

COASTAL RESOURCES FOLIO

(Barkley Sound-Alberni Inlet)

BRITISH COLUMBIA

VOLUME II

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COASTAL RESOURCES FOLIO

BARKLEY SOUND - ALBERNI INLET

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November, 1983

1.0 INTRODUCTION

1.1 THE COASTAL RESOURCES FOLIO PROJECT

The purpose of the Coastal Resources Folio Project is to provide an inventory and synthesis of existing biophysical and land/water use information in a format useful for environmental assessments, integrated and single purpose planning and management programs, coast-wide and regional resource allocation studies, and the identification of baseline study needs.

The Coastal Resources Folio Project was initiated by the Lands Directorate, Environment Canada in the fall of 1979.

This folio - Coastal Resources Folio: Barkley Sound-Alberni Inlet - is the fourth and final of a series for the British Columbia Coastal Zone. Due to the termination of the Lands Directorate Coastal Resources Program, this folio is incomplete, since it does not contain information on the important fish and shellfish resources of the area.

1.2 THE STUDY AREA

The folio study area extends from Port Alberni southwest to Cape Beale and northwest to the entrance of Ucluelet Inlet. The north-eastern boundary includes the Pipestem and Effingham inlets. The landward boundary extends to approximately the 150 metre (500 foot) elevation.

1.3 METHODOLOGY

The following steps are used to develop the Coastal Resources Folio:

- Overall purpose, approach and content of folio developed;
- Meetings held with selected federal, provincial and local agencies to seek advice on priorities and to locate sources of baseline information;
- Initial selection of criteria for each theme made and the collection of baseline information begun;
- Contacts with agency personnel made to obtain baseline data and advice on the type of information that should be presented in the Folio;
- Information transferred to working maps, tables and reports;
- Limited field work supported by air photo and video tape interpretation undertaken to fill some data gaps in shore process information, marine vegetation and land/water uses;
- Documents edited, finalized and published.

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1.4 USE AND LIMITATIONS

1.4.1 Potential Use

A concerted effort has been made to ensure that the data presented in the Folio are technically correct and a true reflection of the original collected information. An effort has also been made to portray information in its primary - baseline form. The transformation of the baseline data into such interpretations as erosion hazards, environmental sensitivities, urban suitability, biological productivity and potential uses or conflicts, are left to the user who will have his/her own specific management responsibilities, criteria and information needs.

1.4.2 Limitations

The following limitations are inherent in the Folio:

1. The Folio is only as complete and accurate as the information upon which it is based. Primary data sources are frequently not consistent in format, quality, level of detail, or date of collection. In other instances baseline data may be absent or not readily available.
2. The Land/Water Use and Status theme maps and tables, because of the nature of the information base, become quickly outdated. This is particularly true of foreshore lease information.
3. The scale of presentation at 1:50,000 is not suited for site-specific investigations. Pockets of marine vegetation, small parks or minor land use zones areas, for example, cannot be depicted at this scale. Further, in the transferring of information from one scale to another, errors in the placement of boundaries can result. For detailed analysis, the original source documents should always be consulted.
4. The marine substrates, physical shore zone, seaweeds and saltmarshes data were supplemented by aerial photo and video tape interpretations and field checks.

The Lands Directorate, Environment Canada, welcomes comments on the use and limitations of the Folio in order that improvements can be made to subsequent Coastal Resources Folio documents.

1.5 FOLIO CONTENT AND FORMAT

1.5.1 Folio Content

The Coastal Resources Folio contains the following sections.

1.0 INTRODUCTION

The introductory section is designed to inform the reader as to the purpose, content and availability of the folio.

2.0 COASTAL RESOURCES MAP SERIES (1:50,000)

The intent of this section is to portray in a standardized form, all available and relevant (spatial and/or point source), information for each of the 11 themes. The maps are designed to permit the overlay of any combination of two or more theme maps. Such an approach was developed in recognition of the value and use of overlay analysis techniques to regional planning, in initial assessments of project proposals, and in the derivation of secondary information based upon the comparison and/or combination of different data sets.

3.0 TABLES

This section consists of Land/Water Use and Status Tables and provides detailed data on such subjects as: foreshore leases - areas, use and leaseholder; land tenure; types of services and number of berths at marinas; and zoning by-laws. Descriptive highlights are provided for each base map and a glossary has been prepared for each table and topic.

4.0 COMPANION REPORT

The purpose of the Companion Report is to provide a summary of existing and selected information on coastal resource values, uses, and processes. The Companion Report is a compilation of information on many topics and is designed to complement those themes and subjects portrayed in the Coastal Resources Map Series.

5.0 SOURCES

The Sources Section provides a list of information sources pertinent to the study area. Sources are organized under the same headings as the previous sections. In addition to a bibliography, the Sources Section includes other primary data sources such as aerial photographs, field surveys, computer print-outs, zoning by-laws, and personal communications.

6.0 GLOSSARY

This section provides definitions of selected terms and categories contained either on the map manuscripts or in the Companion Report.

1.5.2 Folio Format

The Coastal Resources Folio consists of two documents: Volume 1 is an atlas containing Section 1.0 Introduction, Section 2.0 Coastal

Resources Map Series, and Section 3.0 Tables. Volume I consists of two separate folios - one for each of the two base map areas.

Volume II is a report which applies to the entire study area and contains Section 1.0 Introduction, Section 5.0 Companion Report, Section 5.0 Sources, and Section 6.0 Glossary.

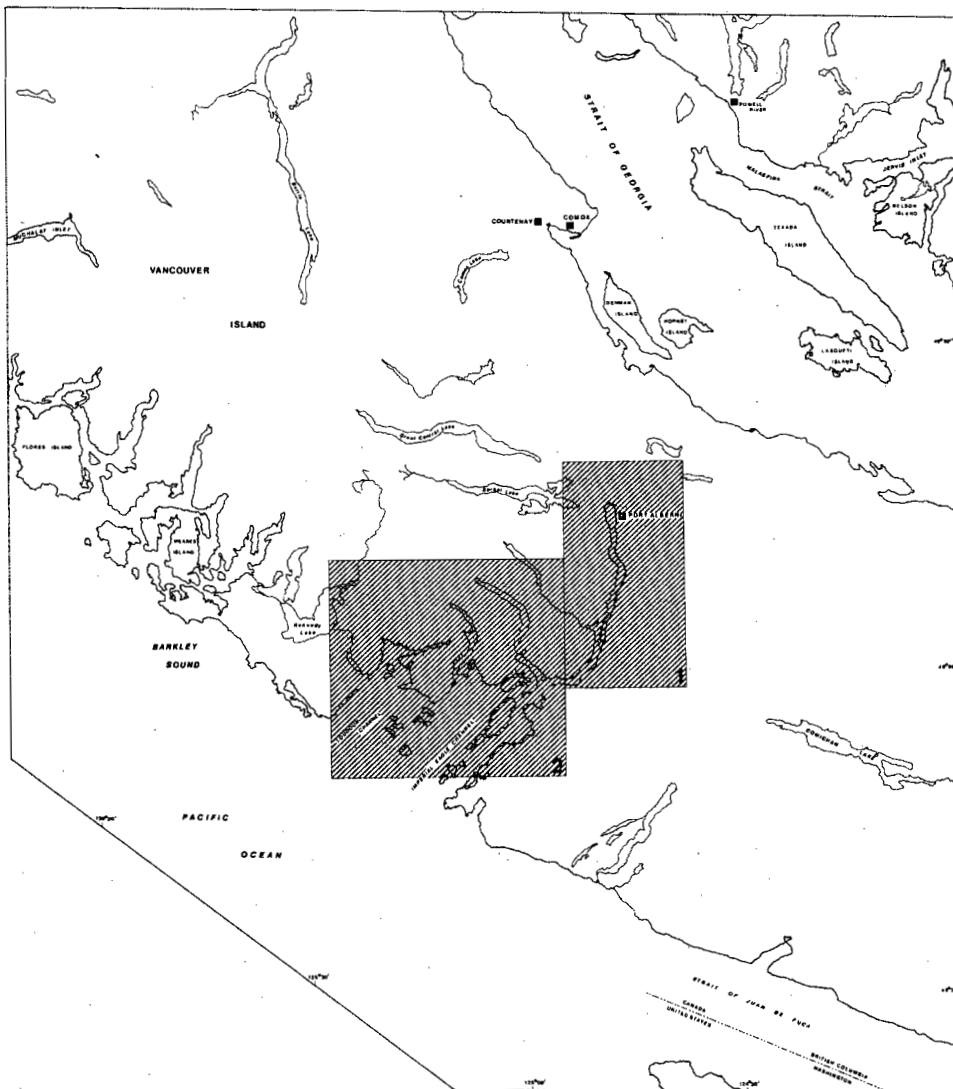
1.6 COVERAGE AND AVAILABILITY

1.6.1 Coverage

The following charts will be of assistance in ordering the Coastal Resources Folio.

1.6.1.1. Area Coverage

Location and boundaries of study area and base maps.



COASTAL RESOURCES FOLIO

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1.6.1.2 Theme Maps (Coastal Resources Map Series)

When ordering 1:50,000 theme maps, please quote year of publication; base maps and theme number, in accordance with the following chart.

Year	Base Maps	Theme Map No. and Title
1983	1, 2	-1 Physical Shorezone
1983	1, 2	-1 Physical Shorezone Units Table
1983	1, 2	-2 Generalized Terrain Limitations
1983	1, 2	-3 Physical Oceanography - Station Distribution
1983	1, 2	-3 Physical Oceanography - Station Summary Table
1983	1, 2	-4 Water Resources - Discharge, Use and Contamination
1983	2	-5 Seaweeds, Saltmarshes and Marine Mammals
1983	1, 2	-6 Marine Bird Surveys
1983	1, 2	-7 Generalized Zoning, Marine Facilities and Selected Administrative Boundaries
1983	1	-8 Land/Water Use Plans and Proposals
1983	1, 2	-9 Land/Water Use and Status
1983	1, 2	-10 Forest Cover
1983	1, 2	-11 Recreational Areas, Special Features and Access

For example 83-1-1 refers to base map number 1, Physical Shorezone published in 1983.

1.6.1.3 Tables

The following tables are available:

- Zoning and Marine Facilities
- Land Use, Plans and Forest Cover
- Land and Water Status

When ordering, please quote table title and required base map coverage.

1.6.1.4 Report

Volume II provides coverage for the entire Barkley Sound-Port Alberni study area.

1.6.2 Availability

The Coastal Resources Folio is available either from:

Environment Canada
P.O. Box 1540, 800 Burrard Street
Vancouver, B.C. V6Z 2J7
Phone: (604) 666-5920

OR MAPS-B.C.
Surveys & Resources Mapping Branch
B.C. Ministry of Environment
Parliament Buildings
Victoria, B.C. V8V 1X5
Phone: (604) 387-1441

1.6.3 Orders and Cost

Requests should be placed by mail. The Folio can be ordered by base map, resource theme, or by section. Section 2.0 Coastal Resources Map Series (1:50,000) Manuscripts can be ordered as either ozalids (paper prints) or as films (diaz or auto-positives).

The cost of your order will be in accordance with the following arrangement.

Document	Request		Cost
	Number of Copies	Type of Product	
Volume I - Atlas	Limited number of single copy theme maps or tables	Ozalid (paper print)	No charge
		Films (diaz or auto-positives)	At current rates established by local printing firms or by the Provincial Map Production Laboratory. Direct billing to apply.
	Multiple (duplicate) copies of theme maps or tables	Ozalids (paper prints)	At current rates established by local printing firms or by the Provincial Map Reproduction Laboratory. Direct billing to apply. Estimated Cost (1983 quotations) \$1.05 - \$2.00 per print*.

Volume II Limited number of copies available free of charge.
Report

* Prices subject to change.

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4.1 INTRODUCTION

PURPOSE

The purpose of this report is to provide complementary information to the maps and tables of the Coastal Resources Folio.

THE STUDY AREA

The Barkley Sound-Alberni Inlet Resources Folio study area extends from Port Alberni southwest to Cape Beale and northwest to the entrance of Ucluelet Inlet. The northeastern boundary includes the Pipestem and Effingham inlets. The landward boundary extends to approximately the 150 metre (500 foot) elevation.

4.2 THE BARKLEY SOUND-ALBERNI INLET ECONOMY

4.2.1 GENERAL SETTING

The study area falls within the Regional District of Alberni-Clayoquot. Forestry is the primary industry in the area with most of the 6,449 square kilometres (km) of land in the regional district under tree farm licence. The regional district population is estimated at 32,558, with the majority of people living in Port Alberni and the Alberni Valley. Located at the head of Alberni Inlet, Port Alberni serves as a deep sea port and the site for three sawmills and a pulp mill.

Bamfield, situated on the southwest coast of Barkley Sound, is the location of the Western Canadian Universities Marine Biological Station. Bamfield Inlet, a designated public harbour, contains the Coast Guard Life Saving Station, two small craft harbours and a wharf (Gray, 1980).

A.V.G. Management Science Ltd. (1980) provides an account of the labour force in the Alberni-Clayoquot Regional District. A comparison of the regional district labour force with that of the province is provided in Table 1.

4.2.2 FORESTRY

Table 2 lists the area of various forest cover types. The provincial Crown owns 88% of the forest land in the study area while 12% is privately held by forest companies (B.C. Forest Service, 1983). The provincial crown land is contained in the Clayoquot and Juan de Fuca provincial forests and is administered by the B.C. Forest Service. The B.C. Forest Service also administers timber tenures under the Nootka Timber Supply area. MacMillan Bloedel is the major private holder operating Tree Farm Licences 20 and 21. B.C. Forest Products operates Tree Farm Licence 22.

TABLE 1

LABOUR FORCE - BY INDUSTRY 1981
ALBERNI-CLAYOQUOT REGIONAL DISTRICT

Industry Division	British Columbia	% of Total	Alberni-Clayoquot Regional District	% of Total
Total Labour Force	1,389,215		16,370	
All Industries	1,376,230		15,965	
Primary Industries*	99,687	7	2,600	16.5
Agriculture	31,575	2.2	125	.78
Forestry	37,035	3.0	2,020	12.6
Fishing and Trapping	5,335	.4	420	2.6
Secondary Industries*	312,000	22.6	5,590	35.4
Manufacturing	204,020	14.8	4,785	30.9
Construction	107,980	22.6	685	4.5
Tertiary Industries	964,550	69.7	7,555	47.7
Transportation, Commun- ication and Other				
Utilities	126,550	9.1	850	5.5
Trade	243,190	17.6	2,010	12.9
Finance, Insurance and Real Estate	78,110	5.6	425	2.8
Community, Business and Personal Service	417,910	30.3	3,390	21.7
Public Administration and Defense	98,790	7.1	760	4.8

* Not all the industries which comprise the major industrial division are shown. Therefore, the major industry totals do not coincide with the sum of the detailed industrial groupings.

SOURCE: Statistics Canada, 1983. 1981 Census of Canada.

TABLE 2
FOREST COVER - AREA¹ IN HECTARES BY FOREST COVER CATEGORY
FOR THE BARKLEY SOUND-ALBERNI INLET AREA

Base Map Number	Immature	%	Mature	%	Not Satisfac torily Stocked	%	Non-Commercial	%	Total Forest	Non Forest	Total Land
1	5 055	62	2 611	32	534	7	-		8 200	900	9 100
2	5 775	12	39 764	84	1 886	4	13	.02	47 438	14 219	61 657
TOTAL	10 830	19	42 475	76	2 420	4	13	.02	55 638	15 119	70 757

¹The areas in some cases represent an area larger than the actual base map sheet.

SOURCE: B.C. Forest Service, 1983. Victoria.

4.2.3 FISHING

In 1980, 284 commercial fishing vessels were licensed in the study area. The commercial value of salmon, herring, halibut and groundfish, expressed as the total average landed value, is shown in Table 3. The total average landed value of shellfish, excluding oysters, for the same (1975-1981) period is shown in Table 4.

Port Alberni Fish Company Ltd. is the only fish processing plant operating in the study area, and is licensed to process salmon and groundfish (T. Proverbs, pers. comm., 1983).

In 1982, the sports fishery was worth an estimated \$1,070,835. Resident anglers fished a total of 71,989 days. Salmon was the largest catch, with chinook the favoured species. Table 5 presents a comparison of sport fishing effort over three years. This information is part of the Department of Fisheries and Oceans B.C. Tidal Sportfishing Diary Program. (L. Bijsterveld, pers. comm., 1983).

TABLE 3
AVERAGE LANDED VALUES (1975-1981) OF SALMON, HERRING AND GROUND FISH
STATISTICAL AREA 23

Fishery	Area 23 (\$000)
Salmon	\$ 13,996
Herring	14,712
Groundfish	3,384
Halibut	<u>106</u>
Total	<u>\$32,198</u>

SOURCE: Fisheries and Oceans Canada, Pacific Region 1975-1981
B.C. Catch Statistics.

TABLE 4

SHELLFISH AVERAGE LANDED VALUES 1975-1981
(\$000)

Species	1975	1976	1977	1978	1979	1980	1981
Shrimp & Prawns	\$37	36	157	112	120	106	249
Clams	34	16	12	13	3	-	-
Abalone	2	4	-	-	-	-	-
Crab	4	-	-	9	15	2	9
Geoduck	-	-	-	-	120	217	145
Total	77	56	169	134	263	325	403

SOURCE: Fisheries and Oceans Canada, Pacific Region. 1975-1981 B.C. Catch Statistics.

TABLE 5

SPORT FISHING EFFORT 1980-1982¹

Fisheries Statistical Area 23			
	1980	1981	1982
Angler Days ¹	35,139	51,500	71,989
\$ Value	527,085.	772,500.	1,079,835.

1 - one angler day is worth \$15.

SOURCE: L. Bijsterveld, 1983. Personal Communication.

4.2.4 TOURISM

The Pacific Rim National Park attracts over half a million visitors to the area each year (Canada/BC, 1983). The park is made up of three units: Long Beach, the Broken Islands Group and the West Coast Trail. The Broken Islands Group and part of the West Coast Trail are located in the study area.

The City of Port Alberni receives on average 30,000 visitors a year. The Lady Rose cruise/transportation operation, MacMillan Bloedel's Pulp and Paper Mill, boat charters and the museum are the major tourist attractions.

The City of Port Alberni has also undertaken a harbour park development project which is a commercial, recreational and cultural revitalization of the harbour front (Canada/BC, 1983).

4.2.5 AGRICULTURE

In 1974, the Agricultural Land Commission designated 7 933 ha of land as Agricultural Land Reserve; since then only 40 ha have been exempted. In 1981, seventy-three farms were operating in the area, twenty-one of which were considered commercial operations, with the remainder being hobby farms. (Statistics Canada, 1983).

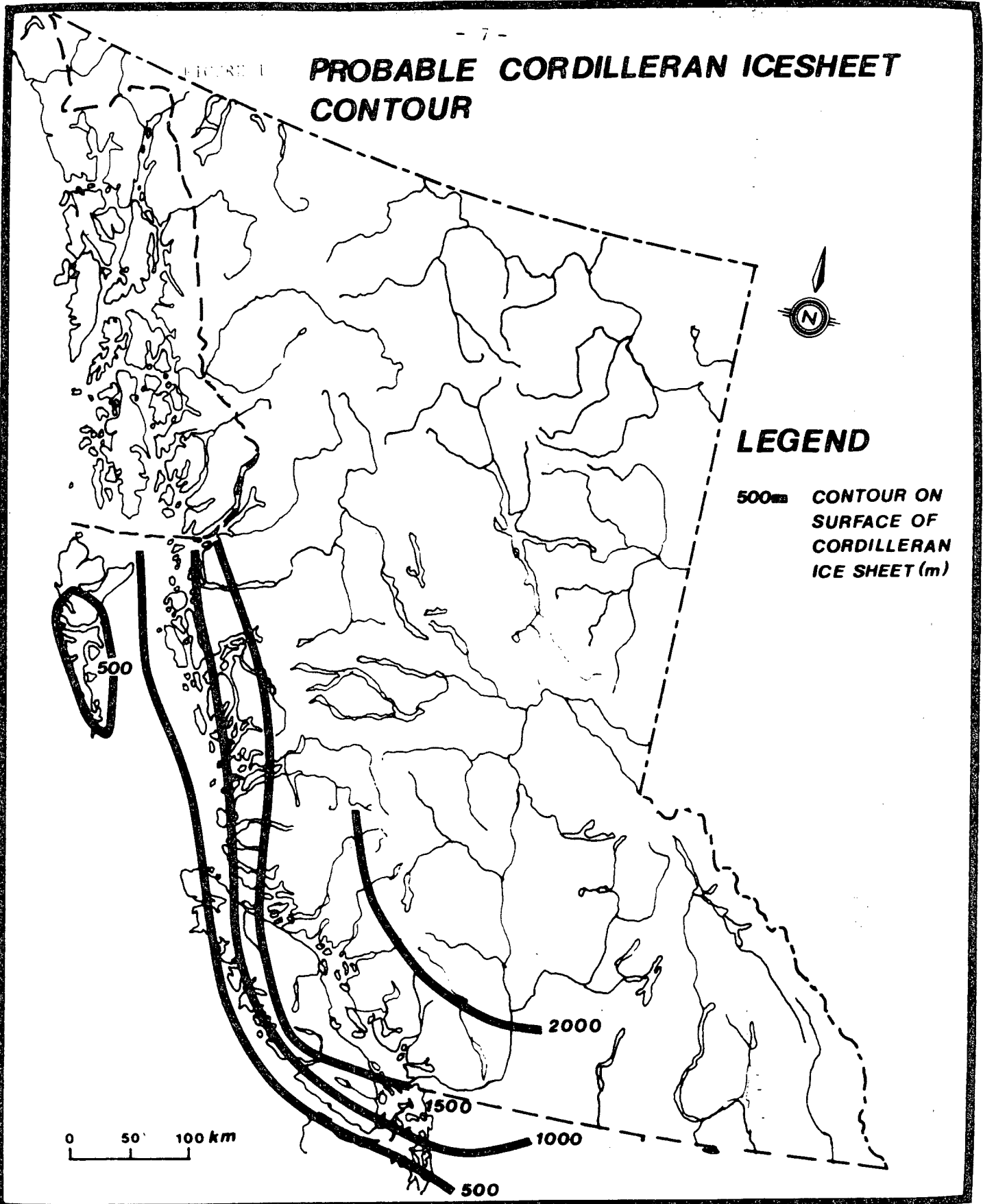
4.3 PHYSICAL FEATURES

4.3.1 PHYSIOGRAPHY

The study area's physiography reflects repeated glacial and interglacial events of the Wisconsin period. Large ice sheets of great thickness covered the entire area. Figure 1 illustrates the probable ice thickness over the region. The weight of ice caused the land mass to depress relative to the sea. Upon deglaciation the land rose which, for this area, meant an elevation change relative to sea level of 90 to 100 m at Port Alberni and < 50 m on the west coast of the island. (Clague, 1981). Figures 2 and 3 show the areas of marine overlap and elevation change for coastal British Columbia.

