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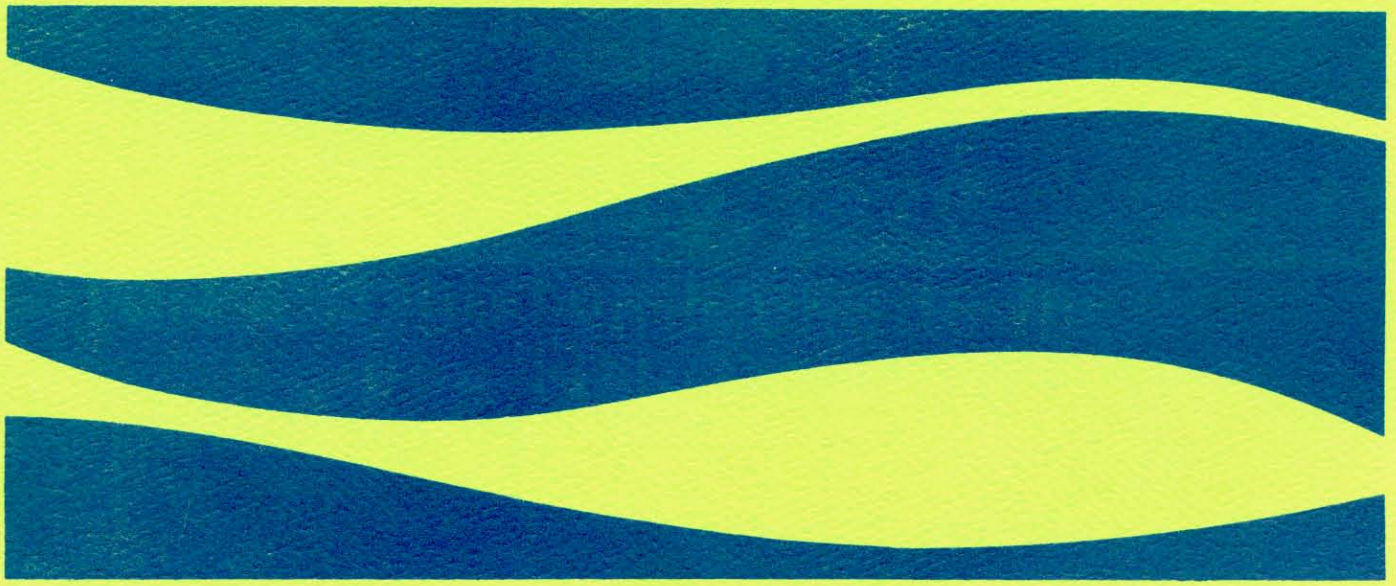

KELP INVENTORY, 1976. PART 4

GOSCHEN ISLAND TO THE TREE NOB GROUP

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 Goschen Island to the Tree Nob Group. Results indicated that 79,170 tonnes of pure Nereocystis luetkeana, 2,563 tonnes of pure Macrocystis integrifolia and 687 tonnes of kelp in mixed stands were available at mean water level in the major beds of this region. Total bed surface area was estimated to be 1,740 hectares. Six charts were drafted showing the position, extent, species, and density classification of every discernable kelp bed for each of three geographic subdivisions: Goschen and Porcher Islands, Prescott and Stephens Islands, and the Tree Nob Group. For management purposes, all inventoried coastlines were divided into permanent, numbered, kilometer wide blocks. A previous survey undertaken by the B.C. Research Council in 1946 is compared with the 1976 survey.

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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 Plants 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 from Goschen, Porcher, Prescott, and Stephen Islands and the Tree Nob Group is the fourth of the series (Field et al, 1977; Field and Clark, 1978; Coon et al, 1979) resulting from that effort. Henceforth in this report we will refer to this group of islands as the Porcher Group.

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).

Cameron (1916) was the first to report extensive kelp beds in certain portions of the Porcher Group and the B.C. Research Council (Anon., 1948) inventoried some of this region in 1946. In a later section we compare the results of the 1976 assessment with those obtained in 1946, where the areas covered by these two surveys overlap.

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 11 and 18, 1976 the Air Survey Branch, Ministry of Provincial Secretary and Travel Industry obtained black and white infrared aerial photography 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 directly from the photographs with the aid of a microscope. 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 August 24 and 25, 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 weight of each section was recorded. It was noted that Nereocystis in Chatham Sound were smaller, had fewer laminae and did not grow as deep as plants in the more exposed portions of the inventory area. Therefore plant biomass was determined separately for "exposed" and "sheltered" plants, and data for the "sheltered" morphology were used in calculations involving Blocks 87 - 102.

Certain areas were photographed when the tide was 1 or 2 m higher than the optimal level (MWL $\pm$ 0.6 m) as outlined by Foreman (1975). This resulted in a lower density of plants or fronds on the photographs than would be seen at MWL. A correction procedure for this is given in Coon et al (1979). This procedure permits the calculation of the plant/frond density at MWL by multiplying the adjusted mean biomass per plant/frond factors given in Table 1 by the plant/frond density recorded from the photographs.

All water depth and tide level calculations were based on values obtained from computer-drawn daily tide curves for Qlawdzeet Anchorage (Blocks 76; 84-97; 106-125) and Refuge Bay (Blocks 1-60; 98-102) obtained from the Federal Department of Fisheries and Oceans.

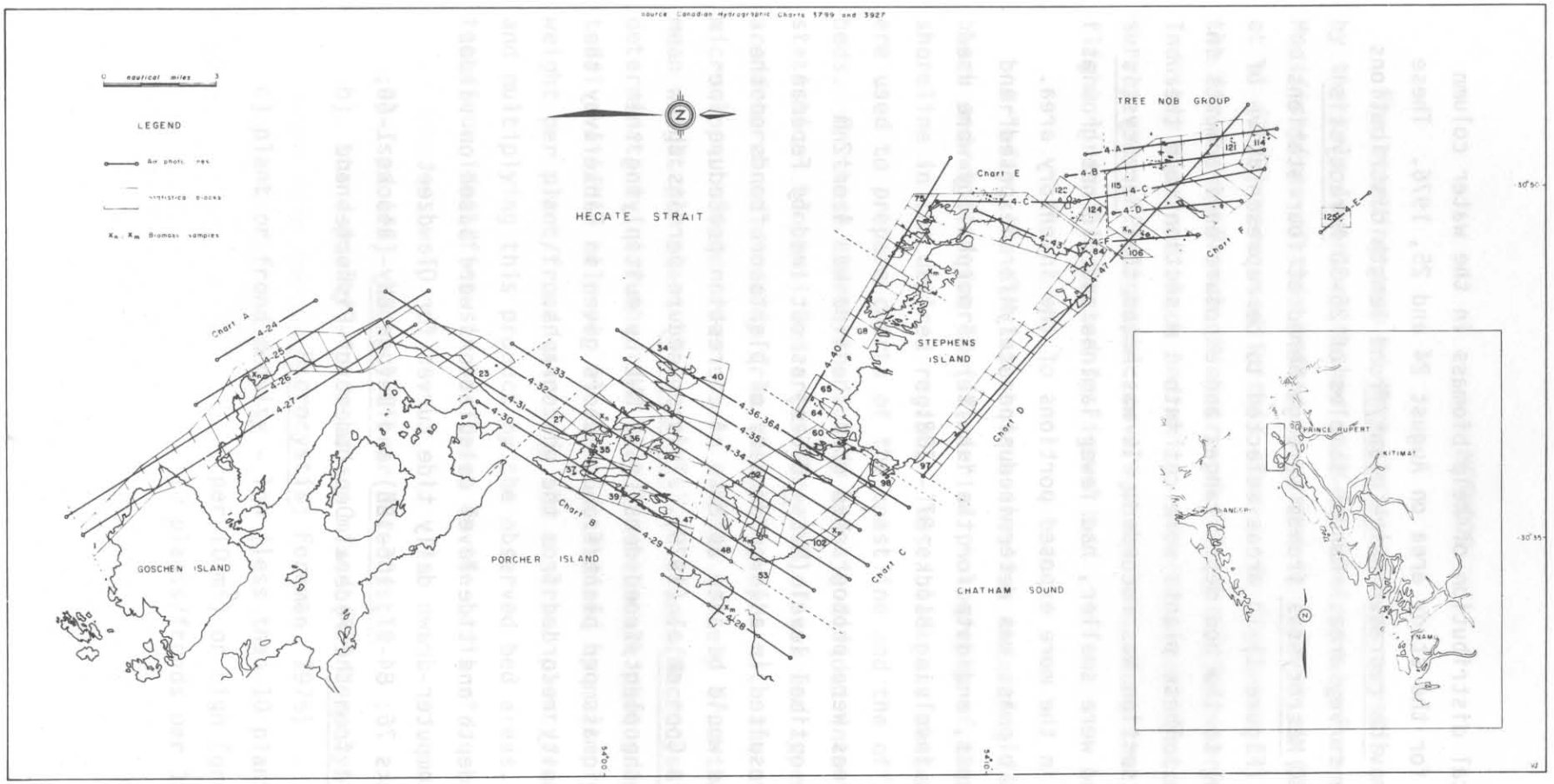

Figure 1. The Porcher Group, showing the area inventoried for floating kelp resources in 1976 and the mode of division of this area into inventory charts (see Appendix). Also indicated are the layout of statistical blocks, aerial photographic flight lines and locations of biomass sampling stations.

RESULTS

Charts A through F (Appendix) illustrate the disposition of kelp resources by bed type in the Porcher Group. 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.

Table 1. Mean biomass per plant or frond (kg) factors used to calculate biomass estimates at MWL for Goschen Island to the Tree Nob Group (see text).

Species	Photography at	Block Nos. (incl.)	$\bar{x}$ Biomass/ plant (kg)
Nereocystis	MWL	76, 84-86, 106-125	5.199
(exposed)	+1m	1-60	7.444
	+2m	64-75, 77-83	10.239
Nereocystis	MWL	87-97	3.239
(sheltered)	+1m	98-102	4.342
Macrocystis	MWL	76, 84-97, 106-125	1.439
	+1m	1-60, 98-102	1.757
	+2m	64-75, 77-83	1.916
Mixed	MWL	76, 84-97, 106-125	3.018
	+1m	1-60, 98-102	3.939
	+2m	64-75, 77-83	4.828

A summary of the field determined biomass data collected on August 24-25, 1976 is given in Table 2. This table gives vertical distribution of kelp biomass in 1 m increments above and below MWL for both "exposed" and "sheltered" pure Nereocystis populations as well as for pure Macrocystis and mixed Macrocystis/Nereocystis populations. See Field and Clark (1978, page 5) for a description of the station location and method used in calculating mean biomass per plant data for the "sheltered" populations.

Tables 3-5 present estimates of bed areas, kelp density and kelp biomass available at MWL, by bed type, for each block as follows:

a) Table 3 - Blocks 1-47, Goschen and Porcher Island.
b) Table 4 - Blocks 48-102; Prescott and Stephens Island.
c) Table 5 - Blocks 106-125; The Tree Nob Group.

Tables 6, 7 and 8 summarize the bed area and biomass estimates in these tables by bed type, by percent composition of biomass, and by percent composition of bed area for each bed type in each geograhical subdivision, respectively. A total of 82,420 metric tons of kelp were estimated to be available at MWL along the surveyed coastline, with Goschen Island and Porcher Island having the most (59,689 tonnes) and Prescott and Stephens Island the least (8,230)(Table 6). The majority (79,170 tonnes, or 96.06%) of the kelp biomass occurred as pure stands of Nereocystis, with 55.58% in low density beds and 40.48% in high desity beds (Table 7). The densest beds were located at Goschen and Porcher Islands. Figure 2 shows both dense Nereocystis and Macrocystis beds near Cape George on the Porcher Peninsula. "Sheltered" Nereocystis, characteristics of the plants in Chatham Sound, weighed just over half as much as the "exposed" plants which were characteristic of the other regions in the inventory area (Table 2). Pure stands of Macrocystis were

Table 2. The cumulative number of plants or fronds and their weight (biomass), and the mean weight per plant or frond at one meter increments for samples of Nereocystis collected in the Goschen Island to Tree Nob Group area.

Cutting Depth (m)	*Nereocystis* (exposed)			*Nereocystis* (sheltered)			*Macrocystis*			Mixed
	Cum B	Cum N	$\bar{x}$B/plant	Cum B	Cum N	$\bar{x}$B/plant	Cum B	Cum N	$\bar{x}$B/frond	$\bar{x}$B/plant or frond
+6	41.170	5	8.234	-	-	-	5.620	11	0.511	3.755
+5	46.565	5	9.313	2.235	1	2.235	11.165	16	0.698	4.316
+4	73.045	11	6.640	11.835	5	2.367	18.565	22	0.844	3.278
+3	119.375	18	6.632	29.235	11	2.658	28.150	32	0.880	3.296
+2	187.985	34	5.529	87.460	31	2.821	40.770	38	1.073	2.945
+1	248.405	47	5.285	215.805	70	3.083	56.085	42	1.335	2.994
MWL	348.340	67	5.199	304.505	94	3.239	73.400	51	1.439	3.018
-1	394.585	72	5.480	346.880	102	3.401	89.115	58	1.536	3.192
-2	426.480	75	5.686	361.020	105	3.438	103.435	70	1.978	3.245
-3	448.755	77	5.828	367.000	105	3.495	118.460	79	1.499	3.317
-4	458.510	77	5.955	370.070	105	3.524	131.790	85	1.550	3.400
-5	464.235	77	6.029	373.290	105	3.555	144.815	97	1.493	3.400
-6	468.885	77	6.089	374.545	105	3.567	154.800	103	1.503	3.429

*Based on 42% *Nereocystis* (exposed) 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.

estimated to contain 2,563 tonnes (3.11% of the standing crop at MWL), most of which occurred along the west coast of Porcher Island. Stands of pure Nereocystis comprised 81.67% of the total bed surface area (Table 8), indicating that Nereocystis beds were somewhat denser than Macrocystis beds.

