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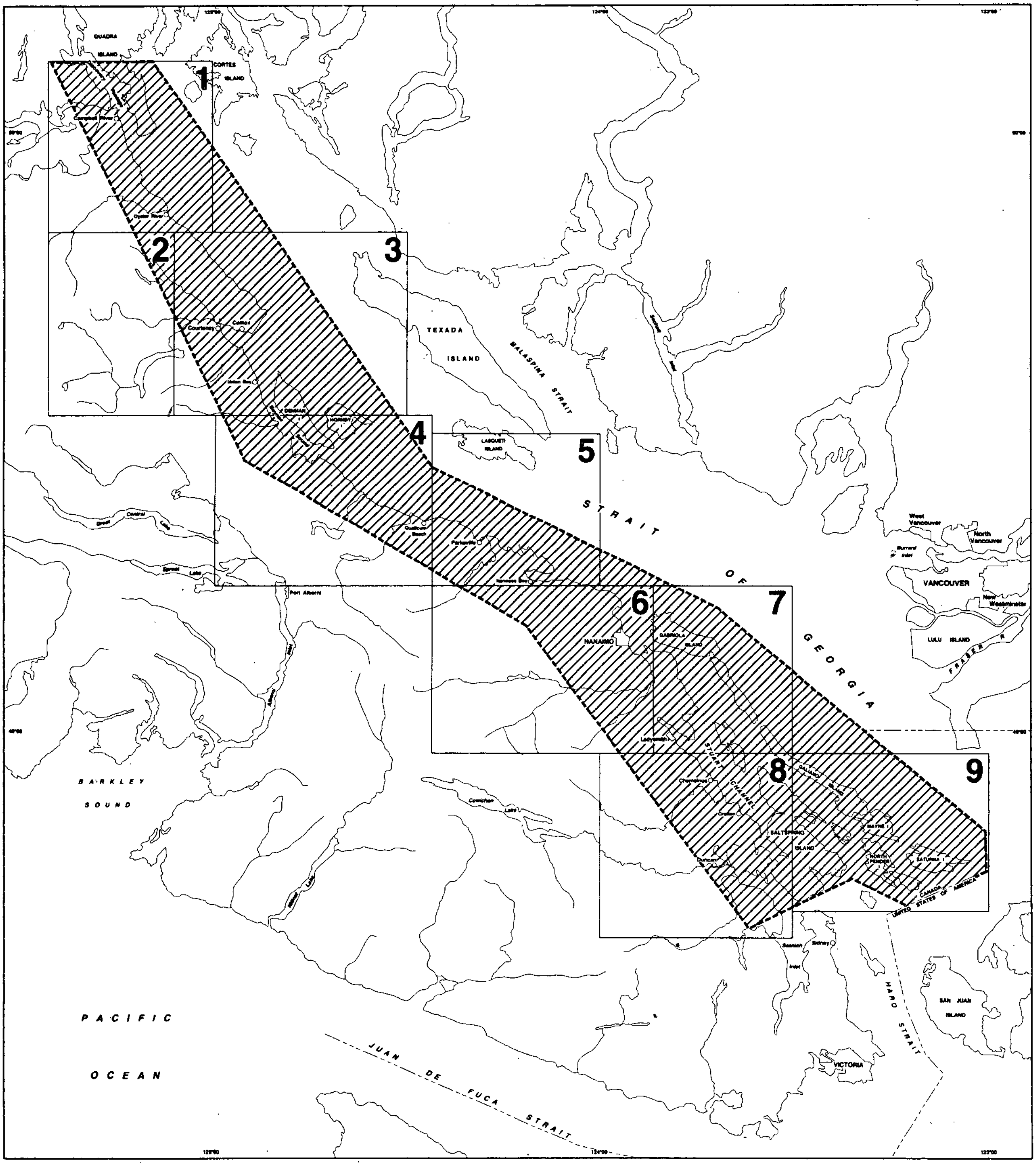

COASTAL RESOURCES FOLIO

EAST COAST OF VANCOUVER ISLAND

(Race Point to Hatch Point and adjacent islands)

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COASTAL RESOURCES FOLIO
EAST COAST OF
VANCOUVER ISLAND
(Race Point to Hatch Point and Adjacent Islands)

PREPARED BY:

M.J. ROMAINE, PROJECT MANAGER
. Project Design
. Folio Layout
. Editorial production

Michael W. DUNN
Research Officer
. Marine substrates
. Surficial Materials and Hazards
. Physical Shorezone
. Physical Processes and Energy
. Physiography

Don M. MOORE
Consulting Marine Ecologist
. Oceanography-Salinity,
Temperature, Circulati
. Fish and Shellfish Re-
sources - Use, Habitat

Trevor J. SUMMERS
Consulting Environmental Planner

Derek A. WOLFF
Research Officer
ve Boundaries
s

CARTOGRAPHY BY:

B. EDWARDS, Chief Cartographer
R. HOEKSTRA, Cartographic Supervisor
H. KINNEY, Cartographic Supervisor
R. ST. JOHN, Photomechanical Supervisor
G. BELOHLAVEK, Cartographer
B. BOULAY, Cartographer

S. BOWKETT, Cartographe
J. CUMMINGS, Cartograph
R. DAVIES, Photomechani
L. DIONNE, Cartographer
S. FLOOD, Cartographer
R. GUILBAULT, Cartograp

:hanical

. 1:50,000 Base Maps . 1:15,840 Estuary Base Maps . 1:50,000 C

o Cover

LAN

Jaan A. TAMM, Cartographer
Lands Directorate,
Vancouver, B.C.
. 1:15,840 Estuary Map Series
. Figures and Tables
. Legends and legend design
. Cartographic coordination and liaison

Gary GILES, Draftsman
Lands Directorate,
Vancouver, B.C.
. Data compilation and
. Figures and Tables

TECHNICAL ASSISTANCE AND ADVICE BY:

Peggy WARD, Research Officer
Lands Directorate
Vancouver, B.C.
. 1:50,000 Map Legend design

Tom PIERCE, Program Of
Lands Directorate
Ottawa, Ontario
. Folio and map design
. Liaison

rvice
legends

FINANCIAL SUPPORT BY:

LANDS DIRECTORATE
ENVIRONMENT CANADA
VANCOUVER, B.C.

REGIONAL DIRECTOR GENERAL'S OFFICE
ENVIRONMENT CANADA
VANCOUVER, B.C.

LANDS DIRECTORATE
ENVIRONMENT CANADA
OTTAWA, ONTARIO

ACKNOWLEDGEMENTS

The Coastal Resources Folio represents a cooperative effort, its contents dependent on information held by various specialists and agencies at the federal, provincial, regional and local levels of government as well as by public and private organizations. In all instances co-operation, advice, assistance, data and, when requested, logistic and technical support, were given freely. The Sources Section (Section 6) of this Folio under "Personal Communications" identifies those individuals and agencies whose valuable contributions are gratefully acknowledged.

November 1981

1.0 INTRODUCTION

1.1 The Coastal Zone

The coastal zone is important to British Columbia and to Canada. Approximately eighty-eight percent of the provincial population lives within eighty kilometres of the coast. The marine waters provide valuable food resources, while coastal lakes and streams provide spawning and rearing habitat for many fish species, as well as a supply of fresh water for a myriad of man's uses. The coastal lowlands and associated estuarine/delta areas are recognized for their high capability for agriculture and forestry, their importance as fish and wildlife habitat, and their economic suitability for residential, commercial and industrial development. The coastal inlets, bays and estuaries serve as natural harbours for the movement of people, goods and materials to domestic and international markets. The sea bed is recognized as an important future source of energy and mineral resources. Finally, the coastal zone forms part of the cultural and aesthetic heritage of the province, a heritage worthy of careful management for the continuing benefit of succeeding generations (Coastal Zone Resource Subcommittee, 1978).

1.1.1 Coastal Zone Defined

In 1978, the Coastal Zone Resource Subcommittee adopted the following working definition for use in British Columbia: "The Coastal Zone is that region of land, marine and estuarine space in which terrestrial, aquatic and atmospheric systems interact. It is a band of variable width overlapping the mainland and the sea, and incorporating all coastal islands and islets. Its boundaries should extend as far inland and seaward as is required or practical to facilitate coastal resource management. While it would be convenient if boundaries conformed to the limits of national or provincial jurisdiction, it is more important that they recognize a systems approach, and relate to the activities of man that influence water quality, marine and terrestrial ecology and the aesthetics of the land and the seascape."

1.1.2 The Study Area

The study area extends from Race Point, north of Campbell River to Hatch Point, south of Duncan. The seaward boundary extends to the mid-point of the Strait of Georgia and includes the Gulf Islands and islets lying within these waters. Landward the boundary includes the Nanaimo lowlands to approximately the 150 metre elevation.

1.2 THE COASTAL RESOURCES FOLIO

1.2.1 Background

In April 1978, the intergovernmental Coastal Zone Resource Subcommittee reported on the state of the art of coastal resource management in British Columbia. This report made several recommendations to deal with current and potential problems facing the B.C. coastal zone. One of the initial requirements identified was the preparation of a Coastal Resource Folio that would provide an overall perspective of the coastal zone with respect to its physiographic, biotic, oceanographic, and climatic regions, as well as its associated processes and natural resource uses and values.

In the fall of 1978, Environment Canada undertook a review of departmental efforts devoted to environmental programs and problems. The review found that, within the department's Pacific and Yukon Region, the majority of personnel time, funds and studies devoted to environmental impact assessments, task force studies and project referrals were related to the B.C. coastal zone. Further, an analysis of forecasted demands on the department for information and advice indicated that this trend would continue and indeed increase over the next 5-10 year period.

In recognition of the above findings, the department initiated the Coastal Resources Folio Project in the fall of 1979.

1.2.2 Purpose

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 that is useful in environmental assessments, integrated and single purpose planning and management programs, coast-wide and regional resource allocation studies, and the identification of baseline study needs.

1.2.3 Methodology

The following steps were 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 priority areas and topics, as well as 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 further advice on the type of information that should be presented in the Folio;
- Systems for classifying, tabulating and standardizing data developed and reviewed with contributing agencies;
- Information transferred and recorded on working maps, or in tabular and report form;
- Meetings held again with representatives of government agencies to provide a project update, to make mid-course corrections and to review draft maps;
- 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;
- Final edited manuscript maps and legends sent to Ottawa for drafting;
- Tables and a report of supplementary information drafted;
- Documents edited; finalized and published.

1.3 USE AND LIMITATIONS

1.3.1 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.

The overall value and use of the Coastal Resources Folio has yet to be critically assessed. The Lands Directorate, Department of the Environment, welcomes comments on the use and limitations of the Folio in order that improvements can be made to subsequent Coastal Resources Folio documents.

1.3.2 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.

- 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 leases information.
- 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, can not 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.
- The marine substrates, physical shore zone, and seaweeds and saltmarshes, data were supplemented by aerial photo and video tape interpretations. Verification by field checks was limited.

1.4 FOLIO CONTENT AND FORMAT

1.4.1 Folio Content

The Coastal Resources Folio contains the following six separate sections.

Section	1.0	INTRODUCTION
	.1	The Coastal Zone
	.2	The Coastal Resources Folio
	.3	Use and Limitations
	.4	Folio Content and Format
	.5	Availability and Coverage

1.4.2 Intent of Folio Sections

Section 1.0 Introduction

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

Section 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 15 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 in 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.

Section 3.0 Land/Water Use and Status Tables

This tabular information along with descriptive highlights, provides quantitative and detailed data on such subjects as areas of foreshore leases, the present use and ownership of industrial zones and the services provided at marinas.

Section 4.0 Estuary Map Series (1:15,840)

Due to the recognized biological importance, and the intensity of land/water uses associated with many of the estuaries on the east coast of Vancouver Island, this series provides supplemental information for five major estuaries - namely the Campbell River, Courtenay-Comox, Nanaimo, Chemainus and Cowichan estuaries and two embayments - Nanoose Bay and Ladysmith Harbour.

Section 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 Reosurces and Estuary Map Series.

Section 6.0 Sources

The Source Section provides a list of information sources pertinent to the study area. Sources are organized under the same headings as the previous Folio 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.

1.4.3 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 (1:50,000, Section 3.0 Land/Water Use and Status Tables, and Section 4.0 Estuary Map Series (1:15,840). Volume I is divided into eight separate folios. Volume I - 1 and 2, contains information pertaining to areas covered by base maps 1 and 2. The remaining seven folios, that is Volume I - 3 through to Volume I -9, relate to the respective areas covered by the seven base maps numbered 3-9.

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

1.5 AVAILABILITY AND COVERAGE

1.5.1 Availability

The Coastal Resources Folio is available from:

Lands Directorate
Environment Canada
904 - 1001 West Pender Street
Vancouver, B. C. V6E 2M7

The publication of the Coastal Resources Folio (1:50,000 and 1:15,840 scale) thematic maps is being scheduled over the next year. As a consequence, coverage for all base maps and themes may not be immediately available at the time of your order.

Requests should be placed by mail. The Folio can be ordered by base map, resource theme, table topic, or by section, Further, Sections 2.0 Coastal Resources Map Series (1:50,000) and 4.0 Estuary Map Series (1:15,840) map manuscripts can be ordered as either ozalids (paper prints) or as films (diazo, autopositive or coloured mylars).

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 autopositives)	At current commercial rates established by local printing firms. Direct billing to apply.
		film(colour-keyed mylars by map theme)	At cost by special arrangement through Lands Directorate.
	Multiple (duplicate) copies of theme maps or tables	Ozalids (paper prints); films (diazo, autopositives or colour-keyed mylars) by map theme.	At current commercial rates established by local printing firms. Direct billing to apply.
Volume II Report.	Limited number of copies available free of charge.		

<u>Estimated Cost - 1981 Quotations</u>

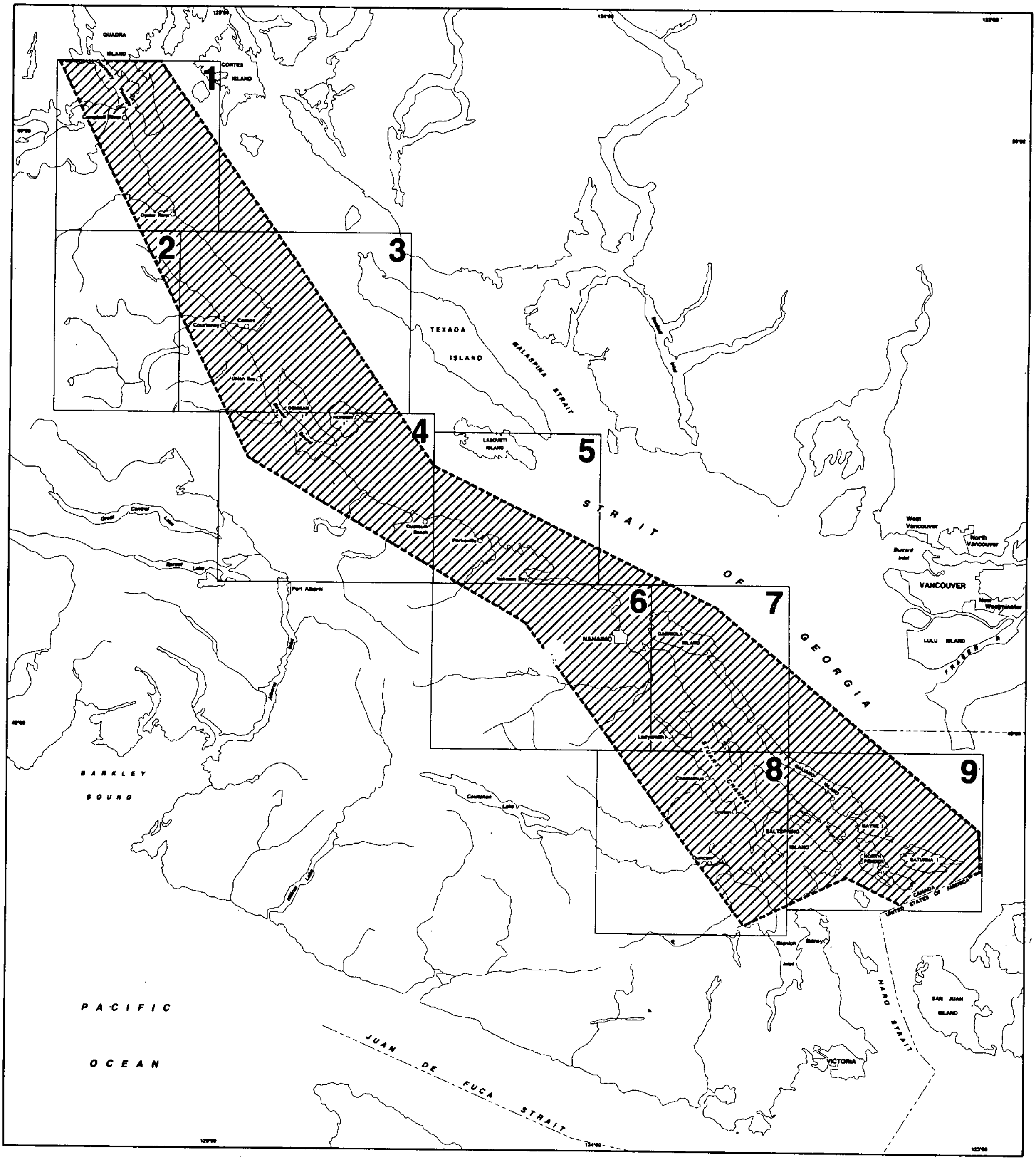
Type of Product	Price
Paper (ozalid) copy	$1.00/print
Film (diazo) copy	$11.60/print (.04mm in thickness) 15.20/print (.07mm in thickness)
Film(autopositive) copy	$46.80/print (mat surface) 47.60/print(clear surface)
Film (coloured mylars) copy	$60.00-$70.00/print

1.5.2 Coverage

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

1.5.2.1 Area Coverage

Location and boundaries of study area and nine base maps.



1.5.2.2 Coastal Resources Map Series (1:50,000)

Theme Map Coverage by Base Map

Theme Map		Base Map 1	2	3	4	5	6	7	8	9
80.1	Marine Substrates	●		●	●	●	●	●	●	●
80.2	Physical Shorezone	●		●	●	●	●	●	●	●
80.2	Physical Shorezone Units Table	●		●	●	●	●	●	●	●
80.3	Generalized Terrain Limitations	●	●	●	●	●	●	●	●	●
80.4	Oceanography - Temperature	●		●	●	●	●	●	●	
80.5	Oceanography - Salinity	●		●	●	●	●	●	●	
80.6	Water Resources: Discharge, Use and Contamination	●		●	●	●	●	●	●	●
80.7	Seaweeds, Saltmarshes and Marine Mammals	●		●	●	●	●	●	●	●
80.8	Marine Bird Surveys	●		●	●	●	●	●	●	●
80.9	Fish and Shellfish Resources	●		●	●	●	●	●	●	●
80.10	Fish Spawning and Rearing Areas	●		●	●	●	●	●	●	●
80.11	Generalized Zoning and Marine Facilities	●	●	●	●	●	●	●	●	●
80.12	Land/Water Use Plans and Proposals	●	●	●	●	●	●	●	●	●
80.13	Selected Administrative Boundaries	●	●	●	●	●	●	●	●	●
80.14	Land/Water Status	●	●	●	●	●	●	●	●	●
80.15	Recreational Areas, Special Features and Access	●		●	●	●	●	●	●	●

When ordering theme maps, please quote year of publication, base map and theme number. For example, 80.3.1 refers to base map number 3, Marine Substrates, published in 1980.

1.5.2.3 Land/Water Use and Status Tables

Table and Topic Coverage by Base Map

Table	Topic	Base Map Coverage 1	2	3	4	5	6	7	8	9
1	Regional and Local Zoning	●	●	●	●	●	●	●	●	●
2	Marinas, Bulk Oil Storage Facilities and Sewage Systems and Treatment	●		●	●	●	●	●	●	●
3	Land Use Plans and Proposals	●	●	●	●	●	●	●	●	●
4	Heavy Industrial Zones	●		●	●	●	●	●	●	●
5	Land and Water Status									
	Provincial Crown Reserves	●	●	●	●	●	●	●	●	●
	Log Storage Leases	●		●		●		●	●	●
	Industrial Foreshore Leases	●		●		●		●	●	
	Commercial Foreshore Leases	●		●	●	●		●	●	●
	Oyster Leases	●			●			●	●	●
	Marine Foreshore Leases	●			●			●		●
	Central Real Property Inventory - Federal Lands	●		●	●	●	●	●	●	●
	Timber Land	●	●	●	●	●	●	●	●	●
	National Second Century Fund Property			●			●			●
	Mineral Exploration Permits	●		●	●	●	●	●	●	●
	Coal, Freehold Rights, Licences and Licence Applications	●	●	●			●	●		

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

1.5.2.4 Estuary Map Series (1:15,840)

Theme Map Coverage by Estuary/Embayments

Theme Map Number	Title	Campbell River	Courtenay Comox	Nanoose	Nanaimo	Ladysmith Harbour	Chemainus	Cowichan
81.1	Surficial Sediments	●	●		●	●	●	●
81.2	Marine Birds	●	●		●	●	●	●
81.3	Seaweeds and Marshes	●	●		●		●	●
81.4	Intertidal Fauna	●	●		●		●	●
81.5	Zoning, Land Use and Foreshore Leases	●	●	●	●	●	●	●
81.6	Land Use Plans and Proposals	●	●		●	●	●	●

When ordering, please quote year of publication, theme map number and name of estuary/ embayment, for which coverage is required. For example, 81.4 - Cowichan refers to the Intertidal Fauna theme map for the Cowichan estuary published in 1981.

SECTION 5: COMPANION REPORT

PREPARED BY

D. M. Moore
M. W. Dunn
T. J. Summers
D. A. Wolff

COMPILED BY

M. J. Romaine

EDITED BY

M. J. Romaine
T. J. Summers

LANDS DIRECTORATE
ENVIRONMENT CANADA
VANCOUVER, B. C.

November, 1981

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5.1 INTRODUCTION

5.1.1 PURPOSE

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

5.1.2 THE STUDY AREA

The study area extends from Race Point, north of Campbell River to Hatch Point, south of Duncan. The seaward boundary extends to the mid-point of the Strait of Georgia and includes the Gulf Islands and islets within these waters. Landward the boundary includes the Nanaimo Lowlands to approximately the 150 metre (500 foot) elevation.

5.2 THE SOUTHEAST COAST ECONOMY

5.2.1 GENERAL SETTING

Vancouver Island's east coast, sheltered from the open Pacific is endowed with an abundance of natural resources. Within the study area, human settlement is concentrated in a linear strip along the coast. There are five major population centres - Duncan, Ladysmith-Namanimo, Parksville Qualicum, Courtenay-Comox and Campbell River. The Island Highway provides- the overland transportation link between these centres, while the Strait of Georgia provides the water link. Ports accommodating deepsea vessels are located at Duncan Bay, Campbell River, Nanaimo, Harmac, Crofton, Chemainus, and Cowichan Bay.

The majority of the towns in the area have a diversified economic base, having past or present connections with farming, fishing, forestry, the military, railway traffic, port activities and tourism (Ministry of Economic Development, 1978.). The B.C. Regional Index, (a report prepared by the Ministry of Economic Development), provides economic, industrial and demographic information for the centres listed above.

5.2.2 THE FOREST INDUSTRY

The forest industry provides a major source of income for the urban areas of eastern Vancouver Island. Each centre is involved in some phase of the industry, be it harvesting, processing or the export of forest products. In 1974 the Crown Grant lands and chiefly those of the Esquimalt and Nanaimo railway grant, contributed 24% to the total harvest of the Vancouver Forest District (Edgell, 1979). Edgell (1979) also notes that the secondary growth starts in the Crown Grant Lands have economic advantages due to their high productivity and proximity to tidewater and processing plants. As a consequence Edgell (1979) predicts that in twenty years' time many of the advanced regrowth stands in the old railway grant will be harvestable. These stands should contribute to more than the 20% of the island harvest.

There are four forest products processing centres within the study area - Crofton-Chemainus, Cowichan Lake-Cowichan Bay, Nanaimo and Campbell River-Courtenay. Although the number of mills has decreased in the past thirty years, total production has increased. Meanwhile, all the centres but Cowichan are again building production facilities in tidewater locations. For instance, Doman industries is looking for sites from Cowichan Bay to Port Hardy to set up a 300 ton per day thermo-mechanical pulp mill, initially to supply pulp to other mills, but eventually to be converted to paper and newsprint production. Crown Zellerbach is considering a thermo-mechanical mill to be built at Duncan Bay, as well as a sawmill and plywood plant. Doman Industries completed a 150 million board foot sawmill at Duke Point in the spring of 1980. The company proposes to build a 500 ton per day thermo-mechanical newsprint mill and sawmill on adjacent lands (Duke Point Development Ltd.). The timber for most of these new developments will come from off Island sources, making the eastern side of the Island, with it's tidewater access, an ideal location to receive and process timber. Processing facilities such as these require a continuous supply of logs. Protected waters, especially estuaries, provide convenient storage areas for logs. On the major estuaries of the east coast where log storage is permitted, there is a shortage of storage space to meet industrial processing demands. This shortage and the demands of other users has resulted in the formulation of intergovernmental task forces to study resource-use conflicts on the Nanaimo, Cowichan, Courtenay and Campbell River estuaries. The west coast log transportation system is undergoing a joint review by the B.C. Council of Forest Industries, and federal and provincial government agencies.

