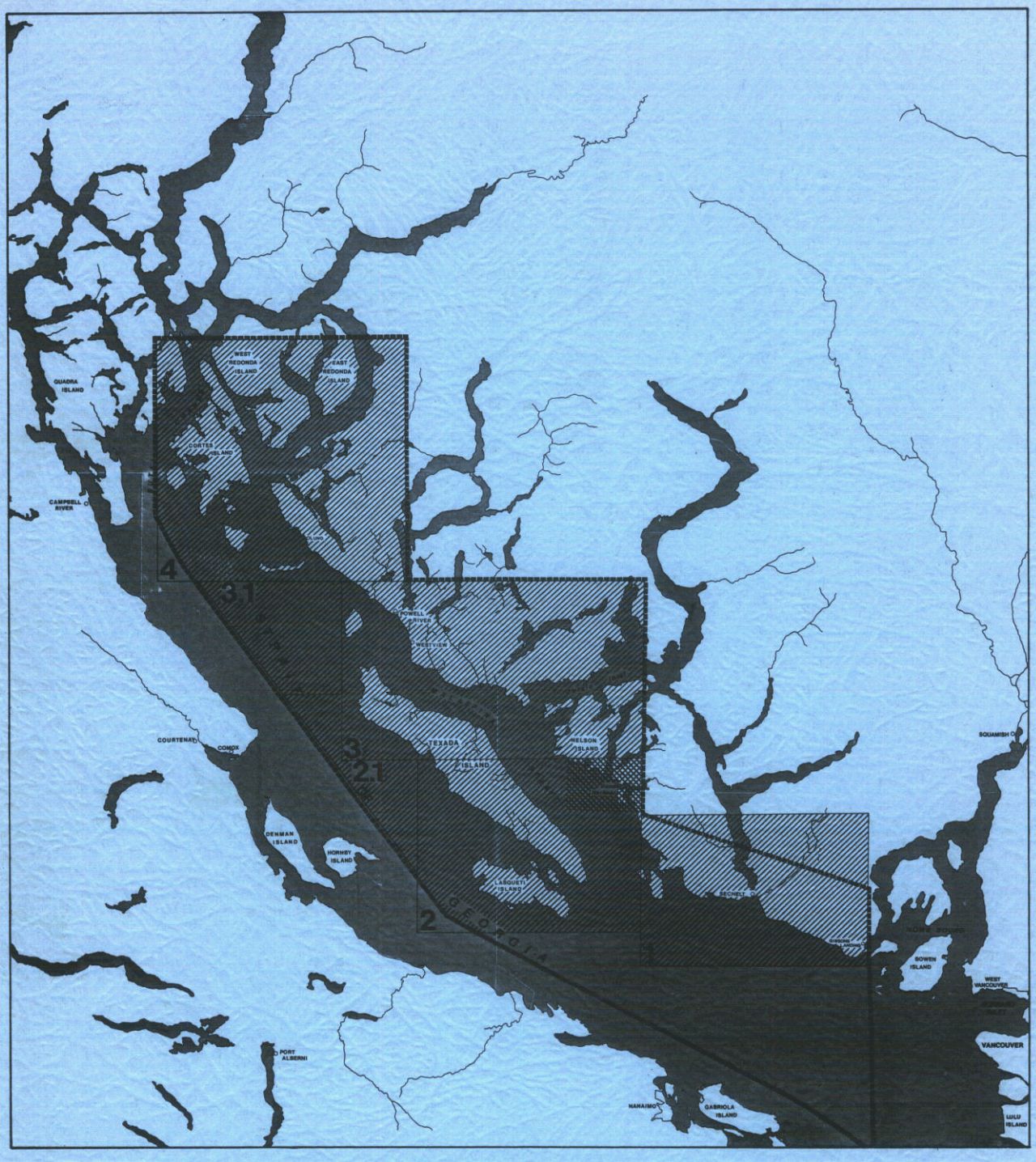

COASTAL RESOURCES FOLIO

SOUTH MAINLAND COAST

(Gibsons Landing to Redonda Islands)

BRITISH COLUMBIA

VOLUME II

LANDS DIRECTORATE
DIRECTION GÉNÉRALE DES TERRES

Environment Canada Environnement Canada

Canada

COASTAL RESOURCES FOLIO

SOUTH MAINLAND COAST

(Gibson's Landing to Redonda Islands)

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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; South Mainland Coast - is the third of a series for the British Columbia Coastal Zone.

1.2 THE STUDY AREA

The South Mainland Coast resources folio study area extends from Gibsons Landing in the south to the Redonda Islands in the north. The seaward boundary extends westward to the mid-point of the Strait of Georgia.

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.

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 salt-marshes data were supplemented by aerial photo and video tape interpretations. Verification by field checks was limited.

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 17 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 leasholder; 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 PENDER HARBOUR MAP SERIES (1:10,000)

Due to the recognized biological importance, and the intensity of land/water uses associated with the Pender Harbour area, this series provides supplemental and more detailed information.

5.0 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.

6.0 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.

7.0 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 I is an atlas containing Section 1.0 Introduction, Section 2.0 Coastal Resources Map Series, Section 3.0 Tables, and Section 4.0 Pender Harbour Map Series. Volume I consists of four separate folios - one for each of the four 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 6.0 Sources, and Section 7.0 Glossary.

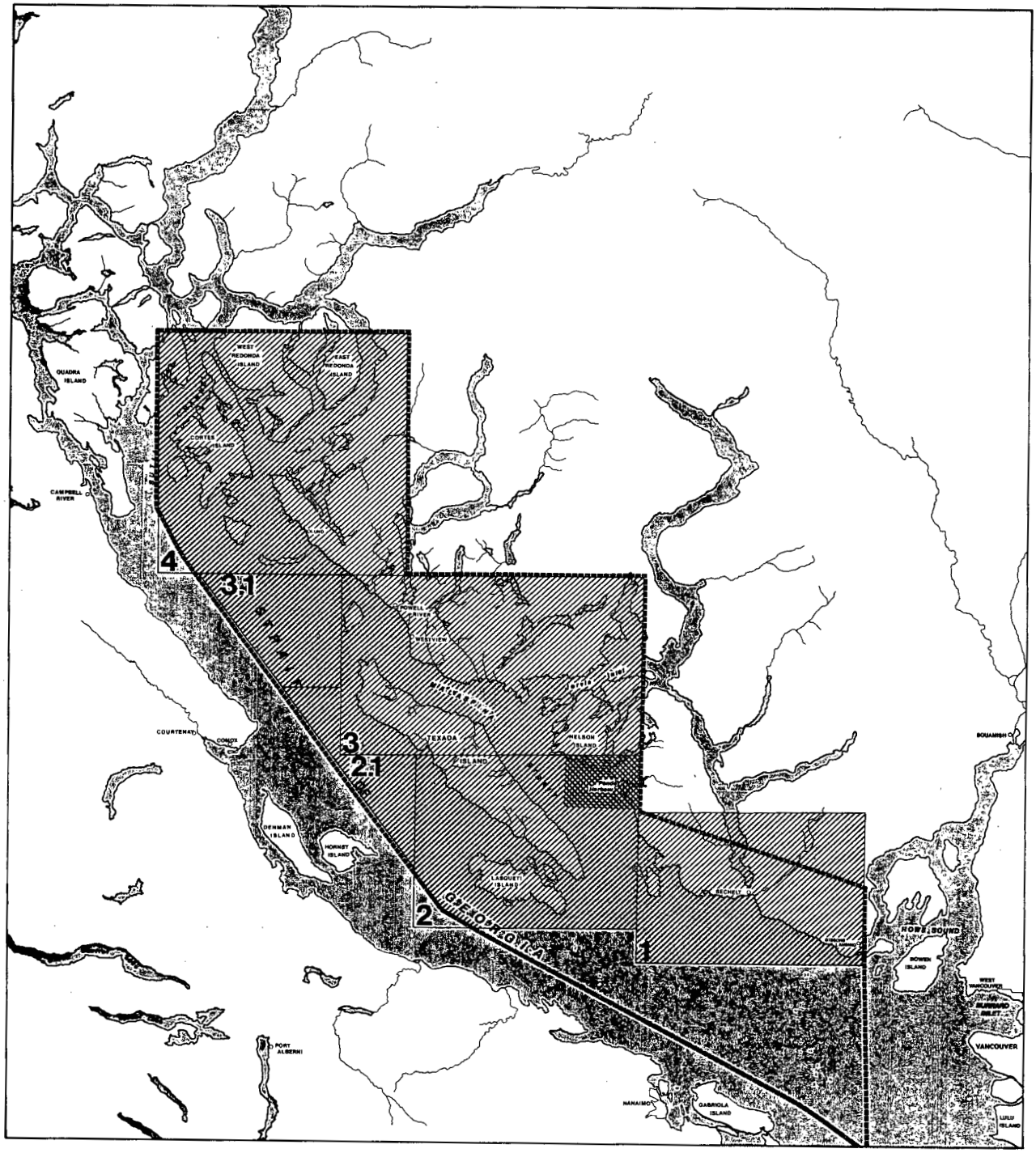
1.6 COVERAGE AND AVAILABILITY

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 four base maps.



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, 2.1, 3, 3.1, 4	-1 Marine Sediments
1983	1, 2, 2.1, 3, 3.1, 4	-2 Submarine Topography
1983	1, 2, 3, 4	-3 Physical Shorezone
1983	1, 2, 3, 4	-3 Physical Shorezone Units Table
1983	1, 2, 3, 4	-4 Generalized Terrain Limitations
1983	1, 2, 3, 4	-5 Physical Oceanography - Station Distribution
1983	1, 2, 3, 4	-6 Physical Oceanography - Station Summary Table
1983	1, 2, 3, 4	-7 Water Resources - Discharge, Use and Contamination
1983	1, 2, 3, 4	-8 Seaweeds, Saltmarshes and Marine Mammals
1983	1, 2, 3, 4	-9 Marine Bird Surveys
1983	1, 2, 3, 4	-10 Fish and Shellfish Resources
1983	1, 2, 3, 4	-11 Fish Spawning and Rearing Areas
1983	1, 2, 3, 4	-12.1 Generalized Zoning and Marine Facilities
1983	2, 3, 4	-12.2 Land/Water Use
1983	1, 2, 3, 4	-13 Land/Water Use Plans and Proposals
1983	1, 2, 3, 4	-14 Selected Administrative Boundaries
1983	1, 2, 3, 4	-15 Land/Water Status
1983	1, 2, 3, 4	-16 Forest Cover
1983	1, 2, 3, 4	-17 Recreational Areas, Special Features and Access

For example 83-3-1 refers to base map number 3, Marine Sediments 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 Theme Maps (Pender Harbour Series)

The following theme maps have been prepared:

83.1 Physical Shorezone

83.2 Fish and Shellfish Resources

83.3 Fish Spawning and Rearing Areas

83.4 Land/Water Status

When ordering, please quote year of publication and theme map number.

1.6.1.5 Report

Volume II provides coverage for the entire South Mainland Coast (Gibsons Landing to Redonda Islands) 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) and Section 3.0 Pender Harbour Series (1:10,000) Manuscripts can be ordered as either ozalids (paper prints) or as films (diazo 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 (diazo 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 Report	Limited number of copies available free of charge.		

* Prices subject to change.

SECTION 5: COMPANION REPORT

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LANDS DIRECTORATE
ENVIRONMENT CANADA
VANCOUVER, B.C.

January 1984

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5.1 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 study area extends from Gibsons Landing in the south to the Redonda Islands in the north. The seaward boundary extends westward to the mid-point of the Strait of Georgia. The landward boundary extends to approximately the 150-metre elevation.

5.2 GENERAL SETTING

5.2.1 POPULATION

The study area covers all of the Powell River Regional District and parts of the Comox-Strathcona and Sunshine Coast Regional districts. Over 35,000 people inhabit the area (Table 1). Like other coastal regions of B.C., settlement has occurred in a linear strip along the coast. The Municipality of Powell River is the largest urban centre.

5.2.2 LABOUR FORCE

The Sunshine Coast Regional District

Hall, Strong and Associates (1980), document the Sunshine Coast region labour force prior to 1980. In 1979, labour force participation (the proportion of the labour force which is working) was low compared to other regional districts throughout the province. Hall, Strong and Associates (1980) attribute this to the large retirement population and the lack of female employment opportunities. The seasonal nature of tourism, fishing, and the semi-retired labour force are also thought to affect employment levels.

In 1981, the Sunshine Coast Regional District labour force was estimated at 6,960. Almost half of the labour force is employed in tertiary industries, of which community business and personal services provide the most jobs. Primary and secondary industries employ only 15%.

TABLE 1

POPULATION OF REGIONAL DISTRICTS

1981

Sunshine Coast Regional District		Population
Electoral area	a	1,846
	b	2,265
	c	2,690
	d	1,739
	e	1,926
	f	1,428
	Gibsons	2,609
	Sechelt	1,096
TOTAL		15,599

Powell River Regional District		Population
Electoral area	a	1,437
	b	1,149
	c	1,893
	d	1,146
	e	316
Powell River		13,423
TOTAL		19,364

Comox-Strathcona Regional District	Population
Cortes Island Electoral Area I	643
Redonda Islands[1]	100
TOTAL	743

Source: Statistics Canada, 1983. Census Data for 1981.

1. Estimated population given by Comox-Strathcona Regional District.

Powell River Regional District

Boyer, Ladret, and Gillies (1977) provide an account of labour force characteristics in the Powell River region prior to 1977. In 1981, the regional district labour force was estimated at 8,990. About 40% of the labour force is employed in tertiary industries. Half of these employees are engaged in community, business and personal service occupations. Another third of the labour force is employed in manufacturing industries. The majority of them are employed at MacMillan Bloedel's wood processing operations at Powell River.

5.2.3 FORESTRY

The Resource Base

The study area covers approximately 242 000 hectares of land, of which about 220 000 hectares are classified as forest land. Immature timber accounts for 80% of the forested land, mature timber accounts for 15% and poor quality timber and stands of non-commercial value account for the remainder (Table 2). Crown land is composed of the Sechelt, Powell and Toba provincial forests, which are administered by the B.C. Forest Service. The Service also administers timber tenures in the Quadra timber supply area, which is composed of the Powell River, Sechelt and Jervis timber supply blocks. MacMillan Bloedel is the major private holder, operating Tree Farm Licence 39 and Tree Farms 47 and 19.

The Sunshine Coast

The B.C. Forest Service (1982) reported four shake and shingle mills and six sawmills in operation. The shake and shingle mills produced an estimated 19.336 thousand board feet (MBM) of shakes and shingles; the sawmills produced 1,859 MBM of lumber.

Logging operations employ between 330 and 390 people, the majority (about 300 on average) are employed by just four companies: B.C. Forest Products, Canadian Forest Products, Weldwood, and O.B. Jervis (Hall, Strong and Associates 1983).

Powell River Regional District

In 1982, six shake and shingle mills were in operation, four of which were reported to have produced 1750 MBM of shakes and shingles. Eight sawmills were in operation, seven of which produced 87,232 MBM of lumber. (B.C.F. 1982).

The MacMillan Bloedel pulp and paper mill is one of the largest in North America. The mill produced over 500,000 tonnes of newsprint, and 50,000 tonnes of air dried pulp in 1983. Also, 83 MBM of lumber were

TABLE 2

FOREST COVER CLASSES (IN HECTARES) FOR THE SUNSHINE COAST AND POWELL RIVER REGIONS

Base Maps	Immature	%	Mature	%	Residual	%	N.S.R.	%	N.C.	%	Total Forest	Non-Forest	Total Land
No. 1	45 413	80.4	7 313	15.1	438	.7	1 979	3.5	1 214	2.1	56 468	5 043	61 511
No. 2	26 648	77.7	5 531	16.1	1 063	30	1 034	30	29	.08	34 305	3 452	37 757
No. 3	49 934	88.2	5 130	9.0	939	1.7	605	1.1	7	.01	56 615		
No. 4	54 104	74.3	15 632	21.5	2 284	3.1	819	1.1	-		72 839	7 220	80 059
Total	176 099	80.0	33 717	15.3	4 724	2.1	4 437	2.0	1 250	.56	220 227	21 799	242 026

Source: B.C. Forest Service, 1983. Burnaby.

cut and dressed. The mill employs approximately 2,200 people. (MacMillan Bloedel, pers. comm. 1983).

Canadian Forest Products and Weldwood of Canada are the two main logging operators in the area; both companies, when active, employ about 80 people. (Marshall, Macklin, Monaghan, 1983).

5.2.4 FISHERIES

In 1980, 286 commercial fishing vessels were registered in the study area (Fisheries and Oceans, 1983). A total of 504 fishermen were employed on board these vessels. In 1981, there were nine fish processing plants in operation (Table 3). Table 4 lists the 1981 wholesale value of sea foods produced in the Sunshine Coast region.

5.2.5 AGRICULTURE

In 1981, 122 farms were operating and had a total capital value of $24,719,186. (see Table 5a), with sales of $792,950. in produce. Individually, the majority of the farms sold less than $10,000 of produce, and were small holdings (under 28 hectares), that supplied local markets. (See Table 5b).

By April 1, 1980, 4 332 hectares of land in the Sunshine Coast Regional District and 10 813 hectares in the Powell River Regional District had been designated as Agricultural Land Reserve. (B.C. Agriculture, 1980).

TABLE 3

FISH PROCESSING PLANTS
SUNSHINE COAST - POWELL RIVER REGION
(1981)

Name	Location	Products
Suncoast Salmon Ltd.	Sechelt	Salmon
Sunshine Coast Oyster	Sechelt	Oysters
Tyee Products Ltd.	Sechelt	Bait
Totem Oyster Co.	Egmont	Oysters
Harmony Sea Foods Ltd.	Egmont	Oysters and clams
Seaman Hope Fisheries	Egmont	Oysters, Clams, mussels
Westview Fisheries Ltd.	Powell River	Salmon, groundfish, prawns, geoducks
Sliammon Indian Seafoods	Powell River	Salmon, herring, groundfish, oysters, clams
Tidal Rush Marine Farms Ltd.	Powell River	Salmon

SOURCE: British Columbia, Ministry of the Environment, Marine Resources Branch. 1982. Trevor Proverbs, personal communication.

TABLE 4

WHOLESALE VALUE OF SEAFOOD PRODUCTION IN COMPARISON TO PROVINCIAL TOTALS

	Vancouver		Vancouver Island		Sunshine Coast[1]		Central & North Coast		Total B.C.
Product	$ Value	% of B.C. Total Fish Value	$ Value	% of B.C. Total Fish Value	$ Value	% of B.C. Total Fish Value	$ Value	% of B.C. Total Fish Value	$ Value
Fresh Dressed Salmon	4,858,309	74.4	1,238,729	18.9	292,424	4.4	141,373	2.2	6,530,835.
Little Neck Clams	73,203	21.4	256,048	75.	12,078	3.5	-	-	341,329.
Oysters--fresh	-	-	1,089,682	84.6	197,473	15.3	-	-	1,287,155.
Prawns(frozen)	640,215	59.9	12,552	1.2	371,314	34.7	44,401	4.1	1,068,482 .
Geoduck Clams meat--frozen	15,923	97.6	-	-	382	2.3	-	-	16,305.
Geoduck Clams neck meat	1,570,414	60.4	934,781	36.0	92,626	3.6	-	-	2,597,821.
Horse Clams	19,024	43.0	15,286	34.6	9,909	22.4	-	-	44,219.
Herring--bait fresh & frozen	389,028	26.3	641,429	43.3	67,147	4.5	382,758	25.8	1,480,362.
Herring Roe mature	42,408,998	61.02	7,383,245	10.6	21,350	3.0	19,682,348	28.3	69,495,941.
TOTAL	49,975,114	60.3	11,571,752	13.9	1,064,703	1.3	20,250,880	24.4	82,862,449

1. The Sunshine Coast region incorporates the Sunshine Coast and Powell River regional districts plus part of the Comox-Strathcona Regional District.

Source: B.C. Ministry of the Environment, Marine Resources Branch. 1982.

TABLE 5a

NUMBER OF FARMS AND REVENUE

	Powell River	Sunshine Coast
Total number of farms	66	56
Total capital value	$13,493.748.	$11,325,438.
Farm Revenue	$ 433,535.	$ 359,415.

Source: Statistics Canada, 1983. Agricultural Census of Canada - Catalogue 96-11.

TABLE 5b

FARM SIZE

	Powell River	Sunshine Coast	Total
Under 3 acres (1.2 ha) improved	21	11	32
3-9 acres(1.2-3.6 ha) improved	19	27	46
10-69 acres(4.0-27.9 ha) improved	25	15	40
70-129 acres (28.3-52.2 ha) improved	1	3	4

Source: Statistics Canada. 1983. Agricultural Census of Canada - Catalogue 96-911.

5.2.6 MINING

Construction Aggregates Ltd. and Canadian Forest Products are the two main operators in the area: Construction Aggregates exports mostly to the Lower Mainland and sends smaller quantities to Vancouver Island, the North Coast and Alaska (Hall, Strong and Associates, 1980).

Four limestone quarries were in operation on Texada Island in 1982, employing a total of 111 persons. These quarries produce about three million tonnes annually, and are considered to be the largest and most important in the province (Marshall, Macklin and Monaghan, 1983).

5.2.7 TOURISM

The Sunshine Coast is a popular vacation area of British Colunbia due to its scenic beauty and outdoor recreation opportunities. The Powell River area not only provides a variety of recreation resources, but also serves as a gateway for many boaters travelling to northern locations; Desolation Sound and adjacent islands and inlets are favourite destinations.

5.3 PHYSICAL FEATURES

5.3.1 PHYSIOGRAPHY

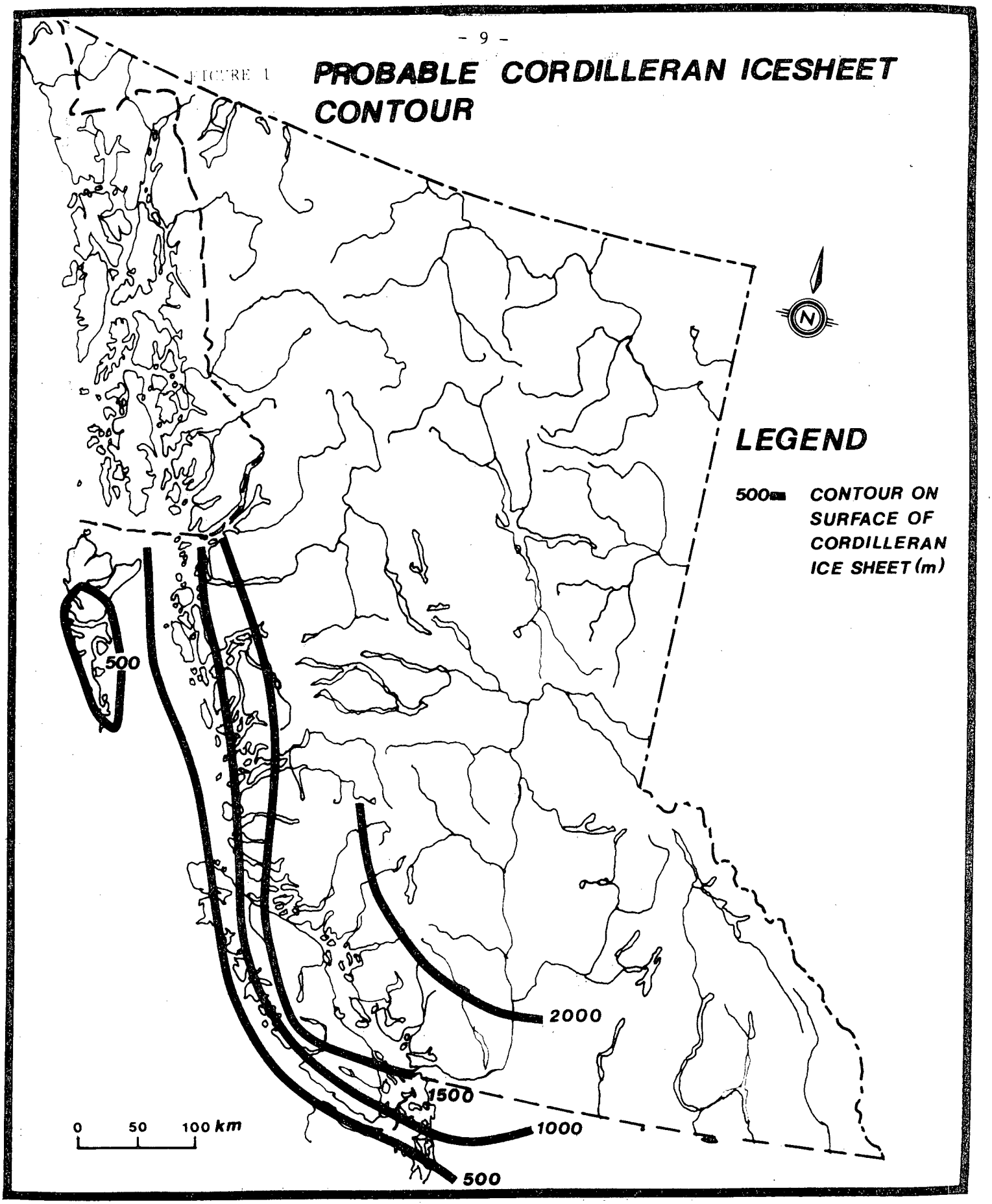
The study area's physiography is the result of repeated glacial and interglacial events of the Wisconsin period; the most recent of which was the Fraser Glaciation (see Figure 1). The lowlands of the study area were submerged for most of this period (Hora and Basham, 1980). Upon deglaciation, the land rose relative to the sea which, for the study area, meant an elevation change of up to 180 metres. Figures 2 and 3 summarize the areas of marine overlap and elevation change for coastal British Columbia. The coastal lowlands bordering the Strait of Georgia are clearly evident in Figure 2.

More specifically, the study area falls within the eastern section of the Georgia Depression, an extensive northwest-southeast coastal trough stretching from Alaska to the Gulf of California (Barker, 1974). The marine component is represented by the Strait of Georgia and contiguous channels. The terrestrial component is represented by the Georgia Lowland and adjacent Coast Mountains.

The Strait of Georgia and Adjacent Channels

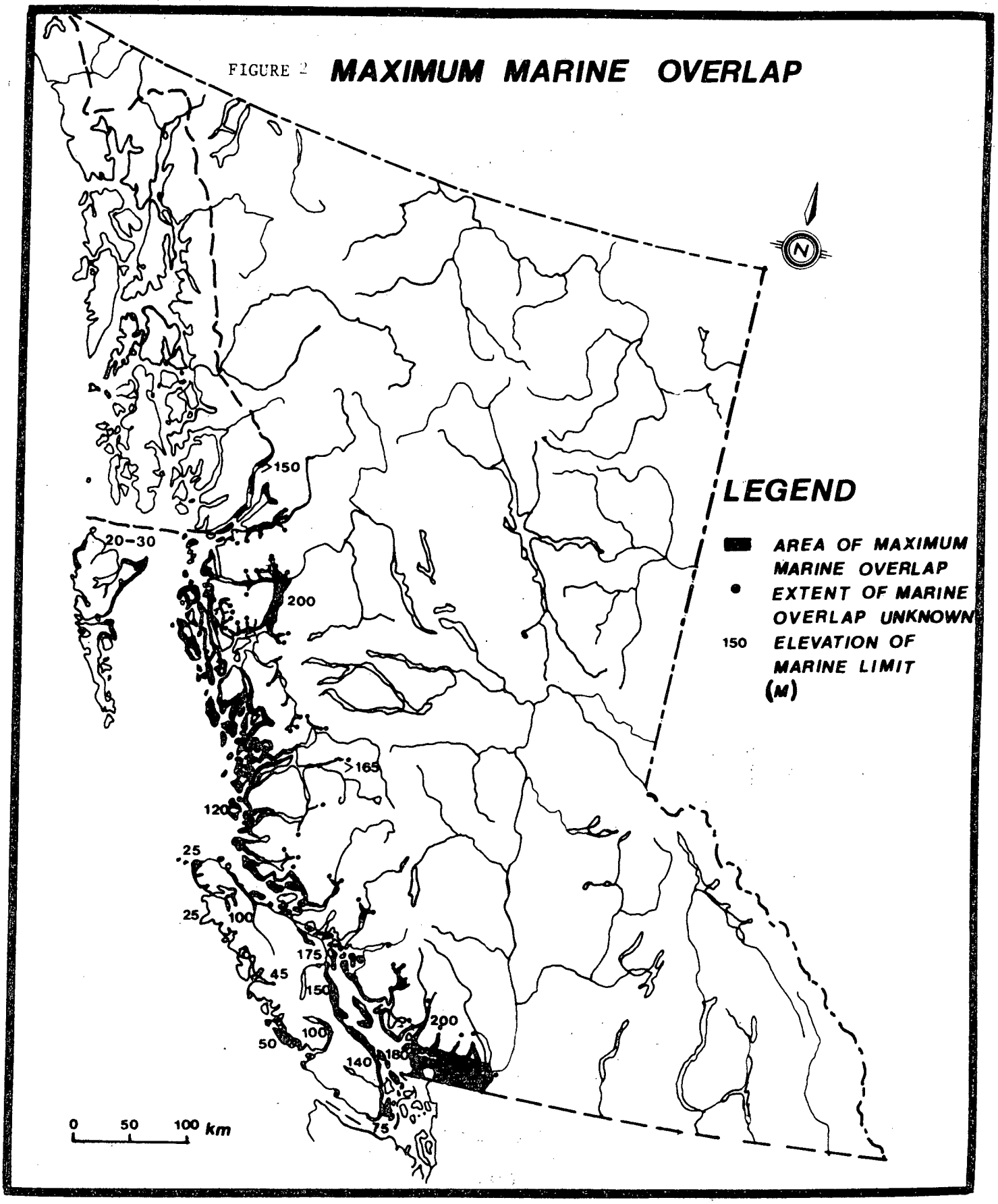
The Strait of Georgia is a semi-enclosed body of water approximately 220 kilometres (km) long with an average width of 33 km. Its mean depth is 157 metres (m) with a maximum depth of 425 m near Texada Island.

FIGURE 1



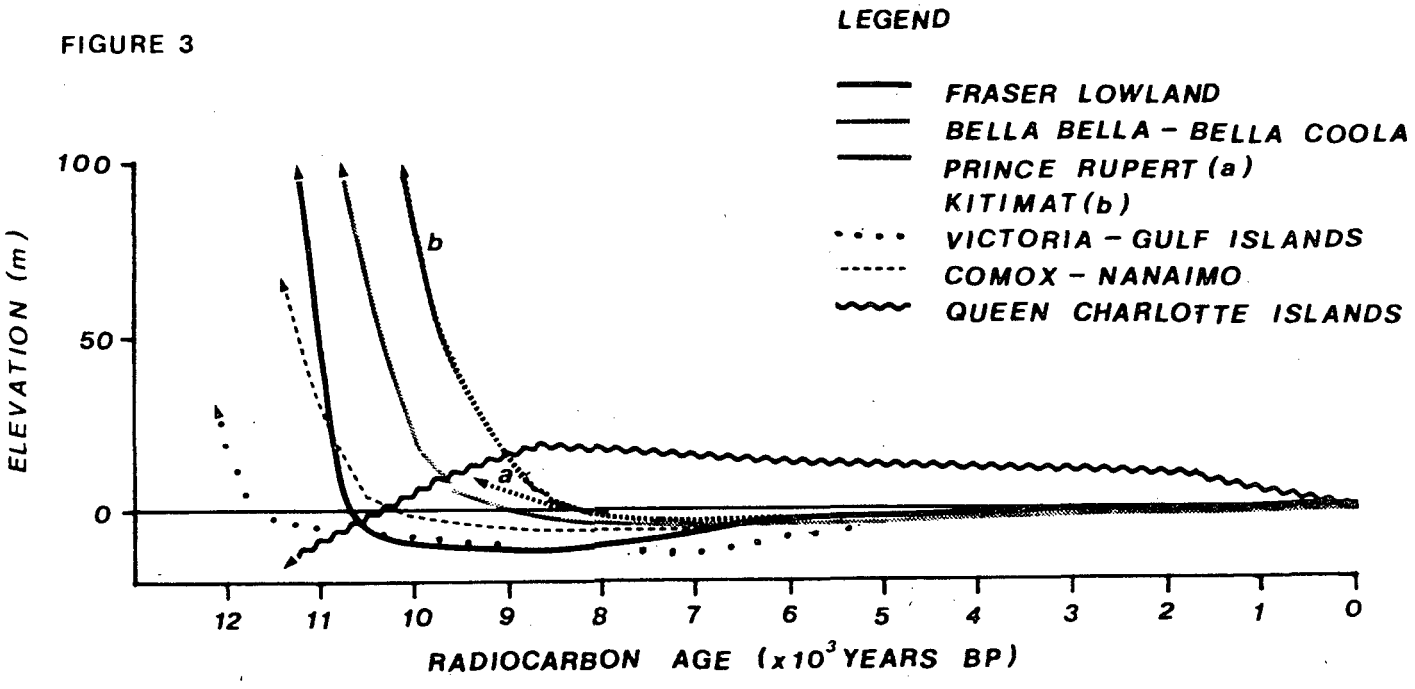
SOURCE: J.J. Clague, J.R. Harper, R.J. Hebda and D.E. Howes, 1982. Later Quaternary Sea Levels and Crustal Movements, Coastal British Columbia. Canadian Journal of Earth Sciences, 19(3). Ottawa.

