# Kelp Inventory, 1976

## Part 3. North & West Coasts

## Graham Island (Q.C.I.)

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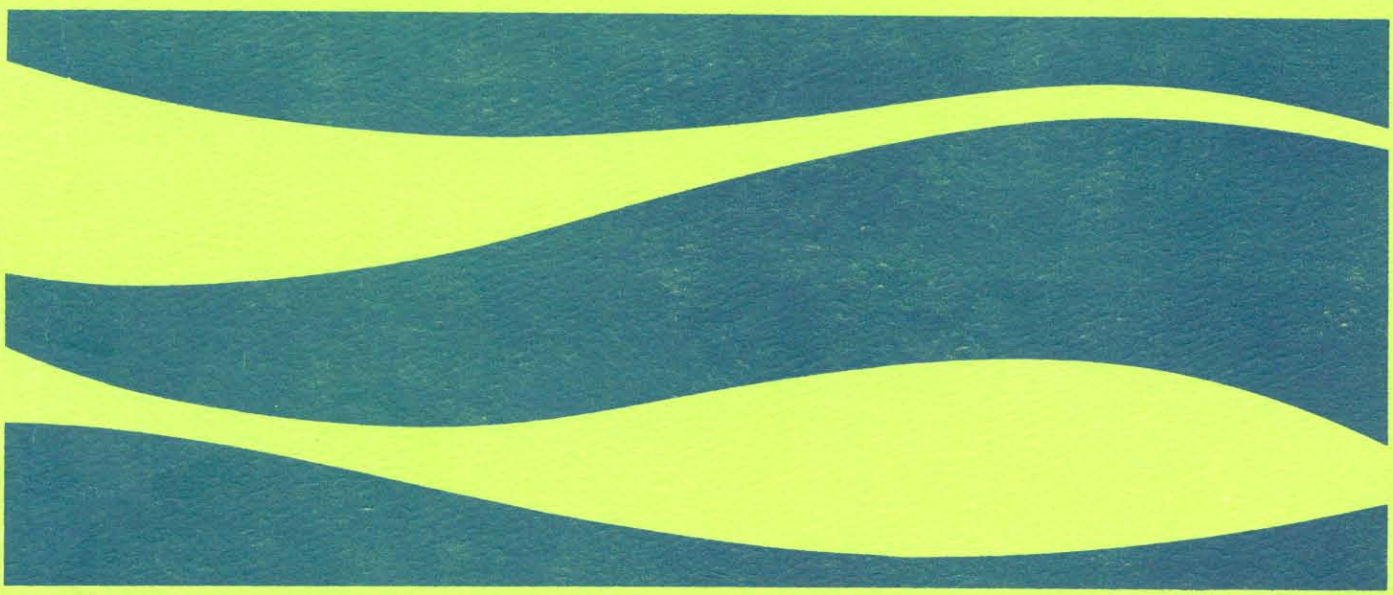

# KELP INVENTORY, 1976. PART 3

## NORTH AND WEST COASTS GRAHAM ISLAND

## (QUEEN CHARLOTTE ISLANDS)

by

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## Introduction

In 1976 the Marine Plant Section of the Marine Resources Branch undertook a program to locate and quantify the standing crop of the economically important canopy-forming kelps, *Macrocystis integrifolia* Bory and *Nereocystis leutkeana* (Mertens) Postels and Ruprecht. Five areas were surveyed in August and September, 1976; this report on the kelp stocks of the northwest and north coasts of Graham Island, in the Queen Charlotte Islands, is the third of the series (Field *et al*, 1977; Field and Clark, 1978). Foreman (1975) developed the basic survey method (KIM-1) used in this program.

Kelp inventory data provide information vital to the evolving kelp management program in British Columbia. Data are collected to provide a basis for resource allocation 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, particularly those preparing environmental impact statements for major coastal developments or oil transport systems. Inventory charts will also be of value to those conducting surveys of herring spawn, abalone and sea urchins (Coon, 1977).

The north coast of Graham Island, the largest land mass of the Queen Charlotte Archipelago, has long been reported to support some of the most extensive kelp beds on the coast of British Columbia. Yet commercial attention did not focus on these kelp resources until 1966. Apparently the relative isolation of the Queen Charlotte Islands accounted for their being neglected by early kelp survey efforts (Cameron, 1916; Anon., 1947).

North Pacific Marine Products Ltd. was granted kelp harvesting licences covering the whole of the Queen Charlotte Islands in late 1966. In 1967 the company performed an inventory of the kelp stocks

between the Mazarredo Islands and Kliki Damen Creek (Figure 1) on the North Coast of Graham Island (Norpac, 1967). In 1969 the company, renamed Canada Kelp Ltd., encountered financial difficulties and went into receivership before their kelp meal plant and harvester were completed.

In 1973, Equatorial Resources Ltd. purchased the Masset kelp processing plant which had been abandoned by Canada Kelp Ltd. A subsidiary, Kelpac Industries Ltd., attempted to modify the plant and produce kelp meal. Financial problems also forced the abandonment of this commercial attempt about a year and a half after it carried out a trial run of the plant in the late summer of 1973 (Whyte and Englar, 1974).

Spurred by the previously described resource development effort, a team with joint Federal-Provincial funding undertook a second inventory of the floating kelp resources in this area during August-September, 1973 (Blakely and Chalmers, 1973). This survey was limited to a region within an 18 mile radius of Masset; this was generally believed to be the economical operating range of a kelp harvesting vessel.

This region was further visited by Marine Resources Branch staff who, in 1974, conducted a preliminary study of the impact of harvesting on *Macrocystis* regrowth in McIntyre Bay (Coon and Roland, 1979).

This report presents the results of the 1976 Marine Resources Branch survey of the standing crop of *Nereocystis* and *Macrocystis*, along the northwest and north coasts of Graham Island. The results are compared with those obtained in the two earlier surveys.

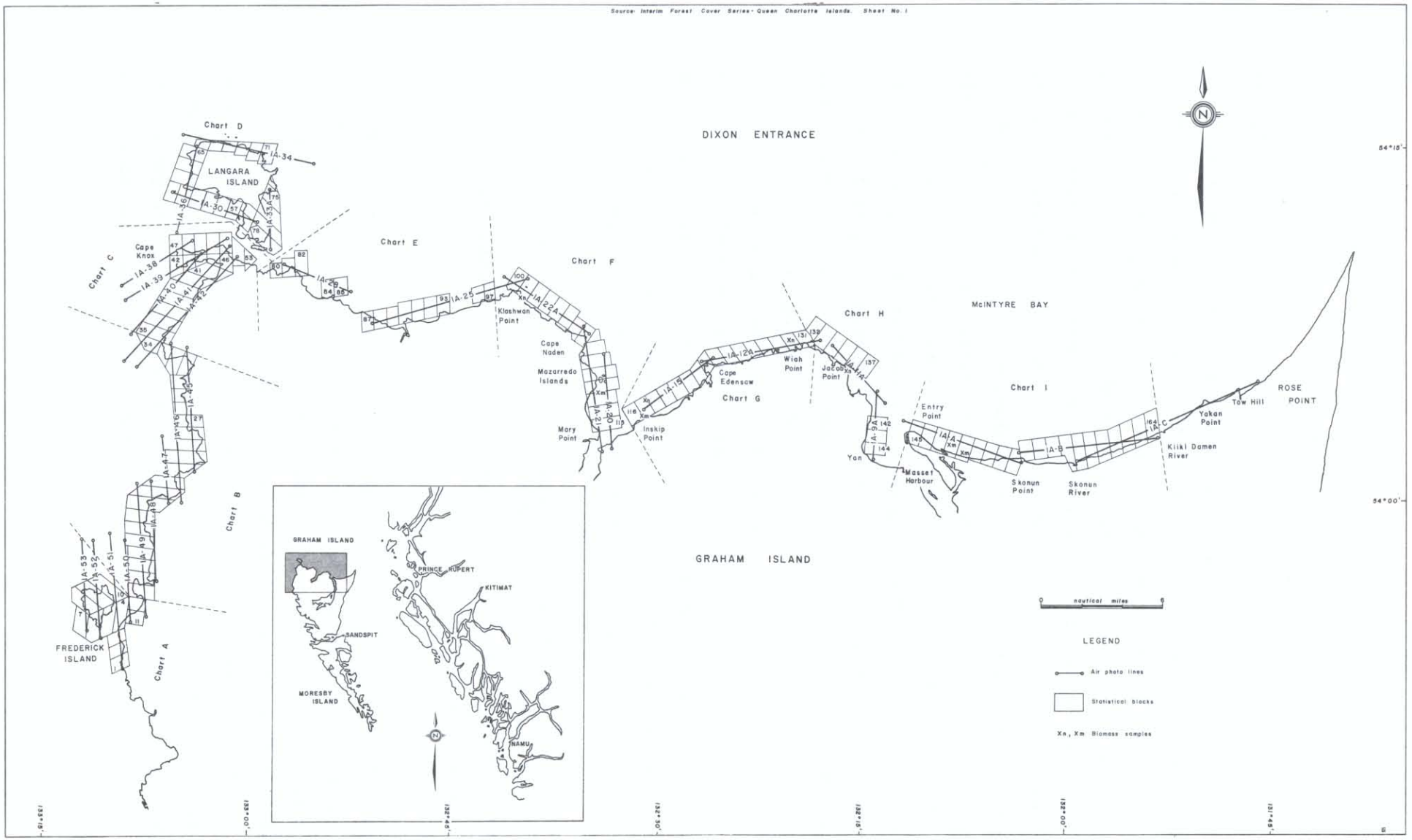


Figure 1: The north and west coast of Graham Island (Q.C.I.), showing the area inventoried for floating kelp resources and the mode of division of this area into inventory charts (see Appendix). Also indicated are the layout of statistical blocks, aerial photographic flight lines and locations of biomass sampling stations.

