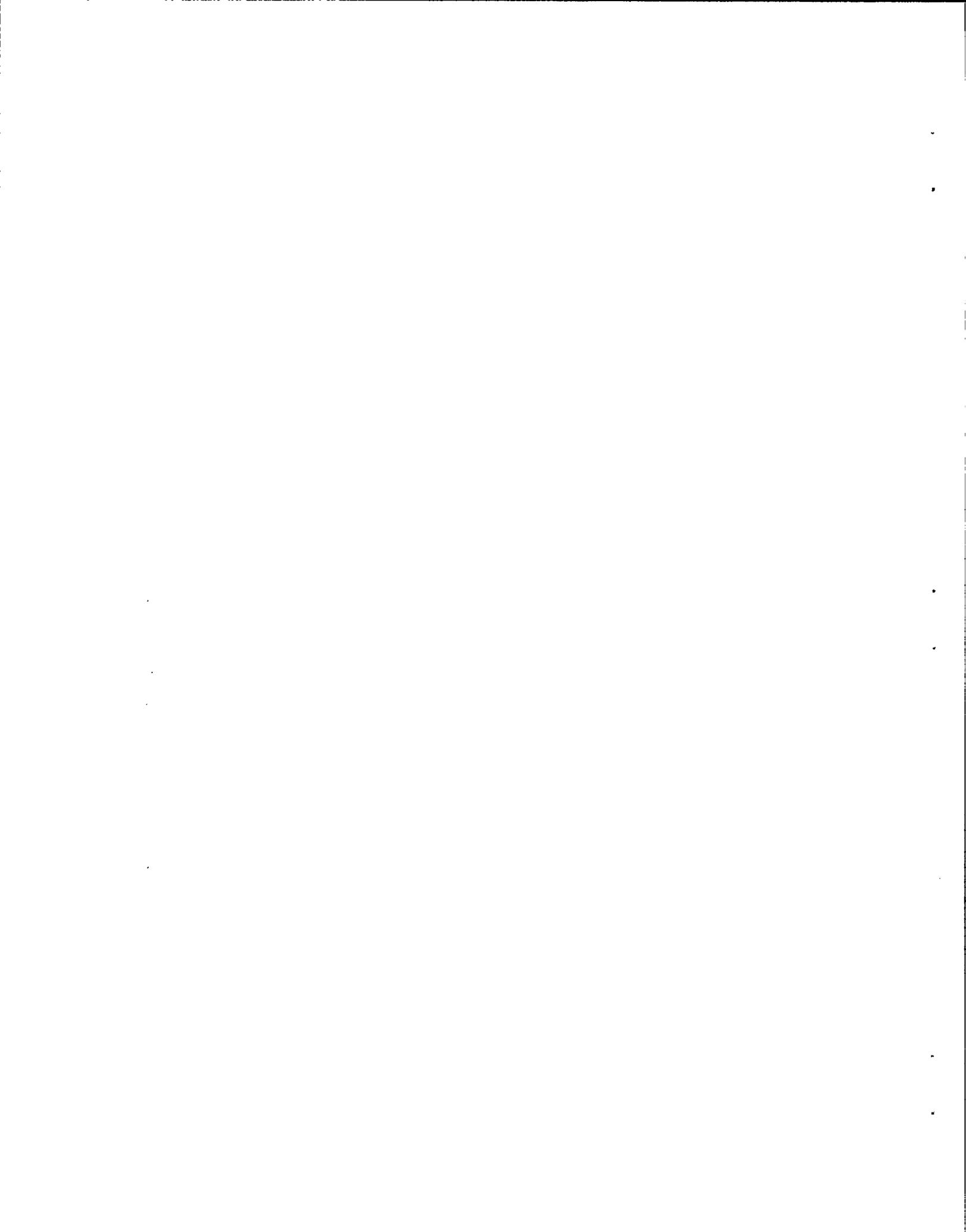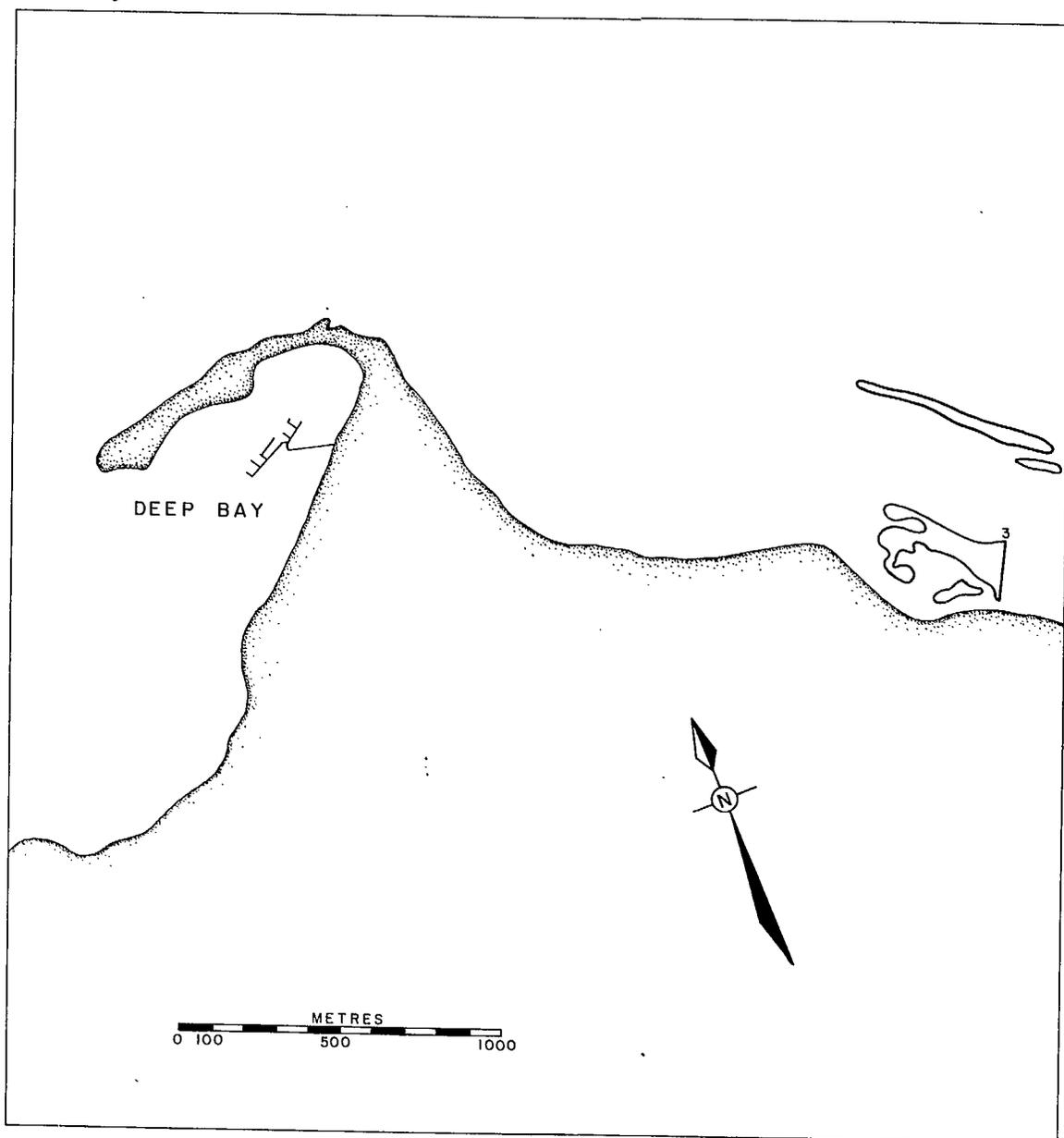
Fig. 11. Herring spawn at Deep Bay on Vancouver Island, surveyed by divers in 1986, with transect locations shown.
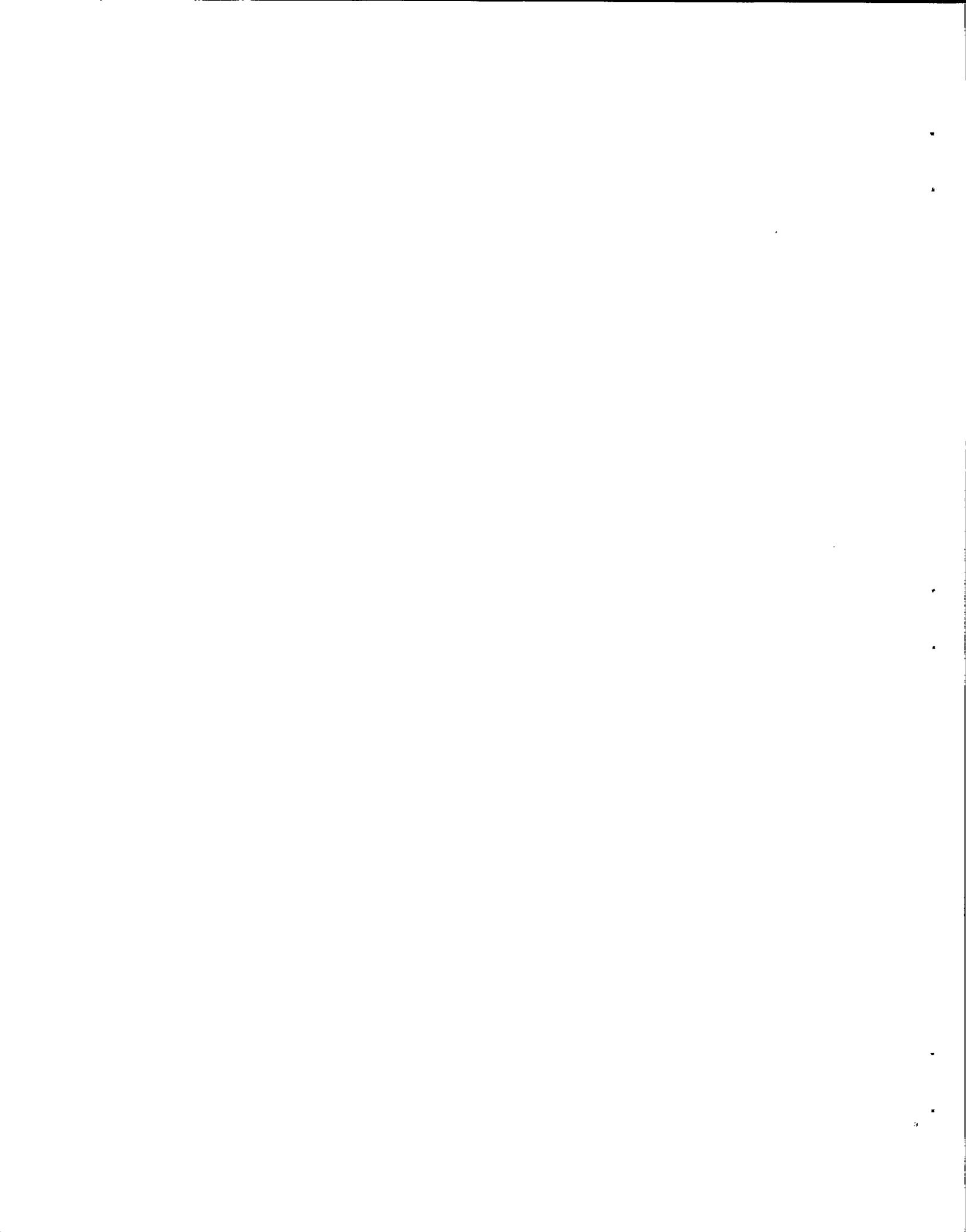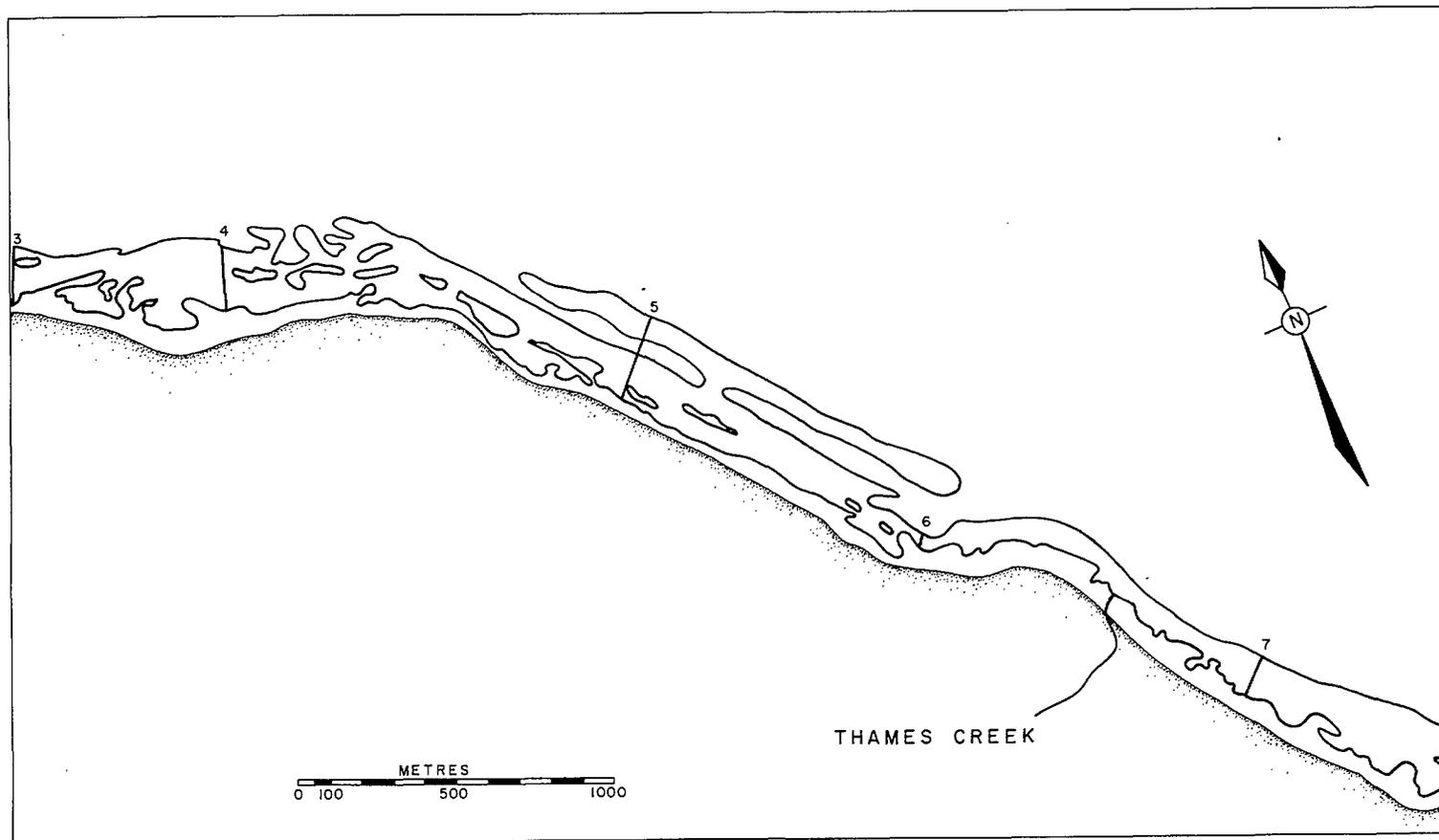
