W.P.

SURVEYS OF HERRING SPAWNING HABITAT

Annette Islands Reserve, Alaska

C RIM PLANNERS, INC.

SURVEYS OF
HERRING SPAWNING HABITAT
on the
ANNETTE ISLANDS RESERVE, ALASKA

January, 1982

Prepared for the

Metlakatla Indian Community

by

Pacific Rim Planners, Inc.
5606 14th Avenue Northwest
P. O. Box 70324
Seattle, Washington 98107

This project was supported, in part, by Federal Coastal Zone Management Program Implementation Funds (P.L. 92-583, Sec. 306) granted to the State of Alaska by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U. S. Department of Commerce.

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INTRODUCTION

Pacific herring spawn at two locations on the Annette Islands Reserve. At Crab Bay, they usually spawn in early April. In the Cedar Point - Smuggler's Cove area, spawning is usually in late April or early May. In years when the herring stocks are large enough to support a harvest, there is a commercial herring roe fishery, which, under ideal conditions, opens just before spawning begins, to catch the herring when the roe is most ripe.

In the late 1960's and early 1970's the Crab Bay stock was subjected to intense fishing pressure, both on the reserve, and in Tongass Narrows, Carroll Inlet and George Inlet, where the fish often winter. Between 1972 and 1977 the winter food and bait fishery took an average of 1400 tons per year from this stock. The roe fishery took 135 tons in 1976, the first year of roe fishing, and 250 tons in 1977. In 1978, hydroacoustic surveys conducted by the Alaska Department of Fish and Game found only small schools of herring in George Inlet and Tongass Narrows, and that spring there was no spawning activity in the Crab Bay area.

At that time the Annette Natural Resource Center began intensive management of the herring fishery. These management activities have included pre-spawning surveys with sonar and recording fathometer, close monitoring of the harvest and fishing effort, and spawning ground surveys. The spawning ground surveys are designed to measure the extent and intensity of herring spawn deposition, to estimate the spawning escapement and provide information for setting a harvest guideline for the following year.

These surveys have been conducted by SCUBA divers, taking samples of eggs from quadrats along predetermined transect lines. The egg counts are extrapolated over the area represented by the samples to give an estimate of total eggs deposited on the spawning grounds.

While it is usually possible to collect an adequate number of spawn samples to estimate the intensity of deposition (eggs per square meter), the estimates of total area extent of spawn are often limited by rough weather, or by the need to manage another herring roe fishery opening. When no other means can be used, the extent is estimated from aerial observations during the time of spawning, but these observations can be misleading, since the tidal current can carry the milt a good distance away from the actual spawn deposition, and make the extent of the spawn look larger than it actually is. Aerial surveys, for example, may show milt in the water in areas where there is no vegetation suitable as a spawning substrate.

This study of the vegetation on the herring spawning grounds had three objectives:

1. Measure the extent, type and coverage of vegetation on the spawning grounds.

2. Map the vegetation for use in future herring spawn surveys.

3. Estimate the carrying capacity of the vegetation as a spawning substrate.

METHODS

Vegetation and bottom substrate were mapped on the herring spawning grounds by SCUBA divers swimming along transect lines. The weighted 150-meter nylon transect lines were set perpendicular to shore along the bottom from a depth at the time of sampling of approximately two feet at the shore.

The transect line was marked with stations at 5-meter intervals. At each station the divers noted on mylar pads their observations of depth, sediment type, vegetation type and percent coverage of vegetation. No samples were taken except where needed for identification of algae. In areas where the vegetation extended farther than 150 meters from shore, the transect line was pulled and reset to continue the original line; the surveys continued to at least the lower limit of the vegetation.

The transect data were plotted on mylar overlays of 20x enlargements of NOAA chart 17434, and are shown in Figures 2b through 6b. Areas of each vegetation type were measured with a dot grid accurate to 100 m^2, and converted by percent coverage to standard areas of 100% coverage. For example, 10 acres of eelgrass bed at 40% coverage was reduced to 4 acres at 100% coverage.

Carrying capacity was estimated by using previous years' egg counts on each vegetation type. Data from samples taken from 1978 through 1981 which had medium spawn (complete coverage of eggs on vegetation, one egg layer deep) were compiled and averaged for each of seven major vegetation types, to give an average number of eggs per square meter at medium intensity for each vegetation type. The area of each vegetation type, corrected to 100% coverage, was multiplied by the average eggs per square meter, to give an estimate of the total number of eggs that would be deposited if all the available vegetation were covered with medium spawn. Finally, this number was divided by the fecundity (approximately 103 million eggs per ton of spawning herring) to give an estimate of the biomass of spawners that could deposit the capacity number of eggs.