5.2.3 TOURISM

The second major source of income for urban centres of the study area is derived from tourism. In 1976 B.C. generated $1.2 billion in tourist revenue. Vancouver Island received $212 million or 18% of this total. In the same year the Island received 1.8 million visitors, which was approximately four times Vancouver Island's population. Tourism contributes to the economic activity in all parts of the region, but is most significant in the Parksville-Qualicum area (Ministry of Economic Development, 1978).

The urban centres of Parksville and Qualicum are attractive because of shallow waters and good beaches (Murphy, 1979). Accomodation for the tourist are well developed; they include campsites, cottages, hotels and motels near the many natural attractions of the area. Sports fishing occurs in all coastal waters although several centres (ie. Cowican and Campbell River) dominate. Several fishing resorts are established in these centres.

An example of tourist activity in the Campbell River area is provided by Ross (1979) who documents 300,000 sport fishermen visiting the region each summer.

5.2.4 THE FISHING INDUSTRY

The fishing industry provides another important source of income for the study region. The salmon and ground fisheries support fishing fleets in Duncan, Ladysmith, Nanaimo, Courtenay-Comox, Parksville-Qualicum, and Campbell River (Table 1). Campbell River has the largest fleet, employing close to 600 people on 289 vessels in 1976.

TABLE 1 - EAST COAST OF VANCOUVER ISLAND FISHING FLEET STATISTICS (1976)

CITY	COMMERCIAL FISHING VESSELS	EMPLOYMENT
Campbell River	289	594
Nanaimo	287	449
Ladysmith	146	248
Parksville-Qualicum	131	223
Courtenay-Comox	130	217
Duncan	71	110

SOURCE: Ministry of Economic Development, 1978, British Columbia Regional Index.

With the exception of the large salmon runs on the Campbell, Qualicum and Cowichan rivers, the commercial fishery of the east coast depends on fish which do not use the streams and rivers of the Island (Ross, 1979). A significant shellfish industry is located on the east coast with Baynes Sound and the Chemainus, and Comox estuaries comprising the major centres of activity.

5.2.5 AGRICULTURE

The agricultural sector of Vancouver Island produces livestock, dairy products, and vegetables. Climatic conditions for agriculture are excellent as the region averages nearly 2500 degree days annualy.

Table 2 illustrates the size of agricultural reserve lands located in regional districts on the southeast coast of the Island.

TABLE 2 - AMOUNT OF LAND IN DESIGNATED AGRICULTURAL LAND RESERVES BY REGIONAL DISTRICT

Regional District	Acres 1975	Acres 1980	Hectares 1975	Hectares 1980	% of Regional District in ALR
Comox-Strathcoma	108,000	102,383	43,200	40,953	2.1
Nanaimo	52,000	51,526	20,800	20,610	10.2
Cowichan Valley	54,300	52,495	21,720	20,998	6.2
Capital	48,400	46,334	19,360	18,534	8.1

SOURCE: Agricultural Land Commission, 1980, Agricultural Land Reserve Statistics, April 1, 1980, Province of British Columbia.

5.3 PHYSICAL FEATURES

5.3.1 PHYSIOGRAPHY

The study area falls within the western half of the Georgia Depression, a section of the northwest - southeast coastal trough stretching from Alaska to the Gulf of California (Barker, 1974). The Depression can be divided into two sub-units which approximate the Coastal Resources Folio study area boundaries: the Nanaimo Lowland (which is the western unsubmerged margin of the Georgia Depression) and the Strait of Georgia (representing the submerged portion).

5.3.1.1 The Nanaimo Lowland

The Lowland is a relatively narrow (30km) strip of land below 600 metres elevation extending from Johnstone Strait to Sooke. Physiographically, this lowland can be divided into two components. The northern component is characterized by undulating topography with extensive coastal bluffs and deeply incised river valleys. Deep unconsolidated materials of marine, glacial and fluvial origins predominate. Bedrock outcrops are rare.

The southern component is characterized by bedrock outcrops interspersed with pockets of unconsolidated materials. Locally the bedrock has undergone differential erosion giving rise to the highly indented coastline of the Gulf Islands and Vancouver Island.

5.3.1.2 The Strait of Georgia

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

Mathews and Murray (1966) divided the central Strait into four submarine physiographic units. They include:

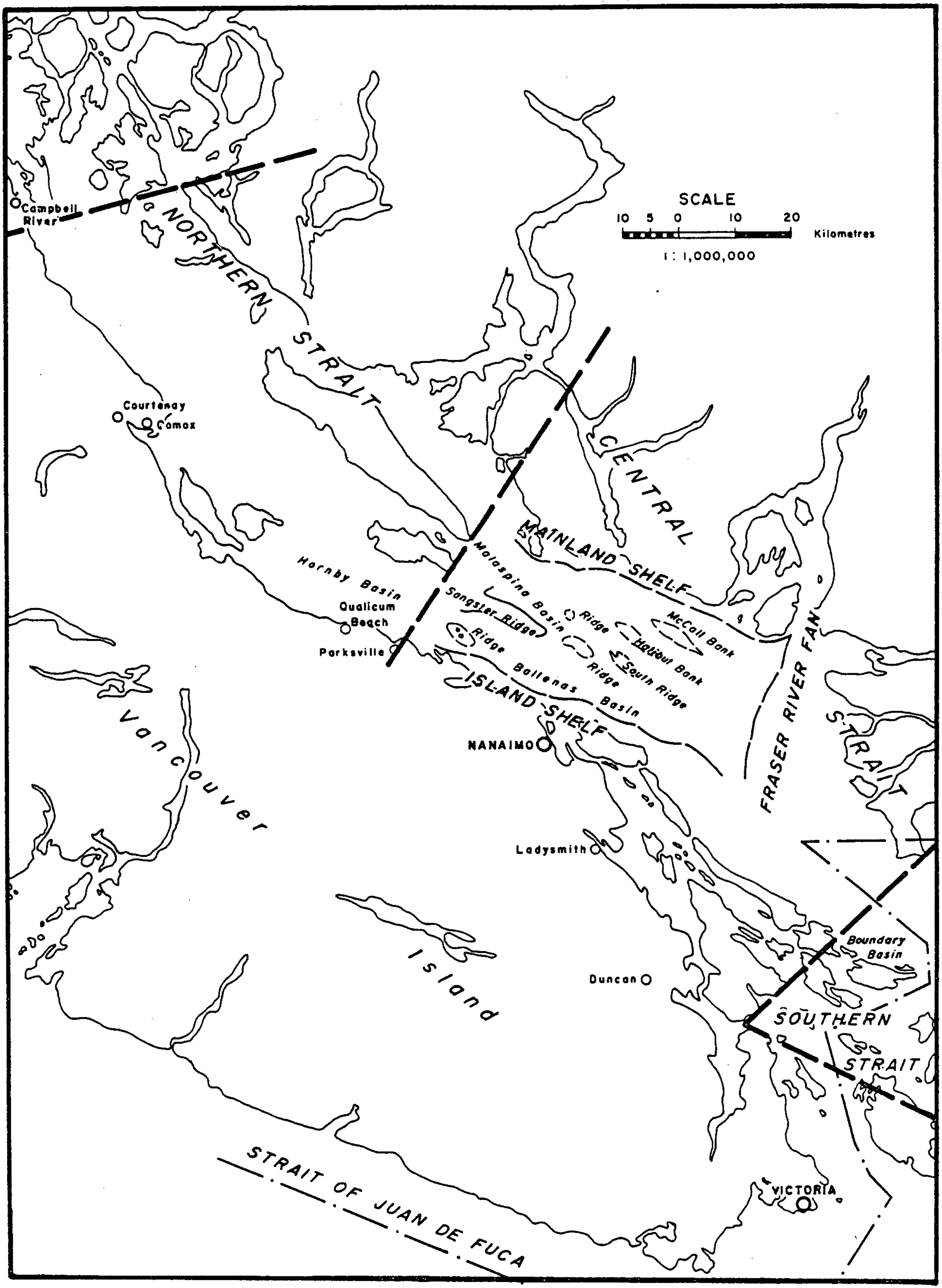
- The Fraser Fan which slopes gently westward and includes a northwest by southeast ridge of possible sedimentary origin.

- The Mainland Shelf and Slope, approximately 2 km wide, which breaks at about 100 metres with the base of the slope at 165 metres.

- The Island Shelf and Slope which encompasses the Gulf Islands and adjacent Vancouver Island. It ranges from 2 to 5 km in width (measured on the outside of the Gulf Islands) with many shoals and rocks. The shelf generally breaks at 100 metres then slopes sharply into the adjacent basins.

- The Bank and Ridge Province which is an area of ridges paralleling the axis of the Strait. The banks and shoals represent the shallowest areas of these ridges. Examples of these are illustrated in figure 1.

Figure 1   OCEANOGRAPHIC AND IDENTIFIED PHYSIOGRAPHIC SUBDIVISIONS



Source: W.H. Mathews and J.W. Murray, 1966. Recent Sediments and Their Environment of Deposition, Strait of Georgia and Fraser River Delta

There are a number of basins within these physiographic units. Basins are defined as deep, flat-bottomed areas with steep side slopes. Figure 1, identifies four basins from Boundary, in the south, through Ballenas, Malaspina and finally Hornby Basin in the north.

A study by Pharo and Barnes (1976) divided the central Strait into two sections with the boundary drawn between Porlier Pass and Bowen Island. The southern section is characterized by smooth topography and rapid sediment deposition, while the northern section is characterized by ridges and basins of extreme relief.

5.3.2 GEOLOGY

The area has been subjected to geological processes of down-folding, subsidence, uplift, glacial scouring and erosion. These processes have continued to modify the area from Mesozoic times ($>150 \times 10^6$ years B.P.). The most extensive period of mass erosion occurred during repeated glaciations and the interglacial periods of the Pleistocene era (Armstrong, 1975).

5.3.2.1 Bedrock

The bedrock of the area consists primarily of late-Cretacious and Tertiary sandstones, conglomerates, and shales. Also present are volcanic rocks of the Triassic period. Summaries of the stratigraphy of the Cretacious and Tertiary rocks are presented in Usher (1952), and Matthews and Murray (1976). A map of this area by Muller (1971) has been updated by Roddick *et al.* (1979). Jackson (1976) provides a generalized geology of the Canadian Cordillera.

5.3.2.2 Surficial

The unconsolidated surficial materials are glacial in origin. These deposits have also been modified by marine and fluvial processes as a result of sea-level changes and the retreat of the glaciers. Modern sediments (Holocene) are represented by channel, floodplain, alluvial fan, deltaic, and beach (marine and lacustrine) deposits. The Nanaimo Lowland is extensively underlain by glacial tills of various textures, depths and surface expressions. They tend to be compact mixtures of stones, sand, silt and clay and locally may exceed tens of metres in thickness. The deposits tend to be shallower in the more hilly areas of the south half of the study area. Sandy-loam textures predominate (Fyles, 1963).

Glacio-fluvial land forms (ie. terraces, abandoned channels and ice-contact alluvial fans) are also present (Fyles, 1963).

Much of the surface of the lowland below 150 metres elevation has been subjected to marine processes. Marine sediments vary in texture from gravels to clay, and the thickness of deposits can vary from less than 1 metre to several metres in depth. The veneers tend to be on slopes and represent coarser deposits. The deepest and finest deposits are found in depressions and low lying areas.

Colluvial deposits of post-glacial origin are common in the Lowland where bedrock is at or near the surface. Colluvial deposits vary in thickness from centimetres to metres, the deeper deposits found as talus cones at cliff bases.

Organic deposits occupy poorly drained depressional areas overlying impermeable tills, bedrock, or fine textured marine deposits.

Accounts of the glacial history of the study area and the resulting deposition of sediments can be found in Fyles (1963). Mapped surficial geology and stratigraphy are available for the Duncan, Shawnigan Lake, Nanaimo, Parksville, Horn Lake, Courtenay and Oyster River mapsheets. Terrain inventory maps for most of the study area have been done by the British Columbia Ministry of Environment.

5.3.3 SOILS

Soils of the study region include those of the Brunosolic and Podzolic orders. Between the southern shore of Nanoose Harbour and the southern boundary of the study area, Dystric Brunisol soils are dominant. North of Nanoose Harbour podzolic soils are dominant.

Dystric Brunisol 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 semiarid moisture regime. A high moisture deficit, low summer rainfall and warm temperatures lead to little chemical transformation which is characteristic of soils with low water holding capacity. Vegetation provides a thick, poorly decomposed surface litter layer with little incorporation of organic matter into the mineral soil. Sombric brunisols occur in the very driest sites, usually below the 50 metre contour, and are generally associated with a Garry-Oak and grass community.

Humo-furric podzol soils have developed on permeable, course 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).

The soils of the study area have been mapped by Day, et al. 1959. This area is currently being remapped by the British Columbia Ministry of Environment.

5.3.4 CLIMATE

5.3.4.1 Temperature and Precipitation

The Lowlands and nearshore islands fall within a relatively homogeneous climatic zone. Annual mean temperatures range from 9°C at more northerly and inland locations to 10°C at southern locations near the water. Precipitation varies from 75 cm in the south to 150 cm in the north. The majority of this precipitation falls in the winter months.

The study area has a long frost-free period of 180 to 220 days.

5.3.4.2 Wind Patterns

Wind patterns are controlled by seasonally dominant atmospheric pressure systems and the major topographic features of southwestern British Columbia. The northwest-southeast orientation of the Vancouver Island and Coast mountains constrains surface winds to blow in either of these two directions. In winter, the Aleutian Low dominates atmospheric circulation over the northeastern Pacific Ocean resulting in prevailing southeasterly winds. A complicating factor in winter is the existence of an Artic High in the interior of the Province. This 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. In summer the pattern is complicated by onshore-offshore winds created by diurnal temperature gradients between the land and water (Schaefer, 1980 pers. comm.).

5.3.5 PHYSICAL OCEANOGRAPHY

5.3.5.1 Tides

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 minnutes. 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 1 metre, thus generating strong currents (e.g. Seymour Narrows) (Giovando, 1976).

5.3.5.2 Currents

Waldichuk (1957) divided the Strait of Georgia into three areas based on surface current regime: Northern, Central, and Southern Strait.

5.3.5.2.1 Northern

The tidal currents are weak and highly variable. Speeds rarely exceed 1 knot although they may be faster in some channels.

Wind-driven currents are also weak even during strong winter winds. There is a probable counter-clockwise drift around the northern part of the Strait.

5.3.5.2.2 Central

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.

5.3.5.2.3 Southern

The tidal currents are stronger and typically greater than 1 knot. The narrow passages allow tidal mixing. Wind driven currents are significant during summer months when the Fraser River plume extends to this area. The Canadian Hydrographic Service is compiling a current atlas for the Strait of Georgia. The primary source of data for the tidal current predictions is the tidal model developed by Crean at the Institute of Oceanography, University of British Columbia (Crean, 1976). The model pre-edictions have been tested extensively and are found to correlate closely with measured values. The influence of the Fraser River discharge on current circulation is being studied for incorporation into the model.

5.3.5.3 Waves

The generation of waves depends upon wind speeds, their duration, and fetch. The Strait of Georgia is fetch and duration limited (McCann and Hale, 1980) and therefore rarely develops large sea waves. Winds blowing along the axis of the Strait can generate waves up to 3 metres for approximately 5% of the time during winter months (Owens, 1977).

5.3.6 WATER RESOURCES

5.3.6.1 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 Nanaimo Lowland region falls mainly as rain. Consequently, freshet occurs in mid-winter (December and January) when rainfall is greatest. Hydrographs for the Qualicum and Koksilah rivers exhibit this trend (figures 2 and 3). Rivers that are also fed by snowpack melt streams exhibit a second peak in discharge in late spring. Hydrographs for the Puntledge and Oyster rivers show this phenomenon (figures 4 and 5). The low flow period occurs during late August and September when some streams are dry or have sub-surface or base flows.

The Nanaimo Lowland region experiences an annual moisture deficit as evidenced in the accompanying graphs (Figures 6,7, and 8). Within the Gulf Islands, deficits range from 1524 mm to 2032 mm. On several islands, shortages or freshwater have resulted in subdivision controls that

FIGURE 2: HYDROGRAPH FOR THE QUALICUM RIVER

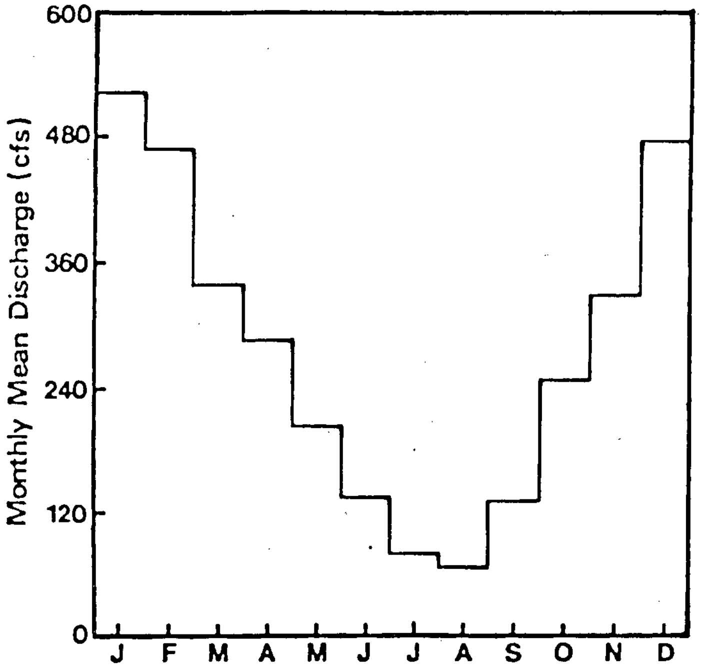
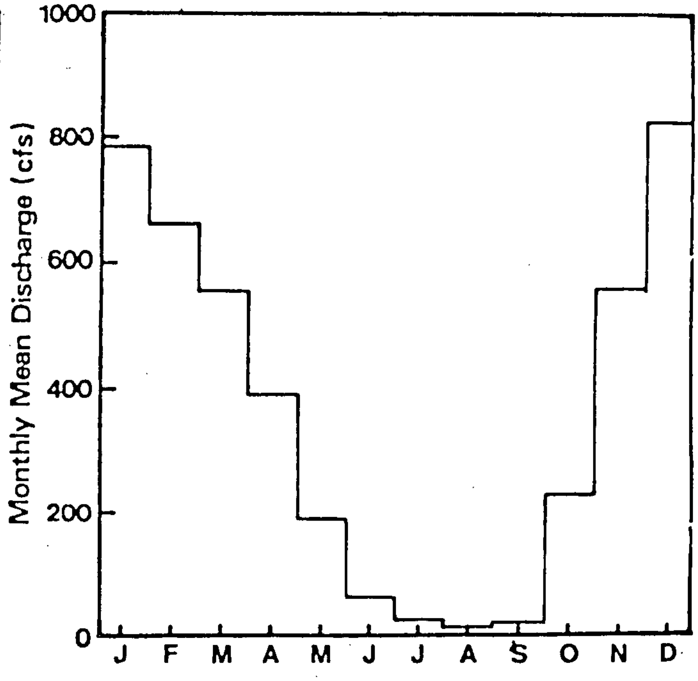


FIGURE 3: HYDROGRAPH FOR THE KOKSILAH RIVER



SOURCE: Inland Waters Directorate, 1979. Historical Streamflow Summary, Water Survey of Canada, Ottawa

FIGURE 4: HYDROGRAPH FOR THE PUNTLEDGE RIVER

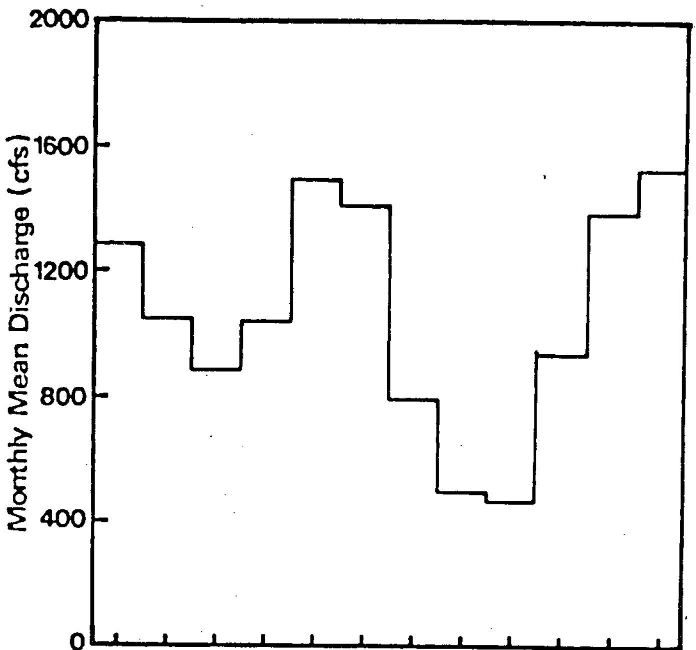
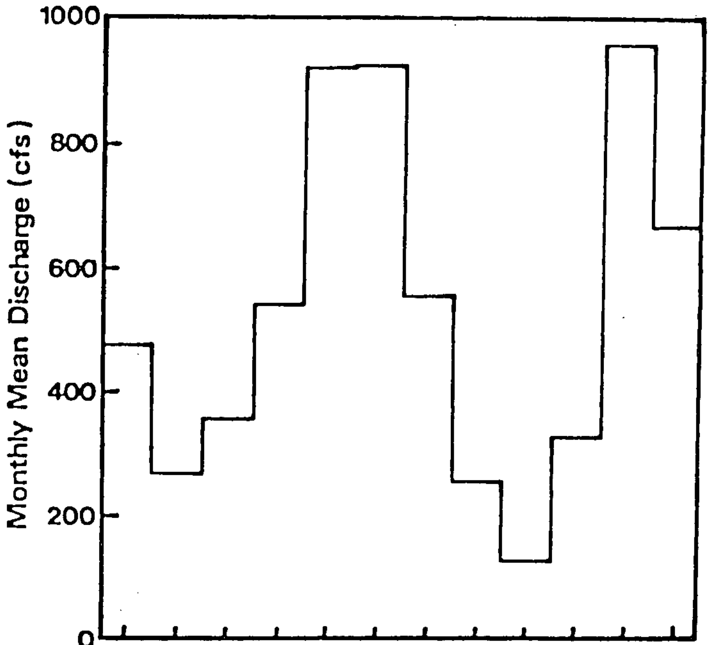


FIGURE 5: HYDROGRAPH FOR THE OYSTER RIVER BELOW WOODHUS CREEK



SOURCE: Inland Waters Directorate, 1979. Historical Streamflow Summary, Water Survey of Canada, Ottawa.

Figure 6 Moisture Balance for *Campbell River*

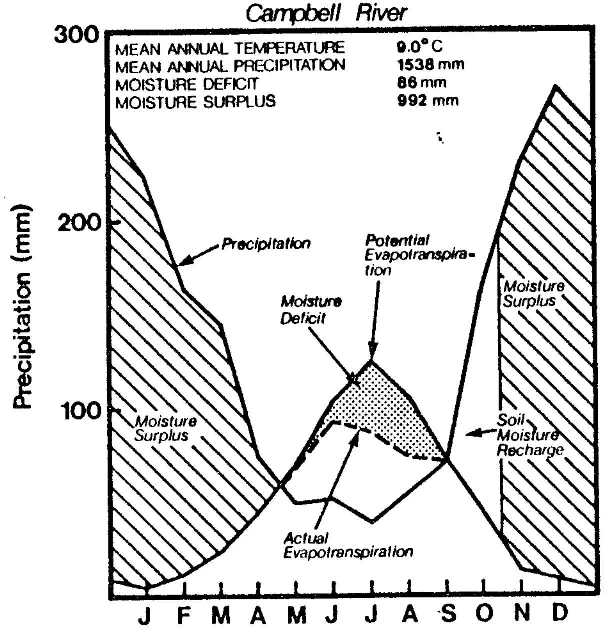


Figure 7 Moisture Balance for *Comox Airport*

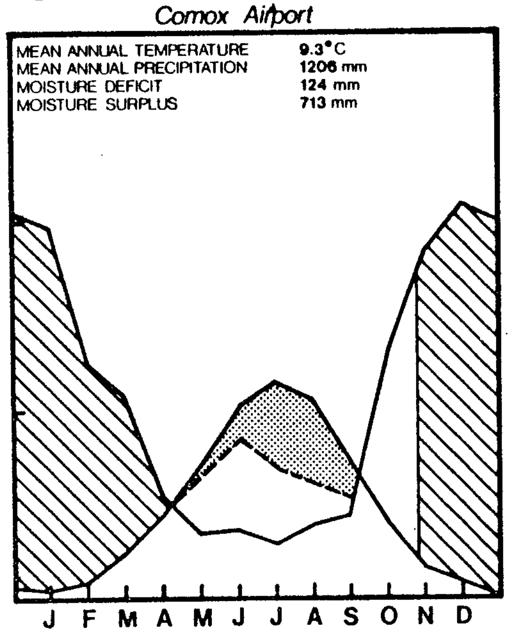
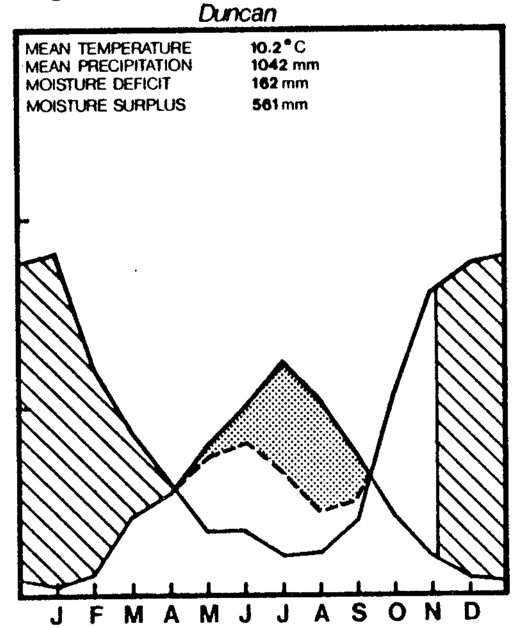


Figure 8 Moisture Balance for *Duncan*



Source: D.W. Phillips, 1976. Monthly Water Balance Tabulations for Climatological Stations in Canada. DS#4-76, Environment Canada, Atmospheric Environment Service, Downsview, Ont.

ultimately will limit growth of population and development.

