MASSET KELP INVENTORY

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Final Report

Masset Kelp Inventory

jointly by

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This report contains the results of a kelp survey carried out in the vicinity of Masset, B. C., for the Department of the Environment, Fisheries Operations in the late summer and early autumn of 1973. The purposes of the survey were: to locate and identify the major kelps present; to subsequently estimate the standing crop and potential sustained yield of the area; to identify the flora and fauna associated with the kelp; and to estimate the associated sea urchin and abalone populations. The survey area encompassed the region within an eighteen mile radius of Masset. The field work was completed between August 22nd and September 25th, 1973. The results of this field work have been briefly stated in an Interim Report (Chalmers and Blakley, Nov., 1973), and in this report are presented on 1:1320 scale maps (Charts 1, 2, and 3, and Tables I-VIII).

Several methods and techniques were considered for locating and quantifying the kelps and associated marine life. While it was necessary to carry out an intensive SCUBA diving survey of the area to obtain density and biological association data, it was anticipated that traditional survey techniques would prove unwieldy and relatively inaccurate under the circumstances. Factors taken into consideration included the large size of the area to be surveyed, the large size of the kelp beds, the limited time available (one month) for completion of the field work, the generally poor weather prevalent in the area at that time of year, the limited manpower (two biologists and a boat skipper), and the limited range and resolution of the survey equipment available. Attempts were made to assess bed area with chain, stadia, and transit; with optical range finder with an effective range of only 500 ft.; and with boat radar with reso-

lution limited to 25 yd. All attempts proved unsuccessful, due particularly to the large size of the beds and to the poor weather. Remote sensing techniques were considered, and a review of the literature led to the choice of aerial photography using true colour and infrared false colour film for the project (Jamieson, 1971; Howard, 1970; Eastman Kodak Company, 1972; and Welsh, 1971).

The aerial photography was undertaken by Integrated Resources Photography Ltd. (Vancouver), using twin Vinten aerial reconnaissamce cameras with a focal length of 3.1 inches, mounted in a Cessna 172 aircraft. Kodak 2448 false colour infrared reversal film was exposed through a Wratten #12 filter at f/2, shutter speed 1/1,000 sec. Kodak 2443 colour reversal film was simultaneously exposed through a Skylight filter at f/2, shutter speed 1/1,000 sec. Sequential exposures were made with just sufficient overlap (about 10-15%) to permit facile matching for plotting purposes. This was done in order to reduce costs. These photographs are present as false colour-true colour pairs, in sequence in the Photograph Supplement, and as prints in Plates I to XI. True colour 9x9 in. format and infrared black-and-white and infrared false colour 70 mm. photographs taken in summer 1973 by the Canada Centre for Remote Sensing are also presented in the Supplement. These were purchased in the hope that the information provided by them might supplant the need to do specific project oriented regional photographic surveys in inventories of this nature. They do provide useful information, but they do not provide sufficient contrast or resolution for the accurate mapping of kelp beds.

Considerable difficulties were experienced due to the poor weather,

and a first photographic mission on August 20th and 21st had to be aborted due to dense fog. A subsequent mission on August 30th and extending to September 2nd proved successful, but was interrupted for two days because of gale force winds.

Photographs were taken of the entire area at a height of 7,000 ft. (approximate photograph scale 1:44,000; see Charts 1, 2, and 3, and Plates I, II, V, VI, VII, VIII). Photographs were then taken from 700 ft. (approximate photograph scale 1:3,600) along a weaving course within the kelp beds (Airborne Traverses 1, 2, 3, and 4). These were used to complement the small scale photographs in bed distribution and area determination, and also to provide species identification; i.e., to distinguish the limits of Nereocystis and Macrocystis beds where they occur in close proximity (Plates III and IV). Differences in kelp bed density are also readily apparent on these photographs (Plates IX, X, and XI), and it is possible that by the use of a densitometer they could provide accurate kelp bed density data when related to specific dive-sample sites located on the photographs.

An unfortunate accident occurred during the processing of our film at the National Air Photo Library in Ottawa. About half of a roll (125 frames, comprising about 15% of the total number of photographs) of the film exposed at 700 ft. was destroyed, and the remainder of the roll was very badly damaged. A number of frames of the other rolls were also damaged in processing (see Photograph Supplement frames numbered 97-...). This accident was particularly unfortunate as a small region southeast of Striae Islands which was the most intensively ground truthed was missed

in the small scale photographs but had been well covered by the destroyed portion of large scale photographs. It is also unfortunate that we were unable to obtain the developed aerial photographs until the last week of the field survey. Had they been available before the initiation of field work, a more efficient sampling strategy might have been developed and undertaken.

Large scale (¼ mile to one inch) mapping photographs were obtained from the Map Production Division, Lands Service, Victoria, B. C., and from these an identical scale map was traced on Kodopak plastic film. This map was used in the field to accurately locate landmarks for dive-site positioning, and as a base map on which the kelp beds were finally plotted. This was done by projecting the aerial photographs to the appropriate scale, and tracing the kelp beds onto the film. As it was not possible to obtain a good reproduction of the coloured lines drawn in felt pen on the plastic, this map was redrawn on draughting paper and is presented as Charts 1, 2, and 3.

Bed areas were calculated from the tracings on the Charts, by use of a digitizer-computer system and/or dot counting grid (Plates XIII, XIV, and XV, and Tables I, II, III, VI, VII, and VIII). Error associated with bed area determination may be considerable and may arise from several factors. These include slight variations in photograph scale due to camera tilt ($\pm$ 2%), variation in kelp bed scale due to plotting errors ($\pm$5%), errors in interpretation and plotting of kelp bed limits ($\pm$ 5%), and errors associated with measurements of plotted areas ($\pm$5%). Thus the cumulative error associated with area may be as much as $\pm$17%.

A preliminary survey of the entire area by boat indicated that the kelp was restricted to a margin along the coastline of the area, extending seaward not more than two miles at any point. From Masset west to Cape Naden, the major kelp was Nereocystis luetkeana (Mertens) Postels and Ruprecht, with one fairly large bed of Macrocystis integrifolia Bory present between Cape Edensaw and Inskip Point, and two small ones near Refuge Island and Hidden Island. There was little if any kelp present in Naden Harbour. From Masset east to Tow Hill, the major kelp was Macrocystis integrifolia, with a sparse seaward border of Nereocystis luetkeana. The area from Masset south to Ship Island was characterized by a few very small beds and scattered individual plants of Nereocystis luetkeana. Ship Island, Sloop Islet, and the associated rock were encircled by a narrow ring of N. luetkeana except for the western side of Ship Island, which was bare of kelp.

The kelp occurs as a virtuously continuous ribbon of varying width and density along most of the northern coastline; the ends of individual kelp beds are not often clearly demarcated. Due to this continuity and due also to the relative homogeneity found among the samples by t-tests, the entire area was divided into six zones for sampling purposes: Masset to Wiah Point, Wiah Point to Cape Edensaw, Cape Edensaw to Inskip Point, Mary Point to Cape Naden, Masset to Tow Hill, and the Masset Inlet-Ship Island area. Within each zone, a modified random sampling technique was employed. Transects were drawn out from shore at fixed intervals, at headings approximately at right angles to the shore (see Interim Report). In order to draw these transects, the coastline from Masset to Cape Na-

den was divided into five segments based on "natural" changes in the average heading of the coastline (Chart 2). These segments were: Yan to Jacob Pt.; Jacob Pt. to Wiah Pt.; Wiah Pt. to Cape Edensaw; Cape Edensaw to Inskip Pt.; and Mary Point to Cape Naden. Diving was done along transects drawn at one or half mile intervals as time and working conditions permitted. They were located by reference to geographic features of the coastline on the ¼ mile to one inch scale base map and on the appropriate marine charts of the largest scale available.

The Masset-Tow Hill coastline is characterized by a paucity of distinctive, localized geographic features. To compensate for this, a series of large (three foot by four foot) fluorescent red painted markers were placed along the beach at one mile intervals (Plate XXII). Transects were drawn from these markers, or from between adjacent ones in the case of half mile intervals.

Dive sites were chosen at random along the transects and within the kelp beds. At each site, an anchor was lowered out of the boat. Two pieces of rope, each five feet in length, attached to the anchor were used to describe a circle of radius five feet (an area of approximately seventy-eight square feet). All the kelp plants in this circle were counted, collected, and weighed in baskets on a platform balance. From this data, the average densities of areas were determined. The standing crop for each area was then calculated. These data are recorded in Tables I and II. Densities for submerged kelps (Order Laminariales, with the exception of N. luetkeana and M. integrifolia; Table IV) were roughly estimated at each sample site. The standing crop of these species as associated with the floating

kelp beds is recorded in Table III.

The flora and fauna associated with the kelp beds was identified and recorded at each dive site, but is not limited to just that found in the small area of the sample site. One specimen of most of the species present was photographed or collected and preserved or photographed (Plates XIV, XV, XVI, XVII, XVIII, XIX, XX, and XXI); the preserved specimens are submitted with this report (Supplementary Specimen Collections 1, 2, and 3).

The populations of abalone (Haliotis kamschatkana) and sea urchins (Strongylocentrotus drobachiensis and S. franciscanus) were calculated in the same manner as the standing crop of the kelp. The areas are necessarily those encompassed by the kelp beds, as those were the areas surveyed. The abalone and sea urchins within the five foot radius circle at each dive site were counted and recorded. The average densities were then calculated and multiplied by the appropriate areas. These populations are recorded in Tables VI, VII, and VIII.

All marine flora and fauna were identified on the basis of Clemens and Wilby (1961), Cornwall (1970), Druehl (1966, 1970), Furlong and Pill (1970), Griffith (1967), Guberlet (1956), Phillips and Vadas (1967), Liburdi and Truitt (1973), Markham (1972), Quayle (1973), Ricketts and Calvin (1968), Scagel (1957, 1969, 1971, 1946), Smith (1962), and Widdowson (1964, 1970).

The sample area size was determined on the basis of a number of trial samples in Nereocystis beds near Striae Islands. It was found that the $\frac{1}{2}m.^2$ quadrat used in the 1972 Queen Charlotte Island Kelp Survey (Jenkins and Britt, 1972) resulted in extremely large standard de-

viations due to the patchy distributions of the kelp plants. Two possible approaches to this problem are: an increase in the number of samples or an increase in sample size. It was found that the greatest cost in time involved in the sampling arose in moving between the samples and in setting up to do the samples. As time was limited, it was decided to increase sample size. This involved a relatively small increase in time allotment per sample site and then to sample intensively, as time allowed. The plot size chosen (circle of five ft. radius) provided relative sample homogeneity, but was just small enough not to provide an unwieldy amount of seaweed.

Accurate estimates of sustained yields of exploitable resource populations require an intimate knowledge of the species population dynamics for the area being considered. It is difficult on the basis of the published literature and/or on the basis of one month of field work, to arrive at any accurate estimate of the sustained yields possible for the kelps in the area.

Nereocystis is essentially an annual plant which does not regenerate after the pneumatocyst or stipe have been severed or damaged (Scagel, 1947). While it is known that the kelp in British Columbia coastal waters actively sporulates from mid-summer until late fall, it is not known whether recruitment is principally from "early" or "late" spores or from some fraction of both. Little or nothing is known of the spore dispersal patterns or range. It is possible that the spores have a very short dispersal range; e.g., only a few meters, as is sometimes the case for isolated Macrocystis plants (Anderson and North, 1965). If this is the

case, it could take four to five years for a large area to recover from harvesting (R. F. Foreman, personal communication). In a case where an area is denuded of its cover of floating kelp, there is a possibility that heavy colonization and growth of submerged flora will take place in the understory, making recolonization by the kelp impossible or very slow.

Conservative harvesting strategy, in view of the dearth of information presently available, would appear to require one or a combination of the following harvest techniques to be employed: (1)postponement of harvesting until late in the summer, (2)harvesting leaving strips uncut at frequent intervals, as recommended by Scagel (1947), or (3) harvesting as in (2), and not harvesting any area more frequently than once every four to five years.