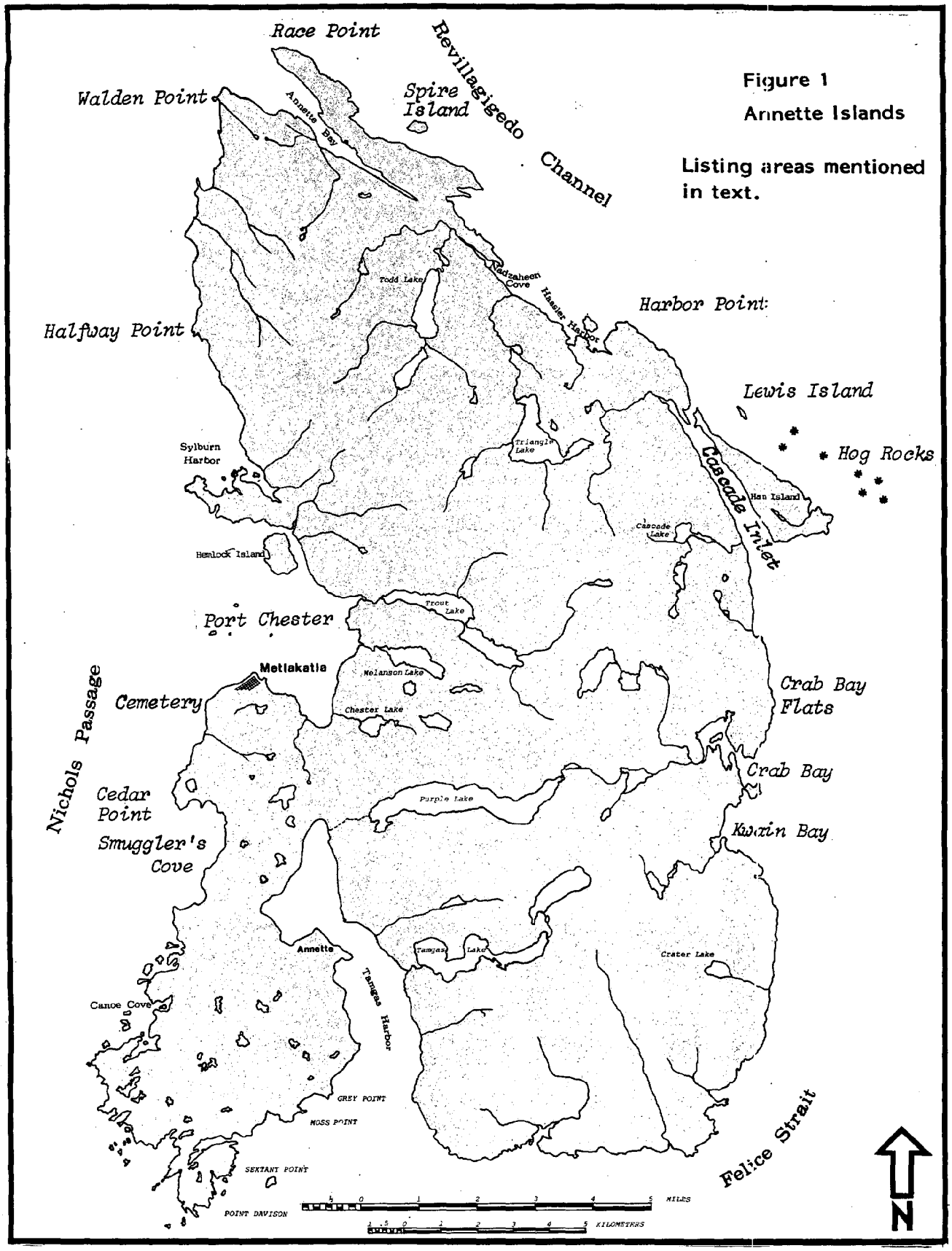


Figure 1

Annette Islands

Listing areas mentioned in text.

RESULTS AND DISCUSSION

EXTENT OF SPAWNING VEGETATION

A total of 53 hectares (130 acres) of vegetation was mapped and measured in the Crab Bay area (Table 1). Nearly three-quarters of this vegetation, or 38 hectares, is kelp, which grows profusely on the rock outcroppings at the mouth of Crab Bay and on rock outcroppings and boulders on Crab Bay Flats. This figure does not include areas such as the rocks on the south side of Crab Bay's mouth where kelp grows, but no herring spawn has been seen, so the extent of the kelp in the area is considerably greater. The kelp averages about 46% bottom coverage in the kelp beds, but in some areas was much thicker. The growth of kelp on the rocky point on the north side of Crab Bay covered the rocks completely, several layers thick.

Eelgrass was the second most abundant vegetation, with about 8 hectares (20 acres) of eelgrass bed measured along the north half of Crab Bay Flats and inside Crab Bay. The eelgrass grows in mixed gravel, sand, and mud sediment, and so is not found in any great abundance on the rock- and boulder-covered bottom along the southern half of the Flats or at the mouth of Crab Bay. Where the eelgrass does grow, it averages about 60% bottom coverage, although the coverage ranges from a sparse 2% to a luxuriant 100%.

VEGETATION ZONATION

The vegetation mapped by the divers generally grows in bands, or zones, parallel to the shoreline. These zones are arranged according to depth. *Fucus* (rockweed) grows on the rocks above the 0 tide level (mean lower low water). Below that level grow other brown algae, and red algae such as *Rhodomela*, a much-used substrate for herring spawning. Eelgrass thrives on a mud, sand or gravel bottom from the 0 tide level out to about -10 or -20 feet. If the lower intertidal or shallow subtidal bottom is made up of cobbles, boulders or bedrock outcropping, it is vegetated with kelp (*Laminaria* or *Agarum*) and/or with hair-kelp or leggy *(Desmarestia)*.

Green algae generally grows higher up on the beach. Since the herring seldom spawn at the upper tide levels, the green algae was not mapped.