Fig. 12. Herring spawn at Thomas Creek near Bowser, surveyed by divers in 1986, with transect locations shown.
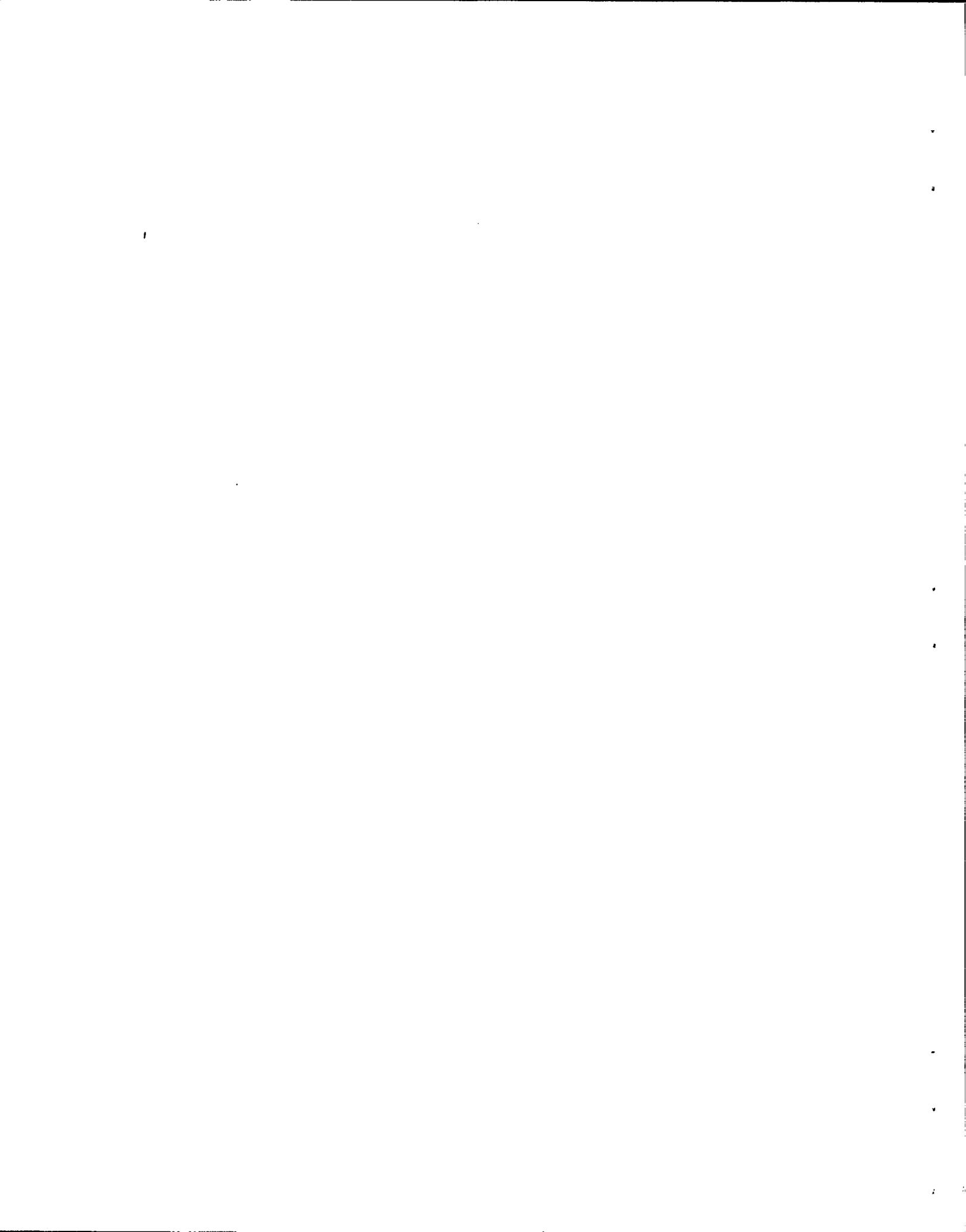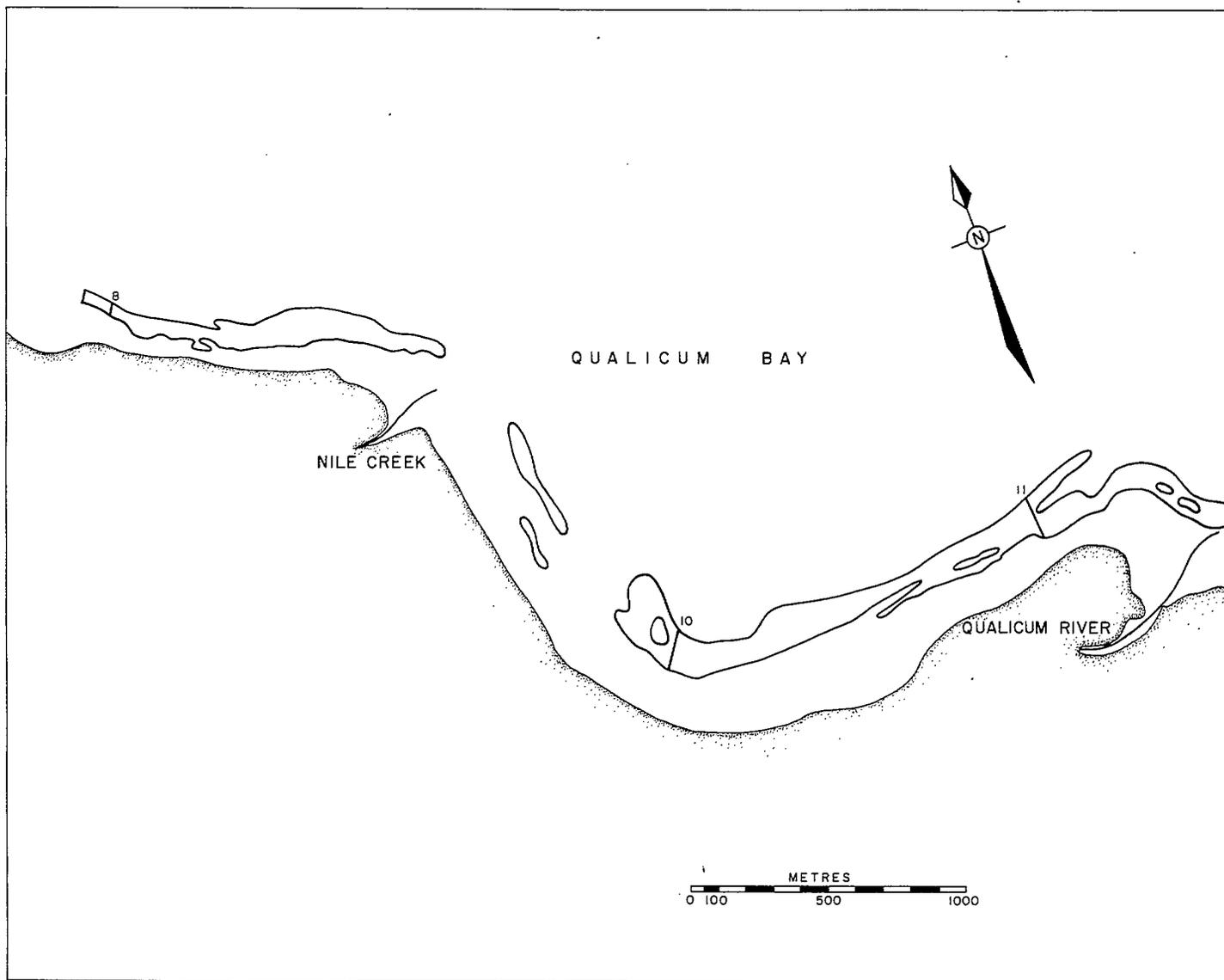
Fig. 13. Herring spawn from Nile Creek to Qualicum