Assessment of Herring Spawnings in the Vicinity of Nanoose Bay, B.C.

C.W. Haegele and R. D. Humphreys

Research and Resource Services
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

October 1977

Fisheries & Marine Service Manuscript Report 1437

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ASSESSMENT OF HERRING SPAWNINGS IN THE VICINITY OF NANOOSE BAY, B.C.

by

C. W. Haegele and R. D. Humphreys

Pacific Biological Station
Fisheries and Marine Service
Research and Resource Services
Nanaimo, British Columbia V9R 5K6

Cat. no. Fs 97-4/1437 ISSN 0701-7618

ABSTRACT

Haegele, C. W., and R. D. Humphreys. 1977. Assessment of herring spawnings in the vicinity of Nanoose Bay, B.C. Fish. Mar. Serv. MS Rep. 1437: 37 p.

An intensive underwater survey of two herring spawnings in and near Nanoose Bay, Strait of Georgia, was conducted during the 1976 herring spawning season. The spawnings were up to 650-m wide and eggs were deposited on a wide variety of substrates. An assessment of the spawnings by traditional techniques underestimated the area of the spawnings by 41% and 96%, mainly as a result of low width estimates of the subtidal portion of the spawn. Detailed topographic maps of spawning localities showing vegetation zones should alleviate problems associated with detecting and measuring herring spawn.

Key words: Herring, spawnings, Nanoose Bay.

RÉSUMÉ

Haegele, C. W., and R. D. Humphreys. 1977. Assessment of herring spawnings in the vicinity of Nanoose Bay, B.C. Fish. Mar. Serv. MS Rep. 1437: 37 p.

Une étude sous-marine intensive de deux frayères de harengs près de Nanoose Bay, dans le détroit de Géorgie, a été réalisée au cours de la saison du frai de 1976. Les frayères pouvaient avoir jusqu'à 650 m de large, et les oeufs étaient déposés sur une grande variété de substrats. Les techniques traditionnelles ont donné des estimations inférieures de 41 % et de 96 % de la surface des frayères, surtout à cause d'estimations trop faibles des parties infralittorales. Des cartes topographiques détaillées des frayères de harengs, indiquant les zones de végétation, devraient faciliter leur détection et la mesure de leur superficie.

Mots clés: Hareng, frayères, Nanoose Bay.

INTRODUCTION

Each year, in late winter and early spring, Pacific herring deposit their adhesive eggs primarily on rooted vegetation in the intertidal and upper subtidal zones. These spawnings are surveyed annually by personnel of the Fisheries and Marine Service, Department of Fisheries and the Environment, Government of Canada. For each spawning located, the length, width, and spawning density is recorded. These data are used to estimate the number of spawners involved for stock assessments.

A 1975 study of herring spawnings in Barkley Sound on the west coast of Vancouver Island (Humphreys and Haegele 1976) demonstrated that subtidal spawnings were not adequately assessed by current procedures. Between February 20 and March 27, 1976 this study was continued in the Strait of Georgia at Nanoose Bay and Icarus Point (Fig. 1) where spawning locality, topography, and vegetation differed in some important respects from the Barkley Sound study area. Maps of shoreline vegetation prepared from aerial photographs were available for the Nanoose Bay area (Haegele and Hamey 1976), and a diver survey of the vegetation on the spawning ground was undertaken (Haegele and Humphreys 1976a). Diver survey techniques were used to systematically catalogue the type, distribution, and abundance of vegetative and other substrates on the spawning grounds and to demonstrate how these factors influence the distribution of herring eggs.

Herring spawnings occurred in Nanoose Bay and at Icarus Point between March 10 and March 14. The Nanoose Bay spawning was surveyed by diving transects between March 15 and March 21. Part of the spawning at Icarus Point was survey by diving transect between March 19 and March 25.

METHODS

SURVEYING

Except for some minor modifications, survey techniques used during the 1975 Barkley Sound study (Humphreys and Haegele 1976) were adopted for this survey. Instead of using regular intervals between transects as in 1975, transects were shot from the baseline, usually perpendicular to the beach, at intervals determined by the degree of desired coverage and measured by stadia rod. They ranged between 146 and 312 m apart at Icarus Point and 118 and 296 m apart at the head of Nanoose Bay. Transects were marked, as in 1975, with gillnet leadline consisting of 20-m lengths shackled together. Leadline was laid out to a depth of 30 m (as determined by echo sounder). When this depth was not attainable with the amount of available leadline (440 m), the leadline was laid from the edge of the water or the upper edge of the spawn, whichever was furthest from the baseline. In this manner, marked transect lengths of up to 750 m were obtained. When spawn occurred beyond the end of the leadline, the divers proceeded seaward with the aid of a compass to the outer edge of the spawning.

As in 1975, sampling stations were established by diver and marked with buoys at approximately 20-m intervals along the leadline. Positions of sampling stations were determined by surveyors taking angle bearings on the snubbed buoys by theodolite from positions on the baseline (Fig. 2). Distances were calculated to within 1 m by sine rule:

$$a = \frac{b}{\sin B} \sin A$$

SAMPLING

As with the surveying methods, the sampling methods used in the 1975 Barkley Sound study (Humphreys and Haegele 1976) were adapted with minor modification for use in Nanoose Bay.

The sampling team consisted of three divers and two support vessels (5-m power boat) manned by one person each. One vessel tended divers and determined the depth from surface to bottom to the nearest 0.1 m with a weighted measuring tape at each sampling station. Depths were later corrected to chart datum from tide gauge heights recorded by the Institute of Ocean Sciences at Winchelsea Islands (Fig. 1). The other vessel supplied the divers with buoys and sample bags, retrieved the buoys and samples, and informed the surveyors by walkie-talkie when the buoys were snubbed so that angles could be shot by theodolite.

Information recorded on a waterproof label by the lead diver was as follows:

1) Baseline, transect, and station number,
2) Date,
3) Bottom type (as per Table 1),
4) Cover value (as per Table 2),
5) Description of general area,
6) Size of sample quadrat (1/4 m^2 or 1 m^2),
7) Additional pertinent information.

The two other divers sampled alternate stations, selecting the size of sample quadrat specified by the first diver and placing it on the bottom at the sample station. All vegetation rooted within the quadrat was removed with a knife and placed in a burlap sack along with the label. The sack was attached to the buoy line, which was then released from the leadline so that it could be raised to the surface by the divers' tender. Spawn exposed on the beach at the time of the survey was sampled by the surveyors in a similar manner.

SAMPLE PROCESSING

(a) In the field

Samples were removed from the burlap sack and separated according to species of vegetation into fractions, using keys by Widdowson (1973 and 1974), and Scagel (1972). Where identification in the field was not positive, samples of vegetation were preserved in buffered formal saline for subsequent sectioning and identification. The total weight (vegetation plus spawn) of each fraction was determined and a portion of each fraction, usually sufficient to fill a 1-ℓ jar, was weighed and preserved in Gilson's fluid. Additional information recorded for each fraction was:

1) Age of eggs (using criteria established by Outram 1955),
2) Eggs per 2 cm of substrate if plant was less than 2 cm wide or per 4 cm^2 if plant was more than 2 cm wide,
3) Mortality of eggs (% of total dead),
4) Layers of eggs (on both sides of vegetation),
5) Egg intensity (based loosely on Table 3).

(b) In the laboratory

After a minimum of 6-wk preservation, the spawn samples were handled according to the procedures described in Humphreys and Haegele 1976.

The number of eggs for each vegetation fraction was calculated by the equation:

$$N = n\ (2^s)\ (\frac{W}{w})$$

where N = number of eggs in fraction
n = number of eggs in subsample
s = number of splits
W = weight of fraction
w = weight of preserved sample

The number of eggs per sample was obtained by summing N for all fractions, and then dividing by the area of the sample quadrat to obtain eggs/m^2.