FIGURE 2 **MAXIMUM MARINE OVERLAP**



SOURCE: J.J. Clague, 1981. Late Quaternary Geology and Geochronology of British Columbia: Part 2 - Summary and Discussion of Radio Carbon-Dated Quaternary History. GSC Paper 80-35. Canada, Department of Energy, Mines and Resources. 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.

The submarine topography of the eastern strait, a series of shallow banks and ridges separated by deep basins and troughs, is generally parallel to the strait axis. These bottom characteristics are a result of the glacial history and recent deposition processes of the region (Clague, 1975). See also the Submarine Topography (1:50,000) map series of this folio.

The channels of the study area, while subject to the same processes, exhibit features characteristic of fjords;

a) They are narrow, commonly under five kilometres in width;
b) They are steep-walled;
c) They are very deep with maximums of greater than 700 metres;
d) They have, in some instances, relatively shallow sills in their lower reaches.

The Georgia Lowland

The Georgia Lowland is of variable width, 5 to 20 km, extending from Sayward south to the Fraser Lowland (Leaming, 1968). It includes Quadra, Texada, Cortes, Lasqueti, Nelson, and the smaller islands of the eastern Strait of Georgia. The lowland features are a result of glacial and marine processes and are characterized by gently sloping, low surface relief. The inland boundary approximates the 600 m contour (Clague and Bornhold, 1980).

5.3.2 GEOLOGY

The glaciers of the last major ice advance began retreating about 15,000 years before present (B.P.) and reached their present extent by about 9500 years B.P. (Clague, 1981). Above 300 m elevation, bare bedrock or veneers of glacial deposits were left, while below that elevation thick deposits of materials derived from glacial, glacio-marine, marine and fluvial processes occur (McCammon, 1977).

Bedrock

The study area is primarily plutonic rock (metamorphic) of unknown age. Granodiorite and quartz diorite dominate this complex. Notable exceptions are Texada and Lasqueti islands, which are primarily basalts and lavas of the Upper Triassic period. Of economic interest are the Triassic limestone rocks on Texada Island.

The most recent generalized mapping of the bedrock geology is found in Roddick *et al* (1979).

Surficial Geology

The unconsolidated surficial materials are primarily of glacial or inter-glacial origin, some of these have been further modified by such marine and fluvial processes as sea-level changes and glacial meltwater. Modern sediments in the study area are represented by channel, floodplain, alluvial fan, deltaic and beach deposits. Colluvial, landslide, and till veneer deposits dominate the mountainous and steep-sloped parts of the study area, while organic deposits have developed in poorly drained depressional areas and at lake margins. The Georgia Lowland is extensively overlain by glacial till of variable texture, depth and surface expression. Below 180 m elevation, the surface has been reworked and modified by marine and glaciomarine processes.

Glaciofluvial land forms, such as terraces, abandoned channels and ice-contact fans are also present, though more abundant in the southern part of the study area.

Spectacular eroding coastal bluffs within the region are predominantly exposures of the interglacial outwash deposit called Quadra sand. It is generally overlain by a till layer with a marine deposit at the surface. Notable examples of these bluff formations are found on North Thormanby, Savary, Hernando and Marina islands.

Accounts of the glacial history, stratigraphy and textures of surficial deposits can be found in Clague (1976) and (1981); surficial geology and stratigraphy has been mapped by McCammon (1977) and Clague (1976); and textural analysis and observed stratigraphy are available in Leaming (1966), McCammon (1977), and Hora and Basham (1980). Reconnaissance terrain inventory mapping has been done for the study area by the British Columbia Ministry of Environment (1980).

5.3.3 SOILS

Soils of the study region are predominantly those of the Brunosolic and Podzolic orders.

Dystric Brunisol soils are found primarily in the south (Gibson's Landing to Sechelt). These soils occur on relatively young geologic sediments and are thought to be in a transitional stage of development. The soil temperature class is mild mesic with a semi-arid moisture regime. The high moisture deficit, dry summer and warm temperatures of the region lead to little chemical transformation which is characteristic of rapidly drained soils. Vegetation provides a thick, poorly decomposed surface layer with little incorporation of organic matter into the mineral soil.

North of Sechelt, humo-ferric podzols predominate. These soils have developed on permeable, coarse-textured glacial till or colluvium parent materials. The soil temperature is mild mesic cool boreal, with a humid soil moisture regime. Similar to Dystric Brunisols, vegetation provides a thick organic surface layer that is acidic and poorly decomposed.

Steep slopes tend to have shallow, coarse textured 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 generally have organic deposits. Glacio-marine and glacio-fluvial deposits (especially terraces) have coarse textured, and very rapidly drained soils on moderate slopes (Frank, 1980).

There appears to be no mapped soils information for the study area. For a general account see Valentine, et al (1978).

5.3.4 CLIMATE

Temperature and Precipitation

The Georgia Lowland and adjacent islands fall within a relatively homogeneous climatic zone. Annual mean temperatures range from 8.8°C at Powell River airport to 10.5°C at Merry Island. Temperature extremes range between -18° to -11°C for lows, while the extreme highs are between 30° and 36°C (Atmospheric Environment Service, 1983). Rainfall is variable throughout the region with a maximum observed mean annual total of 1359 mm at Gower Point while the minimum observed mean annual total was 929 mm on the northwest coast of Texada Island. Increased values would be expected for higher elevations or more inland locations. Port Mellon, slightly inland of the study area, has an annual average of 3110 mm. The majority of this precipitation occurs during late fall and winter months.

Wind Patterns

Wind patterns for the area are controlled by two major factors:

a) the seasonally dominant atmospheric pressure systems;
b) the major topographic features of southwestern British Columbia;

The northwest-southeast orientation of the Vancouver Island and Coast Mountains forces surface winds to blow in either of these two directions. In winter, the Aleutian Low dominates atmospheric circulation over the northeastern Pacific Ocean, southeasterly winds prevail. An Arctic High in the Interior of the province, however, results in strong northeasterly outflow winds down the inlets and valleys to the coast. In summer the Pacific High dominates. Consequently, the prevailing winds are westerly to

northwesterly. The summer pattern is complicated by onshore-offshore winds created by diurnal temperature gradients between the land and water (Schaefer, 1983 pers. comm.).

5.3.5 PHYSICAL OCEANOGRAPHY

Tides

The tidal wave enters the Strait of Georgia via Juan de Fuca Strait and reflects off the north end of the strait, producing a standing wave and a south to north increase in tidal range (Thomson, 1981). The tides range from a 3-metre maximum and a 2-metre mean in southern waters to more than a 5-metre maximum and a 4-metre mean in northern waters. In the Strait of Georgia, the time difference between corresponding tidal heights at any point and Point Atkinson never exceeds 30 minutes. Tides are mixed, mainly semi-diurnal.

Flood tides from the north take about three hours longer to enter the northern Strait of Georgia than do the southern tidal currents. This can create differences in water elevation in passages of up to one metre, thus generating strong currents (Giovando, 1977).

Currents

Waldichuk (1957) divided the Strait of Georgia into northern, central and southern areas based on surface current regime.

Northern

The northern region extends to the southern tips of Texada and Lasqueti islands. The tidal currents are weak (to 10 cm/sec), and highly variable. Speeds rarely exceed one knot, although they may be faster in some channels. Wind-driven currents are also weak, even during strong winter winds, due to the absence of stratification. A counter clockwise drift around the northern part of the Strait has been postulated.

Central

The central region stretches from Texada and Lasqueti islands south to a line joining Point Roberts and the Saanich Peninsula.

The tidal currents are stronger and have a distinct southeast-northwest ebb and flood respectively. The Fraser River, especially during peak run-off, strongly influences this section of the Strait. The upper layer exhibits complex movements under the influence of wind, tides and Coriolis force.

Southern

The tidal currents are stronger and typically greater than one knot. The narrow passages allow tidal mixing. Wind driven currents are significant during summer months when the Fraser River plume extends to this area.

Waves

The Strait of Georgia is fetch and wind duration limited for developing large sea waves (McCann and Hale, 1980). During storm situations, though, fetch and width limitations would be the principal controlling factors (Hale and McCann, 1982). Winds blowing along the axis of the strait can generate waves up to 3 m in open water (Owens, 1977, Hale and McCann, 1982). There is a higher probability of this occurring during winter months than at any other time of the year.

5.3.6 WATER RESOURCES

Hydrology

The study area has a number of freshwater rivers, lakes, and wetlands. Most, however, are characteristically small, Although a snow pack accumulates in the mountain ranges during winter, precipitation in the Georgia Lowland region falls mainly as rain. Consequently, freshet occurs in mid-winter (December and January) when rainfall is greatest. Hydrographs for Lang and Roberts creeks exhibit this trend (Figures 4 and 5). Rivers that are also fed by snowmelt streams exhibit a second peak discharge in late spring. The low flow period occurs during late August and September when some streams are dry or have sub-surface or base flows.

The Georgia Lowland region experiences annual moisture deficits of between 122 mm to 170 mm (see Figures 6, 7, and 8).

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 LANG CREEK
STATION No. 08GB007
REGULATED

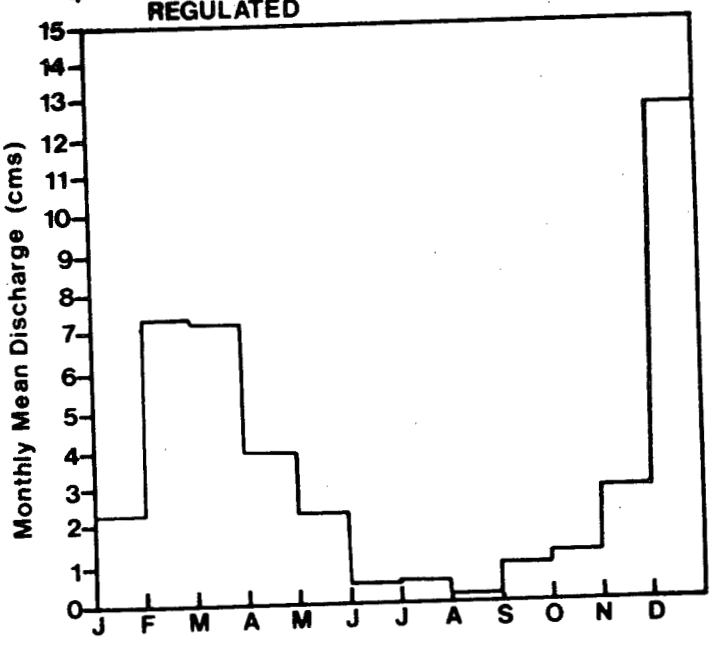
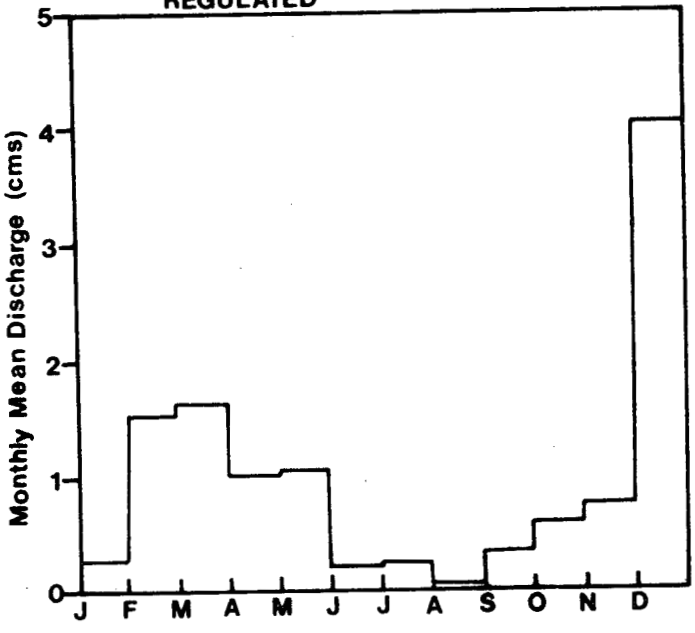


FIGURE 5 :HYDROGRAPH FOR ROBERTS CREEK
STATION No. 08GA047
REGULATED



SOURCE: Canada, Department of Environment, 1981. Historical Streamflow Summaries. Inland Waters Directorate. Ottawa.

Figure 6 Moisture Balance for Cortes Island

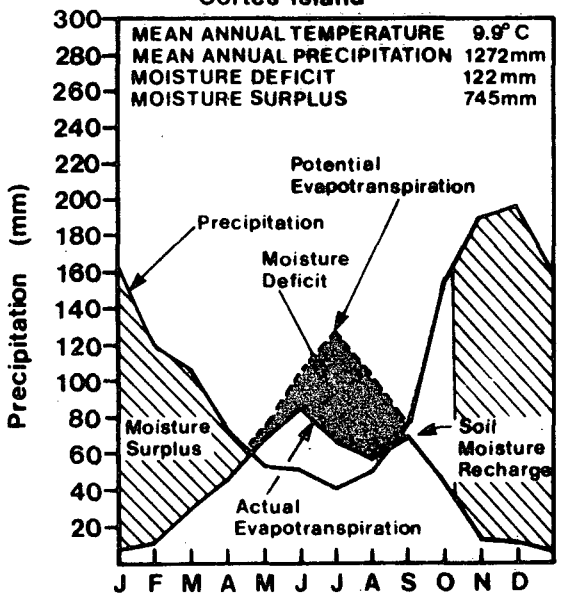


Figure 7 Moisture Balance for Merry Island

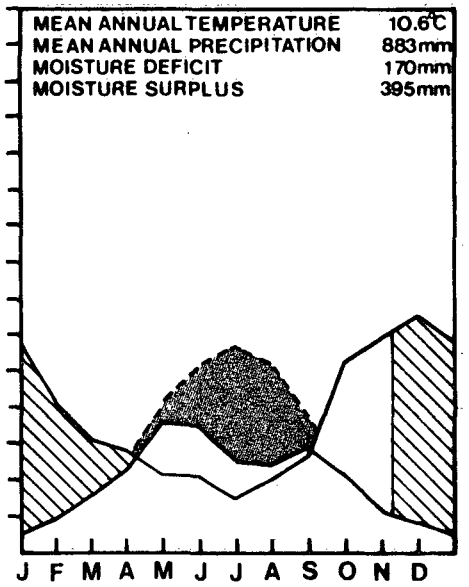
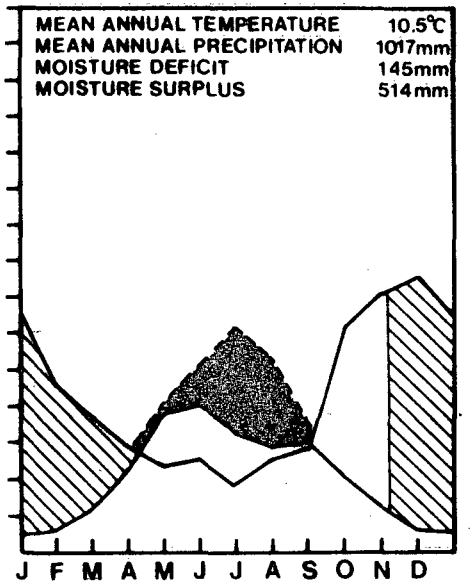


Figure 8 Moisture Balance for Powell River



SOURCE: Canada, Department of Environment, 1983. Moisture Balance Data. Atmospheric Environment Service. Vancouver.

5.4 BIOLOGICAL RESOURCES

5.4.1 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 the Mesothermal Formation; the Pacific Coast Mesothermal Forest Region, and the Coastal Douglas Fir and Coastal Western Hemlock zones. Both zones are further subdivided by Krajina:

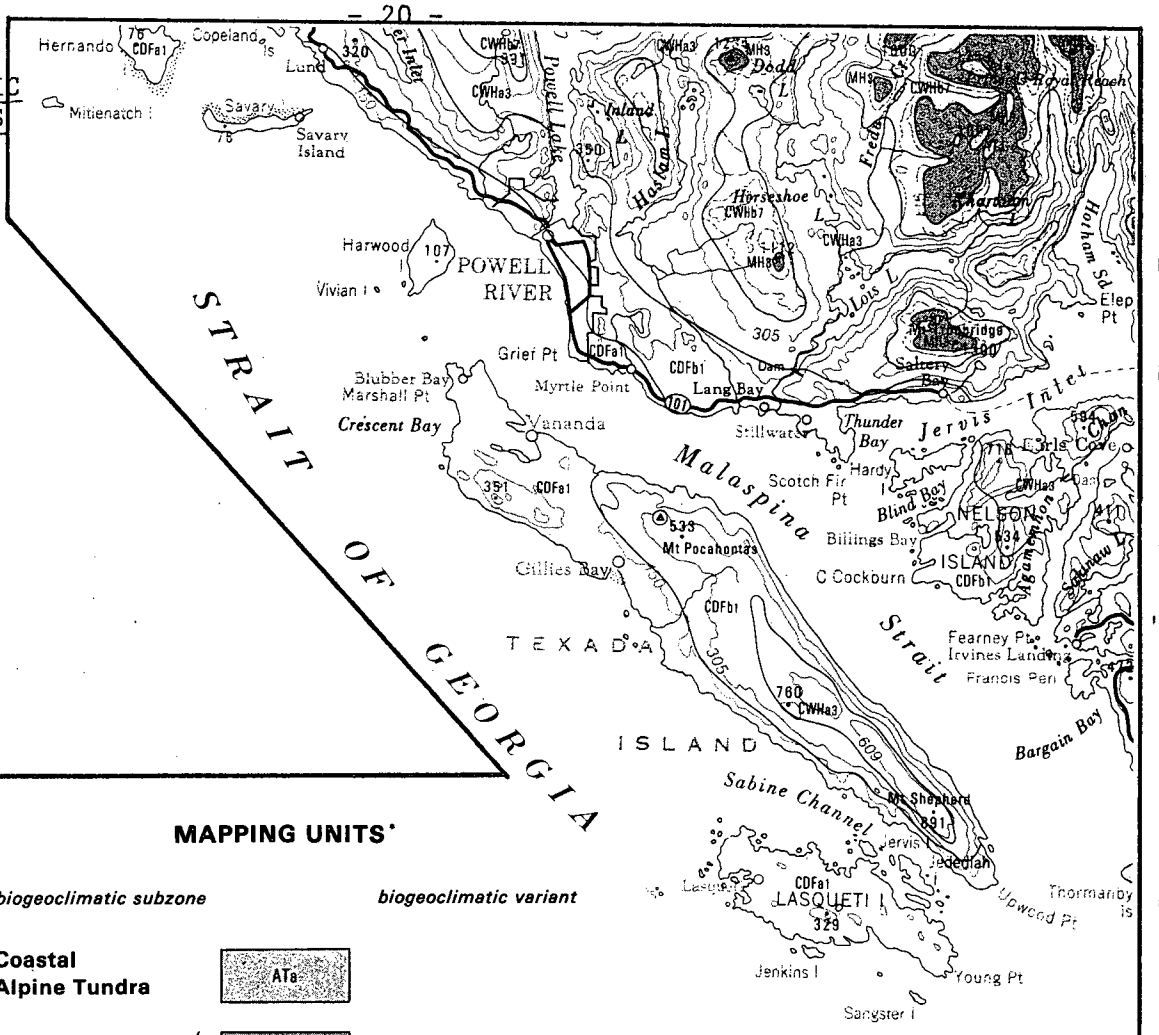
- Coastal Douglas Fir Zone - dry subzone (Garry oak - Douglas fir)
  - wet subzone (Madrona-Douglas fir)
- Coastal Western Hemlock Zone - drier subzone (Douglas fir-western Hemlock)
  - wetter subzone (Pacific silver fir-western Hemlock)

The biogeoclimatic mapping of Klinka, Nuszdorfer, and Skoda (1979) for the central section of the study area (Figure 9) refines further the biogeoclimatic boundaries. The zones, subzones, and variants include:

- Coastal Douglas Fir Zone - Drier Maritime - Nanaimo + Georgia Drier Coastal Douglas Fir
  - Wetter Maritime - Nanaimo + Georgia Wetter Coastal Douglas Fir Maritime
- Coastal Western Hemlock Zone - Drier Maritime Coastal Western Hemlock - Pacific Ranges Maritime Coastal Western Hemlock
  - Wetter Maritime Coastal Western Hemlock - Pacific Ranges Montane Wetter Maritime Coastal Western Hemlock
- Montane Hemlock Zone - Maritime Forested & Parkland Montane Hemlock - Pacific Ranges Maritime Forested & Parkland Montane Hemlock

The climatic description, characteristic combinations of species, and a schematic profile of the eastern Strait of Georgia are illustrated in Tables 6, 7, and Figure 10 respectively. A synopsis of some components of these biogeoclimatic zones is also provided by Krajina, Klinka, and Worrall (1982) (Table 8a); and their climatic data, for comparative purposes, are listed in Tables 8b and c. Further data provided by these researchers indicate that this region exhibits one of the highest tree species diversity (25 to 34 species) found anywhere within the province.

FIGURE 9 BIOGEOCLIMATIC ZONES OF PARTS OF THE STUDY AREA



SOURCE: See Table 6

MAPPING UNITS*

biogeoclimatic zone	biogeoclimatic subzone		biogeoclimatic variant
Alpine Tundra (AT)	**Coastal Alpine Tundra**	ATa	
Mountain Hemlock (MH)	**Maritime Forested and Parkland Mountain Hemlock**	MH1	West Vancouver Island Maritime Forested and Parkland Mountain Hemlock
		MH2	East Vancouver Island Maritime Forested and Parkland Mountain Hemlock
		MH3	Pacific Ranges Maritime Forested and Parkland Mountain Hemlock
Coastal Douglas-fir (CDF)	**Drier Maritime Coastal Douglas-fir**	CDFa1	Nanaimo and Georgia Drier Maritime Coastal Douglas-fir
	Wetter Maritime Coastal Douglas-fir	CDFb1	Nanaimo and Georgia Wetter Maritime Coastal Douglas-fir
Coastal Western Hemlock (CWH)	**Drier Maritime Coastal Western Hemlock**	CWHa1	West Vancouver Island Drier Maritime Coastal Western Hemlock
		CWHa2	East Vancouver Island Drier Maritime Coastal Western Hemlock
		CWHa3	Pacific Ranges Drier Maritime Coastal Western Hemlock
	Wetter Maritime Coastal Western Hemlock	CWHb1,2	Estevan and West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock
		CWHb3	West Vancouver Island Montane Wetter Maritime Coastal Western Hemlock
		CWHb4	East Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock
		CWHb5	East Vancouver Island Montane Wetter Maritime Coastal Western Hemlock
		CWHb7	Pacific Ranges Montane Wetter Maritime Coastal Western Hemlock

*Ecosystems were mapped at the level of biogeoclimatic variant. Mapping units may have up to 15% of their area composed of adjacent biogeoclimatic variants. Due to the pattern of distribution and relatively small map scale, subzones of the Mountain Hemlock Zone and the Estevan and the West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock variants were mapped as composite mapping units

Table 6:

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 (Koppen-Trewartha)	mean annual precipitation mm	mean temperature of the coldest month °C	index of continentality Ly	mean radiation during growing season mm	mean precipitation April–September mm	mean temperature of the warmest month °C	accumulated degree days over 5.6 °C days	frost free period days	mean precipitation of the driest month mm	mean precipitation of the wettest month mm	mean annual temperature °C	number of months with mean temperature >10 °C	number of months with mean temperature <0 °C	water surplus mm	water deficit mm	number of months with water deficit	maximum snow depth cm	number of months with snow	potential evapotranspiration mm	actual evapotranspiration mm	actual/potential evapotranspiration %	actual evapotranspiration April–September mm
MOUNTAIN HEMLOCK ZONE	Maritime Forested Mountain Hemlock [2]	milder	3339	-3.3	9	40100	782	9.9	392	127	115	522	3.2	1.1	4.5	2998	27	0.8	261	7.3	376	348	93	340
		Dfc	1248	1.8	8	1780	342	1.9	198	18	188	172	0.5	1.0	0.8	1239	43	0.9	78	0.9	26	29	11	31
	Maritime Parkland Mountain Hemlock [2]	colder	3358	-5.0	11	39500	755	8.9	280	109	78	532	1.7	0.3	5.1	3087	3	0.2	361	8.4	272	269	99	269
		Dfc	1435	2.0	8	1590	397	1.5	133	25	48	200	0.5	0.5	0.8	1409	6	0.4	138	0.5	22	19	2	19
COASTAL DOUGLAS-FIR ZONE	Drier Maritime Coastal Douglas-fir [3]	drier	907	3.2	11	45700	214	17.1	1753	253	22	152	10.0	5.8	0.0	543	288	4.0	0.9	0.2	632	384	58	311
		Csb	140	0.7	3	2510	52	1.0	131	37	8	24	0.4	0.5	0.0	111	70	0.7	2.0	0.4	36	42	9	49
	Wetter Maritime Coastal Douglas-fir	wetter	1202	2.0	13	43000	279	16.8	1578	217	28	197	9.1	5.2	0.0	798	181	3.4	10	1.0	583	405	69	358
		Csb	233	1.1	4	1430	52	1.1	185	24	7	43	0.7	0.7	0.0	223	35	0.7	11	1.0	19	38	5	40
COASTAL WESTERN HEMLOCK ZONE	Drier Maritime Coastal Western Hemlock [2]	drier	1867	1.4	15	40600	488	17.3	1700	211	48	291	8.4	5.4	0.0	1383	72	1.8	19	1.4	556	483	87	440
		Cfb	269	0.9	5	2030	88	1.1	205	19	11	54	0.8	0.5	0.0	276	47	0.7	17	1.0	20	41	8	39
	Pacific Ranges Drier Maritime Coastal Western Hemlock		1785	1.8	14	39800	496	17.5	1769	218	50	267	8.7	5.8	0.0	1279	45	1.6	12	1.0	551	505	92	459
			232	0.8	4	1580	59	0.8	164	17	10	40	0.6	0.5	0.0	214	28	0.8	10	0.8	19	28	5	30
	Wetter Maritime Coastal Western Hemlock [2]	wetter	3038	0.8	6	40200	713	12.9	938	193	74	461	6.7	3.4	0.8	2535	35	0.8	80	3.7	489	455	93	426
		Clb/c	1048	2.6	7	1490	282	1.9	338	42	30	130	1.7	1.7	1.2	897	57	1.2	71	2.5	36	85	11	53

(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

(3) A single variant has been recognized in each of these two subzones on this map sheet. The differentiating climatic characteristics for the subzones, therefore, also differentiate between the variants

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

Table 7:
CHARACTERISTIC COMBINATIONS OF SPECIES [1]

zone		subzone [2]		variant [2]	
Alpine Tundra	On this sheet a single subzone is recognized in this zone. Thus, the characteristic combination of species for the subzone is identical to that for the zone	Coastal Alpine Tundra	*Cassiope mertensiana* *Cassiope tetragona* *Luiseleuria procumbens*	*Luetkea pectinata* *Lycopodium alpinum* *Lycopodium sitchense*	*Phyllodoce empetriformis* *Cetraria subalpina*
Mountain Hemlock	*Abies amabilis* *Chamaecyparis nootkatensis* *Tsuga mertensiana* *Menziesia ferruginea* *(Vaccinium membranaceum)* [3] *Athyrium distentifolium** [3] *(Lycopodium annotinum)* *(Polystichum lonchitis*)* *(Rubus pedatus)* *Orthocaulis floerkii* *Pseudoleskea baileyi* *Rhytidiopsis robusta*	Maritime Forested Mountain Hemlock	*(Tsuga heterophylla)* *Vaccinium alaskaense* *(Blechnum spicant)* *(Clintonia uniflora)* *(Streptopus streptopoides)* *(Tiarella unifoliata*)* *Dicranum pallidisetum* *Rhizomnium nudum*	Pacific Ranges Maritime Forested Mountain Hemlock	*Cladothamnus pyroliflorus* *(Caltha biflora*)* *(Lonicera utahensis*)* *(Rhododendron albiflorum*)*
		Maritime Parkland Mountain Hemlock	*(Cassiope mertensiana)* *Gaultheria humifusa* *(Phyllodoce empetriformis)*	*(Rhododendron albiflorum)* *Vaccinium deliciosum* *Carex nigricans**	*Luetkea pectinata*
Coastal Douglas-fir	*Abies grandis* *Arbutus menziesii* *Cornus nuttallii* *Pseudotsuga menziesii* *(Amelanchier alnifolia)* *(Apocynum androsaemifolium*)* *Arctostaphylos columbiana** *Gaultheria shallon* *Holodiscus discolor* *(Juniperus scopulorum*)* *Mahonia aquifolium** *Mahonia nervosa* *Oemleria cerasiformis** *Ribes lobbii* *(Rosa gymnocarpa)* *Symphoricarpos mollis* *(Vaccinium parvifolium)* *Aira caryophyllea** *Allotropa virgata* *Boschniakia hookeri* *Campanula scouleri* *Delphinium menziesii** *Moehringia macrophylla* *Navarretia squarrosa** *Plectritis congesta** *Rhytidiadelphus triquetrus* *Stokesiella oregana* *Trachybryum megaptilum*	Drier Maritime Coastal Douglas-fir	*Quercus garryana** *Lonicera hispidula* *Brodiaea coronaria** *Bromus carinatus* *Camassia leichtlinii** *Camassia quamash** *Carex pensylvanica** *Claytonia perfoliata*	*Collinsia grandiflora* *Danthonia californica** *Dodecatheon hendersonii* *Erythronium oregonum* *Galium aparine* *Lomatium utriculatum** *Mimulus alsinoides** *Nemophila parviflora*	*Poa bulbosa** *Sanicula crassicaulis* *Sisyrinchium douglasii** *Vulpia microstachys**
		Wetter Maritime Coastal Douglas-fir	*(Tsuga heterophylla)* *(Paxistima myrsinites)* *(Carex rossii*)* *(Chimaphila menziesii)* *Hemitomes congestum*	*(Hypopitys monotropa)* *(Listera cordata)* *(Pyrola picta)* *(Smilacina stellata)*	
Coastal Western Hemlock	*Tsuga heterophylla* *(Menziesia ferruginea)* *(Oplopanax horridus*)* *Blechnum spicant* *Cornus canadensis* *Dryopteris austriaca* *Bazzania ambigua* *Bazzania denudata* *Bazzania tricrenata* *Isopterygium elegans* *Isothecium stoloniferum* *Plagiothecium undulatum* *Rhytidiadelphus loreus* *Scapania bolanderi* *Lobaria oregana* *Usnea mollis*	Drier Maritime Coastal Western Hemlock	*(Acer macrophyllum)* *(Arbutus menziesii*)* *(Cornus nuttallii*)* *(Pseudotsuga menziesii)* *Gaultheria shallon* *Mahonia nervosa* *(Vaccinium parvifolium)* *Achlys triphylla* *(Stokesiella oregana)*	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	*Abies amabilis* *Vaccinium alaskaense* *(Vaccinium ovalifolium)* *(Clintonia uniflora)* *(Rubus pedatus)* *(Pilophoron clavatus*)*	Pacific Ranges Montane Wetter Maritime Coastal Western Hemlock	*Chamaecyparis nootkatensis* *(Vaccinium membranaceum*)* *(Tsuga mertensiana*)* *(Rhizomnium nudum*)* *(Sorbus sitchensis)* *(Rhytidiopsis robusta)*

