

70585

EA 1208

**DRAFT**

# Kyuquot Sound ENVIRONMENT LIBRARY Salmonid Enhancement Reconnaissance and General Feasibility Study

for

LIBRARY  
PACIFIC BIOLOGICAL STATION  
FISHERIES & OCEANS  
NANAIMO, BRITISH COLUMBIA  
CANADA V9R 5K6

Canada.

Department of  
Fisheries and the Environment

Department of  
Supply and Services

prepared by

**envirocon Ltd.**

Vancouver, B.C.

March, 1977

## TABLE OF CONTENTS

	<u>Page</u>
List of Figures	(i)
List of Tables	(iii)
List of Appendices	(iv)
1.0 SUMMARY AND CONCLUSIONS	1
2.0 INTRODUCTION	6
3.0 STUDY AREA DESCRIPTION	7
3.1 Climate	10
3.2 Hydrology	15
3.3 Forest Resources	25
3.3.1 Tahsish River	28
3.3.2 Kaouk River	29
3.3.3 Artlish River	29
3.3.4 Kauwinch River	29
3.3.5 Kashutl River	30
3.3.6 Chamiss, Jansen, Easy and Elaine Creeks	30
3.3.7 Narrowgut, Amai and Cachalot Creeks	31
3.4 Marine Environment	31
4.0 THE SALMONID RESOURCE	32
4.1 Salmon	32
4.1.1 Escapements	33

	<u>Page</u>
4.1.2 Spawning Distribution	45
4.1.3 Spawning Timing	50
4.2. Anadromous Trout	51
5.0 THE FISHERIES	52
5.1 Commercial Fishery	52
5.1.1 Chum Salmon	53
5.1.2 Pink Salmon	57
5.1.3 Other Salmon Species	57
5.2 Sport Fishery	58
5.3 Native Food Fishery	59
6.0 STATUS OF KYUQUOT SALMON STOCKS	60
6.1 Chum Salmon	61
6.2 Pink Salmon	63
6.3 Chinook Salmon	66
6.4 Coho Salmon	66
7.0 THE SETTING FOR ENHANCEMENT	69
7.1 Freshwater Environment	69
7.1.1 Fluctuations in Adult Returns	70
7.1.2 Effects of Logging	72
7.2 Inshore Marine Environment	74
7.3 Stock Manageability	75

Page

8.0	APPLICATION OF ENHANCEMENT TECHNIQUES	79
8.1	Chinook and Coho Salmon, Steelhead Trout	79
8.2	Pink and Chum Salmon	82
8.3	Sockeye Salmon	83

ACKNOWLEDGEMENTS

REFERENCES CITED

## LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
3.1	Kyuquot Sound and vicinity.	8
3.2	Logging roads in Kyuquot Sound watersheds.	9
3.3	Location of hydrometric and meteorological recording sites adjacent to the Kyuquot study area.	11
3.4	Topographic map of Kyuquot Sound watersheds.	13
3.5	Gradient profiles of Kyuquot Sound streams.	16 - 18
3.6	Comparison of mean monthly discharges in west coast (Zeballos) and east coast (Kokish) of Vancouver Island rivers located near the study area, expressed on a per area of watershed basis.	21
3.7	Comparison of discharge fluctuations during two storm periods, January 9 - 16, 1961 in west coast (Zeballos) and east coast (Kokish) of Vancouver Island rivers located near the study area.	24
3.8	Logging areas in Kyuquot Sound watersheds.	26
4.1	Southern British Columbia fisheries statistical areas.	34
4.2	Estimated escapements of chum, pink, chinook and coho salmon to Kyuquot Sound study area streams, 1951-1975.	36
4.3	Pink and chum salmon spawning distribution in Kyuquot Sound streams.	39

<u>Figure</u>		<u>Page</u>
4.4	Generalized graph of salmon spawning timing in Kyuquōt study area streams.	41
5.1	Current commercial net and troll fishing boundaries within Kyuquōt Sound (solid lines) and seaward boundary for salmon net fishing (dotted line).	54
5.2	Commercial net catches of chum and pink salmon in Area 26, 1951-1975.	55
6.1	Comparison of chum salmon stocks returning to Kyuquōt (Area 26), the west coast of Vancouver Island (Area 22-27) and Johnstone Strait-Georgia Strait (Areas 12-18 and 28-29).	62
6.2	Comparison of even-year pink salmon stocks returning to Kyuquōt (Area 26), the west coast of Vancouver Island (Areas 22-27) and Johnstone Strait-Georgia Strait (Areas 12-16), troll catches excluded.	64
6.3	Comparison of chinook salmon escapements to Kyuquōt (Area 26) and the west coast of Vancouver Island (Areas 22-27).	67
6.4	Comparison of coho salmon escapements to Kyuquōt (Area 26) and the west coast of Vancouver Island (Areas 22-27).	68
7.1	Area 26 pink salmon adult returns (total stock) relative to maximum daily river discharge during incubation period, for 1960 to 1974 brood years. Discharge data are from Zeballos River.	71
7.2	Seasonal timing of commercial chum salmon catch in Area 26, 1953 and 1954.	78

LIST OF TABLES

<u>Table</u>	<u>Page</u>
3.1 Average and extreme measures of precipitation and air temperature on an annual basis at three locations near the Kyuquot study area, based on records from 1941-1970.	14
3.2 Listing of drainage areas, lengths and source elevations of Kyuquot Sound streams.	19
3.3 Comparative discharges and physical features of a west coast (Zeballos) and an east coast (Kokish) river system situated near the Kyuquot study area.	22
3.4 Extent of logging and proposed logging activity in Kyuquot Sound watersheds, shown as a percentage of the watershed area.	27
4.1 Estimated chum salmon escapements to Kyuquot Sound streams during the 1951-1975 period, with streams ranked in order of watershed size.	37
4.2 Chum salmon escapements to Kyuquot Sound streams, compared on the basis of watershed size and stream length utilized.	38
4.3 Estimated pink salmon escapements to Kyuquot Sound streams during the 1952-1974 period, with streams ranked in order of watershed size.	40
4.4 Estimated chinook salmon escapements to Kyuquot Sound streams during the 1951 to 1975 period, with streams ranked in order of watershed size.	42
4.5 Estimated coho salmon escapements to Kyuquot Sound streams during the 1951 to 1975 period, with streams ranked in order of watershed size.	43
4.6 Comparative distribution of pink and chum salmon spawners at respective peaks of spawning in the Kaouk River during 1976.	47
7.1 Generalized inshore migration timing of adult salmonids at Kyuquot Sound.	76

Appendix

- N Estimated escapement, net catches and total pink salmon stocks in Areas 22-27 (west coast of Vancouver Island) from 1952 to 1974.
- O Estimated escapement of chinook salmon to Area 26 and to Areas 22-27, (west coast of Vancouver Island) from 1951 to 1975.
- P Estimated escapement of coho salmon to Area 26 and to Areas 22-27, (west coast of Vancouver Island) from 1951 to 1975.

## 1.0 SUMMARY AND CONCLUSIONS

1. Envirocon Limited was contracted in September, 1976 to undertake a field reconnaissance and to provide a general assessment of opportunities for salmonid enhancement in the Kyuquot Sound area of Vancouver Island. The analysis presented in this report is based on field surveys during October and November, 1976 and on the reports and unpublished records of government agencies.
2. The study area, situated in a remote part of the Vancouver Island west coast, includes Kyuquot Sound and the thirteen salmonid-producing streams draining into it. The Sound is a sheltered body of saltwater, with many inlets and islands. Industrial activity in the area has been confined to commercial fishing in season and to logging, which has been carried out to varying extent in nine of the thirteen study area watersheds.
3. Kyuquot Sound streams support populations of five Pacific salmon species, chinook, coho, chum, pink (even-year stock) and sockeye, as well as two species of anadromous trout, the steelhead and the coastal cutthroat. Both summer and winter runs of steelhead trout are known to occur in some study area streams.

Commercial fisheries pursued in the area include a seine and gill net fishery for local stocks of chum and pink salmon, and a troll fishery which exploits stocks of chinook, coho, sockeye and pink salmon from a broad geographic area along the Pacific coast. Though in the last two decades the local net fishery has been severely restricted for conservation reasons, annual catches of up to 131,000 chum salmon and 65,000 pink salmon have been taken from the Kyuquot area.

Due to the remoteness of the area, sport fishing activity has been limited. A small marine sport fishery exploits mature chinook and coho salmon within Kyuquot Sound, and a small freshwater sport fishery for summer and winter steelhead trout has developed in recent years. A native food fishery exploits sockeye, chinook, and chum salmon to a limited extent.

4. The general patterns of abundance changes in Kyuquot chum and pink salmon stocks since 1951 have been similar to those in other areas of south coastal British Columbia. Adult returns generally improved in the late 1960's and early 1970's. The relatively strong returns of pink salmon to Kyuquot since 1966 appear to be correlated with the occurrence of significantly colder winters since 1964-65, which may have indirectly enhanced survival during the egg-to-fry or early marine life stages.

Chinook and coho salmon escapements to Kyuquot Sound streams have declined since the early 1950's.

Relative to populations on the Vancouver Island west coast generally, chinook escapements have shown a comparable trend, whereas coho escapements have remained at a lower level, having failed to recover as in some areas to the south.

5. Kyuquot Sound watersheds are in general relatively small and of steep topography, with little natural capacity to store runoff. Data from an adjacent watershed indicates that the intense precipitation characteristic of the area frequently produces extreme high stream discharges during the salmon spawning and incubation periods. Instability of stream flow in the egg-to-fry stage appears to have influenced considerably the strength of pink salmon adult returns to Kyuquot Sound. Similar impact on other species is likely, but not demonstrable due to the lack of adult age composition information, which would allow environmental data to be correlated with the success of specific year classes.
6. From a knowledge of the general physical characteristics of study area watersheds, and by extrapolation of stream flow data from an adjacent watershed, several general conclusions were developed with respect to the application of enhancement techniques to Kyuquot Sound salmonid populations:

(1) a strategy of improving adult salmon access to additional spawning and nursery area above migrational obstructions would have limited application, except in the Tahsish River system;

(2) the four largest river systems appear to have suitable land and probably have sufficient flow to meet the surface water requirements of a large-scale hatchery for chinook and coho salmon, and steelhead trout;

(3) artificial spawning channel installations to enhance the production of pink and chum salmon would likely be technically feasible on the larger streams, but their design and location must take into account the need to ensure proper allocation of water to natural spawning areas in the adjacent stream bed; and

(4) substrate incubators or incubation boxes warrant consideration as alternatives to artificial spawning channels for pink and chum salmon enhancement, particularly on the smaller streams, because of their relatively low water and space requirements.

7. The existing physical and biological data base is inadequate to allow implementation of a well-founded enhancement program for Kyuquot Sound salmonid populations. In the development of an enhancement strategy for the area priority should be given to investigating stock manageability aspects, particularly

the problem of harvesting stocks subjected to enhancement measures without overharvesting other stocks which have not been enhanced. In this regard, the limited available data suggest that Kyuquot chum salmon stocks possess little diversity in terms of adult migration timing through inshore commercial fishing areas, and coho salmon stocks overlap to some degree with chum salmon in their respective periods of migration. This would indicate that the adoption of a multi-stock enhancement strategy may be a necessary prerequisite to salmonid enhancement at Kyuquot Sound.

## 2.0 INTRODUCTION

The governments of Canada and British Columbia are currently planning the implementation of a 20-year salmonid enhancement program, the goal of which is to restore production of salmon and anadromous trout in British Columbia to historic levels. As part of the planning for this program, the federal departments of Fisheries and the Environment and Supply and Services contracted Envirocon Limited in September, 1976 to undertake a field reconnaissance and to provide a general assessment of opportunities for salmonid enhancement in the Kyuquot Sound area of Vancouver Island. The contract included the following major tasks:

- (1) compilation and analysis of existing information on salmonid populations of the study area, including commercial and sport fishery landings, salmon escapements, and trends in these statistics relative to other areas of south coastal British Columbia;
- (2) description of study area watersheds, including stream hydrology and gradient, extent of logging, road access and physical barriers to migrations;
- (3) qualitative description of the 1976 salmon spawning escapements in the major study area streams, to include the timing and distribution of spawning by species in each of the major streams; and
- (4) assessment of the major streams as sites for the application of enhancement techniques.

The analysis presented here is based mainly on the reports and unpublished records of government agencies, augmented by field surveys and interviews conducted by the firm during the fall of 1976.

### 3.0 STUDY AREA DESCRIPTION

The study area is situated in a relatively remote part of the Vancouver Island west coast, approximately 140 km west of Campbell River (Figure 3.1). The area includes Kyuquot Sound and the thirteen salmonid-producing streams draining into it. Only in the last five years has the area been accessible by road.

Industrial activity in the study area has been confined to logging and commercial fishing. A permanent fishing community, Kyuquot is located at the north entrance to Kyuquot Sound (Figure 3.1), and two active logging camps operate on the west side of the Sound, at Chamiss Bay and at East Bay near Jansen Lake (Figure 3.2). Fair Harbour, on the east side of the Sound, is currently the base for a two-man logging operation. During the summer and fall period, the B.C. Forest Service campsite at Fair Harbour serves a considerable number of sport fishermen and hunters. Fair Harbour and some of the study area streams are shown in Plates 1 - 4.

Road networks and stream systems within the study area are shown in Figure 3.2. The principal road access to the area is by a 43-km gravel logging road, from Zeballos to Fair Harbour, which opened in 1971. This road is heavily used by

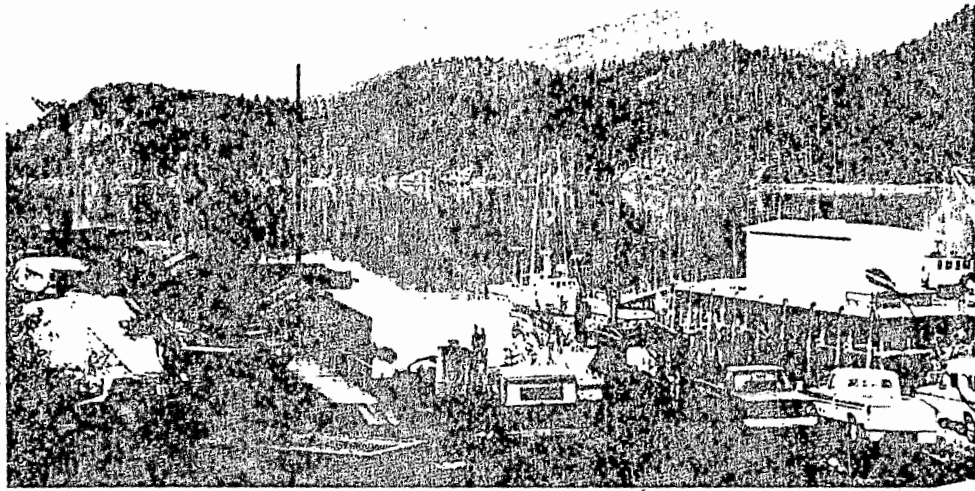


PLATE 1. Docking facilities at Fair Harbour.

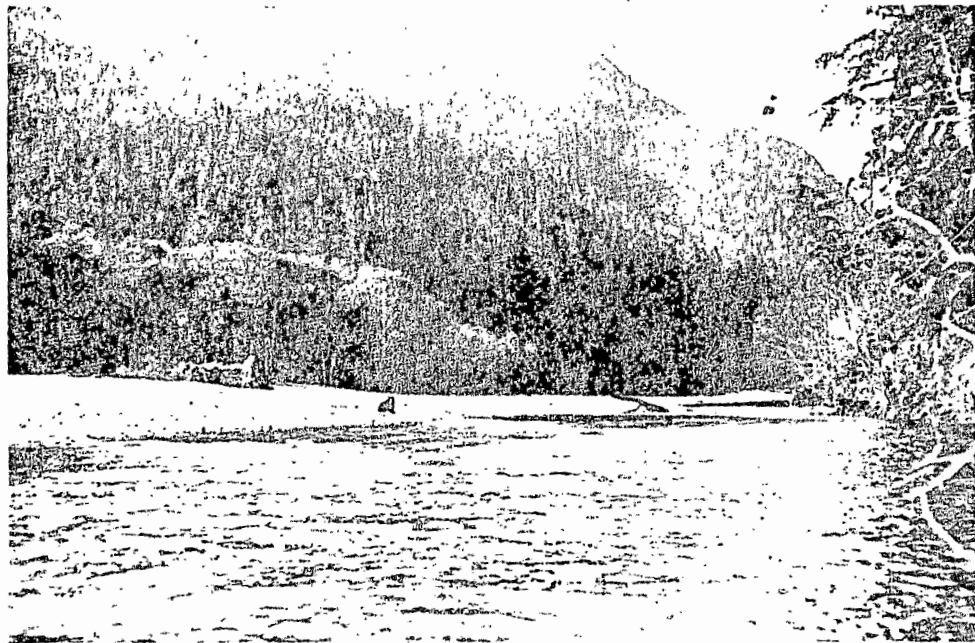


PLATE 2. Lower Tahsish River where black bear was observed feeding on salmon carcasses.

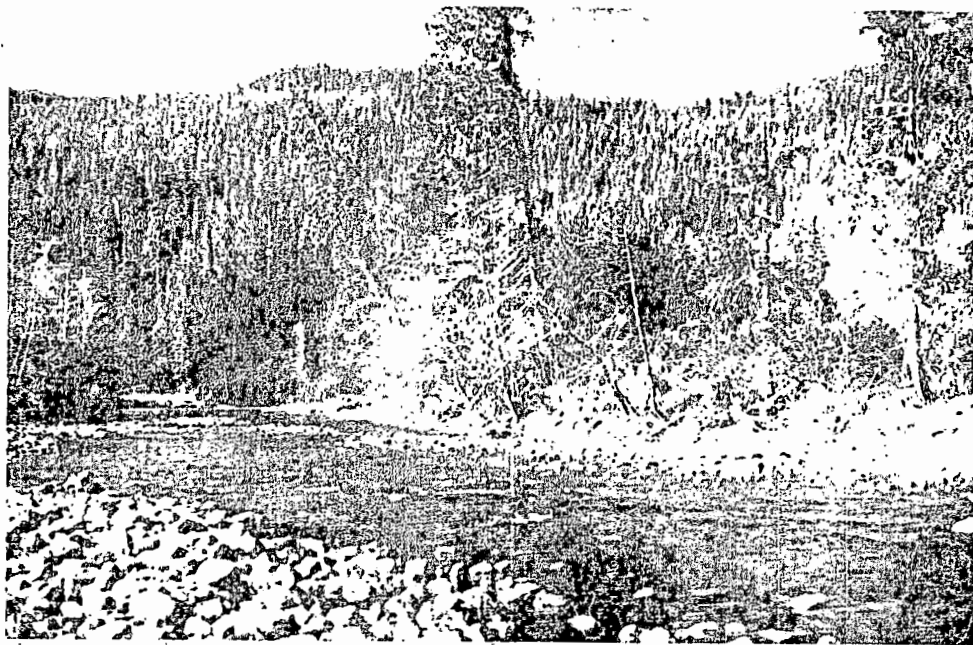


PLATE 3. Lower Kauwinch River below canyon.

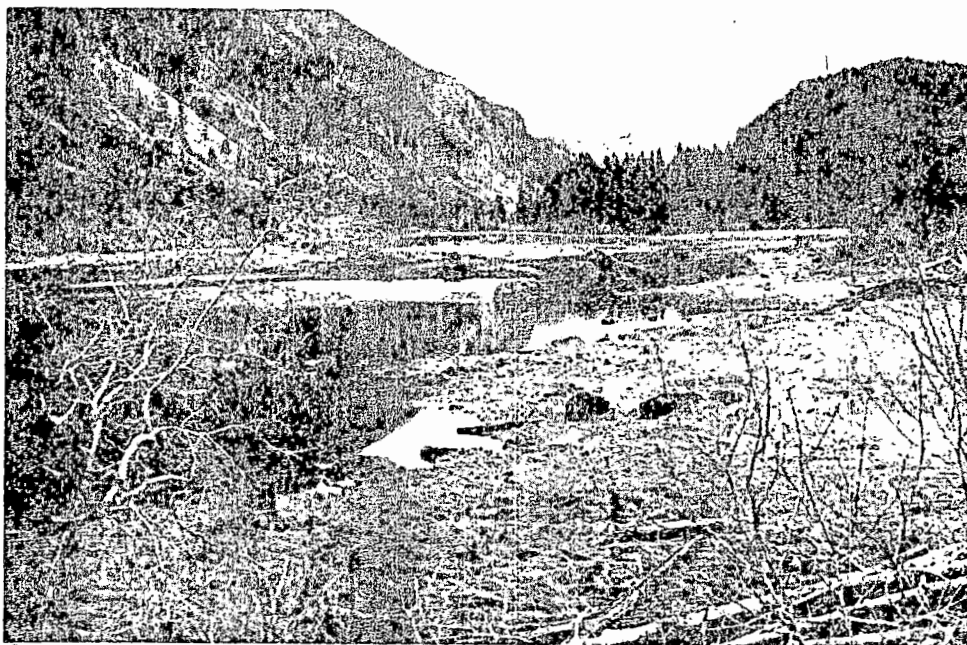


PLATE 4. Kaouk River estuary with causeway to Fair Harbour in the background.