Methods

Bed areas, plant or frond densities and biomass of *Nereocystis* and *Macrocystis* were determined by the Kelp Inventory Method (KIM-1) established by Foreman (1975). Modifications of the method as stated by Coon *et al* (1976) and Field *et al* (1977) were employed in this study. Briefly, the KIM-1 technique involves obtaining black and white infrared aerial photographs of the kelp bed and shoreline in the desired region. These photographs 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. 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 identified 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 /$m^2$) or high (greater than 10 plants/fronds/$m^2$).

The vertical distribution of kelp biomass in the water column was determined along the northwest coast of Graham Island during September 12 - 14, 1976. Random samples of 25 *Nereocystis* plants and 25 *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.

Infrared photographs of the survey area were taken by the Air Services Branch, Ministry of the Provincial Secretary and Travel Industry on September 11, 1976. Flight and photographic parameters were as outlined by Foreman (1975). Figure 1 indicates the flight line centers and flight line designations, and illustrates the layout of statistical blocks. Blocks 1 - 20 and 137 - 164 were photographed while the respective tide levels were 1 m lower and 1 m higher than the acceptable level (Mean Water Level $\pm$ 0.6 m) as outlined by Foreman (1975). This resulted in a higher or lower density of fronds or plants on the respective photographs than would occur if the photographs were taken at MWL. A correction procedure for this situation is given below, because the KIM-1 method is dependent on an estimate of plant/frond density at MWL $\pm$ 0.6 m. The correction is made as follows:

To calculate the total biomass obtainable at MWL for blocks photographed at tide heights other than within the acceptable range:

FIRST calculate an adjusted mean biomass per plant/frond factor for MWL as follows:

1) Obtain mean biomass per plant/frond from Table 1 at the tide height at which the photographs were taken. (e.g. 3.559 for + 1 m above MWL)

2) Divide this value (3.559) by the appropriate combined biomass and density correction factor in Table 10* for the tide height at which the photographs were taken. (e.g. 0.76 for + 1 m above MWL)

This dividend is the adjusted mean biomass per plant factor for MWL (e.g. 4.683 for statistical blocks 137 - 164; this value appears in Table 2**)

SECOND calculate the total biomass available at MWL for each bed type in each block as follows:

| | | | | |
|---|---|---|---|---|
| Adjusted mean biomass per plant/frond value | X | The density of fronds/ plants counted in the photographs for that bed type in that statistical block | X | The area of bed type within the block |

All water depth and tide level calculations were based on values obtained from computer-drawn daily tide curves for MacPherson Point and Wiah Point. Cape Naden was the tidal boundary between these tide stations.

Results

Charts A, B, C, and D (Appendix) illustrate the disposition of kelp resources by bed type off the northwest coast of Graham Island, including Lanagara Island. Charts E, F, G, H, and I cover inventoried areas of the north coast of Graham Island. 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.

Tables 3 - 6 present estimates of bed areas and kelp biomass available at MWL, by bed type, for each block as follows:

a) Table 3 - Blocks 1-46; Frederick Island to Cape Knox
b) Table 4 - Blocks 47-97; Cape Knox to Klashwun Point
c) Table 5 - Blocks 100-144; Klashwun Point to Masset Harbour
d) Table 6 - Blocks 145-164; Entry Point to Yakan Point

Tables 7, 8, and 9 summarize the data in these tables by bed type, percent composition of biomass and bed area for each bed type in each geographical subdivision.

A total of 61,528 metric tonnes of kelp were estimated to be available at MWL along the surveyed coastline, with Klashwun Point to Masset Harbour having the most (26,691 tonnes) and Entry Point to Yakan Point the least (6,620 tonnes) (Table 7). The majority (53,185 tonnes, or 86.44%) of the total kelp biomass occurred as pure stands of *Nereocystis*.

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* The combined biomass and density and correction factors in Table 10 were obtained by dividing the cumulative biomass values given in Table 1 by the cumulative biomass values for levels above and below MWL.

** These adjusted values in Table 2 do not represent the actual biomass at MWL for these blocks. The same result could be obtained by multiplying the mean biomass per plant/frond value in Table 1 by the observed density, then dividing by the proper combined biomass and density correction factor. However, calculating an adjusted biomass value for MWL is more efficient when performing repetitive calculations and maintains the basic procedure of multiplying mean biomass per plant/frond, times the density, times the bed area to obtain the total biomass of each block.

Table 1. 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* and *Macrocystis* collected off the north coast of Graham Island.

| 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/pl or fr |
| +6 | 2.120 | 1 | 2.121 | 31.995 | 36 | 0.889 | 1.406 |
| +5 | 20.835 | 7 | 2.976 | 42.305 | 39 | 1.085 | 1.879 |
| +4 | 45.370 | 18 | 2.520 | 53.435 | 44 | 1.214 | 1.763 |
| +3 | 109.330 | 34 | 3.215 | 66.260 | 48 | 1.380 | 2.151 |
| +2 | 192.110 | 59 | 3.256 | 80.485 | 56 | 1.437 | 2.201 |
| +1 | 291.810 | 82 | 3.559 | 96.415 | 64 | 1.506 | 2.368 |
| MWL | 383.800 | 96 | 3.998 | 114.070 | 68 | 1.678 | 2.652 |
| -1 | 421.298 | 100 | 4.213 | 132.090 | 78 | 1.693 | 2.751 |
| -2 | 440.448 | 103 | 4.276 | 148.400 | 88 | 1.686 | 2.774 |
| -3 | 448.413 | 103 | 4.353 | 163.291 | 102 | 1.601 | 2.757 |
| -4 | 452.403 | 103 | 4.392 | 181.306 | 107 | 1.694 | 2.827 |
| -5 | 458.113 | 104 | 4.405 | 187.286 | 110 | 1.703 | 2.838 |
| -6 | 461.968 | 104 | 4.442 | 191.906 | 110 | 1.745 | 2.878 |

* Values 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 biomass estimates at MWL for north and west coasts Graham Island (see text).

| Species | No. of Stations | Photography at MWL Blocks 21-136 | Photography at -1m Blocks 1-20 | Photography at +1m Blocks 137-164 |
|---|---|---|---|---|
| *Nereocystis* | 4 | 3.998 | 3.830 | 4.683 |
| *Macrocystis* | 4 | 1.678 | 1.459 | 1.782 |
| Mixed * | - | 2.652 | 2.435 | 2.960 |

* Based on 42% *Nereocystis* and 58% *Macrocystis*

Table 3: Estimates of kelp area and biomass for the west coast of Graham Island: Frederick Island to Cape Knox, September