Projected population increases to the year 2000 for the study region are about 90,000 people which will bring the population to about 255,000. By that time the capacity of current water delivery systems will be inadequate. Moreover, the demand for freshwater from domestic, comercial/industrial, recreational, and wildlife concerns may well exceed the supply. Uncertainties regarding climatic changes may well exacerbate the supply/ demand situation at that time.

5.3.6.2 Water Quality

Domestic sewage and industrial effluents are the major contributors of marine and fresh waters contaminants. River and marine outfalls, septic tanks, and wastes from vessels contribute nutrients and coliform bacteria, while industrial and commercial outfalls add poisons, metals, and heat. Although the marine waters are relatively well flushed by tidal and current action, water quality in many 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 (i.e. the sewage lagoon by the Comox estuary) and coastal freshwater lakes similarly contribute to the eutrophication of these water bodies.

5.3.6.3 Groundwater

Groundwater resources of the study region are not comprehensively studied, although several reports are completed. From the evidence presented, groundwater resources are relatively plentiful although several of the Gulf Islands lack aquifers sufficiently large enough to sustain normal urban population densities. In such areas, minimum lot sizes are designated in order to ensure adequate supplies. A test drilling programme is required in most areas of the study region in order to obtain complete knowledge of the groundwater resources.

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 in the mesothermal biogeoclimatic formation, the Pacific Coastal Mesothermal forest region, and the coastal Douglas Fir zone. Subzones also identified by Krajina include the Garry Oak-Douglas Fir zone subzone and the Madrono-Douglas Fir subzone. MacMillan Bloedel's biogeoclimatic map (1974) refers to these subzones as Wet Douglas Fir and Dry Douglas Fir while Klinka and Nuszdorfer (1979) refer to the drier maritime coastal Douglas fir and wetter maritime coastal Douglas fir subzones. The subzone boundaries of the above three classification approaches are, for the most part, continguous.

Douglas fir is the dominant tree species within the coastal Douglas fir zone. It is a moderately shade-tolerant species that can regenerate on most sites under a mature canopy because it is well adapted to subhumid or dry climates. On mesic sites it is shade-tolerant only in the coastal Douglas fir zone; on sub-hygric sites and hygric sites it is a shade-intolerant species. Douglas fir is adapted to become a final climatic climax tree on mesic sites in the moderately humid coastal Douglas fir zone. Within this zone it is often accompanied by western red cedar, grand fir, Garry oak or Pacific madrone.

The Resource Analysis Branch has inventoried the forest capability of the study area. Forest capabilities range from very high mean annual increments (greater than 15.0 cubic metres per hectare per year) to very low mean annual increments (less than 2.2 cubic metres per hectare per year).

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 pigmenation; hence the algal groups are Chlorophyceae (green algae), Phaeophyceae (brown algae), and Rhodophyceae (red algae). A fourth group of plants, the sea-grasses, have two genera occurring in British Columbia - *Zostera* and *Phyllospadix*. Saltmarsh species include the genera *Salicornia*, *Distichlis*, and *Triglochin*. Several genera (i.e. *Scirpus*, *Typha*, *Carex*) are better adapted to brachish 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, or herbivary. 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, while 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 (Kozloff, 1973; Ricketts and Calvin, 1968; Carefoot, 1977; Stephenson and Stephenson, 1972). On rocky coasts, the uppermost zone - the supralittoral 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, Nerocystis luetkeana, Sargassum muticum; the green Codium fragile; 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 are 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 inhabit 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 saltwater. 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, Typya, Carex, Juncus communities.

5.4.3 MARINE MAMMALS

The marine mammals of the Strait of Georgia and Juan de Fuca 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 3). Within the study area Orcinus orca (killer whale) is the largest resident species. Three family groups of 80 individuals are resident all months of the year and are occasionally joined by about thirty transient individuals. The range of the killer

TABLE 3 - CETACEANS OCCURRING IN WASHINGTON STATE AND BRITISH COLUMBIA

Order Cetacean--whales and dolphins	British Columbia
Suborder Mysticeti--whalebone whales	
Family Eschrichtiidae--gray whales	
Eschrichtius robustus Lilljeborg, gray whale	C
Family Balaenopteridae--furrow-throated whales	
Balaenoptera physalus Linnaeus, fin or finback whale	C
B. borealis lesson, peri whale	C
B. acutorostrata lacepede little piked whale, minke whale	NC
B. musculus Linnaeus, blue whale	NC
Megaptera novaeangliae Borowski, humpback whale	NC
Family Balenidae--smooth-throated whales	
Balena glacialis Muller, northern or black right whale	R
Suborder Odontoceti--toothed whales and dolphins	
Family Ziphiidae--beaked whales	
Berardius bairdii Stejneger, Baird's beaker whale	C
Mesoplodon stejnegeri True Stejneger beaked whale	R
M. carlhubbsi Moore, Hubbs' beaked whale	R
Ziphius cavirostris Cuvier, Cuvier's beaked whale	R
Family Physeteridae--sperm whales	
Physeter catodon Linnaeus, sperm whale	C
Kogia breviceps Blainville, pygmy sperm whale	NC
Family Delphinidae--ocean dolphins	
Stenella sp., spotted dolphin	R
Delphinus delphis Linnaeus, Pacific common dolphin	R
Lissodelphis borealis Peale, northern right-whale dolphin	R
Lagenorhynchus obliguidens Gill, Pacific white-sided dolphin	C
Orcinus orca Linnaeus, killer whale or orca	A
Grampus griseus Cuvier, gray grampus or Risso's dolphin	R
Globicephala macrorhyncha, shortfin pilot whale	NC
Phocoena phocoena Linnaeus, Pacific harbour porpoise	A
Phocoenoides dalli True, Dall porpoise	C

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

SOURCE: Adapted from: Pike and MacAskie 1969.
C.A. Simenstad, B.S. Miller, C.F. Nyblade, K. Thronburgh, 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. p. 260.

whale in the study area is about 200 nautical miles, although the northern pods from Johnston Strait do not mix with the southern pods. 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 Johnston 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 4). Although a preferred habitat of killer whales is identified north of the current study are a (Robson Bight) no such areas are known within this region.

The harbour seals populations of the study area are permanent residents although they are nomadic 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 easliy approached by predators. Seals prey mainly on littoral fish although a number of other species are taken. (Table 4).

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, leaving the water during the daytime. They prey primarily on fish although, as documented in the Puget Sound area, many other species are eaten (Table 4).

5.4.4 MARINE BIRDS

The estuaries and coastal waters of the study region are major resting sites for migrating birds on the Pacific flyway, and overwintering areas for a large population of marine birds. The environmental advantages of this region during the winter months include a relatively mild winter climate, abundant food, and a relatively sheltered coastline. During the summer months the marine bird population is low. The paucity of breeding species at this time is thought to be a response to the general variability of environmental factors such as ocean currents and meteorology (Myres, 1979) in spite of the success that wintering populations have found. The Canada Land Inventory rates all of the Gulf Island shorezone and much of the northern study area coast as important for wintering migratory birds. It is considered less important for production.

TABLE 4 - 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
Nearshroe	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 vitulina)
			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. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca. U.S. Environmental Protection Agency, Washington. p. 262 - 264

Seabirds are at the top of marine food webs. They eat a variety of organisms and feed in a variety of environments. Table 5 presents seabird prey taxa for major species common to the study area but sampled in northern Puget Sound and the Strait of Juan de Fuca. It is evident that saltmarsh and marine plants play an important role in providing food for marine birds. Indeed, many of their prey spend some, if not all of their life cycle with in the protection of algal communities.

Several major breeding colonies are found in the Gulf Islands (Rodway and Campbell, 1976) although relative to breeding grounds north of the study area the populations are small. Reasons why the area has not become a major breeding ground are obscure, although food availability and preferred nesting habitat may be significant limiting factors. The populations of seabird prey species are themselves subject to fluctuation and shifts in geography. Many seabirds have survived by adapting one or more of their functions (i.e. reproduction) to the behavior of a prey species (i.e. herring spawn). When the expected behavior of a prey species fails to materialize, however, catastrophic results may occur to the seabird population in the form of reproductive failures or adult mortality. When reproductive failures become chronic because of natural or human pertubations, the existence of a colony or population is threatened, although an adult enumeration 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, leading to erroneous conclusions about the reasons for colony extinction. Very little is known about the cyclical phenomena of seaird populations.

Stress and mortality within seabird populations result from a variety of natural and human peturbations. Increased commercial and recreational boat traffic disrupts their behavioural patterns related to feeding and seeking shelter during bad weather; shoreline developments destroy habitat or disturb breeding times leading to higher mortalities of the young; and predators introduced to isolated islands significantly reduce the reproductive success of breeding populations. Breeding colony disturbances by recreationists results in the temporary abandonment of nests and predation of the young by other birds. Commercial fishing claims seabirds by drowning in fishing nets. Oil spills and chemical pollution from transportation activities pose additional threats to the integrity of seabird populations.

5.4.5 <u>FISH AND SHELLFISH RESOURCES</u>

5.4.5.1 <u>Introduction</u>

5.4.5.1.1 The Nature of Marine Resources

The geographic spread of a species is its range, but not everywhere in its range is a species evenly distributed. For the purpose of coastal resource management and impact assessment the interpretation of environmental and biotic data requires a solid understanding of species distributions. Marine populations, except for birds, some marine mammals and certain intertidal organisms, are not easily observed. Almost

Table 5 - 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 Black-legged kittiwake Common tern Rhinoceros auklet Western grebe	Northern anchovy Eulachon Pacific herring Pacific sand lance Juv. rockfish Juv. Pacific salmon Surf smelt Night smelt Walleye pollock Threespine stickleback
	Facultative piscivore	Tufted puffin Marbled murrelet Ancient murrelet	Pacific sand lance Pacific herring 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 Bonaparte's gull	Euphausids 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	Limpets Chitons Black turnstone Bivalve molluscs Barnacles Polychaete annelids
Inshore sand-gravel beaches	Obligate benthivore	Spotted sandpiper Surfbird Least sandpiper Sanderling	Polychaete annelids Amphipods Bibalve 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 Redpbreasted 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 Snake prickleback 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 Saltmarch 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	Polychaete annelids
		Long-billed dowitcher	Univalve molluscs
			Bivalve molluscs
			Crabs
			Shrimp
			Isopods
			Amphipods
	Facultative benthivore	Greater yellowlegs	Molluscs
			Crustaceans
			Fish
Universal	Facultative benthivore	Glaucous-winged gull	Chitons
		Western gull	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.

everything known about a species distribution is based upon indirect observation or sampling. Population-oriented investigations are few. It is often difficult to set distribution boundaries with current information and, particularly in the case of most fish species, map boundaries are not representative of population limits, but rather of areas of known concentration.

Fish exhibit seasonal behaviour. Their distribution patterns are diffuse and shifting. Consequently, our understanding of fish distributions is limited to easily observable events such as major spawning migrations. In a restricted sense, the exploitation patterns of our fisheries may be taken as a rough guide to the actual distribution of the species. Subject to other factors such as location, seasonality, economic, and recreational values of each fishery - exploitation patterns heavily favour areas of stock abundance.

Although our level of understanding of fish is related to their economic value, there is increeasing awareness that future problems in the management of the sea may occur at lower levels of the food chain. At least equal effort is required to investigate the structure and dynamics of marine ecosystems as is now devoted to the study of particular species.

5.4.5.2.1 Importance of the Study Area

The waters of the study area form an integral part of the Strait of Georgia system, and are an important producer of salmon, herring, groundfish, shrimp, oyster, clams and other resource species which are exploited by commercial and recreational fishing.

The recording of fisheries catches and measures of resource abundance and yield is by Statistical Areas, of which there are five in the study area (Figure 9).

The relative importance of the fish and shellfish resources in the study area in relation to the Strait of Georgia is shown in Table 6. As shown in this table, apart from catches of commercial salmon and clams, the yield to fisheries of the major resource groups is upwards of one half and more of the total harvest in the Strait of Georgia. More than half of these resource groups exceed three quarters of the herring spawning stock, nearly all of the oysters and all of the important groundfish stocks in the Strait of Georgia. It also attracts more than two thirds of the sport salmon fleet.

The breakdown by area (Table 6) reveals that the major species caught in the northern and central sectors are salmon, herring and shellfish while groundfish dominate catches in the south.

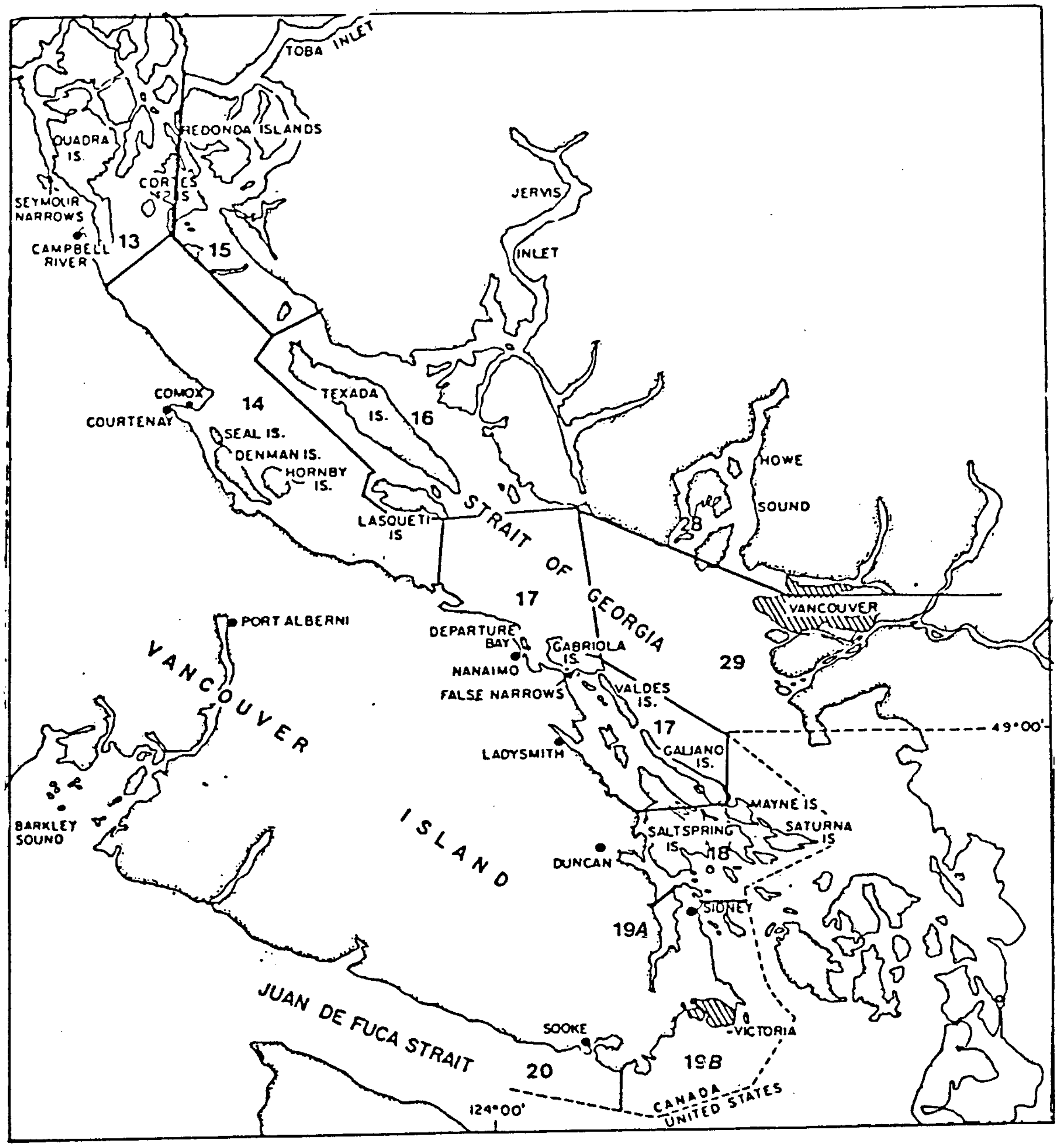
5.4.5.2 <u>Fisheries (fin fish)</u>

5.4.5.2.1 Salmonids.

5.4.5.2.1.1 Resource

A comprehensive review of the salmon fishery in British Columbia (1951-63) is provided by Aro and Shepard (1967). Traditional salmon fishing areas include the study area although commercial activities are

FIGURE 9. FISHERIES STATISTICAL AREAS OF THE STRAIT OF GEORGIA PLUS NORTHERN (AREA 13) AND SOUTHERN (AREAS 19, 20) APPROACHES.



Source: Adapted from Fisheries and Oceans Canada

Note: Areas 14, 17 and 18 enclose nearly all of the study area which extends only a short distance into Area 13.

TABLE 6 - FISH AND SHELLFISH RESOURCES OF THE EAST COAST OF VANCOUVER ISLAND STUDY AREA (Fisheries Statistical Areas 14,17, and 18)

TOTAL STUDY AREA*

SALMON	22%	Commercial (1975-79)
	68%	Sport (1972-76), incl., areas 13, 19A
HERRING	99%	Roe Landings (1974-78)
	77%	Spawning Stocks (1971-79)
GROUNDFISH	43%	Lingcod (1973-77), incl., area 13
	85%	Dogfish (1960-77)
	76%	Groundfish (1960-77), incl., areas 12, 13
	10 of 10	Regulated Areas (most productive)
SHELLFISH	43%	Shrimp (1975-79), incl., area 13
	38%	Clams (1975-79), incl., area 13
	86%	Sea Urchin (1975-79), incl., area 13
	43%	Geoduck Clam (1975-79), incl., area 13
	92%	Oyster (1975-79), incl., area 13

INDIVIDUAL FISHING AREAS

AREA 14

SALMON	13%	Commercial (1975-79), second only to Howe Sound - Fraser River (areas 28, 29)
	42%	Sport (1972-76), incl., areas 13,19A
	27 of 51	Spawning streams (1975-79), study area
	12 of 24	Streams Average > 1000 spawners/yr., study area
	1 of 2	Streams Average > 10,000 spawners/yr., study area
	3 of 4	SEP Major Facilities
HERRING	56%	Roe Landings (1974-78)
	57%	Average Spawn Abundance (1942-79), study area
	60%	Spawning Stocks (1971-79)
GROUNDFISH	6%	Lingcod (1973-77), incl., area 13
	17%	Dogfish (1960-77)
	20%	Groundfish (1960-77), incl., areas 12, 13
	7 of 10	Regulated Areas (most productive)

INDIVIDUAL FISHING AREAS (cont.)

AREA 14 (cont.)

SHELLFISH	8%	Shrimp (1975-79), indl., areas 13
	14%	Clams (1975-79), incl., area 13
	25%	Sea Urchins (1975-79), incl., area 13
	25%	Geoduck Clam (1975-79), incl., area 13
	75%	Oyster (1975-79), incl., area 13

AREA 17

SALMON	6%	Commercial (1975-79)
	11%	Sport (1972-76), incl., areas 13,19A
	15 of 51	Spawning Streams (1975-79), study area
	8 of 24	Streams Averaging > 1000 spawners/yr., study area
	2 of 9	Streams Averaging > 10,000 spawners/yr., study area
HERRING	44%	Roe Landings (1974-78)
	41%	Average Spawn Abundance (1942-79), study area
	10%	Spawning Stocks (1971-79)
GROUNDFISH	31%	Lingcod (1973-77), incl., area 13
	30%	Dogfish (1960-77), incl, areas 12, 13
	2 of 10	Regulated Areas (most productive)
SHELLFISH	21%	Shrimp (1975-79), incl., area 13
	21%	Clams (1975-79), incl., area 13
	18%	Sea Urchins (1975-79), incl., area 13
	17%	Geoduck Clams (1975-79), incl., area 13
	17%	Oyster (1975-79), incl., area 13

AREA 18

SALMON	3%	Commercial (1975-79)
	15%	Sport (1972-76), study area
	3 of 51	Spawning streams (1975-79), study area
	2 of 24	Streams Averaging > 1000 spawners/yr., study area
HERRING	2%	Average Spawn Abundance (1942-79), study area
	7%	Spawning Stocks (1971-79)

INDIVIDUAL FISHING AREAS (cont.)

AREA 18 (cont.)

GROUNDFISH	6%	Lingcod (1973-77), incl., area 13
	38%	Dogfish (1960-77)
	34%	Groundfish (1960-77), incl., areas 12, 13
	1 of 10	Regulated Areas (most productive)
SHELLFISH	16%	Shrimp (1975-79), incl., area 13
	3%	Clams (1975-79), incl., area 13
	43%	Sea Urchins (1975-79), incl., area 13
	1%	Geoduck Clam (1975-79), incl., area 13

NOTES: 1. Differences in Geographical area and length of coastline between areas are not taken into consideration. A small portion of area 13 forming the northern tip of the study area cannot be partitioned away from the remainder of that area which covers Discovery Passage and Eastern Johnstone Strait.

2. A regional perspective of salmon spawning streams is limited to the study area.

* In proportion to the total fisheries yield in the Strait of Georgia (Areas 14,15,16,17,18,28 and 29) plus adjoining waters where specified. (Calculations are approximate and intended only as a rough guide).

SOURCES: Fisheries and Oceans Canada, B.C. Catch Statistics; Salmon Enhancement Program (SEP), Annual Reports; and District Fisheries Officers Salmon Stream and Spawning Reports.

concentrated in locations depicted in the Coastal Resources Map Series (1:50,000) section, Fish and Shellfish Resources.

The average annual salmon catch between 1975-1979 in southern British Columbia is given in Table 7. The Strait of Georgia plus the lower half of Johnstone Strait and Discovery Passage (Area 13) accounted for approximately one quarter (24%) of the average annual salmon catch during this period. Similarly, areas 14, 17 and 18 produce nearly one quarter (22%) of the average annual salmon catch in the Strait of Georgia (excluding the northern approach) - the second largest harvest after the Fraser River and Howe Sound fishery (Areas 28 and 29).

The Strait of Georgia Head Recovery Program (Fisheries and Oceans Canada) led to a revision of earlier sport catch estimates for the period 1972-76 (Table 8). The sport catch (number of fish) of chinook and coho salmon has been close to three times greater than the commercial troll fishery for these species - or 75% of the total catch - and it is believed that this estimate may be conservative.

A substantial portion of the total sport catch in the Strait of Georgia and adjoining waters is taken along the eastern coast of Vancouver Island : coho 76%, chinook 60% and pink (including minor catches of sockeye and chum) 45%. Aerial surveys from 1965 to 1971 revealed intensive competition between commercial trollers and sports fishing boats primarily in three areas: Nanoose Harbour to Nanaimo, Hornby and Denman Islands, and in the Campbell River region. Further detailed studies of the sport fishery are currently under way (Fisheries and Oceans Canada).

5.4.5.2.1.2 Habitat Requirements.

Spawning Escapement

Most salmon return to freshwater habitat to spawn, although some chum spawn in intertidal approaches to streams. The average annual spawning escapement to streams on the east coast of Vancouver Island in the period 1975-79 is given in Table 9.

