Pacific Coast Oil Spill Concept
Preliminary Site Survey
NW Coast Vancouver Island

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by

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EXECUTIVE SUMMARY

This report provides preliminary results of an aerial survey and ground observations at a limited number of sites which have potential or represent the type of physical and biological environment being considered for a possible oil spill experiment.

The survey encompasses four great sounds or inlet complexes of the northwest coast of Vancouver Island, Nootka, Esperanza, Kyuquot, and Quatsino. Of these the first three areas fall within the Nuu-Chah-Nulth Tribal Council lands.

The aerial survey covered over 350 km of shoreline and identified eight potential locations which appeared to possess at least a portion of the desired physical and biological attributes established prior to the survey. Of these sites, two general locations, one at the north end of Cook Channel (entrance to Tahsis Inlet) and one at the western end of Esperanza Inlet, were ranked in the final analysis as coming close enough to meeting both the physical and biological criteria to be considered as candidate locations. Each of these locations contained several embayments which could act as a control site for the main experiment. Access is available to these sites by local coastal steamer, small boats, or logging road.

Many other factors must be considered before either of these locations is considered for further baseline study. Local environmental and cultural issues affecting the suitability of both locations include herring spawning (Cook Channel) and the presence of several indian reserves (including an abandoned village) within 15 km of the site on Esperanza Inlet.

The survey was a complete success in that it accomplished all of its objectives under almost perfect weather conditions. Wind and swell conditions permitted almost unlimited floatplane access to all but the most exposed locations.

1.0 INTRODUCTION

This preliminary site survey was commissioned to determine whether or not there were any suitable sites for the proposed oil spill experiment on the west coast of Vancouver Island.

The general survey area selected for examination included the sounds, inlets and bays from the entrance to Nootka Sound in the south to Quatsino Sound in the north. Areas further south were rejected because of their proximity to the Pacific Rim Park, the communities of Tofino and Ucluelet, and their high environmental and recreational profile (e.g., Barkley Sound and Clayoquot Sound).

Each of the four sounds and inlets falling within the study area of interest (Nootka, Esperanza, Kyuquot, and Quatsino) was subjected to a preliminary screening (independent assessment by Hammond Bay Environmental Services) in order to identify sensitive areas according to the following criteria:

- Salmon escapement
- Herring spawn (both intermittent and constant)
- known areas of clam beaches, geoduck, crabs, prawn, shrimp
- bird colonies
- seal haulouts
- sea otters
- aquaculture sites (where known)
- ecological reserves (including parks and recreation areas)
- communities
- indian reserves

Rough maps are available showing the distribution of these sensitive areas (they are not reproduced here due to a lack of resources to confirm and present the preliminary results). The preliminary sensitivity assessment was used to guide the survey team and to qualify the final conclusions regarding suitability of the suggested sites.

This report cannot be considered a rigourous scientific study. The survey accomplished its objectives and provided an overview of the entire area originally selected as the first target region for the proposed experiment. The results indicate that there are a limited number of suitable sites within that area. Any final selection will require detailed ground truthing along with initial environmental evaluations of selected sites.

2.0 OVERVIEW OF GENERAL SITE REQUIREMENTS

Sergy and Harper (1990) outlined the following preferred physical and biological characteristics which were used to evaluate potential sites during both the aerial and the ground surveys (Section 4.0):

1. **highly permeable surface and subsurface sediments** because (a) these types of sediments have a high retention potential, and (b) are difficult to clean;

2. **coarse sediments** because (a) the sediments are generally not as susceptible to reworking by wave action, and they tend to support a more diverse intertidal fauna;

3. **minimal freshwater run off** because (a) this could cause a poorly controlled flushing of oil, and (b) run-off is an indication of finer, impermeable subsurface sediments;

4. **uniform sediment and wave exposure** to allow inter comparison of results from the various experimental treatments;

5. **in the order of 500 to 1,000 km of shoreline** to allow for a numerous treatments and for adequate separation between treatment sites; and

6. **moderate wave exposure** with fetch distances such as 20 to 100 km or subjected to indirect swell.

7. The overriding concern from the point of initial **biological screening** was that the sites be biologically productive, and well represented, with sufficient numbers of one or more potential indicator species in both the intertidal and nearshore subtidal zones to allow a meaningful sampling program.

These screening points were used subjectively during the aerial surveillance to identify ground sites for further investigation, and confirmed on the ground through documentation of beach profiles, permeability and substrate (see Section 4.3 and Appendices).

3.0 AERIAL SURVEY

3.1 Attributes/Constraints

A low level aerial reconnaissance is useful in assessing beaches for potential ground surveys based on the cover of marine species visible either because of large individual size or high population density. Examples of intertidal species or genera of sufficiently large size and distinctive form include larger kelps such as Agarum spp., Egregia menziesii, Laminaria spp., Postelsia palmaeformis, and Macrocystis integrifolia.

Examples of species with high population densities and which tend to occur in horizontal bands in various intertidal zones include:

-the lichen/blue green alga: Verrucaria sp. in the supralittoral
-blue green algae generally in the high littoral
-the barnacle Balanus glandula in the mid littoral
-mussels Mytilus spp.in the mid littoral
-the rockweed Fucus gardneri in the mid littoral
-the sea lettuce Ulva sp. in the low-mid intertidal
-the Japanese weed Sargassum muticum in the low-mid intertidal
-the eelgrass Zostera marina in the low intertidal
-the surfgrass Phyllospadix scouleri in the low intertidal
-broadleaved red algae generally in the low intertidal

Major constraints to identifying such species include: altitude above the beach, viewing angle to the plane of the beach, sunlight and sun direction, fog, tidal height, and water clarity (for submerged species). An additional constraint during this study was that the biologist was seated on the seaward side of the plane such that his field of view through the shoreward window was limited.

A fundamental assumption was made that the species abundance and population densities identifiable from the air were an indication of overall species diversity and abundance on the shore.

3.2. Aerial Survey Methods

Physical

An aerial reconnaissance of the shoreline was conducted to identify possible experimental sites. The shoreline was observed at low altitudes, 100 - 700 ft. from a fixed-wing aircraft. The first day of the field survey covered all of the potential study areas from Nootka Sound in the south to Quatsino Sound in the north. Any beaches meeting the above-listed criteria were marked for ground investigation during the following two days. Additional aerial photography and video was obtained of the primary sites following each of the ground surveys.

Video-recorded and photographic images logged during the entire three day survey. Times were recorded every few minutes along the flightline marked on large-scale hydrographic charts. Aerial still photographs by D. Dickins are marked with time/date for future reference against the flightmaps. Manual logs are available for all other photographs by other study team members.

Selected photographs are included in Appendix A of the primary sites identified and discussed in Section 4.

Biological

A qualitative judgement was made of the potential biological diversity or richness of those beaches which were considered to be potentially acceptable for ground truthing by physical criteria and sensitivity assessment (see also above discussion of attributes and constraints associated with aerial surveys of biological diversity).

3.3 Aerial Survey Results

An estimated 350 km of shoreline were covered during the aerial reconnaissance. Although much of the shoreline surveyed would be classified as a pebble (cobble) type beach, the majority of areas also had low wave exposure (fetches <10 km). Subsequent ground surveys documented fine, impermeable subsurface sediments in a number of sites which looked promising from the air.

The aerial survey identified a total of only eight sites (refer to maps in Appendix A) which came sufficiently close to the desired physical and biological criteria to warrant landing for closer inspection. Of these sites, two areas (Strange Island in Nootka Sound and Esperanza Inlet) were subjected to more detailed beach profiles, permeabilty tests, and biological documentation (Appendices B through D).

The coastal type considered desirable for the proposed experiment represented a small proportion of shoreline surveyed; this result was not surprising given the basic constraints of geography, access, and environmental sensitivity controlling the available survey area (refer to further discussion of these external constraints in Section 2.0)

The fact that the availability of the desired shoreline was scarce in the survey area is not a true reflection of the relative importance of the desired shoreline in the overall context of West Coast clean-up. The shoreline characteristics identified in the original PCOS concept document are still considered most appropriate for experimental testing for three primary reasons:

1. This shoreline type has proved to be the most difficult to remediate at the EXXON Valdez due to deeper penetration of oil and difficulty in subsequently removing oil;

2. it represents the most severe case in the terms of oiling retention in pebble/cobble beaches; and

3. the substrate of large, relatively immobile sediment supports a diverse intertidal biological community.

Biological

The species which were identified on boulder and cobble beaches during the aerial survey include:

-blue green algae generally in the high littoral
-the rockweed Fucus gardneri in the mid littoral
-the sea lettuce Ulva sp. in the low-mid intertidal
-the Japanese weed Sargassum muticum in the low-mid intertidal
-the eelgrass Zostera marina in the low intertidal
-the surfgrass Phyllospadix scouleri in the low intertidal
-broadleaved red algae generally in the low intertidal

3.4 Discussion

The following discussion provides an overview of aerial observations made by the marine biologist during the course of the survey.

The potential indicator species varied in their applicability to boulder/cobble beaches. The band of Verrucaria which is typically very evident on solid rock surfaces at and above the high tide line was not evident on most of the cobble beaches where cobble size decreased toward the upper intertidal. Cobble stability would vary directly with size, other factors being equal and the relatively unstable cobble on upper beaches probably cannot support significant growth.

Blue-green algae somewhat lower in the intertidal tend to have a grey-black colour which was readily apparent where cobbles were otherwise light coloured. The absence of such a dark colour was useful as an indicator of cobble instability in the mid-high intertidal.

The rockweed Fucus gardneri appeared as either a dark green (wet) or black (dry) band. Its absence on cobble beaches together with presence on adjacent solid rock beaches was considered an indicator of high instability of the beach, and likely a depauperate epibiota.

The presence of Fucus and a green band somewhat higher in the intertidal is often an indication of the absence or low population densities of herbivores in this zone such as limpets and littorine snails (pers. observation). An exception is the presence of Enteromorpha intestinalis which is an indicator of fresh water outflow. Bands of mussels and barnacles were not present or were insufficiently defined to identify on the cobble beaches although they were often present on adjacent solid rock shores.

Somewhat lower in the intertidal broad patches of green Ulva were considered an indication of at least moderate beach stability. The brown seaweed Sargassum muticum is an introduced species on this coast and now covers broad areas of the lower mid intertidal in semi-exposed to protected beaches. Broad brown bands in this zone during the aerial survey were considered probable populations of this species. This was confirmed at those sites visited. The presence of this species was also considered an indicator of at least moderate beach stability.

Vegetation in the lower intertidal could only be observed during those times of the aerial survey when the tide level was approximately 1 meter or lower, in part depending on water clarity.

> The presence of Zostera marina was considered an indicator of a soft substrate of mud with varying admixtures of sand. The presence of eelgrass, Phyllospadix scouleri, and/or abundant red coloured foliose algae was taken as an indicator of proximity to oceanic waters in contrast to the more sheltered, less vertically mixed water of the inlets and fjords. The latter waters would have a surface layer of relatively low salinity water--particularly during periods of rain and fresh water runoff from higher elevations (e.g., Picard, 1963). Intertidal species diversity can be expected to be lower in these latter regions (pers. observation).

In summary the biotic cover observable during the aerial survey served as an indicator of species diversity related to issues of:

- beach stability
- water salinity (and perhaps related suspended sediment)
- ambient water movement (through wave and/or swell exposure)

Areas of moderate to high tidal currents were not assessed because appropriate cobble beaches were not found in such areas. Areas with large sources potential pollution (such as from pulp mills and mines) were not assessed for similar reasons.

4.0 GROUND OBSERVATIONS

The assessment team went ashore at eight sites which the aerial survey analyses suggested were potentially suitable either in biological or physical terms for an experimental study (see list below: station numbers in brackets were those employed by the marine biologist and used in Appendix C.

Sites flagged with an asterisk met the both the basic biological and physical criteria which could be evaluated from the air; the other sites appeared to meet the basic physical criteria from the air but appeared less promising in terms of biology. Landings were made at these locations to confirm their lack of suitability and to gain confidence in the aerial rejection or acceptance of sites as potential candidate locations.

<u>Nootka Sound</u>
* -Southeast shore of Zuciarte Channel [31/91]
* -Northeast end of Spouter Island [32/91]
* -South end of Strange Island [26A&B/91, 33/91]

<u>Esperanza Inlet</u>
* -on north shore, east of Espinosa Inlet [27/91. 29/91]

<u>Kyuquot Sound</u>
-northeast shore of Moketas Island [29/91]
-entrance to Kashutl Inlet, north of Chamiss Bay [30/91]

<u>Quatsino Sound</u>
-south shore, east of Koskimo Bay [24/91]
-north shore, east of Koprino Harbour [25/91]

General site locations marked on regional maps are shown in more detail on photocopied extracts from the large scale hydrographic charts of the area (1: 37,000 to 1: 48,000) - see Appendix A. Selected photographs of the different sites are included in Appendix A - note that only a small sample of the photographs identified by J. Harper (geomorphologist) and W. Austen (marine biologist) could be included in this report.

The detailed results from the physical and biological ground observations and measurements are contained in Appendices B to D.

4.1 Methodology

The survey was timed to coincide with a tide window ranging from three feet above low low water on the falling tide to three feet above low low water on the rising tide. During the three day period available for the survey, April 17 to 19, 1991, this meant that the surveys could take place between 7:30 AM and 12:30 PM. The detailed surveys at the most promising sites were scheduled to fall within 45 minutes either side of the low low water level.

Physical

The physical documentation methods consisted of a systematic description of the material gradation from the upper intertidal zone to the lower intertidal zone, a description and photographs of the vertical gradation of particle size and character within a series of pits dug from the LITZ to the UITZ, profiles of the beach gradient (plotted in Appendix B), and measurements of substrate permeability at different locations (Appendix D). Aerial photographs of each site were obtained after competing the ground surveys (including additional video).

Access points such as nearby logging roads were noted from the air.

Each site was also assessed in terms of its potential for wave exposure (both from the charts and siting on the ground).

The availability of suitable control sites was assessed as part of the overall ranking.

Biological

General information collected at each site included:

-a station number
-location name, latitude and longitude
-date and time
-predicted tidal height at time of assessment
-weather conditions
-wave and/or swell conditions
-significant water currents if any
-water turbidity
-description of the site
-photographic documentation of the site

A biological assessment was made over a traverse from high to low intertidal zones during an ebbing tide, and in the reverse direction during a flooding tide. Macroscopically visible animals and plants were identified. These included species living a. on exposed surfaces; b. under boulders and cobbles; and c. to a more limited extent within sediments. For each species populations were ranked as: abundant, some, few, or 1-2. The duration of each assessment ranged from 20 to, typically, 50 minutes.

At three sites with appropriate substrate a trial assessment was made of the smaller, mobile animals within coarser sediments. For the purposes of this study these animals will be referred to as the "Interstitial Fauna". About 0.2m above the tide line a pit was dug and allowed to fill with water percolating in from the sides. The water was stirred and 10 liters were poured through a 0.5mm filter. Organisms retained on the filter were collected and subsequently identified under a dissecting microscope.

Species identifications are based on the biologist's personal knowledge supported by reference material including: Smith and Carlton (1975), Abbott and Hollenberg (1976), Lambe and Edgell (1986), Gabrielson et al (1987), Kozloff (1987), Species names are based on Austin (1985), Gabrielson et al 1987, and Lamb and Edgell (1986).

4.2 Results

Physical

Table 1 provides a preliminary ranking of all sites based on ground observations. Only the Nootka Sound and Esperanza Inlet sites provide the desired combination of moderate wave exposure, high to low permeability, and pebble/cobble character.
Detailed notes, profiles, the results of permeabilty tests, and photographs are provided in the Appendices.

Biological

The biological attributes of intertidal communities characterized by combinations of substrate type, slope, wave exposure, salinity, and tidal height have been subject to numerous studies in the northeast Pacific. These attributes are summarized in publications such as Austin et al (1972); Carefoot (1977); Kozloff (1983); Ricketts, Calvin and Hedgpeth (1985); and Dethier (1990).

The biological components of cobble dominated beaches are typically a mix of three community habitat types:

a. plants and animal living on upper cobble surfaces [epibiota]
b. animals living under cobble surfaces plus a few plant species around the lower periphery of cobbles.
c. animals living within the underlying sediment [infauna]

Species may be sessile (e.g., adults of plants, many colonial animals, barnacles, mussels); semi-sessile (e.g., sea anemones, some limpets, most clams), or vagile (e.g., crabs, fish).

The biota of beaches dominated by cobble varies considerably at a given tidal height, in part relating to physical factors such as cobble size and mix (stability), ambient water movement, salinity, silt, nutrients, light, and underlying substrate. Biotic factors such as herbivores, predators, prey, obligate associates

TABLE 1

PRELIMINARY RANKING OF SITES

General Location	Site	Approx. Length(m)	Approx. Dimension (m)	Character	Permeability
Nootka Sound	Strange Is.#1	400m	50m	pebble, cobble, boulder beach	High to low
	Strange Is.#2	70m	50m	pebble, cobble, boulder beach	High to low
Esperanza Inlet	Espinosa	300m	50m	cobble, boulder beach	High to low
Nootka Sound	Spatter Is.	100m	20m	pebble/ cobble veneer	Low
[Sites below judged significantly less suitable]					
Nootka Sound	Discovery Bay	100m	50m	boulder beach	
Kyuquot Sound	Moketas Is.	500m	20m	cobble, boulder over clay and sand	low
	Chamiss Bay	200m	30m	pebble/ cobble over sand	low
Quatsino Inlet	South side	200m	40m	pebble/ cobble over sand	low
	North side	1,000m	30m	pebble over sand & mud	low

also may be major determinants of community composition. Recruitment for most but not all species populations is from swimming juvenile stages (e.g., spores, larvae) subject to another series of physical and biotic viables in the offshore water masses.

At a given site, species populations may also vary seasonally due to factors such as insolation, predation, temperature, salinity, wave action; or inherent short duration of one or more life cycle stages.

Given the range of variables which may affect biotic composition on a cobble beach, the study included a qualitative assessment of certain of these to the degree possible over a 20-50 minute period at each site. In this preliminary assessment, the analyses of biotic composition were understood to be largely site specific with limited capability for application in detail to other sites. Alternatively, some members of the biota were assessed with a view toward identifying indicator species representative of cobble beaches under certain physical and biotic conditions.

The beach surveys emphasized assessment of those macrosocpic species which were visable either directly or by turning over boulders and cobbles. Sampling of interstitial fauna (within underlying sediments) was undertaken on a trial basis at three sites.

The field data for each station are included in appendix C. Corresponding photographs of the beach and selected communities at each station are included in Appendix A together with location maps.

Stations which on preliminary assessment were deemed marginally acceptable at best were assessed for a relatively short period of time (typically, at less than ideal tidal levels). Since these factors may affect the total number of species observed, they are indicated in Table 2. Table 2 also includes qualitative determinations of exposure to wave &/or swell conditions for each station (see listing above under 4.0 for cross referencing between station numbers and site locations)

Table 2

Comparative values for wave/swell exposure, tide level at time of assessment, and duration of assessment.

STATION	Wave/swell exposure	Tide level [meters]	Time [minutes]
24	protected	2.2	30
25	protected	2.3	30
26A	semi-exposed	0.4	45
26B	semi-exposed	0.2	45
27	semi-exposed	0.2	45
28	semi-exposed	0.5	20
29	semi-protected	0.7	15
30	semi-protected	1.2	15
31	exposed	0.6	20
32	semi-protected	0.3	45
33	semi-exposed	0.3	60

Macrobiota:

The number of macrobiotic species observed at each station are shown in Table 3.

Table 3

No. of species in each major taxon at each station

[NA = not assessed due to tide level]

STATION > TAXON	24	25	26A	26B	27	28	29	30	31	32	33
GREEN ALGAE	2	0	3	3	1	2	2	1	2	2	2
BROWN ALGAE	1	1	2	4	5	3	1	1	2	3	3
RED ALGAE	NA	NA	1	9	13	3	0	0	6	2	7
LICHENS	0	0	1	1	2	1	1	1	1	1	1
ANGIOSPERMS	NA	NA	1	1	0	0	0	0	1	0	1
SPONGES	0	NA	0	1	1	0	0	0	0	1	0
COELENTERATES	NA	NA	1	1	1	0	0	0	1	1	1
NEMERTEANS	NA	NA	0	0	1	0	0	0	0	0	0
BRYOZOANS	NA	NA	0	2	6	3+	NA	NA	1	5+	3
CHITONS	NA	NA	0	0	0	0	0	0	0	1	0
GASTROPODS	1	0	0	4	7	4	2	2	3	8	5
BIVALVES	0	0	2	3	2	1	1	1	1	5	2
POLYCHAETES	NA	NA	0	2	3	2	0	NA	0	3	2
SIPUNCULIDS	NA	NA	0	0	0	1	0	NA	0	0	0
BARNACLES	1	1	1	4	2	2	2	2	2	3	4
ISOPODS	NA	NA	0	2	0	1	NA	NA	0	1	1
AMPHIPODS	NA	NA	0	2	1	1	0	NA	0	1	3
DECAPODS	1	1	0	3	5	3	1	1	1	5	3
SEA CUCUMBERS	NA	NA	0	0	0	0	NA	NA	0	1	0
SEA URCHINS	NA	NA	0	0	1	0	NA	NA	0	0	0
SEA STARS	NA	NA	1	3	4	2	0	0	0	6	2
ASCIDIANS	NA	NA	0	0	0	0	NA	NA	0	0	0
FISH	NA	NA	1	1	1	0	NA	NA	0	1	1
TOTALS	**6**	**3**	**14**	**46**	**55**	**29**	**10**	**9**	**21**	**50**	**41**

The number of species in each tide zone is shown in Table 4. Species abundance typically varies inversely with intertidal height.