| | *Nereocystis* - low density | | | | *Nereocystis* - high density | | | | *Macrocystis* - low 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 |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | 8,470 | 1.037 | 32.50 | 33.7 | | | | | 4,580 | 1.814 | 6.68 | 12.1 |
| 4 | 8,470 | 0.134 | 31.44 | 4.2 | 11,510 | 0.155 | 44.48 | 6.9 | 4,580 | 9.590 | 6.68 | 64.1 |
| 5 | 8,470 | 5.754 | 32.42 | 186.5 | 11,510 | 0.363 | 44.31 | 16.1 | 4,370 | 4.043 | 6.39 | 25.8 |
| 6 | 6,860 | 12.701 | 26.27 | 333.6 | 11,510 | 0.207 | 44.41 | 9.2 | 4,370 | 0.259 | 6.20 | 1.6 |
| 7 | 5,190 | 21.825 | 19.88 | 433.9 | 11,510 | 2.436 | 44.02 | 107.2 | | | | |
| 8 | 6,130 | 7,258 | 23.48 | 170.4 | 11,510 | 3.525 | 44.11 | 155.3 | | | | |
| 9 | 7,150 | 17.988 | 27.38 | 492.5 | 11,570 | 6.013 | 44.33 | 266.6 | | | | |
| 10 | 7,320 | 4.354 | 28.06 | 122.2 | 15,210 | 1.400 | 58.27 | 81.6 | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | 4,370 | 5.443 | 6.38 | 34.7 |
| 13 | | | | | | | | | 4,370 | 0.207 | 6.34 | 1.3 |
| 14 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | 7,320 | 5.391 | 28.06 | 151.3 | 15,210 | 1.503 | 58.34 | 87.7 | 4,070 | 0.207 | 5.64 | 1.2 |
| 17 | 6,000 | 6.791 | 22.95 | 155.9 | 15,210 | 1.348 | 58.24 | 78.5 | 4,070 | 2.903 | 5.93 | 17.2 |
| 18 | 5,970 | 11.146 | 22.85 | 254.7 | 13,380 | 0.622 | 51.11 | 31.8 | 4,070 | 3.266 | 5.94 | 19.4 |
| 19 | 5,110 | 21.565 | 19.57 | 422.1 | 13,380 | 2.800 | 51.29 | 143.6 | 5,530 | 3.421 | 8.06 | 27.6 |
| 20 | 5,300 | 4.821 | 20.34 | 98.0 | 13,380 | 1.089 | 51.35 | 55.9 | 5,530 | 2.800 | 8.08 | 22.6 |
| 21 | 7,310 | 6.895 | 29.22 | 201.5 | 16,310 | 0.881 | 65.38 | 57.6 | 5,530 | 5.495 | 9.28 | 51.0 |
| 22 | 5,550 | 0.259 | 21.62 | 5.6 | | | | | 5,230 | 0.311 | 8.63 | 2.7 |
| 23 | 5,550 | 2.125 | 22.21 | 47.2 | 16,310 | 0.104 | 65.38 | 6.8 | 5,230 | 1.140 | 8.83 | 10.1 |
| 24 | 5,550 | 9.279 | 22.19 | 205.9 | 16,310 | 0.726 | 65.01 | 47.2 | 5,230 | 2.540 | 8.79 | 22.3 |
| 25 | 6,300 | 1.659 | 25.32 | 42.0 | 16,310 | 0.137 | 64.23 | 8.8 | 5,230 | 0.726 | 8.78 | 6.4 |
| 26 | 6,300 | 0.829 | 25.09 | 20.8 | 16,310 | 0.137 | 64.23 | 8.8 | 5,230 | 0.052 | 9.68 | 0.5 |
| 27 | 6,300 | 8.865 | 25.17 | 223.1 | 16,310 | 0.622 | 64.95 | 40.4 | 5,230 | 4.821 | 8.77 | 42.3 |
| 28 | | | | | | | | | 4,360 | 1.555 | 7.34 | 11.4 |
| 29 | | | | | | | | | 4,360 | 1.089 | 7.24 | 7.9 |
| 30 | 5,530 | 0.311 | 21.86 | 6.8 | | | | | 4,360 | 0.933 | 7.37 | 6.9 |
| 31 | | | | | | | | | 4,360 | 0.052 | 6.45 | 0.3 |
| 32 | | | | | | | | | 4,360 | 0.274 | 7.35 | 2.0 |
| 33 | | | | | | | | | 4,360 | 1.348 | 7.34 | 9.9 |
| 34 | | | | | | | | | | | | |
| 35 | 5,530 | 10.834 | 22.11 | 239.5 | 16,310 | 2.800 | 65.25 | 182.7 | 4,360 | 2.281 | 7.28 | 16.6 |
| 36 | 6,800 | 17.677 | 27.18 | 480.5 | 16,310 | 11.042 | 65.20 | 720.0 | 5,680 | 6.324 | 9.53 | 60.2 |
| 37 | 7,110 | 1.063 | 25.60 | 30.4 | 14,010 | 9.072 | 56.01 | 508.1 | 5,680 | 0.830 | 9.50 | 7.9 |
| 38 | 7,110 | 3.370 | 28.49 | 96.0 | 14,010 | 0.570 | 56.14 | 32.0 | 5,680 | 0.674 | 9.46 | 6.4 |
| 39 | 7,110 | 3.940 | 28.40 | 111.9 | 14,010 | 0.104 | 57.69 | 6.0 | 5,680 | 0.622 | 9.44 | 5.9 |
| 40 | 7,110 | 3.525 | 28.45 | 100.3 | 14,010 | 0.155 | 56.77 | 8.8 | 5,680 | 0.778 | 9.49 | 7.4 |
| 41 | 7,110 | 0.104 | 26.92 | 2.8 | | | | | 5,680 | 0.622 | 9.44 | 5.9 |
| 42 | 7,110 | 0.052 | 30.77 | 1.6 | | | | | 5,680 | 1.400 | 9.59 | 13.4 |
| 43 | | | | | | | | | 5,680 | 0.674 | 9.46 | 6.4 |
| 44 | | | | | | | | | 5,680 | 0.104 | 9.68 | 1.0 |
| 45 | | | | | | | | | 5,680 | 0.052 | 9.68 | 0.5 |
| 46 | | | | | | | | | | | | |
| Totals | | 192 | | 4,675 | | 48 | | 2,668 | | 69 | | 533 |
| Means | | 4.2 | | 101.6 | | 1.0 | | 58.0 | | 1.5 | | 11.6 |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

1976. See Charts A, B, and C (Appendix).

| *Macrocystis* - high density | | | | Mixed - low density | | | | Mixed - high density | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$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 |
| | | | | | | | | | | | | nil | nil |
| 11,140 | 0.104 | 16.83 | 1.8 | | | | | | | | | 0.104 | 1.8 |
| 11,140 | 0.622 | 16.19 | 10.1 | | | | | | | | | 3.473 | 55.9 |
| 11,140 | 17.055 | 16.25 | 277.2 | | | | | | | | | 26.934 | 352.4 |
| 12,190 | 5.858 | 17.78 | 104.2 | | | | | | | | | 16.018 | 332.6 |
| | | | | | | | | | | | | 13.167 | 344.4 |
| | | | | | | | | | | | | 24.261 | 541.1 |
| | | | | | | | | | | | | 10.783 | 325.7 |
| | | | | | | | | | | | | 24.001 | 759.1 |
| 12,190 | 2.125 | 17.78 | 37.8 | | | | | | | | | 7.879 | 241.6 |
| | | | | | | | | | | | | nil | nil |
| 12,190 | 1.762 | 17.80 | 31.4 | | | | | | | | | 7.205 | 66.1 |
| 11,780 | 0.052 | 16.83 | 0.9 | | | | | | | | | 0.259 | 2.2 |
| | | | | | | | | | | | | nil | nil |
| | | | | | | | | | | | | nil | nil |
| | | | | | | | | | | | | 7.101 | 240.2 |
| 11,780 | 1.192 | 17.14 | 20.4 | | | | | | | | | 12.234 | 272.0 |
| 11,780 | 1.451 | 17.19 | 24.9 | 3,990 | 1.400 | 9.74 | 13.6 | | | | | 17.885 | 344.4 |
| 11,780 | 2.800 | 17.20 | 48.1 | | | | | | | | | 30.586 | 641.4 |
| 11,780 | 1.762 | 17.22 | 30.3 | | | | | | | | | 10.472 | 206.8 |
| 13,810 | 2.229 | 23.19 | 51.7 | | | | | | | | | 15.500 | 361.8 |
| 13,810 | 0.259 | 23.32 | 6.0 | | | | | | | | | 0.829 | 14.3 |
| 13,810 | 1.659 | 23.16 | 38.4 | | | | | | | | | 5.028 | 102.5 |
| 13,810 | 0.881 | 23.24 | 20.5 | | | | | | | | | 13.426 | 295.9 |
| 13,810 | 0.207 | 23.51 | 4.9 | | | | | | | | | 2.729 | 62.1 |
| | | | | | | | | | | | | 1.018 | 30.1 |
| 13,810 | 1.244 | 23.20 | 28.9 | | | | | | | | | 15.552 | 334.7 |
| 14,100 | 0.259 | 23.97 | 6.2 | | | | | | | | | 1.814 | 17.6 |
| 14,100 | 0.137 | 23.27 | 3.2 | | | | | | | | | 1.226 | 11.1 |
| | | | | | | | | | | | | 1.244 | 13.7 |
| 14,100 | 0.052 | 22.59 | 1.2 | | | | | | | | | 0.104 | 1.3 |
| 14,100 | 0.052 | 22.59 | 1.2 | | | | | | | | | 0.326 | 3.2 |
| 14,100 | 0.259 | 23.97 | 6.2 | | | | | | | | | 1.607 | 16.1 |
| | | | | | | | | | | | | nil | nil |
| 14,100 | 5.443 | 23.65 | 128.7 | | | | | | | | | 21.358 | 567.5 |
| 14,100 | 8.169 | 23.66 | 193.3 | 3,990 | 5.132 | 10.59 | 54.4 | | | | | 48.344 | 1,508.4 |
| 14,100 | 0.674 | 23.65 | 15.9 | | | | | | | | | 11.639 | 562.3 |
| 14,100 | 0.933 | 23.74 | 22.1 | | | | | | | | | 5.547 | 156.5 |
| 14,100 | 0.415 | 23.86 | 9.9 | | | | | | | | | 5.081 | 133.7 |
| 14,100 | 0.829 | 23.68 | 19.6 | | | | | | | | | 5.287 | 136.1 |
| 14,100 | 0.363 | 23.58 | 8.6 | | | | | | | | | 1.089 | 17.3 |
| 14,100 | 0.985 | 23.68 | 23.3 | | | | | | | | | 2.437 | 38.3 |
| | | | | | | | | | | | | 0.674 | 6.4 |
| | | | | | | | | | | | | 0.104 | 1.0 |
| 14,100 | 0.259 | 23.97 | 6.2 | | | | | | | | | 0.311 | 6.7 |
| | | | | | | | | | | | | nil | nil |
| | 60 | | 1,183 | | 7 | | 68 | | nil | | nil | 375 | 9,127 |
| | 1.3 | | 25.7 | | 0.1 | | 1.5 | | | | | 8.1 | 198.4 |