River, surveyed by divers in 1986, with transect locations shown.
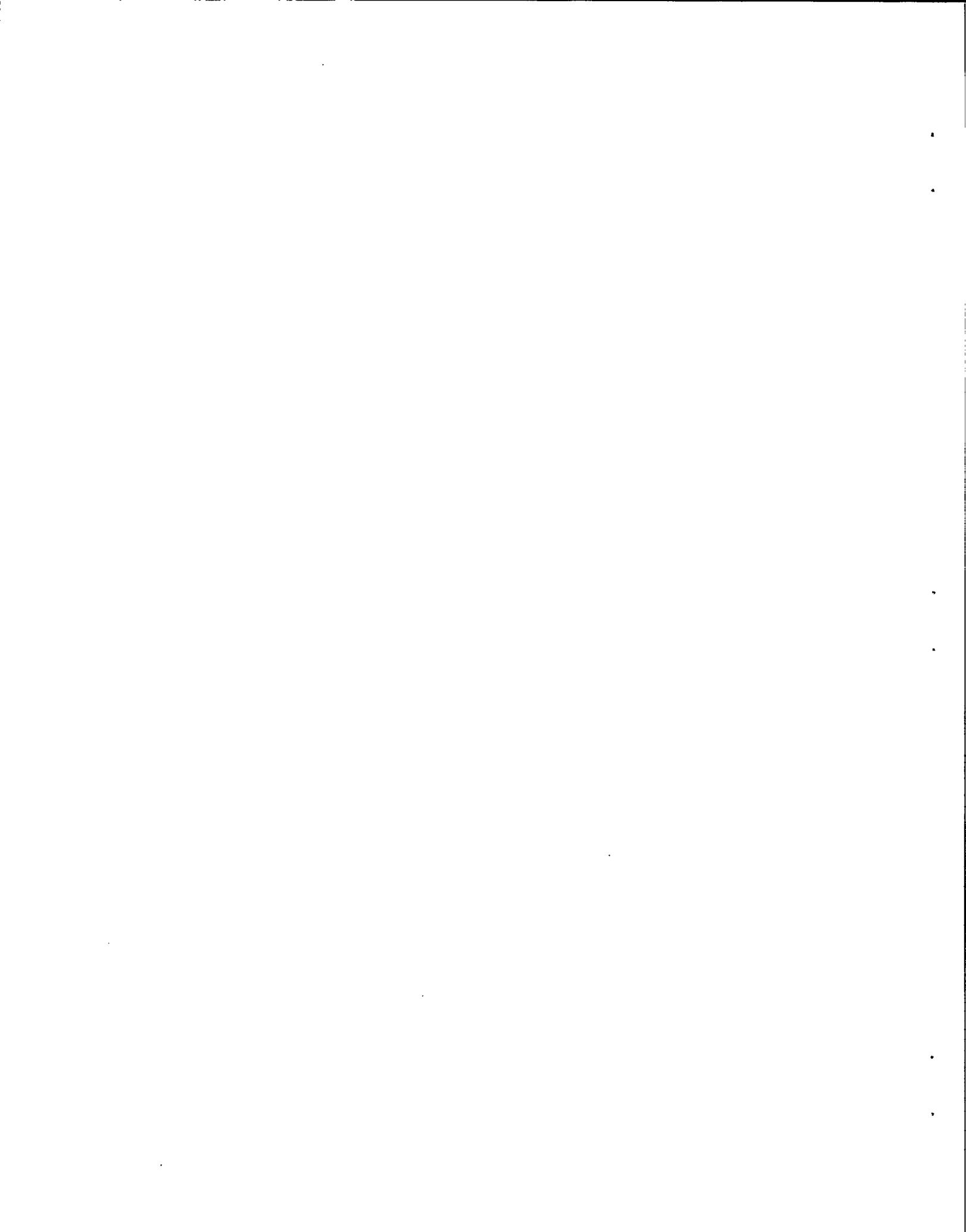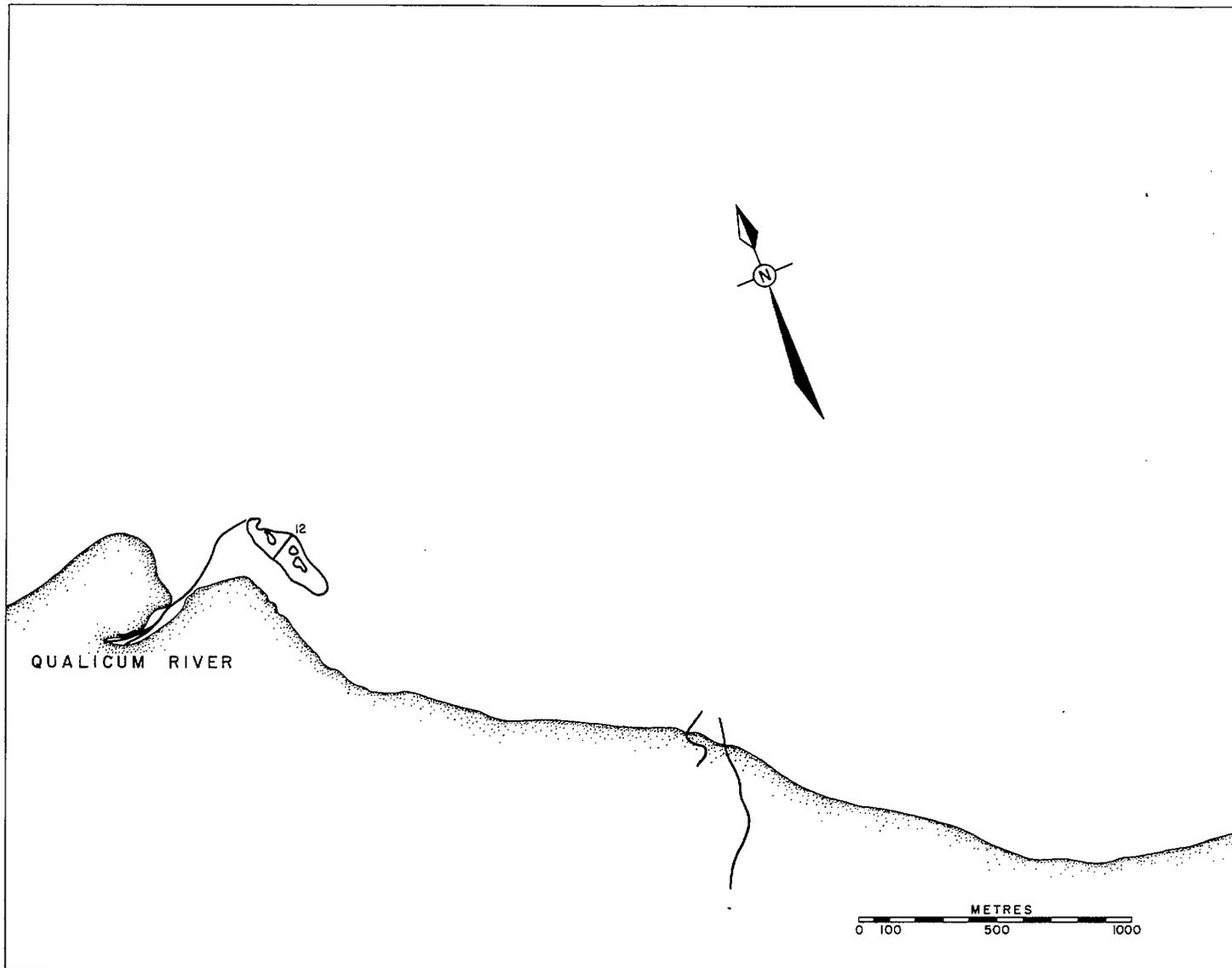
Fig. 14.  Herring spawn near the Big Qualicum River, surveyed by divers in 1986, with transect locations shown.