Factors for estimating biomass at selected cutting levels other than MWL are presented in Table 9. 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 10 for the entire survey area. We estimated the total standing crop for all of the surveyed area in September, 1976 to be 113,436 tonnes. This was thought to be a somewhat conservative estimate primarily because of incomplete photographic coverage, and, very secondly, to inevitable losses of kelp laminae during field sampling procedures which result in under-estimation of mean biomass per plant/frond.

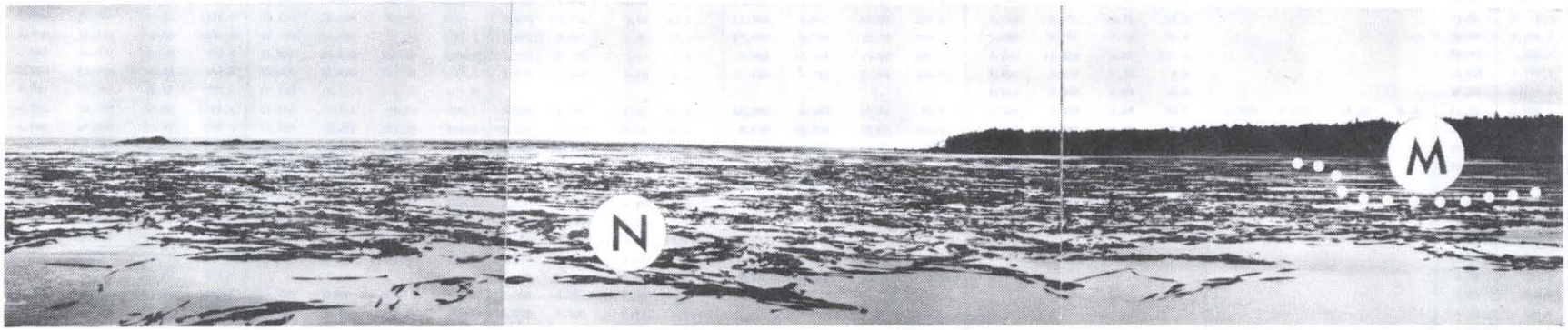

Figure 2. Photomosaic of a dense *Nereocystis* bed (N) lying offshore of a dense *Macrocystis* bed (M) in block 12, August, 1976. This embayment is situated immediately northwest of Cape George on the Porcher Penninsula.

Table 3. Estimates of kelp bed density, area and biomass for the west coasts of Goschen and Porcher Islands, 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	6,230	34.370	46.37	1593.8	14,490	15.034	107.84	1621.3																	49.40	3,215.1
2	5,780	24.880	43.02	1070.4	15,900	15.241	118.34	1803.7	6,160	3.058	10.80	33.0	11,650	6.791	20.47	139.0	3,240	6.584	12.75	83.9	12,700	1.607	50.00	80.4	58.16	3,210.4
3	4,800	3.058	35.78	109.4	14,500	0.985	108.07	106.4	6,160	0.259	10.85	2.8													4.30	218.6
4	4,800	4.199	35.81	105.4	14,500	0.518	107.78	55.8																	4.72	206.2
5	4,800	24.728	35.73	883.6	14,500	1.269	107.94	137.0																	26.00	1,020.6
6	6,060	34.111	45.11	1538.7	14,360	15.346	106.91	1640.7																	49.46	3,179.4
7	4,320	24.210	32.16	778.6	14,340	8.761	106.72	935.0																	32.97	1,713.6
8	6,290	30.586	46.83	1432.2	12,230	7.154	91.05	651.4																	37.74	2,083.6
9	6,090	28.719	45.33	1302.0	14,500	7.932	107.92	856.1																	36.65	2,158.1
10	6,150	31.467	45.78	1440.4	13,920	10.005	103.64	1036.9	6,160	0.104	10.14	1.1													41.58	2,478.4
11	6,260	6.532	46.61	304.5	13,920	5.391	103.56	558.3	6,160	0.052	10.14	0.5													11.98	863.3
12	6,260	8.865	46.60	413.1	15,640	24.313	116.44	2831.0	6,160	1.854	10.80	20.0	10,820	10.161	19.00	193.1	3,240	2.903	12.76	37.0					48.10	3,494.2
13	6,230	18.092	46.37	838.9	19,020	36.340	141.59	5145.3	3,070	1.970	5.35	10.5	11,650	0.363	20.33	7.4	3,240	2.955	12.80	37.8					59.72	6,039.9
14	5,630	32.970	41.90	1381.6	17,260	11.871	128.49	1525.3	3,070	3.318	5.40	17.9	11,650	2.592	20.47	53.1	3,240	1.970	12.80	25.2					52.72	3,003.1
15	4,920	30.741	36.61	1125.5	12,700	16.924	94.52	1599.7	3,070	11.716	5.40	63.3	11,300	8.087	19.86	160.6	3,240	5.340	12.76	68.2					72.81	3,017.3
16	5,710	38.413	42.50	1632.5	12,700	14.100	94.55	1333.2	3,050	8.865	5.35	47.4	10,650	8.709	18.72	163.0	1,890	6.791	7.43	50.4					76.88	3,226.5
17	4,890	21.721	36.40	790.6	18,270	25.142	135.99	3419.0	3,050	0.777	5.43	4.2	8,860	18.249	15.57	284.1	2,200	12.856	8.67	111.5					78.75	4,609.4
18	5,400	11.405	40.21	458.6	13,610	11.405	101.30	1155.3	3,050	1.141	5.39	6.1	12,450	6.791	21.86	148.5	1,890	0.254	7.76	2.0					31.00	1,770.5
19	4,320	29.549	32.17	950.6	13,610	4.717	101.32	477.9									1,460	3.318	5.69	18.9					37.59	1,447.4
20	4,030	48.989	30.00	1469.4	13,460	1.244	99.93	124.3	5,350	6.947	9.41	65.4	10,190	4.769	17.91	85.4	1,460	3.318	5.69	18.9	12,700	0.933	49.82	46.5	66.20	1,809.9
21	4,560	14.463	33.97	491.3	13,460	2.488	100.23	249.4	5,350	7.413	9.41	69.8	8,910	12.856	15.65	201.2	2,550	2.851	10.09	28.8					40.07	1,040.5
22	4,370	7.361	32.56	239.7	13,460	5.651	100.25	566.5	5,350	11.508	9.40	108.2	10,190	4.666	17.89	83.5	2,550	2.385	10.07	24.0					31.57	1,021.9
23	6,250	11.042	46.52	513.6	14,950	9.072	111.27	1009.4									2,550	0.052	7.58	0.4					20.17	1,523.4
27	6,710	4.251	49.91	212.2	11,250	1.296	83.86	108.7	2,580	1.037	4.57	4.7	8,910	0.052	16.89	0.9	2,550	1.710	10.14	17.3					8.35	343.8
28	6,710	2.281	49.93	113.9	11,250	1.348	83.94	113.1	2,580	0.881	4.59	4.0					2,550	1.040	10.23	10.6					5.55	241.6
29	5,610	10.472	41.73	437.0	11,250	0.829	83.51	69.2	2,580	0.259	4.75	1.2					2,550	0.780	10.10	7.9					12.34	515.3
30	6,380	10.420	47.51	495.0	11,250	0.467	84.48	39.5	2,580	3.162	4.56	14.4													14.03	548.9
31	6,710	5.962	49.94	297.8	11,250	5.960	83.81	499.5	2,580	1.140	4.47	5.1													13.06	802.4
32	5,860	5.754	43.63	250.9					2,580	0.467	4.51	2.1	8,910	0.156	15.77	2.5									6.38	255.5
33	5,860	8.398	43.60	366.2	11,250	0.311	83.77	26.1	2,580	0.363	4.36	1.6													9.07	393.9
34	6,800	5.028	50.61	254.6	11,250	0.880	83.75	73.7	2,580	0.518	4.53	2.3													6.43	330.6
35									2,490	1.032	4.43	4.6													1.03	4.6
36									2,580	4.510	4.52	20.4													4.51	20.4
37									2,710	6.428	4.76	30.6													6.43	30.6
38									2,710	5.599	4.77	26.7													5.60	26.7
39									2,710	6.221	4.77	29.7													6.22	29.7
40	5,660	13.478	42.14	568.0	11,250	1.192	83.68	99.7	2,710	0.933	4.71	4.4													15.60	672.1
41	5,940	3.110	44.28	137.7	11,250	0.260	83.03	21.6																	3.37	159.3
42	5,940	7.361	44.20	325.3	11,250	0.100	81.88	8.2	2,830	2.074	5.00	10.4													9.54	343.9
43	5,940	5.702	44.27	252.4	11,250	0.410	83.52	34.2	2,830	0.104	5.07	0.5													6.22	287.1
44	5,930	11.249	44.14	496.5					2,830	0.829	4.87	4.0													12.08	500.5
45	8,100	8.657	60.26	521.8	11,250	1.710	83.58	142.9	2,830	14.360	4.97	71.3													24.73	736.0
46	7,070	10.731	52.66	565.0					2,390	10.627	4.20	44.6													21.36	609.6
47	5,470	10.057	40.70	409.4	11,250	0.360	84.78	30.5	2,390	10.886	4.20	45.7													21.30	485.6
Totals		643		26,613		266		30,106		130		779		84		1,522		55		543		3		127	1,182	59.689
Means	5765.1	16.5	42.9	682.4	13,376.4	7.4	99.5	836.3	3,466.5	3.8	6.1	22.9	10472.3	6.5	18.5	117.1	2525.0	3.4	9.8	33.9	12,700.0	1.5	49.9	63.5	26.9	1,356.6

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean (obtained by averaging only those blocks containing kelp)

ha = Hectare

Table 4. Estimates of kelp density, bed area and biomass for Prescott and Stephens Islands, September, 1976. See Charts C and D.