Table 4: Estimates of kelp area and biomass for the north coast of Graham Island: Cape Knox to Klashwun Point, September

| | *Nereocystis* - low density | | | | *Nereocystis* - high density | | | | *Macrocystis* - low 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 |
| 47 | 8,090 | 7.206 | 32.35 | 233.1 | 16,380 | 1.814 | 65.43 | 118.7 | | | | |
| 48 | 8,090 | 5.391 | 32.33 | 174.3 | 16,380 | 0.466 | 65.24 | 30.4 | - | | | |
| 49 | 7,500 | 3.784 | 29.99 | 113.5 | 16,380 | 2.592 | 65.55 | 169.9 | 4,840 | 0.415 | 8.09 | 3.4 |
| 50 | 7,500 | 19.595 | 29.99 | 587.7 | 16,380 | 7.465 | 65.49 | 488.9 | 4,840 | 1.607 | 8.14 | 13.1 |
| 51 | 5,590 | 13.426 | 22.36 | 300.2 | 16,920 | 11.768 | 67.64 | 796.0 | 4,840 | 0.259 | 8.42 | 2.2 |
| 52 | 6,750 | 24.883 | 26.99 | 671.7 | 14,390 | 0.570 | 57.54 | 32.8 | 4,840 | 1.296 | 8.16 | 10.6 |
| 53 | 6,750 | 1.296 | 26.85 | 34.8 | 14,390 | 0.778 | 57.58 | 44.8 | 4,840 | 0.363 | 8.32 | 3.0 |
| 55 | 6,750 | 4.354 | 26.99 | 117.5 | 14,390 | 1.089 | 57.67 | 62.8 | | | | |
| 56 | 6,750 | 5.236 | 26.95 | 141.1 | 14,390 | 0.466 | 57.51 | 26.8 | 4,840 | 0.052 | 9.68 | 0.5 |
| 57 | 8,820 | 6.895 | 35.26 | 243.1 | 14,390 | 3.058 | 57.52 | 175.9 | | | | |
| 58 | 8,820 | 3.836 | 35.22 | 135.1 | 14,390 | 4.251 | 57.56 | 244.7 | 4,840 | 0.052 | 9.68 | 0.5 |
| 59 | 8,820 | 4.251 | 35.26 | 149.9 | 21,860 | 0.985 | 92.48 | 91.1 | 4,840 | 0.104 | 8.07 | 0.8 |
| 60 | 8,820 | 1.089 | 35.26 | 38.4 | 21,860 | 0.052 | 84.61 | 4.4 | | | | |
| 61 | 8,820 | 2.125 | 35.20 | 74.8 | 21,860 | 0.570 | 87.72 | 50.0 | 4,840 | 0.207 | 8.11 | 1.7 |
| 62 | 8,820 | 1.296 | 35.18 | 45.6 | 21,860 | 1.348 | 87.46 | 117.9 | | | | |
| 63 | 8,820 | 8.813 | 35.24 | 310.6 | 21,860 | 1.037 | 87.46 | 90.7 | 4,840 | 0.881 | 8.19 | 7.2 |
| 64 | 6,570 | 3.266 | 26.33 | 86.0 | 21,860 | 3.266 | 87.38 | 285.4 | | | | |
| 65 | 8,390 | 5.391 | 33.52 | 180.7 | 21,860 | 3.836 | 87.43 | 335.4 | | | | |
| 66 | 8,390 | 1.659 | 33.51 | 55.6 | 15,580 | 0.622 | 62.38 | 38.8 | | | | |
| 67 | 8,390 | 3.056 | 33.47 | 102.3 | 15,580 | 1.555 | 62.19 | 96.7 | | | | |
| 68 | 8,390 | 3.318 | 33.48 | 111.1 | 15,580 | 1.451 | 62.23 | 90.3 | | | | |
| 69 | 8,390 | 3.732 | 33.52 | 125.1 | 15,580 | 1.400 | 62.21 | 87.1 | | | | |
| 70 | 8,390 | 2.903 | 33.58 | 97.5 | 15,580 | 1.140 | 62.46 | 71.2 | | | | |
| 71 | 8,390 | 3.577 | 33.52 | 119.9 | 15,580 | 1.866 | 62.32 | 116.3 | | | | |
| 74 | 7,510 | 1.192 | 30.20 | 36.0 | 15,580 | 0.207 | 61.83 | 12.8 | | | | |
| 75 | 7,510 | 7.983 | 30.05 | 239.9 | 15,580 | 2.074 | 62.25 | 129.1 | 4,840 | 1.866 | 8.09 | 15.1 |
| 76 | 6,440 | 11.508 | 25.74 | 296.2 | 15,580 | 14.204 | 62.28 | 884.7 | | | | |
| 77 | 7,100 | 8.813 | 28.40 | 250.3 | 14,490 | 15.241 | 57.92 | 882.7 | 4,840 | 0.155 | 8.66 | 1.3 |
| 78 | 7,100 | 13.893 | 28.37 | 394.2 | 14,120 | 7.206 | 56.42 | 406.6 | 4,840 | 1.555 | 8.09 | 12.6 |
| 80 | 7,220 | 1.192 | 28.86 | 34.4 | 14,120 | 2.177 | 56.36 | 122.7 | | | | |
| 81 | 7,220 | 2.644 | 28.89 | 76.4 | 14,120 | 2.644 | 56.39 | 149.1 | | | | |
| 82 | 7,220 | 3.836 | 28.86 | 110.7 | 14,120 | 4.199 | 56.46 | 237.1 | 4,840 | 1.037 | 8.09 | 8.4 |
| 84 | 7,220 | 0.363 | 28.65 | 10.4 | 18,920 | 0.052 | 76.92 | 4.0 | | | | |
| 85 | 7,220 | 1.607 | 28.87 | 46.4 | 18,920 | 1.711 | 75.69 | 129.5 | 4,840 | 2.333 | 8.13 | 19.0 |
| 87 | 7,220 | 0.415 | 28.91 | 12.0 | | | | | 4,840 | 0.155 | 8.66 | 1.3 |
| 88 | 7,220 | 3.681 | 28.88 | 106.3 | 18,920 | 8.294 | 75.63 | 627.3 | 4,840 | 0.466 | 8.28 | 3.9 |
| 89 | 7,220 | 2.022 | 28.88 | 58.4 | | | | | | | | |
| 90 | 7,220 | 2.592 | 28.86 | 74.8 | 14,170 | 4.925 | 56.67 | 279.1 | | | | |
| 91 | 6,730 | 26.024 | 26.90 | 700.0 | 14,170 | 9.124 | 56.65 | 516.9 | | | | |
| 92 | 6,500 | 30.119 | 25.99 | 782.8 | 20,600 | 11.871 | 82.34 | 977.5 | | | | |
| 93 | 6,040 | 6.532 | 24.17 | 157.9 | 14,640 | 3.473 | 58.48 | 203.1 | | | | |
| 96 | 7,190 | 0.674 | 28.49 | 19.2 | 14,640 | 0.518 | 58.69 | 30.4 | | | | |
| 97 | 7,190 | 2.903 | 28.76 | 83.5 | 14,640 | 2.851 | 58.47 | 166.7 | | | | |
| Totals | | 268 | | 7,739 | | 144 | | 9,426 | | 13 | | 105 |
| Means | | 6.2 | | 180.0 | | 3.4 | | 219.2 | | 0.3 | | 2.4 |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

1976. See Charts D and E (Appendix).

| *Macrocystis* - high density | | | | Mixed - low density | | | | Mixed - high density | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$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 |
| | | | | | | | | | | | | 9.020 | 351.8 |
| | | | | | | | | | | | | 5.857 | 204.7 |
| | | | | | | | | | | | | 6.791 | 286.8 |
| 8,980 | 1.244 | 15.11 | 18.8 | | | | | | | | | 29.911 | 1,108.5 |
| 8,980 | 1.192 | 15.06 | 18.0 | 3,990 | 4.251 | 10.61 | 45.1 | | | | | 30.896 | 1,161.5 |
| 8,980 | 1.711 | 15.10 | 25.8 | 3,990 | 3.058 | 10.58 | 32.4 | | | | | 31.518 | 773.3 |
| 8,980 | 0.726 | 15.02 | 10.9 | 3,990 | 0.415 | 10.86 | 4.5 | | | | | 3.578 | 98.0 |
| 8,980 | 0.415 | 14.96 | 6.2 | | | | | | | | | 5.858 | 186.5 |
| | | | | | | | | | | | | 5.754 | 168.4 |
| | | | | | | | | | | | | 9.953 | 419.0 |
| 8,980 | 0.259 | 14.90 | 3.9 | | | | | | | | | 8.398 | 384.2 |
| | | | | | | | | | | | | 5.340 | 241.8 |
| | | | | | | | | | | | | 1.141 | 42.8 |
| | | | | | | | | | | | | 2.902 | 126.5 |
| | | | | | | | | | | | | 2.644 | 163.5 |
| | | | | | | | | | | | | 10.731 | 408.5 |
| | | | | | | | | | | | | 6.532 | 371.4 |
| | | | | | | | | | | | | 9.227 | 516.1 |
| | | | | | | | | | | | | 2.281 | 94.4 |
| | | | | | | | | | | | | 4.611 | 199.0 |
| | | | | | | | | | | | | 4.769 | 201.4 |
| | | | | | | | | | | | | 5.132 | 212.2 |
| | | | | | | | | | | | | 4.043 | 168.7 |
| | | | | | | | | | | | | 5.443 | 236.2 |
| | | | | | | | | | | | | 1.399 | 48.8 |
| 8,980 | 0.052 | 16.13 | 0.8 | 3,990 | 0.104 | 10.20 | 1.1 | | | | | 12.079 | 386.0 |
| | | | | | | | | | | | | 25.712 | 1,180.9 |
| | | | | | | | | | | | | 24.209 | 1,134.3 |
| 8,980 | 0.518 | 15.23 | 7.9 | | | | | | | | | 23.172 | 821.3 |
| | | | | | | | | | | | | 3.369 | 157.1 |
| | | | | | | | | | | | | 5.288 | 225.5 |
| | | | | | | | | | | | | 9.072 | 356.2 |
| | | | | | | | | | | | | 0.415 | 14.4 |
| 8,980 | 0.311 | 15.11 | 4.7 | | | | | | | | | 5.962 | 199.6 |
| | | | | | | | | | | | | 0.570 | 13.3 |
| | | | | | | | | | | | | 12.441 | 737.5 |
| | | | | | | | | | | | | 2.022 | 58.4 |
| | | | | | | | | | | | | 7.517 | 353.9 |
| | | | | | | | | | | | | 35.148 | 1,216.9 |
| | | | | | | | | | | | | 41.990 | 1,760.3 |
| | | | | | | | | | | | | 10.005 | 361.0 |
| | | | | | | | | | | | | 1.192 | 49.6 |
| | | | | | | | | | | | | 5.754 | 250.2 |
| | 6 | | 97 | | 8 | | 83 | | nil | | nil | 440 | 17,450 |
| | 0.1 | | 2.3 | | 0.2 | | 1.9 | | | | | 10.2 | 405.8 |