The levels of these zones relative to tidal levels, when biotically defined, vary with degree of wave exposure, amplitude and period, but for the purposes of this study are roughly equivalent to:

a. low = -0.2 to 0.6 meters (lowest lower low water to mean lower low water)
b. mid = 0.6 to 3 meters (mean lower low water to mean lower high water)
c. high = 3 to 4 meters (mean lower high water to highest high water)

Table 4
No. of species in high, mid and low tide zones
[NA = not assessed due to tide level]

TIDE ZONE>	High	Mid	Low
STATION			
24	3	3	NA
25	1	2	NA
26A	2	5	10
26B	8	16	32
27	5	17	37
28	3	10	15
29	2	8	NA
30	2	7	NA
31	3	11	8
32	4	23	31
33	9	15	26

The relative abundance of species is shown in table 5. On beaches with low numbers of species (10 or less) the abundance of individual species tends to be low. On beaches with higher numbers of species about one-half the species are abundant. However, on species rich beaches about one-half the species are cryptic in habit. They occur under boulders and cobbles.

Table 5
Abundance of species & whether exposed or cryptic

STATION	Total	1-Few	Some	Abund	Exposed	Cryptic
24	6		6		5	1
25	3	1	2		2	1
26A	13	5	3	6	12	2
26B	46	9	16	21	25	22
27	56	8	20	28	30	25
28	29	2	6	21	16	13
29	10		9	1	9	1
30	9	2	4	3	8	1
31	21	5	9	7	18	5
32	50	6	13	31	20	30
33	41	6	14	21	20	21

Interstitial Fauna:

The results of trial sampling of small vagile animals in the substrate underlying the cobble in the low tide zone are shown in table 6.

Table 6
Interstitial fauna sampled from low tide zone.

STATION >	24	26B	33
FLATWORMS	0	few	0
NEMATODES	1	abund	abund
OLIGOCHAETES	3	0	abund
OSTRACODS	0	some	some
BARNACLE LARVAE	abund	0	0
HARPACTICOID COPEPODS	1	some	some
CUMACEANS	0	0	1
AMPHIPODS	0	0	few
MITES	3	0	1
FLY LARVAE	2	some	0

4.3 Discussion

Physical

A discussion of each site in terms of geomorphology is contained in Appendix B.

Biological

Macrobiota

The assessment of suitability of those sites visited for an experimental site is based on the following general criteria:

1. Species diversity
2. Species abundance
3. Species habitat
4. Community stability
5. Availability of a control site

Differences in duration of assessment on different beaches (Table 2.) may have resulted in some bias toward higher numbers of species discovered with longer assessment times. However, in fact, the duration of assessment was directly related to the apparent species diversity. On beaches visited for relatively short periods of time, there was relatively less to discover.

Differences in tidal height between beaches during visits would bias species enumeration. Given that species diversity tends to increase from the high tide zone to the low tide zone, beaches visited during higher tide regimes would be less adequately assessed. Seven sites were visited when the low tidal zone was exposed (< 0.6 m) with a range of tidal height variability of 0.4 m (Table 2.). This variability, while not insignificant, is not likely to produce errors in sampling bias greater than that relative to the beach as a whole in preliminary assessments such
as were made for this survey.

Inspection of species abundance in both mid and low tide zones at these stations (table 4, stations 26A, 26B, 27, 28, 31, 32, 33) suggests that relative abundance between the stations in the low tide zone is comparable to that in the mid tide zone. The one exception is station 31 where the number of species in the low tide zone is relatively low. This beach had the highest wave energy of those sites visited (table 2). The bedding, and shape of the cobbles together with the underlying substrate indicate a highly unstable beach. It would be expected that few sessile or semi-sessile animals could populate such a beach. This was confirmed during the site assessment (Appendix C, station 31/91).

The four remaining sites (24, 25, 29, 30) were sampled during higher tide levels and total species numbers were likely underestimated. However, the species diversity in the high and mid-intertidal, which was adequately sampled, was significantly lower than that at the other stations (except for substation 26A) (table 4.). It is likely that the low diversity at these four station is due to some combination of low ambient water flow, periodic low salinities from fresh water runoff, and periodic high levels of suspended silt from runoff.

On the basis of species diversity, stations 26, 27, 28, 31, 32, 33 are accepted and stations 24, 25, 29, 30 are rejected.

The general congruence of species diversity with species abundance (table 5.) may be fortuitous but does support the above evaluation of accepted and rejected sites.

The high percentage of cryptic species (table 5.) indicates a need to include this biotic component in an experimental study in order to assess potential impacts of a controlled oil spill and remedial measures on the total macrobiota. But, perhaps more importantly, this cryptic biota is more likely to be confronted by introduced materials over an extended period due to longer residence time in <u>under</u> rock habitats than in wave exposed <u>on</u> rock habitats.

A few of the vagile forms such as crabs, hermit crabs and some limpets would likely move out from under rocks at night and/or when covered by water during high tides.

Community stability is difficult to evaluate in a one-time preliminary assessment. Periodic unstable substrate due to e.g., winter storms with associated increased wave and swell conditions are indirectly indicated through the degree of cobble angularity and bedding as well as apparent fetch considered under the physical assessment. The location of certain sessile species may also indicate degree of instability.

> For example, the barnacle Balanus glandula occurred on boulders, cobbles and pebbles at stations 24/91 and 25/91 in Quatsino Sound, but was limited to larger cobbles and boulders at a more wave exposed site on the southern end of Strange Island in Nootka Sound. At the latter site, among others, this species also tended to be restricted to the edges of larger cobbles where impacts from moving substrate would be less likely to occur than on the upper cobble surfaces.
>
> Another indicator of stability would be the size classes for particular species to the degree these represent age classes. On relatively unstable beaches such as station 31/91 in Zuciarte Channel sessile species populations of e.g., barnacles and mussels were largely composed of small individuals less than one year old. Other taxa such as some of the red algae were predominantly annuals.
>
> Alternatively, a stable beach such as station 32/91 on Spouter Island in Nootka Sound included species populations over a considerable size range such as the sessile snail Petaloconchus vermetus and many species which are long lived such as the large turbin snail Astraea gibberosa.

Potential control sites proximal to potential experimental sites on Strange Island (sta. 33/91 control, sta. 26B/91 experimental) and on Esperanza Inlet (sta. 28/91 control, sta. 27/91 experimental) indicated a high but not total level of species population similarity. It should be noted, however, that even on the same beach, species composition and abundance may vary at different points along the beach at the same intertidal height. This is exemplified by comparison of species composition between station 26A/91 and station 26B/91 on Strange Island. Differences between these latter sites were also evident in substrate composition. A potential control site was not assessed to compare with sta.

32/91 on Spouter Island. However, the aerial survey suggested that beaches with a similar biota are located nearby.

No attempt has been made to formulate a diversity index based on the data obtained from this macrobiota survey. It is this biologist's bias that such a diversity index would have much less information content than inspection of the field records of species and their abundance by a knowledgeable naturalist.

Interstitial Fauna

The assessment of the interstitial fauna in sediment underlying cobble beaches was limited in scope and designed to test the feasibility of such an approach. The data are not sufficient to assess differences between beaches in the present study. The technique does appear feasible given the following limitations and or modifications:

1. Several of the taxa are difficult if not impossible for the non-expert to identify to species level. These include flatworms, nematodes and, to a lesser extent, ostracods and oligochaetes. Some soft bodied forms also require special techniques of preservation, fixation and sectioning.

2. Some of the taxa were represented by species smaller than 0.5mm (flatworms, ostracods and copepods). A 0.2mm mesh screen would be more appropriate to retain members of these groups.

3. The technique does not adequately exclude species which may have been carried in from surface sediment. This was demonstrated by the presence of barnacle larvae which were, perhaps, in the process of settling on cobble surfaces. The use of a cofferdam might minimize but not eliminate such sample contamination.

4. A larger volume of interstitial water should be sampled to adequately sample the populations.

5. Given this is a destructive sampling technique, the precise same area cannot be accurately resampled over time.

6. Effective sampling requires that pits be dug just above the tide level so that to assess the interstitial biota over the full tidal range requires sampling over one-half a tide cycle.

7. Little is known about the biology of at least the majority of species.

A similar assessment was made under an EXXON study program in Prince William Sound. Although subject to some limitations, it did demonstrate that such a sampling program could provide useful data. The results of this study, however, cannot be released at this time

Other biota:

Potential macroinfauna below the cobble veneer was not adequately sampled due to constraints of time and the difficulty of extracting sufficient sediment.

Animals such as cancroid crabs and fish which move in and out with the tides were not assessed.

5.0 CONCLUSIONS

Physical

Based on the physical requirements for moderate wave exposure, sufficient shoreline length, nearby controls, and a range in permeability (allowing oil penetration and associated oil residence for a number of seasons) only two locations appear suitable: Nootka Sound - Strange Island, and Esperanza Inlet. These sites were ranked second and third in terms of biological criteria (see below).

Biological

Based on the results of assessments of the six site locations (note that Strange Island consisted of two adjacent sites one of which would be considered the control, and Quatsino Sound consisted of two sites on opposite sides of the inlet) and employing the criteria of inferred community stability, and species diversity and abundance, the biological suitability of sites is rated as follows in decreasing order:

1. Spouter Island, Nootka Sound [sta. 32/91]
2. Esperanza Inlet [sta. 27/91 and 28/91-control]
3. Strange Island [sta. 26/91 and 33/91-control]
4. Zuciarte Channel [sta. 31/91]
5. Kyuquot Sound [sta. 29/91 and 30/91]
6. Quatsino Sound [sta. 24/91 and 25/91]

Logistics

The two sites which appear to satisfy the basic physical and biological criteria both have reasonable access. Of the two Esperanza is favoured because of the close proximity of an active logging operation. It appears that it would be possible to drive to within a few hundred meters of this site from Zeballos. The Strange Island site falls on the route of regular coastal steamer services between

Gold River and Tahsis, both of which communities can be reached by highway from the east side of Vancouver Island.

Environmental/Cultural Concerns

Each of the sites ranked highly in this survey has number of environmental and social concerns. The Strange Island site

An abandoned village once occupied by the Ehatisaht Tribe is situated 13 km to the east of the proposed site on Esperanza Inlet. This is also the location of the one of the finest totem poles on the West Coast. There are three reserve locations along the coast to the east of the proposed site, two (E10A and B straddling Graveyard Bay immediately to the east) and one further east associated with the abandoned village.

The Strange Island site is within 20 km of two reserves belonging to the Mowachat Tribe (M8 and M9). Each of these reserves would be isolated from the proposed experiment by the geography (refer to map in Appendix A). Of more concern is the relatively constant herring spawn stretching along the western shore of Cook Inlet and Kendrick Channel. The extent to which this spawn includes the Strange Island site requires further investigation before drawing any conclusions as to the potential conflict.

6.0 RECOMMENDATIONS

Given approval in principal by the tribal council to entertain such an experiment either at the sites suggested in this preliminary survey or at some alternate locations, a more detailed physical examination of a number of specific sites will be required to make a final selection (taking into account local environmental sensitivities and concerns).

If one or more sites are chosen for further assessment it is recommended that a baseline study on each beach incorporate a quantitative determination of species and their abundance and other population parameters over time to account for seasonal variability, over the full tidal range to account for tide zone variability, and along each beach to account for substrate variability, wave exposure variability and edge effects. The life styles of species should also be determined to the degree information is available in the literature.

The study should include both sessile and vagile forms, both exposed and cryptic forms, both epifauna and infauna.

For non-destructive sampling of epi-macrobiota (e.g., determination and enumeration without removal of biota, and return of rocks and cobbles to precisely the same position), the precise same locations should be examined over time using standard surveying techniques and photography to ensure congruency of sample sites on repeated visits.

Those species which may move in and out with the tide such as some fish, seastars and crabs should also be assessed. They could potentially be, at least qualitatively assessed, with beach seines although a cobble substrate, particularly with angular rock would limit the effectiveness of a seine. SCUBA observations during high tide periods would perhaps be more effective although qualitative on such beaches.

Recommendations on a potential sampling program for interstitial fauna are given in the discussion of that fauna above.

Assessment of animals living within the sediment underlying the cobble veneer would entail destructive sampling such that subsequent sampling of the precise same area would give erroneous results due both to previous removal of organisms, and modification of the sediment texture and layering from previous digging. Therefore a program would be required to assess species fidelity and relative abundance in replicate samples. A $0.1m^2$ quadrat frame would be sufficient for quantitative sampling in stable sediments; however, a cofferdam might be necessary in less stable sediments.

Accurate recovery of organisms from samples containing a large size range of sediment (e.g., pebble, gravel, coarse and fine sand) would require multiple sieving through a range of mesh sizes (e.g., 5mm, 2mm and 1mm).

Details on sampling methods can be elaborated on if a baseline study is given further consideration.

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Khoyatan Marine Laboratory

PHOTOGRAPHS: Keyed to photo sets A through F

1. Spouter Island, Nootka Sound [sta. 32/91]
   32/91 E36a: View of beach
   F0 : Algal cover in low intertidal
   F3 : Encrusting organisms under rock low tide zone

2. Esperanza Inlet [sta. 27/91 and 28/91-control]
   27/91 D4a: View of low tide zone
   D6a: Algal cover in low and mid tide zone
   D7a: Encrusting organisms under rock in low tide zone
   28/91 No photos available unless John has some

3. Strange Island [sta. 26/91 and 33/91-control]
   26A/91 = photo labels of 26/91
   [C26: Shore transportation system]
   C27: View of beach during low tide
   C28: Algae on boulders in mid-low tide zone
   C29: Eelgrass in low tide zone
   26B/91 C31: View of mid and low tide zones
   C32: Barnacles in mid tide zone
   C33: Rock weed, sea lettuce in mid tide zone
   C34: Shallow tide pool in low intertidal
   C35: View of mid and low tide zones
   C36: View of high and supratidal zones

   33/91 F4: View up beach from low intertidal
   F5: View across beach in low intertidal
   F8: Algal cover in mid intertidal
   F6: Algal and eelgrass cover in low intertidal
   F7: Encrusting organisms under rock in low tide zone
   F10: Water in pit sampled for interstitial fauna [and high tech sampling equipment]

4. Zuciarte Channel [sta. 31/91]
   31/91 E32: View along beach at east end [sample site near far end of large log]
   E34: Low intertidal boulders
   E35: Algal cover in mid intertidal
   E36: Algal cover in low intertidal

5. Kyuquot Sound [sta. 29/91 and 30/91]
   29/91 D10a: View along beach in mid tide zone
   D 9a: Algal cover in low-mid tide zone

   30/91 D11a: View along from mid tide zone

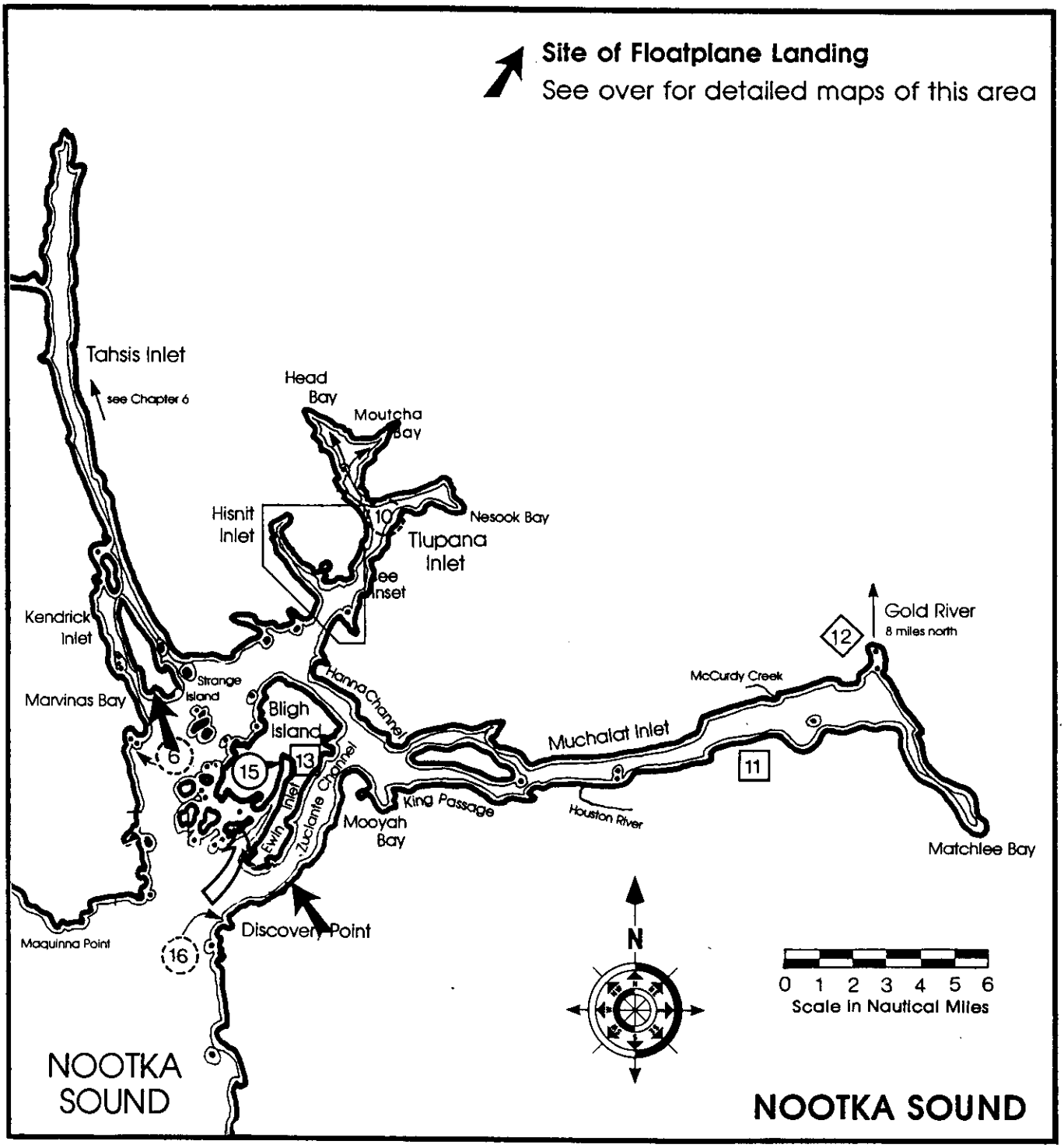
6. Quatsino Sound [sta. 24/91 and 25/91]
   24/91 C 2: View of low tide zone
   C 1: Water in pit sampled for interstitial fauna
   [C 3: Seaward view from beach and survey plane

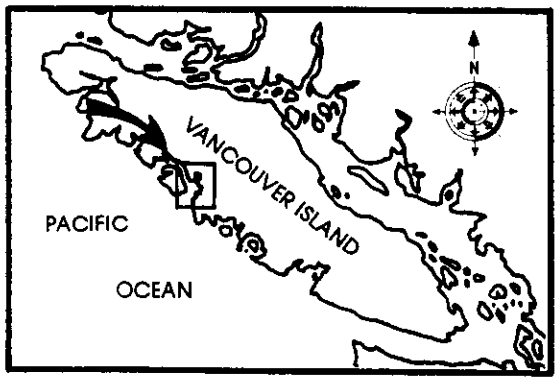
   25/91 C 5: View of beach
   C 6: Hardpan sediment underlying cobble veneer

PCOS RECONNAISSANCE SURVEY

AERIAL VIDEO LOCATOR GUIDE
(17 APRIL 1991)

	PDT
NOOTKA SOUND	
MOCHALAT INLET	0645-0655
HANNA CHANNEL	0656-0657
STRANGE IS.	0700-0702
BLIGH IS	
SAN CARLOS PT TO CONCEPTION PT	0710-0715
ZUCHIANTE CHANNEL	0715-0718
DISCOVERY PT TO ANDERSON PT	0720-0727
NE BLIGH IS	0731-0732
ESPERANZA INLET	
HECATE CHANNEL	0756-0758
ESPERANZA INLET (E) TO ESPINOSA INLET (E)	0759-0806
ESPINOSA INLET (W) TO ELIZA INLET	0807-0812
ESPERANZA INLET (S)	0815-0822
KYUQUOT	
CHACHALOT INLET TO PINNACLE CHANNEL	0928-0937
KACHUTL INLET (W)	0939-0946
UNION IS (NE)	0950-0953
HOHOAE IS	1001-1009
MOKETAS IS	1011-1017
UNION IS	
SURPRISE IS TO WHITE CLIFF HEAD	1023-1026
KYUQUOT CHANNEL	
RUGGED PT TO CHACHALOT INLET	0955-0958
QUATSINO SOUND	
CLIFF PT TO BROKEN IS	1103-1114
TIDSTAD IS TO NORDSTROM COVE	1115-1124

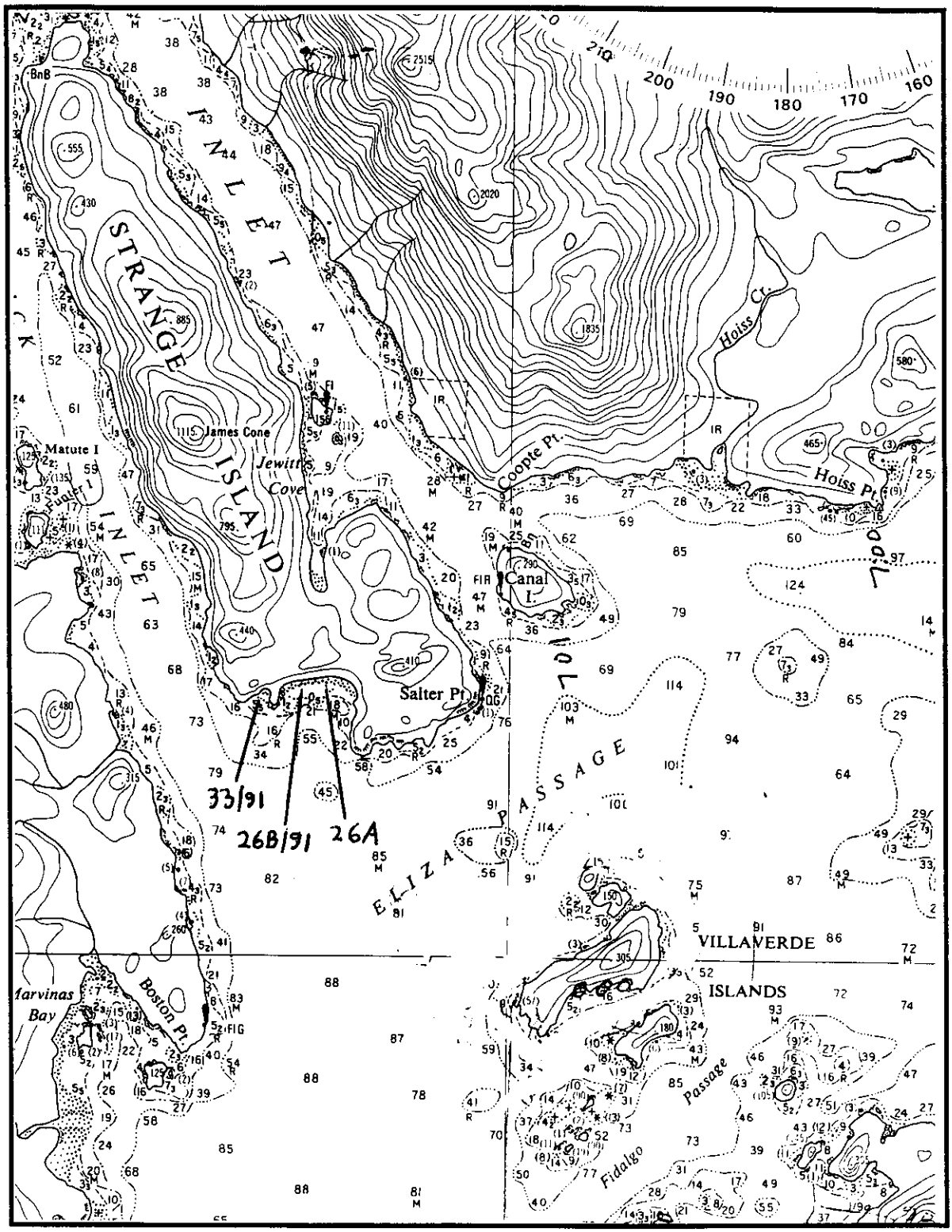




SYMBOL LEGEND

- Anchorage
- Conditional Anchorage
- Public Float
- Public Mooring Buoys
- Marina
- Aid to Navigation
- Point of Interest
- Settlement
- Trail
- Park or Reserve

Not to be used for navigation. Obtain appropriate CHS charts.