	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
48	7,470	4.251	55.52	236.0	12,490	2.230	93.13	207.7																	6.48	443.7
49	7,470	3.059	55.71	170.5	12,490	0.980	92.67	90.8	3,660	1.296	6.37	8.3													5.34	269.6
50	7,470	2.385	55.67	132.5	12,490	0.207	93.50	19.4	3,660	4.199	6.44	27.1													6.79	179.0
51	7,470	1.711	55.72	95.3					3,270	3.991	5.77	23.0	8,190	0.467	14.30	6.7									6.17	125.0
52	7,470	3.938	55.57	218.9					3,270	0.518	5.77	3.0													4.46	221.9
53	7,470	2.348	55.58	132.5					3,270	1.969	5.71	11.2					1,650	0.362	6.53	2.4					4.72	146.1
54									3,270	2.488	5.72	14.2													2.49	14.2
55									3,270	0.829	5.72	4.7													0.83	4.7
56									3,070	5.806	5.39	31.3	8,190	0.058	15.15	0.9									5.86	32.2
57	6,980	3.991	52.04	207.7					3,070	5.418	5.38	29.2													9.41	236.9
58	6,980	1.503	52.00	78.2	10,450	1.503	77.76	116.9	3,070	1.192	5.45	6.5													4.20	201.6
59	6,980	3.036	52.00	156.3	10,450	0.104	78.73	8.2	3,070	1.969	5.35	10.5													5.08	173.0
60	6,980	3.732	51.86	193.5					3,070	6.739	5.40	36.4					1,650	0.259	6.08	1.6					10.73	231.5
64	5,710	4.925	56.42	287.7	10,450	0.207	108.82	22.5																	5.13	310.2
65	5,710	0.726	57.82	42.0																					0.73	42.0
68	5,710	1.399	58.55	81.9																					1.40	81.9
69	5,710	5.028	58.44	293.9					3,070	1.814	5.91	10.7													6.84	304.6
70	5,710	0.622	59.26	36.9																					0.62	36.9
71	5,710	1.607	58.62	94.2																					1.61	94.2
72	5,460	5.495	55.90	307.2	10,450	0.207	108.82	22.5																	5.70	329.7
73	6,140	8.554	62.84	537.5	10,450	0.570	107.78	61.4																	9.12	598.9
74	5,460	4.925	55.92	275.4	10,450	0.259	106.74	27.6																	5.18	303.0
75	6,410	1.969	65.52	129.0																					1.97	129.0
76	7,860	0.272	40.14	10.9																					0.27	10.9
77	7,860	7.257	80.42	583.6																					7.26	583.6
78	7,050	12.027	72.19	868.3	11,210	2.022	114.95	232.4																	14.05	1100.7
79	7,050	3.784	72.25	273.4																					3.78	273.4
80	7,050	0.985	71.72	70.6																					0.99	70.6
81	7,050	0.829	71.64	59.4																					0.83	59.4
82	7,050	0.622	72.43	45.1																					0.62	45.1
83	7,050	1.088	72.46	78.8																					1.09	78.8
84	7,050	1.140	36.48	41.6																					1.14	41.6
85	6,870	7.828	35.73	279.7	11,210	0.674	58.62	39.5																	8.50	319.2
86	7,570	1.711	39.50	67.6	14,920	0.104	79.98	8.3	3,550	0.518	5.00	2.6													2.33	78.5
87	7,570	1.452	24.54	35.6	14,920	0.052	48.83	2.6	3,550	1.089	5.15	5.6	8,190	0.052	11.07	0.6									2.65	44.4
88	7,570	3.992	24.50	97.8	14,920	0.622	48.43	30.1	3,550	1.814	5.07	9.2					4,370	0.415	13.09	5.4					6.84	142.5
89	7,670	1.037	24.99	25.9	14,920	0.104	49.83	5.2	3,550	0.259	5.00	1.3													1.40	32.4
90	7,670	0.829	25.01	20.7	14,920	0.259	48.77	12.6	3,550	0.104	5.53	0.6	8,190	0.104	12.45	1.3									1.30	35.2
91	7,670	0.466	25.02	11.7	14,920	0.622	48.43	30.1	3,550	0.104	5.53	0.6													1.19	42.4
92	7,670	2.799	24.88	69.6	14,920	0.518	48.15	24.9																	3.32	94.5
93	7,670	2.436	24.86	60.6	14,920	0.363	48.18	17.5	3,550	0.259	5.00	1.3	8,190	0.207	11.82	2.4									3.27	81.8
94	7,670	1.969	24.84	48.9	14,920	0.622	48.43	30.1	3,550	0.104	5.53	0.6	8,190	0.104	12.45	1.3									2.80	80.9
95	7,670	0.104	24.91	2.6	14,920	0.363	48.18	17.5	3,550	0.207	4.87	1.0	8,190	0.052	11.07	0.6	4,370	0.570	13.24	7.5					1.30	29.2
96	7,670	0.881	25.00	22.0	14,920	0.052	49.83	2.6	3,550	0.674	5.12	3.5													1.61	28.1
97	7,670	2.385	24.85	59.3	14,920	0.052	49.83	2.6	3,550	0.622	5.09	3.2													3.06	65.1
98	7,670	1.192	33.15	39.5	14,920	0.104	66.80	6.9																	1.30	46.4
99	7,670	0.570	33.51	19.1																					0.57	19.1
100	7,670	0.570	33.51	19.1	14,920	0.518	64.54	33.4																	1.09	52.5
101	7,670	0.881	33.51	29.5	14,920	0.570	64.75	36.9																	1.45	66.4
102	7,670	2.436	33.33	81.2	14,920	1.763	64.77	114.1																	4.20	195.3
Totals		127		6,729		16		1,224		44		246		1		14		2		17					189	8,230
Means	7,074.0	2.7	47.6	143.2	13,381.9	0.6	71.7	45.3	3,380.8	1.8	5.5	10.3	4,190.0	0.1	12.6	2.0	3,010.0	5.0	9.8	4.3					3.8	144.4

D = Density (no. of plants or fronds)
A = Area (hectares)
B = Biomass (metric tonnes)
$\bar{x}$ = Mean (obtained by averaging only those blocks containing kelp)
ha = Hectare

Table 5. Estimates of kelp density, bed area and biomass for the Tree Nob Group, September, 1976. See Chart 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
106	7,000	13.064	36.41	475.7	11,210	0.674	58.62	39.5																	13.74	515.2
107	7,100	14.515	36.93	536.0	11,210	0.363	58.72	21.3																	14.88	557.3
108	6,800	26.231	35.36	927.5	11,210	1.296	58.17	75.4																	27.53	1002.9
109	7,040	20.839	36.59	762.7	12,600	0.155	67.08	10.4	3,550	0.259	5.00	1.3													21.25	774.4
110	6,530	33.592	33.96	1140.7	12,600	1.399	65.41	91.5																	34.99	1232.2
111	7,490	19.129	38.95	745.0	12,600	1.296	65.39	84.7																	20.43	829.7
112	7,130	31.726	37.07	1176.0	12,600	1.607	65.35	105.0																	33.33	1281.0
113	8,280	15.448	43.04	665.0	11,850	3.214	61.63	198.1	3,550	0.155	5.57	0.9													18.82	864.0
114	7,300	24.313	37.96	922.8	11,850	3.732	61.57	229.8																	28.05	1152.6
115	7,140	0.829	36.99	30.7																					0.83	30.7
116	7,140	2.488	37.19	92.5																					2.49	92.5
117	7,140	5.651	37.19	209.5	10,980	0.829	57.07	47.3																	6.48	256.8
118	7,070	15.863	36.67	582.8	10,980	0.731	56.90	41.6																	16.59	624.4
119	6,880	18.922	35.77	676.9	10,980	3.162	57.05	180.4																	22.08	857.3
120	7,890	18.507	41.01	759.1	10,980	5.028	57.08	286.9																	23.54	1046.0
121	7,570	27.994	39.36	1101.7	10,980	5.806	57.13	331.7																	33.80	1433.4
122	6,350	6.169	33.04	203.8	11,210	0.104	59.99	6.2																	6.27	210.0
123	6,890	6.169	35.82	221.0																					6.17	221.0
124	7,000	3.525	36.43	128.4	11,210	0.259	58.21	15.1																	3.78	143.5
125	7,100	30.067	36.92	1110.0	11,430	4.458	59.48	265.1																	34.53	1375.1
Totals		335		12,468		34		2,030		0		2													370	14,500
Means	7,142.0	16.8	37.2	623.4	11,558.0	2.0	60.3	119.4	3,550.0	0.0	5.3	1.1													18.5	725.0

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean (obtained by averaging only those blocks containing kelp)

ha = Hectare

Table 6: Summary of biomass and kelp bed area estimates; by geographical subdivision and bed type, for the Goschen Island to Tree Nob Group area, 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		
Goschen & Porcher Is.	1-47	26,613	643
Prescott & Stephens Is.	48-102	6,729	127
Tree Nob Group	106-125	12,468	335
	High Density Nereocystis		
Goschen & Porcher Is.	1-47	30,106	266
Prescott & Stephens Is.	48-102	1,224	16
Tree Nob Group	106-125	2,030	34
	Low Density Macrocystis		
Goschen & Porcher Is.	1-47	779	130
Prescott & Stephens Is.	48-102	246	44
Tree Nob Group	106-125	2	0
	High Density Macrocystis		
Goschen & Porcher Is.	1-47	1,522	84
Prescott & Stephens Is.	48-102	14	1
Tree Nob Group	106-125	nil	nil
	Low Density Mixed		
Goschen & Porcher Is.	1-47	543	55
Prescott & Stephens Is.	48-102	17	2
Tree Nob Group	106-125	nil	nil
	High Density Mixed		
Goschen & Porcher Is.	1-47	127	3
Prescott & Stephens Is.	48-102	nil	nil
Tree Nob Group	106-125	nil	nil
	Totals		
Goschen & Porcher Is.	1-47	59,689	1,182
Prescott & Stephens Is.	48-102	8,230	189
Tree Nob Group	106-125	14,500	370
Grand Totals	1-125	82,420	1,741
	Totals by Species		
Nereocystis	1-125	79,170	1,421
Macrocystis	1-125	2,563	259
Mixed	1-125	687	60

Table 7: Estimated percent composition by bed type of the kelp biomass in each of the three geographic subdivisions in the 1976 survey area. The last column gives percent composition of biomass available at MWL for the three areas combined.

Bed type	Goschen/ Porcher	Prescott/ Stephens	Tree Nob Group	Combined
Nereocystis				
- low density	44.59	81.76	85.99	55.58
- high density	50.44	14.87	14.00	40.48
Macrocystis				
- low density	1.31	2.99	0.01	1.25
- high density	2.55	0.17	nil	1.86
Mixed				
- low density	0.91	0.21	nil	0.68
- high density	0.21	nil	nil	0.15

Table 8: Estimated percent composition by bed type of the bed surface area in each of the three geographic subdivisions in the 1976 survey area. The last column gives the percent composition of total bed area for the three areas combined.

Bed type	Goschen/ Porcher	Prescott/ Stephens	Tree Nob Group	Combined
Nereocystis				
- low density	54.45	66.84	90.69	63.51
- high density	22.52	8.42	9.20	18.16
Macrocystis				
- low density	11.01	23.16	0.11	10.00
- high density	7.11	0.53	nil	4.89
Mixed				
- low density	4.66	1.05	nil	3.28
- high density	0.25	nil	nil	0.17

Table 9: Combined biomass and density correction factors for cutting levels six meters above and below MWL for the Goschen Island to Tree Nob Group (1976).

Cutting Level (m)	Nereocystis (exposed) n=77	Nereocystis (sheltered) n=105	Macrocystis n=105	Mixed *
+6	0.12	-	o.08	0.18
+5	0.13	0.01	0.15	0.28
+4	0.21	0.04	0.25	0.33
+3	0.34	0.10	0.38	0.49
+2	0.54	0.29	0.56	0.61
+1	0.71	0.71	0.76	0.76
MWL	1.00	1.00	1.00	1.00
-1	1.13	1.14	1.21	1.17
-2	1.22	1.19	1.41	1.34
-3	1.29	1.21	1.61	1.49
-4	1.32	1.22	1.80	1.59
-5	1.33	1.23	1.97	1.73
-6	1.35	1.23	2.11	1.81

*Based on 42% and 58% Macrocystis.

Table 10: Total kelp biomass at selected depth levels for the Goschen Island to Tree Nob Group area in September 1976.

Depth Level (m)	Nereocystis*	Macrocystis	Mixed	Total
+6	9,382	205	124	9,711
+5	10,171	384	192	10,747
+4	16,458	641	227	17,326
+3	26,682	974	337	27,993
+2	42,510	1,435	419	44,364
+1	56,225	1,948	522	58,695
MWL	79,190	2,563	687	82,420
-1	89,495	3,101	804	93,400
-2	96,582	3,614	921	101,117
-3	102,074	4,126	1,024	107,224
-4	104,430	4,613	1,092	110,135
-5	105,222	5,047	1,189	111,458
-6	106,785	5,408	1,243	113,436

*The combined biomass and density for sheltered Nereocystis (Table 9) were used to determine biomass in Blocks 87 through 102.

Table 11: Comparison of bed area and biomass estimates between the 1946 and 1976 kelp inventories in the Porcher Group. For both surveys biomass estimates are at 4 meters below MWL (approximately MLLW). The 1946 bed area estimates are at -4 m and 1976 estimates are at MWL or 1 or 2 m above MWL.

	NEREOCYSTIS				MACROCYSTIS			
	Area (ha)		Biomass (t)		Area (ha)		Biomass (t)	
	1946	1976	1946	1976	1946	1976	1946	1976
Welcome Harbour	6.4	84.9	622.0	5,766.9	65.2	67.6	3,184.2	562.7
(% of 1976)	(8)		(11)		(96)		(566)	
Prescott/Stephens	25.4	128.5	2,908.9	9,274.4	3.8	44.2	140.6	462.6
(% of 1976)	(20)		(31)		(9)		(30)	
Tree Nob Group	28.5	318.9	2,571.5	16,563.6	nil	0.4	nil	4.0
(% of 1976)	(9)		(16)		(0)		(0)	
TOTAL	60.3	532.3	6,102.4	31,604.9	69.0	112.2	3,324.8	1,029.3
% of 1976	(11.3)		(19.3)		(61.5)		(323)	

methods. Density of Nereocystis was determined from a small, but undefined, number of "representative" plant counts within 100 ft^2 plots. Average weight per plant of Nereocystis, which was determined "periodically" throughout the survey area by weighing plants cut 6-8 ft below the seasurface, was multiplied by the density to obtain the biomass per unit area. Plant density and biomass per unit area for Macrocystis were estimated by cutting a 100 ft^2 plot. Biomass per unit area was then multiplied by bed area estimates to estimate total harvestable biomass in each subdivision of the survey area.

With an error of only $\pm$8%, the most accurate procedure of the KIM-1 technique is the determination of bed area from aerial photographs. The determination of density directly from these photographs also has estimated errors (Foreman, 1975). The determination of the vertical distribution of biomass in the water column is the most subjective and probably the least well sampled parameter. Even so, Coon et al (1977) determined that the sampling procedure used produces a truly representative mean biomass per plant/frond estimate. Because of these factors we believe that the KIM-1 method is the most accurate kelp inventory technique available, and we recommend that the estimates of kelp biomass produced with this technique be relied on in making quota allocations in this survey area. We refer the reader to a more thorough discussion and comparison of these two inventory procedures given in Field and Clark (1978).

REFERENCES

Anon. 1948. Marine plants of 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). 17 pp.

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 (2nd Edition). 27 pp.

Coon, L. M., W. Roland, E. J. Field, and W. E. L. Clayton. 1979. Kelp inventory, 1976, Part 3. North and West Coasts Graham Island (Q.C.I.). British Columbia Marine Resources Branch, Fish. Management Rep. No. 13. 26 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. 81 pp.