LITTLE QUALICUM RIVER - WEST
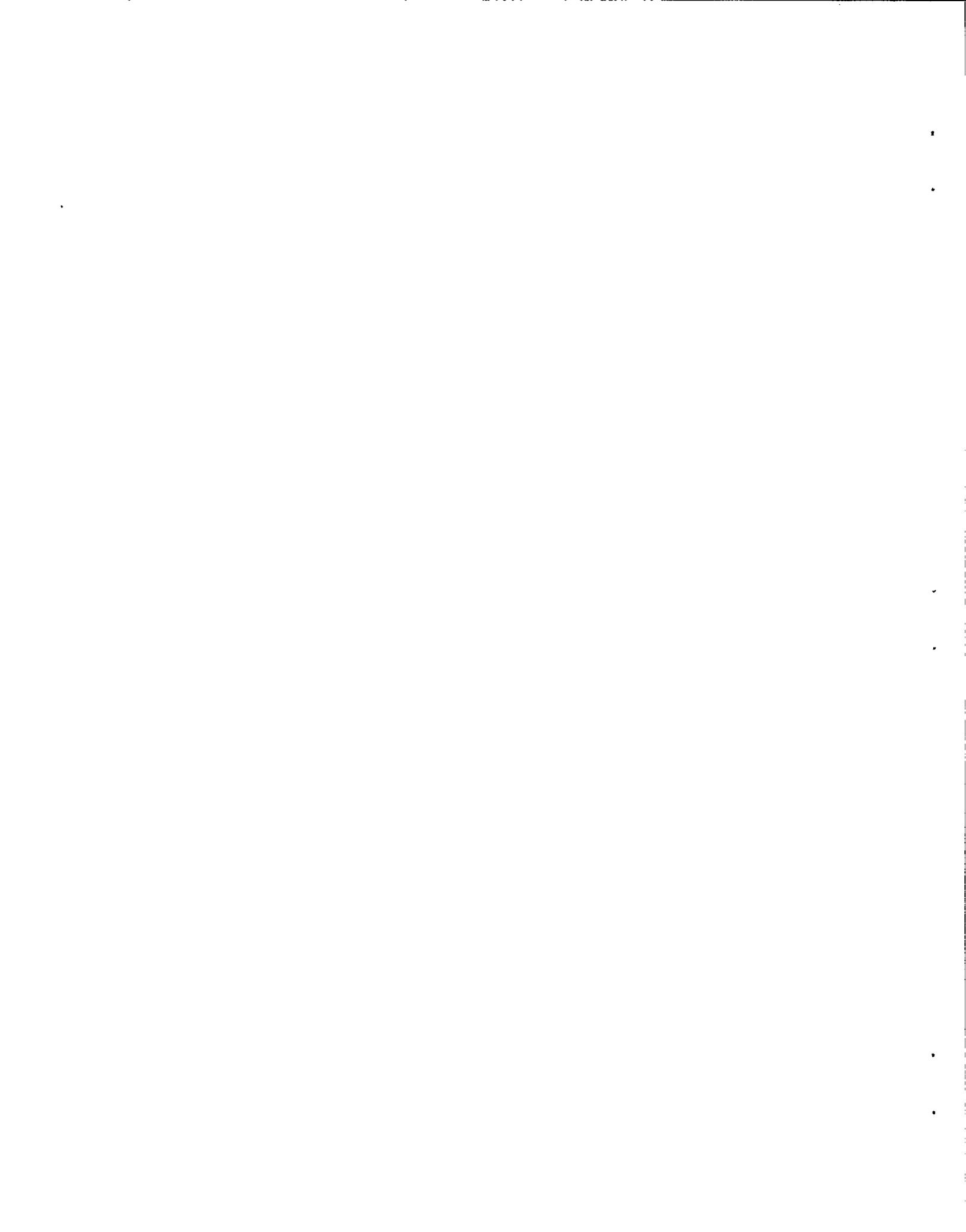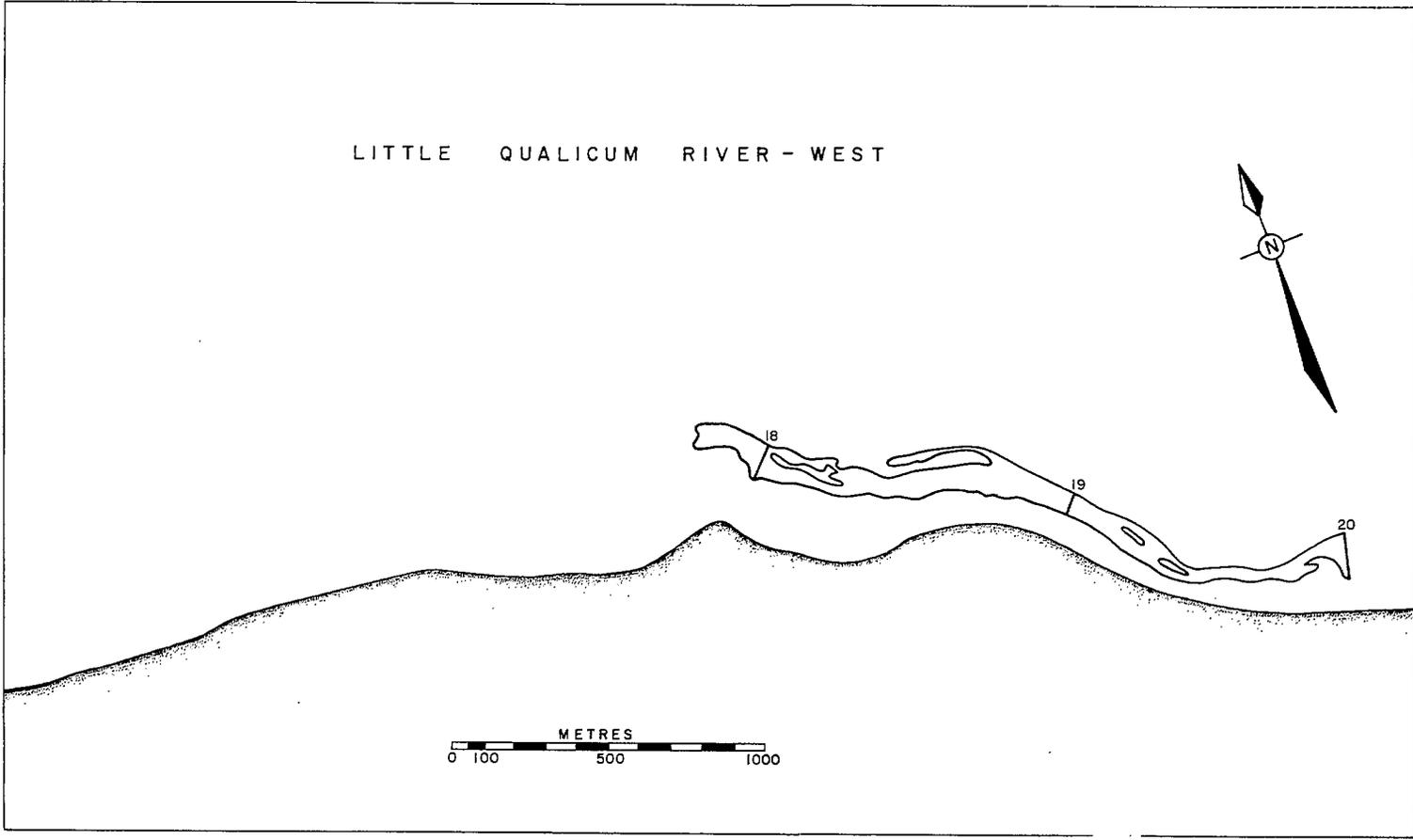
Fig. 15. Herring spawn just west of the Little Qualicum River, surveyed by divers in 1986, with transect locations shown.
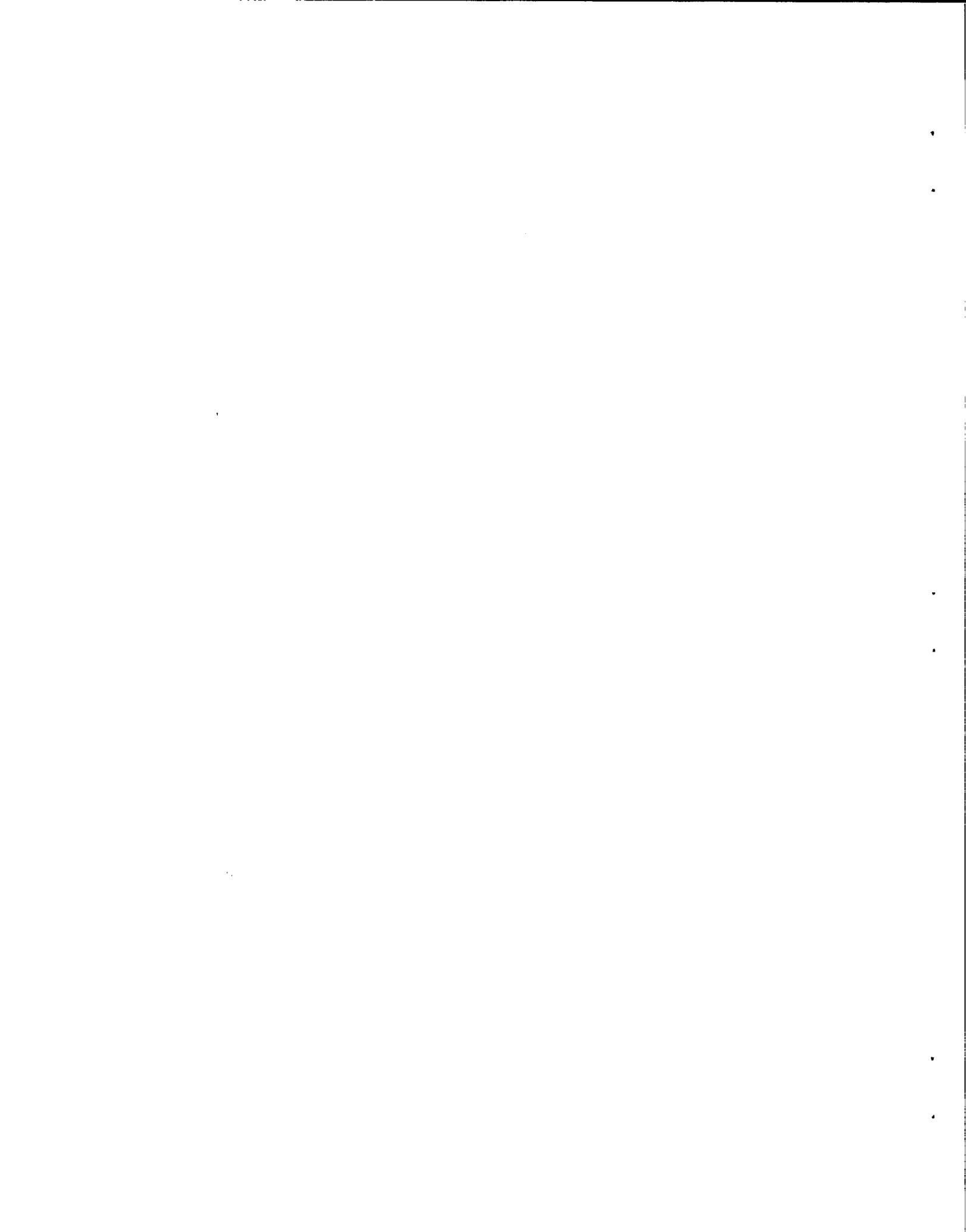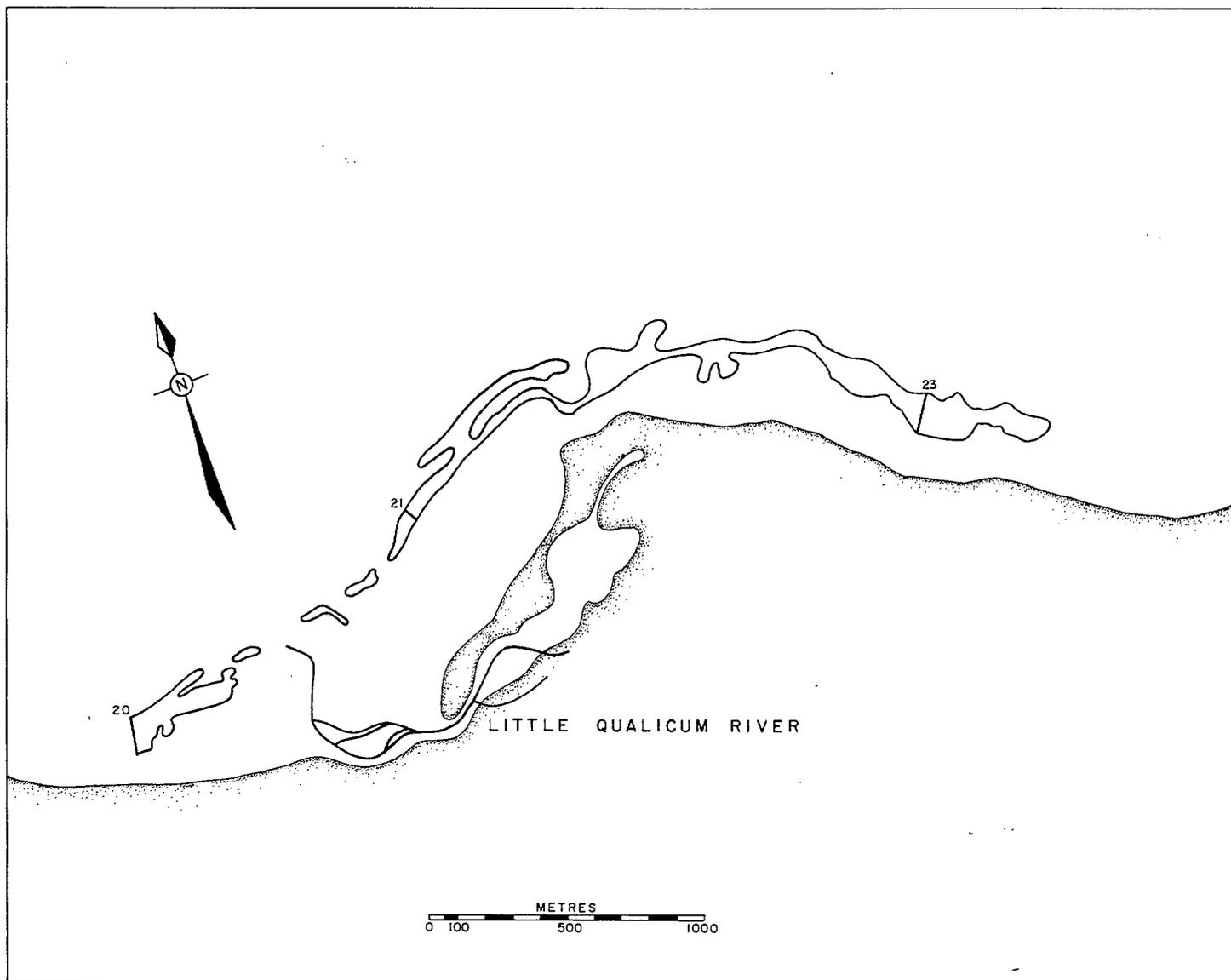