Samples were classified by substrate type according to percent contribution by number of eggs. The substrate group with the largest number of eggs served as the classification for the sample. In all cases, this was greater than 50% of the total number of eggs.

RESULTS

DISTRIBUTION OF HERRING SPAWN AT NANOOSE BAY AND ICARUS POINT

The extreme range of spawn densities and the likelihood of encountering several substrate types at all cover values for any individual spawning was apparent for both spawnings. Of the 91 samples collected at Nanoose Bay, 81 contained sea grasses (Zostera marina) as a spawn substrate, 7 contained kelps (two species), 10 contained red algae (five species), and 1 contained green algae (Ulva sp.). Of the 98 samples collected at Icarus Point, 19 contained sea grasses (Zostera marina) as a substrate, 14 contained rockweed (Fucus distichus and sp.), 34 contained kelps (four species), 4 contained other brown algae (Sargassum muticum) and 81 contained red algae (21 species). Transect spawn samples at both localities ranged from a cover value of 1 and very light egg intensity at 0.5 egg layers to a cover value of 5 and heavy egg intensity at 6 egg layers (Tables 4 and 5).[1]

Nanoose Bay

The herring spawning at the head of Nanoose Bay was completely surveyed. It was 2 km long and up to 320 m wide, covering an area of 313,111 m^2. A vegetation chart for this locality (Fig. 3) was prepared from information obtained on five preliminary vegetation survey transects (B12T3 [V], B14T1, B17T3, and B18T3), ten spawn survey transects (B12T1 through B46T2, excluding the vegetation transects named above, in Fig. 4) and from aerial photographs (Haegele and Humphreys 1976a). Most of the vegetative substrate below +1.8 m chart datum was used for spawning and nearly 99% of the spawn was on Zostera marina at depths to -2.4 m. Eight zones (Fig. 5) were identified on the basis of spawn density, substrate, and cover value (Table 6).

Icarus Point

A section of herring spawn 1.7 km long was studied at Icarus Point. The spawning was 460 m wide at the most easterly spawn transect, B57T1 (Fig. 6 and 7), widening to 650 m at B55T1 and narrowing westward to 430, 270, 120, and 110 m at transects B53T4, B52T3, B52T1, and B51T1, respectively, The total area of this section of spawn was calculated to be 715,078 m^2. On the basis of spawn density, spawn substrate, and cover value (Table 7), eight zones of spawn (Fig. 7) were discernible. The vegetation chart for this section of beach (Fig. 8) is a combination of information from the diving survey and from aerial photographs (Haegele and Humphreys 1976a). Virtually all of the vegetation substrate was utilized for spawning. The spawn extended from +3.0 m chart datum to -7.5 m.

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[1]The raw data for the 1976 study are available in the form of a Data Record (Haegele and Humphreys 1976b).

CALCULATION OF NUMBERS OF EGGS DEPOSITED

For our diver surveys, in which small areas of the coast are studied intensively, our best estimate of egg deposition is obtained by separating the spawnings into zones with similar spawn density, spawn substrate, and cover value, and multiplying the area of each zone by the average number of eggs per sample for that zone. This estimate for the number of eggs deposited at the head of Nanoose Bay and on the section of shoreline studied at Icarus Point was, respectively, 2.71×10^{11} and 8.29×10^{11} eggs.

DISCUSSION

COMPARISON OF SURVEY RESULTS WITH TRADITIONAL HERRING SPAWN ASSESSMENT

The magnitude of spawn depositions is assessed annually from Fishery Officers' estimates of area of deposition and spawn density and eggs per unit area estimates for the various egg intensity categories (Table 3). In addition, a standard egg-loss factor (Outram 1958) is applied to all calculations of total egg deposition to compensate for eggs lost through predation and storm damage between the time of spawning and the time of observation. It has become apparent throughout the course of our recent studies (Humphreys and Haegele 1976) that egg loss during the incubation period is most often quite light, so that the egg-loss factor has no firm basis in fact and should be abandoned. The factor has, in some cases, compensated for undetected deep spawnings, but this has been only a fortuitous occurrence of no real significance.

A comparison of the estimates of area of deposition and number of eggs deposited derived from the two types of survey (traditional vs. diver) is shown below:

	Area of deposition (m^2)		Total number of eggs ($\times 10^{11}$) deposited	
Area of observation	Traditional survey	Diver survey	Traditional survey	Diver survey
Nanoose Bay Head	185,000	313,111	1.63	2.71
Icarus Point	31,000	715,078	0.27	8.29

The estimates of total egg deposition are unadjusted for egg loss. The area of deposition is seriously underestimated by the traditional method at both localities surveyed, but to a much greater degree at Icarus Point than at the head of Nanoose Bay. This is attributed to the fact that the Icarus Point spawning is largely on deep beds of red and brown algae which cannot readily be detected from the surface and which are not easily picked up by spawn rake. The spawning at the head of Nanoose Bay, on the other hand, is mainly on shallow beds of eelgrass which are much more readily observed from the surface and picked up on a spawn rake.

The length of most spawnings can usually be identified from shore at low tide or by grappling methods from a vessel and by plotting these observations on a large-scale map. The widths of the spawnings, on the other hand, are not as easily determined. For wider spawnings such as those encountered during this study, a large area would have to be searched to ensure coverage of spawn depositions up to 650 m wide. Our studies have also suggested (Humphreys and Haegele 1976) that there is a considerable effect of substrate type on numbers of eggs deposited per unit area. Both these data requirements, i.e., width and substrate type, can be best obtained with the provision of detailed maps of major spawning areas showing depth contours and vegetation zones. Maps of this type are presently being prepared from aerial photographs.

ACKNOWLEDGEMENTS

We wish to express our sincere gratitude to our Program Head, Dr. A. S. Hourston, for guidance and encouragement throughout the planning and implementation of this study, and to everyone who gave so generously of their time and talents during its course.

We are especially grateful to our divers, Doug Miller, Tom Kessler, Heather Washburn, and John Edwards who daily descended into very cold water to collect our samples. Our surface crew members, Rick Hobbs and Tom Mayes, also ventured forth daily, often under very adverse weather conditions, to do their part in tending divers and manning surveyor's instruments. They also performed the onerous task of separating the egg samples and counting the eggs. To all of them we are grateful for processing numerous samples in our shipboard laboratory, often late into the night.

To our cook, Kerry Stubbington, we all extend our warmest appreciation for always having a delicious meal cheerfully ready for us.

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Table 1. Bottom type classification

Bottom type	Particle size	Code
Mud	< 0.02 cm	M
Sand	0.02 to 0.15 cm	S
Pebbles	0.15 to 6.0 cm	P
Cobbles	6.0 to 25.0 cm	C
Boulders	> 25.0 cm	B
Solid substrate	Rockshelf	R
Shells	Usually bivalve	s

Table 2. Scale of estimated plant coverage.

Cover value	Degree of coverage
5	76-100% of area
4	51- 75% of area
3	26- 50% of area
2	6- 25% of area
1	1- 5% of area
+	< 1% of area

Table 3. Egg intensity categories and eggs per unit area by intensity from Hourston et al. 1972 (modified to metric measurements).

Intensity	VL	VL-L	L	L-M	M	M-H	H	H-VH	VH
Eggs/m^2 ($\times 10^3$)	61	184	307	584	860	1351	1842	2825	3807
Eggs/2 cm (Range)	1-20		21-80		81-200		201-400		400 up
Eggs/4 cm^2 (Range)	1-30		31-120		121-300		301-600		600 up

Table 4. Distribution of spawn transect samples at Nanoose Bay by cover value, egg intensity, and egg layers.