Detailed Location Map

CHS Chart No. 3664 Numbers refer to biology Sta. # - Appendix C

Scale 1:40,000

Aerial view of "control" bay at Strange Island

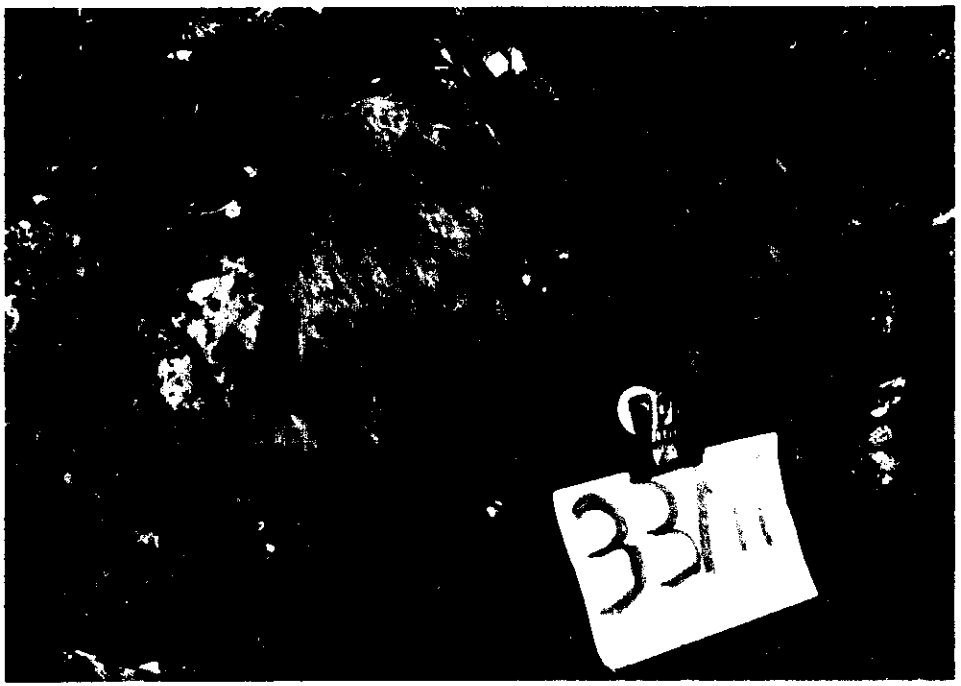
View of mid to upper intertidal zones

Pit #3 in the mid-intertidal

Pit #1 in the upper intertidal

View across the beach in the lower intertidal

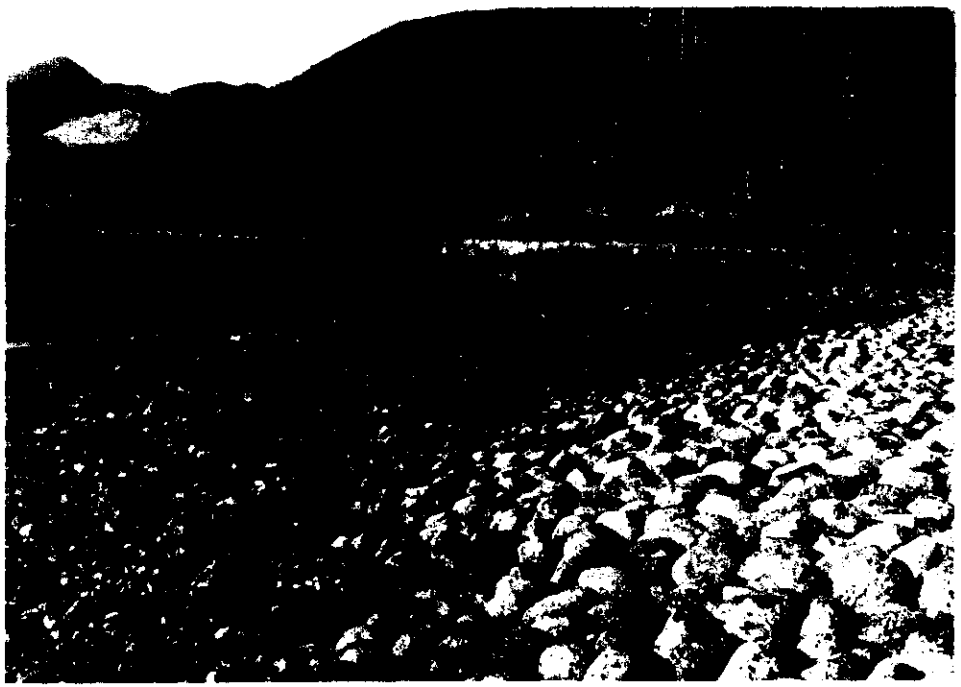
Algal and eelgrass cover in the low intertidal



Algal cover in the mid-intertidal

Aerial view of the Strange Island site

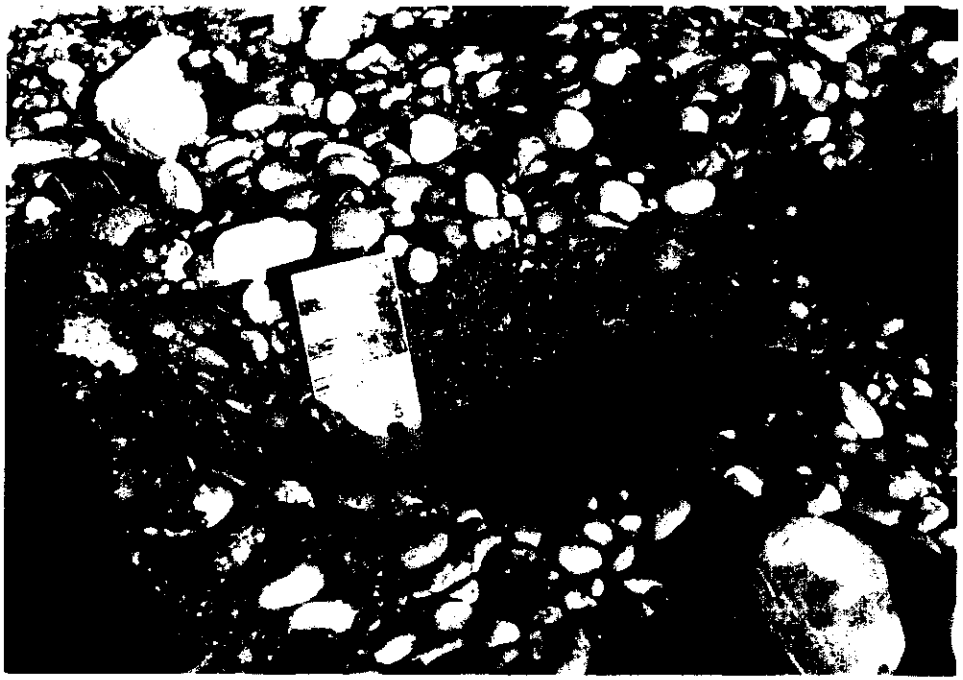
View showing the beach in the vicinity of Profile 1 (see App B)



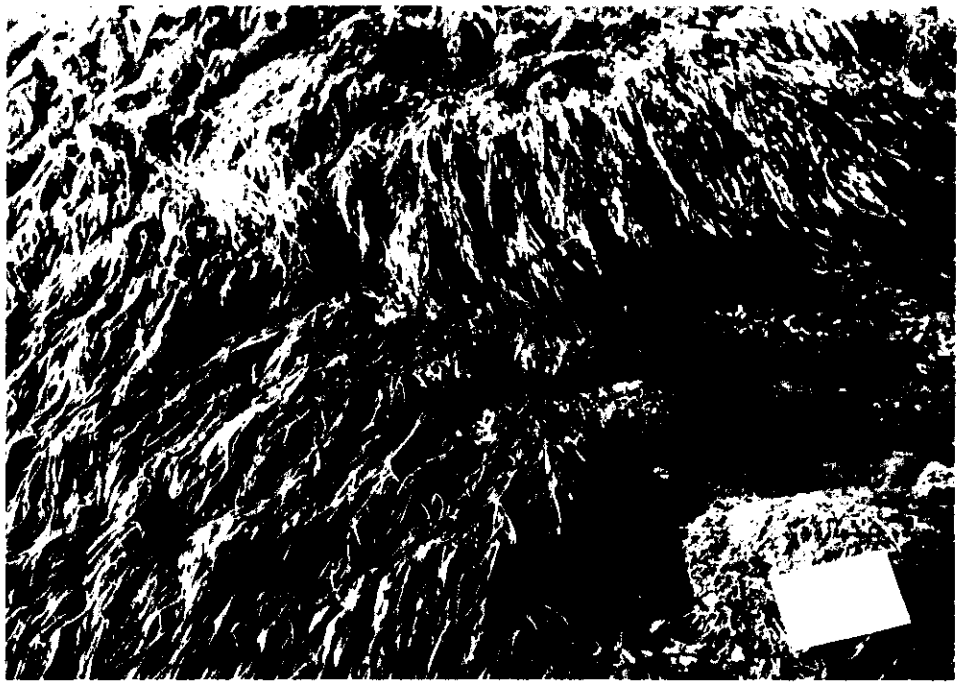
View of mid to lower-intertidal zones.

Pit #2 uppper inter-tidal zone

Pit in lower intertidal zone



Pit #4 mid-intertidal zone

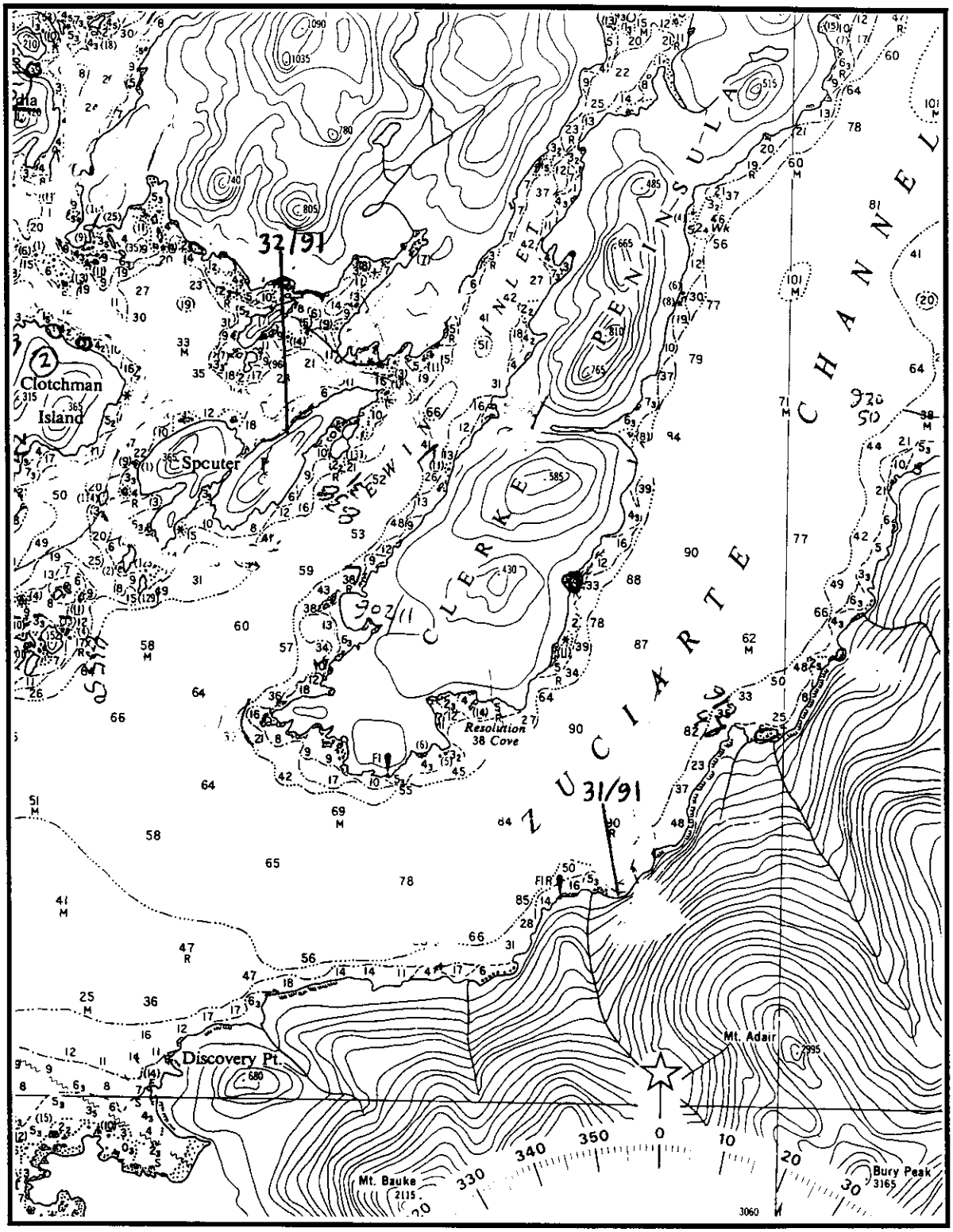


Eelgrass in lower intertidal (see bio profile 26A)

Barnacles in the mid-intertidal (see bio profile 26B)

Rock week, sea lettuce in the mid intertidal (26B)

Shallow tide pool in the lower intertidal

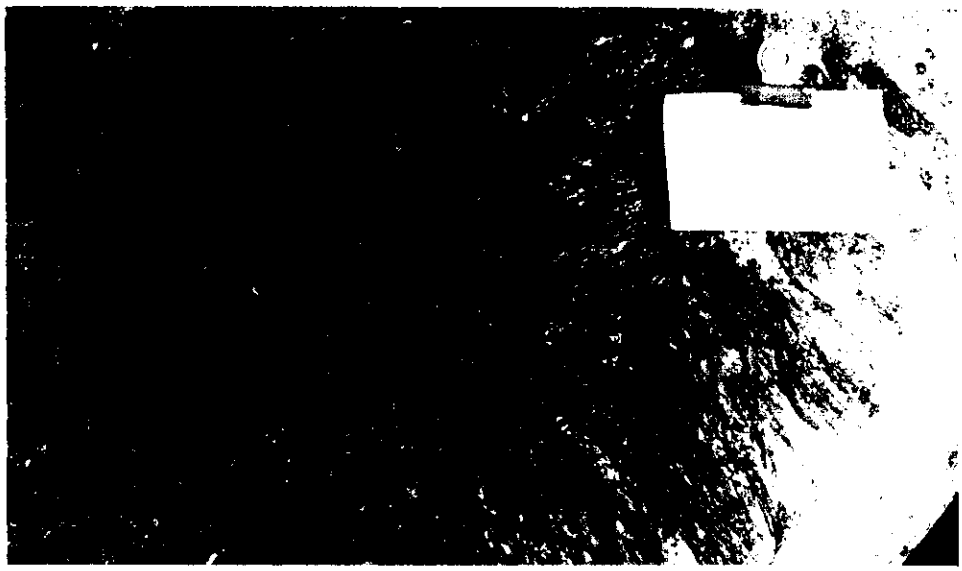


Detailed Location Map

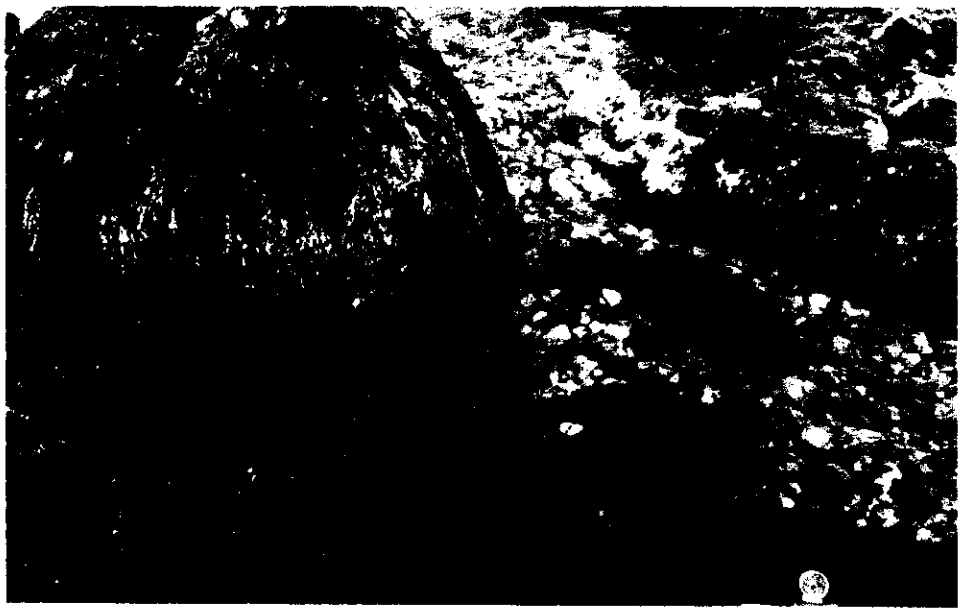
CHS Chart No. 3664 Numbers refer to biology Sta. # - Appendix C

Scale 1:40,000

Zuciarte Channel site



Algal cover in the mid-intertidal zone

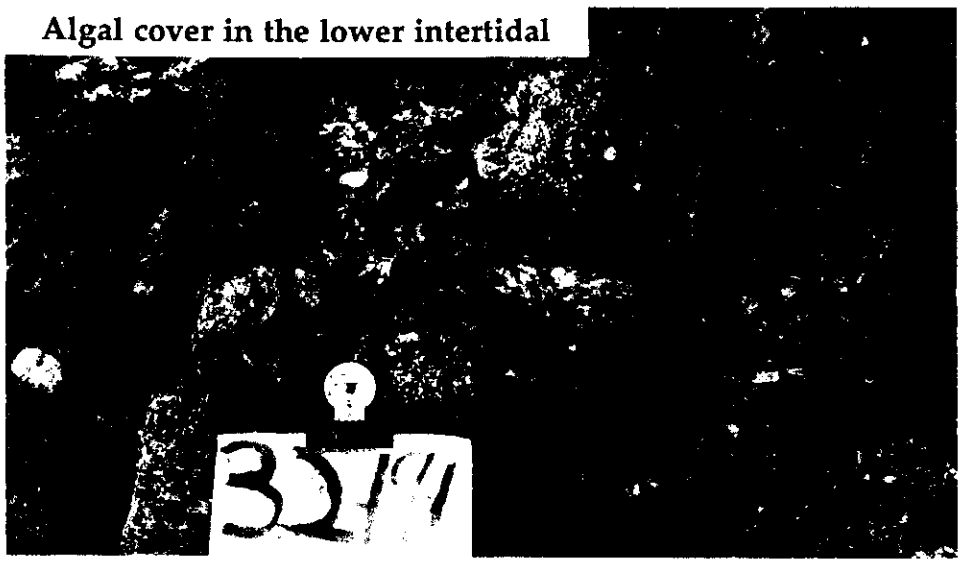


Algal cover in the lower intertidal zone

Spouter Island mid intertidal zone

Pit in the mid-intertidal (see App B)