**FIG: 3.1**

# KYUQUOT SOUND AND VICINITY

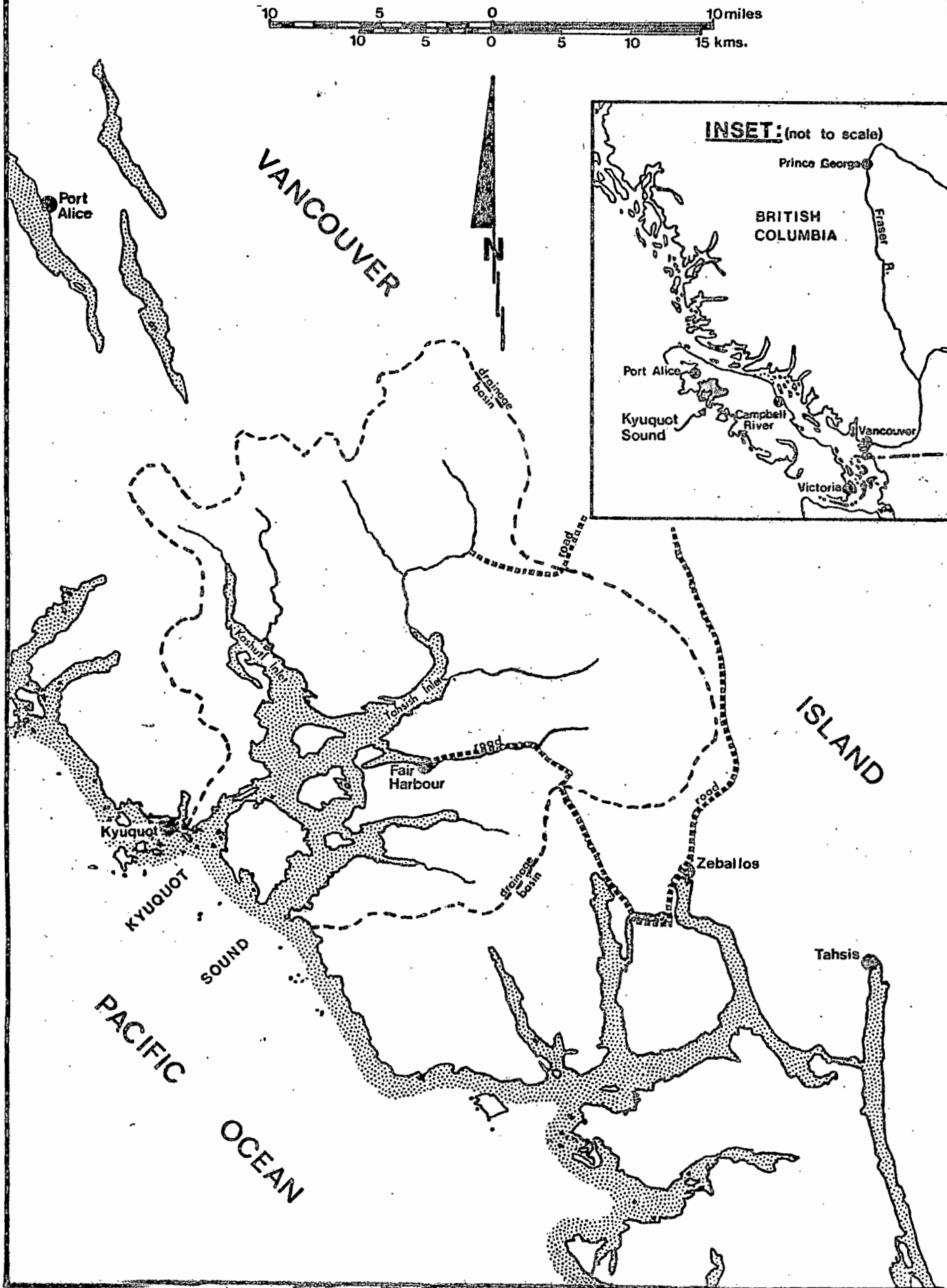


Figure 3.2

LOGGING ROADS IN KYUQUOT SOUND WATERSHEDS

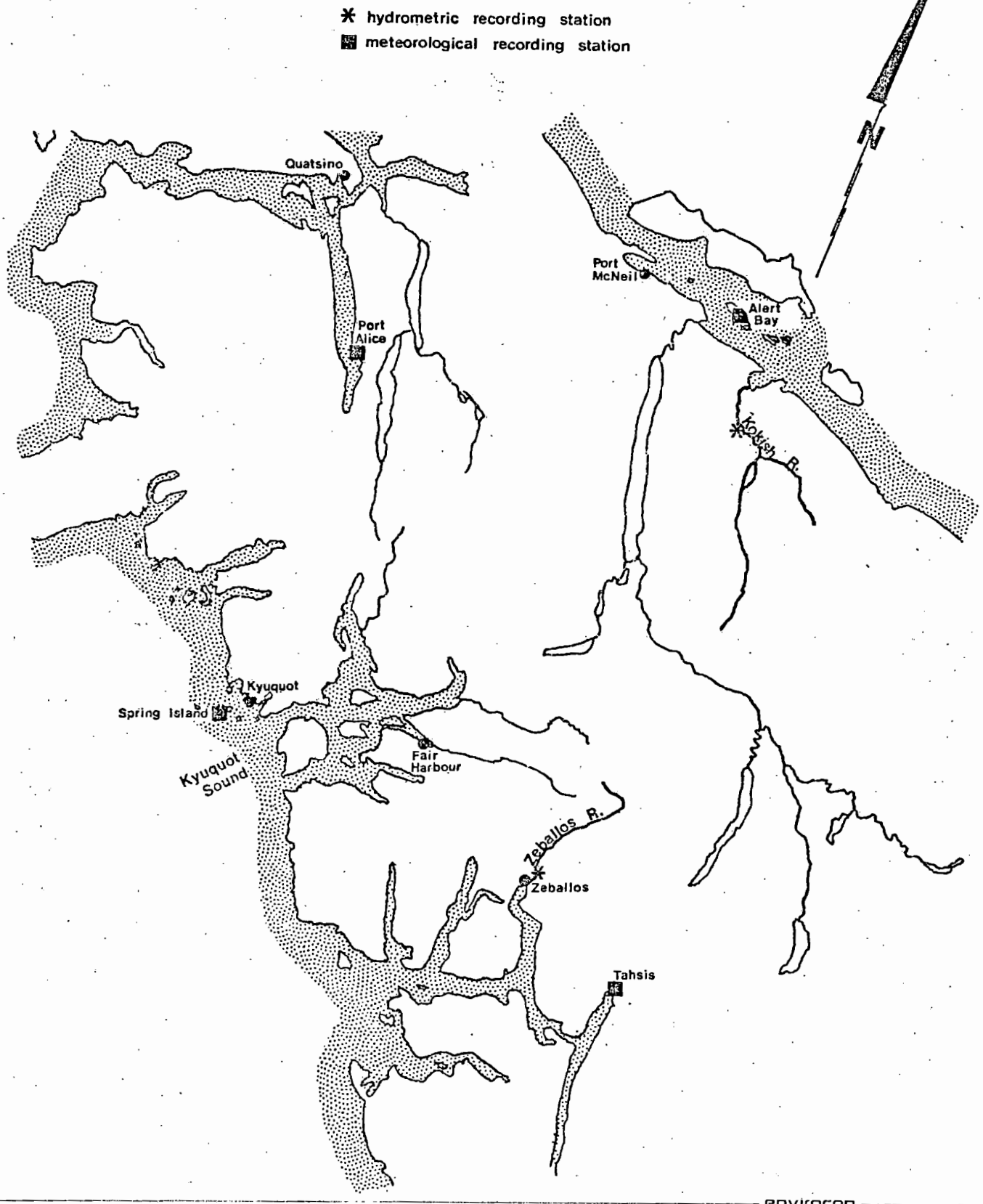
the public. Because of the road access and government wharf facilities, Fair Harbour serves as a distribution point for boat traffic to the settlement of Kyuquot and to logging camps in the area. Logging roads branching off the main road from Zeballos to Woss Camp on the Nimpkish River system also provide access to the upper Tahsish watershed (via Atluck Lake) and to the extreme headwaters of the Artlish River.

Though only the Kaouk River and the upper reaches of the Tahsish system are directly accessible by road, logging roads starting at tidewater provide access along several streams. A road network extends from Chamiss Bay camp to Jansen Lake and to Chamiss, Elaine and Easy creeks. In the last two years a road has been constructed in preparation for logging along the Kashutl River at the head of Kashutl Inlet. Abandoned logging road networks exist on Amai Creek and on the Kauwinch River (Kashutl Inlet). The Amai Creek road connects with the Zeballos-Fair Harbour road, but numerous washouts now preclude vehicle access to the lower reaches of this stream.

### 3.1 Climate

The Kyuquot area of Vancouver Island falls in the Marine West Coast climatic classification, as outlined by Strahler (1965). These middle latitude climates are windward, west coast areas which receive frequent cyclonic storms. Temperature ranges are generally small due to the moderating influence of the ocean. Annual precipitation is well distributed, with a winter maximum.

**FIG: 3.3** Location of hydrometric and meteorological recording sites adjacent to the Kyuquot study area.



Major topographic features affecting the climate and hydrology of the Kyuquot area are the Pacific Ocean to the west and the mountains of Vancouver Island to the east. The coast is characterized by numerous inlets. The land rises sharply from the coast to elevations of over 1200 metres above sea level. Depending on meteorological conditions, air masses either rise quickly and pass over the mountains, thereby producing short periods of heavy precipitation, or they stall against the mountains, causing longer periods of light precipitation. At the same time, the mountains protect the west coast from periodic outbreaks of cool continental air.

Meteorological recording stations have not been established within the study area. This has necessitated the use of data from three stations in the vicinity of Kyuquot Sound (Spring Island, Port Alice and Tahsis) to depict likely rainfall and temperature conditions within the study area. Station locations are shown in Figure 3.3, and summaries of the long-term records are given in Table 3.1.

The above stations represent three types of coastal microclimate. Spring Island records are typical of locations on the outer coast. Tahsis is typical of a mountain-base station at the head of a long inlet, while Port Alice represents a protected inshore location, intermediate in character.

Rainfall increases with progression from the offshore (Spring Island) to the mountain base location (Tahsis). Snowfall is markedly less on the outer coast due to the moderating influence of the ocean. Data from the Tahsis and Port Alice

Figure 3.4  
TOPOGRAPHIC MAP OF KYUQUOT SOUND WATERSHEDS

TABLE 3.1 Average and extreme measures of precipitation and air temperature on an annual basis at three locations near the Kyuquot study area, based on records from 1941 to 1970. Tahsis temperature data were not available.

Station	Precipitation (cm)					Temperature (°C)					
	Avg. Rain-Fall	Avg. Snow-Fall	Avg. Total Precip.	Days with Measurable Precip.	Max. 24-hr. Precip.	Days with Frost	Avg. Daily	Avg. Daily Max.	Avg. Daily Min.	Max. Re-corded	Min. Re-corded
Spring Island (elev. 11.3 m ASL)	292.0	39.4	296.0	208.0	14.1	27.0	9.1	11.8	6.3	34.4	-11.1
Port Alice (elev. 15.2 m ASL)	315.2	58.7	320.7	208.0	19.7	33.0	9.4	13.1	5.7	34.4	-12.8
Tahsis (elev. 4.6 m ASL)	366.9	72.1	374.1	-	-	-	-	-	-	-	-

Source: Environment Canada, Atmospheric Environment Service, Temperature and Precipitation 1941-1970.

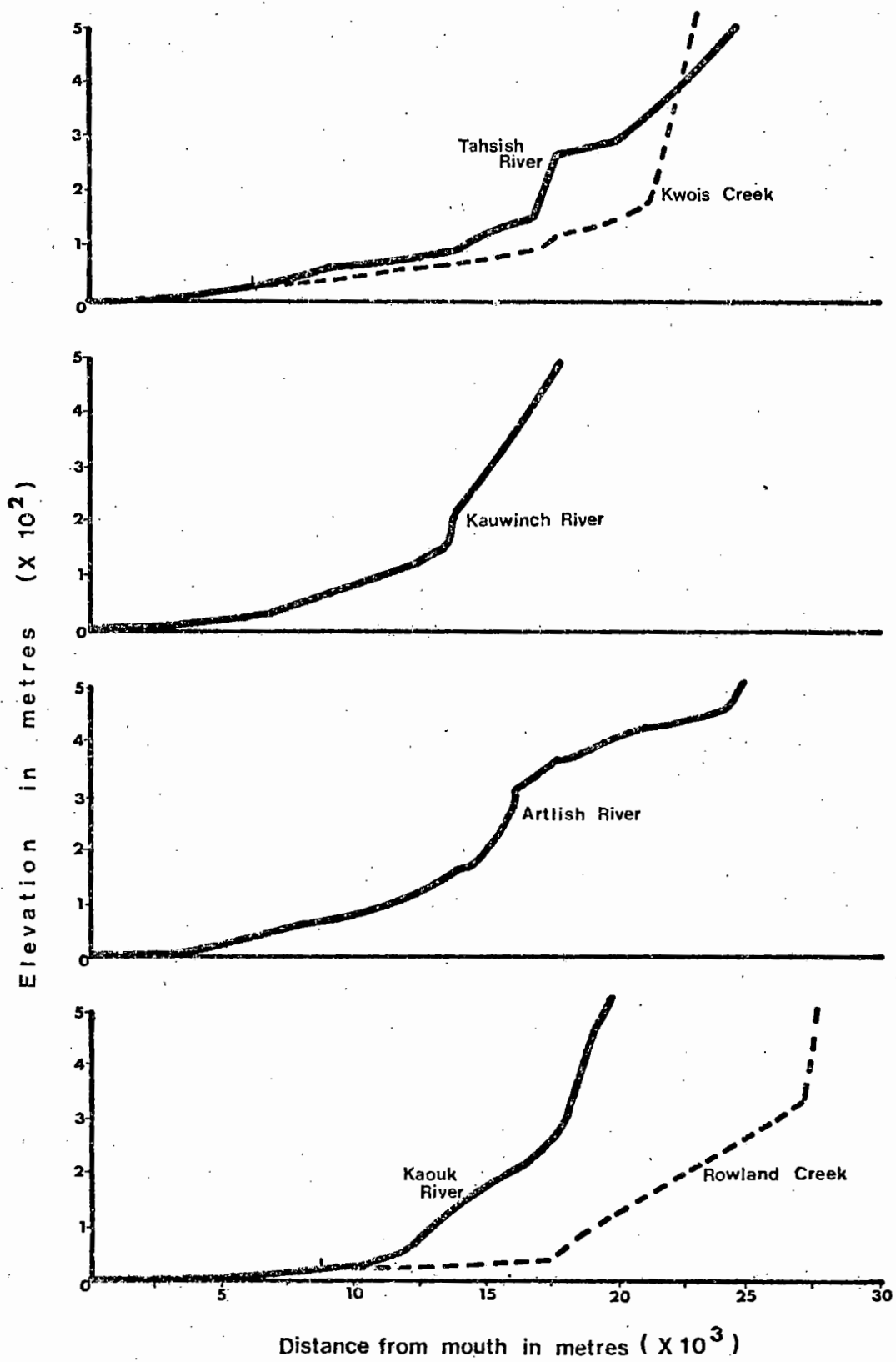
stations will therefore more likely represent the situation within Kyuquot Sound. On this basis, it is estimated that total precipitation in the lower reaches of the study area drainage basins will be in the order of 290 cm to 370 cm per year.

Temperature data were only available from the Spring Island and Port Alice stations. The data indicate a very mild climate, having an annual average of 27 - 33 days with frost. Examination of detailed monthly temperature data indicates that frosty days are well distributed throughout the winter, with a 24-hour minimum temperature of  $-12.8^{\circ}\text{C}$  at Port Alice in December. A 24-hour maximum temperature of  $34.4^{\circ}\text{C}$  was recorded at Spring Island and Port Alice during July. Temperatures in the Kyuquot study area will likely be similar to those recorded at the Spring Island and Port Alice stations.

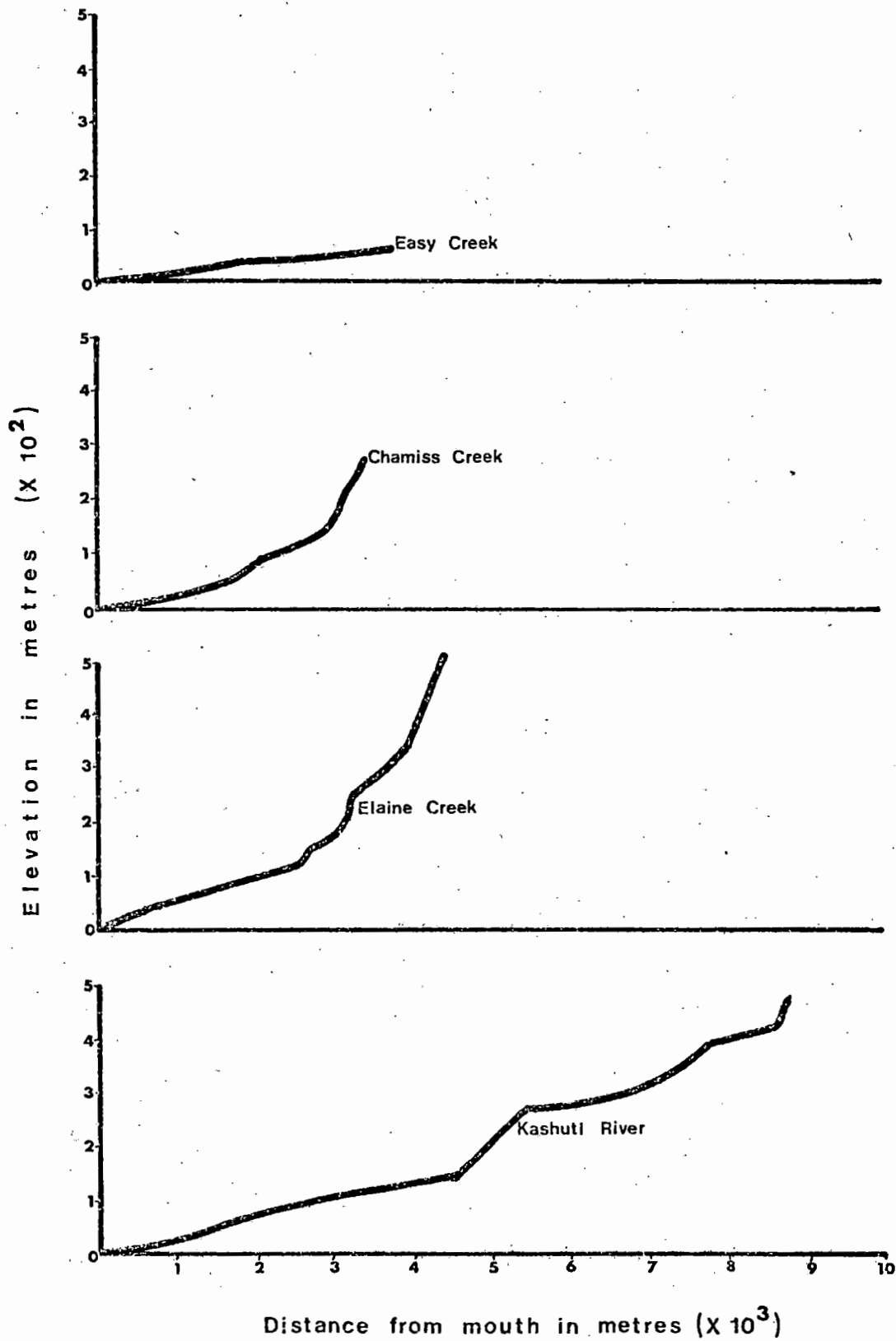
### 3.2 Hydrology

The watersheds of the thirteen study area streams range in size from  $260\text{ km}^2$  (Tahsish R.) to  $3.6\text{ km}^2$  (Jansen Ck.), and drain an overall area of  $640\text{ km}^2$ . As shown on the topographic map (Figure 3.4), most of the streams are relatively short and steep. Because of this, in all but the four largest systems the principal salmon spawning areas are confined to short sections of moderate gradient within 1.5 km of tide head. Table 3.2 presents information on the size and elevation of each stream system, and Figures 3.5.1 - 3.5.3 depict stream gradient profiles up to approximately 500 m.

FIG: 3.5.1 Gradient profiles of Kyuquot Sound streams.



**FIG: 3.5.2** Gradient profiles of Kyuquot Sound streams.



**FIG: 3.5.3** Gradient profiles of Kyuquot Sound streams.

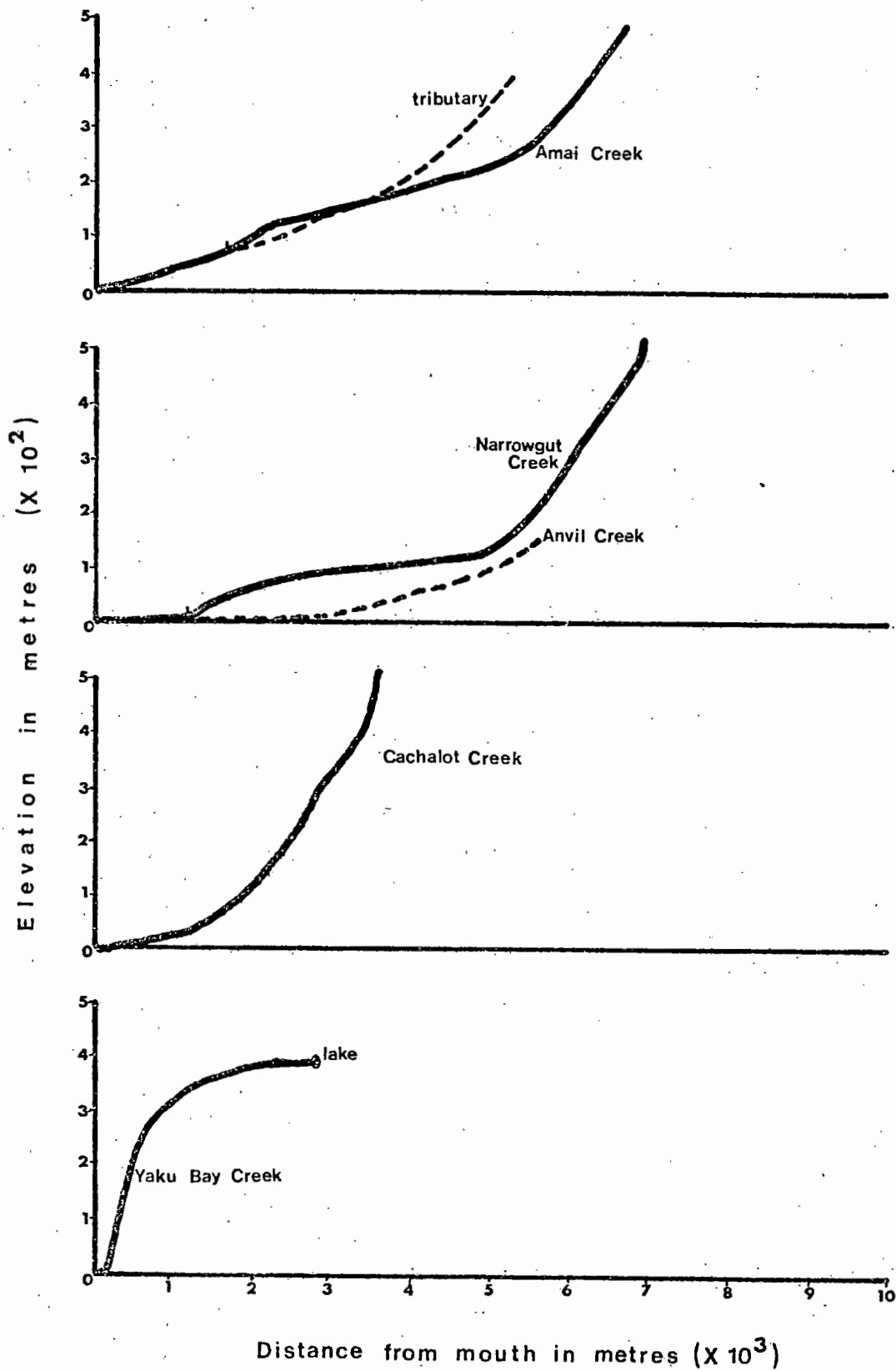


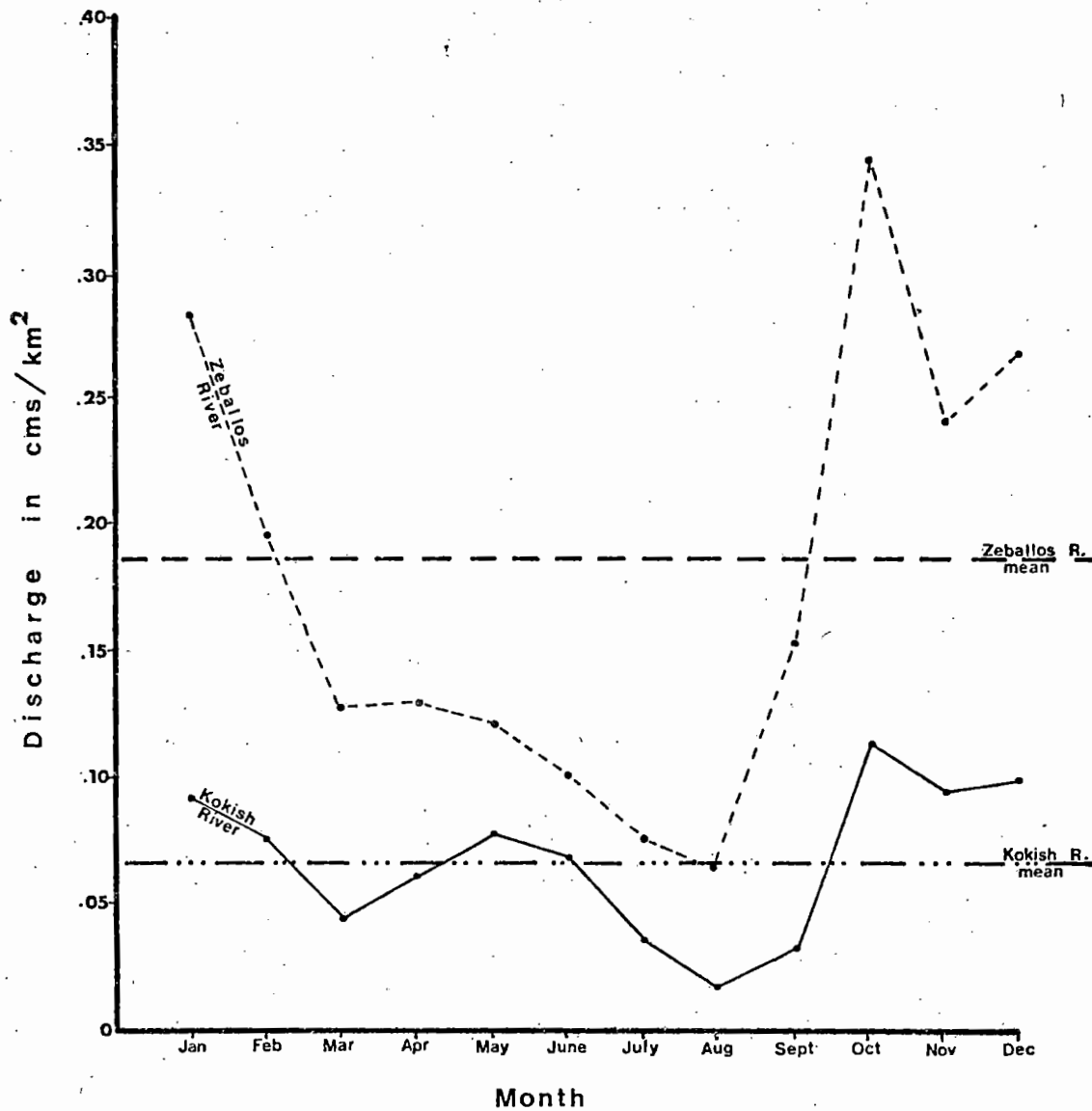
TABLE 3.2 LISTING OF DRAINAGE AREAS, LENGTHS AND SOURCE ELEVATIONS OF KYUQUOT SOUND STREAMS.