The study area straddles two distinctive physiographic regions - the Estevan Coastal Plain and the Vancouver Island Mountains (part of the Insular Mountain Chain).

FIGURE 1 PROBABLE CORDILLERAN ICESHEET CONTOUR



SOURCE: J.J. Clague, J.R. Harper, R.J. Hebda and D.E. Howes, 1982. Later Quaternary Sea Levels and Crustal Movements, Coastal British Columbia. Canadian Journal of Earth Sciences, 19(3). Ottawa.

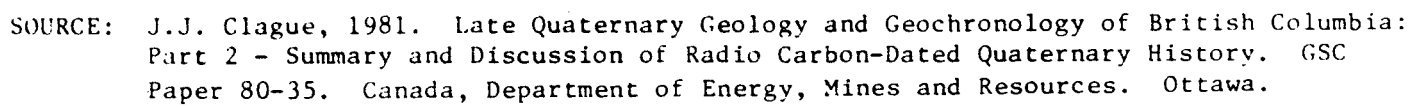
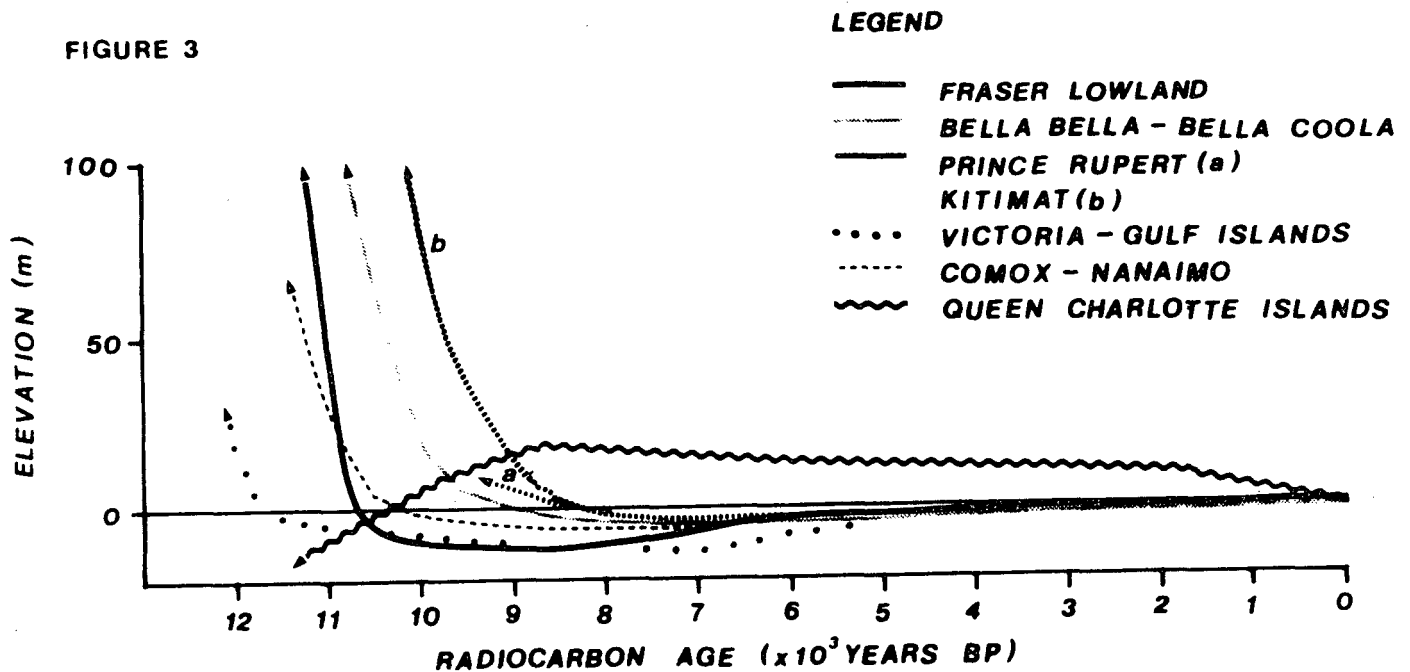


FIGURE 3



SUMMARY OF OBSERVED RELATIVE SEA-LEVEL CHANGES IN BRITISH COLUMBIA

SOURCE: J.J. Clague, J.R. Harper, R.J. Hebda, and D.E. Howes, 1982. Late Quaternary Sea Levels and Crustal Movements, Coastal British Columbia. Canadian Journal of Earth Sciences. Volume 19 (3). Ottawa.

Estevan Coastal Plain

This narrow lowland extends from Juan de Fuca Strait to the Brooks Peninsula, a total of about 270 km. Its width rarely exceeds 4 km, while its elevation is generally less than 50 m. (Clague and Bornhold, 1980).

The Estevan Coastal Plain is best developed on the northwest side of Barkley Sound.

Barkley Sound represents a marine component of the Estevan Coastal Plain. It is a southwest by northeast trending depression dissected by many channels and islands. The three major channels Loudoun, Imperial Eagle, and Trevor, have the following dimensions (Carter, 1971).

	<u>Length(km)</u>	<u>Width(km)</u>	<u>Average depth(m)</u>	<u>Maximum depth(m)</u>
Loudoun	11.2	2.4	48	77
Imperial Eagle	19.3	6.4	88	117
Trevor	22.5	2.2	135	259

Carter (1971) also comments that the bottom topography of Barkley Sound is very complex, with two distinct halves. The southeast half contains several elongated depressions aligned with the Sound's axis. Average depths are 109 m, while the deepest basin is near the mouth of Alberni Inlet at 255 m. The northwest half of the Sound is much shallower, averaging about 37 m.

Bamfield Inlet, as described by Carter (1971), is typically shallow, has no sill at mouth, and has well-developed tidal flats at its head. He suggests that it is an ice erosion feature modified by heavy sedimentation. The central channel, he feels, is a tidal scour feature.

Vancouver Island Mountains

These mountains are the southern extension of the Insular Mountains physiographic region described by Holland, 1964. They dominate the topography of Vancouver Island and attain elevations of up to 2200 m (Clague and Bornhold, 1980). Within the study area, however, 1000 m peaks are more common. This rugged topography is indented by numerous inlets, five of which occur within the study area. Carter (1971) classifies these inlets as fjords since they have steep sides, are very deep, have sills, and generally have a "U"-shaped profile.

The following table provides the comparisons of the inlets. Note that Uchucklesit Inlet does not have a sill.

TABLE 6 CHARACTERISTICS OF INLETS

Inlet	Length(km)	Average Width(km)	Mid-channel Depth(km)	Maximum depth (m)	Sill depth (m)
Uchucklesit	5.8	1.0	35	86	-
Useless	4.8	.5	31	44	15
Pipestem	8.1	.6	45	70	34
Effingham	14.5	1.2	95	205	56
Alberni	59.5	1.1	145	365	88

SOURCE: L. Carter, 1971. Surficial Sediments of Barkley Sound and the Adjacent Continental Shelf, Vancouver Island, British Columbia. University of British Columbia, Department of Geology. Vancouver. Unpublished Ph.D thesis.

4.3.2 GEOLOGY

Bedrock

The study area is a complex of sedimentary, metamorphic and igneous rocks. Dominant are basalts, andesites, Granodiorite, and diorites of Mesozoic age. Tertiary sandstones and glacial deposits overlay these rocks on the coastal plain. (Carter, 1973).

Geologic mapping of the area has been done by Muller (1970) and Roddick et al (1979).

Surficial Geology

The unconsolidated surficial materials are primarily of glacial and interglacial origin which have been further modified by sea-level changes and recent fluvial processes. Modern sediments are represented by channel, floodplain, alluvial fan, deltaic and beach deposits. The Estevan Coastal Plain is extensively overlain by glacial till of variable textures, especially on the northern side of Barkley Sound. Much of this same area has also been modified by marine and glacio-marine processes. Glacio-fluvial land forms such as terraces, abandoned channels and ice contact fans are also present, though more abundant in the Alberni Valley and adjacent uplands.

Colluvial and till veneer deposits dominate the mountainous and steep sloped parts of the study area. Organic deposits have developed in poorly drained depressional areas and at lake margins.

Accounts of the glacial history, stratigraphy and textures of surficial deposits can be found in Day, et al (1959), Fyles (1963), Carter (1970, 1973), and Clague (1981). Reconnaissance terrain inventory mapping has been done by the British Columbia Ministry of Environment (1972).

4.3.3 SOILS

The soils of the study area are predominantly of the Podzolic Order. Ferro-humic podzols are primarily found on the lowland part of the study area, while humo-ferric podzols dominate the mountainous, eastern portion of the study area.

In general, steep slopes tend to have shallow, coarse textures and rapidly drained soils; bedrock outcrops are common. Less steep terrain has sandy to gravelly soils with rapid to imperfect drainage. Gently sloping, low lying positions have medium to fine textured soils subject to water table fluctuations. Depressional or level areas usually underlain by marine clays generally have organic soils. Glacio-marine and glacio-fluvial deposits (especially terraces) have coarse textured, and very rapidly drained soils on moderate slopes (Frank, 1980).

Mapped soils information for the Alberni Valley is available in Day, et al (1959). Valentine et al (1978) provide a general account of soil landscapes of the area.

4.3.4 CLIMATE

Temperature and Precipitation

The study area has a relatively homogeneous temperature regime. Annual means do not vary greatly among the 12 recording stations, ranging from 8.6° C to 10.1° C. Extreme maximums and minimums, however, do reflect the moderating effect of the ocean on outside coastal stations. Extremes for the four coastal stations range from 28.9° to 32.8° C for maximums and from -10.6° to -15.6° C for minimums. By contrast, the eight inland stations show extremes of 34.4° to 41.7° C for highs and from -14.6° to -25.6° C for lows; a much greater range of values. (Atmospheric Environment Service, 1983).

Rainfall values, too, can also be grouped between the coastal and inland stations. Port Alberni and area have a similar rainfall regime according to the mean annual values for the eight stations - the range was from 1853.5 mm to 2176.8 mm. The seven coastal stations recording precipitation showed much higher values, with ranges from 2770.5 mm to 3455.1 mm. Schaefer (1983 pers. comm.) commented that some of the west facing mountains east of Ucluelet are probably the wettest places in Canada. He cited Ucluelet Brynnor Mines with a mean annual rainfall total of over 6000 mm!

Wind Patterns

The topography of the study area greatly influences the wind patterns. Winds are constrained by the Vancouver Island Mountains so that they blow generally in southeasterly or northwesterly direction. The inlets, however, funnel the winds so that directions generally parallel the channel axis. The prevailing winds of the study area blow southeasterly in winter and northwesterly in summer on the outer coast (Faulkner and Schaefer, 1978). In Alberni Inlet and the Somass Valley, however, the prevailing winds are from the south in summer and the northwest in winter (Morris and Leaney, 1980). During summer, land-sea breezes occur over the Somass Estuary. Within Alberni Inlet, winds are not uniformly distributed across the width of the channel, especially at the bends (Morris and Leaney, 1978).

4.3.5 WATER RESOURCES

Hydrology

Discharge data for two stations (Sarita River and Somass River) are provided in Figures 4 and 5. The moisture balance data are illustrated in Figures 6 and 7.

Water Quality

Domestic sewage and industrial effluents are the major contaminants of marine and freshwaters of the study region. Sewage outfalls, septic tanks, and wastes from vessel contribute nutrients and coliform bacteria, while several industrial and commercial outfalls add poisons, metals, and heat. Although most marine waters are relatively well flushed by tidal action, water quality in many nearshore areas is, or is suspected to be, below the standards set for shellfish harvesting and water contact recreation. Certain land use and waste disposal practices adjacent to estuaries, coastal freshwater lakes and rivers similarly contribute to the reduced quality of these water bodies.

FIGURE 4: HYDROGRAPH FOR THE SARITA RIVER
STATION No. 08HB014
NATURAL FLOW

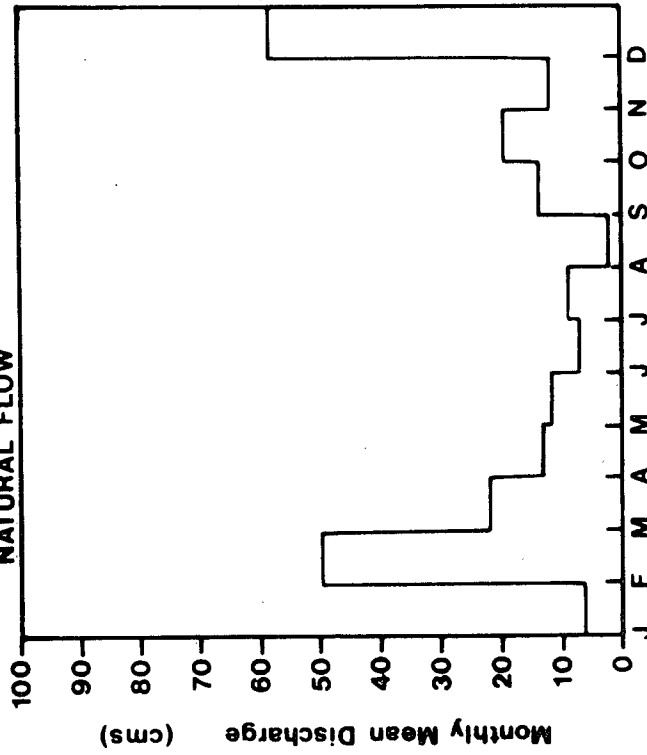
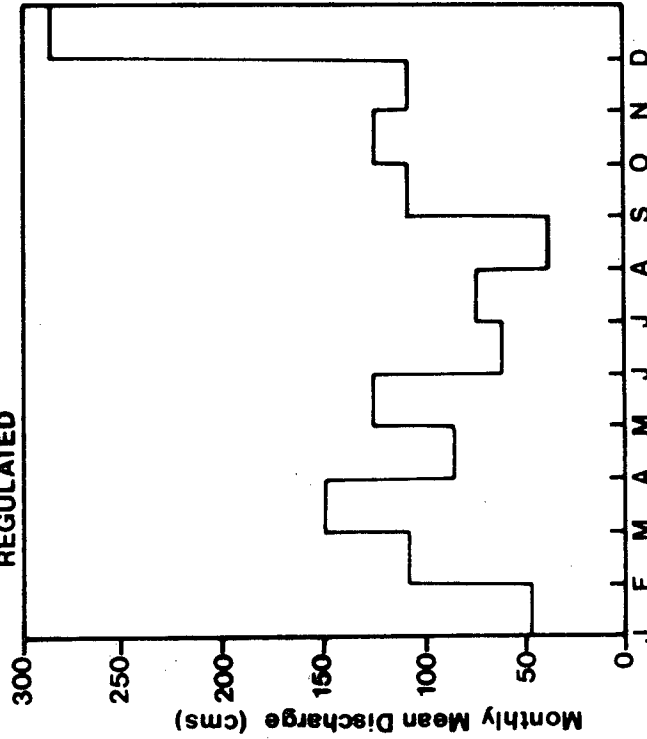


FIGURE 5: HYDROGRAPH FOR THE SOMASS RIVER
STATION No. 08HB017
REGULATED



SOURCE: Canada, Department of Environment, 1981. Surface Water Data. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa.

Figure 6 Moisture Balance for Amphitrite Point

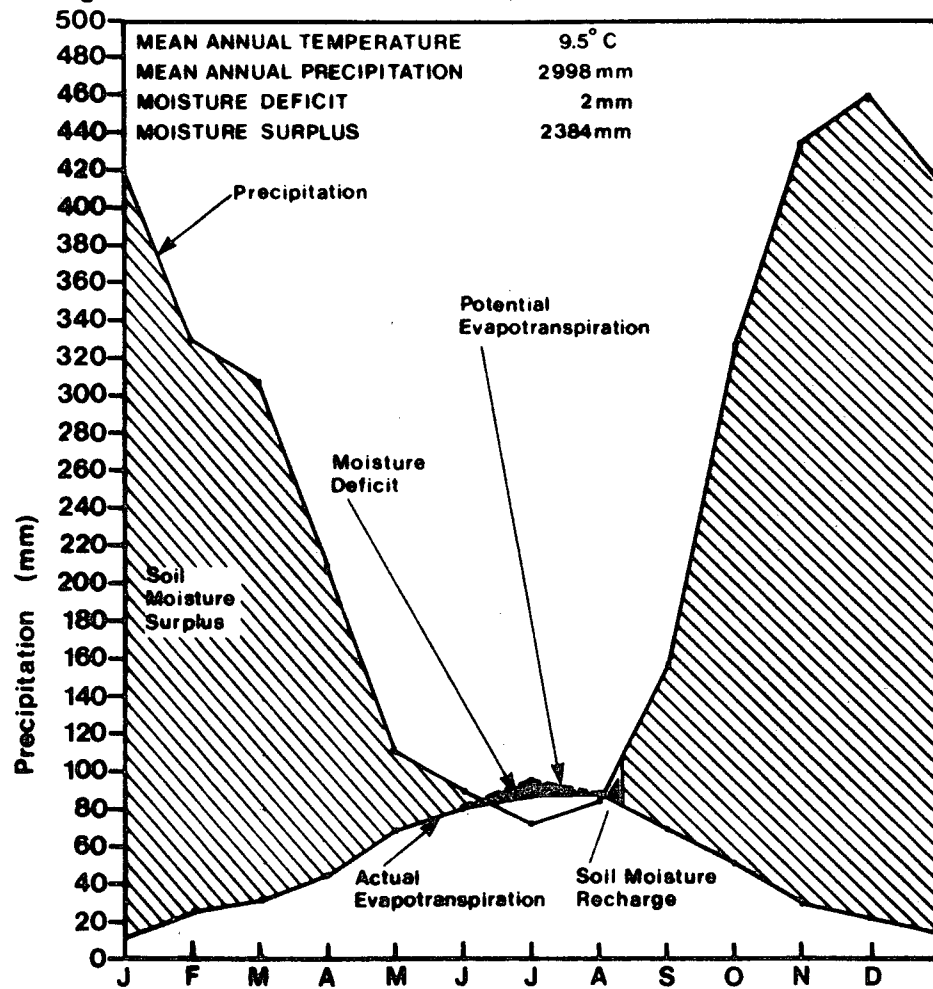
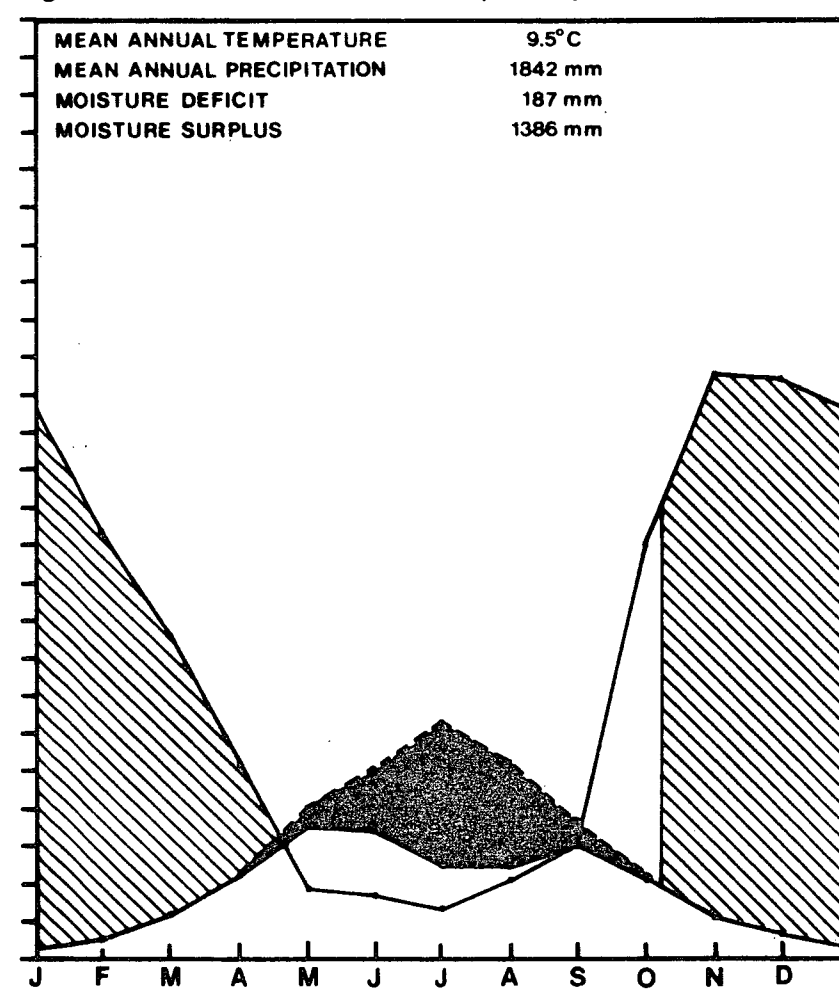


Figure 7 Moisture Balance for Lupsi Cupsi



SOURCE: Canada, Department of Environment, 1983. From Data provided by Atmospheric Environment Service, Vancouver.

4.4 BIOLOGICAL RESOURCES

4.4.1 TERRESTRIAL VEGETATION

The biogeoclimatic units of British Columbia, derived by Krajina (1969), include four formations, seven regions, and eleven zones. Of these, the study area falls within Mesothermal Biogeoclimatic Formation, the Pacific Coastal Mesothermal Forest Region, and the Coastal Western Hemlock Zone.

The biogeoclimatic mapping of Klinka, Nuszdorfer, and Skoda (1979) for this study area indicates the presence of two zones with subdivisions:

- . Coastal Western Hemlock Zone - Wetter Maritime - Estevan and West
Coastal Western Vancouver Island
Hemlock Subzone Submontane Wetter
Maritime
Coastal Western Hemlock

West Vancouver Island
Montane Wetter Maritime
Coastal Western Hemlock
- . Coastal Douglas fir Zone - Wetter Maritime - Nanaimo and Georgia
Coastal Douglas fir Wetter Maritime Coastal
Douglas fir Douglas fir

The climatic characteristics, characteristic combination of species, and a schematic profile of western Vancouver Island are illustrated in tables Tables 7, 8 and Figure 8 respectively. Krajina, Klinka, and Worrall (1982) provide a synopsis of these zones and their specific characteristics. Further data provided by these researchers indicates that this region exhibits a high diversity of tree species (number of tree species - 20 to 29) compared to other areas of the province.