Algal cover in the lower intertidal

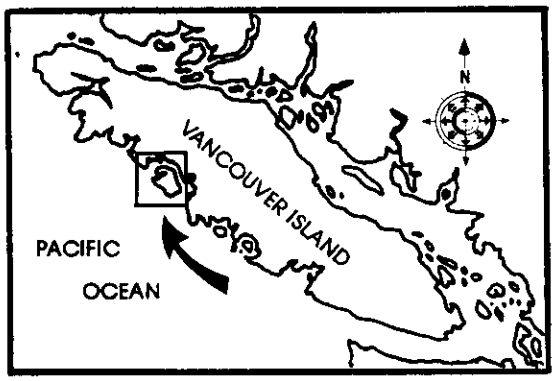


ESPERANZA INLET

Scale in Nautical Miles
0 1 2 3 4 5

See Chapter 5

Zeballos
Zeballos Inlet
Espinosa Inlet
Little Espinosa Inlet
Tahsis
Port Eliza
Esperanza
Ceepeecee
Ehatisaht
Queen Cove
Rolling Roadstead
Tahsis Narrows
Esperanza Inlet
Hecate
McBride Bay
Blowhole Bay
Tahsis Inlet
Catala Island
Gillam Channel
Port Langford
Benson Point
Inner Basin
Nuchatlitz
Mary Basin
Nuchatlitz Inlet
Tsowwin Narrows
Ferrer Point
Louie Bay
Nootka Island
N
Bajo Point
Bajo Reef
Site of Floatplane Landing
See over for detailed maps of this area
Nootka Sound



SYMBOL LEGEND

- Anchorage
- Conditional Anchorage
- Public Float
- Public Mooring Buoys
- Marina
- Aid to Navigation
- Point of Interest
- Settlement
- Trail
- Park or Reserve

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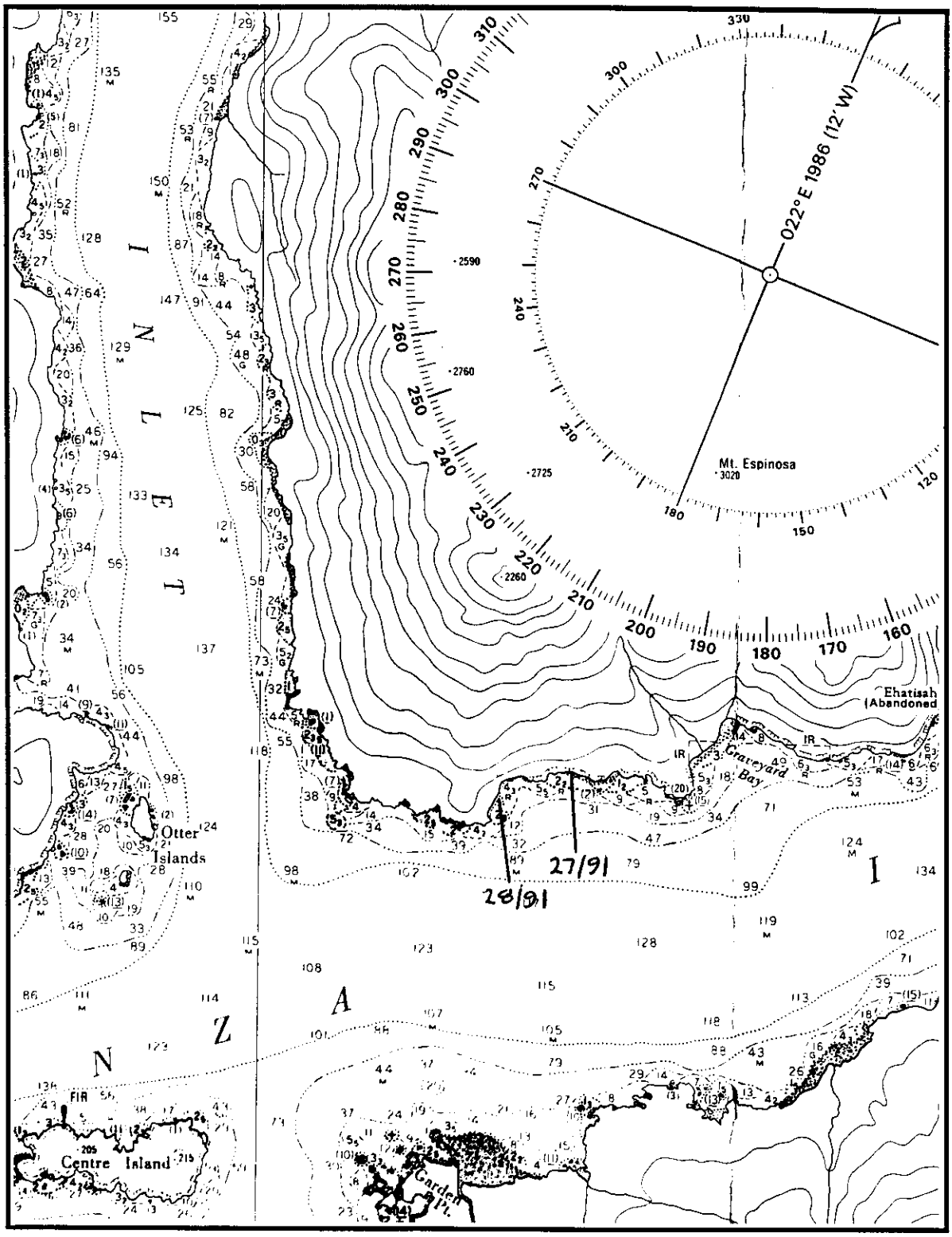


Detailed Location Map

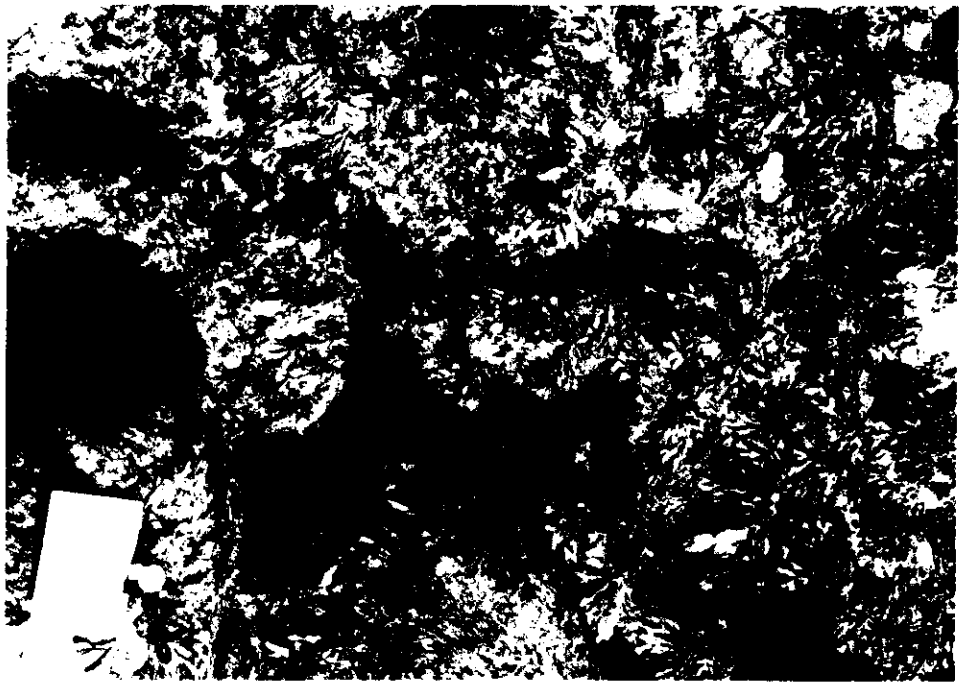
CHS Chart No. 3663_ Numbers refer to biology Sta. # - Appendix C

Scale 1:40,000

Aerial view of Esperanza Inlet site

Mid-intertidal zone

View of low intertidal zone (see Biological notes 27/91)



Algal cover in low and mid-intertidal zone

Pit #1 upper intertidal zone (see App B)

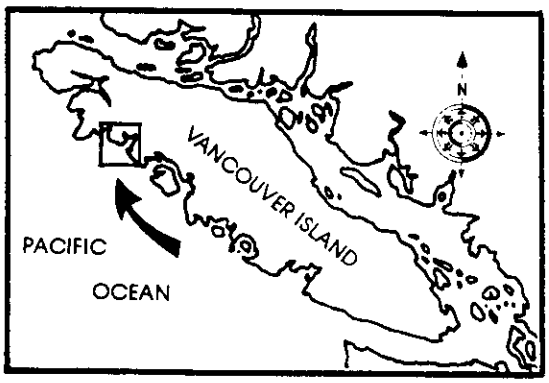
Pit #3 mid- intertidal zone (see App B)

KYUQUOT SOUND

Scale in Nautical Miles
0 1 2 3 4 5

Site of Floatplane Landing
See over for detailed maps of this area

Wood Cove
Malksope Inlet
Easy Inlet
Hankin Cove
Yaku Bay
Tahsish Inlet
Eelstow Passage
Moketas Island
Chamiss Bay
See inset
Surprise Island
Channel
See Chapter 4
Kyuquot
Fair Harbour
Amai Inlet
Crowther
Union Island
Amos Island
Nicolaye Channel
Kyuquot Channel
Cachalot Inlet
Ship Peak
Anvil Peak
Remarkable Cone
N
Clear Passage
Jurassic Point
Tatchu Point



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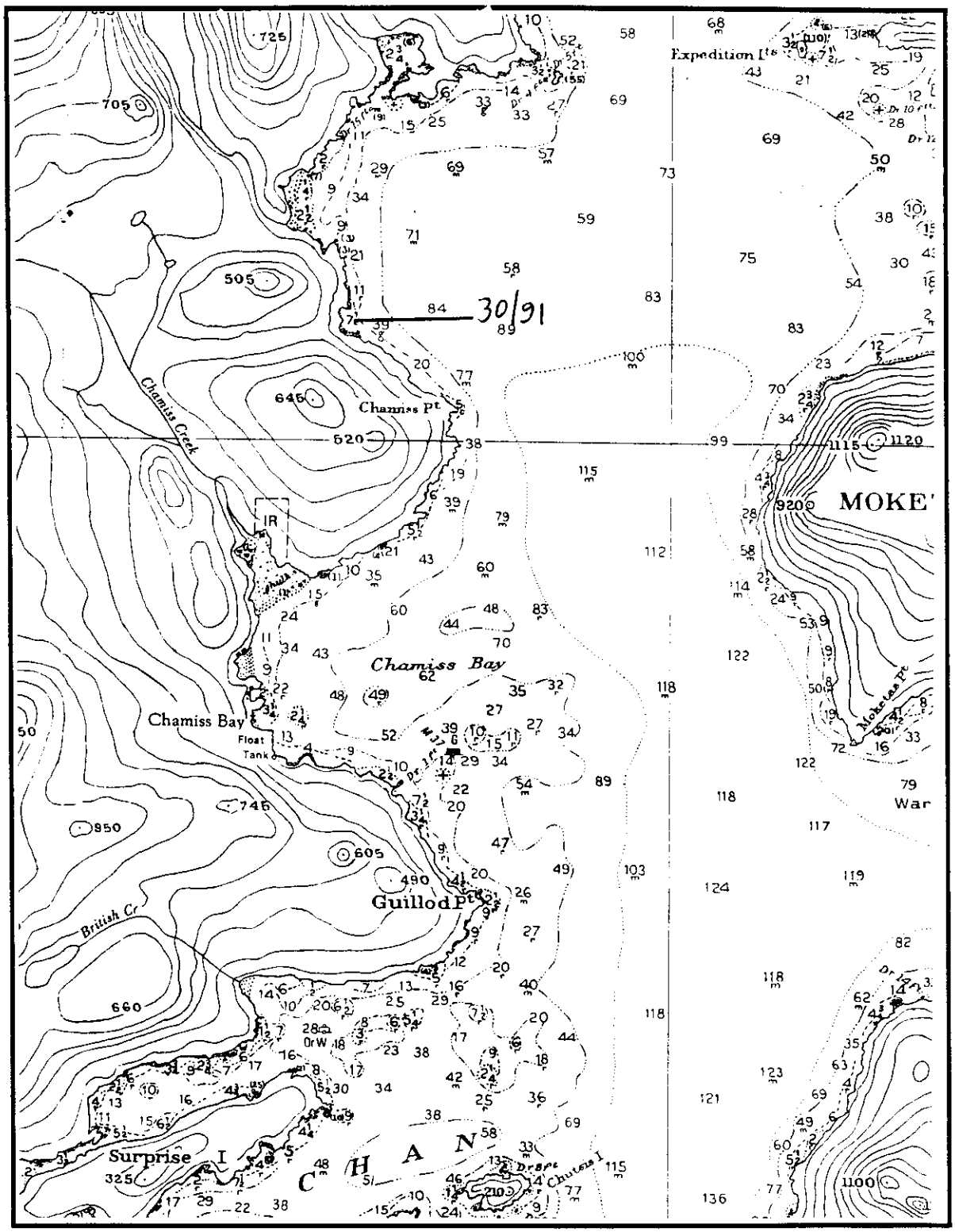


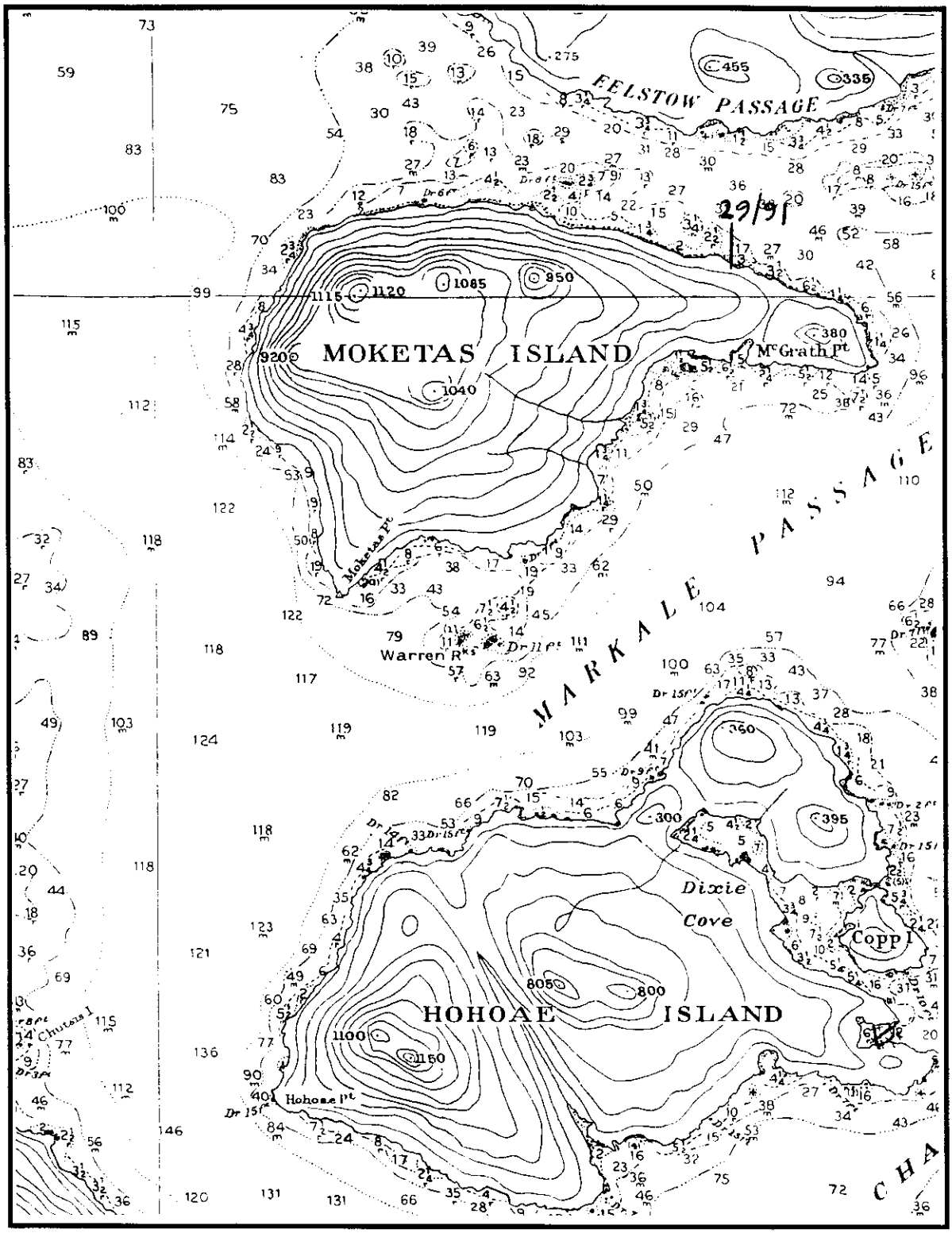
Detailed Location Map

CHS Chart No. 3682 Numbers refer to biology Sta. # - Appendix C

Scale 1:36,700

Site north of Chamiss Point (see bio profile 30/91)

Pit #2 in the mid-intertidal zone (see Appendix B)



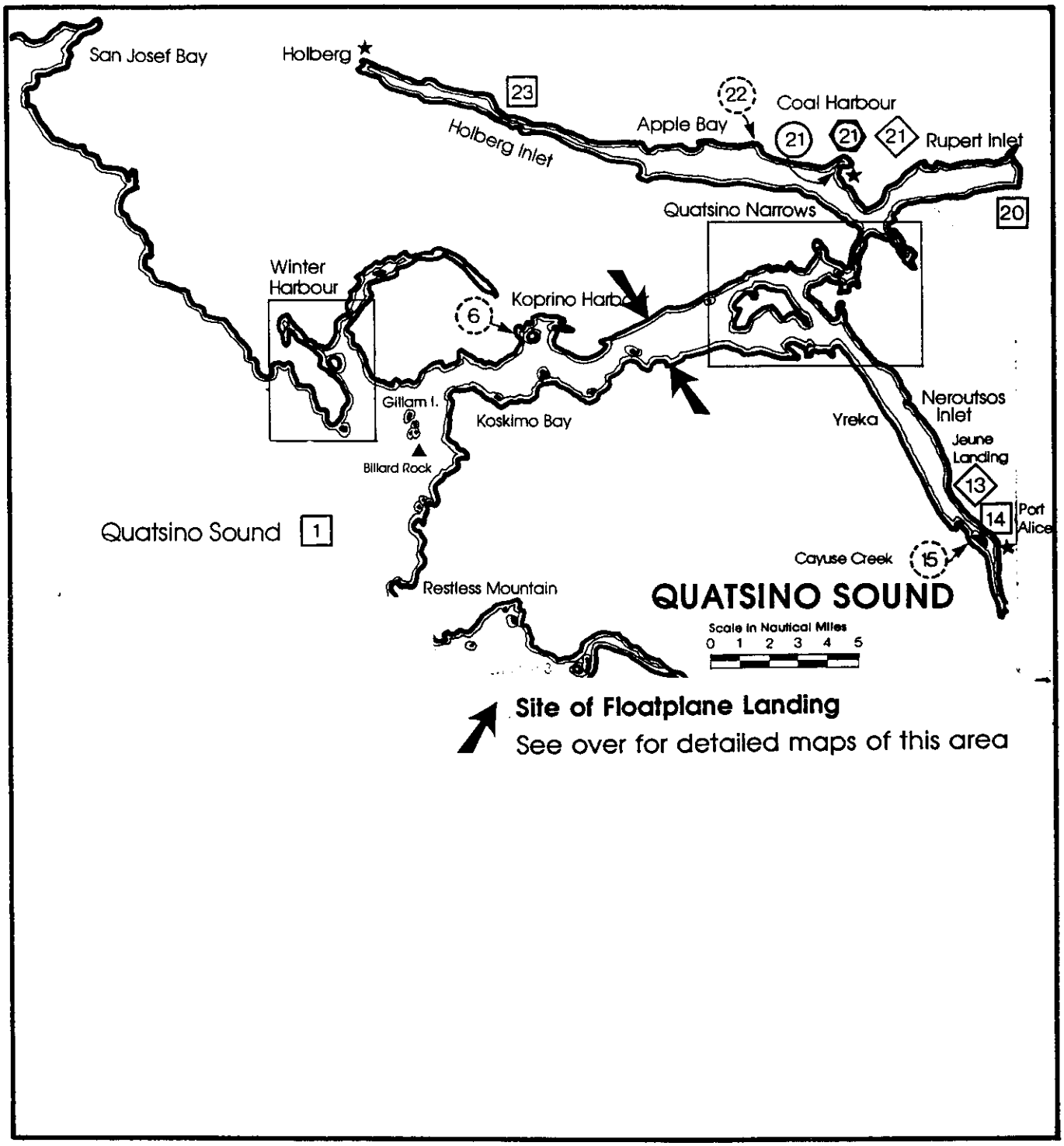
Detailed Location Map

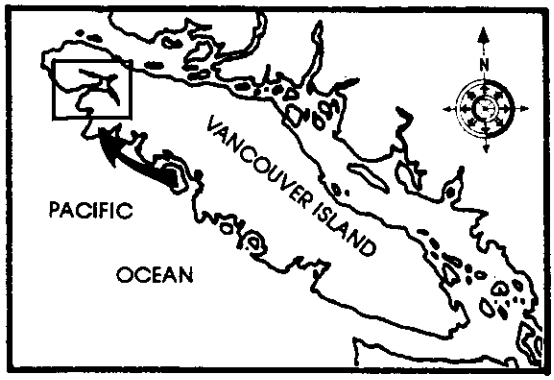
CHS Chart No. 3682__ Numbers refer to biology Sta. # - Appendix C