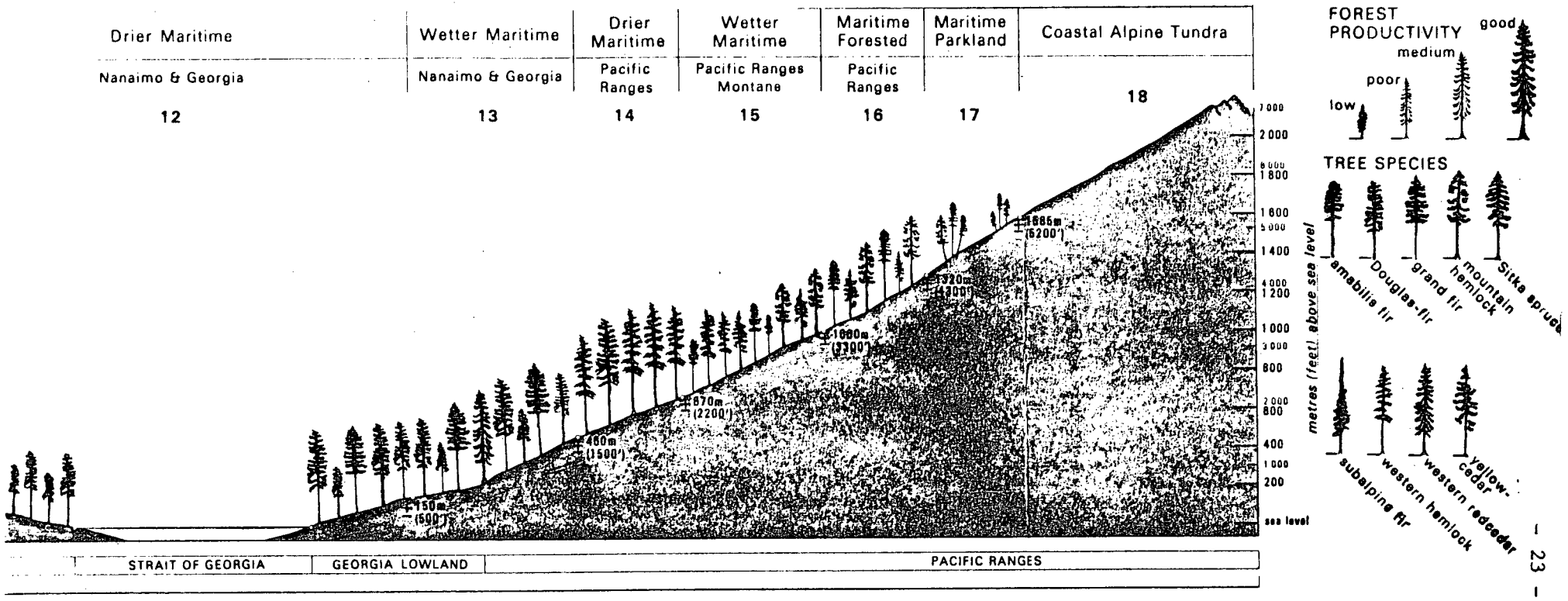
A single variant is recognized in each subzone of the CDF Zone on this map sheet. Therefore, characteristic combinations of species for the variants are identical to those for the subzones

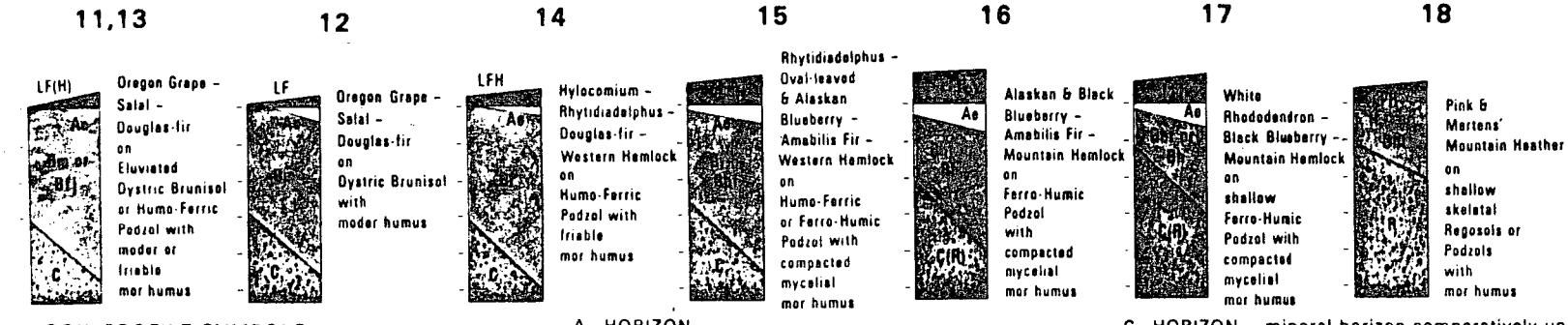
(1) *The selected plant species are arranged alphabetically in the order of trees, shrubs, herbs, mosses (including liverworts) and lichens*

(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 zone and the subzone*

(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 6.





SOIL PROFILE SYMBOLS

ORGANIC HORIZON – accumulation of organic matter mainly derived from leaves, twigs and woody material:
L – original structures easily discernible
F – material partly decomposed, original structure difficult to recognize
H – material decomposed, original structure indiscernible

A HORIZON
e – eluviation of clay, Fe, Al or organic matter
h – enrichment with organic matter (also in B horizons)

B HORIZON
f – enrichment with Al and Fe combined with organic matter
m – slight alteration by hydrolysis, oxidation or solution, or combination of all three processes
fj – some accumulation of pyrophosphate-extractable Al+Fe but not enough to meet the limits of Bf horizon

C HORIZON – mineral horizon comparatively unaffected by pedogenic processes
R – consolidated bedrock that is too hard to break with the hands or to dig with a spade when moist and does not meet the requirements of a C horizon

Figure 10: SCHEMATIC SEQUENCE and RELATIONSHIP of BIOGEO-CLIMATIC VARIANTS REPRESENTED by ZONAL ECOSYSTEMS.

SOURCE: Ibid. Table 6.

Table 8: *A synopsis and some characteristics of biogeoclimatic units of British Columbia*

a.

Biogeoclimatic zone Name and symbol	Clouds	Elevation (m)	Major soils	Major pedogenic processes	Major zonal subdivision
(2) Mountain Hemlock (MH)	most common esp. in winter; the least in summer or spring	North: 300 – 900 South: 850 – 1500 on windward side 900 – 1800 on leeward side	Ferro-Humic Podzols, Humic-Podzols, Gleysols and organic soils	mor formation, podzolization, gleization, paludization, kaolinization, "snow patch" sedimentation, clay disintegration	upper (parkland) and lower (forested) maritime (with Pacific silver fir) or subcontinental (with subalpine fir)
(11) Coastal Douglas-fir (CDF)	common in winter, rare in summer	Vancouver Island: 0 – 450 south coast of mainland: 0 – 150	Dystric Brunisols, Humo-Ferric Podzols, Gleysols and organic soils	moder (and mor) formation, kaolinization, melanization, gleization, weak podzolization, weak laterization, weak solodization	drier (AMTP = 637 – 1016mm) and wetter (AMTP = 1016 – 1741)
(12) Coastal Western Hemlock (CWH)	very common in winter, less common in summer	North: 0 – 300 South: windward side: 0 – 900 leeward side: 150 – 1050	Humo-Ferric and Ferro-Humic Podzols, Gleysols and organic soils	mor formation, kaolinization, clay disintegration, podzolization, gleization, very weak laterization, paludization	drier (AMTP = 737 – 2800mm) and wetter (AMTP = 1800 – 6655mm) maritime (with Pacific silver fir) or subcontinental (with subalpine fir)

b.

Biogeoclimatic zone Name and symbol	Number of frost free days	Mean annual temperature (°C)	January mean monthly (°C)	July mean monthly (°C)	Number of months above 10°C	Number of months under 0°C	Annual range of temperature (°C)	Absolute maximum (°C)
(2) Mountain Hemlock (MH)	105 – 210	2 – 7	-10 – -1	11 – 14	1 – 4	1 – 5	16 – 24	24 – 30
(11) Coastal Douglas-fir (CDF)	280 – 354	9 – 11	0 – 4	15 – 19	5 – 6	0 – 1	6 – 11	31 – 41
(12) Coastal Western Hemlock (CWH)	170 – 344	4 – 11	-10 – 5	13 – 19	4 – 7	0 – 3	9 – 25	26 – 43

SOURCE: V.J. Krajina, K. Klinka, and J. Worrall, 1982. Distribution and Ecological Characteristics of Trees and Shrubs of British Columbia. Faculty of Forestry, University of British Columbia. Vancouver.

8c.

Biogeoclimatic zone Name and symbol	Absolute minimum (°C)	Annual mean total precipitation (mm)	Annual mean snowfall (cm)	Snowfall in % of A.M.T.P.	Driest month (in monthly precipitation) (mm)	Driest month (in monthly precipitation) (mm)	Seasonal occurrence
(2) Mountain Hemlock (MH)	-43 – -22	1780 – 4400	280 – 3000	16 – 70	33 – 88	305 – 475	North: wet - autumn (30-35%) dry - summer (10-15%) South: wet - winter (30-40%) dry - spring or summer (10-15%)
(11) Coastal Douglas-fir (CDF)	-25 – -12	657 – 1741	25 – 162	2 – 10	13 – 48	115 – 270	wet - winter (40-45%) dry - summer (5-10%)
(12) Coastal Western Hemlock (CWH)	-45 – -12	737 – 6655	18 – 792	1 – 41	15 – 162	61 – 1161	North: wet - autumn (30-40%) dry - summer (10-15%) South: wet - winter (30-45%) dry - summer (7-15%)

SOURCE: Ibid. Table 8a,b.

5.4.2 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 seagrasses, 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, 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 luetkeana, 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 Districhlis 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.

5.4.3 MARINE MAMMALS

The marine mammals of the Strait of Georgia and Juan de Fuca Strait include sixteen genera of the order Cetacean (whales and dolphins) and two families of pinnipeds - Otariidae (the eared seals) and Phocidae (the earless seals - Table 9). Within the study area Orcinus orca (killer whale) is the largest resident species. Three family groups of 80 individuals are resident all year and are occasionally joined by about thirty transient individuals. The range of the killer whale in the study area is about 200 nautical miles, although the northern pods from Johnstone Strait do not mix with the southern pods (Bigg, 1981, personal communication). The area immediately north of Cape Lazo represents the southern limit of the northern pods' range and the northern limit of the southern pods' range. Coincidentally, a meeting of the flood tides from Johnstone and Juan de Fuca straits occurs in this area.

Killer whales 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). Although a preferred habitat of killer whales is identified north of the current study area (Robson Bight), no such areas are known 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	
Eschrichtius robustus, grey whale	C
Family Balaenopteridae--furrow-throated whales	
Balaenoptera physalus, fin or finback whale	C
B. borealis, peri whale	C
B. acutorostrata, little piked whale, minke whale	NC
B. musculus, blue whale	NC
Megaptera novaeangliae, humpback whale	NC
Family Balenidae--smooth-throated whales	
Balena glacialis, northern or black right whale	R
Order Odontoceti--toothed whales and dolphins	
Family Ziphiidae--beaked whales	
Berardius bairdii, Baird's beaked whale	C
Mesoplodon stejnegeri, Stejneger beaked whale	R
M. carlhubbsi, Hubbs' beaked whale	R
Ziphius cavirostris, Cuvier's beaked whale	R
Family Physeteridae--sperm whales	
Physeter catodon, sperm whale	C
Kogia breviceps, pygmy sperm whale	NC
Family Delphinidae--ocean dolphins	
Stenella sp., spotted dolphin	R
Delphinus delphis, Pacific common dolphin	R
Lissodelphis borealis, northern right-whale dolphin	R
Lagenorhynchus obliguidens, Pacific white-sided dolphin	C
Grampus griseus, gray grampus or Risso's dolphin	R
Family Phocoenidae--porpoises	
Phocoena phocoena, Pacific harbour porpoise	A
Phocoenoides dalli, Dall's porpose	C
Family Globicephalidae--pilot and killer whales	
Globicephala macrorhyncha, shortfin pilot whale	NC
Orcinus orca, 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

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

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).

5.4.4 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 plaktivore	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

	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

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

5.4.5 FISH AND SHELLFISH RESOURCES

Importance of the Study Area

The South Mainland Coast study area is complex, encompassing unsheltered, open waters, portions of several coastal fjords, and numerous islands. These marine waters are integral to the Strait of Georgia-Juan de Fuca Strait system, producing stocks of salmon, groundfish, herring and shellfish. The adjoining fresh waters support anadromous and resident fish populations of salmon, trout and char. These stocks are the object of commercial, recreational and native Indian fisheries.

The federal Department of Fisheries and Oceans has divided British Columbia's waters into the "Statistical Areas" shown in Figure 11. Most fisheries statistics (landings, escapements, economic values) are compiled according to these areas. To illustrate the local and regional perspective, data are organized by Statistical Area, by Coastal Resource Folio study area, and by the entire Strait of Georgia-Juan de Fuca Strait region (Areas 13 to 20, 28, 29). Statistical area boundaries may vary slightly from the Pacific Fishery Management Areas recently defined under the Pacific Fishery Management Area Regulations.

The present study area includes Statistical Areas 15 and 16, plus portions of areas 13, 14, 17, 28 and 29. In most cases, it is impossible to accurately apportion statistics from a statistical area to a more specific locality; activity in Areas 13, 14, 17 and 29 is primarily outside the South Mainland Coast. Therefore, except where subdivision is possible (e.g. escapements), the study area will be considered, for statistical purposes, to be limited to Areas 15 and 16.

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

Family, common name and scientific name	OVI*
Gaviidae	
Common loon (Gavia immer)	47
Arctic loon (G. Arctica	58
Podicipedidae	
Western grebe (Aechmorphorus occidentalis)	56
Hydrobatidae	
Leach's storm-petrel (Oceanodroma leucohoa)	63
Phalacrocoracidae	
Double-crested cormorant (Phalacrocorax auritus)	52
Brandt's cormorant (P. penicillatus)	57
Pelagic cormorant (P. pelagicus)	63
Ardeidae	
Trumpeter swan (Olorcygnus buccinator)	63
Canada goose (Branta canadensis)	34
Black brant (B. nigricans)	70
Snow goose (Chen hyperborea)	32
Mallard (Anas platyrhynchos)	36
American widgeon (M. americana)	36
Greater scaup (Aythya marila)	52
Barrow's goldeneye (Bucephala islandica)	56
Bufflehead (B. albeola)	52
Oldsquaw (Clangula hyemalis)	66
Harlequin duck (Histrionicus histrionicus)	60
Surf scoter (Melanitta deglandi)	72
Common merganser (Mergus merganser)	56
Accipitridae	
Bald eagle (Haliaeetus leucocephalus)	58
Pandionidac	
Osprey (Pandion haliaetus)	37
Falconidae	
Peregrine falcon (Falco peregrinus)	41
Haematopodidae	
Black oystercatcher (Haematopus bachmani)	65

Family, common name and scientific name	OVI*
Scolopacidae	
Wandering tattler (Heteroscelus incanum)	48
Dunlin (Erolia alpina)	41
Western sandpiper (Eremryrd msuti)	47
Phalaropodidae	
Red phalarope (Phalaropus fulicarius)	58
Stercorariidae	
Parasitic jaegar (tercorarius parasiticus)	43
Laridae	
Glaucous-winged gull (Larus glaucescens)	56
Herring gull (L. argentatus)	38
Thayer's gull (L. thayeri)	42
California gull (L. californicus)	38
Mew gull (L. canus)	44
Alcidae	
Common murre (Uria aalge)	70
Pigeon guillemot (Cepphus columba)	82
Marbled murrelet (Brachyramphus marmoratus)	84
Rhinoceros auklet (Cerorhinca monocerata)	74
Horned puffin (Fratercula corniculata)	72
Tufted puffin (Lunda cirrhata)	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.

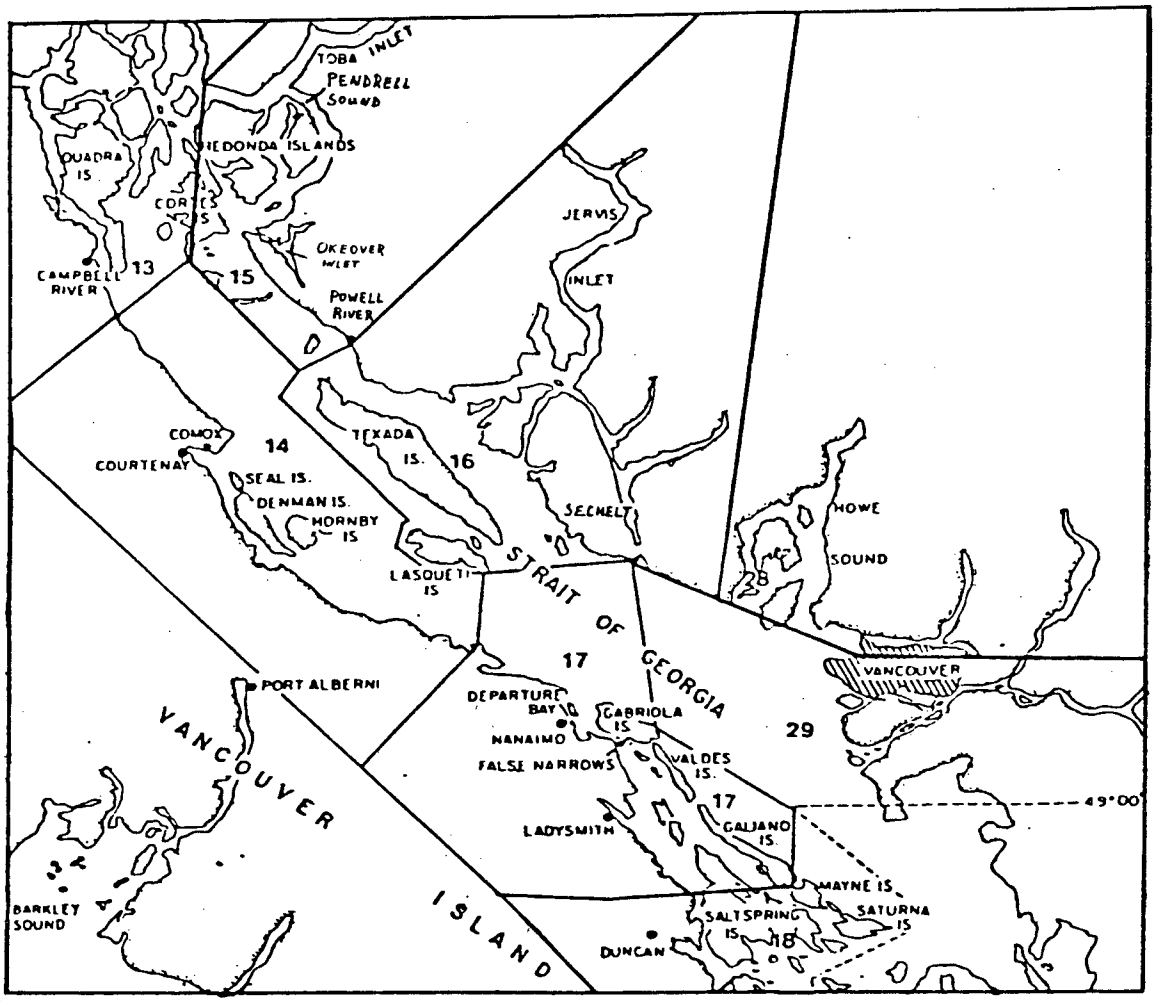
SOURCE: J.G. King and G.A. Sanger, 1979. "Oil Vulnerability Index for Marine Oriented Birds". In: Conservation of Marine Birds of Northern North America. J.C. Bartonek and D.N. Nettleship (eds.). U.S. Department of Interior, Fish and Wildlife Service, Wildlife Research Report 11, Washington.

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	- deposition of bark and wood - tow boat prop wash - scours sediments - land requirements	- smothers vegetation - disturbs sediments - destroys vegetation - destroys shoreline habitat
	2) Log Storage	- leachates enter water - bark and debris increase B.O.D. - physical shading of substrate and water column - scouring during low tides	- toxic substances for some organisms - decreased dissolved oxygen - lower rate of photosynthesis - destruction of vegetation - destruction of benthic communities
Dyking	1) General	- change from saline marsh to freshwater marsh over short time period	- change in vegetation species (habitat type) - change in waterfowl composition
	2) Agricultural	- loss of bird habitat - use of pesticides, herbicides, etc.	- elimination of many bird species from area - bird mortality
	3) Transportation	- loss of bird habitat - toxic wastes from industrial development - increased air and noise pollution	- elimination of many bird species - increased bird mortality
Dredging	General	- destruction of benthic communities - destruction of seaweed substrate - increased turbidity - alteration of tidal prism - increased B.O.D.	- 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, Terrestrail Studies Branch. Victoria.

FIGURE 11 FISHERIES STATISTICAL AREAS OF THE STRAIT OF GEORGIA.



NOTE: The study area includes all of Areas 15 and 16 and portions of Areas 13, 14, 17, 28 and 29.

Table 16 summarizes the contribution of the South Mainland Coast commercial fishery to the Strait of Georgia-Juan de Fuca Strait region. The study area supplies only 4% of the total salmon, 10% of the groundfish, and a maximum of 4% of the herring. In contrast, the area produces 22% of theshellfish (excluding oysters). The majority of commercial salmon, groundfish and herring landings are from Area 16, while Area 15 is the primary source of shellfish.

The sport fishery has greater significance in the region (Table 17). It accounted for 26% of the Strait of Georgia-Juan de Fuca Strait region's groundfish in 1982, and 22% of the clams, abalone and cutthroat trout in 1981. As in the commercial fishery, Area 16 was the more active area. Table 17 also shows that 75% of the study area's Indian food catch originated in Area 15.

TABLE 16 PERCENTAGE OF STRAIT OF GEORGIA-JUAN DE FUCA STRAIT (COMMERCIAL FISH AND SHELLFISH CATCH ORIGINATING FROM THE SOUTH MAINLAND COAST)

Species	Area 15	Area 16	Total
Salmon (1975-1981)			
Chinook	4	4	8
Coho	2	2	4
Chum	0	0.1	0.1
Sockeye	0	6	6
Pink	0	2	2
All Salmon	1	3	4
Groundfish (1979-1982)			
Pacific cod	0	0	0
Dogfish	5	14	19
Hake	1	9	10
Walleye pollock	0.1	7	7
Rockfish	3	8	11
Ling cod	2	1	3
Sablefish	2	1	3
All Groundfish	2	8	10
Herring (1976-1983)			
roe	4	0	4
food and bait	0	0.4	0.4
Shellfish (1975-1981)			
Shrimps and prawns	2	12	14
Clams (excludes geoducks)	30	8	38
Geoduck clam(1977-1981)	19	14	33
Crabs	0	1	1
Oysters	7	1	8
All Shellfish (except oysters)	14	8	22

NOTE: Percentages calculated from Table18(salmon), Table 26 (groundfish), Table 29 (herring) and Table30a(shellfish). All original values in tonnes except for oysters (U.S. gallons shucked) and herring (short tons).

TABLE 17 PERCENTAGE OF STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SPORT AND INDIAN FOOD FISHERIES CATCHES ORIGINATING FROM THE SOUTH MAINLAND COAST

Species	Area 15	Area	Total catch
Sport fishery			
Total Salmonid (1980-1981)	2	14	16
Total Salmon (1982)	2	14	16
Cutthroat trout (1981)	0	22	22
Groundfish (1982)			
Rockfish	3	13	27
Ling cod	3	22	25
All Groundfish	3	23	26
Herring (1981)	0	0	0
Shellfish (1981)			
Shrimp and prawns	0	0	0
Clams	2	20	22
Abalone	3	19	22
Crabs	0	5	5
Oysters	0.5	20	20
Indian subsistence food fishery (1972-1976)	6	2	8

NOTE: Percentages calculated from Table 18 (total salmonid, total salmon and cutthroat), Table 27 (groundfish), text (herring) and Table 30b (shellfish). All original values in actual numbers or pieces.

Anadromous and Resident Fish Species

Resource

A comprehensive review of the commercial salmon fishery in British Columbia for the years 1951 to 1963 has been provided by Aro and Shepard (1967). Although salmon have been fished traditionally throughout the study area, activity now is concentrated at the locations shown on the Coastal Resources Map Series (1:50,000 and 1:10,000) Fish and Shellfish Resources. Trolling occurs throughout the study area, whereas seining and gillnetting are conducted in a few areas such as near the Trail Islands and the west side of Texada Island. Table 18 compares the average annual salmon catch for Statistical Areas 15 and 16 with the Strait of Georgia-Juan de Fuca Strait catch for the years 1975 to 1981. The table also provides a comparison of catch statistics between the present folio area and two previous folios. The South Mainland Coast accounts for only 4% of the total regional landings; Area 16 contributes three-quarters of that total due to the much greater sockeye and pink catches. Steelhead are caught only incidentally during the fishery. (British Columbia, Ministry of Recreation and Conservation, 1970-71 to 1980-81).

TABLE 18 SALMON FISHERY OF SOUTH MAINLAND COAST: AVERAGE ANNUAL COMMERCIAL SALMON CATCH (NEAREST TONNE) 1975 TO 1981, THE GEORGIA STRAIT-JUAN DE FUCA SYSTEM

	South Mainland Coast		East Coast Vancouver Is.	South Coast Vancouver Is.			Total All Areas
Species	15	16	13	14, 17, 18	19	20	28, 29	
Chinook	50	47	208	351	114	446		1,216
Coho	27	27	202	191	884	116		1,447
Chum	0	2	1081	263	213	376		1,935
Sockeye	0	219	1084	55	1028	1554		3,940
Pink	2	68	723	54	2317	380		3,544
Total	79	363	3298	2872	4556	2872		12,082
	(1%)	(3%)	(28%)	(24%)	(38%)	(24%)		(100%)

SOURCE: Canada, Department of Fisheries and Oceans, 1975-1981. British Columbia catch statistics (annual reports). Vancouver, B.C.

The tidal salmon sport fishery occurs predominantly along the more populated mainland coast, with relatively little activity in mid-strait or the more remote localities. Several studies released between 1976 and 1978 suggest previous sport catch statistics under-estimate the actual

catch values; subsequently, efforts have been directed toward improving the estimation procedures. Results of the province-wide Tidal Sport-fishing Diary Program (MacGregor, 1982 and Bijsteweld, 1983) and the Strait of Georgia-oriented program of aerial overflights and landing site surveys (Shardlow, 1983) are presented in Table 19. Although the methodologies and survey periods differ, both data sets indicate that Areas 15 and 16 together account for about 16% of the total regional catch. As in the commercial harvest, most of the study area (85-90%) landings came from Area 16.

Chinook represented 73 to 81% of the total catch. These results are consistent with those of Argue, Coursley and Harris (1977) who revised sport catch estimates based on data from the 1972 to 1976 Strait of Georgia Head Recovery Program (Table 20). Their data also demonstrated (Table 21) that the combined chinook and coho catch almost tripled that of the commercial troll fishery for these species.

Sport catch estimates for sea-run cutthroat trout and steelhead have been compiled, respectively, during the 1981 Department of Fisheries and Oceans Tidal Diary Program (Table 19) and during the provincial Fish and Wildlife Branch annual Steelhead Harvest Analysis (Table 22). Area 16 cutthroat catches were the second largest of the statistical areas surveyed in the region. Most of the steelhead harvest returns come from Lang and Chapman creeks, with intermittent success in some smaller streams such as Forbes, Gray and Roberts creeks.

The South Mainland Coast food fishery conducted by the Klahoose (from Squirrel Cove on Cortes Island) and the Sliammon and Sechelt Indian bands is concentrated around Squirrel Cove, the Sliammon River, the eastern side of Harwood Island, the head of Okeover Inlet, Lang Bay and Frail Bay. Friedlander and Reif (1979) reviewed the provincial Indian food fishery with respect to salmonid enhancement opportunities. The average annual subsistence catches for Statistical Areas 15 and 16 for 1972 to 1976 are compiled in Table 23. As in other areas, chum represents the largest percentage (74-90%) of that total. Unlike the commercial and sport fishery patterns, Area 15 contributed the largest share of study area catch.

The study area contains resident fish stocks of Dolly Varden char, kokanee (land-locked sockeye), cutthroat, and rainbow trout (non-migratory steelhead), all of which are fished recreationally. Cutthroat trout are the most frequently harvested species. Again, the level of freshwater fishing activity is related to population distribution, accessibility and stock availability. South of Pender Harbour, sport fishing occurs most frequently in the lower reaches of streams near the main highway; the more extensively utilized Chapman Creek is an exception. To the north (including Texada and other islands), lake fishing predominates. Locations of, and estimates of the relative intensity of, resident sport fishing are portrayed on the accompanying Coastal Resource Folio map series. Recreational catch statistics for the South Mainland Coast are not presently available.

TABLE 19 SALMON AND TROUT FISHERY OF SOUTH MAINLAND COAST: SPORT FISHING CATCH (THOUSANDS OF FISH), 1980 TO 1981, 1982, RELATIVE TO THE GEORGIA STRAIT-JUAN DE FUCA STRAIT SYSTEM

Species	South Mainland Coast		East Coast Vancouver Island				South Coast Vancouver Island				Total All Areas
	15	16	13	14	17	18	19A	19B+[a]	28	29	
July 1980 to June 1981[b]											
Chinook	4.8	32.1	40.1	32.5	57.8	27.4	8.7	25.4	17.9	20.3	323.7
Coho	15.8	82.3	177.0	124.5	44.8	17.6	31.9	58.9	18.5	22.2	536.8
Total Salmonid	21.1	115.1	219.9	1 61.0	103.4	48.4	41.0	86.9	37.0	43.4	877.2
1982[c]							19	20			
Chinook	1.9	15.0	14.2	19.5	21.1	18.0	24.5	8.8	10.2	12.2	145.4
Coho	5.8	62.0	63.6	126.9	58.9	23.9	17.0	14.2	4.4	13.4	390.1
Total Salmon	7.7	81.0	82.7	149.8	81.8	43.7	43.7	24.1	15.7	28.0	558.2
1981[c]											
Cutthroat		3.0	0.1	0.1	2.0	0.4			2.8	5.5	13.8

NOTE: [a] Area 19B+ data also includes that portion of Area 20 east of Sheringham Point.

SOURCES: [b]Shardlow, T. 1983. Personal communication. Data from creel survey conducted by DPA Consulting Ltd. Canada Department of Fisheries and Oceans, Nanaimo, B.C.

[c]Bijsterveld, L. 1983. Personal communication. Tidal sport fishing diary program data. Canada, Department of Fisheries and Oceans, Vancouver, B.C.

TABLE 20 SALMON FISHERY OF SOUTH MAINLAND COAST: AVERAGE ANNUAL SPORT CATCH (THOUSANDS OF FISH), 1972 TO 1976, RELATIVE TO THE GEORGIA STRAIT-JUAN DE FUCA STRAIT SYSTEM

Species	13, 14[a]	15, 16	17	18, 19B	28, 29	19B,20	Total All Areas
Coho	263	80(17%)[b]	47	47	15	18	470
Chinook	84	44(13%)	45	76	38	55	342
Pink[c]	6	1(5%)	1	2	1	9	20
Total	353	125(15%)	93	125	54	82	832

NOTE: [a]Includes minor catches of sockeye and chum.