STREAM	DRAINAGE AREA (km <sup>2</sup> )	MAIN STREAM MEANDER LENGTH (km)	ESTIMATED ELEVATION AT SOURCE (m)
Tahsish R.	259.5	27.5	640
Kaouk R.	102.3	21.0	1130
Artlish R.	95.8	25.5	1190
Kauwinch R.	73.8	17.5	580
Narrowgut Ck.	25.9	7.5	670
Kashutl R.	25.4	10.0	760
Amai Ck.	13.7	6.5	460
Easy Ck.	11.9	4.0	60
Chamiss Ck.	8.8	3.8	520
Cachalot Ck.	7.0	3.8	610
Yaku Bay Ck.	6.5	3.0	400
Elaine Ck.	6.2	5.0	610
Jansen Ck.	3.6	0.2	<30

Due to the steep topography of the drainage basins, the time lag between precipitation and runoff can be expected to be short. In the absence of a prolonged dry season the water table should generally be high, and thus most precipitation would contribute to surface runoff. Conditions at Kyuquot are probably comparable to those in the Carnation Creek watershed, a west coast of Vancouver Island stream flowing into Barkley Sound, where Scrivener (1975) observed that 92% of the precipitation resulted in surface runoff. He estimated evapotranspiration from the Carnation Creek watershed at only 8% on an annual basis, much lower than levels reported for streams in other areas of North America.

As no discharge records are available for streams in the study area, estimation of their discharge regimes necessitates extrapolation of data from the Zeballos River, an adjacent watershed. This river drains the area adjacent to headwaters of two study area systems, the Artlish and Kaouk rivers (Figure 3.3). The discharge per area from the Zeballos watershed (shown in Table 3.3 and Figure 3.6) can be used to estimate approximate discharge of similar study area streams. Such estimates must be used with caution, however, because even watersheds in close proximity can receive different amounts of precipitation, and may differ with respect to a variety of factors, such as elevation, slope, infiltration rates, and orientation of the basin. These factors may influence the magnitude and seasonal pattern of surface runoff.

**FIG: 3.6** Comparison of mean monthly discharges in west coast (Zeballos) and east coast (Kokish) of Vancouver Island rivers located near the study area, expressed on a per area of watershed basis.



source: Inland Waters Directorate  
Historical Streamflow Summary, 1974

TABLE 3.3 COMPARATIVE DISCHARGES AND PHYSICAL FEATURES OF A WEST COAST (ZEBALLOS) AND AN EAST COAST (KOKISH) RIVER SYSTEM SITUATED NEAR THE KYUQUOT STUDY AREA.<sup>2</sup>

	<u>ZEBALLOS RIVER</u>	<u>KOKISH RIVER</u>
Drainage Area (km <sup>2</sup> )	181	269
Mainstem Source Elevation (m)	970	1310
Stream Length (km) (including major tributary)	32.5	44
Average Gradient (%)	5.9	4.7
Mean Annual Discharge (cms) <sup>1</sup>	33.9	18.1
Mean Annual Discharge per unit of Drainage Area (cms/km <sup>2</sup> )	0.19	0.07

<sup>1</sup> cms = cubic metres per second

<sup>2</sup> Discharge data from Inland Waters Directorate, Historical Stream Flow Summary, British Columbia, 1974.

Given the relatively steep topography and high rainfall in watersheds of the study area, stream flow regimes will be characterized by extreme fluctuations relative to other areas, such as the streams draining to the east coast of Vancouver Island. It is therefore useful to compare the flow regime of the Kokish River, an east coast stream of similar size, with headwaters only 19 km northeast of the Zeballos system. Table 3.3 lists several features of these two river systems, and Figure 3.6 compares their mean monthly discharges, expressed on a per area of watershed basis. The conclusions drawn from

this comparison can be briefly summarized as follows:

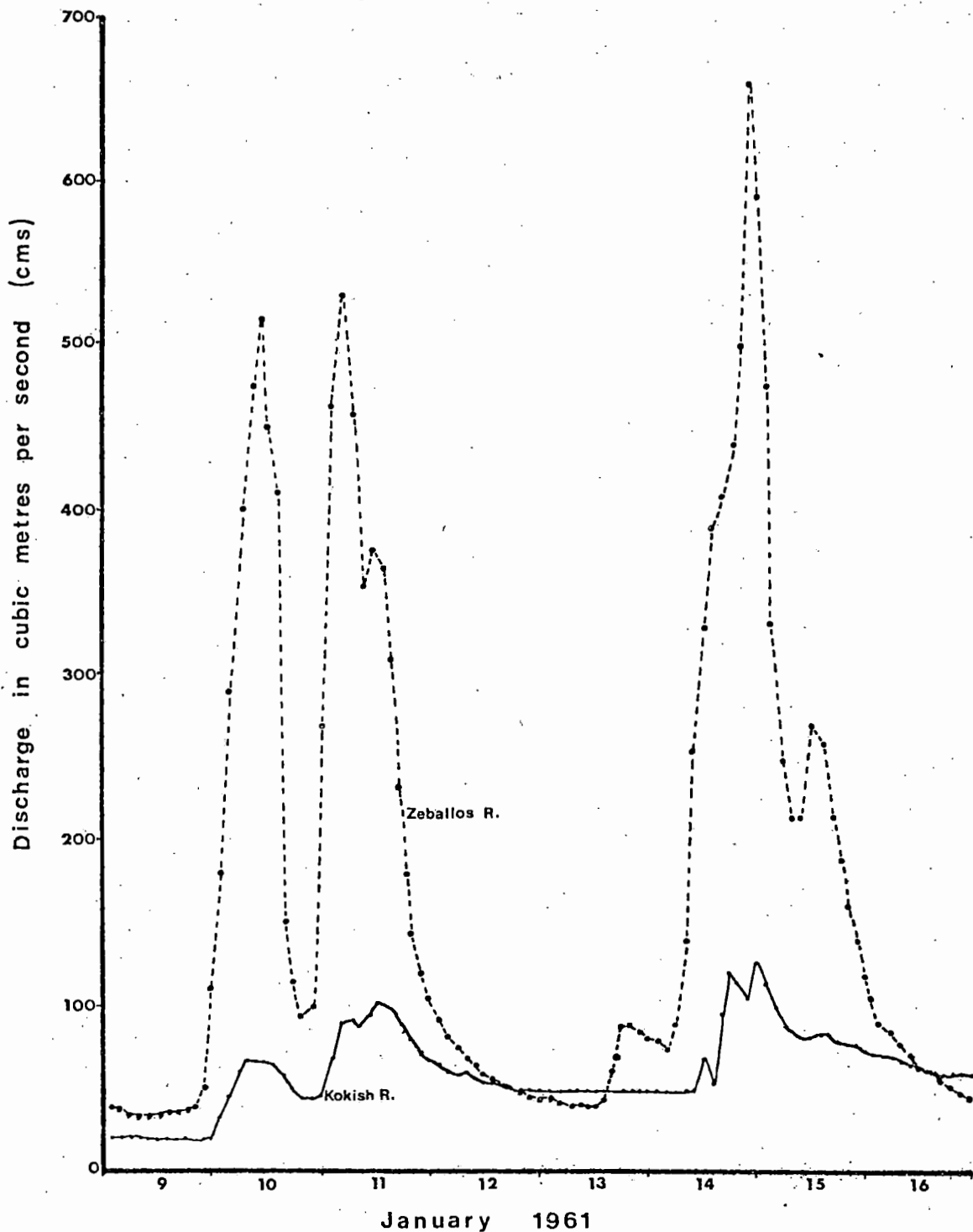
1. mean annual discharge per area of watershed is 2.8 times greater from the west coast system;
2. discharge maxima and minima occur in the same months;
3. snow melt during the April to June period has much greater influence on the east coast river regime.

The relative tendency of these two river systems to produce extreme high instantaneous discharges, which may affect salmon egg-to-fry survival, was determined from charts of continuous water level recorders operating coincidentally on the Zeballos and Kokish from 1960 to 1964. Plots of discharge at two-hour intervals during seven major storms were analyzed to determine the comparative response of each river system. The analysis indicated that discharge fluctuations were much more extreme in the Zeballos River. The ratio of the instantaneous peak flow to the pre-freshet base flow for each storm averaged (geometric mean) 21.3 on the Zeballos River, compared to 8.8 on the Kokish River. Figure 3.7 depicts this relationship.

These observed differences between the two rivers are probably due to (1) greater intensity of rainfall on the Zeballos watershed, and (2) the dampening effect of natural storage provided by Bonanza Lake, situated on the south branch of the Kokish River.

**FIG: 3.7**

Comparison of discharge fluctuations during two storm periods, January 9-16, 1961 in west coast (Zeballos) and east coast (Kokish) of Vancouver Island rivers located near the study area.



sources: Inland Waters Directorate  
BC Hydro & Power Authority

### 3.3 Forest Resources

The Kyuquot study area is part of the Coastal Western Hemlock biogeoclimatic zone (Krajina, 1970). The major marketable species in the area are western hemlock, (Tsuga heterophylla), amabilis fir, (Abies amabilis), Douglas fir (Pseudotsuga menziesii), and western red cedar, (Thuja plicata). A detailed distribution of tree species is available on forest cover maps (scale: 1 in. = 20 chains) prepared by the B.C. Forest Service. In addition to species composition, information on the age and height of timber stands are indicated as well as logging and replanting histories.

The forest lands in the Kyuquot study area are part of the Nootka Public Sustained Yield Unit. A public sustained yield unit (P.S.Y.U.) consists of crown lands managed according to the growth capacity of the area. Crown timber in the P.S.Y.U. is generally disposed of by timber sale licenses or timber sale harvesting licenses. Both types of licenses are held in the Kyuquot area and established licensees include Tahsis Company Ltd., Canadian Forest Products Ltd., MacMillan Bloedel Ltd., and Crown Zellerbach Canada Ltd., as well as a number of hand loggers.

Large-scale logging of Kyuquot Sound watersheds began in 1960. Prior to this, logging was confined to the sea coast, and had not penetrated into the river valleys. Figure 3.8 shows the status of logging in the study area to 1975, and sites proposed for logging in the 1976 - 1980 period. It should be noted that logging activity is shown for the thirteen study area watersheds only.

Figure 3.8

LOGGING AREAS IN KYUQUOT SOUND WATERSHEDS

TABLE 3.4 EXTENT OF LOGGING AND PROPOSED LOGGING ACTIVITY  
 IN KYUQUOT SOUND WATERSHEDS, SHOWN AS A PERCENTAGE  
 OF THE WATERSHED AREA.

	PERCENTAGE OF WATERSHED LOGGED TO 1975	PERCENTAGE OF WATERSHED PROPOSED FOR LOGGING (1976 - 1980)
Tahsish R.	5	<5
Kaouk R.	30	5
Artlish R.	<5	10
Kauwinch R.	15	<5
Narrowgut Ck.	5	0
Kashutl R.	0	10
Amai Ck.	30	0
Easy Ck.	25	5
Chamiss Ck.	45	5
Cachalot Ck.	0	0
Yaku Bay Ck.	0	0
Elaine Ck.	15	30
Jansen Lake Ck.	10	0

The information on logged areas shown in Figure 3.8 has been derived from updated forest cover maps made available for review by the B.C. Forest Service. Proposed logging areas are based on harvesting and road development plans submitted to the Forest Service by the licensees as a requirement of their Timber Sale Harvesting License (T.S.H.L.) and/or timber licenses. It should be noted, however, that the map does not necessarily include all logging activity to be

undertaken in the 5-year period, 1976-1980. Companies holding timber licenses which were inactive at the time of this review, may submit logging plans prior to 1980.

The following section provides a brief description of logging activities in each watershed. Table 3.4 shows the percentage of each watershed which has either been logged or will be logged in 1976 - 1980, according to plans submitted to date.

### 3.3.1 Tahsish River

Logging activity in the Tahsish watershed has been concentrated in the upper reaches. Major operations in this area were conducted by Canadian Forest Products from 1963 to 1969, and much of the area was replanted in the 1970's. Logging plans for the Tahsish watershed show future activity in the headwaters of the north fork during the period 1976 to 1980.

Although MacMillan Bloedel holds timber licenses in the lower valley and along Kwois Creek, a logging plan for this area is not available. Contact with the company indicated, however, that the area is being considered for logging as early as 1978, but that the decision to proceed will depend on the resource folio requirements of the Forest Service and on market conditions.

### 3.3.2 Kaouk River

The road along the Kaouk River was built in 1958 and Tahsis Company started operations there in 1960. Logging was extensive along the lower river, including the two major tributaries, Rowland Creek and a south branch which enters about 5 km from the river mouth. The logging camp at Fair Harbour, which was active in the 1960's, was abandoned in 1970 upon completion of the road to Zeballos, the site of a larger camp. The upper watershed is presently being logged, and Tahsis Company has developed a 5-year plan for the headwater area.

### 3.3.3 Artlish River

Only a small portion of the Artlish watershed has been logged to date. Logging operations began in the extreme headwaters in 1971, and a 5-year plan by Canadian Forest Products shows further logging in the upper watershed. Although, Crown Zellerbach holds timber licenses in the lower Artlish system, there is no road access or logging activity in this area. With respect to future plans for the lower Artlish, contact with Crown Zellerbach indicated that although some logging in the area had been considered for 1979, logging plans have been postponed indefinitely for economic reasons.

### 3.3.4 Kauwinch River

The Kauwinch River watershed was extensively logged from 1968 to 1972 and the timber licenses held by Tahsis Company have reverted to the Crown. Although there is no present logging activity in the system, a proposal by Crown Zellerbach to log a section in the lower valley has recently been approved.

### 3.3.5 Kashutl River

The Kashutl River has not been logged to date. However, road construction in preparation for logging began in 1975. Logging plans for the Kashutl, which will involve about 10 percent of the watershed, have been submitted by Tahsis Company.

### 3.3.6 Chamiss, Jansen, Easy and Elaine Creeks

Two logging camps are presently active on the west side of Kyuquot Sound at Chamiss Bay, and at East Bay near Jansen Lake. Of the watersheds in this area, Chamiss Creek has been logged most extensively. Logging operations in that system began prior to the 1960's, but the major portion was logged between 1964 and 1967. A small area near the headwaters is scheduled for logging in 1977.

The Jansen Lake watershed has also been heavily logged along the periphery of the lake. Operations began there in the 1950's, but the west shore of the lake was logged as recently as 1974.

Logging of the Elaine Creek watershed has been limited to the lower valley, which was logged in the early 1960's. Several areas in the upper watershed are proposed logging sites in 1976 to 1980.

Most logging in the Easy Creek watershed area took place in the 1970's and was concentrated in the headwaters and middle reaches. Two small headwater sites have been proposed for future operations.

### 3.3.7 Narrowgut, Amai and Cachalot Creeks

There is no major logging operation in these three watersheds at the present time. Both the Narrowgut and Amai creek watersheds have been logged, but the only activity in these areas at present is a small-scale operation by an independent logger stationed at Fair Harbour.

Logging operations in the Amai watershed began in 1961. Logging activity shifted from the lower valley during 1963 to 1965 to the upper valley during 1966 to 1969. The logging contractor left the area in 1972 and the camp at Amai Inlet and the associated roads were abandoned.

The Narrowgut watershed has not been as extensively logged as Amai Creek. The logging which took place in the early 1960's, was restricted to the lower valley. Cachalot Creek remains unlogged.

### 3.4 Marine Environment

Kyuquot Sound is a deep, sheltered body of water, protected from severe Pacific storms by the islands at its entrance (Figure 3.4). Within the Sound there are two major inlets, Tahsish and Kashutl, with respective lengths of 11 km and 13 km, plus four smaller inlets. Except in the vicinity of stream mouths, the shoreline and bottom morphometry of the Sound is very steep.

The Sound has a maximum depth of 265 m. In common with other west coast of Vancouver Island inlets, Kyuquot Sound has a shallow sill, approximately 60 m in depth, at its entrance. This sill restricts the circulation and replacement of the deeper water within the Sound (Pickard, 1963).

A limited oceanographic survey of the Sound, carried out in May, 1959 by the University of British Columbia (Institute of Oceanography), indicated that surface salinities at that time of year were reasonably uniform throughout, measuring about 29 parts per thousand, except at the heads of inlets, in the vicinity of stream mouths.

#### 4.0 THE SALMONID RESOURCE

##### 4.1 Salmon

The study area supports populations of five Pacific salmon species: chum (Oncorhynchus keta), pink (O. gorbuscha), chinook (O. tshawytscha), coho (O. kisutch), and sockeye (O. nerka). This section of the report summarizes available information on each species. Fisheries and Marine Service (Dept. of Fisheries and the Environment) records were the major source of information. These were supplemented by one aerial reconnaissance and three ground surveys of salmon spawning streams by Envirocon staff in October and November, 1976.

#### 4.1.1 Escapements

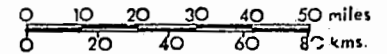
Records of salmon escapements to the Kyuquot Sound streams are available from spawning survey reports prepared each year by the fishery officer responsible for Statistical Area 26. The boundaries of Area 26 and other fisheries statistical areas in southern British Columbia are shown in Figure 4.1. In addition to the report for each salmon stream on the coast, the fishery officer for each statistical area summarizes statistics and comments generally on salmon runs and fisheries in an annual Area History.

At Kyuquot, as in most other areas of British Columbia, spawning escapement estimates are derived visually from either aircraft, boat or foot surveys. Visual estimates are acknowledged to have limitations, in that their accuracy may vary in relation to stream accessibility, water conditions, frequency of observation, and the observer. These problems must be considered in any data analysis, and particularly when comparing salmon production from different areas in absolute terms. However, within a given statistical area, escapement data should provide indices of relative abundance over time.

It should be noted that the study area (those streams which drain into Kyuquot Sound) includes only 13 of the 20 salmon streams in Statistical Area 26. Although this report will emphasize streams within the study area, salmon escapements to the total area will also be treated, particularly in Section 6.0 which deals with catch and escapement trends.

FIG: 4.1

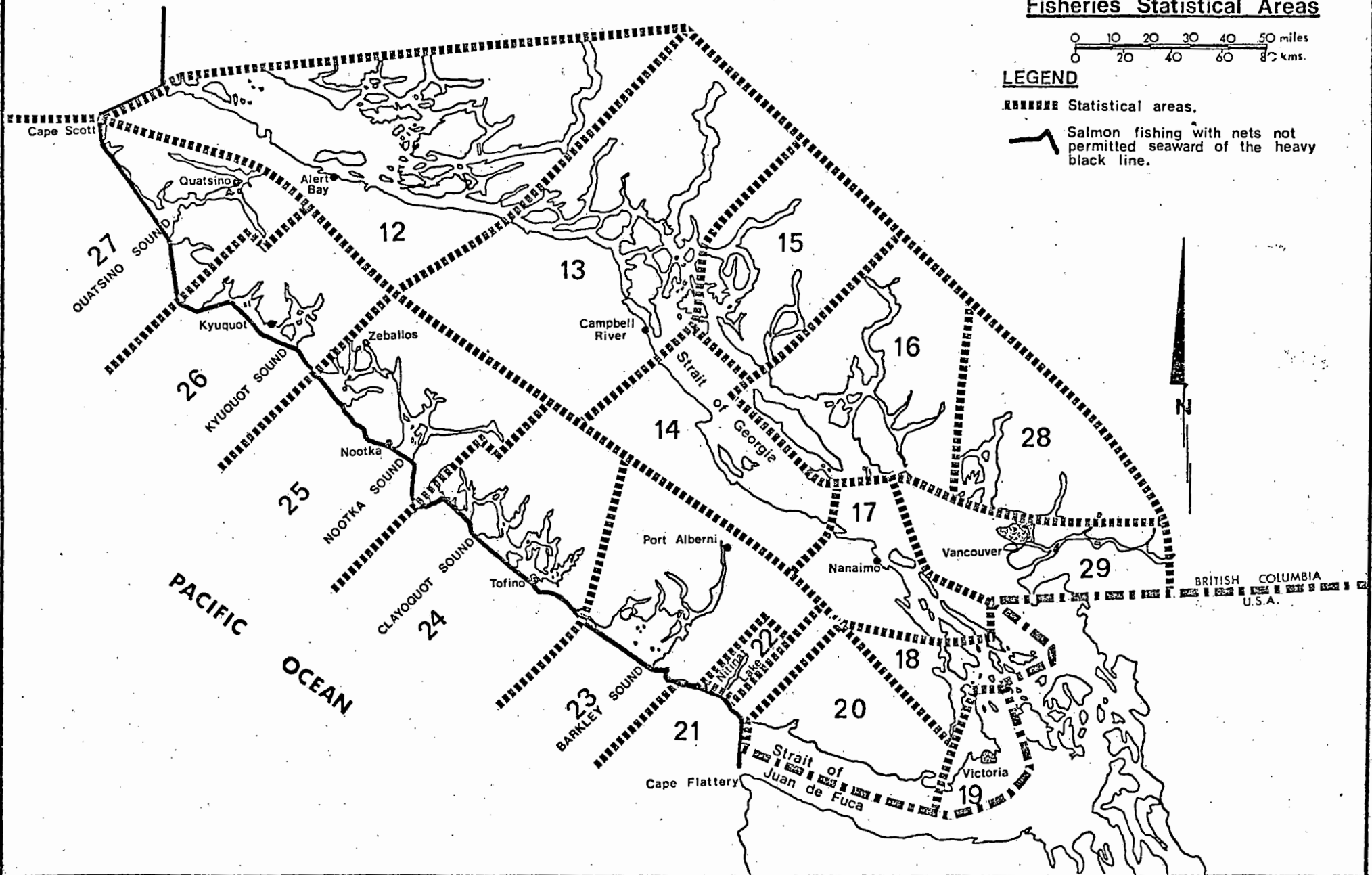
**Southern British Columbia Fisheries Statistical Areas**



**LEGEND**

----- Statistical areas.