Scale 1:36,700

View along the beach, north side of Moketas Island

Algal cover in the low to mid-intertidal zone (see App C profile 29/91)





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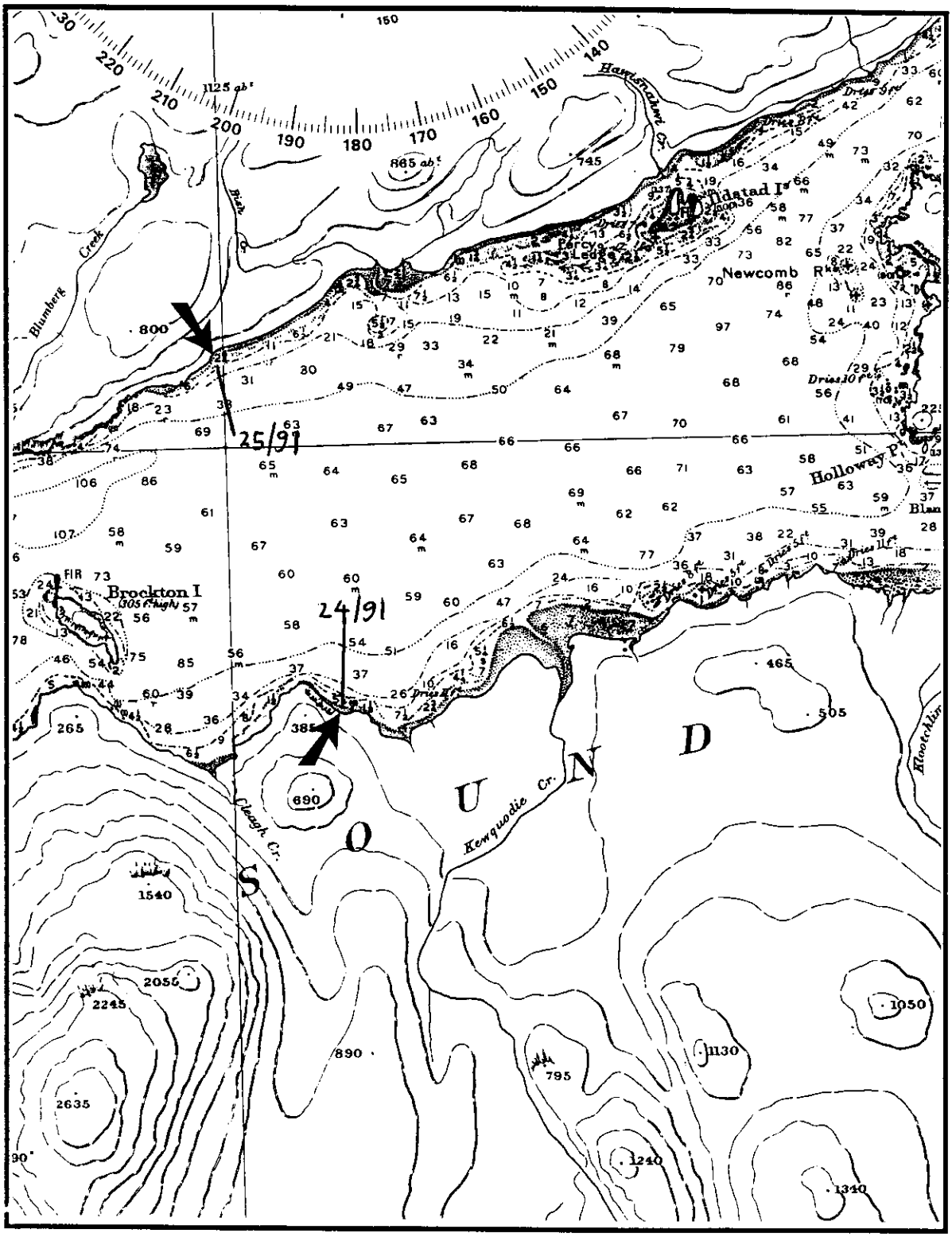


Detailed Location Map

CHS Chart No. 3617__ Numbers refer to biology Sta. # - Appendix C

Scale 1:36,500

Quatsino Sound (south site) general view

View showing the thin cobble veneer (similar at the north site)

PRELIMINARY RANKING OF SITES

General Location	Site	Approx. Length(m)	Approx. Dimension (m)	Character	Permeability
Nootka Sound	Strange Is.#1	400m	50m	pebble, cobble, boulder beach	High to low
	Strange Is.#2	70m	50m	pebble, cobble, boulder beach	High to low
Esperanza Inlet	Espinosa	300m	50m	cobble, boulder beach	High to low
Nootka Sound	Spatter Is.	100m	20m	pebble/ cobble veneer	Low
[Sites below judged significantly less suitable]					
Nootka Sound	Discovery Bay	100m	50m	boulder beach	
Kyuquot Sound	Moketas Is.	500m	20m	cobble, boulder over clay and sand	low
	Chamiss Bay	200m	30m	pebble/ cobble over sand	low
Quatsino Inlet	South side	200m	40m	pebble/ cobble over sand	low
	North side	1,000m	30m	pebble over sand & mud	low

Strange Is. Site (18 April 1991, 0800-1000)

This site is located at the south end of Strange Island and is a long, 300-400m, pocket beach grading from pebble sand in the east to cobble boulder in the west. The site attracted attention because of (a) its uniformity, (b) exposure to refracted Pacific swell and (c) flora/fauna assemblage.

Initial landing was in the eastern one third of the beach (Strange Is., Profile 1). Profiles were surveyed and pits dug. However, the pits revealed a fine subsurface and no permeability testing was conducted. The finer sediment, more prevalent in the LITZ, made this location less interesting than locations to the west.

A second profile was surveyed on the western third of the beach. This section of the beach graded from pebble, cobble material in the UITZ to cobble, boulder in the LITZ. The marine limit extended to above +5m from chart datum. The backshore consisted of a heavily vegetated slope.

Permeability of the beach ranged from high in the UITZ to low in the LITZ where finer material was present in the subsurface.

The site was considered potentially suitable from a geomorphological point of view because (a) UITZ and MITZ sediments were highly to moderately permeable respectively, (b) approximately 200m of uniform linear beach occurs at the western end of the pocket, and (c) the substrate in the LITZ was sufficiently large and immobile to support a stable flora and fauna.

[Photos: JRH #2, FR 1 - 12, Profile 1]
[FR 13 - 23, Profile 2]

Strange Is. Pocket Beach (19 April 1991, 1100)

This site was a small, 70m long pocket beach, located to the west of the main Strange Is. site. It was evaluated as a possible experimental control site. As such observations were similar to that of the Strange Is. site.

As with the main site, the beach graded from pebbles in the UITZ to cobble/boulders in the LITZ, although sand was also common in the LITZ.

Permeability was similar to that of the main Strange Is. site, with high permeability in the UITZ and low permeability in the LITZ/MITZ. The lower permeability zone extended higher on this beach than on the main site.

The pocket beach was considered potentially suitable for experimental work for the same reasons as the main site.

[Photos: JRH #4, FR 32 - 36]
[JRH #5, FR 1 - 9]

Strange Is. #1 18 April 1991

Horizontal		Vertical			
Inc.	Cum.	Inc.	Cum.	Sed	Notes
	40.4		5.88	P	
2.46	38.0	-102	4.86	P	approx, marine limit
2.00	36.0	-10	4.76	P	storm log line
1.11	34.9	-33	4.43	P	LHTS
1.86	33.0	-53	3.90	P	to Pit #2
3	30.0	-58	3.32	P	
3	27.0	-47	2.85	P	Pit #3
3	24.0	-46	2.39	P	Pit #4
3	21.0	-43	1.96	P,C	
3	18.0	-40	1.56	G,P,C	Pit #5
3	15.0	-44	1.12	C,P,G,S	LTT
5	10.0	-35	0.77	C,S,P	
5	5.0	-16	0.61	S,C,P	
5	0.0	0	0.61	S,C	Tide +0.61 at 0815
12.2	-12.2	-26	0.35	S,P	Eel Grass

TEN SECOND PERMEABILITY TEST RESULTS

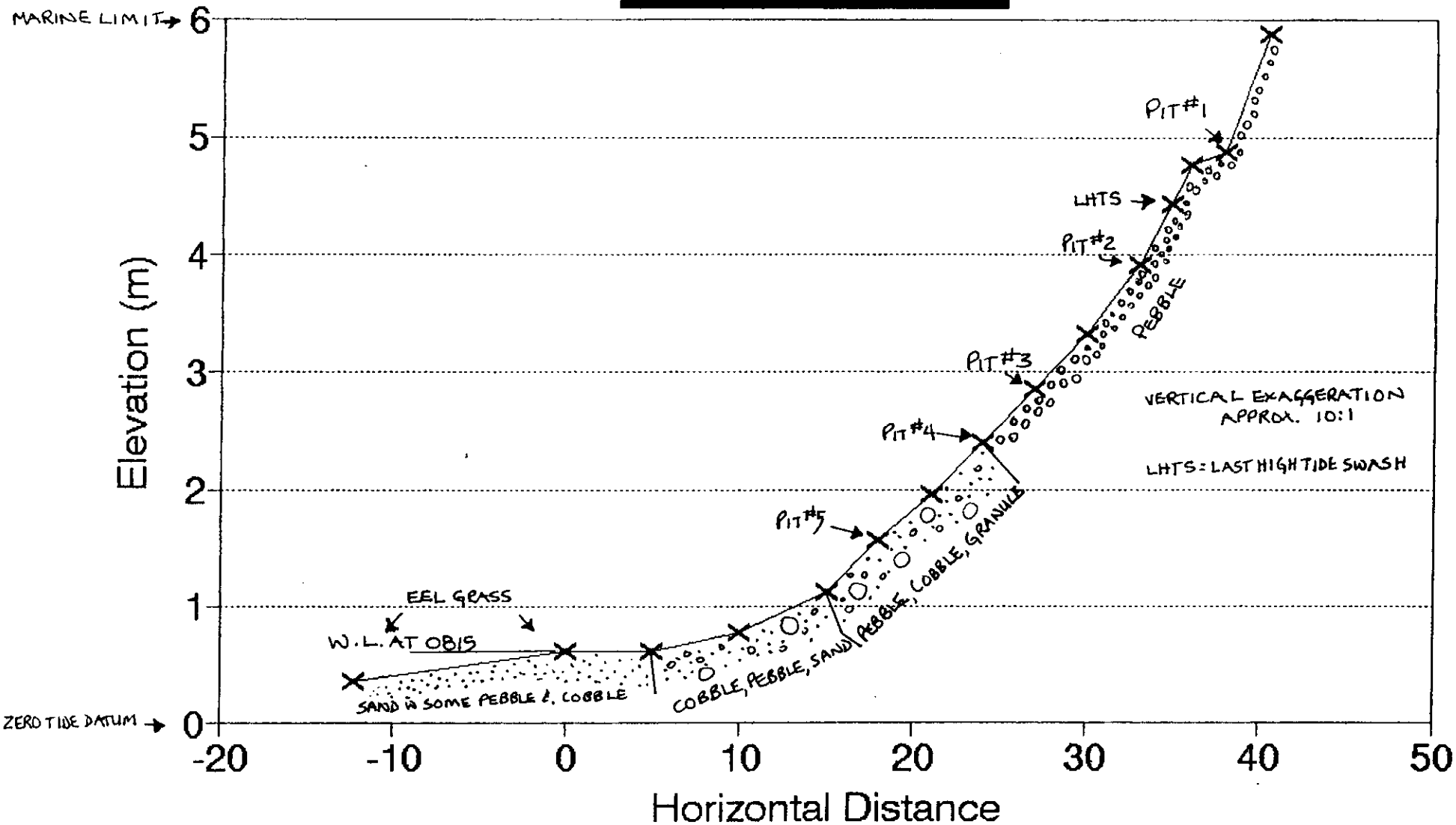
Location	Time	Permeability Index

NO PERMEABILITY TESTS CONDUCTED DUE TO HIGH SAND CONTENT IN SUBSURFACE

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ(LHTS)	0 - 10	well sorted pebble
		10 - 40	poorly sorted coarse sand (terrestrial) with organics
#2	UITZ	0 - 30	well-sorted pebble; some organics
		30 - 35	coarse sand
#3	MITZ	0 - 3	well-rounded pebble
		3 - 30	coarse sand
#4	MITZ/LITZ	0 - 10	well rounded, well sorted pebble
		10 - 12	well-sorted granule
		12 - 30	coarse sand

Strange Is
Profile 1



Strange Is. #2 18 April 1991

Horizontal		Vertical			
Inc.	Cum.	Inc.	Cum.	Sed.	Notes
	64.2		5.40	C,P	marine limit
1.25	62.9	-80	4.60	C,P	storm log line
1.5	61.4	-13	4.47	C,P	Pit #1
1.5	59.9	25	4.72	C,P	
2.9	57.0	-86	3.86	C,P	Pit #2
5	52.0	-114	2.72	C,P	
5	47.0	-42	2.30	C,P	Pit #3
5	42.0	-2	2.28	C,B,P	
5	37.0	-44	1.84	C,P,B	Pit #4
10	27.0	-55	1.29	C,B,P	Pit #5
10	17.0	-24	1.05	B,C	top of fucus
4	13.0	-54	0.51	P	
13	0.0	-38	0.13	C,B,P	Tide +0.13 at 0920 LTT

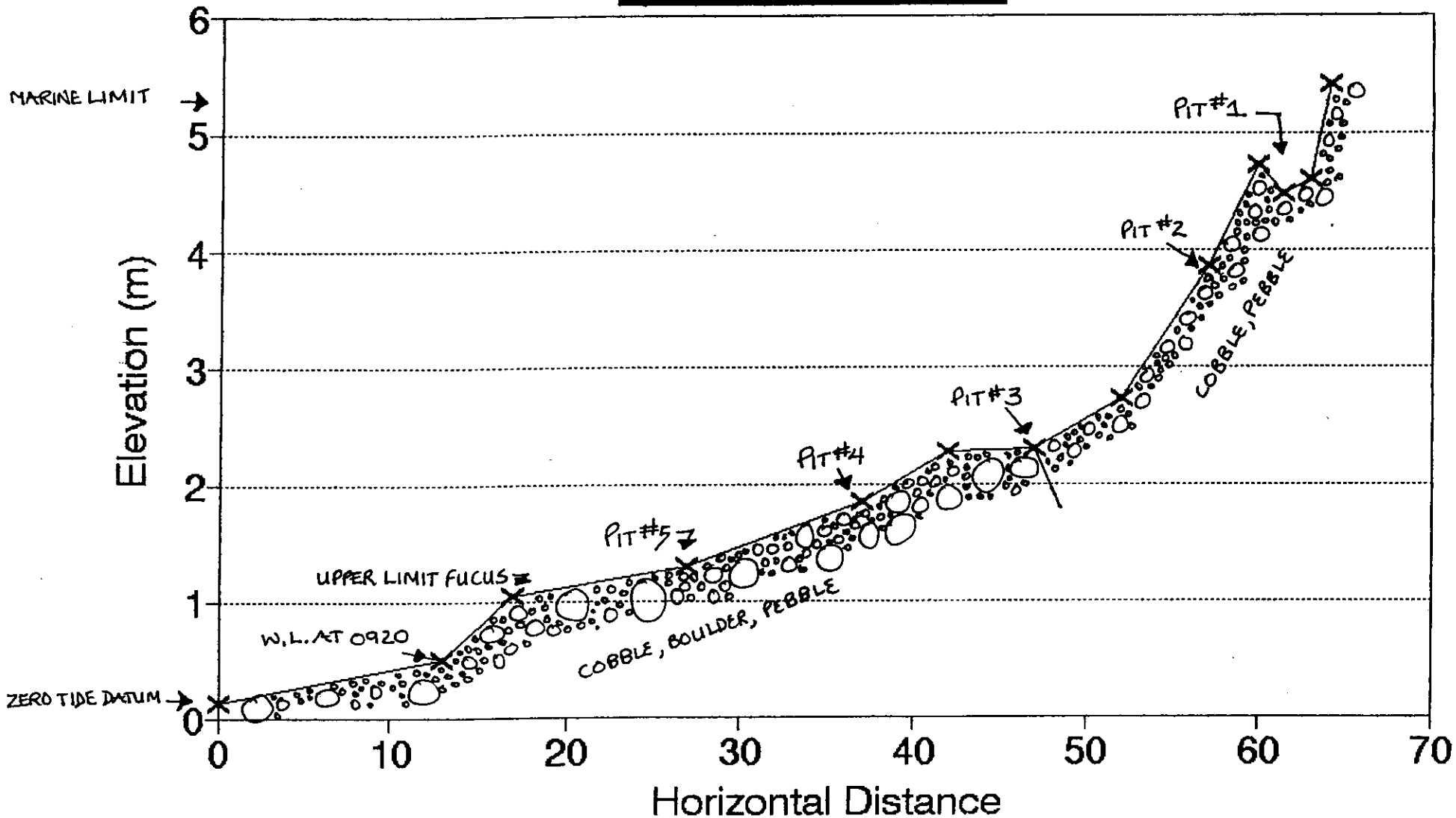
Ten Centimetre Permeability Tests

Location	Time	Permeability Index
Pit #1	8.2 sec.	High Permeability
Pit #2	74 sec.	Moderate Permeability
Pit #3	195 sec.	Low Permeability

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	STZ	0 - 10	poorly sorted pebble, cobble, granule
		10 - 30	poorly sorted granule, sand, pebble, cobble
#2	UITZ(LHTS)	0 - 15	cobble, pebble
		15 - 30	granule, pebble
		30 - 45	pebble, granule
#3	UITZ/MITZ	0 - 10	cobble, pebble, granule
		10 - 30	poorly sorted sand granule
#4	MITZ	0 - 15	cobble, boulder, pebble veneer
		15 - 30	poorly sorted sand and pebble (abundant shell hash)

Strange Is
Profile 2



Strange Is. #3 19 April 1991

Horizontal		Vertical			
Inc.	Cum.	Inc.	Cum.	Sed.	Notes
	46.3		4.75	P,C	Pit #1
4	42.3	-92	3.83	C,P	
1.8	40.5	-34	3.49	B,C	Pit #2
9	31.5	-126	2.23	B,P,S	Pit #3
11	20.5	-98	1.25	P,B,S	top of algae
3	17.5	-18	1.07	C,S	Pit #4
10	7.5	-28	0.79	S,C,P	Pit #5
7.5	0.0	-18	0.61	S,P,C	Tide +0.30 m at 1125 zostera

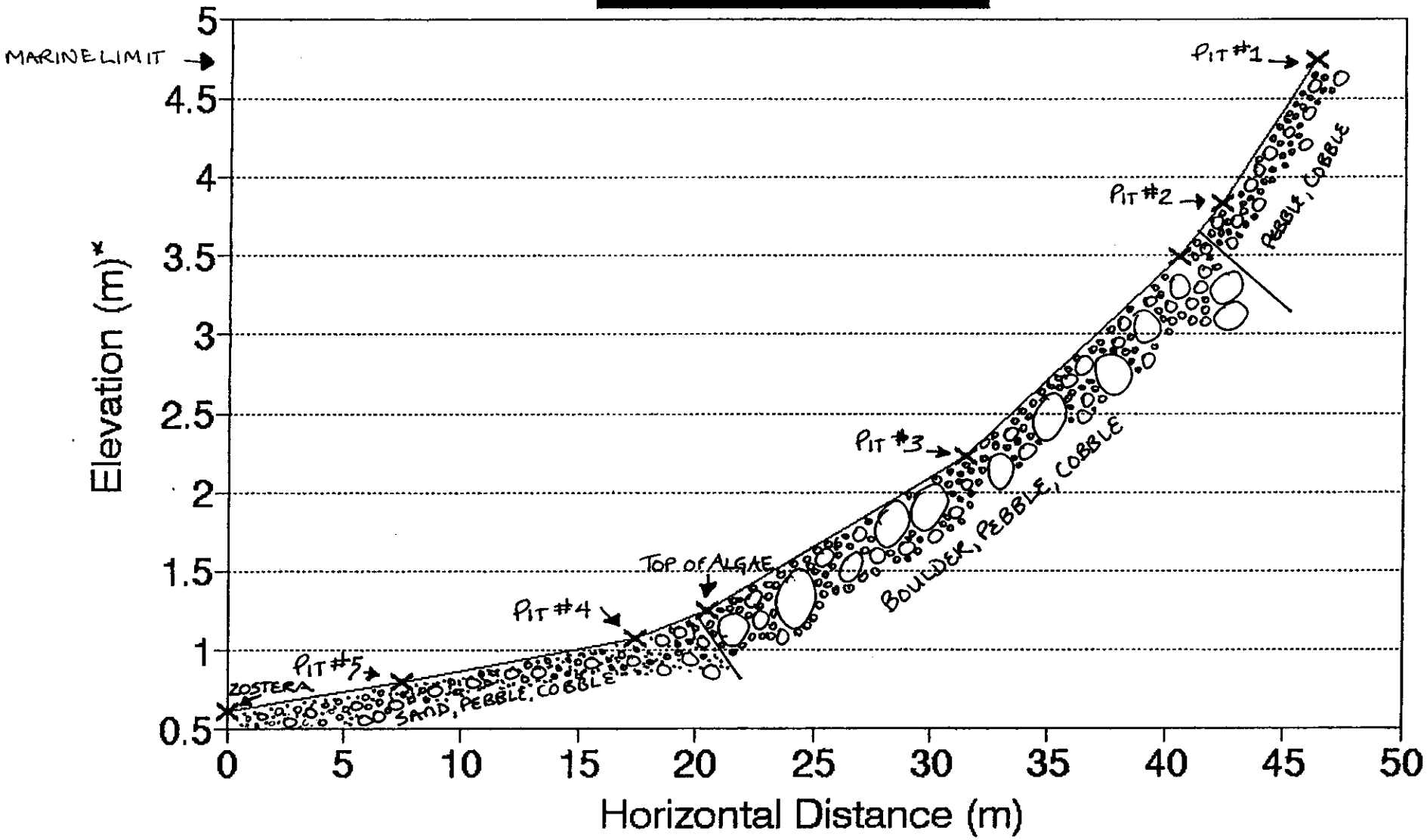
Ten Centimetre Falling Head Permeability Test

Location	Time	Permeability Index
Pit #2	15 sec.	High Permeability
Pit #3	284 sec.	Low Permeability

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ(LHTS)	0 - 15	poorly sorted, well rounded pebble, granules
		15 - 25	sandy granules with pebbles and cobbles
#2	UITZ	0 - 10	poorly sorted, well rounded pebble cobble
		10 - 20	coarse sand, granules
#3	MITZ	-	boulder cobble SURFACE LAYER
		-	sand/granule subsurface
#4	LITZ	-	pebble/cobble surface veneer
		-	poorly sorted sand granule material in subsurface

Strange Is
Profile 3



*ADD 18 cm TO CORRECT FOR COMPUTATIONAL ERROR.