Should technique one be employed, the sustained yield should be approximately equal to the standing crop of any given area (Tables I, II, and III). Harvesting technique (2) should result in a sustained yield equal to the standing crop less the leave strips. Present B. C. regulations provide for a leave strip of about 3%; giving a sustained yield of 97% of the total standing crop in any given area (Plates I, II and III). We feel that this policy may not be particularly effective, andin view of the present lack of information available, we feel that the interval between leave strips might be considerably reduced. In the case of utilizing technique (3), only 20-25% of the standing crop of an area would be made available for exploitation annually, but this technique would apparently offer the least chance of endangereing this resource. In any given area, then, the sustained yield would be 20-25% of the standing crop (Tables I, II and III).

Macrocystis is a perennial plant, at least from the base, and can

regenerate following harvesting provided that the holdfast and growing points are not damaged. Further, the plant should be harvested at a minimum of three to four feet above the holdfast so that the sporophylls are not damaged. It is estimated that this harvest strategy should yield two crops per year (Scagel, 1947).

If at least 80% of the mass of the plant occurs above the four foot limit, this harvesting strategy should yield 80% of the total standing crop at the first harvest, and probably somewhat less at the second; near 70% of the original standing crop. The total sustained yield, then would be 150% of the totals expressed in Table II.

We do feel, however, that these estimates are not well founded, and that much more long term research needs to be done on these plants and their habits before it will be possible to give an accurate estimate of this aspect of kelp harvesting.

Table I

Nereocystis luetkeana Standing Crop

Location	Area ($ft.^2$)	Density ($lb./ft.^2$)	95% Confidence Interval ($lb./ft.^2$)	Standing Crop Tons	Standing Crop Kg.
Yan to Jacob Pt.	15,117,008	1.1886	0.6727-1.7045	8,984.0	8,150,100
Jacob Pt. to Wiah Pt.	15,252,104	1.1886	0.6727-1.7045	9,064.3	8,223,000
Wiah Pt. to Cape Edensaw	15,932,804	0.6534	0.3981-0.9087	5,205.3	4,772,100
Cape Edensaw to Inskip Pt.	12,874,830	3.4257	0.981-0.9087	22,052.7	20,005,700
Mary Pt. to Mazarredo Is.	10,632,692	0.6534	0.3891-0.9087	3,473.7	3,151,300
Mazarredo Is. to Cape Naden	9,594,737	0.6534	0.3981-0.9087	3,134.6	2,843,600
Masset to Skonun Pt.	4,315,276	0.1856	0.1438-0.2274	400.5	363,300
Skonun Pt. to Tow Hill	8,128,839	0.1856	0.1438-0.2274	754.4	684,300
Masset Sound-Ship Island	7,554,082	0.2699	0.0763-0.4635	1,019.5	924,800

Table II

Macrocystis integrifolia Standing Crop

Location	Area ($ft.^2$)	Density ($lb./ft.^2$)	95% Confidence Interval ($lb./ft.^2$)	Standing Crop Tons	Standing Crop Kg.
Jacob Pt. to Wiah Pt.	1,004,919	3.4257	0.5895-6.2618	1,721.3	1,561,500
Cape Edensaw to Inskip Pt.	13,563,481	3.4257	0.5895-6.2618	23,232.2	21,075,800
Masset to Skonun Pt.	49,901,296	1.2481	0.7018-1.7944	31,140.9	28,250,400
Skonun Pt. to Tow Hill	30,962,659	1.2481	0.7018-1.7944	19,322.2	17,528,800

Table III

Submerged Kelps Standing Crop*

Location	Area ($ft.^2$)	Approximate Density ($lb./ft.^2$)	Standing Crop Tons	Standing Crop Kg.
Yan to Jacob Pt.	15,117,000	0.23	1,739	1,579,000
Jacob Pt. to Wiah Pt.	16,257,000	0.15	1,215	1,183,000
Wiah Pt. to Cape Edensaw	15,993,000	0.20	1,544	1,547,000
Cape Edensaw to Inskip Pt.	26,438,000	0.21	2,776	2,521,000
Mary Pt. to Cape Naden	20,227,000	0.16	1,613	1,465,000
Masset Sound-Ship Island	7,554,000	0.10	378	343,000
Masset to Tow Hill	93,308,000	0.10	4,666	4,536,000
Total			13,931	13,174,000

*for species composition see Order Laminariales Table

Table IV

Associated Flora

Species	Masset to Skonun Pt.	Skonun Pt. to [illegible]	Masset Sound -Inlet
Phylum Chlorophycophyta			
Class Chlorophyceae			
Order Ulotricales			
Ulva lactuca	X		X
Enteromorpha linza		X	X
Order Siphonales			
Halicystis ovalis	X	X	
Codium setchellii			
Phylum Rhodophycophyta			
Class Rhodophyceae			
Order Bangiales			
Porphyra sp.	X	X	X
Order Nemalionales			
Bonnemaisonia nootkana	X		
Order Cryptonemiales			
Calliarthron regenerans	X	X	
Gallophyllis flabellulata			
Constantinea subulifera	X	X	X
Grateloupia pinnata	X	X	
Bosiella sp.		X	
Lithothamnion sp.	X	X	X
Corallina vancouveriensis			

Table IV cont'd.

Associated Flora

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Order Gigartinales			
Ahnfeltia plicata	X	X	X
Gigartina exasperata	X	X	X
Iridaea sp.	X	X	X
Opuntiella californica			X
Plocamium sp.	X	X	
Rhodoglossum latissimum			
Order Rhodymeniales			
Halosaccion glandiforme	X		X
Rhodymenia palmata	X	X	X
Rhodymenia pertusa	X	X	
Order Ceramiales			
Hymenena flabelligera			
Myriogramme pulchra		X	
Odonthalia kamschatica			
Odonthalia washingtonensis	X		
Pterosiphonia sp.	X	X	
Phylum Phaeophycophyta			
Class Phaeophyceae			
Order Ectocarpales			
Ectocarpus sp.	X		
Order Desmarestiales			
Desmarestia herbacea	X	X	

Table IV cont'd.

Associated Flora

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Desmarestia intermedia			
Desmarestia media			X
Desmarestia munda	X	X	
Order Laminariales			
Agarum cribrosum	X	X	
Alaria marginata	X	X	
Costaria costata		X	X
Cymathere triplicata		X	X
Egregia menziesii	X	X	
Laminaria groenlandica	X	X	
Laminaria saccharina	X	X	X
Laminaria setchellii			X
Laminaria yezoensis	X	X	X
Macrocystis integrifolia	X	X	
Nereocystis luetkeana		X	X
Pleurophycus gardneri	X	X	
Order Fucales			
Fucus sp.			X
Pelvetiopsis limitata			
Sargassum muticum	X		
Marine Seed Plants			
Zostera marina	X	X	X

Table IV cont'd.

Associated Flora

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Phylum Chlorophycophyta			
Class Chlorophyceae			
Order Ulotricales			
Ulva lactuca	X	X	X
Enteromorpha linza	X	X	X
Order Siphonales			
Halicystis ovalis	X	X	
Codium setchellii	X	X	X
Phylum Rhodophycophyta			
Class Rhodophyceae			
Order Bangiales			
Porphyra sp.	X	X	X
Order Nemalionales			
Bonnemaisonia nootkana	X		
Order Cryptonemiales			
Calliarthron regenerans	X	X	X
Callophyllis flabellulata			
Constantinea subulifera			
Grateloupia pinnata			
Bosiella sp.	X		X
Lithothamnion sp.	X	X	X
Corallina vancouveriensis	X	X	X

Table IV cont'd.

Associated Flora

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Order Gigartinales			
Ahnfeltia plicata	X	X	X
Gigartina exasperata			
Iridaea sp.	X	X	X
Opuntiella californica	X	X	X
Plocamium sp.			
Rhodoglossum latissimum	X		
Order Rhodymeniales			
Halosaccion glandiforme			
Rhodymenia palmata	X	X	X
Rhodymenia pertusa	X		X
Order Ceramiales			
Hymenena flabelligera	X		
Myriogramme pulchra	X		
Odonthalia kamschatica	X		
Odonthalia washingtonensis			
Pterosiphonia sp.			
Phylum Phaeophycophyta			
Class Phaeophyceae			
Order Ectocarpales			
Ectocarpus sp.		X	
Order Desmarestiales			
Desmarestia herbacea			X

Table IV cont'd.

Associated Flora

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Desmarestia intermedia		X	
Desmarestia media	X	X	X
Desmarestia munda			
Order Laminariales			
Agarum cribrosum		X	X
Alaria marginata			X
Costaria costata	X	X	X
Cymathere triplicata	X	X	X
Egregia menziesii	X	X	
Laminaria groenlandica	X	X	X
Laminaria saccharina	X	X	X
Laminaria setchellii	X	X	
Laminaria yezoensis	X	X	
Macrocystis integrifolia	X	X	
Nereocystis luetkeana	X	X	X
Pleurophycus gardneri		X	X
Order Fucales			
Fucus sp.	X		
Pelvetiopsis limitata			
Sargassum muticum			
Marine Seed Plants			
Zostera marina			

Table IV cont'd.

Associated Flora

Species	Cape Edensaw to Inskip Pt.	Mary Pt. to Cape Naden
Phylum Chlorophycophyta		
Class Chlorophyceae		
Order Ulotricales		
Ulva lactuca	X	
Enteromorpha linza	X	X
Order Siphonales		
Halicystis ovalis		X
Codium setchellii	X	X
Phylum Rhodophycophyta		
Class Rhodophyceae		
Order Bangiales		
Porphyra sp.		X
Order Nemalionales		
Bonnemaisonia nootkana	X	
Order Cryptonemiales		
Calliarthron regenerans	X	X
Callophyllis flabellulata	X	X
Constantinea subulifera		
Grateloupia pinnata		X
Bosiella sp.	X	X
Lithothamnion sp.	X	X
Corallina vancouveriensis		X

Table IV cont'd.

Associated Flora

Species	Cape Edensaw to Inskip Pt.	Mary Pt. to Cape Naden
Desmarestia intermedia	X	X
Desmarestia media		
Desmarestia munda		
Order Laminariales		
Agarum cribrosum		
Alaria marginata		
Costaria costata	X	X
Cymathere triplicata	X	X
Egregia menziesii		
Laminaria groenlandica	X	X
Laminaria saccharina	X	X
Laminaria setchellii	X	X
Laminaria yezoensis	X	X
Macrocystis integrifolia	X	
Nereocystis luetkeana	X	X
Pleurophycus gardneri		
Order Fucales		
Fucus sp.		X
Pelvetiopsis limitata	X	
Sargassum muticum		
Marine Seed Plants		
Zostera marina	X	X

Table V

Associated Fauna

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Phylum Coelenterata			
Class Hydrozoa			
Order Chondrophora			
Velella velella	X	X	
Class Scyphozoa			
Order Semaeostomeae			
Chrysaora isoceles			
Cyanea capillata	X		
Aequoria aequoria		X	
Metridium sp.			
Phylum Ctenophora			
Class Tentaculata			
Pleurobrachia pileus			
Phylum Bryozoa			
Membranipora membranacea	X	X	X
Phylum Annelida			
Class Polychaeta			
Eudistylia vancouveri	X	X	
Phylum Arthropoda			
Class Crustacea			

Table V cont'd.

Associated Fauna

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Order Thoracica			
Balanus nubilis	X	X	
Class Malacostraca			
Order Decapoda			
Pandalus danae	X		
Caprella sp.	X	X	X
Cancer productus			X
Cancer magister			
Pugettia producta		X	
Scyra sp.	X	X	
Lopholithodes mandtii			
Thais sp.		X	X
Phylum Mollusca			
Class Amphineura			
Cryptochiton stelleri		X	X
Mopalia muscosa	X	X	X
Tonicella lineata	X	X	X
Class Gastropoda			
Order Archaeogastropoda			
Acmaea mitra	X		X
Acmaea sp.	X	X	X
Calliostoma annulatum	X	X	

Table V cont'd.