[b]Percentage of catch in study area compared to the total for the system.

[c]Sport Salmon Fishing in Area 13, covering the northern approach to the Strait of Georgia, is predominantly within the Campbell River region.

TABLE 21 A COMPARISON OF SPORT VERSUS COMMERCIAL SALMON CATCH (THOUSANDS OF FISH) IN THE STRAIT OF GEORGIA REGION FOR THE PERIOD 1972-1975

Species	Commercial (troll)	Sport	Total	% Sport
Coho	98	470	568	83%
Chinook	183	343	526	65%
Total	281	813	1094	74%

SOURCE: A.W. Argue, J. Coursley and G.D. Harris, 1977. Preliminary revision of Georgia Strait and Juan de Fuca Strait tidal salmon sport catch statistics, 1972 to 1976, based on Georgia Strait Head Recovery Program data. Technical Report Series PAC/T-77-16. Canada, Department of Fisheries and Environment, Fisheries and Marine Service, Vancouver.

TABLE 22 ESTIMATED ANNUAL STEELHEAD TROUT CATCH (NUMBERS OF FISH) FOR THE SOUTH MAINLAND COAST, 1973-1974 TO 1982-1983

Stream	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
Statistical Area 15										
Forbes Creek								3		
Statistical Area 16										
Gray Creek	3	3		3	3		3	3	2	
Lang Creek	67	92	111	71	20	30	61	59	29	31
Statistical Area 28										
Chapman Creek		21	49	67	31	12	45	15	8	27
Roberts Creek					6	3				
Wilson Creek		3								
Total Catch	70	119	160	141	60	45	109	80	39	58

SOURCES: British Columbia, Ministry of Recreation and Conservation, 1970-71 to 1980-81. Steelhead harvest analyses. Fish and Wildlife Branch, Victoria.

Billings, S. 1983. Personal communication. British Columbia, Ministry of Environment, Fish and Wildlife Branch, Victoria.

TABLE 23 SALMON AND STEELHEAD FISHERIES OF SOUTH MAINLAND COAST: AVERAGE ANNUAL NATIVE INDIAN SUBSISTENCE CATCH (NUMBERS OF FISH), 1972 TO 1976

Species	South Mainland Coast		East Coast Vancouver Is.	South Coast Vancouver Is.			Total All Areas
	15	16	13	14,17,18	19, 20	28	29	
Chinook	177(129)	15(23)	95	2,119	128	451	26	1,173
Chinook	126(129)	61(77)	353	2,574	543	2490	927	5,080
Chum	1984(2552)	324(772)	5506	13,280	1823	2932	435	24,824
Sockeye		27(103)	1022		64		1618	2,731
Pink	1(1)	(32)	725		50	400	25	1,202
Steelhead	2(2)	2(3)		30	20	46	5	77
Total	2290	429	7701	17,973	2628	6319	3036	35,087

NOTES: Caution should be exercised in making comparisons between statistical areas due to the wide variability in methods for estimating catch between districts.

SOURCES: Aro, K.V. 1972- 1980. Indian subsistence catch statistics on file. Canada, Department of Fisheries and Oceans, Resource Services Branch, Nanaimo.

Friedlander, M. J. and G. Reif. 1979. Working paper on Indian food fisheries and salmonid enhancement. Prepared for Canada, Department of Fisheries and Oceans, Vancouver, by Edwin, Reid and Associates Ltd.

Habitat Requirements

Spawning Escapements

Anadromous fish species such as salmon, steelhead and coastal cutthroat trout, characteristically spend parts of their lives in freshwater environments. Resident fish species inhabit fresh water throughout their life history, and may restrict their movements to relatively localized areas, or migrate long distances, depending on habitat availability and access. The general biology of anadromous and resident fishes is described in Hart (1973) and Scott and Crossman (1973).

Successful spawning requires specific environmental conditions. Schmidt, Graham and McDonald (1979), in an annotated bibliography of the literature describing British Columbia salmon and trout environments, noted the following four major determinants of stream productivity:

a) water temperature, which regulates levels of biological activity and may induce stress or mortality;

b) stream hydrology, which influences the nature and availability of habitat through changes in water depth, velocity, width, channel configuration, gradient and bed roughness;

c) spawning gravel, which determines egg and alevin subgravel development;

d) downstream juvenile migration, the success of which ultimately determines size and vigor of adult populations.

The major physical characteristics of study area streams and the species utilizing them are summarized in Table 24.

The South Mainland Coast contains 31 salmon spawning streams (Table 25); most of these also contain sea-run cutthroat, while a handful contain steelhead. Suitable anadromous habitat for the majority of watercourses is within the first three to four kilometres. Six systems - Sliammon Creek, the Theodosia River, Pender Harbour Creeks, the Sakinaw Lakes, Love Creek and Chapman Creek - support anadromous populations much farther upstream, and all but the last two (which contain steelhead) support average annual escapements of greater than 5000 spawners. Coho (the major species present), chum and coastal cutthroat trout occur in most of the area streams, while the Sakinaw Lakes support moderate runs of sockeye. The streams north of Jervis Inlet support minimal quantities of pinks.

Resident populations of cutthroat trout are present in the upper reaches of watersheds throughout the study area, while rainbow and kokanee occur less frequently.

Stream, Estuarine and Nearshore Rearing

Coho, sockeye, chinook, sea-run cutthroat and steelhead all utilize streams or lakes for rearing. Coho and sockeye remain in fresh water from one to several years before migrating to the sea; chinook remain in fresh water for three months to a year. Pinks and chum juveniles arrive in the estuary shortly after emergence from the spawning ground. Although chum and chinooks are the chief users of estuaries, some stocks of coho, pink and sockeye salmon are also known to depend on estuaries as juveniles.

Salmonid Enhancement Program (SEP)

Several SEP projects are presently being conducted within the study area, including a coho, chum and chinook hatchery and rearing facility at Sechelt, a chum and coho hatchery and counting fence on Sliammon Creek, and on Lang Creek, a coho incubation tray and rearing ponds. Eggs from Kelly and Whittal creeks are also incubated at the latter site. In addition, a variety of smaller voluntary projects are also being undertaken.

TABLE 24 INVENTORY OF MAJOR PHYSICAL CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL FISH SPECIES

	Length (km)[a]	Width (m)[b]	Drainage area(km^2)[c]	Substrate[d] % composition	Lake(s)	Discharge(cfs)[e]	Extreme flows Low	Extreme flows High	Water No.	Licenses[f] Total	Licenses[f] Volume	Comments	SK	CH	Fish Species Present[g] CO	CM	PK	ST	CT-ANAD	CT-RES	DV	KO	RB	Anadromous access(km)[h]
13															*	*								
Evans	1														*	*								
Hansens	2																							2
15																								
Black L	4				*										*				*R(0)	*				4
Forbes	5			10,30,60,0(0.5)	*			*				Lower portion diverted			*R(0)	*R(0)	*	*						1.5 falls
Ellis Cassel L's	9				*							Sluice gate							*					0
Hague-Gunflint L's	4				*		*								*	*			*	*				
Inland L.	4																			*S		*	*S	
Mouat	7								2	2000g					*	*	*R(0)		*R(0)					
Okeover	5						*								*S	*S	*			*U				2
Olsen	5			10,40,50,0(2) 20,30,50,0(4)								Regulated Flow								*U	*			5
Pendrell Sound															*	*	*							
Powell L.	53				*				8	1,177,454g	3,892cs;	Regulated Flow								*S	*	*	*	to dam
Refuge Lagoon	4				*							Sluice Gate			*	*			*	*				4
Sliammon	8				*	11.4Mx,0.028Mn	*		1	100,000g		Ch & Co counting fence			*	*	*	*	*	*		*		5 falls
"Squirrel Cove"	4				*										*	*			*					1
Theodosia	24			10,60,30,0(1.5) 20,20,60,0(4)	*	52.7Mx,0.038-0.38Mn	*	*	1	210,000g		Regulated flow severe flash floods heavily logged	*		*S	*	*	*	*	*	*R		*	5 falls
Unwin L.	4				*										*				*	*				4
16																								
Angus	5	5-6 Upstream 8 mouth	10.7	10,30,60,0(0)		4.47i			1		6cs				*	*	*	*	*	*				2
"BoatCove"	3				*	0.34Mx,0Mn													*					
Bruce	3	2			*				4	3,500g	2cs; 10af									*				0 falls
Burnet	5	4 mouth	7.7	10,40,50,0(0) 90,10,0,0(0.5)					6	21,000g		Effluent discharges												
Carlson	11	9 mouth 7 at 3.5km	23.4	20,80,0,0(0) 90,30,70(6)	*										*R(0)	*S,R(0)	*		*	*				1.5 falls
Coluin	2	2	3.8	70,30,0,0(0)											*	*R			*	*				1
Cranby	3				*							Dammed			*	*			*	*				2
Deighton	3								5	5,000g	35af				*	*				*U				1.5
Gray	15	15 mouth	58.6	0,20,80,0(0) 10,30,60,0(8)		20-30	*	*							*S	*S	*S	*	*	*			*	1 falls
Halfmoon	9	8-12	12.1	0,10,70,20(0) 20,60,20,0(2)					10	6,000g					*R	*R			*	*				1 falls
Haslam	2	6 Upstream	15.8	50,40,10(3)					7	406,000g	2cs; 401.5af									*				0.3 falls
Homesite	9	6 mouth 20 middle	21.8	10,40,50,0(3) 10,10,70,20(7)												*				*U				0 falls
Irvine	3		4.4		*										*				*					0.3
Jefferd	3	8 mouths		20,40,40,0(0)			*	*	24	93,000g					*	*R(0)	*R(0)		*					0.5
Jergens	4	2.3			*		*								*	*			*					0.5 falls
Kelly	7						*	*	7	3,600g	0.53af				*	*R(0)	*R(0)		*					0.5
Kenyon	3	3-4	6.0	10,30,40,20(0)															*					0.3
Lang	27					46.7Mx,0.048-0561Mn			12	42,700g	7af	Heavy debris below Duck L			*R	*R	*R	*	*R	*S		*	*	01
Lois	36				*	163MxOMn	*	*	3		469,000af	1,300cs			*	*R(0)	*R(0)	*	*S	*				0.3 falls
Myrtle	8				*				12	55,500g	12.1af				*	*R(0)	*R(0)			*U				0.3
Paq	6	2	1.6		*										*S					*U				0.3
Pender Harbour	7	2.5 downstream													*R(0)	*R(0)		*R(0)	*R(0)					3
Quarry	0.3				*															*U				
Rainy day	4	3		30,50,20,0(1)			*								*	*								3
Sakinaw L's System	12		71.9		*				19	226,900g	1,006af		*R		*R,S	*			*	*R,S				
Saltery Bay	3	5		20,60,20,0(0.5)											*	*R(0)			*					1
Silversands	3	6	12.9	0,0,40,60(0) 40,20,60,70,0															*	*				0
Snake Bay	2		3.2												*	*			*					1 falls
Trout L.	3		4.6		*				3	60,000g	40af									*U			*	0 falls
West L.	6		6										*		*	*	*		*	*		*		6
Whittal	3		3				*		9	3,000g	41.27af				*	*R(0)	*R(0)		*					to head waters
28																								
Chapman	23	13-20	70.1	10,20,70,0(1) 10.80,10,0(5) 10,10,70,10(12)	*	193Mx,0.034-096Mn		*	6	1,325,00g	745af	Regulated flow past scouring			*	*	*	*	*	*	*			5 falls
Chester	3	3.7	8.8	10,20,70,0(0)		0.35Mx.OMn			14	257,00g		past scouring			*	*	*S		*	*				2 falls
Flume	3	1.4	14.0	10,30,60,0(0)	*	0.31i	*		27	13,600g					*	*			*	*				1 falls
Hudson	4	1.2	5.9			1i									*					*U				1
Malcolm	2	3.6	2.0	30,50,60,0(0)		5i									*	*			*					0.3
Roberts	8	2.8	29.0	10,30,60,0(0) 0,40,50,10,(1.5)		31.1Mx,0.024-0.105Mn			10	7,100g		Regulated flow past scouring			*R(0)	*R(0),S		*R	*R	*	*			1 falls
Robinson	6	1.2	6.8	10,30,60,0(1)		0.25-0.5i			9	4,800g									*					0.5 falls
Wakefield	4		14.6	10,30,60,0(0) 40,80,10,0(3)	*			*		6,500g		Regulated flow			*R(0)	*R(0)		*	*	*				2 falls
Wilson	7		25.3	10,60,30,0(0)		3.56			5	3,000g	3af	Incubation box; first ladder			*R(0)	*R(0)		*R(0)	*R(0)	*R(0)				

NOTES:

• indicates presence

a - measured from topographic map.

b - From Aquatic Studies Branch(ASB) biophysical maps and Harding and Erickson (1975)

c - from ASB computer file

d - % fines, gravels, larges, bedrock (distance in km upstream from mouth) from ASB biophysical maps.

e - *i*-Instantaneous values from Harding and Erickson (1975), Mx - maximum value Mn - minimum value .

f - g - gallons; af - acre feet; cs - ft^3/sec

g - Species: SK - Sockeye, CH - Chinook, CO - Coho, CM - Chum, PK - Pink, ST - steelhead, CT-ANAD, CT-RES (*U - CT Unspecified), DV - Dolly Varden, KO - Kokanee, RB - Rainbow, R - Rearing, S - Spawning, (0) indicates activity at mouth or estuary.

h - Upstream limit from mouth; if falls form the barriers; "falls" appear with the distance upstream.

TABLE 25

Average Annual Spawning Escapements (number of fish) to South Mainland Coast Streams 1967 - 1976 and 1977 - 1981

Stream	1967-1976					1967-1976	1977-1981					1977-1981
	*CH	CO	CM	SK	PK	All Species	CH	CO	CM	SK	PK	All Species
Statistical Area 13												
Evans Creek		65	1255			1320		82(4)	475(4)			557(4)
Hanson's Creek		12(8)	222			234	File unavailable					
Statistical Area 15												
Forbes Creek		4	940		40	984			854			854
Okeover		56	1576		1	1633		5	4310			4315
Pendrell Sound Creek		91(8)	200		5	296			338(4)			338(4)
Refuge Lagoon		283	60			343		100(3)				100(3)
Salt Lagoon		98	122			220	1977-0; No Records					
Sliammon Creek		520	5060			5880		12(4)	12500(4)			12512(4)
Small Creek			267			267	No Records					
Theodosia River	20	1430	6400		19	7869		420	1770		18	2208
Statistical Area 16												
Angus Creek		55	1452			1507		5	1156		4	1161
Carlson Creek			776			7761		4	704			709
Dayton Creek		2(9)	666(9)			668(9)		9	1216			1225
Gray Creek		17	68		5	703	No Records					
Jefferd Creek		12	403			415		1	2490			2491
Kelly Creek		20	634			654		12	1006			1018
Lang Creek		470	2355			2825		806	2453		36	3295
Lois River			216			216		7	465			472
Myrtle Creek		22	352			374		45	930			975

Stream	1967-1976					1967-1976	1977-1981					1977-1981
	CH	CO	CM	SK	PK	All Species	CH	CO	CM	SK	PK	All Species
Pender Harbour Creek		485	7800			8285		139	5330			5469
Sakinaw Lake System		2130	275	6820		9225		4644	240	4400		5684
Saltery Bay Creek		58	10440			10498		47				
Snake Bay Creek		16	191			207		2	688			690
West Lake Creek		200(7)	329(7)	7(7)		600(7)		44	710			754
Whittal Creek		104	754			858		66	2850		23	2939
Statistical Area 28												
Chapman Creek		25	1465	18		1508		40	1040		2	1082
Chaster Creek		1	75(6)			76		8	116			124
Flume Creek			25(5)			25(5)			N10			
Roberts Creek			1368			1368			630			630
Wakefield Creek			557(7)			557(7)			180			180
Wilson Creek		36(7)	23(7)			59(7)		53(4)	244(4)			297

NOTES:

(#) Number of years for which average was calculated if less than 5 or 10 years.

Escapements averaged for odd plus even years.

Steelhead escapements have been rated for following: area streams: Sliammon(1966), Lang, Sakinaw (1968), Chapman(pre1976), Wilson (pre1976).

SOURCES:

Lashmar M. 1983. Updates from Operations Branch Files, 1975 to 1981. Canada, Department of Fisheries and Oceans, Vancouver, B.C and various authors (see sources section), 1976 to 1977.

Marshall, D.E. Preliminary catalogues of Salmon Streams and Spawning escapements of Statistical Areas 13(Campbell River), 16(Pender Harbour), 15)Powell River), and 28(Howe Sound - Burrard Inlet). Technical Report Series PAC/D-77-1, PAC/D-76-1,2 and 4,

* CH=Chinook; CO=Coho; CH=Chum; SK=Sockeye; PK=Pink;

Details concerning the nature and locations of these and other local projects are available from the Salmonid Enhancement Program, Fisheries and Oceans Canada, Vancouver and from the Ministry of Environment, Fish and Wildlife Branch, Province of British Columbia, Victoria.

Groundfish

Resource

Due to closures and a lack of grounds suitable for trawling, the South Mainland Coast groundfish harvest is minor compared to the remainder of the Strait of Georgia-Juan de Fuca Strait system. Similarly, the Strait of Georgia harvest is small compared to the offshore fishery. Approximately 70% of Strait of Georgia trawl landings occur during the October to March fishery (Westrheim, 1980). Westrheim (1979), Ketchen (1980), and Stocker (1981) provide historical sketches of commercial activity and assess stocks, while Forrester and Ketchen (1963), Forrester and Smith (1979), Ketchen (1979), and Westrheim (1980) focus specifically on the trawl fishery.

Dogfish, hake (since 1979) and walleye pollock (since 1976) are the major species harvested. Most dogfish are landed by longline in the waters between Gower Point and Lang Bay, and in Algerine Passage. Midwater hake are trawled off the east and west sides of Lasqueti Island, throughout Malaspina Strait and around northern Harwood Island to Mystery Reef; pollock are trawled in the midwaters of northern Malaspina Strait and past Harwood Island to Mystery Reef. Midwater and bottom trawling are closed throughout most of the study area north of a line connecting Shelter Point and Lund, and bottom trawling is prohibited south and west of Texada Island. Rockfish, lingcod, Pacific cod, and small quantities of sablefish are caught by longline. Although rockfish and lingcod may be taken wherever suitable habitat exists, most activity occurs north of Texada Island.

Dogfish excepted, landing statistics for Areas 15 and 16 ("Minor Areas" in the groundfish fishery) for most of the 1960's and 1970's are unavailable due to the grouping of the data by Major or Minor Areas (e.g. 12, 13, 15 and 16). Annual Area 16 dogfish catches for 1973 to 1978 inclusive averages 355.2 tonnes, but fluctuated from 5.1 to 962.2 tonnes per year, whereas Area 15 landings ranged from nil (for three years) to an average of 209.7 tonnes for the remaining three years (Saunders, pers. comm.). In Table 26, 1979 to 1982 values for the South Mainland Coast are compared with the Strait of Georgia-Juan de Fuca Strait region as a whole. Combines, Areas 15 and 16 accounted for 10% of the total regional catch (cf Westrheim (1980) who found that Minor Areas 12, 13, 15, 16 for the 1960 to 1977 years accounted for 6% of the landings for the Strait of Georgia and Juan de Fuca), with Area 16 alone contributing 8%. Table 27 presents the average annual catches by species for 1979 to 1982 for Areas 15, 16 and the Area 29 Sechelt locality.

TABLE 26 GROUNDFISH FISHERY OF SOUTH MAINLAND COAST: ANNUAL COMMERCIAL CATCH (TONNES), 1979 to 1982, RELATIVE TO STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEM

Year	South Mainland Coast * 15	16	13	East Coast * Vancouver Is. 14,17,18	South Coast * Vancouver Is. 19, 20	28	29	Total All Areas
1979	251.6	459.5	120.0	3,846.6	1,413.3	58.5	1,475.1	7,624.6
1980	120.6	388.4	180.8	2,393.3	1,550.6	63.3	701.2	5,398.2
1981	23.0	449.0	158.8	1,538.3	1,603.3	14.5	1,858.8	5,645.7
1982	81.4	660.7	169.7	3,221.9	1,012.3	22.4	174.2	5,342.6
	119.2	489.4	157.3	2,750.0	1,394.9	39.7	1,052.3	6,002.8

NOTES: Includes trawl, longline and trap landings of species found only in Areas 15 and 16, less miscellaneous species; does not include handline and troll.

* Other folio areas included for comparison.

SOURCES: Smith, J.E., 1982; Leaman, J.E., 1979-1981. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1978-1981 (annual reports). Technical Report nos. 891, 961, 1032, and 1124. Canada, Department of Fisheries and Oceans, Resource Services Branch, Nanaimo.

Leaman, J.E., 1983. Personal communication. Canada, Department of Fisheries and Oceans, Resource Services Branch, Nanaimo.

TABLE 27 GROUNDFISH FISHERY OF SOUTH MAINLAND COAST: ANNUAL COMMERCIAL CATCH[a] (TONNES), 1979 TO 1982, RELATIVE TO THE STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEM

	15					16					Total All Areas				
Species	1979	1980	1981	1982	$\bar{x}$	1979	1980	1981	1982	$\bar{x}$	1979	1980	1981	1982	$\bar{x}$
Pacific cod	-- [c]	0.1	-- [c]	0.2	--[c]	1.0	1.3	-- [c]	0.2	0.9	1184.9	1607.3	1744.2	1008.7	1386.3
Dogfish	245.7	116.1	11.4	36.5	102.4	410.8	276.5	165.5	297.7	287.6	4325.9	2100.0	763.5	1240.4	2107.4
Hake		0.3	15.2	35.3	12.7	24.5	100.0	98.5	355.6	145.9	516.3	508.4	2408.6	2823.8	1564.3
Walleye pollock				3.8	1.0	2.5		178.2	11.4	50.9	1339.3	1055.7	566.1	100.1	765.3
Rockfish[b]	4.7	3.3	1.6	3.0	3.2	15.1	8.7	4.0	5.1	8.2	185.8	76.8	83.1	74.6	105.1
Lingcod	0.2	0.6	0.1	2.7	0.9	0.1	0.2	2.7		0.8	36.1	39.3	70.2	84.4	57.5
Sablefish	1.0	--			0.3	0.4	0.6			0.2	34.4	10.6	9.6	10.5	16.3
Total	251.6	120.5	28.3	81.5	120.5	459.4	388.4	448.9	670.0	491.7	7622.7	5398.1	5645.3	5342.5	6002.2

NOTES: a. Species trawled - hake, pollock, dogfish, Pacific cod. All species caught by longline except hake and pollock. Species trapped - sablefish, lingcod and rockfish.
Table includes trawl, longline and trap landings of species found only in Areas 15 and 16, less miscellaneous species. A portion of Area 29, dogfish landings are caught within study area (Sechelt locality - 1979 - 127.0 t, 1980 - 52.7 t, 1981 - 122.2 t, 1982 - 112.0 t, 1979-1982 - 103.5 t. Walleye pollock 1979-1982 landings - 10.9 t. (1980).

b. includes two or more species.

c. -- = <.1.

SOURCES: Smith, J.E. 1979-1981; Leaman, J.E. 1982. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1979-1981 (annual reports) Technical Report Nos. 891, 961, 1032, and 1124. Canada, Department of Fisheries and Oceans, Resource Services Branch, Nanaimo.

Saunders, M. 1983. Personal communication. Canada, Department of Fisheries and Oceans, Resource Services Branch, Nanaimo.

Recreational groundfish harvesting is directed primarily toward rockfish and lingcod. Although both species are present throughout the study area, most of the rockfish harvesting occurs north of Texada Island, while lingcod fishing occurs as far south as Lasqueti Island. Reliable recreational groundfish catch estimates are now available from the Tidal Sportfishing Diary Program (Bijsterveld, 1983, MacGregor, 1982). Table 28 suggests that, in 1982, 26% of the total Strait of Georgia and Juan de Fuca lingcod and rockfish landings originated from Areas 15 and 16, with the latter contributing 25% of the regional total.

TABLE 28 GROUNDFISH FISHERY SOUTH MAINLAND COAST: SPORT CATCH (NOS. OF FISH) FOR 1982 RELATIVE TO THE STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEM

	South Mainland Coast			East Coast* Vancouver Island	S. Coast Vancouver Island			
Species	15**	16	13	14,17,18	19,20	28	29	Total All Areas
Lingcod	3,372	29,975	22,024	51,925	14,940	8,279	4,389	134,904
Rockfish	8,208	61,936	26,814	92,681	34,224	25,289	9,107	258,759
Total	11,580	91,911	48,838	144,606	49,664	33,568	13,496	393,663

* Other folio areas for comparison.

** Fishery Statistical Areas.

Source: Bijsterveld, L. 1983. Personal communication. Tidal sportfishing diary program data. Canada, Department of Fisheries and Oceans, Vancouver.

Habitat Requirements

Pacific cod

Pacific cod, the long-time mainstay of the domestic trawl fishery, is the only true cod in the North Pacific and is similar in appearance to its more famous cousin in the North Atlantic. In Canadian waters it is close to the southern limit of its range and occupies intermediate depths along the continental shelf. It is fast-growing and

short-lived. Pacific cod reach commercial size as 2-3 year-olds and mature at about the same age. Few cod live beyond 5 or 6 years of age as the natural mortality rate is relatively high (possibly as much as 50% per year). With few age groups, cod populations exhibit considerable instability. Large and almost cyclical fluctuations in abundance have a profound effect on the annual success of fishing. As yet these fluctuations cannot be reliably predicted.

Pacific cod spawn in February and March, the eggs being fertilized in the water column. To date no fertilized eggs have been observed or collected in the sea but laboratory evidence suggests that cod eggs incubate on the bottom. Bottom temperatures on spawning grounds in British Columbia are usually 7-8°C.

In general, small cod eat plankton (euphausids and shrimp) and larger fish eat crabs, shrimp and other fish (mainly herring and sandlance). Cod tend to disperse for feeding and to congregate for spawning. Similarly, they move into deeper water in autumn and return to shallow water in spring.

Lingcod

The lingcod is widely distributed along the continental shelf from Mexico to the western Gulf of Alaska, but the centre of abundance appears to be off British Columbia. It occurs from the inter-tidal zone to depths of 366 m (200 fm). Adult tagging programs suggest that lingcod are relatively non-migratory, forming numerous large, localized stocks. Other studies suggest that pre-spawning aggregation, spawning activity, and incubation occur from November to April.

Lingcod spawn in rocky, current-swept areas, depositing their egg masses in crevices. These egg clusters are defended by the male. After a 2-3 month pelagic stage, larval lingcod assume a bottom-dwelling life. Growth rate is relatively rapid in the early years of life, so that commercial size is reached at 3-5 years of age. The majority of lingcod mature at 4-5 years of age, or a length of 65-76 cm. They cease to be of significance in commercial landings beyond the age of 10-12 years, but may live as long as 18 years.

Lingcod are fished commercially in Canadian waters primarily by bottom trawl and handline or troll methods. During 1968-79, lingcod comprised an average of 11% of the total groundfish landings, excluding halibut. As well as being of commercial interest, lingcod are also landed by recreational fishermen using jig, troll and spear fishing gear.

Spiny Dogfish

The spiny dogfish range extends from southern California to the Gulf of Alaska; it is most abundant between southern Oregon and Dixon Entrance. Dogfish are characterized by slow growth, a low birth rate and a long life span. The young are born after a uniquely long gestation period of nearly two years. The young dogfish diet begins with planktonic organisms, yet adults too have been observed eating planktonic euphausiids. Principal foods include herring, hake, sandlance, and a wide variety of invertebrates such as crabs, shrimp and octopus. Males mature at a length of 62 cm or in their 25th year. During the 1979 Strait of Georgia fishery, the average size was 84 cm and 102 cm for males and females respectively. The dogfish's low reproductive rate makes it particularly sensitive to overfishing, thus the harvest must be carefully monitored.

Dogfish have been fished commercially for over 100 years, beginning in the 1870's when the liver and body oils were used as a lubricant and fuel for lamps. The major fishery occurred between 1937 and 1949 as a result of a strong market for dogfish livers as a source of Vitamin A. From 1950 to about 1975 the resource remained virtually unexploited. New foodfish markets abroad, increased dogfish landings briefly from 1976 to 1979, but poor 1980 markets reduced the landings once again. Although a significant fishery still occurs within the Strait of Georgia, elsewhere along the coast, especially in Hecate Strait, the species remains unexploited and interferes with other commercial fisheries. The impact of dogfish as a predator on other groundfish and herring is not fully understood. Little evidence exists to indicate that they are serious predators of salmon.

Rockfish

Rockfish constitute a large, complex portion of west coast bottomfish resources. There are more than 30 species of which at least seven are of importance to the domestic trawl fishery. As a group they are characterized by slow growth; a prolonged period of immaturity (11-13 years); an even longer time to become commercially viable (13-15 years); an extended life span in which, depending on species, an age of 50-60 years is not uncommon; and a natural mortality rate which in most species is probably less than 5% per annum.

Rockfish occupy a wide range of depths, but individual species occupy more restricted ranges from intermediate depths on the continental shelf (73-110 m) to the upper continental slope (183-457 m).

The frequent overlap of their distributions often results in conflicting management policies for different species. The basic biological parameters of most rockfish species are not well known, particularly the relationship between spawning stock and recruitment. It was only recently that rockfish (except Pacific ocean perch) warranted study because of increased economic importance to Canadian fishermen). Although composed of many age groups, rockfish stocks are highly vulnerable to over-exploitation. Indeed, many were decimated during the years when uncontrolled foreign fleets were present off British Columbia (1965-1976). Particularly hard hit were the stocks of Pacific ocean perch located off Dixon Entrance, off the west coast of Vancouver Island and in Queen Charlotte Sound. Critical information on recruiting rates to determine the sustained level of fishing tolerable is still needed.

Pacific Hake

Pacific hake have only recently (1979) begun to be exploited in the Strait of Georgia to meet the demand for less expensive white-fleshed fish. Common along the west coast of North America, studies suggest the existence of three major stocks - one in the Strait of Georgia, a second in Puget Sound and the third in the offshore coastal waters between the Gulf of California and the Gulf of Alaska.

Within the Strait of Georgia, hake spawn between March and May in the deep waters between Gabriola and Texada islands (the recent Strait of Georgia fishery occurs at this time). After about eight days, the pelagic eggs hatch. Most of the larvae rear in the central strait, feeding on copepods or copepod eggs by early summer. Juveniles mature at four years, spawn, congregate briefly in schools and then disperse by fall.

Offshore, spawning occurs off California, although the appearance of one and two year-olds suggests the possibility of a local stock off the B.C. coast. Older, larger individuals (four to six-year + classes) predominate in the northern portions of the range. Eggs hatch after three days and larval feeding commences by spring. The adult diet consists chiefly of euphausiids and sand lance, but may also include herring, smelt, anchovy and shrimp. Hake are believed to be essentially nocturnal feeders.

Adults inhabit depths from the surface to 900 metres, but seem to prefer the midwaters in association with dogfish, their major predator, and walleye pollock.

Walleye Pollock

Walleye pollock is a recent foodfish. It occurs in both midwater and on the bottom at intermediate depths. There appear to be several stocks in the Canadian zone, but as yet their interrelationships are not fully understood. It is possible that the adults, which spawn (in midwater) in the Strait of Georgia may make their way out of the strait to the west coast of Vancouver Island in spring and summer. Georgia Strait aging results suggest the existence of one stock from Texada to Point Roberts, but with different age groups being harvested in that area.