Cover value	Egg intensity	Egg layers 0.5	1	2	3	4	5	6	7	All
1	VL	2								2
	L	1	1							2
	All	3	1							4
2	VL	4								4
	L		3							3
	M			1						1
	All	4	3	1						8
3	VL	8								8
	L	1	1							2
	M			1						1
	All	9	1	1						11
4	VL	1								1
	L		4	2						6
	M				1	1				2
	All	1	4	2	1	1				9
5	VL	7								7
	L	1	14	16	5					36
	M				7	3	2	2	1	15
	H							1		1
	All	8	14	16	12	3	2	3	1	59
All	VL	22								22
	L	3	23	18	5					49
	M			2	8	4	2	2	1	19
	H							1		1
	All	25	23	20	13	4	2	3	1	91

Table 5. Distribution of spawn transect samples at Icarus Point by cover value, egg intensity, and egg layers.

Cover value	Egg intensity	Egg layers 0.5	1	2	3	4	5	6	All
1	VL	3							3
	L		1	1					2
	M					1			1
	All	3	1	1		1			6
2	VL	2	1						3
	L		4	1					5
	M					1			1
	All	2	5	1		1			9
3	VL	6							6
	L		8	4					12
	M				2				2
	All	6	8	4	2				20
4	VL	2							2
	L		6	7					13
	M					3			3
	H						1		1
	All	2	6	7		3	1		19
5	VL	2							2
	L		5	8	1				14
	M				12	10	2		24
	H						2	2	4
	All	2	5	8	13	10	4	2	44
All	VL	15	1						16
	L		24	21	1				46
	M				14	15	2		31
	H						3	2	5
	All	15	25	21	15	15	5	2	98

Table 6. Zones of spawn deposition at head of Nanoose Bay, 1976.

Zone	Depth range (m)	Egg int.	Egg lay	Cover value	No. of samples	Av. eggs/m^2 ($\times 10^3$)	% of total eggs	% of total area	Substrate species: Major	Substrate species: Incidental
1	+1.1 to +0.7	L	2	5	2	1752	2	1	*Zostera marina*	-
2	+1.7 to -1.9	VL	0.5	4	22	311	12	32	*Zostera marina*	-
3	+1.3 to -0.9	L	1	5	19	882	29	28	*Zostera marina*	-
4	+1.2 to -0.9	L	2	5	18	980	17	15	*Zostera marina*	*Polysiphonia hendryi* *Gracilaria* sp.
5	+1.8 to -2.4	M	4	5	18	1850	38	18	*Zostera marina*	*Sargassum muticum* *Polysiphonia hendryi*
6	+1.5	L	2	5	1	971	1	1	*Zostera marina*	-
7	+0.3 to -0.3	L	3	5	2	1532	1	1	*Rhodomela larix*	-
8	-1.4 to -5.4	VL	0.5	2	6	11	<1	4	*Agarum fimbriatum* *Laminaria groenlandica*	*Gigartina* sp. *Gracilaria* sp.

Table 7. Zones of spawn deposition at Icarus Point, 1976.

Depth range (m)	Egg int.	Egg lay.	Cover value	No. of samples	Average eggs/m^2 ($\times 10^3$)	% of total eggs	% of total area	Substrate species: Major	Substrate species: Minor	Substrate species: Incidental
Zone 1										
-4.3 to -7.4	VL-L	1	4	9	267	3	14	*Agarum fimbriatum* *Laminaria groenlandica*	*Constantinea subulifera* *Odonthalia flocossa*	*Zostera marina* *Cryptopleura* sp. *Gymnogongrus* sp. *Laurencia spectabilis* *Opuntiella californica* *Polyneura latissima* *Rhodymenia pertusa*
Zone 2										
-3.4 to -3.8	M	3	5	4	2538	22	10	*Cryptopleura* sp. *Odonthalia flocossa* *Rhodymenia pertusa*	*Constantinea subulifera* *Gigartina exasperata* *Gymnogongrus* sp. *Laurencia spectabilis*	*Gigartina* sp. *Gracilaria* sp. *Neoagardhiella baileyi*

Table 7 (cont'd)

Depth range (m)	Egg int.	Egg lay.	Cover value	No. of samples	Average eggs/m^2 ($\times 10^3$)	% of total eggs	% of total area	Substrate species: Major	Substrate species: Minor	Substrate species: Incidental
Zone 3										
-3.5 to -6.7	L	1	2	19	228	4	18	Cryptopleura sp. Neoagardhiella baileyi Odonthalia flocossa	Zostera marina Laminaria groenlandica Gracilaria sp. Laurencia spectabilis Rhodymenia pertusa	Constantinea subulifera Corallina sp. Gigartina sp. Gymnogongrus platyphyllus Gymnogongrus sp. Polysiphonia hendryi Ptilota sp.
Zone 4										
-2.1 to -5.5	L	2	5	15	980	11	13	Constantinea subulifera Cryptopleura sp. Laurencia spectabilis Odonthalia flocossa	Laminaria groenlandica Gymnogongrus sp. Neoagardhiella baileyi Rhodymenia pertusa	Agarum fimbriatum Constantinea simplex Gigartina exasperata Gigartina sp. Gracilaria sp. Gymnogongrus leptophyllus Gymnogongrus platyphyllus Polyneura latissima

Table 7 (cont'd)

Depth range (m)	Egg int.	Egg lay.	Cover value	No. of samples	Average eggs/m^2 ($\times 10^3$)	% of total eggs	% of total area	Substrate species: Major	Substrate species: Minor	Substrate species: Incidental
Zone 5										
-1.1 to -3.8	M	4	5	23	2253	48	25	Cryptopleura sp. Gymnogongrus platyphyllus Laurencia spectabilis Odonthalia flocossa	Laminaria groenlandica Constantinea subulifera Gracilaria sp. Gymnogongrus sp. Neoagardhiella baileyi Rhodymenia pertusa	Zostera marina Sargassum muticum Gigartina sp. Rhodoptilum plumosum
Zone 6										
-0.3 to -1.7	L	2	3	6	609	1	2	Zostera marina	-	-
Zone 7										
+2.8 to -2.2	L-M	2	4	19	753	9	14	Zostera marina Fucus sp. Odonthalia flocossa Rhodomela sp.	Gigartina sp. Gracilaria sp. Gymnogongrus platyphyllus Gymnogongrus sp. Laurencia spectabilis	Costaria costata Sargassum muticum Constantinea subulifera Cryptopleura sp. Neoagardhiella baileyi Polysiphonia hendryi
Zone 8										
+3.0 to +1.1	L-M	3	4	5	607	2	3	Fucus distichus	Rhodomela larix	Ulva sp.