4.4.2 SEaweEDS AND SALTMARSHES

There are in excess of 500 species of attached marine algae in British Columbia (Scagel, 1978). The classification of algae is based partly on pigmentation; hence the algal groups are Chlorophyceae (green algae), Phaeophyceae (brown algae), and Rhodophyceae (red algae). A fourth group of plants, the sea-grasses, have two genera occurring in British Columbia - Zostera and Phyllospadix. Saltmarsh species include the genera Salicornia, Distichlis, and Triglochin. Several genera (i.e. Scirpus, Typha, Carex) are better adapted to brackish waters, while others (i.e. Festuca, Juncus, Hordeum) inhabit coastal wetlands.

A conspicuous feature of most coastlines is the zonation of seaweeds. Seaweeds occur as horizontal bands, theoretically at least, as a function of their receptivity to different wavelengths of the light spectrum, and the differential attenuation of wavelengths with increasing water depth. Consequently,

TABLE 7

CLIMATIC CHARACTERISTICS⁽¹⁾

Means (upper figures) and standard deviations (lower figures) of differentiating climatic characteristics for subzones and variants of the CDF, CWH and MH zones

biogeoclimatic units		climate (Köppen-Trewartha)																							
		mm	°C		Ly	mm	°C	days	mm	mm	°C		mm	mm	°C		mm	mm	cm		mm	mm	%	mm	
		mean annual precipitation	mean temperature of the coldest month	index of continentality	mean radiation during growing season	mean precipitation April-September	mean temperature of the warmest month	accumulated degree days over 5.6 °C	frost free period	mean precipitation of the driest month	mean precipitation of the wettest month	annual temperature	number of months with mean temperature > 10 °C	number of months with mean temperature > 0 °C	water surplus	water deficit	number of months with water deficit	maximum snow depth	number of months with snow	potential evapotranspiration	actual evapotranspiration	actual/potential evapotranspiration	actual evapotranspiration April-September		
COASTAL DOUGLAS FIR ZONE	Drier Maritime Coastal Douglas-fir	drier Csb	907 140	3.2 0.7	11 3	45700 2510	214 52	17.1 1.0	1753 131	253 37	22 8	152 24	10.0 0.4	5.6 0.5	0.0 0.0	543 111	268 70	4.0 0.7	0.9 2.0	0.2 0.4	632 38	364 42	58 9	311 49	
	Wetter Maritime Coastal Douglas-fir	wetter Csb	1202 233	2.0 1.1	13 4	43000 1430	279 52	16.6 1.1	1578 185	217 24	28 7	197 43	9.1 0.7	5.2 0.7	0.0 0.0	798 223	181 35	3.4 0.7	1.0 1.1	1.0 1.0	583 19	405 38	89 5	358 40	
COASTAL WESTERN HEMLOCK ZONE	Drier Maritime Coastal Western Hemlock ⁽²⁾	drier Cfb	1867 269	1.4 0.9	15 5	40800 2030	468 88	17.3 1.1	1700 205	211 19	48 11	291 54	9.4 0.8	5.4 0.5	0.0 0.0	1383 278	72 47	1.8 0.7	1.9 1.7	1.4 1.0	556 20	483 41	87 8	440 38	
	East Vancouver Island Drier Maritime Coastal Western Hemlock		2080 287	0.9 1.1	15 5	42200 2130	404 38	16.8 1.5	1540 214	188 16	38 4	347 41	8.7 0.6	5.0 0.0	0.0 0.0	1628 263	133 17	2.2 0.4	3.5 2.0	2.2 1.2	567 19	432 13	76 2	398 18	
	Pacific Ranges Drier Maritime Coastal Western Hemlock		1785 232	1.8 0.8	14 4	39900 1580	498 59	17.5 0.8	1769 184	218 17	50 10	267 40	9.7 0.6	5.8 0.5	0.0 0.0	1279 214	45 28	1.6 0.8	1.2 1.0	1.0 0.8	551 19	505 26	92 5	459 30	
	Wetter Maritime Coastal Western Hemlock ⁽²⁾	wetter Cfb/c	3038 1048	0.8 2.8	6 7	40200 1490	713 262	12.9 1.9	938 336	193 42	74 30	461 130	6.7 1.7	3.4 1.7	0.8 1.2	2535 897	35 57	0.8 1.2	8.0 7.1	3.7 2.5	489 36	455 85	93 11	426 53	
	Estevan Submontane Wetter Maritime Coastal Western Hemlock		3018 71	4.8 0.4	11 0	40300 3100	774 148	14.2 0.7	1390 145	283 11	63 6	445 20	9.2 0.4	5.1 0.8	0.0 0.0	2485 73	0 0	0.0 0.0	0 0	0.0 0.0	531 11	531 11	100 0	485 9	
	West Vancouver I. Submontane Wetter Maritime Coastal Western Hemlock		3819 853	2.1 1.0	11 2	38400 1840	678 76	12.4 1.6	820 1242	208 15	91 17	64 19	7.1 0.9	3.8 0.9	0.1 0.3	3072 138	0 0	0.0 0.0	3.8 3.2	2.5 1.3	502 8	502 8	100 0	458 10	
	West Vancouver Island Montane Wetter Maritime Coastal Western Hemlock		3941 412	0.1 1.0	2 2	38600 1570	687 136	10.2 1.0	602 118	170 14	102 20	687 55	6.0 0.5	0.8 1.0	0.4 0.9	3516 421	3 9	0.2 0.8	1.39 3.8	6.0 0.8	436 15	433 8	99 2	419 9	
	East Vancouver I. Submontane Wetter Maritime Coastal Western Hemlock		1804 729	-1.2 0.5	15 2	41600 1190	373 108	14.8 0.8	1082 129	173 3	36 6	326 114	6.4 0.5	4.0 0.0	1.2 0.6	1568 672	109 36	2.5 0.6	8.9 4.8	5.5 0.8	497 28	388 54	78 7	376 54	
	East Vancouver Island Montane Wetter Maritime Coastal Western Hemlock		1892 741	-2.3 1.0	16 3	41400 1740	376 121	13.6 0.6	879 88	150 14	38 10	324 122	5.4 0.4	3.7 0.7	2.7 0.8	1512 702	106 52	2.3 0.7	1.30 7.1	5.5 0.6	488 23	381 43	79 10	366 48	

(1) Characteristics derived by discriminant analysis from 138 observations, with 32 variables each, from all the climatic stations located within the coastal area of the Vancouver Forest Region. Data supplied by the Climate Division, Resource Analysis Branch, Ministry of the Environment
The discriminant analysis incorporated observed as well as predicted data. Climatic data for the Alpine Tundra Zone were not available from a sufficient number of stations to justify inclusion in the analysis

(2) Differentiating climatic characteristics are not presented for the West Vancouver Island Drier Maritime Coastal Western Hemlock, Pacific Ranges Montane Wetter Maritime Coastal Western Hemlock and Pacific Ranges Maritime Forested Mountain Hemlock variants due to the lack of climatic data

SOURCE: K. Klinka, F.C. Nuszdorfer, L. Skoda, 1979. Biogeoclimatic Limits of Central and Southern Vancouver Island. British Columbia Ministry of Forests, Victoria.

TABLE 8 CHARACTERISTIC COMBINATIONS OF SPECIES⁽¹⁾

Coastal Douglas fir	<i>Abies grandis</i> <i>Arbutus menziesii</i> <i>Cornus nuttallii</i> <i>Pseudotsuga menziesii</i> (<i>Amelanchier alnifolia</i>) (<i>Apocynum androsaemifolium</i> *) <i>Arctostaphylos columbiana</i> * <i>Gaultheria shallon</i> <i>Holodiscus discolor</i> (<i>Juniperus scopulorum</i> *) <i>Mahonia aquifolium</i> * <i>Mahonia nervosa</i> <i>Oemleria cerasiformis</i> * <i>Ribes lobbii</i>	(<i>Rosa gymnocarpa</i>) <i>Symphoricarpos mollis</i> (<i>Vaccinium parvifolium</i>) <i>Aira caryophyllae</i> * <i>Allotropa virgata</i> <i>Boschniakia hookeri</i> <i>Campanula scouleri</i> <i>Delphinium menziesii</i> * <i>Moehringia macrophylla</i> <i>Navarretia squarrosa</i> * <i>Plectritis congesta</i> * <i>Rhytidiadelphus triquetrus</i> <i>Stokesiella oregana</i> <i>Trachybryum megaptitum</i>	Drier Maritime Coastal Douglas-fir	<i>Quercus garryana</i> * <i>Lonicera hispidula</i> <i>Brodiaea coronaria</i> * <i>Bromus carinatus</i> <i>Camassia leichtlinii</i> * <i>Camassia quamash</i> * <i>Carex pensylvanica</i> * <i>Claytonia perfoliata</i>	<i>Collinsia grandiflora</i> <i>Danthonia californica</i> * <i>Dodecatheon hendersonii</i> <i>Erythronium oregonum</i> <i>Galium aparine</i> <i>Lomatium utriculatum</i> * <i>Mimulus alsinoides</i> * <i>Nemophila parviflora</i>	<i>Poa bulbosa</i> * <i>Sanicula crassicaulis</i> <i>Sisyrinchium douglasii</i> * <i>Vulpia microstachys</i> *	A single variant is recognized in each subzone of the CDF Zone on this map sheet. Therefore, characteristic combinations of species for the variants are identical to those for the subzones
			Wetter Maritime Coastal Douglas-fir	(<i>Tsuga heterophylla</i>) (<i>Paxistima myrsinites</i>) (<i>Carex rossii</i> *) (<i>Chimaphila menziesii</i>) <i>Hamitomes congestum</i>	(<i>Hypopitys monotropa</i>) (<i>Listera cordata</i>) (<i>Pyrola picta</i>) (<i>Smilacina stellata</i>)		
Coastal Western Hemlock	<i>Tsuga heterophylla</i> (<i>Menziesia ferruginea</i>) (<i>Oplopanax horridus</i> *) <i>Blechnum spicant</i> <i>Cornus canadensis</i> <i>Dryopteris austriaca</i> <i>Bazzania ambigua</i> <i>Bazzania denudata</i> <i>Bazzania tricrenata</i> <i>Isopterygium elegans</i> <i>Isoetecium stoloniferum</i> <i>Plagiothecium undulatum</i> <i>Rhytidiadelphus loreus</i> <i>Scapania bolanderi</i> <i>Lobaria oregana</i> <i>Usnea mollis</i>	Drier Maritime Coastal Western Hemlock	(<i>Acer macrophyllum</i>) (<i>Arbutus menziesii</i> *) (<i>Cornus nuttallii</i> *) (<i>Pseudotsuga menziesii</i>) <i>Gaultheria shallon</i> <i>Mahonia nervosa</i> (<i>Vaccinium parvifolium</i>) <i>Achlys triphylla</i> (<i>Stokesiella oregana</i>)	West Vancouver Island Drier Maritime Coastal Western Hemlock	(<i>Abies amabilis</i> *) (<i>Abies grandis</i> *) (<i>Vaccinium alaskaense</i>)	(<i>Vaccinium ovalifolium</i>) <i>Diaporium smithii</i>	
			East Vancouver Island Drier Maritime Coastal Western Hemlock	(<i>Amelanchier alnifolia</i>) (<i>Mahonia aquifolium</i> *) (<i>Paxistima myrsinites</i> *)	(<i>Rosa gymnocarpa</i>) <i>Boschniakia hookeri</i> * (<i>Trachybryum megaptitum</i>)		
			Pacific Ranges Drier Maritime Coastal Western Hemlock	This variant lacks a distinct characteristic combination of species. It is therefore characterized by the subzonal combination of species and the absence of the species for the other variants in the subzone			
		Wetter Maritime Coastal Western Hemlock	Estevan Submontane Wetter Maritime Coastal Western Hemlock	<i>Picea sitchensis</i> (<i>Pinus contorta</i> *) (<i>Gaultheria shallon</i>) <i>Vaccinium ovatum</i>	(<i>Vaccinium parvifolium</i>) (<i>Calamagrostis nutkanensis</i>) (<i>Polypodium scouleri</i>) <i>Usnea longissima</i>		
			West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock	(<i>Picea sitchensis</i>) (<i>Gaultheria shallon</i>) (<i>Vaccinium parvifolium</i>)	<i>Hookeria lucana</i> <i>Mylia taylori</i> (<i>Rhizomnium glabrescens</i>)		
			West Vancouver Island Montane Wetter Maritime Coastal Western Hemlock	<i>Chamaecyparis nootkatensis</i> (<i>Tsuga mertensiana</i> *) (<i>Caltha biflora</i> *) (<i>Streptopus roseus</i> *)	(<i>Streptopus streptopoides</i>) (<i>Tiarella unifoliata</i> *) (<i>Rhizomnium nudum</i> *) (<i>Rhytidopsis robusta</i> *)		
			East Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock	(<i>Pinus monticola</i>) (<i>Pseudotsuga menziesii</i>) (<i>Gaultheria shallon</i>) (<i>Mahonia nervosa</i>)	(<i>Rosa gymnocarpa</i> *) (<i>Vaccinium parvifolium</i>) (<i>Rhytidopsis robusta</i>)		
			East Vancouver Island Montane Wetter Maritime Coastal Western Hemlock	(<i>Abies lasiocarpa</i> *) <i>Chamaecyparis nootkatensis</i> (<i>Pinus monticola</i> *) (<i>Pseudotsuga menziesii</i>)	(<i>Gaultheria ovatifolia</i> *) (<i>Vaccinium membranaceum</i>) <i>Dicranum pallidisetum</i> (<i>Rhytidopsis robusta</i>)		
			Pacific Ranges Montane Wetter Maritime Coastal Western Hemlock	<i>Chamaecyparis nootkatensis</i> (<i>Tsuga mertensiana</i> *) (<i>Sorbus sitchensis</i>)	(<i>Vaccinium membranaceum</i> *) (<i>Rhizomnium nudum</i> *) (<i>Rhytidopsis robusta</i>)		

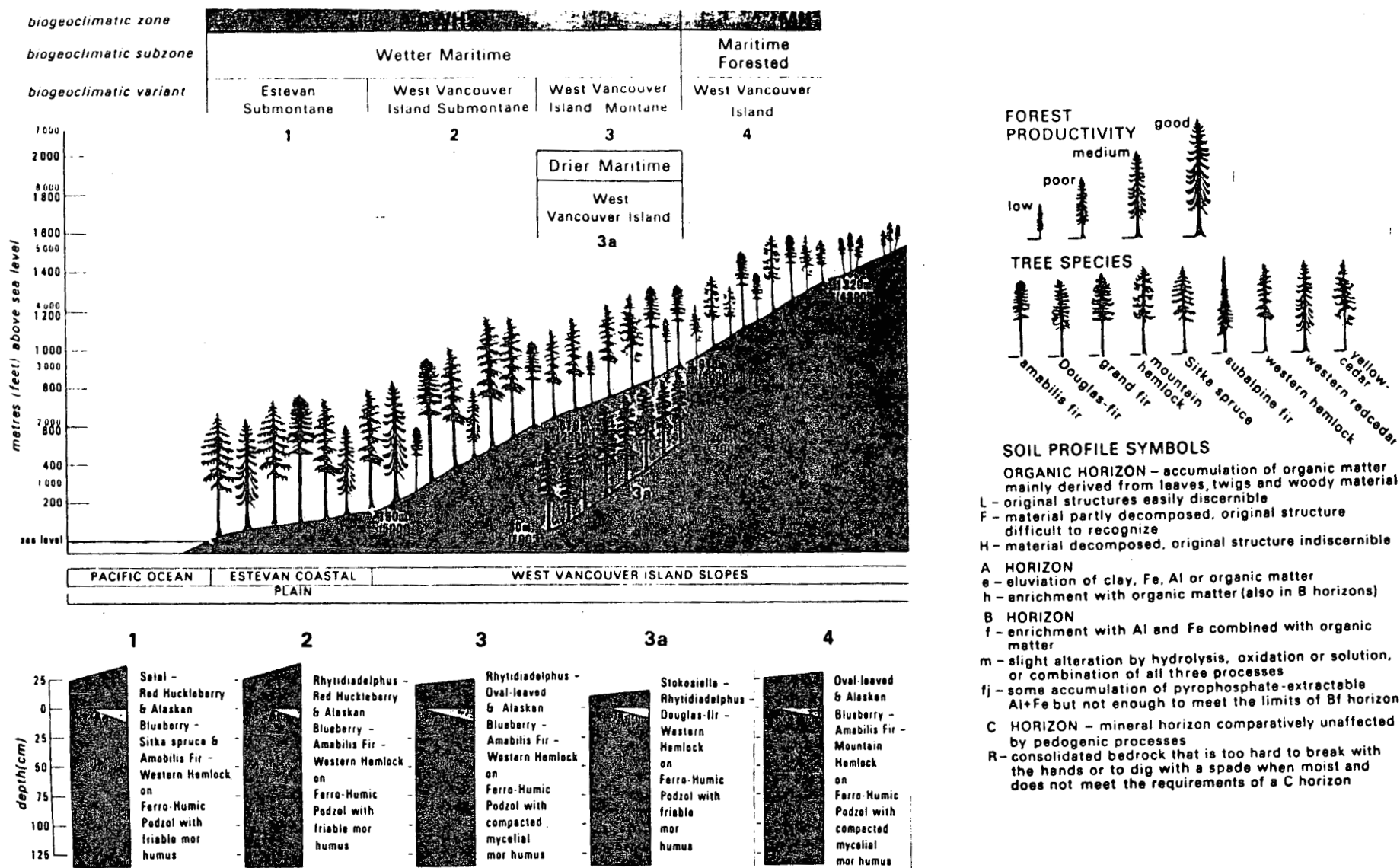
(1) The selected plant species are arranged alphabetically in the order of trees, shrubs, herbs, mosses (including liverworts) and lichens

(2) Characteristic combination of species for a subzone also includes species listed for the corresponding zone. Characteristic combination of species listed for a variant also includes species listed for the corresponding

(3) Plant species listed in parenthesis are less characteristic or less frequently occurring in a particular combination. Species marked with an asterisk occur either on drier, wetter, poorer or richer soils than those in zonal ecosystems

SOURCE: Ibid. Table 7.

Figure 8 SCHEMATIC SEQUENCE AND RELATIONSHIP OF BIOGEOCLIMATIC VARIANTS REPRESENTED BY ZONAL ECOSYSTEMS



SOURCE: Ibid. Table 7.

green algae, brown algae, and red algae should inhabit the upper, middle, and lowermost zones respectively. But other biological and physical factors play a large part in the distribution of seaweeds. A species' tolerance to the factors of dessication (temperature, wind, and humidity) and ultraviolet light are important in setting the upper limits of growth while the lower limits may be determined by the competition between species. Further, preferences for a particular substrate, the wave energy environment and seawater temperatures are important in defining the vertical and horizontal limits of species. Druehl (1967), for instance, found that the horizontal distributions of two forms of Laminaria groenlandica could be explained on the basis of temperature, salinity gradients, and tolerance to wave shock. De Wreede (1978) speculates that Sargassum muticum and Zostera marina L. will not compete due to different preferences of substrate, while Vadas (1972) has determined that the upper limits for Nereoscystis leutkeana are determined by the competition for light; the lower limits are set by light attenuation. Both Foreman (1977) and Mann (1977) have documented a reduction of algal populations at their lower limits and a succession of species resulting from herbivore grazing.

The intertidal zonation of species on seacoasts is documented by numerous workers (Ricketts and Calvin, 1968; Stephenson and Stephenson, 1972), Kosloff, 1973; Carefoot, 1977). On rocky coasts, the uppermost zone - the supra-littoral fringe - is affected only by the higher tides and wave splash. This band may contain lichens (g. Verrucaria), and where fresh water seepage occurs, the green algae g. Enteromorpha is often found. The upper mid-littoral zone usually harbours the brown algae Fucus distichus, (with which the barnacles are closely associated), the red Endocladia muricata, Cumagloia andersonii, Bangia fuscopurpurea, and Porphyra spp. and the green algae Ulva as the major seaweeds. The lower mid-littoral and sub-tidal zones contain numerous genera, but the most common are Ulva, Spongomorpha coalita (green algae); Hedophyllum sessile, Fucus and Leathesia difformis (brown algae); and Halosaccion glandiforme (red algae). In the infralittoral region are found the surfgrass Phyllospadix, many Laminarians (e.g. Laminaria setchellii), Egregia menziesii, Pterygophora californica, Alaria marginata, Nereocystis leutkeana, Sargassum muticum; the green algae Codium fragile, and the red algae Gigartina exasperata and Iridaea cordata.

Estuarine areas and quiescent mud/sand shores characteristically exhibit Enteromorpha in the upper zone where freshwater seepage is prevalent, scattered Ulva in the lower intertidal where substrate for holdfasts is available, and subtidal beds of Zostera marina (eelgrass). With the growth of eelgrass in the summer months, numerous algae species (such as the red algae Smithora naiadum) colonize the leaves while others, the surface muds around the base. The generation of detritus from numerous plant species within eelgrass beds, and its subsequent invasion by bacteria, forms one of the most productive ecosystems known.

Saltmarshes exhibit zonation from the sea landward although the critical factor that determines band width is the tolerance of species to salt-water. Closest to saline conditions in a primarily mud substrate is found Salicornia virginica and S. europaea commonly known as saltwort. Parasitizing Salicornia is the flowering plant Cuscuta salina and growing beneath it on the substrate are diatoms, blue, and bluegreen algal mats. The saltgrass Distichlis spicata and arrowgrass Triglochin maritimum are commonly associated with Salicornia spp. Moving progressively inland towards a freshwater influence, one encounters Scirpus, Carex, Typha, and Juncus communities.

The ecological importance of seaweeds and saltmarshes is documented in the literature (Perkins, 1974; Cushing and Walsh, 1976; Carefoot, 1977; and Harrison, 1980). Seaweeds provide food for grazers, shelter for numerous organisms including fish, and substrate for reproduction (e.g. herring spawn). Further, some seaweed and seagrass species are extremely important in nutrient cycling within coastal waters. By reducing water current velocities and wave shock they allow nutrient-rich sediments and particulate matter to settle out, thus enriching the substrate for benthic fauna. Marshes are invaluable as nutrient reserves within estuaries, as upland mammal and reptile habitat, and as marine and shorebird habitat. Geese, widgeon, and pintails eat the salt-marsh plant Salicornia, while eelgrass is an important food source for brant.