Like Pacific cod, pollock off British Columbia are near the southern limit of their range. Their life span is relatively short; maturity is reached in 2-4 years; there are as few as 3-5-year classes in unexploited stocks; natural mortality rate is relatively high (45%) and there are substantial variations in recruitment. These factors produce much instability in the populations; predictions of abundance are difficult.

Other Finfish

Herring

Hourston's extensive 1977 and 1982 bibliographies reference reports describing various aspects of the British Columbia herring fishery; Hourston and Haegele (1980) describe both herring biology and the past and present fisheries. Selected references can be found in the Sources section.

The reopening of the herring fishery in 1971 following the late 1960's collapse brought a changeover from reduction processing to foreign marketing of herring roe. Herring, which have been traditionally intercepted on their fall migration routes and holding grounds, are now taken in winter or early spring on the immediate approaches to their spawning grounds. Due to the difficulty in timing the harvest to ensure quality roe plus the efficiency of the fishery, a very short but extensive harvest has developed. The winter Strait of Georgia food fishery focuses on herring migrating to the spawning grounds, while the bait fishery coincides with the longline food fishery. As Table 29 illustrates, commercial herring fishing on the South Mainland Coast has been initially non-existent since 1977-78, with only minor previous landings. A notable exception occurred during the 1983 Area 15 roe herring harvest, when 3200 tons were landed. The Copeland Islands-Lund area, Blubber Bay, the Secret Cove vicinity and Quarry, Green, Vananda and Blind bays have all experienced past activity.

TABLE 29 HERRING FISHERY OF SOUTH MAINLAND COAST: ANNUAL (SHORT TONS) COMMERCIAL FISHERY CATCH, 1974 TO 1983 RELATIVE TO THE STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEM

	South Mainland Coast			East Coast* Vancouver Is.	South Coast Vancouver Is.	
Year	15	16	13	17,17,18	19, 20	All Areas
Food and Bait Fishery (sales slip landings)						
1975-76	10	141	1,018	4,270		5,339
1976-77		39	539	4,953	10	5,541
1977-78		29	4,055	10,654		14,738
1978-79			1,831	11,719		13,550
1979-80			2,300	2,114		5,525
1980-81			100	5,995		6,095
1981-82			100	6,074		6,174
1982-83			50	1,288		1,438
$\bar{x}$	1	26	1,249	6,035	1	7,301
Roe Herring Fishery (sales slip landings/*hailed tonnages*)						
1974	2	69	472	3,713	*4*	
1975	49	491	367	5,834		
1976	65	1	166	7,643/*7306*		*7,306*
1977				12,723/*12,004*		*12,004*
1978	59	17		11,847/*12,812*		*12,812*
1979				7,537/*5,500*		*5,500*
1980				*4,047*		*4,047*
1981				*9,907*		*9,907*
1982				*9,400*		*9,400*
1983	*3,200*			*12,233*		*15,433*
$\bar{x}$(1983-hailed landings only)	*400*	*0*	*0*	*9,151*	*0*	*9,551*

*Other coastal folio study areas for comparison.

The recreational herring fishery consists of two activities - the food harvest, and the bait fishery. The food harvest occurs mainly during March or April when the herring congregate to spawn; 50% of the sport catch may be taken at this time. The bait fishery occurs during the remainder of the year. The following 1981 herring sport catch statistics (numbers of fish) from the Tidal Sportfishing Diary Program (Bijsteweld, pers. comm.), suggest that the South Mainland Coast's contribution is minor.

South Mainland Coast			East Coast* Vancouver Is.	South Coast Vancouver Is.		
15	16	13	14, 17, 18	19, 20	28, 29	All Areas
0	0	36,008	101,869	2,072	0	139,949

* Other coastal folio study areas for comparison.

Habitat Requirements

Herring spawning occurs on a limited number of intertidal and shallow subtidal areas scattered throughout the Pacific coast. While few areas appear to provide suitable spawning habitat, those which do are heavily utilized. Herring spawn in winter and early spring when salinity and temperature are reduced. Adhesive eggs are deposited onto seaweeds, primarily rockweed (Fucus), Japweed (Sargassum), and eelgrass (Zostera). The deposition of eggs can range from above low water to 10-15 m below. Due to predation by marine birds and intertidal fish, and to the dislodging of egg-laden seaweed during storms, egg survival during the two to three-week incubation period does not exceed 30%.

During the larval phase, mortality is estimated to reach 99%. Evidence suggests this is chiefly due to larvae being carried offshore by surface currents, the lack of food (plankton), and predation. By summer, juveniles school in shallow bays and inlets, typically near kelp beds, feeding in surface waters at dawn and dusk on small zooplankton (copepods, euphausiids and amphipods).

Near the end of their first summer, herring migrate from the Strait of Georgia via the Juan de Fuca Strait to offshore feeding grounds, mainly off the lower west coast of Vancouver Island. A small number of herring remain behind to form minor resident populations. The fall return migration begins in their third or fourth year. Strait of Georgia herring remain separate from stocks elsewhere on the

coast during their spawning migrations. Thus all production and recruitment of the fishery stock must come from within the Strait system.

Hourston and Leaman (1979) list the localities where herring spawning has been recorded to the present. Similarly, Haegele (pers. comm.) has produced a series of maps and charts depicting spawning ground utilization by years. The Fish Spawning and Rearing Series of the Coastal Resource Folio shows those South Mainland Coast areas more recently utilized. Historical data of spawning intensity, timing, and local habitat characteristics are currently being analyzed by researchers of the Pacific Biological Station (Fisheries and Oceans Canada).

On individual herring spawning grounds, no clear relationship exists between spawning intensity and the number of spawning days. This makes the prediction of the timing and abundance of local, individual roe herring fisheries difficult.

It is suggested that changes in preferred spawning grounds are related to broad-scale variations in environmental conditions. It is not known, however, if such shifts are the result of changes in herring migratory patterns or in variable survival rates for different spawning grounds. The differences in times of spawning from year to year appear to be related more to local rather than regional environmental conditions.

Shellfish

Resource

Bernard (1982) and Fralick and Tillapough (1979) review the current provincial shellfish stocks, fishery and mariculture industry. The South Mainland Coast supports a variety of shellfish, including oysters, geoducks and other clams, shrimps, prawns, and crabs. Geoducks, oysters, and other clams inhabit the inter- or subtidal zones of virtually all the study area islands.

Commercial activity is divided between the less intensive harvest of wild stocks and intensive mariculture concentrated mostly in Okeover Inlet. Pendrell Sound has been set aside as a reserve for oyster spat production for the mariculture industry. The commercial catch statistics for 1975 to 1981 summarized in Table 30a show that geoduck clams landed in the study area composed 33% of the regional total, while all other clams landed composed 38% of the total. In contrast, 8% of the oysters shucked (both wild and cultured oysters) in the Strait of Georgia-Juan de Fuca Strait region originated from the South Mainland Coast.

Shellfish are more commonly harvested recreationally near population centres or more accessible locations. Reliable recreational shellfish landings recently have become available through the Tidal Sportfishing Diary Program (MacGregor, 1982; Bijsterweld, 1983). During 1981, 20 to 22% of the region's recreation clam, abalone and oyster landings originated from Statistical Areas 15 and 16 (Table 30b).

Habitat Requirements

Shrimps and Prawns

Five shrimp and one prawn species are fished commercially in British Columbia waters. Although shrimp are found in a wide variety of habitats, from rock to mud and pelagic to demersal, they are associated more frequently with the softer substrates. Shrimp are of great value to the diets of commercial fish, marine mammals, and large invertebrates. In turn, shrimp prey upon other crustaceans, many types of invertebrates, and recycle dead or decaying organic matter. No detailed ecological studies exist because of difficulties in species identification.

Commercial shrimp are fished mainly by trawls over muddy or sandy bottoms in 95 to 135 metres of water, whereas prawns are taken almost exclusively by traps. Both shrimps and prawns are fished throughout the year, although their respective harvests peak in summer and spring. Within the South Mainland Coast, shrimp trawling is confined to the waters northeast of Savary and Hernando islands. In contrast, prawns are trapped throughout the study area. Since 1976, prawn trap versus shrimp trawl landings provincially have increased from 2% to 54% of the total landings. The majority of the area shrimp and prawn landings are from Area 16. Recreational harvesting in Areas 15 and 16 for 1981 (the only year for which data are available) was minimal.

Clams

The manila clam lives on mud-gravel beaches at about the mid-tide mark while its close relative, the native littleneck clam, is typically found in a mixture of fine sand, shell and gravel in the lower half of the intertidal zone. The main populations of the large geoduck clam are found in subtidal sand or mixed sand-mud, but can also be found in the lower part of an intertidal beach. The butter clam is found in many types of sediments but is most abundant in the lower third of the intertidal zone of beaches and bars composed of a mixture of sand, broken shell and gravel.

Considered either as a group or by species, the commercial clam harvest of the South Mainland Coast contributes 33% of the geoducks, 53% of the Japanese littleneck or manila clams, and 64% of "mixed" clams (Table 30a) to the regional total. Returns from the recreational fishery during 1981 (Table 30b) totalled 22% of the regional catch.

Crab

The edible crab lives on firm sand from the low tide mark to as deep as 190 metres. Spawning occurs in late fall or early winter with eggs being carried by the female until hatching in the spring. Crab larvae swim freely among plankton for three or more months before settling to the bottom. The adult diet includes clams, marine worms and small fish. The Pacific, edible or Dungeness crab is generally trapped on the bottom in less than 38 m of water.

Limited crab habitat exists within the study area. Although historic concentrations have been reported in the Thormanby Islands area, Porpoise Bay is the only commercial harvest area. Tables 30a and 30b record the commercial and recreational landings from a local and regional perspective.

Oysters

Pacific oysters normally inhabit intertidal flats of firm mud, sand, or gravel, although they are often grown commercially at the lowest tidal levels. Oysters require relatively sheltered surroundings to prevent being dislodged or buried in the sediment. Following reproduction, the microscopic larvae or spat (essentially miniature unshelled adults) settle on to suitable surfaces (a process known as spatfall). Pendrell Sound has the only consistently large spatfall in the study area and has, therefore, been designated as a Shellfish Reserve.

Commercial permit harvesting of wild stocks (other than in Pendrell Sound) is limited to scattered populations sustained through local spatfalls. Most wild stocks are reserved for the recreational harvest.

The commercial shellfish industry, therefore concentrates on artificial propagation or mariculture which provides a variety of surfaces (or cultch) on which spat from Pendrell Sound can settle and grow. Commercial production for 1975 to 1980 and recreational landings for 1981 are presented in Tables 30a and 30b respectively. Area 15 landings dominated the commercial harvest, probably reflecting the distribution of mariculture leases, whereas Area 16 landings dominated the recreational harvest, likely reflecting the distribution. Foreshore leases for mariculture are shown on the accompanying Land/Water Status Map series.

TABLE 30a SHELLFISH FISHERY OF SOUTH MAINLAND COAST: AVERAGE ANNUAL COMMERCIAL CATCH (NEAREST TONNE) OF MAJOR SPECIES, 1975 TO 1981, RELATIVE TO THE STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEMS

Species	South Mainland Coast 15	16	13	East Coast* Vancouver Is. 14,17,18	South Coast Vancouver Is. 19, 20	28	29	Total All Areas
Shrimp and prawns[a]	4	31	12	62	9	66	70	254
Butter clam	2	1	7	115	5			130
Japanese littleneck(Manila)	138	16	44	82	12			292
Native littleneck	20	14	43	50	10			137
Mixed clams[c]	39	23	19	12	5			98
Total Clams	199	54	113	321	32	66	70	657
Geoduck clam (1977-1981)	142	108	64	359	86			759
Abalone			1		4			5
Crabs		3	2	58	74	33	249	419
Oysters[b] (1975-1980)	5	1		51	18			75
Sea urchins (1979 only)				266	47			313

NOTES: [a] captured primarily by trap

[b] 1981 data unavailable by Statistical Area. Catch expressed in nearest 1000 U.S. gallons shucked. Includes both cultured (from leases) and wild oysters (from permits).

[c] Includes all other species.

* Other coastal folio study areas for comparison.

SOURCE: Canada, Department of Fisheries and Oceans. 1975-1981. British Columbia catch statistics (annual reports). Vancouver.

TABLE 30b RECREATIONAL SHELLFISH FISHERY OF SOUTH MAINLAND COAST (NUMBERS) FOR 1981 RELATIVE TO THE STRAIT OF GEORGIA-JUAN DE FUCA STRAIT SYSTEM

Species	South Mainland Coast 15	16	13	East Coast* Vancouver Is. 14,17,18	South Coast Vancouver Is. 19, 20	28, 29	Total All Areas
Shrimps and prawns				4,260	19,132	5,477	28,869
Clams	8,327	69,903	17,151	238,544	14,342	1,043	349,310
Abalone	274	2,125		7,953	691		11,043
Crabs		6,037	5,719	58,976	31,753	27,240	129,725
Oysters	1,556	63,666	20,585	234,731	5,454	7,546	333,538
Other	274	2,058		46,461			48,793

* Other coastal resource folio study areas for comparison.

SOURCE: Bijsterveld, L. 1983. Personal communication. Tidal sport fishing diary program data. Canada, Department of Fisheries and Oceans, Vancouver.

Species Names

In this report, common names are used throughout but, in order to avoid confusion, the scientific names are given below. Common names of fish are those of Hart (1973), shrimp of Butler (1980), and clams of Quayle and Bourne (1972).

Salmon

Chum	*Oncorhynchus keta*
Chinook	*O. tshawytscha*
Coho	*O. kisutch*
Pink	*O. gorbuscha*
Sockeye	*O. nerka*
Coastal Cutthroat trout	*Salmo clarki clarki*
Steelhead	*S. gairdneri*
Pacific herring	*Clupea pallasii*

Groundfish/Midwater Fish

Pacific cod	*Gadus macrocephalus*
Walleye pollock	*Theragra chalcogramma*
Pacific hake	*Merluccius productus*
Tomcod	*Mocrogadus proximus*
Slender sole	*Lyopsetta exilis*
English (Lemon) sole	*Parophys vetulis*
Flathead sole	*Hippoglossoides elassodon*
Rex sole	*Glytocephalus zachirus*
Rock sole	*Lepidopsetta bilineata*
Dover sole	*Microstomus pacificus*
Sand sole	*Psettichthys melanostictus*
Arrowtooth flounder	*Atheresthes stomias*
Butter sole	*Isopsetta isolepis*
Starry flounder	*Platichthys stellatus*
Speckled sanddab	*Citharichthus stigmaeus*
Pacific halibut	*Hippoglossus stenolepsis*
Rockfish	*Scorpaenidae*
Spiny Dogfish	*Squalus ocanthias*
Lingcod	*Ophiodon elongatus*

Shellfish

Prawn Shrimp	*Pandalus Platyceros* *P. jordani* *P. borealis* *P. hypsinotus* *P. danae* *Pandalopsis dispar*
Edible (Dungeness) crab	*Cancer magister*
Razor clam	*Siliqua patula*
Butter clam	*Saxidomus giganteus*
Manila clam	*Venerupis japonica*
Littleneck clam	*Protothaca staminea*
Horse clam	*Tresus capax*
Geoduck clam	*Panope generosa*
Oyster	*Crassostrea gigas*
Sea Urchin	*Strongylocentrotus franciscanus*
Mussels	*Mytilus edulis*
Red squid	*Beryteuthis magister*
Opal squid	*Loligo opanescens*
Octopus	*Octopus spp.*
Abalone	*Haliotus rufescens*

5.5 RECREATIONAL RESOURCES

The Sunshine Coast provides abundant opportunities for outdoor recreation. There are numerous bays, harbours, scenic shorelines, shore process features and wilderness areas to attract recreationalists. Although not abundant, there are large sandy beaches within the study area that are heavily used during the summer months. The backshore clearings are important for camping and upland activities for boaters and are, in some areas, the only means of access to the shorezone. The major harbours are developed but still provide a suitable environment for viewing, nature appreciation, and boating; further, many of the rocky coasts contain a diversity of marine life that attracts divers. Most of this coast is rated by the Canada Land Inventory as having moderate to very high capability for outdoor recreation (Canada, Department of Environment, 1978).

5.5.1 COMPETITION FOR SPACE AND RESOURCES

Competing for the resources of the study area are recreationalists from local communities, Greater Vancouver, and the influx of tourists. Currently, tourism within the Strait of Georgia region adds almost two million people annually. In 1979, about 83 thousand households within the region owned one or more recreational boats; also in 1973, nearly ten thousand tourist boaters visited the coastal waters of the Strait. By 1985, the boater population is expected to increase by 32% (Eby, 1979); the demand for boating facilities and associated coastal recreation areas may be equally high in view of the projected population growth.

Doubtless, competition for resources will be manifested at three levels: a) between major classes of activities (i.e. recreational use of shorelines vs industrial development), b) between sub-groups 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 several of the natural harbours. Industrial developments, commercial operations and residential developments are often attracted to these areas because of the degree of coastal protection provided, and by the economics of construction. While much of the foreshore of the study coastline remains unalienated, numerous authorized and unauthorized structures have been constructed.

These structures include concrete ramps for boat launching, wharves, floats, and floating buildings tied to the foreshore. Occasionally, evidence of excavation and levelling by machines is found in the intertidal areas. These occurrences may be incidental to backshore construction projects, or the result of private individuals using intertidal materials for personal projects.

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 unprotected. 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 constriction on the foreshore or backshore zones preempts recreational use as effectively as numerous licenced 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 the longshore sediment transport system 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.

5.5.2 ACCESS

One of the most pressing coastal zone problems of other jurisdictions (e.g. California, Sweden) is the lack of public access to the shoreline. Although much of the study shoreline is accessible to the public, many regions are virtually inaccessible. A combination of private waterfront ownership, heavy forest cover and rock cliffs precludes the use of many potential recreational areas by the non-boating public. Similarly, marinas with security fences, and adjacent commercial-industrial developments either physically prevent access or render the site physically unattractive for recreational purposes. In other coastal areas, access to the water is either unmarked or inadequate for vehicles and pedestrians. Log booming and storage on the intertidal flats of major estuaries similarly prevents their unobstructed enjoyment while also reducing the habitat of recreational wildlife species. Backshore developments and foreshore leases destroy the wilderness concept and the aesthetics of many sections of scenic coast. While many miles of unobstructed shoreline remain for recreationists wishing to enjoy the scenery and biota of the coastal zone in solitude and beyond sight of human activities, the issuance of new foreshore leases into new areas could in time eliminate all vestiges of isolation in the study area.

5.5.3 POLLUTION

Marine water quality in the study region currently restricts recreational activities in local areas. Sewage outfalls from municipalities and cities are responsible for numerous shellfish closures along the coast. Boat wastes in natural harbours, marinas, as well as 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 (e.g. Desolation Sound) evidence poor visual and aesthetic water quality.

Water contact sports (i.e. swimming) conducted in areas 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. The consumption of marine and intertidal biota are important recreational activities in this area; water quality, therefore, is of great concern. In many instances, the costs of pollution are external to the originating sources and are thus borne by the recreational community.

5.6 PHYSICAL PROCESSES AND ENERGY

5.6.1 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 sedimentation of harbours.

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

Recreationalists are concerned with the stability of coastal bluffs and beaches (fronting recreational properties), marina protection, and the maintenance of sandy beaches.

The following discussion does not attempt to cover the current state of the art in wave theory, but instead reviews what is known about the wave characteristics of the study area. For further, general reading on the subject, Bascom (1980) and Thomson (1981) are excellent laymen's texts. For scientific works of Canadian conditions, reports by the Associate Committee for Research on Shoreline Erosion and Sedimentation (ACROSES) (1980, 1983) and McCann (1980) are available. Thomson (1974-1977) has written an excellent series of articles as well as a text (Thomson, 1981) on the oceanography of the study area. Volume II of the East Coast Vancouver Island Coastal Resources Folio provides a summary of the status of knowledge of wave climate for the western Strait of Georgia (Environment Canada, Lands Directorate, 1981).

Most of the wave climate and wave energy studies in the strait have been concentrated on the eastern shore of Vancouver Island between Victoria and Campbell iver. Knowledge obtained from these studies, in some instances, can be applied to the present study area.

Wave Height

Wave height is a function of three variables.

i) Wind strength - the speed of the generating wind.

ii) Wind duration - the time the generating wind has been blowing at a particular speed.

iii) Fetch - the unobstructed area of water over which the generating wind can blow.

Wind Strength

Owens (1980) notes that the direction of the strongest winds is more significant to wave generation than prevailing wind patterns. For coastal British Columbia the stronger winds generally occur in winter. Figures 12 and 13 display the percentage frequency of winds over 30 km/hour for two representative stations: Ballenas Lightstation and Merry Island. Here, winds from the southeasterly quadrant dominate in all seasons. The lower northwesterly component could reflect the sheltering effects of Texada and Lasqueti islands. Regardless, over open water, the less frequent northwesterly maximums can approach the strength of the southeasterlies (Schaefer, 1983 pers. comm.). This was verified earlier by Guenther and Faulkner (1979). They compared all the station records for the Strait of Georgia and concluded:

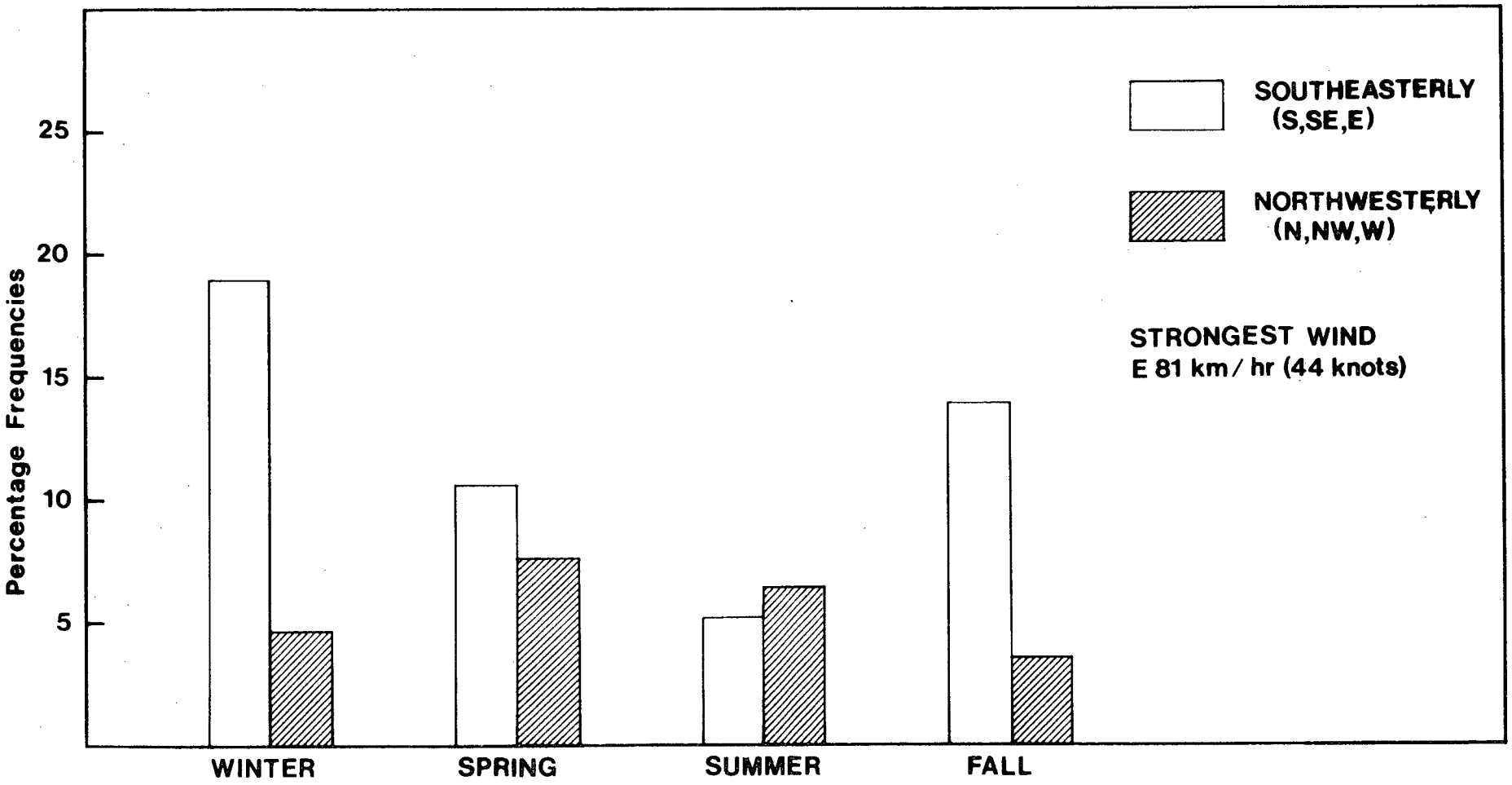
"...that the strongest recorded winds at most stations in the Strait are southeasterly, but in some months, for example January, at Entrance Island, the strongest winds are northwesterly". The figures also identify the strongest winds observed at each of the stations. In both cases, they are from the southeasterly quadrant and represent the observed extremes for those stations.

The National Building Code sets structural requirements for all buildings in Canada. One of the requirements identified is wind force; all structures must withstand the specified force as a minimum. The forces are calculated as probabilities of being exceeded in any one year. They are based on hourly wind speeds with a 1 in 10, 30 and 100 chance of being exceeded (NRC, 1975). Powell River is the only station in the study area to have calculated values*:

a)	1 in 10	92 km/hr
b)	1 in 30	105 km/hr
c)	1 in 100	119 km/hr

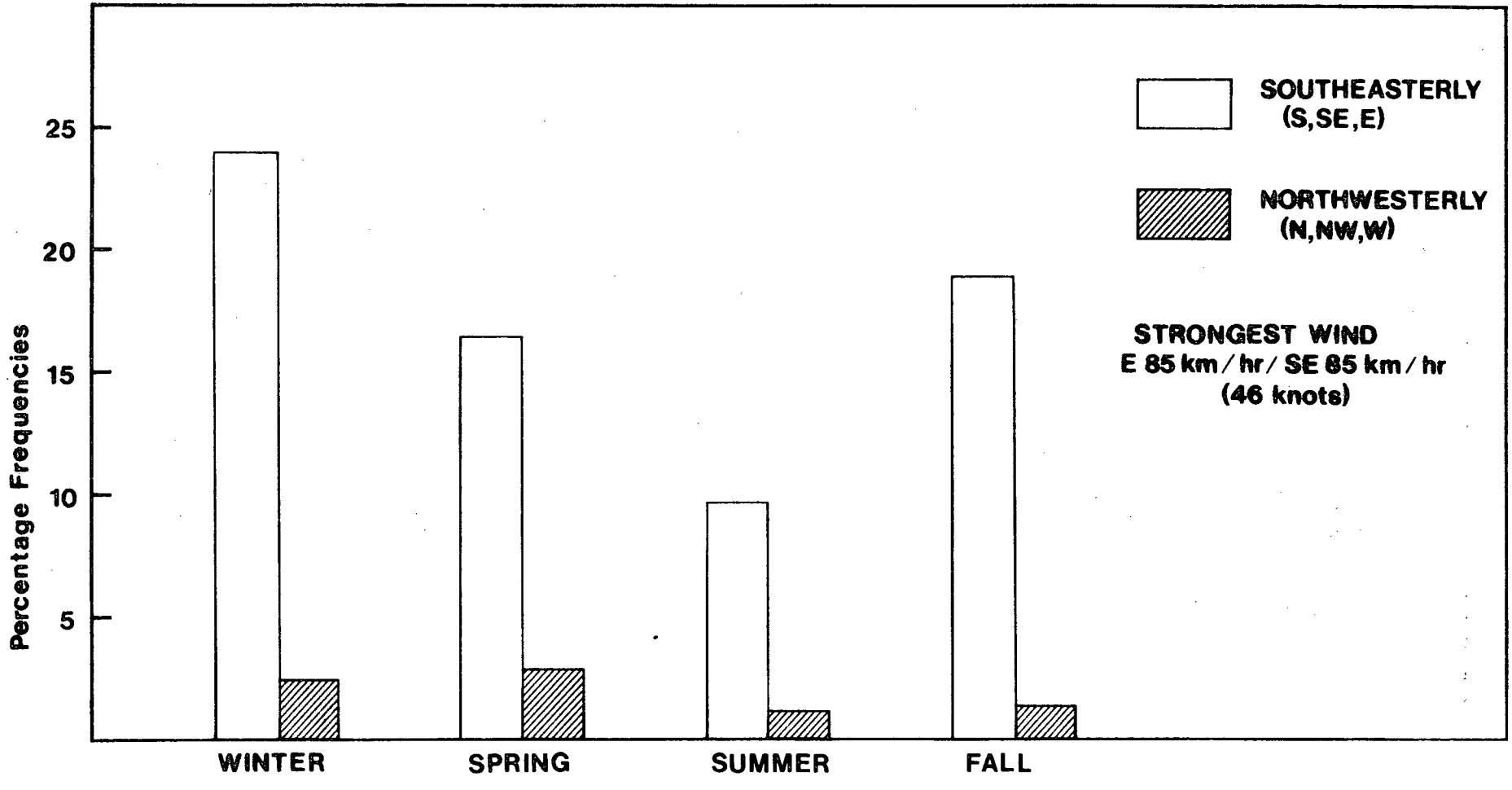
*Calculated from formula for wind pressure: $P = CV^2$
where
C - constant, .0027; V - maximum hourly wind velocity and P - velocity pressure; solved for V. (NRC, 1975)

Figure 12 . Percentage Frequencies of Hours with Wind Speeds 30 km / hr (17 knots) or Greater for Ballenas Lightstation (1967 – 80)



SOURCE: Canada, Department of Environment, 1982. Canadian Climate Normals 1951-1980- Wind. Volume 5. Atmospheric Environment Service. Downsview.

Figure 13 . Percentage Frequencies of Hours with Wind Speeds 30 km / hr (17 knots) or Greater for Merry Island (1963-80)



SOURCE: Canada, Department of Environment, 1982. Canadian Climate Normals 1951-1980-Wind. Volume 5. Atmospheric Environment Service. Downsview.

Statistically, then, very strong winds are possible. All the values cited represent the more exposed coasts of the study area. Winds in more sheltered areas are highly variable, reflecting local topographic effects rather than seasonal climate. The inlets of the study area are examples.

Most of the inlets of the region are aligned so that they are not affected by the prevailing or even strong wind patterns. The topographic effects are dominant. Of significance are the winter outflow winds called Squamishes. They are primarily associated with polar continental air (or Arctic air) over the interior of the province flowing seaward. This cold, dense air is funnelled through the inlets to produce up to gale force winds. Howe Sound, Jervis and Toba inlets are susceptible to these wind conditions. Few data are available on Squamishes, but measurements taken for Howe Sound are indicative. These measurements show that wind speeds frequently reach 55 km/hr with gusts to over 100 km/hr (Thomson, 1981).

Wind Duration

Hale and Greenwood (1980) state that "waves take a certain length of time to develop over any significant fetch...". Thus the duration of a certain wind speed is critical to the size of waves that can be generated within a given fetch. McCann and Hale (1980) used a minimum of six hours for their wave calculations on eastern Vancouver Island. Hale and McCann (1982) refined this estimate somewhat by observing that "Maximum wave conditions for Craig Bay are therefore generated in a relatively short time (usually much less than six hours)". Harper (1982), on the other hand, noted that one hour should produce significant waves in less exposed sites. These observations are verified by Hale and McCann's (1982) calculations for Craig Bay on eastern Vancouver Island. Table #31 and Table #32, though for an area outside of the present study, reveal the relationship between effective fetch and wind duration to produce maximum wave heights; note that as the velocity increases, the duration decreases. Thomson (1981) also notes that from the sparse data on Squamishes for Howe Sound, it was observed that these winds can persist for up to five days and occur, on average, for five to six days in December and January.

