# Kelp Inventory, 1976

## Part 5. North Coast Vancouver Island, Hope, Nigei and Balaklava Islands

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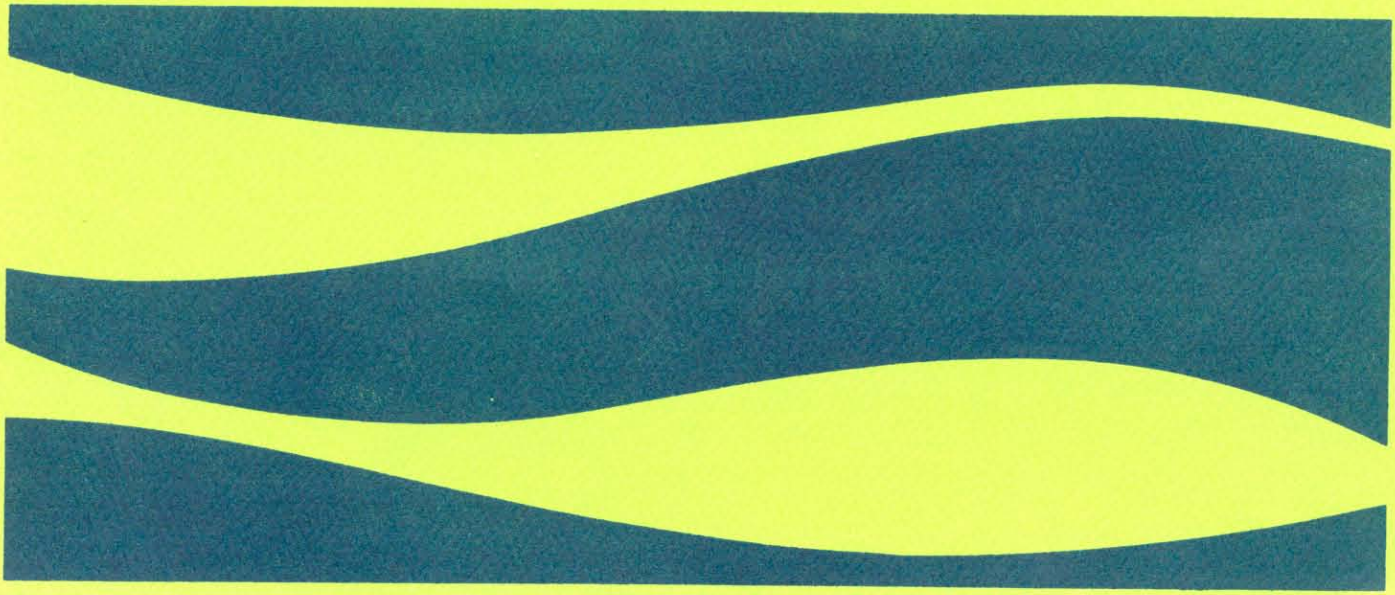

# KELP INVENTORY, 1976. PART 5.

## NORTH COAST VANCOUVER ISLAND, HOPE, NIGEI AND BALAKLAVA ISLANDS

by

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## ABSTRACT

The kelp inventory method (KIM-1) developed by Foreman (1975) was used to estimate standing crop biomass of two canopy forming kelps from the north coast of Vancouver Island and portions of Hope, Nigei and Balaklava Islands. The 30,563 tonnes of Nereocystis luetkeana and 110 tonnes of Macrocystis integrifolia in pure stands and 710 tonnes of these kelps in mixed stands were located in beds totalling 885 hectares in surface area. Five charts are presented which show the position, extent, species, and density classification of every discernable kelp bed in this survey area. For management purposes all inventoried coastlines were divided into permanent, numbered kilometer wide blocks. The results of this survey are compared to those obtained in a private kelp survey performed in 1967.

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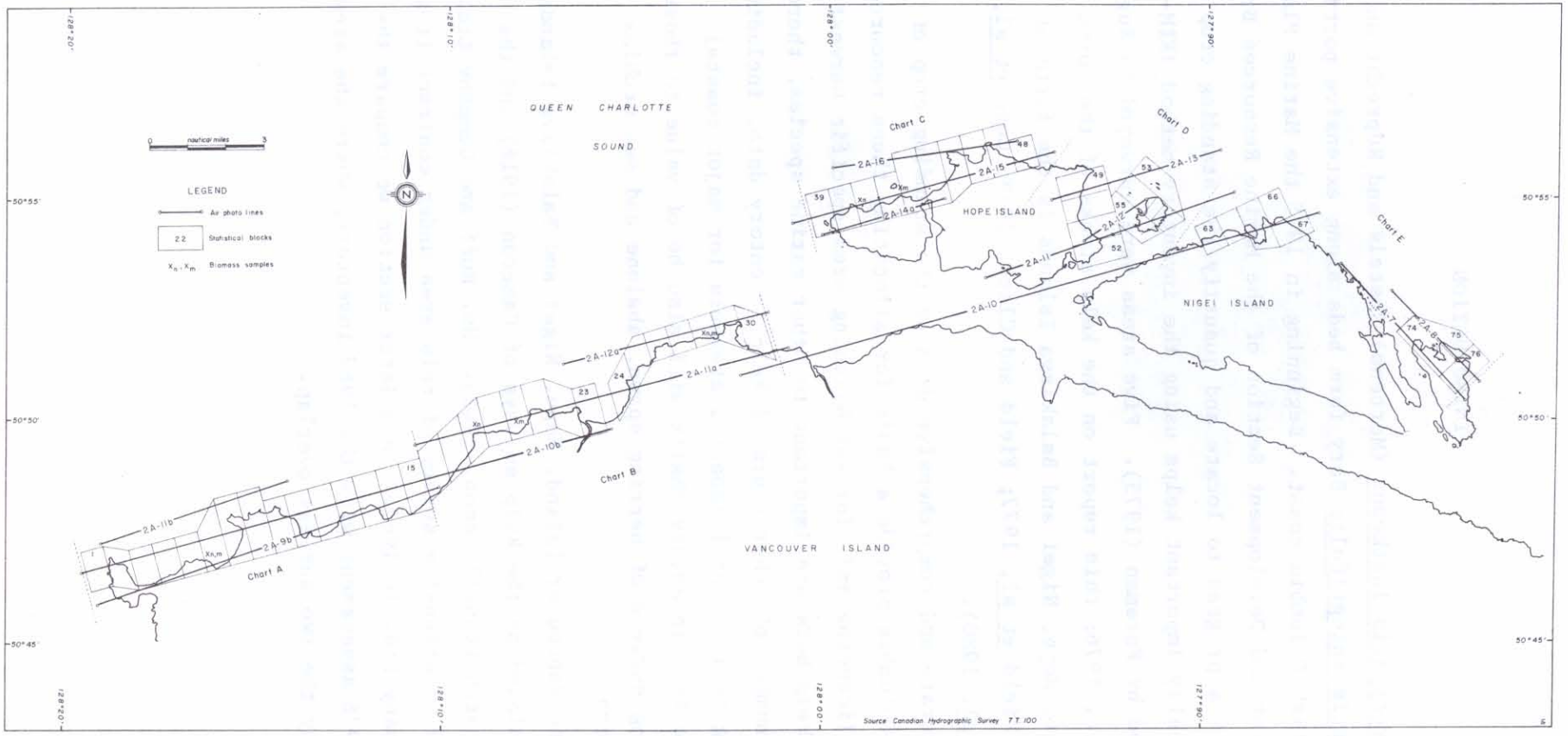
## INTRODUCTION

Nereocystis luetkeana (Mertens) Postels and Ruprecht and Macrocystis integrifolia Bory form beds along extensive portions of the British Columbia coast. Beginning in 1975 the Marine Plant Management and Development Section of the Marine Resources Branch undertook a program to locate and quantify the standing crop of these economically important kelps using the inventory method (KIM-1) developed by Foreman (1975). Five areas were surveyed in August and September, 1976; this report on the kelp stocks of the north coasts of Vancouver, Hope, Nigei and Balaklava Islands is the fifth of the series (Field et al, 1977; Field and Clark, 1978; Coon et al, 1979, Coon et al, 1980).

Accurate and comprehensive data on the standing crop of kelp in British Columbia provide a basis for allocating these resources through licencing and, for establishing area specific harvest quotas. Because kelp beds are important to other marine species, there are a growing number of other users of kelp inventory data, including those preparing environmental impact statements for major coastal developments. Inventory charts will also be of value to those conducting surveys of herring spawn, abalone and sea urchins (Coon, 1977).

North Vancouver Island, Hope, Nigei and Balaklava Islands were largely missed by the kelp surveys of Cameron (1916) and the B.C. Research Council (Anon, 1942). Wm. Huff and Company Ltd. conducted an extensive survey of this area under contract from Pacific Kelp Company Ltd. in 1967. In a later section we compare the results of the 1976 assessment with the 1967 inventory, where the areas covered by the two surveys overlap.

Figure 1: The north coast of Vancouver Island and portions of Hope, Nigei and Balaklava Islands, showing the area inventoried for floating kelp resources and the mode of division of this area into inventory charts (see Appendix). Also indicated are the layout of statistical blocks, aerial photographic flight lines and locations of biomass sampling stations.



## METHODS

The standing crop of Nereocystis and Macrocystis was estimated by the kelp inventory method (KIM-1) developed by Foreman (1975). Modifications of this method as stated by Coon et al (1977) and Field et al (1977) were used in this study. On September 15, 1976 the Air Survey Branch, Ministry of Provincial Secretary and Travel Industry obtained black and white infrared aerial photographs of the survey area. Photographic coverage was made along the prescribed flight lines illustrated in Figure 1.

Briefly, the KIM-1 technique involves obtaining 24 cm format black and white infrared (IR) aerial photography of the kelp bed and shoreline in the desired region. These black and white IR negatives are used to prepare charts of the coastline and the offshore kelp beds. On these charts the survey area is divided into 1 km wide statistical blocks. Bed areas for each of six bed types listed below are determined for each block. The density of kelp is determined directly from the photographs with the aid of a microscope using a point-intercept counting technique. Field crews obtain samples of kelp from the area for mean weight per plant (Nereocystis) or frond (Macrocystis) determination, near the time that the beds are photographed. The total available kelp per block is determined by multiplying the mean weight per plant/frond values by the observed plant/frond densities, and multiplying this product by the observed bed areas. The KIM-1 technique identifies six bed types on the basis of:

a) species - Macrocystis or Nereocystis

b) stand purity - pure bed or mixed (42% Nereocystis and 58% Macrocystis; Foreman, 1975)

c) plant or frond density - low (less than 10 plants/fronds per 10 $m^2$) or high (greater than 10 plants/fronds per 10 $m^2$).

The vertical distribution of kelp biomass in the water column was

determined for the study area on September 25 and 26, 1976. These samples also provide representative plant/frond length distributions for kelp in the survey area. Random samples of 25-30 Nereocystis plants and 25-30 Macrocystis fronds were gathered at four stations for each genus (Figure 1) in areas selected to be representative of and proportional to the bed depth ranges and exposure environments in the survey area. These plants were cut into 1 m sections and the weights of each section recorded.

All water depth and tide level calculations were based on values obtained from computer-drawn daily tide curves for Cape Scott (blocks 1-30) and Shushartie Bay (blocks 39-76) obtained from the Tidal Surveys Branch, Department of Fisheries and Oceans.

## RESULTS

Charts A through E (Appendix) illustrate the disposition of kelp resources by bed type along the north coast of Vancouver Island, and portions of Hope, Nigei and Balaklava Islands. It will be noted from these charts and Figure 1 that certain portions of the coastline are not represented. This is due either to incomplete photographic coverage or the absence of detectable kelp. However, sufficient space and block numbers have been reserved for these unsurveyed areas should the need arise for their inclusion in a later inventory.

A summary of the field determined biomass data collected on September 25-26, 1976 is given in Table 1. This table gives vertical distribution of kelp biomass in 1 m increments above and below MWL for Nereocystis and Macrocystis and mixed Nereocystis/Macrocystis beds. Table 2 presents the mean biomass plant/frond values used to calculate estimates of biomass at MWL in the survey area.

Tables 3 and 4 present estimates of bed areas, kelp density, and biomass available at MWL, by bed type, for each block as follows:

a) Table 3 Blocks 1-30; North Coast Vancouver Island

b) Table 4 Blocks 39-76; Hope, Nigei and Balaklava Islands.

Tables 5, 6 and 7 summarize the bed area and biomass estimates in these tables by bed type, by percent composition of biomass and percent composition of area for each bed type in each geographical subdivision.

A total of 31,383 tonnes of kelp were estimated to be available at MWL along the surveyed coastline, with 18,291 tonnes between Hope and Balaklava Islands, and 13,092 tonnes along the north coast of Vancouver Island (Table 5). The majority (30,563 tonnes or 97.38%) of the kelp biomass available at MWL occurred as pure stands of Nereocystis, with 49.14% in low density beds and 48.24% in high density beds (Table 6). Statistical blocks containing the highest amount of biomass (over 1,000 tonnes) were located around Fredericksen Point (Chart A) and just north of Christensen Point (Chart B) on the

2.5

north coast of Vancouver Island, and along the north coast of Hope Island (Chart C), the north coast of Vansittart Island (Chart D) and the north coast of Balaklava Island (Chart E).