Fig. 16. Herring spawn at the Little Qualicum River, surveyed by divers in 1986, with transect locations shown.
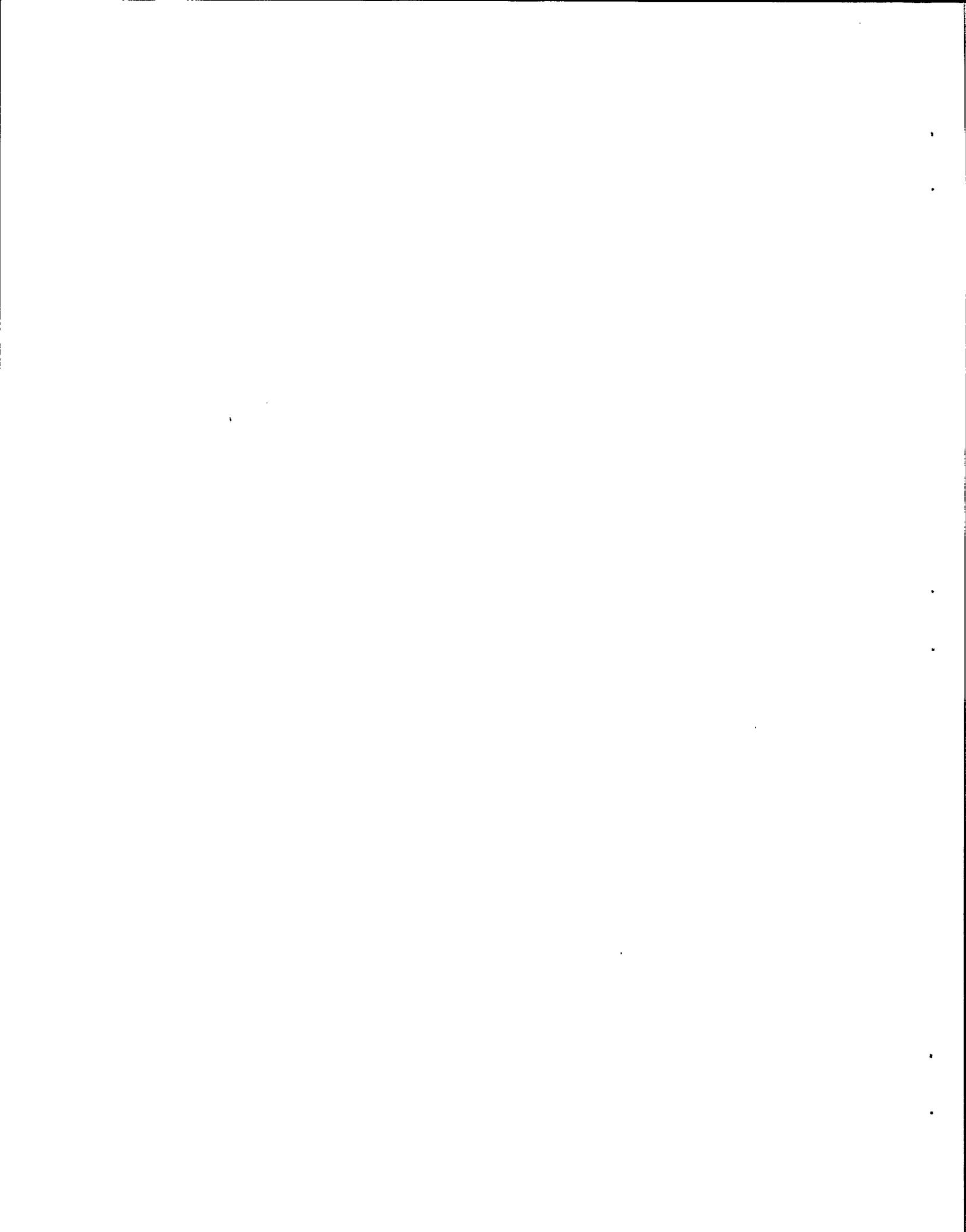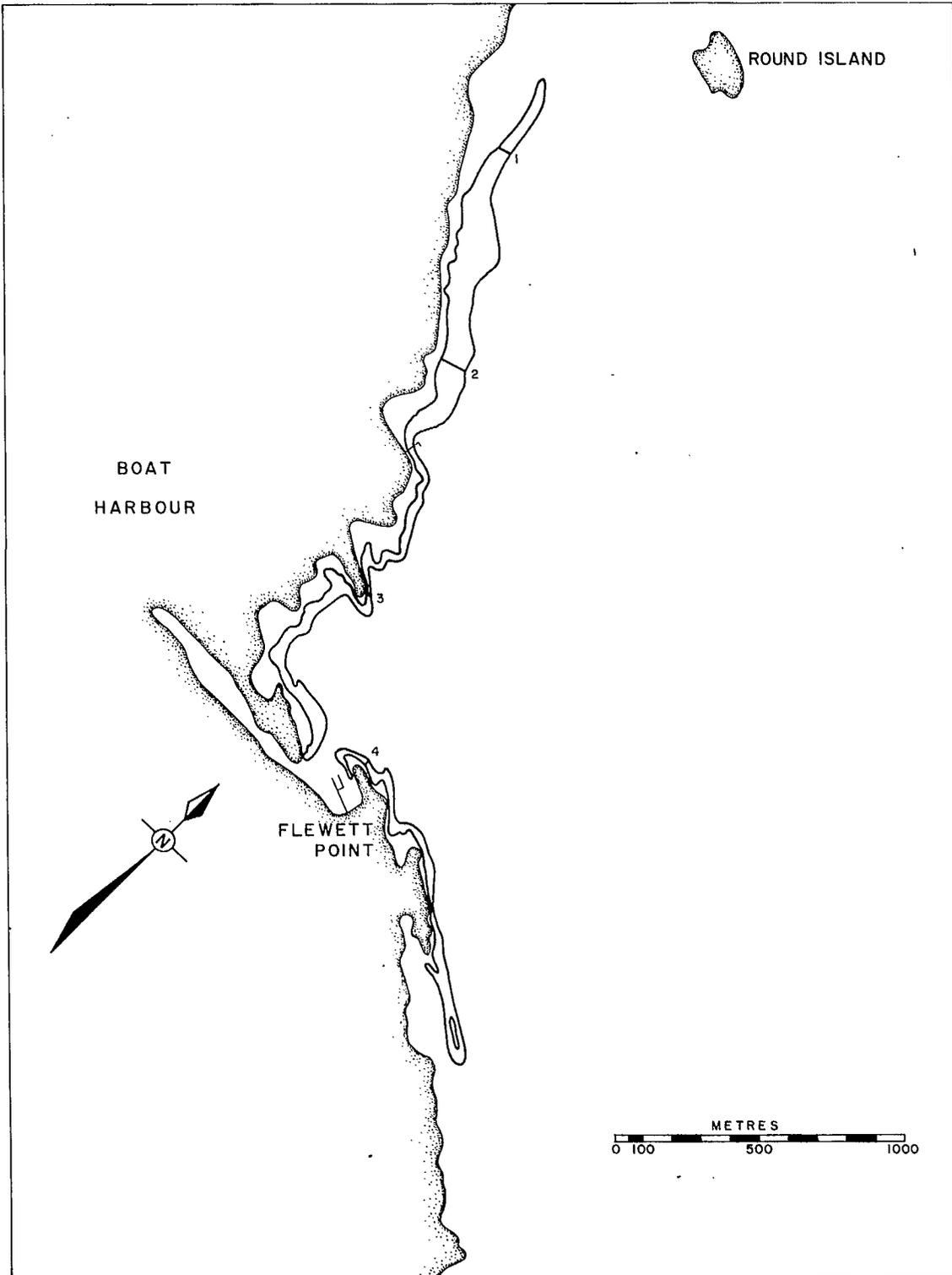
Fig. 17. Herring spawn from Round Island to Boat Harbour in Stuart Channel, surveyed by divers in 1986, with transect locations shown.