— Salmon fishing with nets not permitted seaward of the heavy black line.



Escapement data for the period 1951 to 1975 are reviewed in this section. A detailed breakdown of study area escapement data by year, species and stream is presented in Appendices A-D.

### Chum Salmon

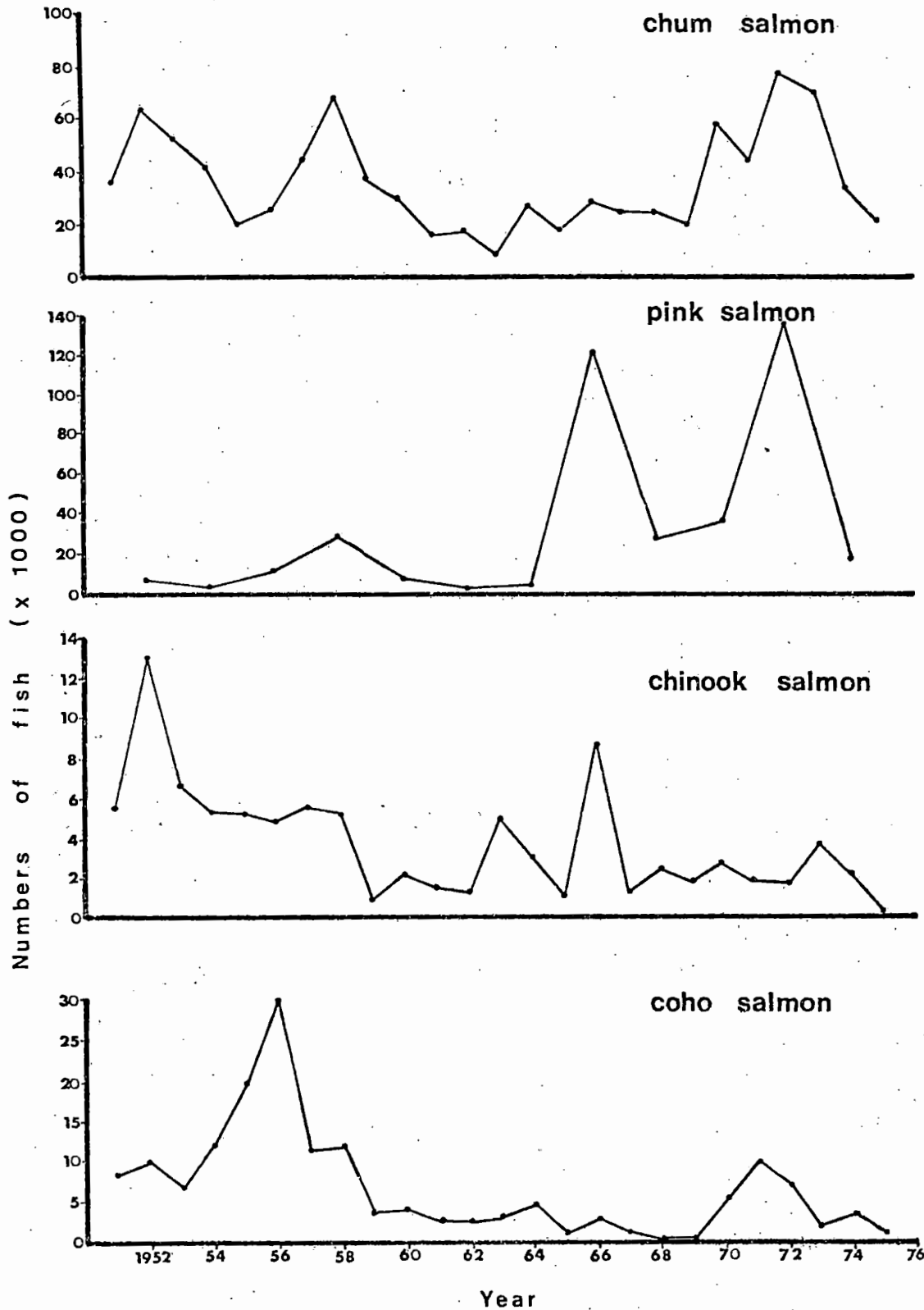
Chum salmon are the most abundant salmon species, utilizing all streams in the study area. Fluctuations in total chum escapements to the area during the 1951 to 1975 period are plotted in Figure 4.2. The average and extreme escapements to individual streams in that same period are presented in Table 4.1.

Escapements to the major chum salmon producers in the study area have all fluctuated in a similar manner, declining in the late 1950's, and returning to relatively high levels in the early 1970's (Figure 4.2).

Based on escapements, the most productive chum salmon streams in the study area have been the Tahsish, Chamiss, Kashutl, Kauwinch and Kaouk. The Tahsish River, the largest stream in the area, has received the highest average escapement. However, the second highest average escapement has been to Chamiss Creek, a small stream compared to the Tahsish (Table 3.2).

The Kashutl River has also received relatively good escapements for its size, contrasting markedly with the rather low escapements to the much larger Artlish River.

**FIG: 4.2** Estimated escapements of chum, pink, chinook and coho salmon to Kyuquot Sound study area streams, 1951 - 1975.



source: Fisheries and Marine Service Spawning Survey Reports

envirocon

TABLE 4.1 ESTIMATED CHUM SALMON ESCAPEMENTS TO KYUQUOT SOUND STREAMS DURING THE 1951 - 1975 PERIOD, WITH STREAMS RANKED IN ORDER OF WATERSHED SIZE.

STREAM	ESCAPEMENT		
	Average	Minimum	Maximum
Tahsish R.	9,100	3,500	31,000
Kaouk R.	3,200	75	15,000
Artlish R.	1,400	75	5,500
Kauwinch R.	3,600	400	13,000
Narrowgut Ck.	2,300	75	7,500
Kashuti R.	3,600	400	7,500
Amai Ck.	2,000	75	7,500
Easy Ck.	2,000	75	7,500
Chamiss Ck.	6,900	400	20,000
Cachalot Ck. <sup>1</sup>	650	25	2,000
Yaku Bay Ck. <sup>1</sup>	300	n/o <sup>2</sup>	1,600
Elaine Ck.	500	25	1,500
Jansen Ck.	100	n/o	3,500

<sup>1</sup> Escapement data available only since 1957

<sup>2</sup> No fish observed

TABLE 4.2 CHUM SALMON ESCAPEMENTS TO KYUQUOT SOUND STREAMS, COMPARED ON THE BASIS OF WATERSHED SIZE AND STREAM LENGTH UTILIZED.

STREAMS	WATERSHED AREA	AVERAGE ESCAPEMENT (1951-1975)	AVERAGE STREAM LENGTH UTILIZED	AVERAGE ESCAPEMENT PER STREAM LENGTH
Tahsish, Kaouk, Artlish and Kauwinch rivers	73.8 - 259.5 km <sup>2</sup>	4325	5.6 km	772/km
Narrowgut Ck. and Kashutl R.	25.4 and 25.9 km <sup>2</sup>	2950	1.8 km	1639/km
Amai, Easy, Chamiss, Cachalot, Yaku Bay, Elaine and Jansen creeks	3.6 - 13.7 km <sup>2</sup>	1779	1.0 km	1779/km

In general, smaller systems have received chum escapements either equal to or greater than the larger systems, based on the length of stream utilized (Table 4.2). Unfortunately, no accurate estimates of spawning area are available. Had spawning area rather than stream length been used as the basis for comparison, the discrepancy between the larger and smaller systems would have been much greater.

These differences in the escapements to larger versus smaller stream systems in the study area indicate differences in the productivity (return per spawner) of stocks perhaps related to conditions in freshwater, eg. stream flow stability (see Section 7.1.1), or estuarial conditions which might affect

marine survival. It is also possible that the differences in escapement levels reflect differential exploitation by the commercial net fishery.

### Pink Salmon

Pink salmon have a strict two-year life cycle, and depending on the geographic area, either an even-year or odd-year cycle dominates. In the Kyuquot area, pink salmon return in the even years. A total of 13 streams in Area 26 are steady producers of pink salmon, including the six largest streams in the study area (Tahsish, Kaouk, Artlish, Kauwinch, Narrowgut and Kashutl). Escapements to these six study area streams are summarized in Table 4.3 for the period 1952 to 1974. Fluctuations in total escapements to Kyuquot Sound streams during the same period are shown in Figure 4.2.

The Kaouk and Kauwinch Rivers have experienced the largest escapements with maximum returns of 75,000 and 100,000 fish respectively. In the last decade, escapements to these streams have increased significantly over the levels observed in the previous decade (Figure 4.2).

In the peak years of 1966 and 1972, escapements to the study area were concentrated in the Kaouk and Kauwinch Rivers. In 1966, for example, the Kauwinch River received over 80 percent of the total escapement. In 1972, 98 percent of the escapement was observed in the Kaouk and Kauwinch rivers.

Pink salmon escapements to the other study area streams have been insignificant compared to those in the Kaouk and Kauwinch, ranging from an average of 3500 in Narrowgut Creek to an

Figure 4.3

PINK AND CHUM SALMON SPAWNING DISTRIBUTION IN  
KYUQUOT SOUND STREAMS

TABLE 4.3 ESTIMATED PINK SALMON ESCAPEMENTS TO KYUQUOT SOUND STREAMS DURING THE 1952 - 1974 period, WITH STREAMS RANKED IN ORDER OF WATERSHED SIZE<sup>2</sup>.

STREAM	ESCAPEMENT		
	Average	Minimum	Maximum
Tahsish R.	1,500	n/o <sup>1</sup>	3,500
Kaouk R.	11,000	400	75,000
Artlish R.	300	n/o	750
Kauwinch R.	18,000	n/o	100,000
Narrowgut Ck.	3,500	25	15,000
Kashutl R.	300	75	750

<sup>1</sup> No fish observed.

<sup>2</sup> Includes only those study area streams in which pink salmon were observed in most cycle years.

average of only 300 spawners in the Kashutl and Artlish Rivers. The escapements to the Tahsish and Artlish are surprisingly low, considering the available spawning area.

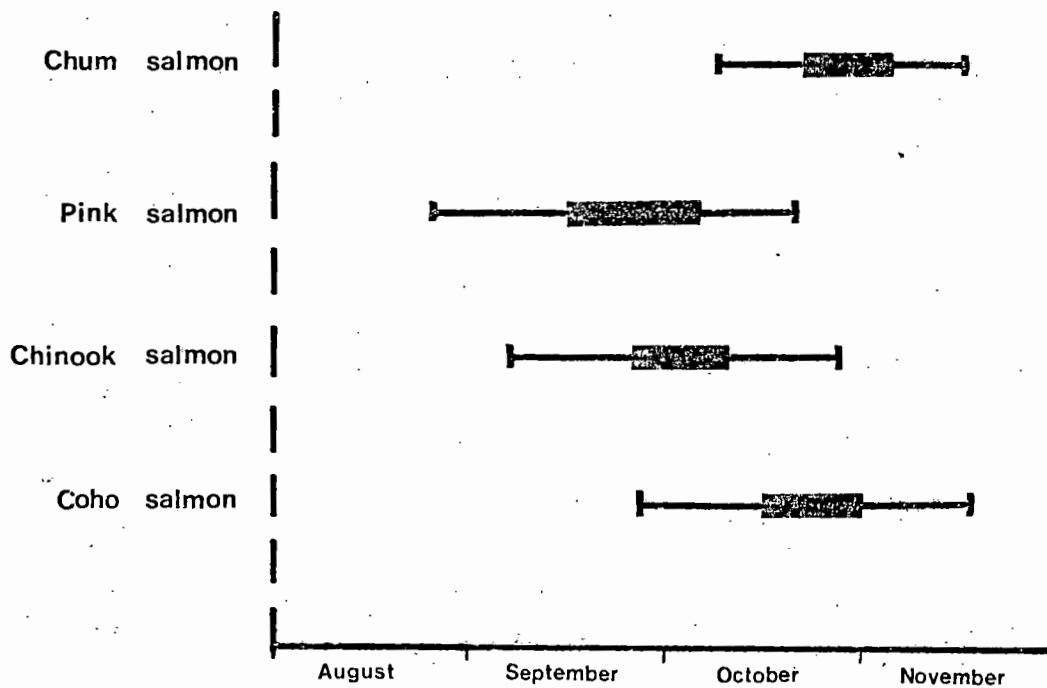
#### Chinook Salmon

Only the four largest streams in Kyuquot Sound, the Tahsish, Kaouk, Artlish and Kauwinch rivers, support chinook salmon in any significant number. Escapement statistics for these streams are presented in Table 4.4. The Tahsish River has received the largest chinook escapement, averaging 2,000 fish during the 1951 to 1975 period. The three remaining

**FIG: 4.4** Generalized graph of salmon spawning timing\* in Kyuquot study area streams.

**LEGEND**

- range in peak spawning timing
- represents 25 to 75 percent of spawning



\* Data on sockeye salmon spawning not available

SOURCE: Fisheries and Marine Service  
Spawning Survey Reports

TABLE 4.4 ESTIMATED CHINOOK SALMON ESCAPEMENTS TO KYUQUOT SOUND STREAMS DURING THE 1951 - 1975 PERIOD.

STREAM	ESCAPEMENT		
	Average	Minimum	Maximum
Tahsish R.	2,000	25	7,500
Kaouk R.	700	75	3,500
Artlish R.	800	25	3,500
Kauwinch R.	200	n/o <sup>1</sup>	750

<sup>1</sup> No fish observed.

streams averaged less than 1,000 spawners during the same period. Chinook salmon also spawn in other Kyuquot Sound streams, but they are not observed every year and their numbers generally do not exceed 25 fish in any given year.

Over the period 1951 to 1975, it is apparent that chinook escapements to study area streams have declined (Figure 4.2).

TABLE 4.5 ESTIMATED COHO SALMON ESCAPEMENTS TO KYUQUOT SOUND STREAMS DURING THE 1951 - 1975 PERIOD, WITH STREAMS RANKED IN ORDER OF WATERSHED SIZE.

STREAM	ESCAPEMENT		
	Average	Minimum	Maximum
Tahsish R.	1,800	25	7,500
Kaouk R.	1,000	25	3,500
Artlish R.	1,200	25	7,500
Kauwinch R.	550	25	1,500
Narrowgut Ck.	300	n/o <sup>1</sup>	750
Kashutl R.	350	n/o	1,500
Amai Ck.	300	n/o	1,500
Easy Ck.	300	n/o	1,500
Chamiss Ck.	250	n/o	1,500
Elaine Ck.	100	n/o	400
Jansen Ck.	600	n/o	3,500

<sup>1</sup> No fish observed.

#### Coho Salmon

Coho salmon escapements have been reported for eleven of the thirteen streams in Kyuquot Sound. Based on the estimates, the four largest watersheds, the Tahsish, Kaouk, Artlish and Kauwinch, support the largest coho salmon populations (Table 4.5). Relative to total Area 26 escapements of coho salmon, Kyuquot Sound streams receive on the average almost 70 percent of the total.

The general trend in coho escapements is shown in Figure 4.2. Since the early 1950's escapements have declined, with some improvement apparent in the early 1970's.

Although the number of coho spawners is estimated annually by the fishery officer, it should be noted that the estimates for this species are probably less reliable than for the other species, at least in absolute terms. This is because coho spawning is widely distributed in each river system, it is spread over a relatively long time period, and it occurs in late fall and early winter, when discharge conditions are least suitable for observation.

#### Sockeye Salmon

Although small numbers of sockeye salmon are observed each year in all the larger streams of the study area, only the Jansen Creek system (including Jansen Lake) supports any significant numbers. Sockeye escapements to Jansen Lake from 1951 to 1975 averaged 2250 fish, and reached an estimated maximum of 3500 fish.

Until the 1970's the Jansen Lake escapement was relatively consistent in numbers, but during the years 1970 to 1974 no spawners were observed. This may be due to the fact that the Jansen Lake population has in recent years experienced difficulty in gaining access to the lake (R.A. Slater, pers. comm.). The lake outlet is relatively steep, and is only passable for salmon at high water levels. A log jam at the lake outlet has also impeded access in recent years.

#### 4.1.2 Spawning Distribution

The distribution of salmon spawning in study area streams is briefly described in this section, with emphasis on the major systems. This description is based on a review of Fisheries and Marine Service spawning survey reports, and on field observations made by Envirocon staff in October and November, 1976. The latter are summarized in Appendices E and F.

Pink and chum salmon spawning distribution is shown on a map of study area streams (Figure 4.3). Recorded data on chinook and coho salmon spawning distribution are too limited for any comprehensive mapping. As the only significant population of sockeye salmon spawns in tributaries to Jansen Lake, that species will not be discussed in the following section.

##### Tahsish River

Spawning of chum, chinook and pink salmon is restricted to the lower 6 km of river, between the river mouth and a canyon which extends for 3 km above the confluence of the Tahsish River and Kwois Creek (Figure 4.3). In November, 1976 coho salmon spawning was observed in the lower 6 km of river, and also in the main river canyon, up to 1 km above the confluence with Kwois Creek. Coho were also observed spawning in Kwois Creek to a point about  $\frac{1}{2}$  km above its mouth.

A series of falls within the canyon of the Tahsish are reported to be impassable to adult salmon (R.A. Slater, pers. comm.). No salmon spawning has ever been observed upstream of the canyon by Fisheries and Marine Service staff, and limited observations in that area by Envirocon staff on November 7, 1976 also failed to reveal any salmon spawning.

The study team of Envirocon staff surveyed the Tahsish between the lower canyon and the mouth on October 15 and November 3, 1976 to document spawning distribution. Spawner counts were recorded for two sections, respectively 1-3 km and 3-6 km upstream of the mouth. Chinook and chum salmon were distributed throughout the 6 km of river, with the majority of chinook (67%) and chum (84%) spawners observed in the lower 3 km. Some chum salmon spawners utilized the upper part of the intertidal area. A small number of pink salmon spawners (43) was observed on October 15 in the lower 3 km of river.

#### Kaouk River

On the Kaouk River, salmon spawning takes place from the upper intertidal zone to an impassable falls 17 km from the mouth. Most spawning of pink, chum and chinook takes place in the lower 12 km of river, downstream of the Zeballos - Fair Harbour road crossing.

TABLE 4.6 COMPARATIVE DISTRIBUTION OF PINK AND CHUM SALMON SPAWNERS AT RESPECTIVE PEAKS OF SPAWNING IN THE KAOUK RIVER DURING 1976.

Distance upstream from river mouth	PERCENT OBSERVED	
	Pink Salmon	Chum Salmon
0 - 5.5 km	46.4	9.3
5.5 km - 9 km	44.9	88.0
9 km - 12 km	8.7	2.7
TOTAL NO. OBSERVED	25,602	2,202

The study team surveyed the lower 12 km of river on October 1 and November 2, dates which were judged to be close to the respective peaks of spawning for pink and chum salmon. The spawner counts, which were recorded by stream section, indicated that the two species differed in distribution (Table 4.6). The major portion (88%) of the relatively small chum population was observed in the middle section, 5.5 km to 9 km above the mouth, whereas the pink population was evenly distributed between the middle and lower sections. Apparently chum salmon preferred the noticeably higher gradient of the middle section of river. Even within the same section, it was evident that chums preferred spawning sites with higher velocities than those chosen by pinks, thereby minimizing superimposition on the redds of the earlier spawning pink salmon.

On the two surveys, only 34 chinook salmon spawners were observed, all in the lower 5 km of river.

#### Kauwinch River

In the Kauwinch, salmon spawning occurs up to 9 km upstream of the mouth. The majority of pink and chum spawn in the lower 3 km. Above this point, the river flows through a steep canyon section for 3 km. Spawning area is available upstream of this canyon section, and in years of high pink salmon escapements a significant proportion of the run utilizes this upper section. Coho and chinook salmon spawning is distributed throughout the river.

Surveys were conducted by the study team on October 16 and November 5, 1976. The first survey extended to the upper end of the canyon section. Due to late timing of the surveys, no chinook salmon and only 16 pink salmon were observed. The chum salmon escapement was evidently extremely low and was concentrated in the lower 3 km of river.

#### Artlish River

Spawning survey reports indicate that spawning areas extend upstream about 10 km from the mouth of the Artlish River. Normally, pink and chum salmon utilize the lower 6 km, while chinook and coho salmon are found throughout the river.

In a survey by Envirocon staff on October 14, 1976 in the lower 6.5 km, only 1 chinook and 2 pink spawners were observed, all in the lower 2.5 km of river. Survey timing was too late to document spawning distribution of these species.

No chum salmon had entered the river at the time of the first survey. A second survey on November 4, 1976 produced a total count of 177 chum in the lower 4 km of river, of which 80% were observed between 2.5 km and 4 km from the mouth.

#### Kashutl River

This river was surveyed by the study team on October 16, 1976 to a point 2.5 km above the mouth. At 2 km from the mouth the river passes over two falls in close succession. At each point, the river passes through a very narrow gorge and drops vertically 2.5 m and 4 m respectively. The lowermost drop of 4 m, is judged to be impassable to adult salmon. Spawning gravel is limited to the lower 1.5 km of stream.

Based on a survey of a 0.5 km section upstream of the falls and observations from aircraft, the stream bottom above this point is of bouldery composition. There appears to be very little spawning potential upstream of these obstructions.

## Small Systems

In the remaining small streams of the study area, salmon access upstream is seldom more than 2 - 3 km. Generally the access and availability of spawning grounds is limited by the steep terrain.

In 1976, each stream was surveyed by Envirocon staff only once during the chum salmon spawning period. These limited observations permit only general comment on spawning distribution. The extent of spawning in each of these streams, based on fishery officer reports and 1976 field observations by the study team, is indicated in Figure 4.3.

### 4.1.3 Spawning Timing

The spawning periods of chum, pink, chinook and coho salmon in the Kyuquot study area are summarized in Figure 4.4. The information presented in this figure was obtained from Fisheries and Marine Service spawning survey reports spanning a 28-year period.

Observations by the study team in 1976 produced results which, coho salmon excepted, were consistent with the above reports. For example, pink salmon were near the peak of spawning on October 1 and had completed spawning by mid-October. Chinook salmon spawners were observed on October 1 and again in mid-October; by the latter date chinook spawning was near completion. Chum salmon had commenced spawning in some streams by mid-October, and were nearing completion of spawning in nearly all streams by the first week of November. However, in 1976 coho salmon had not commenced spawning until early November, more than a month later than is shown in Figure 4.4.