Factors for estimating biomass at selected cutting levels other than MWL are presented in Table 8. By multiplying these factors times the biomass at MWL, the amount of kelp available at other tide heights can be obtained. Estimates of Nereocystis and Macrocystis standing crops at the different depth levels are given in Table 9 for the entire survey area. We estimate the total standing crop for the whole area surveyed in September, 1976 to be 38,077 tonnes. This is thought to be a slightly conservative estimate primarily because of the inevitable losses of kelp laminae during field sampling procedures which result in low estimates of mean biomass per plant.

Table 1: The cumulative number and weight (biomass) of plants or fronds, and mean weight per plant or frond at one meter increments for samples of Nereocystis and Macrocystis collected along the north coast of Vancouver, and portions of Hope, Nigei and Balaklava Islands, September 1976.

| Cutting Depth (m) | Nereocystis | | | Macrocystis | | | Mixed |
|---|---|---|---|---|---|---|---|
| | Cum B | Cum N | $\bar{x}$B/plant | Cum B | Cum N | $\bar{x}$B/frond | * $\bar{x}$B/plant or frond |
| +6 | 4.08 | 1 | 4.080 | - | - | - | 1.714 |
| +5 | 4.84 | 1 | 4.840 | - | - | - | 2.033 |
| +4 | 35.43 | 6 | 5.905 | - | - | - | 2.480 |
| +3 | 89.24 | 14 | 6.374 | 0.81 | 6 | 0.135 | 2.755 |
| +2 | 197.61 | 37 | 5.341 | 3.46 | 14 | 0.247 | 2.386 |
| +1 | 373.59 | 84 | 4.447 | 10.76 | 22 | 0.489 | 2.151 |
| MWL | 456.10 | 95 | 4.801 | 23.95 | 52 | 0.461 | 2.284 |
| -1 | 493.78 | 98 | 5.039 | 38.58 | 65 | 0.594 | 2.461 |
| -2 | 511.52 | 100 | 5.115 | 48.14 | 73 | 0.659 | 2.531 |
| -3 | 521.62 | 100 | 5.216 | 63.61 | 89 | 0.715 | 2.605 |
| -4 | 530.94 | 100 | 5.309 | 75.00 | 95 | 0.789 | 2.687 |
| -5 | 537.15 | 100 | 5.372 | 80.14 | 99 | 0.809 | 2.725 |
| -6 | 543.60 | 100 | 5.436 | 85.46 | 105 | 0.814 | 2.755 |

*Based on 42% Nereocystis and 58% Macrocystis

Cum N = cumulative number of plants or fronds

Cum B = cumulative biomass, in kilograms

$\bar{x}$B/plant (frond) = mean biomass per plant or frond

Table 2: Mean biomass per plant or frond (kg) factors used to calculate estimates of biomass at MWL along the north coast of Vancouver Island and portion of Hope, Nigei and Balaklava Island.

| Species | #Stns. | $\bar{x}$ |
|---|---|---|
| Nereocystis | 4 | 4.801 |
| Macrocystis | 4 | 0.461 |
| Mixed* | - | 2.284 |

*Based on 42% Nereocystis and 58% Macrocystis

Table 3: Estimates of kelp bed density, area, and biomass (at MWL) for the north coast of Vancouver Island, September, 1976. See charts A and B.

| | Nereocystis - low density | | | | Nereocystis - high density | | | | Macrocystis - low density | | | | Macrocystis - high density | | | | Mixed - low density | | | | Mixed - high density | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Block | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | Total A | Total B |
| 1 | 6,560 | 8.346 | 31.52 | 263.1 | 12,610 | 6.221 | 60.50 | 376.4 | | | | | | | | | | | | | | | | | 14.57 | 639.5 |
| 2 | 6,950 | 9.383 | 33.36 | 313.0 | 12,610 | 0.829 | 60.50 | 50.4 | | | | | | | | | | | | | | | | | 10.21 | 363.4 |
| 3 | 6,470 | 5.495 | 31.10 | 170.9 | 12,610 | 1.296 | 60.38 | 78.3 | | | | | | | | | | | | | | | | | 6.79 | 249.2 |
| 4 | 6,470 | 2.281 | 31.15 | 71.1 | 13,770 | 3.318 | 66.13 | 219.4 | | | | | | | | | | | | | | | | | 5.60 | 290.5 |
| 5 | 7,010 | 8.605 | 33.64 | 289.5 | 13,770 | 2.281 | 66.09 | 150.8 | | | | | | | | | | | | | | | | | 10.89 | 440.3 |
| 6 | 7,010 | 3.629 | 33.60 | 122.0 | 16,390 | 3.266 | 78.64 | 256.9 | 5,020 | 1.348 | 2.33 | 3.1 | | | | | | | | | | | | | 8.24 | 381.9 |
| 7 | 6,760 | 28.097 | 32.45 | 911.7 | 15,670 | 11.301 | 75.24 | 850.3 | | | | | | | | | | | | | | | | | 39.40 | 1,762.0 |
| 8 | 5,890 | 19.544 | 28.27 | 552.6 | 16,390 | 0.570 | 78.33 | 44.7 | 5,020 | 1.866 | 2.32 | 4.3 | 13,120 | 1.607 | 6.05 | 9.7 | | | | | | | | | 23.59 | 611.3 |
| 9 | 5,340 | 12.234 | 26.61 | 325.5 | 16,390 | 0.518 | 78.78 | 40.8 | 5,020 | 0.674 | 2.33 | 1.6 | 13,120 | 2.851 | 6.05 | 17.2 | 3,780 | 1.452 | 8.65 | 12.6 | | | | | 17.73 | 397.7 |
| 10 | 6,310 | 12.390 | 30.30 | 375.4 | 16,390 | 0.259 | 77.85 | 20.2 | 5,020 | 1.555 | 2.31 | 3.6 | | | | | 3,780 | 1.192 | 8.62 | 10.3 | | | | | 15.40 | 409.5 |
| 11 | 5,400 | 1.659 | 26.05 | 43.2 | 16,390 | 0.311 | 78.78 | 24.5 | 5,020 | 0.311 | 2.37 | 0.7 | | | | | 3,780 | 0.363 | 8.81 | 3.2 | | | | | 2.64 | 71.6 |
| 12 | 5,400 | 25.505 | 25.92 | 661.1 | 11,950 | 4.769 | 57.38 | 273.7 | 3,080 | 1.814 | 1.75 | 3.2 | | | | | 3,780 | 1.763 | 8.68 | 15.3 | 12,050 | 0.518 | 27.34 | 14.. | 34.36 | 967.4 |
| 13 | 5,560 | 8.865 | 26.69 | 236.7 | 12,170 | 0.415 | 57.84 | 24.0 | 3,080 | 2.333 | 1.76 | 4.1 | 13,120 | 0.156 | 5.91 | 0.9 | | | | | | | | | 11.77 | 265.7 |
| 14 | 5,560 | 4.406 | 26.69 | 117.6 | 12,170 | 1.192 | 58.40 | 69.6 | 3,080 | 0.467 | 1.77 | 0.8 | | | | | | | | | | | | | 6.07 | 188.1 |
| 15 | 5,090 | 23.432 | 24.44 | 572.8 | 12,170 | 0.674 | 26.53 | 39.4 | | | | | | | | | | | | | | | | | 24.11 | 612.1 |
| 16 | 5,440 | 48.937 | 26.12 | 1278.0 | 12,170 | 0.933 | 58.66 | 54.7 | 5,120 | 2.540 | 2.36 | 6.0 | 13,120 | 0.933 | 6.03 | 5.6 | 3,780 | 3.318 | 8.50 | 28.6 | | | | | 56.66 | 1,372.9 |
| 17 | 4,250 | 17.004 | 20.41 | 347.1 | 12,170 | 0.052 | 55.39 | 2.9 | 5,120 | 2.074 | 2.36 | 4.9 | 13,120 | 0.104 | 6.21 | 0.7 | | | | | | | | | 19.23 | 355.5 |
| 18 | 6,180 | 10.368 | 29.68 | 307.7 | | | | | 5,120 | 0.518 | 2.40 | 1.2 | | | | | | | | | | | | | 10.89 | 309.0 |
| 19 | 6,970 | 11.301 | 33.48 | 378.3 | 12,170 | 1.503 | 58.46 | 87.9 | 5,120 | 0.985 | 2.34 | 2.3 | | | | | | | | | | | | | 13.79 | 468.5 |
| 20 | 6,130 | 9.020 | 29.43 | 265.5 | | | | | 5,120 | 1.140 | 2.35 | 2.7 | | | | | 3,780 | 1.711 | 8.68 | 14.9 | | | | | 11.87 | 283.0 |
| 21 | 7,220 | 14.152 | 34.67 | 490.7 | 14,640 | 4.614 | 70.24 | 324.1 | 5,120 | 0.363 | 2.41 | 0.9 | | | | | | | | | | | | | 19.13 | 815.6 |
| 22 | 6,990 | 8.761 | 33.54 | 293.8 | 14,640 | 2.281 | 70.29 | 160.4 | | | | | | | | | | | | | | | | | 11.04 | 454.2 |
| 23 | 6,230 | 20.425 | 29.89 | 610.7 | 14,640 | 2.333 | 70.38 | 164.2 | | | | | | | | | | | | | | | | | 22.76 | 774.9 |
| 24 | 6,990 | 1.244 | 33.58 | 41.8 | | | | | | | | | | | | | | | | | | | | | 1.24 | 41.8 |
| 25 | 6,500 | 0.052 | 27.69 | 1.4 | | | | | | | | | | | | | | | | | | | | | 0.05 | 1.4 |
| 26 | 6,500 | 1.089 | 31.30 | 34.1 | | | | | | | | | | | | | | | | | | | | | 1.09 | 34.1 |
| 27 | 6,500 | 2.851 | 31.15 | 88.8 | | | | | 5,120 | 0.052 | 2.66 | 0.1 | | | | | | | | | | | | | 2.90 | 89.0 |
| 28 | 6,500 | 3.992 | 31.15 | 124.4 | 14,640 | 0.570 | 69.91 | 39.9 | | | | | | | | | | | | | | | | | 4.56 | 164.2 |
| 29 | 7,070 | 4.769 | 33.93 | 161.8 | 14,640 | 0.674 | 70.52 | 47.5 | | | | | | | | | | | | | | | | | 5.47 | 209.3 |
| 30 | 7,070 | 1.711 | 33.95 | 58.1 | 14,640 | 0.156 | 70.78 | 11.0 | | | | | | | | | | | | | | | | | 1.87 | 69.1 |
| Totals | | 330 | | 9,508 | | 50 | | 3,411 | | 18 | | 40 | | 6 | | 34 | | 10 | | 85 | | 1 | | 14 | 414 | 13,093 |
| Means of blocks with kelp | 6.049 | | 80.08 | | 12,418 | | 69.04 | | 4,678 | | 2.26 | | 13,122 | | 6.96 | | 3,708 | | 15.87 | | 12,050 | | 27.34 | | | |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

Table 4: Estimates of kelp bed density, area, and biomass (at MWL) for the area between Hope Island and Balaklava Island, September, 1976. See charts C-E.