With few exceptions, coho and chum are the predominant spawners in local streams throughout this region. In the five-year period, 24 streams averaged over 1000 spawners annually. Nine streams accommodated over 10,000 fish each: Campbell, Chemainus, Cowichan, Koksilah, Little Qualicum, Nanaimo, Puntledge, Big Quilicum and Quinsum rivers. There is a large difference in escapement figures between the third ranking river, Little Qualicum (37,505) and the top two rivers, Cowichan and Big Qualicum, which received over 100,000 spawners annually. Over fifty-one rivers and creeks in the study area support salmon spawning populations (District Fisheries Officers, 1980 pers. comm.).

An annotated bibliography of salmon stream environments in British Columbia is available in Schmidt et al. (1979). This report specifies four primary determinants of spawning stream suitability for salmon production:

(a) water temperature - the key factor in regulation of biological activity, stress and mortality;

TABLE 7 - REGIONAL PERSPECTIVE OF AVERAGE ANNUAL SALMON CATCH (METRIC TONS) FOR THE PERIOD 1975-79.

FISHERIES STATISTICAL AREAS

	STRAIT OF GEORGIA							
	STUDY AREA							
SPECIES	14	17	18	15	16	28 + 29	13	SOUTH COAST
CHINOOK	144	177	19	53	50	555	193	4986
COHO	187	32	8	31	29	118	212	6960
CHUM	221	9	6	-	2	435	1158	3941
SOCKEYE	3	58	61	-	115	1621	1014	7251
PINK	8	17	39	2	40	390	530	8393
ALL SPECIES	563	293	133	86	236	3119	3107	31531

SUMMARY - AVERAGE ANNUAL CATCH, ALL SPECIES

	TOTAL	PERCENTAGE
ALL AREAS	7537	24%
SOUTH COAST	31531	76%
	39068	100%
STUDY AREA	989	22%
STRAIT OF GEORGIA (EXCLUDING AREA 13)	4430	78%
	5419	100%

NOTE: 1. No landings were reported for the Canadian side of the southern approach (Area 19)

2. Pre-1978 landings converted to nearest metric ton. Landings below 1 metric ton are omitted.

SOURCE: Fisheries and Oceans Canada. B.C. Catch Statistics. Annual Reports.

TABLE 8 - REGIONAL PERSPECTIVE OF AVERAGE ANNUAL SPORT SALMON CATCH (NUMBER OF FISH) FOR THE PERIOD 1972-75.

SPORT CATCH (x 1000 FISH) BY AREA

	STRAIT OF GEORGIA AND VICINITY								
	STUDY AREA								
	13 + 14[2]	17	18 + 19B	TOTAL STUDY AREA	15 + 16	28 + 29	19B + 20	TOTAL ALL AREAS	% STUDY AREA
COHO	263	47	47	357	80	15	18	470	76%
CHINOOK	84	45	76	205	44	38	55	342	60%
PINK[1]	6	1	2	9	1	1	9	20	45%
TOTAL	353	93	125	571	125	54	82	832	69%

SPORT VERSUS COMMERCIAL CATCH (x 1000 FISH)

	COMMERCIAL (TROLL)	SPORT	TOTAL	% SPORT
COHO	98	470	568	83%
CHINOOK	183	343	526	65%
COHO + CHINOOK	281	813	1094	74%

NOTE:

1. SPORT SALMON FISHING IN AREA 13, COVERING THE NORTHERN APPROACH TO THE STRAIT OF GEORGIA, IS PREDOMINANTLY WITHIN THE STUDY AREA IN THE CAMPBELL RIVER REGION.

2. INCLUDES MINOR CATCHES OF SOCKEYE AND CHUM.

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. Canada, Fisheries and Marine Service. Technical Report SEries PAC/T-77-16.

TABLE 9 - AVERAGE SALMON SPAWNING ESCAPEMENT TO EAST COAST VANCOUVER ISLAND RIVERS AND CREEKS IN THE PERIOD 1975-1979

STREAM	CHINOOK	COHO	CHUM	SOCKEYE	PINK	ALL SPECIES
AREA 13 (WITHIN STUDY AREA)						
CAMPBELL R.*	3250	520	6540	25	2653	12988
MENZIES CR.	-	20	100	-	40	160
MOHUN CR.	-	225	140	-	-	365
QUINSUM R.*	160	6705	471	32	16029	23397
SIMMS CR.	-	420	-	-	-	420
SWANSKY CR.	-	690	-	-	-	690
AREA 14						
ANNIE CR.	-	26	-	-	-	26
BLACK CR.	-	5673	-	-	-	5673
CHEF CR.	-	660	90	-	-	750
COOK CR.	-	285	3570	-	-	3855
COUGAR CR.	-	150	224	-	-	374
GRAIG CR.	-	22	-	-	-	22
ENGLISHMAN R.	30	1070	2750	75	27	3952
FILLONGLEY CR.	-	160	-	-	-	160
FRENCH CR.	-	1380	105	-	-	1485
HART CR.	-	36	1	-	-	37
KITTY COLEMAN CR.	-	95	9	-	-	104
LARD CR.	-	310	-	-	-	310
LITTLE R.	-	225	-	-	-	225
LITTLE QUALICUM R.*	146	2980	34300	79	-	37505
MCNAUGHTON CR.	-	286	1520	-	-	1806
NILE CR.	-	21	25	-	-	46
OYSTER R.	-	2880	540	-	540	3960
PUNTLEDGE R.*	882	3600	38900	20	2870	11262
QUALICUM R.*	3730	37714	104077	-	-	145521

STREAM	CHINOOK	COHO	CHUM	SOCKEYE	PINK	ALL SPECIES
AREA 14 (CONT'D)						
ROSEWALL CR.	-	240	330	-	-	570
THAMES CR.	-	30	-	-	-	30
TRENT R.	-	125	885	-	-	1010
TSABLE R.	-	192	3120	-	53	3365
TSOLUM R.	-	2160	205	-	6460	8825
WATERLOO CR.	-	165	345	-	-	510
WILFRED CR.	-	250	430	-	-	680
WOODS CR.	-	125	-	-	-	125
AREA 17						
BLOODS CR.	-	5	-	-	-	5
BONELL CR.	-	173	2303	-	-	2476
BONSALL CR.	-	1418	1259	-	-	2677
BUSH CR.	-	136	943	-	-	1079
CHASE R.	-	128	89	-	-	217
CHEMAINUS R.*	151	452	11200	-	-	11803
DEPARTURE CR.	-	44	-	-	-	44
HOLLAND CR.	-	36	1026	-	-	1062
KNARSTON CR.	-	35	-	-	-	35
NANAIMO R.*	2259	1932	22360	1	3	26555
NANOOSE CR.	-	880	4240	-	-	5120
PORTERS CR.	-	7	-	-	-	7
ROCKY CR.	-	4	4	-	-	8
STOCKING CR.	-	44	2440	-	-	2484
WALKERS CR.	-	121	648	-	-	769
AREA 18						
COWICHAN R.*	6200	36440	68100	-	-	110740
FULFORD CR.	-	250	-	-	-	250
KOKSILAH R.*	450	6700	5350	-	-	12500

Note: Water Courses receiving over 1000 spawners annually on average are underlined, over 10,000 spawners marked with an asterisk.

Source: D.E. Marshall, R.F. Brown, V.D. Chahley and D.G. Demontier. 1976. Preliminary catalogue of salmon streams and spawning escapements of Statistical Areas 17 and 18 (Nanaimo-Ladysmith-Duncan). Canada, Fisheries and Marine Service. Data Report Series PAC/D-76-6.

R.F. Brown, V.D. Chahley and D.G. Demontier. 1977. Preliminary catalogue of salmon streams and spawning escapements of Statistical Area 14 (Comox-Parksville). Canada, Fisheries and Marine Service. Data Report Series PAC/D-77-12.

(b) stream hydraulics - water depth, velocity, width, channel shape, gradient and bed roughness;
(c) spawning gravel - determining success of egg and alevin subgravel development: and
(d) downstream migration - interference due to water use conflicts.

Spawning Streams

Table 10 provides an inventory of the major physical stream characeristics of spawning streams and a checklist of utilization by individual salmonid species.

Estuarine and Nearshore Rearing

Pink and chum hatchlings arrive in the estuaries shortly after emergence from stream spawning gravel. Chinook delay their descent to estuaries for three months to a year, while coho and sockeye remain in freshwater from one to several years before migrating to sea.

Although chinook and chum are the main users of estuaries, some stocks of coho, pink and sockeye salmon, herring, flounders and shrimp are also known to depend on estuaries in their juvenile stages. Extensive nearshore waters of the study area support the developing young of all five salmon species. Some localized observations of herring and flounder rearing have also been reported.

Estuarine rearing of juvenile salmon has been studied only recently. In the study area, evidence of salmon rearing has been accumulated for a number of estuarine regions including Campbell River (E.V.S. Consultants, 1978), Lynn Creek and Big Qualicum River (Mason, 1974), the Nanaimo River (Nanimo Esturay Task Force, 1980), the Chemainus River (M. Healey, pers. comm.) and Cowichan Bay (B. Hillaby, pers. comm. 1980).

Juvenile chum show complex patterns of transition from freshwater to saltwater. They prefer freshwater layers in estuaries which serves to delay seaward migration (Mason, 1974). In the Nanaimo estuary, chum fry arrive in early March to June. The earliest arrivals to the estuary remain the longest (several weeks) while the last runs pass through the estuary in a few days and occupy other nearshore nursery areas (Nanaimo Estuary Task Force, 1980). The principal food of chum in the Nanaimo estuary is a small bottom-dwelling copepod which is most abundant among eelgrass. The growth of chum is potentially limited by the abundance of this prey.

Juvenile chinook use estuaries from March to May for a three-week stay before moving offshore. Unlike chum, chinook appear to be restricted entirely to the brackish waters of estuaries, avoiding fresh and marine waters. Juvenile chinook depend upon the availability of a spectrum of suitably-sized foods. In early spring, the fish eat small bottom-dwelling copepods and cladocerans; later in the season, when the fish are larger, amphipods and mysids are more important.

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Campbell R.	Menzies Cr.	Mohun Cr.	Quinsum River	Simms Cr.	Swansky Cr.	Annie Cr.	Black Cr.	Chef Cr.	Cook Cr.	Cougar Cr.
STATISTICAL AREA	13	13	13	13	13	13	14	14	14	14	14
LENGTH (MI)	3.5	1.0	6.0	16.0				16.4	3.4	1.6	
WIDTH (FT)								18	15	33	
WETTED AREA (YD SQ)								173,184	29,920	30,976	
SPAWNING AREA (YD SQ)								58,000	21,000	14,000	
DRAINAGE (MI SQ)	679			107		16		25.0	2.7	7.3	
BEDROCK)										1%	
BOULDER)						Lower area: Boulders/		12	8%	40%	
COARSE)						Gravel		17	34%	18%	
FINE)= %						Upper area: Gravel/		17	39%	28%	
SILT/SAND)						Mud		42	11%		
OTHER)								Pools 12	Pools 8	Pools 13	
TEMPERATURE								41F (Nov 15-30, 1968)			
x DISCHARGE (CFS)	1540 CFS (1957)			211 CFS (1976)							
MAX DISCHARGE								720.0			
MIN DISCHARGE	562-1660 CFS			31.4-81.8 CFS				0.0			
LOW FLOWS		Severe, Frequent					Common	Farming & Common	)very stable	Severe, Common	
HIGH FLOWS								Landclearing	)	Extreme	
SCOURING				68 Floods Caused						30% Prone	
SILTATION				Damage							
FRY STANDING											
DEBRIS				Occasionally bad		Log jams common					
COVER					Culverts Plug	Culverts plugged at times	Good				
AGRI. RUNOFF					Abundant	Very good, 2nd growth					
IND. WASTES											
DOMESTIC WASTES											
WATER LICENCES #	16		3	5				13			
WATER LICENCES TOTAL	17,209 CFS		.014	189.7				1.15 (During Summer)			
MIN FLOW REQUIRED											
BANK MODIFICATION				Bank Protection							
BED MODIFICAITON											
HATCHERY				Yes							
OTHER					Clearance in						
FLOW CONTROL				Yes			Partial Storage Dam				
SOCKEYE	x			x							
CHINOOK	x			x							
COHO	x	x	x	x	x	x	x	x	x	x	
CHUM	x	x	x	x					x	x	
PINK (o or e)	x (o,e)	x (o,e)	x (o,e)	x (o,e)							
STEELHEAD	x			x				x			
CUTTHROAT							x	x		x	
DOLLY VARDEN					X						
RAINBOW											
TYPE OF ESTIMATE				Counting Fence				Counting Fence			
JUVENILE ENUMERATION				Yes				Yes			

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Nile Cr.	Oyster R.	Puntledge R.	Qualicum R.	Rosewall Cr.	Thames Cr.	Trent R.	Tsable R.	Tsolum R.	Waterloo Cr.	Wilfred Cr.
STATISTICAL AREA	14	14	14	14	14	14	14	14	14	14	14
LENGTH (MI)	3.3	13.0	8.8	6.5	2.4	3.4	5.6	3.2	18.0	2.0	2.4
WIDTH (FT)	26	100	195	75	48		54	75	72	18	39
WETTED AREA (YD SQ)	50,297	762,590	1,006,720	305,100	67,584		177,408	140,800	760,320	21,120	54,912
SPAWNING AREA (YD SQ)	35,000	160,000	131,000	140,300	36,000		17,700	53,500	244,000	5,300	27,400
DRAINAGE (MI SQ)	7.0	70.0	200.0	58.0	17.5		25.2	42.0	98.0	3.2	12.8
BEDROCK)		36%	38%			)	45%		5%		
BOULDER)	5%	36%	23%	27%	31%	)	45%	56%	38%	75%	47%
COARSE)	35%	12%	8%	23%	27%	) = Gravel and Boulders	5%	19%	16%	13%	27%
FINE)= %	35%	9%	5%	23%	27%	)	5%	19%	16%	12%	23%
SILT/SAND)						)			1%		
OTHER)	Pools 25	Pools 7	Pools 26	Pools 27	Pools 15	)		Pools 6	Pools 24		Pools 3
TEMPERATURE											
x DISCHARGE (CFS)	24.6 (1970)	508 (1915)	746 (1942)	161 (1970)			60.7 (May-Sept)		262 (1970)		
MAX DISCHARGE							377				
MIN DISCHARGE	2.3-7.7	35.0-90.0	180.0-470.0	13.7-124.0			1.1-14.2		1.1-14.2		
LOW FLOWS						Common			Common (Water Diver-	Common	Acute, Frequent
HIGH FLOWS		Frequent							sion)		
SCOURING		Severe, Frequent			Fine Gravel Shifts				Common	Occasional	Extreme
SILTATION		Common, Problems	Light, in Lowest Por-		Constant			Heavy in 75	Severe in Winter	Severe in 75	Moderate
FRY STRANDING			tion						Gravel Removal Opera-		Moderate
DEBRIS									tions in 1944		
COVER											
AGRI. RUNOFF							Run Decreased Several				
IND. WASTES							Decades Age Due to	Mine Effluent at one			
DOMESTIC WASTES							Mine Effluent	Time			
WATER LICENCES #	4	4	6	2	1		5		31		11
WATER LICENCES TOTAL	0.19	0.43	676.59	696.1	10.0		0.05		0.61		0.25
MIN FLOW REQUIRED											
BANK MODIFICATION		Bank Protection					Bank Protection, Dykes		Bank Protection		Bank Protec-
BED MODIFICAITON			Some Gravel Removal								tion
HATCHERY			Spawning Channel,	Yes				Occasionally Mine	Extensive Gravel		
OTHER			Rearing Ponds	Spawning channels,ponds	Field Station			Effluents Enters	Removal		Transplant
FLOW CONTROL	Yes		Yes	Yes	FRBC				Yes, From Wolf Lake		1958
SOCKEYE											
CHINOOK			x (s&f)	x							
COHO	x	x	x	x	x	x	x	x	x	x	x
CHUM	x	x	x	x	x		x	x	x	x	x
PINK (o or e)		x (e,o)	x (e,o)					x (o,e)	x (e)		
STEELHEAD	x	x (s,w)	x		x	x (?)	x	x	x	x	x
CUTTHROAT	x	x			x	x			x	x	x
DOLLY VARDEN		x									
RAINBOW		x									
TYPE OF ESTIMATE				Counting Fence							
JUVENILE ENUMERATION				Yes							

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Holland Cr.	Knarston Cr.	Nanoose Cr.	Nanaimo R.	Porters Cr.	Rocky Cr.	Stocking Cr.	Walkers Cr.
STATISTICAL AREA	17	17	17	17	17	17	17	17
LENGTH (MI)	2.0		3.0	22	1.0	0.25	0.30	1.25
WIDTH (FT)	36) Chum		27) Chum				33) Chum	12) Chum
WETTED AREA (YD SQ)	13,386) Spawning		39,126) Spawning				2,697) Spawning	1,711) Spawning
SPAWNING AREA (YD SQ)	1,999) Area		16,017) Area				1,445) Area	239) Area
DRAINAGE (MI SQ)				264				
BEDROCK)				Bedrock, Boulders /			)	
BOULDER)				Above Highway; Good			)	
COARSE)				Gravel Below			) Very Good Gravel	
FINE)= %							)	
SILT/SAND)							)	
OTHER)				High (above 70 deg F.)			)	
TEMPERATURE			Very Flashy, But	995 (1970)				
x DISCHARGE (CFS)			Stabilizing					
MAX DISCHARGE								
MIN DISCHARGE		0.01-0.02	0.17-0.30	43.2-224				
LOW FLOWS	Residential Use			Common	Common			Yes
HIGH FLOWS	Potential Problems							
SCOURING							Almost Non-Existant	
SILTATION	Very little							
FRY STANDING	Very little							
DEBRIS		Common		Polkinghome Channel				Yes, Helps Conserve
COVER			Several Log Jams		Large Amounts			Water
AGRI. RUNOFF			Excellent					
IND. WASTES								
DOMESTIC WASTES								
WATER LICENCES #	3	Seriously Large: 12	5	5			5	
WATER LICENCES TOTAL	1.52	0.017	0.39	125.41			0.21	
MIN FLOW REQUIRED								
BANK MODIFICATION			Log Jams Cleared 1967	Bank Protection				
BED MODIFICAITON					Clearance	Relocated in 1971		
HATCHERY				Gravel Removal				Culverts Impassable
OTHER			Beavers Dams Removed	Clearance				At Low Flows, Sand-
FLOW CONTROL	Yes, Storage Dam & Diversion							Bag Culvert to Flow
SOCKEYE				x				
CHINOOK				x (sp)				
COHO	x	x	x	x	x	x	x	x
CHUM	x	x	x	x	x	x	x	x
PINK (o or e)				x				
STEELHEAD			x	x				
CUTTHROAT		x		x		x		
DOLLY VARDEN				x			x	x
RAINBOW				x				
TYPE OF ESTIMATE								
JUVENILE ENUMERATION								

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Woods Cr.	Bloods Cr.	Bonell Cr.	Bonsall Cr.	Bush Cr.	Chase R.	Chemainus R.	Departure Cr.	
STATISTICAL AREA	14	17	17	17	17	17	17	17	
LENGTH (MI)	4.0	0.5	3.0	5.0	1.5	3.0	8.0	.75	
WIDTH (FT)			39) Chum	24	33) Chum		120) Chum		
WETTED AREA (YD SQ)			10,739) Spawning	7,208	22,014) Spawning		163,864) Spawning		
SPAWNING AREA (YD SQ)			6,589	599	5,000) Area		23,316) Area		
DRAINAGE (MI SQ)						13 Approx.			
BEDROCK)			Boulders and Upper:	Mainly Sand, Silt	Gravel, Stones to Power-	Mainly Gravel and	Mile 39-25: Gravel, Stones, Sand		
BOULDER)			Coarse Gravel	and mud, very little	line then Rock, Boulders	Boulders	Mile 25-7: Bedrock, Boulders		
COARSE)			Lower Mile: Gravel Bars	Gravel			Mile 7 : Sand, Gravel		
FINE)= %									
SILT/SAND)									
OTHER)									
TEMPERATURE							Extreme Fluctuations		
x DISCHARGE (CFS)			Highly Variable Flows		Very Constant, Stable	10.7 (1976)	461 (1957) Extreme Fluc.		
MAX DISCHARGE		60 (estimated)			300 (Estimated)				
MIN DISCHARGE		1 (estimated)		0.05	1 (Estimated)	2.5	2.5-40.0		
LOW FLOWS	Extreme, Frequent	Common	Extreme	Common in Whitehores CR		Common; Upper Sections			
HIGH FLOWS			Common				Severe		
SCOURING			Common	Very Little			Bank, Channel S's		
SILTATION				Very Little		Extensive Below Resi-	Heavy		
FRY STANDING			Fry/Adults Stranded			dential			
DEBRIS	Some Logging Debris	Tidal, Gravel Buildup					Log Jams		
COVER							Poor		
AGRI. RUNOFF									
IND. WASTES									
DOMESTIC WASTES									
WATER LICENCES #		4		8	1	4	14	2	
WATER LICENCES TOTAL		0.006		0.13	0.38	1.0	2.60	0.006	
MIN FLOW REQUIRED							Bank Protection		
BANK MODIFICATION			Gravel Removal to Improve	Clearance			Dredging/Gravel Removal		
BED MODIFICAITON			Escapement Annually					Dredging for	
HATCHERY							Transplant 1970-cleaning	Flood Control	
OTHER			Intertidal Spawn (Chum)	Indian Food Fishery	Provincial Park		Indian Fishery-Water Diversion		
FLOW CONTROL			Common			Reservoir	Dam		
SOCKEYE									
CHINOOK							x		
COHO	x	x	x	x	x	x	x	x	x
CHUM		x	x	x	x	x	x		x
PINK (o or e)							x (o)		
STEELHEAD			x		x	x	x (sp,s)		
CUTTHROAT		x	x	x	x	x	x		
DOLLY VARDEN									
RAINBOW				Walkdown, Counting	x	x			
TYPE OF ESTIMATE				Weir					
JUVENILE ENUMERATION				Yes			Yes		

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Craig Cr.	Englishman R.	Fillongley Cr.	French Cr.	Hart Cr.	Kitty Coleman Cr.	Lard Cr.	Little R.	Little Qualicum R.	McNaughton Cr.
STATISTICAL AREA	14	14	14	14	14	14	14	14	14	14
LENGTH (MI)	2.0	10.0	1.4	9.2	0.5	1.4	1.5	1.0	7.2	1.5
WIDTH (FT)	10	130		40		6	15	13	93	30
WETTED AREA (YD SQ)	11,616	762,603		215,858		4,928	13,200		392,832	26,400
SPAWNING AREA (YD SQ)	5,200	130,000		86,000		2,400	9,900		209,000	15,000
DRAINAGE (MI SQ)	5.9	110.5		28.2		4.0	1.4	1.6	96.0	3.4
BEDROCK)		8%		19%					3%	
BOULDER)		69%		19%		50%	5%		8%	37%
COARSE)	22%	12%		20%		25%	30%	12%	27%	29%
FINE)= %	23%	5%		20%		25%	45%	13%	27%	29%
SILT/SAND)	49%						20%	75%		
OTHER)	Pools 6	Pools 6	Pools 22						Pools 35	Pools 5
TEMPERATURE			See Burns 1971				10 Deg. Warmer than Surrounding streams			
x DISCHARGE (CFS)		450 (1915)							282 (1970)	
MAX DISCHARGE										
MIN DISCHARGE		3.0-40.8		0.0-0.03					26.0-94.4	
LOW FLOWS	Partially Spring Fed, Common	Extreme	Common	Acute, Frequent		Common 1970-75	Common-not severe	Residential, CFB, Farming Uses		Common
HIGH FLOWS		Extreme		Occasional						Occassional
SCOURING		Severe		Severe in 68, 72, 73						Moderate, New Chan-nelization
SILTATION		Severe	Heavy					Lower Since 1972	Severe, Especially 73, 75	
FRY STANDING	Some Problems									
DEBRIS										Logging Debris Left
COVER										
AGRI. RUNOFF					At One Time Coal Washing Facility					
IND. WASTES								75 Fry Poisoned By Effluent		
DOMESTIC WASTES										
WATER LICENCES #	2	16		Large #	4			2	Large #5	
WATER LICENCES TOTAL	0.063	2.43			5.98			0.004	45.38	
MIN FLOW REQUIRED										
BANK MODIFICATION	Swamp Portion Modi-fied 1974	Bank Protection		Bank Protection					Dykes/Bank Protection	
BED MODIFICAITON				Gravel Removal				1972-Log Jams, B. Dams Cleared		
HATCHERY		Gravel Removal	Clearance 1970							
OTHER		Clearance							Channel Cleaning	
FLOW CONTROL					Dam no longer functions					
SOCKEYE		x		11					x	
CHINOOK		x		0.25					x	
COHO	x	x	x	x	x	x	x	x	x	x
CHUM		x		x	x	x			x	x
PINK (o or e)									x	
STEELHEAD		x(Heaviest Sp)		x	x		x		x	x
CUTTHROAT	x	x	x (R,A)				x		x	x
DOLLY VARDEN								x		
RAINBOW		x						x	x	
TYPE OF ESTIMATE										
JUVENILE ENUMERATION									Yes	

TABLE 10 - INVENTORY OF MAJOR PHYSICAL STREAM CHARACTERISTICS OF SPAWNING STREAMS AND A CHECKLIST OF UTILIZATION BY INDIVIDUAL SALMONID SPECIES

STREAM NAME	Cowichan River	Fulford Cr.	Koksilah R.
SOCKEYE			
CHINOOK	x (sp,su)		x (sp,su)
COHO	x	x	x
CHUM	x	x	x
PINK (o or e)			
STEELHEAD	x		x
CUTTHROAT	x	x	x
DOLLY VARDEN	x		x
RAINBOW	x		x
TYPE OF ESTIMATE	Float, Walkdown	Walkdown	Float, Walkdown
JUVENILE ENUMERATION	Yes	No	Yes

SOURCES: This table was compiled from the following referenced sources identified by J. Fryxell, Lands Directorate, Environment Canada (1980):

District Fisheries Offices, Fisheries and Oceans, Canada Fish and Wildlife Branch, Ministry of Recreation and Conservation, British Columbia.