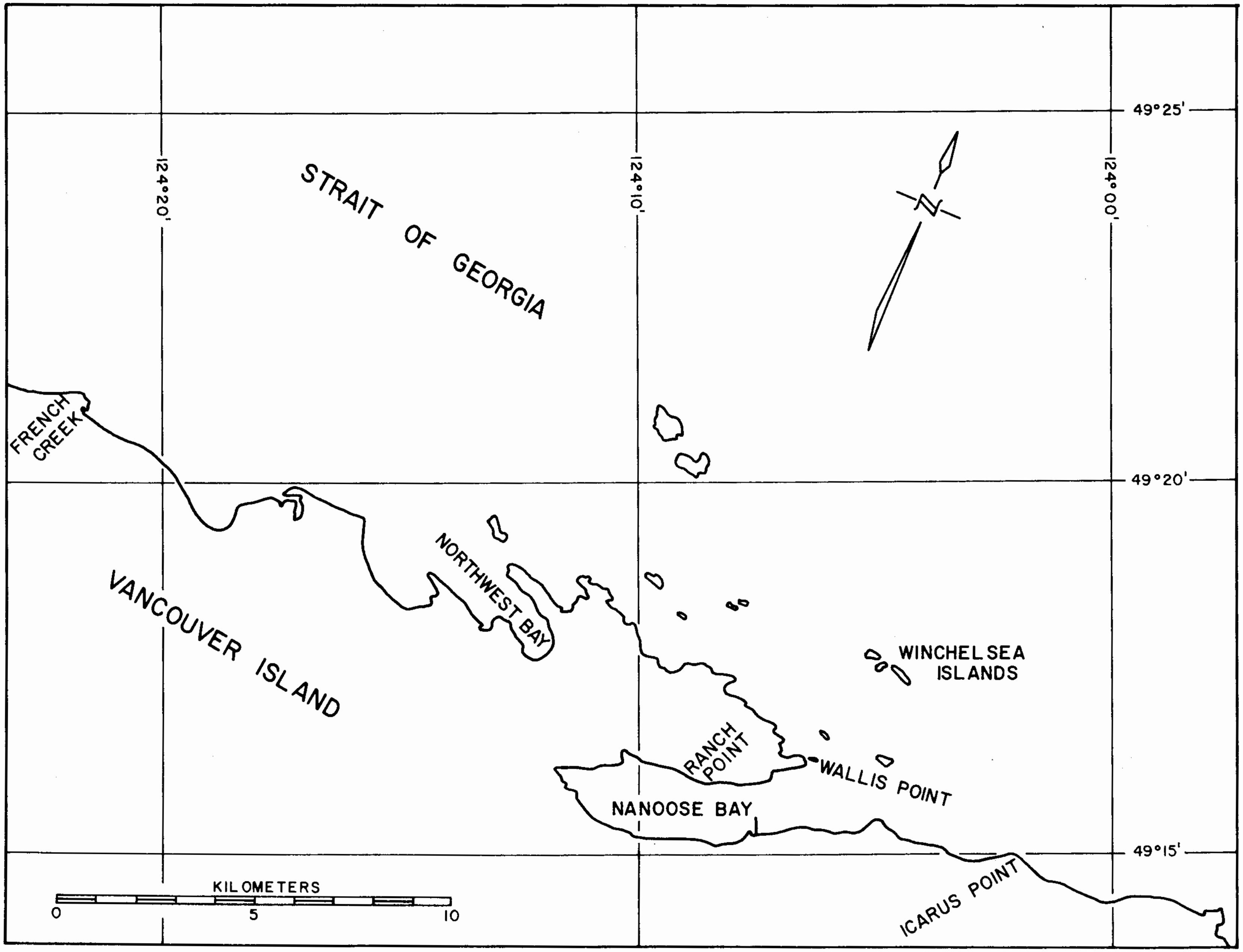


Fig. 1. Sampling and recording locations near Nanoose Bay.

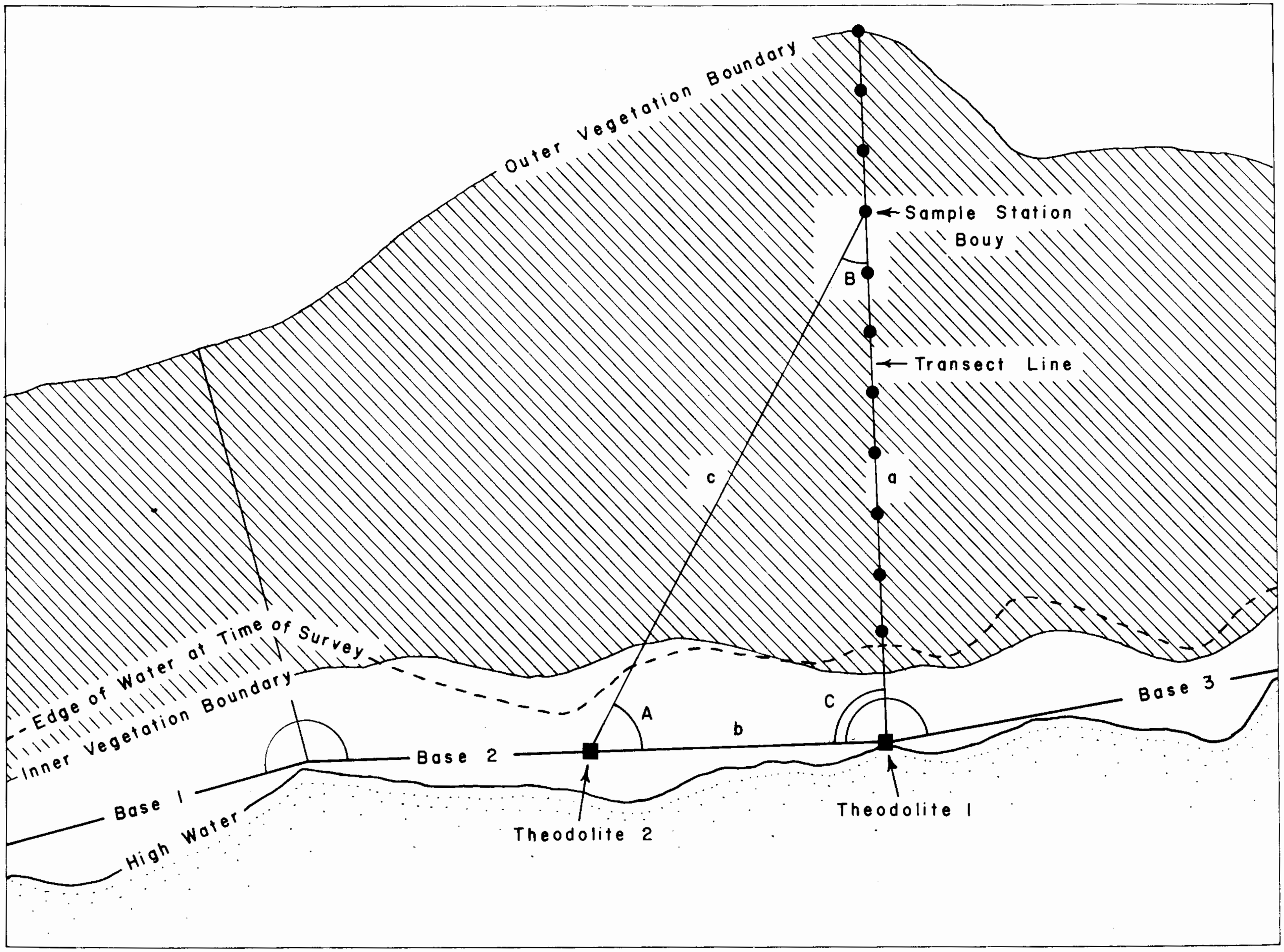


Fig. 2. Graphic representation of typical survey situation.