| | Nereocystis - low density | | | | Nereocystis - high density | | | | Macrocystis - low density | | | | Macrocystis - high density | | | | Mixed - low density | | | | Mixed - high density | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Block | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$ D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | Total A | Total B |
| 39 | 4,610 | 10.316 | 22.15 | 228.5 | 12,000 | 3.266 | 57.63 | 189.2 | | | | | | | | | | | | | | | | | 13.58 | 417.7 |
| 40 | 5,830 | 10.368 | 27.97 | 290.0 | 12,000 | 3.421 | 57.68 | 197.3 | | | | | | | | | | | | | | | | | 13.79 | 487.3 |
| 41 | 6,040 | 10.627 | 29.00 | 308.2 | 12,000 | 4.614 | 57.65 | 266.0 | | | | | | | | | | | | | | | | | 15.81 | 578.8 |
| 42 | 5,710 | 12.753 | 27.41 | 349.5 | 12,990 | 4.510 | 62.38 | 281.3 | | | | | | | | | 3,540 | 0.570 | 9.01 | 4.6 | | | | | 15.81 | 578.8 |
| 43 | 3,870 | 33.953 | 18.58 | 630.9 | 12,990 | 15.293 | 62.38 | 954.0 | | | | | | | | | 3,540 | 9.901 | 8.07 | 79.9 | 12,050 | 0.674 | 27.44 | 18.5 | 27.84 | 739.3 |
| 44 | 5,230 | 60.238 | 25.11 | 1512.3 | 11,480 | 7.983 | 55.08 | 439.8 | | | | | | | | | 950 | 20.736 | 2.17 | 45.0 | 12,050 | 0.156 | 27.82 | 4.4 | 70.14 | 1634.2 |
| 45 | 5,710 | 5.962 | 27.38 | 163.2 | 11,480 | 0.726 | 54.88 | 39.9 | | | | | | | | | 950 | 0.518 | 2.20 | 1.1 | 12,050 | 0.156 | 27.82 | 4.4 | 68.90 | 1957.6 |
| 46 | 5,710 | 0.415 | 27.76 | 11.5 | 11,480 | 4.147 | 55.11 | 229.5 | 3,650 | 0.104 | 1.73 | 0.2 | | | | | | | | | | | | | 6.69 | 203.1 |
| 47 | 5,710 | 1.607 | 27.49 | 44.2 | 11,480 | 2.592 | 55.19 | 143.1 | | | | | | | | | 950 | 0.726 | 2.20 | 1.6 | | | | | 4.67 | 241.2 |
| 48 | 5,710 | 1.607 | 24.79 | 39.9 | 11,480 | 1.711 | 54.99 | 94.1 | | | | | | | | | | | | | | | | | 4.20 | 187.2 |
| 49 | 5,160 | 6.791 | 24.74 | 168.0 | | | | | 3,650 | 6.687 | 1.68 | 11.3 | | | | | | | | | | | | | 3.32 | 133.9 |
| 50 | 4,690 | 7.880 | 22.54 | 177.6 | | | | | 3,650 | 0.518 | 1.66 | 0.9 | 13,120 | 2.592 | 5.51 | 14.3 | 6,720 | 5.34 | 15.36 | 82.0 | | | | | 18.82 | 261.2 |
| 51 | 3,870 | 17.988 | 18.58 | 334.2 | 15,580 | 1.089 | 74.95 | 81.6 | 3,650 | 1.089 | 1.69 | 1.8 | | | | | 6,720 | 3.421 | 15.36 | 52.5 | 12,050 | 1.140 | 27.45 | 31.3 | 15.53 | 276.6 |
| 52 | 3,870 | 0.778 | 18.51 | 14.4 | 18,440 | 1.555 | 88.61 | 137.8 | 3,650 | 0.104 | 1.73 | 0.2 | | | | | | | | | | | | | 20.17 | 417.6 |
| 53 | 5,160 | 12.079 | 24.76 | 299.1 | 18,440 | 25.713 | 88.52 | 2276.2 | 3,650 | 1.503 | 1.69 | 2.5 | | | | | 6,720 | 1.244 | 15.42 | 19.2 | | | | | 2.44 | 152.4 |
| 54 | 6,640 | 10.679 | 31.87 | 340.4 | 15,580 | 12.960 | 74.79 | 969.3 | 3,650 | 0.985 | 1.69 | 1.7 | | | | | 6,720 | 0.985 | 15.30 | 15.1 | | | | | 40.54 | 2597.0 |
| 55 | 6,640 | 4.251 | 31.85 | 135.4 | 15,580 | 5.962 | 74.81 | 446.6 | 3,650 | 0.104 | 1.73 | 0.2 | 13,120 | 0.155 | 6.95 | 0.9 | 6,720 | 0.259 | 14.99 | 3.9 | 12,050 | 1.192 | 27.59 | 32.9 | 25.61 | 1326.4 |
| 56 | 6,640 | 0.829 | 31.86 | 26.4 | 15,580 | 4.873 | 74.78 | 364.4 | | | | | | | | | | | | | | | | | 11.92 | 619.3 |
| 63 | 5,550 | 2.592 | 26.67 | 69.1 | 18,210 | 3.370 | 87.47 | 294.8 | | | | | | | | | 5,590 | 0.104 | 13.18 | 1.4 | | | | | 5.70 | 390.8 |
| 64 | 5,550 | 2.644 | 26.69 | 70.6 | 18,210 | 3.681 | 87.39 | 321.7 | | | | | | | | | | | | | | | | | 6.07 | 365.3 |
| 65 | 4,640 | 12.597 | 22.41 | 282.3 | 18,210 | 4.095 | 87.46 | 358.2 | | | | | | | | | | | | | | | | | 6.33 | 392.2 |
| 66 | 5,550 | 2.851 | 26.61 | 75.9 | 18,210 | 8.657 | 87.40 | 756.6 | | | | | | | | | | | | | | | | | 16.69 | 640.4 |
| 67 | 5,550 | 2.385 | 26.57 | 63.4 | 18,210 | 4.095 | 87.46 | 358.2 | | | | | | | | | 5,590 | 0.311 | 12.48 | 3.9 | | | | | 11.82 | 836.4 |
| 74 | 5,550 | 5.547 | 26.66 | 147.9 | 18,510 | 17.677 | 88.87 | 1570.9 | | | | | 13,120 | 0.052 | 6.21 | 0.3 | 5,590 | 1.140 | 12.82 | 14.6 | | | | | 7.67 | 436.5 |
| 75 | 5,550 | 3.007 | 26.61 | 80.2 | 16,660 | 8.346 | 79.96 | 667.3 | 3,650 | 0.207 | 1.78 | 0.4 | 13,120 | 0.207 | 6.01 | 1.2 | 5,590 | 4.147 | 12.78 | 53.0 | 12,050 | 2.281 | 27.54 | 62.8 | 29.86 | 1835.8 |
| 76 | 5,550 | 1.970 | 26.56 | 52.3 | 16,660 | 3.525 | 79.95 | 281.8 | | | | | | | | | 5,590 | 0.467 | 12.72 | 5.9 | 12,050 | 0.104 | 26.35 | 2.7 | 12.13 | 756.6 |
| | | | | | | | | | | | | | | | | | 5,590 | 1.866 | 12.72 | 23.8 | 12,050 | 1.711 | 27.49 | 47.1 | 9.07 | 405.0 |
| Totals | | 243 | | 5,915 | | 154 | | 11,729 | | 11 | | 19 | | 3 | | 17 | | 52 | | 407 | | 7 | | 204 | 469 | 18,291 |
| Means of blocks with kelp | 5,396 | | 25.81 | | 15,061 | | 72.31 | | 3,650 | | 1.70 | | 13,120 | | 6.18 | | 4,810 | | 11.05 | | 12,050 | | 27.56 | | | |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

Table 5: Summary of biomass and kelp bed area estimates, by geographical subdivision and bed type for the north coasts of Vancouver Island and portions of Hope, Nigei, and Balaklava Islands in September, 1976. Estimates are biomass at MWL ± 0.6 m and not total standing crop.

| Geographical area | Blocks | Biomass (tonnes) | Area (hectares) |
|---|---|---|---|
| | | Low Density Nereocystis | |
| N. Vancouver Island | 1-30 | 9,508 | 330 |
| Hope to Balaklava | 39-76 | 5,915 | 243 |
| | | High Density Nereocystis | |
| N. Vancouver Island | 1-30 | 3,411 | 50 |
| Hope to Balaklava | 39-76 | 11,729 | 154 |
| | | Low Density Macrocystis | |
| N. Vancouver Island | 1-30 | 40 | 18 |
| Hope to Balaklava | 39-76 | 19 | 11 |
| | | High Density Macrocystis | |
| N. Vancouver Island | 1-30 | 34 | 6 |
| Hope to Balaklava | 39-76 | 17 | 3 |
| | | Low Density Mixed | |
| N. Vancover Island | 1-30 | 85 | 10 |
| Hope to Balaklava | 39-76 | 407 | 52 |
| | | High Density Mixed | |
| N. Vancouver Island | 1-30 | 14 | 1 |
| Hope to Balaklava | 39-76 | 204 | 7 |
| | | Totals by Geographic Subdivision | |
| N. Vancouver Island | 1-30 | 13,092 | 415 |
| Hope to Balaklava | 39-76 | 18,291 | 470 |
| Grand Totals | 1-76 | 31,383 | 885 |
| | | Totals by Species | |
| Nereocystis | 1-76 | 30,563 | 777 |
| Macrocystis | 1-76 | 110 | 38 |
| Mixed | 1-76 | 710 | 70 |

Table 6: Estimated percent composition by bed type of the kelp biomass in each of the geographic subdivisions in the survey area. The last column gives percent composition of biomass available at MWL for the combined areas.

| Bed Type | | N. Vancouver Isl. | Hope to Balaklava | Combined |
|---|---|---|---|---|
| Nereocystis | - low density | 72.62 | 32.34 | 49.14 |
| | - high density | 26.05 | 64.12 | 48.24 |
| Macrocystis | - low density | 0.31 | 0.10 | 0.19 |
| | - high density | 0.26 | 0.09 | 0.16 |
| Mixed beds | - low density | 0.65 | 2.23 | 1.57 |
| | - high density | 0.11 | 1.12 | 0.69 |

Table 7: Estimated percent composition by bed type of the bed surface area in each geographic subdivision in the survey area. The last column gives the percent composition of the total bed area for the combined areas.

| Bed type | | N. Vancouver Is. | Hope to Balaklava | Combined |
|---|---|---|---|---|
| Nereocystis | - low density | 79.52 | 51.70 | 64.75 |
| | - high density | 12.05 | 32.77 | 23.05 |
| Macrocystis | - low density | 4.34 | 2.34 | 3.28 |
| | - high density | 1.44 | 0.64 | 1.02 |
| Mixed beds | - low density | 2.41 | 11.06 | 7.01 |
| | - high density | 0.24 | 1.49 | 0.90 |

Table 8: Combined biomass and density correction factors for various cutting levels six meters above and below MWL for the north coast of Vancouver Island, and portions of Hope, Nigei and Balaklava Islands.

| Cutting level (m) | Nereocystis | Macrocystis | Mixed |
|---|---|---|---|
| | n=100 | n=105 | * |
| +6 | 0.01 | - | 0.00 |
| +5 | 0.01 | - | 0.01 |
| +4 | 0.08 | - | 0.04 |
| +3 | 0.19 | 0.03 | 0.16 |
| +2 | 0.43 | 0.14 | 0.35 |
| +1 | 0.82 | 0.45 | 0.65 |
| 0 | 1.00 | 1.00 | 1.00 |
| -1 | 1.08 | 1.61 | 1.21 |
| -2 | 1.12 | 2.01 | 1.33 |
| -3 | 1.14 | 2.66 | 1.52 |
| -4 | 1.16 | 3.13 | 1.63 |
| -5 | 1.18 | 3.35 | 1.69 |
| -6 | 1.19 | 3.57 | 1.77 |

*based on 42% Nereocystis and 58% Macrocystis

Total 9: Total kelp biomass at selected depth levels for the north coast of Vancouver Island, Hope, Nigei and Balaklava Island survey area in September, 1976.

| Cutting Level (m) | Cumulative Biomass (tonnes) | | | |
|---|---|---|---|---|
| | Nereocystis | Macrocystis | Mixed | Total |
| +6 | 273 | - | 3 | 276 |
| +5 | 324 | - | 4 | 328 |
| +4 | 2,374 | - | 28 | 2,402 |
| +3 | 5,980 | 4 | 114 | 6,098 |
| +2 | 13,242 | 16 | 251 | 13,509 |
| +1 | 25,034 | 49 | 459 | 25,542 |
| MWL | 30,563 | 110 | 710 | 31,383 |
| -1 | 33,088 | 177 | 861 | 34,126 |
| -2 | 34,277 | 221 | 947 | 34,445 |
| -3 | 34,953 | 292 | 1,082 | 36,327 |
| -4 | 35,578 | 344 | 1,158 | 37,080 |
| -5 | 35,994 | 368 | 1,202 | 37,564 |
| -6 | 36,370 | 393 | 1,258 | 38,077 |

## DISCUSSION

Sixty percent of the coastline surveyed in 1976 overlapped with the survey conducted by Huff (1967); estimates of biomass, bed area, and plant density in regions where the two surveys overlap are compared in Table 10. The results of the two surveys indicate that a substantial portion of the Macrocystis population which existed in 1967 had been replaced by Nereocystis by 1976. Huff reported lower estimates of Nereocystis for biomass (13.93% of 1976) and area (8.72% of 1976) and higher estimates for Macrocystis biomass (763.90% of 1976) and area (172.25% of 1976). While Huff's estimates of density for Nereocystis were only 159.68% higher than in 1976, his estimate for Macrocystis density was 465.14% higher; this latter value could explain much of the difference in total biomass estimates made in the two survey efforts. Huff's surveys were carried out in the summer months when Macrocystis canopy density and mean frond weight are maximal. The 1976 survey, on the other hand, was conducted in late September by which time both these parameters are sharply reduced (Coon and Roland, in prep.).

While the beds appear to have drastically changed in the ten year interim between the two surveys, it is possible that at least some of the difference between estimates was due to differences in the accuracy and adequateness in the sampling techniques employed. The reader is referred to Coon et al (1977) for a more thorough comparison of Huff's methods to the KIM-I procedure.