CHART A


1
2
3
4
5
6
7
Joachim Pt.
Goschen Island
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12
13
Joachim Rk.
Hecate St


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Bass Rk
Oval Point
Porcher Peninsula
1/4 nautical mile
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meters
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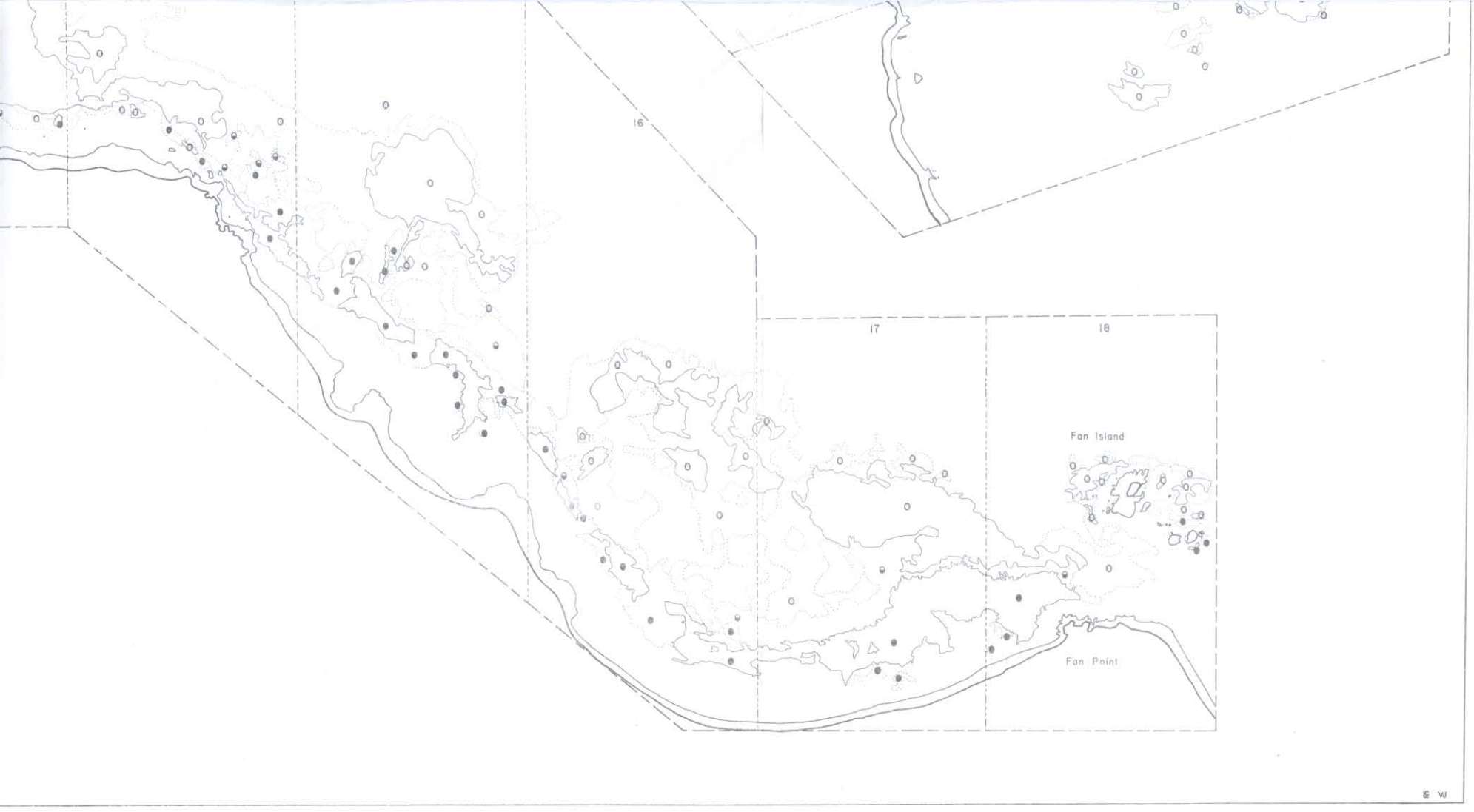
LEGEND
edge of terrestrial vegetation
water level at time of photography
boundary of statistical block
boundary of photographic line
border between adjacent blocks
Nereocystis beds
Macrocystis beds
mixed beds of Nereocystis and Macrocystis
19 block number
high density bed
low density bed
rocks
houses and buildings


Cape George
Porcher Peninsula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17
18
Fan Island
Fan Point

