A REVIEW OF THE OCEANOGRAPHY AND MARINE ECOLOGY OF PRINCE RUPERT HARBOUR *A PROPOS* SEWAGE OUTFALLS

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1 INTRODUCTION

The oceanography and marine biology of Prince Rupert Harbour are essential considerations in decisions about relocating sewage outfalls from the foreshore of Prince Rupert. The present outfalls create high coliform levels near shore and are visually displeasing. At present the harbour is closed to fishing because of these high coliform counts and because of high dioxin levels from a nearby pulp mill. There has been a suggestion to move the outfalls further from shore and into deeper water, at a cost of about $5M. Local environmental groups (*eg.* the "Friends of the Harbour") have publicly challenged this plan, concerned that the existing database may not be sufficient to make a decision on the effects of moving the outfalls. This review examines some of what we know about Prince Rupert Harbour and its environs to determine whether enough information exists to be able to judge the environmental impacts of moving and perhaps modifying the sewage outfalls that presently exist. This short review does not assess this impact, and merely identifies the problems likely to be encountered. The intention is to say where we can be confident in our knowledge of this harbour and where we might want to bolster the database with new observations.

1.1 Site

Dixon Entrance, formed by the Queen Charlotte Islands on the south and the Alaska Panhandle island on the north, see figure 1, exposes the BC mainland coast near Prince Rupert to the Westerlies. The moisture carried by these winds is dropped as it encounters the coastal mountains, meaning that on average it rains more than half the days of every month (in October, on average only 7 days do not have rain). At the east end of Dixon Entrance is Chatham Sound, separated from the open sea by a series of island and reefs. The names of local features are in Figure 2. The city of Prince Rupert is on the northwest slope of Kaien Island, and is separated from Chatham Sound and Dixon Entrance by the low and marshy Digby Island, the site of the airport.

Prince Rupert Harbour is a long narrow channel running north-south between Kaien and Digby Islands and continuing northeast into Tuck Inlet. It is, on average, about 40 m deep, below the depth of the seasonal thermocline in this area. The maximum depth, in front of the townsite, is 90 m. Of great consequence, the harbour does not have a shallow sill, the shallowest depth of the main entrance to the harbour, near Fairview, is 38 m (data from CHS chart 3958, new in 1986). This means the bottom water throughout most of the harbour can exchange with waters of equal depth (*i.e.* density) in Chatham Sound. The deepest part of the harbour may be isolated from the ocean. There has been some confusion over the sill, possibly from confusing the channel depth of 20 fathoms with meters.

A convoluted and shallow second connection to Prince Rupert Harbour is to the east through Venn Passage, by the Metlakatla Indian Reserve. This passage is locally known as Metlakatla Passage, and is rich in marine wildlife. Outside of Venn Passage, there are extensive shallows such as in Metlakatla Bay, Duncan Cove, and Tugwell Island. Other important shallows are on the inside of Venn Passage, such as Pillsbury Cove. The harbour ecology is complicated by the long, narrow, and sometimes very shallow passage to the east of Kaien Island. Water from this third connection starts from the ocean via Porpoise Channel into Porpoise Harbour, past a pulp mill of ill repute, then through Zanardi Rapids to poorly flushed Wainwright Basin, and thence by Galloway Rapids to Morse Basin and Fern Passage before arriving at Prince Rupert Harbour. The rapids just named, and a scenic reversing falls at the south end of Fern Passage, indicate energetic tidal stirring (if not effective flushing) in the surface water of the channels, and the entire passage must have been rich in molluscs, fish, birds and mammals before the white man came.

1.2 Required Data

The oceanography of Prince Rupert Harbour integrates the various mechanisms that influence circulation, according to how they can penetrate into the Harbour, and according to how the complex of channels and harbour interact. To understand the effects of adding sewage at some locations and depths in the harbour, we should know the following oceanography:

1.2.1 **Runoff** into the Harbour from local rainfall, and the runoff patterns of the Skeena River since it produces estuarine circulation over the entire region. The vertical stratification and circulation from runoff directly affects flushing of pollutants.

1.2.2 **Winds** in Prince Rupert and throughout the larger region, at small and large scales, "drive the ocean".

1.2.3 **Currents** in the greater region, in the harbour, and connecting basins are fundamental to the marine ecology. The residual currents, by season, help to establish a maximum residence time for water in the harbour.

1.2.4 **Tides and water levels** inside and outside the harbour, ideally with some vertical resolution. This allows estimating the exchange (a transfer function) between the harbour and outside.

1.2.5 **Temperature and salinity** (TS) patterns of the harbour, connecting basins, and Chatham Sound, throughout the year. As well as directly affecting the biota, TS analyses provide clues to the sources and sinks of water, and allow characterizing the estuarine circulation as well mixed or not.

1.2.6 **Dissolved oxygen** levels in the harbour and surrounding waters. Lack of oxygen is the most important short-term consideration in the impact of sewage. We should like assurance that Prince Rupert Harbour will never go anoxic. This means estimating *in situ* ventilation (oxygen input) rates, as well as the inputs of oxygen-rich and oxygen-consuming waters from out of the harbour.

1.2.7 **Sediments** in the harbour reveal the maximum currents to be expected, by the grain size remaining when finer particles are swept away. They also indicate how prone the harbour is to sediment accumulation of heavy metals. Disturbing heavily contaminated sediments should be avoided, especially during seasons of poor flushing. Sediment is an important habitat measure in its own right, *eg.* mudflats.

Appraising the likely impact of sewage requires certain biological information which is interpreted in conjunction with the oceanography:

1.2.8 **Benthic animals** indicate the productivity of the region in general, and by the nature of the species present, suggest how prone the harbour is to benthic bioaccumulation of metal and organochloride toxins. The loss of commercial and recreational use of benthic animals is an obvious consideration.

1.2.9 **Benthic plants** indicate the productivity of the area, and suggest the nature of the associated food web, particularly the existence of kelp forests and eelgrass beds.

1.2.10 **Fisheries** information, from spawning sites to juvenile nursery grounds, and including adult distributions and catches, indicate the value of the habitat not only fishes, but to marine mammals (including man) and birds.

1.2.11 **Pollutants** of various sorts need to be appraised, not just in the sewage, but especially from surrounding industry. For instance, sources of biological oxygen demand (BOD) in addition to the sewage may already be straining respiration of the harbour ecosystem.

1.2.12 **Birds and mammals** that share the region with humans should have their habitat use delimited, so that habitat may avoid negative impacts.

2 REVIEW

2.1 Runoff

Chatham Sound guides the runoff from the large Skeena River, which enters at the south end of the Sound, to the north and past Prince Rupert Harbour. The Skeena River median spring flood is about 4730 m^3s^{-1} (late May, early June) and the mean flow is about 920 m^3s^{-1} (after NEAT 1975). Runoff is maximal in spring (snowmelt) and late fall (peak rainfall), and a runoff minimum from the Skeena is in summer. The freshwater is forced to turn right by the Coriolis effect, thus flowing north along the coast. Dilution is substantial, but surface salinities can show over 15% Skeena River water, and are likely to vary greatly as winds and runoff vary the concentration of Skeena water off the harbour. A large component of the total circulation in Chatham Sound will be from estuarine circulation induced in the entire region by the Skeena.

Local runoff is small because of the relatively small catchement area, although the rainfall is high. Prince Rupert Harbour is basically an estuary because of the local runoff, such as from Silver Creek and McNichol Creek, although we did not determine how local estuarine effects compare to the wind, tide, and external circulation effects.

2.2 Winds

Winds are summarized in Chevron (1982), and are usually along the coast (northwest or southeast). These winds cause strong downwelling in winter, and variable upwelling in summer. This region is transitional between upwelling and downwelling coastal domains, and has great interannual variability. The upwelling near Prince Rupert is summarized in Table 2 (after CHEVRON 1982).

Table 1: Upwelling in the Prince Rupert vicinity. The mean is for the period 1948-1967, and the minimum and maximum are for the period 1972-1975. The units are $10^{-2}m^3s^{-1}m$.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	-64	-36	-12	-5	4	15	16	12	-3	-40	-58	-57
Min	-75	-72	-25	-9	-20	-15	8	7	-6	-35	-91	-81
Max	5	-37	2	17	2	38	17	44	38	9	2	-7

The action of these winds is dynamic and complex. The winter downwelling from storms (recall that the surface stress is proportional to velocity cubed) pushes the sea water up against the coast. After each storm, as these winds relax, the potential energy of the slope in sea heights produces strong alongshore currents through the Coriolis effect. This active winter circulation is largely barotropic (low stratification), and will be effective at flushing Prince Rupert Harbour.

Although Wainwright and Morse Basins are protected from the wind, Prince Rupert Harbour is exposed to storms and their stirring, and will absorb energy from storm surges. Winds are high enough in Prince Rupert Harbour that, combined with poor anchorage (see section 2.7 Sediments), large ships frequently drag anchor and there have been several accidents because of this (pers. comm., Capt. John Anderson, IOS). These winds are a further reason to expect reasonable flushing and efficient vertical mixing during the winter. Calm periods exist in Prince Rupert during the April to September, a season of less vigorous estuarine circulation.

2.3 Currents

Using the IOS Ocean Data Information Service (ODIS), a computerized inventory with a map interface, 5 current meter records from Chatham Sound were located, including a summer record from 35 m deep in Prince Rupert Harbour. The locations of these meters are in figure 3, and the statistics from 4 useful moorings are in the Appendix. There is another set of moorings, coastal and north of Prince Rupert, that would have been valuable for this review, but they collected data from only one day (according to ODIS).

In and out of the harbour, the overall mean current is relatively small, 0.007 ms^{-1} at 35 m and 0.010 ms^{-1} at 15 m. The maximum current recorded in the harbour at 35 m is 0.20 ms^{-1} whereas outside in Chatham Sound the maximum at 15 m is over 0.80 ms^{-1}. The proportion of time with currents of 0.10 ms^{-1} or greater is 18% inside and about 67% outside. In the harbour 8% of the current observations are less than the minimum measurable (0.01 ms^{-1}) while almost no outside current observations are this slow. These summer calms in the harbour pose the risk of stagnation.

Further to the south, Hecate Strait acts as a funnel to intensify wind-induced northward currents toward Chatham Sound. In numerical models of Hecate Strait-Dixon Entrance circulation (Hannah *et al.* 1991), strong northward currents pass from Hecate Strait into Chatham Sound, across the bathymetry barrier (figure 4). This is particularly noticeable in tracks from simulated Lagrangian drifters. A series of current meters are now collecting data between the islands forming the western border of Chatham Sound to clarify this circulation, their locations are in Figure 4 (pers comm., Mike Foreman, IOS).

2.4 Tides and Water Levels

Hecate Strait, Dixon Entrance, and Chatham Sound form basins in which currents may oscillate harmonically with various tidal harmonics, and these trapped harmonics can be "rectified" by non-linear bottom friction into residual currents. Tides in Chatham Sound are very strong, as evident in figure 5 which shows the results from IOS tidal models (pers. comm., Mike Foreman, IOS). The semi-major axis of the M2 tidal current is about 0.2 ms^{-1} outside Prince Rupert Harbour, which we should consider as moderately strong. These maps are from barotropic models, and ignore the effect of vertical stratification of the water. In convoluted inshore regions with strong stratification, these barotropic results are not necessarily applicable.

Prince Rupert Harbour has a permanent tide gauge, and the mean tidal range of water level is 4.9 m, with a large range of 7.7 m. These are large tides, sufficient to create rapids and reversing falls in the channel constrictions. Note that these rapids are features of the surface layer. Harmonic analysis tables for the current meter records retrieved from ODIS allow a quick comparison of tides and currents in and out of the harbour, as in Table 2.

Table 2: A comparison of the tidal constituents measured at 15 m in Chatham Sound May to September 1982 (IOS meter 19770051/R01) and at 35 m in Prince Rupert Harbour (IOS meter 19770079/PRH), July-August 1977. The major and minor tidal ellipse values are the semi-axis values in $10^{-3}ms^{-1}$, and the incline of the ellipse is in degrees true.

Tidal Constituent	Period	Symbol	Prince Rupert Harbour major/minor	incline	Chatham Sound major/minor	incline
Mean			7	0	10	180
Principal Lunar	12.42	M2	7/0	17	276/8	142
Principal Solar	12.00	S2	2/1	139	100/5	157
Larger Lunar Elliptic	12.66	N2	3/2	98	72/16	135
Luni-solar Diurnal	23.93	K1	4/1	144	42/5	235
Lunar Fortnightly	327.86	M4	3/0	237	39/16	90
Lunar Monthly	661.40	MM	22/1	287	35/14	332

Table 2 shows that damping of tidal velocities is on the order of 30 times from outside to inside the harbour for the three main constituents. This suggests that tides in the harbour bottom are nearly lost. Exchange with the exterior must be small in order to produce this damping. Note that at 0.07 ms^{-1} (table 2) the diurnal tide in the harbour will move water back and forth only about 1 km, and will be ineffective at exchanging the harbour water. There is a difference between excursion and exchange that needs to be noted here: tidal excursions may move water out of the harbour on the ebb tide, but the flow tide may bring much of that same water back in, so there is less exchange than suggested by calculating the excursion. But still, in Prince Rupert the surface level of the harbour water changes with an amplitude of about 5 m and there are reversing falls in the system: hardly a domain of meagre tides. What allows this seeming contradiction of strong surface tides, but weak tides near the bottom at 35 m (assuming the instrument records and analyses are correct)?

A clue is given in a 24 hour series of currents measured throughout the water column in Prince Rupert Harbour by Waldichuk (1968). This series from 24-25 October 1964 shows strong attenuation of the tidal currents at the thermocline (15 to 20 m), so the deeper currents are mainly non-cyclic (to the north at about 0.05 ms^{-1}). The tidal currents are strongly damped in the deep layer of the harbour (where the 1979 current meter was), but not so damped at the surface, hence the surface height amplitudes and reversing falls. It may be that a baroclinic component of the circulation suppresses the tidal exchange of bottom water and slows the mean circulation near the bottom. A formal analysis might be relatively complex, but certain "diagnostic" parameters may possibly be evaluated from the data at hand, avoiding things like 3-D numerical simulations.

Such a situation of baroclinic tidal currents means that the circulation in the harbour is more complicated than might have been hoped for by the city's engineers. If the tidal energy is not penetrating to the bottom of the harbour, mixing and exchange from other energies may also be poor. The threat, again, is that there may be prolonged periods of little exchange for the bottom waters, during which stagnation would threaten the biota and release heavy metals.

2.5 Temperature and Salinity

A substantial database for TS data exists throughout this region. ODIS has records for 309 TS stations in the Prince Rupert region (figure 7). The database now includes a thorough CTD survey of Dixon Entrance and Chatham Sound in 1991 (pers. comm., Bill Crawford, IOS), the locations of which are in figure 8. Representative TS profiles from Chatham Sound 1991 were examined, and are included in the Appendix. They show strong stratification above 20 m with low salinities above 20 m and salinities greater than 31 below 20 m.

The TS database appears adequate for watermass analysis in Prince Rupert Harbour, although coincident exterior and interior studies are limited.

2.6 Dissolved Oxygen

One would expect, as a consequence of the BOD from the pulp mill, with additional BOD from sewage, fish plants, and log booms, that dissolved oxygen would be low in the harbour, but in the observations it is actually not low (Table 3). The levels measured near the bottom in 1961 and 1974 are about 60% saturated. This is the same oxygen level as in the middle of Chatham Sound at the same depths (40 m) and seasons. We were unable to discover any summer samples of oxygen in Prince Rupert Harbour, and are not aware of any oxygen measurements made after the Watson Island pulp mill effluent was diverted from Porpoise Harbour to an outfall closer to the entrance to Prince Rupert Harbour. This is a serious gap in the database.

Table 3: Dissolved oxygen observations in the deep layer of Prince Rupert Harbour, with accompanying TS values. Oxygen values are in ppm or kg m^{-3}. Data from NEAT (1975).

Date	Oxygen	Temperature	Salinity
20 Oct- 8 Nov, 1974	7.5	9.5	30
15-18 Apr, 1961	9	6	32

Wainwright Basin and Morse Basin historically showed oxygen depletion below 5 ppm, intolerable to fish, because of the pulp mill effluent, but this did not extend to the harbour (Waldichuk 1962). The effect of moving the pulp mill outfall to Chatham Sound remains to be seen but it is of concern to us that this effluent may now be drifting directly north into Prince Rupert Harbour. If the pulpmill effluent is entrained into sea water between about 20 to 40 m (under the thermocline), there may be a BOD loading of Prince Rupert Harbour bottom waters that is presently unnoticed. Adding BOD to the harbour bottom by lowering the sewage outfalls to 40 m could compound this BOD loading.

2.7 Sediments

Poor anchorages reported in Prince Rupert Harbour (pers comm., Capt. John Anderson, IOS) are thought to be because a thin layer of mud overlies smooth rock. This suggests little sedimentation in the Harbour. Perhaps much of this sediment is very recent, from deforestation, from industrialization, and from the townsite's sewage.