Espinosa Site (18 April 1991, 1110)

This site attracted attention because of its uniformity, length and moderate wave exposure.

The main site consists of a 200-300m long cobble/boulder beach with a south-westerly facing orientation. A smaller steeper beach of angular cobble veneer over bedrock lies immediately to the west. Although the coastal orientation is different, the beach is oriented towards the southeast, it is potentially suitable as a site.

The intertidal zone width is approximately 30m with a +4.51m elevation of the active marine limit. During the site visit, 12 second period groundswells were observed, indicating exposure to refracted Pacific swell.

Permeability ranged from high to low from the UITZ to the MITZ.

The site was considered potentially suitable because of its moderate wave exposure, high permeability (UITZ only), and large immobile substrate that supports flora and fauna in the LITZ.

[Photos: JRH #3, FR 1 - 8]

Espinosa #1 18 April 1991

Horizontal		Vertical				
Inc.	Cum.	Inc.	Cum.	Sed.	Notes	
	33.6		4.51		P	Marine Limit +70cm
1.5	32.1	-38	4.13		P	Pit #1
2	30.1	-42	3.71		C,P	
6.3	23.8	-22	3.49		B	Pit #2
7	16.8	-114	2.35		B,C,P	Pit #3
7.5	9.3	-98	1.37		B,C	
5.5	3.8	-86	0.51		B,C	
3.8	0.0	-26	0.25		B,C	Tide at +0.25 m at 1110

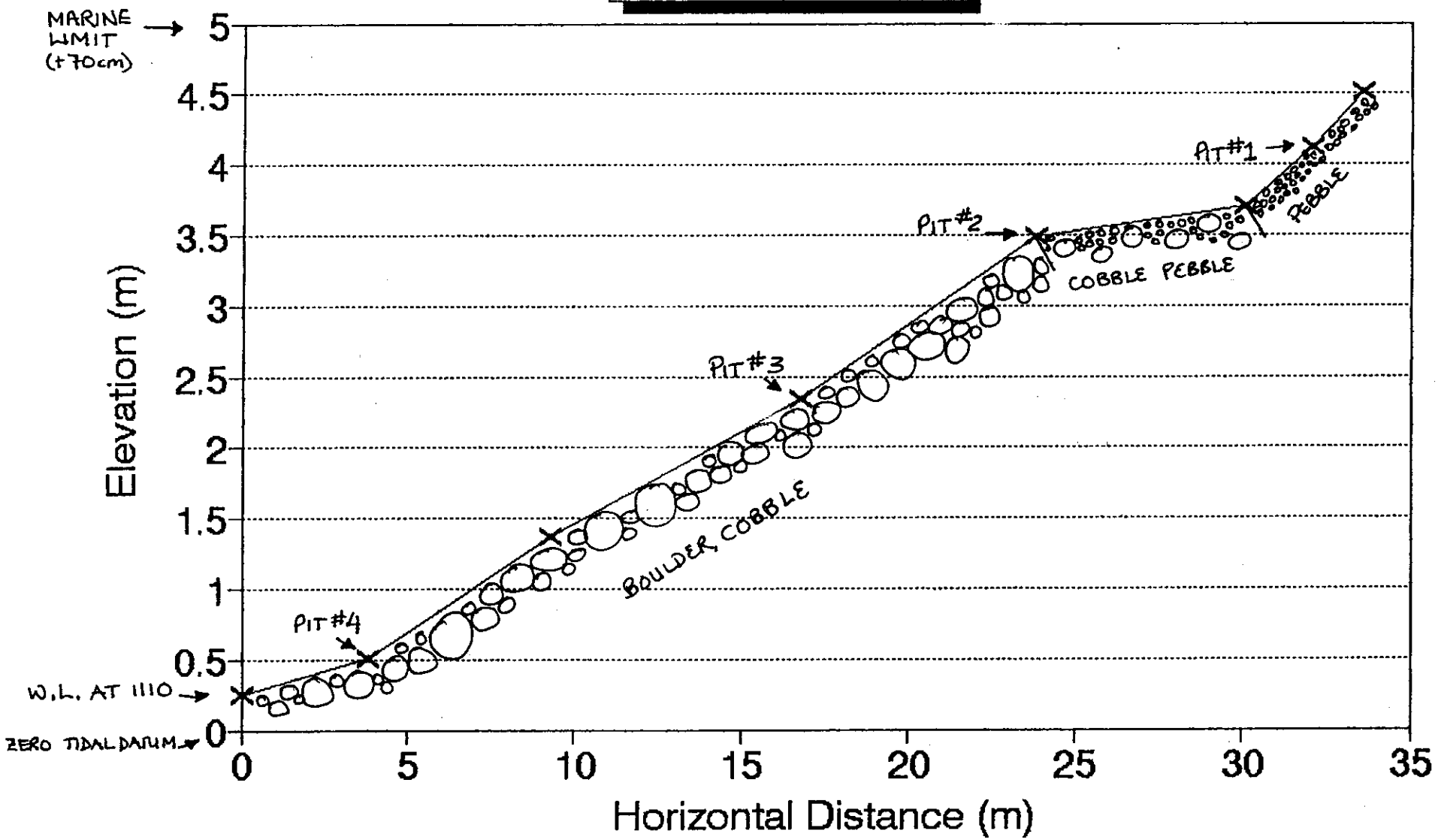
Ten Centimetre Falling Head Permeability Test

Location	Time	Permeability Index
Pit #2	2 sec.	High Permeability
Pit #3	330 sec.	Low Permeability

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ(LHTS)	0 - 40	well-sorted, "pea-sized" pebbles
#2	UITZ	0 - 10	cobble, boulder, pebble surface veneer
		10 - 50	poorly sorted, subangular pebbles
#3	MITZ	0 - 40	poorly sorted, boulder cobble
		40 - 60	cobble, sand, pebble
#4	LITZ	0 - 50	boulder, cobble, surface veneer
		50 - 60	sand, pebble, cobble, boulder

Espinosa
Profile 1



Espinosa #2 Site

This site lies immediately to the west of the main Espinosa site. Although the coastal orientation is different (east-facing rather than south-facing), refracted swell from Esperanza Inlet probably reaches the site. The site was evaluated as a "ancillary" location to the main site.

The site consisted of a high tide platform of angular pebble granule material over sand (est. 10 m in width), and a ramp of angular cobble/boulder sediment; this cobble/boulder material forms a thin veneer over (a) bedrock or (b) calcareous sand. Bedrock crops out sporadically along the shore.

No Stage 2 assessment was conducted because of (a) the low subsurface permeability and (b) the spatial variability of sediments (e.g. bedrock outcrops). However, in view of the proximity to the main Espinosa site, further attention is probably warranted.

North ~~Spatter~~ Spouter Island (19 April 1991, 1018)

This site was an approximate 100 m long cobble, pebble beach on the norther, sheltered side of ~~Spatter~~ Spouter Island. The site was selected for grounds observations as it appeared representative of the numerous pocket beaches on the lee-side of the islands.

The beach consisted of a high-tide platforms of pebbles and sand approximately 10 m wide. From this platform a veneer of cobbles sloped steeply (est. 15°) to the subtidal; this steep ramp is about 10 m in width.

Although pockets of permeable pebbles and granules occurred the high tide platform is, for the most part, a thin veneer of pebbles over sand. The ramp consists of a veneer of angular cobbles over cobbles and pebbles within a calcareous sand matrix.

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ(LHTS)	0 - 3	angular granules and pebbles
		3 - 10	poorly sorted coarse sand
#2	UITZ	0 - 20	poorly-sorted pebbly sand
#3	UITZ	0 - 30	well-sorted, angular pebbles (highly permeable)
#4	MITZ	0 - 5	poorly-sorted, angular, barnacle-encrusted cobbles and pebbles
		5 - 30	calcareous pebbly sand
#5	LITZ	0 - 5	poorly-sorted, angular to subangular cobble/pebble (barnacle encrusted)
		5 - 3	calcareous sand with some pebbles and cobbles (abundant shell fragments)

[Photos: JRH #4, FR 22 - 31]

Northeast of Discovery Bay (19 April 1991, 0930)

This site was located 2 km. NE of Discovery Bay and attracted attention because of (a) its moderate to high wave exposure near the mouth of Nootka Sound and (b) a similar companion bay located about 1 km to the northeast.

The beach is about 200m long and grades from sand in the northeast to large, well-rounded and well-sorted boulders in the southwest. Bedrock crops out at some locations along the beach.

The beach was not considered for a Stage 2 evaluation because (a) extensive freshwater run off was occurring through the beach, (b) sand was abundant in the eastern one-third of the beach and (c) the large boulders (> 1m diameter) would make logistics extremely difficult.

[Photos: JRH #4, FR 18 - 21]

Moketas Island (18 April 1991, 1250)

This site was selected as a representative low wave exposure, cobble/boulder beach typical of much of the interior of Kyuquot Sound.

The ground survey revealed a 20m-wide cobble/boulder/pebble veneer over sandy clay. The site was judged unsuitable for further investigation because of the low permeability of the subsurface.

North of Chamiss Bay (18 April 1991, 1320)

Two seventy-metre long pocket beaches were observed to the north of Chamiss Bay. Their aggregate length and uniformity merited further attention.

As with other protected beaches in Kyuquot Sound, there was a thin veneer of pebble/cobble material of sandy subsurface sediments in the UITZ and MITZ. The site was judged unsuitable for further investigation because of the impermeable subsurface material and impoverished fauna.

PCOS Ground Sites

Quatsino # 1 (17 April 1991, 1315)

This is a pebble cobble beach about 300m in length and 40m in width. A stream near the centre of the beach provided sediment along this east-facing coast.

While pits near the landing area showed reasonable permeability (well sorted granules to coarse sand in subsurface), pits 100m to the north showed a thin veneer of pebbles and cobbles over sand.

The site was not considered for a Stage 2 assessment due to low permeability and impoverished flora/fauna.

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ(HWL)	0 - 30	well-sorted granules
#2	UITZ	0 - 30	granules (~80%). pebbles, cobbles
#3	MITZ	0 - 15	granules and cobbles
	(W.L.1315)	15 - 30	pebbles and sand
#4	UITZ(HWL)	0 - 30	pebbly sand
#5	UITZ	0 - 5	well-sorted, well-rounded pebble
		5 - 30	pebbley, cobbley sand
#6	MITZ(W.L.)	0 - 10	pebble, cobble
		10 - 30	pebbley, cobbley sand

[Photos: JRH #1, FR 17 - 20]

Quatsino #2 (17 April 1991)

This long pebble/cobble beach along the north shore of Quatsino Sound attracted attention because of its uniformity and length (> 1km). However, pits showed that the pebble/cobble material formed only a thin veneer of weathered sand and clay.

No Stage 2 assessment was conducted due to the low permeability.

PIT LOG

PIT	ZONE	DEPTH (cm)	SEDIMENT
#1	UITZ	0 - 3	pebbles
		3 - 20	weathered sandy clay

[Photos: JRH #1, FR 21 - 22]

KHOYATAN MARINE LABORATORY **Station No.: KML 24/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: S. side of Quatsino Sound, 1/2km SE of Koskimo Island

Latitude start: 50° 27.94'N; Longitude start: 127° 49.90'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at 0930 PDT
Predicted tide level: 2.2 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 17 April 1991 Time [PDT] start: 1215 finish: 1245
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) Sand(<2mm) Mud Shell Other--
Exposure: Protected Semi-protected Semi-exposed Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: open beach, primarily pebble, some cobble
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: nil
Currents: NIL
Turbidity: slight
Other:

Description of area: low slope open beach facing NE with fetch across inlet of about 2km and up inlet of about 5km, no fetch directly to open sea. Primarily pebble with some cobble, boulders and silt. Low wave energy beach.

Biological notes: The presence of barnacles on 5cm cobbles indicates stable over some period of time. Short period of assessment and water up to midtide level but appears very impoverished in macro species.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	mid	some	on rocks
Enteromorpha intestinalis	hi	some	fresh water
BROWN ALGAE			
Fucus gardneri	mid	some	on rocks
RED ALGAE [not assesses]			
LICHENS [none observed]			
ANGIOSPERMS [not assessed]			
SPONGES [not assessed]			
COELENTERATES [not assessed]			
NEMERTEANS [not assessed]			
BRYOZOANS [not assessed]			
CHITONS [not assessed]			
GASTROPODS			
Lottia digitalis	hi	some	on rocks
BIVALVES [none observed]			
POLYCHAETES [not assessed]			
SIPUNCULIDS [not assessed]			
BARNACLES			
Balanus glandula	mid	some	on cobbles
ISOPODS [not assessed]			
AMPHIPODS [not assessed]			
DECAPODS			
Hemigrapsus oregonensis	hi	some	under rocks
SEA CUCUMBERS [not assessed]			
SEA URCHINS [not assessed]			
SEA STARS [not assessed]			
ASCIDIANS [not assessed]			
FISH [not assessed]			

Supplemental Assessment: water [10 liters] was collected from lower mid-intertidal pit and organisms retained on 0.5mm mesh were qualitatively assessed. Results are tabulated under interstitial fauna.

TAXA [Interstitial Fauna]	TIDE ZONE	NUMBERS	LOCATION
NEMATODES	low	1	in substrate
OLIGOCHAETES	low	3	in substrate
BARNACLE LARVAE	low	>15	on? substrate
HARPACTICOID COPEPODS	low	1*	in substrate
FLY LARVAE [chironomids]	low	2	in? substrate
MITES	low	3*	in substrate

*likely underestimate as less than 0.5mm in size.

KHOYATAN MARINE LABORATORY **Station No.: KML 25/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: S. side of Quatsino Sound, 1/2km SE of Koskimo Island

Latitude start: 50° 30.39'N; Longitude start: 127° 44.90'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at 0930 PDT
Predicted tide level: 2.3 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 17 April 1991 Time [PDT] start: 1245 finish: 1315
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock Boulder(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) Sand(<2mm) **Mud** Shell Other--
Exposure: Protected Semi-protected Semi-exposed Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: open beach, primarily pebble, some cobble
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: nil
Currents: NIL
Turbidity: slight
Other:

Description of area: low slope open beach facing S with fetch across inlet of about 3km.; no fetch directly to open sea. Primarily pebble with some cobble, over a clay sediment. Low wave energy beach.

Biological notes: The presence of barnacles on pebbles indicates stable over some period of time. Short period of assessment and water up to midtide level but appears very impoverished in macro species.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE [none observed]			
BROWN ALGAE			
Fucus gardneri	mid	few	on cobbles
RED ALGAE [not assesses]			
LICHENS [none observed]			
ANGIOSPERMS [not assessed]			
SPONGES [not assessed]			
COELENTERATES [not assessed]			
NEMERTEANS [not assessed]			
BRYOZOANS [not assessed]			
CHITONS [not assessed]			
GASTROPODS [none observed]			
BIVALVES [none observed]			
POLYCHAETES [not assessed]			
SIPUNCULIDS [not assessed]			
BARNACLES			
Balanus glandula	mid	some	on cobb/pebble
ISOPODS [not assessed]			
AMPHIPODS [not assessed]			
DECAPODS			
Hemigrapsus oregonensis	hi	some	under rocks
SEA CUCUMBERS [not assessed]			
SEA URCHINS [not assessed]			
SEA STARS [not assessed]			
ASCIDIANS [not assessed]			
FISH [not assessed]			

KHOYATAN MARINE LABORATORY **Station No.: KML 26A/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: SW end of Strange I., Nootka Sound [experimental site]

Latitude start: 49° 40.98'N; **Longitude start:** 126° 36.08'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 **m** at 1000 **PDT**
Predicted tide level: 0.4 **m at time of station**
Depth uncorrected: m; Corrected: m **N/A**
Date: 18 April 1991 **Time [PDT] start:** 0800 **finish:** 0845
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: **Marine** Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) **Sand**(<2mm) **Mud** Shell Other--
Exposure: Protected Semi-protected **Semi-exposed** Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: **Shore** Snorkel Scuba Submersible Vessel Other--
Equipment: **Hand** Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: **35mm col.** 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: Upper and upper-mid intertidal with primarily pebble veneer over course sand, lower mid intertidal with boulder and cobble veneer grading into mud in lower intertidal with few cobbles.
Weather: clear, sunny, offshore fog
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: small swell
Currents: NIL
Turbidity: low
Other:

Description of area: pocket beach about 500m wide, facing SW with narrow exposure [1.7km wide] to open ocean approximately 11 km due south. The station is about **midway** along the beach.

Biological notes: The beach survey was abbreviated when it was concluded that this site would not be satisfactory for an experimental site and a survey was initiated toward the western end of the beach [sta. 26B/91]. See notes on comparison with western end of beach [station 26B/91]

The upper 1/2 of the beach with little or no macro surface biota. This is likely related to the unstable primarily pebl substrate. The rich cover of green algae in both low and lower-mid intertidal areas may be a reflection of the lack or paucity of herbivores such as certain snails and limpets. It is likely that this growth could develop over a short [months] period of time.

Other slower growing surface biota such as Fucus, barnacles and mussels were absent or very limited in distribution. Alternatively, some burrowing forms such as sand clams (Macoma secta) and butter clams (Saxidomus giganteus) were moderately abundant as was eelgrass (Zostera marina).

The paucity of epifauna in the mid and high intertidal also suggests that the cobbles here are unstable.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low,mid	abund.	top of rocks
Cladophora sp.	low,	v.abund.	top of rocks
long filamentous greens	mid	abund.	top of rocks
BROWN ALGAE			
Sargassum muticum	mid-low	abund.	top of rocks
Fucus gardneri	mid	scarce	top of rocks
RED ALGAE			
Pterosiphonia bipinnata	low	some	top of rocks
LICHENS			
'Verrucaria'	hi	scarce	on large rocks
ANGIOSPERMS			
Zostera marina	low	abund	in sediment
SPONGES [none observed]			
COELENTERATES			
Anthopleura artemisia	low	2	in sediment
NEMERTEANS [none observed]			
BRYOZOANS [none observed]			
CHITONS [none observed]			
GASTROPODS [none observed]			
BIVALVES			
Macoma secta	low	abund	in sediment
Saxidomus giganteus	low	some	in sediment
POLYCHAETES [none observed]			
SIPUNCULIDS [none observed]			
BARNACLES			
Balanus glandula	mid,hi	scarce	edges rocks
ISOPODS [none observed]			
AMPHIPODS [none observed]			
DECAPODS [none observed]			
SEA CUCUMBERS [none observed]			
SEA URCHINS [none observed]			
SEA STARS			
Pisaster ochraceous	low	2	on sediment
ASCIDIANS [none observed]			
FISH			
unidentified cottid	low	some	in water

KHOYATAN MARINE LABORATORY **Station No.: KML 26B/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: SW end of Strange I., Nootka Sound [experimental site]

Latitude start: 49° 40.98'N; **Longitude start:** 126° 36.14'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 **m** at 1000 **PDT**
Predicted tide level: 0.2 **m at time of station**
Depth uncorrected: m; Corrected: m **N/A**
Date: 18 April 1991 **Time [PDT] start:** 0900 **finish:** 0945
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) **Sand**(<2mm) Mud Shell Other--
Exposure: Protected Semi-protected **Semi-Exposed** Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: Veneer of boulder/cobble over shell-sand
Weather: clear, sunny, offshore fog
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: small swell
Currents: NIL
Turbidity: low
Other:

Description of area: pocket beach about 500m wide, facing SW with narrow exposure [1.7km wide] to open ocean approximately 11 km due south. On surface high intertidal cobble, lower intertidal with some boulders, moderate slope high, lower slope low with lowest forming a shallow tidal pool but which may drain over time as the tide falls. Shell sand below surface.