Fetch

The Strait of Georgia is fetch limited for developing large sea waves. The present study area is further sheltered by the presence of Texada and Lasqueti islands. Dunn (1983) defined 95 general fetch units for the study area. Of the straight line fetches measured, 13% were greater than 100 km; all to the southeast quadrant. The southeast quadrant, in total, accounted for 56 of all the measurements made while the northwest quadrant accounted for 38%. These values are significant when one reviews the strong wind data.

TABLE 31 MINIMUM DURATION (MINUTES) TO GENERATE MAXIMUM WAVE HEIGHTS FOR CRAIG BAY

Direction	Effective Fetch (km)	Wind Speed (km/h) 16.1	32.2	48.3	64.4	80.5
W	5.0	55	42	35	31	28
NW	32.1	360	250	200	175	160
N	26.5	320	240	190	170	150
NE	23.8	275	200	170	140	120
E	18.8	235	100	85	75	68

Source: P.B. Hale and S.B. McCann, 1983. "Rhythmic Topography in a Mesotidal, Low-Wave Energy Environment". Journal of Sedimentary Petrology, Vol.52, No.2, June, 1982. pp.415-429.

TABLE 32 MINIMUM FETCH AND DURATION TO PRODUCE FULLY DEVELOPED SEAS AT VARIOUS WIND SPEEDS

Wind Speed km/h	18.5	28	37	46	55.5	74	93
Fetch (km)	19	63	139	296	518	1315	2630
Duration (h)	2.4	6	10	16	23	42	69
Average Height (m)	0.3	.8	1.5	2.7	4.3	8.5	14.6
Significant Height[1] (m)	.4	1.1	2.4	4.3	6.7	13.4	23.8
Average of the highest 10% (m)	.6	1.5	3.1	5.5	8.4	17.4	30.2
Period having the greatest concentration of energy (seconds)	4	6	8	10	12	16	20

[1] The Significant Height is the average height of the highest 1/3 of the existing waves. The maximum wave height is about 1.8 times the significant height.

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.

Synthesis

The study area is primarily fetch limited in developing large sea waves. The present study area is further sheltered by the presence of Texada and Lasqueti islands play a significant role in reducing available fetch. The largest waves are generated by winds from the southeast or northwest, while dominant waves are from the southeast (Clague and Bornhold, 1980). This correlates with the strong wind directions and longest fetches discussed earlier. Recent studies on the waves of the Strait of Georgia concluded that the maximum height would always be less then 4 m (Hale and McCann, 1982 and Thomson, 1981). A notable exception, however, is waves associated with strong tidal flows and opposing winds, then waves have been known to attain 5 m (Thomson, 1981).

There are good records of actual wave measurements for the study area. Figure 14 shows the calculations for the highest one-third (significant height) and the maximum height of waves probable for each station. Four stations (Powell River, Lund, Gibson's Landing and Fisherman's Cove) represent waves likely in sheltered locations of the study area's outside coast.

Halibut Bank gives values likely for the exposed areas; Roberts Bank provides a comparison. For the sheltered areas significant wave heights never exceeded 1 m over the period of record. In fact, only 10% of the time did they ever exceed .3 m. These values are affected by the number of calm conditions recorded as well. Percentage calms were high for all four stations:

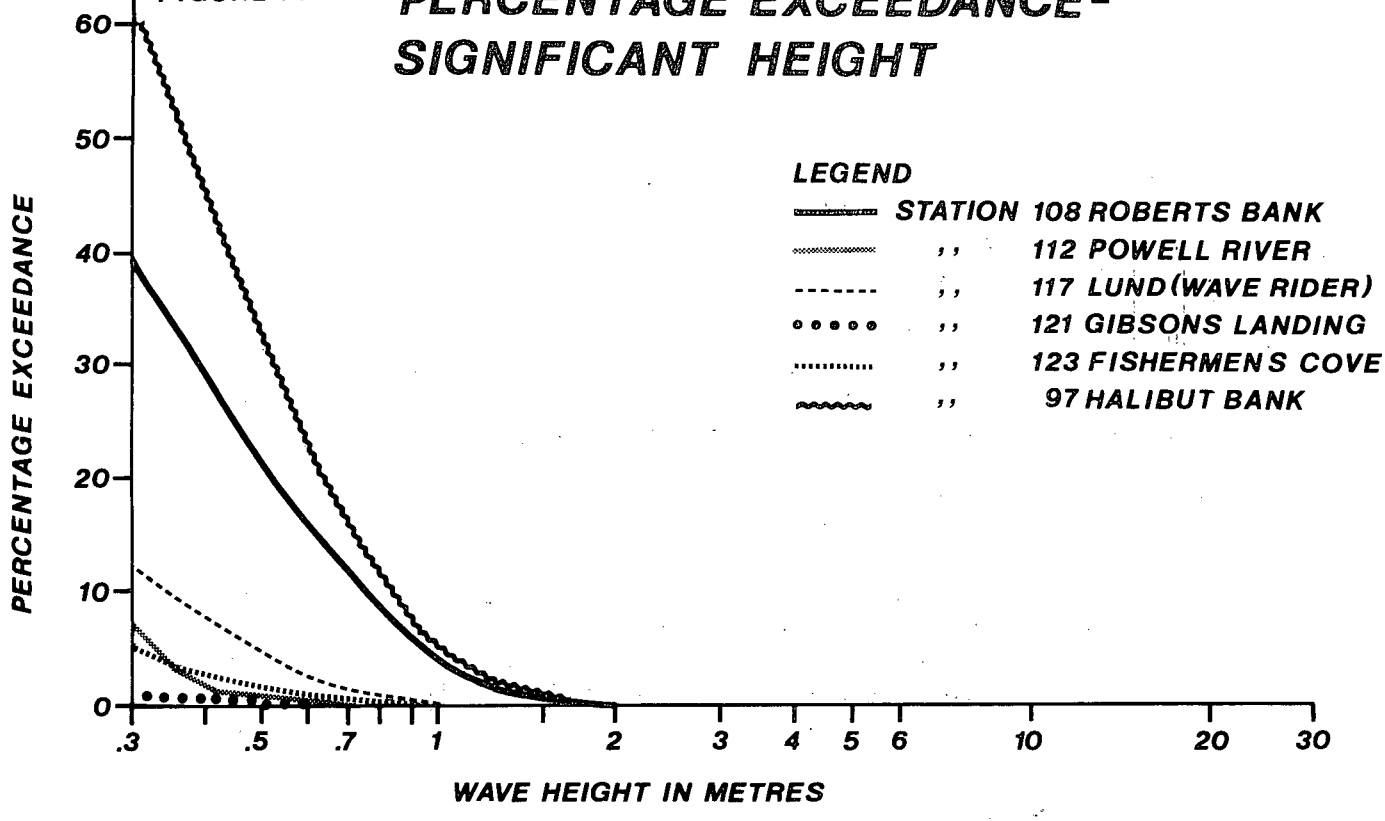
a) Powell River - 79% calm over three-month record
b) Lund - 75% calm over six-month record
c) Gibsons Landing - 98% calm over 12-month period
d) Fisherman's Cove - 64% calm over 12-month period

Maximum heights probable for these localities are also low; 1.5 m would never be exceeded, while .3 m would only be exceeded 20% of the time. Halibut Bank, on the other hand, exhibits much higher values indicative of the more exposed location. Wave heights exceeded .3 m 60% of the record period, but they were never larger than 1.5 m. Also of significance is that there were no periods of calm during the measurements. Maximum values for the station exceed .3 m with a probable maximum never exceeding 2.4 m.

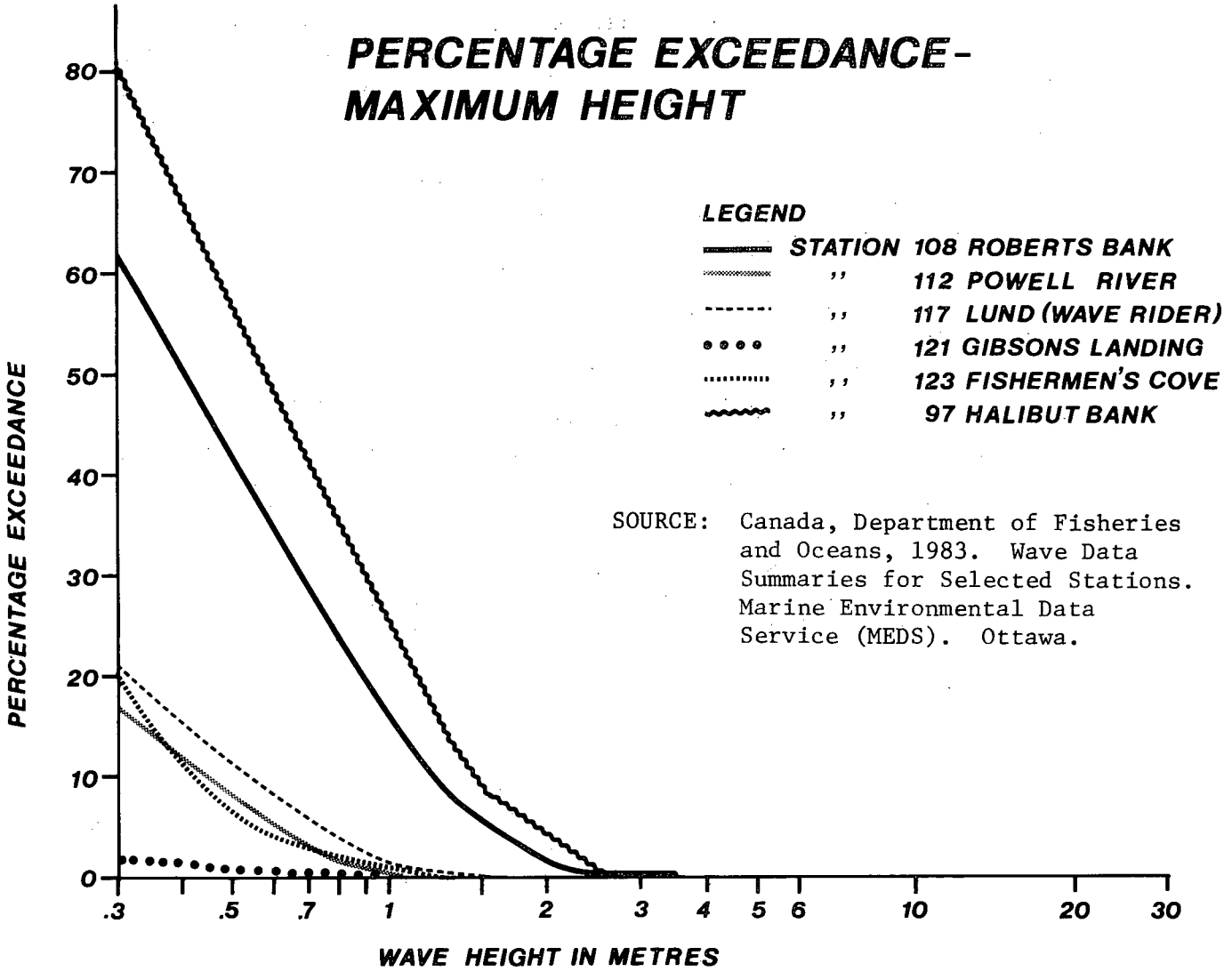
No direct wave measurements have been made of the inlets in the study area. The longest fetches are generally parallel to the axis of the inlet and protected from waves generated by prevailing winds. Squamish

FIGURE 14

PERCENTAGE EXCEEDANCE - SIGNIFICANT HEIGHT



PERCENTAGE EXCEEDANCE - MAXIMUM HEIGHT



SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Selected Stations. Marine Environmental Data Service (MEDS). Ottawa.

winds are the most significant contributing factor to highest wave generation. Waves associated with these winds tend to be of short period and steep. For example, the highest waves probably for Howe Sound are 1.5 m, although 2.5 m waves are possible during the Squamishes (Thomson, 1981).

Wave Energy (See Figure 15)

Wave Period

Thomson (1981) indicates that a great majority of the waves in the Strait of Georgia (off the Fraser River) have periods between two and four seconds. This is confirmed by the wave periods recorded in the present study area (Figures 16 through 21). 76% of the waves had two to four second periods. The remainder of the wave periods were generally less than six seconds. Waves generated in inlets would predominantly be of short periods.

Water Levels

Owens (1980) notes that as tidal range increases, available wave energy can dissipate over a larger vertical area. Maximum tidal ranges in the study area are between 5 and 5.5 m. A notable exception is Porpoise Bay, at the head of Sechelt Inlet; its range is just under 3 m. A complication of these water levels are storm surges; a combination of strong winds and high tides. The most recent surge within the study area was in December 1982. Figure 22 shows the observed tides less the predicted tides for two stations south and west of the study area. The maximum surge level attained was about 1 m above predicted levels. Murty (1983, pers. comm.) states that the return probability of these surges is about 10 to 12 years in certain locations and up to 20 years in others. Steep coasts are generally not adversely affected, but low-lying coasts are highly vulnerable. Storm surges, in effect, are rapid sea level changes.

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:

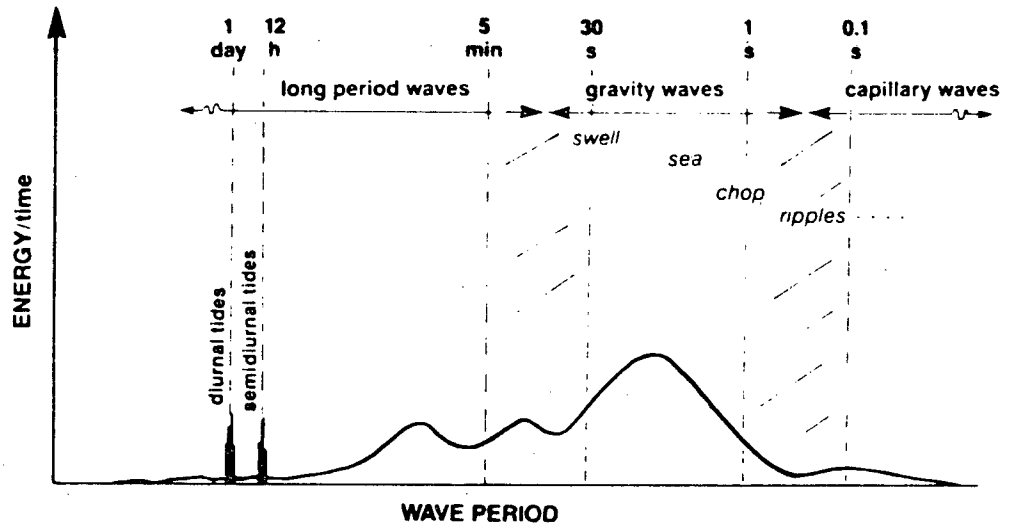
a) Tidal stations

Vancouver, Point Atkinson, Prince Rupert	1-2 mm/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

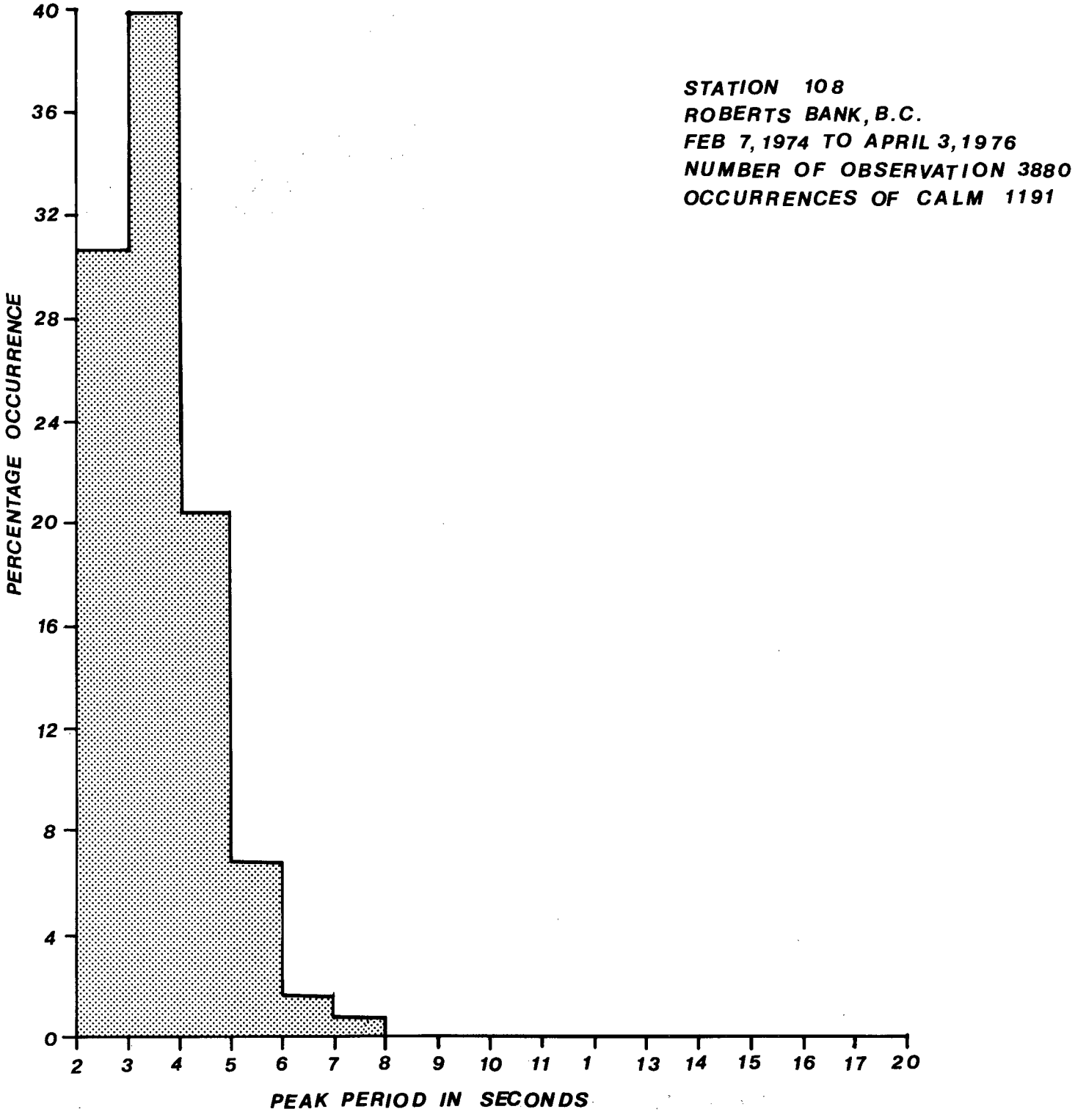
FIGURE 15 POWER SPECTRUM OF RELATIVE AMOUNT OF ENERGY CONTAINED BY WAVES OVER A RANGE OF WAVE PERIODS



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).

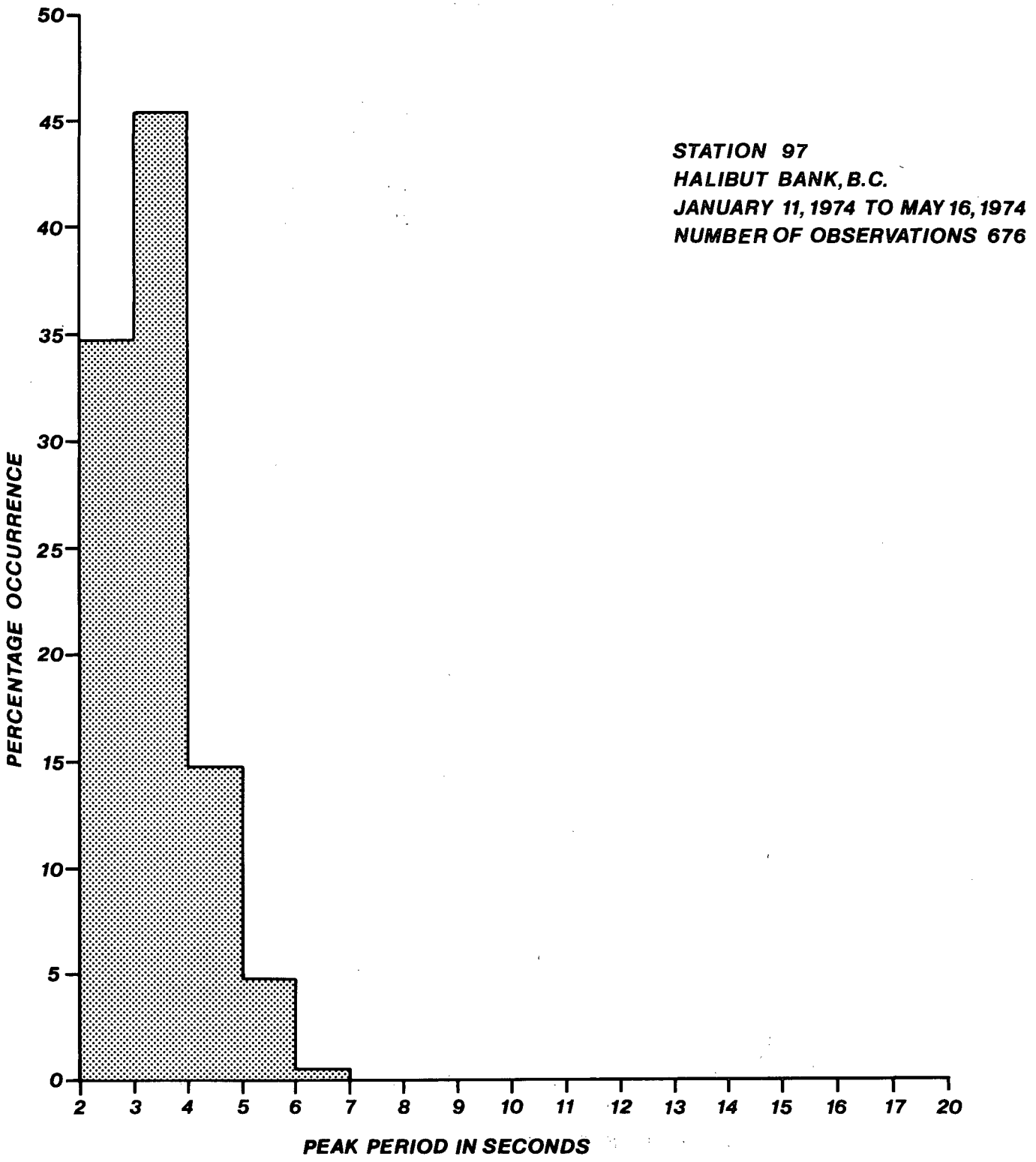
Source: R.E. Thomson, 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Aquatic Sciences 56. Fisheries and Oceans Canada. Ottawa. p.89.

FIGURE 16 PERCENTAGE OCCURRENCE OF PEAK PERIODS, ROBERTS BANK



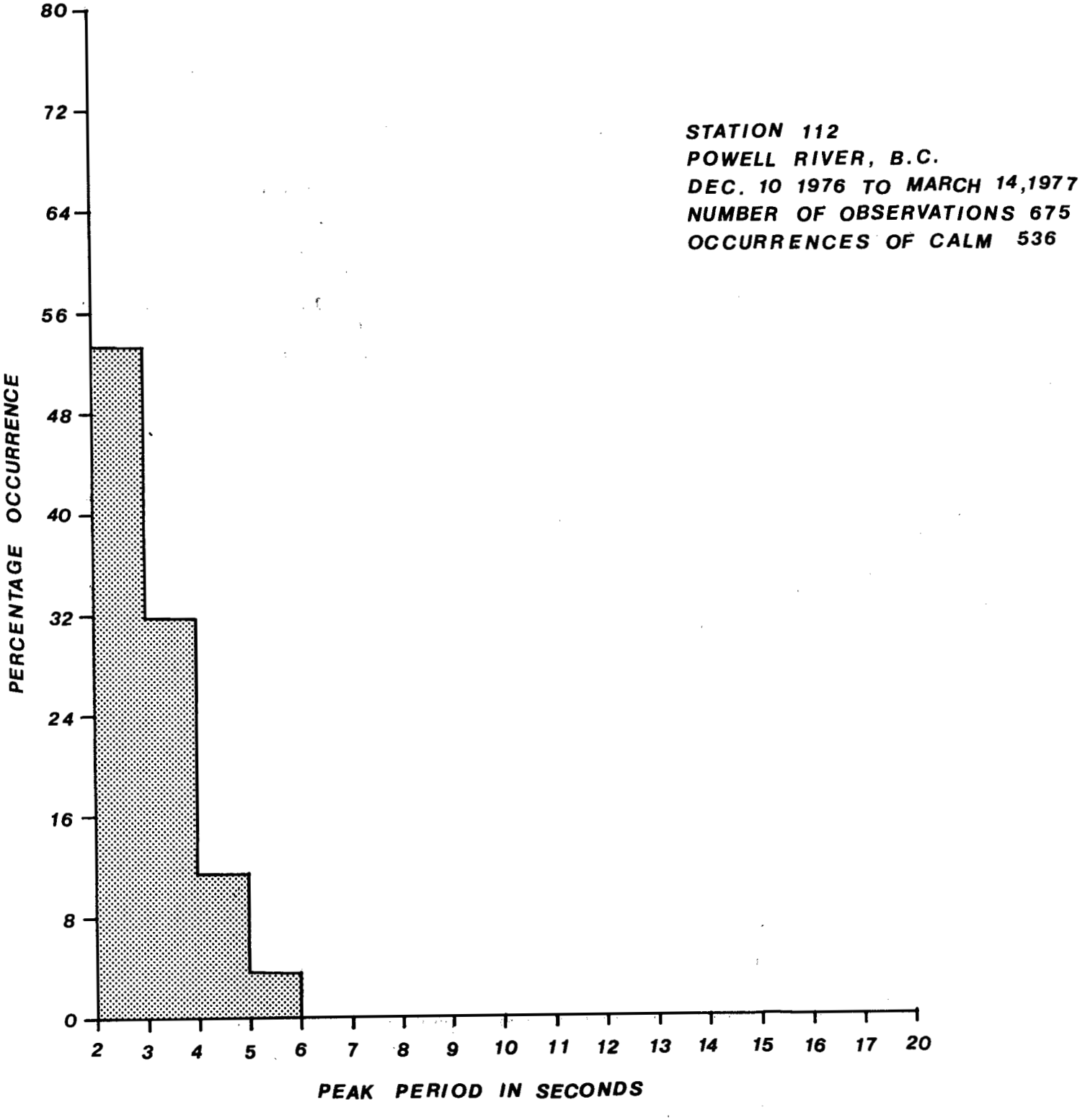
SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 108, Roberts Bank. Marine Environmental Data Service. (MEDS). Ottawa.

FIGURE 17 PERCENTAGE OCCURRENCE OF PEAK PERIODS, HALIBUT BANK



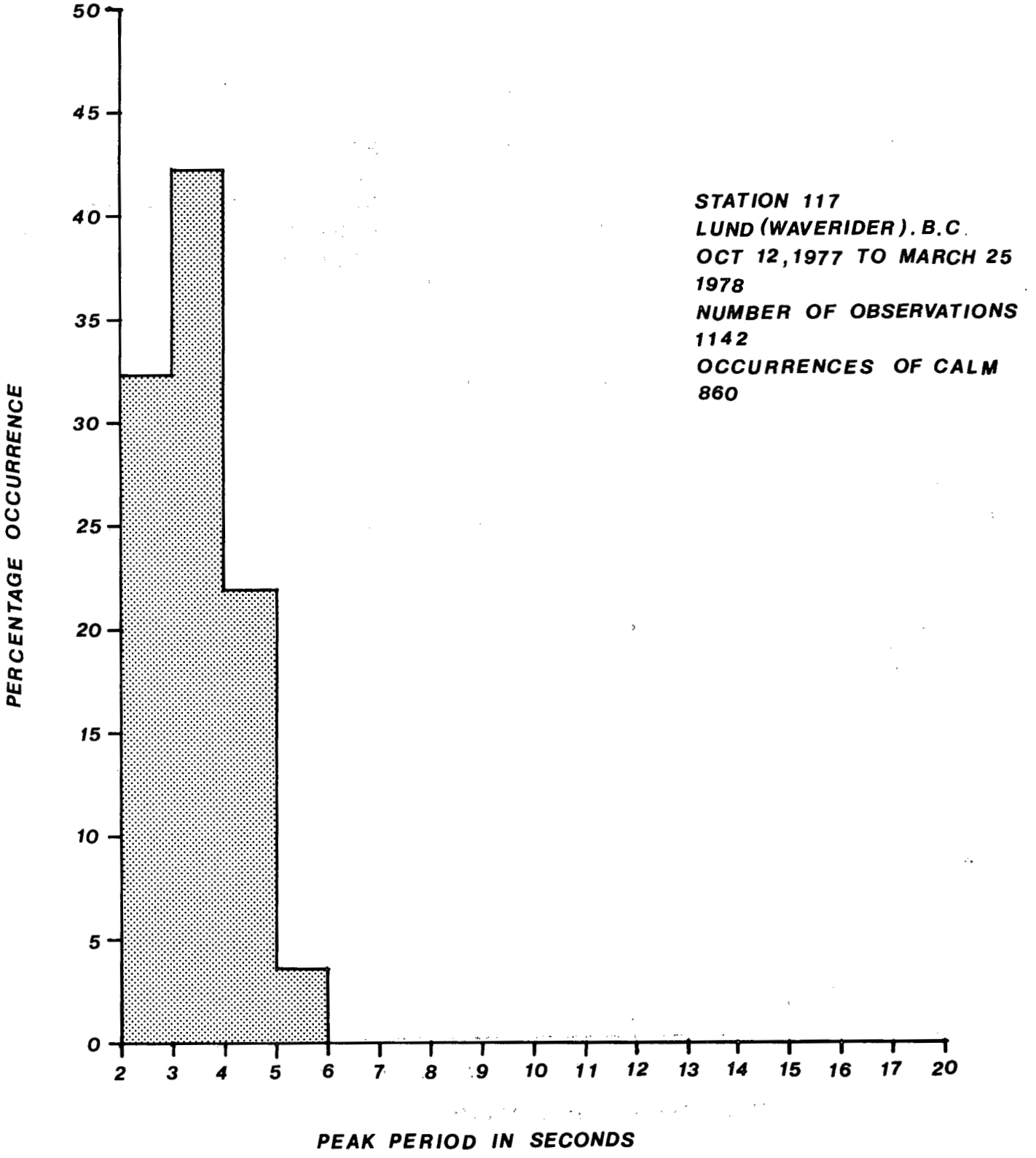
SOURCE: Canada Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 97, Halibut Bank. MEDS. Ottawa.