Table 10: Comparison of bed area (ha), density ($kg/m^2$), and biomass (t) estimates between 1967 and 1976 inventories for selected portions of the Cape Scott to Balaklava Island area.

| 1976 | | Nereocystis | | | | | | Macrocystis | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1967 | | | 1976 | | | 1967 | | | 1976 | | |
| Blocks | Location | Area | Density | Biomass[a] | Area | Density | Biomass[b] | Area | Density | Biomass[a] | Area | Density | Biomass[b] |
| 1-7 | Cape Scott - Frederiksen Pt. | 0.186 | 6.88 | 12.8 | 94.348 | 5.08 | 4788.8 | 2.325 | 5.96 | 138.8 | 1.348 | 0.72 | 9.7 |
| 8-18 | Frederiksen Pt. - Christensen Pt. | 0.070 | 7.75 | 5.4 | 194.073 | 0.10 | 6285.2 | 18.581 | 4.74 | 882.5 | 19.803 | 1.20 | 236.9 |
| 19-29 | Christensen Pt. - Cape Sutil | 1.160 | 4.65 | 54.3 | 85.639 | 4.50 | 3850.0 | 13.935 | 4.52 | 630.3 | 1.711 | 2.72 | 46.6 |
| 39.45 | Mexicana Pt. - Ashby Pt. | 37.161 | 10.17 | 3781.5 | 184.030 | 3.70 | 6805.3 | 0.465 | 4.86 | 22.6 | 0 | 0 | 0 |
| 47-52 | Secretary Pt. - Turn Pt. | 5.574 | 4.87 | 271.3 | 43.598 | 3.29 | 1434.1 | 27.870 | 4.86 | 1356.4 | 11.052 | 0.81 | 89.3 |
| 53-55 | Vansittart Is. | 11.148 | 1.62 | 180.9 | 71.644 | 7.24 | 5187.3 | 0.372 | 4.85 | 18.1 | 2.765 | 0.60 | 16.6 |
| 74-76 | North End Balaklava Is. | 6.960 | 1.41 | 98.1 | 40.072 | 8.11 | 3248.5 | - | - | - | - | - | - |
| | TOTALS | 62.259 | 7.07 | 4404.3 | 713.408 | 4.43 | 31599.2 | 67.548 | 5.07 | 3048.7 | 36.649 | 1.09 | 399.1 |
| | Percentage of 1976 Value | 8.720 | 159.68 | 13.9 | | | | 172.25 | 465.14 | 763.9 | | | |

a Based on cuts made at 1.5 m below zero tide level.

b Corrected for 2 m below zero tide level (4 m level MWL) using combined biomass and density factors for various cutting levels in Table 8.

## REFERENCES

Anon. 1948. Marine plants and economic importance in British Columbia coastal waters, Part II. B.C. Research Council Tech. Bull.

Cameron, A. T. 1916. The commercial value of the kelp beds of the Canadian Pacific coast - a preliminary report and survey of the beds. Contrib. Canadian Biol. 1914 - 1915, Sessional Paper No. 38a: 24-39.

Coon, L. M. 1977. Marine plant management program in British Columbia. A paper presented at the IXth International Seaweed Symposium at Santa Barbara, California, U. S. A. in August, 1977. (Mimeo).

Coon, L. M., E. J. Field and Canadian Benthic Ltd. 1977. Nootka Sound kelp inventory, 1975. British Columbia Marine Resources Branch, Fish. Management Rep. No. 2. 26 pp.

Coon, L. M., W. Roland, E. J. Field, and W. E. L. Clayton. 1979. Kelp inventory, 1976, Part 3. North West Coasts Graham Island (Q.C.I.). British Columbia Marine Resources Branch, Fish. Management Rep. No. 13. 26 pp.

Coon, L. M., W. G. Roland, E. J. Field, W. E. L. Clayton, and V. Jensen. 1980. Kelp Inventory, 1976, Part 4. Goschen Island to the Tree Knob Group. British Columbia Marine Resources Branch, Fish. Management Rep. No. 19. 19 pp.

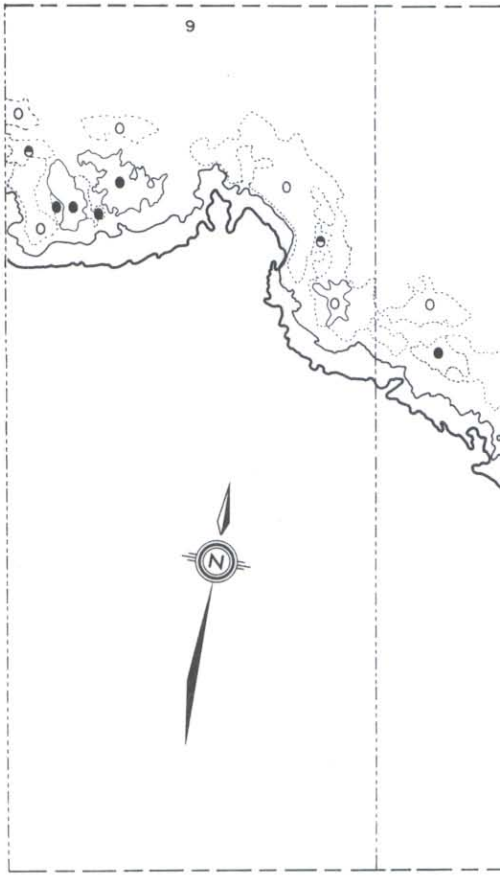
Field, E. J. and E. A. C. Clark. 1978. Kelp Inventory, 1976, Part 2. The Dundas Group. British Columbia Marine Resources Branch, Fish. Management Rep. No. 11. 21 pp.

Field, E. J., L. M. Coon, W. E. L. Clayton and E. A. C. Clark. 1977. Kelp Inventory 1976, Part I: The Estevan Group and Campania Island. British Columbia Marine Resources Branch, Fish. Management Rep. No. 9. 19 pp.

Foreman, R. E. 1975. KIM-1. A method for inventory of floating kelps and its application to selected areas of Kelp Licence Area 12. Benthic Ecological Research Program Report 75-1. Report to Federal Fisheries and Marine Service and Provincial Marine Resources Branch.

Huff, M. W. 1967. A quantitative survey of portions of the East and West Coasts of Vancouver Island, British Columbia for species Macrocystis integrifolia and Nereocystis luetkeana. M. W. Huff and Company - Consulting Engineers for Pacific Kelp Company Ltd., Vancouver, British Columbia. 38 pp.