Biological notes: see notes on potential control site [33/91] for biotic comparisions. This western section of the beach has greater apparent biodiversity than central portion of beach, 26A/91 [=26/91 in photos]. This may be related to decrease in soft sediment in western section. Small size of several species of hermit crabs, barnacles,limpets, mussels suggests that much of community with annual turnover. The barnacle, B. glandula tends to be restricted to the sides of cobbles and is less abundant with decreasing size of cobbles. This suggests that the cobbles are unstable to varying degrees on at least an annual basis. Mortalities evident from basal scars were approx. 30%. This could be due to either biotic [predator] or physical factors.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low,mid	abund.	top of rocks
Cladophora sp.	low,hi	abund.	top of rocks
green tinge on rocks	hi	abund.	top of rocks
BROWN ALGAE			
Sargassum muticum	mid-low	abund.	top of rocks
Scytosiphon lomentaria	mid	some	top of rocks
Fucus gardneri	mid	abund.	top of rocks
Heterochordaria abietina	low	some	top of rocks
RED ALGAE			
Pterosiphonia sp. [yell-brwn]	low	abund.	top of rocks
Pterosiphonia bipinnata	low	some	top of rocks
Cryptosiphonia woodii	low	some	top of rocks
Odanthalia floccosa	low	abund.	top of rocks
Rhodomela laryx	low	some	top of rocks
Prionitis sp.	low	some	top of rocks
Corallina vancouveriensis	low	abund.	top of rocks
"*Lithothamnion*" sp.	low	some	sides of rocks
'*Petrocelis*' stage: *Mastocarpus*	mid	abund	top of rocks
LICHENS			
'*Verrucaria*'	hi	some	on rocks
ANGIOSPERMS			
Zostera marina	low	some	in sediment
SPONGES			
Halichondria panicea	mid	some	under rocks
COELENTERATES			
Obelia geniculata	low	abund.	under elev. rocks
NEMERTEANS [none observed]			
BRYOZOANS			
white encrusting cheilostome	low	abund.	under rocks
red encrusting cheilostome	low	some	under rocks
CHITONS [none observed]			
GASTROPODS			
Lottia pelta [most small]	mid,hi	abund	sides of rocks
Tectura scutum [small]	low	few	sides of rocks
Littorina scutulata	hi	abund	top of rocks
Fusinus harfordi	low	few	under rocks
BIVALVES			
Crassostrea gigas	mid	few	on rocks
Mytilus edulis [small]	hi-mid	some	sides of rocks
Saxidomus giganteus	low	some	in sediment
POLYCHAETES			
"*Spirorbis*" sp.	low	abund	under rocks
Serpula vermicularis	low	few	sides of rocks
SIPUNCULIDS [none observed]			

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
BARNACLES			
Balanus glandula	mid,hi	some	edges rocks
Balanus crenatus [small]	low	few	edges of rocks
Semibalanus cariosus [small]	mid	few	top of rocks
Chthamalus dalli	mid	abund.	top/bot. rocks
ISOPODS			
Gnorimosphaeroma oregonensis	low-mid	abund.	under rocks
Idothea fewkesii?	low	1	under rocks
AMPHIPODS			
small gammarids	hi	abund.	under rocks
small gammarids	mid	abund.	under rocks
DECAPODS			
Pagurus granosimanus [small]	low	abund.	under rocks
Pagurus hirsutiusculus ["]	low	some	under rocks
Hemigrapsus oregonensis	low,mid,hi	abund.	under rocks
SEA CUCUMBERS [none observed]			
SEA URCHINS [none observed]			
SEA STARS			
Pisaster ochraceous	low	few	on rocks
Evasterias troschellii	low	1	on sand
Dermasterias imbricata	low	some	on sand
ASCIDIANS [none observed]			
FISH			
Xiphaster atropurpureus	low,mid	abund.	under rocks

Supplemental Assessment: water [10 liters] was collected from lower mid-intertidal pit and organisms retained on 0.5mm mesh were qualitatively assessed. Results are tabulated under interstitial fauna.

TAXA [Interstitial Fauna]	TIDE ZONE	NUMBERS	LOCATION
FLATWORMS	low	few*	in substrate
NEMATODES	low	abund	in substrate
OSTRACODS	low	some*	in substrate
COPEPODS	low	some*	in substrate
FLY LARVAE [chironomids]	low	some	in? substrate

*likely underestimate as less than 0.5mm in size

Supplemental Assessment: an epiphytic diatom/filamentous red algal assemblage was collected and briefly examined under a dissecting microscope. This "community" included abundant: flatworms, nematodes, ostracods, tanaids, copepods, amphipods, and mites.

KHOYATAN MARINE LABORATORY **Station No.: KML 27/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: Esperanza Inlet, 1.5km east of Espinosa Inlet

Latitude start: 49° 52.25'N; Longitude start: 126° 53.25'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at 1010 PDT
Predicted tide level: 0.2 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 18 April **1991 Time [PDT] start: 1030 finish: 1115**
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) Pebble(1/2-6cm) Granule(2-4mm) **Sand**(<2mm) Mud Shell Other--
Exposure: Protected Semi-protected **Semi-exposed** Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: boulder, cobble veneer over shell sand.
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: slight
Currents: NIL
Turbidity: clear
Other:

Description of area: Beach about 300m wide, facing SSW with fetch of 8 km to open ocean to the west through 2 km wide channel. Located approx 1 km west of Indian Resere 10B.

Biological notes: see potential control site [28/91] for comparison. Moderately high diversity of both plants and animals. Limited distribution of barnacles in mid and high intertidal to larger well bedded rocks suggests some degree of instability of cobbles related to wave action. This is also suggested by apparent absence of mussels and few or no representatives of sessile community which necessarily more than one year old.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low	abund	on rocks
BROWN ALGAE			
Sargassum muticum	low	abund	on rocks
Scytosiphon lomentaria	low	abund	on rocks
Heterochordaria abietina	low	abund	on rocks
Colpomenia peregrina	low	few	on rocks
Fucus gardneri	mid	abund	on rocks
RED ALGAE			
'*Lithothamnion*'	low	some	on rocks
Corallina vancouverensis	low	abund	on rocks
Gigartina sp.	low	some	on rocks
Prionitis lyalli?	low	some	on rocks
Plocamium sp.	low	some	on rocks
Rhodomela laryx	low	some	on rocks
Cryptosiphonia woodii	low	abund	on rocks
Delesseria decipiens	low	few	on rocks
Polysiphonia hendryi	low	some	on rocks
'*Petrocelis*' of *Mastocarpus*	mid	abund	on rocks
Odonthalia floccosa	mid	some	on rocks
Porphyra sp.	mid-hi	some	on rocks
Microcladia borealis?	mid	some	on rocks
LICHENS			
'*Verrucaria*'	hi	abund	on rocks
Caloplaca sp.	hi	some	on rocks
ANGIOSPERMS [none observed]			
SPONGES			
Halichondria panicea	low	some	under rocks
COELENTERATES			
Obelia geniculata	low,mid	abund	under rocks
NEMERTEANS			
small white sp.	low	abund	under rocks
BRYOZOANS			
red encr. cheilostome	low	abund	under rocks
orange encr. cheilostome	low	abund	under rocks
2+ other encr. " spp.	low	abund	under rocks
Crisia sp.	low	abund	under rocks
Dendrobeania lichenoides	low	abund	under rocks
CHITONS [none observed]			
GASTROPODS			
Lottia pelta	mid	abund	on rocks
Tectura scutum	mid	some	under rocks
Littorina sitkana	mid	abund	on rocks
Littorina scutulata	hi	some	on rocks
Bittium attenuatum?	low,mid	abund	under rocks
Archidoris montereyensis	mid	1	under rock
Nucella lamellosa	mid	1	under rock
BIVALVES			
Hiatella arctica	low	abund	under rocks
Protothaca staminea	mid	abund	in substrate
[no *Mytilus*]			

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
POLYCHAETES			
'Spirorbis' sp.	low	abund	under rocks
Serpula vermicularis	low	abund	under rocks
Nereis sp.	low	some	under rocks
SIPUNCULIDS [none observed]			
BARNACLES			
Chthamalus dalli	mid	abund	on rocks
Balanus glandula	hi	some	only lg.rocks
ISOPODS [none observed]			
AMPHIPODS			
gammerids	mid	abund	under rocks
DECAPODS			
Pagurus hemphilli	low	some	under rocks
Pagurus hirsutiusculus	low,mid	some	under rocks
Cancer productus [juv.]	low	1	under rock
Petrolisthes cinctipes	low	abund	under rocks
Hemigrapsus or[illegible]is	mid	abund	under rocks
SEA CUCUMBERS [none [illegible]]			
SEA URCHINS			
Stronyglocentotus droebachiensis	low	some	under rocks
SEA STARS			
Dermasterias imbricata	low	few	on rocks,sand
Pycnopodia helianthoides	low	2	on sand
Asterina miniata	low	some	on sand
Evasterias troschelli	low	few	on rocks
ASCIDIANS [none observed]			
FISH			
Xiphaster atropurpureus	low	abund	under rocks

KHOYATAN MARINE LABORATORY **Station No.: KML 28/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: Esperanza Inlet, 1.0 km east of Espinosa Inlet

Latitude start: 49° 52.18'N; Longitude start: 126° 53.70'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at 1010 PDT
Predicted tide level: 0.5 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 18 April 1991 Time [PDT] start: 1130 finish: 1150
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) Pebble(1/2-6cm) Granule(2-4mm) **Sand**(<2mm) Mud Shell Other--
Exposure: Protected Semi-protected **Semi-exposed** Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: boulder, cobble veneer over shell sand.
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: slight
Currents: NIL
Turbidity: clear
Other:

Description of area: Beach narrower and steeper than proposed experimental site [sta. 27/91]; rocks also more angular; facing SSE with fetch of 8 km to open ocean to the west through 2 km wide channel but facing >90 degrees away so more wave refraction to affect beach. Together suggests more wave sheltered beach than 27/91.

Biological notes: Short site visit [no photos] so less intensive assessment of biota than at proposed experimental site [sta. 27/91]. Tide level also somewhat higher than at sta. 27/91. However, appears to be somewhat less diversity of both plants and animals. The abundance of barnacles including on cobbles in the upper-mid intertidal supports the physical evidence of a somewhat more protected beach.

TAXA [Macrobiota]	**TIDE ZONE**	**NUMBERS**	**LOCATION**
GREEN ALGAE			
Ulva sp.	low	abund	on rocks
Enteromorpha intestinalis	hi	some	on rocks

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
BROWN ALGAE			
Sargassum muticum	low	abund	on rocks
Scytosiphon lomentaria	low	abund	on rocks
Fucus gardneri	mid	abund	on rocks
RED ALGAE			
'*Lithothamnion*'	low	some	on rocks
Corallina vancouverensis	low	abund	on rocks
'*Petrocelis*' of *Mastocarpus*	mid	abund	on rocks
LICHENS			
'*Verrucaria*'	hi	abund	on rocks
ANGIOSPERMS [none observed]			
SPONGES [none observed]			
COELENTERATES [none observed]			
NEMERTEANS [none observed]			
BRYOZOANS			
red encr. cheilostome	low	abund	under rocks
orange encr. cheilostome	low	abund	under rocks
1+ other encr. " spp.	low	abund	under rocks
CHITONS [none observed]			
GASTROPODS			
Lottia pelta	mid	abund	on rocks
Littorina sitkana	mid	abund	on rocks
Littorina scutulata	hi	some	on rocks
Petaloconchus compactus	low	some	under rocks
BIVALVES			
Protothaca staminea	mid	abund	in substrate
[no *Mytilus*]			
POLYCHAETES			
'*Spirorbis*' sp.	low	abund	under rocks
Serpula vermicularis	low	abund	under rocks
SIPUNCULIDS			
Phascolosoma aqassizi	low	some	under rocks
BARNACLES			
Chthamalus dalli	mid	abund	on rocks
Balanus glandula	hi	abund	on rocks
ISOPODS			
Gnorimospheroma oregonensis	mid	some	under rocks
AMPHIPODS			
gammerids	mid	abund	under rocks
DECAPODS			
Pagurus hirsutiusculus	low,mid	some	under rocks
Petrolisthes cinctipes	low	abund	under rocks
Hemigrapsus oregonensis	mid	abund	under rocks
SEA CUCUMBERS [none observed]			
SEA URCHINS [none observed]			
SEA STARS			
Dermasterias imbricata	low	few	on rocks, sand
Evasterias troschelli	low	few	on rocks
ASCIDIANS [none observed]			
FISH [none observed]			

KHOYATAN MARINE LABORATORY **Station No.: KML 29/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: North side of Molketas I, Kyuquot Sound

Latitude start: 50° 05.10'N; Longitude start: 127° 12.08'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at PDT
Predicted tide level: 0.7 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 18 April **1991 Time [PDT] start: 1145 finish: 1200**
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) Pebble(1/2-6cm) Granule(2-4mm) Sand(<2mm) Mud Shell Other--
Exposure: Protected **Semi-protected** Semi-exposed Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: angular boulder and cobble
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: nil
Currents: NIL
Turbidity: clear
Other:

Description of area: open beach facing north with fetch almost tangential to beach of about 10km up Tahsish Inlet; no fetch to open ocean so expect no swell. some boulders, most cobble which angular.

Biological notes: Only brief observations and low intertidal largely covered by water. However, appears impoverished in both animal and plant species. Low biotic diversity may be related to some combination of low wave energy, low water currents and low sur: salinities; the latter relating to freshwater runoff primarily into Tahshis and Kashutl Inlets.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	mid	some	on rocks
Cladophora sp.	mid	some	on rocks
BROWN ALGAE			
Scytosiphon lomentaria	mid	some	on rocks
RED ALGAE [none observed]			
LICHENS			
'*Verrucaria*'	hi	some	on rocks
ANGIOSPERMS [none observed]			
SPONGES [none observed]			
COELENTERATES [none observed]			
NEMERTEANS [none observed]			
BRYOZOANS [not assessed]			
CHITONS [none observed]			
GASTROPODS			
Lottia pelta	mid	some	on rocks
Littorina scutulata	hi	some	on rocks
BIVALVES			
Crassostrea gigas	mid	some	on rocks
POLYCHAETES [not assessed]			
SIPUNCULIDS [not assessed]			
BARNACLES			
Chthamalus dalli	mid	abund	on rocks
Balanus glandula	mid	some	on rocks
ISOPODS [not assess			
AMPHIPODS [not obse			
DECAPODS			
Hemigrapsus oregonensis	mid	some	under rocks
SEA CUCUMBERS [not assessed]			
SEA URCHINS [not assessed]			
SEA STARS [none observed]			
ASCIDIANS [not assessed]			
FISH [not assessed]			

KHOYATAN MARINE LABORATORY **Station No.: KML 30/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: Kashutl Inlet, 2km N of Chamiss Bay, Kyuquot Sound

Latitude start: 50° 05.40'N; Longitude start: 127° 16.65'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.2 m at PDT
Predicted tide level: 1.2 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 18 April **1991 Time [PDT] start: 1230 finish: 1245**
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) Pebble(1/2-6cm) Granule(2-4mm) Sand(<2mm) Mud Shell Other--
Exposure: Protected **Semi-protected** Semi-exposed Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: angular boulder and cobble
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: nil
Currents: NIL
Turbidity: clear
Other:

Description of area: pocket beach about 200m wide facing west with fetch of about 7km north and south. No fetch into open ocean so would expect no ocean swells. Cobble high and angular cobble and boulder in mid intertidal.

Biological notes: Only brief observations and low intertidal covered by water. However, appears impoverished in both animal and plant species. Low biotic diversity may be related to some combination of low wave energy, low water currents and low surface salinities; the latter relating to freshwater runoff primarily into Kashutl Inlet.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Cladophora sp.	mid	some	on rocks
BROWN ALGAE			
Fucus gardneri	mid	some	on rocks
RED ALGAE [none observed]			
LICHENS			
'*Verrucaria*'	hi	some	on rocks
ANGIOSPERMS [none observed]			
SPONGES [none observed]			
COELENTERATES [none observed]			
NEMERTEANS [none observed]			
BRYOZOANS [not assessed]			
CHITONS [none observed]			
GASTROPODS			
Lottia pelta	mid	abund	on rocks
Littorina scutulata	hi	abund	on rocks
BIVALVES			
Mytilus edulis	mid	few	on rocks
POLYCHAETES [not assessed]			
SIPUNCULIDS [not assessed]			
BARNACLES			
Chthamalus dalli	mid	some	on rocks
Balanus glandula	mid	abund	on rocks
ISOPODS [not assessed]			
AMPHIPODS [not assessed]			
DECAPODS			
Hemigrapsus oregonensis	mid	few	under rocks
SEA CUCUMBERS [not assessed]			
SEA URCHINS [not assessed]			
SEA STARS [none observed]			
ASCIDIANS [not assessed]			
FISH [not assessed]			

KHOYATAN MARINE LABORATORY **Station No.: KML 31/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: Zuciarte Channel, 3.2km NE of Discovery Point

Latitude start: 49° 35.76'N; Longitude start: 126° 30.90'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.3 m at 1105 PDT
Predicted tide level: 0.6 m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 19 April **1991 Time [PDT] start: 0930 finish: 0950**
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) **Sand**(<2mm) Mud Shell Other--
Exposure: Protected Semi-protected Semi-exposed **Exposed** N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: Boulder and cobble veneer over pebble or sand
Weather: clear, sunny, offshore fog
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: low swell
Currents: NIL
Turbidity: clear
Other:

Description of area: Beach facing NNW, approx 300m wide; moderate slope of rounded boulders mixed with cobble over sand in NE portion but pebble in SW portion where sampled. Increasing % pebble toward lower end of beach. About 4 km from open sea to the west through a broad 3km wide entrance into Nootka Sound. A stream entered the beach near the SW end.

Biological notes: A luxuriant algal growth in low intertidal. This may be related to the paucity of herbivores due to high wave energy with resultant periodic movement of cobbles. The algae are species which would be expected to grow rapidly [few months]. Some [e.g., Alaria nana] were those associated with exposed coasts. Sessile animals small suggesting are < one year old. The short duration of the biotic assessment dissallowed detailed study but overall can consider as having low species diversity which may relate to the high wave energy conditions on an unstable beach. Species diversity was greater and animals were larger on adjacent solid rock shoreline.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low,mid	abund	on rocks
Cladophora sp.	mid	abund	on rocks
BROWN ALGAE			
Sargassum muticum	low	abund	on rocks
Scytosiphon lomentaria	mid	v.abund	on rocks
RED ALGAE			
Odonthalia floccosa	low	abund	on rocks
Alaria nana	low	abund	on rocks
Pterosiphonia bipinnata	low	v. abund	on rocks
Cryptosiphonia woodii	mid	some	on rocks
Iridaea cornucopiae	mid	some	on rocks
Rhodomela laryx	mid	some	on rocks
LICHENS			
'*Verrucaria*'	hi	some	on rocks
ANGIOSPERMS			
Phyllospadix scouleri	low	some	on rocks
SPONGES [none observed]			
COELENTERATES			
Obelia geniculata?	low	some	under lg.rocks
NEMERTEANS [none observed]			
BRYOZOANS			
circular cheilostome	low	some	under lg.rocks
CHITONS [none observed]			
GASTROPODS			
Lottia digitata	hi	few	on rocks
Lottia pelta	mid	few	on,under rocks
Littorina sitkana	mid	few	on rocks
BIVALVES			
Mytilus californianus [small]	mid	some	on rocks
POLYCHAETES [none observed]			
SIPUNCULIDS [none observed]			
BARNACLES			
Chthamalus dalli	mid	some	on,under rocks
Balanus glandula [small]	mid	few	on rocks
ISOPODS [none observed]			
AMPHIPODS [none observed]			
DECAPODS			
Hemigrapsus nudus	hi	few	under rocks
SEA CUCUMBERS [none observed]			
SEA URCHINS [none observed]			
SEA STARS [none observed]			
ASCIDIANS [none observed]			
FISH [none observed]			

KHOYATAN MARINE LABORATORY **Station No.: KML 32/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: NE side of Spouter I., Spanish Pilot Group, Nootka Sd.

Latitude start: 49° 37.54'N; Longitude start: 126° 32.53'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.3m at 1102 PDT
Predicted tide level: 0.3m at time of station
Depth uncorrected: m; Corrected: m N/A
Date: 19 April **1991 Time [PDT] start: 0945 finish: 1030**
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) Pebble(1/2-6cm) Granule(2-4mm) Sand(<2mm) Mud Shell Other--
Exposure: Protected **Semi-protected** Semi-Exposed Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: boulders and cobbles over coarse sand
Weather: clear, sunny
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: none
Currents: NIL
Turbidity: clear
Other:

Description of area: pocket beach about 200+m? wide, facing NW with short direct fetch [650m] but possibly subject to strongly refracting waves entering from the open sea some 7km to the SW. Boulders and cobbles are angular and well bedded suggesting low wave energies.