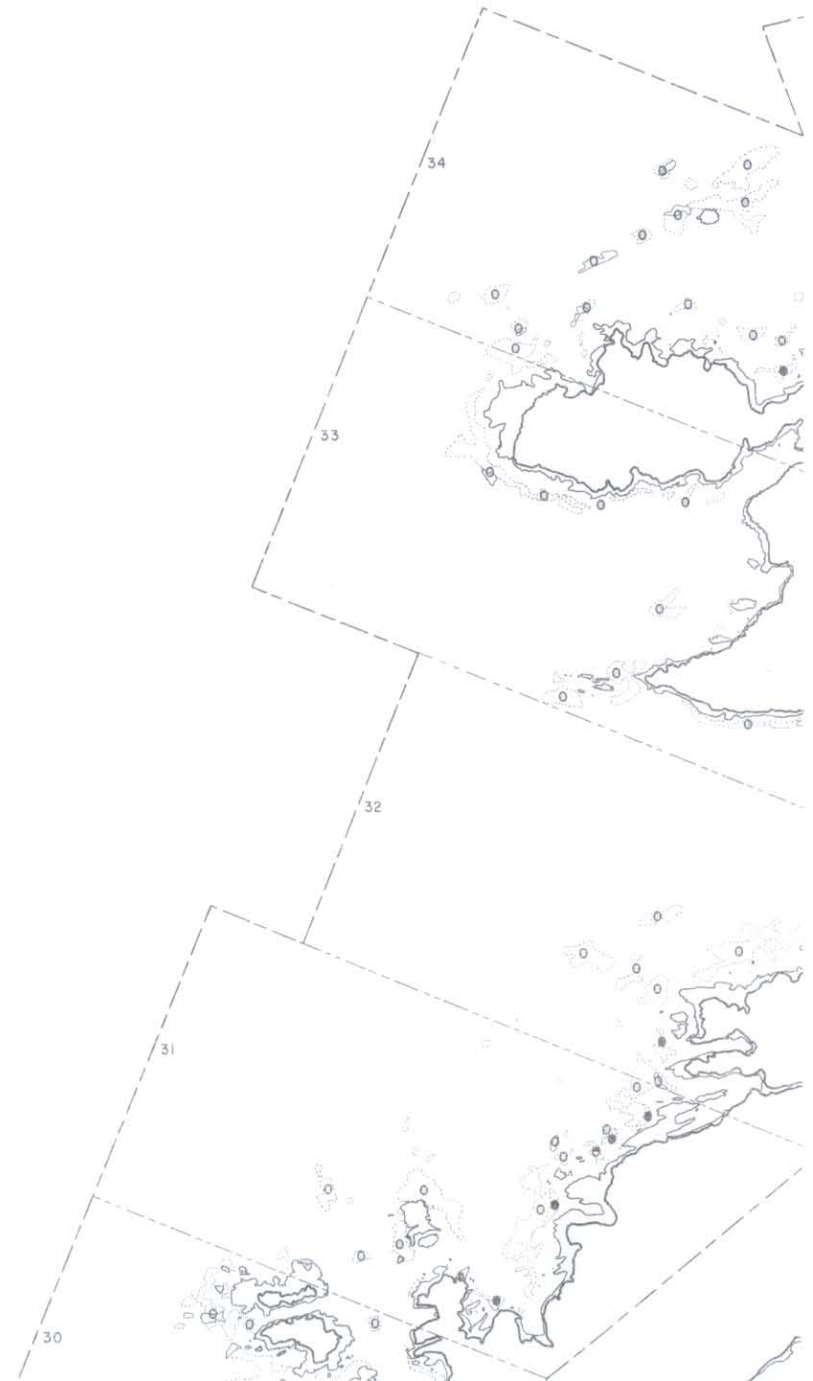
CHART B

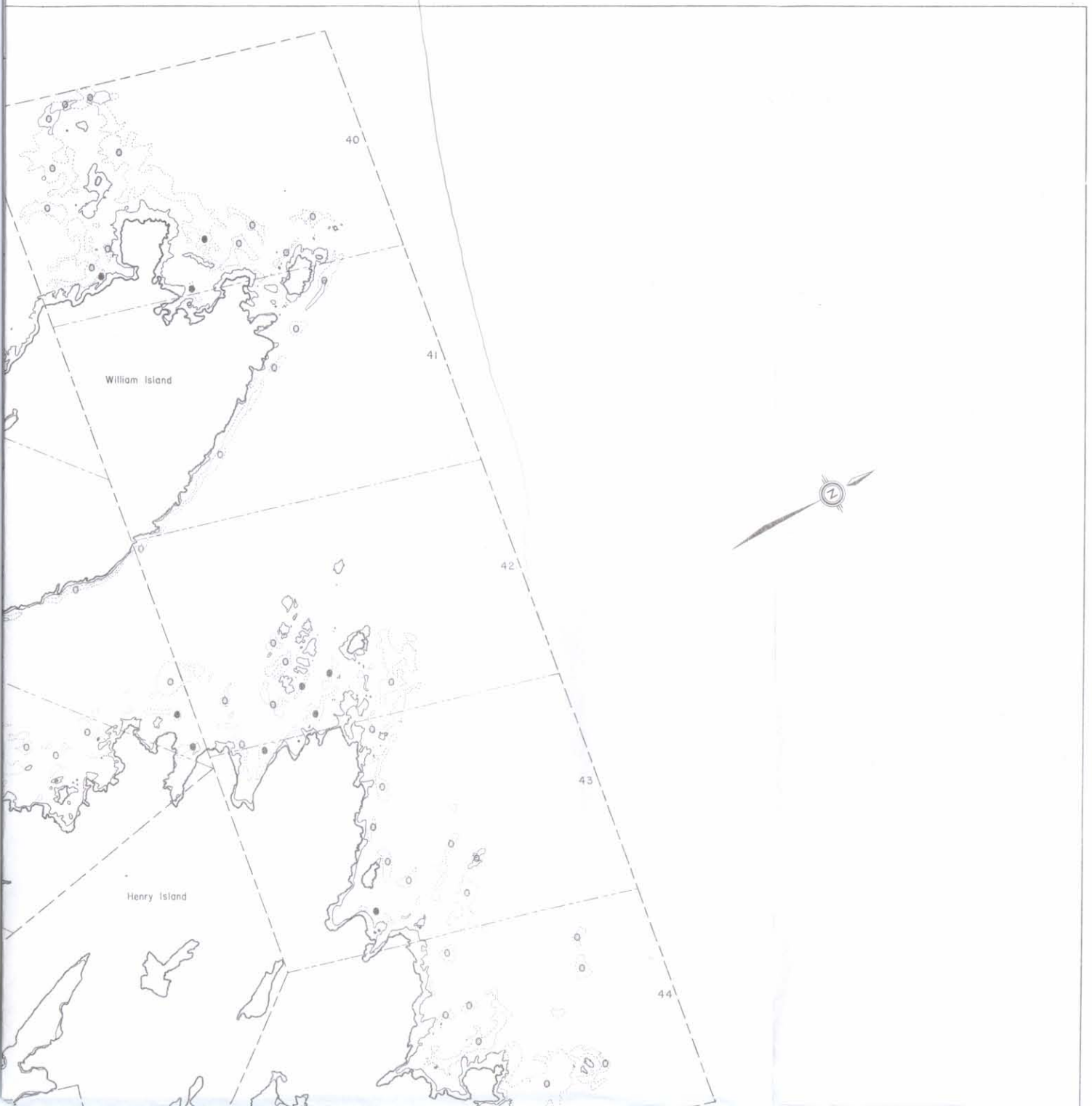
1/4 nautical mile

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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Henry Island
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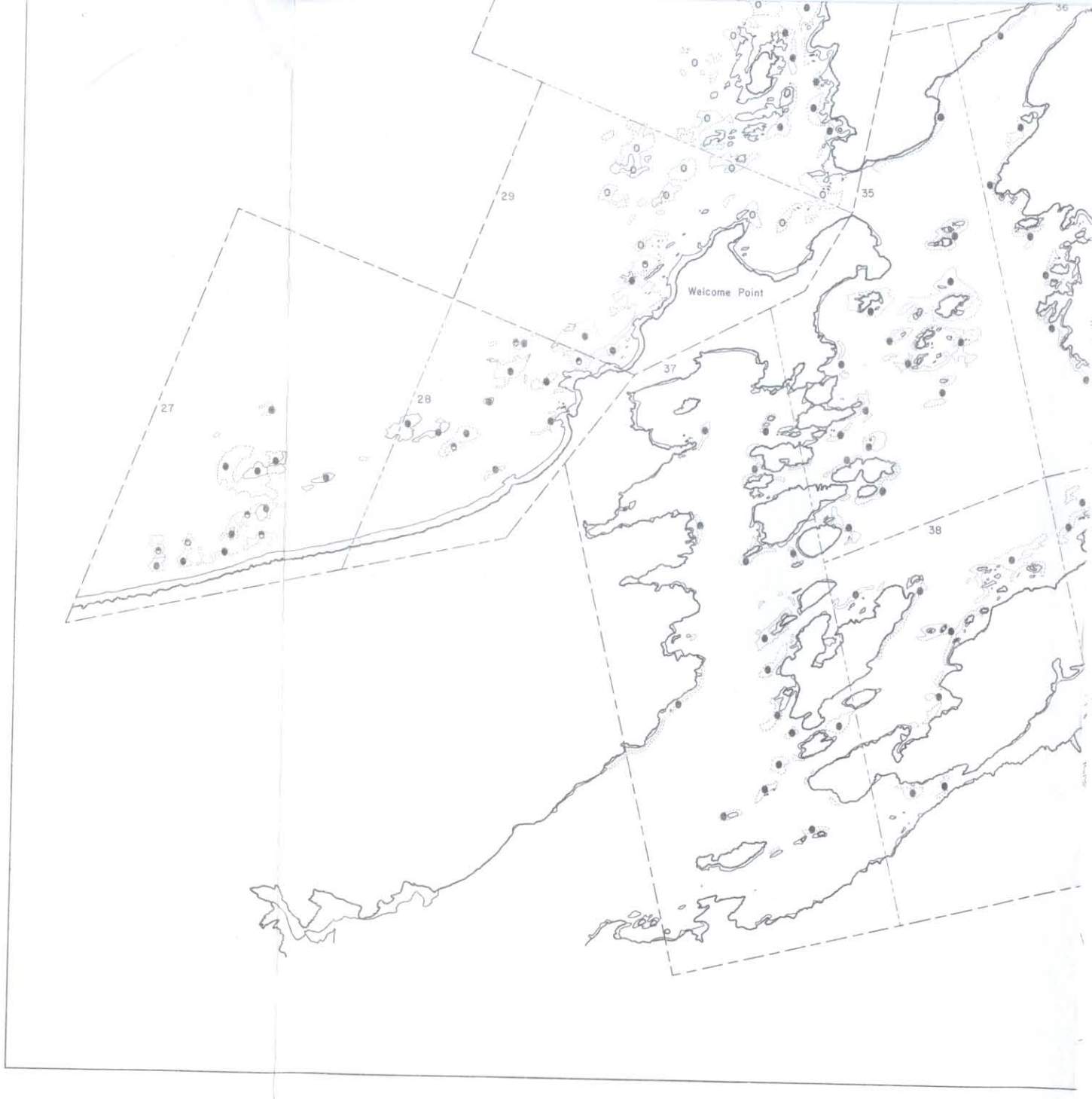
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Welcome Point
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Dancey Island
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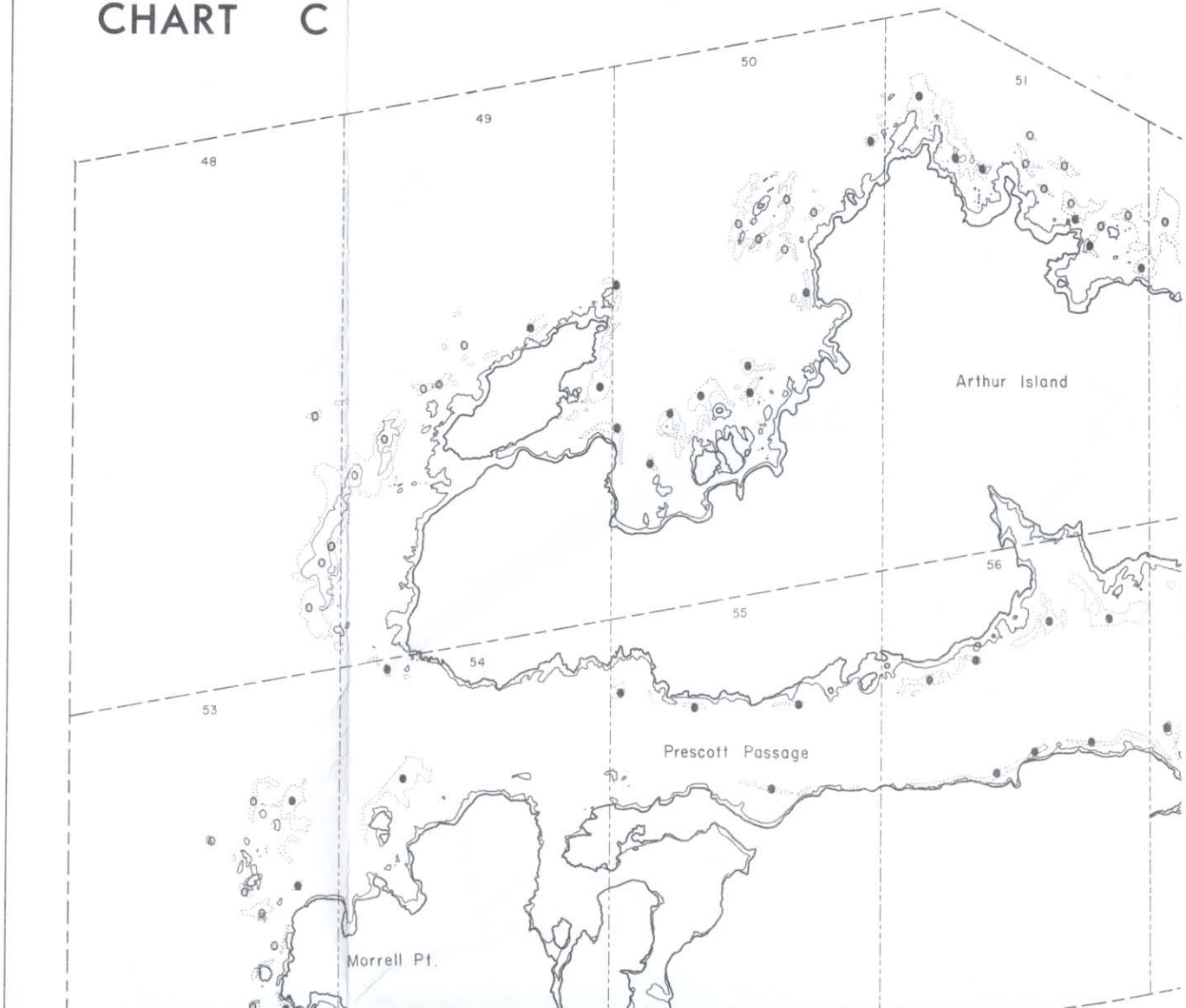
Edwin Point
Porcher Island

CHART C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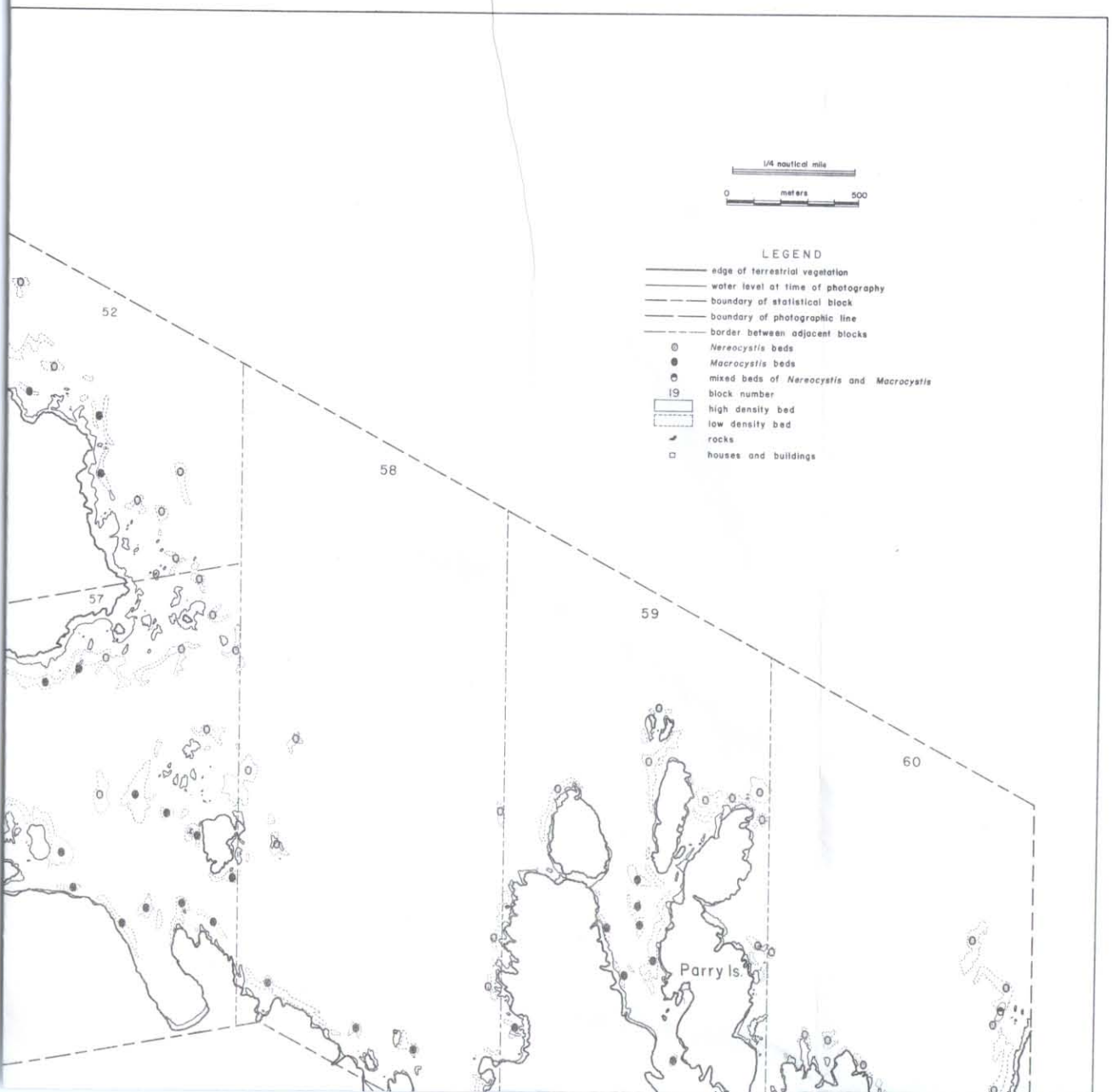
Prescott Passage
Morrell Pt.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LEGEND
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boundary of photographic line
border between adjacent blocks
Nereocystis beds
Macrocystis beds
mixed beds of Nereocystis and Macrocystis
19 block number
high density bed
low density bed
rocks
houses and buildings
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Parry Is.


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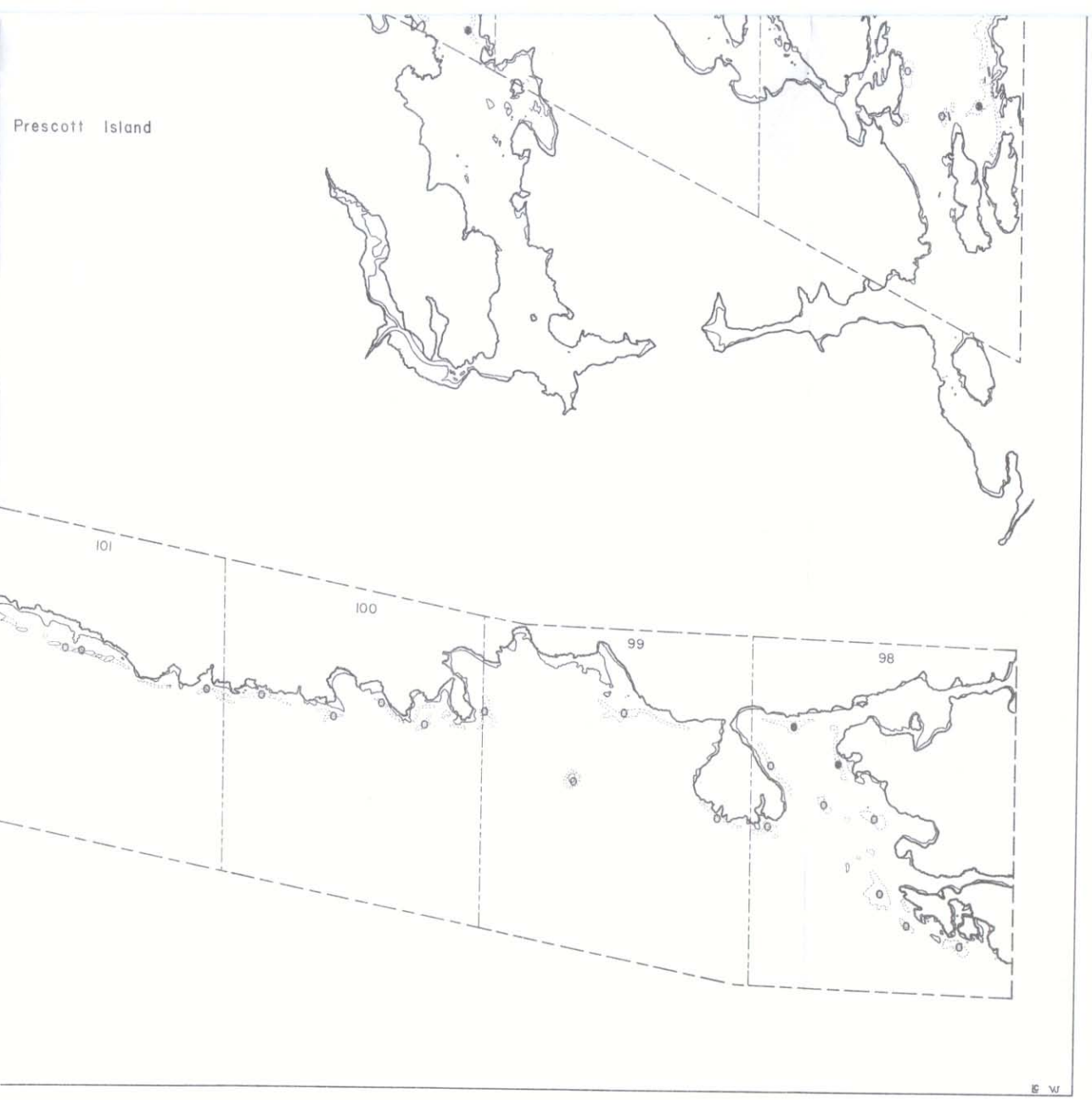
102