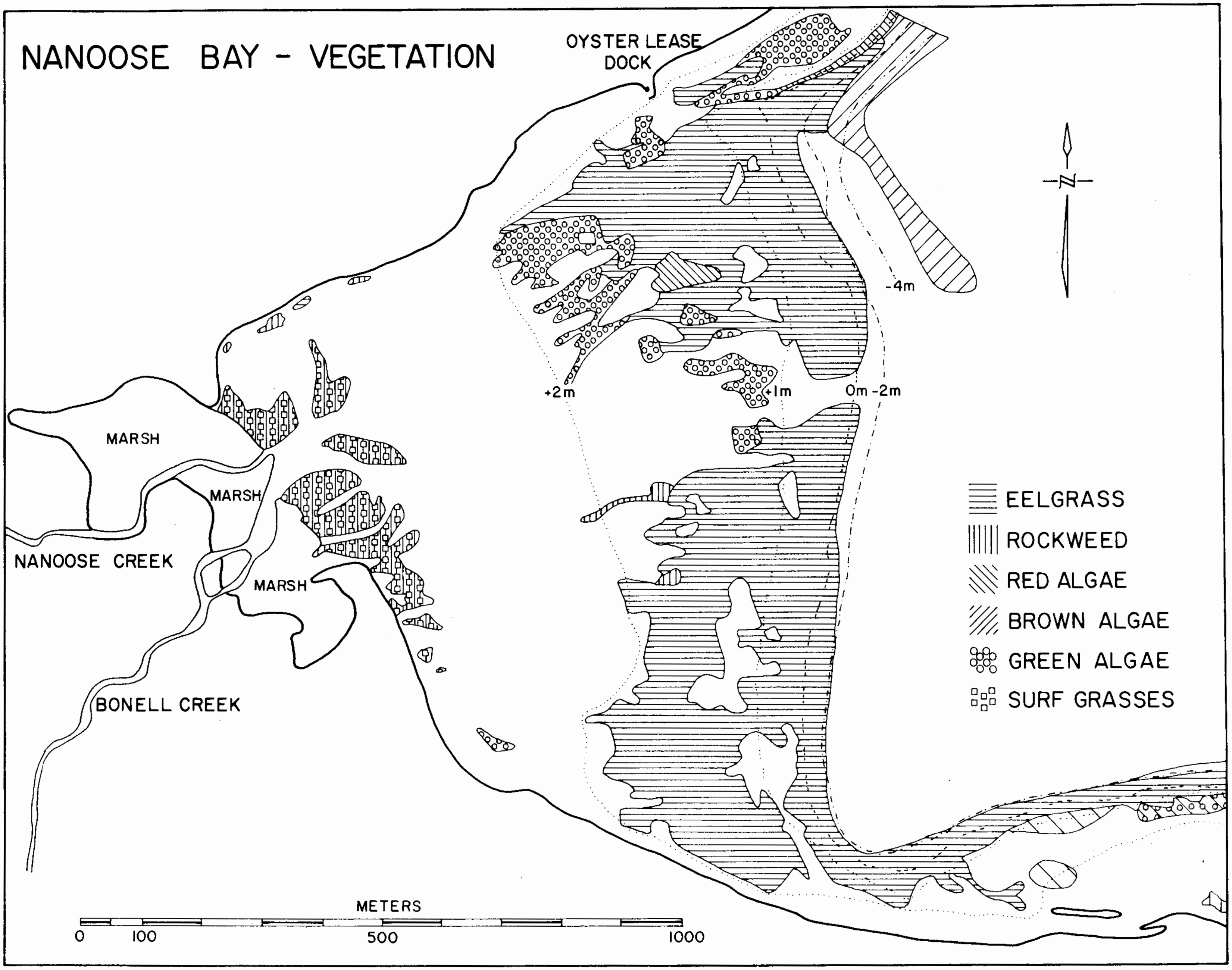


Fig. 3. Vegetation chart for the head of Nanoose Bay.

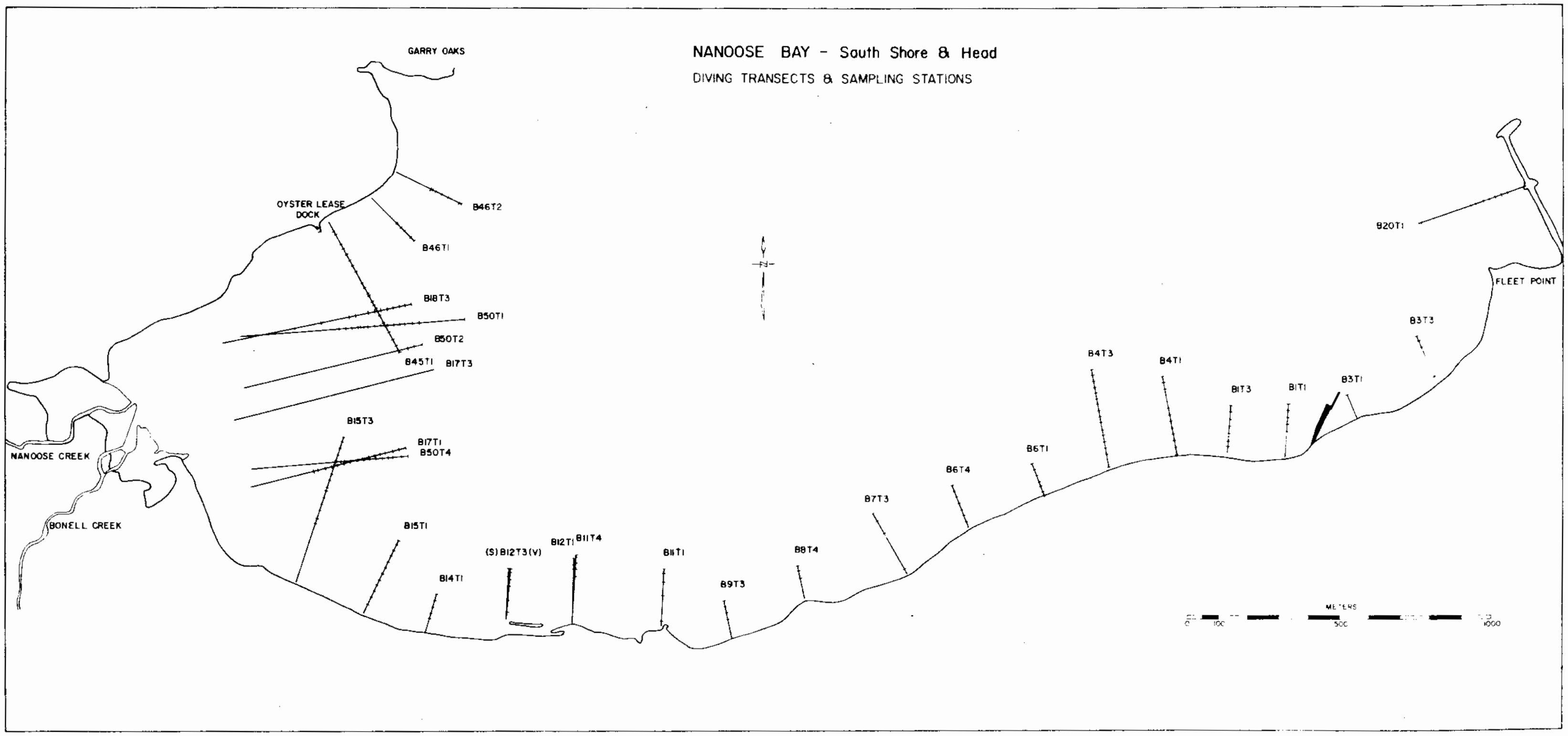


Fig. 4. Diving transects and sampling stations in Nanoose Bay.