Sediments have been examined frequently in Prince Rupert Harbour, including small dredges (Waldichuk 1962b) and photographic transects (unanalyzed, NEAT 1975). Except for the constriction between Digby and Kaien Island where occasional currents have scoured the bottom (sand and shells remain), the harbour bottom is black mud. This suggests high organic levels, rapid sedimentation rates, and sediment trapping of pollutants. It further suggests a good habitat for molluscs, shrimps, and crabs. There are anecdotal accounts of anoxic sediments (sulphurous mud on anchors) presumably from the deeper parts of the harbour (pers. comm., Dick Herlinveaux, IOS).

Metal concentrates from Equity Silver mine have been shipped from Fairview for 16 years. This is likely to be a source of high levels of Cadmium in local sediments, but we are uncertain whether this has been documented. It is also likely that sediments immediately around shipyards in the area exhibit high levels of toxic metals. Further toxins in the sediments are expected to have arrived from warehouse drains and the storm sewers. Extensive sediment analyses near the pulp mill have been conducted for dioxins and other organochlorines (Dwernychuk 1989) and sediment maps for the region are available or possible (Williams 1991).

2.8 Benthic Animals

Crabs, bivalves, shrimp, prawns have been harvested from the harbour, in both commercial and recreational fisheries. There is a potential for harvesting green sea urchins. At present, Prince Rupert Harbour is closed to benthic harvesting because of coliform contamination and dioxin pollution. If the harbour becomes anoxic, even for a day, these invertebrate populations could be greatly reduced and their fisheries lost for years.

2.9 Benthic Plants

Marine vegetation sampling has been undertaken for the Prince Rupert region, and the coastline geomorphic classification allows expanding these samples into maps (Williams 1991). We find ourselves most concerned with the eelgrass beds in and outside Venn Passage, which are downstream of Prince Rupert Harbour. These should be examined more carefully than the sampling in Williams (1991) represents, perhaps by aerial mapping using CASI and subsequent image classification. To the extent habitat mapping is important in this region, such digital surveys could provide important baseline information for GIS databases.

Venn Passage, specifically Pillsbury Cove at the inner end of Venn Passage, was used as the source for eelgrass transplants in April 1990 (pers. comm., Leslie Powell, DFO Prince Rupert). These transplants were placed on Digby Island across from the Fairview terminal as compensation for habitat loss from the terminal expansion. The success of this transplant is being monitored for three years. This observation attests to the quality of eelgrass habitat in Venn Passage. There is local concern that Venn Passage accumulates pollution from the Prince Rupert townsite, but there is little or no information to confirm or contradict this worry (pers. comm., Leslie Powell, DFO Prince Rupert).

2.10 Fisheries

Within the harbour, the heavy rainfall produces local runoff, and at least one stream, McNichol Creek, is identified as supporting salmon. Both Silver Creek (a large stream entering at the north end of the harbour) and Kloiya Creek (off Morse Basin), as well as a number of smaller creeks in Tuck Inlet support Coho. Sewage does not pose a direct threat to these streams, but the regional intertidal habitat that supports smolts is, technically, exposed to risk from sewage. Salmon smolts are reported from beach seining in the harbour (NEAT 1975, CHEVRON 1982). Since the harbour is used by fry on their out-migration, there may be food chain impacts if the benthos are affected.

There are major spawning grounds for herring in the Prince Rupert and Kitkatla areas, especially associated with eelgrass beds (pers comm., Doug Hay, PBS; Humphreys and Halgete 1976; Hay et al. 1989). Herring spawning is in March-April, when flushing from winds would be brisk. The outflow of Prince Rupert Harbour surface waters through Venn Passage poses a pollution risk to the eggs at that time, but the risk would be in terms of oil spills or other acute pollution events rather than chronic pollution. The effect of sewage and pollution on the herring is likely to be indirect, through loss of the Venn Passage eelgrass beds, rather than by killing herring or eggs directly. The Watson Island pulp mill removed an important herring feeding ground in Wainwright Basin (Waldichuk 1962) but we do not know whether the region is now being used by herring as it was before 1952 when the mill was built. Herring are reported to spawn in Porpoise Harbour now, whereas it was previously denied to them because of sulphite effluents (pers. comm., Leslie Powell, DFO Prince Rupert).

Fisheries information was compiled in bibliographic form by Williams (1991). The figures from that compilation are included in the Appendix. There are currently two major fish plants in Prince Rupert Harbour, and there have been as many as six. There are recreational fisheries for clams and crabs, an unknown level of commercial crab fishing, and potential for green sea urchin harvests (Drinnan and Webster 1974, NEAT 1975, CHEVRON 1982). The harbour is presently closed because of pollution.

2.11 Pollutants

Wainwright Basin was devastated by a pulp mill which began operations in 1952 (Drinnan and Webster, 1974). Waldichuk (1962) shows anoxia and a 3 meter thick field of pulp sludge in what was once the littoral zone this basin. The "spent sulphite liquor" (SSL) from the mill used to flow, in the surface waters, into Prince Rupert Harbour, probably largely by way of Morse Basin and Fern Passage. In Prince Rupert

Harbour itself, the water in April 1961 was 10 to 14% SSL near the bottom, and up to 35% SSL in the surface layers, assuming the original liquor was 10% sulphite (Waldichuk 1962).

This concentration of SSL, even if inapplicable in 1991 (the pulp mill now pumps SSL into Chatham Sound rather than Wainwright Basin these days, and presumably has reduced waste), acts as a tracer for water from Wainwright Basin. Our interpretation is that about 15% of the bottom water in Prince Rupert Harbour comes in by surface water via Morse Basin, or from horizontal connection to pollution in Porpoise Harbour. For the surface water in Prince Rupert Harbour, we may expect that about 30% of the water comes from the vicinity of the pulp mill, following both routes. Apart from the poisons in the SSL, the impact of SSL is in its BOD, which aggravates the BOD from sewage in a harbour that is connected to oxygen-poor waters at 40 m in Chatham Sound.

Waldichuck (1962) mentions that herring immediately re-invade Wainwright Basin when the Watson Island pulp mill is stopped for repairs, doubtless they are feeding on the amphipods abundant in the mill effluent. These amphipods may be an important vector for bioaccumulation of various poisons into herring and herring eggs, and a vector by which poisons may reach birds and mammals.

An ongoing series of water quality studies have been conducted in the Prince Rupert region in conjunction with the Watson Island pulp mill (Dwernychuk 1988, see Williams 1991 for further references). Organochlorine studies in the sediments and biota have also been carried out (Dwernychuk 1989). There is enough work on pollutants to expect no pollution surprises exist in Prince Rupert Harbour.

Relocation of the pulp mill outflow has recently been accomplished by pumping the SSL across Ridley Island to Chatham Sound. The presumption must have been that stronger tides and currents would improve mixing and dilution of the SSL. We note that the outfall is now much closer to Prince Rupert Harbour, and that it is likely discharging in the 20 - 40 m depth. This is the depth of water exchanging with the bottom layer of Prince Rupert Harbour, and has historically been measured as only half saturated with oxygen. It may be that the new outfall has increased the BOD loading in the bottom layer of Prince Rupert Harbour, but we are unable to determine to what extent this has occured.

2.12 Birds and Mammals

Sufficient information exists on the bird populations in the vicinity of Prince Rupert and the habitats they use (NEAT 1975, Chevron 1982). However, little attention ihas been paid to the seasonality or biological timing of habitat use (*eg*. possible dependence of migratory birds upon herring spawn). The coasts facing

Chatham Sound are all seabird habitat of importance, and the region seaward of Venn Passage especially so.

Virtually no mention of marine mammals was encountered in this cursory search, but we are willing to assume that not only are diverse species found in the region, but that there are a few, such as river otters, sea otters, and killer whales, in which there is substantial popular interest. The mobility and habitat of most marine mammals make environment destruction from relocating sewage outfalls an insignificant population risk, but there is an unassessed danger from infecting marine mammals with sewage borne diseases. We discovered no reason to expect Prince Rupert Harbour to be unique with respect to marine mammals.

3 CONCLUSIONS

The database for Prince Rupert Harbour is fair to poor. At least one major gap in our knowledge needs to be filled: a risk assessment for summer stagnation of the harbour bottom. We know that the water below the summer thermocline in Chatham Sound is about half saturated with oxygen (or half depleted) There is no sill at the southwest end of Prince Rupert Harbour, *i.e.* most of the harbour is at the same depth as across from Fairview. Density profiles in the harbour are similar to Chatham Sound. We conclude that the bottom water in the harbour comes from the same level (20 to 40 m) outside the harbour. The exchange rate for this bottom water is critical to maintain dissolved oxygen levels at levels that support fish and macrobenthos. We have discovered that, despite obvious activity in the surface layer (reversing falls, 5 m tides, oxygen saturation, reasonable currents), tidal currents in the bottom levels of the harbour are strongly damped, by a factor of about thirty compared to the outside. In summer, both winds and runoff from the Skeena are minimal, removing important energy sources for flushing the harbour. Although occasional strong (0.2 ms^{-1}) currents show in the current meter from the harbour, enough to do some scouring of sediments southwest of the townsite, mean currents in the harbour are weak (0 to 0.005 ms^{-1}).

Apparently the bottom waters of the harbour (40 m) may be without effective replacement for periods of weeks at a time during the summer. The BOD from the pulpmill (now moving perhaps more directly into the harbour from a new outflow), from seafood processing plants, from increasing numbers of log booms, and from ever increasing amounts of sewage would then be essentially in a contained basin, one with a lid on it from summer stratification. The likelihood of a catastrophic dip in dissolved oxygen levels is greater from June to September than other seasons because of warm temperatures promoting bacterial growth and the increased stratification and decreased lower flushing. Lowering of dissolved oxygen levels has an element of positive feedback, as killed biota (plant and animal) further contribute to BOD. The release of metals from the sediments, with cadmium, lead, and mercury being of special concern, would not occur until the bottom water redox potential (related to oxygen levels) actually went negative and caused the reduction of presently oxidized surface sediments (which in themselves represent an chemically bound oxygen pool that buffers the redox potential of the water). Note that reduced surface sediments and high BOD levels already exist beneath the log booms in the harbour. In short, the oceanography of the bottom of Prince Rupert Harbour needs to be examined, and sewage should not be added to water below the main channel depth (*i.e.* avoid adding sewage to water below 38 m).

To quantify the risk of summer stagnation in Prince Rupert Harbour, we must (a) understand why the tides are effectively damped at the bottom of the harbour, and (b) clarify the mean circulation of the harbour. Civil engineering handbooks may suggest extensive measurements are necessary, but detailed recommendations on what needs to be done are beyond the scope of this little report. Much progress in our knowledge can, however, be made with relatively little expense. At the least, a current meter time series (or several) during the summer is recommended, supplemented by repeated and accurate CTD, dissolved oxygen, and BOD surveys. This dataset could be collected by university summer students and borrowed equiptment. The analysis of these data would involve determining water sources, exchange rates, and oxygen levels in the harbour under various scenarios of insolation, runoff and winds. The risk of having the harbour suffocate during a prolonged calm could be determined from such a model, plus an analysis of the historical statistics of wind, runoff and stratification. The existing database is sufficient to determine these statistics. Such a model could be consulted during worrisome summer calms. After discovering a high risk of anoxia, one could switch to surface outfalls and curtail industrial BOD loading. Relieving summer BOD loading should be considered in the light of a model of the harbour's respiration, including changes to log booming procedures.

The question of where to locate the sewage (assuming one could put it anywhere) is difficult, but we can speculate a bit with the data at hand. The most important ecological risk appears to be Venn Passage, with an native reservation, eel-grass beds, and important fish, benthos, and fowl populations. If the outflow of sewage fouled the eelgrass with heterotrophic bacteria, or if anoxic water washed over the eelgrass beds, then not only could the eelgrass *per se* and the associated cover and habitat be lost, but it is then possible to lose the fine sediments that are anchored in shallow, storm-swept water by the eelgrass. Loss of the Venn Passage ecosystem would be classified as a major event of habitat degradation, on a scale exceeded only by the earlier destruction of Wainwright Basin. The risk of such a habitat loss cannot be determined without a lot analysis, and we see no reason for alarm at present. Our point is merely that one would wish to preserve Venn Passage.

Unless the sewage outfall can be north of Venn Passage, directly into Chatham Sound, the risks described will be present at some level. While going outside and north of Venn Passage looks like the best solution, it is expensive (the outfall would be distant, sewage and storm drains are combined, no lateral collection) and the outfall would be exposed to storm waves. We note that the pulp mill has an outflow into Chatham Sound, and it may be possible to divert the sewage to the same outfall (leaving storm drains to flow into Prince Rupert Harbour). We speculate that there is a tradeoff between putting the outfall in the harbour near Venn Passage and reducing the risk of anoxia at the expense of increasing the risk of fouling the eelgrass beds, or putting the outfall southwest of Prince Rupert to allow biodegradation of sewage but at increased risk of anoxia. Certainly we should avoid adding sewage to the deepest parts of the harbour, noting these will have little exchange and are already coping with BOD from the pulp mill, fish plants, and log booms.

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APPENDIX

contents:

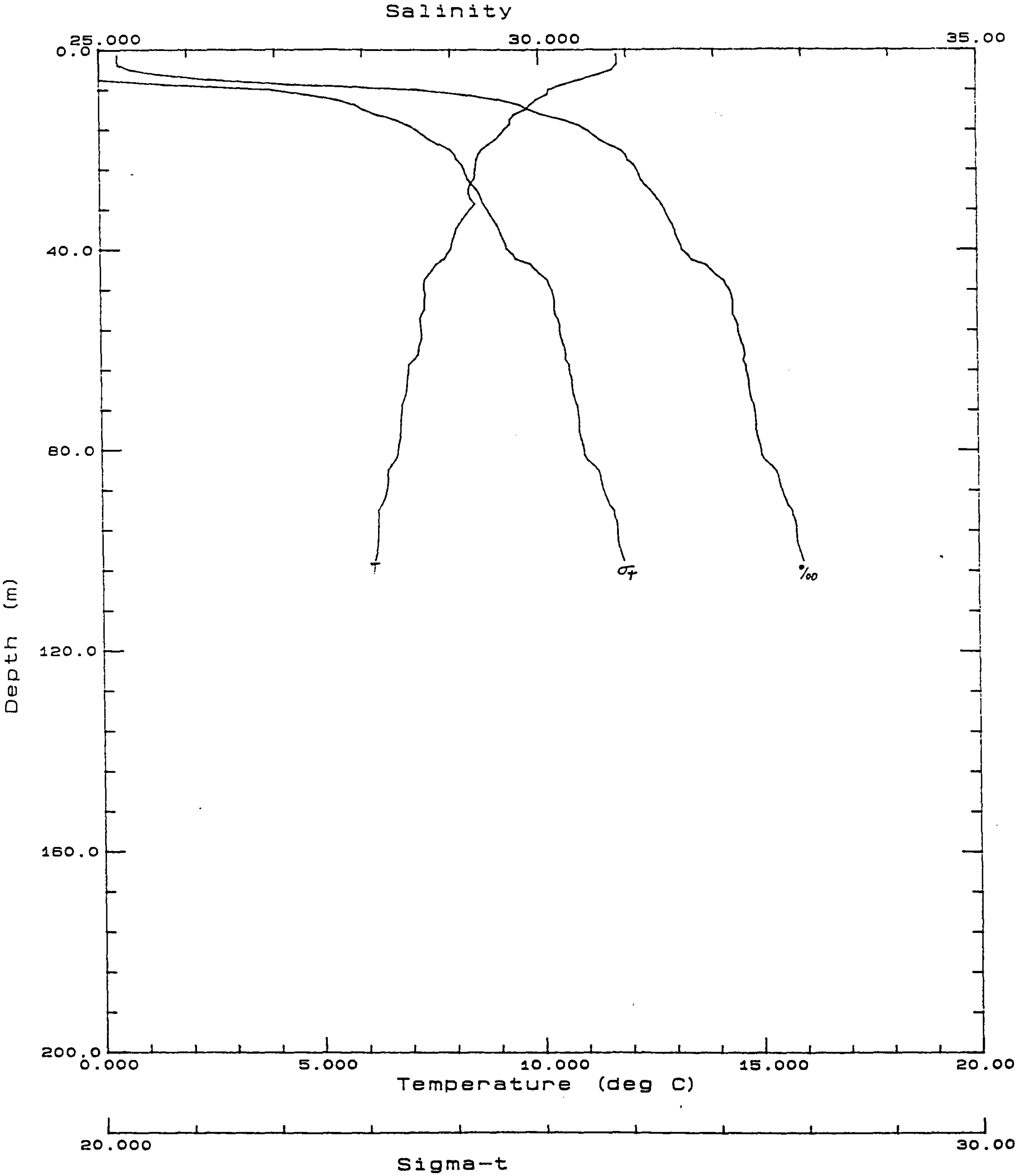
November 15, 1991

Queen Charlotte Surface Current Study
(plus Hiekish Narrows)