Associated Fauna

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Diodora aspera	X	X	
Haliotis kamschatkana			
Tegula sp.	X	X	X
Order Neogastropoda			
Ceratostoma foliata	X	X	
Fusitriton oregonensis			
Order Nudibranchia			
Anisodoris nobilis			
Cadlina sp.			
Diaulula sandiegensis			
Dirona albolineata	X		
Hermissenda opalescens	X		X
Triopha carpenteri			
Class Pelecypoda			
Order Filibranchia			
Pododesmus macroschisma			
Entodesma saxicola	X		
Hinnites multirugosus	X		
Class Cephalopoda			
Octopus dofleini		X	
Phylum Echinoderma			
Class Asteroidea			

Table V cont'd.

Associated Fauna

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Dermasterias imbricata		X	X
Evasterias troscheli		X	X
Henricia leviuscula	X	X	X
Leptasterias hexactis		X	X
Mediaster aequalis			
Pisaster brevispinus			
Pisaster ochraceous			
Pteraster tessalatus			
Pycnopodia helianthoides	X	X	X
Solaster dawsoni	X	X	X
Class Ophiuroidea			
Ohiopholis aculeata	X	X	
Class Echinoidea			
Strongylocentrotus drobachiensis	X	X	
Strongylocentrotus franciscanus		X	
Strongylocentrotus purpuratus		X	
Class Holothuroidea			
Cucumaria sp.			
Eupentacta pseudoquinquesemita		X	X
Psolus chitonoides			
Stichopus californicus			X

Table V cont'd.

Associated Fauna

Species	Masset to Skonun Pt.	Skonun Pt. to Tow Hill	Masset Sound -Inlet
Phylum Chordata			
Subphylum Urochordata			
Perophora viridis	X	X	
Subphylum Craniata			
Class Pisces			
Onchorhynchus kisutch	X		
Ophiodon elongatus			
Oxylebius pictus			
Sebastodes melanops			
Family Hexagrammidae	X	X	X
Pholis laeta			
Family Pholidae			
Class Mammalia			
Phoca vitulina			
Eumetopias jubata	X		

Table V cont'd.

Associated Fauna

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Phylum Coelenterata			
Class Hydrozoa			
Order Chondrophora			
Velella velella	X	X	X
Class Scyphozoa			
Order Semaeostomeae			
Chrysaora isoceles	X		
Cyanea capillata	X	X	
Aequoria aequoria	X	X	
Metridium sp.		X	
Phylum Ctenophora			
Class Tentaculata			
Pleurobrachia pileus	X	X	
Phylum Bryozoa			
Membranipora membranacea	X	X	X
Phylum Annelida			
Class Polychaeta			
Eudistylia vancouveri	X		
Phylum Arthropoda			
Class Crustacea			

Table V cont'd.

Associated Fauna

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Order Thoracica			
Balanus nubilis	X		
Class Malacostraca			
Order Decapoda			
Pandalus danae	X		X
Caprella sp.	X	X	X
Cancer productus	X		
Cancer magister		X	X
Pugettia producta		X	X
Scyra sp.	X	X	X
Lopholithodes mandtii	X		
Thais sp.	X	X	
Phylum Mollusca			
Class Amphineura			
Cryptochiton stelleri	X		X
Mopalia muscosa	X	X	X
Tonicella lineata	X	X	X
Class Gastropoda			
Order Archaeogastropoda			
Acmaea mitra	X	X	X
Acmaea sp.	X	X	X
Calliostoma annulatum	X	X	X

Table V cont'd.

Associated Fauna

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Diodora aspera	X	X	X
Haliotis kamschatkana	X	X	X
Tegula sp.	X	X	X
Order Neogastropoda			
Ceratostoma foliata	X		
Fusitriton oregonensis			
Order Nudibranchia			
Anisodoris nobilis			X
Cadlina sp.	X	X	X
Diaulula sandiegensis	X	X	X
Dirona albolineata	X	X	
Hermissenda opalescens	X	X	
Triopha carpenteri	X	X	X
Class Pelecypoda			
Order Filibranchia			
Pododesmus macroschisma			
Entodesma saxicola			
Hinnites multirugosus			
Class Cephalopoda			
Octopus dofleini			
Phylum Echinoderma			
Class Asteroidea			

Table V cont'd.

Associated Fauna

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Dermasterias imbricata	X		X
Evasterias troscheli	X		X
Henricia leviuscula	X	X	X
Leptasterias hexactis	X		X
Mediaster aequalis			
Pisaster brevispinus			X
Pisaster ochraceous	X		X
Pteraster tessalatus			
Pycnopodia helianthoides	X	X	X
Solaster dawsoni		X	X
Class Ophiuroidea			
Ophiopholis aculeata	X	X	X
Class Echinoidea			
Strongylocentrotus drobachiensis	X	X	X
Strongylocentrotus franciscanus	X	X	X
Strongylocentrotus purpuratus	X	X	X
Class Holothuroidea			
Cucumaria sp.	X		
Eupentacta pseudoquinquesemita	X		
Psolus chitonoides	X		
Stichopus californicus	X	X	

Table V cont'd.

Associated Fauna

Species	Yan to Jacob Pt.	Jacob Pt. to Wiah Pt.	Wiah Pt. to Cape Edensaw
Phylum Chordata			
Subphylum Urochordata			
Perophora viridis		X	
Subphylum Craniata			
Class Pisces			
Onchorhynchus kisutch			
Ophiodon elongatus		X	
Oxylebius pictus	X	X	X
Sebastodes melanops	X	X	X
Family Hexagrammidae	X	X	X
Pholis laeta			X
Family Pholidae	X	X	X
Class Mammalia			
Phoca vitulina	X		
Eumetopias jubata			

Table V cont'd.

Associated Fauna

Species	Cape Edenshaw to Ins[illegible] Pt.	[illegible] Pt. to Cape Naden
Phylum Coelenterata		
Class Hydrozoa		
Order Chondrophora		
Velella velella	X	X
Class Scyphozoa		
Order Semaeostomeae		
Chrysaora isoceles		
Cyanea capillata	X	X
Aequoria aequoria	X	X
Metridium sp.	X	X
Phylum Ctenophora		
Class Tentaculata		
Pleurobrachia pileus	X	X
Phylum Bryozoa		
Membranipora membranacea	X	X
Phylum Annelida		
Class Polychaeta		
Eudistylia vancouveri	X	
Phylum Arthropoda		
Class Crustacea		

Table V cont'd.

Associated Fauna

Species	Cape Edensaw to Inskip Pt.	Mary Pt. to Cape Naden
Order Thoracica		
Balanus nubilis		
Class Malacostraca		
Order Decapoda		
Pandalus danae	X	X
Caprella sp.	X	X
Cancer productus	X	X
Cancer magister	X	
Pugettia producta	X	X
Scyra sp.	X	X
Lopholithodes mandtii		
Thais sp.	X	X
Phylum Mollusca		
Class Amphineura		
Cryptochiton stelleri	X	X
Mopalia muscosa	X	X
Tonicella lineata	X	X
Class Gastropoda		
Order Archaeogastropoda		
Acmaea mitra	X	X
Acmaea sp.		X
Calliostoma annulatum	X	X

Table V cont'd.

Associated Fauna

Species	Cape Edensaw to Inskip Pt.	Mary Pt. to Cape Naden
Diodora aspera	X	X
Haliotis kamschatkana	X	X
Tegula sp.	X	X
Order Neogastropoda		
Ceratostoma foliata	X	
Fusitriton oregonensis		
Order Nudibranchia		
Anisodoris nobilis		X
Cadlina sp.		X
Diaulula sandiegensis		
Dirona albolineata		X
Hermissenda opalescens		
Triopha carpenteri	X	X
Class Pelecypoda		
Order Filibranchia		
Pododesmus macroschisma	X	
Entodesma saxicola		
Hinnites multirugosus		
Class Cephalopoda		
Octopus dofleini	X	
Phylum Echinoderma		
Class Asteroidea		

Table V cont'd.

Associated Fauna

Species	Cape Edensaw to Inskip Pt.	[illegible] Pt. to Naden
Dermasterias imbricata		X
Evasterias troscheli	X	X
Henricia leviuscula	X	X
Leptasterias hexactis	X	X
Mediaster aequalis	X	
Pisaster brevispinus	X	
Pisaster ochraceous	X	X
Pteraster tessalatus	X	
Pycnopodia helianthoides	X	X
Solaster dawsoni	X	X
Class Ophiuroidea		
Ophiopholis aculeata	X	X
Class Echinoidea		
Strongylocentrotus drobachiensis	X	X
Strongylocentrotus franciscanus	X	X
Strongylocentrotus purpuratus	X	X
Class Holothuroidea		
Cucumaria sp.	X	
Eupentacta pseudoquinquesemita	X	
Psolus chitonoides		
Stichopus californicus	X	X

Table V cont'd.

Associated Fauna

Species	Cape Edensaw to Inskip Pt.	Mary Pt. to Cape Naden
Phylum Chordata		
Subphylum Urochordata		
Perophora viridis		
Subphylum Craniata		
Class Pisces		
Onchorhynchus kisutch		
Ophiodon elongatus		X
Oxylebius pictus	X	X
Sebastodes melanops		
Family Hexagrammidae		X
Pholis laeta	X	
Family Pholidae	X	X
Class Mammalia		
Phoca vitulina		
Eumetopias jubata		

Table V I

Abalone Population

Location	Area ($ft.^2$)	Density (no. per $ft.^2$)	Population
Yan to Jacob Pt.	15,117,008	0.0165	249,000
Jacob Pt. to Inskip Pt.	44,069,738	0.0035	154,000
Mary Point to Cape Naden	20,227,429	0.0664	1,343,000
Masset to Tow Hill			none
Masset Sound-Ship Island			none
Total			1,747,000

Table VII

Strongylocentrotus drobachiensis Population

Location	Area ($ft.^2$)	Density (no. per $ft.^2$)	Population
Yan to Jacob Pt.	15,117,008	0.0639	966,000
Jacob Pt. to Inskip Pt.	56,628,138	0.0082	464,000
Mary Pt. to Cape Naden	20,227,429	0.0254	514,000
Masset to Tow Hill	93,308,070	0.0020	187,000
Masset Sound-Ship Island			none
Total			2,131,000

Table VIII

Strongylocentrotus franciscanus Population

Location	Area ($ft.^2$)	Density (no. per $ft.^2$)	Population
Yan to Jacob Pt.	15,117,008	0.0928	1,402,900
Jacob Pt. to Cape Edensaw	32,189,827	0.3685	11,862,000
Cape Edensaw to Inskip Pt.	26,438,311	0.03398	898,400
Mary Pt. to Cape Naden	20,227,429	0.0503	1,017,400
Masset to Tow Hill	93,308,070	0.0085	793,100
Total			15,973,700