# CHART A

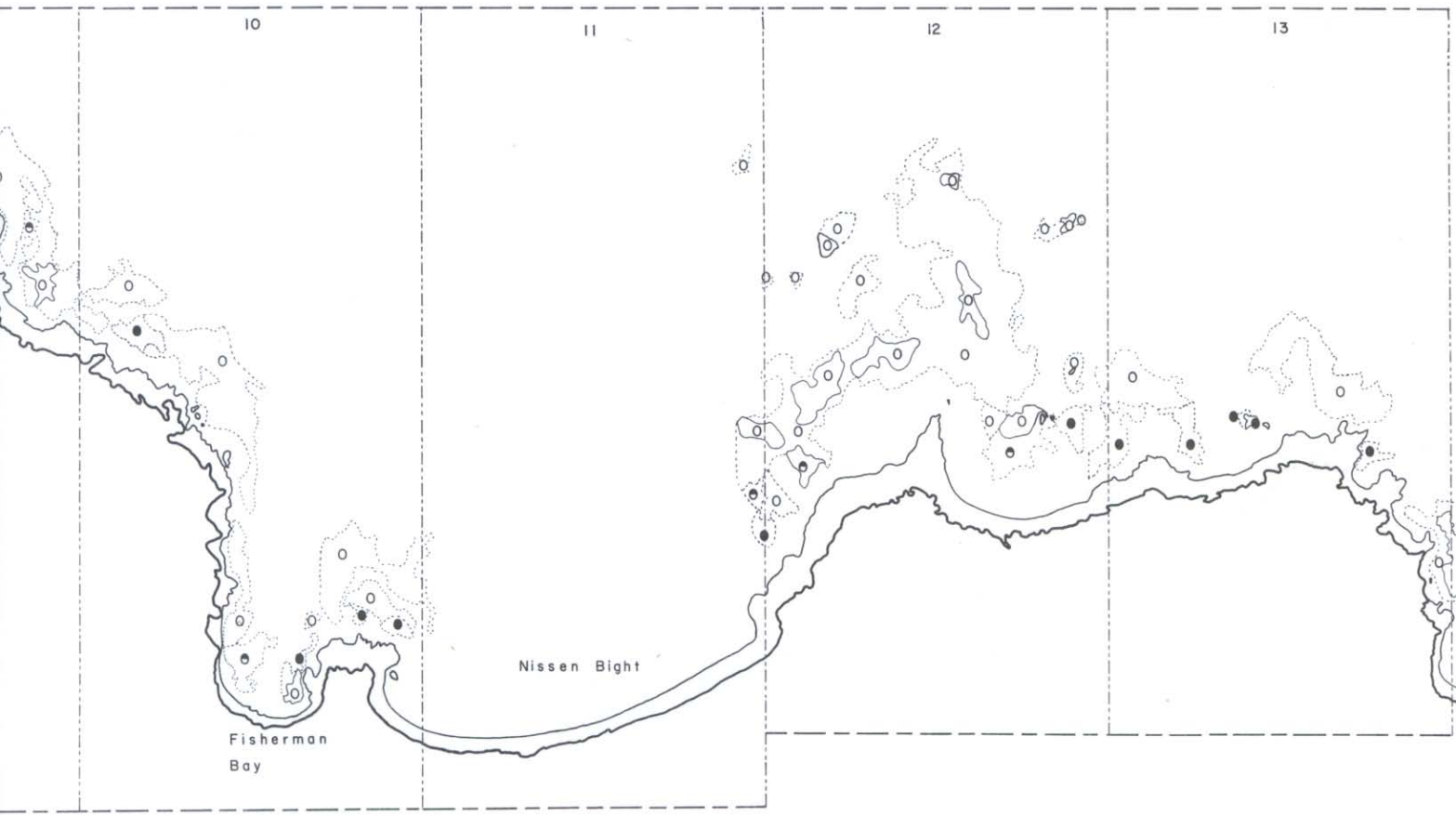



1/4 nautical mile

0 meters 500

LEGEND

- edge of terrestrial vegetation
- water level at time of photography
- boundary of statistical block
- boundary of photographic line
- border between adjacent blocks
- *Nereocystis* beds
- *Macrocystis* beds
- mixed beds of *Nereocystis* and *Macrocystis*
- 19 block number
- high density bed
- low density bed
- rocks
- houses and buildings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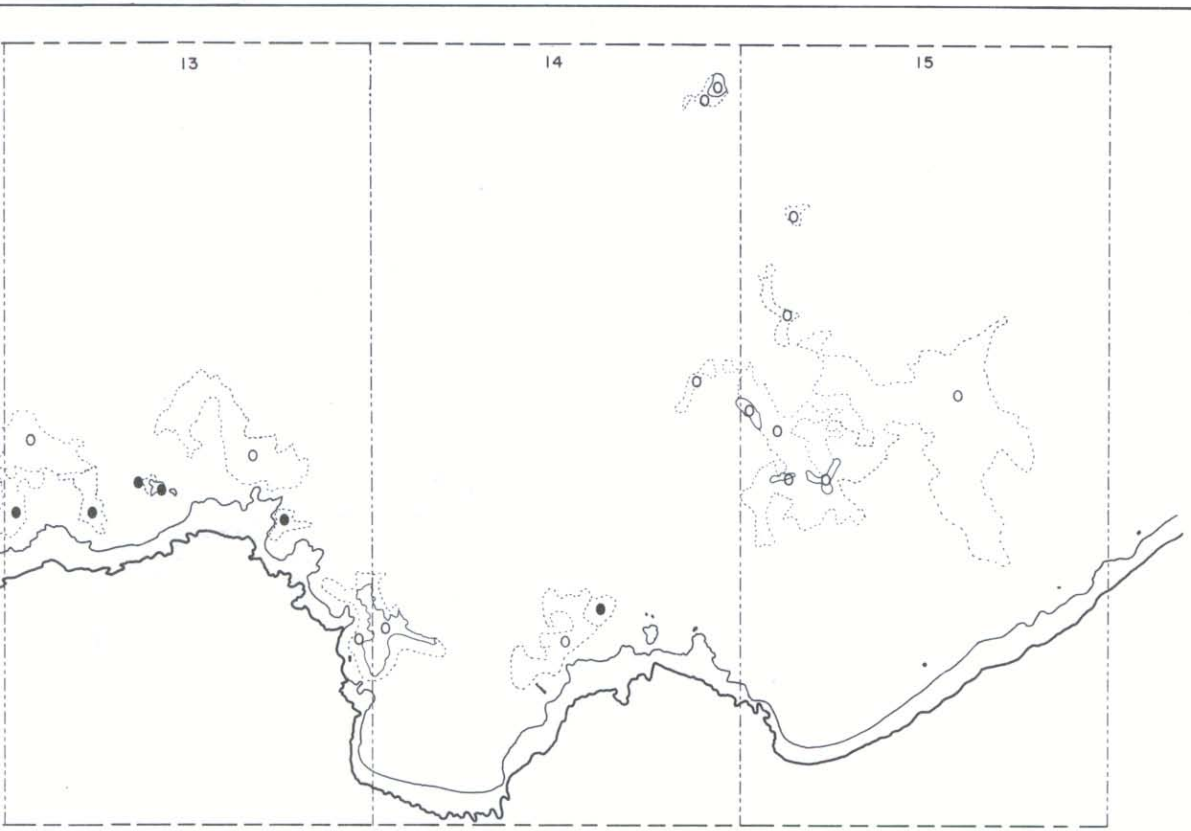
12
13
Nissen Bight
Fisherman
Bay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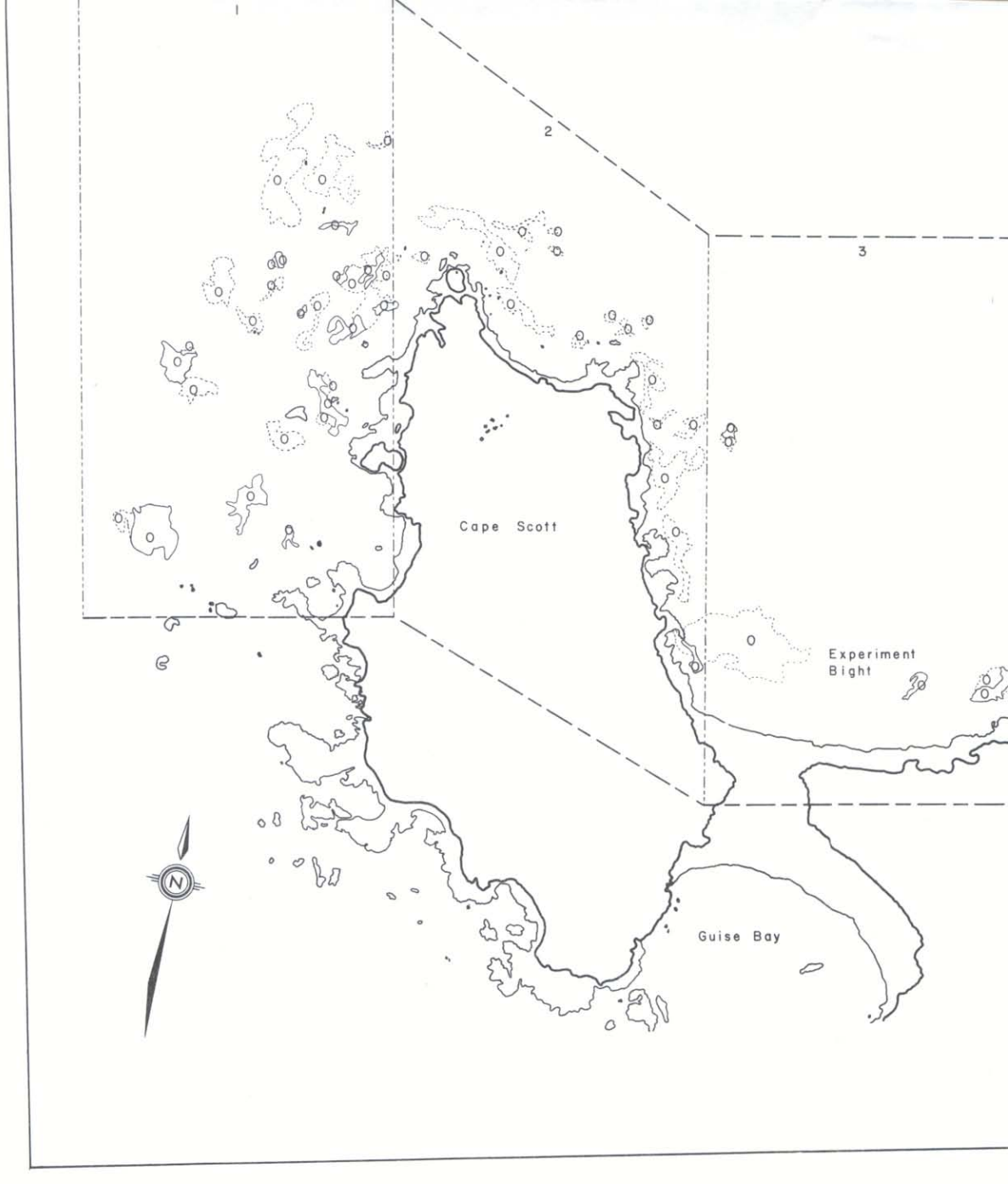
15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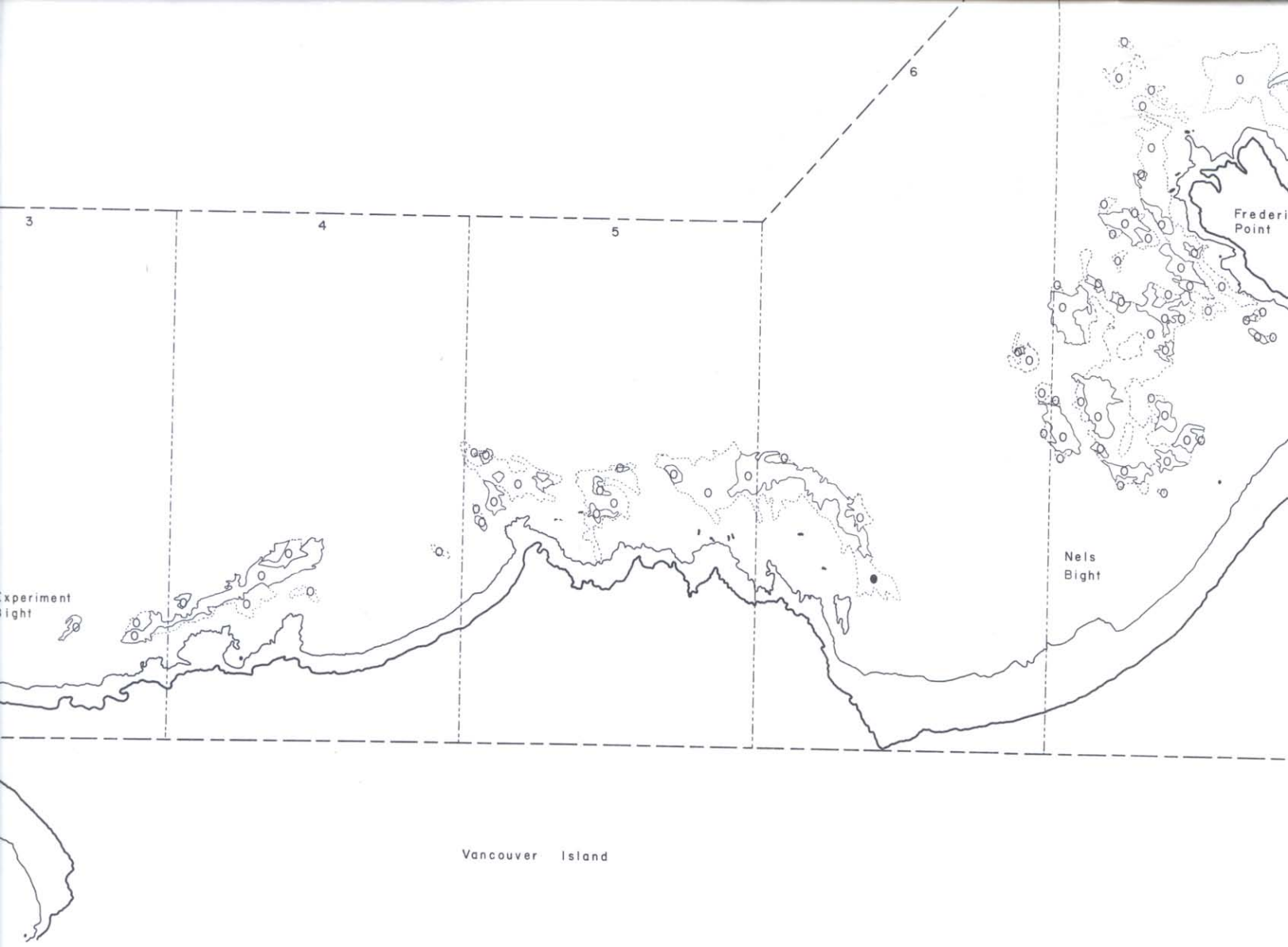
Experiment
Bight
Guise Bay
N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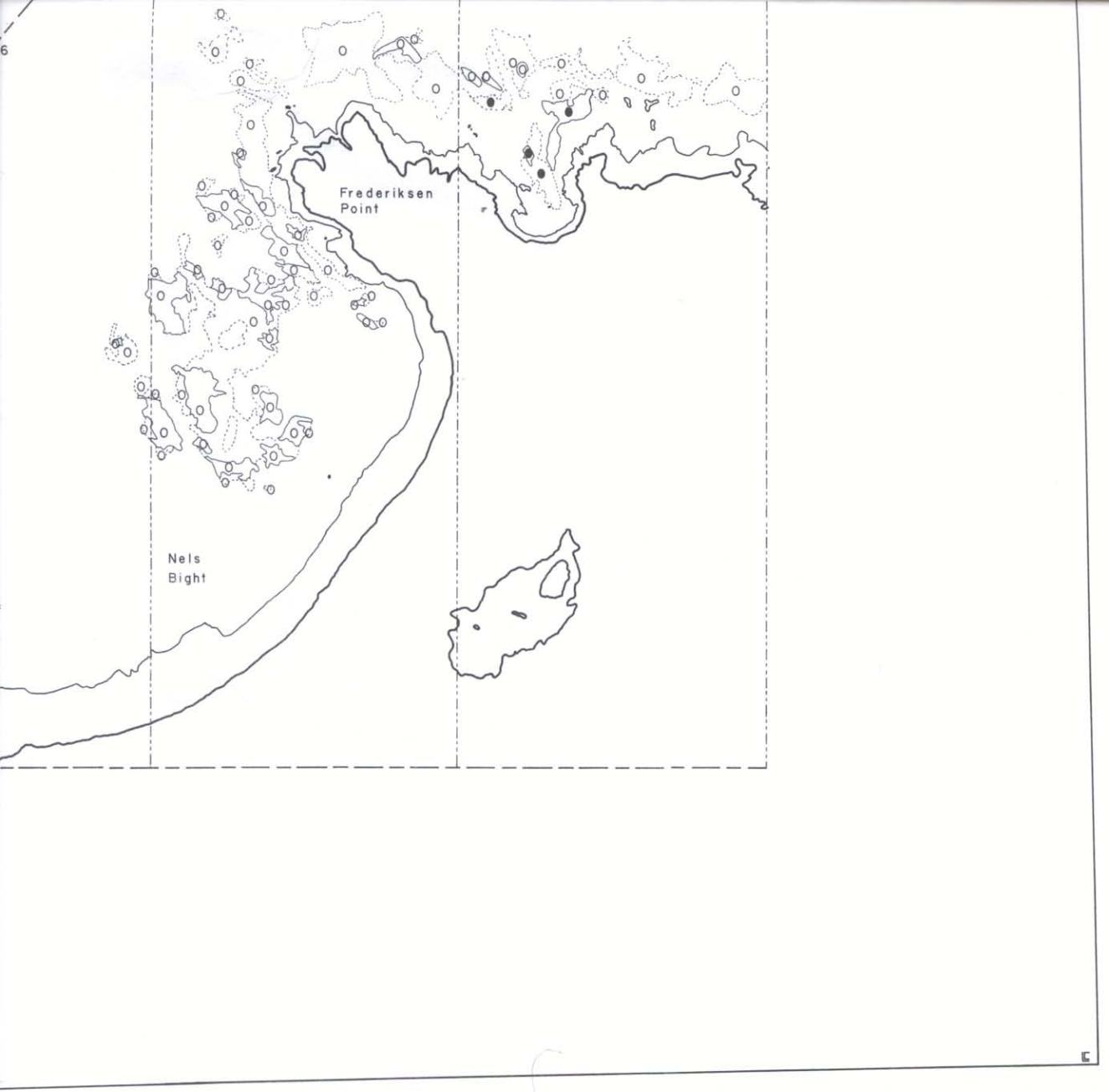
Point
Nels
Bight
Experiment
Bight
Vancouver Island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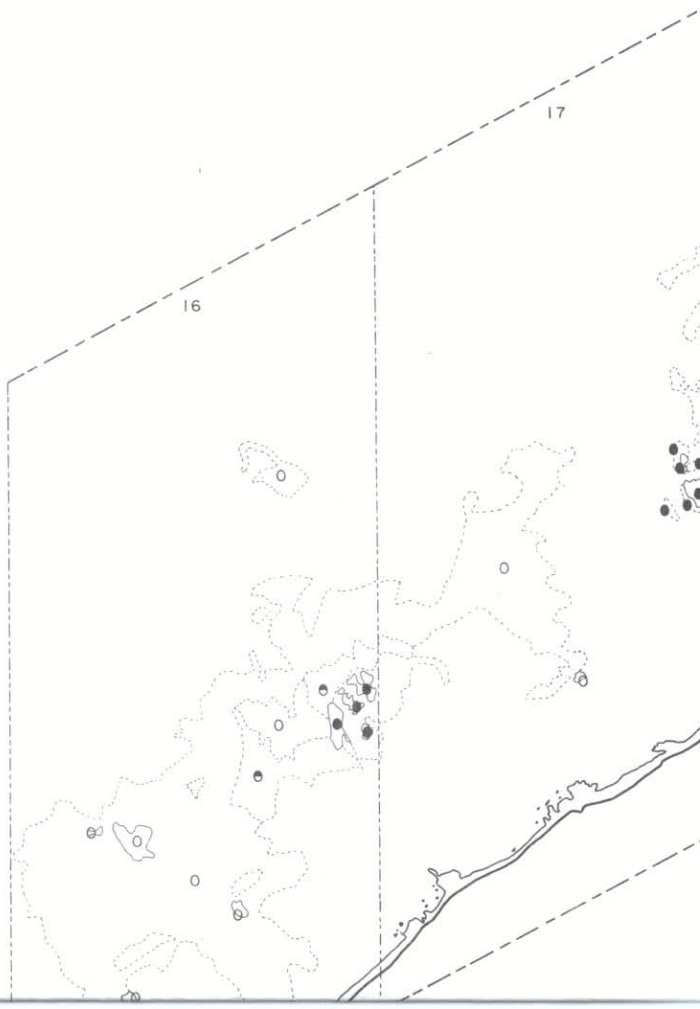
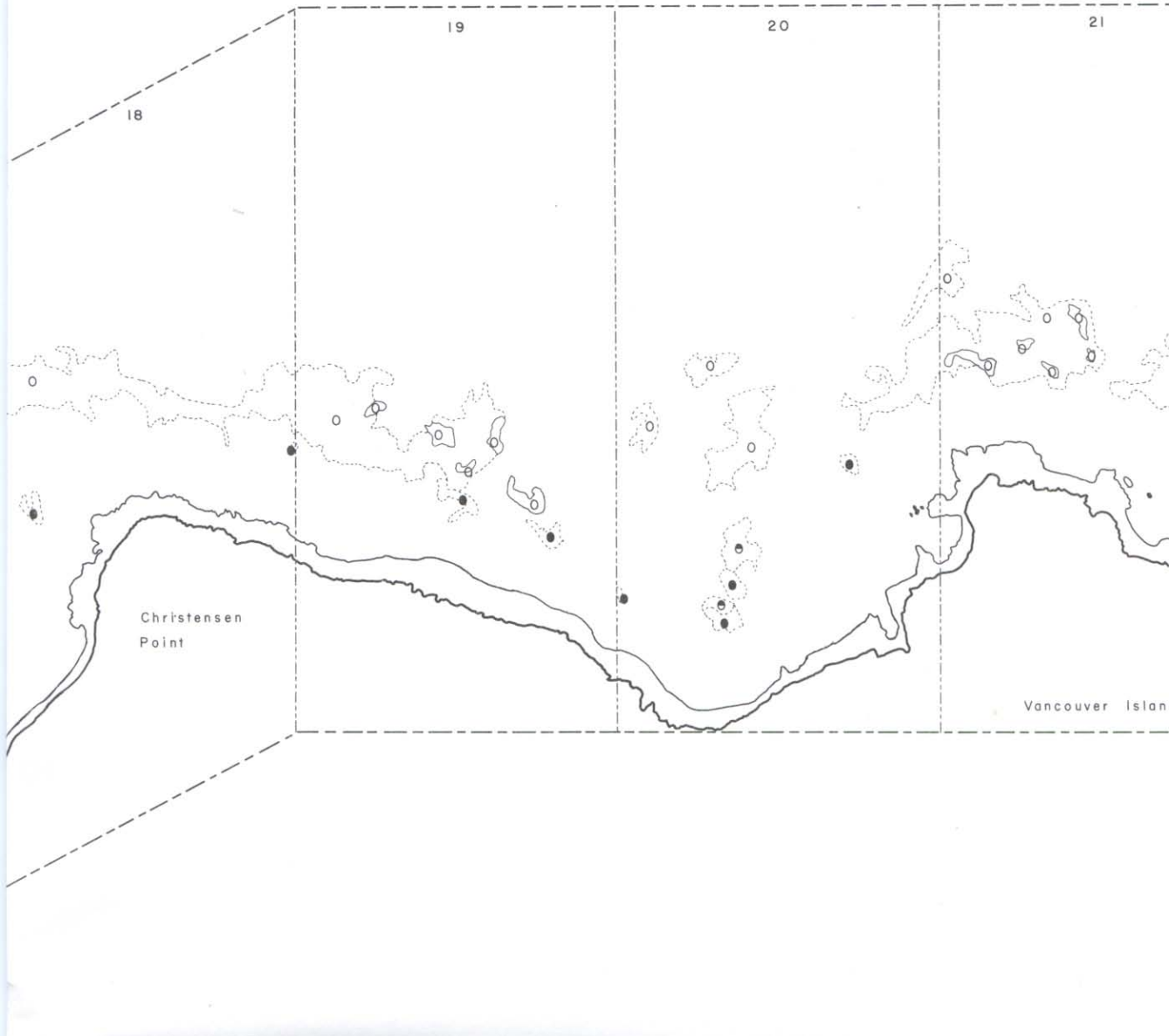
Point
Nels
Bight