Examination of long-term records of spawning timing does not indicate between-stream differences for any salmon species. Field observations in 1976 on the four largest streams in the study area did indicate some small differences among chum salmon populations in terms of entry and spawning timing. During the period October 14 - 17, chum salmon had entered and commenced spawning in the Tahsish and Kauwinch rivers, whereas none were observed in the Artlish and Kaouk rivers at that time (Appendix E). These four streams were again surveyed in the period November 2 - 5, at which time chum spawning was near completion in the Tahsish and Kauwinch, but was either at or near the peak of activity in the Artlish and Kaouk.

The overall impression gained from the 1976 field surveys, during the period of chum salmon spawning at least, was one of a relatively uniform environment over the study area in terms of stream temperatures, and a relatively compressed and similar spawning period, i.e. mid-October to mid-November, for all chum salmon populations. However, the fact that in 1976 stream flows were exceptionally low until late October may well have delayed entry of some stocks and therefore given a false impression of their preferred spawning periods.

#### 4.2 Anadromous Trout

Two species of anadromous trout, the steelhead (Salmo gairdneri) and the coastal cutthroat (Salmo clarki clarki), are present in the study area. As there has been no inventory of freshwater fish resources in the area, information on the presence, timing and abundance of trout is based mainly on information from sport fishermen.

Summer runs of steelhead trout are known to enter the Tahsish and Artlish rivers during the May to September period (G. Reid, pers. comm.). Winter runs of steelhead, with February - March run timing, also occur in the Tahsish and Kaouk rivers (J. Vivian, pers. comm.)

During spawning ground surveys of the Artlish River in October, 1976, Envirocon staff observed an estimated 30 steelhead holding in two pools in the lower 2 km of river. These steelhead were dark in coloration, and had evidently been in freshwater for some period of time. During the same period, six steelhead were observed in the lower Kashutl River, within 1 km of tidewater. Cutthroat trout were also observed and angled near head of tide on the Kashutl River.

Steelhead trout could quite likely have been present in other streams visited by the study team, but not observed due to poor visibility.

## 5.0 THE FISHERIES

### 5.1 Commercial Fishery

The B.C. Revised Catch Statistics and the Area History reports prepared by the Fisheries and Marine Service record annually the landings by each gear type, the fishing seasons and other regulations which apply in each statistical area. Based on these sources, the 1951 to 1975 net fisheries for salmon in Statistical Area 26 (including Kyuquot Sound) are described in this section. The available data do not permit estimation of the proportion of the Area 26 salmon catch contributed by Kyuquot Sound stocks.

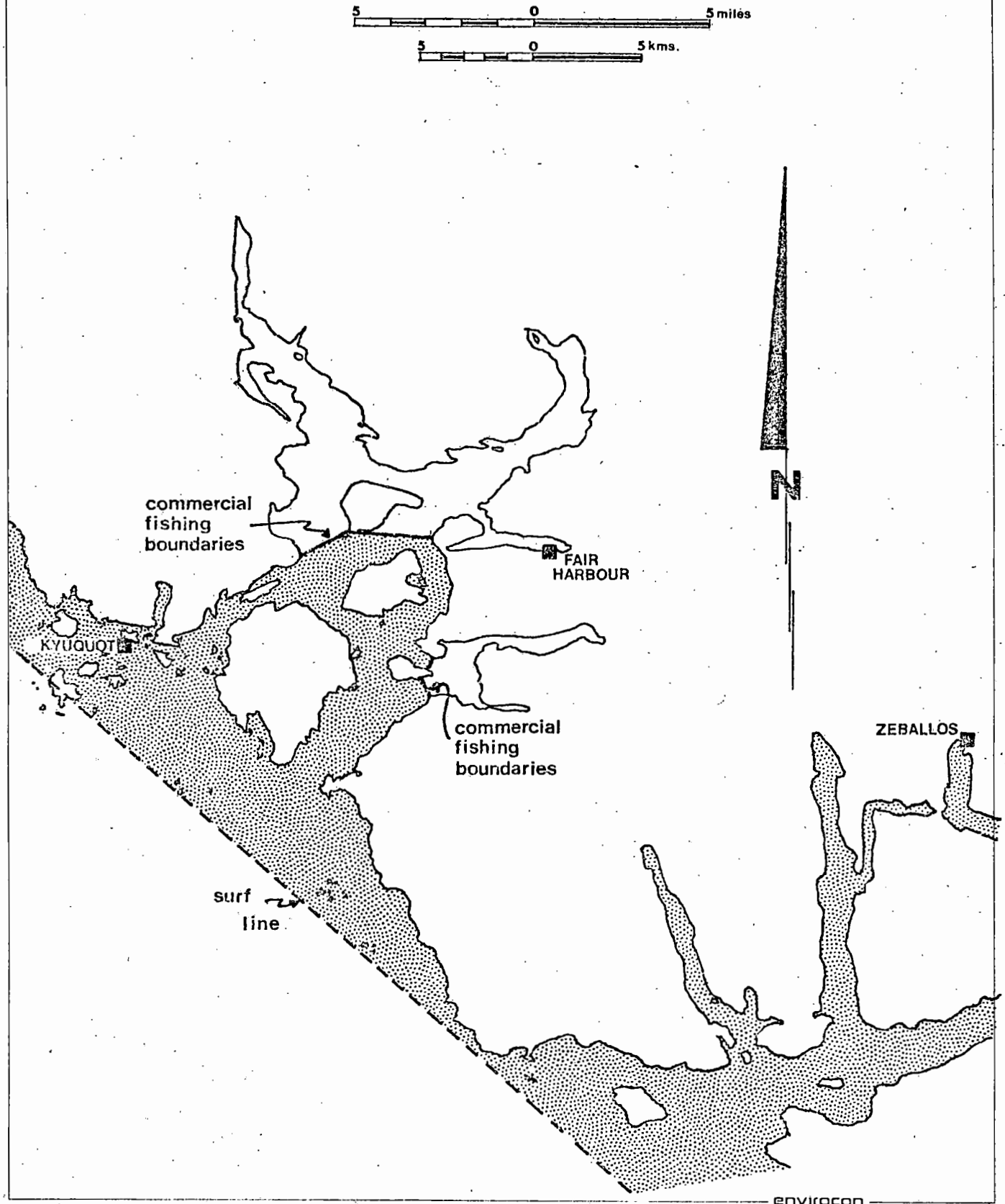
Figure 5.1 shows the recent landward boundaries for commercial net and troll fishing within Kyuquot Sound, and the seaward limit for salmon net fishing i.e. surfline, off the mouth of the Sound.

A troll fishery which operates along the west coast of Vancouver Island also takes large catches of the five salmon species in Area 26. Catches of coho, chinook and sockeye salmon are known to be comprised of many different stocks, from a broad geographic area (Aro and Shepard, 1967). This situation likely also applies to the troll catches of pink and chum salmon in Area 26. Certainly, the odd-year pink salmon troll catch is not derived from west coast of Vancouver Island stocks. Because it reflects neither the status nor the production of Kyuquot Sound salmon stocks, the Area 26 troll fishery is not included in the following discussion.

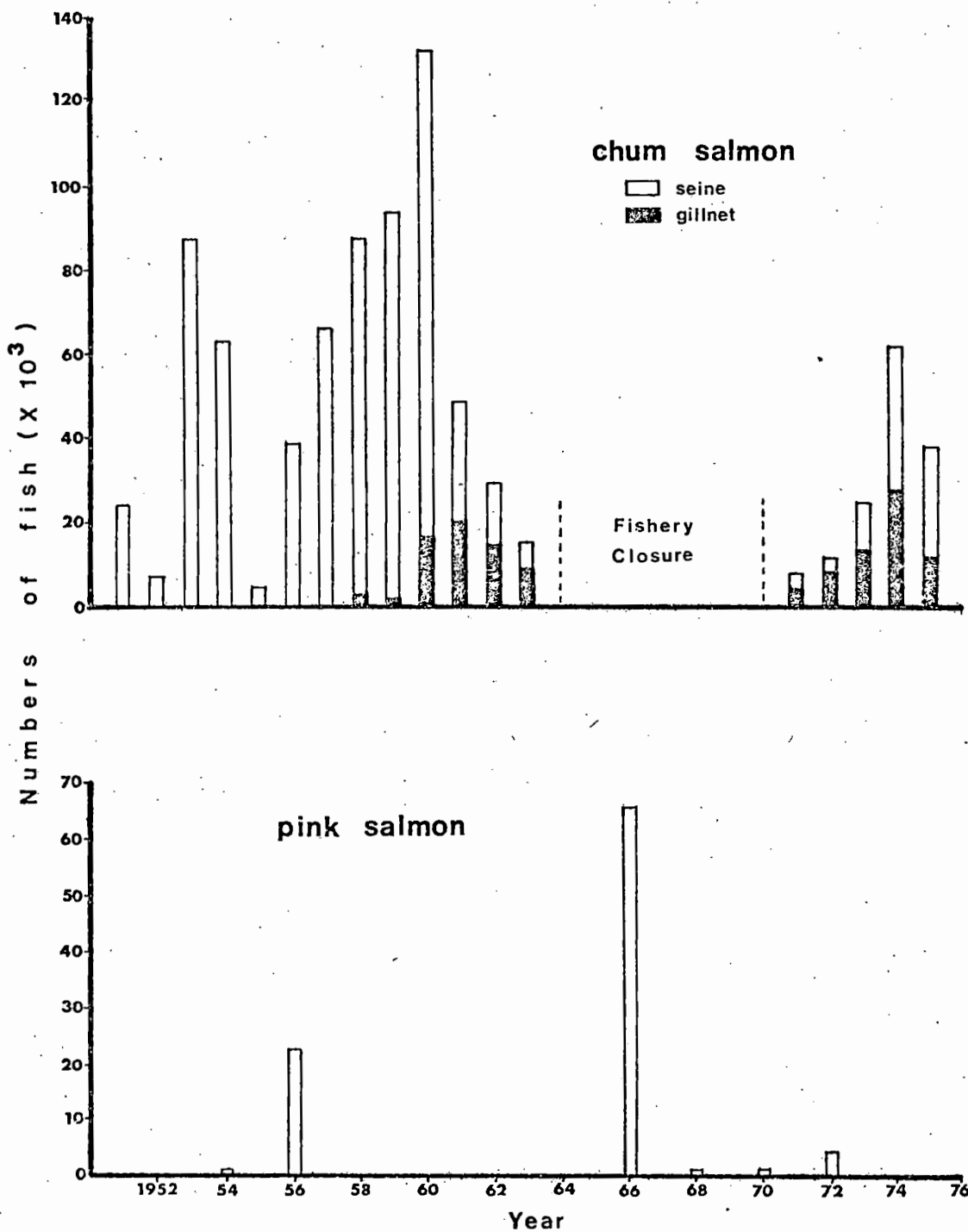
#### 5.1.1 Chum Salmon

Chum salmon in Kyuquot Sound are exploited landward of the surf line by a seine and gill net fishery. Because fishing occurs relatively close to the spawning streams, a large proportion of the catch is likely to be of local origin, and the commercial catches should reflect the abundance of Kyuquot chum salmon stocks. Seine and gill net catches from 1951 to 1975 are presented in Appendix G, and depicted graphically in Figure 5.2.

**FIG: 5.1** Current commercial net and troll fishing boundaries within Kyuquot Sound (solid lines) and seaward boundary for salmon net fishing (dotted line).



**FIG: 5.2** Commercial net catches of chum and pink salmon in Area 26, 1951-1975.



source: Fisheries and Marine Service  
B.C. Catch Statistics

In the early 1950's, the chum salmon fishery operated on a 4-day fishing week from mid-September to mid-October. Chums were fished mainly by seine, but effort by gillnetters began to increase in the late 1950's (Figure 5.2). Total catches during this decade averaged about 60,000 pieces annually, with a maximum catch of 131,000 in 1960. However, during this period catches were declining, and as a result the commercial fishery was curtailed in an attempt to prevent overexploitation (Roberts, 1970). Beginning in 1956, the fishing season was closed in September, and the number of fishing days per week in October was reduced. In addition to a reduced fishing season, there were also major changes in fishing boundaries. In 1958 and 1959, boundaries in Kashutl, Tahsish, Amai and Cachalot inlets, and in Chamiss Bay were extended seaward to protect chum salmon stocks. Fishing effort also increased to a peak in 1961, when 50 seiners and 58 gillnetters operated in the Sound. Despite more stringent fishery regulations, the stocks continued to decline and a total closure of the chum net fishery was imposed from 1964 to 1970.

Since 1971, the fishery has been opened for three 2-day weeks in September and early October. The catches during this five-year period averaged about 28,500 fish, considerably lower than the average catch prior to the closure. However, recent statistics may underestimate actual catch in Area 26, since an increasing proportion of deliveries are being made to fish packers outside the Area, thus increasing the likelihood that Area 26 landings are being misidentified and credited to other statistical areas.

### 5.1.2 Pink Salmon

Pink salmon runs to west coast of Vancouver Island streams occur only in the even years. Even-year commercial catches of pink salmon in Area 26 from 1952 to 1974 are tabulated in Appendix H, and are also shown in Figure 5.2.

Area 26 pink salmon stocks have not been large enough to support a local net fishery on a regular basis. In 1966, however, the exceptional return of pink salmon to Kyuquot Sound streams provided a seine catch of 65,000 fish. Although pink salmon returns in 1972 were also relatively large and a net fishery was permitted, low fishing effort and poor timing resulted in small catches. Because of the low pink salmon return in 1974, there was no net fishery.

It appears that Area 26 pink salmon stocks can support a small fishery, but the unpredictable nature of the returns makes regulation of the fishery difficult.

### 5.1.3 Other Salmon Species

Coho, chinook and sockeye salmon originating in Kyuquot Sound streams make only a minor contribution to the commercial net fishery in Area 26. Although small numbers are taken by seine and gill net, these catches are incidental to the chum and pink fisheries, and thus likely do not reflect the status of local stocks (See Appendices I and J). Coho and chinook net catches have not exceeded 4,900 fish and 1,600 fish respectively. The sockeye net catch is generally less than 200 fish, but in 1975 it reached 2,400 fish.

## 5.2 Sport Fishery

Kyuquot Sound supports a relatively minor saltwater sport fishery for salmon. Consequently, catch and effort statistics from the area are not available on a consistent basis. Annual reports of the local fishery officer indicate that sport fishing effort has increased in recent years, because of expanding logging operations and the establishment of road access to Fair Harbour.

Saltwater sport fishing effort has concentrated mainly on mature chinook salmon which are available in the Sound during the latter part of August and early September. A count made on Labour Day, 1974, revealed 25 boats sport fishing, all in the Tahsish Inlet area. During the 1969 to 1972 period annual salmon sport catch were estimated at 40 - 200 chinook salmon and 60 - 130 coho salmon. Comparable estimates for more recent years are not available.

The freshwater sport fishery is also of modest scale, with the fishing effort being applied mainly by local loggers and residents of Zeballos and other nearby logging communities. Sport fishermen take steelhead and cutthroat trout, plus the occasional coho salmon in the streams of the study area.

There is no quantitative documentation of the freshwater sport fishery; however, the annual steelhead trout catch is estimated to be in the order of 100 fish (G. Reid, pers. comm.). Angling for winter-run steelhead occurs during February-March in the Kaouk and Tahsish rivers, and summer-run fish are taken in the May-September period in the lower Tahsish River.

The Tahsiḥ fishery for summer-run steelhead has to date been pursued by ardent fly fishermen, seeking a high quality experience. These summer-run steelhead, taken by surface fly fishing, generally weigh in the 1.5 - 3 kg range (J. Vivian, pers. comm.):

### 5.3 Native Food Fishery

Food fishing permits are issued yearly by the local fishery officer to members of the native Indian Band living at Kyuquot settlement. Their fishing effort has generally been light, with many permits not being used.

The local run of sockeye salmon to Jansen Lake is exploited solely by natives, using gill nets. Permits are also issued to gillnet chum salmon at the mouths of certain streams near Kyuquot. As many of the Band members own and operate commercial trollers, they are given food fishing permits on a limited basis to troll for mature chinook salmon inside the existing commercial fishing boundaries.

Based on Area History reports, food fishing effort for sockeye salmon has declined since the early 1960's, when annual catches of up to 750 fish were recorded. Since 1967, no sockeye catch has been reported. During the 1970 to 1975 period, food fishing for chum salmon yielded from 50 to 730 fish per year. In the same period, chinook troll catches by the Indian Band in Tahsish Inlet ranged from 29 to 250 fish.

## 6.0 STATUS OF KYUQUOT SALMON STOCKS

This section compares changes in the strength of Area 26 salmon stocks, the major portion of which are produced in Kyuquot Sound streams, with the strength of stocks in other areas of south coastal British Columbia during the period 1951 to 1975. For chum and pink salmon, trends in total Area 26 stocks, i.e. catch plus escapement, are compared to trends in stocks on the west coast of Vancouver Island generally (Areas 22 - 27) and in the Johnstone Strait - Georgia Strait area (Areas 12 - 18 and 28 - 29). For reference as to the location of these areas see Figure 4.1. A similar analysis involving west coast Vancouver Island chum salmon stocks during 1934 to 1968 was reported by Roberts (1970).

A basic assumption in the chum and pink salmon analysis is that the catch in a given statistical area or group of areas is contributed by stocks spawning in the streams of that area. For Area 26, this assumption is considered to be reasonably valid; however, at this point it has not been confirmed by any tagging studies.

In the case of chinook and coho salmon, the analysis has been limited to a comparison of escapement trends in Area 26 with those on the west coast of Vancouver Island generally. This is due to the fact that commercial catches of chinook and coho in those areas where the troll fishery predominates are comprised of stocks from many rivers along the Pacific coast (Milne, 1964). Therefore, fluctuations in the troll catch in one area do not necessarily reflect the strength of stocks produced in the rivers of that same area.

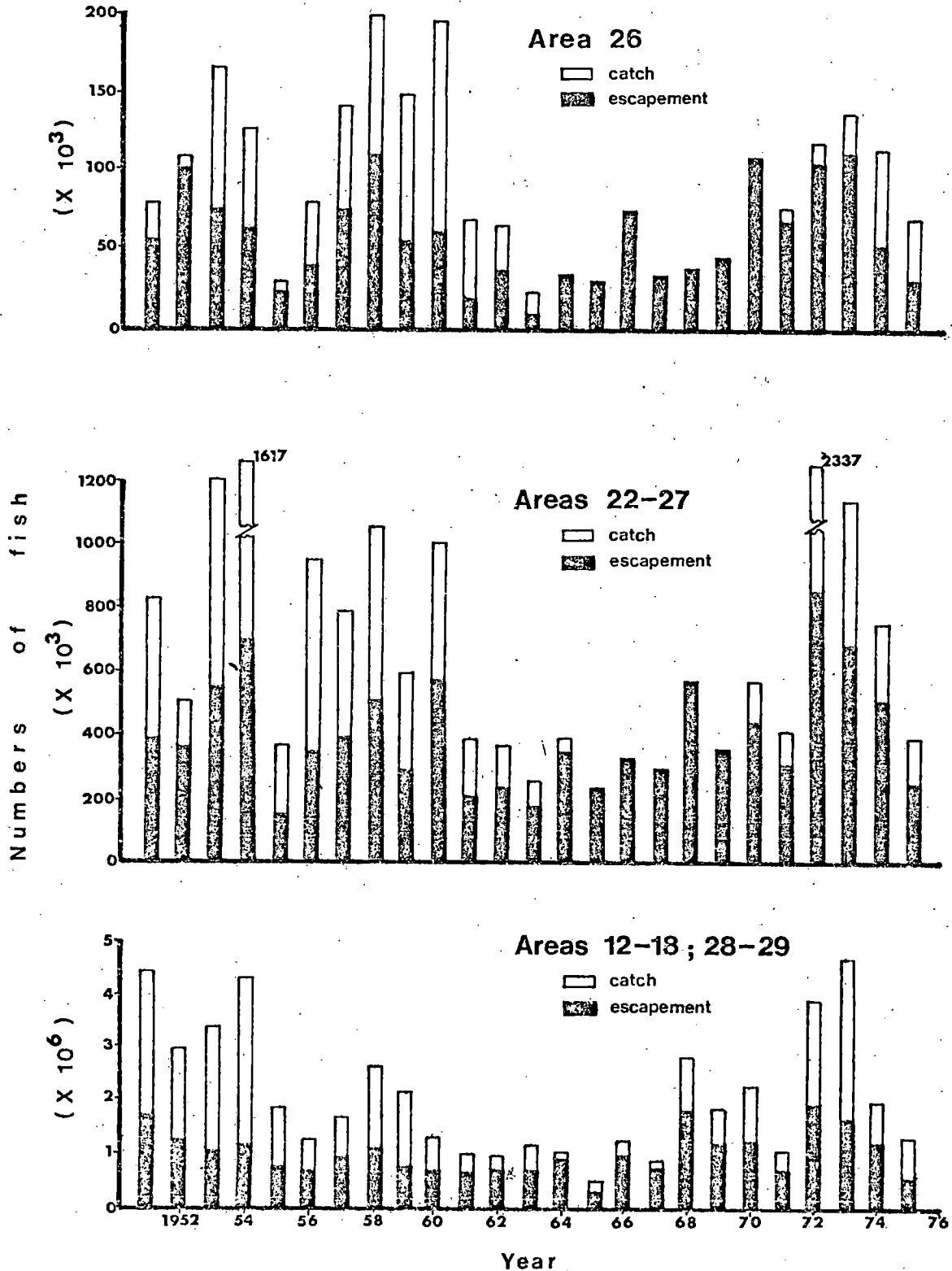
Sockeye salmon have not been included in this analysis because of their relatively minor role in Kyuquot Sound salmon production.

#### 6.1 Chum Salmon

Chum salmon escapements to the Kyuquot study area streams comprise, on the average, 60% of the total chum escapement to Area 26. The Area 26 escapement averages approximately 15% of the total chum salmon escapement to west coast Vancouver Island streams (Areas 22-27). In relation to the total commercial chum salmon catch on the west coast of Vancouver Island, the Area 26 catch represented about 13% during the 1950's and 20% in the 1960's. Since 1971, when the chum salmon fishery was reopened, the Area 26 contribution has been of the same order, between 10% and 25% of the west coast Vancouver Island total. Annual chum salmon escapements and catches in Area 26 and in Areas 22 -27 are tabulated in Appendices K and L.

The trend in chum salmon returns and exploitation in Area 26 reflects the trend on the entire west coast of Vancouver Island (Figure 6.1). The relatively high stock level and high apparent exploitation rate in the 1950's was followed by a severe decline in stock and escapement in the early 1960's. The resultant fishing closure imposed from 1964 to 1970 was not restricted to Area 26, but included the entire west coast of Vancouver Island. Despite this protection, chum stocks did not rebuild until the early 1970's. The very strong returns in 1972 and 1973 were followed by a decrease in 1974 and 1975, which was less severe in Area 26 than in other areas. The exceptional 1972 return to Areas

**FIG: 6.1** Comparison of chum salmon stocks returning to Kyuquot (Area 26), the west coast of Vancouver Island (Areas 22-27) and Johnstone Strait - Georgia Strait (Areas 12-18 and 28-29).



source: Fisheries and Marine Service  
Spawning Survey Reports and B.C.  
Catch Statistics

22 - 27 (2.6 million fish) was comprised mainly of Nitinat River (Area 22) fish, which contributed 70% of the catch and 54% of the total stock.