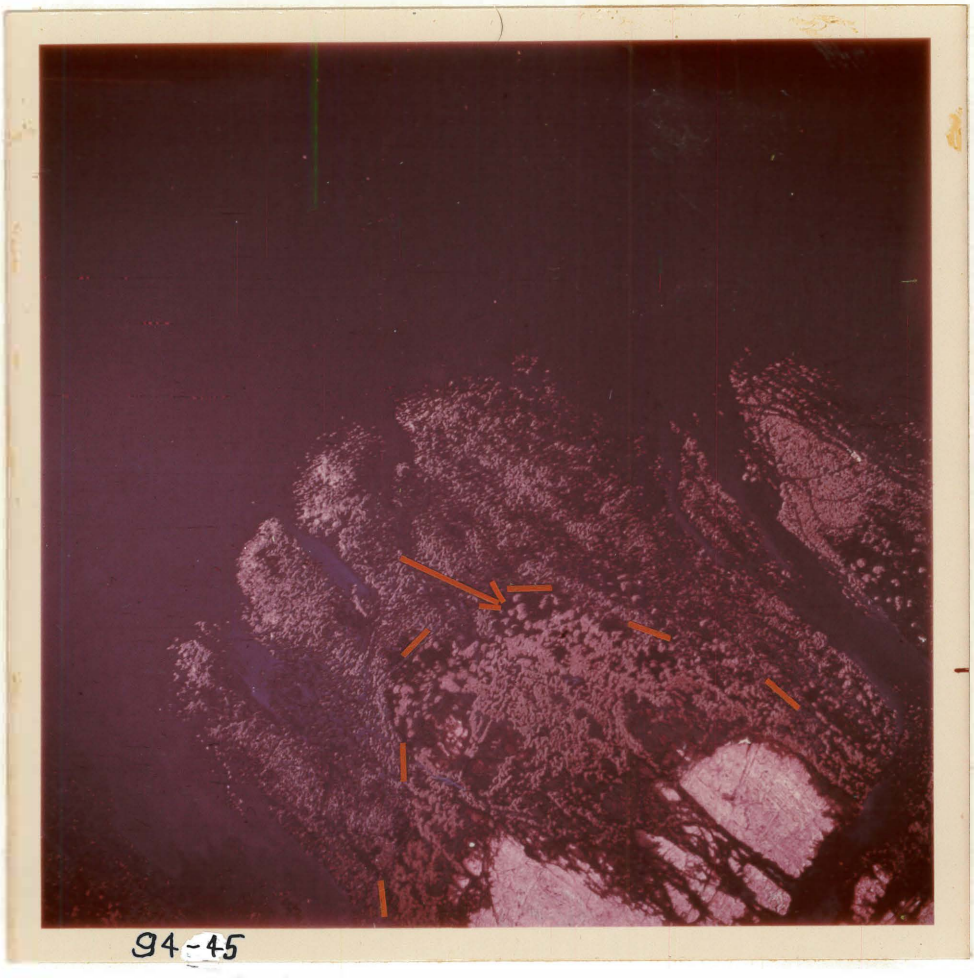
Plates I-IV

Macrocystis and Nereocystis beds in the region of Hidden Island. Plates I and II are small scale (1:22,000) and were taken from approximately 7,000 ft. Plate I was photographed on Kodak 2447 infrared false colour reversal film using a Wratten #12 filter, shutter speed 1/1,000 sec., f/2. Plate II was photographed on Kodak 2448 true colour reversal film using a Skylight filter, shutter speed 1/1,000 sec., f/2. Plates III and IV are large scale (1:2,200) and were taken from approximately 700 ft. Photographic parameters: Plate III as per Plate I and Plate IV as per Plate II.

Both kelp types are readily detectable on even the small scale photographs of either type (Plates I and II). It is difficult to distinguish between the kelp types on the true colour print (Plate II) in which both kelps appear as light brown areas, but a slight difference in texture is discernible, Macrocystis being more dense and of a coarser texture. On the false colour print (Plate I) the great contrast between the red kelp and the blue water makes the kelp much easier to detect. The slight difference in hue and intensity between the two types of kelp, the Nereocystis appearing slightly bluish and the Macrocystis being slightly more reddish, facilitates distinguishing between them. The brightness of the Macrocystis is also slightly greater.

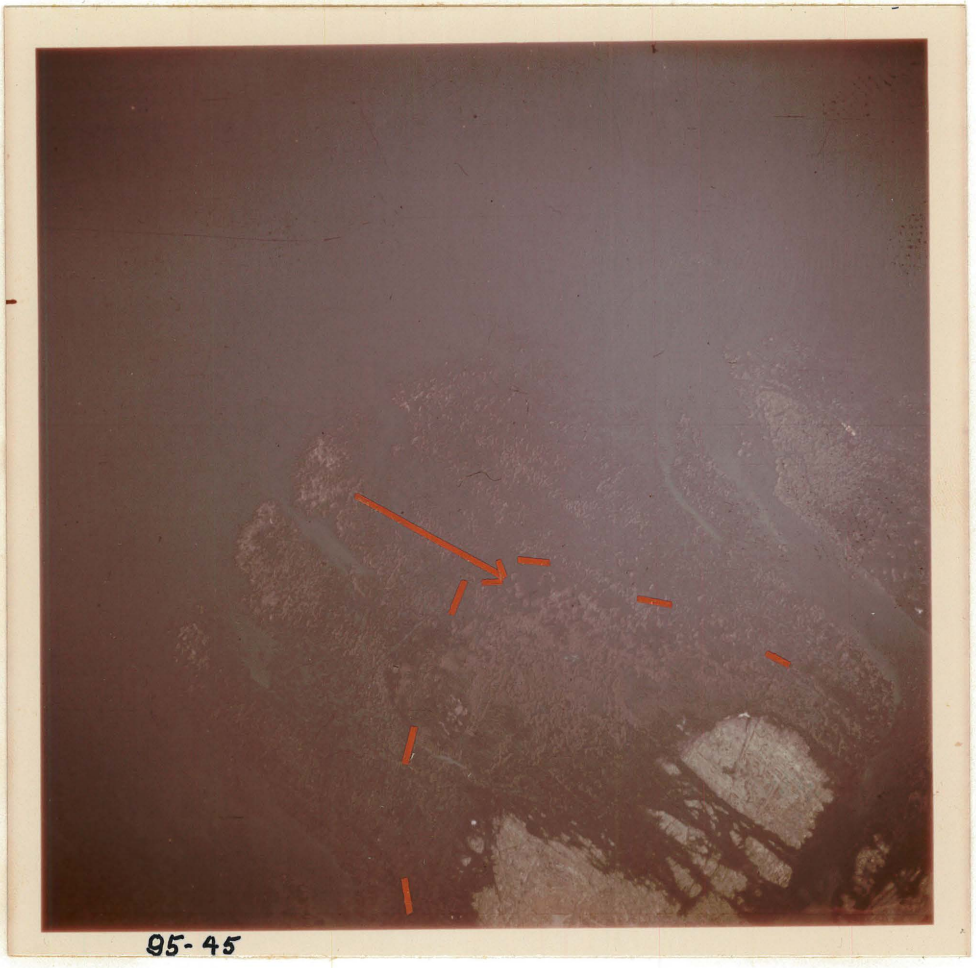
The large scale photographs permit both ready detection of and facile discrimination between the two types of kelp (Plates III and IV). Macrocystis appears as large dense clumps in contrast to Nereocystis which appears as much smaller aggregations (Plate III). The differences in hue and intensity are also more marked at this scale.

Plate I



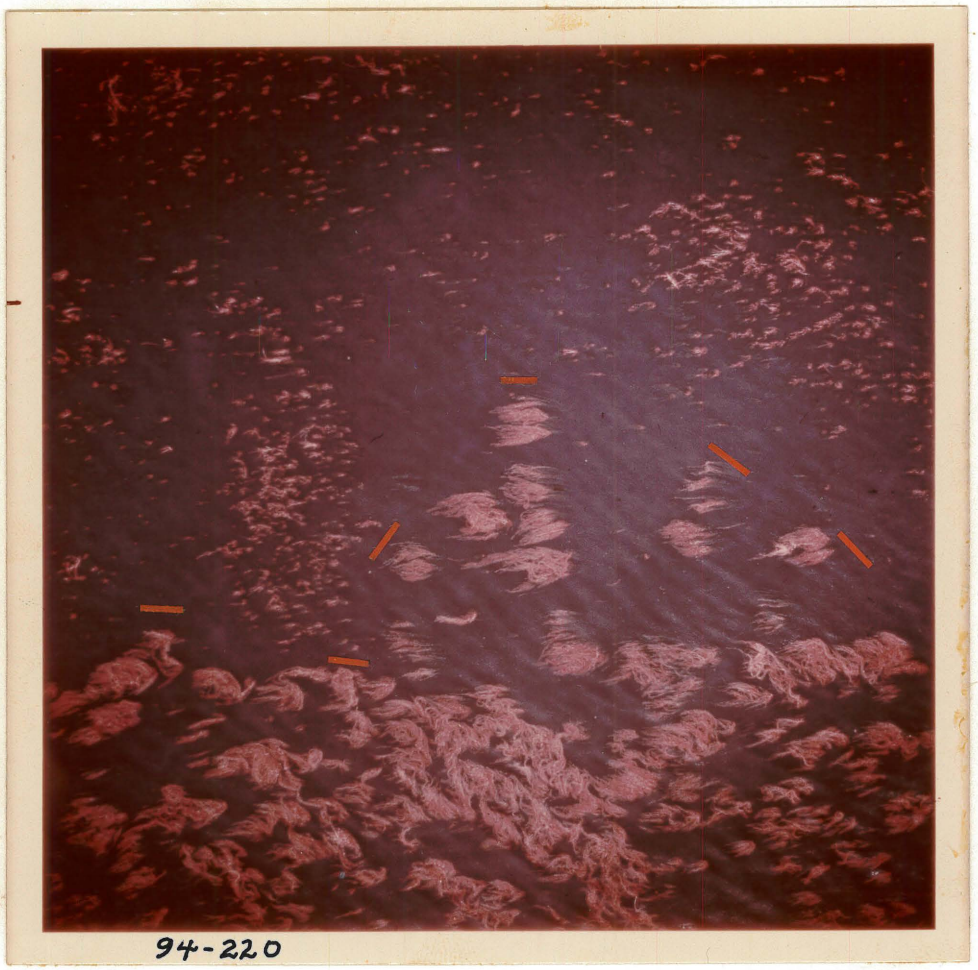
Macrocystis and Nereocystis beds in the region north-east of Hidden Island. Print enlarged 2X from 70 mm. false colour transparency (frame no. 94-45, see Chart 1) taken from approximately 7,000 ft. Print scale is approximately 1:22,000. The Nereocystis bed is seaward of the Macrocystis bed. The border is indicated by orange tape. The arrow indicates the photocentre of Plates III and IV.

Plate II



Macrocystis and Nereocystis beds in the region north-east of Hidden Island. Print enlarged 2X from 70 mm. true colour transparency (frame no. 95-45, see Chart 1) taken from approximately 7,000 ft. Print scale approximately 1:22,000. Kelp beds as in Plate I.

Plate III

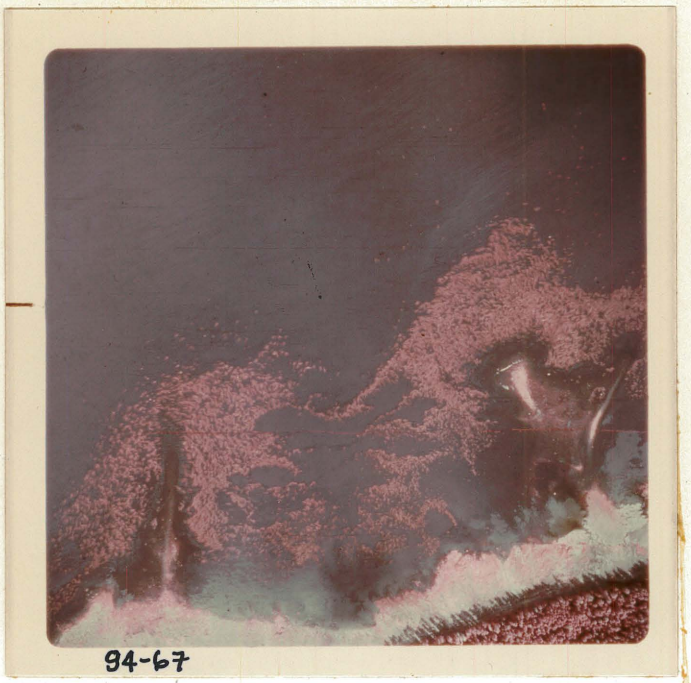


Macrocystis and Nereocystis beds in the region north-east of Hidden Island. Print enlarged 2X from 70 mm. false colour transparency (frame no. 94-220, exact location shown on airborne traverse Plot 1; photo-centre of Plate III is indicated by the arrow in Plate I). Print scale approximately 1:2,200. The Nereocystis is seaward (top of Plate) of the Macrocystis. The border is indicated by the orange tape. The photograph was taken from about 700 ft.