The zonation of vegetation is evident along fairly uniform lengths of shoreline, such as at the north end of Crab Bay Flats (Figure 2b) and the shoreline from the Metlakatla Cemetery to Cedar Point (Figures 4b and 5b). Although the bands of vegetation shown on the map are partly an artifact of the mapping process, in which the vegetation data was extrapolated beyond the transect lines, the bands of eelgrass and kelp extend beyond just one or two transects. Future spawn sampling, therefore, can be designed around these large extents of vegetation.

TABLE 1

EXTENT OF MARINE VEGETATION

(Area in hectares)[1]

	Fucus	*Macrocystis* Kelp	Other Kelp	*Desmarestia*	Other Brown & Red Algae	Eelgrass	Totals
CRAB BAY AREA							
Vegetated Area	2.87	0	38.11	1.19	2.37	8.02	52.56
Adjusted for Coverage	1.47	0	17.38	.30	2.37	4.78	26.30
SMUGGLER'S COVE-CEDAR POINT AREA							
Vegetated Area	3.14	1.05	33.35	8.34	1.29	14.43	61.36
Adjusted for Coverage	2.48	1.05	20.68	4.93	1.25	13.74	43.89

[1] One hectare = 10,000 square meters = 2.471 acres

Once the limits of the spawn are found, the north half of Crab Bay Flats, for example, could probably be fairly reliably sampled by two well-placed transects, as additional transects would only duplicate the data. Other areas, such as the mouth of Crab Bay, are more variable, and would require more intensive sampling to reliably estimate the amount of spawn deposition.

CARRYING CAPACITY

The 26 hectares of vegetation mapped in the Crab Bay area could be used as a substrate for an estimated 294 billion herring eggs if those eggs were deposited one layer thick. The conversion of 103 million eggs deposited by one ton of spawning herring indicates that the vegetation could support the eggs of about 2,850 tons of spawners (Table 3).

At the Cedar Point - Smuggler's Cove area, the 44 hectares of vegetation mapped could provide a substrate for at least 672 billion herring eggs, which would be deposited by 6,277 tons of spawning herring (Table 4).

Tables 3 and 4 also show the estimated 95% confidence interval, or the range within which we can be 95% confident the spawning capacity would fall. These figures are derived mathematically, and should be used with some caution. The lower limit of the confidence interval for Crab Bay is 485 tons, but since 1,200 tons of spawning escapement has been documented in the Crab Bay area, the 485-ton figure is of only academic interest.

The capacity estimates themselves should be considered very conservative estimates for several reasons. First, the surveys only covered areas in which herring spawn has been sampled since 1978. They did not cover the north shoreline of Smuggler's Cove, which has eelgrass and kelp, but has not been used recently for herring spawning. They also did not cover Cascade Inlet on the east side of Annette Island, which was used for herring spawning in 1977 at a time when heavy southeast winds forced the fish north from Crab Bay Flats. Cascade Inlet was not surveyed since the spawning at Cascade Inlet appeared to be due to the storm rather than to the desirability of the spawning substrate. Nevertheless, if the herring stocks reached a level above the estimates shown in Tables 3 and 4, they might use these other areas for spawning as well.

Second, the medium spawn intensity, used here, one egg layer thick on the vegetation is not necessarily the upper limit of egg survival. Herring eggs can survive through incubation and hatching at more than one egg layer thick. If good survival could be obtained at two egg layers thick, all these estimates could be doubled. Table 5 shows the decline in hatching success that could be expected for herring eggs in layers of varying thickness, in water temperatures and salinities approximating

TABLE 2

ANNETTE ISLANDS
HERRING SPAWN DEPOSITION
AT MEDIUM SPAWN INTENSITY
with 95% Confidence Intervals

Vegetation Type			
Common Name	Scientific Name	Eggs per 0.1 m^2	Billion Eggs per Hectare
Rockweed, popweed	*Fucus*	85,444 ± 49,110	8.5 ± 4.9
Kelp	*Laminaria, Agarum*	105,089 ± 83,536	10.5 ± 8.4
Hair kelp, Leggy[1]	*Desmarestia*	93,264	9.3
Other Brown and Red Algae		148,532 ±308,091	14.9 ±30.8
Eelgrass	*Zostera*	126,728 ±117,503	12.7 ±11.8

[1] No confidence intervals were calculated for *Desmarestia* because only two samples with medium spawn were taken.

TABLE 3

CRAB BAY AREA
ESTIMATED CARRYING CAPACITY
OF SPAWNING GROUND VEGETATION

Vegetation Type	Area (Hectares)[1]	Billion eggs/hectare (at Medium Spawn)	Total Eggs at Medium Spawn (Billions) Estimate	Range[2]
Fucus	1.47	8.5 ± 4.9	12.6	5.4 - 19.8
Kelp	17.38	10.5 ± 8.4	182.5	37.4 - 327.6
Desmarestia	0.30	9.3	2.8	2.8 - 2.8
Other Brown and Red Algae	2.37	14.9 ±30.8	35.3	0 - 108.3
Eelgrass	4.78	12.7 ±11.8	60.7	4.3 - 117.1
Totals:	26.30		293.9	49.9 - 575.6
Tons of herring depositing spawn[3]:			2,853	485 - 5,588

[1] Area in hectares is adjusted for percent coverage. See Table 1.
[2] Range indicates the 95% confidence interval.
[3] Conversion used is 103 million eggs deposited by one ton of herring.