Prescott Island
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100
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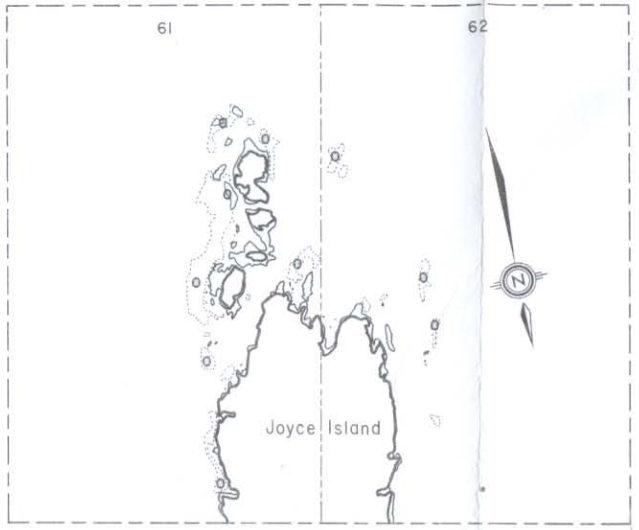
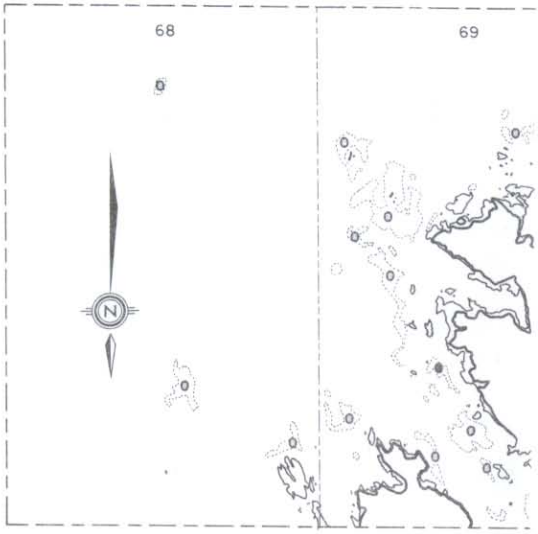
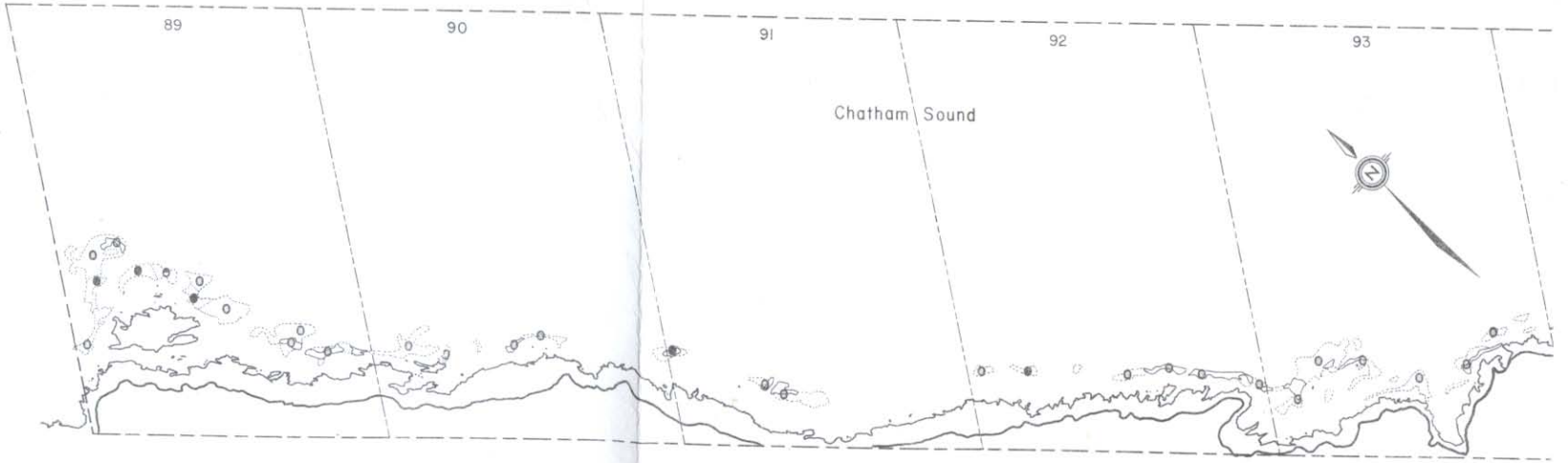
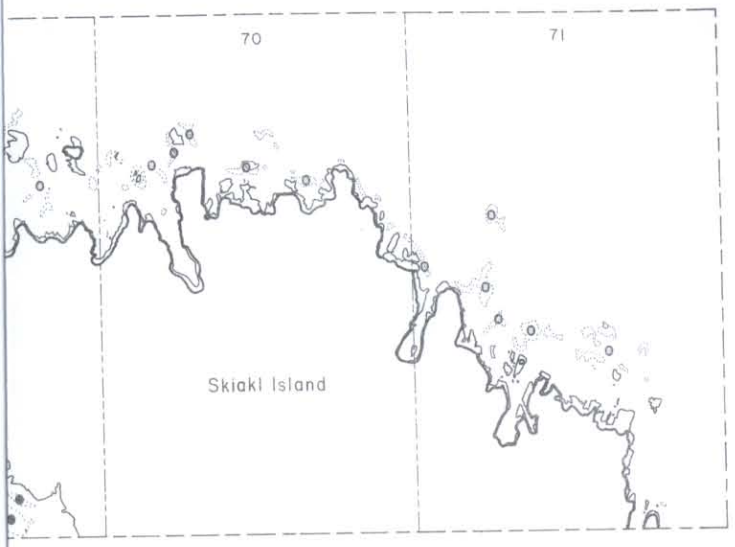
CHART D