Plate IV

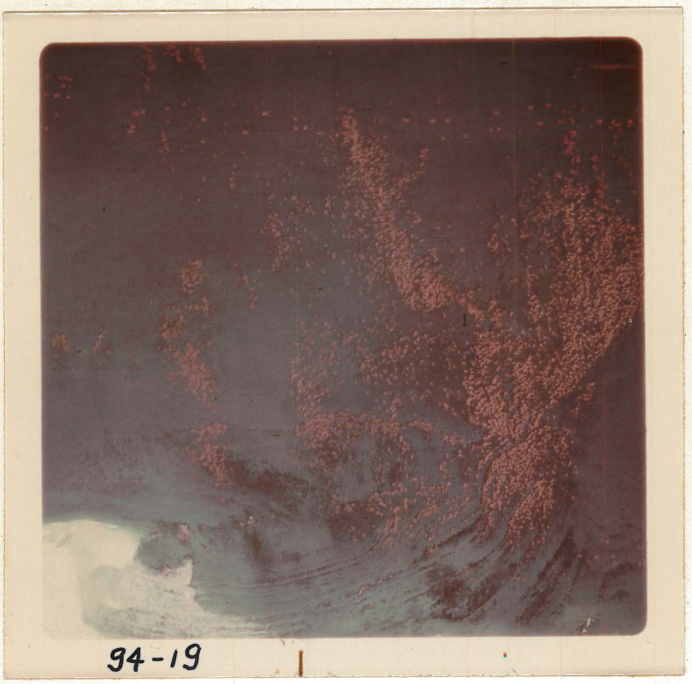
Macrocystis and Nereocystis beds in the region north-east of Hidden Island. Print enlarged 2X from 70 mm. true colour transparency (frame no. 95-220, exact location is shown on airborne traverse Plot 1; photo-centre of Plate IV is indicated by the arrow in Plate I). Print scale approximately 1:2,200. The Nereocystis is seaward (top of Plate) of the Macrocystis. The border is indicated by orange tape. The photograph was taken from about 700 ft.

Plate V



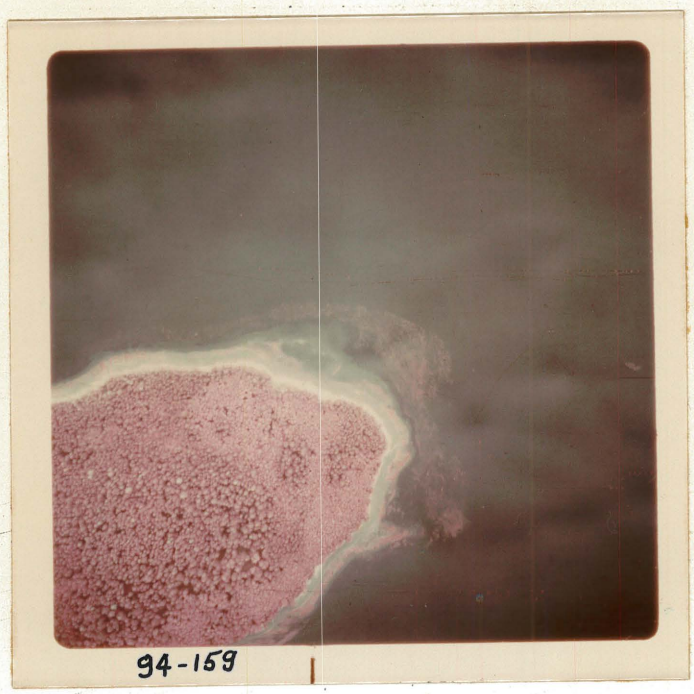
Macrocystis in the region of Inskip Pt. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 7,000 ft. (frame 94-67, see Chart 1 for location). Print scale approximately 1:33,000. The density of Macrocystis in this region is 3.4 lb./ft.^{2}.

Plate VI



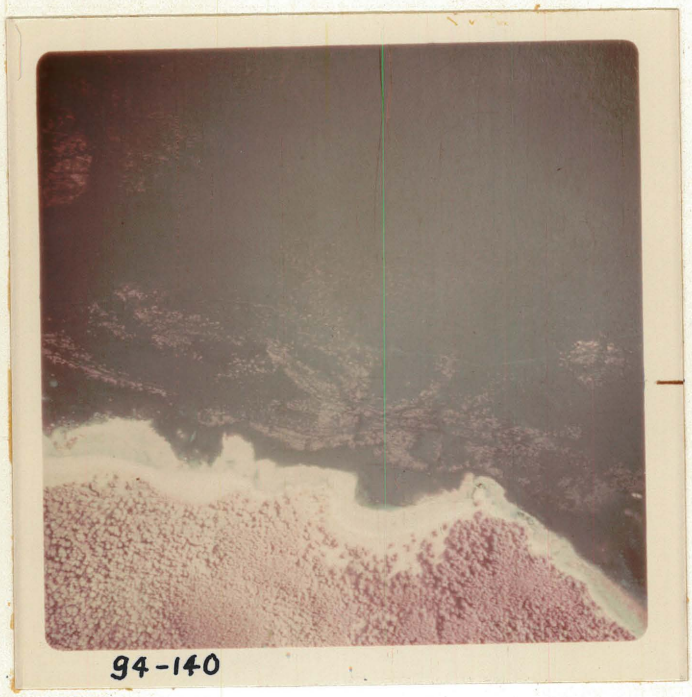
Macrocystis in the region of Skonun Pt. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 7,000 ft. (frame no. 94-19, see Chart 2 for location). Print scale approximately 1:33,000. The density of Macrocystis in this region is 1.2481 lb./ft.^{2}.

Plate VII



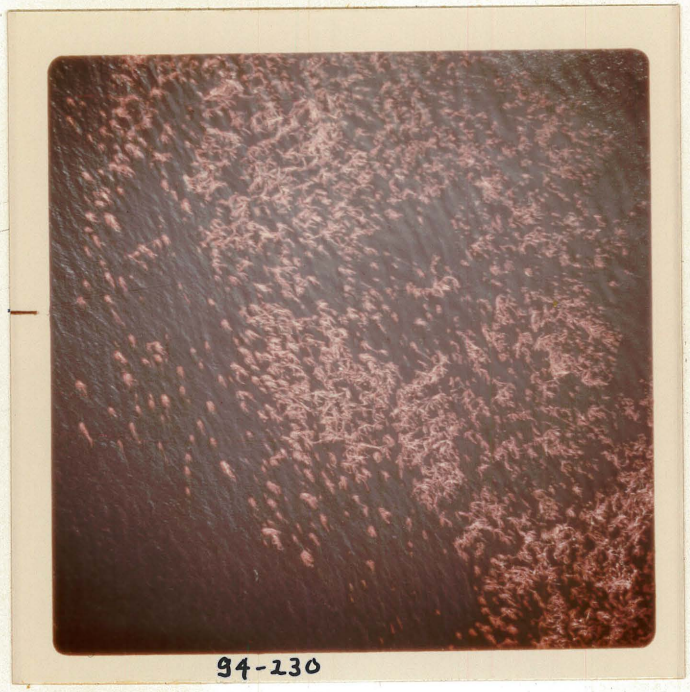
Nereocystis in the region of Ship Island. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 7,000 ft. (frame #94-159, see Chart 3 for location). Print scale approximately 1:33,000. The density of the Nereocystis in this area is 0.27 lb./ft.^{2}.

Plate VIII



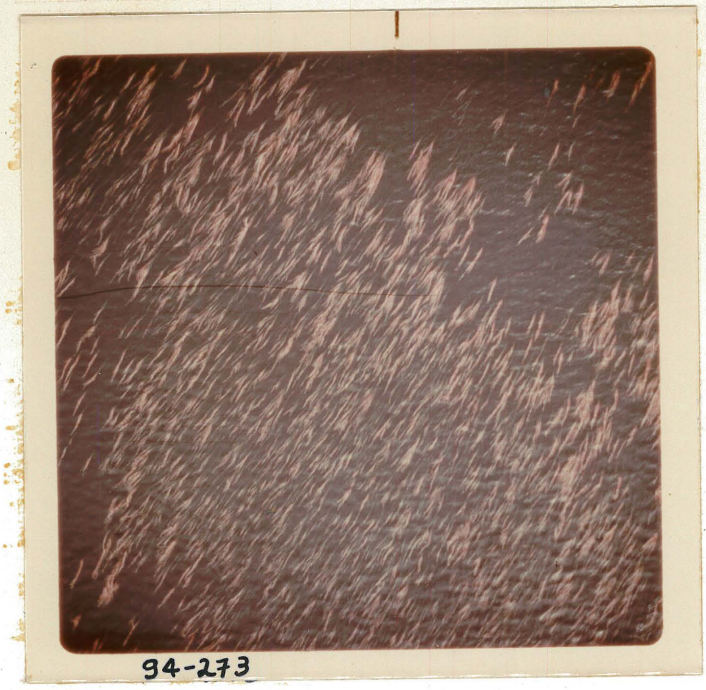
Nereocystis in the vicinity of Yan. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 7,000 ft. (frame no. 94-140, see Chart 1 for location). Print scale approximately 1:33,000. The density of the Nereocystis in this area is 1.19 lb./ft.^{2}.

Plate IX



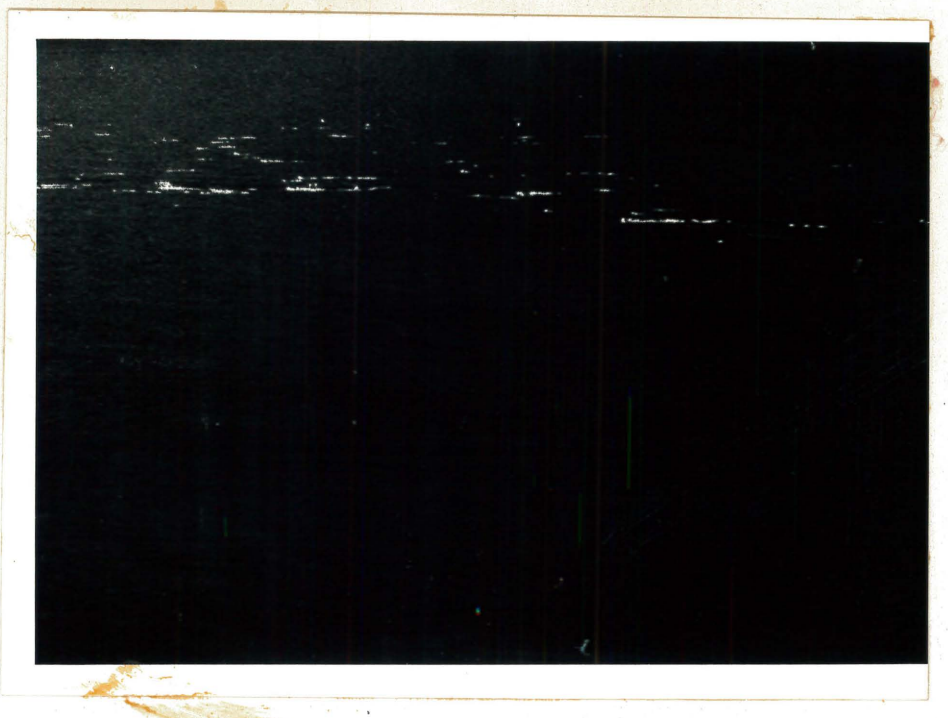
Nereocystis in the vicinity of Refuge Island. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 700 ft. (frame 94-230, see airborne traverse Plot 1 for location). Print scale approximately 1: 3,300. The density of the Nereocystis in this area is 1.19 lb./ft.^{2}.