Water Rights Branch, Ministry of Environment, British Columbia.
R.F. Brown et al. 1977. Preliminary catalogue of salmon streams and spawning escapements of statistical area 14 (Comox-Parksville). Fisheries and Environment Canada.

T. Burns 1971, Stream summaries of Vancouver Island streams, B.C. Fish and Wildlife Branch.

J.E. Burns 1971, Chemainus River Stream Survey, B.C. Fish and Wildlife Branch
R. Hamilton 1978, Black Creek, Vancouver Island, B.C.: Hydrology fishery resource and watershed development.

A.F. Lill et al. 1975, Conservation of Fish and Wildlife of the Cowichan-Koksilah Flood Plain. Canada Fisheries and Marine Service and B.C. Fish and Wildlife Branch.

D.E. Marshall et al. 1976, 1977. Prelimianry Catalogue of Salmon Streams and Spawning Escapements of Statistical Areas 13,17 and 18: Enivronment Canada. Fisheries and Marine Service.
G.D. Taylor. 1963. Preliminary inventory of the Cowichan River 1962, 1963, B.C. Fish and Wildlife Branch.

A recent surface water survey in the southern half of the study area (see subsection on Exploratory Surveys and Resource Potential) found juvenile salmon close to Vancouver Island and within the protection of the Gulf Islands, and rarely in the open waters of the Strait. Coho were the most abundant in the survey followed by chum, chinook, pink and sockeye. Most of the salmon sampled were captured in the vicinity of Kulleet Bay and Yellow Point in Stuart Channel. At the northern section of Stuart Channel chum out numbered the three other species. Coho were by far the dominant rearing salmon on the east coast of Gabriola Island while chum dominated the catch in Pylades Channel opposite Gabriola Passage. The number of rearing salmon captured in the approaches to Fulford Harbour, Saanich Inlet, and Cowichan Bay were one half that caught in the Kulleet Bay - Yellow Point area. Sampling revealed equal populations of chinook and coho. A small number of salmon were counted in southern Pylades Channel and the least number were captued in Trincomali Channel, Captain Passage, and at the head of Swansum Channel.

5.4.5.2.1.3 Salmonid Enhancement Program.

The Salmonid Enhancement Program (SEP), intitiated in 1977, is a joint federal-provincial effort to enhance Pacific salmon populations to historical levels (1930's) which were double those of today.

Major salmonid enhancement facilities are located on Quinsom, Puntledge, Big Qualicum and Little Qualicum Rivers. The latest facility to be developed on the Little Qualicum River, is expected to be in full production by 1984 with an anticipated annual contribution of 100,000 chum to fisheries. Construction of spawning channels began in 1978 and was completed in time for the 1979 autumn run. The first returning salmon are expected in 1983.

Table 11 shows the average annual productivity of the SEP facilities on the other three rivers from 1977 to 1979, the 1979 escapement of returning salmon, and an estimate of 1980 smolts released from two of the facilities. The fraction of surviving salmon which join the fishery stocks is estimated to be 2% chum, 3% chinook, 4% steelhead and 15% coho.

The Big Qualicum River facility is the most productive (2.8 million smolts), followed by the Quinsum River facility (2.4 million smolts) and the Puntledge River (0.5 million smolts).

Following renovations to spawning channels at the Big Qualicum River facility in 1979, 45 million chum were released in the spring of 1980. The value of chum to local economies is illustrated by two gillnet and seine fisheries which, in 1978, captured 160,000 chum from the Big Qualicum river stocks.

Coho were the most abundant salmon in the 1977-79 period at the Quinsum River facility with chinook the next most common species. During 1980 pink salmon are expected to outnumber chinook. If this occurs this will represent the largest pink salmon production of any of the SEP facility in the study area. Complete 1980 production figures will be made available in the corresponding SEP annual report issued in 1981.

TABLE 11 - PRODUCTIVITY, IN TERMS OF SMOLT RELEASES, OF MAJOR SALMONID ENHANCEMENT PROGRAM (SEP) FACILITIES ON THE EAST COAST OF VANCOUVER ISLAND:

	SMOLT RELEASES x 1000					ESCAPEMENT x 1000
SPECIES	1977	1978	1979	AVERAGE 1977-79	1980[1]	(1979)
QUINSUM RIVER						
CHINOOK	964	776	849	863	1250	1
COHO	2102	567	1572	1414	2950	12
CHUM	237			79		
PINK					1750	
STEELHEAD	36	36	55	42	20	
	ALL SPECIES AVERAGE			2398		
PUNTLEDGE RIVER						
CHINOOK	133	639	724	498	670	1
COHO	20	25	40	28	1380	3
CHUM					1500	25
PINK					75	11
STEELHEAD	3	1	1	2	31	21
	ALL SPECIES AVERAGE			528		
QUALICUM RIVER (BIG)						
CHINOOK	772	2806	2555	2028		11
COHO	783	838	615	745	N/A[2]	63
CHUM		48		16		132
STEELHEAD	24	39	72	45		1
	ALL SPECIES AVERAGE			2834		

NOTE: 1. EXPECTED FIGURES

2. NOT APPLICABLE, SEE TEXT

Source: Fisheries and Oceans Canada and Salmonid Enhancement Program. Annual reports.

Steelhead trout are being produced by all four facilities in numbers well below those of salmon. The steelhead commercial catch is insignificant relative to sports stream angling for this fish. A stream-by-stream summary of steelhead angling catch in the period 1975-78 is provided in table 12.

A number of minor projects administered by the Salmonid Enhancement Program are located in the study area. The Cowichan Indian Band has operated an incubation box for Cowichan River chum for several years. In 1979 this facility reared 700,000 chum fry which were released. Floating pen facilities off Fulford Creek in Fulford Harbour are small projects which are expected to yield 10,000 coastal cutthrout trout annually. Fulford Creek is a valuable cutthroat producer. Details concerning the nature and locations of these and other local projects are available from the Salmonid Enhancement Progam, Fisheries and Oceans, Canada and from the British Columbia, Ministry of Environment.

5.4.5.2.2 Herring.

5.4.5.2.2.1 Resource.

Recent studies of the commercial herring fishery and spawning stock assessment are reported by Hourston (1979), Hourston and Hamer, (1979) and Webb, Hourston, and Jubinville (1980).

The re-opening of the herring fishery in 1971, following the collapse of the fishery in the late 1960's, brought a changeover from reduction processing of herring to foreign marketing of the herring roe. Herring, which have traditionally been fished on their fall migration routes and holding grounds, are now taken in winter as imminent spawners on the immediate approaches to their spawning grounds.

The roe fishery is extremely short in duration, intensive and difficult to predict. Area 14 was the only region in the northern Strait of Georgia with a roe fishery in 1978. A total catch of 1700 metric tons was taken by 200 gillnetters between March 6 and 14. The main fishery occurred in the region of Denman and Hornby Island, Qualicum Beach and Northwest Bay where a week's fishing produced 11% of the total B.C. roe herring catch.

Areas 14 and 17 accounted for 13% of the provincial catch during 1974-75 to 1978-79 (Table 13).

In a provincial context, most of the food and bait herring are taken in Areas 17 and 18 in the Gulf Islands region because of the abundance of resident and migrating herring stocks and the proximity to shore processing facilities. The principal fishing locations include Satellite Channel, Plumper Sound, Navy Channel, Trincomali Channel and Pylades Channel. Most of the catches occur between November and January, prior to the roe fishery.

During a recent surface water survey (see sub-section on Exploratory Surveys and Resource Potential), Pacific herring were very abundant in southern Pylades Channel opposite Porlier Pass and in central Stuart Channel. Their numbers were one order of magnitude greater than those east of Gabriola Island and in northern Pylades Channel.

TABLE 12 - SUMMARY OF REPORTED ANNUAL STEELHEAD TROUT CATCH (NUMBERS OF FISH) AT EAST COAST VANCOUVER ISLAND STREAMS IN THE STUDY AREA IN THE THREE SEASON PERIODS 1975-76 to 1977-78.

	SEASON		
STREAM	1975-76	1976-77	1977-78
BLACK CR.	10	16	5
CAMPBELL R.	164	78	75
CHASE R.	1		
CHEMAINUS R.	42	18	32
COAL CR.	2	1	
COURTENAY R.	1		
COWICHAN R.	277	189	296
ENGLISHMAN R.	106	71	37
FRENCH CR.	12	4	7
HASLAM CR.	13	1	2
HOLLAND CR.	1		
KOKSILAK R.	37	13	26
LITTLE QUALICUM R.	113	49	71
MOHUN CR.	9		1
NANAIMO R.	202	140	139
OYSTER R.	83	24	12
PUNTLEDGE R.	42	6	12
QUALICUM R. (BIG)	87	66	232
TRENT CR.	12	8	6
TSABLE R.	8	5	2
TSOLUM R.	32	7	8
TOTAL	1254	701	963

Note: Streams with reported catches in any season exceeding 100 steelhead are underlined.

Source: British Columbia Ministry of Recreation and Conservation. 1979. Steelhead Harvest Analysis. Fish and Wildlife Branch, Victoria, B.C.

TABLE 13 - AVERAGE ANNUAL ROE HERRING AND FOOD AND BAIT HERRING CATCHES (1000 TONS) OVER THE 1974-75 TO 1977-78 SEASONS BY HERRING DIVISION AND FISHERY STATISTICAL AREAS.

DIVISION	AREA	LANDINGS				
		ROE HERRING[1]			FOOD AND BAIT[2] HERRING	
		TONS (x1000)	% STRAIT OF GEORGIA	% OVERALL CATCH	TONS (x1000)	% OVERALL CATCH
QUEEN CHARLOTTE	2	12		17	-	
NORTH COAST	3 4 5	2 1 2		7	- - 0.7	36
CENTRAL	6 7	2 9		16	1.0 -	
JOHNSTONE STRAIT	12	1		2	-	
STRAIT OF GEORGIA	14 17 18	5 4 -	56 44 -	13	- 1.4 1.6	64
TOTAL S. OF GEORGIA		9	100%			
WEST COAST VANCOUVER ISLAND	23 24 25	12 11 7		44	- - -	
OVERALL TOTAL		68		100%	4.7	100%

NOTES: 1. Excluding areas with catches less than 1000 tons.
2. Excluding areas with catches less than 500 tons.

Source: L.A. Webb. 1966. Review of the 1975-76 herring fishery and spawn abundance. Canada, Fisheries and Marine Service, Technical Report Series PAC/T-76-19.

L.A. Webb, A.S. Hourston and B.C. Jubinville. 1980. Review of the 1977-78 British Columbia herring fishery and spawn abundance. Canadian Industry Report of Fisheries and Aquatic Sciences. No.112.

Based on spawning ground assessments, the regions of Comox to Nanaimo, Yellow Point, Ganges Harbour and Plumper Sound have produced 77% of the average annual herring stock in the Strait of Georgia (Table 14). The Comox-Nanaimo region produced between 45-60% of the herring stock.

5.4.5.2.2.2 Habitat Requirements and Locations.

The reproduction of herring occurs on a limited number of intertidal and shallow subtidal spawning grounds. Few areas throughout the West Coast appear to offer a suitable spawning habitat but where these occur, they are heavily utilized.

Herring spawn in winter and early spring when salinity and temperatures are reduced. Female fish deposit adhesive eggs onto seaweeds, primarily rockweed (*Fucus*), Japweed (*Sargussum*), and eelgrass (*Zostera*). The depostition of eggs can range from above low water to 15 metres below. Egg survival during the incubation period of two to three weeks does not exceed 30% due to predation by marine birds, intertdal fish and exposure to storms.

TABLE 14 - A REGIONAL PERSPECTIVE OF PACIFIC HERRING ABUNDANCE (1000 TONS) IN THE STRAIT OF GEORGIA BASED ON SPAWNING GROUND SURVEYS BY HERRING MANAGEMENT UNIT IN THE PERIODS 1951-70 AND 1971-79

MANAGEMENT UNIT		SPAWNING STOCK					
		1951-70			1971-79		
Number	Name	Tons (x1000)	% Overall Abundance		Tons (x1000)	% Overall Abundance	
22	Comox-Nanaimo	58	45		58	60	
23	Yellow Point	25	20	77	10	10	77
24	Ganges-Plumper	16	12		6	7	
25	Area 29-Fraser River	16			3		
26	Other (Mainland)	6			1		
21	Powell River	5		23	17		23
27	Other (Vancouver Is.)	2			1		
OVERALL TOTAL		128		100%	96		100%

SOURCE: A.S. Hourston, 1979. Stock assessment for British Columbia herring management units in 1979 and forecasts of the available roe catch in 1980. Canada, Fisheries and Marine Service, Manuscript Report No. 1550.

Herring mortality is estimated at 99% during the larval phase. The evidence suggests that their movement offshore by wind-driven surface currents, the lack of laval food (plankton), and predation are major causes of mortality. By summer, juveniles school in shallow bays and inlets, typically near kelp beds, feeding in surface waters at dawn and dusk on zooplankton (copepods, euphausids and amphipods).

Near the end of their first summer, herring migrate from the Strait of Georgia to offshore feeding grounds, mainly off the lower west coast of Vancouver Island . A small number of herring remain 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, so all production and recruitment of the fishery stock must come from within the Strait of Georgia system, particularly the present study area.

A list of individual herring spawning grounds throughout the study area is available (Hourston and Hamer, 1979). 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).

Herring are unpredictable in spawning. There is no apparent relationship between the intensity of spawning and spawning duration. Furthermore, evidence suggests that changes in preferred spawning grounds are related to variations in environmental conditions, but it is not known whether such shifts are the result of changes in herring migratory patterns or in variable survival rates for different herring populations. The actual timing of spawning in any year and locality appears to be related to local vagaries of the environment rather than to oceanographic and climatic patterns.

5.4.5.2.3 Groundfish.

5.4.5.2.3.1 Resource.

The Strait of Georgia groundfish trawl fishery is minor compared to the offshore fishery. Nevertheless it is an important part of the provincial economy.

Most of the catch is taken in the winter fishery from October to March (Table 15).

The most productive region for groundfish landings has been the southern section of the Gulf Islands plus Nanoose Bay area (Area 17). They account for over half the total groundfish landings in the Strait of Georgia and adjoining waters.

Trawling is restricted inside a number of Regulated Areas (RA's) in an effort to conserve major spawning populations and rearing fish. Table 16 shows the relative productivity, in terms of commercial landings, for Statistical Areas 14, 17 and 18 plus the enclosed regulated areas for which accurate data are available. Restrictive measures appear to have failed in preventing a decline of some important groundfish stocks in most of the regulated areas.

The area between Discovery Passage and Cape Lazo is unproductive (in terms of catch) for groundfish while 87% of the winter catch in Area

TABLE 15 - AVERAGE LANDINGS (1000lbs) OF ALL FOOD GROUNDFISH (EXCLUDING DOGFISH) IN THE STRAIT OF GEORGIA AND ADJOINING INSIDE WATERS BY STATISTICAL AREA ON AN ANNUAL (OCTOBER-SEPTEMBER) AND A WINTER SEASON (OCTOBER-MARCH) BASIS FOR THE PERIOD 1960-77.

AREA	LANDINGS (1000 lb.) October-September			October-March		
12,13,15,16	107	6%		85	6%	
14	333	18%	73%	306	20%	76%
17	393	21%		338	22%	
18	632	34%		511	34%	
19	304	16%		225	15%	
28	---			---		
29	91	5%		50	3%	
	1860	100%		1515	100%	

SOURCE: S.J. Westrheim, 1980. The trawl fishery in the Strait of Georgia and vicinity, 1945-77. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1563.

14, during 1960-77, was taken from the regulated areas, RA1-3, RA6 and RA7. Closures elsewhere and unsuitable substrate limit trawling in Area 17 primarily in RA8 and RA9.

Studies of the groundfish trawl fishery in the regulated ares are available (Forrester and Ketchen, 1963; Ketchen, 1979; Westrheim, 1974, 1977, 1980). Populations of the three principal species, English sole, Pacific cod, and Lingcod have recently declined in the RA's 1-3 (Cape Lazo - Baynes Sound), RA7 (Qualicum - Parksville), RA8 (Nanoose Bay), and RA9 (Boat Harbour - Pylades Channel). Regulated areas RA4 (Fanny Bay) and RA5 (Deep Bay) are permanently closed to trawling to protect rearing English sole. RA6 supports the major commercial stocks of Rock sole and Starry flounder in the Strait of Georgia.

TABLE 16 - AVERAGE LANDINGS (1000 lbs) OF ALL FOOD GROUNDFISH (EXCLUDING DOGFISH) BY FISHERY STATISTICAL AREAS AND THE ENCLOSED REGULATED AREAS (RA) OF THE EAST COAST OF VANCOUVER ISLAND GROUND FISHERY, OCTOBER TO MARCH 1960-77.

LOCATION	LANDINGS			SPECIES-PROPORTIONS OF CATCH (%)					
	AREA	RA	RA/AREA %	PACIFIC COD	ENGLISH SOLE	LINGCOD	STARRY FLOUNDER	ROCK SOLE	OTHER FLOUNDER
AREA 14	306	......	100%	37%	37%	4%	-%	-%	22%
RA1,2		110	36	37	46	3	-	-	14
RA3		55	18	10	73	2	4	-	11
RA4		-	-	-	-	-	-	-	-
RA5		-	-	-	-	-	-	-	-
RA6		81	26	47	-	3	15	13	22
RA7		21	7	22	15	23	-	-	40
AREA 17	338	......	100%	73	13	3	-	-	11
RA8		176	52	92	-	1	-	-	7
RA9		-	-	-	-	-	-	-	-
AREA 18	511	......	100%	73	11	2	-	-	14
RA10		-	-	-	-	-	-	-	-

SOURCE: Westrheim, S.J. 1980. The Trawl Fishery in the Strait of Georgia and Vicinity, 1945-77. Canadian Manuscript Report of Fisheries and Aquatic Science No. 1563.

Dogfish are abundant in the Strait of Georgia - estimated in 1975 between 26-40 million fish or about one third of the harvestable stocks throughout the west coast and since the 1970's represents an increasing commercial food fishery. In the period 1960-77, the principal source of dogfish has been in Areas 14 (17%), 17 (30%) and 18 (38%).

Walleye pollock became commercially attractive in 1976 to supplement catches of traditional groundfish which were no longer being adequately supplied to markets. By 1978, the Gulf Islands and open water of the Strait yielded 14% of the total west coast landings. It is estimated that the Strait of Georgia contains almost twice the amount of pollock as the other major producing area, Dixon Entrance - North Hecate Strait.

5.4.5.2.3.2 Habitat Requirements.

Pacific Cod

Pacific cod spawn in February and March. The eggs are fertilized in the water column. Fertilized eggs have not 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.

Small cod prey on planktonic organisms (euphausids and shrimp) while larger individuals prey on crab, shrimp and other fish (mainly herring and sandlance). In the Strait of Georgia, cod disperse to feed and congregate to spawn. They move into deeper water in autumn and return to shallow water in spring.

Two major populations of cod are found in the study area. The northern stock lies north of Nanoose Bay, (in the Yellow Rock to Cape Lazo, area), and is separate from the southern stock in the Nanoose Bay and Gulf Islands region. The southern stock mixes to some extent with fish of the southern Strait of Georgia and U.S. waters.

English Sole

This fish is most abundant on grounds where the bottom is composed of soft sand or mud. After hatching English sole are found in the intertidal zone and shallow waters, moving into deeper waters as they grow. Each year the fish move into shallow waters in spring and deeper waters in winter.

Tagging studies have shown that adult fish of Union Bay and Cape Lazo are independent stocks which do not mix. Although minor migrations to Cape Lazo and northwestwards may occur, Union Bay flounders primarily migrate south to Fanny Bay where they spawn in winter. Offspring can be found rearing in Fanny Bay and Deep Bay from where maturing fish return to Union Bay to join the commercial stock. Young fish are commonly found in sandy intertidal areas. Food for this flounder consists mainly of clams and other molluscs, marine worms, small crab, shrimp and brittle stars.

Lingcod

Lingcod are sedentary fish which appear to live in large but localized independent stocks.

This fish spawns in rocky, current-swept areas, depositing large egg masses in crevices where the male of the species broods for several months. This habit exposes the male to excessive fishing pressure, particularly from sports spear-fishing. Stocks appear to have declined dramatically throughout the Strait of Georgia in recent years.

Dogfish

The female dogfish (a true shark) carries its young for two years which limits the fecundity of the population. As with other slow-growing, late-maturing, long-lived species, the dogfish is highly susceptible to over-fishing.

Newborn dogfish form large schools in surface waters, where they remain up to 15 years. They are later caught as groundfish.

During a recent surface water survey (see sub-section on Exploratory Surveys and Resource Potential), young dogfish were more abundant in the open Strait and open waters between Nanoose Harbour and Departure Bay than in the sheltered waters of the Gulf Islands. Furthermore, a distinct increase in the abundance of rearing dogfish was observed with increasing distance offshore.

Young dogfish prey upon planktonic organisms, although adults will also eat planktonic euphausids. Principal foods include herring, hake, sandlance, and a wide variety of invertebrates such as crab, shrimp and octopus. Little evidence exists to indicate that dogfish are serious predators of salmon.

Pollock

Little is known of the life history of pollock despite a mid-1970's survey conducted in Swanson Channel. Pollock may spawn in Stuart Channel since mature individuals have been observed there in February, imminent spawners in March-April, and spawned out pollock in May. It is not known if adult pollock are resident in Stuart Channel.

5.4.5.2.4 Midwater Fish

A recent winter survey (see sub-section on Exploratory Surveys and Resource Potential), revealed the most abundant midwater fish species to be Pacific hake. Some populations were located in deep water close to shore, specifically by Shelter Point - Cape Lazo, Qualicum - Parksville, and the Ballenas - Five Finger Islands regions. By summer, concentrations of midwater fish have moved into shallow waters in the 50-150 metres range. These fish are especially abundant close to shore from north of Cape Lazo to south of Denman and Hornby Islands but also occurs in patches off Parksville - Ballenas Island, Nanoose Bay and north of Gabriola Island. Young dogfish are abundant close to shore only in the region south of Hornby Island. Dense schools of hake are found between Snake Island and Five Finger Island at 100-160 metres depth.

Euphausids in the plankton are the most common food of both large and small adult hake, although older hake may consume increasing proportions of schooling fish (sandlace, herring, eulachon). Other foods include mixed lantern-fish, young rockfish, pandalid shrimps, northern anchovy, as well as squid and kelp.

5.4.5.3 Shellfish

5.4.5.3.1 Resource and Habitat Requirements

Forty-six percent of all shellfish taken in southern British Columbia come from the Strait of Georgia where 40% are captured in the study area (Table 17). The proportion of the catch for each resource group in the Strait is crab (14%), prawn (20%), shrimp (25%), clams (38%), Geoduck clam (43%), sea urchin (86%), and oyster (91%).

5.4.5.3.1.1 Crab.

The Pacific, edible or Dungeness crab is generally trapped on firm sand bottoms in less than 20 fathoms (38 metres) of water. Negligible commercial catches are made in Area 14. Highest landings are reported from the southern Gulf Islands (Area 18) where the catch is over three times that of adjoining Area 17.

The edible crab lives mainly on firm sand from the low tide mark to 100 fathoms. Spawning ocurs in late fall or early winter with eggs carried by the female until spring hatching. Crab larvae swim freely among the plankton for three or more months before settling to the bottom. The adult diet includes clams, marine worms, and small fish.

5.4.5.3.1.2 Shrimp.

Commercial shrimp are trawled mainly from muddy or sandy bottoms in 50-70 fathoms (95-130 metres). Prawns, and some shrimp, live on rocky bottoms where they are taken by means of baited traps. The Denman - Hornby Islands region is one of the three commercial shrimp grounds in the Strait of Georgia; the major channels of the Gulf Islands are also commercially fished. These areas continue to support a small but active fishery with highest landings in 1975-79 coming from the Gulf Islands.

Shrimp are found in a wider variety of habitats (rock to mud, pelagic to demersal). Shrimp are of great value in the diets of commercial fish, marine mammals and large invertebrates. In turn, shrimp prey upon other crustaceans, inadvertenly recycling dead or decaying organic matter. No detailed ecological studies exist because of the difficulties in species identification.