TABLE 4

CEDAR POINT - SMUGGLER'S COVE AREA
ESTIMATED CARRYING CAPACITY
OF SPAWNING GROUND VEGETATION

Vegetation Type	Area (Hectares)[1]	Billion eggs/hectare (at Medium Spawn)	Total Eggs at Medium Spawn (Billions) Estimate	Range[2]
Fucus	2.48	8.5 ± 4.9	21.2	8.9 - 33.2
Kelp	20.68	10.5 ± 8.4	217.1	43.4 - 390.9
Desmarestia	4.93	9.3	45.8	45.8 - 45.8
Other Brown and Red Algae	1.25	14.9 ±30.8	18.6	0 - 57.1
Eelgrass	13.74	12.7 ±11.8	174.5	12.4 - 336.6
Macrocystis Kelp[3]	0.81		169.3	86.8 - 169.3
Totals:	43.89		646.5	197.3 - 1058.9
Tons of herring depositing spawn[4]			6,277	1,915 - 10,281

Notes:
1. Area in hectares is adjusted for percent coverage. See Table 1.
2. Range indicates 95% confidence interval, except for *Macrocystis*.
3. *Macrocystis* capacity is estimated as 50% greater than 1979 deposition in eggs/plant, and deposited on 30% more plants than in 1979. Lower limit of range is estimated egg deposition for 1979.
4. Conversion used is 103 million eggs deposited by one ton of herring.

those around Annette Island during herring spawning season. The table shows a decline in hatching with additional egg layers;

TABLE 5

PERCENT HATCHING SUCCESS OF HERRING EGGS

Temperature (°C)	Salinity 0/00	Egg Layers Thickness 1	2	4	8	12	16
8.7 to 9.5	20	69.8	45.3	21.8	22.8	1.0	2.5
8.7 to 9.5	30	31.0	20.8	12.5	3.5	0.5	3.5

Source: Taylor, F.H.C., 1971. Variation in Hatching Success of Pacific Herring (*Clupea pallasii*) Eggs with Water Depth, Temperature, Salinity and Egg Mass Thickness. Rapp P-V Reun. Cons. Perm. Inter. Explor. Mer. 160:34-41.

however, the decline between one and two egg layers is not enough to negate the additional larvae that could be produced by incubating twice as many eggs. It is therefore reasonable to consider that the carrying capacity of the vegetation may be as much as double the estimates shown in Tables 3 and 4.

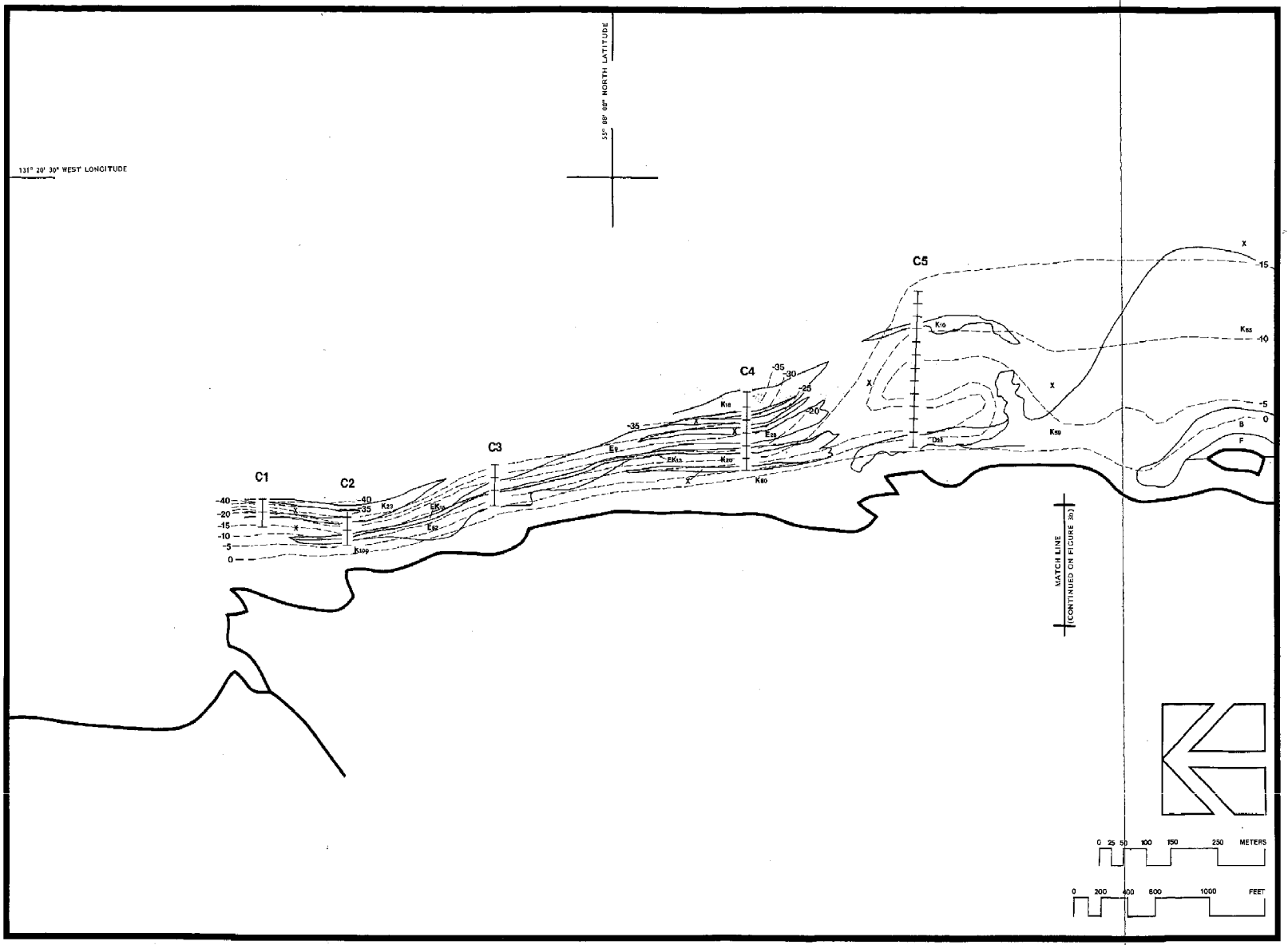
If the estimates in Tables 3 and 4 do either approximate or underestimate the carrying capacity of the vegetation as a spawning substrate for herring, then the availability of spawning substrate clearly does not limit the herring population at this time. In the Crab Bay area, the carrying capacity is more than twice the highest escapement level that has been documented since 1977, when spawn sampling began on the Annette Islands Reserve. In the Cedar Point - Smuggler's Cove area, the carrying capacity is over four times the highest level documented since 1977. The herring populations, then, can certainly grow a great deal before they become limited by spawning vegetation.