Plates X and XI



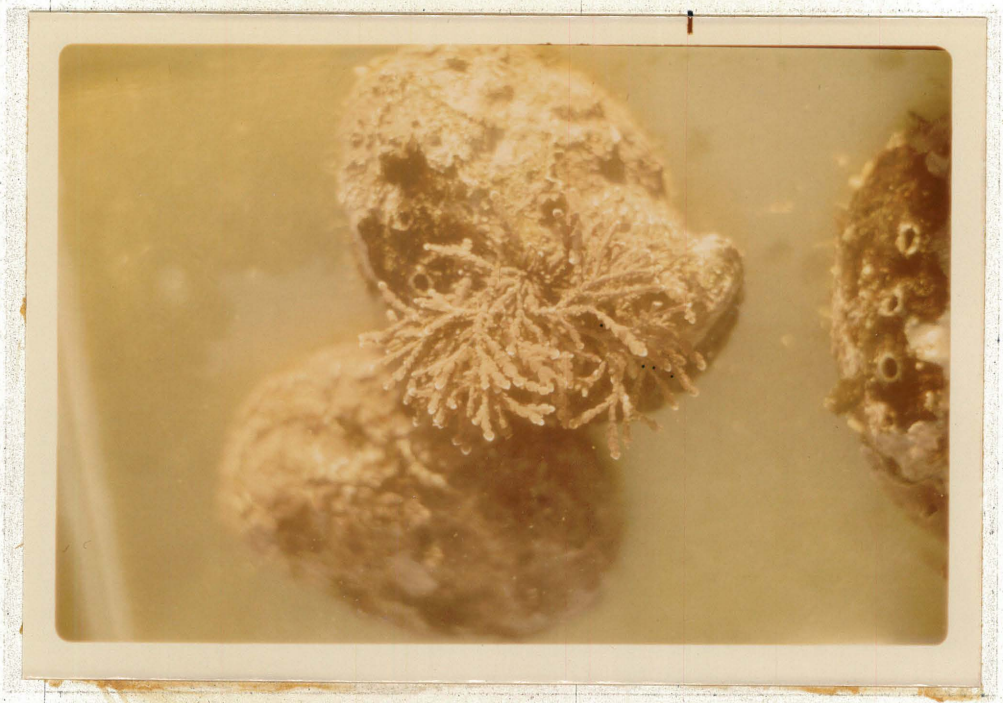
Nereocystis between Entry Pt. and Skonun Pt. Print enlarged approximately 1.5X from 70 mm. false colour transparency taken from approximately 700 ft. (frames 94-273, -308, see airborne traverse Plot 2 for location). Print scale approximately 1:3,300. The density of the Nereocystis in this area is 0.19 lb./ft.^{2}.

Plates XII and XIII



Nereocystis beds near Cape Edensaw. Photographs taken from survey vessel. Plate XII is on high speed Ektachrome, Plate XIII is on high speed Black-and-White Infrared film. Both photographs taken with Pentax S V camera.

Plate XIV



Corallina vancouveriensis growing epiphytically on Haliotis kamschatkana; specimens collected in the vicinity of Hussan Bay near Naden Harbour.

Plate XV

Strongylocentrotus franciscanus and *Balanus nubilis* in the vicinity of Striae Islands, in *Nereocystis* bed.

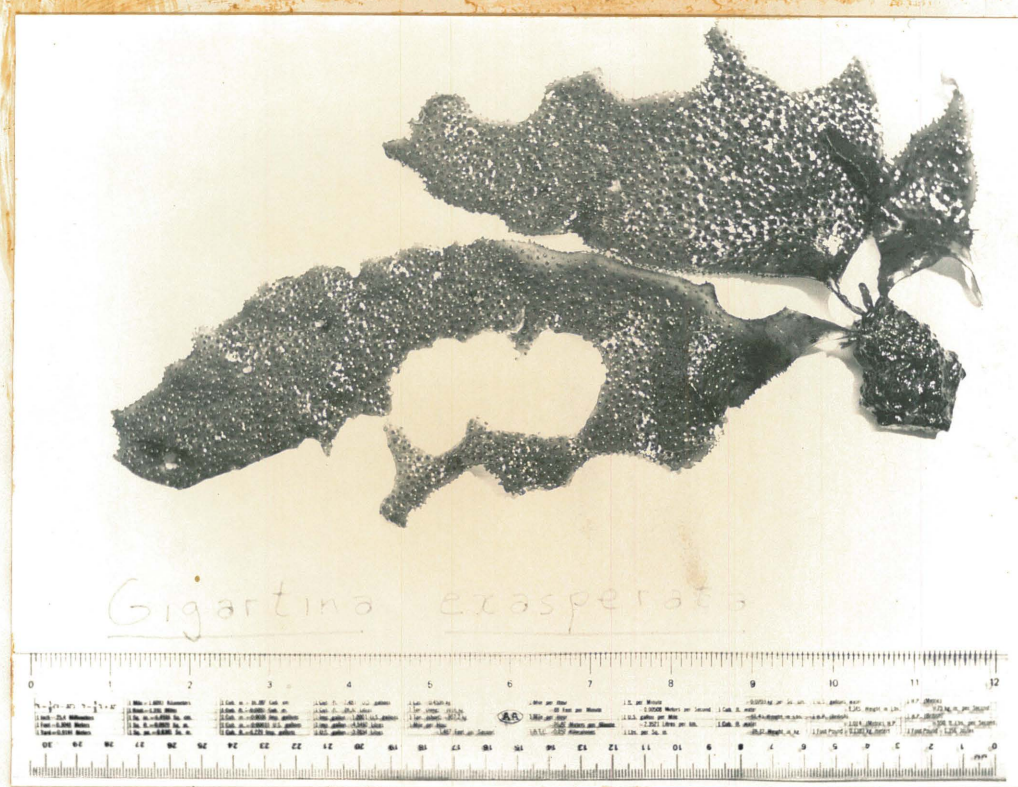
Plate XVI

Laminaria saccharina, *Zostera marina*, and *Eudistylia vancouveri* near Skonun Pt. east of Masset. Photograph taken underwater with Nikonos camera.

Plate XVII

Strongylocentrotus drobachiensis and Metridium sp. near Refuge Island.

Plate XVIII

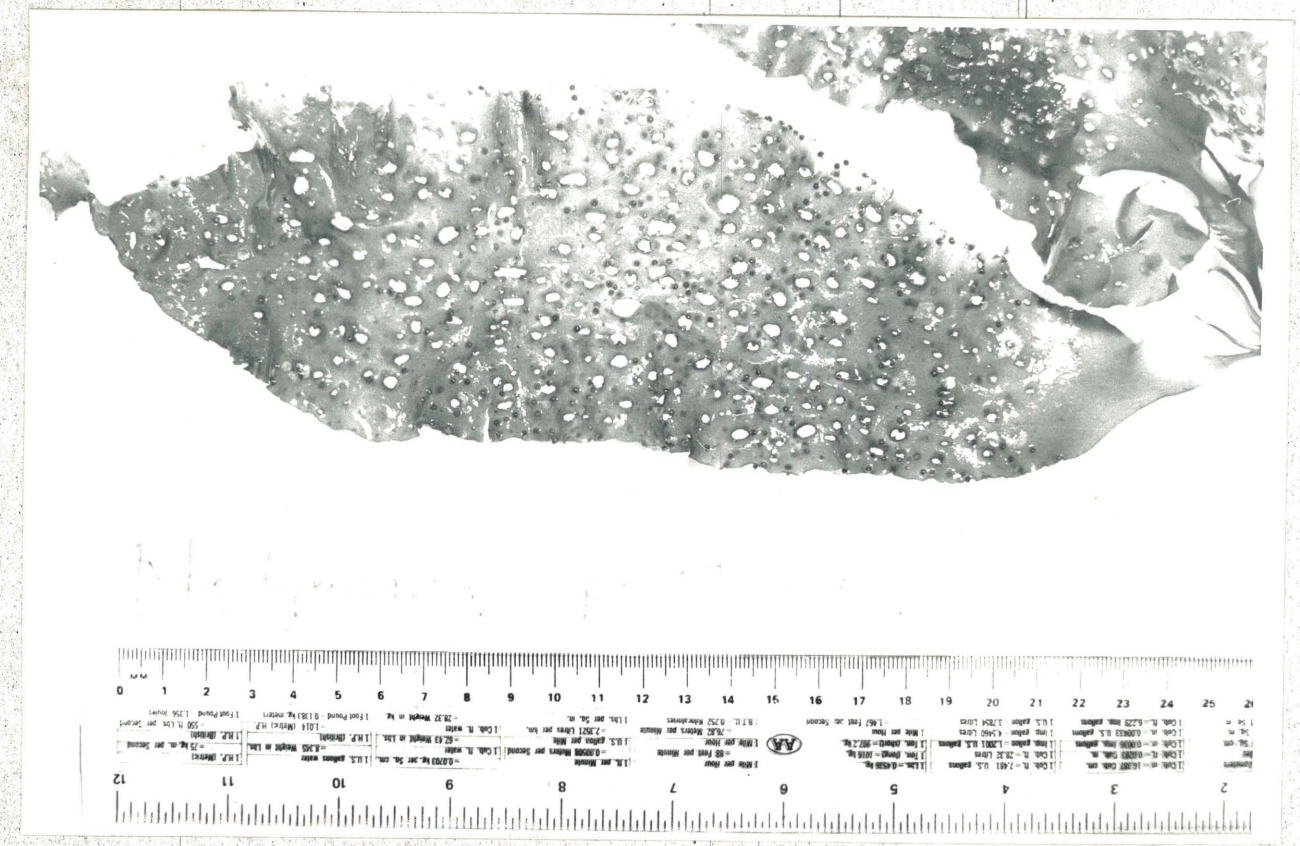


Photograph of Gigartina exasperata collected near Ship Island. Photograph taken on Tri-X black-and-white film with Pentax S V camera.

Plate XIX

Photograph of specimen of Rhodymenia pertusa collected near Yakan Pt. east of Masset. Photographed on Tri-X with Pentax S V camera.

Plate XX



Close up photograph of Rhodymenia pertusa collected near Yakan Pt. See Plate XIX. This species was frequently encountered from Masset to Tow Hill.

Plate XXI

Photograph of Pterosiphonia sp. collected near Skonun Pt. east of Masset.

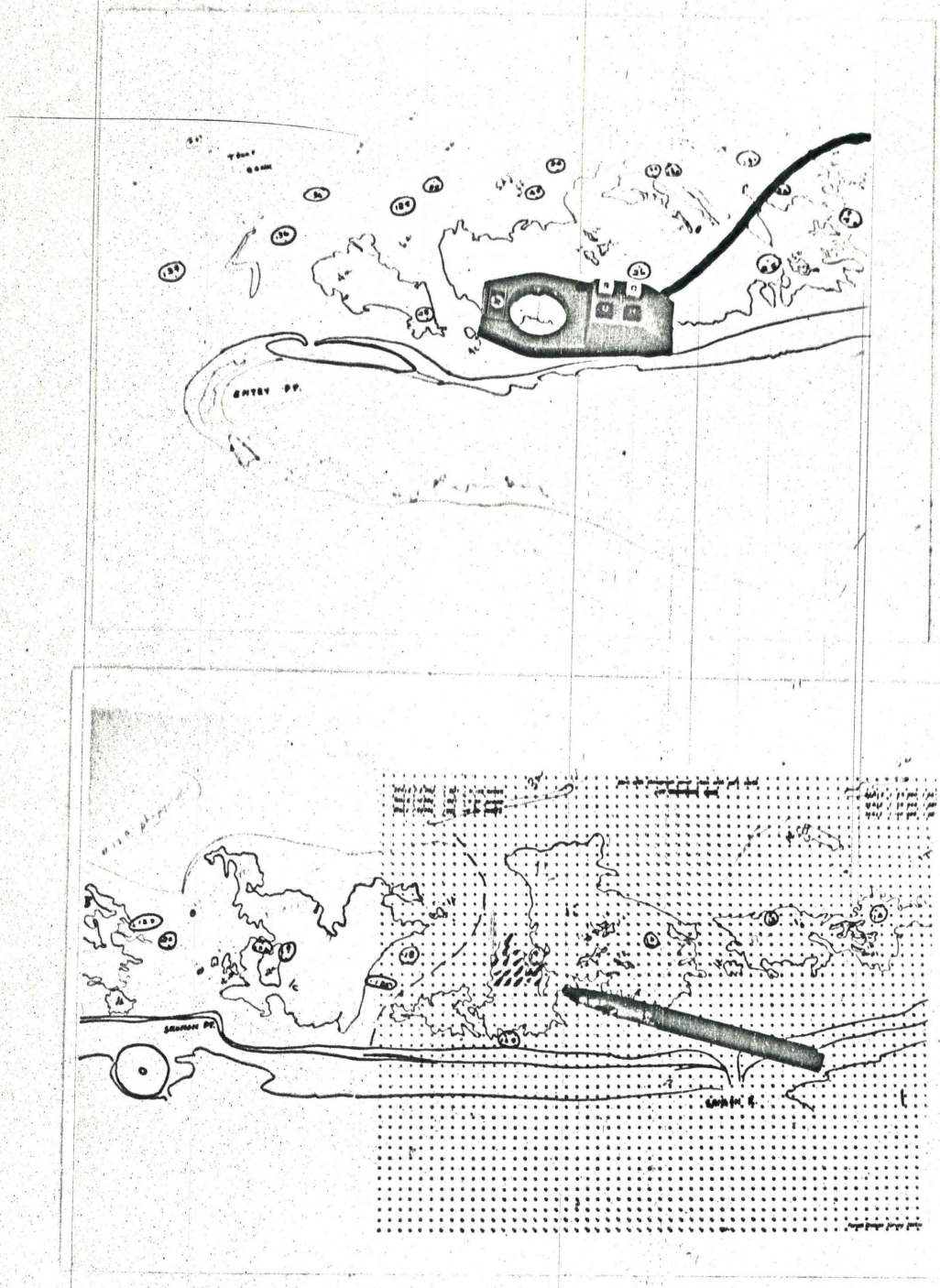
Plate XXII

Placing markers on beach at Entry Point, near Masset.