The economic importance of seaweeds is identified by Greenius (1967) and Carefoot (1977). The natural products of red and brown algae include agar, carrageenan, and algin. They are used in myriad commercial products from food to soaps, paper products, and pharmaceuticals. The genera Gigartina, Iridaea, Nereocystis, Macrocystis, Gracilaria and Gracilariopsis are especially important for these purposes. Currently there are several sites within Barkley Sound where experimental algal culture is being conducted for Pleurophycus gardneri, Cymathere triplicata, and Laminaria saccharina (Druehl, 1980a; 1980b; 1981). and one site for the study of the ecology of fish in Nereocystis beds (Leaman, 1980).

4.4.3 MARINE MAMMALS

The marine mammals of the Strait of Georgia and Juan de Fuca Strait include sixteen genera of the order Cetacea (whales and dolphins) and two families of pinnipeds - Otariidae (the eared seals) and Phocidae (the earless seals - Table 9). Within the study area most of these species also occur, although the Grey whale (Eschrichtius robustus) is the largest species that passes through as a migrant between Alaskan and southern Mexican waters.

Killer whales (Orcinus orca) are regular visitors to Barkley Sound, although less is known of these pods than the pods of the Straits of Georgia and Juan de Fuca (Bigg, 1983, pers. comm.). They are nomadic, cruising at 3-4 knots. Their migratory routes are commonly between one and three miles offshore where they are thought to prey primarily on salmon and other fish. Published data for northern Puget Sound and the Strait of Juan de Fuca (Simenstad et al 1979) suggest, however, that prey from several trophic levels are taken (Table 10). No preferred habitat of killer whales is identified within this region.

The harbour seals of the study area are permanent residents, although they roam between haulouts. They frequent estuaries, river deltas, tidal rocks and shallow sublittoral waters within the region. Their daily movements include hauling out during low tides while during high tides they disperse over several miles to feed. Harbour seals generally use haulouts that are not easily approached by predators. Seals prey mainly on littoral fish, although a number of other foods are taken. (Table 10).

TABLE 9 - CETACEANS OCCURRING IN WASHINGTON STATE AND BRITISH COLUMBIA
(Taxonomic Classes after Watson (1981))

Cetacea - whales and dolphins

British Columbia

Order Mysticeti--whalebone whales	
Family Eschrichtiidae--grey whales	
<u>Eschrichtius robustus</u> , grey whale	C
Family Balaenopteridae--furrow-throated whales	
<u>Balaenoptera physalus</u> , fin or finback whale	C
<u>B. borealis</u> , peri whale	C
<u>B. acutorostrata</u> , little piked whale, minke whale	NC
<u>B. musculus</u> , blue whale	NC
<u>Megaptera novaeangliae</u> , humpback whale	NC
Family Balenidae--smooth-throated whales	
<u>Balena glacialis</u> , northern or black right whale	R
Order Odontoceti--toothed whales and dolphins	
Family Ziphiidae--beaked whales	
<u>Berardius bairdii</u> , Baird's beaked whale	C
<u>Mesoplodon stejnegeri</u> , Stejneger beaked whale	R
<u>M. carlhubbsi</u> , Hubbs' beaked whale	R
<u>Ziphius cavirostris</u> , Cuvier's beaked whale	R
Family Physeteridae--sperm whales	
<u>Physeter catodon</u> , sperm whale	C
<u>Kogia breviceps</u> , pygmy sperm whale	NC
Family Delphinidae--ocean dolphins	
<u>Stenella</u> sp., spotted dolphin	R
<u>Delphinus delphis</u> , Pacific common dolphin	R
<u>Lissodelphis borealis</u> , northern right-whale dolphin	R
<u>Lagenorhynchus obliquidens</u> , Pacific white-sided dolphin	C
<u>Grampus griseus</u> , gray grampus or Risso's dolphin	R
Family Phocoenidae--porpoises	
<u>Phocoena phocoena</u> , Pacific harbour porpoise	A
<u>Phocoenoides dalli</u> , Dall's porpoise	C
Family Globicephalidae--pilot and killer whales	
<u>Globicephala macrorhyncha</u> , shortfin pilot whale	NC
<u>Orcinus orca</u> , killer whale	A

Note: A= abundant, C- common, NC- not common, R= rare.

SOURCE: Adapted from: C.A. Simenstad et al (1979). Food web relationships of northern Puget Sound and the Strait of Juan de Fuca. U.S. Environmental Protection Agency, Washington, D.C. p.262-264.

TABLE 10- FUNCTIONAL FEEDING GROUPS AND REPRESENTATIVE PREY TAXA OF MARINE MAMMALS KNOWN OR SUSPECTED TO OCCUR IN NORTH PUGET SOUND AND THE STRAIT OF JUAN DE FUCA

<u>Habitat</u>	<u>Feeding Group</u>	<u>Predator Species</u>	<u>Representative Prey Taxa</u>
Nearshore	Obligate piscivore	Northern sea lion California sea lion Pacific harbour seal Harbour porpoise	Pacific Herring (<u>C. harengus pallasi</u>) Pacific sand lance (<u>A. hexapterus</u>) Walleye pollock (<u>T. chalcogramma</u>) Salmon (<u>Oncorhynchus</u> sp.) Starry flounder (<u>Platichthys stellatus</u>) Pacific tomcod (<u>Microgadus pacificus</u>) Rockfish (<u>Sebastes</u> sp.) Skate (<u>Rajiidae</u>) Pacific cod (<u>Gadus macrocephalus</u>) Pacific hake (<u>M. productus</u>) Spiny dogfish (<u>Squalus acanthias</u>) Plainfin midshipman (<u>Porichthys notatus</u>) Greenling (<u>Hexagrammidae</u>) Shiner perch (<u>Cymatogaster aggregata</u>) Shrimp Crab (<u>Cancer</u> Sp.) Octopus (<u>Octopus</u> Sp.)
	Facultative carnivore	Orca (killer whale)	California sea lion (<u>Zalophus californianus</u>) Northern sea lion (<u>Eumetopias jubatus</u>) Harbour seal (<u>phoca vitulina</u>) Elephant seal (<u>Mirounga californianus</u>) Harbor porpoise (<u>Phocoena phocoena</u>) Dall porpoise (<u>Phocoenoides dalli</u>) Minke whale (<u>Balaenoptera acutorostrata</u>) Nursing calves of humpback (<u>Megaptera novaengliae</u>), finback (<u>Balaenoptera physalus</u>), and gray whale (<u>Eschrichtius robustus</u>) Lingcod (<u>O. elongatus</u>) Salmon (<u>Oncorhynchus</u> sp.) Steelhead trout (<u>Salmo gairdneri</u>) Pacific halibut (<u>Hippoglossus stenolepis</u>) Pacific herring (<u>C. harengus pallasi</u>)?

SOURCE: Adapted from: C.A.Simenstad et al. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca. U.S. Environmental Protection Agency, Washington, D.C. p.262-264.

Sea lions, Stellar and California, are resident in the study area during the winter months from November to March. During the summer, California sea lions migrate south while the Stellar sea lions move to rookeries on north Vancouver Island and the Queen Charlotte Islands.

In the study area the two species intermix on tidal rocks. These sites are often chosen in good feeding areas near deep water, isolated from terrestrial predators. Sea lions are nocturnal feeders and prey primarily on fish although, as documented in the Puget Sound area, many other foods are eaten. (Table 10).

4.4.4 MARINE BIRDS

Ecology

The Strait of Georgia provides a major resting and overwintering environment for migrating birds on the Pacific flyway. The environmental advantages of the region include a relatively mild winter climate, abundant food, and a relatively sheltered coastline. Myriad habitat types are found in the estuaries, inlets, coastal embayments and waters for the many species that visit here. Reasons why the Strait of Georgia has not become a major breeding area for most species are somewhat obscure, although food availability during summer and preferred nesting habitat may be significant limiting factors.

Many sea birds survive by adapting one or all of their functions (e.g. reproduction) to the behavior of a prey species (e.g. herring spawn). As the populations of prey species are subject to fluctuations and shifts in location, expected behavior or occurrence may not materialize. The consequences may be catastrophic to sea bird populations in the form of reproductive failures and high adult mortality. When reproductive failures become chronic because of natural or human perturbations, the existence of a colony or population is threatened. Adult enumerations, however, may not reveal the seriousness of the event for some time; complicating natural factors that play important roles in the dynamics of seabird populations may be missed. This leads to erroneous conclusions about the reasons for colony extinction. There is still considerable research required concerning the cyclical phenomena of seabird populations.

Sea birds prey on a diverse array of marine organisms (Table 11) from several trophic levels. Their method of feeding (Table 12) is a consequence of their anatomical design, while the location of their feeding habitat is determined by the distribution of their preferred prey. Similarly, nesting habitat (Table 13) for local breeding species differs significantly among species and almost always is associated with an immediate source of food. It is in this sense that the saltmarshes, eelgrass, and kelp beds are extremely important within the study region for they contain, or support, the food items that permit overwintering survival and reproductive success.

Table 11 - FUNCTIONAL FEEDING GROUPS AND REPRESENTATIVE PREY TAXA OF MARINE AND SHORE BIRDS COMMON TO
NORTHERN PUGET SOUND AND THE STRAIT OF JUAN DE FUCA

Habitat	Trophic position	Predator species	Prey taxa
Offshore neritic	Obligate piscivore	Common murre	Northern anchovy
		Black-legged kittiwake	Eulachon
		Common tern	Pacific herring
		Rhinoceros auklet	Pacific sand lance
		Western grebe	Juv. rockfish
			Juv. Pacific salmon
			Surf smelt
			Night smelt
			Walleye pollock
			Threespine stickleback
	Facultative piscivore	Tufted puffin	Pacific sand lance
		Marbled murrelet	Pacific herring
		Ancient murrelet	Surf smelt
			Northern anchovy
			Rockfish
			Shiner perch
			Juv. rockfish
			Sea urchins
			Bivalve molluscs
			Euphausiids
	Obligate planktivore	Cassins auklet	Calanoid copepods
			Hyperiid amphipods
			Euphausiids
	Facultative planktivore	Mew gull	Euphausiids
		Bonaparte's gull	Hyperiid amphipods
			Pacific herring (larvae?)
			Pacific sand lance (larvae?)
	Parasite	Parasitic jaeger	Foods of gulls and terns

Nearshore kelp beds	Facultative avivore	Bald eagle	Gulls Pigeon guillemots Cormorants Puffins Pacific herring Pacific salmon Dolly Varden Cutthroat trout Flatfishes Sculpins Sea urchins Crabs
	Obligate piscivore	Brandt's cormorant	Redtail surfperch Kelp greenling Black rockfish Cabezon Pacific sand lance
	Facultative piscivore	Heermann's gull	Pacific herring Pacific sand lance
Inshore rocky littoral	Obligate benthivore	Black oystercatcher Whimbrel Black turnstone	Limpets Chitons Bivalve molluscs Barnacles Polychaete annelids
Inshore sand-gravel beaches	Obligate benthivore	Spotted sandpiper Surfbird Least sandpiper Sanderling	Polychaete annelids Amphipods Bivalve molluscs Univalve molluscs
Nearshore shallow sublittoral	Obligate piscivore	Double-crested cormorant Red-necked grebe Common merganser	Penpoint gunnel Crescent gunnel Pacific sand lance Shiner perch Snake prickleback Staghorn sculpin Pacific herring Juv. Pacific salmon Northern anchovy



Inshore, saltmarsh and mudflats	Facultative piscivore	Arctic loon Common loon Red-throated loon Pelagic cormorant Pigeon guillemot Red breasted merganser Caspian tern	Crescent gunnel Pacific sand lance Penpoint gunnel Staghorn sculpin Northern clingfish Snake prickleback Pacific herring Surf smelt Black prickleback Threespine prickleback Juv. flatfish Shrimp Crabs
	Obligate planktivore	Eared grebe	Mysids Amphipods
	Facultative benthivore	Lesser scaup Common goldeneye Bufflehead Oldsquaw Surf scoter	Bivalve molluscs Crustaceans Fish Pacific herring eggs Eelgrass
Inshore, saltmarsh and mudflats	Obligate herbivore	Canada goose Black brant Snow goose American coot	Eelgrass Saltmarsh plants
	Omnivore, Facultative herbivore	Mallard Pintail Northern shoveler American widgeon	Eelgrass Saltmarsh plants, seeds Amphipods Insect larvae
	Omnivore	Dunlin Knot Western sandpiper	Saltmarsh plants, seeds Amphipods Polychaete annelids Oligochaetes Bivalve molluscs Tanaids Nematodes

Universal	Obligate piscivore	Great blue heron	Staghorn sculpin Starry flounder Shiner perch Penpoint gunnel
	Obligate benthivore	Short-billed dowitcher Long-billed dowitcher	Polychaete annelids Univalve molluscs Bivalve molluscs Crabs Shrimp Isopods Amphipods
	Facultative benthivore	Greater yellowlegs	Molluscs Crustaceans Fish
	Facultative benthivore	Glaucous-winged gull Western gull	Chitons Starfish Sea cucumbers Sea urchins Crabs Bivalve molluscs Polychaete annelids Pacific herring Northern anchovy Surf smelt Pacific herring eggs Cormorant fledglings Murre fledglings

Source: Adapted from: C.A. Simenstad, B.C. Miller, C.F. Nyblade, K. Thornburgh, and L.J. Bledsoe. 1979.
Food web relationships of northern Puget Sound and the Strait of Juan de Fuca.
U.S. Environmental Protection Agency, Washington. pp. 218-224.

**TABLE 12 - SIZE RELATIONSHIPS AND FEEDING METHODS OF
MAJOR SPECIES IN THE EASTERN NORTH PACIFIC
AND BERING SEA (D=dive, SS=surface seize,
PP=pursuit plunge, Di=dip, P=plunge, T=tip,
x=eats seabirds, A=piracy, SP=shallow plunge)**

Species	Body length (cm)	Bill length (mm)	Feeding method
<i>Gavia immer</i>	61.0	80-82	D
<i>G. arctica</i>	45.7	51-52	D
<i>Podiceps grisegena</i>	33.0	48-50	D
<i>P. nigricollis</i>	22.9	24-26	D
<i>Aechmophorus occidentalis</i>	45.7	65-76	D
<i>Oceanodroma furcata</i>	19.0	15	DiSS
<i>O. leucorhoa</i>	19.0	16	DiSS
<i>Branta</i> spp. (bernicla)	43.5	33-36	T
<i>Anas</i> spp.	40.0	32-35	T
<i>Clangula hyemalis</i>	38.1	25-27	D
<i>Histrionicus histrionicus</i>	30.5	25-28	D
<i>Melanitta deglandi</i>	35.6	41-44	D
<i>M. perspicillata</i>	40.3	ca.40	D
<i>M. nigra</i>	35.6	42-47	D
<i>Mergus serrator</i>	40.3	45-54	D
<i>Haliaeetus leucocephalus</i>	80.0	52-54	x
<i>Falco peregrinus</i>	37.5	21-25	x
<i>Stercorarius parasiticus</i>	40.3	32	SS,A
<i>Larus hyperboreus</i>	61.0	55-60	SS
<i>L. glaucescens</i>	55.9	54-58	SS
<i>L. occidentalis</i>	53.0	54-57	SS,Di
<i>L. argentatus</i>	50.8	48-54	SS,Di
<i>L. californicus</i>	43.5	45-50	SS,Di
<i>L. canus</i>	35.6	34-36	SS,Di
<i>Uria aalge</i>	35.6	43-47	D
<i>U. lomvia</i>	35.6	39-42	D
<i>Lunda cirrhata</i>	31.8	57-60	D
<i>Cerorhinca monocerata</i>	29.2	34-35	D
<i>Cephus columba</i>	26.7	32-33	D
<i>Brachyramphus marmoratus</i>	20.3	15	D
<i>Synthliboramphus antiquus</i>	20.3	13	D
<i>Ptychoramphus aleuticus</i>	17.8	19	D

SOURCE: Adapted from Ainley, D.G. and G.A. Sanger, 1979. "Trophic Relations of Seabirds in the Northeastern Pacific Ocean and Bering Sea" In: Conservation of Marine Birds of Northern North America. J.C. Bartonek and D.N. Nettleship (eds.). U.S. Department of Interior, Fish and Wildlife Service, Wildlife Service, Wildlife Research Report 11, Washington.

TABLE 13 - NEST-SITE PREFERENCE FOR SEABIRDS BREEDING FROM
CAPE FAIRWEATHER, ALASKA, TO THE COLUMBIA RIVER,
WASHINGTON

Nest-site type	Bird species
Burrow-rock crevice	
Diurnal	Pigeon guillemot Horned puffin Tufted puffin
Nocturnal	Fork-tailed storm-petrel Leach's storm-petrel Kittlitz's murrelet Ancient murrelet Cassin's auklet Rhinoceros auklet
Open nests	
Flat or slope	Double-crested cormorant Brandt's cormorant Glaucous-winged gull Herring gull Western gull Black oystercatcher
Cliff face	Pelagic cormorant Common murre Black-legged kittiwake
Tree branch	Marbled murrelet

Source: D.A. Manuwal and R.W. Campbell (1979). "Status and Distribution of Breeding Seabirds of Southeastern Alaska, British Columbia, and Washington". In: Conservation of Marine Birds of Northern North America", J.C. Bartonek and D.N. Nettleship (eds.), U.S. Department of Interior, Fish and Wildlife Service, Wildlife Research Report 11, Washington.

Stress and mortality within seabird populations result from a variety of causes, both natural and human. For instance, commercial and recreational boat traffic is disruptive to feeding and loafing activities; shoreline developments may destroy habitat or disturb breeding times, resulting in higher mortality of the young; predators introduced to isolated islands often result in marked reductions in the breeding population and its reproductive success; many diving birds are drowned in the nets of commercial fishermen; agricultural chemicals and spent lead shot may kill or poison birds; and oil spills may destroy entire populations or habitat.

Oil affects the plumage, physiology, and reproduction of marine birds. Contamination of the plumage by oil reduces the insulation characteristics, thereby inducing thermal stress. Further, soiled plumage will impair the ability to fly or float. Consequently, a contaminated bird will be less successful at feeding or escaping predators. The ingestion of oil by birds may result in a variety of internal disorders that affect the fitness of the individual as well as its ability to reproduce. Contaminated adult birds returning to the nest inadvertently contaminate the eggs or young, thereby reducing their probability of survival. An oil vulnerability index devised for water birds provides some insight as to the relative risk to representative species (Table 14).

There are also numerous additional human activities which affect the lives of marine bird species, especially in estuaries and lagoons. These coastal forms are relatively flat and commonly become in focus for industrial, agricultural, and commercial projects. A synopsis of the impacts caused by many activities found within estuaries is presented in Table 15.

TABLE 14 - OIL VULNERABILITY INDEX (OV1) FOR REPRESENTATIVE WATERBIRDS IN THE NORTHEAST PACIFIC REGION

Family, common name and scientific name	OV1*
Gaviidae	
Common loon (<i>Gavia immer</i>)	47
Arctic loon (<i>G. Arctica</i>)	58
Podicipedidae	
Western grebe (<i>Aechmophorus occidentalis</i>)	56
Hydrobatidae	
Leach's storm-petrel (<i>Oceanodroma leucohoa</i>)	63
Phalacrocoracidae	
Double-crested cormorant (<i>Phalacrocorax auritus</i>)	52
Brandt's cormorant (<i>P. penicillatus</i>)	57
Pelagic cormorant (<i>P. pelagicus</i>)	63
Ardeidae	
Trumpeter swan (<i>Olorcygnus buccinator</i>)	63
Canada goose (<i>Branta canadensis</i>)	34
Black brant (<i>B. nigricans</i>)	70
Snow goose (<i>Chen hyperborea</i>)	32
Mallard (<i>Anas platyrhynchos</i>)	36
American widgeon (<i>M. americana</i>)	36
Greater scaup (<i>Aythya marila</i>)	52
Barrow's goldeneye (<i>Bucephala islandica</i>)	56
Bufflehead (<i>B. albeola</i>)	52
Oldsquaw (<i>Clangula hyemalis</i>)	66
Harlequin duck (<i>Histrionicus histrionicus</i>)	60
Surf scoter (<i>Melanitta deglandi</i>)	72
Common merganser (<i>Mergus merganser</i>)	56

Family, common name and scientific name	OVI*
Accipitridae	
Bald eagle (<i>Haliaeetus leucocephalus</i>)	58
Pandionidae	
Osprey (<i>Pandion haliaetus</i>)	37
Falconidae	
Peregrine falcon (<i>Falco peregrinus</i>)	41
Haematopodidae	
Black oystercatcher (<i>Haematopus bachmani</i>)	65
Scolopacidae	
Wandering tattler (<i>Heteroscelus incanum</i>)	48
Dunlin (<i>Erolia alpina</i>)	41
Western sandpiper (<i>Eremryrd msuti</i>)	47
Phalaropodidae	
Red phalarope (<i>Phalaropus fulicarius</i>)	58
Stercorariidae	
Parasitic jaeger (<i>tercorarius parasiticus</i>)	43
Laridae	
Glaucous-winged gull (<i>Larus glaucescens</i>)	56
Herring gull (<i>L. argentatus</i>)	38
Thayer's gull (<i>L. thayeri</i>)	42
California gull (<i>L. californicus</i>)	38
Mew gull (<i>L. canus</i>)	44
Alcidae	
Common murre (<i>Uria aalge</i>)	70
Pigeon guillemot (<i>Cepphus columba</i>)	82
Marbled murrelet (<i>Brachyramphus marmoratus</i>)	84
Rhinoceros auklet (<i>Cerorhinca monocerata</i>)	74
Horned puffin (<i>Fratercula corniculata</i>)	72
Tufted puffin (<i>Lunda cirrhata</i>)	72

* The Oil Vulnerability Index is based on the rating of five categories - species range, population, habits, mortality and annual exposure. The higher the OVI number the more vulnerable the species would be to oil spills.

SOURCE: J.G. King and G.A. Sanger, 1979. "Oil Vulnerability Index for Marine Oriented Birds". In: Conservation of Marine Birds of Northern North America. J.C. Bartonek and D.N. Nettleship (eds.). U.S. Department of Interior, Fish and Wildlife Service, Wildlife Research Report 11, Washington.