Table 5: Estimates of kelp area and biomass for the north coast of Graham Island: Klashwun Point to Masset Harbour,, Septe

| | *Nereocystis* - low density | | | | *Nereocystis* - high density | | | | *Macrocystis* - low 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 |
| 100 | 7,190 | 1.711 | 28.75 | 49.2 | 14,640 | 1.140 | 58.60 | 66.8 | | | | |
| 101 | 7,190 | 2.903 | 28.76 | 83.5 | 13,460 | 5.495 | 53.83 | 295.8 | | | | |
| 102 | 7,190 | 1.762 | 28.83 | 50.8 | 13,460 | 3.629 | 53.76 | 195.1 | | | | |
| 103 | 10,350 | 2.177 | 41.29 | 89.9 | 13,700 | 1.400 | 54.86 | 76.8 | | | | |
| 104 | 10,350 | 0.466 | 41.20 | 19.2 | | | | | | | | |
| 105 | 10,350 | 0.674 | 41.54 | 28.0 | | | | | | | | |
| 106 | 10,350 | 3.940 | 41.39 | 163.1 | 13,700 | 3.577 | 54.77 | 195.9 | 4,840 | 0.104 | 8.07 | 0.8 |
| 107 | 8,210 | 6.946 | 32.81 | 227.9 | 13,700 | 4.458 | 54.80 | 244.3 | 4,840 | 0.155 | 8.66 | 1.3 |
| 108 | 6,410 | 4.406 | 25.58 | 112.7 | 13,090 | 4.717 | 52.30 | 246.7 | | | | |
| 109 | 6,410 | 10.316 | 25.62 | 264.3 | 13,360 | 11.560 | 53.40 | 617.3 | 4,270 | 2.177 | 7.17 | 15.6 |
| 110 | 6,360 | 28.616 | 25.43 | 727.6 | 12,900 | 20.943 | 51.58 | 1,080.2 | 4,270 | 2.540 | 7.13 | 18.1 |
| 111 | 6,080 | 38.828 | 24.30 | 943.5 | 14,350 | 10.472 | 57.38 | 600.9 | | | | |
| 112 | 7,510 | 5.754 | 30.01 | 172.7 | 14,310 | 11.716 | 57.23 | 670.5 | 4,270 | 6.635 | 7.16 | 47.5 |
| 113 | 6,780 | 18.766 | 27.10 | 508.5 | 14,240 | 8.035 | 56.92 | 457.4 | | | | |
| 114 | 6,460 | 30.283 | 25.82 | 782.0 | 13,800 | 23.950 | 55.17 | 1,321.3 | | | | |
| 115 | 6,250 | 12.079 | 24.98 | 301.8 | 14,420 | 3.888 | 57.69 | 224.3 | | | | |
| 116 | | | | | | | | | 4,750 | 16.900 | 4.62 | 78.0 |
| 117 | 5,950 | 12.286 | 23.78 | 292.2 | 14,420 | 0.570 | 57.54 | 32.8 | 5,050 | 12.182 | 8.47 | 103.2 |
| 118 | 6,480 | 18.973 | 25.89 | 491.3 | 16,640 | 1.970 | 66.55 | 131.1 | 5,510 | 20.425 | 9.24 | 188.8 |
| 119 | 5,830 | 21.202 | 23.30 | 494.1 | 16,440 | 13.530 | 65.71 | 889.1 | 4,450 | 9.850 | 7.46 | 73.5 |
| 120 | 4,910 | 2.436 | 19.70 | 48.0 | 24,230 | 0.051 | 94.12 | 4.8 | | | | |
| 121 | 4,910 | 11.249 | 19.62 | 220.7 | | | | | | | | |
| 122 | 7,790 | 20.010 | 31.15 | 623.3 | 24,230 | 17.729 | 96.87 | 1,717.5 | 3,040 | 17.574 | 5.10 | 89.6 |
| 123 | 8,210 | 3.577 | 32.85 | 117.5 | 14,260 | 0.622 | 57.23 | 35.6 | 3,950 | 0.778 | 6.69 | 5.2 |
| 124 | 8,210 | 7.361 | 32.81 | 241.5 | 14,260 | 1.400 | 57.14 | 80.0 | 3,950 | 2.281 | 6.62 | 15.1 |
| 125 | 7,480 | 11.146 | 29.91 | 333.4 | 14,260 | 4.147 | 56.98 | 236.3 | 3,950 | 2.851 | 6.65 | 19.0 |
| 126 | 7,480 | 15.241 | 29.91 | 455.8 | 14,260 | 1.555 | 57.04 | 88.7 | 3,950 | 2.696 | 6.60 | 17.8 |
| 127 | 6,810 | 5.080 | 27.22 | 138.3 | 12,830 | 5.236 | 64.90 | 339.8 | 3,990 | 3.577 | 6.71 | 24.0 |
| 128 | 6,810 | 8.554 | 27.25 | 233.1 | 16,240 | 3.784 | 64.98 | 245.9 | 3,990 | 0.933 | 6.65 | 6.2 |
| 129 | 8,640 | 9.383 | 34.55 | 324.2 | 16,240 | 3.007 | 64.88 | 195.1 | 4,900 | 0.622 | 8.09 | 5.0 |
| 130 | 7,940 | 3.162 | 31.72 | 100.3 | 14,680 | 1.762 | 58.74 | 103.5 | 4,900 | 2.074 | 8.25 | 17.1 |
| 131 | 7,600 | 14.308 | 30.37 | 434.6 | 14,680 | 6.324 | 58.66 | 371.0 | 4,900 | 1.607 | 8.25 | 13.3 |
| 132 | 7,110 | 7.102 | 28.43 | 201.9 | 21,040 | 7.620 | 84.11 | 640.9 | 4,900 | 1.192 | 8.16 | 9.7 |
| 133 | 7,110 | 17.574 | 28.43 | 499.7 | 18,850 | 9.590 | 75.37 | 722.8 | 4,900 | 5.028 | 8.21 | 41.3 |
| 134 | 5,520 | 20.840 | 22.06 | 459.8 | 13,970 | 14.671 | 55.86 | 819.6 | 4,140 | 8.087 | 6.95 | 56.2 |
| 135 | 5,480 | 14.722 | 21.91 | 322.6 | 12,890 | 19.180 | 51.53 | 988.3 | 4,140 | 2.800 | 6.95 | 19.5 |
| 136 | 5,480 | 11.457 | 21.92 | 251.1 | 12,950 | 19.233 | 51.78 | 995.9 | | | | |
| 137 | 5,100 | 1.555 | 23.79 | 37.0 | 12,870 | 6.791 | 60.27 | 409.3 | | | | |
| 142 | 5,100 | 2.954 | 23.94 | 70.7 | 12,260 | 1.918 | 57.38 | 110.1 | | | | |
| 143 | 5,100 | 12.027 | 23.87 | 287.1 | 12,260 | 6.480 | 57.38 | 371.8 | | | | |
| 144 | 5,100 | 2.800 | 23.92 | 67.0 | 12,260 | 0.881 | 57.41 | 50.6 | | | | |
| Totals | | 425 | | 11,270 | | 263 | | 15,874 | | 123 | | 866 |
| Means | | 10.4 | | 274.9 | | 6.4 | | 387.2 | | 3.0 | | 21.1 |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

ber 1976. See Charts F, G, and H (Appendix).

| *Macrocystis* - high density | | | | Mixed - low density | | | | Mixed - high density | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$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 |
| | | | | | | | | | | | | 2.851 | 116.0 |
| | | | | | | | | | | | | 8.398 | 379.3 |
| | | | | | | | | | | | | 5.391 | 245.9 |
| | | | | | | | | | | | | 3.577 | 166.7 |
| | | | | | | | | | | | | 0.466 | 19.2 |
| | | | | | | | | | | | | 0.674 | 28.0 |
| | | | | | | | | | | | | 7.621 | 359.8 |
| 8,980 | 0.207 | 15.40 | 3.2 | | | | | | | | | 11.766 | 476.7 |
| | | | | | | | | | | | | 9.123 | 359.4 |
| 8,920 | 0.778 | 14.88 | 11.6 | | | | | | | | | 24.831 | 908.8 |
| | | | | | | | | | | | | 52.099 | 1,825.9 |
| | | | | | | | | | | | | 49.300 | 1,544.4 |
| 8,920 | 4.354 | 14.95 | 65.1 | | | | | | | | | 28.459 | 955.8 |
| | | | | | | | | | | | | 26.801 | 965.9 |
| | | | | | | | | | | | | 54.233 | 2,103.3 |
| | | | | | | | | | | | | 15.967 | 526.1 |
| 8,920 | 0.985 | 14.99 | 14.8 | | | | | | | | | 17.885 | 92.8 |
| 8,920 | 18.818 | 14.97 | 281.7 | 1,210 | 0.829 | 3.20 | 2.7 | | | | | 44.685 | 712.6 |
| | | | | 1,210 | 4.613 | 3.22 | 14.9 | | | | | 45.981 | 826.1 |
| | | | | | | | | | | | | 44.582 | 1,456.7 |
| | | | | | | | | | | | | 2.487 | 52.8 |
| | | | | | | | | | | | | 11.249 | 220.7 |
| 9,370 | 0.674 | 15.68 | 10.6 | | | | | | | | | 55.987 | 2,441.0 |
| | | | | | | | | | | | | 4.977 | 158.3 |
| | | | | | | | | | | | | 11.042 | 336.6 |
| | | | | | | | | | | | | 18.144 | 588.7 |
| | | | | | | | | | | | | 19.492 | 562.3 |
| | | | | | | | | | | | | 13.893 | 502.1 |
| | | | | | | | | | | | | 13.271 | 485.2 |
| | | | | | | | | | | | | 13.012 | 524.3 |
| 9,370 | 0.104 | 16.13 | 1.7 | 3,700 | 0.104 | 10.20 | 1.1 | | | | | 7.206 | 223.7 |
| 9,370 | 0.933 | 15.65 | 14.6 | | | | | | | | | 23.172 | 833.5 |
| 9,370 | 0.259 | 15.55 | 4.0 | | | | | | | | | 16.173 | 856.5 |
| 9,370 | 1.762 | 15.71 | 27.7 | 3,700 | 0.881 | 9.93 | 8.8 | | | | | 34.835 | 1,300.3 |
| 9,370 | 9.745 | 15.72 | 153.2 | 3,700 | 6.687 | 9.80 | 65.5 | | | | | 60.030 | 1,554.3 |
| | | | | | | | | | | | | 36.702 | 1,330.4 |
| | | | | | | | | | | | | 30.690 | 1,247.0 |
| | | | | | | | | | | | | 8.346 | 446.3 |
| | | | | | | | | | | | | 4.872 | 180.8 |
| | | | | | | | | | | | | 18.507 | 658.9 |
| | | | | | | | | | | | | 3.681 | 117.6 |
| | 39 | | 588 | | 13 | | 93 | | nil | | nil | 862 | 28,691 |
| | 0.9 | | 14.3 | | 0.3 | | 2.3 | | | | | 21.0 | 699.8 |