5.4.5.3.1.3 Clams.

Traditionally, the clam fishery has included Butter clams, Japanese Littleneck or Manila clams, and the Native Littleneck clam. Landings of Geoduck clams first reported in 1977 exceed the average annual landings of the traditional species in the study area. Horse clams were first reported in the commercial fishery in 1979.

Comox Bar is one of the most important commercial clamming regions of the study area along with scattered shoals and beaches throughout Areas 14 and 17. While 1975-79 clam landings in Area 14 are generally improved over 1951-60 landings, both Areas 17 and 18 have experienced a decline in landings of two or three of the traditional species.

TABLE 17 - AVERAGE ANNUAL LANDINGS (METRIC TONS) OF SHELLFISH IN THE STRAIT OF GEORGIA, Including Northern (Area 13) and Southern (Area 19) Approaches plus Total South Coast Landings in the Period 1975-79.

Shellfish	FISHERY AREAS													
	East Coast Vancouver Island			(A)		Strait of Georgia and Approaches					(B)			
	14	17	18	14 17,18	% Clams	13	15	16	28,29	19	All Areas	% (A)	South Coast	% (B)
Prawn	4	6	2	12		10	2	21	16		61	20	150	41
Shrimp	1	18	21	40				1	116		157	25	1681	9
				52							218	24	1831	
Crab		14	45	59		3		1	329	44	436	14	659	66
Razor Clam													2	
Butter Clam	38	45	7	90	38	9	2				101		322	
Manila Clam	4	57	6	67	28	47	154	21			289		350	
Littleneck Clam	12	30	7	49	20	37	13	18			117		206	
Horse Clam (1979)	26			26	11			7			33		37	
Unsorted Clams	5	3		8	3	18	31	26		5	88		97	
	85	135	28	240	100%						628	38	1012	62
Geoduck (1977-79)	182	123	5	310		61	221	30		98	720	43	1240	58
Oyster (shucked x1000 U.S. gallon)	44	10		54			4	1			59	91	80	74
Sea Urchin (1979)	77	56	133	266						45	311	86	317	98
TOTAL (excluding oyster)	393	362	226	927							2313	40%	5059	46%

SOURCE: Fisheries and Oceans Canada - Annual Reports, and B.C. Catch Statistics.

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. Manila clams live 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 they can also be found in the lower part of an intertidal beach.

5.4.5.3.1.4 Oyster.

During 1975-79, Areas 14 and 17 accounted for 91% of the total oyster production of the Strait of Georgia and adjoining waters. Area 14 is by far the most important producer of oysters, yielding 75% of the Strait of Georgia shucked oysters. The British Columbia oyster industry is based on the Pacific oyster, originally introduced from Japan. The study area is the centre of oyster culture in the province.

The natural habitat of the Pacific oyster is mid-tide level on broad flats of firm mud, sand or gravel, although it is grown commercially at the level of lowest tides. Oysters require relatively sheltered surroundings, free from wave action which might dislodge or bury it in the sediment. Often the right combination of shelter and soil is found in estuaries, but commercial operations occur along many parts of the east coast. Comox Harbour, Baynes Sound and Lambert Channel, for example, are well suited to oyster culture operations. The exact locations of commercial oyster leases are shown in the Coastal Resource Map Series (1:50,000) section "Land/Water Status".

The reproduction of oysters occurs by a natural process known as spatfall. Oysters, like most marine animals, begin life as microscopic larvae which drift in the water column. Eventually the larva metamorphose and fall from the water column, settling onto various suitable surfaces as miniature, shell-less adults or spat.

Commercial culturing provides a variety of surfaces to which spat can attach, and future abundance of harvestable adults is guaged in large measure by the intensity of spatfall which can be highly variable from year to year.

During the summer of 1977 spatfall occurring in the usual locations in the Strait of Georgia was well below the high levels recorded in 1942, 1958, and 1961 (Heritage and Bourne, 1979). Oyster breeding was reported for 1977 from three separate locations in Baynes Sound and spatfall was observed in the Union Bay area in late August of that year. Other records for that year came from Departure Bay and Ladysmith Harbour.

Traditionally, Ladysmith Harbour was the major source of spat to the oyster industry but spatfall there has declined drastically in recent years. At present, spat are collected in Pendrell Sound and transported to Comox Harbour where they are stored temporarily and distributed later to commercial operators in the Baynes Sound region.

5.4.5.3.1.5 Sea Urchin.

Limited harvesting of red sea urchin in the Strait of Georgia began in 1972. In the period 1975-79 86% of the sea urchin harvest from southern British Columbia came from the study area with the only other significant landings recorded for Area 19. The largest commercial catches have been made in Area 18, followed by Areas 14 and 17. Harvesting is done by divers who are limited in their operations by depth and currents. Therefore, only the densest populations can economically support the fishery.

The densest populations of red sea urchins occur on rocky bottoms in, or near large algae beds, generally 3-5 metres below low tide. Populations below 15 metres are limited to small isolated clusters.

5.4.5.3.1.6 Squid.

The red and opal squid have commercial potential in the Strait of Georgia. Widely distributed near or on the bottom, red squid are commonly an incidental catch in the groundfish trawl fishery. Opal squid are usually too dispersed to be fished economically except when they congregate to spawn. Neither comprehensive surveys of distribution and abundance nor test fishing studies have been conducted although incidental catches have been monitored since 1977 by the Pacific Biological Station (Fisheries and Oceans, Canada).

Despite the possibility of supporting an indiviual trawl fishery, the biology of the red squid remains unknown. The opal squid is found in most shallow waters of the west coast. Squid spawn throughout most of the year but one major spawning occurs during March in the Strait of Georgia. Eggs are deposited on flat sand or mixed sand and mud bottoms in sheltered bays and inlets between 5-40 metres depth. Several squid spawning grounds are shown in the Coastal Resource Map Series (1:50,000) section, "Fish Spawning and Rearing". Hatchlings grow rapidly in mid-water, at first schooling near the surface but later scattering near the bottom as they develop. They return to surface schooling when approaching maturity one to three years later.

5.4.5.3.1.7 Mussels.

The Bay mussel is relatively abundant in British Columbia but Canadian production occurs primarily on the Atlantic coast. Only limited studies exist of the potential for mussel culture on the Pacific coast. One preliminary study (Quayle, 1978) of this potential fishery recommends two locations - Departure Bay and Baynes Sound, for further site-specific studies.

5.4.5.4 <u>Exploratory Surveys and Resource Potential</u>

5.4.5.4.1 Resource

5.4.5.4.1.1 Surface Fish.

The initial survey of fishes inhabiting the surface waters of the Strait of Georgia, including the study area between Nanoose Harbour and Satellite Channel (Areas 17 and 18), was conducted in the summer months of 1974. Of 14 species sampled, most were rearing commercial species, including five species of salmon, coastal cutthroat trout, Pacific herring, spiny dogfish plus six non-commercial species. Table 18 summarizes the major commercial species and their numbers captured in survey trawl sets located in the general areas indicated in the Coastal Resources Map Series (1:50,000) section "Fish and Shellfish Resources".

5.4.5.4.1.2 Midwater Fish.

Midwater surveys in the mid 1970's showed Pacific hake to be the most abundant fish in both winter and summer, followed by spiny dogfish in winter and Walleye pollock in summer.

The Strait of Georgia Pacific hake stock represents an important potential fishery since the only other known major stock in British Columbia waters forms part of the large offshore migratory population which is exploited by foreign fleets. Midwater pollock are not abundant enough to support an individual fishery while dogfish are primarily young individuals.

5.4.5.4.1.3 Bottom Fish.

Bottom trawl surveys in 1975 revealed a spatial distribution of commercial species similar to the location of major fisheries. A survey of bottom fish at numerous locations in the study area is provided in Table 19.

Within Area 14, Baynes Sound supported a larger number of cod and flatfish species than did Cape Lazo bight or the pelagic waters off Cape Lazo. Pollock, and hake, were the most abundant cod species, with English sole and Slender sole (the latter not commercially viable) comprising most of the flounder catch.

Cod are generally common throughout Area 17. Flounders showed high diversity only in the Porlier Pass - Trincomali Channel region. They were absent in the trawl survey of Houston Passage. Cod populations are larger than those of flounders in most waters.

Cod species were equally as diverse in Area 18 as in Area 17, but the number of flounders was greater in the latter area. Pollock remained the dominant cod, but Dover sole outnumbered English sole and Slender sole. The diversity of flounders in the eastern section of Satellite Channel at the approach to Fulford Harbour and at the head of Swanson Channel was comparable to that found in the surveys of Cape Lazo - Baynes Sound.

5.4.5.4.1.4 Geoduck Clam.

An extensive survey of Geoduck clams in southern British Columbia in 1977 (Cox and Charman, 1978) show that the only important stocks are located in the study area.

Much of the substrate in Area 14 is favourable for Geoduck growth. Most of the populations are accesible in the depths ranging between 1-13 metres. Highest counts are recorded off Qualicum Beach. Major locations in Area 17 which support commercial quantities of Geoduck include: Nanoose, southeast Gabriola Island, Stuart Channel, Thetis Island, Pylades Channel, southern Ladysmith Channel and Kuper Island. Many of the small bays and harbours in the southern section of the Gulf Islands have unsuitable substrate for Geoducks. Their abundance in Area 18 is low.

TABLE 18 - MAJOR SPECIES AND AVERAGE NUMBERS CAPTURED PER TRAWL SET IN THE SURFACE WATERS OF THE GENERAL AREAS LABELLED IN THE COASTAL RESOURCES MAP SERIES (1:50,000), "FISH AND SHELLFISH RESOURCES"

SPECIES	NUMBERS						
	S_1	S_2	S_3	S_4	S_5	S_6	S_7
(# SETS AVERAGED)	(6)	(3)	(3)	(3)	(2)	(6)	(3)
CHUM	5	15	23	3	32	2	1
COHO	31	5	7	3	8	4	12
CHINOOK	2	6	3	5	12	1	15
PINK	5	12	14	2	3	1	1
TOTAL SALMON	43	38	47	13	55	8	29
	H_1	H_2	H_3	H_4			
(# SETS AVERAGED)	(1)	(1)	(3)	(1)			
PACIFIC HERRING	5000	6000	58000	50000			
	D_1	D_2	D_3				
(# SETS AVERAGED)	(2)	(3)	(1)				
SPINY DOGFISH	3	54	149				

Source: R.J. Beamish, J.R. Scarsbrook and F.P. Jordan. 1976a. A bottom trawl study of Pacific hake and Walleye pollock along the inshore areas adjacent to Vancouver Island in the Strait of Georgia. Canada, Fisheries and Marine Service, Data Record No.4.

TABLE 19 - ABUNDANCE OF GROUNDFISH SPECIES CAPTURED IN RESEARCH BOTTOM - TRAWL SETS in the

(A) Cape Lazo - Baynes Sound Regions (Area 14)

AREA 14										
SPECIES	TRAWL SET LOCATIONS									
	CAPE LAZO			LAZO BIGHT		BAYNES SOUND				
	A	B	C	D	E	F	G	H	I	J
TRUE CODS										
COD	1	1	4	1	1		1	2	3	1
POLLOCK	68	25	20		18	249	179	60	62	16
HAKE		4	10		79		1	15		8
TOMCOD						287	99	99	92	
NO. SPECIES	2	3	3	1	3	2	4	4	3	3
FLOUNDERS										
SLENDER SOLE	42	360	163	84	106	1	28	128	83	190
ENGLISH SOLE	21	92		37	14	125	135	589	380	2
FLATHEAD SOLE	1	49				34	146	66	2	
REX SOLE	3	1		5	1	1		1	1	8
ROCK SOLE	2			124		3	6		27	
DOVER SOLE	1	1			8					
SAND SOLE						9	3	1		
ARROWTOOTH FL.	1									
BUTTER SOLE				2						
STARRY FLOUNDER						8				
SPECK. SANDDAB						40				
NO. SPECIES	7	5	1	5	4	8	5	5	5	3
OTHERS										
ROCKFISH	27	8	5	144	147	4	1	2	2	16
SPINY DOGFISH	14	6	1		2	11	13	9	8	1
LINGCOD				4		9	5		3	2
ORIGINAL TRAWL SETS NO.'S	41,42	33,34	35	37	36	43,44	45	46	32	31

(B) Northern Section of the Gulf Islands (Area 17)

AREA 17								
SPECIES	TRAWL SET LOCATIONS							
	NORTH STUART CH.		SOUTH STUART CH.			PORLIER PASS, HOUSTON PASS, TRINCOMALI CH.		
	A	B	C	D	E	F	G	H
TRUE CODS								
COD	4	3	1	3	6	17	3	5
POLLOCK	31	78	8	125	7	368	45	212
HAKE	•	46	140	60	7	2	4	1
TOMCOD	1	1				18	18	29
NO. SPECIES	4	4	3	3	3	4	4	4
FLOUNDERS								
SLENDER SOLE	•	•		•	26	13		
ENGLISH SOLE	3	•	12	•		22		3
FLATHEAD SOLE	•	•	•	•		15		5
REX SOLE								5
ROCK SOLE						10		8
DOVER SOLE				1	3	17		
SAND SOLE								1
ARROWTOOTH FL.								3
BUTTER SOLE								
STARRY FLOUNDER								
SPECK. SANDDAB								
NO. SPECIES	3	3	2	4	2	5		6
OTHERS								
ROCKFISH		2	2	17	5	5		1
SPINY DOGFISH	1	5	8	11	5	44	2	3
LINGCOD	1	1	•	1	1	2	1	
ORIGINAL TRAWL SETS NO.'S	13,14	19,66	29,67	22,24	23,24	7,8	17,18	53,54

(C) Southern Section of the Gulf Islands (Area 18)

AREA 18					
SPECIES	TRAWL SET LOCATIONS				
	SATELITE CHANNEL			SWANSON CHANNEL	
	I	J	K	L	M
TRUE CODS					
COD	9	21	3	8	5
POLLOCK	110	424	32	33	143
HAKE	1	2			1
TOMCOD	18	56	32	40	8
NO. SPECIES	4	4	3	3	4
FLOUNDERS					
SLENDER SOLE	8	242	6	2	•
ENGLISH SOLE	5	162	26	26	1
FLATHEAD SOLE		3	9		
REX SOLE			4	2	2
ROCK SOLE			12	26	
DOVER SOLE	8	331	21	7	5
SAND SOLE			1	1	
ARROWTOOTH FL.	1				
BUTTER SOLE			1	6	
STARRY FLOUNDER					
SPECK. SANDDAB					
NO. SPECIES	4	4	8	7	4
OTHERS					
ROCKFISH		2	4	2	1
SPINY DOGFISH	25	15	3	1	
LINGCOD					
ORIGINAL TRAWL SETS NO.'S	65	64	60,61	56,62	58,59

Source: Adapted from R.J. Beamish, J.R. Scarsbrook and F.P. Jordan 1976a. A bottom trawl study of Pacific hake and Walleye pollock along the inshore areas adjacent to Vancouver Island in the Strait of Georgia. Canada Fisheries and Marine Service, Data Record No.4.

The 1977 Geoduck survey indicated that highest densities were found in Area 17, although the highest landings from 1975 to 1979 occurred in Area 14. Geoduck locations are shown in the Coastal Resources Map Series (1:50,000) section "Fish and Shellfish Resources".

5.4.5.5 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, shrimp, and clams are those provided respectively by Hart (1973), Butler (1980), and 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	Citharichthys stigmaeus
Rockfish	Scorpaenidae
Spiny dogfish	Squalus ocanthias
Lingcod	Ophiodon elongatus

Shellfish

Prawn	Pandalus Platyceros
Shrimp	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 cam	Tresus capas
Geoduck clam	Panope generosa
Oyster	Crassotrea gigas
Sea urchin	Strongylocentrotus franciscanus
Mussels	Mytilus edulis
Red squid	Beryteuthis magister
Opal squid	Loligo opanescens

5.5 RECREATIONAL RESOURCES

The eastern coast provides abundant opportunities for outdoor recreation. There are numerous bays, harbours, scenic shorelines, and shore process features to attract recreationists. Small sand and shell beaches are common, although beaches of considerable size with good quality sand are few. The many level backshore clearings are ideal for camping and upland activities and are, in the Gulf Islands, the only means of access to some coastal areas. The major estuaries provide easy access to the shorezone for viewing, walking, nature study and boating, while the rocky coasts contain a diversity of species that attracts divers. Within the coastal uplands, marine-oriented recreational opportunities are complimented by recreational rivers, hiking trails, scenic environments, and parks. The Canada Land Inventory rates much of the shorezone of the study area class 1 to class 4, signifying that the study coast has a very high to moderate capability for outdoor recreation.

5.5.1 COMPETITION FOR SPACE AND RESOURCES

Competing for the resources of the study area by 1985 will be recreationists from a projected local population of 255 thousand and a regional population of 1.5 million people. Currently, tourism within the Strait of Georgia region adds almost 2 million people annually. In 1973, about 83 thousand households within the region owned 1 or more recreational boats; also in 1973, nearly 10 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 estuaries vs industrial development), b) between subgroups within one activity (i.e. recreational boat noise vs shoreline recreational cottage areas), and c) between individuals within one sub-group (i.e. crowding at campsites or beaches). Efforts to accommodate the increase in recreation demands may include myriad forms of management approaches, but as evidence from other jurisdictions shows, only by reserving a range of recreational areas, (from virgin wild land to high-use sites managed according to multiple or compatible-use principles), will all recreational needs be satisfied.

The competition for space and resources is currently most acute in several of the major estuarine areas. Industrial developments and commercial operations are often attracted to estuaries because of the degree of coastal protection provided, and by the economics of contruction in estuaries versus rocky coasts. A very small percentage of the total estuarine area is presently allocated for recreational purposes. 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 leveling 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 longshore sediment transport that feed 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.

5.2.2 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 in the Gulf Islands 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 marinas and wharves contribute to local shellfish harvesting restrictions. Sewage discharged from recreational boats in open waters is not yet identified as problematic, although several heavily used anchorages evidence poor visual and aesthetic water quality.

Water contact sports (i.e. swimming) conducted in area of contamination pose definite health risks to recreationists. Leachates from log booming and storage, and effluent from coastal industries threaten the recreational value of coastal waters by jeopardizing the integrity of coastal ecosystems. 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 a engineering, planning, and recreational point of view. Engineers are concerned with the effect of waves on coastal structures such as breakwaters or wharves as well as the sedimentation of harbours. Planners, on the other hand, are concerned with wave effects on coastal bluffs, the probability of inundation during storms, and the sensitivity of certain shoreforms, such as spits, to erosion. Recreationists are concerned about the stability of coastal bluffs (on 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 reviews what is known in the study area. For further reading on the subject, Bascom (1980) is an excellent layman's text. For works in the field relating to the Canadain conditions, reports by ACROSES (1980), and McCann (1980) are available. Also, an excellent series of articles by Thompson (1974 to 1977) apply directly to the study area.

5.6.1.1 Wave Heights

Wave height is a function of the generating wind, its strength, (speed), duration, (time for which it has been blowing at a particular speed), and fetch (the unobstructed length of water over which the wind can blow).

5.6.1.1.1 Wind Strength

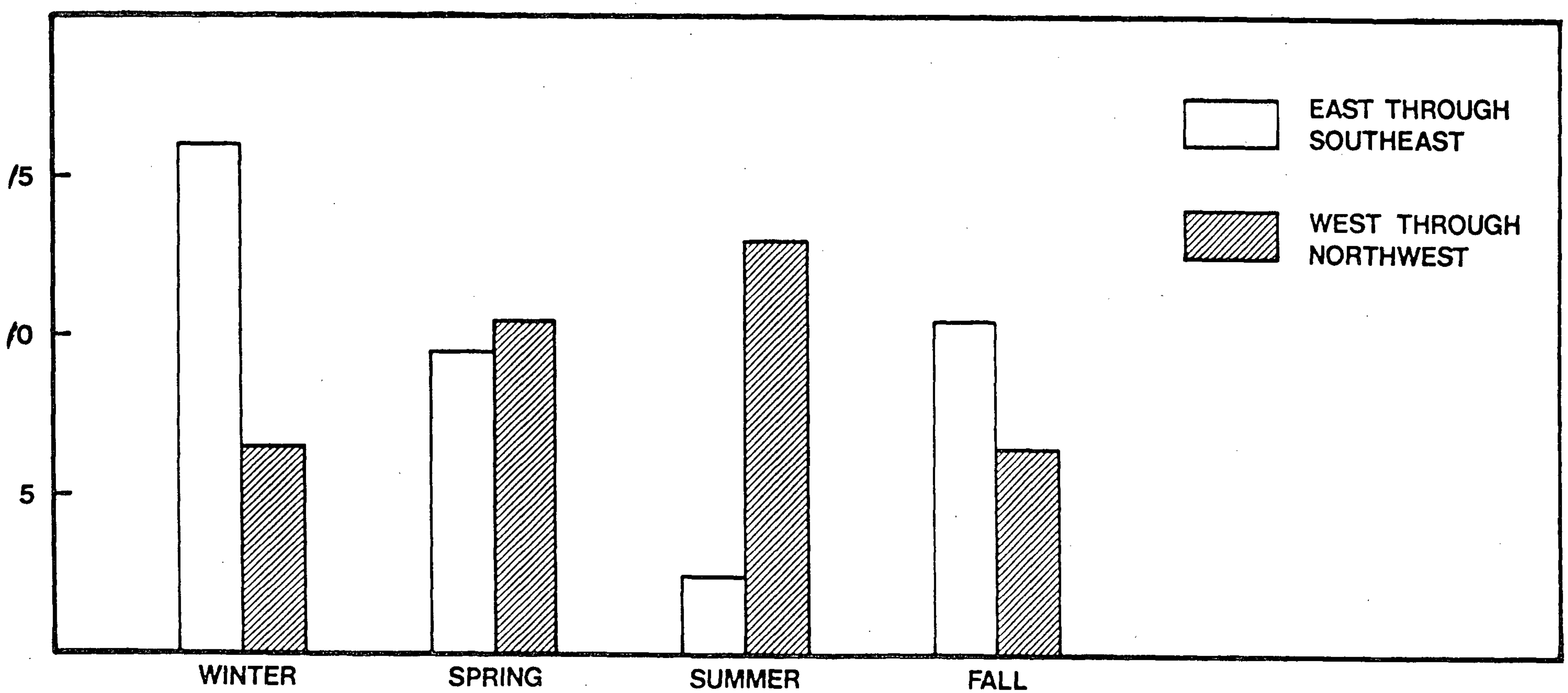
Owens (1980), in his work on Saltspring Island, notes that the direction of strongest winds is more significant in wave generation than prevailing wind patterns. McCann and Hale (1980), studying sediment dispersal patterns on the eastern-central coast chose wind speeds of between 32 and 48 km/hr to simulate storm conditions. Hale and Greenwood, (1980), in their work on storm wave clamatology, selected 19 km/hr. (12 mi/hr.) as the lowest speed to define a storm. Figure 10 displays the seasonal percentage frequency of hours with wind speeds greater than 30 km/hr (17 knots) for a representative area: Entrance Island near Nanaimo. Here winds blow almost exclusively from the east through southeast or west through northwest. The wind from all other directions accounts for less than 0.5 percent of the hours on an annual basis. The reversal of the summer and winter patterns and the transitional nature of spring and fall are clearly evident in the figure (Schaefer, 1980). These values apply to the more exposed "outside" coasts of the study area. Winds on the "inside" coasts are highly variable reflecting topographic controls rather than seasonal climate.

Guenther and Faulkner (1978) state: "We find that the strongest recorded winds at most stations are southeasterly, but in some months (for example, January at Entrance Island) strongest winds are northwesterly."

5.6.1.1.2 Wind Duration

Hale and Greenwood (1980) arbitrarily chose six hours as the minimum duration of a storm event (i.e. winds greater than 19 km/hr.) stating

Figure 10. PERCENTAGE FREQUENCIES OF HOURS WITH WIND SPEEDS 30 km/hr (17 knots) OR GREATER FOR ENTRANCE ISLAND (1969 - 77)



Source: D.G. Schaeffer. 1980. Unpublished report. Canada Department of Environment, Atmospheric Environment Service. Vancouver.

that "waves take a certain length of time to develop over any significant fetch...". They also note that this figure proved to be conservative when related to the actual series of storm events studied. McCann and Hale (1980) also chose six hours as the minimum duration in their forecasts. Harper (1980 pers. comm.), on the other hand, feels that a minimum duration of only one hour would produce significant waves for less exposed sites. He bases this comment on his work on the Saanich Peninsula (Harper, in prep.).

The following climatic pattern is frequently observed (Guenther and Faulkner, 1978): "A Pacific frontal system in a generally north-south line approaches the coast from the west. As it does so, easterly or south-easterly winds freshen reaching their peak, often gale strength or greater, just ahead of the front. After the frontal passage winds veer to the south or southwest, slacken and gradually return to their usual easterly or southeasterly dirction. However, if the front is accompanied by a very sharp trough of low pressure, as is often the case, winds may veer sharply to the northwest and strengthen quickly to gale force. After blowing from the northwest for a few hours, or perhaps a day, they gradually abate and slowly revert to easterly."