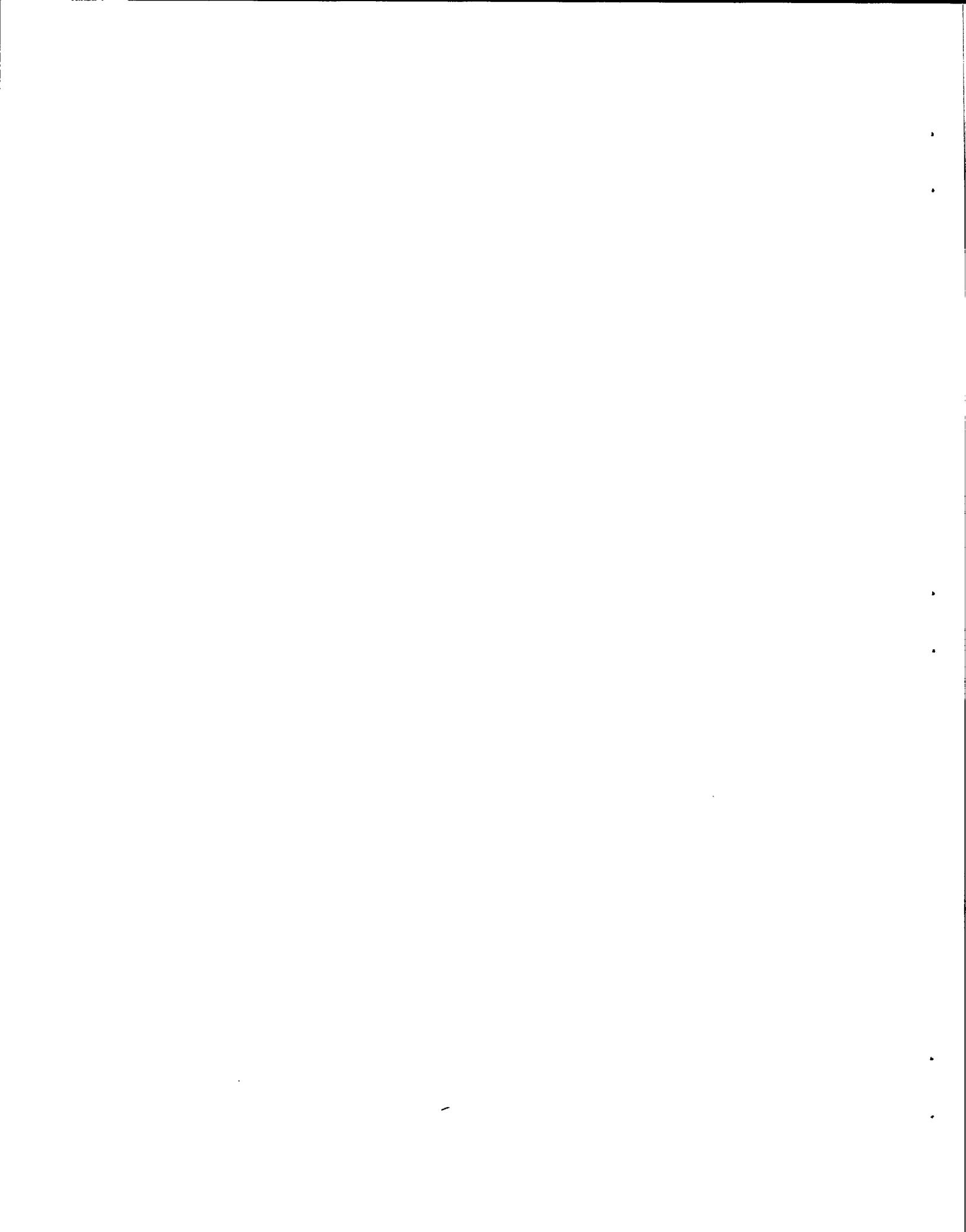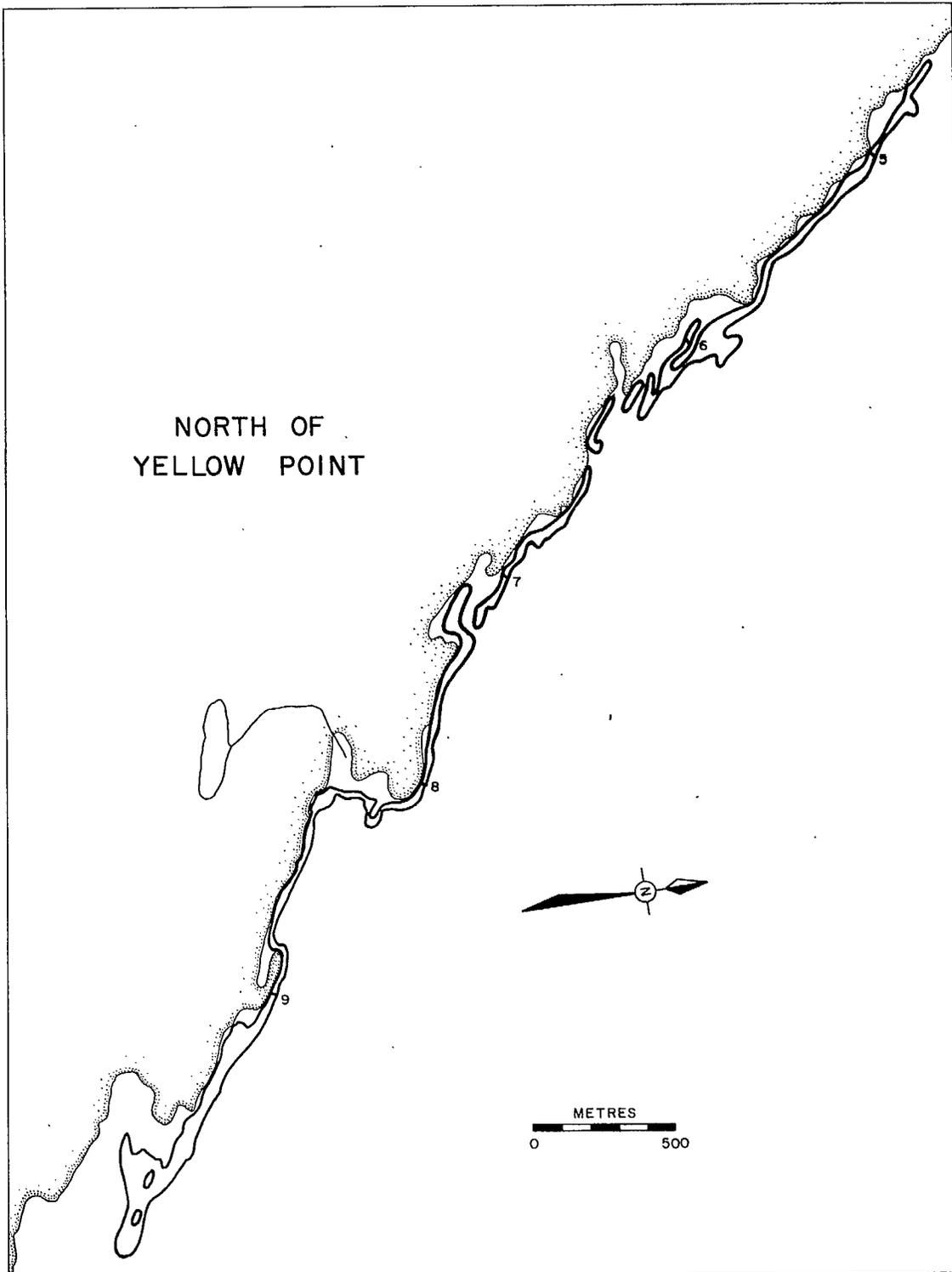
Fig. 18. Herring spawn north of Yellow Point in Stuart Channel, surveyed by divers in 1986, with transect locations shown.
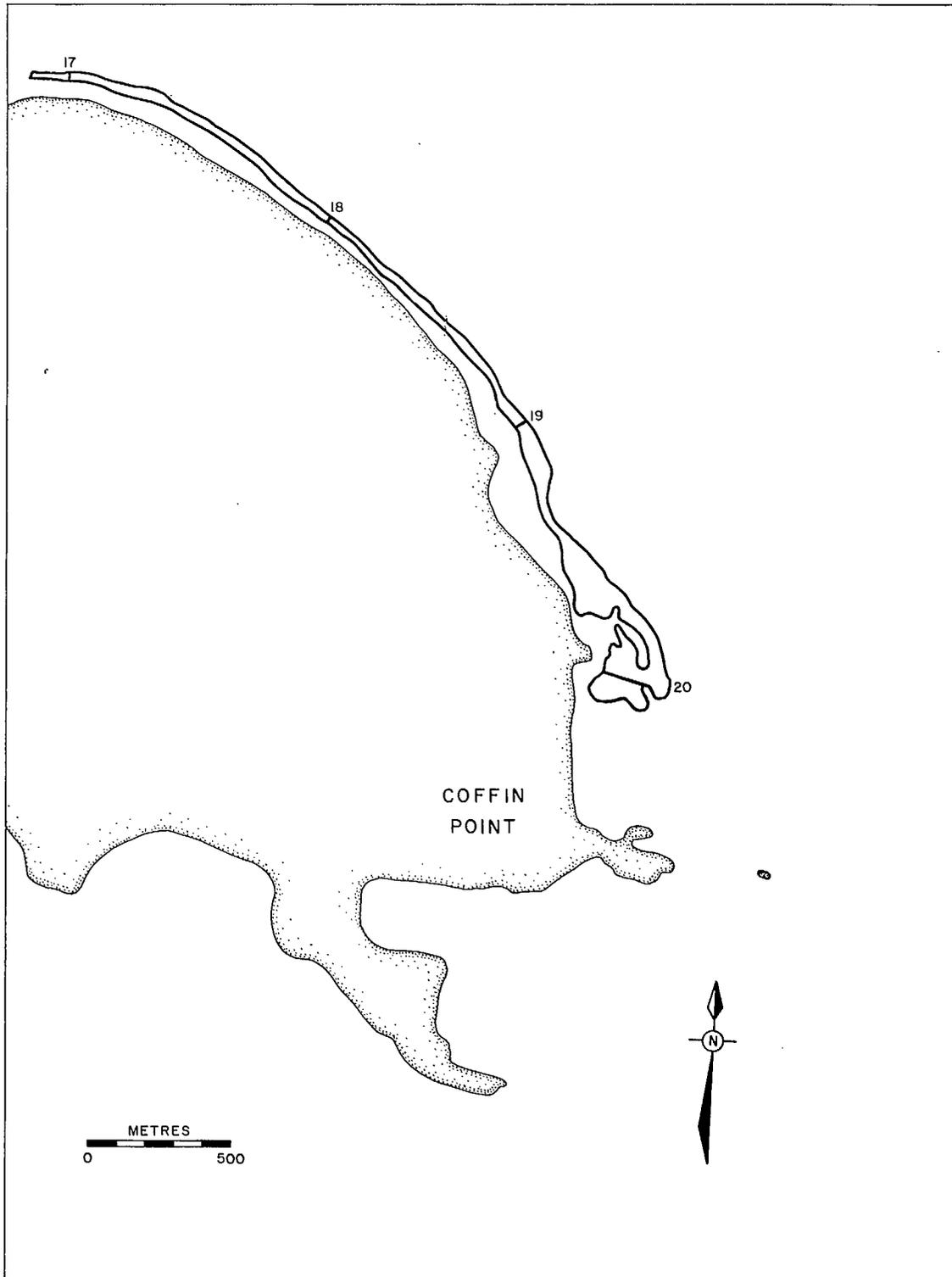
YELLOW POINT