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

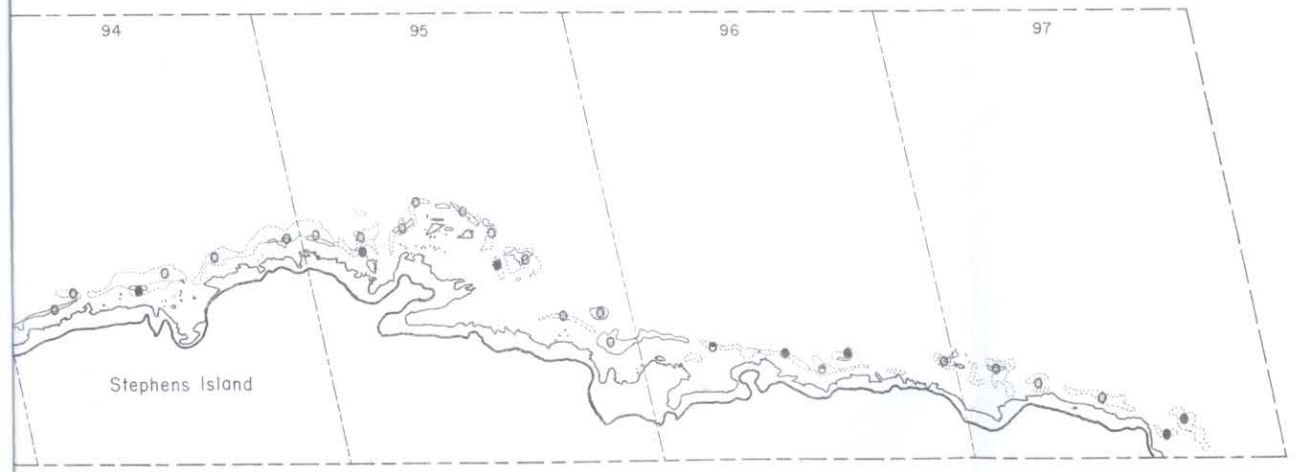
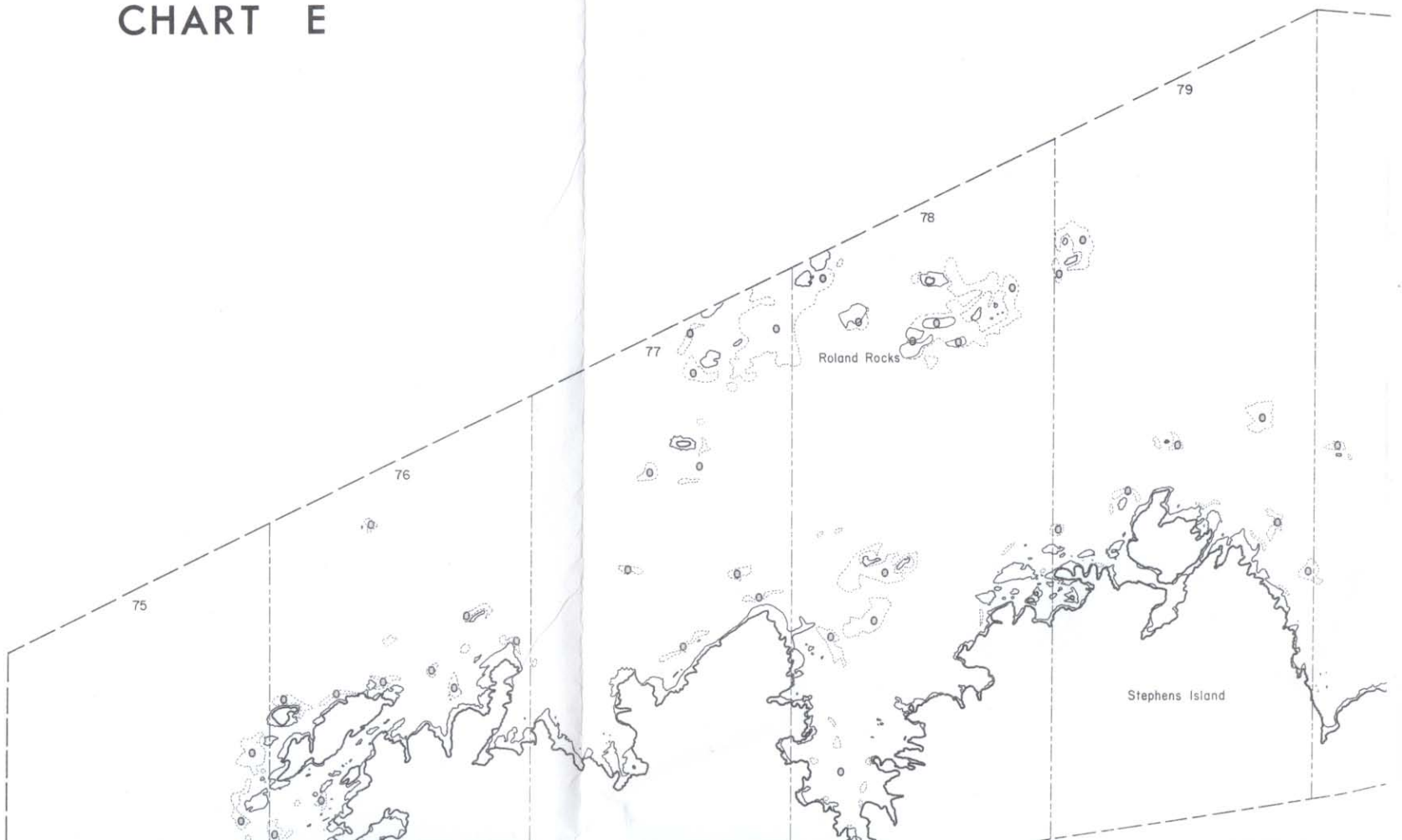
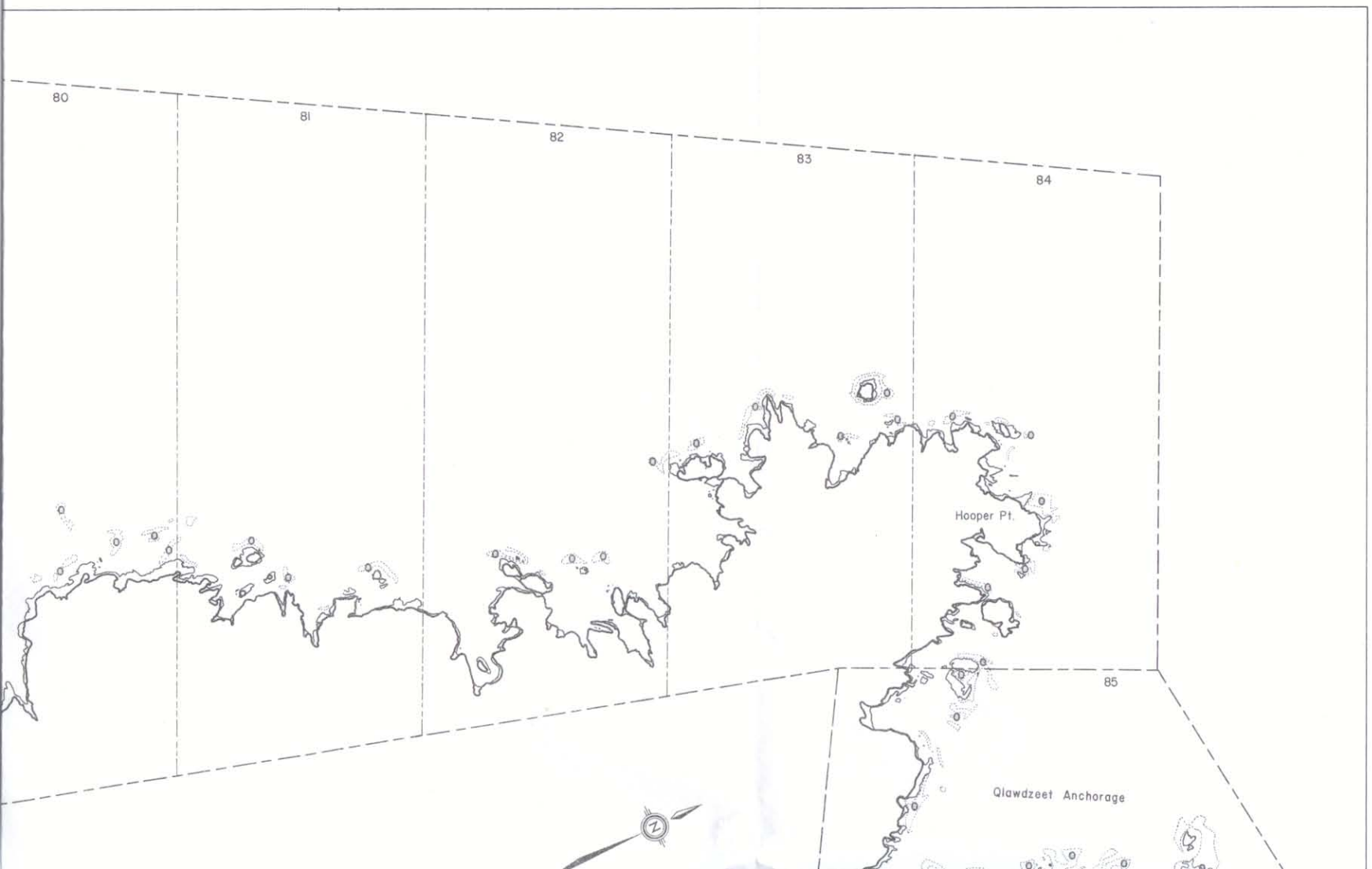
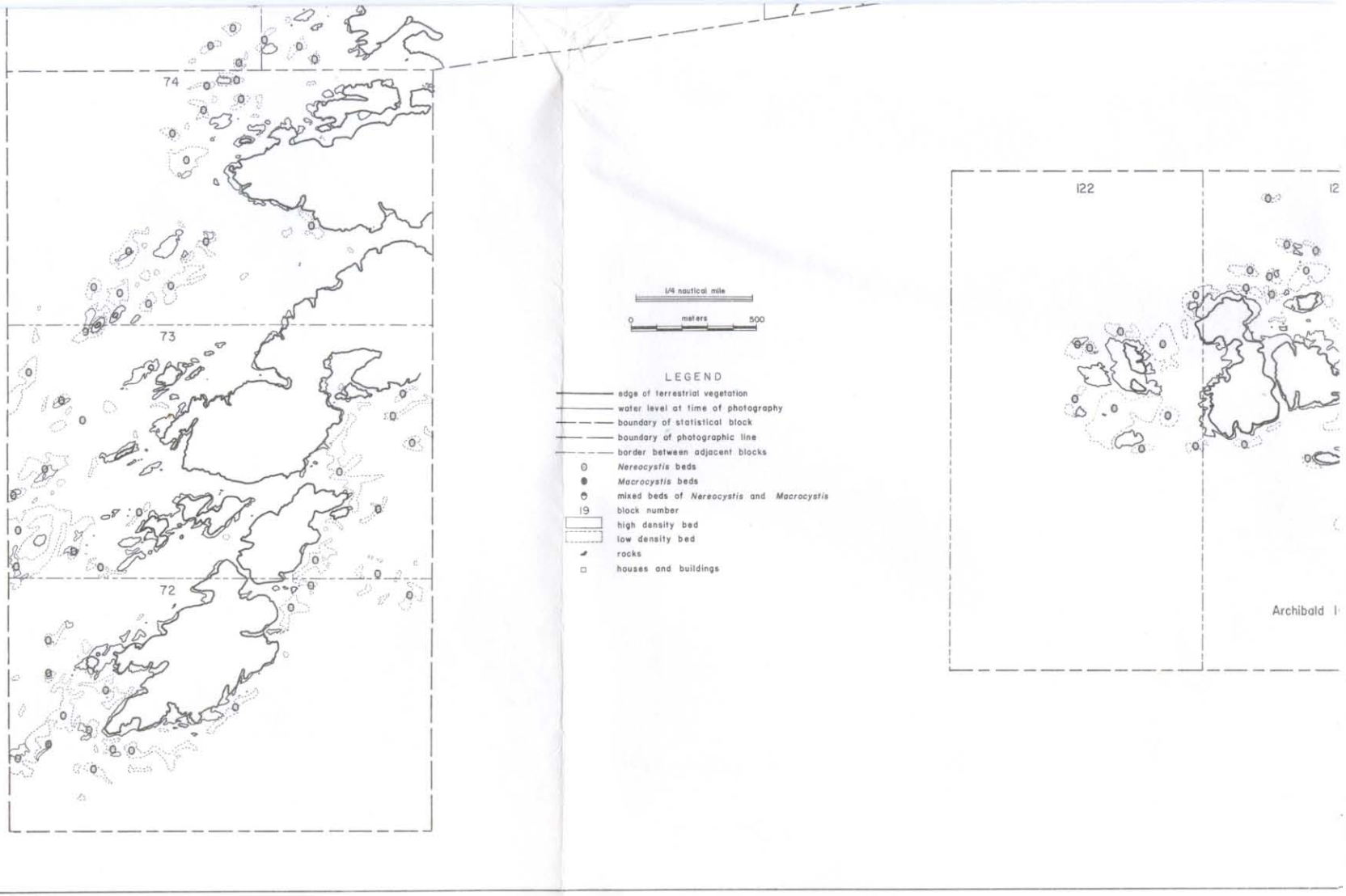


CHART E




80
81
82
83
84
85
Hooper Pt.
Qlawdzeet Anchorage
N


74
73
72
122
12
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
Archibald I