TABLE 15 A SYNOPSIS OF THE IMPACTS CAUSED BY SELECTED
ACTIVITIES COMMON WITHIN ESTUARIES

Activity		First Effect	Second Effect
Logging	1) Log Dumping and Sorting	<ul style="list-style-type: none"> - deposition of bark and wood - tow boat prop wash - scours sediments - land requirements 	<ul style="list-style-type: none"> - smothers vegetation - disturbs sediments - destroys vegetation - destroys shoreline habitat
	2) Log Storage	<ul style="list-style-type: none"> - leachates enter water - bark and debris increase B.O.D. - physical shading of substrate and water column - scouring during low tides 	<ul style="list-style-type: none"> - toxic substances for some organisms - decreased dissolved oxygen - lower rate of photosynthesis - destruction of vegetation - destruction of benthic communities
Dyking	1) General	<ul style="list-style-type: none"> - change from saline marsh to freshwater marsh over short time period 	<ul style="list-style-type: none"> - change in vegetation species (habitat type) - change in waterfowl composition
	2) Agricultural	<ul style="list-style-type: none"> - loss of bird habitat - use of pesticides, herbicides, etc. 	<ul style="list-style-type: none"> - elimination of many bird species from area - bird mortality
	3) Transportation	<ul style="list-style-type: none"> - loss of bird habitat - toxic wastes from industrial development - increased air and noise pollution 	<ul style="list-style-type: none"> - elimination of many bird species - increased bird mortality
Dredging	General	<ul style="list-style-type: none"> - destruction of benthic communities - destruction of seaweed substrate - increased turbidity - alteration of tidal prism - increased B.O.D. 	<ul style="list-style-type: none"> - elimination of habitat and bird species - smothering of adjacent benthic communities

SOURCE: Adapted from: R.A. Hunter and L.E. Jones, 1982. Coastal Waterfowl and Habitat Inventory Program: Summary Report and Appendices. British Columbia, Ministry of Environment, Terrestrial Studies Branch. Victoria.

4.5 RECREATIONAL RESOURCES

Barkley Sound and environs provide abundant opportunities for outdoor recreation. There are numerous bays, inlets, coves, scenic shorelines, and wilderness areas to attract recreationists. Although not abundant, there are small sand and shell-hash pocket beaches within the study area that attract boaters and shore-based recreationists. Because of steep, rocky terrain, the few backshore clearings are important for camping and upland access for boaters and are, in many areas, the only means of access to the shorezone. Much of this study area is considered to have a moderate to moderately high capability for outdoor recreation (Canada, Department of Environment, 1978).

4.5.1 COMPETITION FOR SPACE AND RESOURCES

Competing for the resources of the study area are recreationists from local communities, the regional population, and summer tourists. Data from Summers (1979) indicates that there is a very high participation rate in marine-related activities by the local population, a high number of tourist boaters, and the potential for a very high participation rate in marine activities by visitors. Further, the data indicates that Barkley Sound is already perceived as crowded by some visitors. Projections in this study indicate that use of the area as a recreational destination will continue to grow significantly within the near future.

Doubtless, competition for resources will be manifested at three levels: a) between major classes of activities (i.e. recreational use of estuaries vs industrial development), b) between subgroups within one activity (i.e. recreational boat noise vs shoreline recreational cottage areas), and c) between individuals within one sub-group (i.e. crowding at campsites or beaches). Efforts to accommodate the increase in recreation demands may include myriad forms of management approaches, but as evidence from other jurisdictions shows, only by reserving a range of recreational areas (from virgin wild land to high-use sites managed according to multiple or compatible-use principles) will all recreational needs be satisfied.

The competition for space and resources is currently most acute in the small coves, inlets, and beach areas of Barkley Sound. Pocket beaches are found in small coves and irregularities of the shoreline, but are not abundant. Frequently these sites are occupied by recreational floating cabins which restrict access by other recreationists. One larger beach in Toquart Bay has been heavily used by shore-based recreationists and is overcrowded much of the time. Barkley Sound is also a heavily used fishing area which generates further interaction with recreationalists of the area. Logging in the watersheds peripheral to the Sound has decimated many landscapes so that the wilderness value is now all but lost.

While many important recreational resources are currently protected from alienation within the coastal zone, unofficial areas currently in use, as well as those with significant potential (including scuba diving sites, shore process features, beaches, backshore camping areas, and recreational rivers), remain un-

protected. With the predicted population growth, competition for many of the areas will doubtless increase. For instance, expansion of current uses such as log storage, commercial fishing, shoreline residential development, and commercial and industrial construction on the foreshore or backshore zones preempts recreational use as effectively as numerous licensed water withdrawals from rivers prevent river boating or fishing. Beaches become alienated through overuse (crowding), misuse (vehicular traffic), inappropriate use (excavation), or indirectly by the interruption of longshore sediment transport that feeds beaches. It is obvious that protection of unique, recreationally valuable sites must occur relatively soon while they still remain, and while the costs of acquisition are not prohibitive.

4.5.2 POLLUTION

Marine water quality in the study region currently restricts recreational activities in local areas. Sewage outfalls from municipalities and cities are responsible for several shellfish closures along the coast. Boat wastes in marinas and wharves contribute to local shellfish harvesting restrictions. Sewage discharged from recreational boats in open waters is not yet identified as problematic, although several heavily used anchorages evidence poor visual and aesthetic water quality.

Water contact sports (i.e. swimming) conducted in area of contamination pose definite health risks to recreationists. Leachates from log booming and storage, and effluent from coastal industries threaten the recreational value of coastal waters by jeopardizing the integrity of coastal ecosystems. In many instances, the costs of pollution are external to the originating sources and are thus borne by the recreational community.

4.6 PHYSICAL PROCESSES AND ENERGY

4.6.1 PHYSICAL SHOREZONE CHARACTERISTICS

The physical shorezone maps of this folio provide a detailed inventory of the shorezone of the study area. The inventory system (Howes and Owens, unpub.) has been generalized by many authors to identify replicate units (Howes, 1980; Owens, 1980; Harper, 1981, 1983; Howes and Dunn, 1983; Bastaja, 1983; Lewis, 1984). The replicate unit is a summary of more simple shoreforms that re-occur throughout an area.

Ten (10) replicate units have been identified for the Alberni Inlet-Barkley Sound study area (Dunn, 1984). Of the total study area shoreline (about 782 km), 69% can be classed as rocky coast, the remainder sediment coast. The following table provides a comparison of the replicate units.

TABLE 16 REPLICATE SHOREZONE UNITS BARKLEY SOUND* - ALBERNI INLET

<u>Unit</u>	<u>Length (km)</u>	<u>Percent Total</u>
<u>Bedrock</u>		
Cliff	353.38	45.2
Platform		
With beach veneer (<1m)	74.48	9.5
No veneer	111.91	14.3
<u>Unconsolidated</u>		
Beach		
Fine-textured	23.21	3.0
Coarse-textured	110.57	14.1
Deltas	70.20	9.0
Tidal Flats	19.13	2.5
<u>Man Modified</u>	18.91	2.4
TOTAL	781.79	100.0

* Does not include the Broken Group Islands and some lesser islands within Barkley Sound.

Cliffs

These are the single most prevalent shoreform within the study area. They range in height from under 2 m to over 10 m; most commonly though, they are in the 5 to 10 m range. The inlets of the study area and some of the more exposed islands are predominantly steep cliffs with little or no foreshore. The erosion of less resistant bedrock types have led to the formation of sea caves and sea stacks. These forms are concentrated on the southwestern shore of the study area where wave energies are highest.

Platforms

These rock forms account for 23.8% of the study area shoreline and are the result of wave erosion in the shorezone producing a horizontal or near-horizontal platform. They develop where the bedrock is non-resistant or wave energies are high. Many of the platforms in the study area are irregular, that is, they have a complex surface relief of up to 2 m. The majority of the sea stacks are found on the rock platforms in the southwest part of the study area.

About 40% of the rock platforms have a covering of sediment with textures ranging from sand to pebble/cobble. The coarser textures are much more common.

These sediments are commonly under 1 m in thickness and occupy from 20% to up to 80% of the intertidal width of the platform.

Beaches

The beaches of the study area account for 17.1% of the total shoreline. About 17% of these are considered fine-textured - sand to fine pebble - with up to 15% coarse textures. Fine-textured beaches are not common in the area (only 3% of the total shoreline) and seem to be concentrated in the areas of relatively high wave energy or in the vicinity of river deltas. They can be found most commonly in the southwestern part of the study area from Tapaltos Bay to Bamfield Inlet and on the western islands of the Deer Group. Another area of fine-textured beaches is formed west of the Toquart River delta.

The coarse-textured beaches are more extensive and can be found throughout the study area as pocket beaches. On the north coast of Barkley Sound, however, the coarse beaches are the most common shore type.

Deltas

These forms are interspersed throughout the study area, accounting for 9% or 70.20 km of the total shoreline. Four of the deltas (the Somass, Sarita, Toquart, and Nahmint), however, take up a significantly high proportion of this length.

The deltas generally are coarse-textured, though they range from silt to cobble. The finer textured deltas seem to be associated with the larger rivers and lower gradient back shores.

The Somass River delta has extensive sand and mud deposits at its seaward end. The Nahmint, Sarita and Toquart river deltas are coarser, ranging from sands to pebbles. The coarsest deltaic deposits are generally associated with the steeper gradient streams in the study area. Textures here range from pebbles to boulders, though more commonly in the pebble-cobble range.

A significant proportion of the deltaic environments have developed marshes in their upper reaches. The most extensive, of course, are on the larger river deltas of the study area. Eelgrass beds are common in the low intertidal zone of many of these larger deltas.

Tidal Flats

These develop in sheltered environments where wave action is negligible and tidal processes become dominant. They occupy only 2.5% of the study area's shoreline. Fine textures characterize these environments commonly in the mud to fine sand range. Eelgrass predominates as the intertidal-upper subtidal

vegetation. Saltmarshes, of limited area, have also developed in some tidal flats. The most extensive tidal flats are found in Bamfield Inlet.

Man-modified

This type occupies 2.4% of the total shoreline, the majority in conjunction with the Port Alberni harbour. Most of the man-altered shorelines are in the form of land fills and wharves for the forest products and fisheries industries in the area. Lesser amounts are associated with marinas and recreational developments.

4.6.2 REGIONAL WAVE CLIMATE

An understanding of the potential for a body of water to produce waves under certain conditions is important from several points of view.

Engineers are concerned with wave effects on coastal structures such as breakwaters or wharves, as well as the sedimentation of harbours.

Planners are concerned with wave effects on coastal bluffs, the probability of inundation during storms, and the vulnerability to certain shoreforms, such as spits, to erosion.

Mariners are concerned with waves and hazards to navigation.

Recreationists are concerned with the stability of coastal bluffs and beaches (fronting recreational properties), marina protection, the maintenance of sandy beaches, and the wave hazard to small boats.

The following provides an overview of what is known about the wave characteristics of the study area. For further general reading, consult Owens (1977), Bascom (1980), and Thomson (1981). For more technical accounts of Canadian conditions, reports by the Associate Committee for Research on Shoreline Erosion and Sedimentation (ACROSES) (1980, 1983a, and 1983b) and McCann (1980) are available.

There is only one wave recording station applicable to the study area. It is Station 103, moored 5.5 km southwest of Long Beach. Waves recorded at this station reflect the more exposed outer coastal wave regime. Inner, more sheltered coastal areas have not been studied in detail.

Wave Characteristics

For the purposes of this report, the study area is divided into three zones based on wave characteristics.

Zone 1 - the exposed outer coast. This zone includes the northwest and southwest portions of Barkley Sound, as well as the western-most islands of the Deer and Broken groups of islands. It is characterized by long available fetches, giving rise to the highest swell and sea waves of the study area. In fact, Davies (1972) classifies the west coast of Vancouver Island as having some of the highest wave energy levels in the world (Harper, 1981).

Swell waves are generated offshore of the study area, so are not specifically influenced by local winds. Their direction of travel, though, is the result of the prevailing wind pattern - southeasterly in winter and west to northwesterly in summer. Swell heights are controlled by the speed of the winds in the generating area. Offshore values were reported by Faulkner and Schaefer (1978). They note that in January, wind speeds of 60 km/hr or less occur 96% of the time, while in July these values are reduced to 39 km/hr for 92% of the time. The authors also grouped the corresponding wave heights as follows.

TABLE 17 PERCENT OCCURRENCE OF WAVE HEIGHTS OFFSHORE
OF VANCOUVER ISLAND

Wave height (m)	Winter (Dec-Feb)	Summer (June-Aug)
	%	%
≤ 2.7	80.2	96.1
2.8-4.9	18.9	3.1
5.0-7.0	0.7	0.5
> 7.0	0.2	0.3

SOURCE: D.A. Faulkner and D.G. Schaefer, 1978. Meteorological Aspects of a West Coast Oil Port. Canada, Department of Environment. Atmospheric Environment Service. Vancouver. Unpublished Manuscript.

Sea waves, those produced by local winds, are more variable in their directions and heights (Thomson, 1981). Off the west coast of Vancouver Island where, during fall and winter, a series of storms track across the coast, sea waves tend to be from the southeast and northwest quadrants slightly more often than other directions. The spring-summer pattern tends to follow the prevailing wind pattern from the northwest (Thomson, 1981). Wave data collected offshore of Long Beach suggests that significant wave heights over the year are less than 3 m about 86% of the time and less than 6 m 99% of the time. (Owens, 1977 and Thomson 1981). Waves were more commonly between 1 m and 2 m in height.

In terms of extreme wave heights possible in this zone, strong wind data would have to be consulted. Faulkner and Schaefer (1978) cite extreme wind speed data for several stations that would represent the outer coast zone.

They also provide a probable return period (mean recurrence interval) for their values.

TABLE 18 EXTREME WIND SPEEDS FOR SELECTED STATIONS

Station	Years of Record	Extremes (km/h)				Maximum hourly Recorded (km/hr)
		Mean Recurrence Interval				
		5 yr.	10 yr.	20 yr.	50 yr.	
Amphritrite Point	10	87	92	98	104	85
Cape Beale	12	105.5	113	118	126	97
Tofino	20	79.5	87	94	104	100

SOURCE: D.A. Faulkner and D.G. Schaefer, 1978. Meteorological Aspects of a West Coast Oil Port. Canada, Department of Environment, Atmospheric Environment Service. Vancouver. Unpublished. Updated to 1980.

By comparison, the design hourly wind speeds calculated at Ucluelet for the National Building Code are 103.5, 112.7 and 122 km/hr, with return probabilities of 1 in 10, 1 in 30 and 1 in 100 respectively. Thomson (1981) shows the following relationship between wind speed, fetch and duration to wave height and period.

TABLE 19 MINIMUM FETCH AND DURATION TO PRODUCE FULLY DEVELOPED SEAS

Wind Speed (km/hr)	Fetch (km)	Duration (hr)	Aug. Height(m)	Significant* Height(m)	Aug. Highest 10% Waves (m)	Period of Greatest Energy Concentration (seconds)
18.5	19	2.4	.3	.4	.6	4
28.0	63	6	.8	1.1	1.5	6
37.0	139	10	1.5	2.4	3.1	8
46	296	16	2.7	4.3	5.5	10
55.5	518	23	4.3	6.7	8.4	12
74	1315	42	8.5	13.4	17.4	16
92.5	2630	69	14.6	23.8	30.2	20

* Average of the highest 1/3 of the waves.

SOURCE: R.E. Thomson, 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Aquatic Sciences 56. Canada, Department of Fisheries and Oceans. Ottawa.

Faulkner and Schaefer (1978) include extreme wave heights with 10- and 25-year return probabilities as shown in Table 20.

TABLE 20 EXTREME WIND SPEEDS AND CORRESPONDING WAVE HEIGHTS

<u>Wind Speed (km/hr)</u>		<u>Significant Wave Height(m)[*]</u>		<u>Maximum Wave Height(m)^{**}</u>	
<u>10 yr.</u>	<u>25 yr.</u>	<u>10 yr.</u>	<u>25 yr.</u>	<u>10 yr.</u>	<u>25 yr.</u>
120	133	11.9	13.7	21.3	24.7

* Average of the highest 1/3 of the waves.

** Highest 1/10 of the waves.

After Quayle and Fulbright, 1975.

SOURCE: D.A. Faulkner and D.G. Schaefer, 1978. Meteorological Aspects of a West Coast Oil Port. Canada, Department of Environment. Atmospheric Environment Service. Vancouver. Unpublished.

The exposed outer coastal zone is susceptible to very large waves, both swell and sea. Tables 19 and 20 confirm that with the long, unobstructed fetches for this zone, the extreme values are a probability. Of course, one has to temper this with the fact that the waves are also affected by water depth, islands, reefs and shoals, all of which either increase or decrease the effects of waves upon the shore.

Zone 2 - the sheltered inlet coast zone

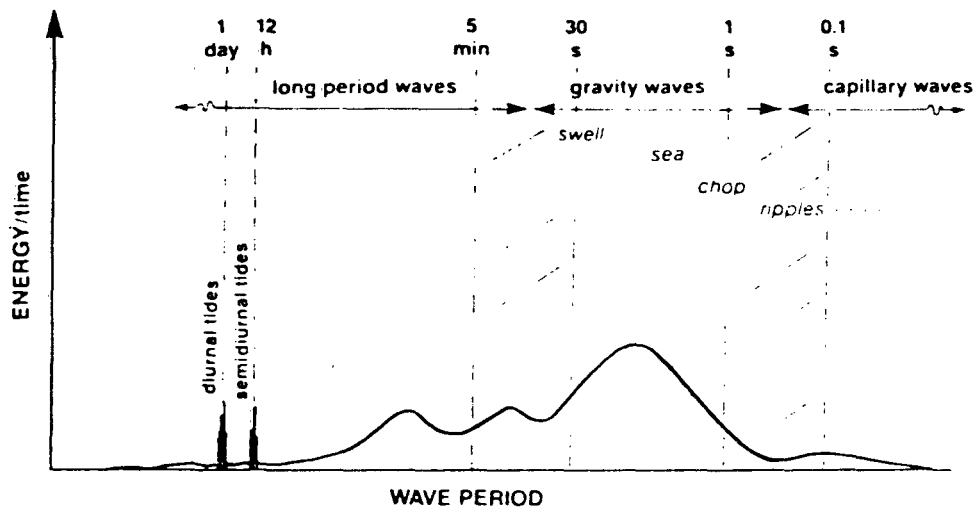
This zone includes Alberni, Effingham, Pipestem, Uchucklesit, Useless and Bamfield inlets.

Direct measurements of waves have not been made in this zone, therefore wave characteristics are based primarily on observations of winds. Winds blowing along the longest axes of the inlets of this zone will likely generate the largest waves. The longest fetches are all under 10 km, so waves of up to 1 m could be possible under strong sustained winds (Morris and Leaney, 1980). The National Building Code design hourly wind speeds for Port Alberni are:

1 in 10 yr.	965. km/hr
1 in 30 yr.	107.8 km/hr
1 in 100 yr.	119.0 km/hr

Very strong winds are theoretically possible in Alberni Inlet. The corresponding theoretical wave heights, however, would likely not materialize because of the narrowness of the water body and the variable water depths. The more common waves would be short and choppy (Morris and Leaney, 1980).

FIGURE 9 POWER SPECTRUM OF RELATIVE AMOUNT OF ENERGY CONTAINED BY WAVES
OVER A RANGE OF WAVE PERIODS



Note: Broken lines show overlap of wave types.
Tidal energy is concentrated within a narrow band of periods near diurnal and semi-diurnal periods. (After Kinsman, 1965).

Source: R.E. Thomson, 1981. Oceanography of the British Columbia Coast.
Canadian Special Publication of Fisheries and Aquatic Sciences 56.
Fisheries and Oceans Canada. Ottawa. p.89.

Zone 3 - the intermediate island groups and eastern Barkley Sound coast zone

This zone includes the eastern portions of the Deer Group, the islands along the northeast and east shore, as well as Toquart, Rainy, and San Mateo bays. It is the most complex zone of the study area in terms of wave regime, since it is influenced by both modified swell waves and locally generated waves. The most exposed areas of this zone are along the major channels which run southwest by northeast. Imperial Eagle Channel and shorelines bordering it would be susceptible to the highest waves of the zone. Reviewing the extreme wind data from Table 18, it can be seen that winds of these magnitudes blowing along the axes of the channels, especially from the south-east, could generate large waves.

Wave Energy

The energy of waves initiates sediment motion, generates turbulence to put sediments into suspension, and drives currents to transport the sediment (Hay, 1983). Wave energy is a function of wave height and wave period. Figure 9 illustrates the relationship of wave energy to wave period and type, while Table 19, from Thomson (1981), identifies the wave periods with the greatest energy for specific wave heights.

Wave measurements for the exposed coast of the study area show that wave periods of ten seconds are most common. Ninety-four percent of all the waves, however, have periods of greater than six seconds; waves of ten seconds or greater occur 50% of the time. Clague and Bornhold (1980) rate the wave energy here as high. Wave energy levels within the inlets and sheltered embayments are generally much lower (Morris and Leaney, 1980).

Carter (1973) calculated the bottom surge velocities of maximum storm waves at three depths. He notes that a velocity of 35 cm/s is required to move fine sand. See Table 21.

TABLE 21 CALCULATED BOTTOM SURGE VELOCITIES
(After Watts and Faulkner, 1968)

Water Depth (m)	Bottom surge velocities (cm/s)		
100	66	99	150
150	26	39	60
200	11	16	25
Maximum wave height (m)	9.1*	13.7**	21.4***

* Maximum annual summer storm

** Maximum annual winter storm

*** Maximum 100-year storm.

SOURCE: L. Carter, 1973. Surficial Sediments of Barkley Sound and the Adjacent Continental Shelf, West Coast Vancouver Island. Canadian Journal of Earth Sciences 10(4), National Research Council, Ottawa.

Carter (1973) cautions that these values are only orbital velocities; the sediment is stirred up. For horizontal transport to take place, tidal or other currents must be present. What the table does indicate, however, is that the large storm waves can influence sand-sized particles to great depths.

Hay (1983) provides some theoretical values of the volume of sediment transported by waves breaking on the shore. There is a relationship between the height of breaking waves, their angle of approach to a shore and the pattern of littoral currents. Generally, the larger the approach angle, the more energy available to transport sediments. For example, based on Hay's (1983) illustration from the Shore Protection Manual, mean wave heights of 3 m breaking at 10° to the shore could transport $19.13 \times 10^5 \text{ m}^3/\text{yr}$ of sediment. Mean wave heights of just under 1 m breaking at about 45° to the shore, however, would transport the same amount of sediment. These values, of course, are based on the assumption that there is unlimited sediment available for transport along the shoreline. Clague and Bornhold (1980) state that littoral sediments are not common for the west coast of Vancouver Island, being isolated to river deltas and the occasional coastal bluff. One-day calculations for Florencia Bay (Bremner, 1970), an area of good sediment supply, saw sediment transport values of $126 \text{ m}^3/\text{hr}$ for a maximum down to between 7 and $11 \text{ m}^3/\text{hr}$ near the headlands. Values of this nature would not be likely for the study area, as there are no extensive unconsolidated bluffs available to wave attack.