# CHART B

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20
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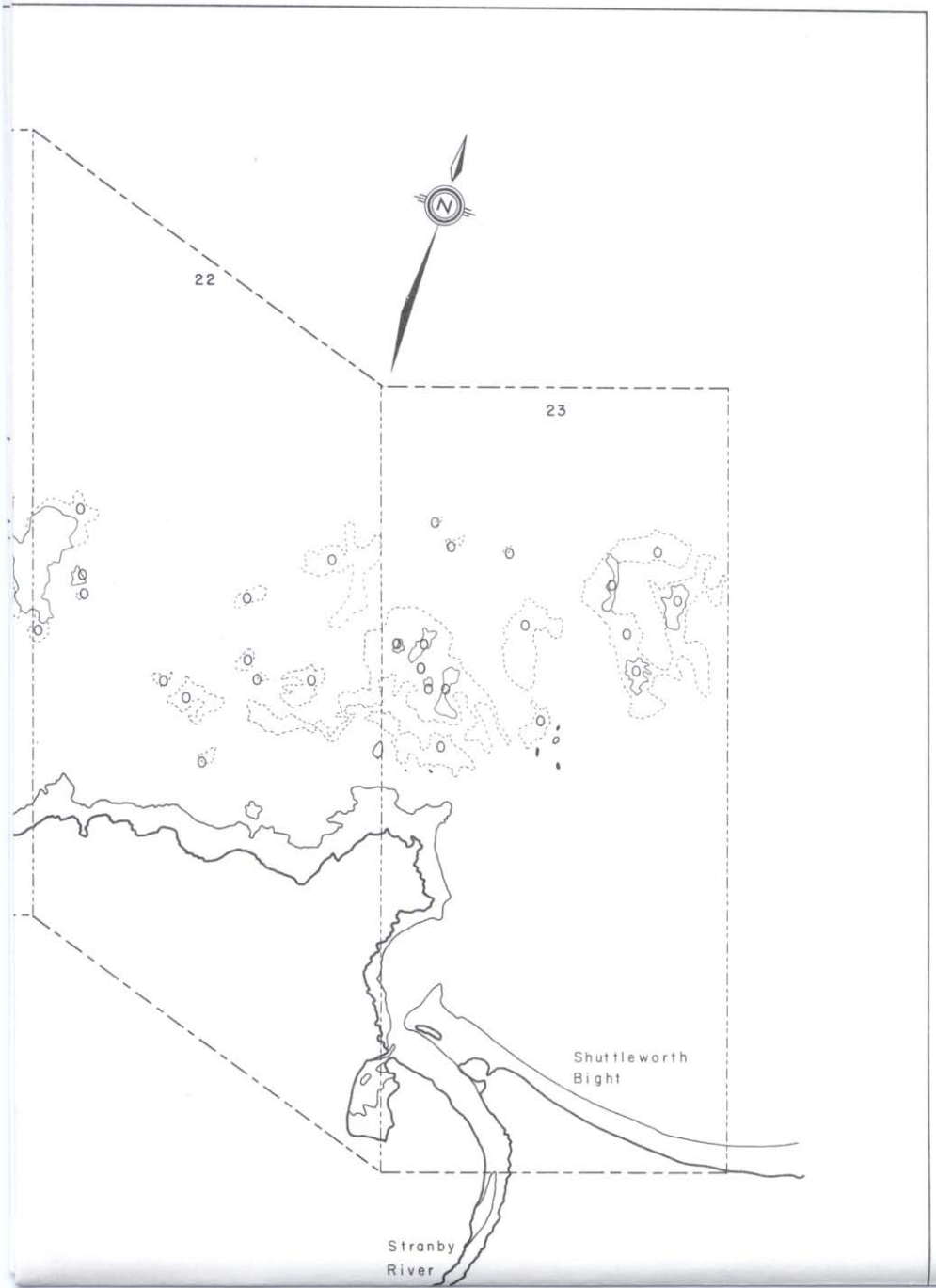
Christensen
Point
Vancouver Islan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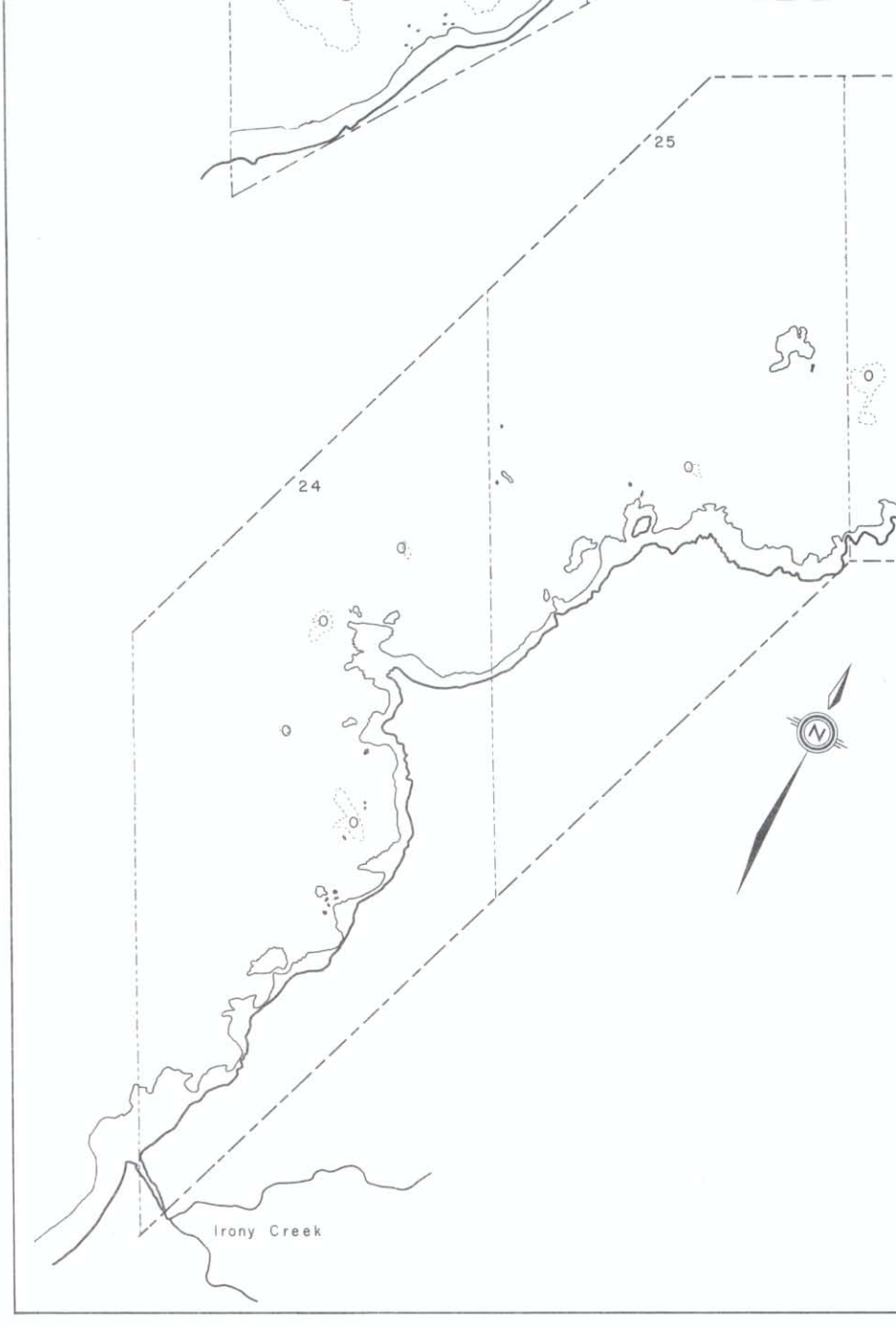
Stranby
River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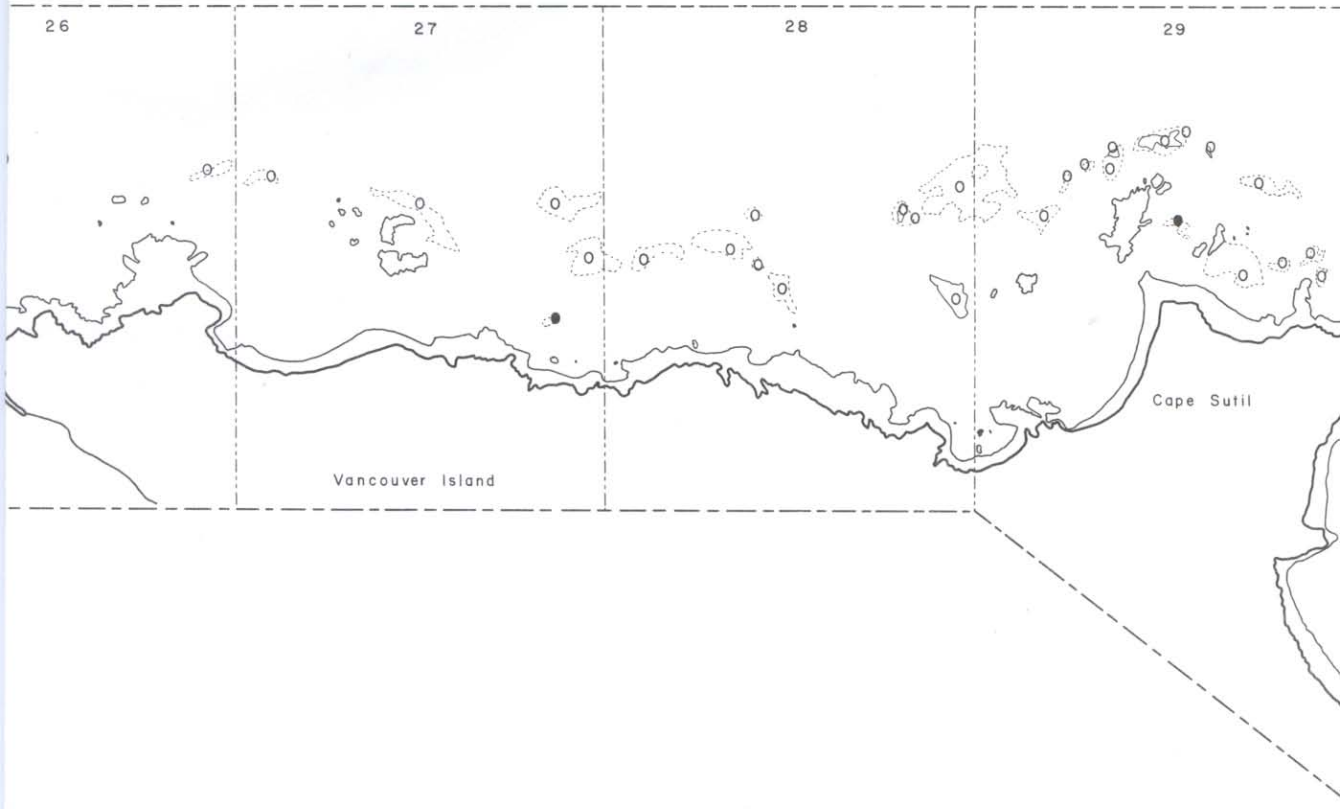