Biological notes: This was the most biologically diverse habitat observed during the survey. The community structure also suggested a high degree of stability [large size range of individual species, long lived species]. Low algal cover in the lower intertidal is probably related to the high densities of the large herbivorous snail Astrea gibberosa. The apparent absence of the large sea urchin Strongylocentrotus franciscanus suggests the possibility that this species may have been subject to predation by sea otters. However, direct confirmation that members of the Bajo Reef population have extended their range into Nootka Sound needs confirmation.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low,mid	abund	on rocks
Cladophora sp.	mid	abund	on rocks
BROWN ALGAE			
Sagassum muticum	low	abund	on rocks
Scytosiphon lomentaria	mid	abund	on rocks
Fucus gardneri	mid	abund	on rocks
RED ALGAE			
"*Lithothamnion*"	low,mid	some	under,sides rocks
'*Petrocelis*' of *Mastigocarpus*	mid	abund	on rocks
LICHENS			
'*Verrucaria*'	hi	abund	[illegible] rocks
ANGIOSPERMS [none observed]			
SPONGES			
Halichondria panicea	mid	some	[illegible]der rocks
COELENTERATES			
Metridium senile	low	some	under rocks
NEMERTEANS [none observed]			
BRYOZOANS			
red cheilostome	low	abund	under rocks
orange cheilostome	low	abund	under rocks
3+ other spp.	low	abund	under rocks
CHITONS			
Mopalia ciliata	low,mid	few	under rocks
GASTROPODS			
Lottia pelta	mid,hi	abund	on rocks
Tectura scutum	mid	some	under rocks
Astrea gibberosa	low	abund	top of rocks
Littorina scutulata	mid-hi	abund	top of rocks
Petaloconchus compactus	low	abund	under rocks
Searlesia dira	low	abund	under rocks
Ocenebra interfossa	low	some	under rocks
Polycera zosterae	low	1	side of rock
BIVALVES			
Mytilus edulis	mid	some	on rocks
Crassostrea gigas	mid	some	on rocks
Pododesmus macroschisma	low	abund	under rocks
Kellia suborbicularis	low	some	under rocks
Protothaca staminea	low,mid	abund	in sediment
POLYCHAETES			
"*Spirorbis*" sp.	low	abund	[illegible]nder rocks
Serpula vermicularis	low	abund	[illegible]nder rocks
Goniadid	low	few	under rocks
SIPUNCULIDS			
BARNACLES			
Balanus crenatus	low	some	under rocks
Balanus glandula	mid,hi	abund	[illegible] rocks
Chthamalus dalli	mid	abund	[illegible]/under rocks
ISOPODS			
Cirolana harfordi	low	abund	[illegible]nder rocks

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
AMPHIPODS			
gammarids	mid	some	under rocks
DECAPODS			
Petrolisthes cinctipes	low	abund	under rocks
Pagurus granosimanus	low,mid	abund	under rocks
Pagurus hirsutiusculus	mid	some	under rocks
Hemigrapsus nudus	mid	abund	under rocks
Lophopanopeus bellus	mid	1	under rock
SEA CUCUMBERS			
Cucumaria miniata	low	abund	under rocks
SEA URCHINS [none observed]			
SEA STARS			
Solaster dawsoni	low	1	top of rock
Asterina miniata	low	some	on sediment
Evasterias troschelli	low	some	top of rocks
Pisaster ochraceous	low,mid	abund	on rocks
Pycnopodia helianthoides	low	few	on sediment
Dermasterias imbricata	low,mid	abund	on rocks
ASCIDIANS [none observed]			
FISH			
Xiphaster atropurpureus	low	abund	under rocks

KHOYATAN MARINE LABORATORY **Station No.: KML 33/91**
Station sheet [choice selections highlighted]

Purpose: General biotic assessment of boulder/cobble beaches
Location: SW end of Strange I., Nootka Sound [control]

Latitude start: 49° 40.97'N; **Longitude start:** 126° 36.33'W
Latitude end: ° 'N; Longitude end: ° 'W SAME
Predicted high or low tide level: 0.3 **m** at 1102 **PDT**
Predicted tide level: 0.3 **m at time of station**
Depth uncorrected: m; Corrected: m N/A
Date: 19 April **1991 Time [PDT] start:** 1100 **finish:** 1200
Collector/Observer: W.C. Austin with J. Harper, D. Dickens

General Habitat: Marine Freshwater Terrestrial
Depth m: 4+ 3-4 1-3 0-1 0-20 20-200 200+ surface **N/A**
Substrate: Cont. rock Discont. rock **Boulder**(25+cm) **Cobble**(6-25cm) **Pebble**(1/2-6cm) Granule(2-4mm) Sand(<2mm) [**Mud**] Shell Other--
Exposure: Protected Semi-protected **Semi-exposed** Exposed N/A
Profile: Cave Overhang Vert. Horiz. >45° 45-10° <10o **per J. Harper**
Operation: Shore Snorkel Scuba Submersible Vessel Other--
Equipment: Hand Pump Trap Beach seine Neuston net Plankton net Midwater trawl Bottom trawl Dredge Grab Corer Hook & line Other--
Addl. Records: 35mm col. 35mm B&W 2x2 Stereo **Video** Audio Vouchers

Geology: per John Harper
Habitat: Veneer of boulder/cobble over finer, incl. mud low littoral
Weather: clear, sunny, offshore fog, moderate wind building
Hydro Temp.: N/A
Salinity: N/A
Waves,swells: small, short chop
Currents: NIL
Turbidity: somewhat turbid due to suspended silt from muddy substrate
Other:

Description of area: pocket beach about 100m wide, facing SW with narrow exposure [1.7km wide] to open ocean approximately 11 km due south. Surface high cobble, lower some boulders, fine sediment in lower littoral and subtidally mixed with cobble. Less sediment toward west edge of beach. A few shallow tidal pools in lower intertidal.

Biological notes: The overall species similarity was high between this potential control site and the adjacent potential experimental site [26B/91]. However, the number of macro species appeared to be less on this site in the lower intertidal. This may be related to increased fine sediment at this site. A more detailed study is necessary including a series of transects along the beach to better assess potent differences.

Small size of several species of hermit crabs, barnacles, limpets, mussels suggests that much of community has an annual turnover.

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
GREEN ALGAE			
Ulva sp.	low,mid	abund.	top of rocks
green tinge on rocks	hi	abund.	top of rocks
BROWN ALGAE			
Sargassum muticum	mid-low	abund.	top of rocks
Scytosiphon lomentaria	mid	some	top of rocks
Fucus gardneri	mid	abund.	top of rocks
RED ALGAE			
Pterosiphonia sp. [yell-brwn]	low	abund.	top of rocks
Odanthalia floccosa	low	abund.	top of rocks
Corallina vancouveriensis	low	abund.	top of rocks
"*Lithothamnion*" sp.	low	some	sides of rocks
'*Petrocelis*' stage: *Mastocarpus*	mid	abund	top of rocks
Porphyra sp.	mid-hi	some	top of rocks
Heterochordaria abietina	low	some	top of rocks
LICHENS			
'*Verrucaria*'	hi	some	on rocks
ANGIOSPERMS			
Zostera marina	low	abund.	in sediment
SPONGES [none observed]			
COELENTERATES			
Obelia geniculata	low	abund.	under rocks
NEMERTEANS [none observed]			
BRYOZOANS			
white encrusting cheilostome	low	abund.	under rocks
circ col. dark cheilostome	low	some	under rocks
red encrusting cheilostome	low	some	under rocks
CHITONS [none observed]			
GASTROPODS			
Lottia digitalis	mid,hi	some	top of rocks
Lottia pelta [most small]	mid,hi	some	sides of rocks
Tectura scutum [small]	low	few	sides of rocks
Littorina scutulata	hi	abund	top of rocks
Archidoris montereyensis	low	1	under rock
BIVALVES			
Mytilus edulis [small]	mid	some	sides of rocks
Saxidomus giganteus	low	some	in sediment
POLYCHAETES			
"*Spirorbis*" sp.	low	abund	under rocks
Serpula vermicularis	low	few	sides of rocks
SIPUNCULIDS [none observed]			
BARNACLES			
Balanus glandula	mid,hi	some	top,edges rocks
Balanus crenatus [small]	low	few	edges of rocks
Semibalanus cariosus [small]	mid	few	top of rocks
Chthamalus dalli	mid	abund	top/bot. rocks
ISOPODS			
Gnorimosphaeroma oregonensis	low	abund	under rocks

TAXA [Macrobiota]	TIDE ZONE	NUMBERS	LOCATION
AMPHIPODS			
small gammarid	mid	abund	under rocks
small gammarids 2 spp.	hi	abund	under rocks
DECAPODS			
Pagurus granosimanus [small]	low	abund	under rocks
Pagurus hirsutiusculus ["]	low	some	under rocks
Hemigrapsus oregonensis	low,mid,hi	abund	under rocks
SEA CUCUMBERS [none observed]			
SEA URCHINS [none observed]			
SEA STARS			
Pisaster ochraceous	low	few	on rocks
Dermasterias imbricata	low	some	on sediment
ASCIDIANS [none observed]			
FISH			
Xiphaster atropurpureus	low,mid	abund	under rocks

Supplemental Assessment: water [10 liters] was collected from lower mid-intertidal pit and organisms retained on 0.5mm mesh were qualitatively assessed. Results are tabulated under interstitial fauna.

TAXA [Interstitial Fauna]	TIDE ZONE	NUMBERS	LOCATION
NEMATODES	low	abund	in substrate
OLIGOCHAETES	low	abund	in substrate
OSTRACODS	low	some*	in substrate
COPEPODS	low	some*	in substrate
CUMACEANS	low	1	in substrate
AMPHIPODS	low	few	in? substrate
MITES	low	1	in? substrate

*likely underestimate as less than 0.5mm in size

This appendix provides a review of field permeability tests that might be used in evaluation of beach permeability with respect to oil. A test suitable for use on course sediment beaches was required.

Four types of standard engineering tests were considered:

(1) the tube test where the water level is drawn down (by pumping) in a cased hole and the rate of filling is then documented,

(2) a falling-head permeability test where a cased hole is filled with water and the rate of fall documented,

(3) a percolation test where a pit is excavated, filled with water and the rate of drawn-down documented,

(4) a auger test where an uncased hole is pumped down and the rate of billing documented.

The percolation test was not considered appropriate to this application because (a) beach sediments are non-isotropic and (b) pits in coarse sediment would drain too rapidly. The test cannot distinguish between the permeability of the side-walls and which is usually highly permeable and the permeability of the base of the pit which is usually much less permeable.

The auger-hole test suffers from the same problem - it is not possible to distinguish between side-wall and base permeabilities and is only appropriate for unstratified sediments. The test only requires that the base of the hole extend below the water-table.

A falling-head permeability test was evaluated prior to the field survey in a medium sand beach. Apparatus included a 30cm diameter sand bucket with the bottom cut-out. The bucket was "seated" with the base 5-10cm below the surrounding beach surface.

The bucket was then filled and the rate of fall documented. Examples are shown in Figure E-1. The test appeared to be simple, of short duration and repeatable and used used during the main survey. Additional results are included in the field observations (Appendix B)

Based on these results, a three-level permeability index is developed. The preliminary rating is based on the amount of time it required the head to fall 10cm.

cm FALL PERIOD (s)	PRELIMINARY INDEX
≤ 20	highly permeability
20 - 100	moderate permeability
≥ 100	low permeability

Testing was also conducted of the tube-method of determining permeability. For these tests, the bucket was seated about 26cm below the beach surface. The ground water table that was essentially at the beach surface was pumped down to a level 8cm from the bucket bottom and allowed to rise (Figure E-2). This test very closely approximates the "tube-method" and permits calculation of the permeability coefficient, k. The computed value for the sands tested is 0.0101 cm/second.

This test is very close to standard engineering tests and as such permeability coefficients can be computed. The test is also conducted with saturated soil conditions, removing an additional source of testing in the experiment. However, two drawbacks are (a) it can only be conducted when the tide level is at or above the point of interest and (b) it appears to be slower than the falling-head test.

Recommendations:

Based on these simple tests and the review, it is recommended that the falling-head test be used for reconnaissance surveys because of its speed and simplicity. However for more detailed surveys, such as might be conducted during a site evaluation survey, the tube-method should be used because it allows estimation of soil permeability coefficients, a standard engineering index.

This appendix provides a review of field permeability tests that might be used in evaluation of beach permeability with respect to oil. A test suitable for use on course sediment beaches was required.

Four types of standard engineering tests were considered:

(1) the tube test where the water level is drawn down (by pumping) in a cased hole and the rate of filling is then documented,

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(3) a percolation test where a pit is excavated, filled with water and the rate of drawn-down documented,

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The percolation test was not considered appropriate to this application because (a) beach sediments are non-isotropic and (b) pits in coarse sediment would drain too rapidly. The test cannot distinguish between the permeability of the side-walls and which is usually highly permeable and the permeability of the base of the pit which is usually much less permeable.

The auger-hole test suffers from the same problem - it is not possible to distinguish between side-wall and base permeabilities and is only appropriate for unstratified sediments. The test only requires that the base of the hole extend below the water-table.

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The bucket was then filled and the rate of fall documented. Examples are shown in Figure D-1. The test appeared to be simple, of short duration and repeatable and used used during the main survey. Additional results are included in the field observations (Appendix B)

Based on these results, a three-level permeability index is developed. The preliminary rating is based on the amount of time it required the head to fall 10cm.

cm FALL PERIOD (s)	PRELIMINARY INDEX
$\leq$ 20	highly permeability
20 - 100	moderate permeability
$\geq$ 100	low permeability

Testing was also conducted of the tube-method of determining permeability. For these tests, the bucket was seated about 26cm below the beach surface. The ground water table that was essentially at the beach surface was pumped down to a level 8cm from the bucket bottom and allowed to rise (Figure D-2). This test very closely approximates the "tube-method" and permits calculation of the permeability coefficient, k. The computed value for the sands tested is 0.0101 cm/second.

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Recommendations:

Based on these simple tests and the review, it is recommended that the falling-head test be used for reconnaissance surveys because of its speed and simplicity. However for more detailed surveys, such as might be conducted during a site evaluation survey, the tube-method should be used because it allows estimation of soil permeability coefficients, a standard engineering index.

"FALLING HEAD TEST"

Time (sec)	WL (cm)	WL (cm)
0	20	20
5	20	20
10	20	20
15	20	20
20	20	20
25	20	19.8
30	20	19.5
35	19	19.3
40	19	19.2
50	19	19
60	18.5	18.5
70	18.2	18.3
80	18.1	18.1
100	18	17.9
140	17	17
180	16	16.1
240	15	15.5
305	14	14.2
380	13	13.5
470	12	12.3

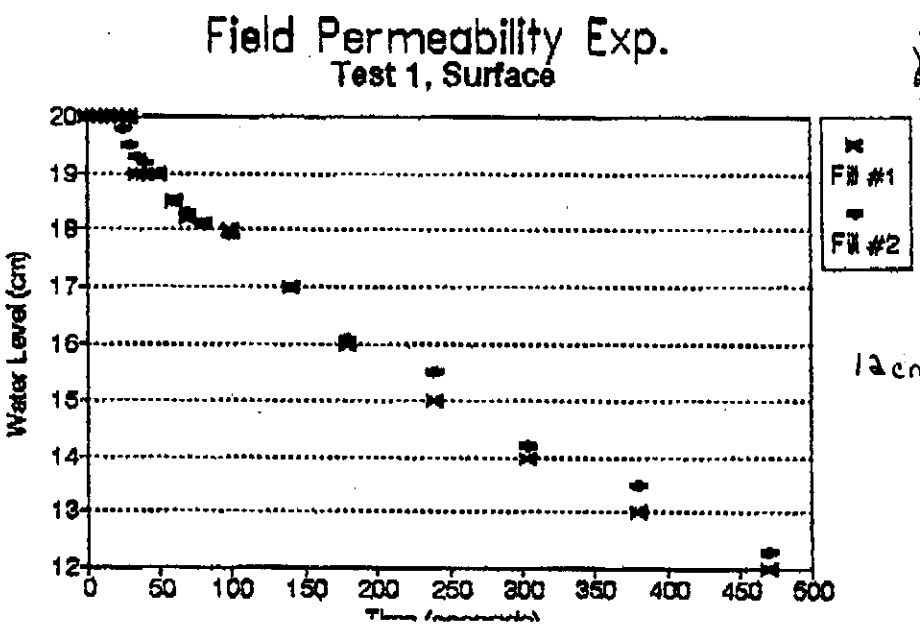
Fill #1

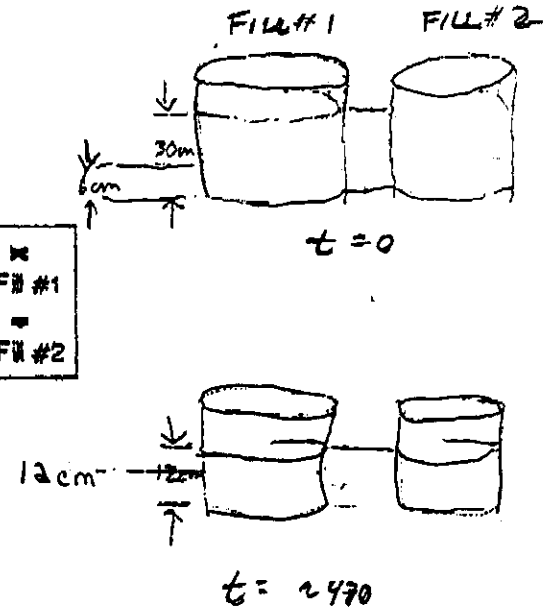
Regression Output:

Constant		1052.035
Std Err of Y Est		21.81764
R Squared		0.975249
No. of Observations		20
Degrees of Freedom		18
X Coefficient(s)	-52.6505	
Std Err of Coef.	1.976994	

Regression Output:

Constant		1116.458
Std Err of Y Est		20.31235
R Squared		0.978546
No. of Observations		20
Degrees of Freedom		18
X Coefficient(s)	-56.0417	
Std Err of Coef.	1.955843	





Time (sec)	Fill #1 WL (cm)	Fill #2 WL (cm)	k #1 (cm/s)	k #2 (cm/s)	
0	20	20	0	0	
5	20	20	0	0	
10	20	20	0	0	
15	20	20	0	0	
20	20	20	0	0.096759	
25	20	19.8	0	0.146987	
30	20	19.5	0.493824	0.099253	
35	19	19.3	0	0.050013	
40	19	19.2	0	0.050406	
50	19	19	0.128374	0.128374	overall
60	18.5	18.5	0.0787	0.052324	100 to 51
70	18.2	18.3	0.026522	0.052899	
80	18.1	18.1	0.013334	0.026743	
100	18	17.9	0.068786	0.062082	
140	17	17	0.072958	0.06546	
180	16	16.1	0.051778	0.03047	
240	15	15.5	0.051094	0.064873	
305	14	14.2	0.047565	0.032446	
380	13	13.5	0.042812	0.04979	
470	12	12.3			
		Average:	0.058192	0.067258	
		Average:	0.055832	0.050853	100 to 470 sec

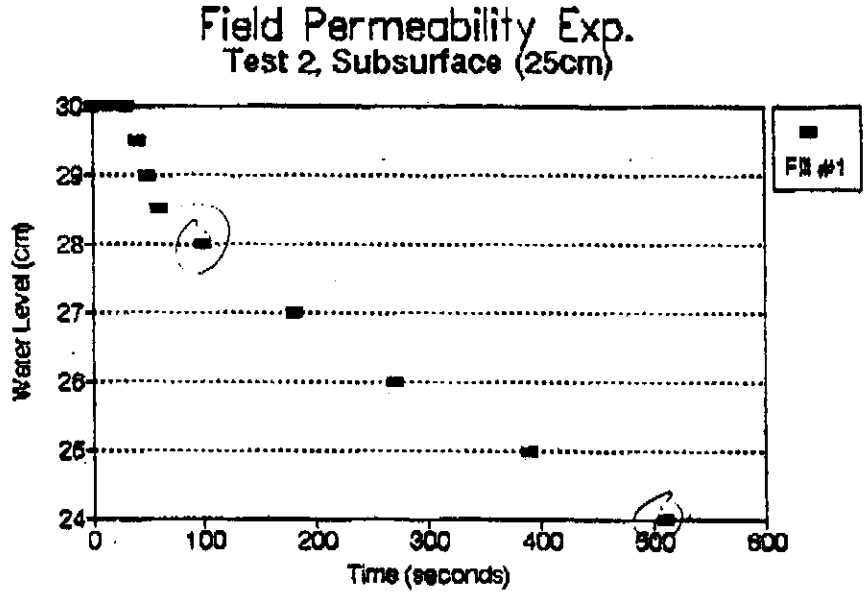
FALLING-HEAD TEST

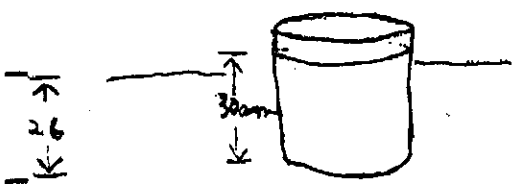
TEST 2

Time (min)	Time (sec)	Time (sec)	WL (cm)
0	0	0	30
0	10	10	30
0	20	20	30
0	30	30	30
0	40	40	29.5
0	50	50	29
1	0	60	28.5
1	40	100	28
3	0	180	27
4	30	270	26
6	30	390	25
8	30	510	24

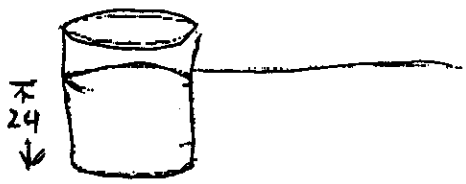
Regression Output:

Constant		2302.597
Std Err of Y Est		36.70768
R Squared		0.956104
No. of Observations		12
Degrees of Freedom		10
X Coefficient(s)	-77.0658	
Std Err of Coef.	5.221799	





t = 0



t = 510

TEST 2 "FALLING HEAD TEST"

Time (min)	Time (sec)	Time (sec)	WL (cm)	k (cm/s)		
0	0	0	30	0		
0	10	10	30	0		
0	20	20	30	0		
0	30	30	30	0.080905		
0	40	40	29.5	0.082288		
0	50	50	29	0.083719		
1	0	60	28.5	0.0213		
1	40	100	28	0.021883		
3	0	180	27	0.020186		
4	30	270	26	0.015733	0.018099	overall
6	30	390	25	0.016375		100 to 510 sec
8	30	510	24			
				==========		
			Average:	0.042799	Average: 0.018544	(100 to 510) sec

TEST 3 PROPER "TUBE TEST"

Time (min)	Time (sec)	Time (sec)	WL (cm)	k (cm/s)		
0	0	0	8	0.244125		
0	44	44	10	0.081928		
1	40	100	11	0.079028		
2	33	153	12	0.080272		
3	21	201	13	0.069948	0.065389	overall
4	12	252	14	0.045495		w/o first reading
5	25	325	15	0.047795		
6	30	390	16			
				==========		
			Average:	0.081074	Average: 0.067411	w/o first reading