Another factor influencing the amount of wave energy available to the shorezone is tidal range. The study area has tidal ranges of 2.8 m during mean tides, and 4.1 m during large tides. Complicating these values are surges which result from atmospheric pressure changes, strong onshore winds and large waves. Murty (1983, pers. comm.) states that, "Usually Barkley Sound and Alberni Inlet are not subjected to storm surges."

Figure 3 shows relative sea level changes since the last glaciation, while Clague et al (1982), upon reviewing historical evidence and recent data, suggest the following trends:

a) Tidal stations

Vancouver, Point Atkinson, Prince Rupert	1-2mm/yr sea level rise
Tofino, Queen Charlotte City	1-2 mm/yr sea level fall
Port Alberni, Little River, Campbell River, Alert Bay, Port Hardy	fall in sea level
Victoria, Fulford Harbour	little or no change

b) Levelling surveys

Fraser Lowland	1.5 mm/yr subsidence
Victoria-Port Alberni	uplift
Parksville-Campbell River	uplift

As much of the study area shorezone is steep and rocky, the effects of waves and water levels are not significant factors.

To summarize, the study area exhibits a complex wave regime ranging from very exposed shorelines to sheltered and narrow inlets. Wave heights and energy are very high, perhaps some of the highest on the coast. Potential littoral current energy is high for the outer sections of the study area, decreasing as one moves eastward. Due to the predominant rocky shorezone, available sediments for the shorezone are in isolated sections throughout the study area.

4.6.3 ATMOSPHERIC MIXING

The capacity of the atmosphere to disperse airborne pollutants is determined by such factors as horizontal transport and vertical mixing. Horizontal transport is a function of wind speed and direction; vertical mixing is a function of the stability of the lower atmosphere. Conditions which inhibit both are ground based inversions and light surface winds.

An estimate of the seasonal frequency of persistent light winds (speeds less than 12 km/h) is presented in Figure 10. These values are based on a national study by Shaw, Hirt and Tilley (1972).

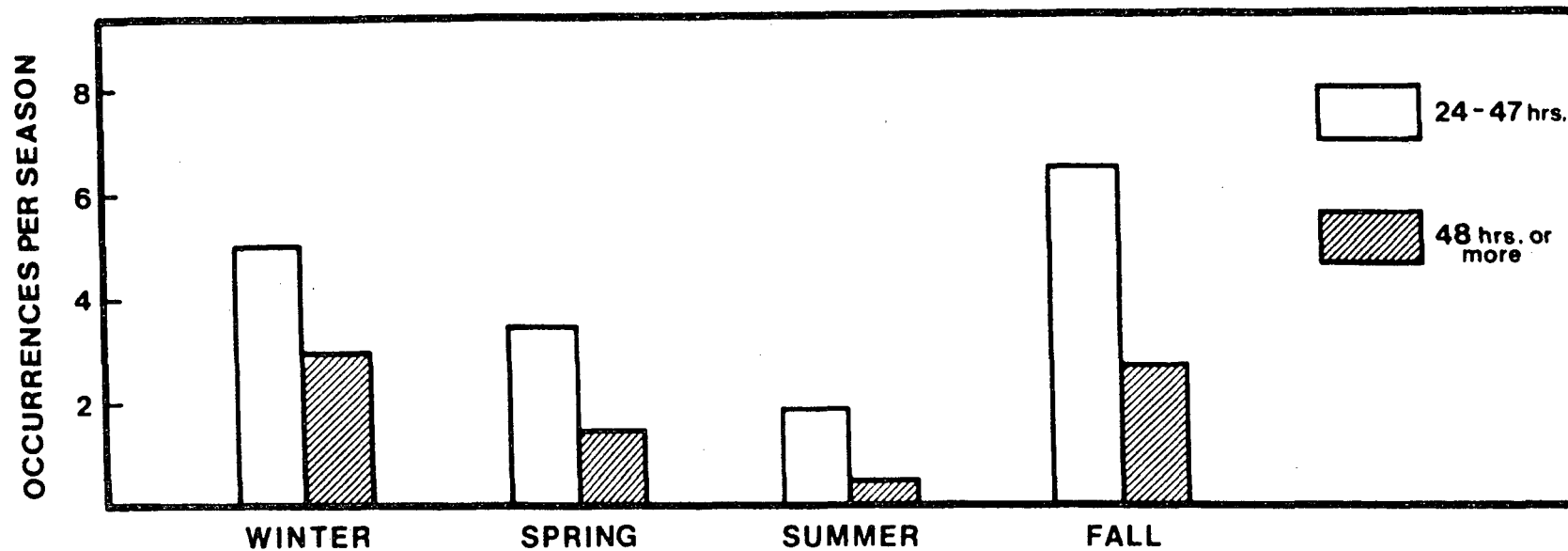
During fall and winter, stationary or slow moving high pressure centres are responsible for the light wind episodes, most commonly lasting less than two days. In the summer months, calms are most frequent in the hours around sunrise and sunset, during reversals of the land and sea breeze circulation pattern.

Inversions prevent convective mixing and limit the vertical dispersal of pollutants. Inversions are most commonly caused by nocturnal cooling of the earth's surface. In such cases, afternoon heating normally restores convective mixing. In the study area, however, several factors lead to more persistent inversions. These include: a) the overrunning of warm air from the southern Pacific Ocean, particularly in fall and winter; b) the cooling effects of the sea breeze in late spring and summer; c) the occasional presence of cold Arctic air in winter months.

Estimates of the diurnal and seasonal percentage frequencies of ground-based inversions for the study are provided in Figure 11. Considerable variation from the indicated values can be expected due to the local influence of water bodies and topography.

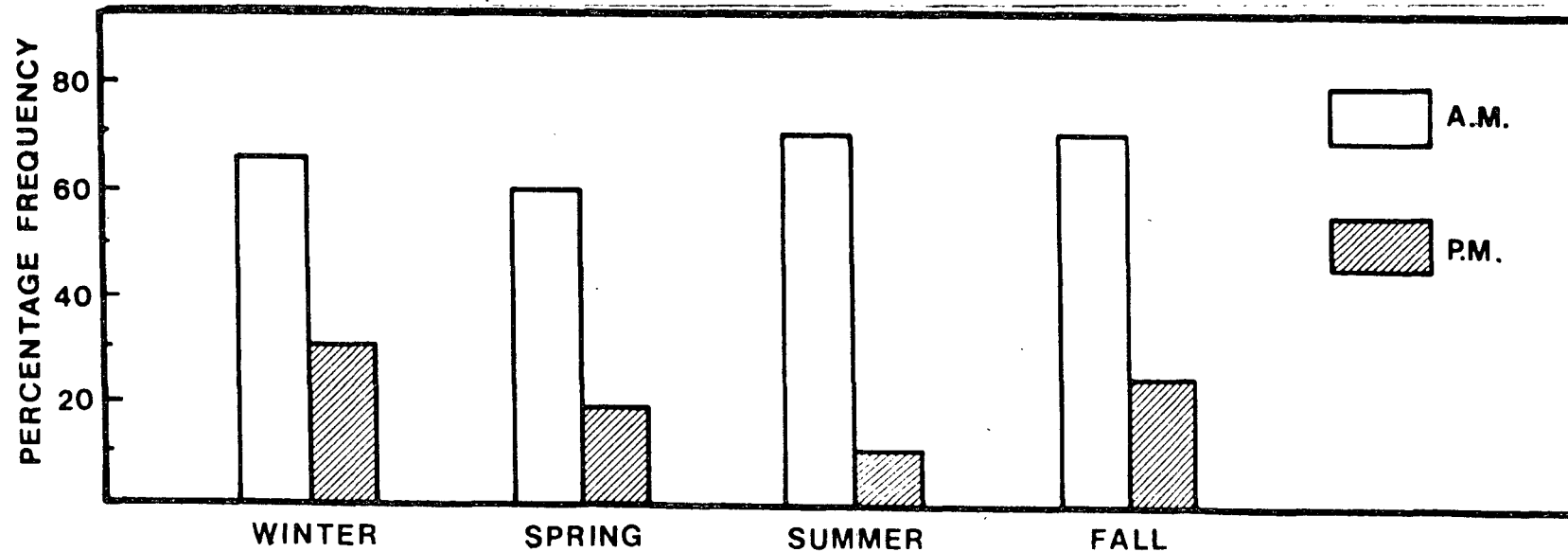
The dispersive capability of the lower atmosphere, the ventilation coefficient, can be calculated. It is the product of the height of the convectively mixed layer and the mean horizontal wind speed in that layer. Portelli's (1977) study of these factors indicate that, for the British Columbia coast, mean afternoon values of the ventilation coefficient peak sharply in spring (April), decline throughout the summer and persist at low levels during fall and winter. Pollutant buildup generally occurs during periods of calm or light winds which coincide with persistent ground-based inversions. Rain and snow partially remove pollutants from the lower atmosphere.

FIGURE 10 FREQUENCIES OF EPISODES OF PERSISTENT LIGHT SURFACE WINDS (SPEEDS LESS THAN 12KM/HOUR) BY SEASON



Source: R.W. Shaw, M.S. Hirt and M.A. Riley, 1972. Persistence of light surface winds in Canada. Atmosphere 10(2): 33-43.

FIGURE 11 PERCENTAGE FREQUENCIES OF GROUND-BASED INVERSIONS BY SEASON



Source: R.E. Munn, J. Tomlin, and R.L. Titus, 1970. A Preliminary Climatology of ground-based Inversions in Canada. Atmosphere 8(2): 52-56.

J.H. Emslie, 1979. Ground-based inversions frequencies determined from surface climatological data. Boundary Layer Meteorology 16(4): 409-419.

Emslie (1979) states, in Morris and Leaney (1980), that Port Alberni is one of the poorest locations in Canada for diluting and dispersing airborne pollutants.

4.6.4 SEISMIC HAZARD

The B.C. coast has a 1 in 100 probability of an earthquake exceeding a horizontal acceleration of 6% of gravity. Horizontal acceleration is an accepted index of ground motion for engineering purposes. Witham and Milne (1972) note that earthquake damage is a function of earthquake magnitude, its depth of focus and mechanism, soil type, distance, and the quality of building construction.

Magnitude

A common measure of earthquake magnitude is the Richter system; earthquake intensities are described by the Modified Mercalli scale. Table 22 provides a comparison of the two methods of measurement. The threshold for significant damage during earthquakes is set at magnitude 5 on the Richter scale. Milne, Rogers, Riddihough, McMechan and Hyndman (1978) calculated a frequency of one in ten years for potentially damaging earthquakes. Figure 12 provides a comparison between the continental and offshore areas. Note that the offshore graph shows a relatively smooth slope with few large releases of strain. The continental area, however, shows large steps which are indicative of high strain release during large earthquakes. The straight lines represent an estimate of the strain accumulation rate (Milne et al, 1978). From this evidence, the authors postulate that if the historical seismicity pattern for the continental area continues, a major part of the present accumulated strain could be released in a significant earthquake within the next decade.

The largest magnitude earthquake to affect the study area was in June 1946; it registered 7.3. Its epicentre was calculated to be west of Comox in the Beaufort Range.

Depth of Focus and Mechanism

The maximum recorded depth of earthquakes in the region is about 70 km. By comparison, depths of up to 700 km are common in similar areas of the world (Milne et al, 1978). The Beaufort Range earthquake epicentre was about 30 km in depth.

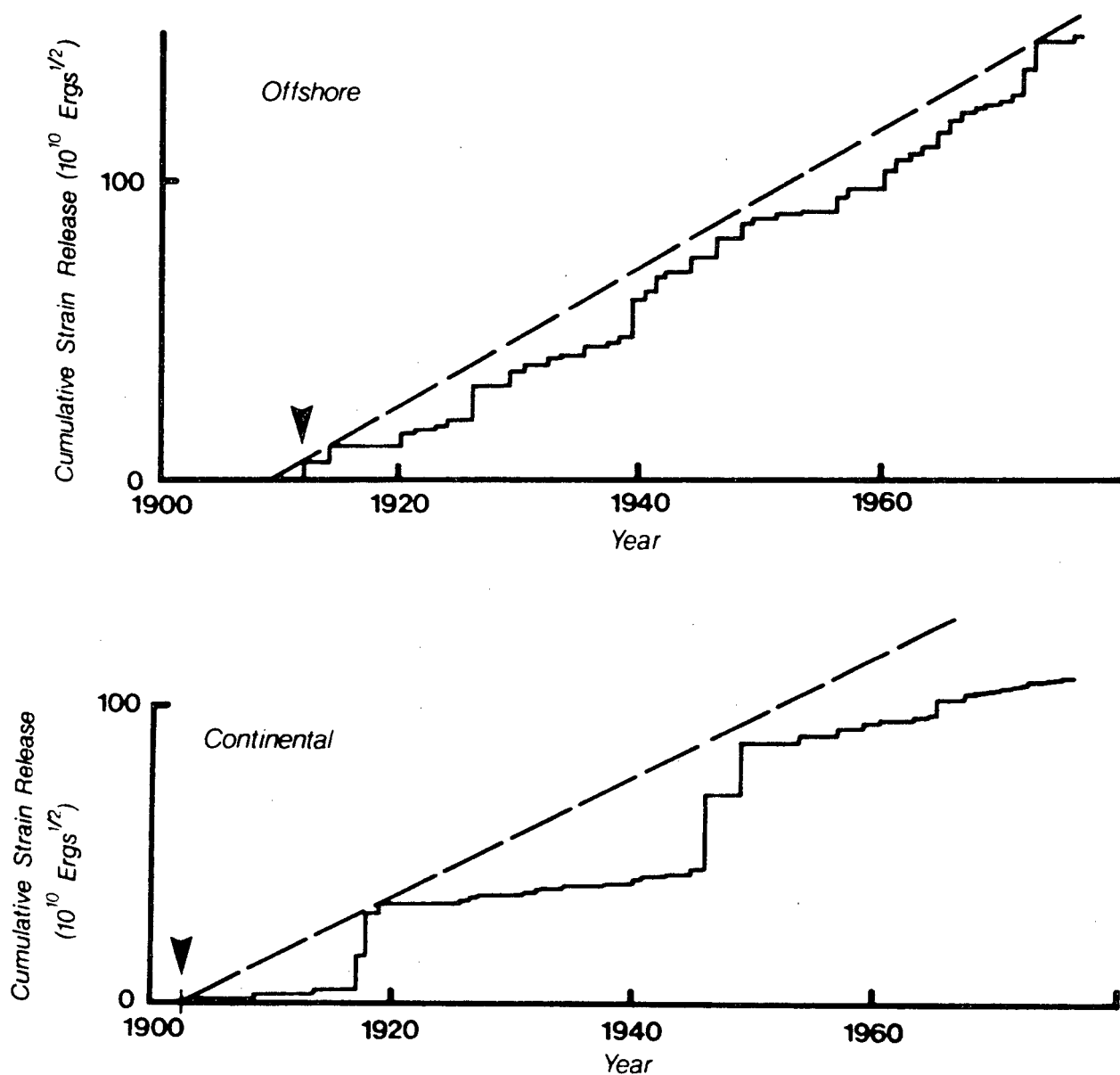
The primary mechanisms of earthquakes in this region are strike-slip and normal faulting (Milne et al, 1978).

TABLE 22 MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES
WITH CORRESPONDING RICHTER MAGNITUDES

Intensity (Modified Mercalli Scale)	Description of Characteristic Effects	Magnitude Approximately Corresponding to Highest Intensity Reached
I	Instrumental: detected only by seismography	
II	Feeble: noticed only by sensitive people	3.5
III	Slight: like the vibrations due to a passing heavy truck; felt by people at rest, especially on upper floors	to 4.2
IV	Moderate: felt by people while walking; rocking of loose objects, including standing vehicles	4.3 to
V	Rather Strong: felt generally; most sleepers are woken and bells ring	4.8
VI	Strong: trees sway and all suspended objects swing; damage by overturning and falling of loose objects	4.9 to 5.4
VII	Very Strong: general alarm, walls crack and plaster falls	5.5 to 6.1
VIII	Destructive: car drivers seriously disturbed; masonry fissured; chimneys fall; poorly constructed buildings damaged	6.2 to 6.9
IX	Ruinous: some houses collapse where ground begins to crack; pipes break open.	
X	Disastrous: ground cracks badly; many buildings destroyed and railway lines bent; land- slides on steep slopes	7.0 to 7.3
XI	Very Disastrous: few buildings remain standing bridges destroyed; all services (railway, pipes, cables) out of action; great land- slides and floods.	7.4 to 8.1
XII	Catastrophic: total destruction; objects thrown into air; ground rises and falls in waves	8.1+

Source: D. Maynard, 1979. Terrain Capability for Residential Settlements: Summary Report, Resource Analysis Branch, Victoria. 61 p.

FIGURE 12 STRAIN RELEASE AS A FUNCTION OF TIME



Source: W. G. Milne, G.C. Rogers, R.P. Riddihough, G.A. McMechan, and R.D. Hyndman, 1978. "Seismicity of Western Canada". Canadian Journal of Earth Sciences

Soil Type

The type of material upon which structures are built directly influences the amplification of earthquakes. Table 23 provides amplification factors for various geological materials and represents the minimum design requirements recommended under the National Building Code. Hodgson (1946) reported that during the 1946 earthquake, most of the damage was confined to low-lying areas. These areas were:

1. Kildonan - the end of the B.C. Packers' cannery dock collapsed while the centre slumped. The facility was built on piles over an alluvial fan. Also, many chimneys and two oil storage tanks were damaged.
2. Port Alberni - primarily chimneys in the townsite and damage to the boiler at the lumber mill.
3. Alberni - many chimneys knocked down.

By way of comparison, Hodgson (1946) also notes that structures on bedrock in all three areas suffered little or no damage.

Distance

Earthquake damage diminishes with distance from the epicentre (Whitman and Smith, 1970). Active faults in recent geological time are the San Juan and Leech river faults. Milne *et al* (1978) report that the more active earthquake areas correspond to the boundaries of the major tectonic plates off the coast. The study area is specifically influenced by the Juan de Fuca and America plates. Known fault lines for the area are identified on the Generalized Terrain Limitations 1:50,000 Map Series of this folio.

In terms of the 1946 earthquake, centred northeast of Port Alberni, Hodgson (1946) concluded that the Alberni Inlet was within, or bordering, the immediate epicentral region. His conclusion was based on observations and reports of damage in the area. Besides those due to foundation condition, Hodgson (1946) describes other incidences which are perhaps more interesting.

The telegraph cables (2) between Bamfield and Port Alberni were damaged. In fact, the repair crews were unable to locate the cables from China Creek to just past Franklin River. The Bamfield ends were cleanly severed, while the Port Alberni end at China Creek could not be pulled to the surface. The repair crews also did soundings of the area and found that the bottom depths were 15 to 60 m greater than the existing Admiralty charts indicated. For instance, the charts showed an area of drying rocks on the east shore of the inlet; the repair crew measured 30 m of water at that site (Hodgson, 1946). The author cautions, however, that the Admiralty charts' depths are not precise as to value or position.

TABLE 23 SEISMIC AMPLIFICATION FACTORS FOR DIFFERENT GEOLOGICAL MATERIALS

TYPE AND DEPTH OF MATERIAL	AMPLIFICATION FACTOR
1. Rock, dense and very dense coarse-grained sediments, very stiff and hard fine-grained sediments, compact coarse-grained sediments and firm and stiff fine-grained sediments from 0 to 15 m deep	1.0
2. Compact coarse-grained sediments, firm and stiff fine-grained sediments with a depth of greater than 15 m; very loose coarse-grained sediments and very soft and soft fine-grained sediments from 0 to 15 m deep	1.3
3. Very loose and loose coarse-grained sediments and very soft and soft fine-grained sediments with depths greater than 15 m	1.5

Note: Prepared by the Associate Committee of the National Building Code 1977

Source: D. Maynard, 1979. Terrain Capability for Residential Settlements: Summary Report, Resource Analysis Branch, Victoria. 61 p.

Quality of Building Construction

Foster and Carey (1976) and Wuorinen (1976), studying the Victoria area, give accounts of the types of structures susceptible to earthquake damage. They also note that the severity of damage can be lessened or magnified by the type of foundation condition. Structures identified as most susceptible:

- a) unreinforced masonry and concrete structures;
- b) wood frame structures under four storeys with poor lateral force bracing at foundation level;
- c) most structures on poor foundation materials such as clays.

Secondary Effects

The secondary effects of a strong earthquake are potentially more damaging than the initial shock. Two prominent effects are landslides and tsunamis.

Landslides were common on Vancouver Island after the 1946 earthquake. Henderson, Great Central and Sproat lakes all experienced slides, most commonly alluvial fans slipping into deep water. There was a general increase in slides for up to two weeks after the initial shock. The slide hazard was further increased by the fact that it had been an unusually wet season (Hodgson, 1946).

The study area is susceptible to damaging tsunamis, though, according to Thomson (1981), it is unlikely that a major earthquake off the west coast of Vancouver Island would generate a tsunami; the faulting mechanism is not the right type. Regardless, water level changes of between 6 and 9 m were observed at Franklin River during the 1946 earthquake. A boat just off the Franklin River also observed "a series of gentle rollers crossing the channel west to east..." (Hodgson, 1946). The study area is exposed to tsunamis generated elsewhere in the Pacific Rim, though in varying degrees. The largest recorded, and the most destructive to date, were the waves generated by the Good Friday Alaskan earthquake in 1964. Damage to Port Alberni harbour and shore developments was extensive. These same waves, however, did not greatly affect Tofino on the outside coast. For example, the maximum tsunami crest recorded at Tofino was .6 m above higher high water, while at Franklin River and Port Alberni it was 2.3 and 2.6 m respectively (Thomson, 1981).

4.7 FACTORS OF BIOLOGICAL PRODUCTIVITY

THE AREA

Barkley Sound is part of the west coast environment of Vancouver Island. It contains numerous islands, islets, and inlets with a range of geomorphic forms. While most of the coastline is rocky, many small pocket beaches may be found. Ricketts and Calvin (1968) identify three major forms of shore habitat for the western coast of North America: the protected outer coast, the open coast, and bays and estuaries. Although elements of all three types are present here, Barkley Sound probably best fits the protected outer coast category of which there are two subdivisions: rocky shores, and sandy beaches.