26
27
28
29
Vancouver Island
Cape Sutil


30
Rock
1/4 nautical mile
0
meters
500
LEGEND
edge of terrestrial vegetation
water level at time of photography
boundary of statistical block
boundary of photographic line
border between adjacent blocks
Nereocystis beds
Macrocystis beds
mixed beds of Nereocystis and Macrocystis
19
block number
high density bed
low density bed
rocks
houses and buildings

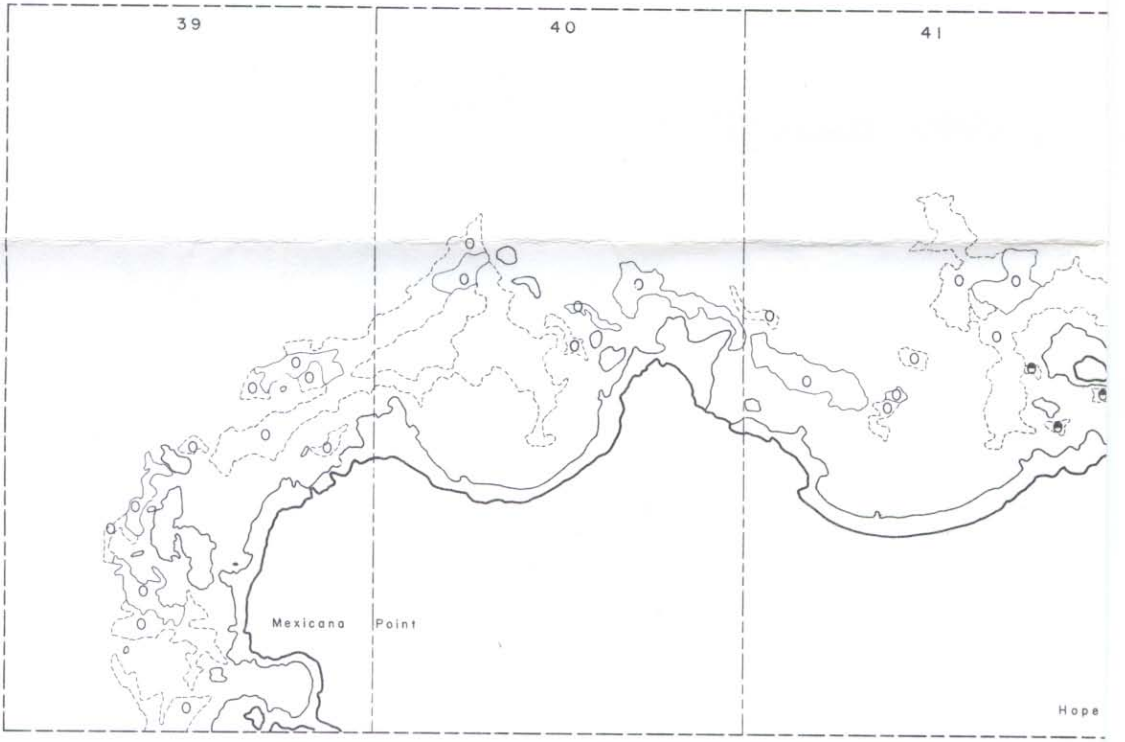
# CHART C

1/4 nautical mile

0 meters

LEGEND

- edge of terrestrial vegetatio
- water level at time of pho
- boundary of statistical blo
- boundary of photographic l
- border between adjacent b
- *Nereocystis* beds
- *Macrocystis* beds
- mixed beds of *Nereocystis*
- 39 block number
- high density bed
- low density bed
- rocks
- houses and buildings