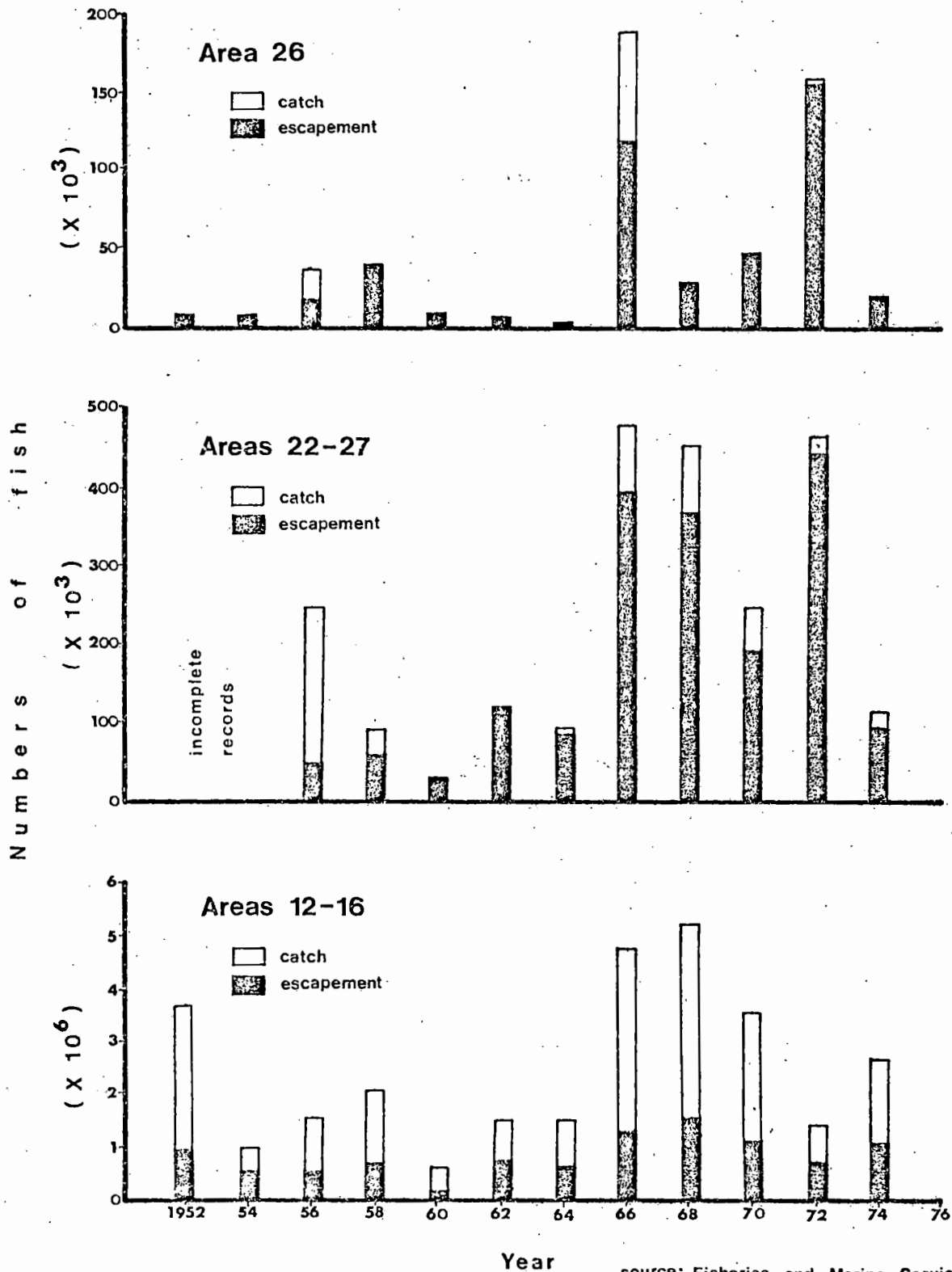
It is worthy of note that similar trends occurred in the Johnstone Strait - Georgia Strait area, which includes the Fraser River (Figure 6.1). The graph of chum salmon stock and escapement in this area has been reproduced for comparison from a report by Anderson (1976). As on the Vancouver Island west coast, declining stocks of the 1950's and early 1960's resulted in fishing restrictions, and a complete closure in 1965 and 1966. The returns have improved since then, reaching peak levels in 1972 and 1973.

## 6.2 Pink Salmon

The majority of the pink salmon stocks on the west coast of Vancouver Island spawn in the northern areas of Nootka, Kyuquot and Quatsino (Areas 25 - 27). Stock levels in Area 26 and the other west coast Vancouver Island areas during 1952 to 1974 are given in Appendices M and N.

Pink salmon returns to the Kyuquot study area have, since 1956, comprised most (85%) of the Area 26 stock. Figure 6.2 compares returning Area 26 stocks during 1952 to 1974 with those on the west coast of Vancouver Island generally and in the Johnstone Strait - Georgia Strait area. The general pattern of abundance changes is common to all these areas, with stock levels being higher since 1966. Year-to-year fluctuations in Area 26 stocks follow more closely the west coast Vancouver Island pattern than the Johnstone Strait - Georgia Strait pattern. However, the Area 26 fluctuations also appear to be more extreme than in the other areas.

**FIG: 6.2** Comparison of even-year pink salmon stocks returning to Kyuquot (Area 26), the west coast of Vancouver Island (Areas 22-27) and Johnstone Strait - Georgia Strait (Areas 12-16), troll catches excluded.



source: Fisheries and Marine Service  
Spawning Survey Reports and B.C.  
Catch Statistics

The relatively strong pink salmon returns to Kyuquot (Area 26) since 1966 have been associated with cooler winters during the respective incubation periods, two years previous. Examination of winter (October to March) average air temperature and winter precipitation data from the Spring Island station shows that the temperatures affecting the 1964 to 1974 brood years (mean 5.8°C; range 5.2 - 6.6°C) were markedly lower than average temperatures affecting the 1950 to 1962 brood years (mean 7.2°C; range 5.7° - 8.7°C). The 1.4 degree difference in the means was statistically significant (P = .01). Though precipitation was also slightly lower during the 1964 to 1974 period (36.1 cm vs. 37.6 cm), the difference was not significant.

Year-to-year fluctuations in pink salmon stocks returning to Area 26 over the 1952 to 1976 period were negatively correlated with corresponding winter incubation temperatures (r = -.45), but the correlation was not statistically significant (P = .13). Such a relationship should not be surprising, when it is considered that Kyuquot pink stocks are near the southern extent of the range for even-year pink salmon. Wickett (1962) suggested that coastal populations of pink salmon in southern British Columbia may exist under the stress of generally above-optimal temperatures during embryonic development, which result in early emergence and seaward migration of fry, prior to the spring bloom of marine zooplankton.

### 6.3 Chinook Salmon

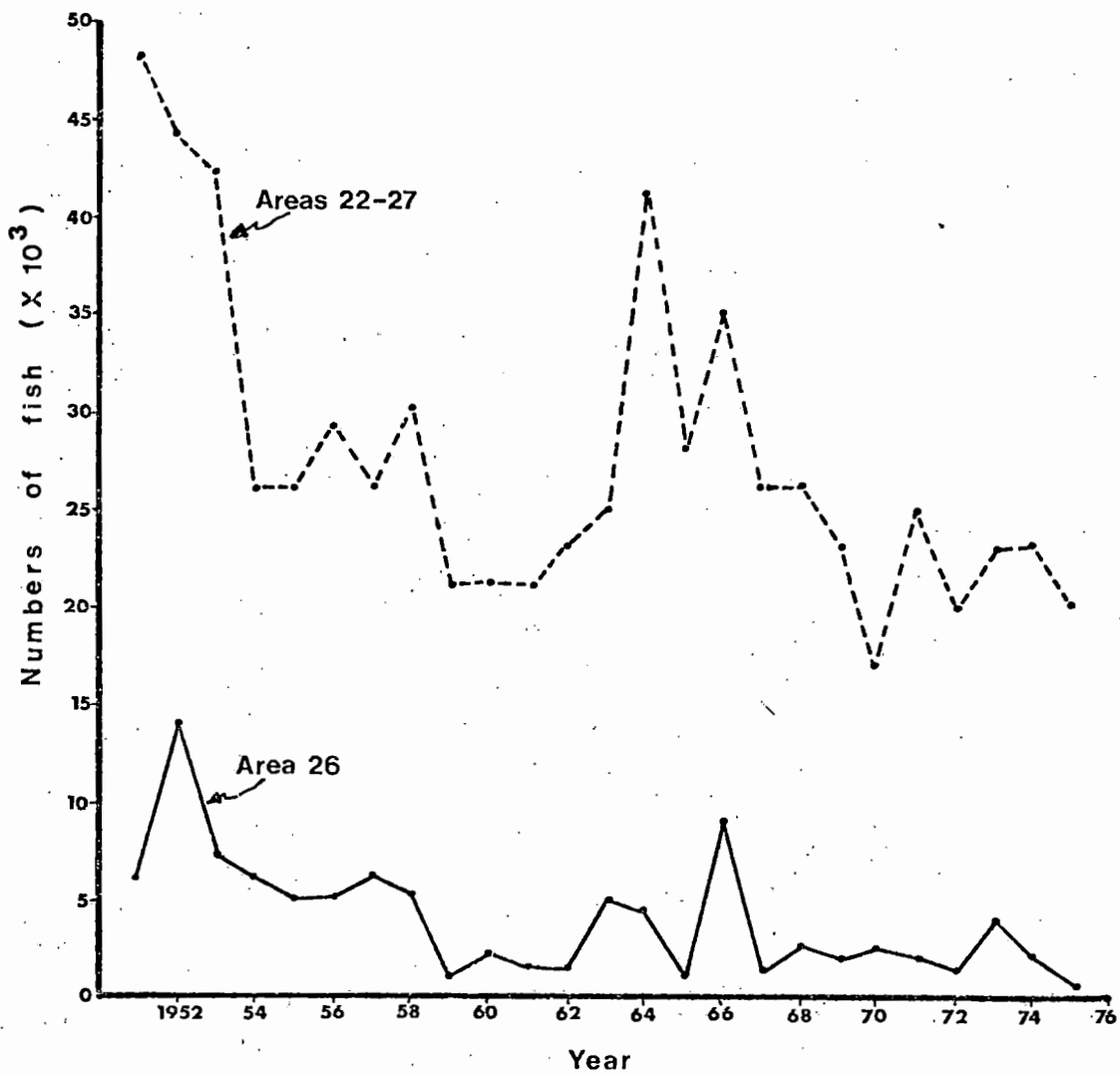
Relatively few streams on the west coast of Vancouver Island produce chinook salmon, and escapements to individual streams generally number less than 1,000 fish. An exception is the Somass River in Area 23, which receives escapements of up to 15,000 fish. This system accounts for a large proportion of the total chinook escapement to the west coast of Vancouver Island (Areas 22 - 27).

Chinook salmon escapements to Area 26 streams exhibit a trend similar to the overall trend of chinook escapements on the west coast of Vancouver Island (Figure 6.3). In both areas, chinook escapements declined rapidly in the 1950's and early 1960's, and recovered briefly in the 1962 to 1967 period. Since then it appears that escapements in both areas continue to decline. Since 1970, Area 26 chinook escapements have ranged from 1,000 to 4,000 fish annually, compared to a west coast Vancouver Island total of 20,000 to 25,000 (Appendix 0).

### 6.4 Coho Salmon

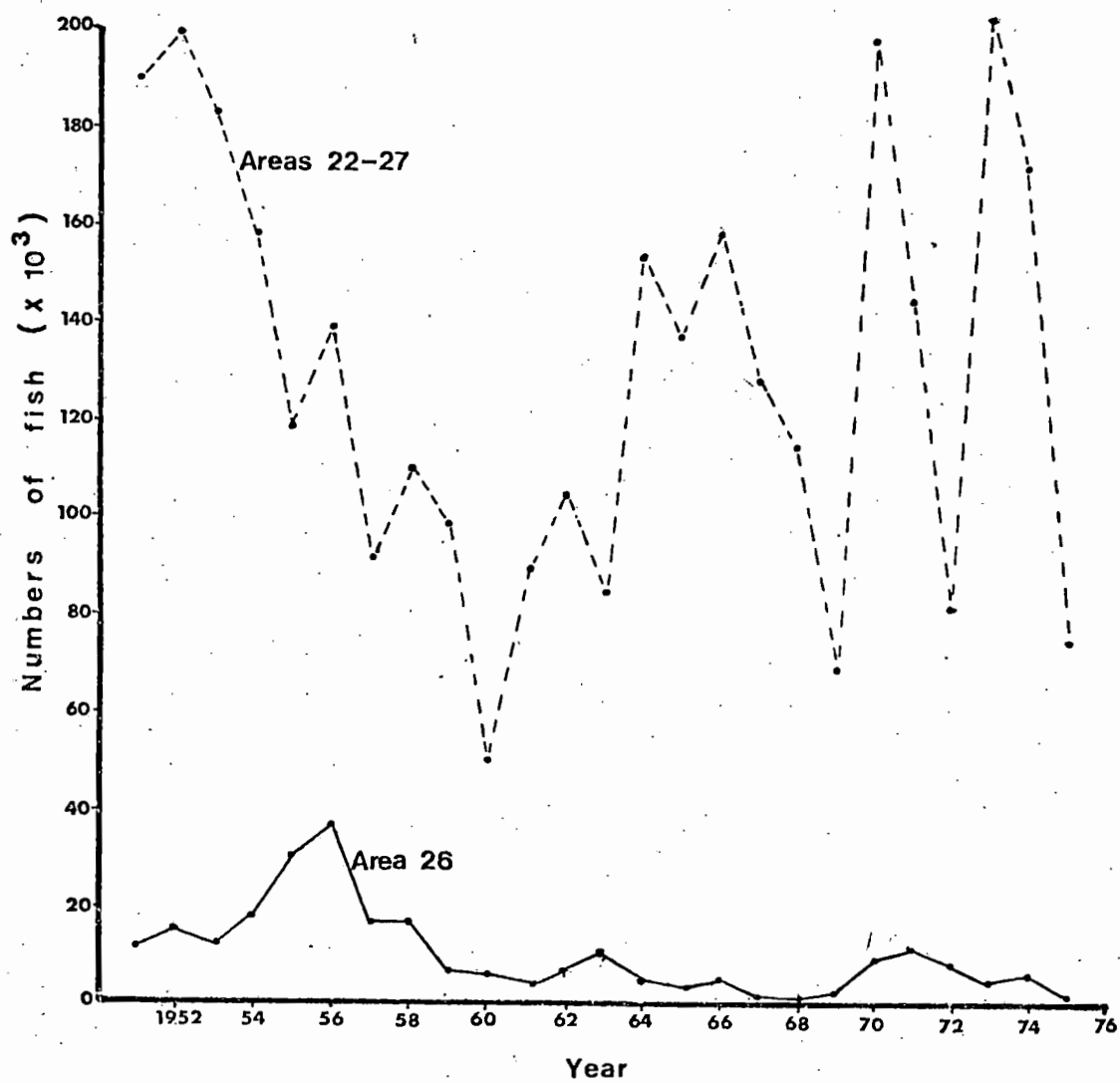
Coho salmon escapements to Area 26 are compared to those on the west coast of Vancouver Island generally in Figure 6.4. Escapements declined in all areas in the late 1950's, but the apparent recovery on the west coast of the Island is not evident in Area 26. Since 1960, total coho escapements to Area 26 have been estimated in the range of 1100 to 12,000 fish (Appendix P).

**FIG: 6.3** , Comparison of chinook salmon escapements to Kyuquot (Area 26) and the west coast of Vancouver Island (Areas 22-27).



source: Fisheries and Marine Service  
Spawning Survey Reports

**FIG: 6.4** Comparison of coho salmon escapements to Kyuquot (Area 26) and the west coast of Vancouver Island (Areas 22-27).



West coast of Vancouver Island coho stocks are dominated by the large Barkley Sound (Area 23) stocks, which from 1970 to 1975 comprised 69% of the total escapement to the area. It is in Barkley Sound and in Nootka Sound (Area 25) that coho escapements increased significantly in the 1960's and early 1970's. In the Clayoquot (Area 24), Quatsino (Area 27) and Kyuquot areas, coho escapements have remained below the levels of the 1950's. Whether these differences reflect between stock differentials in the impact of commercial troll fishery exploitation is not known.

## 7.0 THE SETTING FOR ENHANCEMENT

This section considers the environmental factors which would appear to limit salmonid production in the study area, and those characteristics of the salmonid stocks in the area relevant to planning and implementation of a resource enhancement program. The present information base does not permit, however, more than general and largely hypothetical discussion of these factors.

### 7.1 Freshwater Environment

The dominant physical feature of study area streams is the relatively short length and high gradient, which generally restricts salmon spawning to short sections of moderate slope within 1-2 km of saltwater. Streams are usually confined within one channel; there are few side channels to dissipate the energy of extreme freshets. The watersheds also have few lakes to provide natural storage of runoff. In this physical setting, the intense fall and winter precipitation, characteristic of the area, can produce extreme

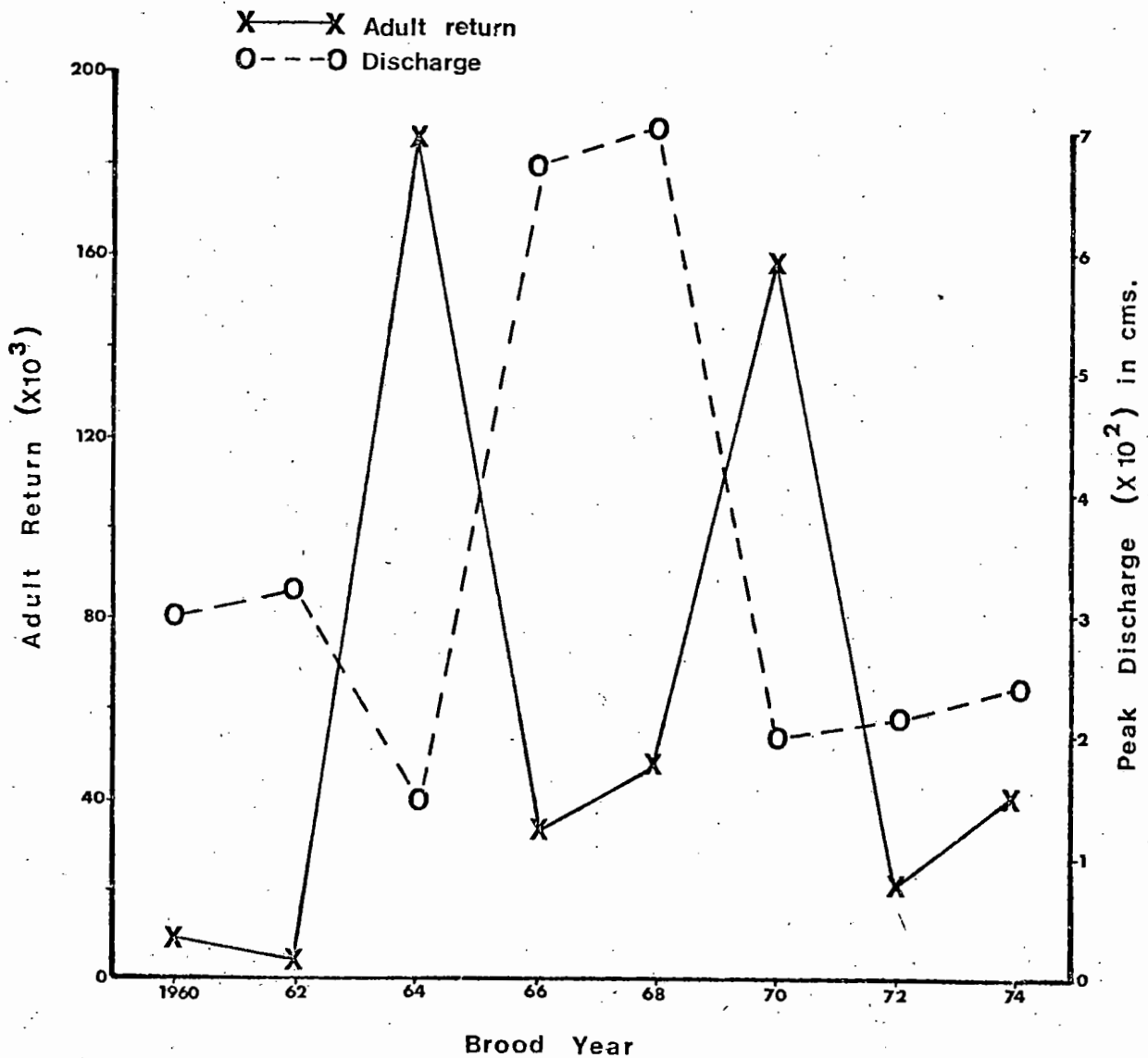
peaks in river discharge during spawning and the early stages of incubation, when salmon eggs are most sensitive to shock (Figure 3.7). The frequency and magnitude of these occurrences, with the attendant shifting of gravel in the stream bed, are likely to be greatest in the steeper west coast Vancouver Island systems, such as those in Kyuquot Sound.

#### 7.1.1 Fluctuations in Adult Returns

The effect of factors in the freshwater environment on returns of adult salmon can be examined by correlation analysis. However, except in the case of pink salmon which have a strict two-year life cycle, environmental data cannot readily be related to particular salmon life stages because of the absence of adult age composition data.

Pink salmon returns to Area 26 (including Kyuquot Sound) have been correlated with an index of the peak river discharge during the corresponding incubation period (October - March) for each brood year (Figure 7.1). This analysis, which used discharge data available since 1960 from a neighbouring system (Zeballos River), indicated that returns from these eight brood years were negatively correlated ( $r = -.41$ ) with peak discharge during the period of spawning and incubation. However, returns of the last two brood years (1972 and 1974) were lower than would be expected on the basis of discharge stability alone, with the result that the correlation is not statistically significant ( $p = .32$ ).

**FIG: 7.1** Area 26 pink salmon adult returns (total stock) relative to maximum daily river discharge during incubation period, for 1960 to 1974 brood years. Discharge data are from Zeballos River.



In section 6.2 it was noted that pink salmon adult return strength was also negatively correlated with average air temperature during the incubation period. Multiple correlation, relating both the winter discharge peak and the temperature to adult returns from the 1960 to 1974 broods, produced a coefficient (r) of  $-.65$ , thus accounting for about 43% of the variance in pink salmon returns. Again, this correlation was not statistically significant, but it does suggest that weather-related factors exert considerable influence on pink salmon brood year strength.

#### 7.1.2 Effects of Logging

As described in Section 3.3, eight of the thirteen salmon-producing watersheds in Kuyquot Sound experienced some logging activity prior to 1975. Although the percentage of total watershed area subjected to logging has in most cases been small, it is significant for fishery resources that the logging has generally been concentrated along major stream courses (Figure 3.8). The most common environmental impacts associated with logging are increased instream debris, reduced flow stability, and increased sedimentation. These changes may have serious direct and indirect effects on survival of salmonids during upstream migration, spawning, incubation and rearing (Narver, 1970; Bell et al., 1974). As the quantitative effects of these changes has been documented to only a limited extent, it has been necessary for fishery scientists to generalize from the results of a few studies of specific areas. This is not necessarily valid, as the effects of logging will depend to a large extent on the characteristics of the particular watershed, as well as the scale and type of logging operation.