FIGURE 18 PERCENTAGE OCCURRENCE OF PEAK PERIODS, POWELL RIVER



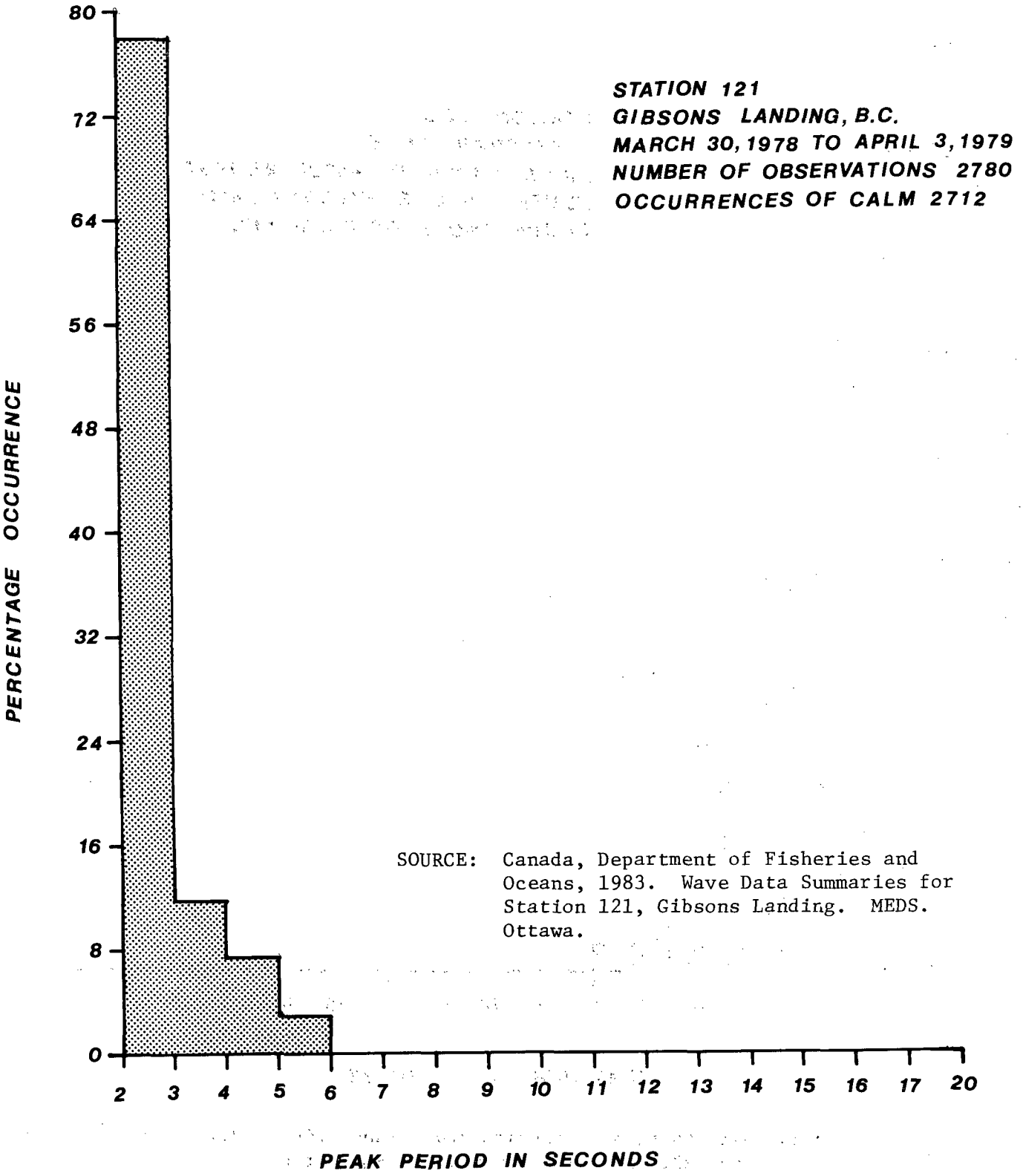
SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 112, Powell River. MEDS. Ottawa.

FIGURE 19 PERCENTAGE OCCURRENCE OF PEAK PERIODS, LUND



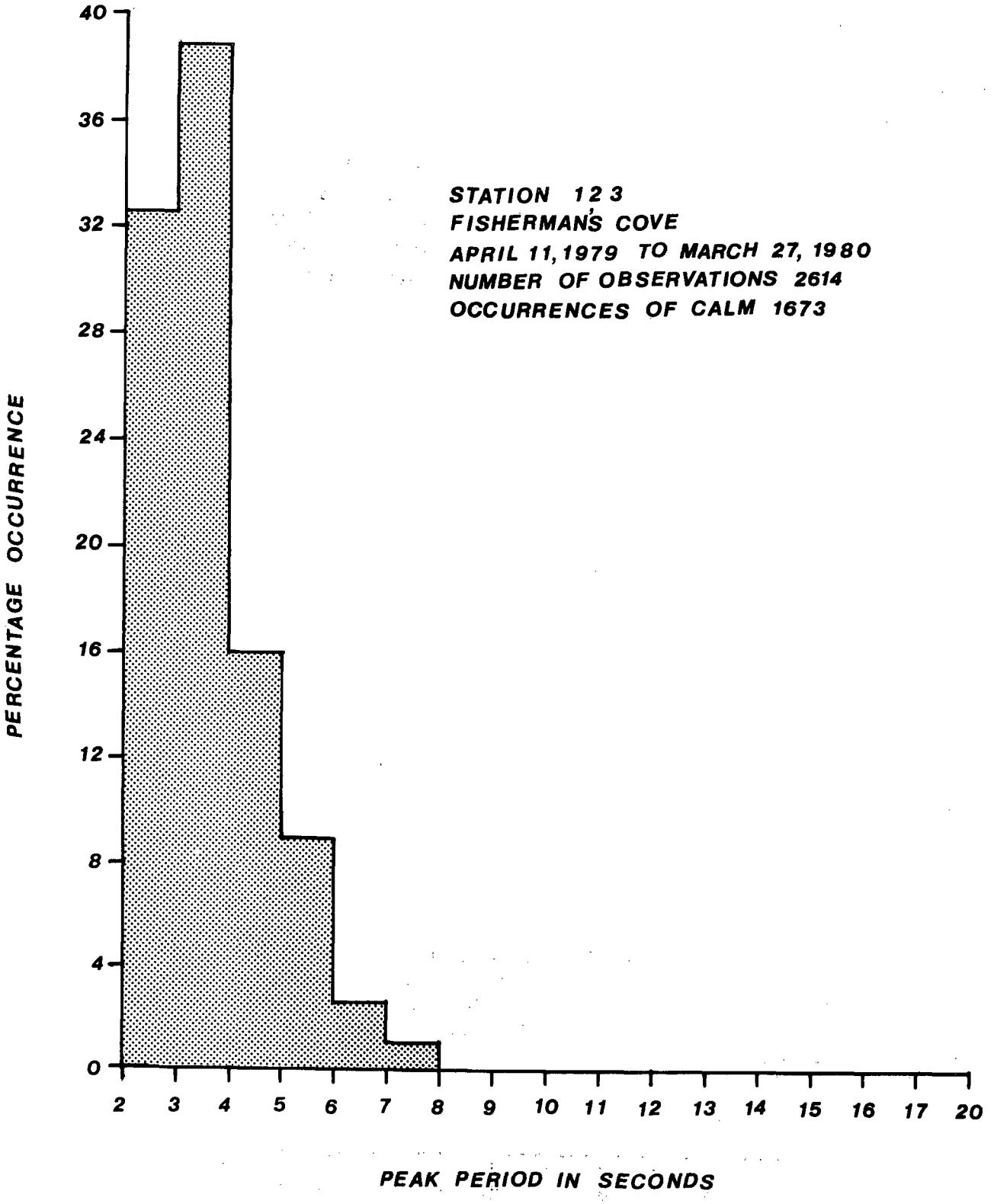
SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 117, Lund. MEDS. Ottawa.

FIGURE 20 PERCENTAGE OCCURRENCE OF PEAK PERIODS, GIBSONS LANDING



SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 121, Gibsons Landing. MEDS. Ottawa.

FIGURE 21 PERCENTAGE OCCURRENCE OF PEAK PERIODS, FISHERMAN'S COVE



SOURCE: Canada, Department of Fisheries and Oceans, 1983. Wave Data Summaries for Station 123, Fisherman's Cove. MEDS. Ottawa.

These long-term trends are important as to how waves affect the shoreline. For instance, a rise in sea level of only several centimetres could cause erosion of a formerly stable bluff, as waves now could reach to the cliff base; the reverse would also be possible.

Nearshore Slope

The amount of wave energy available and how it is dissipated in the shorezone is a function, in part, of the nearshore slope. Long, low slopes tend to dissipate energy gradually as the wave approaches the shore; steep slopes allow wave energy to dissipate directly on the shore. Headlands generally concentrate wave energy, while embayments diffuse it. The shore character of the study area is predominantly steep to moderately steep rock. Unconsolidated shores are also present and tend to have shallower nearshore slopes.

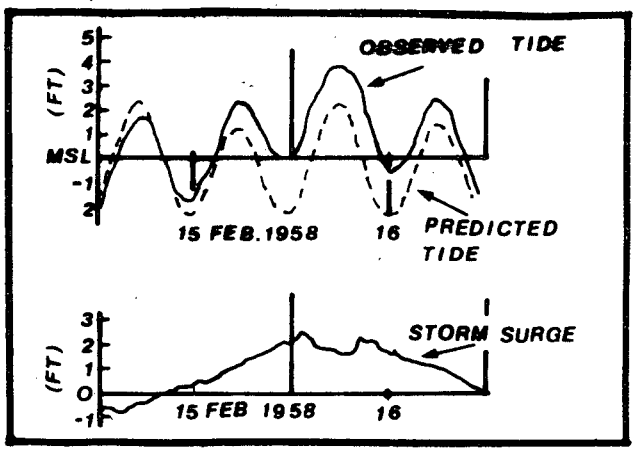
Synthesis

The study area is a moderate to low wave energy environment (Clague and Bornhold, 1980). Wave energy is also dependent on fetch and, as such, waves generated along the strait axis would likely have the highest energy. The study area, by virtue of this observation, would have the highest wave energies from the southeasterly quadrant. Clague and Bornhold (1980) confirm this, noting that the dominant waves in the strait are from the southeast. Thomson (1977c) states that short period waves produce stronger littoral currents than long period waves because they are less susceptible to refraction. This statement implies that there is more energy available to move sediments in these shorter waves. Clague and Bornhold (1980) rate the area as high in terms of littoral current energy.

Examples of the energy waves contain, and to what depth they affect the sediments, are offered by Krauel (pers. comm., 1983, and Harper, 1982). Both examples are outside the present study area, but do illustrate the ability of waves to move sediments in deep water. Krauel recorded large, anomalous wave heights during the storms of mid-December 1982. His wave height recorder was anchored on the bottom at -10 m below chart datum off-shore of Kye Bay on Vancouver Island. Wave heights of greater than 8 m were recorded during the storms. These readings, he deduced, were due to the bouncing of the recorder on the bottom from wave-induced currents. Remember this was during exceptionally high tides, so the water depth would be greater than 10 m at that time. This degree of recorder movement implies that the bottom currents would be strong enough to transport sediments.

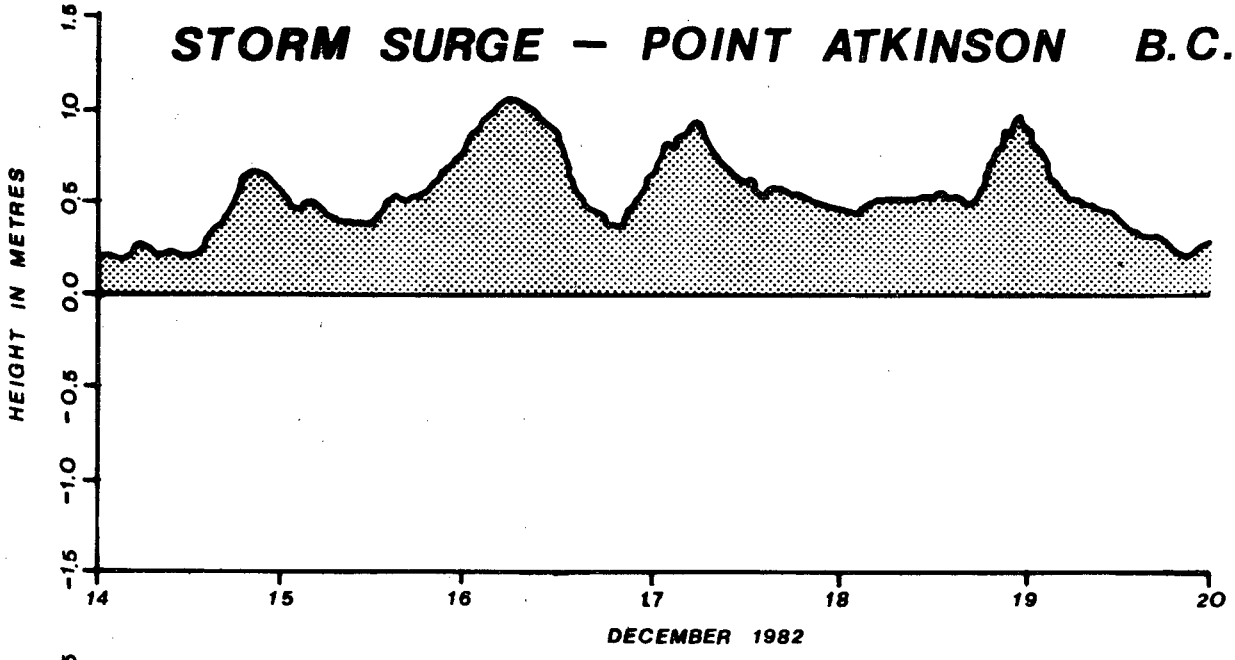
Harper (1982) estimated the maximum depth of bottom disturbance of sand-sized sediments due to wave-induced currents. Table 33 provides these estimates by station and Figure 23 identifies their location. In terms of frequency of disturbance, Harper (1982) cautions that the maximum values may be reached less than one percent of the time; a smaller value may be more frequent. He calculated the largest waves to be less than 2.5 m.

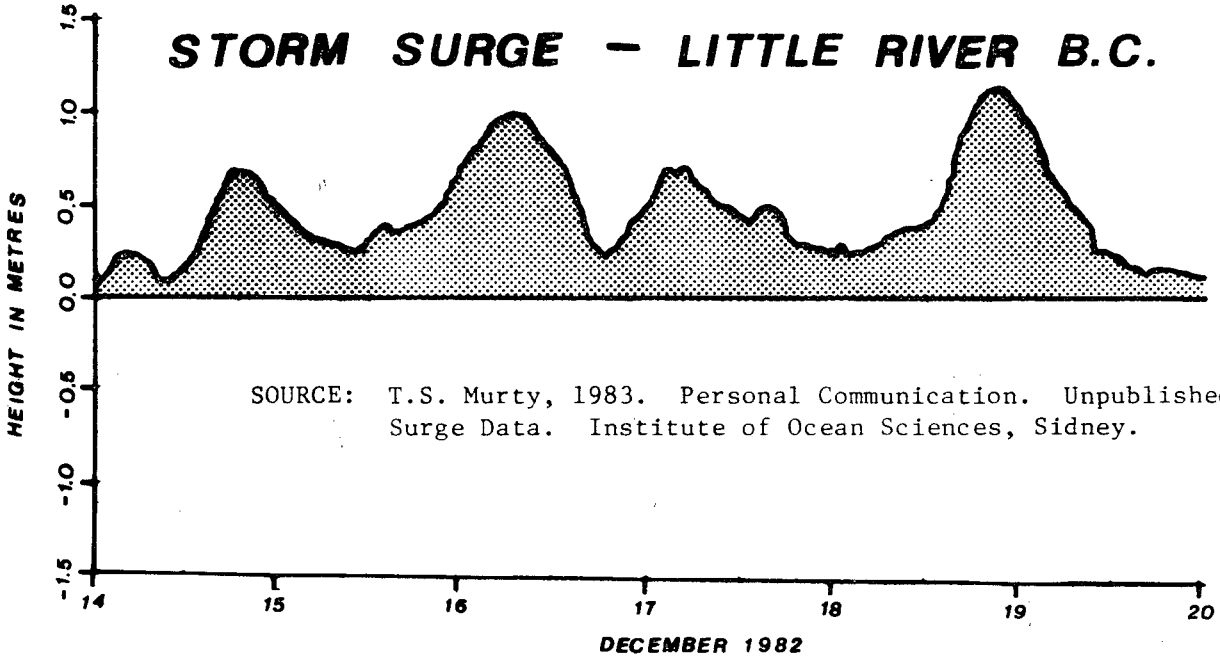
FIGURE 22



Example of how Storm Surge Calculated for Atlantic City, N.J.

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.



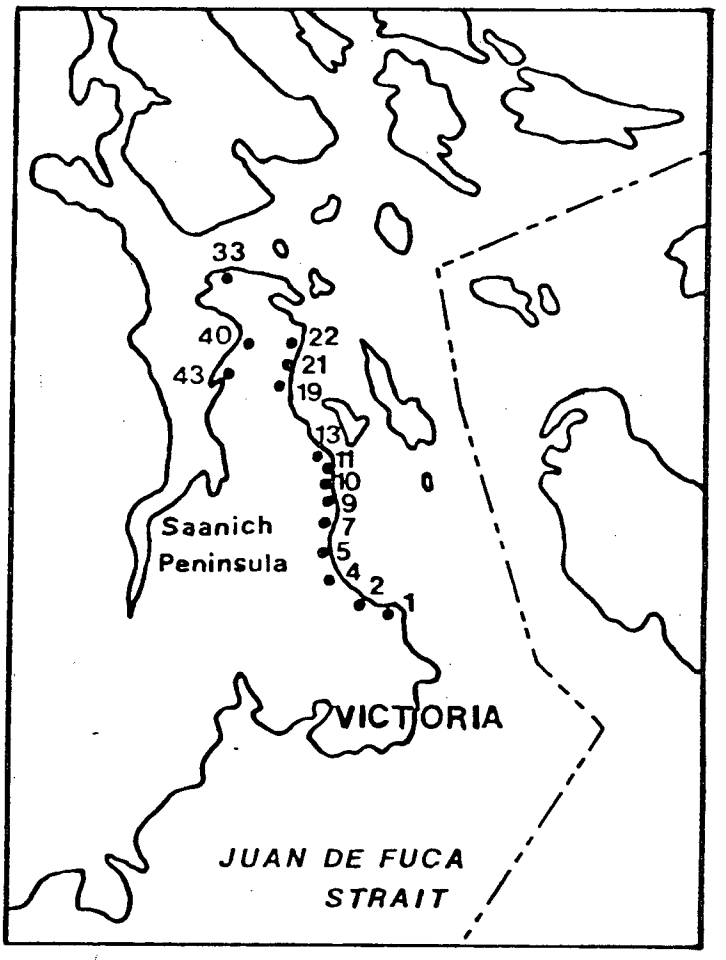


SOURCE: T.S. Murty, 1983. Personal Communication. Unpublished Surge Data. Institute of Ocean Sciences, Sidney.

TABLE 33 MAXIMUM DEPTH OF SEDIMENT (SAND-SIZED) DISTURBANCE DUE TO WAVES

Station	SP01	SP02	SP04	SP05	SP07	SP09	SP10	SP11	SP13
Maximum Depth of Disturbance (m)	12.3	13.2	12.2	17.5	21.7	22.5	21.4	22.7	20.9
	SP19	SP21	SP22	SP33	SP40	SP43			
	7.6	7.8	8.6	8.1	8.1	7.6			

FIGURE 23 LOCATION OF SAMPLE STATIONS



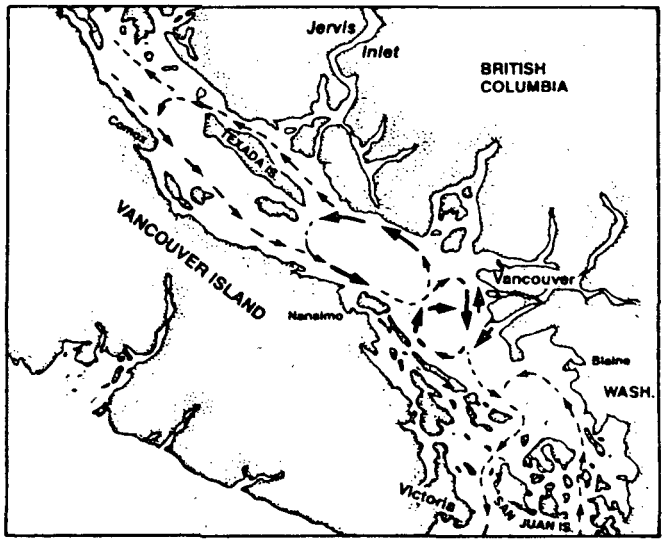
Source: J.R. Harper, 1982. Geologic Applications of a Wave Climate Model with Examples from the Saanich Peninsula. Paper presented at Western Region Workshop, Associate Committee for Research on Shoreline Erosion and Sedimentation, Simon Fraser University.

5.6.2 CIRCULATION

Overall Patterns

Tides, winds, river runoff, coriolis and centrifugal forces all influence circulation patterns. Few current surveys have been conducted in the northern Strait of Georgia compared to the more intensely studied central and southern regions; hence, only general patterns can be determined. The Canadian Hydrographic Services (CHS) Current Atlas (1983), based chiefly on computer models developed at the University of British Columbia, summarizes the Strait of Georgia tidal streams over the tidal cycle, but excludes the effects of winds and river runoff. Figure 24 below depicts the overall "average" surface circulation of the Strait of Georgia inferred by Thomson (1981) from a variety of sources.

FIGURE 24 AVERAGE SURFACE CIRCULATION IN SPRING AND SUMMER IN THE STRAIT OF GEORGIA



NOTE: Large arrows indicate currents measured by current meters and drift drogues. Small arrows indicate currents measured by drift bottles.

SOURCE: R.E. Thomson, 1981. Oceanography of the British Columbia Coast. Special Publication of Fisheries and Aquatic Sciences 56. Canada, Department of Fisheries and Oceans, Institute of Ocean Sciences, Victoria. p.163.

The net circulation is essentially counterclockwise, with ebb and flood streams roughly paralleling the Strait's long axis. The CHS atlas, however, shows that currents in southern Malaspina Strait circulate clockwise during the flood. Along the east coast of Vancouver Island the ebb dominates. Tidal streams achieve maximum flood velocity three hours prior to high water and maximum ebb velocity three hours before low water. Within the broader portion of the Strait, the Coriolis force induces a small tilt towards the mainland, augmenting current speeds slightly on the eastern relative to the western Strait.

Northward and southward advancing tides meet near Lund (tidal exchange through the northern passages is roughly one-fifteenth that of the southern channels), producing weak, highly variable tidal patterns. Tidal currents decrease in strength from south to north, but may increase locally in channels. Velocities in Malaspina Strait and in Sabine Channel between Texada and Lasqueti islands may reach 50 cm per second.

The Fraser River discharge, especially during peak flows, affects much of the central strait, and may override tidal streams. Surface waters from the Fraser River have been found to flow north toward Wilson Creek on the Sechelt Peninsula and then westward towards Texada Island and Lasqueti Island (Thomson, 1981). Away from the influence of the Fraser, surface currents may depend more on local winds and tides.

Currents in the southern Strait are dominated by the tides, though where layering due to freshwater input occurs, the effects of wind may be significant. Velocities are highest in the narrow channels of the Gulf Islands.

Maximum ebb currents, in most cases, flow in the opposite direction to the flood currents. Within the top 100 m, ebb currents are significantly stronger and longer-lasting than flood currents. Conversely, below 100 m, currents are dominated by the flood. This phenomenon is evidently caused by the seaward flow of salt water entrained by surface freshwater coupled with the inward drift of sea water at depth to replace the water carried to the Pacific Ocean within the surface layer (Thomson, 1981).

Factors Influencing the Movement of Oil Spills

Knowledge of the oceanography of the coastal waters is of critical importance in the evaluation of marine resources at risk from oil spills. Oil pollution is a threat because of existing and potential additional oil tanker traffic through Juan de Fuca Strait.

Surface water currents are the major determinant in the movement of a spill when winds are negligible. Tidal currents affect the range of impact, depending at what state of the tide the spill occurred.

Wind-generated surface currents as well as direct effects of wind friction can also be critical factors in the movement of a spill. However, waves created by wind can also contribute to a lessening of impacts of the spill by increasing the attrition of oil by weathering processes - evaporation, emulsification or sinking.

5.6.3 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 25. These values are based on a national study by Shaw, Hirt and Tilley (1972).

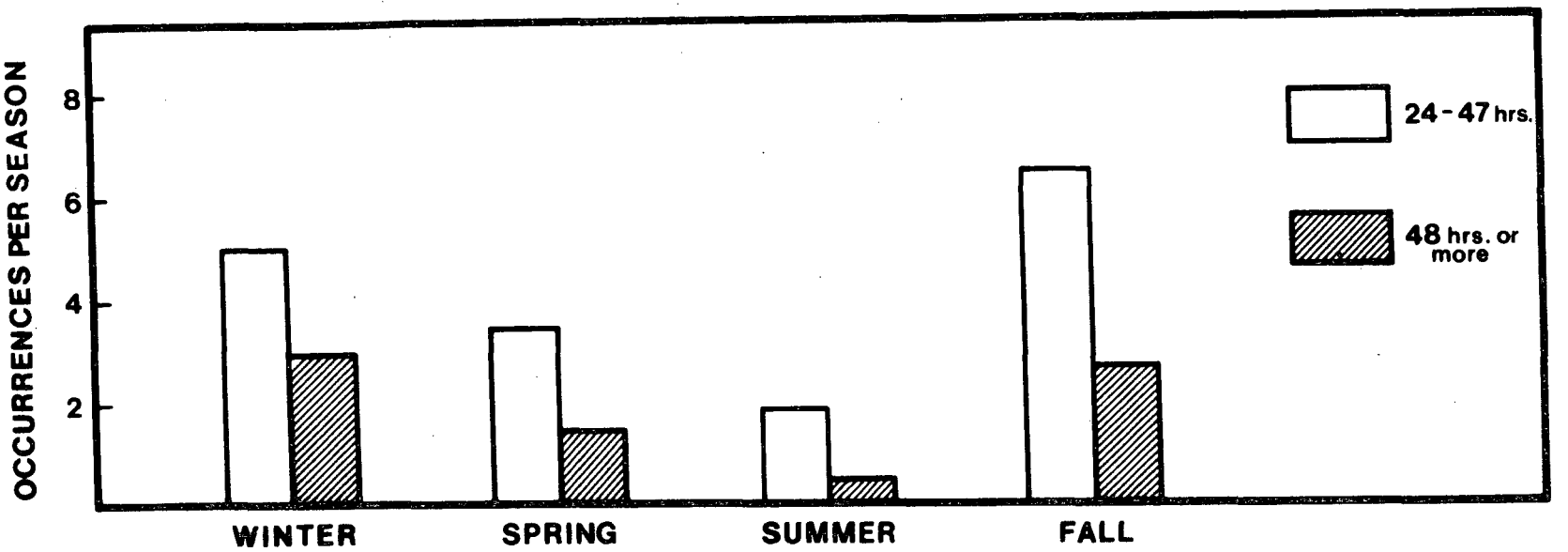
During fall and winter, stationary or slow moving high pressure centres are responsible for the light wind episodes, most commonly lasting less than two days. In the summer months, calms are most frequent in the hours around sunrise and sunset, during reversals of the land and sea breeze circulation 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 26. Considerable variation from the indicated values can be expected due to the local influence of water bodies and topography.

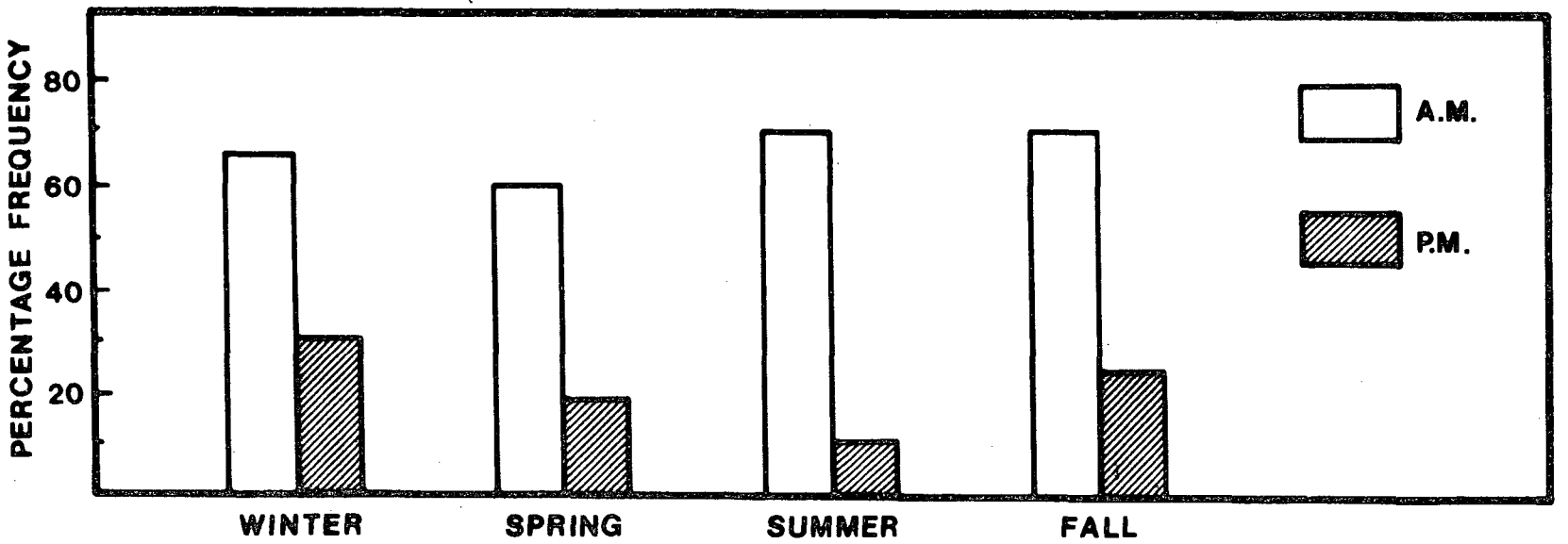
The dispersive capability of the lower atmosphere, the ventilation coefficient, can be calculated. It is the product of the height of the convectively mixed layer and the mean horizontal wind speed in that layer. Portelli's (1977) study of these factors indicate that, for the British Columbia coast, 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 25 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. Rilley, 1972. Persistence of light surface winds in Canada. Atmosphere 10(2): 33-43.

FIGURE 26 PERCENTAGE FREQUENCIES OF GROUND-BASED INVERSIONS BY SEASON



Source: R.E. Munn, J. Tomlain, 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.

5.6.4 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 34 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 27 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).

Soil Type

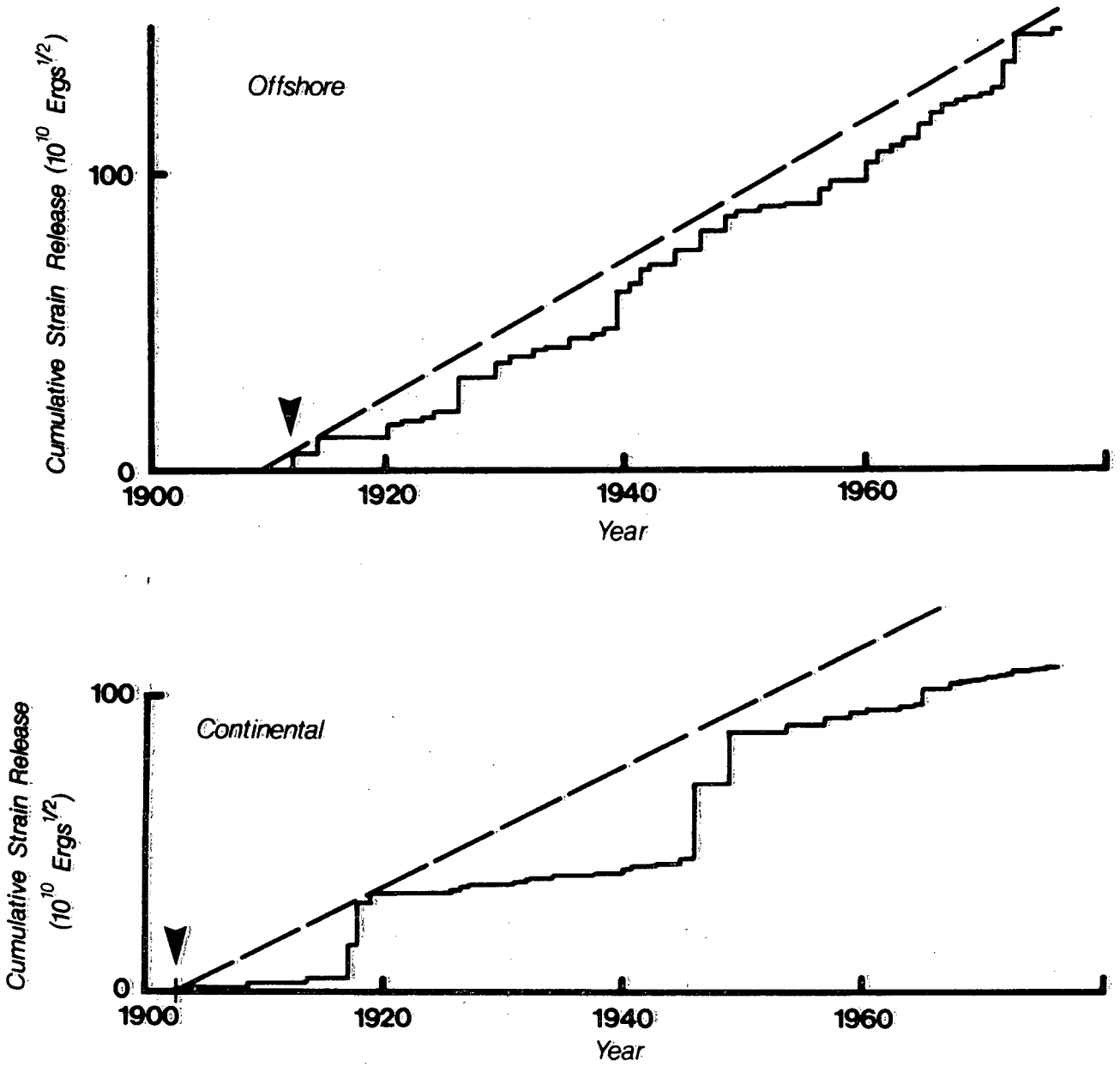
The type of material upon which structures are built directly influences the amplification of earthquakes. Table 35 provides amplification factors for various geological materials and represents the minimum design requirements recommended under the National Building Code. Hodgson (1946) reported that during the 1946 earthquake, Powell River and area suffered minor damage. He also observed that a section of houses built on rock within the damaged area had no perceivable damage.