This conclusion leads to the question of what does limit the herring populations. In the last four years the harvest has been managed very conservatively. While every fish caught does reduce the population, there has been no harvest since 1978 that has taken over 10 percent of the spawning stock, and it is unlikely that fishing is the limiting factor (although there is some evidence that it was the limiting factor in the early 1970's). More likely, the population size is held down by predation or other mortality in the early life history, the egg and/or larval stages. Heavy bird predation on the eggs can be observed most years, and storm damage appears to inflict heavy egg mortalities in some years.

At this point, it appears that the best that can be done to encourage growth of the herring stocks is to continue with a conservative management policy and to investigate and implement methods to improve survival of herring eggs during incubation.

ACKNOWLEGEMENTS

We wish to thank Reggie Atkinson and Bill Bousley, who did the diving and underwater measurements for this survey; Jim Scudero who adapted his fishing boat, the *Jaime Lee*, as a diving boat; and David Oulette, who assisted in map measurements and data analysis.



LEGEND

TRANSECT EXAMPLE

5 METER HORIZONTAL INTERVAL

CONTOUR INTERVAL 5 FEET

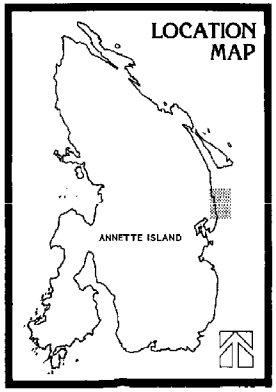
VEGETATION TYPE
PERCENT COVERAGE

S1 — TRANSECT NUMBER

VEGETATION

- B — MIXED BROWN ALGAE
- D — DESMARESTIA
- E — EELGRASS
- F — FUCUS
- K — KELP
- M — MACROCYSTIS KELP
- R — MIXED RED ALGAE
- X — NONE

LOCATION MAP



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HERRING SPAWNING HABITAT
Vegetation