Because of the limited information available from Kyuquot Sound, it is not possible to establish any cause-effect relationship between logging and the status of salmonid populations. But a general analysis, based on escapement data and reports of the local fishery officer, is possible.

The fishery officer's annual spawning survey reports for Kyuquot Sound streams make note of evident increased erosion and silting, in addition to the establishment of log jams in several watersheds after logging had commenced. However, trends in salmon escapements do not consistently reflect impact from logging. For example, though Chamiss Creek has sustained the heaviest logging in the study area, it remains one of the most productive chum salmon streams (Tables 3.4 and 4.1). On the other hand, the Artlish River supports relatively few chum salmon, even though it has been logged very little and appears to have excellent spawning potential.

The direct impact of logging on salmon has been observed on two of the smaller study area streams, Jansen Lake Creek and Amai Creek. At Jansen Lake, sockeye salmon access has been impeded by a log jam at the lake outlet. Also, continued low escapements of chum salmon to Amai Creek in the early 1970's (Appendix A) are considered to reflect the effects of a major stream diversion by a logging contractor (R.A. Slater, pers. comm.).

### 7.3 Stock Manageability

Within a given geographic area, the different stocks of a single species can exhibit substantial differences in their respective seasonal times of adult migration through fishing areas and into spawning streams. Stocks tend to maintain a high degree of chronology, with earlier-spawning stocks exhibiting earlier migration timing (Killick, 1955).

Inter-stock differences in time of migration and spawning are considered to reflect adaptation to a diverse environment, particularly with respect to distance of upstream migration and stream temperature regime (Sheridan, 1962).

Attempts to crop the surplus adult returns of a stock whose production rate has been enhanced, could result in over-exploitation of other naturally-producing stocks which pass through the same fishing areas, and which cannot sustain on the average as high a rate of exploitation. The degree of diversity in spawning and migration timing of species and stocks in a given area dictates to a considerable degree the enhancement strategy appropriate for that area. Relatively uniform timing among stocks may necessitate the application of enhancement measures to most or all stocks, to take full advantage of surplus production and to prevent chronic overexploitation of certain stocks. On the other hand, segregation of particular stocks with respect to migration time or area would enable development of special exploitation strategies to ensure adequate harvest of surplus production. In this case, enhancement effort could be concentrated on specific stocks.

TABLE 7.1 GENERALIZED INSHORE MIGRATION TIMING OF ADULT SALMONIDS AT KYUQUOT SOUND.

SPECIES	MIGRATION TIMING
Steelhead trout	Two runs: May-June and February-March
Sockeye salmon	July
Chinook salmon	August - early September
Pink salmon	August 15 - September 10
Coho salmon	August 15 - October 20 (peak: September 15 - October 10)
Chum salmon	September 5 - October 31 (peak: October 1 - 15)

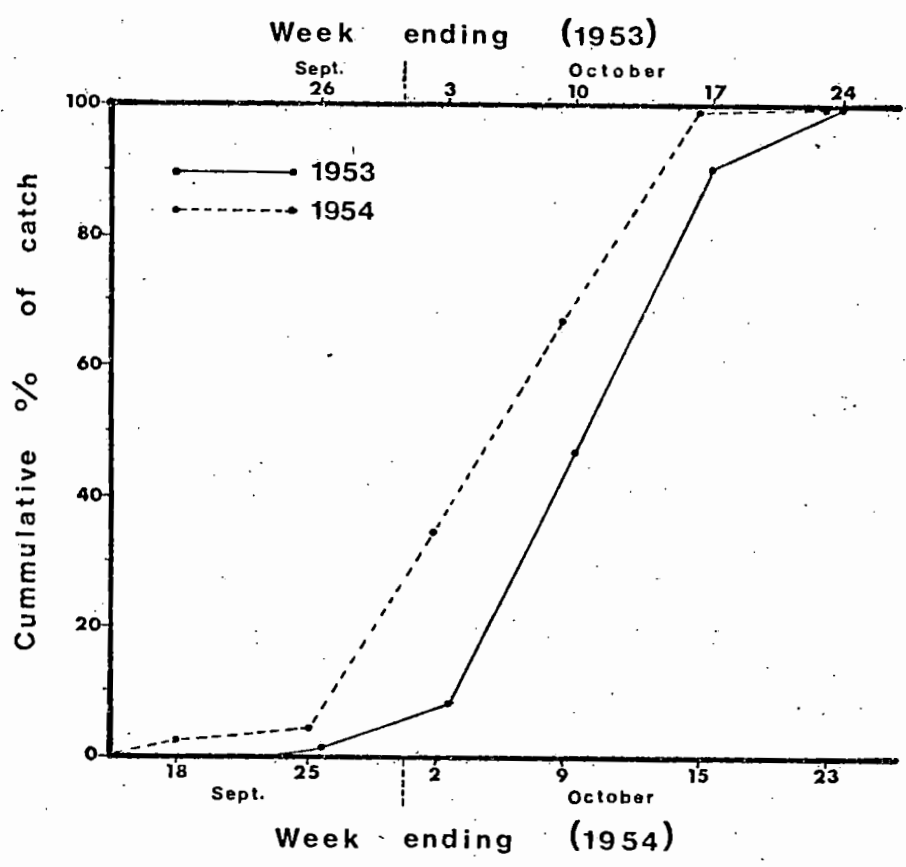
The limited information on the inshore migration timing of salmonid species at Kyuquot Sound is based mainly on catch timing in the sport fishery and the commercial net fishery. Available data are summarized in Table 7.1. The information in this table pertaining to steelhead trout and chinook salmon is based on timing of the sport fishery. Pink, coho and chum salmon net catches formed a more definitive basis for estimating the migration timing of those species. Sockeye salmon migration timing is indicated in the reports of the area Fishery officer.

Net fishery statistics for Area 26 show that coho and chum salmon overlap to a considerable degree in their migration timing (Table 7.1). The incidental catch of coho in 1974, a year of heavy chum salmon exploitation, reached 3800 fish, 43% of the estimated coho stock in Area 26 that year. Should a chum salmon enhancement program be implemented at Kyuquot Sound, the possible incidental overharvest of coho stocks would have to receive consideration.

A more precise indication of chum salmon migration timing can be obtained from net catches in the early 1950's, when the fishery in Area 26 was open in some years for several weeks on a 4 or 5 days per week basis. Figure 7.2 shows the cumulative weekly catches in 1953 and 1954, when Area 26 chum landings amounted to 87,000 and 63,000 fish respectively. Though the fishery was open for 5 weeks and 6 weeks respectively, 70% - 80% of the total harvest was taken in a two-week period in early October.

These data tend to support the observations on spawning timing of the various chum stocks in the Sound, which indicated limited between-stock differences in the time of stream entry and spawning. This would in turn suggest that if overexploitation of certain stocks is to be avoided, a chum salmon enhancement program at Kyuquot Sound would have to include most, if not all, the stocks.

**FIG: 7.2** Seasonal timing of commercial chum salmon catch in Area 26, 1953 and 1954.



source: Area History Report,  
Fisheries and Marine Service.

## 8.0 APPLICATION OF ENHANCEMENT TECHNIQUES

The principal techniques currently used to enhance the production of salmonids are briefly examined in this section, in relation to their application to salmonid resources in the Kyuquot study area. Species with similar life history requirements are discussed as a group. The discussion is general in nature, because no data are available from the study area itself on such features as surface water and groundwater supply, water temperatures, and detailed topography. Estimates of discharge in the major study area streams have been developed by extrapolating data on runoff per watershed area from Zeballos River, on which there have been 16 years of observation (1960 - 1975).

### 8.1 Chinook and Coho Salmon, Steelhead Trout

These three species have life history patterns with a freshwater rearing requirement, ranging from as little as 2-3 months in the case of chinook salmon, to 2-4 years for steelhead trout. Under the artificial rearing conditions of a hatchery, the rearing time required for steelhead to reach the smolt stage is normally reduced to one or, at most, 2 years. The two main approaches to increasing production of these species have been: (1) expansion of spawning and nursery area by providing access for adults upstream of natural or man-made obstructions to migration; and (2) increasing output of seaward migrants by artificial propagation in conventional hatcheries or semi-natural rearing areas.

Because of the short length and high gradient of most streams in the study area, the strategy of making accessible additional spawning and nursery area has rather limited application. Though there are undoubtedly a number of obstructions to adult migration which could be made passable by either blasting or fishway construction, the amount of suitable spawning and nursery area above these obstructions would generally be very limited, eg. Kashutl River. The Tahsish River appears to be an exception, having some 14 km of moderate gradient stream in the upper watershed, above the canyon obstruction.

The suitability of the major study area streams as sites for a large-scale hatchery can be examined at this stage only from the standpoint of surface water and space. The availability of groundwater, which is used to modify surface water temperature extremes, is not known.

With respect to land suitable for hatchery construction, the lower valleys in each of the four largest systems, the Tahsish, Artlish, Kaouk and Kauwinch rivers, all appear to have flat, benchland adequate for construction of a large hatchery. Actual siting would presumably depend on groundwater availability, and on various engineering considerations.

To assess the amount of surface water available relative to the potential demand of a large hatchery, the lowest recorded daily discharge in each month was estimated for major study area streams and compared to the projected monthly water requirements (combined surface water and groundwater) of the Fisheries and Marine Service's Quinsam Hatchery near Campbell

River (Underwood, McClellan and Associates, 1972). The Quinsam operation is relatively large, with an annual production of approximately 1.9 million coho smolts, 3 million chinook fingerlings, and 20,000 steelhead smolts (D.C. Sinclair, pers. comm.).

Comparison of the annual cycle of water requirements at Quinsam Hatchery relative to an estimate of surface water available in major study area streams indicated that the supply in these streams would meet the hatchery requirement at all times. For example, in April - May, when the hatchery requirement is highest (1 cms), the smallest of the four major study area systems (Kauwinch R.) would provide a minimum of about 1.7 cms. This estimate for the Kauwinch is based on the minimum daily discharge recorded in the Zeballos River during that period (.023 cms/km<sup>2</sup> on May 4, 1968). Similarly, during the low flow period of August - September the daily minimum discharge in the Kauwinch would be in the order of 1.3 cms (.017 cms/km<sup>2</sup>), compared to the September hatchery requirement of 0.64 cms.

With respect to temperature regime, the range in study area streams would likely be moderate. Scrivener (1975) reported an annual range of 2°C to 13°C for Carnation Creek, situated on Barkley Sound. This would indicate that there may be little need to moderate surface water temperatures in summer, and that the hatchery requirement for groundwater would be confined to the incubation and early feeding periods, to accelerate development and initiate feeding of fry.

## 8.2 Pink and Chum Salmon

In North America, it has been the general experience that pink and chum salmon have no freshwater rearing requirement prior to their entry into saltwater. For this reason the production-type enhancement techniques used for these species, eg. spawning and incubation channels and substrate incubators, have been designed simply to increase egg-to-fry survival at an economic cost.

The operation of an artificial spawning channel can require a significant amount of water relative to that available in moderate-sized streams such as those in Kyuquot Sound. For example, the spawning channel for chum salmon at Big Qualicum River, British Columbia, operates on a flow of 2.3 cms, 0.2 cms per meter of width, during spawning (D.C. Sinclair, pers. comm.). A pink salmon spawning channel such as the one at Seton Creek, British Columbia, requires a similar flow per unit of width (F.J. Andrew, pers. comm.).

At Kyuquot Sound, low discharges can occur in September and October, at the peak of pink salmon spawning and during the early stages of chum salmon spawning. In an extreme low flow year, the water requirement of a Qualicum-scale spawning channel would equal the entire discharge in one of the larger Kyuquot Sound streams, such as the Kaouk River.

In some study area streams there are sections unsuitable for spawning which would not be adversely affected by the loss of flow to an artificial spawning channel. In most cases, however, spawning channel installations would require careful

planning and location to avoid loss of natural spawning capacity in the adjacent stream bed due to reduced flow.

Under these circumstances the substrate incubator or incubation box offers an attractive alternative to the artificial spawning channel, particularly on the smaller streams. A review of reports by Anderson (1975) and Bams and Simpson (1977) shows that a substrate incubator such as the one operated by Fisheries and Marine Service at Blaney Creek in the Fraser River system has a water requirement per unit of chum salmon fry production (0.5 liters per min./1000 fry) one tenth that of the Big Qualicum River spawning channel. The surface area required for the incubator is also much lower, as fry output per area is about 80 times ( $37,000/m^2$  versus  $470/m^2$ ) that from the spawning channel.

### 8.3 Sockeye Salmon

Sockeye salmon require a lake environment for rearing from the stage of emergent fry to smolt emigration. The potential for natural production of sockeye in the Kyuquot Sound area is limited by the small number of accessible lakes. The only sockeye population of significance in the area utilizes Jansen Lake. Escapements to Jansen Lake, which averaged an estimated 2250 fish from 1951 to 1975, have declined in recent years.

As noted in Section 4.1.1, adults of the Jansen Lake population have in some years experienced difficulty reaching the lake due to log jams in Jansen Creek. In addition, the spawning tributaries entering Jansen Lake may also have deteriorated

due to logging road construction along the lake (R.A. Slater, pers. comm.).

If problems affecting adult access and spawning success can be alleviated, then the use of fertilization to increase the sockeye smolt production capacity of Jansen Lake would be worth considering. Manzer (1976) reported a 5-7 fold increase in adult sockeye salmon returns following intensive fertilization of Great Central Lake, British Columbia. The technical feasibility of increasing sockeye production from Jansen Lake would depend on a variety of factors, of which nothing is presently known. These would include the existing state of nutrient limitation of the juvenile sockeye food supply, the presence of competitor species, and various other characteristics such as lake depth and morphometry, flushing rate and water clarity.

## ACKNOWLEDGEMENTS

The cooperation of government agencies in making available essential information has been greatly appreciated. Messrs. R. Slater, F. Fraser and D. Lightly of the Fisheries and Marine Service provided information on the fish populations of Kyuquot Sound and access to various unpublished records. Messrs. W. Millward, K. Pratt and R. Court of the B.C. Forest Service, were also helpful in assisting the documentation of forest harvesting in the study area.

APPENDIX A ESTIMATED CHUM SALMON ESCAPEMENTS TO STREAMS IN AREA 26 FROM 1951 TO 1975.

STUDY AREA STREAMS	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975		
Tahlish R.	7,500	15,000	15,000	7,500	7,500	3,500	7,500	15,000	15,000	7,500	3,500	3,500	3,500	3,500	3,500	7,500	7,500	3,500	7,500	15,000	15,000	31,000	10,000	7,500	3,500		
Kaouk R.	750	3,500	3,500	3,500	750	3,500	3,500	3,500	750	1,500	750	750	750	75	750	750	750	750	750	3,500	8,000	11,000	15,000	3,500	7,500		
Artlish R.	200	3,500	1,500	5,500	1,500	1,500	1,500	3,500	400	400	750	750	400	-	900	200	1,500	1,500	75	750	400	750	5,000	750	750		
Kawlinch R.	3,500	7,500	7,500	3,500	3,500	1,500	7,500	3,500	1,500	3,500	1,500	1,500	400	1,500	1,500	1,500	3,500	400	750	3,500	8,000	13,000	1,500	1,500	3,500		
Narrowgut Ck.	3,500	7,500	3,500	2,760	75	750	3,500	3,500	1,500	1,500	1,500	1,500	400	7,500	1,500	750	1,500	1,500	1,500	3,500	7,500	3,500	1,500	5,000	7,500		
Kashuti R.	3,500	7,500	3,500	3,500	400	1,500	3,500	7,500	3,500	3,500	1,500	1,500	750	3,500	1,500	7,500	3,500	3,500	3,500	7,500	3,500	1,500	5,000	7,500	400		
Amal Ck.	3,500	7,500	3,500	3,500	1,500	750	3,500	7,500	1,500	3,500	750	3,500	400	750	400	400	400	750	75	400	200	400	2,000	400	no survey		
Easy Ck.	3,500	3,500	3,500	2,120	400	3,500	3,500	3,500	3,500	3,500	1,500	750	400	3,500	3,500	3,500	1,500	3,500	1,500	7,500	3,500		2,000	400	25		
Chamiss Ck.	7,500	7,500	7,500	8,490	3,500	7,500	7,500	15,000	7,500	3,500	3,500	3,500	400	3,500	3,500	3,500	3,500	7,500	3,500	15,000	3,500	15,000	20,000	7,500	3,500		
Cachalot Ck.*								1,500	200	750	200	200	75	750	400	750	400	400	25	25	400	1,500	2,000	1,500	400		
Yaku Bay Ck.*							1,610	1,500	750	750	75			200	75	200	400	200	200	200		200	50	750	no survey		
Elaine Ck.	1,500	400	1,500	750	25	200	750	1,500	75	200	400	25	75	750	400	200	75	400	400	750	400	800	750	25			
Jansen Lake Ck.	200	750	400	119		25	25			25	25					750	25	400	25	25							
TOTALS	35,150	64,150	50,900	41,239	19,150	24,225	43,885	67,000	36,175	30,125	15,950	17,475	7,550	25,525	17,925	27,500	24,550	24,300	19,800	57,650	43,650	76,650	68,300	32,075	20,325		
OTHER STREAMS IN AREA 26																											
Naspartl R.	3,500	3,500	1,500	2,500	400	3,500	1,500	1,500	750	750	200	750	25	750	200	750	750	400	650	1,500	750	750	2,000	3,500	1,500		
Power R.	750	3,500	3,500	1,500		750	3,500	750	400	750	400	1,500	200	400	750	400	400	400	250	200	750	200	200	200	25	200	
Ououkinsh R.	1,500	7,500	3,500	3,500	750	1,500	3,500	3,500	1,500	3,500	400	3,500	400	750	400	1,500	3,500	400	7,000	3,500	3,500	3,500	15,000	3,500	3,500		
Malksopa B.	7,500	15,000	7,500	3,500	3,500	7,500	3,500	15,000	7,500	7,500	750	7,500	1,500	7,500	7,500	7,500	1,500	7,500	15,000	35,000	15,000	13,000	15,000	7,500	3,500		
Clanninick R.	3,500	3,500	3,500	7,500	750	1,500	7,500	15,000	3,500	15,000	1,500	1,500	750	3,500	3,500	35,000	3,500	3,500	1,000	7,500	3,500	7,500	7,500	7,500	3,500		
Battle R.	1,500	3,500	3,500	2,500	25	1,500	7,500	3,500	400	1,500	400	75	200	200	400	400	200	750	200	200		400	400	25			
Hackay R.	3,500	3,500	3,500	1,500	1,500	750	3,500	3,500	3,500	3,500	750	3,500	75	400	750	400	750	750	400	3,500	1,500	3,500	3,500	MISSING	750		
TOTALS	21,750	40,000	26,500	22,500	6,925	17,000	30,500	42,750	17,550	32,500	4,400	18,325	3,150	10,750	13,500	45,950	10,600	13,700	24,500	51,400	25,000	28,850	43,600	22,050	12,950		
TOTAL ESCAPEMENT TO AREA 26	56,900	104,150	77,400	63,739	26,075	41,225	74,385	109,750	53,725	62,625	20,350	35,800	10,700	36,275	31,275	73,450	35,150	38,000	44,300	109,050	68,650	105,500	111,900	54,125	33,275		

\* This stream was not surveyed prior to the late 1950's.  
Source: Fisheries and Marine Service, Annual spawning survey reports.

APPENDIX B ESTIMATED PINK SALMON ESCAPEMENTS TO STREAMS IN AREA 26 FROM 1952 TO 1974.

STUDY AREA STREAMS	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
Tahlish R.		3,500		400		3,500		1,500		750					25	3,500		1,500		1,500		750		750		
Xaouk R.	25	400		800		1,500		3,500		1,500		400		400	200	7,500	25	7,500		15,000	25	75,000		15,000		
Artlish R.		200		400		750		750		750			200	25	25	50		200	25	25		75		750		
Kauwinch R.		400		750		3,500		7,500		1,500				400	25	100,000		15,000		15,000		57,000		750		
Narrowgut Ck.		750		1,780		1,500		15,000		3,500		1,500		3,500	25	7,500		3,500		3,500		750		25		
Kashuti R.		750		200		400		400		400		75		75		75		75	25	400		400		75		
Amal Ck.				25		25																75				
Easy Ck.						25								25		400				750		200		25		
Chanis Ck.		75		53		400								25		200		400		200		25				
Cachalot Ck.																25										
Yaku Bay Ck.																						200				
Elaine Ck.				25																	25					
Jansen Lake Ck.																200										
TOTALS		6,075		4,433		11,600		28,650		8,400		1,975		4,450		119,450		28,175		36,400		134,475		17,375		
OTHER STREAMS IN AREA 26																										
Naspartl R.		200		400		400		400		400		200		25	25	25		25		25		25		25		750
Power R.	25	200		200		750		400		750		1,500				200		75	25	200		3,500		75		
Oouuklnsh R.	25	750		400		400		400		750		400		25	25	750	25	400		3,500		7,500		1,500		
Malksope R.		200				400		750		400		200				200		750		1,500	25	3,500		400		
Clanninck R.	25	750		1,500	200	750		1,500		1,500		750		25		750		750	25	1,500		3,500	75	75		
Battle R.	25	1,500		1,500		1,500		7,500		200		1,500			25	400				3,500		1,500		200		
Mackay R.		25		25		200		200		200		200				20		200		25		75	75	REPORT MISSING	25	
TOTALS		3,625		4,025		4,400		11,150		4,200		4,750		75		2,345		2,200		10,250		19,600		3,000		
TOTAL ESCAPEMENT TO AREA 26		9,700		8,458		16,000		39,800		12,600		6,725		4,525		121,795		30,375		46,650		154,075		20,375		

Source: Fisheries and Marine Service, Annual spawning survey reports.

APPENDIX C ESTIMATED CHINOOK SALMON ESCAPEMENTS TO STREAMS IN AREA 26 FROM 1951 TO 1975.