TABLE 34 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; landslides 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 landslides 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 27 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

TABLE 35 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.

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 major tectonic plates on the coast. The Strait of Georgia and Puget Sound are specifically influenced by the contact of the Juan de Fuca and America plates. Figure 28, the distribution of strain release, shows a concentration around the Gulf Islands - Puget Sound area south of 49°. This led Milne et al (1970) to postulate that this could be evidence of a tectonic feature. Known fault lines can be found on the Generalized Terrain Limitations Map Series of this folio.

In terms of the 1946 earthquake, centred west of Comox, Hodgson (1946) concluded that Powell River was outside the immediate earthquake zone, but still suffered noticeable damage. Two outstanding incidences were reported:

a) The telegraph cable between Texada Island and Powell River was severed at the time of the earthquake.

b) The bluff south of Westview slumped, while "at high-water mark on the beach, a great welt was formed, presumably accompanied by an up-thrown sheet of water. The welt is 180 feet long, about 3 feet wide and was originally 5 feet high. The clay which came out of it is cracked deeply along the centre of the welt, and is of the consistency of rather poorly-made cement". Hodgson (1946).

He further observed that this is the only case where the ground, surface or submarine, was raised by the earthquake. Read Island, in the northwest part of the study area, apparently suffered some of the most spectacular damage during the earthquake. Hodgson (1946) quotes reports of about 4.86 ha of orchard down-dropping 6 to 9 m with crevasses 3 to 6 m wide, extending 275 m into the surrounding woods. This happened at a farm located on Burwood Bay. He attributed this sinking to the drop of foundation rocks beneath the valley which runs east-west across Read Island.

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.

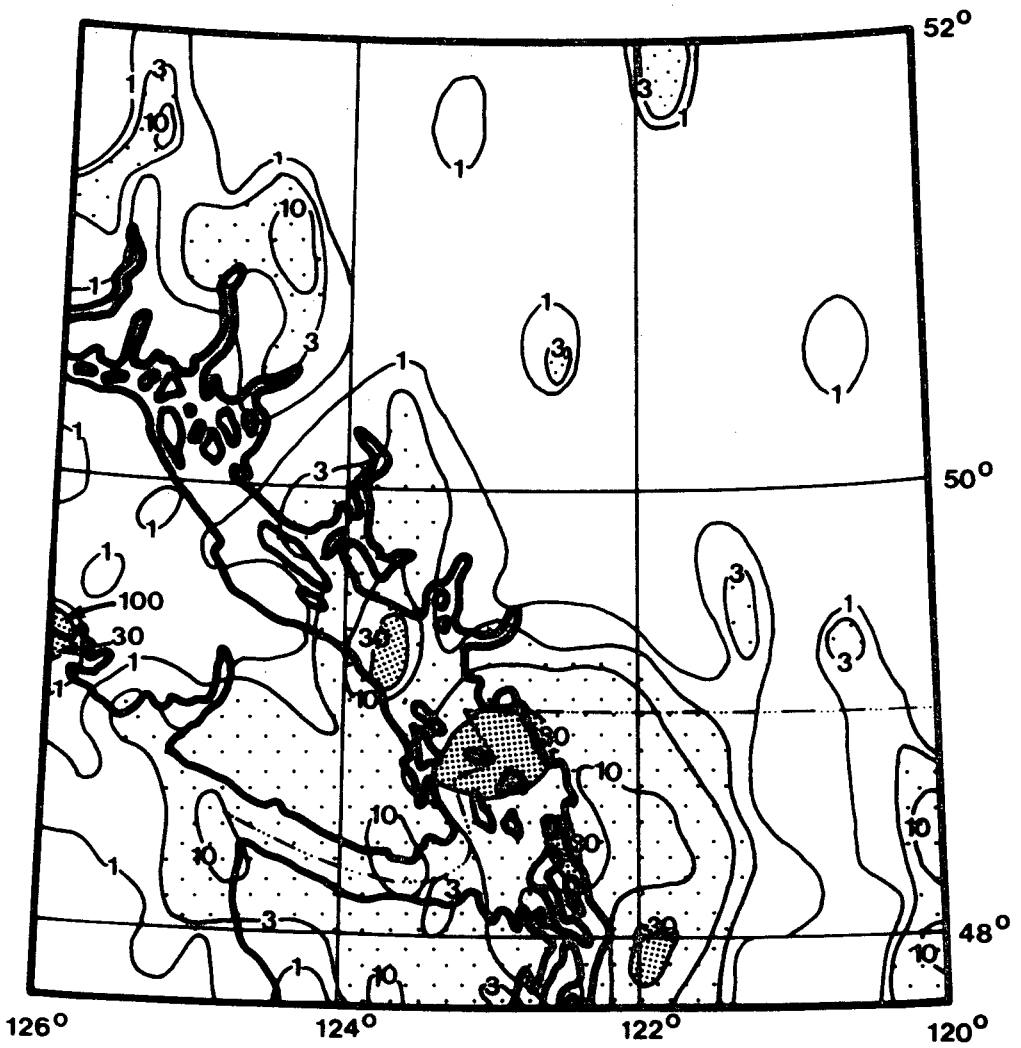
a) unreinforced masonry and concrete structures;

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.

Hodgson (1946) observed that the damaged chimneys of the study area were those in poor repair.

FIGURE 28 'CONTINENTAL' AREA REGIONAL DISTRIBUTION OF STRAIN RELEASE SINCE 1951



NOTE: Contours are equivalent number of magnitude 5 earthquakes per 100 years/100 km^2.

SOURCE: Ibid. Figure 27.

Secondary Effects

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

The probability of a damaging tsunami generated in the Strait of Georgia is less than the probability of a damaging earthquake. Sea waves were generated by the 1946 earthquake. Again, Hodgson's (1946) thorough report details the incident. The Sisters Island lightkeeper's report reads:

> "One tidal wave came at 10:22 a.m., seven minutes after the earthquake. The wave was seven to eight feet high. A second wave 100 feet from the first was four to five feet high. The speed was ten knots".

Ships to the northeast and southwest of Texada Island both report experiencing shocks as if they had run aground; neither reported waves, however. (Hodgson, 1946).

The probability of landslides from seismic activity in the region is highest in areas of unconsolidated deposits and jointed bedrock. No major landslides were observed or reported for the study area during the 1946 earthquake, although steep coastal bluffs and incised river valleys would be vulnerable to failure.

5.7 FACTORS OF BIOLOGICAL PRODUCTIVITY

THE AREA

The Sechelt-Cortes coast offers a mosaic of landscapes, shore processes, and habitats. Geological processes and wave energy have modified the coastline to create a range of geomorphic forms, from low backshore with gently sloping sand beaches to vertical rock cliffs dropping deeply into the sea. Because of the size and configuration of the Strait of Georgia, a range of energy environments exists.

A classification system that describes this environment and that may be considered complementary to that of Ricketts and Calvin (1968) would include (a) estuaries, (b) protected shorelines, (c) channels and protected inner coasts, and (d) unprotected inner coasts. Within these environments differences in substrate, wave energy, and the physical/chemical environment are revealed in the variety of resident biota.

5.7.1 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.

5.7.2 PRIMARY PRODUCTION - PHYTOPLANKTON

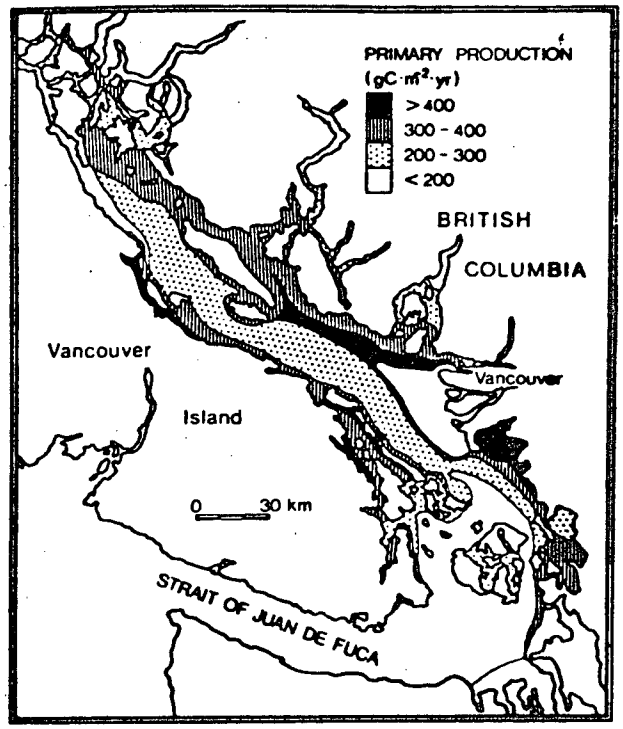
Primary production is the creation of organic material from carbon dioxide, water, and nutrients at the expense of solar energy. Gross primary production refers to the total amount of organic material produced by photosynthesis; net primary production refers to the amount of organic material available 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 ($gC/m^2/year$).

Data for the study area (Figure 29) reveal high rates of primary productivity along the coastline from Gower Point to Cortes Island with lower rates north of Malaspina Peninsula.

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 30 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.

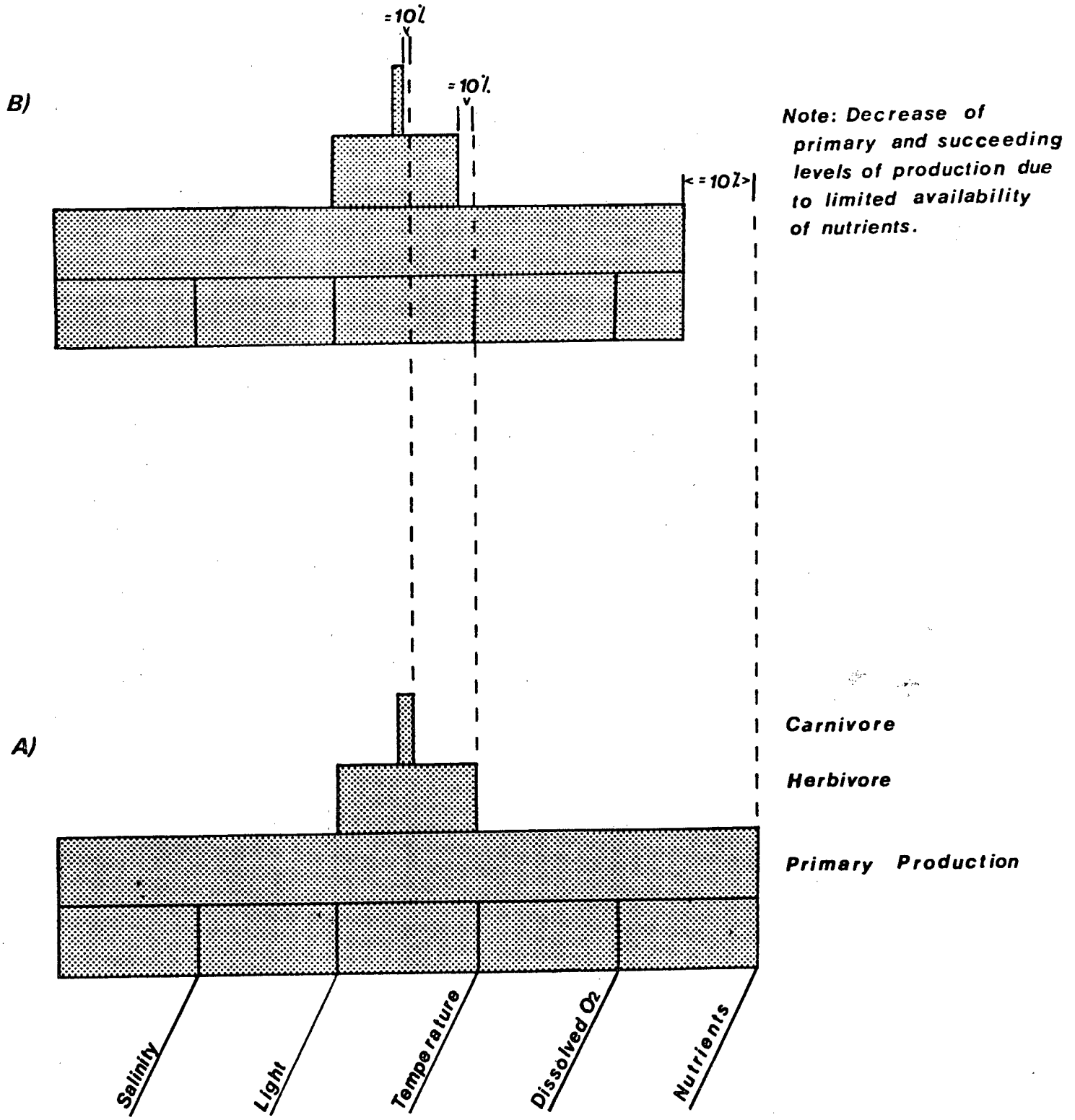
Important fisheries resources in the study area (see Coastal Resources Map Series (1:50,000) section - Fish and Shellfish Resources) are found primarily in the regions of moderate to high primary productivity.

FIGURE 29 GENERALIZED PATTERN OF PRIMARY PRODUCTION (PHYTOPLANKTON) IN THE STRAIT OF GEORGIA-JUAN DE FUCA SYSTEM



SOURCE: J.G. Stockner, D.D. Cliff and K.R.S. Shortread. 1979. Phytoplankton Ecology of the Strait of Georgia, British Columbia. Journal of the Fisheries Research Board of Canada. 36. Ottawa.

Figure 30 - SCHEMATIC OF ENERGY TRANSFER BETWEEN TROPHIC LEVELS IN UNLIMITED (A) AND LIMITED (B) ECOSYSTEMS

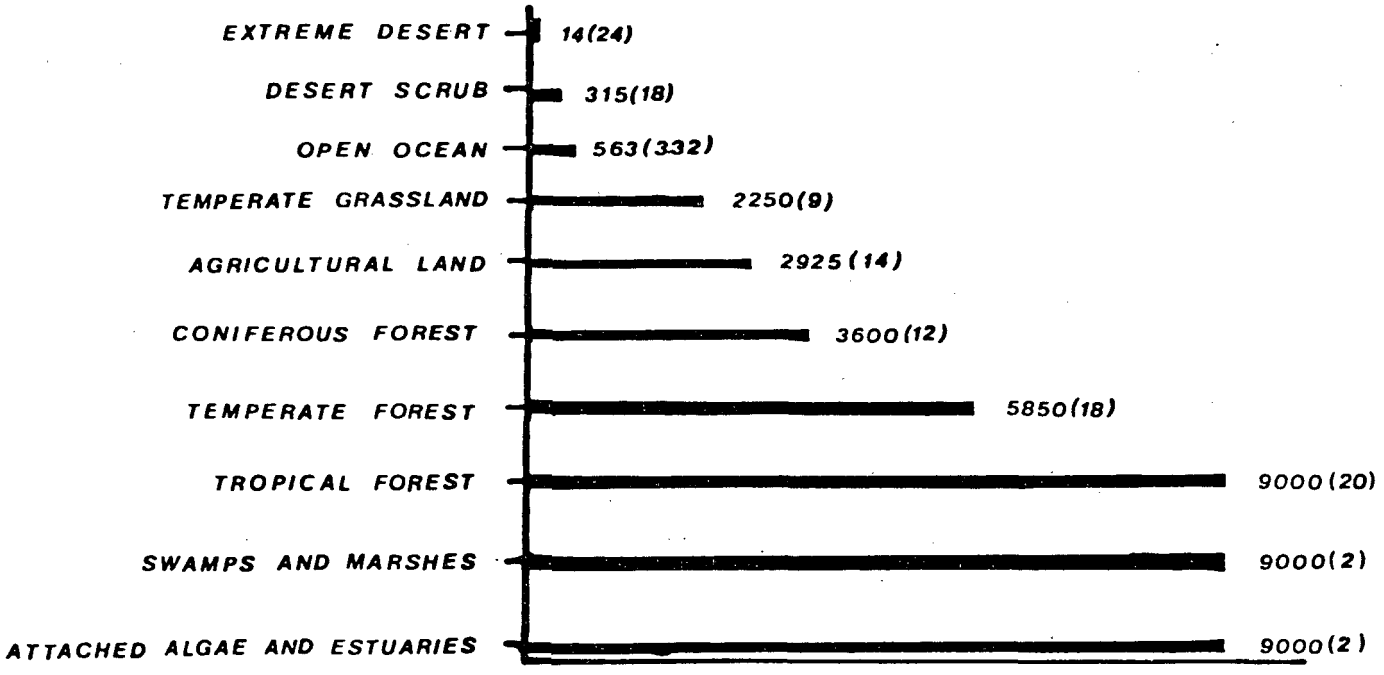


5.7.3 PRIMARY PRODUCTION - SEAWEEDS AND SALTMARSHES

The productivity of seaweed and saltmarsh communities is impressive (Figure 31). 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°/oo to 30.0°/oo (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°/oo salinity level (Figure 32). 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 3°/oo. 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.

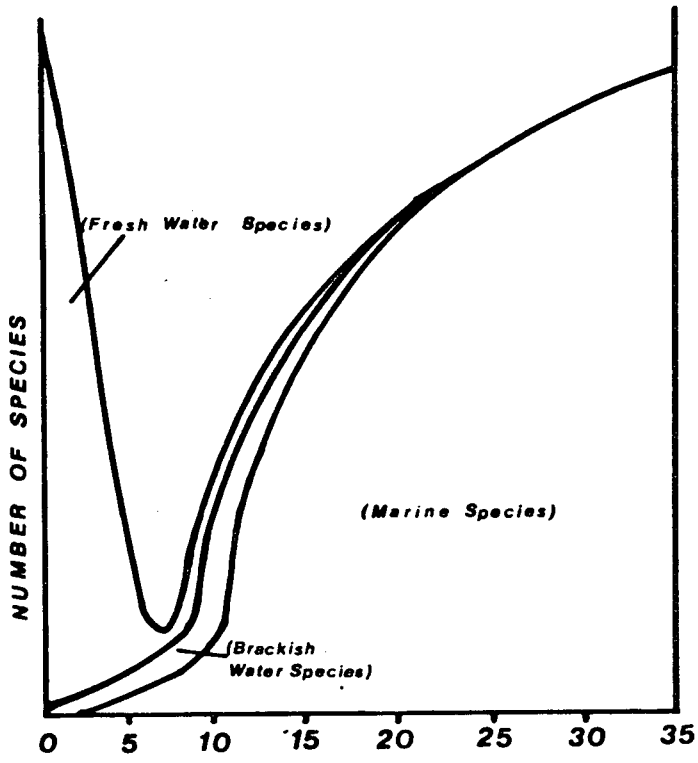
FIGURE 31: AVERAGE ANNUAL RATE OF NET PLANT PRODUCTION FOR SELECTED ECOSYSTEMS



NOTE: The number after the bar is Kcal/m^2/yr; the number within parenthese is area in $10^6 km^2$.

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

FIGURE 32: NUMBER OF SPECIES IN RELATION TO SALINITY LEVEL (°/oo)



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

5.8 THE ADMINISTRATION AND MANAGEMENT OF COASTAL RESOURCES

5.8.1 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.

5.8.2 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 area management plans; an example of such a plan is the Pender Harbour Crown Foreshore Plan (Ministry of Lands, Parks and Housing, 1983).

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, Energy, Mines and Petroleum Resources, and Transportation and Highways.

Crown Lands - Federal

The Small Craft Harbours Branch of the Department of Fisheries and Oceans controls and administers wharves and piers constructed on federal property or with federal funds. The Canadian Wildlife Service may establish reserves for migratory birds. Transport Canada administers public harbours and navigation facilities. The Department of National Defence administers military reserves.

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 Powell River Regional District has three regional parks encompassing a total area of approximately 44 hectares. The regional district plans to acquire an additional 167 hectares of parkland by the year 1992 (Powell River Regional District).

The Sunshine Coast Regional District owns two regional parks which encompass a total area of 66 hectares. The regional district has an official regional park plan which identifies parkland for future acquisition. Two phases are considered in the plan (Phase I 1983-1987 and Phase II 1988-1992), each of which identifies future areas and property for acquisition (Lefeaux, 1982).

Private Lands

Private lands are recorded on the B.C. Assessment Authority's taxation assessment rolls. The lots, their area and boundaries, are recorded on cadastral maps.

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 yields 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.

5.8.3 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.

5.8.4 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.

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 36 REPRESENTATIVE TAXONOMIC BIRD GROUPS PROTECTED UNDER THE MIGRATORY BIRDS CONVENTION ACT

Order	Family	Genus	Species	Common
Gaviiformes	*Gaviidae*	*Gavia*	*artica*	Arctic Loon
Podicipediformes	*Podicipedidae*	*Aechmosphorus*	*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	*marmoratus*	Marbled Murrelet
		Cerorhinca	*monocerata*	Rhinoceros Auklet
		Lunda	*cirrhata*	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.

5.8.5 LOCAL PLANNING

Local governments, i.e. regional districts and municipalities, may regulate the use of the foreshore by designating waterfront zones. The regional districts in the study area have not adopted any formal waterfront zones, but instead use upland zoning to accommodate waterfront uses. The Village of Sechelt and the Town of Gibsons are the only incorporated areas which have designated zones for waterfront useage.

The Sunshine Coast Regional District plans to introduce a waterfront zoning by-law which would entail designating the waterfront a residential zone in order to prevent unwarranted development of the foreshore. In the future, the District intends to identify deep water access sites for industrial uses and then designate these areas as industrial waterfront zones.

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).

Currently, zoning by-laws are being drafted by the Powell River Regional D trict which would establish development permit areas for commercial and industrial developments along the coast. Zones will be established also for the protection of mariculture areas (F. Ladret, personal communication, 1983).

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, hsitoric, scientific, and agricultural; the proposed sequence of urban development; and the resultant infrastructure requirements and plans.

Official Community Plans

Official commumity 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, South Mainland Coast (Gibsons Landing to the Redonda Islands) British Columbia include: Introduction, Coastal Resource Map Series (1:50,000), Tables, Pender Harbour Map Series (1:10,000), Sources and Glossary.

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2212-L	1:36,480	2229-L	1:30,000	2260-S	1:36,480
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The contributions of the individuals and agencies noted below as well as the assistance of numerous others not included due to space limitations is gratefully acknowledged.

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6.2.10 Theme 12.1: Generalized Zoning and Marine Facilities

See 6.3.1. and 6.3.2.

Theme 12.2: Land/Water Use

See 6.3.1 and 6.3.2.

6.2.11 Theme 13: Land/Water Use Plans and Proposals

See 6.3.3.

6.2.12 Theme 14: Selected Administrative Boundaries

See 6.3.

6.2.13 Theme 15: Land/Water Status

See 6.3.4.

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SECTION 7: GLOSSARY

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7.1 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.

7.2 SELECTED DEFINITIONS FOR LAND USE AND STATUS THEMES

7.2.1 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.

7.2.2 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.

7.2.3 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.

7.2.4 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.

7.2.5 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.

7.3 SELECTED DEFINITIONS FOR FISH AND SHELLFISH THEMES

anadromous - refers to fish which, following birth in fresh water, migrate to salt water where they attain maturity, and subsequently return to their freshwater natal stream to reproduce.

aquaculture - the regulation and cultivation of oceanic animals for human use or consumption, e.g. oyster culture, fish farming, salmon rearing.

bivalve - one of a class of molluscs (Pelecypodia) having a shell of two parts joined by a hinge, e.g. clams, oysters, mussels.

char - a small-scaled trout (genus Salvelinus) of the Salmonidae family; includes Dolly Varden and brook trout.

closure - in fisheries context, harvest restrictions imposed for management purposes on commercial or recreational fisheries; may be imposed as seasonal, gear or area closures.

copepod - a member of a large order of crustaceans, usually 0.5 to 10 mm in length. These organisms often are an important food source for fish in temperate and subpolar regions.

cover - plants, rocks, organic debris or other materials in the aquatic habitat providing shelter and protection for fish from adverse conditions and predation.

crustacean - member of one of eight classes of the phylum Arthropoda, which includes crabs, barnacles, shrimps, crayfish.

cultch - material laid down on oyster grounds to furnish points of attachment for the spat. See spat.

euphausiid - a marine, shrimp-like, usually filter-feeding, crustacean approximately one inch long, belonging to the order Euphausiacea; krill.

fry - the young stage of fishes, particularly after the yolk sac has been absorbed and active feeding has commenced.

geoduck - a large, burrowing clam with long, muscular siphons; found subtidally along the Pacific coast from the Gulf of California to Alaska.

gillnet - a net set vertically in the water to catch fish by entangling their gills in the mesh of the net.

headwaters - the streams and creeks forming the sources of a river or other body of water.

invertebrate - an animal without a backbone; in aquatic systems includes insects, crustaceans, shellfish, and worms.

juvenile - a physiologically immature or undeveloped organism.

larva - the immature form of many animals after hatching. An intermediary stage before adulthood; larvae are the dispersal stage for many attached marine invertebrates.

mollusc - a member of the phylum mollusca - an invertebrate with a soft unsegmented body, usually enclosed in a calcareous shell. Includes clams, oysters, squid, octopods, and snails.

oyster lease - a type of foreshore lease granted by the provincial Ministry of Lands, Parks and Housing, and administered by the Marine Resources Branch (Ministry of Environment) for the artificial propagation of oysters.

oyster picking permit - permit granted by the Ministry of Environment, Marine Resources Branch, for the harvesting of wild oyster stocks.

paralytic shellfish poisoning (PSP) - poisoning resulting from eating shellfish (particularly bivalves) which have ingested the toxic planktonic organism Gonyaulax.

purse seine - a large fishing net with floats along the top edge and weights on the bottom edge. The net is set around a school of fish, then the bottom edge is drawn together.

reach - a section of stream of reasonably uniform gradient, stream bed, stream bank and flow pattern.

rearing - adj. - growing; usually pertains to younger growth stages; e.g. fry and juveniles.
vb. - early life activities of growth and survival, including fish feeding, territorial defence and respiration.

resident fish - fish which remain in fresh water throughout their life cycle.

roe - fish eggs, especially when still massed in the ovarian membrane.

roe herring - herring containing mature roe which are captured during the commercial fishery of the same name.

salmonid - a fish of the Salmonidae family, which includes Pacific salmon, trout and char.

seine net - a large fishing net with floats along the top edge and weights along the bottom edge.

shellfish - an aquatic invertebrate animal with a shell; typically an edible mollusc or crustacean.

spat - the microscopic spawn or young of bivalve molluscs; especially refers to oysters.

spatfall - settlement of spat on a substrate.

stock - in fisheries biology, a segment of a population that can be managed as a single unit.

trawl - to fish by dragging a large bag-like net through the water
a) midwater - to trawl midway in the water column.
b) bottom - to trawl along the bottom.

troll - to fish with a line, typically with a revolving lure, trailed behind a moving boat.

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7.4 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 intertidal 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.

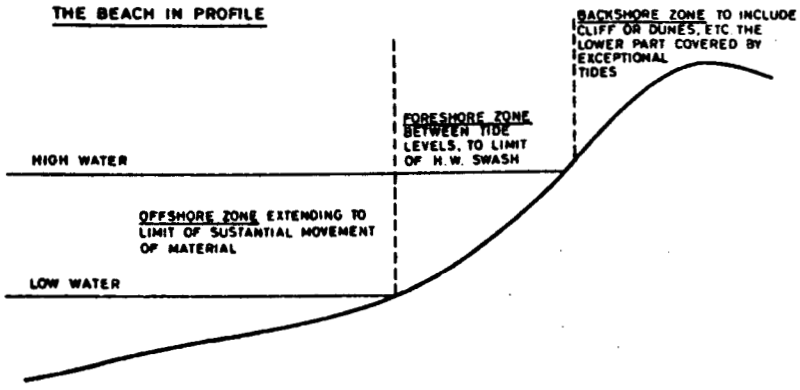
b) river - linear feature which contains the majority of stream or river flow to the shoreline; can be a single channel or a complex system of channels separated by river bars.

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.

a.



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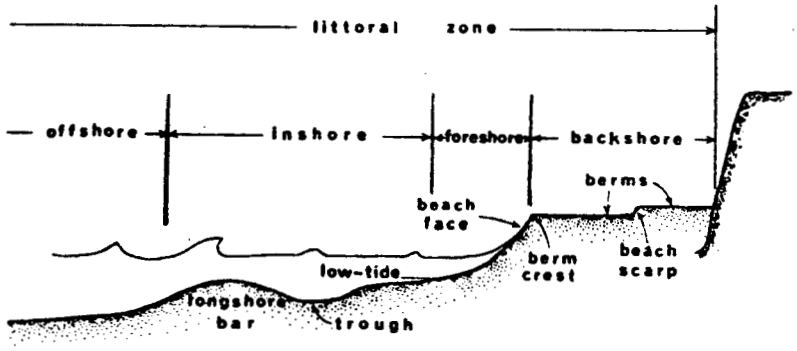

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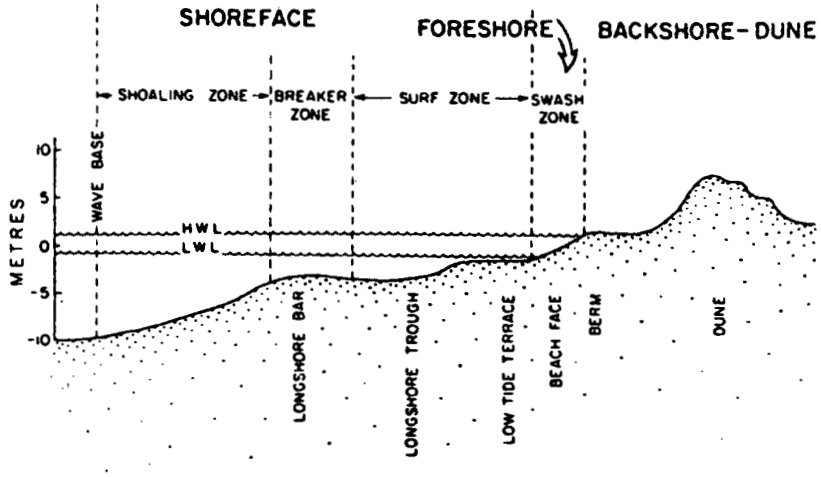

Beach profile terminology; a. after King (1972), b. after Komar (1976), c. after Reinson (1979).

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^{o} 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^{o}.

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^{o}) 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^{o} and 35^{o}.

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^{o}, 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^{o} and 20^{o} 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.