Table 6: Estimates of kelp area and biomass for the north coast of Graham Island: Entr

| | *Nereocystis* - low density | | | | *Nereocystis* - high density | | | |
|---|---|---|---|---|---|---|---|---|
| Block | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | $\bar{x}$D/ha | A | $\bar{x}$B/ha | B |
| 145 | | | | | | | | |
| 146 | | | | | | | | |
| 147 | | | | | | | | |
| 148 | | | | | | | | |
| 149 | | | | | | | | |
| 150 | | | | | | | | |
| 151 | | | | | | | | |
| 152 | | | | | | | | |
| 153 | | | | | | | | |
| 154 | | | | | | | | |
| 155 | | | | | | | | |
| 156 | | | | | | | | |
| 157 | | | | | | | | |
| 158 | | | | | | | | |
| 159 | 5,690 | 33.489 | 26.65 | 892.6 | 12,260 | 1.451 | 57.45 | 83.4 |
| 160 | 4,870 | 4.303 | 22.85 | 98.3 | | | | |
| 161 | 4,870 | 7.724 | 22.80 | 176.1 | | | | |
| 162 | | | | | | | | |
| 163 | 4,890 | 12.338 | 22.89 | 282.4 | | | | |
| 164 | | | | | | | | |
| Totals | | 58 | | 1,449 | | 1 | | 83 |
| Means | | 2.9 | | 72.5 | | 0.1 | | 4.2 |

D = Density (no. of plants or fronds)

A = Area (hectares)

B = Biomass (metric tonnes)

$\bar{x}$ = Mean

ha = Hectare

ry Point to Yakan Point, September 1976. See Chart I (Appendix).

| *Macrocystis* - low density | | | | *Macrocystis* - high density | | | | Mixed - low density | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$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 |
| 3,520 | 10.212 | 6.26 | 64.0 | 8,440 | 3.940 | 15.06 | 59.3 | | | | |
| 3,270 | 24.831 | 5.83 | 144.7 | 8,440 | 21.669 | 15.04 | 325.9 | | | | |
| 2,430 | 87.039 | 4.33 | 376.9 | 10,350 | 8.035 | 18.45 | 148.3 | | | | |
| 3,320 | 79.522 | 5.92 | 470.4 | 10,350 | 12.182 | 18.45 | 224.7 | | | | |
| 3,240 | 32.244 | 5.78 | 186.2 | 11,490 | 3.214 | 20.46 | 65.8 | | | | |
| 3,600 | 32.244 | 6.42 | 206.9 | 11,490 | 0.155 | 20.69 | 3.2 | | | | |
| 2,610 | 26.801 | 4.65 | 124.7 | 11,490 | 6.532 | 20.49 | 133.8 | | | | |
| 3,210 | 23.069 | 5.72 | 132.0 | 11,930 | 1.244 | 21.20 | 26.4 | | | | |
| 2,910 | 4.873 | 5.19 | 25.3 | | | | | | | | |
| 2,910 | 36.495 | 5.19 | 189.2 | 11,930 | 5.806 | 21.27 | 123.5 | | | | |
| 4,560 | 19.181 | 8.13 | 155.9 | 11,930 | 11.871 | 21.26 | 252.3 | | | | |
| 2,990 | 41.420 | 5.33 | 220.6 | 9,690 | 11.975 | 17.26 | 206.7 | | | | |
| 2,700 | 50.907 | 4.81 | 245.0 | 9,880 | 0.829 | 17.63 | 14.6 | | | | |
| 2,730 | 11.094 | 4.87 | 54.0 | | | | | 1,260 | 4.614 | 3.72 | 17.2 |
| 2,700 | 19.388 | 4.81 | 93.2 | | | | | 2,420 | 1.659 | 7.14 | 11.8 |
| 4,710 | 3.421 | 8.39 | 28.7 | | | | | 2,420 | 1.970 | 7.21 | 14.2 |
| 4,710 | 0.104 | 8.57 | 0.9 | | | | | | | | |
| 4,710 | 12.390 | 8.40 | 104.1 | 9,880 | 5.754 | 17.59 | 101.2 | 2,420 | 1.814 | 7.18 | 13.0 |
| 3,660 | 17.211 | 6.52 | 112.3 | 9,880 | 2.696 | 17.58 | 47.4 | | | | |
| 3,660 | 0.466 | 6.50 | 3.0 | | | | | | | | |
| | 533 | | 2,938 | | 96 | | 1,733 | | 10 | | 56 |
| | 26.6 | | 146.9 | | 4.8 | | 86.7 | | 0.5 | | 2.8 |

Mixed - high density

| $\bar{x}$D/ha | A | $\bar{x}$B/ha | B | Total A | Total B |
|---|---|---|---|---|---|
| | | | | 14.152 | 123.3 |
| | | | | 46.500 | 470.6 |
| | | | | 95.074 | 525.2 |
| | | | | 91.704 | 695.1 |
| | | | | 35.458 | 252.0 |
| | | | | 32.399 | 210.1 |
| | | | | 33.333 | 258.5 |
| | | | | 24.313 | 158.4 |
| | | | | 4.873 | 25.3 |
| | | | | 42.301 | 312.7 |
| | | | | 31.052 | 408.2 |
| | | | | 53.395 | 427.3 |
| | | | | 51.736 | 259.6 |
| | | | | 15.708 | 71.2 |
| | | | | 55.987 | 1081.0 |
| | | | | 9.694 | 141.2 |
| | | | | 7.828 | 177.0 |
| | | | | 19.958 | 218.3 |
| | | | | 32.245 | 442.1 |
| | | | | 0.466 | 3.0 |
| | nil | | nil | 698 | 6,260 |
| | | | | 34.9 | 313.0 |

This volume was split almost evenly between low density and high density beds; the densest beds were located from Cape Knox to Masset Harbour (Table 8). Pure *Macrocystis* stands were estimated to be 8,043 tonnes (13.07% of the total standing crop), most of which occurred from Entry Point to Yakan Point. From Frederick Island to Masset Harbour the majority of the kelp was *Nereocystis*, and mean biomass densities ranged from 24.3 - 33.3 tonnes/hectare (calculated from Table 7). But from Entry Point to Yakan Point the density was 8.96 tonnes/hectare, reflecting the high proportion of low density *Macrocystis* in this area. Stands of pure *Nereocystis* comprised 86.44% of the total biomass (Table 8) but only 58.90% of the total surface area (Table 9). This illustrates the important differences in densities of the two species within the areas surveyed.

Factors for estimating biomass at selected cutting levels other than MWL are presented in Table 10. By multiplying these factors times the biomass at MWL, the amount of kelp available at other tide heights can be obtained. Using these factors, estimates of *Nereocystis* and *Macrocystis* standing crops at the different depth levels are given in Table 11 for the entire survey area. We estimated the total standing crop for the whole survey area in September, 1976 to be 77,772 tonnes. This was thought to be a somewhat conservative estimate primarily due to incomplete photographic coverage, and, very secondarily, to inevitable losses of kelp laminae during field sampling procedures which result in low estimates of mean biomass per plant.