INDIAN RESERVE

10

11

12

KULLEET
BAY

14

15

16

13

METRES

0        500
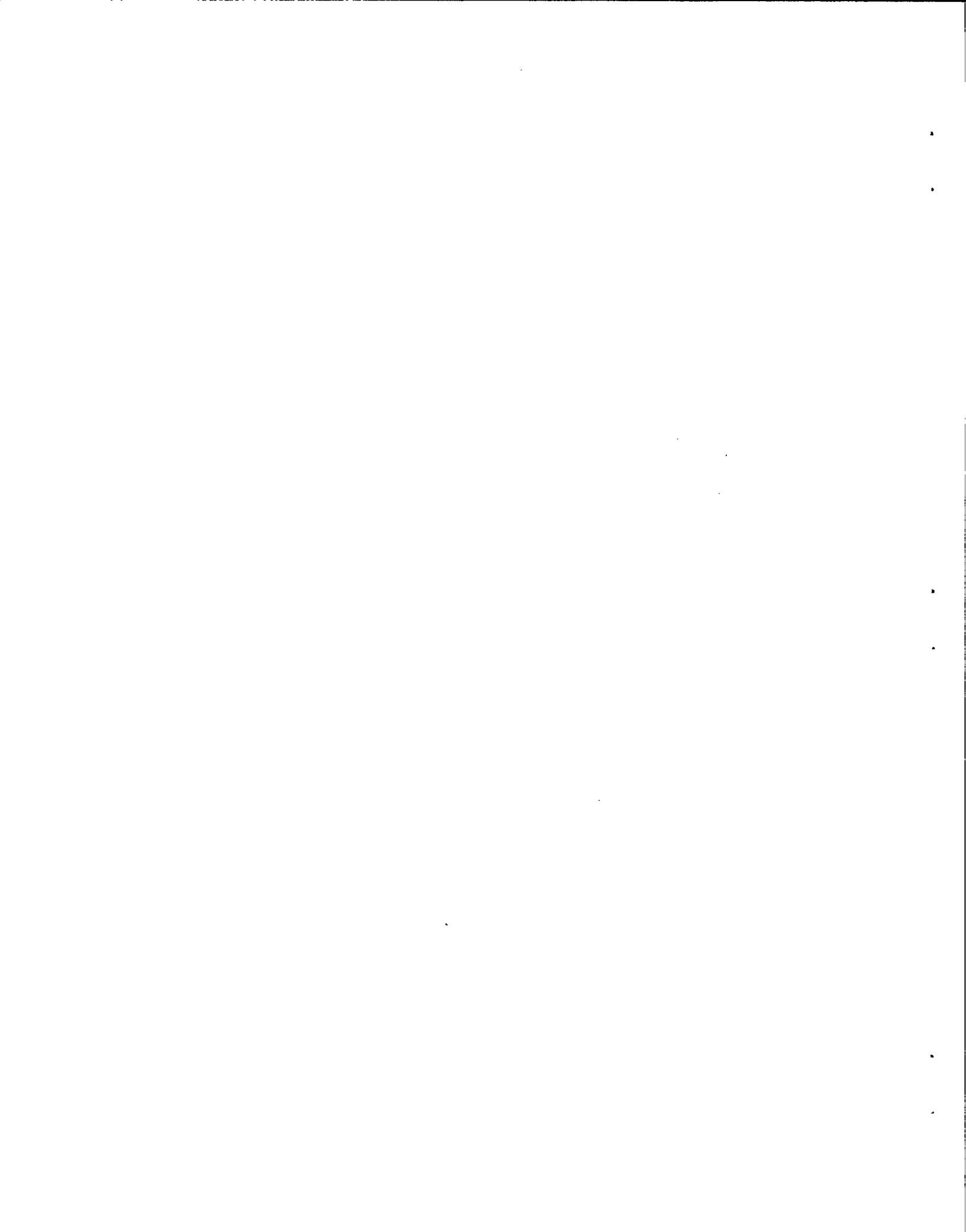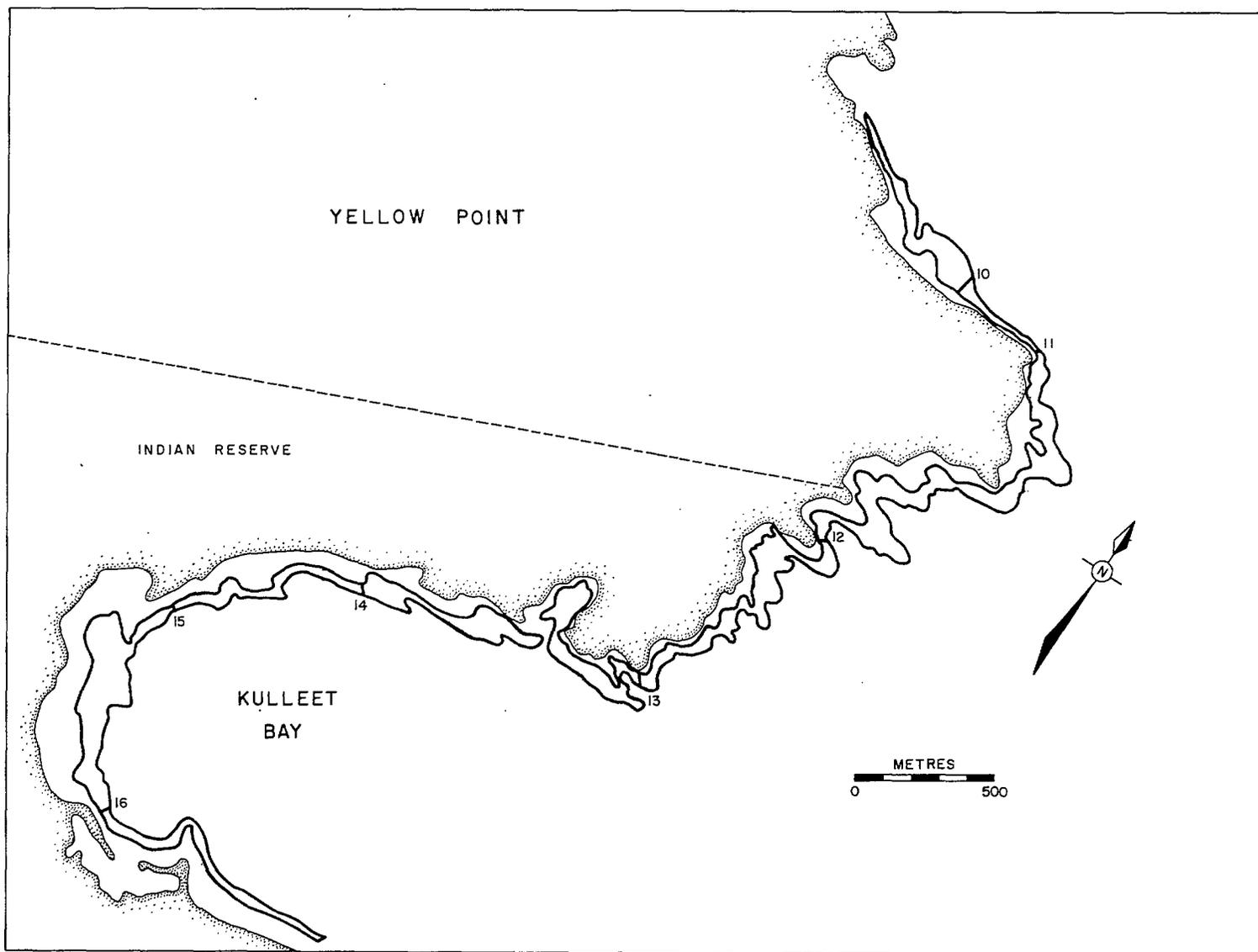
Fig. 19.   Herring spawn from Yellow Point to Kulleet Bay, surveyed by
divers in 1986, with transect locations shown.
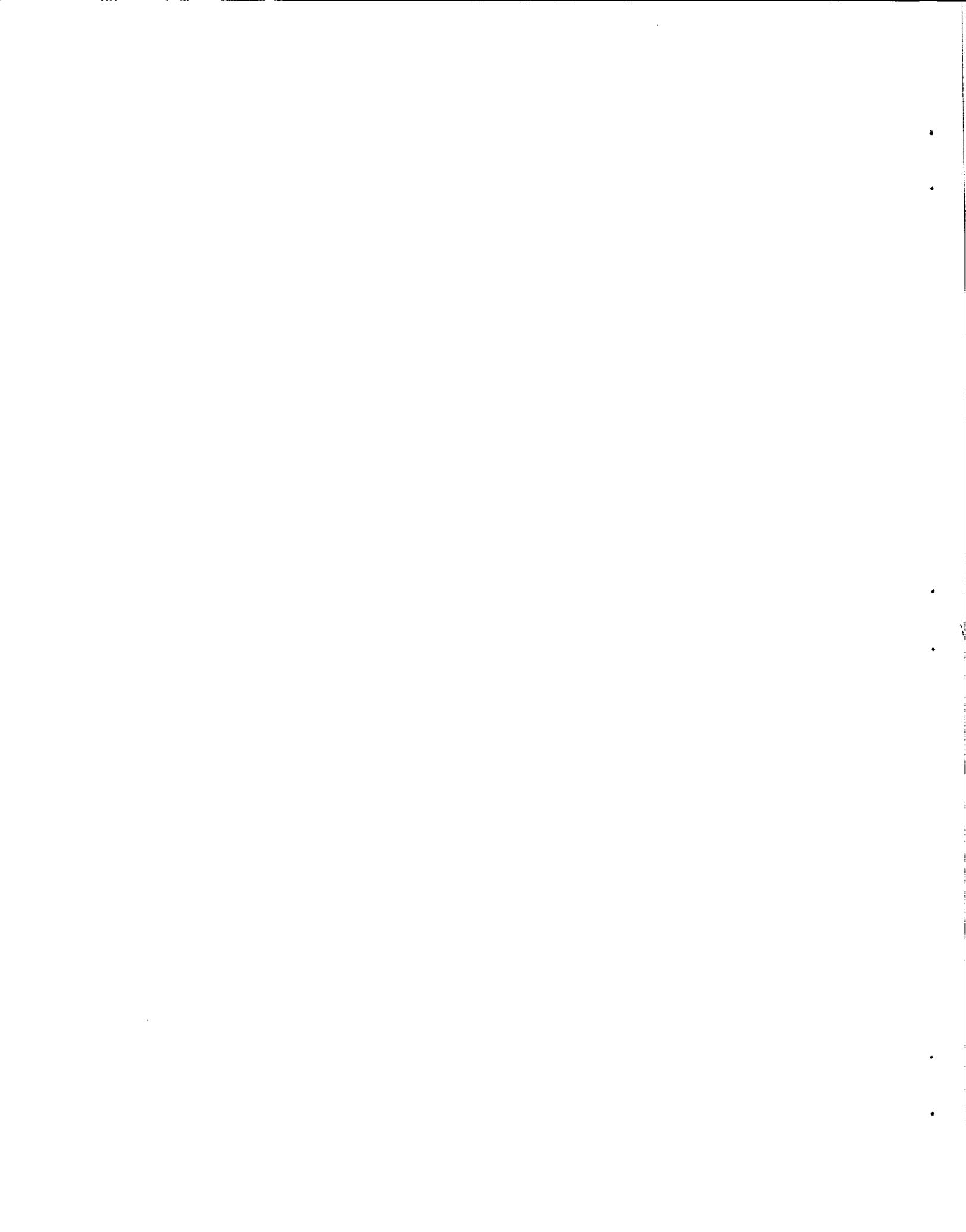
Fig. 20.  Herring spawn from Kulleet Bay to Coffin Point, surveyed by
divers in 1986, with transect locations shown.