Station Locations (Actual as of July/91)							
Stn	(N)	(W)	Water Depth		Instrument Depths (m)		
Name	Latitude	Longitude	(m)	(fm)	Current Meters	Press	status
RP03P	54°01.63′	133°48.67′	1091	597		1091	2R
QF01_	54°33.77′	132°56.02′	388	212	50,100,200,368		R
QF02_	54°19.29′	133°02.40′	474	259	50,100,200,455		2R
DP01P	54°14.07′	132°58.05′	10.6	5.8		10.6	D
DP04P	54°47.63′	131°58.12′	12.1	6.6		12.1	D
DP15_	54°36.63′	131°19.34′	90	49	50		R
DP05P	54°36.93′	130°49.55′	11	6.0		11	D
DP06_	54°40.30′	130°49.79′	328	179	50,100,200,300		R
CP01_	54°22.81′	130°39.54′	119	65	25,50,100		R
CP01S	54°25.49′	130°39.49′	69	38	14		R
CP02_	54°18.49′	130°44.39′	194	106	23,48,98		R
CP02S	54°18.83′	130°45.15′	209	114	15		R
HP11_	53°54.25′	130°54.27′	75	41	25,50		R
HP12_	53°54.37′	131°14.95′	26	14	10		S,R
HP13_	54°06.53′	131°30.93′	21	11	7		S,R
HP02P	54°01.43′	130°36.84′	5.0	2.7		5.0	D
HP04P	52°46.88′	129°17.92′	12.5	6.8		12.5	D
HP09P	52°42.82′	131°34.63′	11.4	6.2		11.4	D
HIEK1	52°52.23′	128°29.44′	11.7	6.4	6.5		D

Status: T = tentative, S = summer only, W = winter deployment,
R = acoustic releases required, D = diver deployed

Note: 1) DP01P is near previous EGER, DP04P is near previous MCL
2) Number of CM moorings: 12; pressure recorder moorings: 7
3) **Positions of RP03P and all current meter moorings except HIEK1 are GPS, use NAD-83 charts or apply corrections.**



DR28EJ1.avg: R28EJ19

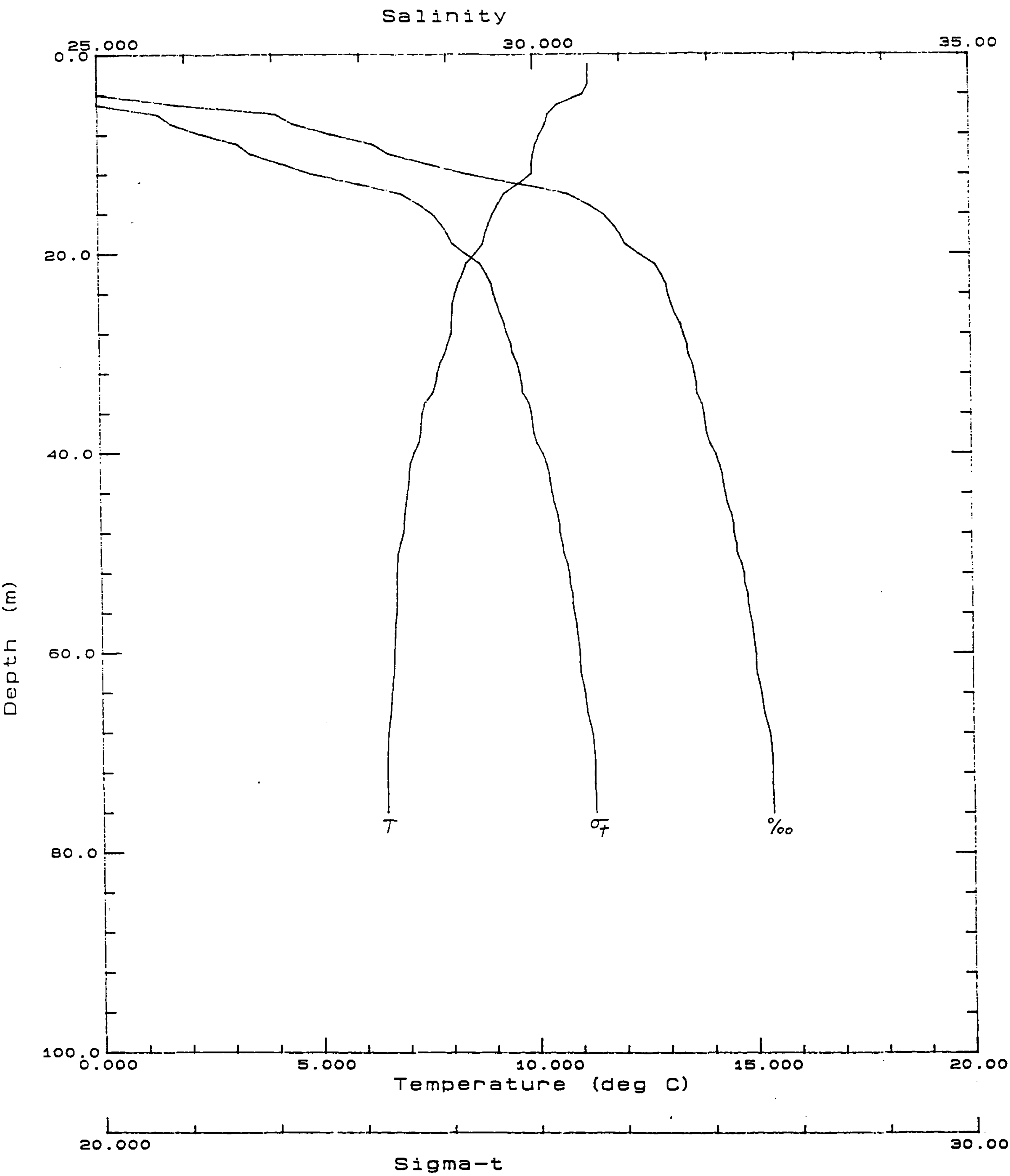
SEAKEM OCEANOGRAPHY LTD.
STATION: R28EJ19
DATE: 20/07/91 TIME: 35 UTC
POSITION: 54-23.33N 130-33.62W
BOTTOM DEPTH: 115 M
SECCHI DEPTH: 2.5 M SST: 12.1 C SURFACE SALINITY: 999 o/oo
RESULTS OF CTD CAST
SEABIRD SBE-19 WAS USED
raw data file = DR28EJ1.dat

METERS	TEMP	SALINITY	SIGMA-T	SVA	DELTA D
1.00	11.79	25.21	19.04	865.80	0.00
2.00	11.79	25.21	19.03	866.07	0.09
3.00	11.79	25.21	19.04	865.81	0.17
4.00	11.68	25.35	19.17	853.31	0.26
5.00	11.36	25.67	19.47	824.38	0.34
6.00	10.95	26.26	19.99	774.08	0.42
7.00	10.59	27.15	20.74	702.14	0.50
8.00	10.23	28.61	21.93	588.08	0.56
9.00	10.21	29.14	22.34	548.29	0.62
10.00	9.97	29.54	22.70	514.55	0.67
11.00	9.83	29.78	22.91	494.54	0.72
12.00	9.71	29.89	23.01	484.75	0.77
13.00	9.47	30.03	23.16	470.25	0.82
14.00	9.35	30.27	23.36	451.07	0.86
15.00	9.35	30.45	23.51	437.31	0.91
16.00	9.23	30.55	23.60	428.17	0.95
17.00	9.14	30.63	23.68	421.00	0.99
18.00	9.03	30.71	23.76	413.58	1.04
19.00	8.88	30.82	23.86	403.43	1.08
20.00	8.71	30.94	23.98	392.07	1.12
21.00	8.63	30.99	24.04	386.64	1.16
30.00	8.44	31.35	24.35	357.28	1.49
50.00	7.38	32.20	25.16	279.92	2.13
75.00	6.82	32.46	25.44	253.77	2.80
100.00	6.26	32.95	25.90	210.57	3.38

DEEPEST MEASUREMENT:

102.00	6.21	32.99	25.94	206.95	3.42

→



DR26J11.avg: R26J11

SEAKEM OCEANOGRAPHY LTD.
STATION: R26J11
DATE: 12/07/91 TIME: 505 UTC
POSITION: 54-16.20N 130-32.30W
BOTTOM DEPTH: 85 M
SECCHI DEPTH: 1.5 M SST: 11.5 C SURFACE SALINITY: 999 o/oo
RESULTS OF CTD CAST
SEABIRD SBE-19 WAS USED
raw data file = DR26J11.dat

METERS	TEMP	SALINITY	SIGMA-T	SVA	DELTA D
1.00	11.29	23.67	17.92	973.11	0.00
2.00	11.28	23.67	17.93	972.79	0.10
3.00	11.28	23.67	17.92	973.02	0.19
4.00	11.15	23.79	18.04	961.52	0.29
5.00	10.56	25.88	19.75	796.89	0.38
6.00	10.34	27.03	20.69	707.06	0.45
7.00	10.28	27.24	20.85	691.02	0.52
8.00	10.15	27.66	21.20	657.60	0.59
9.00	10.05	28.14	21.60	619.91	0.66
10.00	10.00	28.33	21.75	605.08	0.72
11.00	9.96	28.77	22.10	571.76	0.78
12.00	9.96	29.21	22.44	539.08	0.83
13.00	9.66	29.83	22.97	488.50	0.88
14.00	9.33	30.40	23.47	441.18	0.93
15.00	9.19	30.62	23.66	422.39	0.97
16.00	9.06	30.81	23.83	406.56	1.01
17.00	8.96	30.91	23.92	397.53	1.05
18.00	8.87	30.99	24.00	390.20	1.09
19.00	8.82	31.05	24.06	385.02	1.13
20.00	8.65	31.21	24.21	370.70	1.17
21.00	8.43	31.39	24.38	354.40	1.21
30.00	7.91	31.76	24.74	319.82	1.51
50.00	6.81	32.30	25.32	265.10	2.09
75.00	6.51	32.68	25.66	232.96	2.70

DEEPEST MEASUREMENT:

76.00	6.50	32.69	25.66	232.76	2.72

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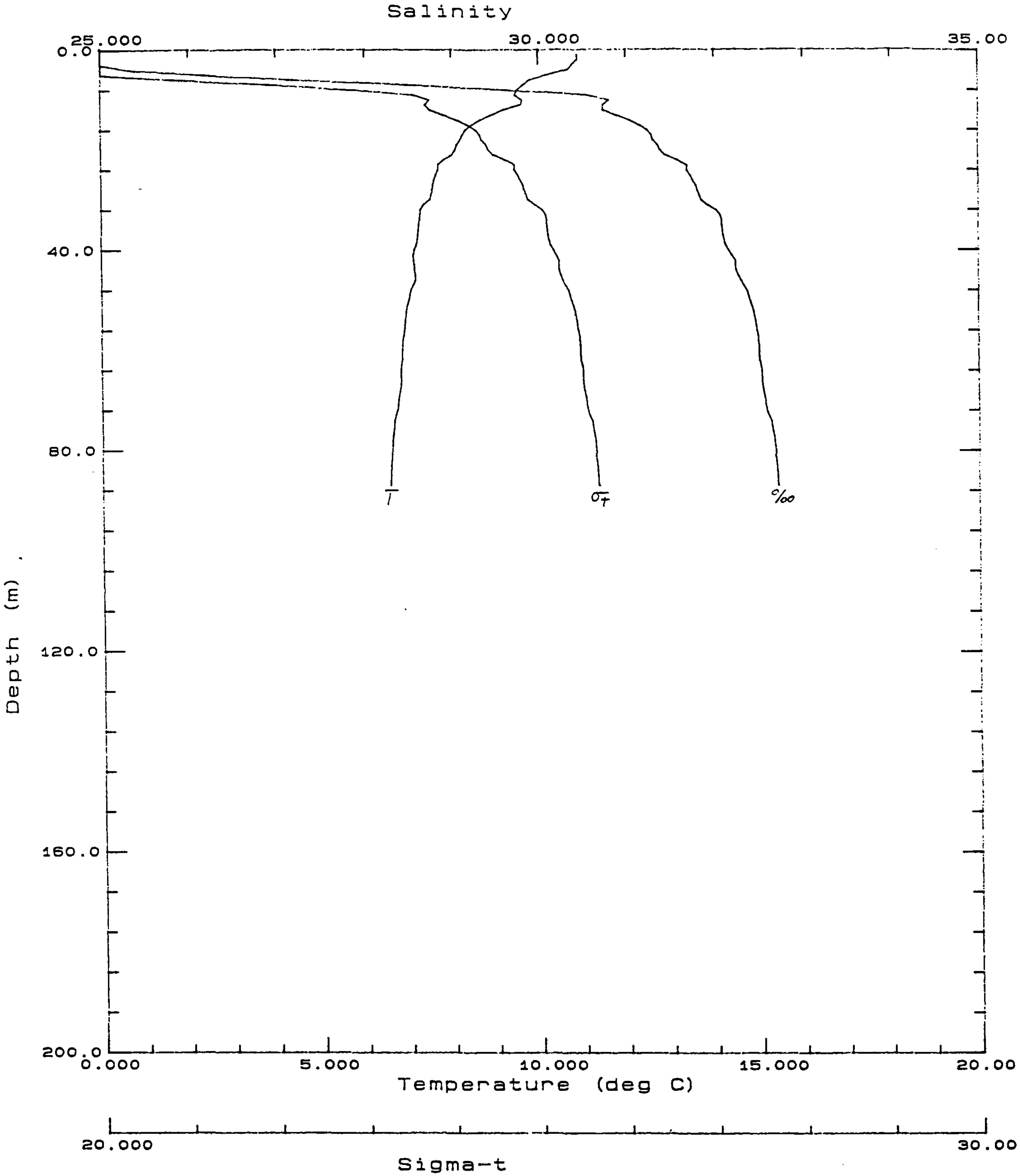

DR24J11.avg: R24J11

SEAKEM OCEANOGRAPHY LTD.
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DATE: 12/07/91 TIME: 300 UTC
POSITION: 54-10.10N 130-28.10W
BOTTOM DEPTH: 111 M
SECCHI DEPTH: 1 M SST: 11.2 C SURFACE SALINITY: 999 o/oo
RESULTS OF CTD CAST
SEABIRD SBE-19 WAS USED
raw data file = DR24J11.dat

METERS	TEMP	SALINITY	SIGMA-T	SVA	DELTA D
1.00	10.90	23.90	18.17	949.37	0.00
2.00	10.90	23.90	18.16	950.08	0.09
3.00	10.78	24.26	18.47	920.72	0.19
4.00	10.68	25.36	19.33	837.31	0.28
5.00	10.22	26.13	20.00	772.84	0.36
6.00	9.80	27.14	20.85	691.26	0.43
7.00	9.65	28.45	21.90	590.95	0.49
8.00	9.51	29.59	22.81	503.85	0.55
9.00	9.46	30.53	23.55	433.12	0.60
10.00	9.63	30.82	23.75	414.28	0.64
11.00	9.59	30.74	23.69	419.39	0.68
12.00	9.20	30.74	23.76	413.39	0.72
13.00	8.95	30.89	23.91	399.05	0.76
14.00	8.68	31.04	24.07	383.43	0.80
15.00	8.48	31.15	24.19	372.52	0.84
16.00	8.33	31.25	24.28	363.55	0.88
17.00	8.25	31.29	24.33	359.09	0.91
18.00	8.20	31.31	24.35	357.10	0.95
19.00	8.12	31.36	24.40	352.03	0.98
20.00	8.08	31.39	24.43	349.77	1.02
21.00	8.01	31.44	24.48	344.67	1.05
30.00	7.49	31.85	24.87	307.16	1.34
50.00	6.99	32.40	25.37	260.04	1.90
75.00	6.63	32.64	25.61	238.04	2.52

DEEPEST MEASUREMENT:

87.00	6.54	32.71	25.67	231.85	2.80

→

OCEANOGRAPHIC DATA INVENTORY SYSTEM (ODIS)
STATION REPORT

DATE : 12-DEC-91 TIME : 15:14:54

DISCIPLINE: PHYSICS ****

REGIONS: Dixon Entrance, Hecate Strait, Queen Charlotte Sound and Adjoining B.C. Coastal Waters, Waters West of Vancouver Island and the Queen Charlotte Islands out to the 200-Mile Fisheries Limit

MEASUREMENTS: Temp/Salin/Conduct.