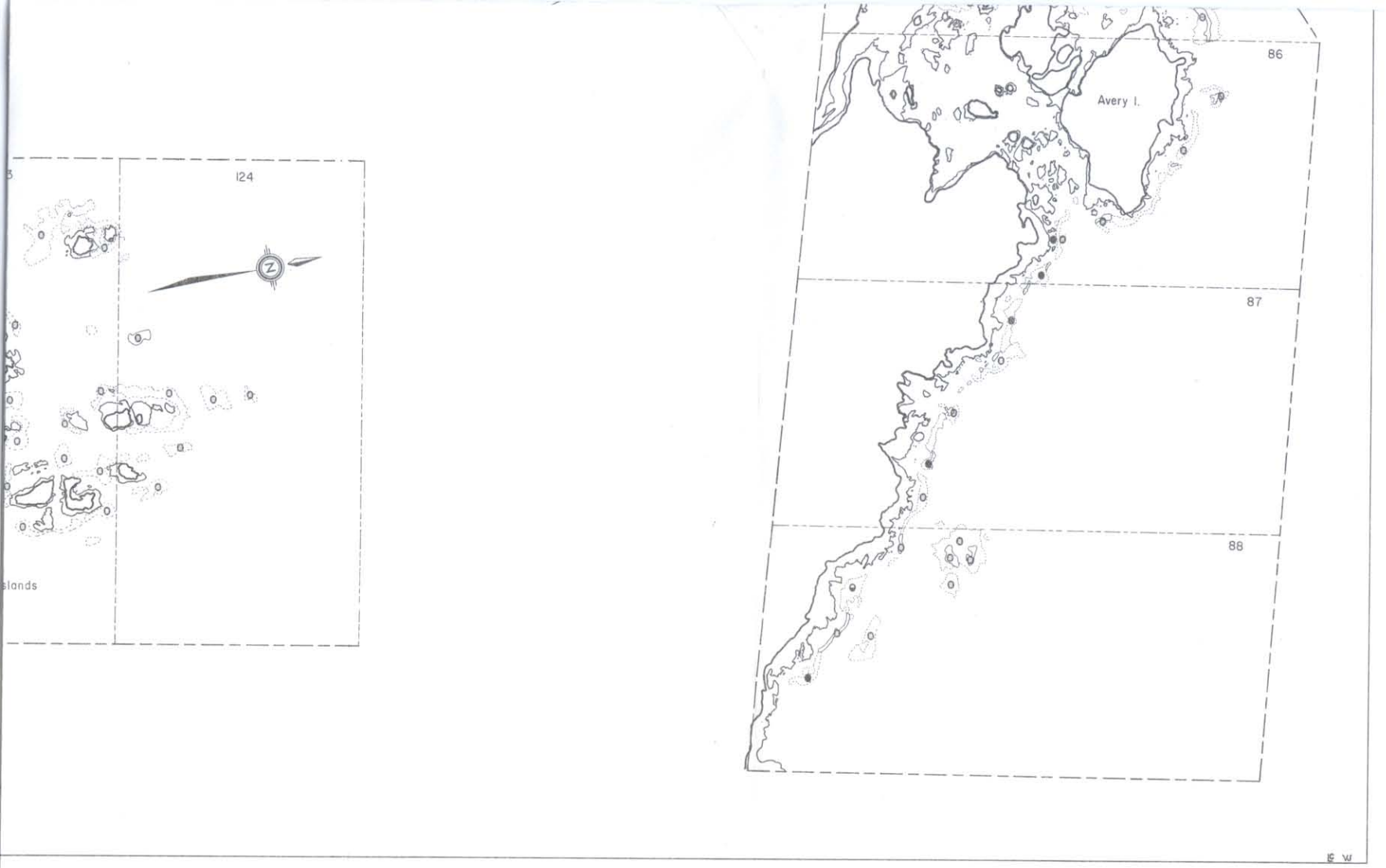
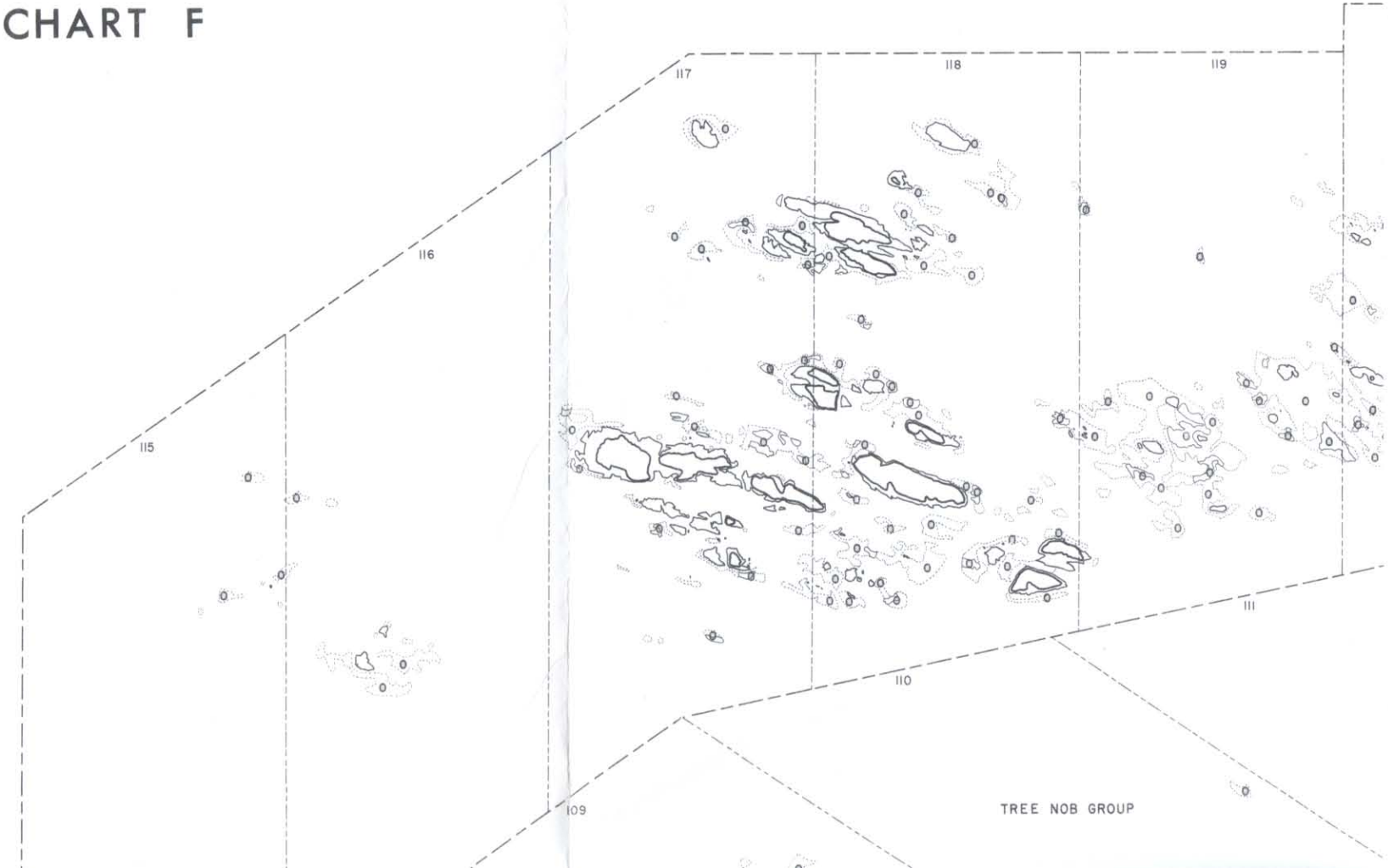
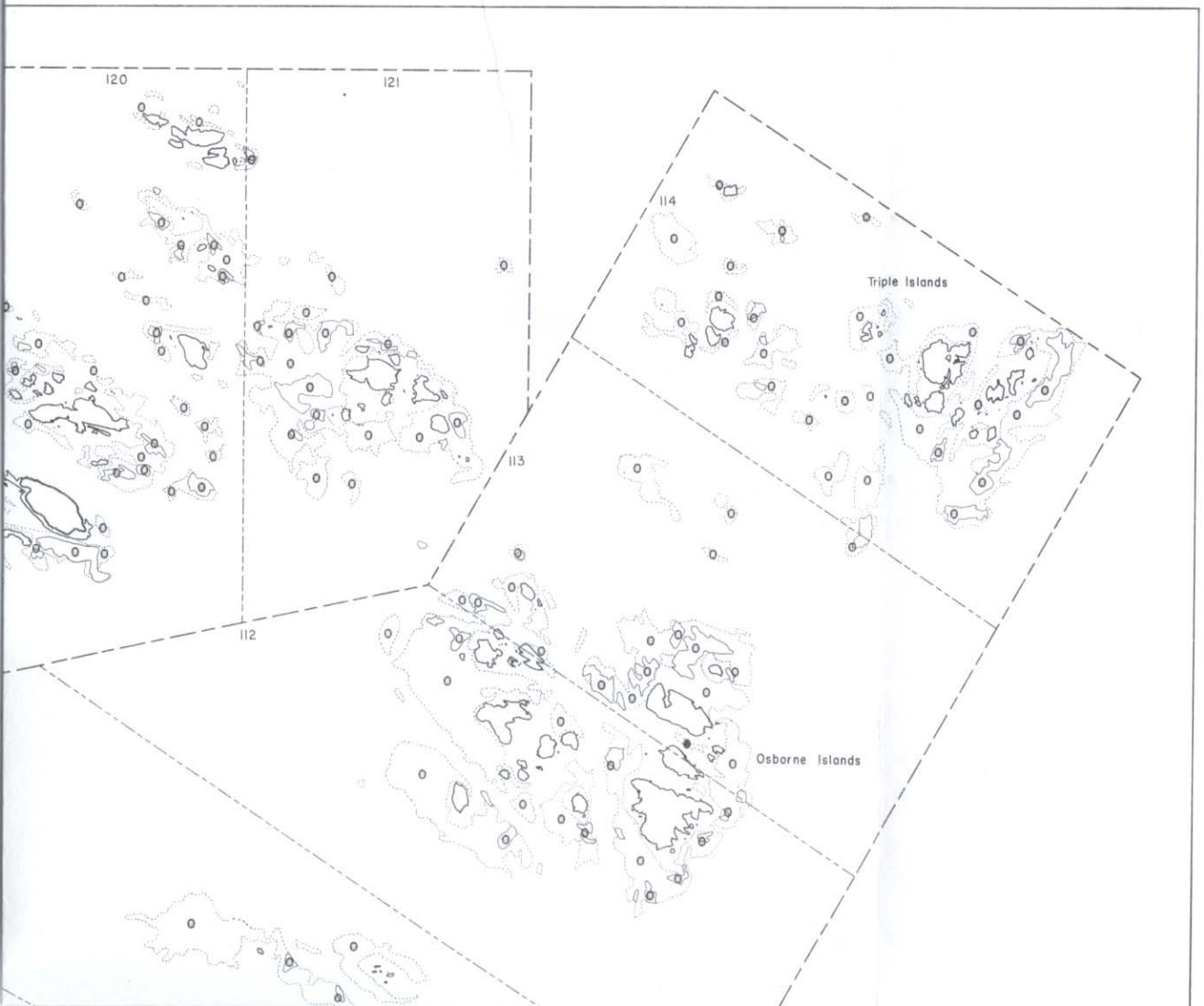
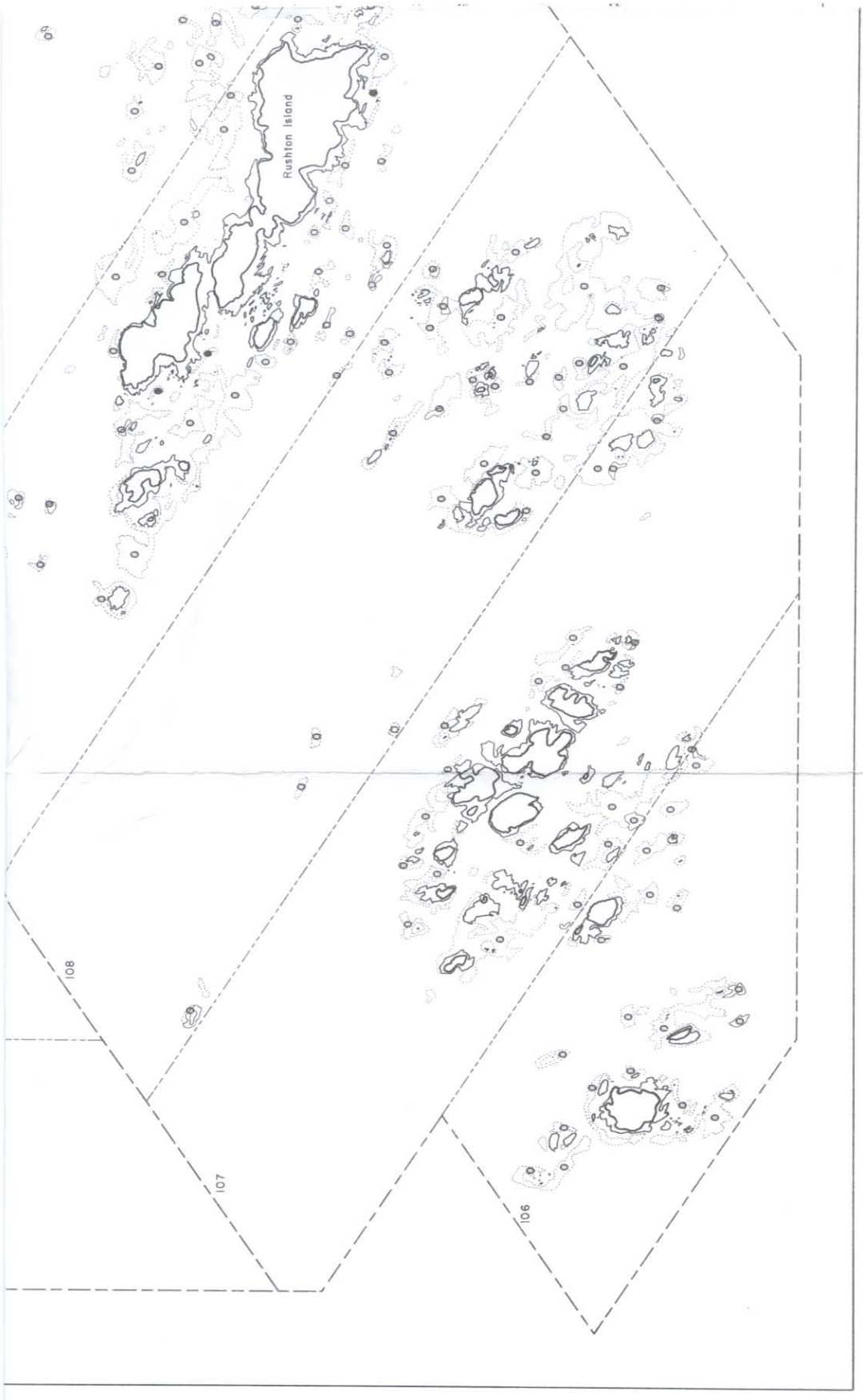
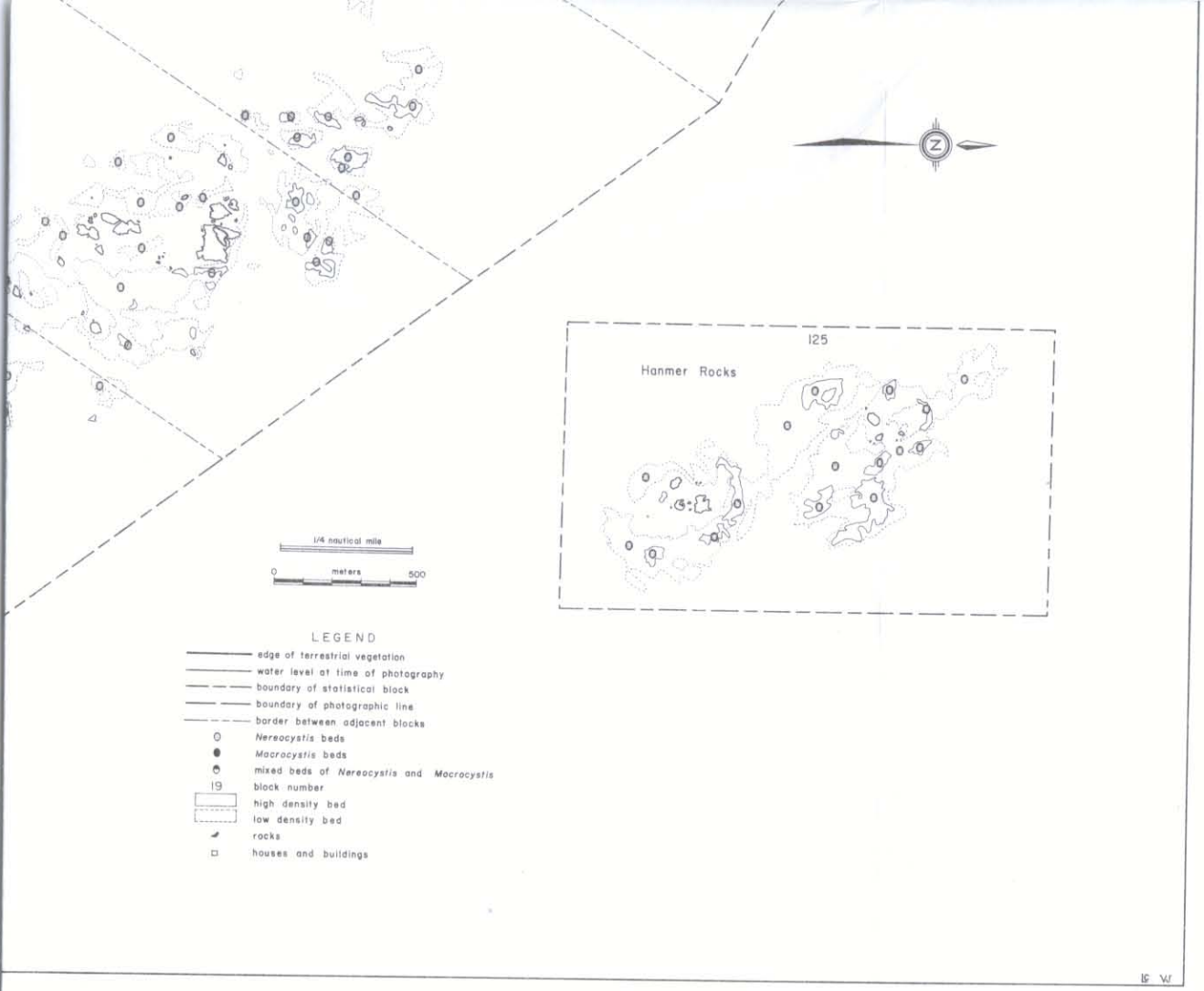

124
Avery I.
86
87
88
slands

CHART F




120
121
114
Triple Islands
113
112
Osborne Islands


Rushton Island
108
107
106



LEGEND

- edge of terrestrial vegetation
- water level at time of photography
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- boundary of photographic line
- border between adjacent blocks
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- low density bed
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- houses and buildings