STUDY AREA STREAMS	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975		
Tahsilsh R.	3,500	7,500	3,500	3,500	3,500	3,500	3,500	1,500	200	750	400	750	3,500	1,500	25	1,500	750	1,500	750	1,500	750	750	2,000	1,500	25		
Koouk R.	750	1,500	750	750	750	400	750	200	75	75	200	400	400	1,500	400	3,500	400	750	750	750	750	300	1,000	200	75		
Artlish R.	750	3,500	1,500	750	750	400	400	3,500	200	750	400	200	750	50	400	3,500	25	25	200	200	200	400	500	200	25		
Kaumlneh R.	400	400	750	400	200	400	750	75	75	75	400		25	25	25	25	25		25	75	100	150	100	75	25		
Narrowgut Ck.								25	25	200	25	25	25		25	25		25	25	75	25						
Kashutl R.		200	75		25	25	25			25	25					25		25	25					25	25		
Anel Ck.				1	25		25		25	25	25		25								25	25	25	25	no survey		
Easy Ck.																25				25					25		
Chamiss Ck.						25	25		25	25	25					25					25				25		
Cachalot Ck.																											
Yaku Bay Ck.																											
Elaine Ck.											25				25					25							
Jansen Lake Ck.																25											
<b>TOTALS</b>	<b>5,400</b>	<b>13,100</b>	<b>6,575</b>	<b>5,401</b>	<b>5,250</b>	<b>4,750</b>	<b>5,475</b>	<b>5,300</b>	<b>625</b>	<b>1,925</b>	<b>1,525</b>	<b>1,375</b>	<b>4,725</b>	<b>3,075</b>	<b>925</b>	<b>8,625</b>	<b>1,200</b>	<b>2,325</b>	<b>1,800</b>	<b>2,650</b>	<b>1,850</b>	<b>1,650</b>	<b>3,625</b>	<b>2,050</b>	<b>225</b>		
<b>OTHER STREAMS IN AREA 26</b>																											
Naspartl R.								75								2		25		25		25			25		
Power R.	400	750	400	400	200	400	400	200	200		75	75	200	1,500	200	200	25	400	400	25	75	25	25	25	25		
Quoukinsh R.	75	400	400	200	75	200	75	200		400	25	25				25			25	25	25		75		25		
Malksope R.				25	75	400	25	200			25	200				75	25	400	200	400	25	75		25	200		
Glanninick R.							25				25								25	25							
Battle R.		75	25	25	25	75	25	25	75	25	25				25					25							
Mackay R.	75	200	400	25	25	25	25	75	25			25			25					25		25	25		25		
<b>TOTALS</b>	<b>550</b>	<b>1,425</b>	<b>1,225</b>	<b>675</b>	<b>400</b>	<b>1,100</b>	<b>575</b>	<b>775</b>	<b>300</b>	<b>425</b>	<b>175</b>	<b>325</b>	<b>200</b>	<b>1,500</b>	<b>250</b>	<b>302</b>	<b>50</b>	<b>825</b>	<b>650</b>	<b>550</b>	<b>125</b>	<b>150</b>	<b>150</b>	<b>50</b>	<b>275</b>		
<b>TOTAL ESCAPEMENT TO AREA 26</b>	<b>5,950</b>	<b>14,525</b>	<b>7,800</b>	<b>6,076</b>	<b>5,650</b>	<b>5,850</b>	<b>6,050</b>	<b>6,075</b>	<b>925</b>	<b>2,350</b>	<b>1,700</b>	<b>1,700</b>	<b>4,925</b>	<b>4,575</b>	<b>1,175</b>	<b>8,927</b>	<b>1,250</b>	<b>3,150</b>	<b>2,450</b>	<b>3,200</b>	<b>1,975</b>	<b>1,800</b>	<b>3,775</b>	<b>2,100</b>	<b>500</b>		

Source: Fisheries and Marine Service, Annual spawning survey reports.

APPENDIX D ESTIMATED COHO SALMON ENHANCEMENTS TO STREAMS IN AREA 26 FROM 1951 TO 1975.

STUDY AREA STREAMS	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
Tahlish R.	3,500	3,500	1,500	750	3,500	7,500	3,500	1,500	750	750	750	750	750	200	200	400	750	200	25	1,500	7,500	3,500	400	400	25	
Kaouk R.	750	750	400	1,500	3,500	3,500	1,500	3,500	400	750	400	400	750	750	400	200	25	0	200	1,500	400	1,500	1,000	1,500	200	
Artlish R.	1,500	1,500	1,500	3,500	3,500	7,500	1,500	1,500	750	750	400	75	400	1,500	200	400	200	25	25	400	400	75	500	750	25	
Kauwinch R.	750	400	750	750	1,500	750	750	1,500	200	400	400	200	400	1,500	25	25	25	25	25	400	400	1,200		750	400	
Harrowgut Ck.	400	400	400	592	75	400	400	750	400	200	200	200	200	200	200	750	25	75	200	200	400	200			75	
Kashutl R.	200	1,500	400	750	1,500	1,500	750	750	200	25	75	200	200	25	25	200	25	25	25	25	200	25	150	25		
Anal Ck.	200	400	400	750	1,500	1,500	400	400	200	400	25	200	25	25	200	400		75		25	200	75	25	25	no survey	
Easy Ck.	200	200	400	640	750	1,500	400	400	400	400	25		400		25	200	25	25	25	750	25	75			75	
Chamiss Ck.	200	750	400	900	200	1,500	750	200	200	75	200	75	25			200		200	25	400	400	25	25		25	
Cachelot Ck.								25		25												25	25	25		
Yaku Bay Ck.							34																			
Elaine Ck.	25	400	200	400	25	75	25	25		25	75			400	200	200			25							
Jansen Lake Ck.	750	400	750	1,500	3,500	3,500	1,500	1,500	200	400	200	750	75			25			25	25		25	25		25	
<b>TOTALS</b>	<b>8,475</b>	<b>10,200</b>	<b>7,100</b>	<b>12,032</b>	<b>19,550</b>	<b>29,225</b>	<b>11,509</b>	<b>12,050</b>	<b>3,700</b>	<b>4,200</b>	<b>2,750</b>	<b>2,850</b>	<b>3,225</b>	<b>4,600</b>	<b>1,475</b>	<b>3,000</b>	<b>1,075</b>	<b>650</b>	<b>600</b>	<b>5,225</b>	<b>9,950</b>	<b>6,725</b>	<b>2,150</b>	<b>3,450</b>	<b>850</b>	
<b>OTHER STREAMS IN AREA 26</b>																										
Naspartl R.	400	400	400	750	750	750	750	400	200	25	75	200	25		25	25	25	25	25	75					200	200
Power R.	750	1,500	1,500	1,500	3,500	3,500	1,500	1,500	750	1,500	400	3,500	3,500		400	400	75	25	400	25	200	75	400	75	200	
Ououkinsh R.	400	750	750	750	750	750	750	400	400	25	75	25	750	25	75	25	25	25	25	750	200	750	400	400	400	200
Halksope R.	400	750	750	750	3,500	1,500	750	1,500	1,500	200	200	200	1,500	400	200	400	75	200	750	1,500	1,500	400	400	75	750	
Clenninck R	200	400	400	400	750	750	400	200	400	75	400	200	400	200	400	400		200	25	400	200	25	400	750	25	
Battle R.	400	750	400	400	750	750	750	200	200	25	200		25			25				200		25	200			
Hackay R.		200	200	25	75	75	75	75	25	25	75	75	25			25				75	200	25	25	no report	25	
<b>TOTALS</b>	<b>2,550</b>	<b>4,750</b>	<b>4,400</b>	<b>4,575</b>	<b>10,075</b>	<b>8,075</b>	<b>4,975</b>	<b>4,275</b>	<b>3,475</b>	<b>1,875</b>	<b>1,425</b>	<b>4,200</b>	<b>6,225</b>	<b>625</b>	<b>1,100</b>	<b>1,300</b>	<b>200</b>	<b>475</b>	<b>1,225</b>	<b>3,025</b>	<b>2,300</b>	<b>1,300</b>	<b>1,825</b>	<b>1,500</b>	<b>1,400</b>	
<b>TOTAL ESCAPEMENT TO AREA 26</b>	<b>11,025</b>	<b>14,950</b>	<b>11,500</b>	<b>16,607</b>	<b>29,625</b>	<b>37,300</b>	<b>16,484</b>	<b>16,325</b>	<b>7,175</b>	<b>6,075</b>	<b>4,175</b>	<b>7,050</b>	<b>9,450</b>	<b>5,225</b>	<b>2,575</b>	<b>4,300</b>	<b>1,275</b>	<b>1,125</b>	<b>1,825</b>	<b>8,250</b>	<b>12,250</b>	<b>8,025</b>	<b>3,975</b>	<b>4,950</b>	<b>2,250</b>	

Source: Fisheries and Marine Service, Annual spawning survey reports.

APPENDIX E SALMON OBSERVATIONS IN THE LARGE RIVER SYSTEMS OF KYUQUOT SOUND,  
OCTOBER - NOVEMBER, 1976.

Stream	Date	Stream Section	Salmon Species				
			Pink	Chum	Chinook	Coho	Sockeye
TAHSISH R.	Oct. 15	Section 1 (0-3 km)	43 S <sup>a</sup> 2 D <sup>a</sup>	335 S 4 D	12 S 12 D	1,200 H <sup>b</sup> 2 D	4 S
		Section 2 (3-6 km)		126 S	6 S	222 H	
	Nov. 3	Section 1		542 S 29 D		37 S 10 H	
		Section 2		40 S 3 D		10 S 46 H	
KAOUK R.	Oct. 1	Section 1 (0-5.5 km)	11,884 S 8,555 H 2,698 D	3 S 1 D	21 S 11 H 1 D	2 H 2 D	1 H 2 D
		Section 2 (5.5-9 km)	11,500 S 2,000 D				2 H
		Section 3 (9-12 km)	2,218 S				
	Oct. 17	Section 1	5,215 S 800 H 10,300 D				
	Nov. 2	Section 1	8 S	180 S 50 H 25 D	2 S		
		Section 2		1,904 S 33 H 18 D			1 H
Section 3			30 S 29 H 3 D		1 H		
ARTLISH R.	Oct. 14	Section 1 (0-2.5 km)	2 S 29 D		11 S	30 H	30 H
		Section 2 (2.5-4 km)	6 D				
		Section 3 (4-5 km)	None Observed				
	Nov. 4	Section 1		35 S 3 D			
	Section 2		142 S				
KAUWIICH R.	Oct. 16	Section 1 (0-3 km)	16 S 1 D	102 S 229 H 3 D		300 H	
		Section 2 (3-6 km)	1 D	6 S			
	Nov. 5	Section 1	1 D	85 S 44 D			

\* S = Spawning  
H = Holding  
D = Dead

APPENDIX F SALMONID OBSERVATIONS IN THE SMALL RIVER SYSTEMS OF  
KYUQUOT SOUND, OCTOBER - NOVEMBER, 1976.

Stream	Date	Distance Surveyed	Chum	Coho	Sockeye	Steelhead
Narrowgut R.	Nov. 4	1.6 km	105 S 46 D			
Kashutl R.	Oct. 16	2 km	60 S 60 H	6 H		6 H
Amai Ck.	Nov. 6	1.6 km	121 S	1 S		
Easy Ck.	Nov. 5	1.6 km	67 S 2 D	2 H		
Chamiss Ck.	Nov. 5	2 km	3217 S 860 D	2 S	2 S	
Cachalot Ck.	Nov. 4	1 km	17 S 48 D			
Yaku Bay Ck.	Not Surveyed					
Elaine Ck.	Nov. 5	0.5 km	20 S	10 S		
Jansen Lake Ck.	Not Surveyed					

APPENDIX G COMMERCIAL NET CATCHES OF CHUM SALMON IN AREA 26 FROM 1951 TO 1975.

Year	Catch in Pieces		Total Net Catch
	Seine	Gillnet	
1951	23,288	412	23,800
1952	6,925	33	6,958
1953	87,258	23	87,281
1954	62,613	-	62,613
1955	5,446	35	5,481
1956	38,772	335	39,107
1957	65,653	791	66,444
1958	84,481	2,812	87,293
1959	91,250	2,213	93,463
1960	115,016	15,928	130,944
1961	28,432	19,877	48,309
1962	13,317	15,324	28,641
1963	5,810	8,724	14,534
1964			
1965			
1966	2		2
1967			
1968		17	17
1969		3	3
1970	75		25
1971	3,379	4,237	7,616
1972	3,123	8,251	11,374
1973	10,482	14,129	24,611
1974	34,667	26,620	61,287
1975	26,332	11,651	37,983

Source: Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX H COMMERCIAL NET CATCHES OF PINK SALMON IN AREA 26 FROM  
 1952 to 1974.

Year	Catch in Pieces		Total Net Catch
	Seine	Gillnet	
1952			
1954	784	418	1,202
1956	22,411		22,411
1958			
1960	5		5
1962			
1964			
1966	65,561	141	65,702
1968	455		455
1970	400		400
1972	3,772		3,772
1974	32	99	131

Source: Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX I • COMMERCIAL NET CATCHES OF CHINOOK SALMON IN AREA 26 FROM  
1951 TO 1975.

Year	Catch in Pieces		Total Net Catch
	Seine	Gillnet	
1951	1		1
1952			
1953	6		6
1954	4		4
1955	1		1
1956	3		3
1957			
1958	12		12
1959	95		95
1960	69	13	82
1961	77	111	188
1962	97	21	118
1963	3	19	22
1964			
1965			
1966	73		73
1967			
1968		6	6
1969			
1970			
1971	1		1
1972	95	8	103
1973	222	131	353
1974	569	88	657
1975	1,454	151	1,605

Source: Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX J COMMERCIAL NET CATCHES OF COHO SALMON IN AREA 26 FROM 1951 TO 1975.

Year	Catch in Pieces		Total Net Catch
	Seine	Gillnet	
1951	2,018	95	2,113
1952	86	8	94
1953	2,727	4	2,731
1954	2,375	15	2,390
1955	2,691	1	2,692
1956	2,532	38	2,570
1957	940	54	994
1958	2,459	183	2,692
1959	3,907	71	3,978
1960	3,347	868	4,215
1961	3,288	1,346	4,634
1962	1,039	1,369	2,408
1963	552	540	1,092
1964			
1965			
1966	284	5	289
1967			
1968	6	158	164
1969		5	5
1970	671		671
1971	391	275	666
1972	660	530	1,190
1973	490	885	1,375
1974	2,255	1,663	3,918
1975	4,087	824	4,911

Source: Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX K ESTIMATED ESCAPEMENT, NET CATCHES AND TOTAL CHUM SALMON STOCKS IN AREA 26 FROM 1951 TO 1975 (IN THOUSANDS).

Year	Estimated Escapement <sup>1</sup>	Net Catches <sup>2</sup>	Total Stock
1951	56.9	23.8	80.7
1952	104.1	7.0	111.1
1953	77.4	87.3	164.7
1954	63.7	62.6	126.3
1955	26.1	5.5	31.6
1956	41.2	39.1	80.3
1957	74.4	66.4	140.8
1958	109.8	87.3	197.1
1959	53.7	93.5	147.2
1960	62.6	130.9	193.5
1961	20.4	48.3	68.7
1962	35.8	28.6	64.4
1963	10.7	14.5	25.2
1964	36.3	-	36.3
1965	31.3	-	31.3
1966	73.4	-	73.5
1967	35.2	-	35.2
1968	38.0	-	38.0
1969	44.3	-	44.3
1970	109.1	-	109.1
1971	68.7	7.6	76.3
1972	105.5	11.4	116.9
1973	111.9	24.6	136.5
1974	54.1	61.3	115.4
1975	33.3	38.0	71.3

Sources: <sup>1</sup>Fisheries and Marine Service, Annual spawning survey reports.

<sup>2</sup>Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX L ESTIMATED ESCAPEMENT, NET CATCHES AND TOTAL CHUM SALMON STOCKS IN AREAS 22-27 (WEST COAST OF VANCOUVER ISLAND) FROM 1951 TO 1975 (IN THOUSANDS).

Year	Estimated Escapement <sup>1</sup>	Net Catches <sup>2</sup>	Total Stock
1951	393	435	828
1952	382	120	502
1953	553	653	1,206
1954	699	918	1,617
1955	173	221	394
1956	349	605	954
1957	385	401	786
1958	520	538	1,058
1959	295	300	595
1960	563	441	1,004
1961	219	175	394
1962	237	126	363
1963	175	78	253
1964	349	46	395
1965	235	<1	235
1966	331	1	332
1967	306	<1	306
1968	572	2	574
1969	356	4	360
1970	448	127	575
1971	313	102	415
1972	853	1,484	2,337
1973	696	449	1,145
1974	515	232	747
1975	257	129	386

Sources: <sup>1</sup> Fisheries and Marine Service, Annual spawning survey reports.

<sup>2</sup> Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX M ESTIMATED ESCAPEMENT, NET CATCHES AND TOTAL PINK SALMON STOCKS IN AREA 26 FROM 1952 TO 1974 (IN THOUSANDS).

Year	Estimated Escapement <sup>1</sup>	Net Catches <sup>2</sup>	Total Stock
1952	9.7	-	9.7
1954	8.5	1.2	9.7
1956	16.0	22.4	38.4
1958	39.8	-	39.8
1960	12.6	-	12.6
1962	6.7	-	6.7
1964	4.5	-	4.5
1966	121.8	65.7	187.5
1968	30.4	0.5	30.9
1970	46.7	0.4	47.1
1972	154.1	3.8	157.9
1974	20.4	0.1	20.5

Source: <sup>1</sup> Fisheries and Marine Service, Annual spawning survey reports.

<sup>2</sup> Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX N ESTIMATED ESCAPEMENT, NET CATCHES AND TOTAL PINK SALMON STOCKS IN AREAS 22-27, (WEST COAST OF VANCOUVER ISLAND) FROM 1952 TO 1974 (IN THOUSANDS).

Year	Estimated Escapement <sup>1</sup>	Net Catches <sup>2</sup>	Total Stock
1952	Incomplete Records		
1954	Incomplete Records		
1956	53	192	245
1958	64	29	93
1960	30	-	30
1962	120	-	120
1964	87	3	90
1966	392	83	475
1968	365	84	449
1970	190	56	246
1972	440	19	459
1974	95	21	116

Source: <sup>1</sup> Fisheries and Marine Service, Annual spawning survey reports.

<sup>2</sup> Fisheries and Marine Service, B.C. Revised Catch Statistics.

APPENDIX 0 ESTIMATED ESCAPEMENT OF CHINOOK SALMON TO AREA 26 AND  
 TO AREAS 22-27 (WEST COAST OF VANCOUVER ISLAND)  
 FROM 1951 TO 1975 (IN THOUSANDS).

Year	Estimated Escapement	
	Area 26	Areas 22-27
1951	5.8	48
1952	13.7	44
1953	6.9	42
1954	5.8	26
1955	5.4	26
1956	5.1	29
1957	5.8	26
1958	5.5	30
1959	0.8	21
1960	1.7	21
1961	1.5	21
1962	1.4	23
1963	4.9	25
1964	4.6	41
1965	1.1	28
1966	8.7	35
1967	1.2	26
1968	2.7	26
1969	2.1	23
1970	2.6	17
1971	1.9	25
1972	1.6	20
1973	4.0	23
1974	2.0	23
1975	0.2	20

Source: Fisheries and Marine Service, Annual spawning survey reports.

APPENDIX P ESTIMATED ESCAPEMENT OF COHO SALMON TO AREA 26 AND TO AREAS 22-27, (WEST COAST OF VANCOUVER ISLAND) FROM 1951 TO 1975 (IN THOUSANDS).

Year	Estimated Escapement	
	Area 26	Areas 22-27
1951	11.0	189
1952	15.0	200
1953	11.5	182
1954	16.6	157
1955	29.6	116
1956	27.3	138
1957	16.5	91
1958	16.3	109
1959	7.2	98
1960	6.1	50
1961	4.2	90
1962	7.1	113
1963	9.5	87
1964	5.2	153
1965	2.6	134
1966	4.3	157
1967	1.3	128
1968	1.1	114
1969	1.8	69
1970	8.3	198
1971	12.3	143
1972	8.0	82
1973	4.0	202
1974	5.0	171
1975	2.3	74

Source: Fisheries and Marine Service, Annual spawning survey reports.

## REFERENCES CITED

- Anderson, A.D. 1976. The 1975 return of chum salmon stocks to the Johnstone Strait - Fraser River study area, and prospects for 1976. Fish. Mar. Serv. Tech. Rept. Ser. PAC/T-73-9.
- Andrew, F.J. (pers. comm.) Engineer, International Pacific Salmon Fisheries Commission.
- Aro, K.V. and M.P. Shepard. 1967. Salmon of the north Pacific Ocean. Part IV. Spawning populations of north Pacific salmon. 5. Pacific salmon in Canada. Internat. North Pac. Fish. Comm. Bull. 23 : 225-327.
- Bams, R.A. and K.S. Simpson. 1977. Substrate incubators workshop - 1976. Report on current state-of-the-art. Fish. Mar. Serv. Tech. Rept. 689.
- Bell, M.A.M., Beckett, J.M. and W.F. Hubbard. 1974. Impact of harvesting on forest environments and resources - A review of the literature and evaluation of research needs. Environment Canada, Forestry Service, Pacific Forest Research Centre.
- Environment Canada. 1974. An environmental assessment of Nanaimo port alternatives. Prepared by Lands Directorate for the Canadian Ports and Harbours Planning Committee.
- Gilhousen, P. 1962. Marine factors affecting the survival of Fraser River pink salmon. In: N.J. Wilimovsky (ed.) Symposium on pink salmon. H.R. MacMillan Lecture Series in Fisheries, University of British Columbia.
- Kaczynski, V.W., Feller, R.J. and J. Clayton. 1973. Trophic analysis of juvenile pink and chum salmon (*Oncorhynchus gorbuscha* and *O. keta*) in Puget Sound. J. Fish. Res. Bd. Can. 30 : 1003-1008.

- Killick, S.R. 1955. The chronological order of Fraser River sockeye salmon during migration, spawning and death. Internat. Pac. Sal. Fish. Comm. Bull. 7.
- Krajina, V.J. 1970. Ecology of forest trees in British Columbia. In: V.J. Krajina and R.C. Brooke, (ed.) Ecology of western North America. Department of Botany, University of British Columbia.
- Lebrasseur, R.J. and R.R. Parker. 1964. Growth rate of central B.C. pink salmon. J. Fish. Res. Bd. Can. 21 : 1101-1128.
- Manzer, J.I. 1976. Preliminary results of studies on the effects of fertilization of an oligotrophic lake on adult sockeye salmon (Oncorhynchus nerka) production. Fish. Mar. Serv. Tech. Rept. No. 678.
- Milne, D.J. 1964. The chinook and coho salmon fisheries of British Columbia. Fish. Res. Bd. Can. Bull. 142.
- Narver, D.W. 1971. Effect of debris on fish production. In: A symposium - Forest Land Uses and Stream Environment; School of Forestry and Department of Fisheries and Wildlife, Oregon State University.
- Pickard, G.L. 1963. Oceanographic characteristics of inlets of Vancouver Island, British Columbia. J. Fish. Res. Bd. Can. 20(5) : 1109-1144
- Reid, G. (pers. comm.) Regional Fisheries Biologist, B.C. Fish and Wildlife Branch, Nanaimo, B.C.
- Roberts, M.E.L. 1970. The status of chum salmon stocks of the west coast of Vancouver Island, 1934-1968, Statistical areas 22-27. Fish. Serv., Pac. Region Tech. Rept. No. 3.
- Scrivener, J. Charles. 1975. Water, water chemistry and hydrochemical balance of dissolved ions in Carnation Creek watershed, Vancouver Island, July, 1971 - May 1974. Fish. Mar. Serv. Tech. Rept. 564.

Sheridan, W.L. 1962. Relation of stream temperatures to timing of pink salmon escapements in southeast Alaska. In: N.J. Wilimovsky, (ed.) Symposium on pink salmon. H.R. MacMillan Lecture Series in Fisheries, University of British Columbia.

Sinclair, D.C. (pers. comm.) Biologist, Fisheries and Marine Service, Vancouver, B.C.

Slater, R.A. (pers. comm.) Fishery Officer, Fisheries and Marine Service, Tahsis, B.C.

Strahler, A.N. 1965. Introduction to physical geography. John Wiley and Sons, Inc., New York.

Underwood - McClellan and Associates. 1972. Preliminary engineering for the proposed Quinsam River fish hatchery.

Vivian, J. (pers. comm.) Sportfisherman, Vancouver, B.C.

Wickett, W.P. 1962. Environmental variability and reproduction potentials of pink salmon populations in British Columbia. In: N.J. Wilimovsky (ed.) Symposium on pink salmon. H.R. MacMillan Lecture Series in Fisheries, University of British Columbia.