Year Range: 1906 to 1984
Month Range: 1 to 12
Data rating range: 2 to 4

Chosen Area: LATITUDE 54 5.92 TO 54 39.47 LONGITUDE 130 3.90 TO 131 7.96

DSID	Lat	Long	Min. Depth m	Max. Depth m	Start Date	Stop Date	Data Rtng
19730031A	54 12.00	130 17.10	10.0	10.0	73/04/10	73/04/10	3
19730031A	54 13.40	130 17.40	10.0	10.0	73/04/10	73/04/10	3
19730031A	54 13.40	130 21.75	30.0	30.0	73/04/11	73/04/11	3
19730031A	54 13.50	130 19.30			73/04/11	73/04/11	3
19730031A	54 13.60	130 19.30			73/04/11	73/04/11	3
19730031A	54 13.70	130 19.10			73/04/11	73/04/11	3
19730031A	54 13.70	130 20.40	30.0	30.0	73/04/11	73/04/11	3
19730031A	54 13.80	130 19.30			73/04/11	73/04/11	3
19730031A	54 14.40	130 17.90	10.0	10.0	73/04/10	73/04/10	3
19730031A	54 14.70	130 16.30	30.0	30.0	73/04/10	73/04/10	3
19730031A	54 15.35	130 15.60	20.0	20.0	73/04/10	73/04/10	3
19730031A	54 16.05	130 14.30	30.0	30.0	73/04/10	73/04/10	3
19730031A	54 16.70	130 21.20	30.0	30.0	73/04/10	73/04/10	3
19730031A	54 17.50	130 20.60			73/04/09	73/04/09	3
19730031A	54 18.30	130 20.20			73/04/09	73/04/09	3
19730031A	54 18.40	130 21.10	30.0	30.0	73/04/09	73/04/09	3
19730031A	54 18.70	130 19.40			73/04/09	73/04/09	3
19730031A	54 19.30	130 18.50			73/04/09	73/04/09	3
19730031A	54 19.70	130 17.40			73/04/09	73/04/09	3
19730031A	54 20.60	130 16.60	30.0	30.0	73/04/09	73/04/09	3
19730031B	54 11.70	130 19.40	30.0	30.0	73/07/11	73/07/11	3
19730031B	54 12.00	130 17.10	10.0	10.0	73/07/11	73/07/11	3
19730031B	54 13.40	130 17.40	10.0	10.0	73/07/11	73/07/11	3
19730031B	54 13.40	130 21.75	30.0	30.0	73/07/12	73/07/12	3
19730031B	54 13.70	130 20.40	30.0	30.0	73/07/12	73/07/12	3
19730031B	54 14.40	130 17.90	10.0	10.0	73/07/11	73/07/11	3
19730031B	54 14.70	130 16.30	30.0	30.0	73/07/11	73/07/11	3
19730031B	54 15.35	130 15.60	20.0	20.0	73/07/11	73/07/11	3
19730031B	54 16.05	130 14.30	30.0	30.0	73/07/11	73/07/11	3
19730031B	54 16.70	130 21.20	30.0	30.0	73/07/10	73/07/10	3
19730031B	54 17.50	130 20.60			73/07/10	73/07/10	3
19730031B	54 18.30	130 20.20			73/07/10	73/07/10	3
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19730031B	54 18.70	130 19.40			73/07/10	73/07/10	3
19730031B	54 19.30	130 18.50			73/07/10	73/07/10	3

19730031B	54	19.70	130	17.40			73/07/10	73/07/10	3
19730031B	54	20.60	130	16.60	30.0	30.0	73/07/10	73/07/10	3
19730031C	54	11.70	130	19.40	30.0	30.0	73/10/24	73/10/24	3
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19730031C	54	13.40	130	17.40	10.0	10.0	73/10/25	73/10/25	3
19730031C	54	13.40	130	21.75	30.0	30.0	73/10/24	73/10/24	3
19730031C	54	13.70	130	20.40	30.0	30.0	73/10/24	73/10/24	3
19730031C	54	14.40	130	17.90	10.0	10.0	73/10/25	73/10/25	3
19730031C	54	14.70	130	16.30	30.0	30.0	73/10/24	73/10/24	3
19730031C	54	15.35	130	15.60	20.0	20.0	73/10/24	73/10/24	3
19730031C	54	16.05	130	14.30	30.0	30.0	73/10/24	73/10/24	3
19730031C	54	16.70	130	21.20	30.0	30.0	73/10/24	73/10/24	3
19730031C	54	17.50	130	20.60			73/10/24	73/10/24	3
19730031C	54	18.30	130	20.20			73/10/24	73/10/24	3
19730031C	54	18.40	130	21.10	30.0	30.0	73/10/25	73/10/25	3
19730031C	54	18.70	130	19.40			73/10/24	73/10/24	3
19730031C	54	19.30	130	18.50			73/10/24	73/10/24	3
19730031C	54	19.70	130	17.40			73/10/24	73/10/24	3
19730031C	54	20.60	130	16.60	30.0	30.0	73/10/24	73/10/24	3
19740040A	54	11.75	130	18.78	15.0	15.0	74/07/09	74/07/09	3
19740040A	54	12.13	130	18.32	24.0	24.0	74/07/09	74/07/09	3
19740040A	54	13.23	130	17.64	20.0	20.0	74/07/09	74/07/09	3
19740040A	54	14.21	130	18.24	15.0	15.0	74/07/09	74/07/09	3
19740040A	54	14.69	130	18.24	15.0	15.0	74/07/09	74/07/09	3
19740040A	54	17.10	130	16.80	25.0	25.0	74/07/10	74/07/10	3
19740040B	54	11.79	130	18.78	15.0	15.0	74/08/07	74/08/07	3
19740040B	54	12.13	130	18.32	20.0	20.0	74/08/07	74/08/07	3
19740040B	54	12.25	130	20.02	10.0	10.0	74/08/06	74/08/06	3
19740040B	54	12.25	130	20.02	10.0	10.0	74/08/08	74/08/08	3
19740040B	54	13.14	130	20.92	30.0	30.0	74/08/06	74/08/06	3
19740040B	54	13.14	130	20.92	30.0	30.0	74/08/08	74/08/08	3
19740040B	54	13.15	130	20.30	10.0	10.0	74/08/06	74/08/06	3
19740040B	54	13.15	130	20.30	10.0	10.0	74/08/08	74/08/08	3
19740040B	54	13.23	130	17.64	15.0	15.0	74/08/07	74/08/07	3
19740040B	54	14.00	130	20.92	40.0	40.0	74/08/06	74/08/06	3
19740040B	54	14.00	130	20.92	40.0	40.0	74/08/08	74/08/08	3
19740040B	54	14.01	130	20.30	10.0	10.0	74/08/06	74/08/06	3
19740040B	54	14.01	130	20.30	10.0	10.0	74/08/08	74/08/08	3
19740040B	54	14.15	130	20.02	2.0	2.0	74/08/06	74/08/06	3
19740040B	54	14.15	130	20.02	2.0	2.0	74/08/08	74/08/08	3
19740040B	54	14.21	130	18.24	15.0	15.0	74/08/07	74/08/07	3
19740040B	54	14.68	130	20.99	40.0	40.0	74/08/06	74/08/06	3
19740040B	54	14.68	130	20.99	40.0	40.0	74/08/08	74/08/08	3
19740040B	54	14.69	130	18.24	10.0	10.0	74/08/07	74/08/07	3
19740040B	54	14.70	130	19.79	20.0	20.0	74/08/06	74/08/06	3
19740040B	54	14.70	130	19.79	20.0	20.0	74/08/08	74/08/08	3
19740043	54	12.50	130	20.00	30.0	30.0	74/10/22	74/10/22	3
19740043	54	13.30	130	24.00	45.0	45.0	74/10/22	74/10/22	3
19740043	54	14.90	130	20.80	40.0	40.0	74/10/22	74/10/22	3
19740043	54	17.50	130	21.90	40.0	40.0	74/10/22	74/10/22	3
19740043	54	18.40	130	21.50	45.0	45.0	74/10/22	74/10/22	3
19740043	54	20.30	130	16.90	50.0	50.0	74/10/22	74/10/22	3
19740043	54	23.20	130	15.00	45.0	45.0	74/10/22	74/10/22	3
19740043	54	35.00	130	25.00	40.0	40.0	74/11/06	74/11/06	3
19740043	54	35.40	130	27.00	45.0	45.0	74/11/06	74/11/06	3
19740043	54	35.40	130	29.00	75.0	75.0	74/11/06	74/11/06	3
19740044	54	12.00	130	18.20	25.0	25.0	74/02/06	74/02/06	2
19740044	54	12.70	130	17.70	20.0	20.0	74/02/06	74/02/06	2
19740044	54	12.80	130	17.40	1.0	1.0	74/02/06	74/02/06	2
19740044	54	12.80	130	20.00	40.0	40.0	74/02/06	74/02/06	2

19740044	54 13.50	130 17.90	20.0	20.0	74/02/06	74/02/06	2
19740044	54 14.00	130 18.00			74/01/06	74/01/06	2
19740044	54 14.00	130 18.00			74/02/06	74/02/06	2
19740044	54 14.00	130 18.00			74/03/06	74/03/06	2
19740044	54 14.00	130 18.00			74/04/06	74/04/06	2
19740044	54 14.00	130 18.00			74/05/06	74/05/06	2
19740044	54 14.00	130 18.00			74/06/06	74/06/06	2
19740044	54 14.00	130 18.00			74/07/06	74/07/06	2
19740044	54 14.00	130 18.00			74/08/06	74/08/06	2
19740044	54 14.00	130 18.00			74/09/06	74/09/06	2
19740044	54 14.00	130 18.00			74/10/06	74/10/06	2
19740044	54 14.00	130 18.00			74/11/06	74/11/06	2
19740044	54 14.00	130 18.00			74/12/06	74/12/06	2
19740044	54 14.00	130 20.00	20.0	20.0	74/02/06	74/02/06	2
19740044	54 14.00	130 22.10	30.0	30.0	74/02/06	74/02/06	2
19740044	54 14.80	130 18.40	15.0	15.0	74/02/06	74/02/06	2
19740044	54 15.00	130 16.90	50.0	50.0	74/02/06	74/02/06	2
19740044	54 15.00	130 21.30	40.0	40.0	74/02/06	74/02/06	2
19740044	54 15.40	130 15.20	15.0	15.0	74/02/06	74/02/06	2
19740044	54 16.70	130 14.70	45.0	45.0	74/02/06	74/02/06	2
19740044	54 17.10	130 21.80	40.0	40.0	74/02/06	74/02/06	2
19770058	54 12.13	130 18.32	25.0	25.0	77/06/06	77/06/06	3
19770058	54 13.23	130 17.64	17.0	17.0	77/06/06	77/06/06	3
19770058	54 14.21	130 18.27	14.0	14.0	77/06/06	77/06/06	3
19770058	54 14.69	130 18.24	20.0	20.0	77/06/06	77/06/06	3
19770079	54 14.77	130 20.87	43.0	43.0	77/07/11	77/07/11	3
19770079	54 14.77	130 20.87	43.0	43.0	77/07/11	77/07/11	9
19770079	54 14.95	130 20.82	43.0	43.0	77/07/09	77/07/09	3
19770079	54 14.95	130 20.82	43.0	43.0	77/07/09	77/07/09	9
19770079	54 18.63	130 19.03	41.0	41.0	77/07/11	77/07/11	3
19770079	54 18.63	130 19.03	41.0	41.0	77/07/11	77/07/11	9
19770079	54 18.80	130 20.70	35.0	35.0	77/07/04	77/07/04	3
19770079	54 18.80	130 20.70	35.0	35.0	77/07/04	77/07/04	9
19770079	54 18.98	130 20.85	43.0	43.0	77/07/11	77/07/11	3
19770079	54 18.98	130 20.85	43.0	43.0	77/07/11	77/07/11	9
19770079	54 19.62	130 18.77	43.0	43.0	77/07/08	77/07/08	3
19770079	54 19.62	130 18.77	43.0	43.0	77/07/08	77/07/08	9
19770079	54 19.62	130 18.77	46.0	46.0	77/07/08	77/07/08	3
19770079	54 19.62	130 18.77	46.0	46.0	77/07/08	77/07/08	9
19770079	54 19.62	130 18.77	43.0	43.0	77/07/09	77/07/09	3
19770079	54 19.62	130 18.77	43.0	43.0	77/07/09	77/07/09	9
19770079	54 19.62	130 18.77	46.0	46.0	77/07/09	77/07/09	3
19770079	54 19.62	130 18.77	46.0	46.0	77/07/09	77/07/09	9
19770079	54 19.75	130 18.98	43.0	43.0	77/07/07	77/07/07	3
19770079	54 19.75	130 18.98	43.0	43.0	77/07/07	77/07/07	9
19770079	54 20.15	130 17.82	43.0	43.0	77/07/11	77/07/11	3
19770079	54 20.15	130 17.82	43.0	43.0	77/07/11	77/07/11	9
19780028B	54 9.00	130 20.00	3.0	3.0	78/07/27	78/07/27	3
19780028B	54 18.00	130 34.00	3.0	3.0	78/07/30	78/07/30	3
19780028C	54 13.00	130 24.00	3.0	3.0	78/08/23	78/08/23	3
19780028C	54 37.00	130 41.00	3.0	3.0	78/08/23	78/08/23	3
19780028D	54 32.00	130 32.00	3.0	3.0	78/09/20	78/09/20	3
19780028E	54 13.00	130 24.00	3.0	3.0	78/10/21	78/10/21	3
19780028E	54 32.00	130 32.00	3.0	3.0	78/10/22	78/10/22	3
19780028G	54 10.00	130 24.00	3.0	3.0	79/04/03	79/04/03	3
19780028G	54 16.50	130 32.00	250.0	250.0	79/04/04	79/04/04	3
19780028G	54 18.00	130 36.00	3.0	3.0	79/04/04	79/04/04	3
19780037	54 11.79	130 18.78	12.0	12.0	78/07/13	78/07/13	3
19780037	54 12.13	130 18.32	20.0	20.0	78/07/13	78/07/13	3
19780037	54 12.79	130 17.48	20.0	20.0	78/07/13	78/07/13	3

19780037	54	13.23	130	17.64	18.0	18.0	78/07/13	78/07/13	3
19780037	54	13.79	130	18.14	15.0	15.0	78/07/13	78/07/13	3
19780037	54	14.21	130	18.27	15.0	15.0	78/07/13	78/07/13	3
19780037	54	14.60	130	18.24	15.0	15.0	78/07/13	78/07/13	3
19780037	54	17.10	130	16.80	25.0	25.0	78/07/13	78/07/13	3
19780049	54	9.00	131	2.00	100.0	100.0	78/03/17	78/03/17	3
19780049	54	16.00	131	3.00	116.0	116.0	78/03/17	78/03/17	3
19780049	54	17.00	130	46.00	178.0	178.0	78/03/19	78/03/19	3
19780049	54	17.00	131	5.00	93.0	93.0	78/03/22	78/03/22	3
19780049	54	18.00	130	42.00			78/03/19	78/03/19	3
19780049	54	20.00	131	4.00	92.0	92.0	78/03/20	78/03/20	3
19780049	54	29.00	130	37.00	92.0	92.0	78/03/23	78/03/23	3
19780052	54	31.00	131	4.00	158.0	158.0	78/07/10	78/07/10	3
19780053	54	9.00	131	1.00	105.0	105.0	78/07/30	78/07/30	3
19780053	54	18.00	131	2.00	106.0	106.0	78/07/30	78/07/30	3
19780054	54	9.00	131	2.00	115.0	115.0	78/09/10	78/09/10	3
19780054	54	17.00	131	2.00	105.0	105.0	78/09/11	78/09/11	3
19790036A	54	11.00	130	21.00	3.0	3.0	79/05/13	79/05/13	3
19790036A	54	34.00	130	30.00	3.0	3.0	79/05/14	79/05/14	3
19790036B	54	9.00	130	24.00	3.0	3.0	79/06/28	79/06/28	3
19790036B	54	30.00	131	5.00	3.0	3.0	79/06/27	79/06/27	3
19790036B	54	36.00	130	32.00	3.0	3.0	79/06/27	79/06/27	3
19790036C	54	9.00	130	23.00	3.0	3.0	79/07/25	79/07/25	3
19790036D	54	8.00	130	19.00	3.0	3.0	80/02/02	80/02/02	3
19790036D	54	12.00	130	28.00	3.0	3.0	80/02/05	80/02/05	3
19790036D	54	25.00	130	34.00	3.0	3.0	80/02/05	80/02/05	3
19790036E	54	6.00	130	22.00	3.0	3.0	80/04/15	80/04/15	3
19790036E	54	24.00	130	34.00	3.0	3.0	80/04/15	80/04/15	3
19790036E	54	31.00	130	31.00	3.0	3.0	80/04/15	80/04/15	3
19790036F	54	7.00	130	18.00	3.0	3.0	80/06/02	80/06/02	3
19790036F	54	10.00	130	23.00	3.0	3.0	80/06/05	80/06/05	3
19790036F	54	20.00	130	34.00	3.0	3.0	80/06/04	80/06/04	3
19790036F	54	37.00	130	42.00	3.0	3.0	80/06/04	80/06/04	3
19790051	54	11.90	130	18.58	25.0	25.0	79/06/03	79/06/03	2
19790051	54	11.90	130	18.58	25.0	25.0	79/06/04	79/06/04	2
19790051	54	12.10	130	18.30	25.0	25.0	79/06/03	79/06/03	2
19790051	54	12.10	130	18.30	25.0	25.0	79/06/04	79/06/04	2
19790051	54	12.51	130	17.72	25.0	25.0	79/06/04	79/06/04	2
19790051	54	13.19	130	17.60	25.0	25.0	79/06/03	79/06/03	2
19790051	54	13.19	130	17.60	25.0	25.0	79/06/04	79/06/04	2
19790051	54	13.22	130	17.63	15.0	15.0	79/06/04	79/06/04	2
19790051	54	13.22	130	17.63	20.0	20.0	79/06/04	79/06/04	2
19790051	54	13.90	130	18.05	20.0	20.0	79/06/04	79/06/04	2
19790051	54	14.25	130	18.40	15.0	15.0	79/06/04	79/06/04	2
19790051	54	14.55	130	18.34	20.0	20.0	79/06/04	79/06/04	2
19790051	54	14.55	130	18.34	25.0	25.0	79/06/04	79/06/04	2
19790051	54	15.03	130	16.95	20.0	20.0	79/06/04	79/06/04	2
19790052	54	8.00	131	4.00	82.0	82.0	79/01/27	79/01/27	3
19790052	54	9.00	131	3.00	97.0	97.0	79/02/01	79/02/01	3
19790052	54	9.00	131	4.00	100.0	100.0	79/01/27	79/01/27	3
19790052	54	21.00	131	3.00	94.0	94.0	79/02/06	79/02/06	3
19790052	54	21.00	131	7.00	91.0	91.0	79/02/03	79/02/03	3
19790052	54	27.00	131	5.00	150.0	150.0	79/01/29	79/01/29	3
19790053	54	10.00	130	30.00	100.0	100.0	79/03/13	79/03/13	3
19790053	54	17.00	131	2.00	114.0	114.0	79/03/19	79/03/19	3
19790056A	54	7.00	131	2.00	110.0	110.0	79/06/29	79/06/29	3
19790056A	54	10.00	130	54.00	103.0	103.0	79/06/29	79/06/29	3
19790056A	54	10.00	131	3.00	100.0	100.0	79/06/29	79/06/29	3
19790056A	54	17.00	131	2.00	122.0	122.0	79/06/30	79/06/30	3
19790056A	54	20.00	131	5.00	100.0	100.0	79/06/30	79/06/30	3