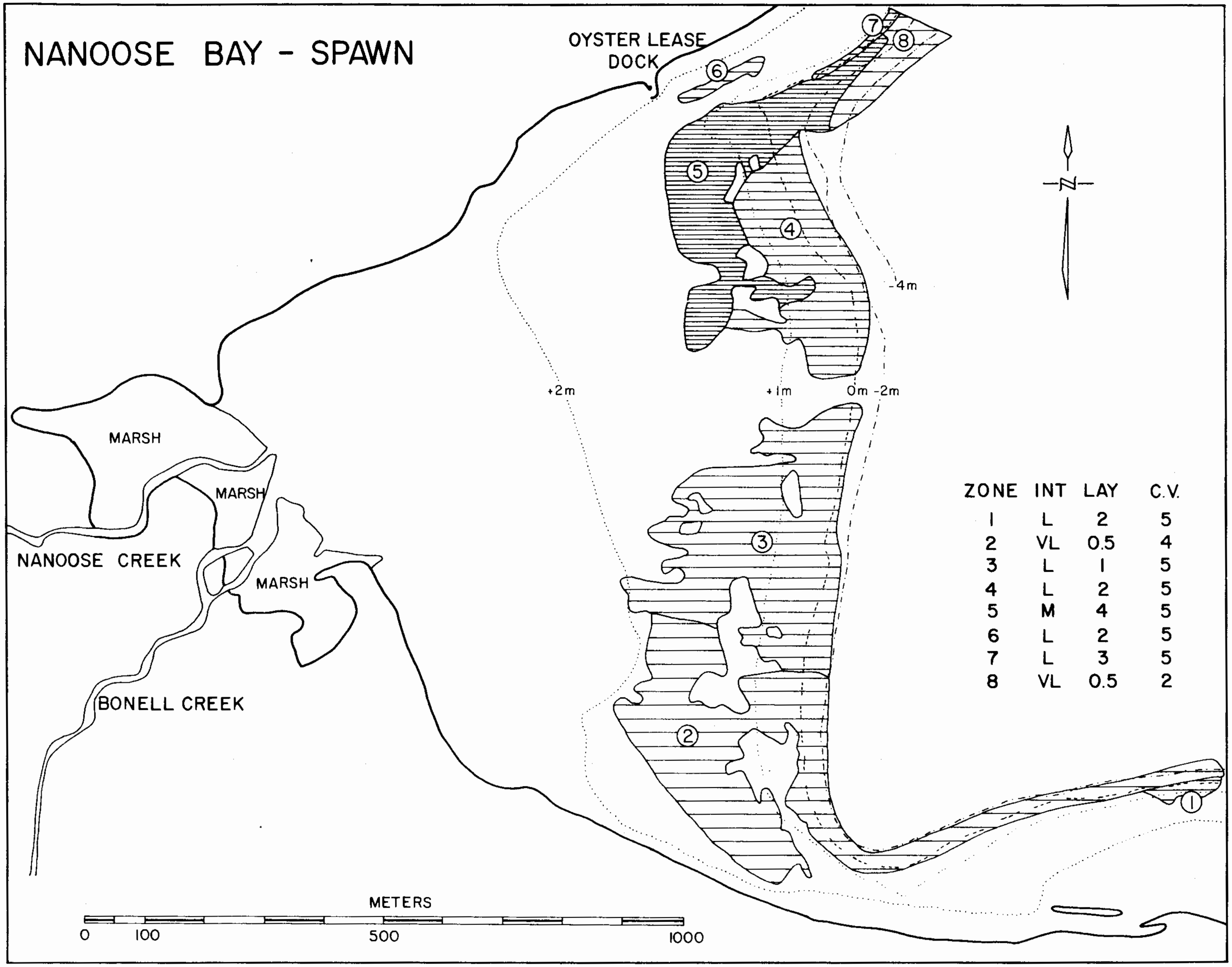


Fig. 5. Distribution of herring spawn at the head of Nanoose Bay (1976).

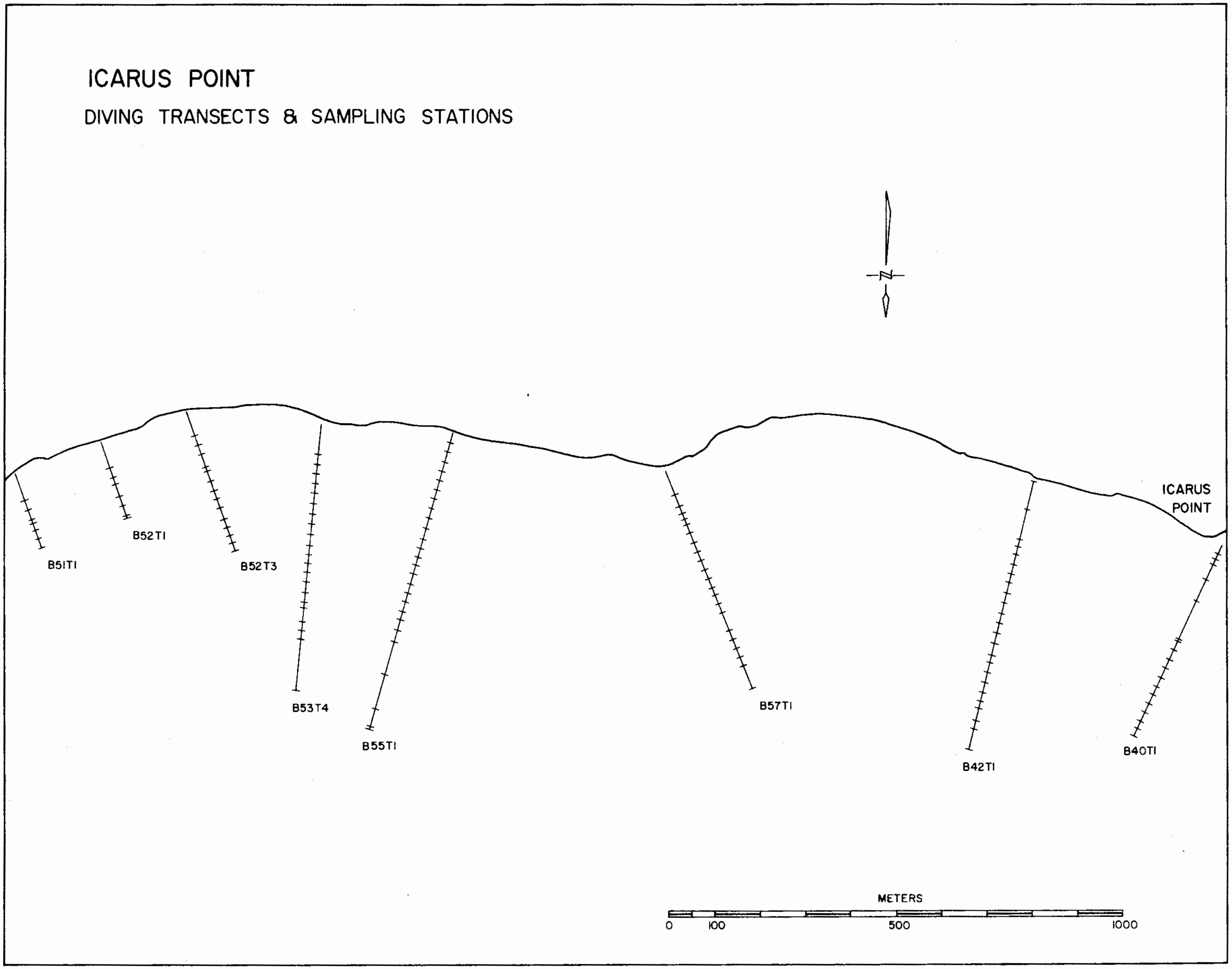


Fig. 6. Diving transects and sampling stations at Icarus Point.