4.7.1 THE PHYSICAL/CHEMICAL ENVIRONMENT

Water temperature, salinity, light penetration, nutrients, and dissolved oxygen are major factors influencing primary production in the sea. Many of the physiological functions (i.e. reproduction, cell growth, respiration) of marine organisms are temperature regulated, occurring only within a narrow temperature range. Similarly, organisms that are unable to regulate their internal environment in response to changes in their external medium, must remain within a relatively narrow range of salinities for survival. Light penetration is necessary for photosynthesis by plants, and for visual predators. Nutrients are required by all marine life forms; and dissolved oxygen is, of course, necessary for respiration to occur.

Water temperatures within a column of seawater are relatively homogeneous during the winter, autumn, and spring. In the summer months, however, the upper layer of water - to perhaps 30 metres - becomes warmer as solar radiation increases. This temperature gradient inhibits mixing with the deeper water by causing a density gradient. Mixing continues, however, within this upper layer as surface winds circulate the water, thus maintaining relatively constant temperatures.

The salinity of seawater varies with the quantity and rate of precipitation, evaporation, and river discharge. Precipitation and river discharge dilute marine surface waters, while evaporation increases the salinity. As fresh water is less dense than salt water, the salinity of the water column increases with depth. Also, the salinity of surface waters increases with increasing distance from river inflows.

The penetration of light into the water column is a function of turbidity. Turbidity results from suspended particulate matter and dissolved organic substances that scatter and diffuse incident light. Coastal waters typically receive no light below 30 metres; the depth to which 1% light transmission occurs (which demarcates the lower limit of plant growth) is characteristically 10 metres (Sumich, 1976).

The distribution of dissolved oxygen within surface waters is usually homogeneous because of frequent wave action and surface mixing. Minor variations may be evident between regions because of atmospheric or

surface phenomena. Dissolved oxygen concentrations in areas of good tidal exchange are normally adequate for all organisms.

The availability of nutrients within surface waters declines during the growing season as plant production increases. Regions of upwelling result in a replenishment of nutrients from the lower strata. River discharges and nutrient regeneration from shallow muds also contribute to the nutrient pool. Tidal and wind currents further redistribute nutrient-rich water within the coastal zone.

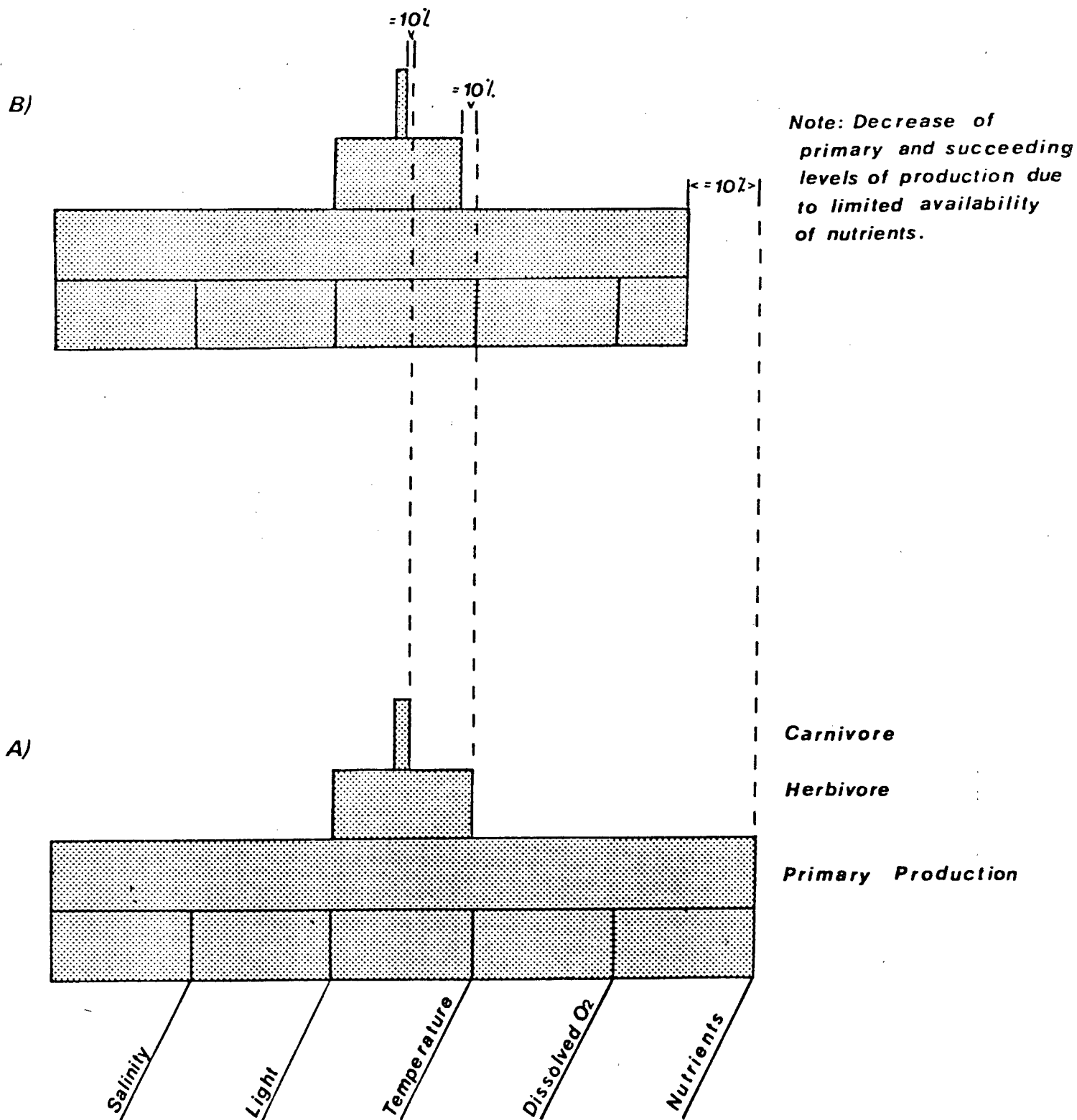
The interested reader will refer to the Coastal Resources Map Series section - "physical oceanography - Station Distribution and Accompanying Table" for Strait of Georgia data on these topics. The "Sources" section should also be consulted for studies relating to the physical and chemical environment.

4.7.2 PRIMARY PRODUCTION - PHYTOPLANKTON

Primary production is the creation of organic material from carbon dioxide, water, and nutrients at the expense of solar energy. Gross primary production refers to the total amount of organic material produced by photosynthesis; net primary production refers to the amount of organic material available to other levels of the food chain after losses to respiration, reproduction, and mortality are considered. Primary production is usually reported in grams of carbon fixed by photosynthesis within a square metre per unit of time ($\text{gC/m}^2/\text{year}$).

With the exception of estuaries, the areas of highest productivity occur where temperature stratification is well developed, salinity is consistently high, and other factors of the physical/chemical environment, described earlier, are in abundant supply. Where this occurs, primary production is limited mostly by the grazing activities of organisms higher on the food web. When the supply of one or more factors exceeds the tolerance limits of phytoplankton species, however, growth of the individual and the population is curtailed. Primary productivity is also limited by the factor in least supply. Figure 13 illustrates the importance of each of the factors of growth in maintaining high productivity. The figure shows, for example, that a reduction in the "quantity" of one factor (i.e. nutrients) results in diminished primary productivity which sequentially limits the energy transmitted to, and populations sustained at, higher levels of the food web. Simply stated, a low phytoplankton crop supports a low zooplankton crop which in turn supports fewer juvenile salmon.

Figure 13 - SCHEMATIC OF ENERGY TRANSFER BETWEEN TROPHIC LEVELS
IN UNLIMITED (A) AND LIMITED (B) ECOSYSTEMS

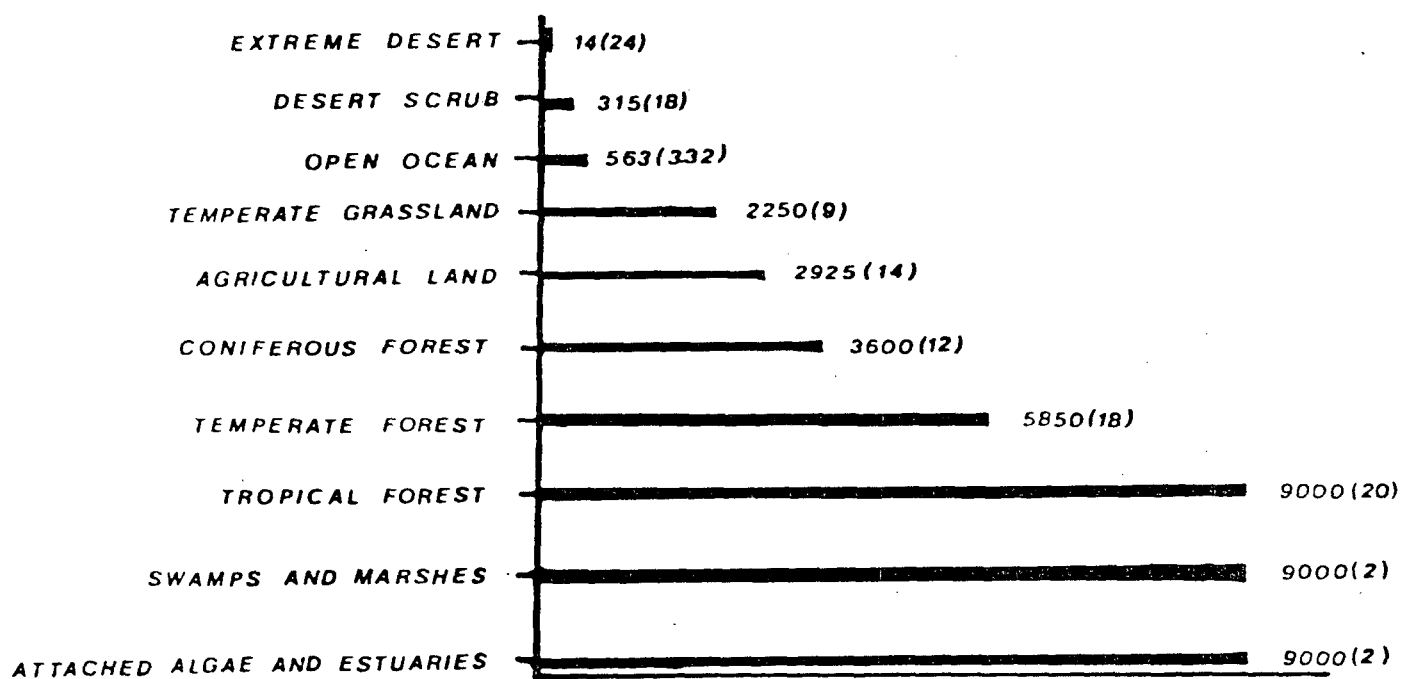


4.7.3 PRIMARY PRODUCTION - SEaweEDS AND SALTMARSHES

The productivity of seaweed and saltmarsh communities is impressive (Figure 14). Seaweed studies from Nova Scotia indicate that Laminaria longieururis on a rock substrate will produce up to 20 times the initial weight of the blade over a two-year period even though 35 to 40% of the gross production is liberated as dissolved organic matter during the same period (Carefoot, 1977). Such high rates of production result from the constant provision of nutrients to the leaves by currents, adequate temperature and light. In estuaries, detrital based eelgrass ecosystems are also highly productive. Their productivity comes from the interaction of numerous species that have evolved complex symbiotic relationships within these communities.

Estuaries are transitional areas, and as such, contain a significantly high proportion of brackish water - water of intermediate salinity. Numerous classifications of brackish water exist, although a common standard is 0.2‰ to 30.0‰ (Remane and Schlieper, 1971). Brackish water originates when salt water is mixed with fresh water. Because of differential inputs of heat and salt water, stratification in estuaries is not common. Under the right wind or wave conditions, particulate matter such as plankton, detritus, or sediment uplifted from the substrate or discharged by rivers, may diminish light penetration and reduce plant growth. Normally, brackish water is poor in species diversity relative to fresh and salt waters; however the populations of species present are usually larger (Remane and Schlieper, 1971). For instance, the lowest number of species occurs at the 5-7‰ salinity level (Figure 15). In addition, a smaller size is attained by organisms living in brackish conditions, although species that migrate to sea water (i.e. salmonids) generally attain rapid growth thereafter. An important seagrass in the ecology of estuaries is Zostera marina. It is acclimated to brackish water conditions and survives salinities to 30‰. The estuarine phase is an extremely important part of the life cycle for many organisms (i.e. salmonids, shrimp) as it prepares them for survival in the sea.

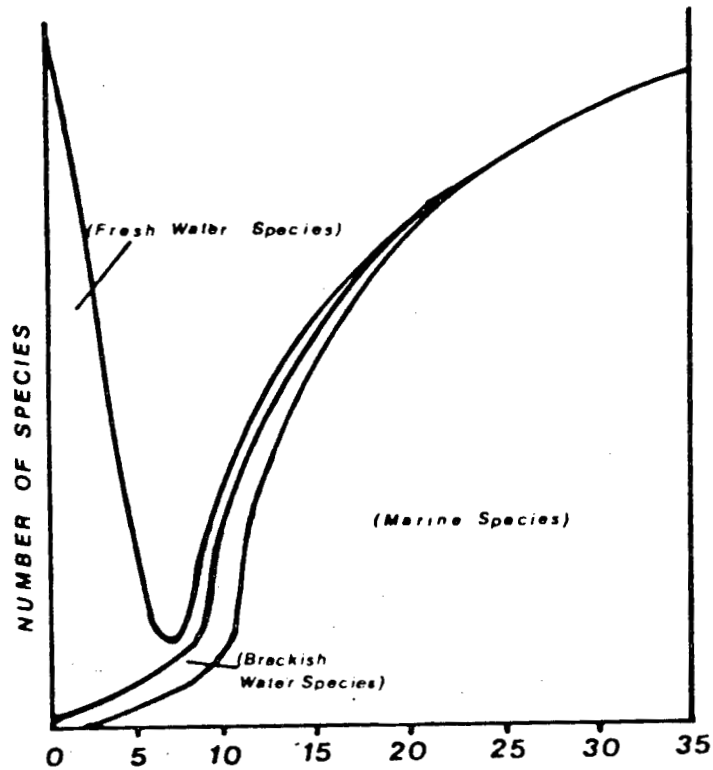
FIGURE 14: AVERAGE ANNUAL RATE OF NET PLANT PRODUCTION FOR SELECTED ECOSYSTEMS



NOTE: The number after the bar is Kcal/m²/yr; the number within parentheses is area in 10⁶km².

SOURCE: Adopted from E.G. Kormondy 1976, Concepts of Ecology, Prentice Hall Inc. New Jersey.

FIGURE 15: NUMBER OF SPECIES IN RELATION TO SALINITY LEVEL (‰)



SOURCE: A. Remane and C. Schlieper, 1971. Biology of Brackish Water. John Wiley and Sons, Inc.

4.8 THE ADMINISTRATION AND MANAGEMENT OF COASTAL RESOURCES

4.8.1 INTRODUCTION

Numerous agencies administer and manage coastal resources. The Coastal Zone Resources Subcommittee publication (1978) identifies agency roles and responsibilities. In 1980 the Land Use Planning section of the Ministry of Lands, Parks and Housing prepared a discussion paper entitled "The Ministry of Lands, Parks and Housing's Role in Foreshore Administration". This document identifies agency mandates, planning programs and responsibilities for foreshore administration. The publication "Land Use Law" by Ince (1977) provides an overview of the legislation governing land use in British Columbia.

4.8.2 THE ADMINISTRATION OF COASTAL LAND

Crown Land - Provincial

The Ministry of Lands, Parks and Housing is a key management and administrative agency in the coastal zone. The Ministry may transfer its management responsibility to other provincial agencies (i.e. Marine Resources Branch) that indicate their particular interest in an area or a resource (i.e. oyster growing areas). The Ministry remains, however, the authority for the issuance of foreshore leases.

The application process for foreshore leases varies according to the type of lease, and the area in which it is located. Log storage lease applications undergo a complex review process through various levels of government (Ministry of Lands, Parks and Housing, 1980). On the other hand, a commercial foreshore lease application may obtain approval at a regional office the same day it is submitted. In areas where management committees and a management plan exist, individual lease applications are reviewed for conformity.

In terms of foreshore regulation, the Ministry of Lands, Parks and Housing uses terms and conditions of foreshore leases to monitor and enforce its own policies. The Ministry is also responsible for preparing area management plans.

While the Ministry of Lands, Parks, and Housing is the primary agency with responsibilities in the coastal zone, direct responsibilities are also held by the Ministries of Environment, Forests, and Transportation and Highways.

Crown Lands - Federal

The Port Alberni Harbour Commission is responsible for the administration, development and operation of the harbour area. The Commission's facilities include a port terminal of 9.3 hectares (17 acres), three deep water berths capable of handling vessels up to 700 feet long and draughts to 40 feet, a commercial fish boat basin with a blast freezing facility and ice plant, and a mile-long industrial road. (Gray, 1980).

The Harbour Commission leases about 214 hectares of foreshore for industrial, commercial, and institutional uses. About two-thirds of this area is leased to forest product companies for log storage. The Commission has also been active in improving the fish processing and cold storage facilities, re-developing the fish boat harbour and constructing and operating the China Creek and Clutesi Haven marinas (Gray, 1980 and Andrew, 1983, pers. comm.).

Under the Indian Act, the band Council, the Cabinet and the federal government (Department of Indian and Northern Affairs) are responsible for land use on Indian Reserves. While the Council may divide the reserve into zones of permitted use, the federal cabinet exercises ultimate control in major land use decisions.

Other Public Lands

The Regional Parks Act of 1965 allows the regional districts to acquire, develop and manage regional parks. The Alberni-Clayquot Regional District has not acquired any regional parks to date. (D. Dryden, pers. comm., 1983).

Private Lands

Tree farms are privately owned land. The owner agrees to follow good forest management practices, in return for which the land is valued by the B.C. Assessment Authority on the basis of the harvest yield predicted from an approved plan of forest management.

Timberland refers to those forest lands where fee-simple ownership is held by forest companies. There are no cut stipulations. Such lands were obtained through Crown grants made early in the history of the province. Ownership of this type of forest land provides greater freedom to the owner to use and develop the land and forest resources than is the case with Crown forest tenure.

4.8.3 WATER MANAGEMENT

Water Supply and Licensing

Federal - Major federal legislation dealing with water supply includes the Canada Water Act and the Fisheries Act. The Canada Water Act permits the federal government to operate a network of streamflow, water level, and sediment stations, to develop flood damage reduction programs, to undertake flood control measures, to undertake shoreline and water resource management programs, and to conduct research on surface and groundwater hydrology. The Fisheries Act allows the Department of Fisheries and Oceans to influence flow regimes of regulated rivers in order to protect the migration and spawning habitat of salmon stocks.

Provincial - The Ministry of Environment, by virtue of the Water Act, manages freshwater supplies by controlling the issuance of water licences, conducts ground and surface water research, and engages in river and flood control programs. Under the Municipal Act, local and regional administrations are responsible for water supply and distribution.

The right to withdraw and use surface water in the province is granted by water licence. Water licences are issued by the Ministry of Environment, Water Management Branch, for domestic, waterworks, mineral trading, irrigation, mining, industrial power generation, hydraulicking, storage, conservation, fluming, conveying and land improvement purposes. Within the study region, domestic waterworks, irrigation, industrial power generation, and conservation purposes require major allocations of freshwater. Water licences have precedence according to the date of issuance so that in low flow situations some users may be denied their allocation. Currently, groundwater may be diverted without licence.

For all but the largest diversions, water licences are reviewed on an ad hoc basis with watershed studies limited to specific issues identified in the application (personal communication - Regional Engineer, Water Management Branch, Nanaimo, 1980). Studies of watershed characteristics upon which to determine optimal patterns of development and resource allocations are not yet available. Streams can be licensed for diversions in excess of the recorded minimum daily discharge. Although not all users divert the maximum licensed quantities, it is possible that under extreme conditions, shortfalls in water supplies could result for some users.

An interagency referral system currently used in British Columbia is designed to account for the stream resource flow requirements of all users in order to avoid conflicts, or situations where users are lost. For instance, for the survival, migration, and spawning of fish a certain discharge is required. Spawning habitat increases or decreases with greater or lesser flows; migration is restricted or blocked at extremely high or low flows, and survival is possible only at certain water temperatures which, in small streams, depends greatly on the discharge. Similarly, recreational use (canoeing) is possible only within a given range of discharges. In the study region, minimum flows for fisheries, recreation, wildlife, or domestic uses are not available.

Water Quality and Waste Management

Water quality comes under the purview of both the provincial and federal governments. As numerous acts regulate the myriad activities involving the use of water, only the major legislation is reviewed here.

Federal Legislation

The Canada Water Act and the Fisheries Act are the most powerful federal statutes. Under the provisions of the Canada Water Act the federal government sets national effluent standards and co-operates with the provinces in controlling pollution of specified water bodies. Part one of the Act allows the federal government, on federally owned water bodies, or the federal and provincial governments to designate a water body as a water management area, thus bringing into force regulations against effluent discharges. Part two of the Act deals with the problem of eutrophication by regulating the concentration of nutrients in cleaning agents that are imported into Canada. The Fisheries Act prohibits the discharge of deleterious substances in any waters frequented by fish. This includes logging debris, obstacles to migration, and activities within the watershed that lead to erosion problems, stream siltation, or the loss of fish, fish eggs, and other marine organisms.

The Canada Shipping Act's environmental provisions apply to all ships (not propelled by oars) in Canadian waters south of the 60° north latitude, including all internal waters, the territorial sea, and all fishing zones established pursuant to the Territorial Sea and Fishing Zones Act. The Canada Shipping Act itself does not prohibit discharges, but authorizes the Federal Cabinet to make regulations prohibiting the discharge from ships of any pollutant specified. The Oil Pollution Prevention Regulations (oils and persistent oily mixtures), the Pollutant Substances Regulations (arsenic, lead, mercury, and phosphorous, etc.) and the Garbage Pollution Prevention Regulations (garbage) are made under this Act. While this represents strong legislation, there are several significant limitations which might hamper its effectiveness in a given situation.

The Ocean Dumping Control Act prohibits the deliberate disposal of substances from ships, aircraft or platforms. It does not, however, apply to accidental discharges, discharges incidental to their normal operation, sea and mineral resources exploitation, or discharges necessary to avoid danger to human life, ship, or aircraft. Further, under the Act, the Minister may issue permits for dumping provided such dumping is not prohibited by another act of parliament.

The Canada Ports Corporation Act, in replacing the National Harbours Board Act, does not specifically deal with environmental protection, but does provide considerable autonomy for "...the direction, conduct and government of the local port corporation and its employees, and the administration, management and control of the harbour, works and property..".

Under the Government Harbours and Port Facilities Act the Governor-in-Council may similarly regulate all works and operations and provide for any protection of persons within the limits of any public harbour or at any public port facility.