19790056A	54	26.00	131	5.00	140.0	140.0	79/06/30	79/06/30	3
19790056B	54	7.00	131	2.00	117.0	117.0	79/09/08	79/09/08	3
19790056B	54	17.00	131	2.00	130.0	130.0	79/09/08	79/09/08	3
19790056B	54	20.00	131	5.00	94.0	94.0	79/09/08	79/09/08	3
19790056B	54	21.00	131	6.00	100.0	100.0	79/09/11	79/09/11	3
19790056B	54	26.00	131	5.00	75.0	75.0	79/09/08	79/09/08	3
19800051A	54	30.00	131	7.00			80/01/08	80/01/08	3
19800051B	54	30.00	131	7.00			80/02/08	80/02/08	3
19800051C	54	30.00	131	7.00			80/03/08	80/03/08	3
19800051D	54	30.00	131	7.00			80/04/08	80/04/08	3
19800052	54	12.10	130	18.30	25.0	25.0	80/08/20	80/08/20	2
19800052	54	12.51	130	17.72	25.0	25.0	80/08/20	80/08/20	2
19800052	54	13.22	130	17.63	20.0	20.0	80/08/20	80/08/20	2
19800052	54	13.90	130	18.05	20.0	20.0	80/08/20	80/08/20	2
19800052	54	14.25	130	18.40	15.0	15.0	80/08/21	80/08/21	2
19800052	54	14.55	130	18.34	25.0	25.0	80/08/21	80/08/21	2
19800052	54	15.03	130	16.95	20.0	20.0	80/08/21	80/08/21	2
19810021A	54	34.00	130	24.00	25.0	25.0	81/05/24	81/05/24	3
19810021A	54	34.00	130	24.00	30.0	30.0	81/05/24	81/05/24	3
19810021A	54	34.00	130	24.00	25.0	25.0	81/05/29	81/05/29	3
19810021A	54	34.00	130	24.00	20.0	20.0	81/06/02	81/06/02	3
19810021A	54	34.00	130	24.00	25.0	25.0	81/06/02	81/06/02	3
19810021A	54	35.00	130	25.00	45.0	45.0	81/06/02	81/06/02	3
19810021A	54	35.00	130	26.00	42.0	42.0	81/05/23	81/05/23	3
19810021A	54	35.00	130	26.00	40.0	40.0	81/05/24	81/05/24	3
19810021A	54	35.00	130	26.00	45.0	45.0	81/05/24	81/05/24	3
19810021A	54	35.00	130	26.00	40.0	40.0	81/05/29	81/05/29	3
19810021A	54	35.00	130	26.00	45.0	45.0	81/06/02	81/06/02	3
19810021A	54	35.00	130	28.00	40.0	40.0	81/05/29	81/05/29	3
19810021A	54	35.00	130	28.00	40.0	40.0	81/06/02	81/06/02	3
19810021A	54	36.00	130	27.00	45.0	45.0	81/05/24	81/05/24	3
19810021A	54	36.00	130	27.00	50.0	50.0	81/05/24	81/05/24	3
19810021A	54	36.00	130	27.00	45.0	45.0	81/05/29	81/05/29	3
19810021A	54	36.00	130	27.00	45.0	45.0	81/06/02	81/06/02	3
19810021A	54	37.00	130	28.00	70.0	70.0	81/05/23	81/05/23	3
19810021A	54	37.00	130	28.00	70.0	70.0	81/05/24	81/05/24	3
19810021A	54	37.00	130	28.00	70.0	70.0	81/05/29	81/05/29	3
19810021A	54	37.00	130	28.00	60.0	60.0	81/06/02	81/06/02	3
19810021B	54	33.88	130	23.51	28.0	28.0	81/08/25	81/08/25	3
19810021B	54	35.00	130	26.00	33.0	33.0	81/08/25	81/08/25	3
19810021B	54	35.15	130	27.88	37.0	37.0	81/08/25	81/08/25	3
19810021B	54	37.00	130	28.00	70.0	70.0	81/08/25	81/08/25	3
19810021C	54	33.88	130	23.51	27.0	27.0	81/11/27	81/11/27	3
19810021C	54	35.15	130	27.88	41.0	41.0	81/11/26	81/11/26	3
19810021C	54	35.28	130	25.53	49.0	49.0	81/11/26	81/11/26	3
19810021C	54	36.78	130	27.54	70.0	70.0	81/11/26	81/11/26	3
19810021D	54	35.28	130	25.53	29.0	29.0	82/01/26	82/01/26	3
19810021D	54	36.78	130	27.54	49.0	49.0	82/01/27	82/01/27	3
19810022	54	33.30	130	27.40	50.0	50.0	81/08/04	81/08/04	3
19810022	54	34.75	130	26.90	45.0	45.0	81/08/04	81/08/04	3
19810022	54	34.90	130	24.50	20.0	20.0	81/08/04	81/08/04	3
19810022	54	35.20	130	28.10	50.0	50.0	81/08/04	81/08/04	3
19810022	54	35.40	130	25.70	25.0	25.0	81/08/04	81/08/04	3
19810022	54	35.50	130	24.30	20.0	20.0	81/08/04	81/08/04	3
19810022	54	35.60	130	26.80	35.0	35.0	81/08/04	81/08/04	3
19810022	54	36.20	130	28.10	90.0	90.0	81/08/04	81/08/04	3
19810022	54	36.50	130	27.30	50.0	50.0	81/08/04	81/08/04	3
19810050	54	11.90	130	18.58	20.0	20.0	81/08/03	81/08/03	3
19810050	54	12.10	130	18.30	20.0	20.0	81/08/03	81/08/03	3
19810050	54	12.51	130	17.72	20.0	20.0	81/08/04	81/08/04	3

19810050	54	13.19	130	17.60	10.0	10.0	81/08/04	81/08/04	3
19810050	54	13.22	130	17.63	10.0	10.0	81/08/03	81/08/03	3
19810050	54	13.90	130	18.05	10.0	10.0	81/08/04	81/08/04	3
19810050	54	14.25	130	18.40	10.0	10.0	81/08/04	81/08/04	3
19810050	54	14.55	130	18.34	10.0	10.0	81/08/03	81/08/03	3
19810050	54	15.03	130	16.95	10.0	10.0	81/08/03	81/08/03	3
19810053F	54	9.00	131	5.00	110.0	110.0	81/08/17	81/08/17	3
19810053F	54	29.00	130	45.00	200.0	200.0	81/08/19	81/08/19	3
19810053G	54	7.00	131	2.00	107.0	107.0	81/08/16	81/08/16	3
19810053G	54	17.00	131	2.00	123.0	123.0	81/08/16	81/08/16	3
19810055	54	7.25	131	1.40	101.0	101.0	81/02/06	81/02/06	9
19820045	54	12.51	130	17.72	25.0	25.0	82/04/29	82/04/29	3
19820045	54	13.19	130	17.60	20.0	20.0	82/04/29	82/04/29	3
19820045	54	13.22	130	17.63	20.0	20.0	82/04/29	82/04/29	3
19820045	54	13.47	130	17.80	15.0	15.0	82/04/29	82/04/29	3
19820045	54	13.68	130	17.91	20.0	20.0	82/04/29	82/04/29	3
19820045	54	13.80	130	18.04	20.0	20.0	82/04/29	82/04/29	3
19820045	54	13.91	130	18.07	10.0	10.0	82/04/29	82/04/29	3
19820045	54	14.25	130	18.40	15.0	15.0	82/04/29	82/04/29	3
19820051	54	11.61	130	24.52	16.0	16.0	82/05/22	82/05/22	9
19820051	54	16.90	130	49.20	15.0	15.0	82/05/22	82/05/22	9
19820051	54	18.40	130	34.25	15.0	15.0	82/05/22	82/05/22	9
19820065	54	12.10	130	18.30			82/04/22	82/04/22	3
19820065	54	12.51	130	17.72			82/04/22	82/04/22	3
19820065	54	13.90	130	18.05			82/04/22	82/04/22	3
19820065	54	14.25	130	18.40			82/04/22	82/04/22	3
19820065	54	14.55	130	18.34			82/04/22	82/04/22	3
19830038	54	12.10	130	18.30			83/04/22	83/04/22	3
19830038	54	12.51	130	17.72			83/04/22	83/04/22	3
19830038	54	13.19	130	17.60			83/04/22	83/04/22	3
19830038	54	13.22	130	17.63			83/04/22	83/04/22	3
19830038	54	13.90	130	18.05			83/04/22	83/04/22	3
19830038	54	14.25	130	18.40			83/04/22	83/04/22	3
19830038	54	14.55	130	18.34			83/04/22	83/04/22	3

CANADIAN HYDROGRAPHIC SERVICE (Pacific Region)
Convert V 2.0 Conversion Routines
Username : WARD

Page: 1
Date: 18-OCT-91
Time: 10:53:30

UTM TO GEOGRAPHIC CONVERSIONS

Datum : NAD27 Ellipsoid : CLARKE 1866 (NAD27) CM : 123

STATION	NORTHING	EASTING	LATITUDE	LONGITUDE
NFHC 137	5448267.32	503127.65	49 11 21.018	122 57 25.479
NFHC 138	5448606.31	503542.03	49 11 31.987	122 57 4.996
PWC 306	5448439.94	502936.97	49 11 26.611	122 57 34.895
NFHC 126	5447393.00	501119.55	49 10 52.730	122 59 4.698
NFHC 129	5447196.04	501952.70	49 10 46.344	122 58 23.546
NFHC 128	5447202.54	501509.87	49 10 46.559	122 58 45.420

19820051 ****

PHYSICS

REGION(S): Dixon Entrance, Hecate Strait, Queen Charlotte Sound and Adjoining B.C. Coastal Waters, Waters West of Vancouver Island and the Queen Charlotte Islands out to the 200-Mile Fisheries Limit

COLLECTION AREA(S): Chatham Sound, Hecate Strait, Queen Charlotte Sound, Cape St. James, Fitz Hugh Sound

COLLECTION PERIOD: May 21, 1982 TO September 25, 1983

REFERENCE OR SOURCE:
Crawford (pers. comm.)

TOTAL NUMBER OF STATIONS: 155

MEASUREMENT	INSTRUMENT			# OF STNS	DATA RTNG
Currents	CM	NS	Unspecified	2	3
	CM	R&V	Aanderaa RCM4	22	3
	CM	R&V	Neyrpic-CMDR-AML	6	3
Temp/Salin/Conduct.	SCT	MInst	AML 750A gauge	5	9
	SCT	MInst	AML TG12 gauge	1	9
	SCT	MInst	Aanderaa RCM4	22	9
	SCT	MInst	Aanderaa TG2A gauge	1	9
	SCT	MInst	Aanderaa TG3A gauge	1	9
	SCT	MInst	Endeco	1	9
	SCT	MInst	Neyrpic-CMDR-AML	6	9
	SCT	NS	Not Specified	1	9
	SCT	PCTD	Guildline 8701	79	3
Water Level	WL	Press	AML 750A gauge	5	3
	WL	Press	AML TG12 gauge	1	3
	WL	Press	Aanderaa TG2A gauge	1	3
	WL	Press	Aanderaa TG3A gauge	1	3

OCEANOGRAPHIC DATA INVENTORY SYSTEM (ODIS)
STATION REPORT

DATE : 12-DEC-91 TIME : 15:04:52

DISCIPLINE: PHYSICS ****

REGIONS: Dixon Entrance, Hecate Strait, Queen Charlotte Sound and Adjoining B.C. Coastal Waters, Waters West of Vancouver Island and the Queen Charlotte Islands out to the 200-Mile Fisheries Limit

MEASUREMENTS: Currents

Year Range: 1906 to 1984
Month Range: 1 to 12
Data rating range: 2 to 4

Chosen Area: LATITUDE 54 5.92 TO 54 39.47 LONGITUDE 130 3.90 TO 131 7.96

DSID	Lat	Long	Min. Depth m	Max. Depth m	Start Date	Stop Date	Data Rtng
19740043	54 35.00	130 25.00	2.0	2.0	74/11/07	74/11/08	3
19740043	54 35.00	130 25.00	10.0	10.0	74/11/07	74/11/08	3
19740043	54 35.00	130 25.00	20.0	20.0	74/11/07	74/11/08	3
19740043	54 35.00	130 25.00	35.0	35.0	74/11/07	74/11/08	3
19770079	54 18.80	130 20.70	35.0	35.0	77/07/04	77/07/15	3
19820051	54 11.61	130 24.52	16.0	16.0	82/05/22	82/09/17	3
19820051	54 16.90	130 49.20	15.0	15.0	82/05/22	82/09/17	3
19820051	54 18.40	130 34.25	15.0	15.0	82/05/22	82/09/17	3

Date:12-DEC-91 HARMONIC ANALYSIS REPORT: CURRENTS Time:15:09:57

Data Set ID:	19770079	Sampling Depth:	35m
Station ID:	PRH	Sampling Interval:	60min
Region Number:	101	Number of Samples:	770
Latitude:	0.000000 N	Instrument Type:	CM R&V Aanderaa RCM4
Longitude:	0.000000 W	Collecting Agency:	IOS, Tides and Currents
Start Date:	07/04/1977		
Stop Date:	08/05/1977	Reference/source:	(see Dataset Report)

FREQUENCY DISTRIBUTION of DIRECTION (deg) and RATE (cm/s)

		001	005	010	015	020	025	030	035	040	045	050	055	060	065	070	075	%
	0- 19	99	95	14														7
	20- 39	90	340	194	14													21
	40- 59	65	50	6														4
	60- 79	38	21															2
	80- 99	27	7															1
d	100-119	12	2	3														1
e	120-139	6	2	1														0
g	140-159	17	15	6														1
r	160-179	38	67	21	16	2												5
e	180-199	59	134	54	7	1												8
e	200-219	89	286	158	6													17
s	220-239	118	212	51	1													12
	240-259	78	95	6	1													6
	260-279	21	8															1
	280-299	8																0
	300-319	4	1															0
	320-339	36	5															1
	340-359	72	30															3
	%	91	63	18	2	0	0	0	0	0	0	0	0	0	0	0	0	