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FIGURE 2b

CAUTION:
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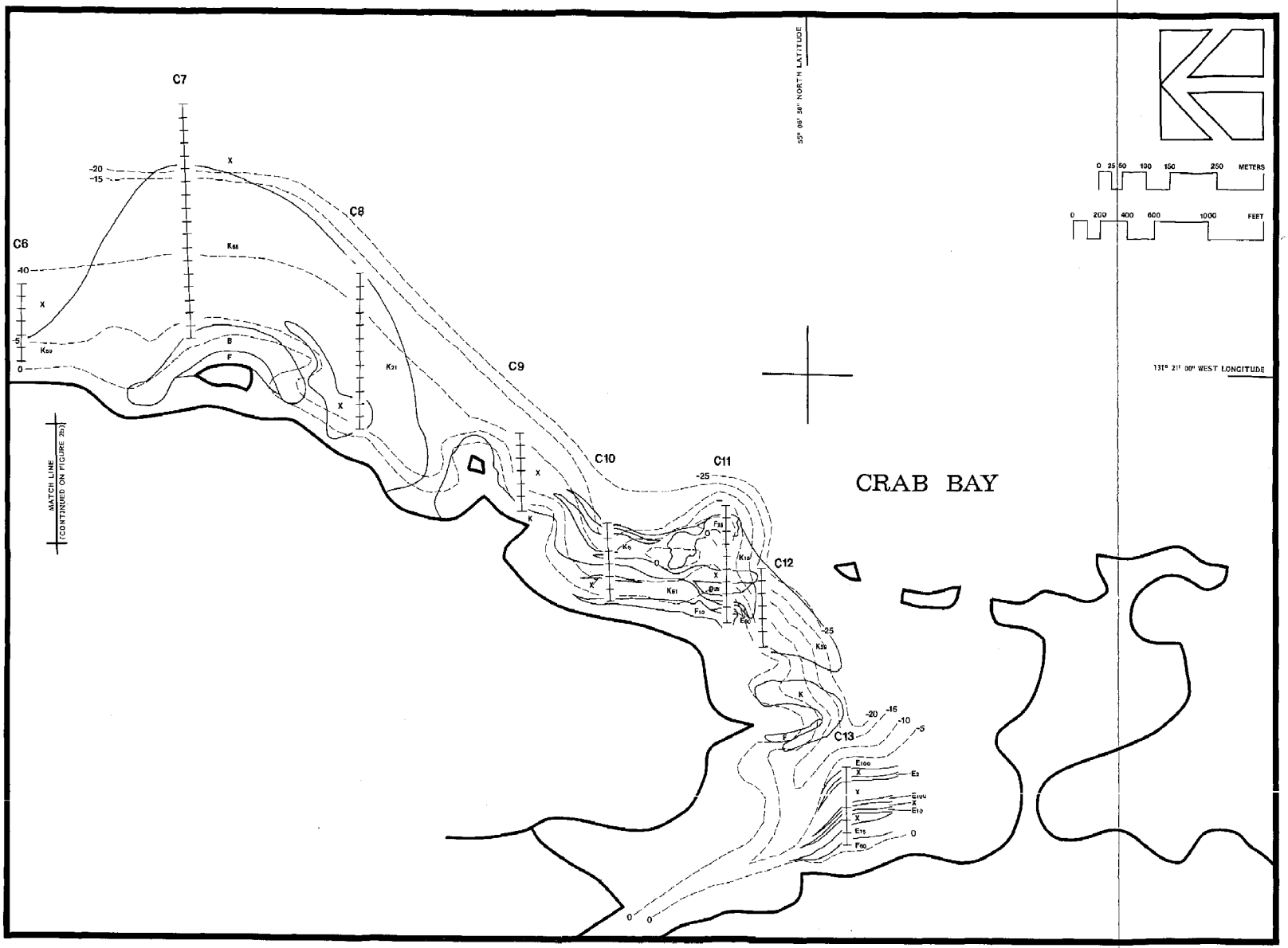

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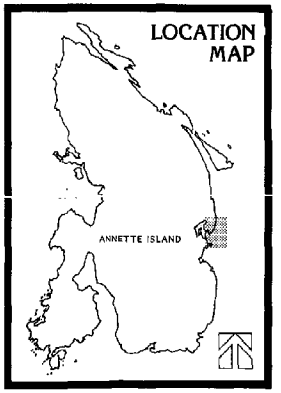

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ANNETTE ISLAND NATURAL RESOURCE CENTER

FIGURE 3b

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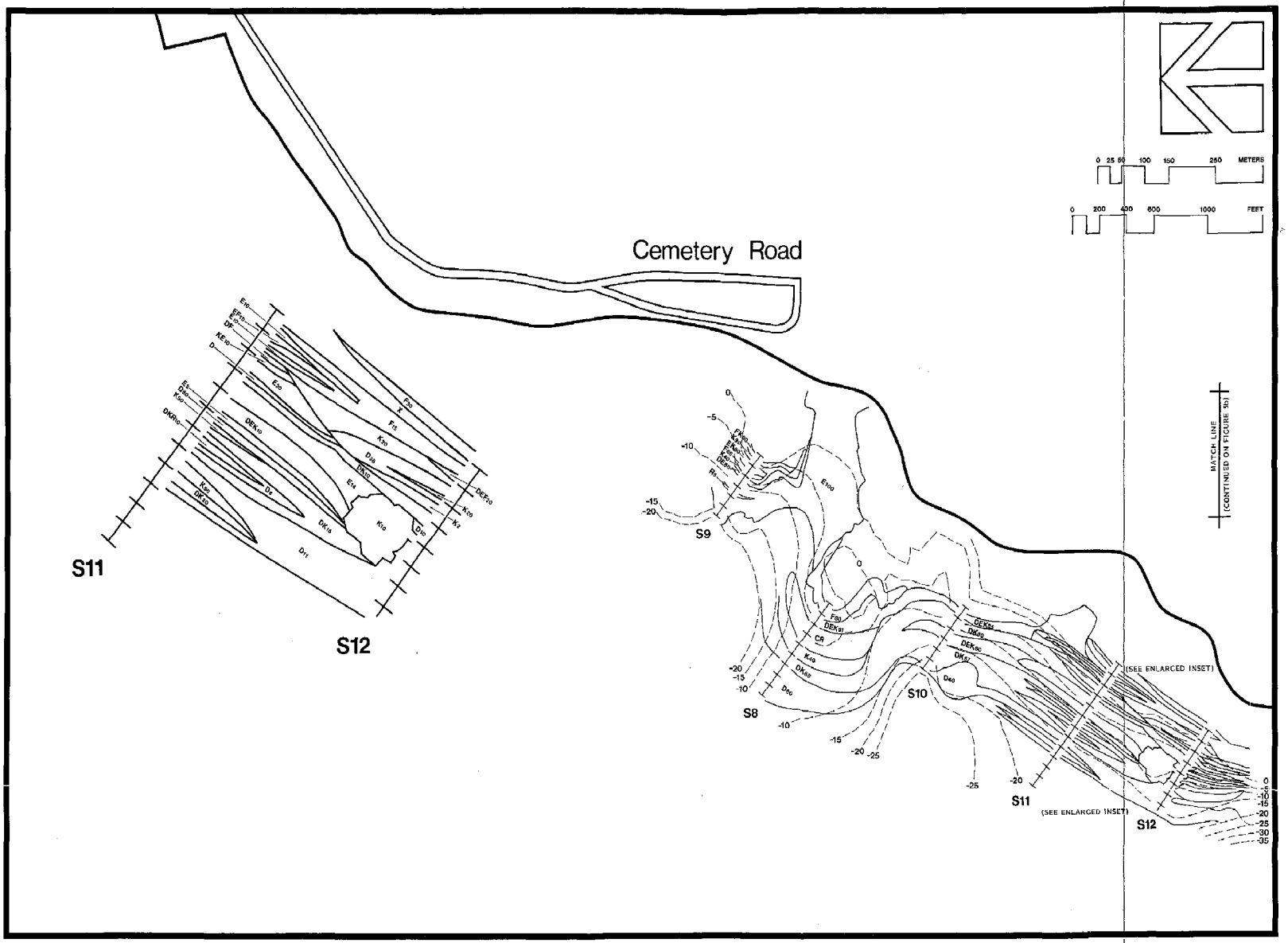