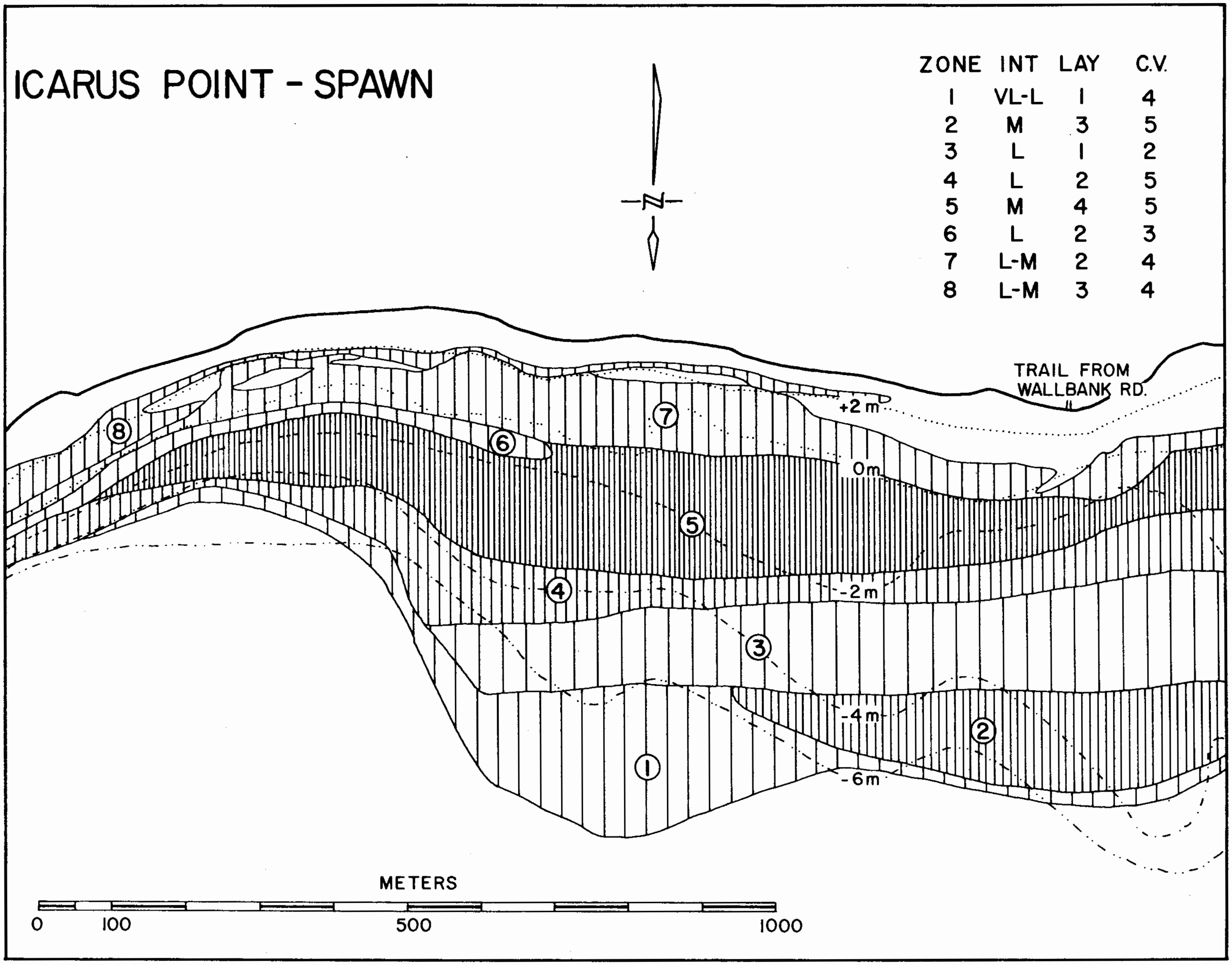


Fig. 7. Distribution of herring spawn at Icarus Point (1976).

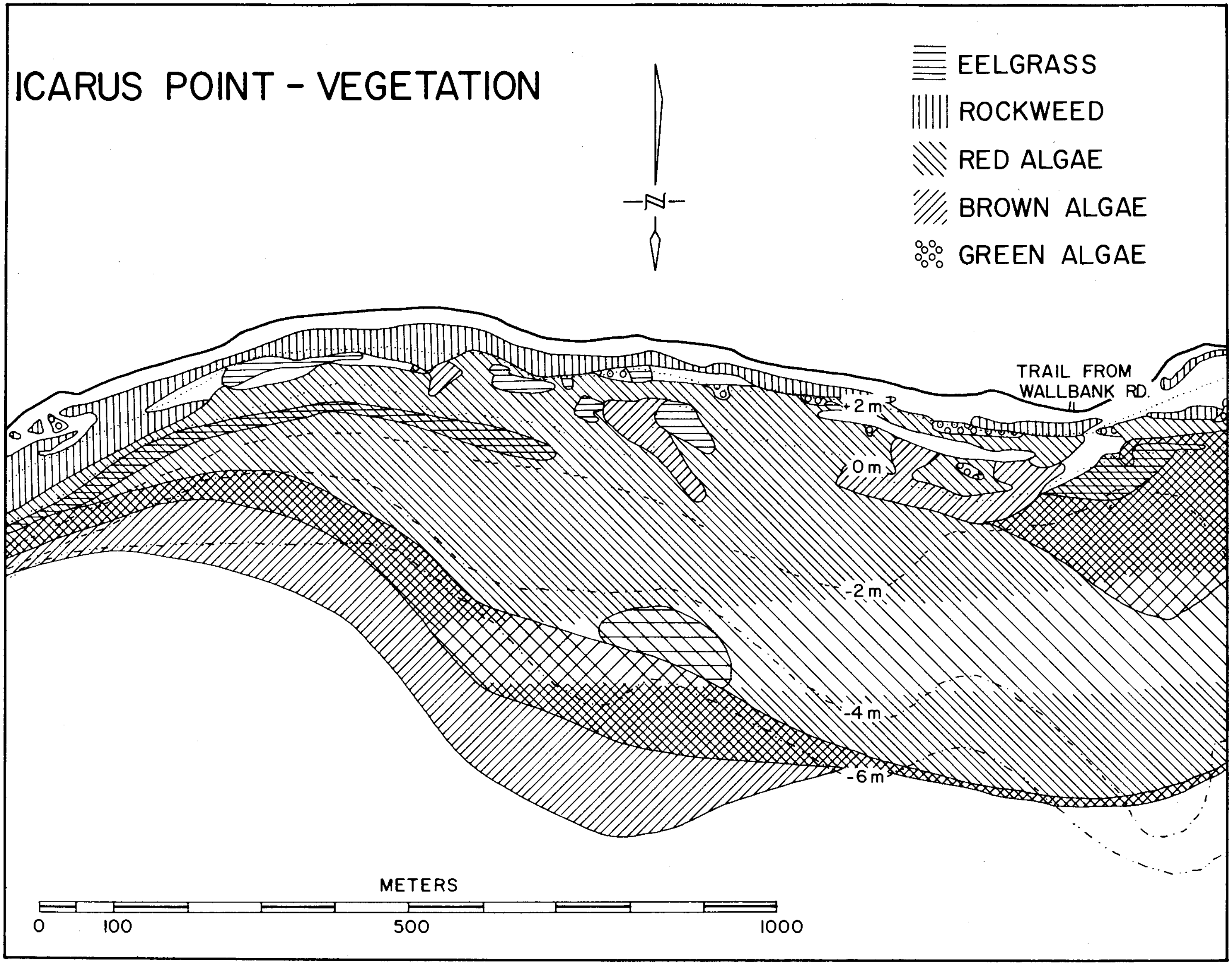


Fig. 8. Vegetation chart for Icarus Point.