Percentage padded & zero rates: 9

TIDAL CURRENT ELLIPSE

Name	Maj Axis	Min Axis	g Phase	Incl.	Name	Maj Axis	Min Axis	g Phase	Incl.
Z0	.007	0.000	35.2	180.0	MM	.022	.001	74.5	287.1
MSF	.003	.000	42.2	271.7	ALP1	.002	.001	150.5	54.6
2Q1	.008	.001	48.2	294.8	Q1	.004	-.003	52.1	272.9
O1	.004	.000	51.6	38.7	NO1	.010	-.002	61.5	329.3
K1	.004	.001	50.2	144.4	J1	.003	.000	173.5	5.5
OO1	.009	-.000	113.0	202.7	UPS1	.010	.002	27.0	179.7
EPS2	.003	-.001	55.1	152.4	MU2	.005	.002	53.7	115.3
N2	.003	-.002	22.9	97.9	M2	.007	.000	16.2	17.0
L2	.005	-.001	44.4	292.5	S2	.002	.001	16.7	138.7
ETA2	.004	-.001	84.1	327.5	MO3	.003	.001	3.2	89.0
M3	.001	-.000	14.0	88.3	MK3	.003	.000	99.1	29.3
SK3	.003	-.001	42.6	85.5	MN4	.004	-.002	149.6	102.4
M4	.003	-.000	165.4	236.6	SN4	.002	-.001	152.7	.6
MS4	.002	-.001	168.1	112.6	S4	.001	.000	65.6	251.6
2MK5	.003	-.002	69.0	30.0	2SK5	.002	-.001	54.1	256.6
2MN6	.002	.000	44.8	298.8	M6	.001	.001	59.2	86.4
2MS6	.001	-.001	170.8	121.2	2SM6	.001	-.000	53.8	270.6
3MK7	.001	-.000	166.3	347.6	M8	.001	.000	86.1	169.0

**RY=1.00MX= .5418MY= .5418

Date:12-DEC-91 HARMONIC ANALYSIS REPORT: CURRENTS Time:15:09:57

Data Set ID:	19820051	Sampling Depth:	15m
Station ID:	R01	Sampling Interval:	60min
Region Number:	101	Number of Samples:	2834
Latitude:	0.000000 N	Instrument Type:	CM R&V Neyrpic-CMDR
Longitude:	0.000000 W	Collecting Agency:	IOS,
Start Date:	05/22/1982		Tides and Currents
Stop Date:	09/17/1982	Reference/source:	(see Dataset Report)

FREQUENCY DISTRIBUTION of DIRECTION (deg) and RATE (cm/s)

		001	010	020	030	040	050	060	070	080	090	100	110	120	130	140	150	%
	0- 19	134	84	7	1													2
	20- 39	99	42	4	1													1
	40- 59	91	34	3														1
	60- 79	91	63	11														1
	80- 99	103	122	63	36	18	8											3
d	100-119	121	209	261	321	279	164	75	15									13
e	120-139	94	273	400	413	322	141	47	7	1								15
g	140-159	111	181	155	55	8	1	1										5
r	160-179	106	128	63	8													3
e	180-199	106	82	15														2
e	200-219	102	106	6														2
s	220-239	127	94	7														2
	240-259	129	103	14	2													2
	260-279	145	245	94	36	5												5
	280-299	180	415	395	191	79	3	2										11
	300-319	139	484	658	457	256	72	11										18
	320-339	146	374	318	203	133	44											11
	340-359	122	158	60	19	12	1											3
	%	100	81	53	31	16	6	2	1	1	0	0	0	0	0	0	0	

Percentage of zero rates: 0

TIDAL CURRENT ELLIPSE

Name	Maj Axis	Min Axis	g Phase	Incl.	Name	Maj Axis	Min Axis	g Phase	Incl.
Z0	.010	0.000	57.9	0.0	MM	.035	.014	123.7	332.1
MSF	.033	.014	124.0	87.8	ALP1	.004	-.000	128.5	209.6
2Q1	.005	-.002	125.4	164.7	Q1	.009	.001	53.2	204.5
O1	.028	.003	141.4	222.9	NO1	.015	-.000	157.4	42.1
K1	.042	.005	140.1	235.2	J1	.003	.002	27.4	281.1
OO1	.008	-.001	121.0	42.4	UPS1	.006	-.002	6.9	86.5
EPS2	.005	-.001	86.8	278.9	MU2	.031	.000	135.3	6.6
N2	.072	-.016	150.6	135.4	M2	.276	-.008	148.3	142.2
L2	.034	-.005	142.4	179.9	S2	.100	.005	144.7	156.6
ETA2	.008	-.006	25.3	294.3	MO3	.006	-.003	146.9	176.7
M3	.005	-.003	151.2	84.0	MK3	.009	.002	170.9	227.1
SK3	.009	.001	137.3	247.3	MN4	.024	-.001	169.4	99.8
M4	.039	.016	140.3	90.0	SN4	.015	-.006	158.1	202.8
MS4	.029	.004	146.8	116.0	S4	.008	-.001	177.1	86.7
2MK5	.004	.001	112.7	203.0	2SK5	.002	-.001	98.3	111.0
2MN6	.014	-.000	154.0	75.3	M6	.017	-.004	141.0	95.2
2MS6	.014	-.000	145.4	101.1	2SM6	.002	-.000	123.7	28.9
3MK7	.004	.001	.9	234.4	M8	.008	.000	145.2	67.6

**RY=1.00MX= .9077MY= .9077

Date:12-DEC-91 HARMONIC ANALYSIS REPORT: CURRENTS Time:15:09:57

Data Set ID:	19820051	Sampling Depth:	15m
Station ID:	R02	Sampling Interval:	60min
Region Number:	101	Number of Samples:	2829
Latitude:	0.000000 N	Instrument Type:	CM R&V Neyrpic-CMDR
Longitude:	0.000000 W	Collecting Agency:	IOS, Tides and Currents
Start Date:	05/22/1982		
Stop Date:	09/16/1982	Reference/source:	(see Dataset Report)

FREQUENCY DISTRIBUTION of DIRECTION (deg) and RATE (cm/s)

		001	005	010	015	020	025	030	035	040	045	050	055	060	065	070	075	%
	0- 19	59	109	79	69	33	11	9	4	2								3
	20- 39	70	77	63	33	17	4	1	5									2
	40- 59	76	70	57	28	8	2		3									2
	60- 79	45	42	39	33	19	13	4										2
	80- 99	61	59	67	54	34	7											2
d	100-119	53	83	90	69	57	32	13	2									4
e	120-139	54	70	126	114	100	71	50	8	2	1							5
g	140-159	70	105	174	235	249	149	56	22	2	3	1						9
r	160-179	73	128	223	298	221	97	44	17	16	8	3	3					10
e	180-199	72	170	236	193	77	24	15	4	2								7
e	200-219	71	173	219	121	36	9	22										6
s	220-239	74	209	187	86	12	3											5
	240-259	118	223	153	70	7												5
	260-279	111	188	198	96	23	7	1										6
	280-299	68	144	131	142	58	17	5	1									5
	300-319	85	148	173	205	141	97	44	15									8
	320-339	97	130	129	194	249	195	121	72	32	4	3	3	1				11
	340-359	75	110	121	132	131	76	21	23	13	8							6
	%	99	87	67	45	26	13	6	2	0	0	0	0	0	0	0	0	

Percentage of zero rates: 1

TIDAL CURRENT ELLIPSE

Name	Maj Axis	Min Axis	g Phase	Incl.	Name	Maj Axis	Min Axis	g Phase	Incl.
Z0	.020	0.000	35.5	180.0	MM	.017	.003	141.4	299.2
MSF	.022	-.006	93.4	5.0	ALP1	.006	.001	100.7	82.2
2Q1	.004	-.000	113.1	112.7	Q1	.003	.000	120.5	29.7
O1	.006	.003	108.5	201.0	NO1	.009	.004	161.0	3.6
K1	.016	.002	94.1	184.6	J1	.005	-.002	40.9	256.1
OO1	.007	-.005	24.4	357.1	UPS1	.004	-.000	58.9	3.3
EPS2	.007	-.005	81.0	299.9	MU2	.012	-.005	136.0	130.1
N2	.027	-.006	125.9	96.0	M2	.143	-.028	130.3	129.4
L2	.015	-.003	97.0	137.1	S2	.035	-.015	138.3	157.1
ETA2	.012	-.007	140.7	163.3	MO3	.003	-.001	112.8	319.6
M3	.003	-.001	82.6	75.0	MK3	.006	-.005	16.4	152.5
SK3	.005	-.000	11.8	158.3	MN4	.011	-.006	135.7	348.8
M4	.019	-.011	132.1	46.2	SN4	.005	-.001	48.6	165.8
MS4	.012	-.009	156.6	54.3	S4	.003	-.001	29.9	168.3
2MK5	.003	-.001	75.2	291.6	2SK5	.003	.000	15.8	108.6
2MN6	.001	-.001	162.8	102.7	M6	.003	-.002	122.4	189.4
2MS6	.002	.001	32.2	129.3	2SM6	.004	-.001	40.8	102.2
3MK7	.002	-.000	159.2	101.4	M8	.002	-.001	94.9	305.3

**RY=1.00MX= .9084MY= .9084

Date:12-DEC-91 HARMONIC ANALYSIS REPORT: CURRENTS Time:15:09:57

Data Set ID:	19820051	Sampling Depth:	16m
Station ID:	R03	Sampling Interval:	60min
Region Number:	101	Number of Samples:	1156
Latitude:	0.000000 N	Instrument Type:	CM R&V Neyrpic-CMDR
Longitude:	0.000000 W	Collecting Agency:	IOS, Tides and Currents
Start Date:	05/22/1982		
Stop Date:	07/09/1982	Reference/source:	(see Dataset Report)

FREQUENCY DISTRIBUTION of DIRECTION (deg) and RATE (cm/s)

degrees	001	005	010	015	020	025	030	035	040	045	050	055	060	065	070	075	%
0- 19	49	43	9	2													2
20- 39	40	50	19	5													2
40- 59	39	52	23	4													3
60- 79	54	39	23	12	3	3											3
80- 99	46	59	33	13	12	10											4
d 100-119	62	52	19	7	2												3
e 120-139	64	41	14	16	6	2											3
g 140-159	60	30	12	4													2
r 160-179	43	17	7														1
e 180-199	43	29	8	2													2
e 200-219	42	45	14	6	2												2
s 220-239	60	76	33	14	8	5	1	1									4
240-259	55	114	163	142	104	65	52	37	31	19	2						17
260-279	69	138	226	160	136	115	91	57	40	27	7	6	5	3			23
280-299	59	127	157	69	27	45	27	19	8	4	5	1					12
300-319	69	76	56	31	14	15	7	8	6	1							6
320-339	58	86	17	7	14	2	2	2	2	1							4
340-359	60	53	17	8	1	2	2	1									3
%	98	77	53	35	24	17	11	7	4	2	1	1	1	1	0	0	

Percentage of zero rates: 2

TIDAL CURRENT ELLIPSE

Name	Maj Axis	Min Axis	g Phase	Incl.	Name	Maj Axis	Min Axis	g Phase	Incl.
Z0	.090	0.000	179.8	.0	MM	.032	.000	11.0	232.1
MSF	.054	-.007	174.7	20.9	ALP1	.005	.002	139.2	77.6
2Q1	.003	-.001	14.3	25.5	Q1	.012	.001	175.9	225.8
O1	.027	.003	3.0	91.2	NO1	.026	.001	165.1	240.3
K1	.051	.004	176.9	279.2	J1	.008	-.003	6.9	221.3
OO1	.010	-.006	1.4	317.4	UPS1	.007	.002	37.1	173.2
EPS2	.008	-.005	102.1	216.1	MU2	.015	-.001	137.4	151.0
N2	.040	-.005	16.4	2.1	M2	.118	.010	5.3	12.9
L2	.007	-.002	96.5	.3	S2	.044	.004	180.0	207.7
ETA2	.012	-.002	160.8	222.4	MO3	.012	-.001	154.5	189.8
M3	.004	-.001	133.7	169.7	MK3	.019	-.003	.3	10.2
SK3	.005	.000	56.1	1.5	MN4	.012	-.004	171.1	81.0
M4	.024	.003	11.2	307.7	SN4	.005	-.001	41.5	163.0
MS4	.011	.003	2.7	323.2	S4	.003	-.000	14.1	161.0
2MK5	.009	-.007	179.5	71.2	2SK5	.003	.001	93.5	15.0
2MN6	.006	.001	47.8	240.5	M6	.012	-.001	179.2	57.7
2MS6	.009	-.000	16.9	258.7	2SM6	.004	.002	119.8	53.1
3MK7	.005	.003	149.0	177.8	M8	.007	-.000	22.9	168.1