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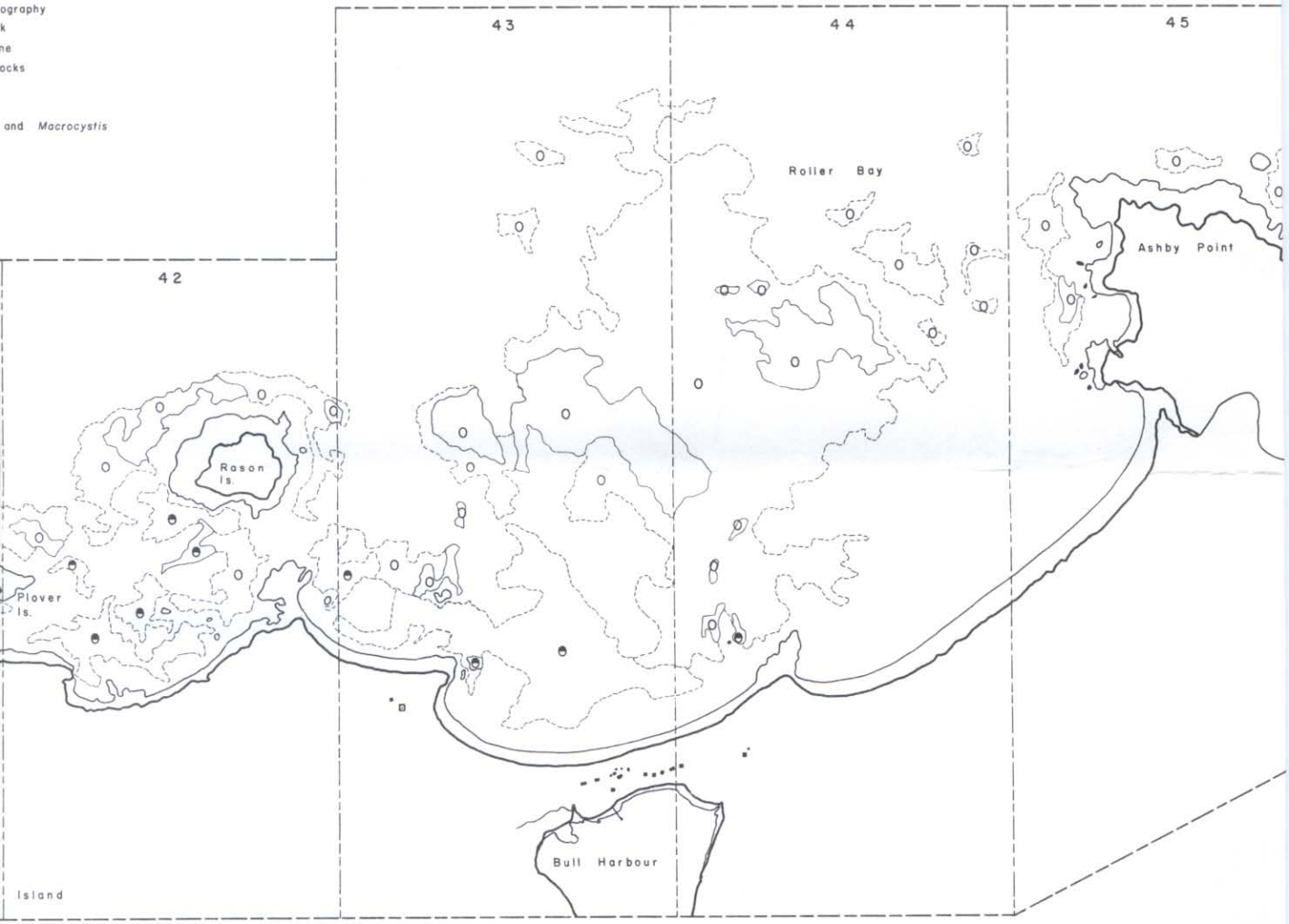
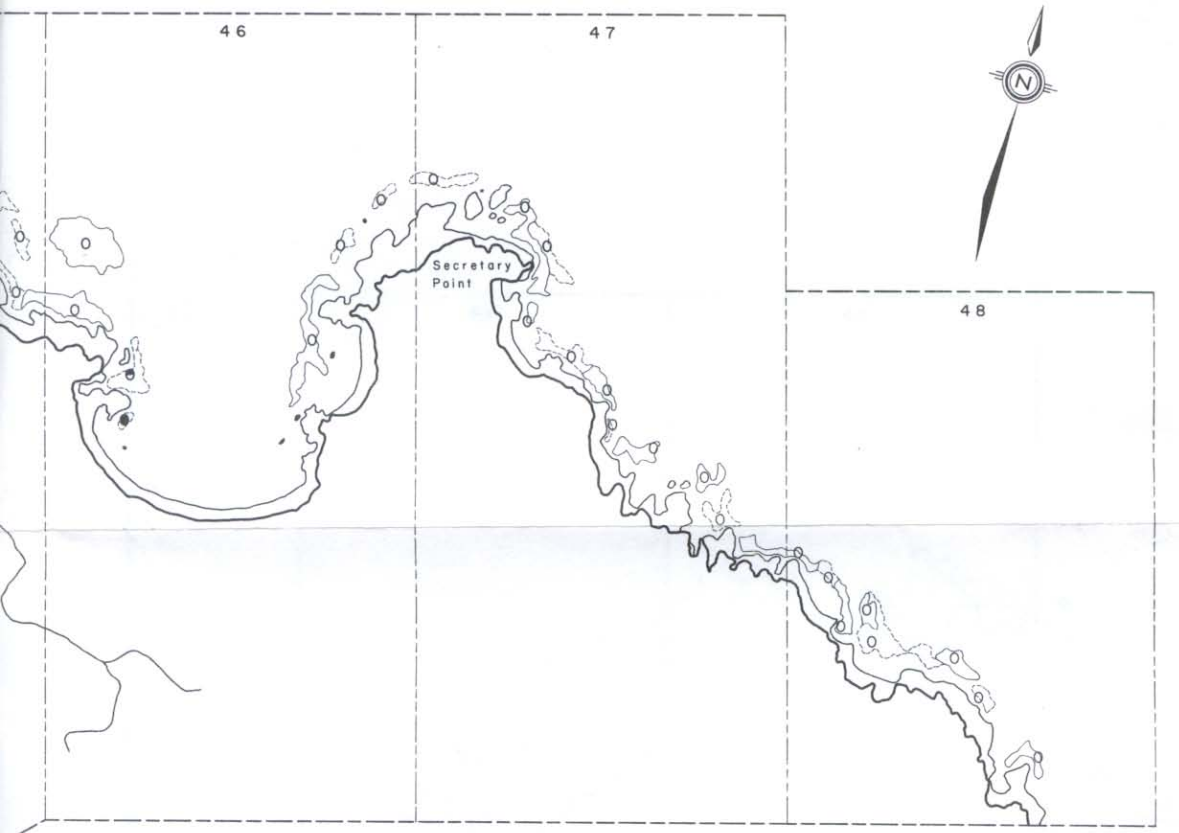
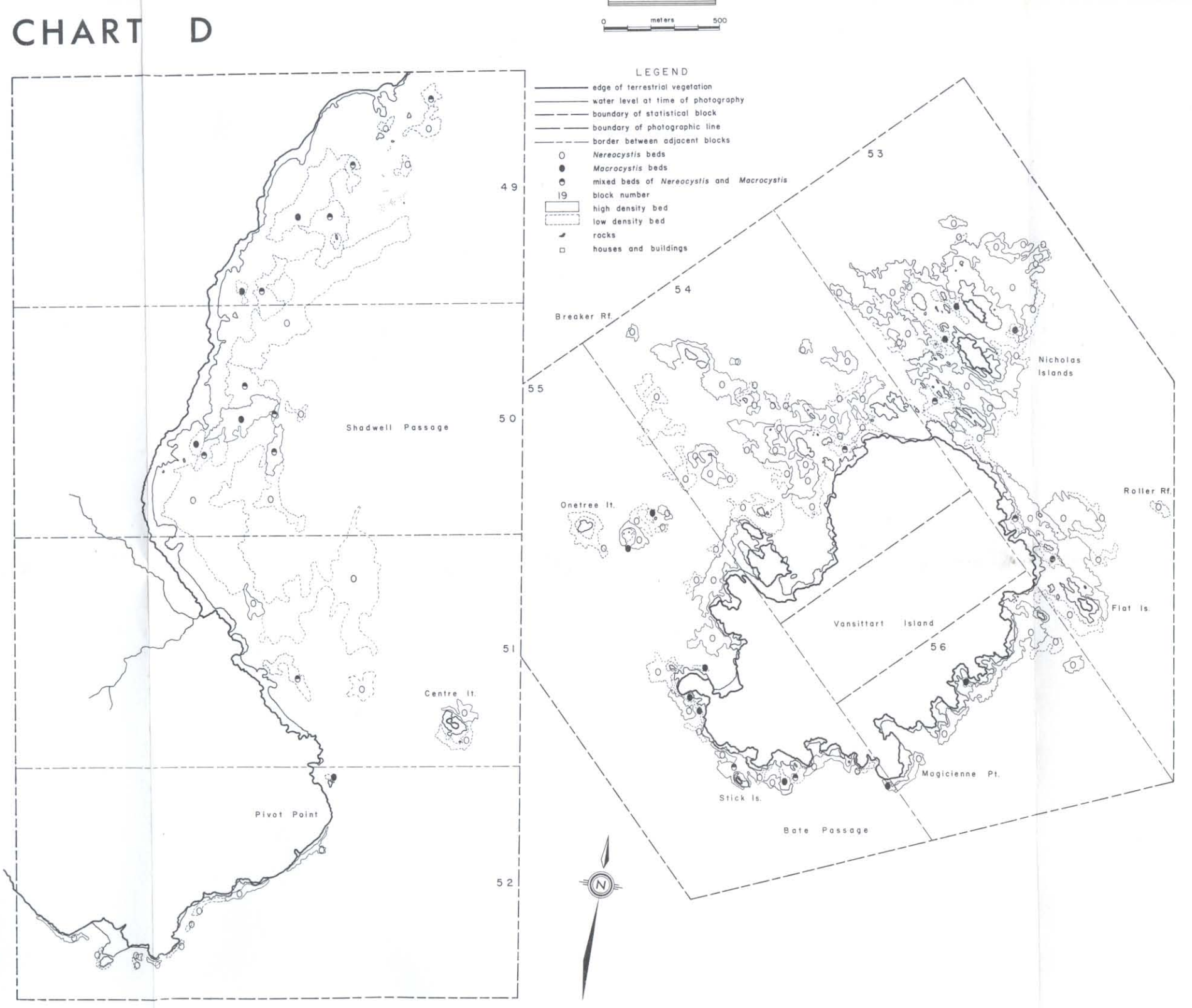
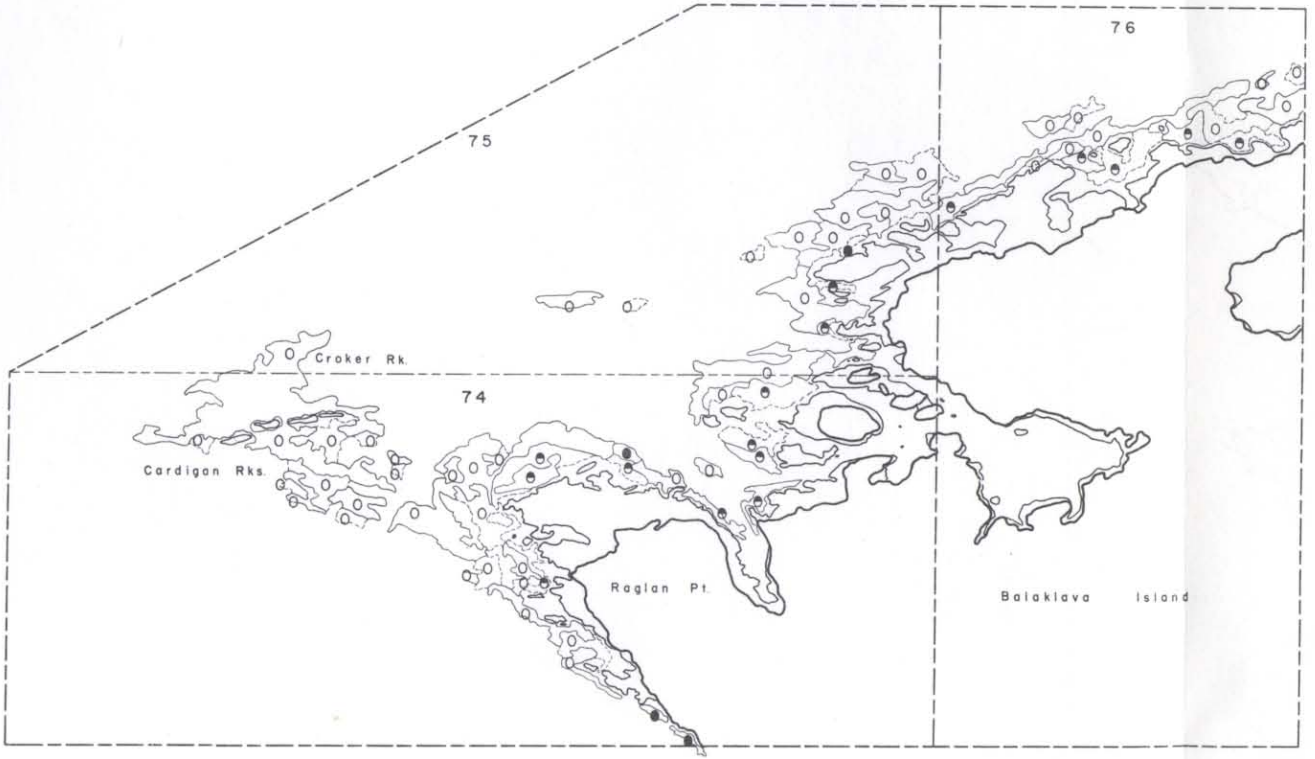



46
47
48
Secretary
Point
N

# CHART D


0 meters 500
LEGEND
edge of terrestrial vegetation
water level at time of photography
boundary of statistical block
boundary of photographic line
border between adjacent blocks
Nereocystis beds
Macrocystis beds
mixed beds of Nereocystis and Macrocystis
19 block number
high density bed
low density bed
rocks
houses and buildings
49
50
51
52
53
54
55
56
Shadwell Passage
Centre It.
Pivot Point
Breaker Rf.
Nicholas Islands
Onetree It.
Roller Rf.
Vansittart Island
Flat Is.
Magicienne Pt.
Stick Is.
Bate Passage
N

# CHART E

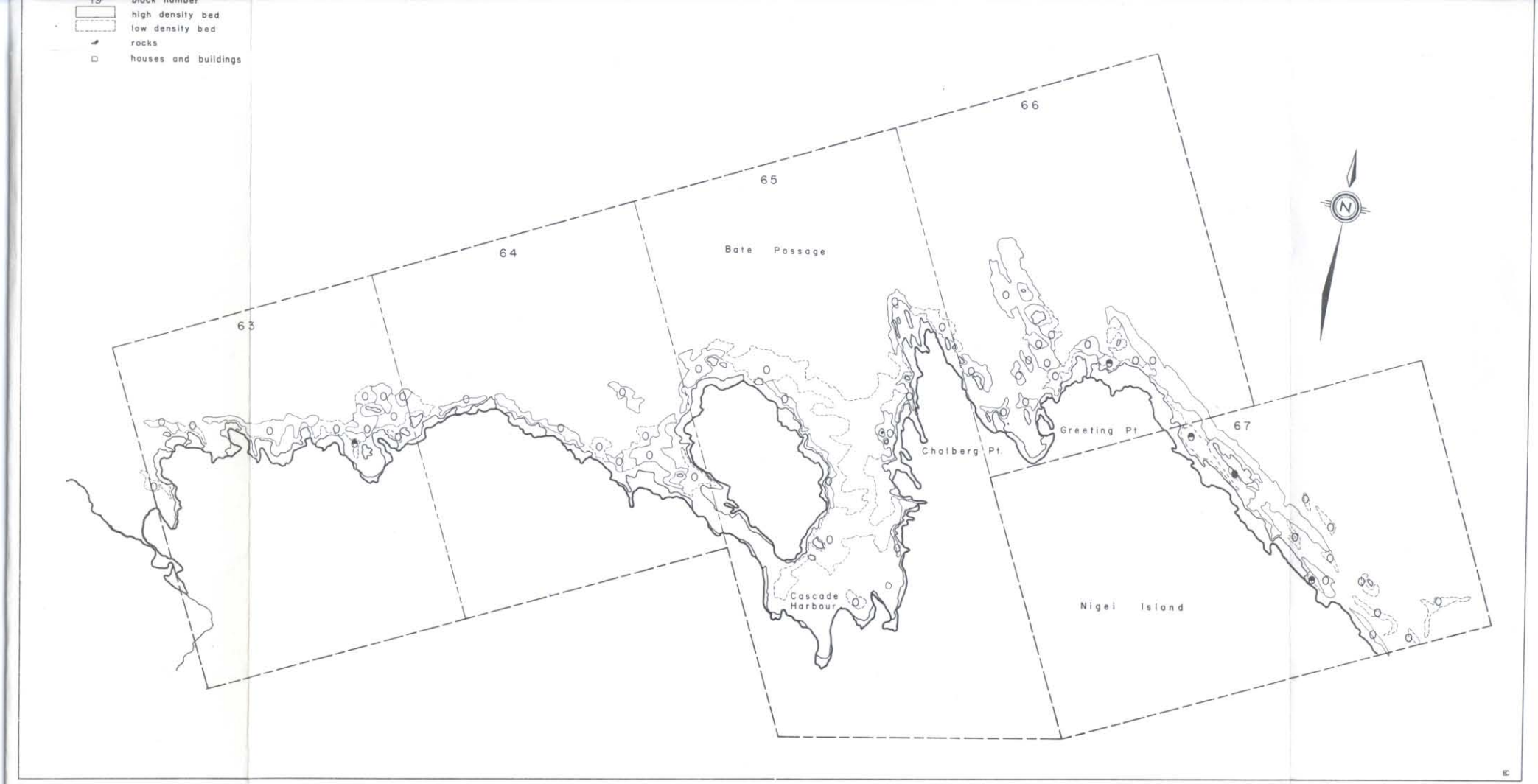



1/4 nautical mile

0 meters 500

LEGEND

- edge of terrestrial vegetation
- water level at time of photography
- boundary of statistical block
- boundary of photographic line
- border between adjacent blocks
- 0 *Nereocystis* beds
- ● *Macrocystis* beds
- ◓ mixed beds of *Nereocystis* and *Macrocystis*
- 19 block number
- high density bed
- low density bed
- rocks


19 block number
high density bed
low density bed
rocks
houses and buildings
63
64
65
66
67
Bate Passage
Cholberg Pt
Greeting Pt
Cascade Harbour
Nigel Island
N