LEGEND

TRANSECT EXAMPLE

5 METER HORIZONTAL INTERVAL

CONTOUR INTERVAL 5 FEET

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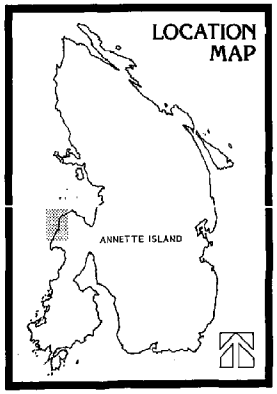

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ANNETTE ISLAND RESOURCE COUNCIL

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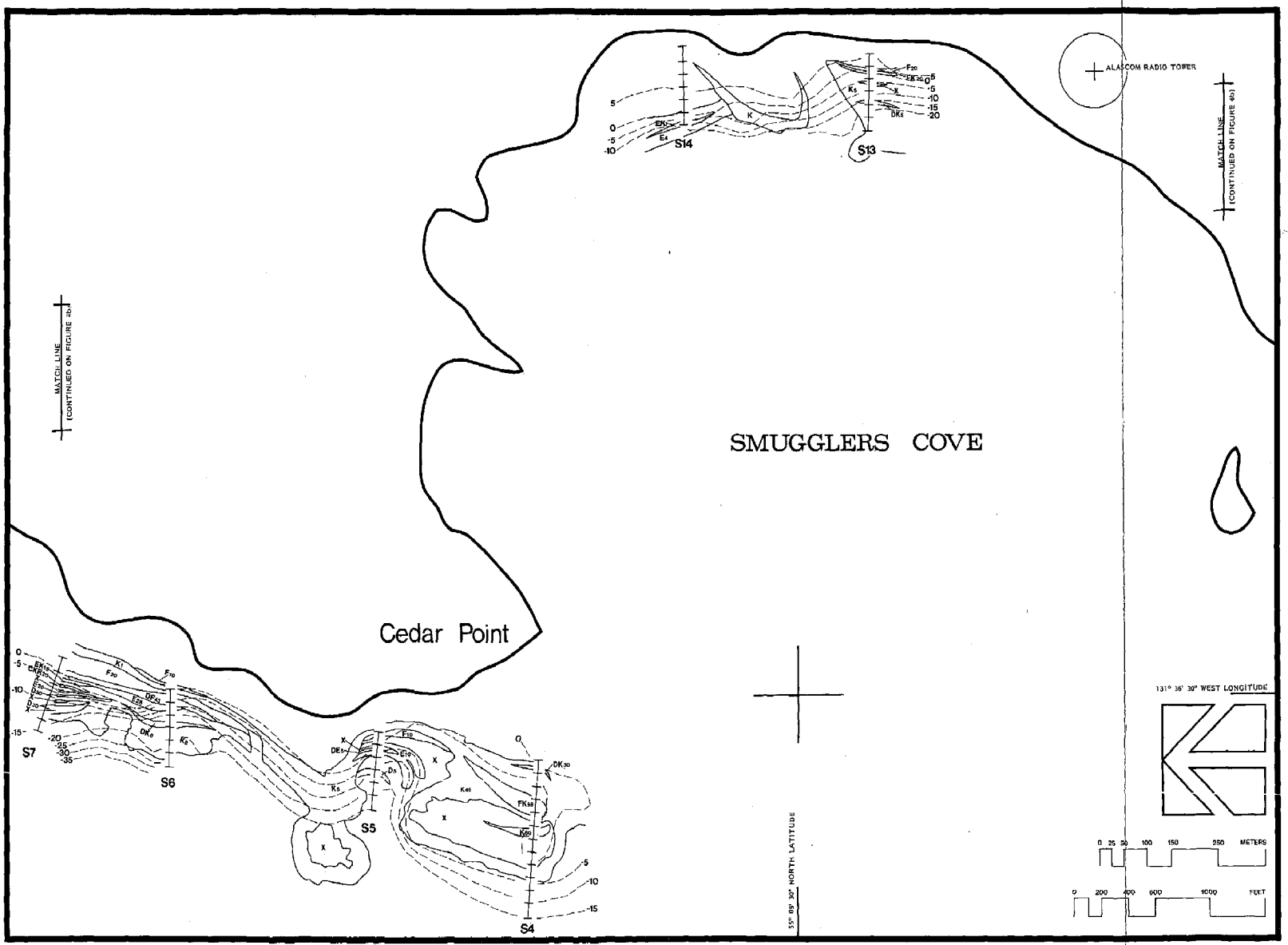