**RY=1.00MX= .4702MY= .4702

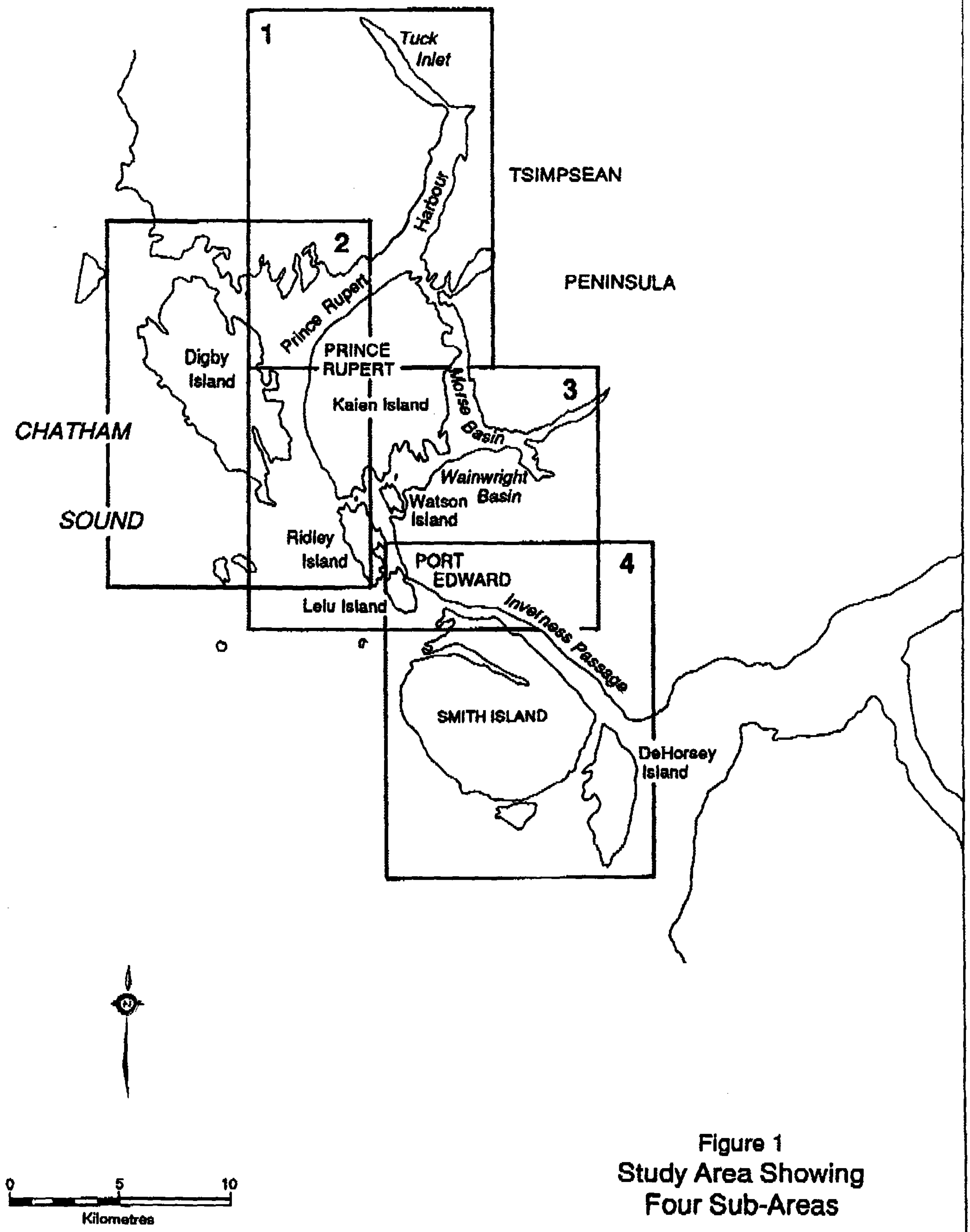


Figure 1
Study Area Showing
Four Sub-Areas

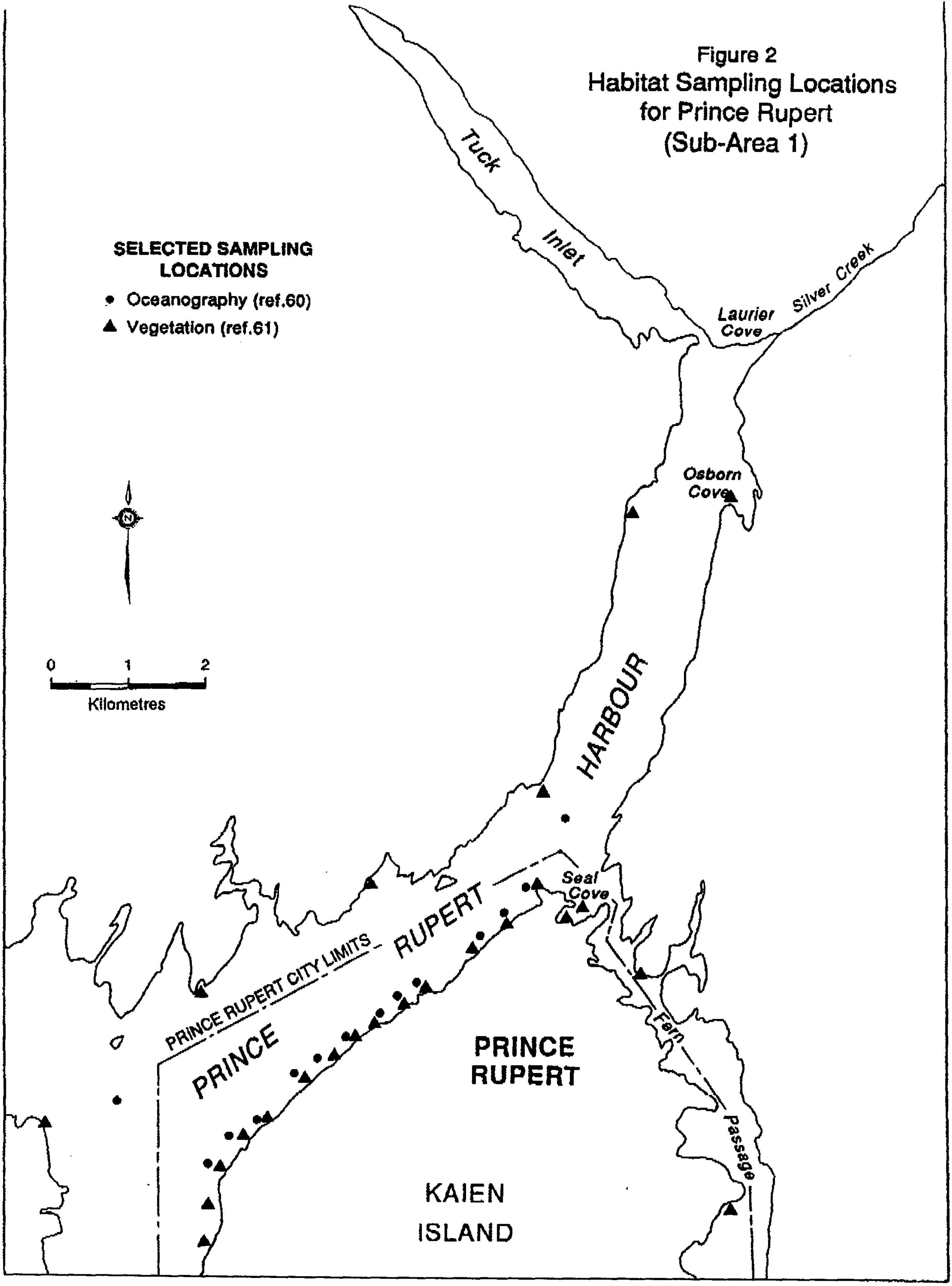


Figure 2
Habitat Sampling Locations
for Prince Rupert
(Sub-Area 1)
SELECTED SAMPLING LOCATIONS
Oceanography (ref.60)
Vegetation (ref.61)
0
1
2
Kilometres
Tuck
Inlet
Laurier Cove
Silver Creek
Osborn Cove
HARBOUR
Seal Cove
PRINCE RUPERT CITY LIMITS
PRINCE
RUPERT
PRINCE RUPERT
Fern
Passage
KAIEN ISLAND

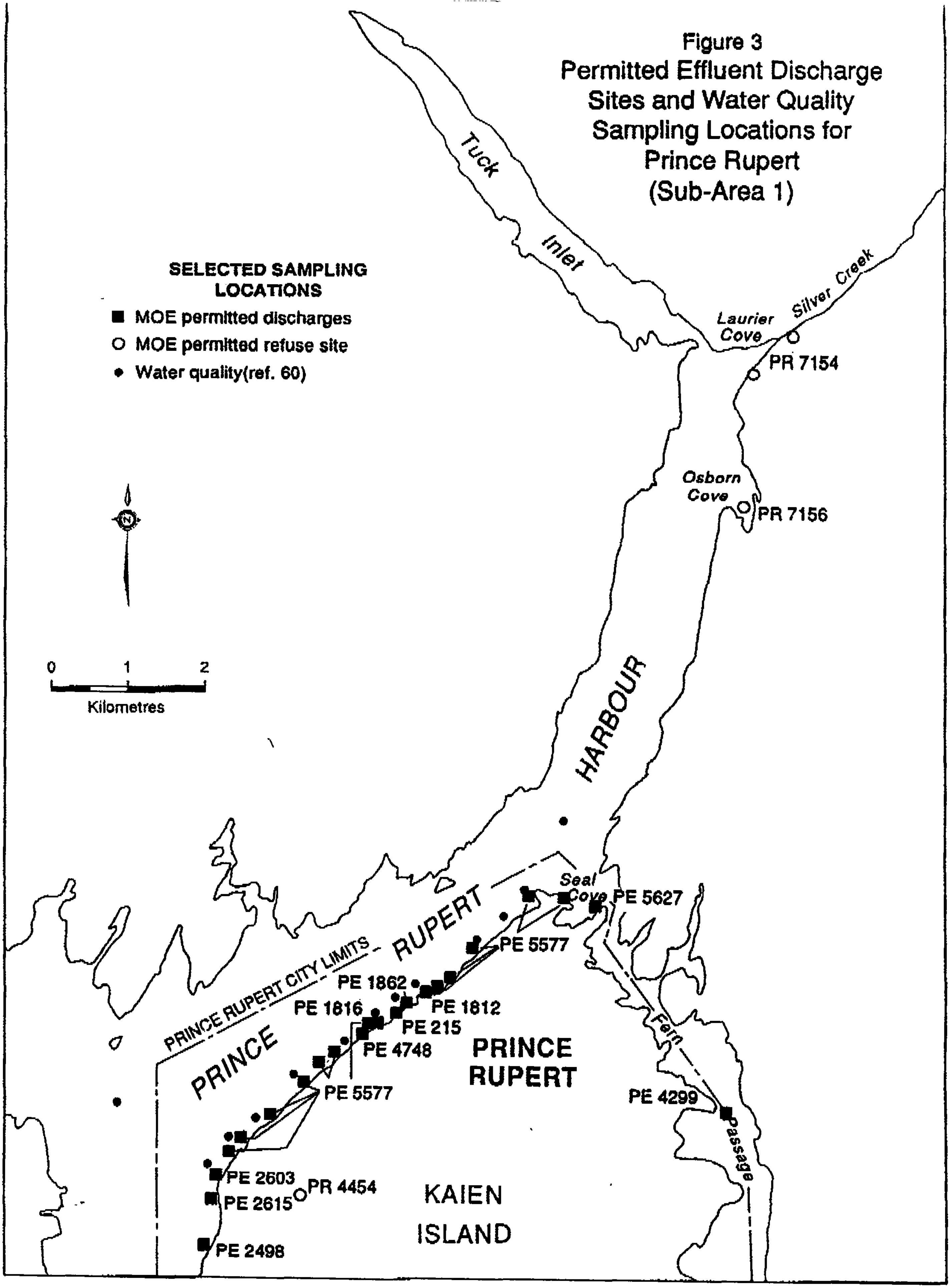


Figure 3
Permitted Effluent Discharge
Sites and Water Quality
Sampling Locations for
Prince Rupert
(Sub-Area 1)
SELECTED SAMPLING LOCATIONS
MOE permitted discharges
MOE permitted refuse site
Water quality(ref. 60)
0 1 2
Kilometres
Tuck Inlet
Laurier Cove
Silver Creek
PR 7154
Osborn Cove
PR 7156
HARBOUR
Seal Cove
PE 5627
PE 5577
PRINCE RUPERT CITY LIMITS
PRINCE RUPERT
PE 1862
PE 1816
PE 1812
PE 215
PE 4748
PRINCE RUPERT
PE 5577
Fern Passage
PE 4299
PE 2603
PE 2615
PR 4454
KAIEN ISLAND
PE 2498

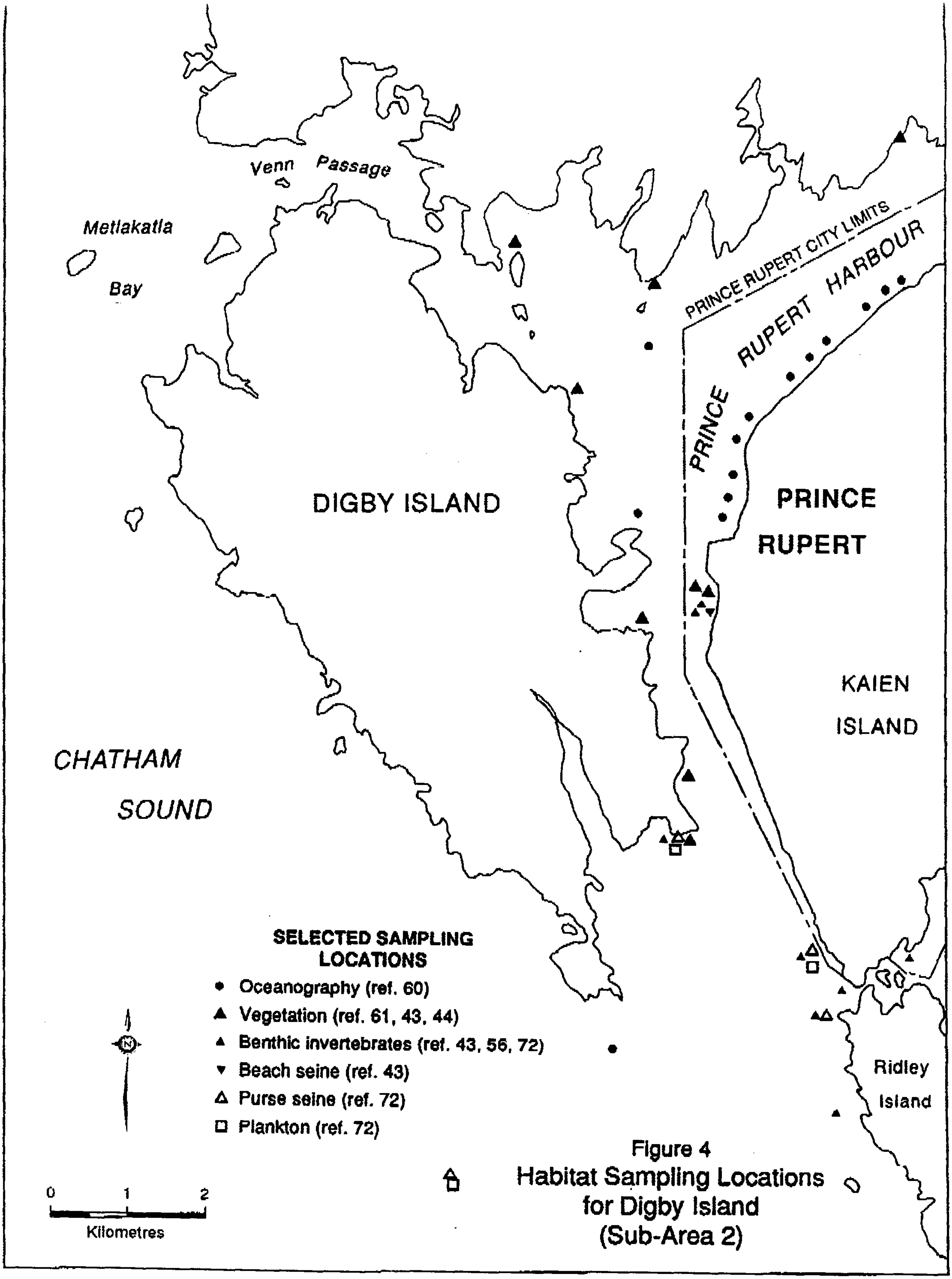


Figure 4
Habitat Sampling Locations
for Digby Island
(Sub-Area 2)

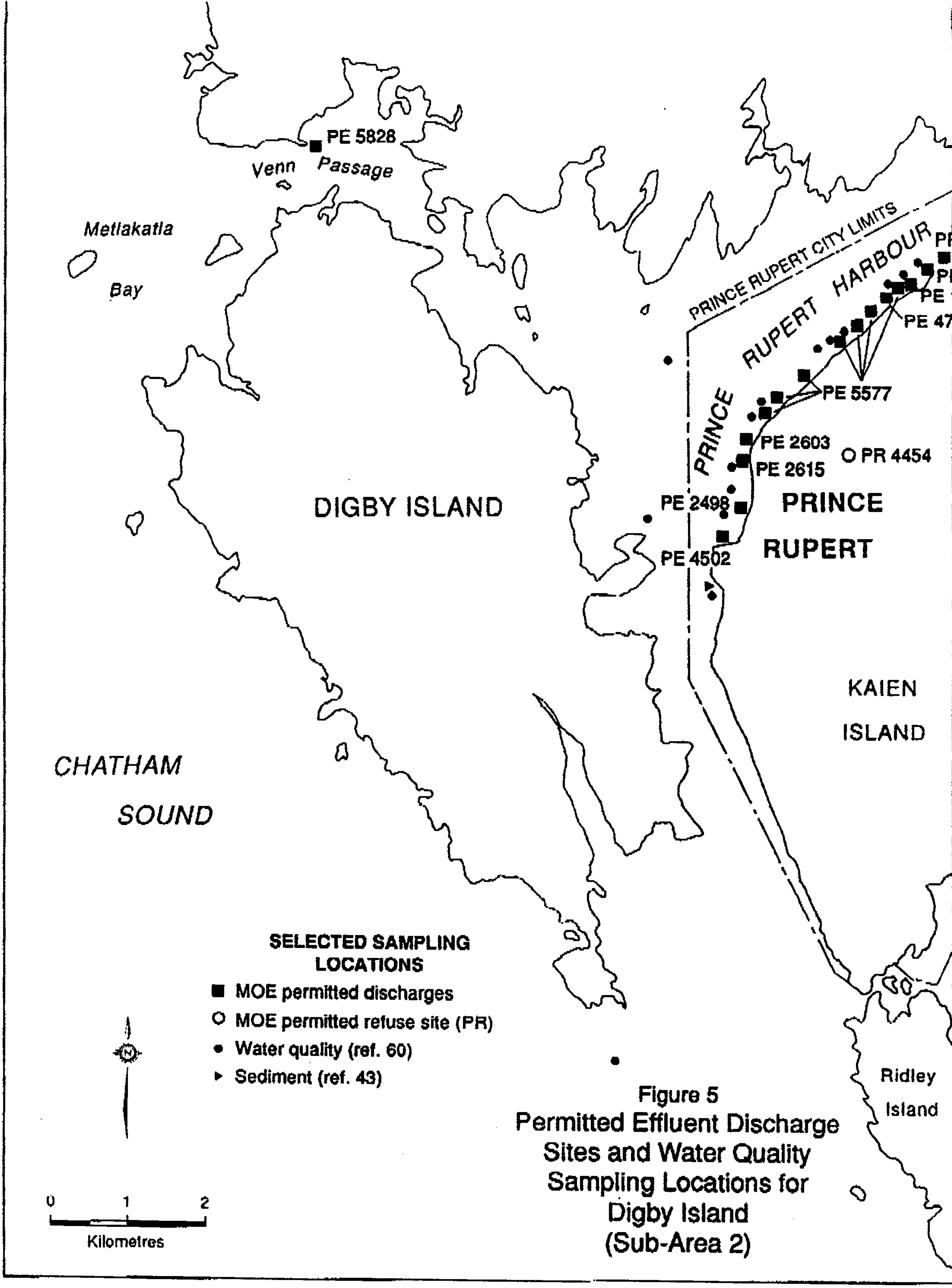


Figure 5
Permitted Effluent Discharge Sites and Water Quality Sampling Locations for Digby Island (Sub-Area 2)