Plate XXIII

Plotting kelp beds.

Plates XXIV and XXV



Determining bed areas by use of the digitizer (Plate XXIV) and by use of the dot grid (Plate XXV).

Plate XXVI

Calculating density confidence intervals and kelp bed areas on digitizer-computer system at Fisheries Service Office.

Plate XXVII

Masset kelp plant. Print enlarged approximately 3X from true colour aerial photograph taken from approximately 7,000 ft.

YAN POINT TO WIAH POINT VERT ROLLS 94(COLOUR IR), 95(COLOUR); EXP. 178-236

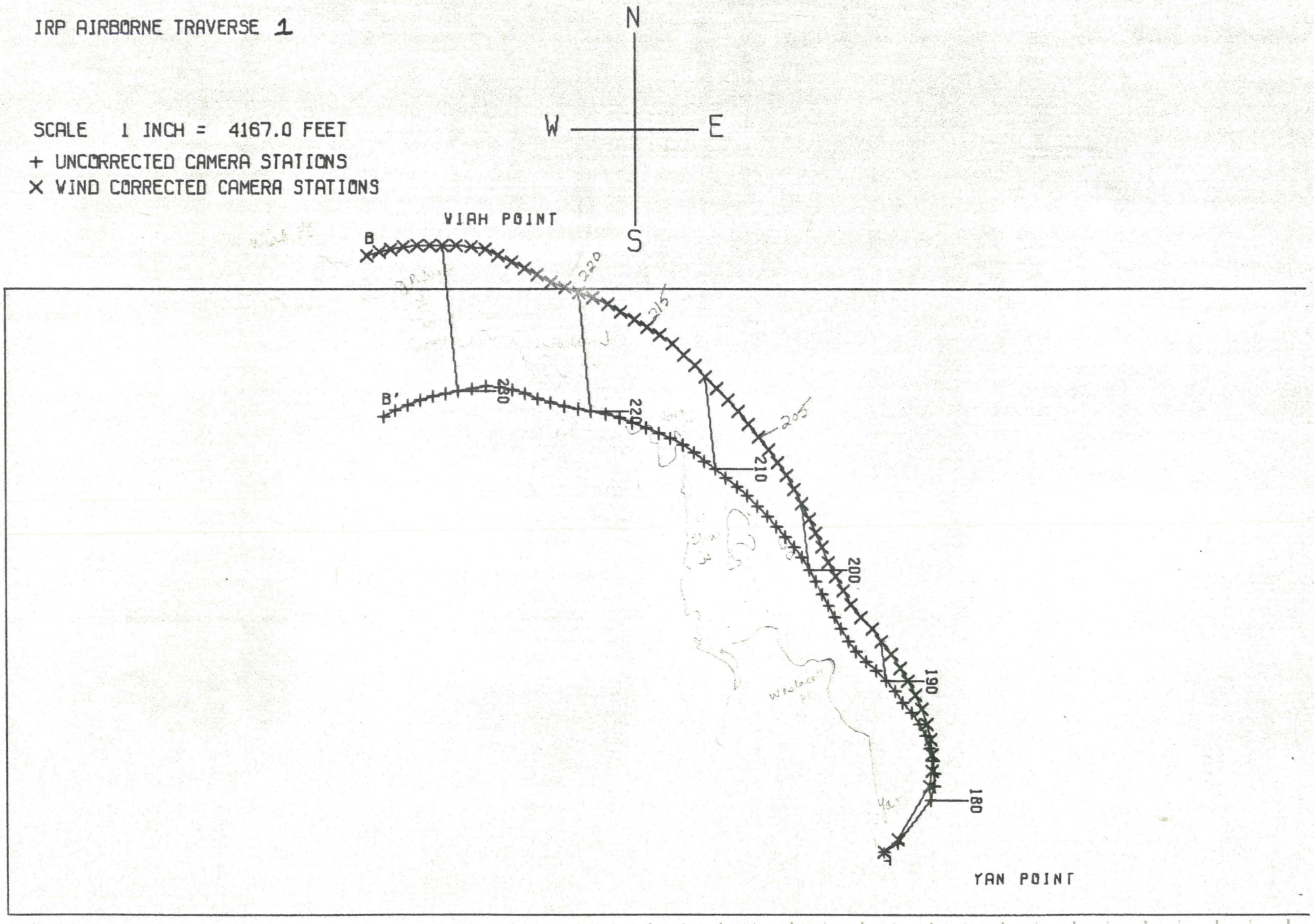
AUG 31 1973 DATA ROLL 96

IRP AIRBORNE TRAVERSE 1

SCALE 1 INCH = 4167.0 FEET

+ UNCORRECTED CAMERA STATIONS

× WIND CORRECTED CAMERA STATIONS



CAPE NADEN TO MAZARREDO ISLANDS ROLL 97(COLOUR IR) EXP. 288-321

SEPT 2 1973 DATA ROLL 96

IRP AIRBORNE TRAVERSE
PLOT NUMBER 2

SCALE 1 INCH = 4167.0 FEET

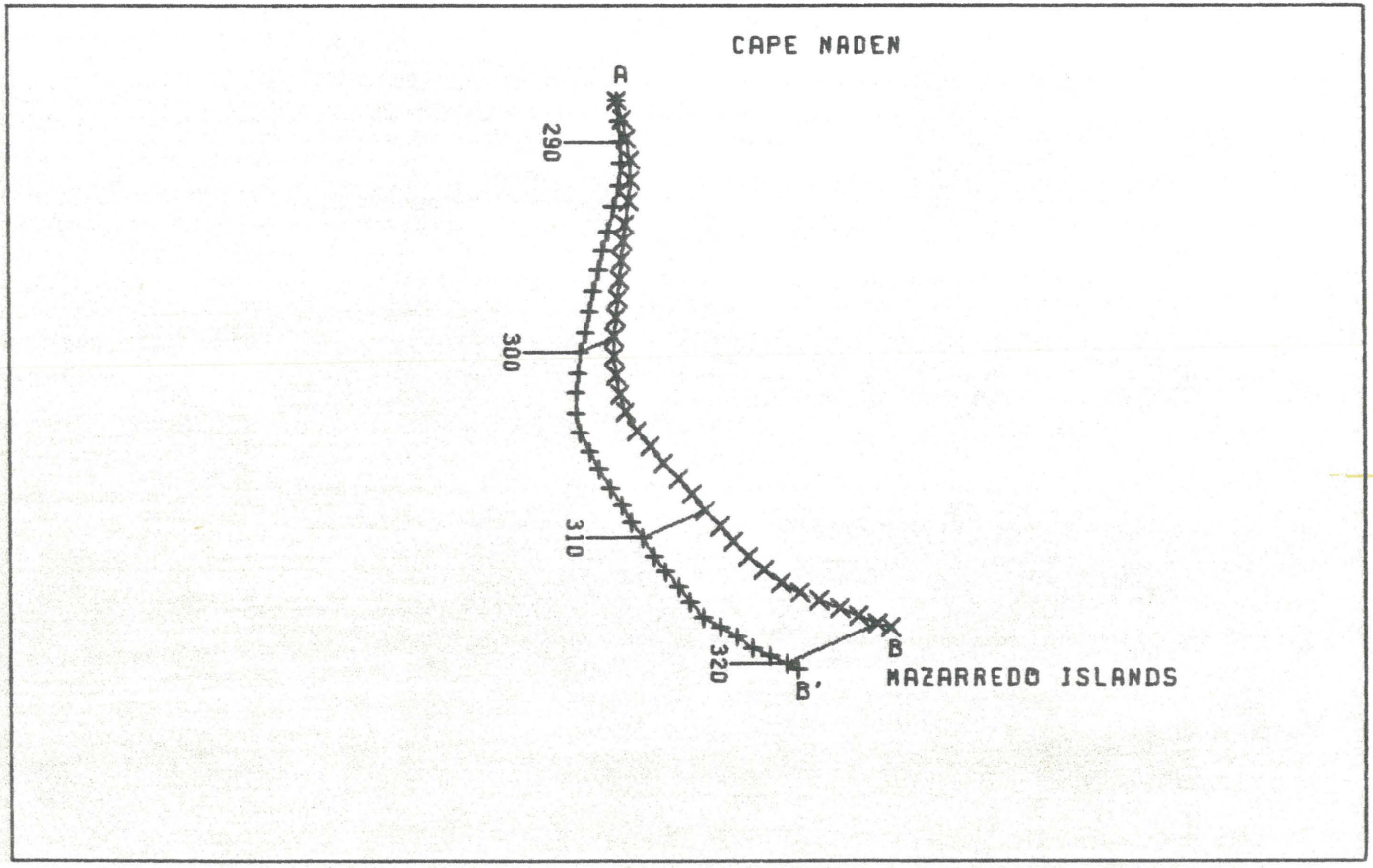
+ UNCORRECTED CAMERA STATIONS

× WIND CORRECTED CAMERA STATIONS

N

W E

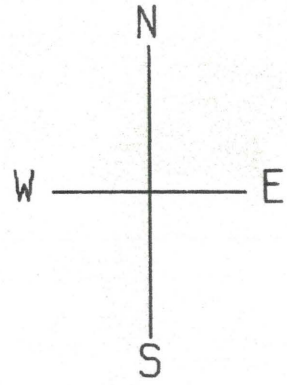
S

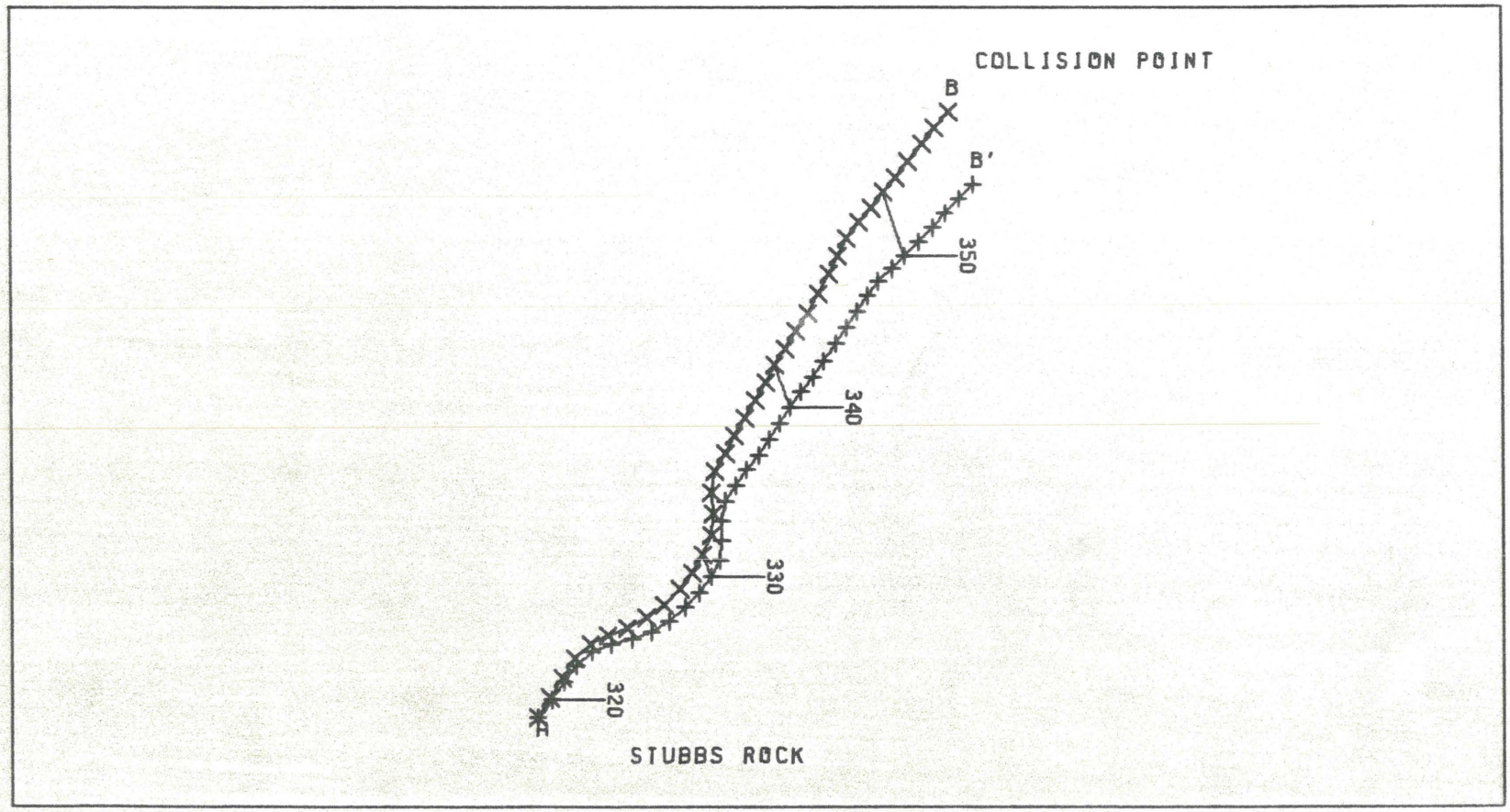


STUBBS RK TO COLLISION PT VERT ROLLS 94(COLOUR IR).95(COLOUR): EXP 319-355
AUG 31 1973 DATA ROLL 96

IRP AIRBORNE TRAVERSE
PLOT NUMBER 3

SCALE 1 INCH = 4167.0 FEET
+ UNCORRECTED CAMERA STATIONS
× WIND CORRECTED CAMERA STATIONS





MARY POINT TO CAPE NADEN ROLL 97(COLOUR IR) EXP.232-287

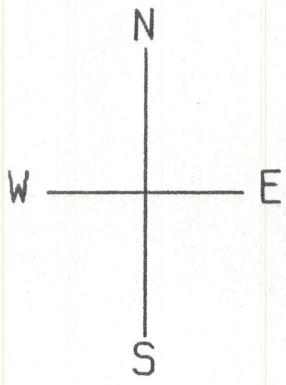
SEPT 2 1973 DATA ROLL96

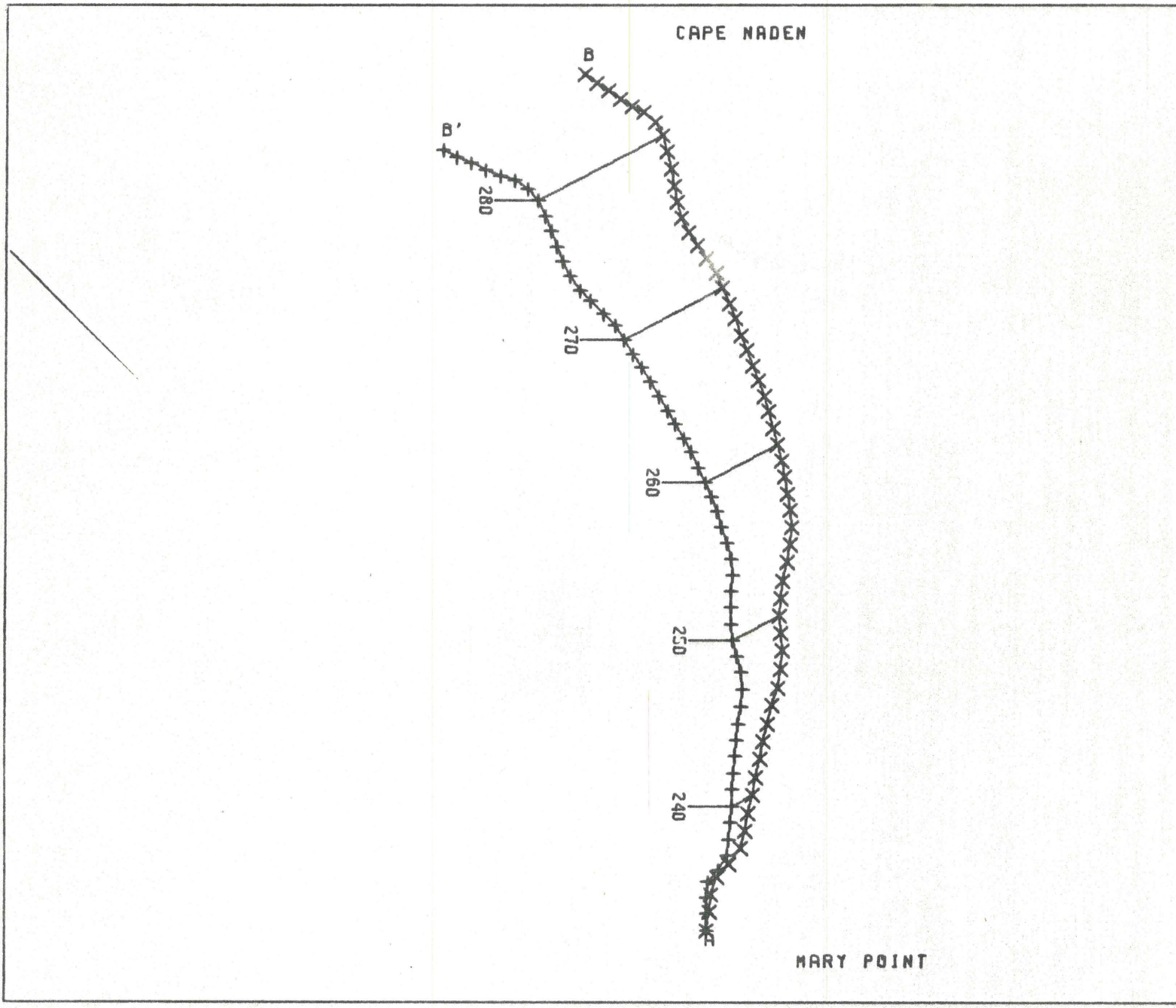
IRP AIRBORNE TRAVERSE
PLOT NUMBER 4

SCALE 1 INCH = 4167.0 FEET