5.6.1.1.3 Fetch

Dunn (1980) has found in the Coastal Resources Map Series (1:50,000) section Physical Shorezone, that maximum fetches for the study area are greater than 150 km. In all cases the maximum fetches are aligned with the axis of the Strait of Georgia. Maximum fetches occur on outer exposed coasts of the study area. McCann and Hale (1980) found maximum fetches of 120 km and 40 km to the southeast and east, respectively. Owens (1980) recorded a maximum fetch of 29 km on Saltspring Island but more frequently recorded fetches of less than 5 km. These values are indicative of inner coasts.

5.6.1.1.4 Synthesis

The study area is fetch and duration limited in developing size-able sea waves (Owens, 1980; McCann and Hale, 1980). Also, detailed studies are lacking; therefore, the probable significant wave height (highest 1/3 of the waves) predictions for the study area are for deep water conditons. Predictions of wave heights at the shoreline requires the consideration of nearshore slope, tides, currents, and obstructions. A rule-of-thumb is to multiply deep water values by 1.5 to approximate near-shore wave heights (Thomson, 1977a; and Krauel, 1980). Clague and Bornhold (1980) state that the largest waves in the Strait of Georgia occurred during the autumn, winter and spring with the smallest waves observed in summer. The largest waves are generated by winds from the southeast or northwest, while dominant waves tend to be from the southeast. They note that local winds generate waves of less than 0.9 metres 80% of the time. Owens (1980) on the other hand, suggests that maximum wave heights, during storm conditions, could be 0.5 to 0.7 metres on exposed coasts. Sheltered coasts (fetch less than 5 km) would rarely have waves exceeding 0.5 metres.

McCann and Hale (1980) predict maximum waves of 2 metres for their study. Thompson (1977) calculates the most probable maximum waves affecting the edge of the Fraser River tidal flats to be 2.9 metres from the northwest. These are enhanced by shoaling and opposing ebb tides during high river discharge (Luternauer, 1980). Frank (1980) in his work in the Gulf Islands, estimates that maximum waves striking the outer coasts of Galiano, Mayne and Valdes Islands are 2.4 metres from the northwest.

Only four sets of real wave data apply to the study area: Sturgeon Bank (winter 1974 and spring 1976) Halibut Bank (winter and spring 1974) and two for French Creek (one shallow water and the other deep water - winter 1976 to 1977). The following records were obtained.

Sturgeon Banks, Station 102 at-100 metres

Largest Wave Record: 2.9 metres with peak period between 6 and 7 seconds.

Greatest Percentage Wave Height and Period: 76 percent less than 0.9 metres with 2-4 second periods.

Exceedance: 10 percent probable maximum exceedance of 1.2 metre waves.

Halibut Bank, Station 97, -53 metres

Largest Wave Recorded: 1.8 metres with peak period between 4 and 6 seconds.

Greatest Percentage Wave Height and Period: 80 percent less than 0.9 metres with 2-4 second periods.

Exceedance: 10 percent probable exceedance of 1.2 metre waves.

French Creek, Station 115 (outer), -72 metres

Largest Wave Recorded: 1.2-1.5 metre with peak period between 6 and 7 seconds.

Greatest Percentage Wave Height and Period: 42 percent less than 0.9 metres with 3-4 second periods (McCann and Hale, 1980).

Exceedance: less than 1 percent probable exceedance of 0.4 metres.

French Creek, Station 114 (inner),-3.6 metres

Largest Wave Recorded: 0.6 metre with peak period 5 to 6 seconds.

Greatest Percentage Wave Height and Period: 64 percent less than 0.3 metres with 4 to 5 second periods.

Exceedance: less than 1 percent probable exceedance of 0.4 metres.

5.6.1.2 Wave Energy

Wave energy is a function of wave height, wave period and near shore slope. An important end product of waves breaking on the shore is the generation of a littoral current. Thompson (1975a) has developed a table (see Table 20) depicting the relationship between factors determining wave height and their energy.

5.6.1.2.1 Wave Period

Wave period is defined as the time required for one complete wave - trough to trough to pass a given point.

Frank (1980) notes that while winter storms bring heavy seas from the southeast, they carry less energy than wave trains over a longer fetch from the northwest. McCann and Hale (1980) calculate a wave period of 5 to 5.5 seconds for their study. Krauel (1980) uses a range of periods from 1 to 6 seconds for his Kye Bay hindcast model.

Wave period data for the four stations mentioned earlier show maximum values of 6 to 8 seconds but more frequently in the 2 to 4 second range.

5.6.1.2.2 Water Levels

Owens (1980) notes that as the tidal range increases, available wave energy dissipates over a larger vertical area. Maximum tidal ranges in the study area vary from 3 metres in the south to more than 5 metres in the north (Giovando, 1977). A combination of strong winds and high tides can cause storm surges which can exceed high tide levels by as much as 0.5 metres (Owens, 1980; Holden, 1980). Storm surges of this magnitude have a 50 to 100 year return probability (Holden, 1980).

5.6.1.2.3 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 shallow slopes dissipate energy as the wave approaches the shore while, steep slopes allow the wave energy to be dissipated directly on the shore. Headlands generally concentrate wave energy while embayments diffuse it. Krauel (1980) used nearshore bathymetry for development of a wave model for Kye Bay. He notes, however, that the available information is not adequate for accurate refraction prediction.

TABLE 20 - MINIMUM FETCH AND DURATION TO PRODUCE FULLY DEVELOPED SEAS OF VARIOUS WIND SPEEDS

Wind Speed (knots)	10	15	20	25	30	40	50
Fetch (nautical miles)	10	34	75	160	280	710	1420
Duration (hours)	24	6	10	16	23	42	69
Average Height (feet)	0.9	2.5	5	9	14	28	48
[1] Significant Height (feet)	1.4	3.5	8	14	22	44	78
Average of the highest 10% (feet)	1.8	5	10	18	28	57	99
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 waveheight is about 1.9 times the significant height.

SOURCE: R.E. Thomson, 1975a. "Waves - The Physical Oceanography of the B.C. Coast - Part 3". Pacific Yachting, Vol. 9, No. 4.

5.6.1.3 Littoral Currents

Littoral currents are generated by waves striking the shoreline at an angle. Thompson (1977a) states that short period waves produce stronger currents than long period waves as they are less susceptible to refraction. Bauer (1977), indicates a consistent northward drift of sediment along the eastern coast with only few exceptions - Goose Spit. Clague and Bornhold (1980) also not the consistent northward trend of spits in the southeast part of the study area. Harper (1980) observes that seasonal changes of wind direction in restricted fetches may produce seasonal reversals of littoral drift. McCann and Hale (1980) find no dominant direction of longshore transport in their study area although they identify eight littoral drift compartments. They note that straight stretches of coast (i.e. Qualicum Beach) are highly exposed (fetch window to 180°); consequently, reversals of littoral drift are common though net sediment transport is low.

Clague (1976) finds that the erosion of coastal bluffs provides the materials for littoral drift. He observes that fine sediments accumulate at the base of eroding bluffs during summer and fall months and are non-existent during the winter. Features - such as Goose Spit - erode and accrete in concert with this seasonal cycle of sediment transport. Krauel (1980) notes that coastal bluffs are more susceptible to erosion when they are saturated with water. An increased supply of sediments to the littoral zone would then occur. Owens, (1980) noted that littoral currents in the narrow bays of Saltspring Island moved the sediments towards the head, net transport rates however were low.

5.6.2 CIRCULATION, TIDAL CURRENTS, TEMPERATURE AND SALINITY

5.6.2.1 Overall Patterns

Circulation in the Strait of Georgia is anti-clockwise with the ebb tide strongest and longest in duration along the east coast of Vancouver Island where the net circulation is southward. Primary factors in producing currents are tides, winds, and river run-off. The Coriolis force and topography influence the anti-clockwise circulation. In narrow passages of the Strait, the currents are driven predominantly by tidal-action such as through Discovery, Gabriola, Porlier, Active and Boundary passes.

In the Northern Strait, tidal currents are weak and variable. Tidal currents in the Central Strait are generally stronger than those to the north while the strongest tidal currents are found in the Southern Strait. Five oceanographic regions are identified.

5.6.2.1.1 Discovery Passage

This region is characterized by intense tidal mixing which results in physical and chemical homogeneity. Surface dilution by Campbell River is limited to a small zone at the river mouth.

5.6.2.1.2 Northern Strait

Bounded to the north by Discovery Passage, this region extends south to the vicinity of Ballenas Island (Waldichuk, 1957) or Entrance Island (Herlinveaux and Giovando, 1969). A halocline is usually present except for northernmost areas during winter.

5.6.2.1.3 Central Strait

This region extends south to Active Pass, excluding waters within the Gulf Islands. The surface layer is dominated by the Fraser River, particularly during the runoff from May to September. This produces marked vertical stratification in salinity and temperature.

5.6.2.1.4 The Gulf Islands

The Gulf Islands act as a partial barrier to Central Strait water. Gulf Island waters are diluted by Central Strait water that moves through the passes (i.e. Porlier Pass). Stratification is, however, poorly developed in the southern section of the Gulf Islands. The gulf Islands region is connected by major channels to the Southern Strait region.

5.6.2.1.5 Southern Strait

This region is characterized by intense tidal mixing which produces a homogenous water column throughout the year. This is particularly true for island passages such as Haro Strait.

5.6.2.2 <u>Local Features</u>

5.6.2.2.1 Baynes Sound

Circulation in northern Baynes Sound is dominated by tides. The flood current enters Comox Bar from the open strait, diverging into Comox Harbour and Baynes Sound. Ebb currents, from Comox Harbour flow into Baynes Sound, so that net circulation through Baynes Sound is southward throughout the tidal cycle. Net circulation is generally anti-clockwise around the Denman - Hornby Islands region.

The area of Comox Harbour - Baynes Sound is characterised by surface stratification with a thin (2-3 metre) surface brackish layer. The thickness of this layer and its salinity varies with the seasonal runoff of the Courtenay River.

Strongest winds occur from the southeast in winter, mixing deeper saline waters into the brackish surface layer thus retarding the seaward flow of surface water. The warm, high-salinity water recorded southeast of Cape Lazo (see Coastal Resources Map Series (1:50,000) section "Oceanography") is evidence of deep water upwelling.

5.6.2.2.2 Nanoose Bay

Nanoose Bay, an inlet with a typical shallow sill at the entrance has neglible fresh-water inflow. Oceanographic patterns in Nanoose Bay are closely related to events at Entrance Island in the open

Strait. During period of southeasterly winds, salinity increases and the temperature decreases. Conversely, northwesterly winds coincide with a drop in salinity and a rise in temperature. Decreasing salinity in Nanoose Bay results from the intrusion of surface water from the Strait during periods of northwest winds in summer while increasing surface salinity results from the intrusion of subsurface water over the sill and displacement of surface water seawards during southeasterly winds over the Strait in winter.

5.6.2.2.3 Five Finger Islands

In the region of Five Finger Islands summer surface stratification occurs to about 15 metres. Winter surface cooling and wind-induced mixing destroy stratification, producing a uniform density. Oceanographic properties in this area are representative of conditions in the Central Strait. Local long term net circulation is easterly or northeasterly. Inshore circulation is confused by tidal currents among the many islands and channels.

5.6.2.2.4 Gulf Islands

Stuart Channel is typical of Gulf Islands channels in terms of salinity and temperature stratification. Low surface salinity in Stuart Channel in winter is caused by river runoff and, in summer, by the intrusion of brackish water of the Central Strait. High temperatures, calm conditions, and low salinity in summer, produce highly stable stratification. Low temperatures in autumn and winter combined with strong winds and large tides results in more readily mixed water. Tidal currents predominate although local winds may have a significant effect. For example, southeast winds cause a clock-wise eddy in Osborne Bay.

5.6.2.2.5 Ladysmith Harbour

Three salinity minima in a year have been recorded in Ladysmith Harbour: two during the autumn and winter freshets and one in mid-summer. They are caused by the intrusion of brackish, Central Strait water into the Stuart Channel - Trincomali Channel system.

5.6.3 SEDIMENTATION

5.6.3.1 Nearshore Sedimentation

The nearshore zone extends from the high tide line to-20 metres depth (10 fathoms). There is agreement that sources of new sediment to the nearshore zone are primarily through erosion of unconsolidated deposits on the backshore (McCann and Hale, 1980; Clague, 1975 and 1976; Clague and Bornhold, 1980; Owens, 1980; Krauel, 1980; and Harper, 1980). McCann and Hale (1980) state that little or no sediment supply occurs from offshore sources. The contribution of river sediments is minor for the Northern Strait (Clague, 1975; McCann and Hale, 1980). Clague (1976) notes that sandsized sediments associated with Willemar Bluff-Goose Spit system are transported offshore and across an adjacent basin. The offshore movement of sediments is also noted by Krauel (1980) for Kye Bay, and by McCann and Hale (1980) for Kye Bay to Parksville. These movements represent a net loss of sediments from the intertidal area.

Fyles (1963) states that recent marine sediments tend to be less than 3 metres in thickness over older till deposits or bedrock. The deepest sediments are associated with Quadra sands and accretion forms such as spits. McCann and Hale (1980) measured thicknesses of greater than 1.5 metres at 18 metres depth for the sandy offshore sediments deposited by erosion of the intertidal areas. McCann and Hale (1980) and Clague (1976) verify that recent sediments overlie coarser and older unconsolidated deposits.

Rates of sedimentation of the nearshore zone are unknown although there are data for coastal bluff recession (Krauel, 1980). The rate of nearshore sedimentation is influenced by the presence of bedrock and coarse textured materials. Owens (1980) also notes that the presence of log debris in the upper tidal area stablized underlying sediments.

5.6.3.2 Deep Basin Sedimentation

The areas containing deep basins may be considered in three parts (Waldichuk, 1957).

5.6.3.2.1 Northern Strait

Deep basin sediment sources are primarily coastal bluffs and shallow submarine banks; sediments from rivers are low (Clague 1975, 1977). Clague's (1976) work near Comox discovered that fine sediments (silt and clay) are transported in suspension and settle in areas of lower energy (ie the deep basin). Sand may be transported in traction to deeper water. Tidal currents around Discovery Passage, however, prevent the deposition of fine materials to depths of 230 metres (Clague, 1975). The thickness of the sediments are calculated to be from 20 metres to 175 metres in the deep basins (Clague, 1977).

5.6.3.2.2 Central Strait

The Fraser River is the major source of sediments, especially during freshets (Pharo and Barnes, 1976). Fine sediments are carried in suspension northwestward, though for parts of the year it is southeastward (i.e. during freshet) with the plume reaching the Gulf Islands. Sediment particle size decreases moving west and northwest from the delta (Pharo and Barnes, 1976). Sediments may also be transported by traction currents. Tiffin (1969) believes that turbidity currents also move sediments. Coarse textured ridges and banks may provide sediments to adjacent basins, but because of strong current receive no deposition of fine material (Clague, 1975; Pharo and Barnes 1976). The thickness of the sediments is calculated to be from 15 to 300 metres moving north to south (Mathews and Murray, 1966 and Cockbain, 1963).

5.6.3.2.3 Southern Strait

Pharo and Barnes (1976) postulate that there is presently no significant sedimentation in this section. The origin of existing sediments is older fluvial and deltaic deposits reworked by strong currents. No data on thickness or sediments are available.

No work has been done on the sedimentation of the passage and channels of the Gulf Islands.

Sedimentation rates are calculated for the Strait of Georgia (Table 21).

TABLE 21 - ESTIMATED RATES OF SEDIMENTATION

AREA	*SEDIMENTATION RATE (cm/yr)	SIGNIFICANCE OF RATE	SOURCE
Fraser Delta front about - 37 metres	34	Average for active delta front	Mathews & Shepard 1962
Fraser Delta front about - 90 metres	37	Average for active delta front	Mathews & Shepard 1962
Strait of Georgia off Fraser Delta	2.7	Maximum	Mathews & Murray 1966
Northern Central Strait of Georgia	0.6	Average in basins	Mathews & Murray 1966
Ballenas Basin	2.6	Maximum	Tiffin 1969
Malaspina Basin	2.3	Maximum	Tiffin 1969
Northern Strait of Georgia	0.1	Average for entire area	Clague 1977
Northern Strait of Georgia	1.4	Maximum in basins	Clague 1977

*Mathews and Murray (1966), and Tiffin (1966) assumed post-glacial time to 10,000 years, while Clague used 12,500 for his calculations.

SOURCE: Summarized from Clague, J.J., 1977. Holocene sediments in northern Strait of Georgia, British in northern Strait of Georgia, British Columbia. In: Report of Activities, Part A, Geological Survey of Canada, paper 77-1A, pp. 51-58.

5.6.4 ATMOSPHERIC MIXING

The following information is provided by Schaefer (1980). The capacity of the atmosphere to disperse airborne pollutants is determined by the factors of 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 vertical mixing and/or horizontal transport 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 11. These values are based on a Canadian study by Shaw, Hirt and Tilley 1972.

During fall and winter, stationary or slow moving high pressure centres produce significant light wind episodes with those persisting 48 hours or more less common than those persisting only 24-47 hours. In the summer months, afternoon sea breezes occur. Calms are most frequent in the hours around sunrise and sunset, when reverals in the land and sea breeze circulations take place.

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 which may last throughout the day. These include; overrunning warm air from more southerly parts of the Pacific Ocean, particularly in fall and winter; cooling effects of the sea breeze in late spring and summer; and the occasional presence of cold Arctic air from the mainland during winter months.

Estimates of the diurnal and seasonal percentage frequencies of ground-based inversions for the study are ~~are~~ provided in Figure 12. Values are based on a national study by Munn, Tomlain, and Titus (1970), a regional study by Emslie (1979) and considerations of local factors. Considerable variation from the indicated values can be expected due to the local influence of water bodies and topography.

A measure of the dispersive capability of the lower atmosphere termed the ventilation coefficient can be calculated a 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 coefficent peak sharply in spring (April), decline throughout the summer and persist at low levels during fall and winter. Problems of pollutant buildup are generally limited to periods of calm or light winds which coincide with persistent ground-based inversions. During the wet season, pollutants are partially removed from the lower atmosphere by rain.

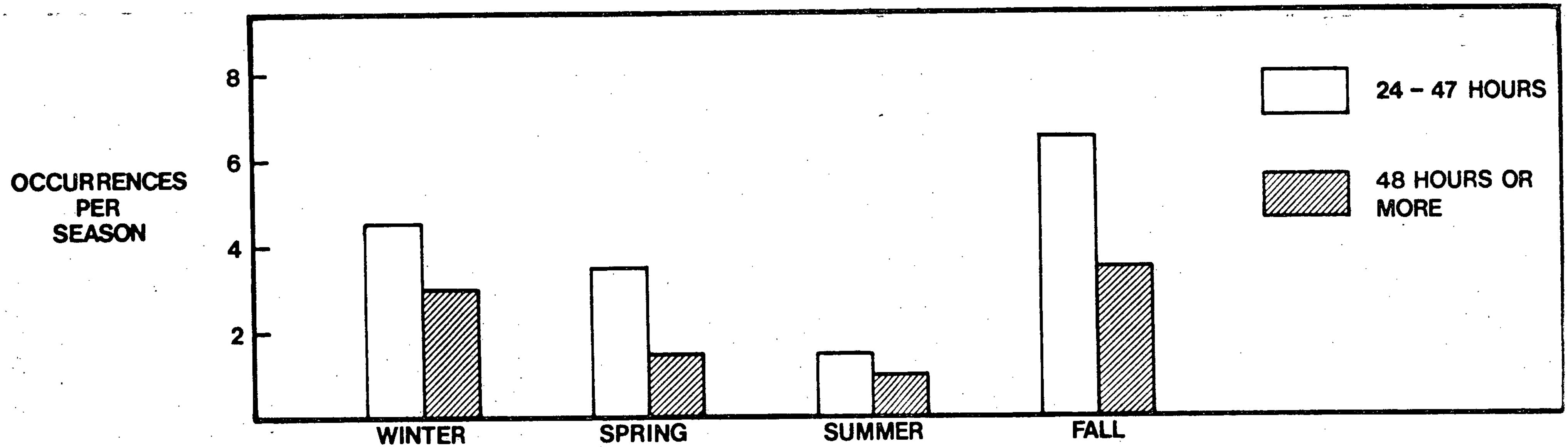


Figure 11. FREQUENCIES OF EPISODES OF PERSISTENT LIGHT SURFACE WINDS (SPEEDS LESS THAN 12KM/HR) BY SEASON

Source: Shaw, Hirt and Tilley, 1972. Persistence of light surface winds in Canada. Atmosphere 10(2): 33-43.

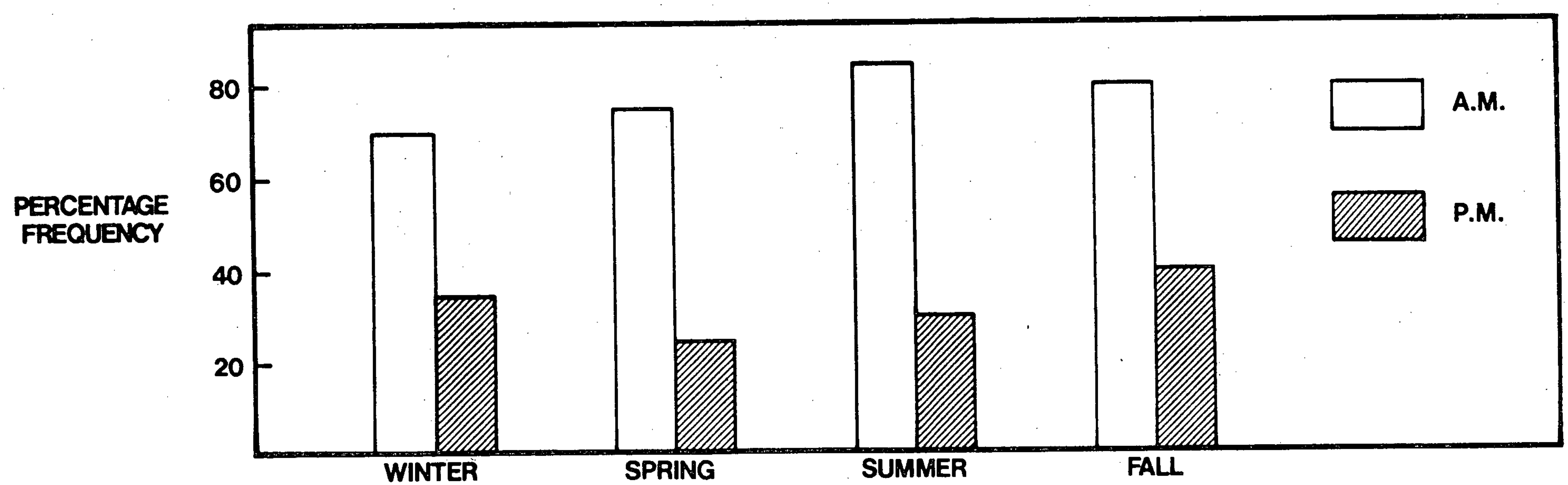


Figure 12. PERCENTAGE FREQUENCIES OF GROUND-BASED INVERSIONS BY SEASON

Source: ~~Shaw, Hirt and Tilley, 1972. Persistence of light surface winds in Canada. Atmosphere 10(2): 33-43.~~

Based on Munn, Tomlain + Titus (1970) and Emslie (1979)

5.6.5 SEISMICITY

The B.C. coast has a 1 in 100 probability of an earthquake exceeding a horizontal acceleration of 6 percent of gravity. Values as high as 8 percent of gravity have been calculated for the study area (B.C. Hydro, 1980). Horizontal acceleration is an accepted index of ground motion for engineering puposes. 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.

5.6.5.1 Magnitude

A common measure of earthquake magnitude is the Richter system; Earthquake intensities are also described by the Modified Mercali scale. Table 22 provides a comparison of the two methods of measurement.

The threshold for significant damage during earthquakes is set at magnitude 5 on the Richter scale. The maximum recorded earthquake occurred in 1946 west of Comox. It registered 7.3. Milne, Rogers, Riddihough, McMechan and Hyndman (1978) calculated a frequency of one in ten years for potentially damaging earthquakes. Figure 13 provides 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 graph, 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 graph, 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.

5.6.5.2 Soil Type

The type of material upon which structures are built directly influences the intensity of earthquakes. Table 23 provides the amplification factors for various geological materials and represents the minimum design requirements recommended under the National Building Code. Marine organic and course textured fluvial deposits would be susceptible to the higher intensities.

5.6.5.3 Depth of Focus, Mechanism and Distance

The depth of epicenters in the region range from 30 km to 70 km. The Beaufort Range earthquake of 1946 represents the shallowest, while the deeper events are more common.

The primary mechanisms of eathquakes in this region are strike-slip and normal faulting (Milne 1978; Rogers, Riddihough, McMachan and Hyndman, 1978; Slawson and Savage, 1979).