Fig. 21.  Physical description of transects along which spawn survey
information was collected by divers in 1986 in Georgia Strait.  Average (with
95% CI.I) transect lengths, beach slopes, depths above (+) and below (-) chart
datum of outer edge of spawn (OES DEPTH) and inner edge of spawn (IES DEPTH)
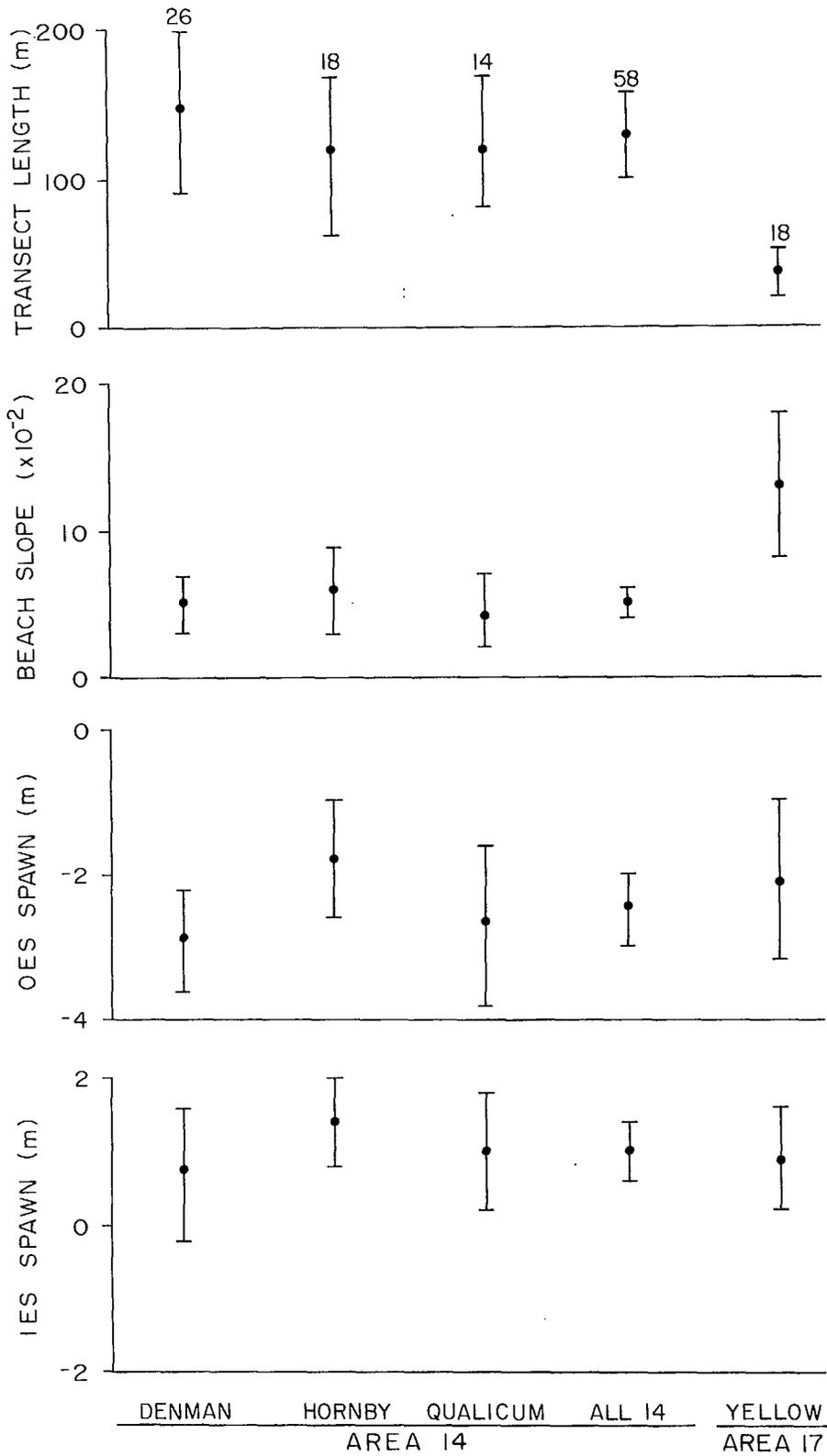and no. of transects sampled are shown.

Fig. 22. Dominant vegetation types upon which eggs were deposited in 1986, summarized by depth intervals [intertidal (above chart datum), upper subtidal (0 to 3 m below chart datum), and middle subtidal (3 to 6 m below chart datum)]. (SG = sea grasses, RW = rockweed, KE = kelp, OB = other brown algae, FO = foliose red algae, FI = filamentous red algae.)
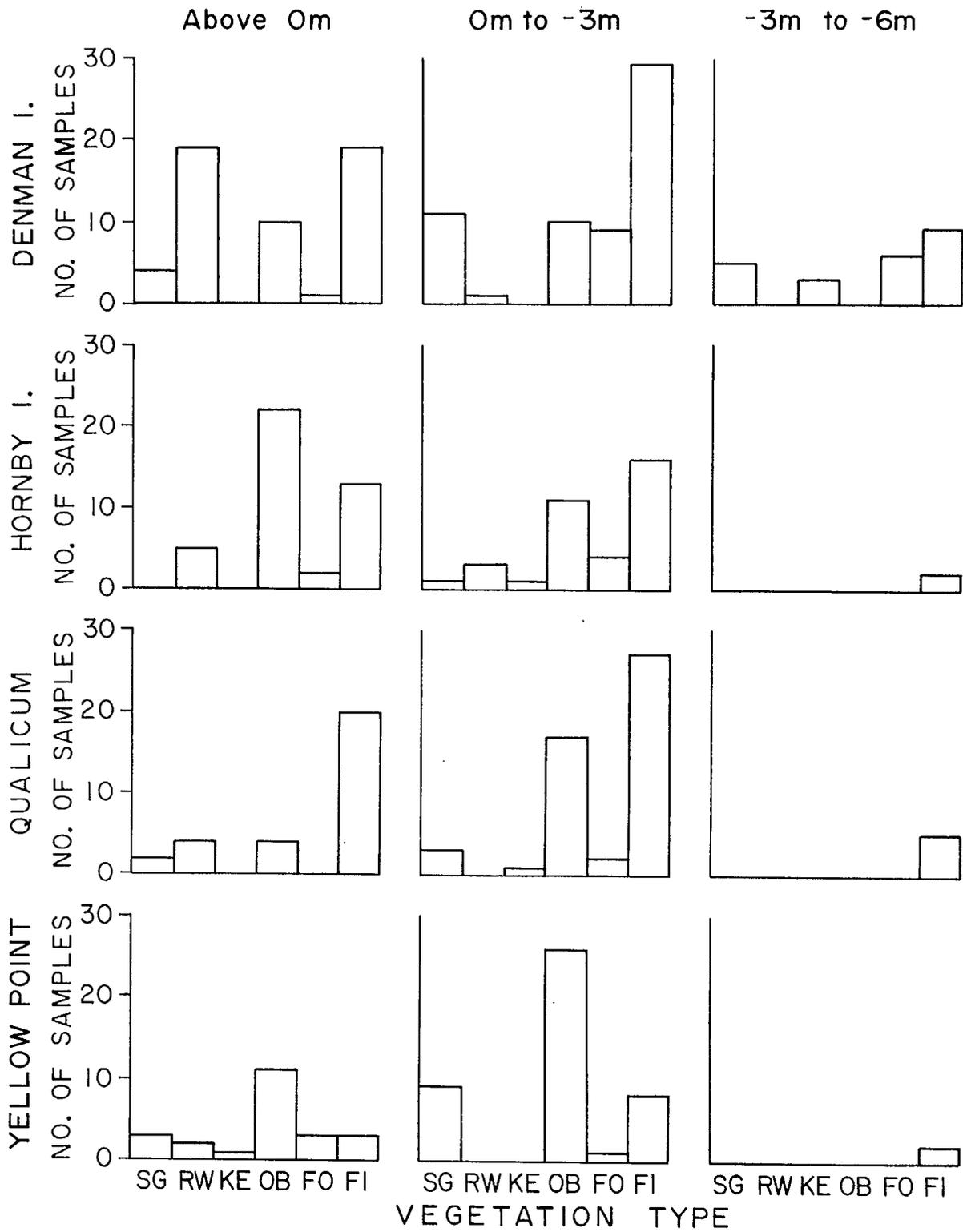
Fig. 23.  Percent cover of vegetation, layers of eggs, eggs per sq. m, and sample weight (Wilcoxon median and 95% C.I.) by depth interval [intertidal (above chart datum), upper subtidal (0 to 3 m below chart datum), and middle subtidal (3 to 6 m below chart datum)] for spawns surveyed by divers in Georgia Strait in 1986.  Sample numbers are shown above C.I. bar.

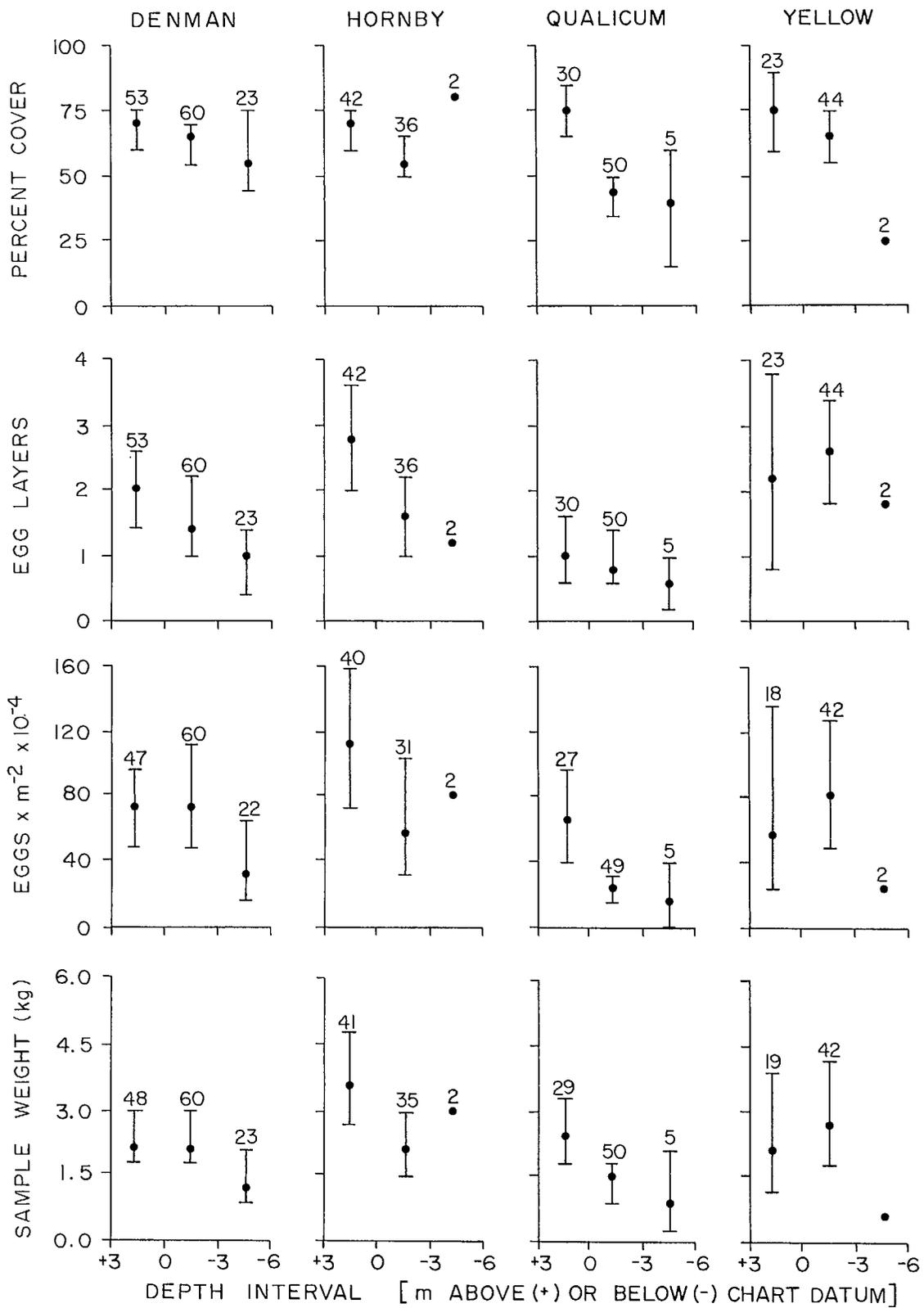DEPTH INTERVAL [ m ABOVE (+) OR BELOW (−) CHART DATUM]

- 64 -

Fig. 24.  Distribution of spawn area and eggs by depth interval [intertidal
(above chart datum), upper subtidal (0 to 3 m below chart datum), and middle
subtidal (3 to 6 m below chart datum)] for spawns surveyed by divers in
Georgia Strait in 1986.