Provincial Legislation

The Pollution Control Act prohibits the direct or indirect discharge of contaminants into any water body without a permit. A referral system requires the Comptroller of Water Rights, the Ministry of Agriculture, the Ministry of Health, and the Ministry of Environment to be notified and sent copies of applications to discharge wastes. The federal Department of Fisheries and Oceans usually co-operates in the setting of terms of permits in order to protect fishery concerns. Pollution control objectives are published for forest products, municipal discharges, food processing, mining, and chemical and petroleum products. They are used primarily as guidelines and have minimal legal force. Landfill sites are also regulated by permit.

The Health Act establishes local Boards of Health comprised of the municipal council. The boards have relatively wide powers to deal with nuisances that relate to public health. An official notice to terminate a nuisance is required before action can be taken under the Act. The discretionary power is held by the Minister and the local board. The Municipal Act deals with nuisances that may not directly involve the public health.

4.8.4 MARINE BIRDS

Legislation - The primary protection for marine birds in Canada is the Migratory Birds Convention Act of 1917. Several of the fifteen orders represented by this Act are identified in Table 36. The Act affords protection of waters frequented by migratory birds, while the Migratory Bird Regulations prohibit the deposit of oil, oily water and other substances in waters frequented by birds. Further, the Regulations prohibits the disturbance of bird nests and shelters except in accordance with a permit. The Canada Wildlife Act authorizes the acquisition of lands for wildlife research and conservation; the establishment of bird sanctuaries is authorized by the Migratory Bird Sanctuary Regulations, and on federal lands, the Wildlife Area Regulations establish wildlife areas in which public use and activities may be restricted. Within this study area, some protection is also afforded marine birds by the presence of Pacific Rim National Park, established under the National Parks Act.

Provincial legislation encompassing the protection of marine birds and their habitat is the Wildlife Act, which provides for the designation, acquisition, management and protection of wildlife habitat; and the Ecological Reserves Act which provides habitat and inviolate protection to a number of major breeding colonies in British Columbia. Indirectly, the Environmental Management Act affords protection by providing for the development of management plans and environmental guidelines, the means to investigate environmental

TABLE 24 REPRESENTATIVE TAXONOMIC BIRD GROUPS PROTECTED UNDER THE
MIGRATORY BIRDS CONVENTION ACT

<u>Order</u>	<u>Family</u>	<u>Genus</u>	<u>Species</u>	<u>Common</u>
Gaviiformes	Gaviidae	Gavia	artica	Arctic Loon
Podicipediformes	Podicipedidae	Aechmophorus	occidentalis	Western Grebe
Procellariiformes	Hydrobatidae	Oceanodroma	leucorha	Leach's Storm Petrel
Ciconiiformes	Ardeidae	Ardea	herodias	Great Blue Heron
Anseriformes	Anatidae	Oor	buccinator	Trumpeter Swan
		Anas	platyrhynchos	Mallard
		Aythya	marila	Greater Scaup
		Melanitta	perspicillata	Surf Scoter
		Mergus	merganser	Common Merganser
Charadriiformes	Haematopodidae	Haematopus	bachmani	Black Oystercatcher
	Charadriidae	Charadrius	hiaticula	Ringed Plover
	Scolopacidae	Calidris	mauri	Western Sandpiper
		C.	alpina	Dunlin
	Laridae	Larus	glaucescens	Glaucous-winged Gull
	Alcidae	Uria	aalgae	Common Murre
		Brachyramphus	marinoratus	Marbled Murrelet
		Cerorhinca	monocerata	Rhinoceros Auklet
		Lunda	cirrhat	Tufted Puffin

SOURCE: Adapted from

Canada, Department of Environment. 1980. Birds Protected in Canada under the
Migratory Birds Convention Act. Occasional Paper Number 1. Canadian Wildlife
Service. Ottawa.

impact and protection issues, the means to prevent environmental damage, and a process for enforcement. Within this study area protection is also afforded marine birds, albeit indirectly, by the Parks Act through the presence of several marine parks.

4.8.5 LOCAL PLANNING

The Regional District of Alberni-Clayoquot has prepared a foreshore plan for Barkley Sound (pending publication in 1984) which designates coastal areas for specific uses and establishes management guidelines for both the protection and development of these areas. (Dryden, 1983, pers. comm.)

Local governments, i.e. regional districts and municipalities, may regulate the use of the foreshore by designating waterfront zones. The regional district has adopted four waterfront zones which are set aside for public, residential, commercial and industrial uses of the waterfront. (Regional District of Alberni-Clayoquot, 1971).

Another means of controlling waterfront development is through the establishment of development control areas. These areas are established to ensure that special precautions and/or protection are provided. Development control areas are based upon Section 717 (Development Permits) of the Municipal Act which states in part that "Permits may require the preservation or dedication of natural water courses and the construction of works to preserve and beautify them in accordance with the terms and conditions specified in the permit and require that an area of land specified in the permit above the natural boundary of streams, rivers, lakes or the ocean remain free of development except as specified in the permit". (Province of British Columbia, 1980).

Regional Settlement and Community Plans

The Municipal Act (Province of B.C., 1980) authorizes local governments to provide five types of plans: regional, official regional, official settlement, community and official community. Each of these plans is designed to fulfill specific goals, objectives and requirements under the Municipal Act. Official plans refer to those plans which have undergone public hearings and have been adopted as by-laws. Unofficial plans, on the other hand, have neither been adopted as by-laws, nor undergone public hearings. They function as an interim means of planning, and provide temporary land designations. They may be dissolved at any time, and have no force or effect under legislation.

Regional Plans

Regional plans as defined under the Municipal Act, are " a general scheme without detail for the projected uses of land within the regional district, including the location of major highways". The regional board can designate a regional plan as an official regional plan. Regional boards are expected, upon completion of an Official Regional Plan, to prepare an Official Settlement Plan (O.S.P.). The O.S.P. encompasses that area of the regional district outside a city, district, town or village, and may apply to all or part of that area. O.S.P.s require the approval of regional council and the provincial Ministry of Municipal Affairs. They must include: the identification of major land useage; the density of residential development; the protection and preservation of special lands, i.e. recreational, hstoric, scientific, and agricultural; the proposed sequence of urban development; and the resultant infrastructure requirements and plans.

Official Community Plans

Official community plans are designed specifically for municipalities, and are approved solely by municipal councils. Under the Act, community plans are defined as an expression of policy for any use of land, including surfaces of water, or the pattern of the subdivision of land. These plans require public hearings before they become official, but the Minister of Municipal Affairs does not need to approve them. The content requirements for these plans are similar to the requirements of the Official Settlement Plans under section 810 of the Municipal Act. They must contain "a statement of broad social, economic and environmental objectives to be achieved by implementation of the plan and a statement of policies of the municipal council on the general form and character of the future land use pattern in the area covered by the plan".

Community Plans

Community Plans refer to working plans that are in the conceptual stages. They are neither regulated by by-law nor approved by council. The Ministry of Municipal Affairs discourages their use.

This report is only part of the documentation available. Other sections of the Coastal Resources Folio, Barkley Sound-Alberni Inlet, include: Introduction, Coastal Resource Map Series (1:50,000), Tables, Sources, and Glossary.

SECTION 5: SOURCES

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**LANDS DIRECTORATE
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5.1 COASTAL RESOURCES MAP SERIES

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SECTION 6: GLOSSARY

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6.1 INTRODUCTION

The Glossary section will aid the reader in understanding some of the terms used for this folio. They are generally accepted definitions in common use on the coast of British Columbia. The listing is not exhaustive, but instead, defines key terms that may cause the most problems in interpretation.

6.2 SELECTED DEFINITIONS FOR LAND USE AND STATUS THEMES

6.2.1 Economic Setting

Basic refers to an economy which exports its raw materials outside the region of origin for manufacturing.

Economic Development Commissions are advisory bodies under the jurisdiction of regional districts established for the purpose of bringing people together and enabling development activities to take place, at the same time improving the economy.

Economic Profiles are economic reports published by economic development commissions which provide an analysis of socio-economic conditions in regional districts.

Labour force participation rate is the proportion of the labour force which is actively employed.

Occupational structure refers to the occupations which make up a region's labour force.

Primary Industries are those industries which are engaged in the extraction of raw materials, i.e. logging, fishing, mining.

Processing Industries refers to those industries which are involved in the manufacturing of goods from their raw state to a secondary stage, i.e. fish canning, sawmills.

Resource-based Industries refers to those industries which harvest or exploit natural resources, e.g. fishing, forestry, mining, agriculture.

Retail and Service Space is the sum total floor space devoted to retail and service businesses.

Retirement Industry refers to the business, income and employment generated from people of retirement age.

Secondary Industries are those industries involved in the manufacturing or processing of raw materials.

Total Capital Value is the dollar value of the sum of accumulated goods devoted to the production of other goods.

6.2.2 Fisheries Section

Angler Days are the number of days fishermen spend fishing.

Average Landed Value is the price paid fishermen for their fish.

Fresh Dressed Salmon refers to salmon which are gutted, but are not frozen.

Sport Fishing Effort refers to the amount of time fishermen spend fishing, e.g. angler days.

Fisheries Statistical Areas are areas designated for the purpose of collecting statistical information on fish catch and value. They were designated by the Department of Fisheries and Oceans.

Wholesale Value refers to the price of fish after processing, i.e. canning.

6.2.3 Generalized Zoning and Marine Facilities

Agricultural Land Commission Act was promulgated in 1977 to freeze the development of all farmland in British Columbia, at which time the Agricultural Land Commission was established to act as the agricultural zoning authority.

Agricultural Land Reserves are designated zones whereby all property, whether public or private, can be used only for agricultural purposes, except as permitted under the Agricultural Land Reserves Act.

Bulk Storage Facility is a storage facility for the containment of bulk commodities like oil, gas and diesel fuels.

Generalized Zoning refers to the grouping of similar land use zones into one general category which is representative of all the zones, e.g. service commercial, retail commercial, and recreational commercial = commercial.

Marine facilities refers to structures which are located on or near the foreshore to enable access to water, e.g. marinas, wharfs, bulk storage facilities.

Regional Districts are established to carry out specific functions which are regional in nature, such as the provision of water and sewer services and regional land use planning.

6.2.4 Land Water Status

Forest Management Units are the forest areas for which the B.C. Forest Service has management responsibility.

Public Sustained Yield Unit is an area designated and managed by the B.C. Forest Service, which provides forest companies with an annual allowable cut.

Status refers to the ownership and/or administration of land and water.

Timber Licences are tenures which give the holder the exclusive right to harvest all merchantable timber in an area of Crown land during the term of the licence. The licence requires five-year management and working plans. It grants the exclusive right to harvest timber under cutting permits.

Timber Supply Areas encompass all categories of timber tenures and are designed to estimate forest yield.

Tree Farm Licence is an amalgamation of Crown and private lands into a management unit and is usually held by a large forest products company.

6.2.5 Land and Water Use Plans and Proposals

The Municipal Act establishes municipalities and regional districts and requires them to do those things specified and no other. Municipalities are autonomous as far as land use decisions are concerned except when land is in the Agricultural Land Reserve or is in a flood plain, or when the Controlled Access Highways Act applies.

6.4 SELECTED DEFINITIONS OF SHOREZONE THEMES

anthropogenic - man-made or man-modified features; includes those constructed by man (docks, marinas), and those removed or deposited by man (riprap, seawalls).

apron - cliff - two or more coalescing fans (see fan) or a simple talus slope.

bar - a ridge of unconsolidated materials built by waves and/or currents, generally running parallel to the shoreline, and can be either inter-tidal or subtidal.

beach - a) a deposit along a shore extending between inner and outer limits of active wave transport. Textures and sorting of materials is variable.

b) the area extending from the limits of storm wave influence to a depth where wave-produced entrainment ceases, except at times of extraordinary sea state.

beach face - the sloping surface of a beach in the zone subject to wave uprush (see Figure).

berm - an accumulation of unconsolidated material above the mean high water level on beaches. The berm is flat, of variable width and characterized by a marked break in slope at the seaward edge (see Figure).

biogenic - materials or deposits produced by plant and animal organisms excluding man.

blowout dune(s) - generally, a sand ridge with a depression on the windward side; the depression is a result of sand removal by wind; the sand accumulates downwind to form the ridge.

cave(s) - a subterranean hollow space in a cliff formed by the action of waves or weathering.

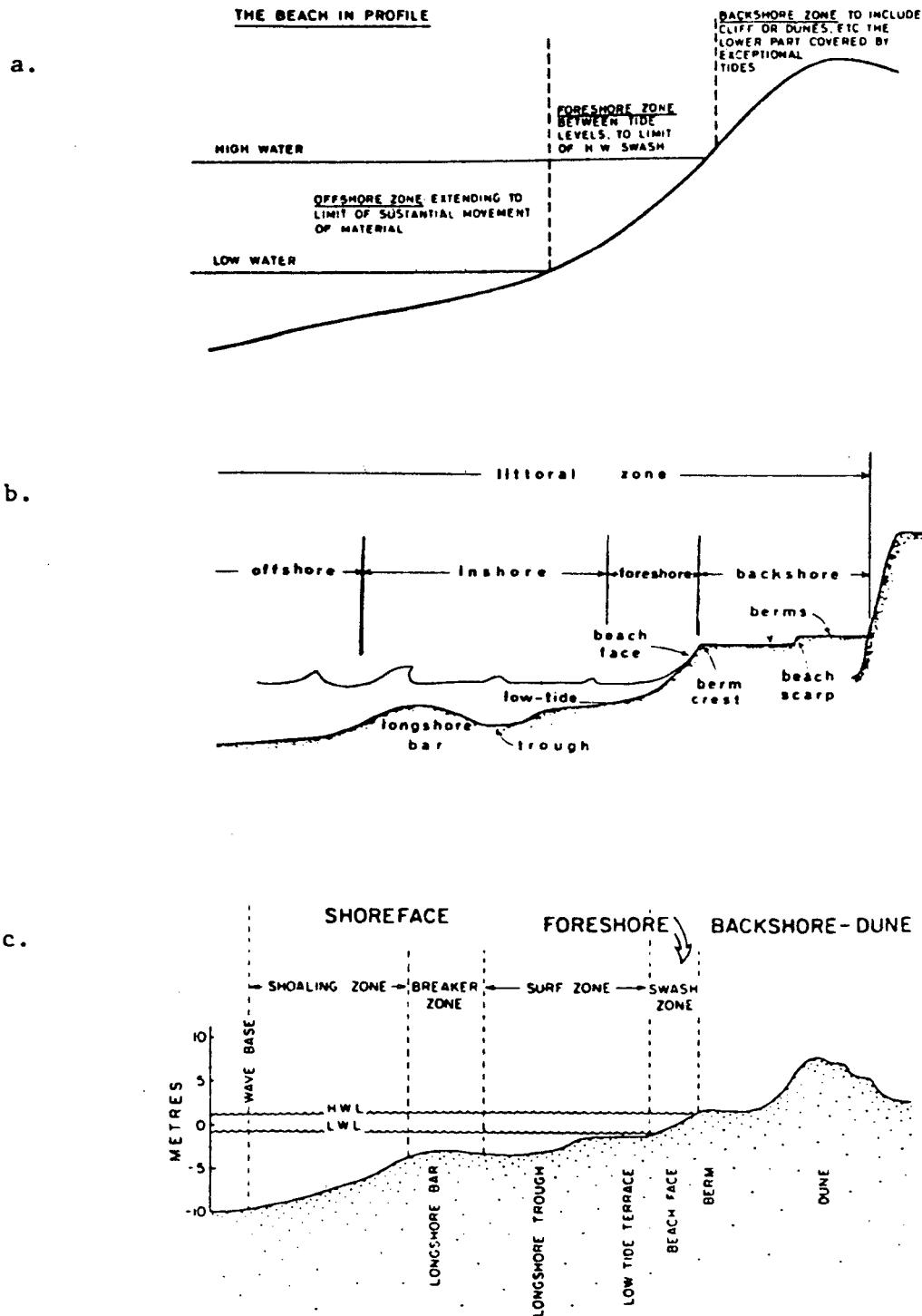
channel(s) - a) delta - a linear feature periodically or continuously containing running water over a delta; it has a bed and banks.

b) river - linear feature which contains the majority of stream or river flow to the shoreline; can be a single channel or a complex system of channels separated by river bars.

c) tidal - a linear feature that dissects the tidal flat surface and is formed by tidal currents; it has a definite bed and banks.

chaotic forms - dunes, ridges and depressions with multi-directional slopes of sand in plan an assemblage of non-linear, generally non-repetitive forms whose local relief is greater than 1 metre.

clastic - materials made up of fragments of rock of any size or shape.



Beach profile terminology; a. after King (1972),
b. after Komar (1976), c. after Reinson (1979).

SOURCE: S.B. McCann, 1980. Shortcourse Lecture Notes Basic Nearshore Processes. National Research Council Canada. Ottawa.

- cliff - a uniform or irregular sloping face, greater than 20° made of bedrock or unconsolidated materials or both.
- debris - mixture of unconsolidated materials (gravels, soils) and man-made materials or refuse such as old building materials and metal products.
- delta - an accumulation of silt, sand or gravels at the mouth of a river or stream where it discharges into the sea, or in tidal channels by flood and ebb tidal streams. Surfaces may be level to inclined and be dissected by one or more channels. Their form is variable from fan-shaped to elongated.
- dolphin(s) - a cluster of pilings, made of lumber or concrete, driven into the seabed for support or protection.
- dune(s) - a mound or ridge, or a collection of mounds and ridges, formed by wind action on sand.
- ebb-tidal - delta - a delta formed by currents generated by falling tides.
- fan -
a) delta - a fan-shaped accumulation of river/stream derived deposits of slope angles greater than 5° .
b) cliff - a fan-shaped accumulation of unconsolidated materials (sand, gravels or rubble) at the base of a cliff derived from mass movement processes affecting the cliff face.
- fetch - distance over which no, or negligible, obstruction interferes with the friction effect of wind against the surface of a water body. Also fetch length.
- flats - tidal - a flat or gently sloping surface (less than 5°) exposed during low tide and derived from tidal processes; usually consists of fine sediments (muds) with or without organic detritus (see also channels, tidal).
- flood-tidal - delta - a delta formed by currents generated by a rising tide.
- foreshore - the zone between the high water line and the low water line. See also intertidal.
- groin (groyne) - low artificial wall of durable material extending from land into water for a particular purpose, such as interfering with the transport of bed load by currents, or protection of a segment of coast.
- high tide platform - rock - a platform extending from the mean water line landward to the high tide line. See also low tide platform, platform.

- inclined - a) beach - a sloping deposit of coarse-textured materials derived from non-marine processes upslope, or, a sloping, fine-textured deposit in sheltered environments, generally the result of tidal, rather than wave, action.
b) cliff - a cliff of slopes between 20° and 35° .
- intertidal - the zone between the high, high water line and the low, low water line. See also foreshore.
- irregular platform - rock - platforms with hummocky surface topography with local relief of greater than 1 metre.
- jetty - a structure extending into the sea designed to prevent shoaling of a channel; usually built at the mouth of a river or tidal inlet to help deepen and stabilize a channel.
- lagoon - shallow stretch of water isolated from the open sea by a barrier but with connection to the sea. Lagoon deposits tend to be fine-textured, except near channels where coarser textures predominate.
- levee - a) delta - a berm or bank of unconsolidated materials raised above the surface of the delta and adjacent channel.
b) tidal flat - a berm or bank of unconsolidated sediment formed beside a tidal channel; it is elevated above the general level of the surface.
- low tide - platform - rock - a platform extending from low water line to the mean water line.
- organic litter - vegetative matter, excluding trees; includes wood detritus, seaweed accumulations and/or marsh plant accumulations.
- platform - rock - a level or inclined surface, less than 20° , formed by long-term marine erosional processes; primarily bedrock, but can have some overlying sediments.
- raised - a) beach - beach deposits that are currently above the limit of storm waves; can result from low sea levels or tectonic uplift.
b) delta - a delta deposit above the high tide line that is no longer accumulating; can result from tectonic uplift or lower sea levels.
c) platform - a platform above the limit of storm waves and no longer subject to marine processes.
- ramp - a) boat - a slope, generally concrete, for launching small boats.
b) platform - regional slope angles of between 5° and 20° on bedrock.
- relict - a cliff, presently above the limit of storm waves, but at one time was produced or affected by marine and mass movement processes; can result from tectonic uplift and/or lower sea levels.

- ridge and swale - dunes - narrow, elongate sand ridges with steep slopes and intervening hollows; an assemblage of linear ridges and hollows with local relief greater than 1 metre.
- seastack - tall, isolated column of rock resulting generally from wave processes that have detached it from a nearby sea cliff.
- shellhash - broken shell material that has accumulated to such a degree that it is an integral part of the beach sediments; variable texture.
- shellpile - a) a recent accumulation of waste shells and shell fragments as a result of commercial shell fishery.
b) a historical deposit of shell refuse associated with man's use of the shellfish resources - Indian shell middens.
- spit - a small point composed of sand and/or gravel projecting from the shore into a body of water; the part exposed above the high water line.
- storm ridge - beach - linear or elongate ridge of coarse-textured beach materials found at the highest level of a beach profile; formed by storm wave processes.
- subtidal - the zone that extends from the low, low water line seaward to the -20 metre isobath.
- supratidal - the zone that extends landward from the high, high water line; landward limit may be established by any one of the following:
1) top of a coastal cliff;
2) to the line of permanent terrestrial vegetation;
3) the landward limit of extreme marine or tidal processes.
- terrace - a) beach - an accumulation of beach materials extending from the low tide line landward to the base of the beach face; usually less than 3%.
b) cliff - alternating steep faces and horizontal or gently sloping surfaces, the steep component is usually more extensive.
c) platform - alternating horizontal or gently sloping surfaces and low, steep faces (less than 2 metres); the horizontal component is more extensive.
- tidepools - pools of seawater remaining in depressions on the surface of a platform at low water.
- tombolo - a spit or beach that extends from the mainland of an island to another island, so that it becomes tied to the shore; part exposed above high water line.
- trench - a long, narrow excavation across the foreshore; or an excavation to provide moorage for small boats in shallow water other than marinas.

veneer - unconsolidated materials of less than one metre thickness overlying bedrock or another different textured material.

washover channel - a channel formed by the advance of seawater beyond normal limits, usually during storms and/or tidal surges in advance of storms, specifically across beach, spit or low dune deposits; also an area where temporary submergence has occurred.

washover fan - a usually fan-shaped deposit on the landward side of a washover channel as a result of sediment being carried through the channel; active while the channel is active.

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