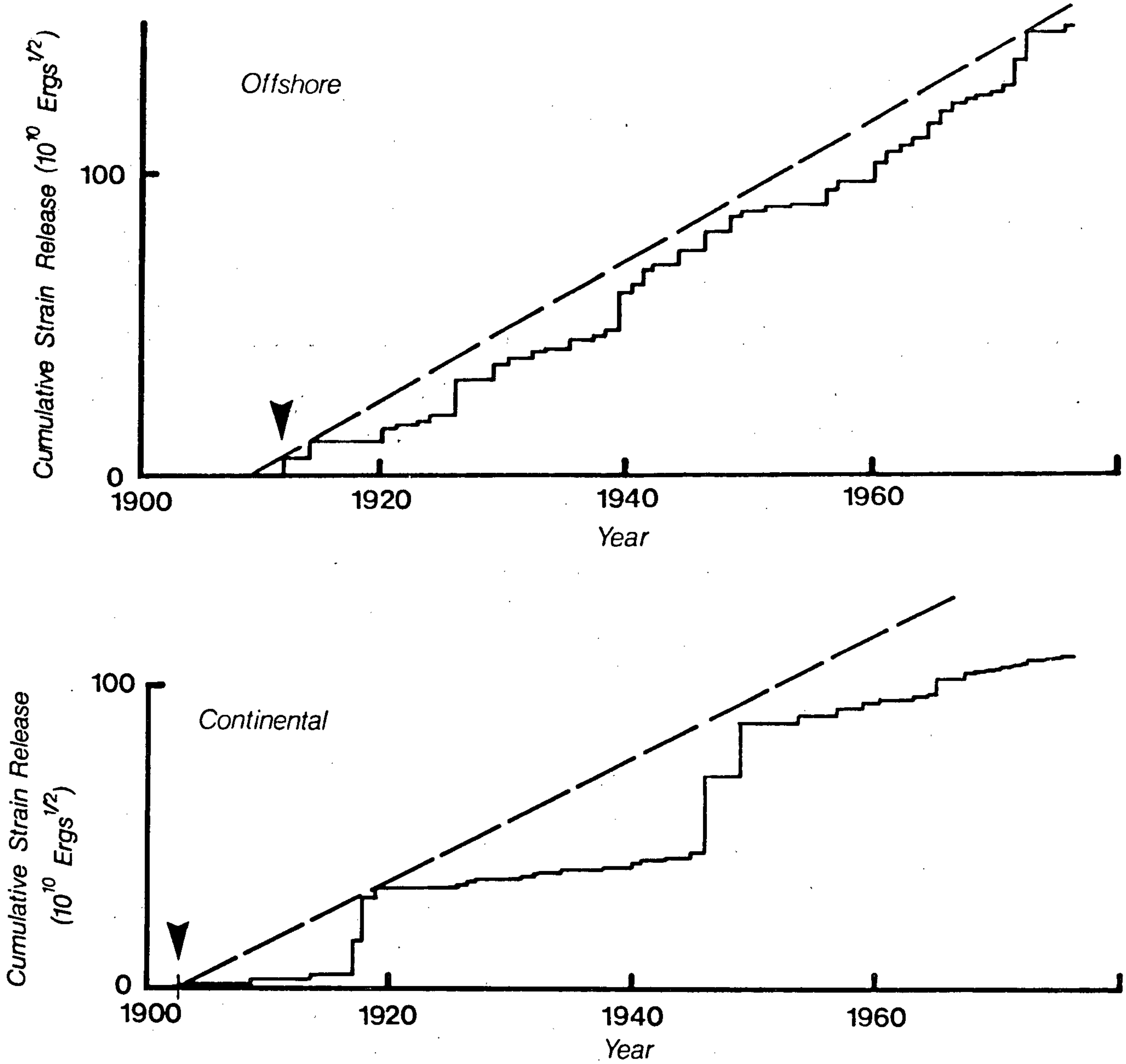
TABLE 22 - MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES WITH APPROXIMATELY CORRESPONDING RICHTER MAGNITUDES.[1]

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

[1]after Holmes, 1965

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

Figure 13. STRAIN RELEASE AS A FUNCTION OF TIME



Source: Milne, W.G., G.C. Rogers, R.P. Riddihough, G.A. McMechan, and R.D. Hundman, 1978. "Seismicity of Western Canada". Canadian Journal of Earth Sciences, vol. 15. pp.1170-1193.

TABLE 23 - SEISMIC AMPLIFICATION FACTORS FOR DIFFERENT GEOLOGICAL MATERIALS

TYPE AND DEPTH OF MATERIAL	AMPLIFICAITON 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 1977b

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

Earthquake damage diminishes with distance from the source (Whitman and Smith, 1970). Active faults in recent geological times are the Beaufort, San Juan, and Leech River faults. Milne, Rogers, Riddehough, McMechan and Hyndman (1978) report that the more active earthquake areas correspond to the boundaries of major tectonic plates on the coast. The Strait of Georgia - Puget Sound are specifically influenced by the contact of the Juan de Fuca and America plates, while central Vancouver Island appears to be influenced by the Explorer and America plates. Milne, Smith, and Rogers (1970) postulate that earthquake epicentres in the Gulf Island are evidence of a tectonic feature on the Strait of Georgia - Puget sound axis.

The secondary effects of earthquakes include tsunami and landslides. The probability of a damaging tsunami in the region is less than the probability of a damaging earthquake. There is evidence that small sea waves were generated in the Strait of Georgia by the 1946 earthquake (Hodgson, 1946). The probability of landslides from seismic activity in the region is highest in areas of unconsolidated deposits and jointed bedrock. Steepy sloped coastal bluffs, and incised river valleys are most vulnerable to failure. Landslides were common in the Courtenay-Comox area during 1946 earthquake.

5.7 FACTORS OF BIOLOGICAL PRODUCTIVITY

5.7.1 THE AREA

The eastern shorezone of Vancouver Island 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 is 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 enviroment are revealed by the differenes in the indigenous biota.

5.7.2 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 with a narrow temperature range. Similarly, organisms that are unable to regulate their internal environment in response to changes within 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. During the summer months, however, the upper layer of water - perhaps 30 metres deep - becomes warmer as solar radiation increases. The resultant temperature gradient inhibits mixing with the deeper water by virtue of the density gradient that accompanies a temperature change. Mixing continues, however, within the upper layer as surface winds circulate the water, thus maintaining relatvely constant temperatures within this strata.

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 for growth 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.

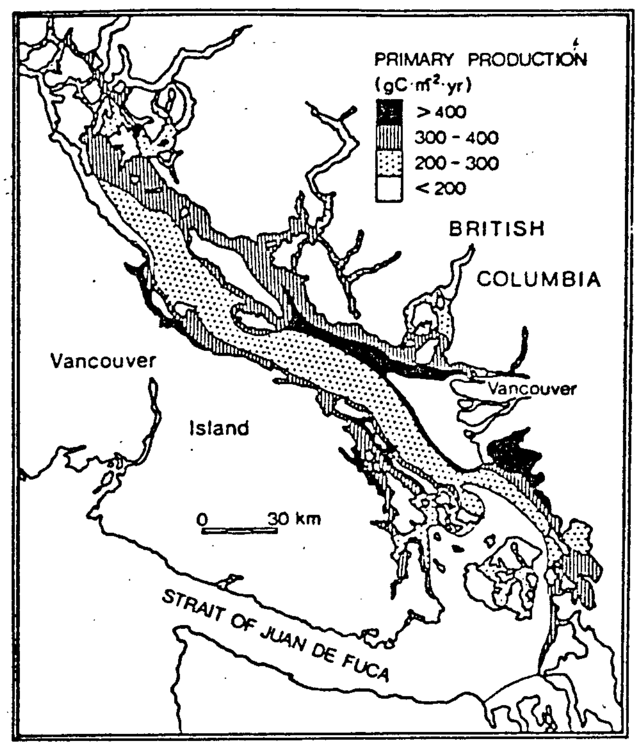
The interested reader will refer to the Coastal Resources Map Series (1:50,000) section - "Oceanography-Temperature" and "Oceanography-Salinity" for Strait of Georgia data on these topics. The "Sources" section should also be consulted for studies relating to the physical and chemical environment.

5.7.3 PRIMARY PRODUCTION - PHYTOPLANKTON

Primary production is the creation of organic material from carbon dioxode, 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 14) reveal relatively high rates of primary productivity along the sheltered coastlines of Baynes Sound and Ladysmith to Kulleet Bay. Much of the remaining coastline shows moderate to high rates of productivity. The Race Point-Cape Lazo nearshore zone is the least productive section of coastline.

FIGURE 14: GENERALIZED PATTERN OF PRIMARY (PHYTOPLANKTON) PRODUCTION IN THE STRAIT OF GEORGIA



SOURCE: J.G. Stockner, D.D. Cliff and K.R.S. Shortread. 1979. Phytoplankton Ecology of the Strait of Georgia, British Columbia. Journal of Fisheries Research Board of Canada. 36: 657-666.

With the exception of estuaries, the areas of highest productivity occur where temperature stratificaiton 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 primarily 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 15 illustrate the importance of each of the factors of growth in maintaining high productivity. The figures show, 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.

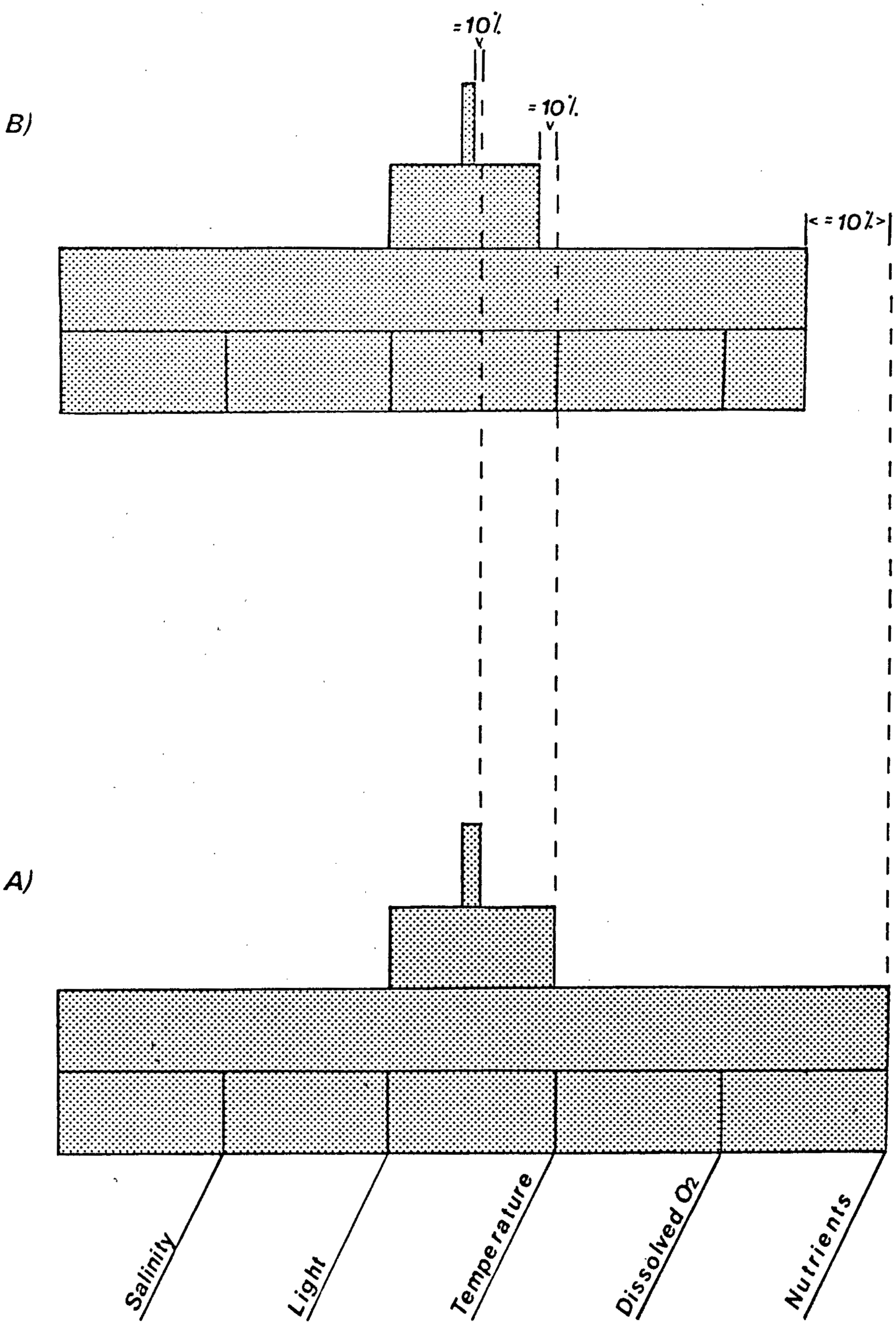
Important fisheries resources in the study area (see Coastal Resources Map Series (1:50,000) section-Fish and Shellfish Resources") are found primarily in the regions of moderate to high primary productivity.

5.7.4 PRIMARY PRODUCTION - SEAWEEDS AND SALTMARSHES

The productivity of seaweed and saltmarsh communities is impressive (Figure 16). 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 derives from the interaction of numerous species that have evolved complex symbiotic relationships within these communties.

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 (Remaine and Schlieper, 1971). Brackish water 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 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 Schieper, 1971). For instance, the lowest number of species occurs at the 5-7°/oo salinity level (Figure 17). 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

Figure 15 - SCHEMATIC OF ENERGY TRANSFER BETWEEN TROPHIC LEVELS IN UNLIMITED (A) AND LIMITED (B) ECOSYSTEMS



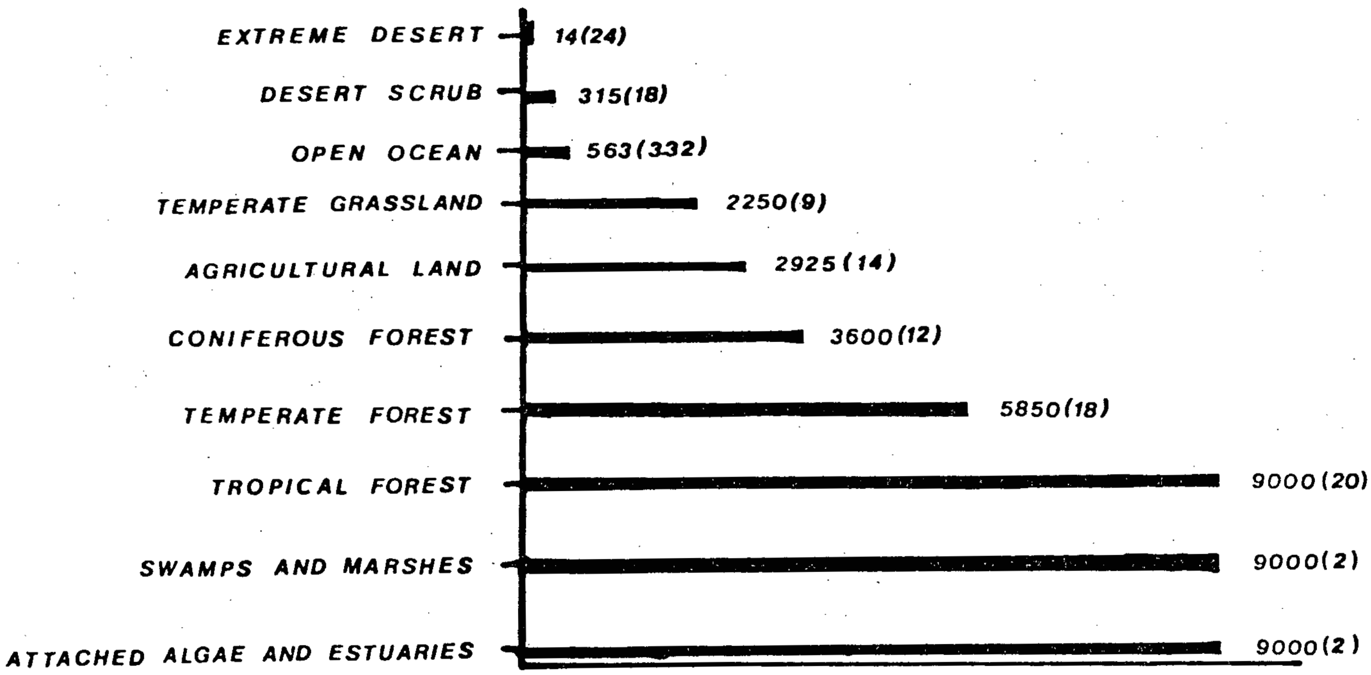
Note: Decrease of primary and succeeding levels of production due to limited availability of nutrients.

Carnivore

Herbivore

Primary Production

FIGURE 16: AVERAGE ANNUAL RATE OF NET PLANT PRODUCTION FOR SELECTED ECOSYSTEMS

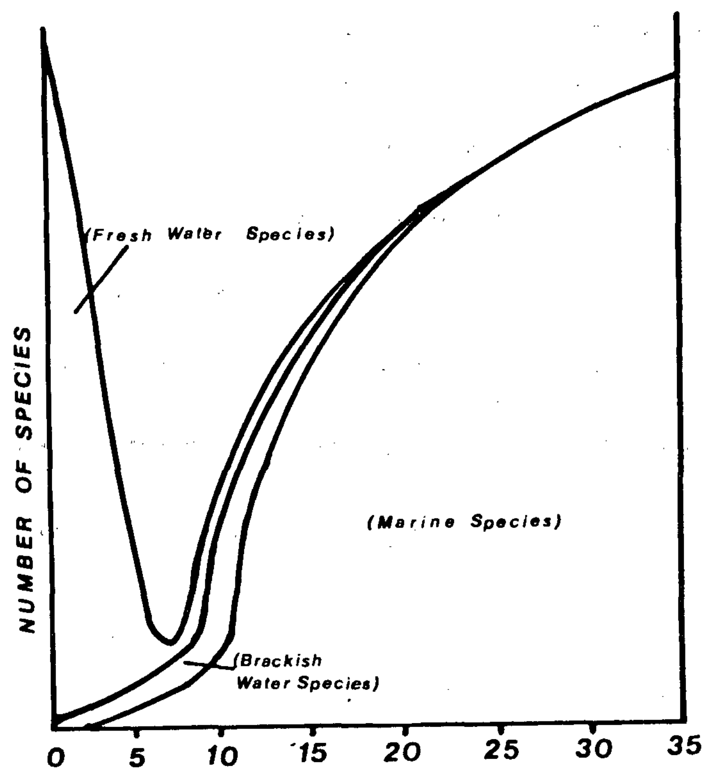


NOTE: The number after the bar is $Kcal/m^2/yr$; the number within parenthese is area in $10^6 km^2$.

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

is Zostera marina. It is acclimated to brackish water conditions and survives to the 3°/oo salt concentration level. 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 17: NUMBER OF SPECIES IN RELATION TO SALINITY LEVEL (°/oo)



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

The ecological importance of seaweeds and saltmarshes is documented in the literature (Perkins, 1974; Carefoot, 1977; Cushing and Walsh, 1976; 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 for estuaries, as upland mammal and reptile habitat, and as marine and shorebird habitat. Geese, widgeon, and pintails eat the saltmarsh plant Salicornia while eelgrass is an important food source for brant.

The economic importance of seaweeds are identified by Greenius (1967) and Carefoot (1977). The natural products of red and brown algae include agar, carrageeman, and algin. They are used in myriad commercial products from food to soaps, paper products, and pharmaceuticals. The genera Gigartina, Iridaea, Nereocystis, Macroycystis, Gracilaria and Gracilariopsis are especially important for these purposes. Although some harvesting of seaweeds has occurred in the study region, only one scientific permit to harvest 100 tons of Macrocystitis has been applied for in the last decade (Coon, 1980). As the Greenius report points out, very little is known of the ecological impacts that result from harvesting.

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. The Land Use Planning section of the Ministry of Lands, Parks and Housing prepared in 1980, a discussion paper entitled "The Ministry of Lands, Parks and Housing's Role in Foreshore Administration". This document identifies agency mandates, planning programs, 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

5.8.2.1 Crown Land - Provincial

The Ministry of Lands, Parks, and Housing is the primary 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. For example, the Ladysmith Harbour Management Committee, represented by local interest groups, meets on a monthly basis to advise Ministry representatives on lease applications and their conformity with a long range plan that the Ministry develops with committee assistance. The concerns of other agencies and levels of government are incorporated through the referral process.

In terms of foreshore regulation the Ministry of Lands, Parks and Housing monitors and enforces its own policies be it a trespass on Crown foreshore or fulfillment of terms and conditions of a foreshore lease. The Ministry is also responsible for area management plans. Examples of such plans include the Ladysmith and Sooke Basin Crown Foreshore Plans.

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

5.8.2.2 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 landuse 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.

5.8.2.3 Private and Other Public Lands

The Regional Parks Act of 1965 allows the regional districts to acquire, develop and manage regional parks. The Comox-Strathcona and Cowichan Valley regional districts have each acquired one park, but planning and development have yet to begin.

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.

A tree farm licence is an amalgamation of Crown and private lands formed under an agreement between the Crown and the owner to combine private lands with unencumbered Crown land to form self-contained sustained yield management units. This combination of lands allow for efficient forest management practices which otherwise would not be possible with divided ownership.

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

The Esquimalt and Nanaimo Railway grant represents a very large private land holding with high forestry values.

5.8.3 WATER MANAGEMENT

5.8.3.1 Water Supply and Licencing

5.8.3.1.1 Federal Role

Major federal legislation dealing with water supply includes the Canada Water Act and the Fisheres 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.

5.8.3.1.2 Provincial Responsibilities

The Ministry of Environment 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 functions.

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 licenses 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 licenced for diversions in excess of the recorded minimum daily discharge. Although not all users divert the maximum licenced 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 are calculated for a limited number of rivers. Similar calculations are not available for recreation, wildlife, or domestic uses.

5.8.3.2 Water Quality and Waste Management

Water quality comes under the purview of the provincial and federal governments. While numerous acts deal with specific environmental issues, only the major legislation is reviewed here.

5.8.3.2.1 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 government 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.

5.8.3.2.2 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 Recreation and Tourism 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 or 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 inolve the public health.

5.8.4 LOCAL PLANNING

Planning varies between regional districts, municipalities, and the Islands Trust. Ince (1971) defines and describes planning mechanisms, jurisdictions, legislative requirements, and land use law for British Columbia. The interested reader is referred to this publication for further information.

Briefly, however, there are four mechanisms to control waterfront or watershed development. The Cowichan Valley and Nanaimo Regional Districts, several islands of the Islands Trust, the town of Ladysmith, and the District of North Cowichan have adopted waterfront zoning. The Campbell River and Comox-Strathcona Regional Districts use residential low density and public assembly zoning as intermediate measures to prevent ad hoc development before management plans are adopted. A general mechanism is the designation of development permit areas. Within development permit areas developers are required to obtain permits prior to development. The permits outline the special nature of area and the restrictions to development. Two clauses under section 717 (Development Permits) of the Municipal Act refer specifically to the protection of the environment. 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.

Watershed zones have been adopted for North Pender and Saltspring islands to protect the watersheds of portable water bodies. In addition, set-back provisions are enforced for sewage disposal fields.

The Regional Settlement and Community Plans provide policies and guidelines for environmental protection. Sensitive environmental areas are identified for protection and development restrictions including land use controls are determined.

The Land/Water Use and Status tables (Section 2) and the Sources (Section 6) provide a comprehensive listing of existing land use plans.

NOTE: This report is only part of the documentation available: Other sections of the Coastal Resources Folio; East Coast of Vancouver Island (Race Point to Hatch Point and adjacent Islands) include Introduction, Coastal Resources Map Series (1:50,000), Land/Water Use and Status Tables, Estuary Map Series (1:15,840), and Sources.

SECTION 6: SOURCES

PREPARED BY

M. W. Dunn
D. M. Moore
T. J. Summers
D. A. Wolff

COMPILED BY

D. M. Moore

EDITED BY

M. J. Romaine

LANDS DIRECTORATE
ENVIRONMENT CANADA
VANCOUVER, B. C.

November, 1981

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6.2.9 Fish and Shellfish Resources and

6.2.10 Fish Spawning and Rearing Areas

Note

The Coastal Resources map series (1:50,000) "Fish and Shellfish Resources" and the complementary series "Fish Spawning and Rearing Areas" are based on the pooled professional knowledge and judgment of a number of specialists in government, university and private agencies whose contributions ranged from site-specific data and local knowledge to region-wide surveys and direction to the relevant literature.

Up-to-date exploratory surveys of the distribution of the adults and young of commercial species are limited. Full references to these few studies are provided in the Companion Report sources (see 6.5.4.5.4)

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District of Campbell River
Nanaimo Regional District
The Town of Comox
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Note

This report is only part of the documentation available: other sections of the Coastal Resources Folio; East Coast of Vancouver Island (Race Point to Hatch Point and Adjacent Islands include Introduction, Coastal Resources Map Series (1:50,000), Land/Water Use and Status Tables, Estuary Map Series (1:15,840), and Companion Report.