Discussion: a comparison with previous surveys

The first survey of the kelp resources on the north coast of Graham Island was privately conducted by North Pacific Marine Products Ltd. (Norpac, 1967). The only available report of this survey presents a summary of the results without mentioning the sampling techniques employed in arriving at those results. A second survey was

Table 7. Summary of biomass and kelp bed area estimates, by geographical subdivision and bed type, for the west and north coasts of Graham Island. Estimates are harvestable biomass at MWL ± 0.6 m.

| Geographical Area | Blocks | Biomass (tonnes) | Area (hectares) |
|---|---|---|---|
| | | Low Density *Nereocystis* | |
| Frederick Is. to Cape Knox | 1-46 | 4,675 | 192 |
| Cape Knox to Klashwun Ptd. | 47-97 | 7,739 | 268 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 11,270 | 425 |
| Entry Pt. to Yakan Pt. | 145-164 | 1,149 | 58 |
| | | High Density *Nereocystis* | |
| Frederick Is. to Cape Knox | 1-46 | 2,668 | 48 |
| Cape Knox to Klashwun Pt. | 47-97 | 9,426 | 144 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 15,874 | 263 |
| Entry Pt. to Yakan Pt. | 145-164 | 83 | 1 |
| | | Low Density *Macrocystis* | |
| Frederick Is. to Cape Knox | 1-46 | 533 | 69 |
| Cape Knox to Klashwun Pt. | 47-97 | 105 | 13 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 866 | 123 |
| Entry Pt. to Yakan Pt. | 145-164 | 2,938 | 533 |
| | | High Density *Macrocystis* | |
| Frederick Is. to Cape Knox | 1-46 | 1,183 | 60 |
| Cape Knox to Klashwun Pt. | 47-97 | 97 | 6 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 588 | 39 |
| Entry Pt. to Yakan Pt. | 145-164 | 1,733 | 96 |
| | | Low Density Mixed | |
| Frederick Is. to Cape Knox | 1-46 | 68 | 7 |
| Cape Knox to Klashwun Pt. | 47-97 | 83 | 8 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 93 | 13 |
| Entry Pt. to Yakan Pt. | 145-164 | 56 | 10 |
| | | Totals | |
| Frederick Is. to Cape Knox | 1-46 | 9,127 | 375 |
| Cape Knox to Klashwun Pt. | 47-97 | 17,450 | 440 |
| Klashwun Pt. to Masset Hbr. | 100-144 | 28,691 | 862 |
| Entry Pt. to Yakan Pt. | 145-164 | 6,260 | 698 |
| GRAND TOTALS | 1-164 | 61,528 | 2,375 |
| | | Totals by Species | |
| *Nereocystis* | 1-164 | 52,884 | 1,399 |
| *Macrocystis* | 1-164 | 8,043 | 938 |
| Mixed | 1-164 | 300 | 38 |

Table 8: Percent composition of low and high density *Nereocystis, Macrocystis* and mixed bed estimates of biomass in each of four geographic subdivisions. The last column gives percent composition of total biomass for the north and west coast of Graham Island.

| Bed Type | | Frederick/Cape Knox | Cape Knox/Klashwun | Klashwun/Masset Hr. | Entry/Yakan | Combined |
|---|---|---|---|---|---|---|
| *Nereocystis* | - low density | 51.22 | 44.35 | 39.28 | 23.15 | 40.85 |
| | - high density | 29.23 | 54.02 | 55.33 | 1.33 | 45.59 |
| *Macrocystis* | - low density | 5.84 | 0.60 | 3.02 | 46.93 | 7.22 |
| | - high density | 12.96 | 0.56 | 2.05 | 27.68 | 5.85 |
| Mixed | - low density | 0.75 | 0.48 | 0.32 | 0.90 | 0.49 |
| | - high density | nil | nil | nil | nil | nil |

Table 9: Percent composition of low and high density *Nereocystis, Macrocystis* and mixed bed estimates of surface area in each of four geographic subdivisions. The last column gives percent composition of total bed area for the north and west coasts of Graham Island.

| Bed Type | | Frederick/Cape Knox | Cape Knox/Klashwun | Klashwun/Masset Hr. | Entry/Yakan | Combined |
|---|---|---|---|---|---|---|
| *Nereocystis* | - low density | 51.13 | 61.04 | 49.23 | 8.29 | 39.68 |
| | - high density | 12.76 | 32.80 | 30.50 | 0.21 | 19.22 |
| *Macrocystis* | - low density | 18.32 | 2.91 | 14.27 | 76.33 | 31.05 |
| | - high density | 16.04 | 1.46 | 4.48 | 13.74 | 8.47 |
| Mixed | - low density | 1.74 | 1.78 | 1.52 | 1.44 | 1.58 |
| | - high density | nil | nil | nil | nil | nil |

Table 10: Combined biomass and density correction factors for cutting levels six metres above and below MWL for the north and west coasts of Graham Island.

| Cutting Level (m) | *Nereocystis* n=104 | *Macrocystis* n=110 | Mixed * |
|---|---|---|---|
| +6 | 0.01 | 0.28 | 0.14 |
| +5 | 0.05 | 0.37 | 0.23 |
| +4 | 0.12 | 0.47 | 0.28 |
| +3 | 0.28 | 0.58 | 0.43 |
| +2 | 0.50 | 0.71 | 0.60 |
| +1 | 0.76 | 0.85 | 0.80 |
| MWL | 1.00 | 1.00 | 1.00 |
| -1 | 1.10 | 1.16 | 1.13 |
| -2 | 1.15 | 1.30 | 1.24 |
| -3 | 1.17 | 1.43 | 1.33 |
| -4 | 1.18 | 1.59 | 1.41 |
| -5 | 1.19 | 1.64 | 1.44 |
| -6 | 1.20 | 1.68 | 1.46 |

* Based on 42% *Nereocystis* and 58% *Macrocystis*

Table 11: Total harvestable kelp biomass at selected depth levels for the north and west coasts of Graham Island, Queen Charlotte Island, in September 1976.

| Depth Level (m) | Cumulative Biomass (tonnes) | | | |
|---|---|---|---|---|
| | *Nereocystis* | *Macrocystis* | Mixed | Total |
| +6 | 293 | 2,252 | 42 | 2,587 |
| +5 | 2,659 | 2,976 | 69 | 5,704 |
| +4 | 6,382 | 3,780 | 84 | 10,246 |
| +3 | 14,892 | 4,665 | 129 | 19,686 |
| +2 | 26,593 | 5,711 | 180 | 32,484 |
| +1 | 40,421 | 6,837 | 240 | 47,498 |
| MWL | 53,185 | 8,043 | 300 | 61,528 |
| -1 | 58,504 | 9,330 | 339 | 68,173 |
| -2 | 61,163 | 10,456 | 372 | 71,991 |
| -3 | 62,226 | 11,501 | 399 | 74,126 |
| -4 | 62,758 | 12,788 | 423 | 75,969 |
| -5 | 63,290 | 13,191 | 432 | 76,913 |
| -6 | 63,461 | 13,512 | 438 | 77,411 |

carried out by Blakely and Chalmers (1973) for the Federal and Provincial governments; the report on this survey includes details of methodology. The 1967 and 1973 inventories covered only the areas from Cape Naden to Tow Hill. Table 12 presents a comparison of bed area and biomass estimates for these two studies. Table 13 compares bed area, biomass, and density estimates from all three surveys for selected areas within this region. All areas could not be compared due to incomplete photographic coverage in 1976. The 1967 and 1973 inventories report total standing crop biomass of the beds, and by using appropriate correction factors for -6 m in Table 10 and the MWL biomass data in Tables 5 and 6, the total standing crop biomass for 1976 was calculated for comparison.

Estimates of total biomass of *Nereocystis* from Inskip Point to Wiah Point were approximately two times higher in 1967 and 1973 than 1976 (18,528; 24,447 and 10,139 tonnes respectively). The *Nereocystis* beds from Entry Point to Skonun Point were not photographed in 1976. Densities of 3 - 6 $kg/m^2$ were reported by all surveys, except between Inskip Point and Cape Estevan where the 1973 survey reported a mean value of 16.7 $kg/m^2$. While this was an area of abundant *Nereocystis* we consider this value to be unrealistically high. Bed area estimates from the 1967 survey were higher than the two later surveys. We believe that the bed area estimates for the 1967 survey were determined by observers in boats, perhaps supplemented by non-photographic aerial observations. We considered the use of aerial photography for bed area determinations in the 1973 and 1976 inventories to be more accurate; it is noteworthy that the estimates of *Nereocystis* bed areas found by these two later surveys are reasonably similar. The 1973 survey employed 70 mm infrared false color transparences which were projected to a scale of 1:15,840. KIM-1 use 9x9 inch (22.9 x 22.9 cm) IR black and white transparences at a scale of 1:7,200.

Estimates of *Macrocystis* total standing crop biomass were 5 - 6 times lower in 1976 than in the other surveys (8,574 tonnes compared

Table 12: Bed areas and standing crops of *Macrocystis* and *Nereocystis* for various regions of the north coast of Graham Island as estimated in the 1967 and 1973 kelp inventories.

| Location | North Pacific Marine Products 1967 Inventory | | | | 1973 Kelp Inventory | | | |
|---|---|---|---|---|---|---|---|---|
| | *Nereocystis* | | *Macrocystis* | | *Nereocystis* | | *Macrocystis* | |
| | Area (hectares) | Standing Crop (Metric tonnes) | Area (hectares) | Standing Crop (Metric tonnes) | Area (hectares) | Standing Crop (Metric tonnes) | Area (hectares) | Standing Crop (Metric tonnes) |
| Cape Naden - Mazarredo Island | N.S. | N.S. | N.S. | N.S. | 89.3 | 2,044 | N.P. | N.P. |
| Mazarredo Island - Mary Point | 218.3 | 9,988 | 13.9 | 545 | 99.0 | 3,151 | N.P. | N.P. |
| Inskip Point - Cape Edensaw | 311.0 | 9,443 | 199.7 | 9,716 | 119.9 | 20,005 | 126.3 | 21,075 |
| Cape Edensaw - Wiah Point | 153.4 | 9,080 | 18.6 | 908 | 148.4 | 4,472 | N.P. | N.P. |
| Wiah Point - Jacob Point | 164.4 | 13,438 | N.P. | N.P. | 142.0 | 8,225 | 9.4 | 1,562 |
| Jacob Point - Yan | 376.6 | 9,357 | N.P. | N.P. | 140.8 | 8,150 | N.P. | N.P. |
| Entry Point - Skonun Point | 152.2 | 2,452 | 645.6 | 33,476 | 40.2 | 363 | 464.7 | 28,250 |
| Skonun Point - Tow Hill | 1,031.2 | 18,483 | 493.9 | 23,136 | 75.7 | 684 | 288.3 | 17,529 |
| Masset Inlet and Sound | 79.0 | 608 | N.P. | N.P. | 70.3 | 925 | N.P. | N.P. |
| COLUMN TOTALS | 2,486.1 | 72,849 | 1,371.1 | 67,781 | 925.6 | 48,819 | 888.7 | 68,416 |

Total Area 1967 = 3,857.2 hectares

Total Standing Crop 1967 = 140,630 tonnes

Total Area 1973 = 1,554.8 hectares

Total Standing Crop 1973 = 117,235 tonnes

N.S. - Not Surveyed

N.P. - Not Present

Table 13: Comparison of estimates of bed surace area, density and biomass for selected areas between the 1967, 1973 and 1976 inventories. N.P. = *Nereocystis* beds in this area were not photographed. Biomass in all cases is total standing crop biomass. Parentheses indicate percent of 1976 values.