\+ UNCORRECTED CAMERA STATIONS

× WIND CORRECTED CAMERA STATIONS





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CAPE NADEN

JOREY POINT

MAZARREDO ISLANDS

HUSSEY BAY

MARY POINT

NADEN HARBOUR

DEEPWATER POINT

INSKIP POINT

CAPE EDENSAW

CHRISTIE RIVER

WIAH POINT

HIDDEN ISLAND

JACOB POINT

STRIBE ISLANDS

WESTACOTT POINT

OTTUN RIVER

YAN

TRUE N

MAG. N

W

E

S

1 MILE

CHART 1
YAN TO CAPE NADEN

TREE LINE
SHORE LINE
DIVE SITE ■
NEREOCYSTIS BED
MACROCYSTIS BED
AERIAL PHOTOGRAPH CENTRE ⊙ FRAME NO.
SCALE : 1 INCH = 1/4 MILE
AIRCRAFT TRACK - - - -

COASTLINE TRACED FROM PROVINCIAL AERIAL PHOTOGRAPHS:
B.C. 4363-024; B.C. 4362-256, 257, 258, 259, 260; B.C. 4362-253; B.C. 4412-219, 193, 189, 150, 149, 098, 094, 046, 043, 098

BY: W.T. CHALMERS, B.B. BLAKLEY

CHART 2
ENTRY POINT TO TOW HILL

TREE LINE
SHORE LINE
DIVE SITE
NEREOCYSTIS BED
MACROCYSTIS BED
AERIAL PHOTOGRAPH CENTRE ⊙ FRAME NO. AIRCRAFT TRACK — — —
SCALE : 1 INCH = 1/4 MILE
COASTLINE TRACED FROM B.C. PROVINCIAL AERIAL PHOTOGRAPHS :

B.C. 4412 - 046, 047, 048, 038, 039, 040, 041, 042, 001 / B.C. 4411 - 257 : B.C. 4342 - 001 : B.C. 4341 - 249, 138, 135, 031, 024, : B.C 4342 - 143, 183, 184, 185, 186

DRAWN BY : B.D. BLAMLEY / W.T. CHALMERS

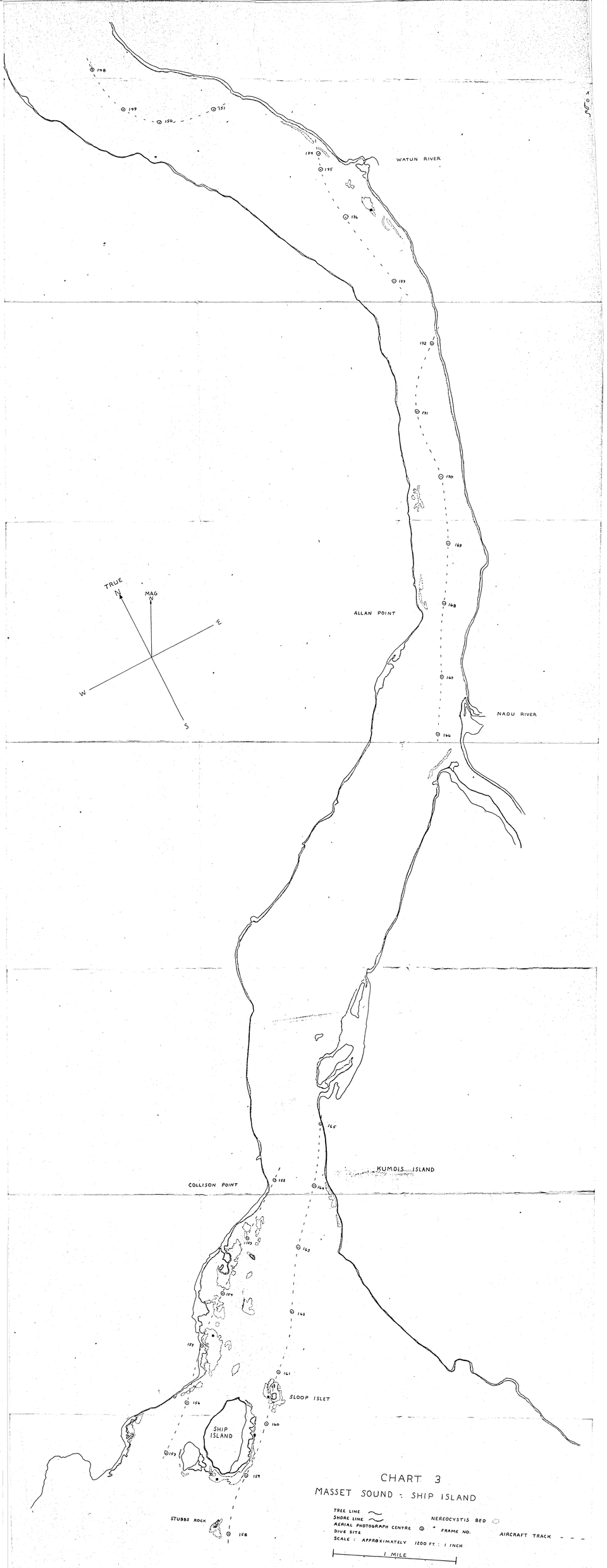

CHART 3

MASSET SOUND : SHIP ISLAND

TREE LINE
SHORE LINE
AERIAL PHOTOGRAPH CENTRE
DIVE SITE
NEREOCYSTIS BED
FRAME NO.
AIRCRAFT TRACK
SCALE : APPROXIMATELY 1200 FT : 1 INCH

1 MILE

DRAWN BY: W.T. CHALMERS, R.B. BLAKLEY