APPENDIX A

ENVIRONMENTAL MONITORING

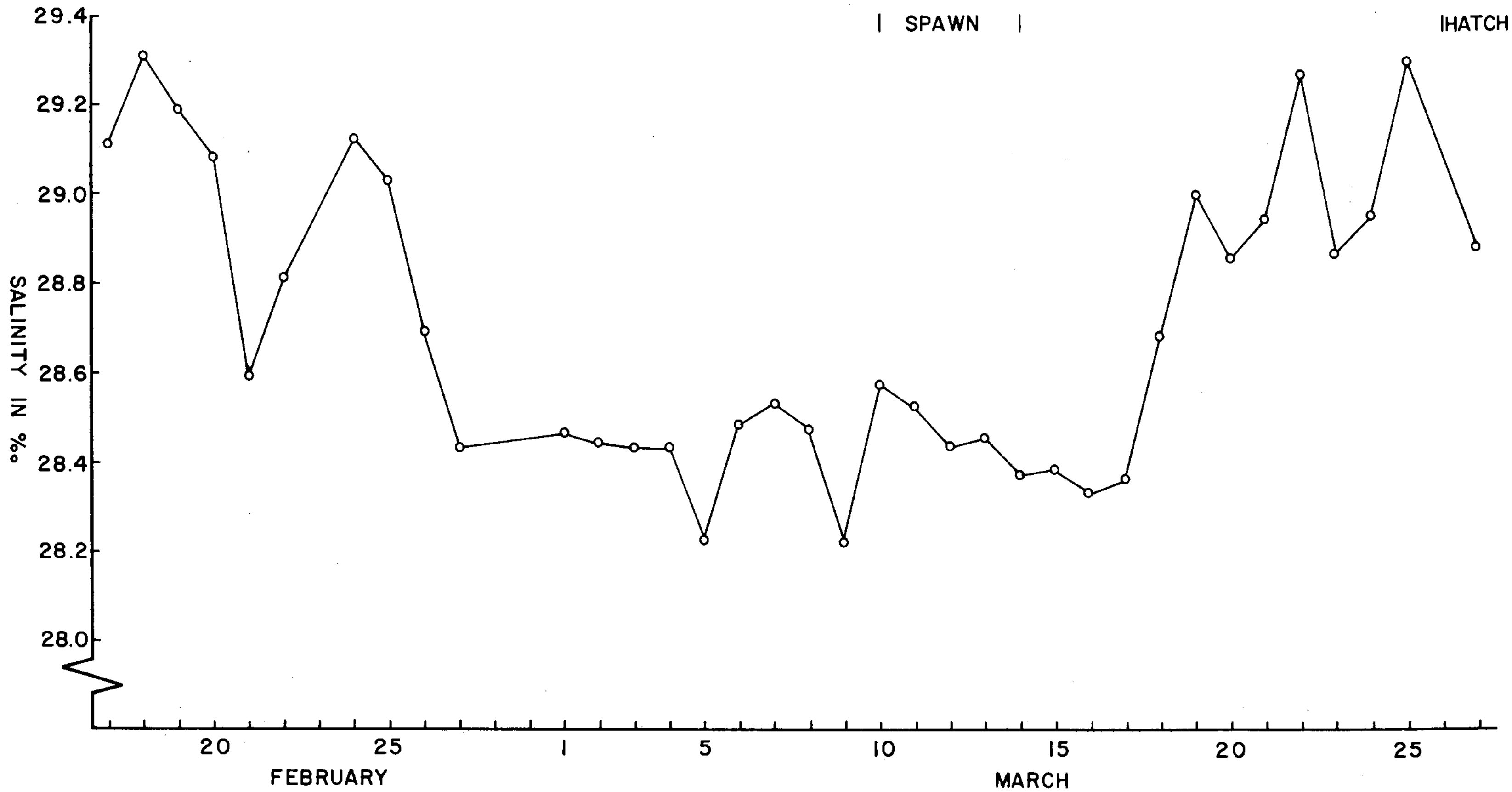
During the research team's presence in Nanoose Bay, daily water temperature and salinity observations were made. From February 17 to 22, observations were made at Navy Buoy no. 2 in the middle of Nanoose Bay, where the bottom depth was 29 m. From February 23 to March 27, observations were made at a mooring at Ranch Point (Fig. 1) where the bottom depth was 23 m.

Water samples were obtained at 10 m from the surface at 1300 hr each day with a Van Dorn bottle, temperatures were taken and a water sample preserved for subsequent salinity determination with an inductively coupled salinometer. Surface water temperature readings were obtained also.

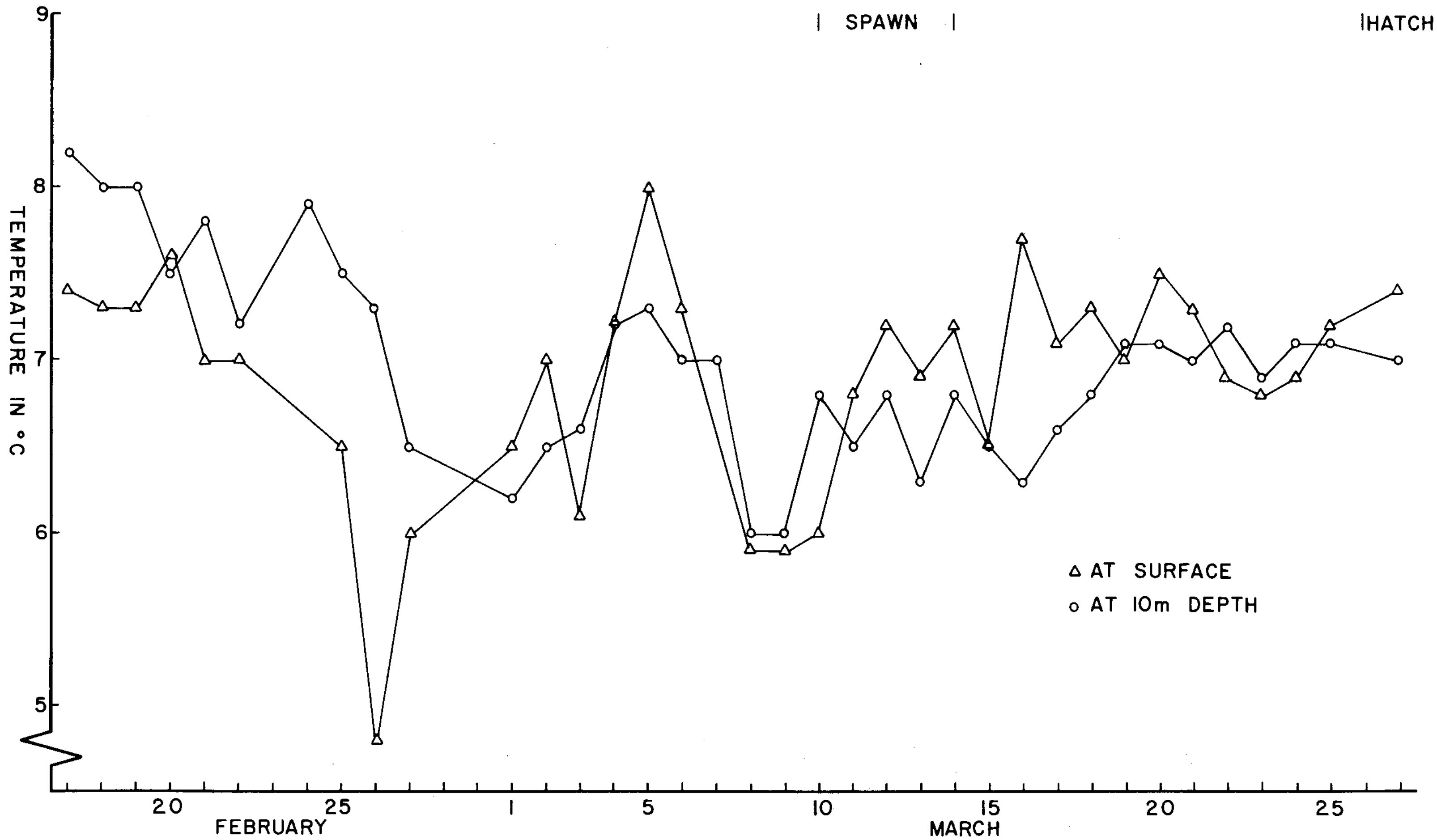
The salinity at 10 m from the surface varied only between 29.31‰ and 28.22‰. Salinities showed a moderate decline from the beginning of observations to the time of herring spawning (Appendix Fig. 1) and increased again to the time of hatching.

The temperatures at 10 m from the surface ranged between 8.2 C and 6.0 C, being lowest just prior to the commencement of spawning (Appendix Fig. 2). During the egg incubation period, 10 m deep temperatures were between 6.3 C and 7.2 C. Surface temperatures fluctuated more widely between 8.0 C and 4.8 C but also were at a low reading of 5.9 C just prior to spawning (Appendix Fig. 2). During the egg incubation period, surface temperatures were between 6.8 C and 7.7 C.

Alderdice and Velsen (1971) working with herring eggs in the laboratory calculated optimum conditions for maximum total hatch: 12.01‰ S, 6.46 C; maximum viable hatch: 16.98‰ S, 8.33 C; maximum length of newly hatched larvae: 20.00‰ S, 5.54 C. Survival of viable larvae to yolk sac obsorption placed the lower limit of thermal tolerance of Pacific herring eggs between 4 and 5 C.



Appendix Fig. 1. Salinity at Ranch Point, Nanoose Bay, at 10 m depth (1976).



Appendix Fig. 2. Temperature at Ranch Point, Nanoose Bay, at surface and 10 m depth (1976).