LEGEND

TRANSECT EXAMPLE

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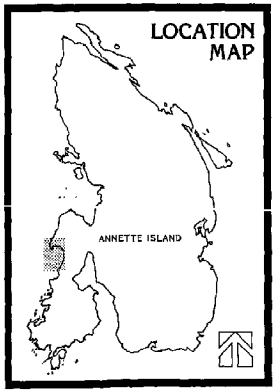

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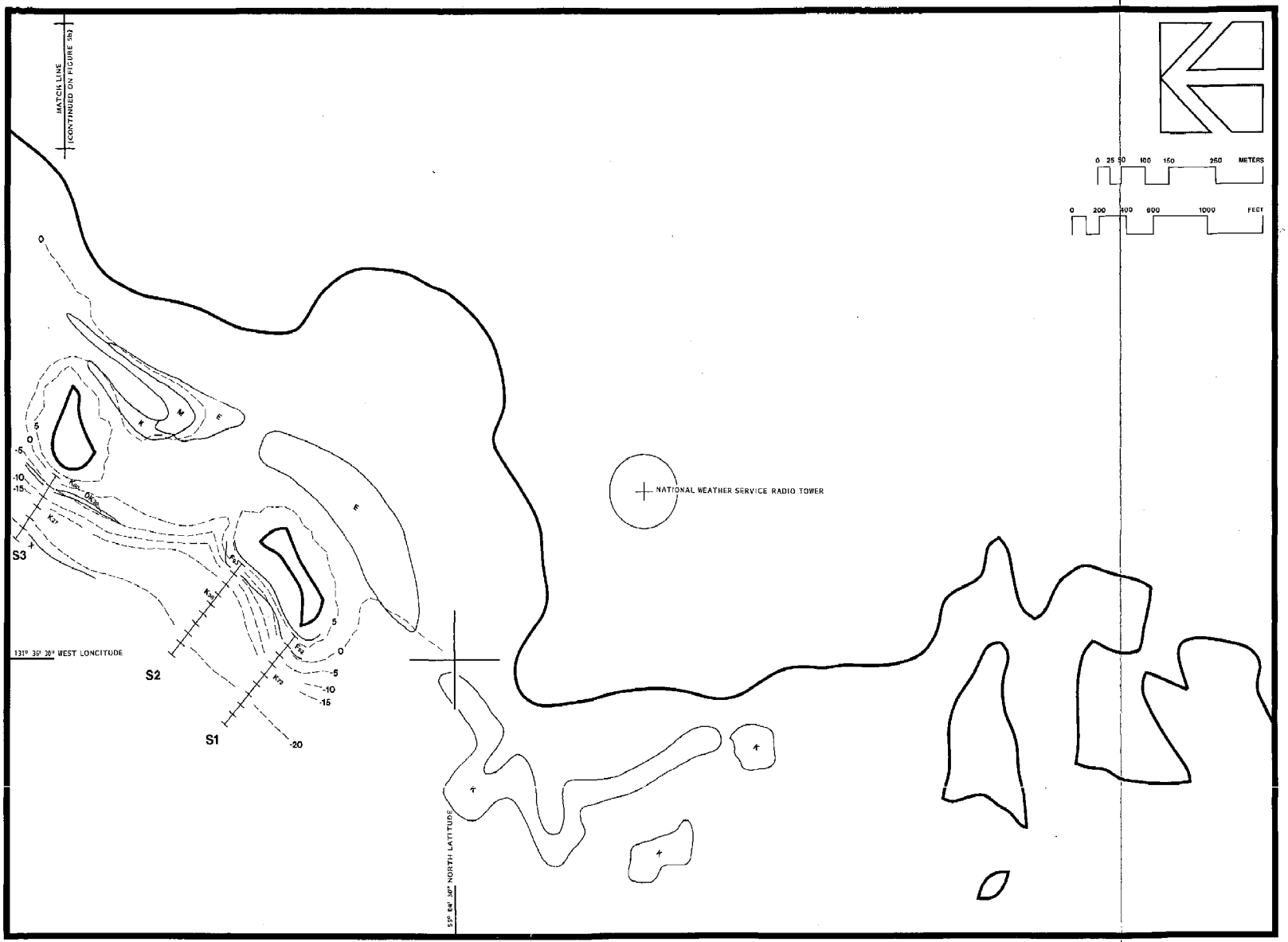

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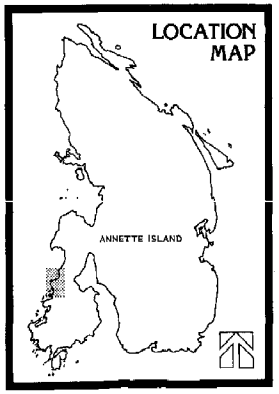

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ANNETTE NATURAL RESOURCES CENTER

FIGURE 6b

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