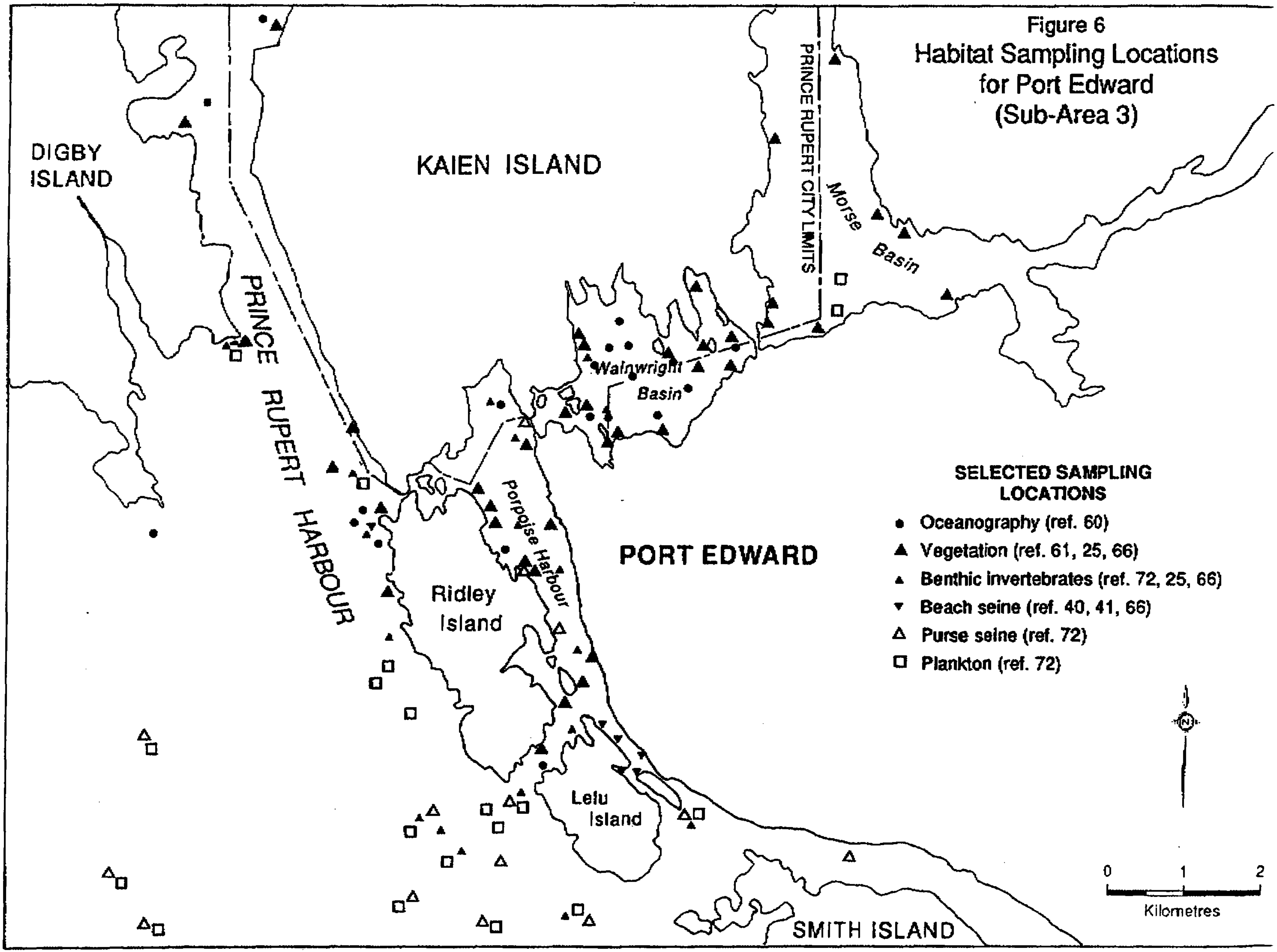


Figure 6
Habitat Sampling Locations for Port Edward (Sub-Area 3)

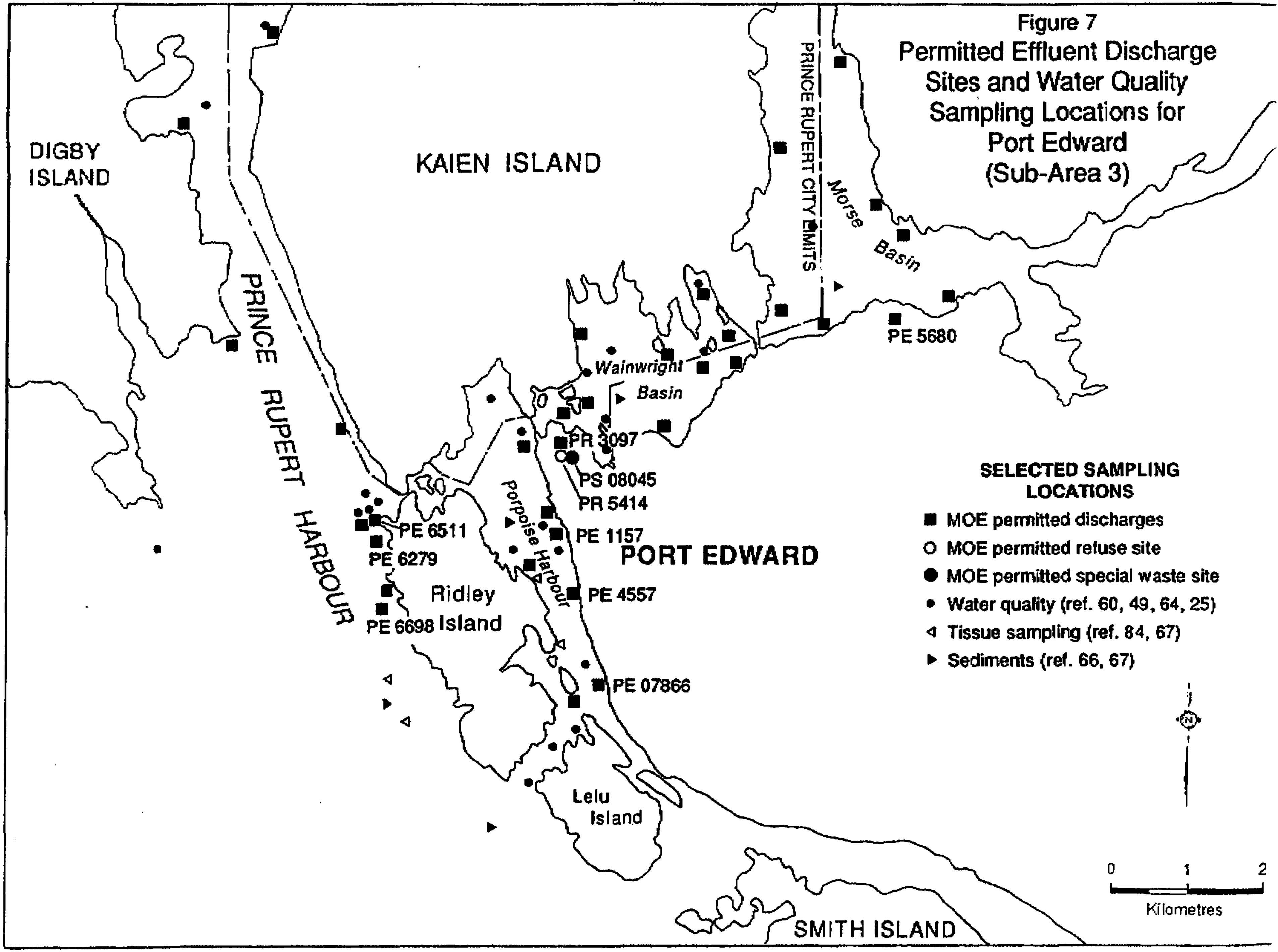


Figure 7
Permitted Effluent Discharge Sites and Water Quality Sampling Locations for Port Edward (Sub-Area 3)
DIGBY ISLAND
KAIEN ISLAND
PRINCE RUPERT HARBOUR
PRINCE RUPERT CITY LIMITS
Morse Basin
Wainwright Basin
PE 5680
PR 3097
PS 08045
PR 5414
PE 6511
PE 6279
PE 1157
PORT EDWARD
Porpoise Harbour
PE 4557
Ridley Island
PE 6698
PE 07866
Lelu Island
SMITH ISLAND
SELECTED SAMPLING LOCATIONS
MOE permitted discharges
MOE permitted refuse site
MOE permitted special waste site
Water quality (ref. 60, 49, 64, 25)
Tissue sampling (ref. 84, 67)
Sediments (ref. 66, 67)
0 1 2
Kilometres

Figure 8

Habitat Sampling Locations for Smith Island (Sub-Area 4)

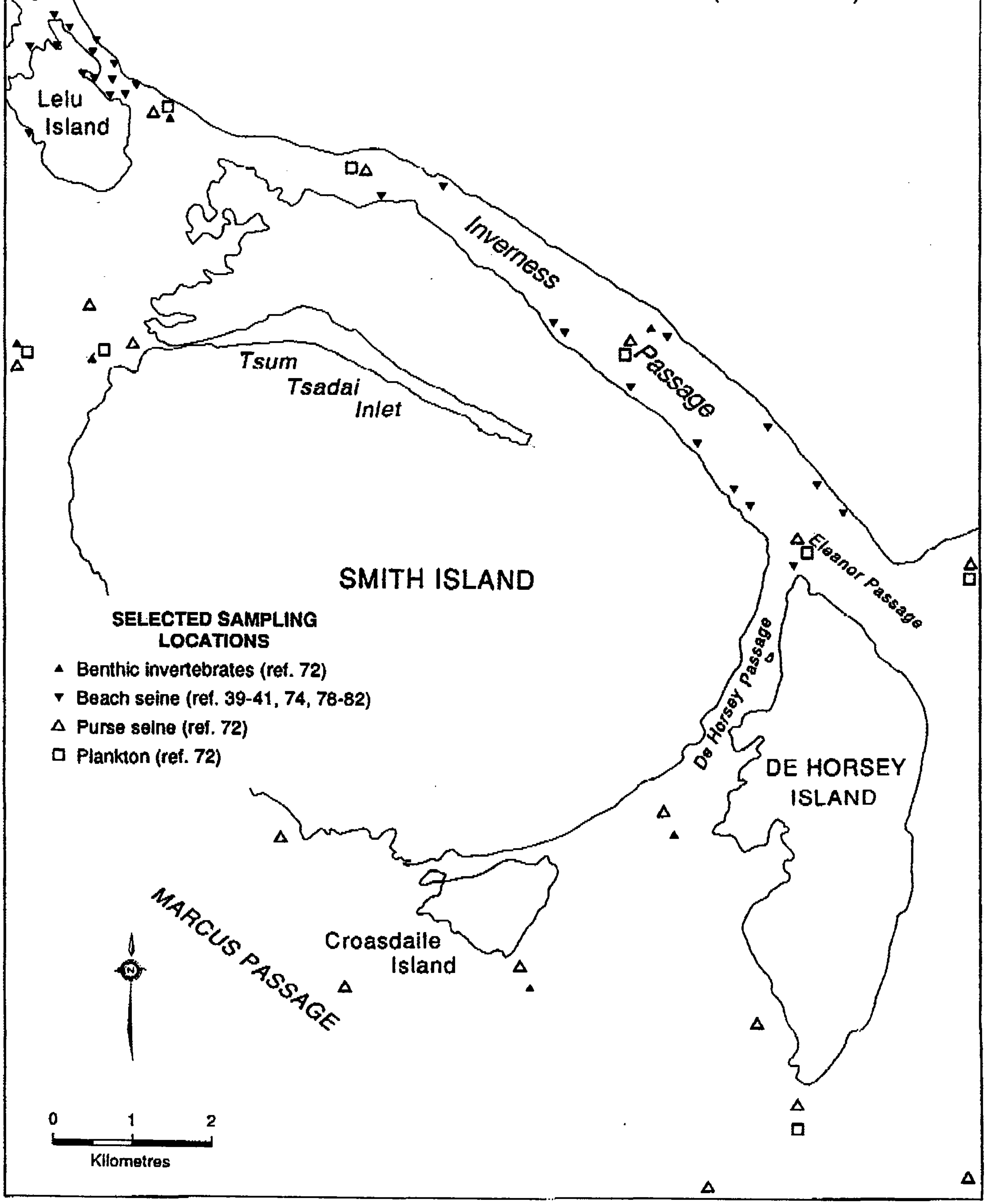
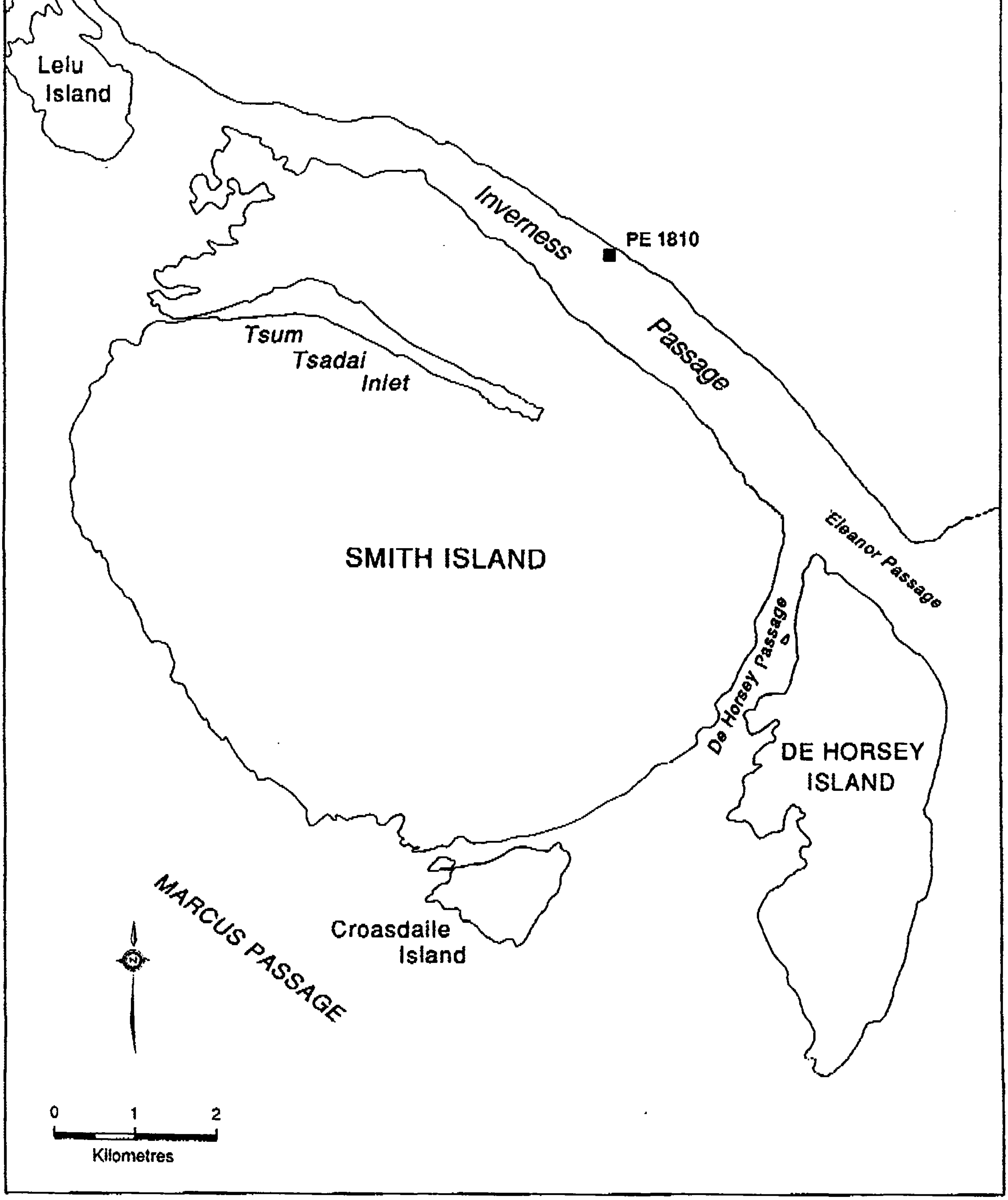


Figure 9
Permitted Effluent Discharge Sites for Smith Island (Sub-Area 4)



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INTRODUCTION

To assist the Department of Fisheries and Oceans (DFO) manage the fisheries resources in the Prince Rupert area, G.L. Williams and Associates Ltd. was retained to compile a bibliography of existing coastal information describing habitats and biota. The study area is bounded by Tuck Inlet in the north, Marcus Passage in the south, Chatham Sound in the west and De Horsey Island in the east. The Skeena River estuary was not included in the study. To facilitate processing the information, the study area was divided into four sub-areas: Prince Rupert, Digby Island, Port Edward and Smith Island (Figure 1).

The report has been organized into two main parts. The first provides a complete alphabetical listing of the citations included in the bibliography, with each citiation given a reference number. The second part lists bibliographic citations according to subject areas related to habitat and water quality. This format was selected during discussions with DFO biologists to provide a practical bibliography that would benefit DFO habitat managers. Report citations which have "bold" typeface indicate they contain original sampling data and, in many cases, the sampling locations have been mapped on the sub-area maps.

Preparation of the report involved compiling listings of existing published primary literature as well as "grey literature" which included internal agency reviews, consultant client reports and file data. The work included searches of in-house DFO information, especially file data, in Prince Rupert and Ministry of Environment files in Smithers to obtain up-to-date listings of permitted effluent discharges. In some cases it was not possible to find the report and the author was unable to conduct a review of its contents. However, the citation was included in the bibliography. Citations were entered according to author, year, title, agency, with "Anon." being used if no author was identified.

One of the objectives of the report was to assist DFO habitat managers identify existing sampling data describing salmonid utilization within the estuary. Original sampling locations were marked on base maps for each of the four sub-areas. The sampling locations mapped provide a **preliminary indication** of the sampling effort, since not all references cited were actually reviewed and not all sampling locations could be mapped at the scale used.

The report provides a useful compilation of existing information for the Prince Rupert coastal area related to fish habitat. It has been entered on computer (i.e.

WordPerfect 5.1) to facilitate access and updating.

Figure 1. Study area showing four sub-areas.

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(bold citations indicate report covers the Marmot River estuary)

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