N.S. - Not Surveyed

*NEREOCYSTIS*

| Geographic Location | Surface Area (ha) | | | Biomass (tonnes) | | | Density ($kg/m^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 1973 | 1976 | 1967 | 1973 | 1976 | 1967 | 1973 | 1976 |
| Inskip Point - Cape Edensaw (Blks. 116-123) | 311.0 (250) | 119.7 (96) | 124.2 | 9,443 (154) | 20,005 (327) | 6,117.9 | 3.0 (61) | 16.7 (340) | 4.9 |
| Cape Edensaw - Wiah Point (Blks. 124-131) | 153.4 (151) | 148.7 (147) | 101.4 | 9,080 (232) | 4,472 (114) | 3,921.5 | 5.9 (148) | 3.2 (80) | 4.0 |
| Entry Point - Skonun Point (Blks. 145-158) | 152.2 | 40.2 | N.P. | 2,452 | 363 | N.P. | 1.6 | 0.9 | N.P. |

*MACROCYSTIS*

| Geographic Location | Surface Area (ha) | | | Biomass (tonnes) | | | Density ($kg/m^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 1973 | 1976 | 1967 | 1973 | 1976 | 1967 | 1973 | 1976 |
| Inskip Point - Cape Edensaw (Blks. 116-123) | 199.7 (203) | 126.3 (128.6) | 98.2 | 9,716 (684) | 21,075 (1,483) | 1,421 | 4.9 (350) | 16.7 (1,193) | 1.4 |
| Cape Edensaw - Wiah Point (Blks. 124-131) | 18.6 (101) | N.S. | 18.4 | 908 (404) | N.S. | 225 | 4.9 (408) | N.S. | 1.2 |
| Entry Point - Skonun Point (Blks. 145-158) | 645.6 (114) | 964.7 (81.9) | 567.3 | 33,476 (485) | 28,250 (409) | 6,901 | 5.2 (433) | 6.1 (508) | 1.2 |

to 44,100 and 49,325 tonnes in 1967 and 1973). Estimated bed areas were reasonably comparable. It would therefore appear that the great differences in standing crop were related to differing estimates of biomass density, which for 1967 and 1973 were 350 and 1,193% of those estimated in 1976. In 1973 *Macrocystis* frond density estimates from Entry Point to Skonun Point were 5.0 fronds/$m^2$ compared to a range of 0.26 - 1.19/$m^2$ in 1976. The mean weights per frond were similar (1.18 kg/frond in 1973 and 1.73 kg/$m^2$ in 1976), indicating that *Macrocystis* was more abundant in 1973 and/or that errors occurred when estimating density.

The two surveys determined densities quite differently. The 1973 survey counted and weighed all *Nereocystis* plants and *Macrocystis* fronds in randomly selected 7.3 $m^2$ sample plots spaced at 0.5 - 1.0 mile (0.3 - 0.6 km) intervals along the coast. Average density (kg/$m^2$) values were derived for each geographical subdivision; total standing crop biomass for each subdivision was calculated by multiplying average density by bed area. Using standard KIM-1 methods, we determined the total biomass for each statistical block on the basis of block-specific bed area and plant/frond density measurements and a more generally applied estimate of mean biomass per plant/frond. Plant/frond density for each block was measured directly from the aerial photographs. Where bed size permitted we enumerated density in a minimum of 10 microscope fields, each sampling 2,500 $m^2$ of sea surface, for each of the six possible bed types present. Thus the KIM-1 technique produced a greater number of density measurements. While both techniques have a known level of precision, they are difficult to compare because the accuracy of each in estimating the actual standing crop present is not known.

Individual *Nereocystis* plants are easily discernable in the aerial photographs employed in the KIM-1 method under most circumstances, but individual *Macrocystis* fronds are not readily identified due to twisting together and layering of the fronds. Foreman (1975) determined the relationship between the number of fronds counted on an aerial

photograph and the number actually present. This relationship is the truly novel aspect of KIM-1 because it permits density estimation (with a known level of precision) for large areas of kelp and the delimitation of beds on the basis of density. For such low density *Macrocystis* beds as those between Entry Point and Skonun Point, the frond density estimates produced with the KIM-1 technique can vary as much as ±58% from the actual; thus even the greatest estimated biomass within this error range for this region would still be far below the 1967 and 1973 estimates. Possibly the density relationships generated by Foreman (1975) for kelp in the Port Hardy/Malcolm Island area in the months of July and August are not strictly applicable to kelp in other areas and at other times of the year. Nevertheless we doubt that the large differences in *Macrocystis* standing crop estimates produced by the 1973 and 1976 inventories is solely related to natural changes in bed density, but is more significantly an artifact of the different density estimation techniques.

Our estimate of 1.2 kg/$m^2$ for *Macrocystis* between Entry Point and Skonun Point (Table 13) appears more realistic than Blakely and Chalmers' mean value of 6.1 kg/$m^2$ for plants growing in 2 - 4 m of water below 0 tide level. The densest *M. integrifolia* ever observed in our kelp inventory program was located in Nootka Sound in 1975 (Coon *et al*, 1977). The canopy in this bed provided over 90% cover of the sea surface. Yet, maximal frond density estimates provided by KIM-1 were 3.3 fronds/$m^2$ and maximal biomass density equaled 3.95 kg/$m^2$. Average standing crop biomass/$m^2$ of *M. pyrifera* in California, where the sea bed is up to 25 meters below 0 tide level is only 6 kg/$m^2$ (Clendenning, 1960). We believe that the KIM-1 technique is more accurate than that employed in 1973 and would recommend that any decision involving allocation of *Macrocystis* resources along the north coast of Graham Island be based on the KIM-1 estimates.

Summary

1) The Kelp Inventory Method (KIM-1) developed by Dr. R.E. Foreman was used to estimate standing crop biomass of two alginophyte species along the north coast of Graham Island, in the Queen Charlotte Islands, British Columbia. Results indicated that 53,185 tonnes of pure *Nereocystis leutkeana*, 8,034 tonnes of *Macrocystis integrifolia* in pure beds and 300 tonnes of mixed kelp were available at mean water level in the major beds in this region. Total bed surface area was estimated to be 2,375 hectares.

2) Nine charts were drafted showing the position, extent, species, and density classification of every discernible kelp bed for each of four geographic subdivisions: Frederick Island to Cape Knox, Cape Knox to Klashwun Point, Klashwun Point to Masset Harbour, and Entry Point to Yakan Point. For management purposes, all inventoried coastlines were divided into permanent, numbered, kilometer-wide blocks.

3) The 1976 estimates of standing crop biomass were substantially lower for both *Nereocystis* and *Macrocystis* than determined by surveys performed in 1967 by a private firm, and by a team funded by the Federal and Provincial governments in 1973. Differing techniques of estimating density of kelp were felt to be the major factor creating these differences. Because of the greater replication inherent in the KIM-1 method, the 1976 estimates were felt to be more accurate than the 1967 and 1973 estimates.

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## REFERENCES CITED

Anon. 1948. Marine plants of economic importance in British Columbia coastal waters, Part II. B.C. Research Council Tech. Bull. No. 10.

Blakely, B.B. & W.T. Chalmers. 1973. Masset Kelp Inventory. Final Report to Dept. Environment, Fisheries Operations, Vancouver, B.C.

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.

Clendenning, K.A. 1960. Organic productivity of giant kelp areas. Quart. Prog. Rep., 1 July-Sept. 1959. Kelp Inv. Prog., Univ. Calif. Inst. Mar. Res., IMR Ref. 60(6): 1-11.

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.

Coon, L.M. and W.G. Roland. 1979. A preliminary study of the impact of harvesting on growth of the giant kelp *Macrocystis integrifolia* Bory in the Queen Charlotte Islands, British Columbia. British Columbia Marine Resources Branch, Fish. Development Rep. 12: (in press).

Field, E.J. and E.A.C. Clark. 1978. Kelp inventory, 1976, Part 2. The Dundas Group. Marine Resources Branch, Victoria British Columbia. 22 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.

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.

REFERENCES CITED (CONT'D)

Norpac. 1967. Survey of the kelp resource within 18 miles of Masset. North Pacific Marine Products Ltd.

Whyte, J.N.C. and J.R. Englar. 1974. Commercial kelp drying operation at Masset, 1973. Fish. Res. Bd. Canada, Tech. Rep. 453: 30 pp.